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Reference Framework

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Data Management Working Group

October 2025

Reference Framework

Data Management Working Group

October 2025

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List of Acronyms and Abbreviations

AhG **Ad hoc Group**

BPMN Business Process Model and Notation

BRP Balance Responsible Party

BTM Behind-the-Meter

CG-SG Coordination Group on Smart Grids

CEN *Comité Européen de Normalisation* (European Committee for Standardisation)

CENELEC *Comité Européen de Normalisation en ÉLectronique et en ÉlectroteChnique* (European Committee for Electrotechnical Standardisation)

DER Distributed Energy Resources

DMWG Data Management Working Group

DR Demand Response

DSO Distribution System Operator

EG Expert Group

EMS Energy Management System

ESCo Energy Service Company

ETSI European Telecommunications Standards Institute

EV Electrical Vehicle

FO Flexibility Offer

FSP Flexibility Service Provider

FTM Front-of-the-Meter

GBP Generic Business Process

GUC Generic Use Case

HEMRM	Harmonized Electricity Market Role Model [9]
IEC	International Electrotechnical Commission
IRM	Interface Reference Model
LEC	Local Energy Community
MO	Market Operator
M&V	Measurement & Verification
P2P	Peer-to-peer
SG-CG	Smart Grid Coordination Group
SGAM	Smart Grid Architecture Model
SGTF	Smart Grid Task Force
SLA	Service Level Agreement
SO	System Operator (i.e. TSO or DSO)
TSO	Transmission System Operator
UC	Use-Case
UML	Unified Modeling Language
WG	Working Group

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Executive Summary

Initially, the topic of "Interoperability of flexibility assets" was discussed and its scope defined during the BRIDGE General Assembly held on 11 and 12 March 2020 in Brussels [1]. A first report [2] on this topic was published in April 2021, including a reference framework made of 3 generic business processes (GBPs) and performing an interoperability analysis over 10 use cases from 4 projects. Then, the reference framework was extended to add 2 new GBPs and propose a first version of the settlement subprocess. This second version of the reference framework was detailed in the "Interoperability of flexibility assets" report version 2.0 [3] completed in June 2022, together with an interoperability analysis based on 36 use cases from 14 projects. A third version [4] of the reference framework was published in June 2023, now describing 7 GBPs and also detailing the settlement subprocess.

An update [5] was written in March 2024 to provide inputs on the way forward for the reference framework. It included the following recommendations:

1. Further improve the reference framework: align GBPs with project use cases, extend the list of GBPs, improve alignment with other frameworks.
2. Reinforce the reference framework to support practical implementation: use-case harmonisation (incl. generic actor list), list of relevant protocols/standards, …
3. Follow up on the application of the settlement guidelines to current and future projects.
4. Share this report with relevant parties such as ENTSO-E / EU DSO Entity JWG (in particular the team in charge of the Demand-Response Implementing Act) and CEN/CLC/ETSO CG-SG.

This report presents the activities achieved in 2023-2024 on these priorities, in particular:

1. A survey was conducted to identify recommendations for the improvement of the reference framework
    - Specifically, feedback on the implementation of the settlement sub-process was required
- The work to establish an updated generic actor list, has continued, to enable harmonisation of the use-cases definition, in particular within the BRIDGE use-case repository.
- Experts from the projects and CEN/CLC/ESTI CG-SG have been involved during the first revision planned at the end of 2024.
2. A survey was conducted to update the list of protocols and standards in link to the GBPs

Introduction

The Data Management Working Group aims to cover a wide range of aspects ranging from the technical means for exchanging and processing data between interested stakeholders to the establishment of rules for exchange, including security issues and responsibility distribution in data handling. Accordingly, the WG has identified 3 areas of collaboration around which mutual exchange of views and discussions have been set:

1. **Communication Infrastructure**, embracing the technical and non-technical aspects of the communication infrastructure needed to exchange data and the related requirements
2. **Cybersecurity and Data Privacy**, entailing data integrity, customer privacy and protection and general security of energy systems
3. **Data Handling**, including the framework for data exchange and related roles / responsibilities, together with the technical issues supporting the exchange of data in a secure and interoperable manner, and the data analytics techniques for data processing

This report deals with the 3rd area, “Data Handling”, and covers the topic of a “Reference framework” for interoperability.

Initially, the topic of “Interoperability of flexibility assets” was discussed and its scope defined during the BRIDGE General Assembly held on 11 and 12 March 2020 in Brussels [1]. A first report [2] on this topic has been published in April 2021, including a reference framework made of 3 generic business processes (GBPs) and performing an interoperability analysis over 10 use cases from 4 projects. Then, the reference framework was extended to add 2 new GBPs and propose a first version of the settlement subprocess. This second version of the reference framework was detailed in the “Interoperability of flexibility assets” report version 2.0 [3] completed in June 2022, together with an interoperability analysis based on 36 use cases from 14 projects. A third version [4] of the reference framework was published in June 2023 to include two new GBPs, and a sub-process on settlement. An update [5] was published in November 2024 to include a guideline for the implementation of settlement.

Following the BRIDGE General Assembly of March 2024, it was decided to focus the activities on the improvement of the reference framework, extending it to include a generic actors list and updating the list of relevant standards.

In 2024-2025, the work around the reference framework focuses on three topics:

- Collecting experiences and feedback on the Reference Framework implementation, in particular on the settlement subprocess
- The defining of the generic actor list, to enable harmonisation of the use-case definition, in particular within the BRIDGE use-case repository.
- Updating the list of relevant standards and protocols

This report presents the results of these three activities. The reference framework is attached in Annex 1.

General Approach

1.1 Context

The reference framework was initially developed to support a methodology to analyse how projects achieve interoperability of flexibility assets, including standards assessment (adequacy, maturity …) and gaps identification.

Used as a common denominator between all the projects, the reference framework's objective was to set out some generic business processes, which are agnostic to any specific technical solution, enabling users to map each of the projects' specific solutions to these GBPs to enable cross-projects comparison and analysis.

The diagram below depicts how the methodology relied on the reference framework to compare and harmonise the contributions from different projects with different technical solutions, and how it was used to analyse these contributions to establish outcomes such as map of standards and assessment and gap identification.

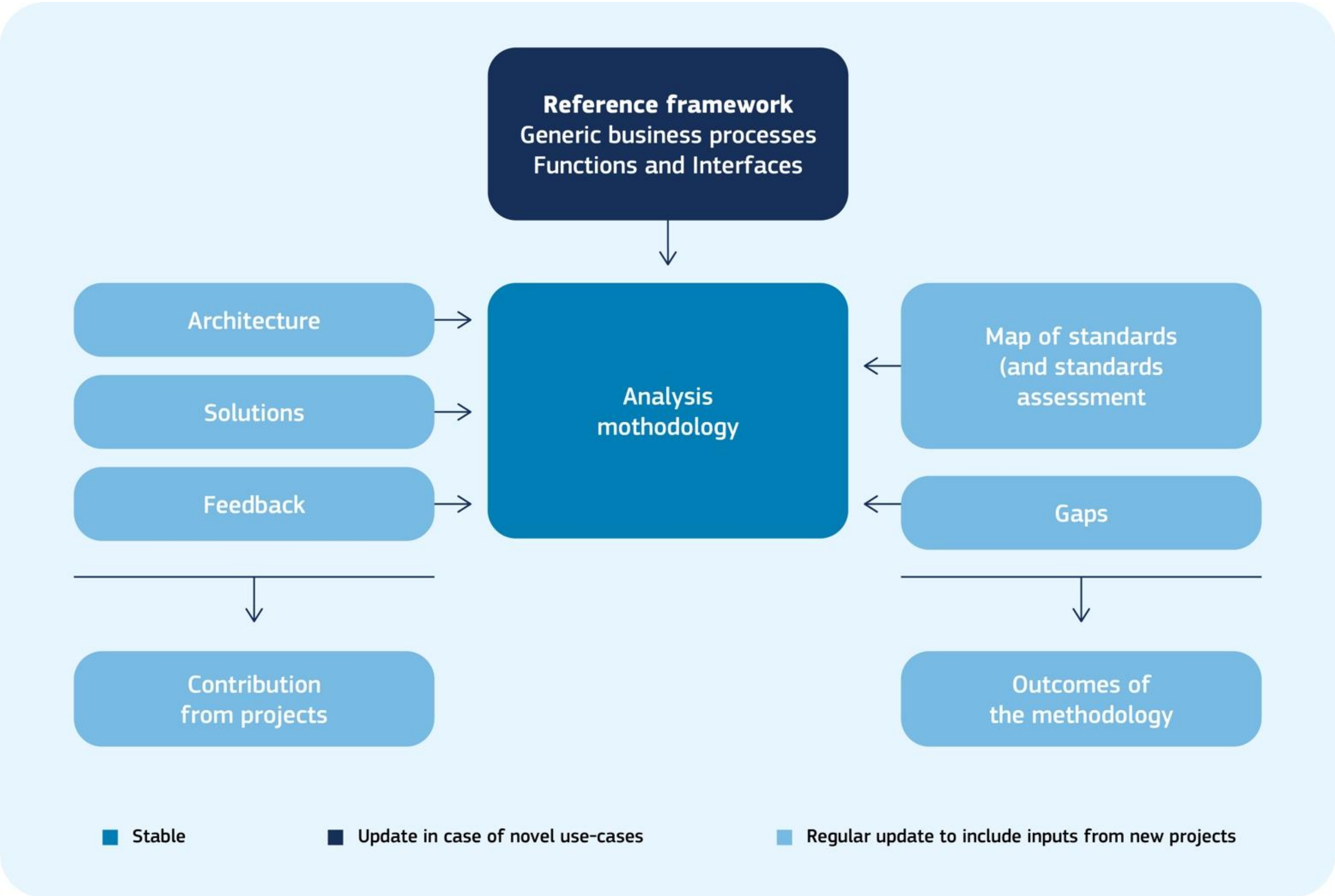

Figure 1 - Description of the reference framework as part of the methodology set in 2020 to study the interoperability of flexibility assets

Following the BRIDGE General Assembly of March 2022, it has been decided to focus on the development and enhancement of the Reference Framework, beyond flexibility, as a tool to support interoperability and to harmonise use-case descriptions between projects (e.g. via the BRIDGE use-case repository).

1.2 Reference Framework Components

The reference framework is a common base to compare and harmonise the use cases from different projects with different technical solutions.

It relies on GBPs, made of functions and interfaces, with which each project's use cases and architecture can be mapped.

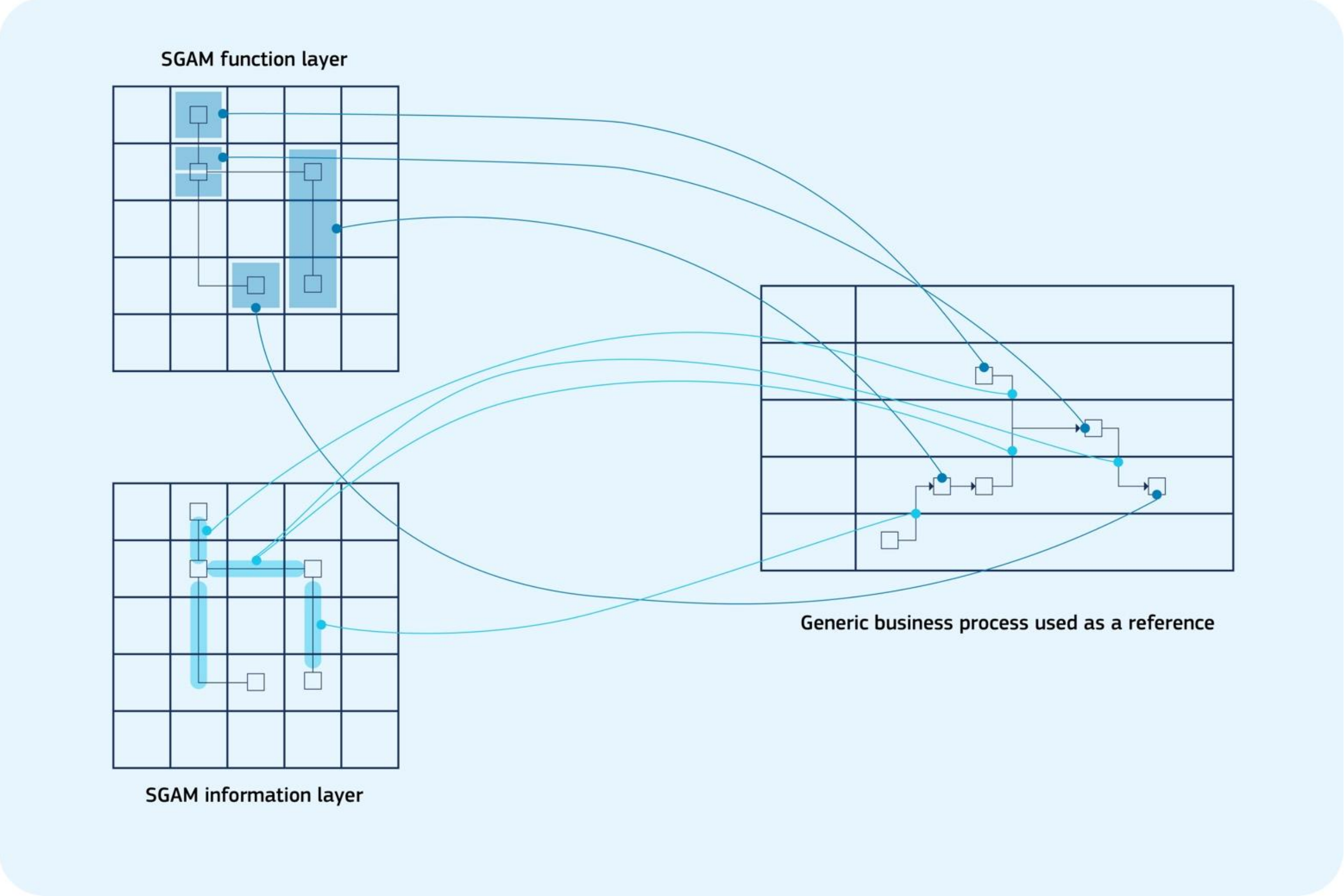

Figure 2 - Example mapping between the SGAM layers of a specific solution/use case and a generic business process used as a reference

1.2.1 Generic Business Process

Each generic business process is a description of a process between business roles such as DSO and aggregator. It is decomposed into subprocesses which are called "functions" (see below). These functions may require information exchange between roles, through interfaces. They may also require external data (e.g. metering data) or external command capabilities (e.g. load control).

Such business process description allows users to cover both the function layer and the information layer of the SGAM, which are the focus for the interoperability of flexibility assets. They are called "generic" because they are independent to any technical solution and several use cases could be mapped to them.

These GBPs are described with a simple diagram derived from BPMN. Each row refers to a role. Functions are represented as rectangles and interfaces are represented as arrows. If several paths are possible, the alternative path is drawn with dotted lines.

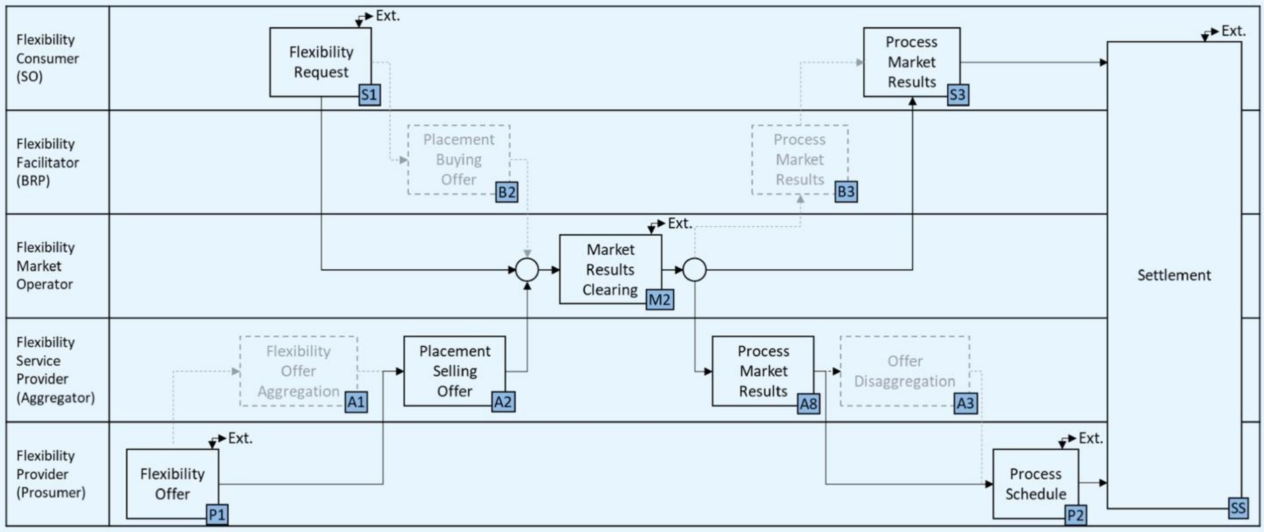

Figure 3 - Example of business process diagram

1.2.2 Functions and Interfaces

The "functions" represent each of the steps of the business process. They receive inputs from the previous function, use external data or commands and finally provide outputs to the following function. They can be broken down into "subfunctions", which might be useful for more detailed mapping with some specific architecture.

They are defined with the following table:

Table 1 - Template for function description

X1 / Function name	
Description	This cell describes the purpose of the function, e.g. "the Aggregator collects flexibility offers of all prosumers and calculates the available flexibility for its portfolio"
Inputs	This cell lists the inputs received from the previous function, e.g. "Flexibility offer of prosumer(s)"
Outputs	This cell lists the outputs provided to the following function, e.g. "Aggregated flexibility"
External required data or command	This cell lists the data or commands that are not linked to the previous or following functions but are required to perform the function. An example of external data could be "weather data", "metering data", etc. An example of command could be "control of flexible loads".

Breakdown into functions/subfunctions	This cell describes the breakdown of the function into subfunctions.

The “interfaces” represent the information exchanges between the functions. They are defined with the following table:

Table 2 - Template for interface description

X1 → Y1	
Purpose	This cell describes the purpose of the information exchange, e.g. “inform Aggregator about possible flexibility on Prosumer side”
Roles involved	This cell lists the roles involved
List of exchanged data	This cell lists the exchanged data, e.g. “Flexibility offer”

The analysis of the functions allows users to study function layer interoperability. The analysis of the interfaces allows them to study information layer interoperability.

1.2.3 Contents of the Reference Framework

The reference framework has been developed and extended over the course of four years. It now includes 7 generic business processes, 1 sub-process, completed by descriptions of all the stakeholders, functions and interfaces. Examples of implementing projects are provided, and a list of standards that have been used by previous projects for each interface is included. Guidelines on the implementation of the settlement are also provided. The processes set out in the framework are:

- GBP1 – Flexibility for SO through open market
- GBP2 – Flexibility for SO via prior bilateral agreement
- GBP3 – Flexibility for BRP portfolio optimisation
- GBP4 – Flexibility for energy community optimisation
- GBP5 – Implicit flexibility using dynamic steering signals
- GBP6 – Energy monitoring and energy management
- GBP7 – P2P Trading in energy community
- Settlement subprocess

The full framework is available in Annex 1.

Increasing the Impact of the Reference Framework

1.3 Investigation from BRIDGE Projects

1.3.1 Reference Framework Feedback Survey

A survey about the reference framework was sent to BRIDGE projects in October 2024. The questions are listed below:

- **BRIDGE Reference Framework Section**
  - How did you use the framework?
  - Did you face any difficulties in using/understanding the framework?
    - If yes, please explain
  - Do you see inconsistencies between BRIDGE Reference Framework and other frameworks?
    - If yes, please explain
- **Generic Business Process (GBP) Section**
  - Please indicate which GBPs are relevant for your project(s)
  - Please rate the level of alignment of your UC with GBPx
  - Please describe main misalignment points (if any)
  - Please indicate how satisfied you are with the level of detail of the GBP analysis
  - Please indicate any suggestions for improvement of the GBP analysis
  - Are there any GBPs that you would like to see added in the Framework? Please, briefly describe them
- **Settlement sub-processes section**
  - Has settlement been performed in your project?
  - Did you use the settlement sub-process to implement it?
    - If yes, was the sub-process easy to understand and to use?
    - If no, is the settlement sub-process aligned with your project implementation?
- **Conclusion section**
  - Do you have suggestions on how to make the Reference Framework more practical?

1.3.2 Answers to the Feedback Survey

The survey received 16 answers from 15 projects (OMEGA-X, Hedge-IoT, REEFLEX, ACCEPT, SERENE, Parmenides, MAESHA, PEDvolution, ENFLATE, MASTERPIECE, RESONANCE, SYNERGIES, WEDUSEA, SUSTENANCE and Data Cellar)

1.3.2.1 BRIDGE Reference Framework Section

1.3.2.1.1 Q1: How did you use the framework:

Project	Use of the framework
	We are using already different techniques in running EU projects and are aligning them to the bridge framework.

SUSTENANCE	As part of our current running projects, the reference Frameworks has not been used / implemented.
Data Cellar	to verify if Data Cellar reference architecture (compliant with the Gaia-X and ISDA frameworks) also matches the federation principles of DERA.
PEDvolution	Considered in the UC definition
SERENE	As an idea for setting up frameworks for flexibility provision in local communities
REEFLEX	For the architecture definition of some projects' tools.
MASTERPIECE	Although it is not directly instantiated in MASTERPIECE, the European (Energy) Data Exchange Reference Architecture 3.0 is used as a reference. This framework provides fundamental guidance on interoperability and layer definition, which are essential for designing energy management, especially within the context of energy communities. The architecture enables the integration of multiple actors and data sources, promoting a structured and efficient approach to ensure systems can exchange information seamlessly, thereby optimising operations within the shared energy domain.
Parmenides	We used the framework to help define the architecture of the project, and to identify standards relevant to some of the interfaces.
ENFLATE	To discuss business scenarios
Hedge-IoT	Support the use case creation process
WEDUSEA	We reviewed the Generic Business Processes that have been developed. The framework gives a common base to compare and harmonise the use cases from different projects with different technical solutions.
OMEGA-X	To align the project's approach to the common European understanding.
ACCEPT	We used the framework in order to see how some of our UCs can be translated to a settlement sub-process
MAESHA	Since the use cases of the MAESHA project had to be defined before July 2021, this project

	didn't use the Reference framework for use case definition.
RESONANCE	The 5 GBPs defined in the 2022 version of the BRIDGE Reference Framework have been listed as generic use case sources to be used for the definition of the RESONANCE project's generic use cases. These 5 GBP are the following : - Flexibility for System Operator (DSO or TSO) through open market - Flexibility for System Operator (DSO or TSO) via prior bilateral agreement - Flexibility for Balance Responsible Party (BRP) portfolio optimisation - Flexibility for energy community optimisation - Implicit flexibility using dynamic steering signals. Nevertheless, after carefully examining the different generic use cases sources within the project, it has been decided to select business use cases from IEC 62746-2 since the Reference framework GBP focuses more on flexibility trading/procurement than on flexibility provision/activation (which is closer to the focus of the RESONANCE project).
SYNERGIES	The various GBPs were assessed against their alignment to the scope of SYNERGIES. Those that were in scope were further analysed and considered in the relevant work flows and use cases delivered by the project.

For most of the projects, the framework is used to help define the use cases, architecture and frameworks of the project. The framework is generally first assessed to check the alignment of the different GBPs against the use cases of the project, then the most relevant ones are used for setting out the specifications. The framework can also be used to compare different projects.

1.3.2.1.2 Q2: Did you face any difficulties in using/understanding the framework?

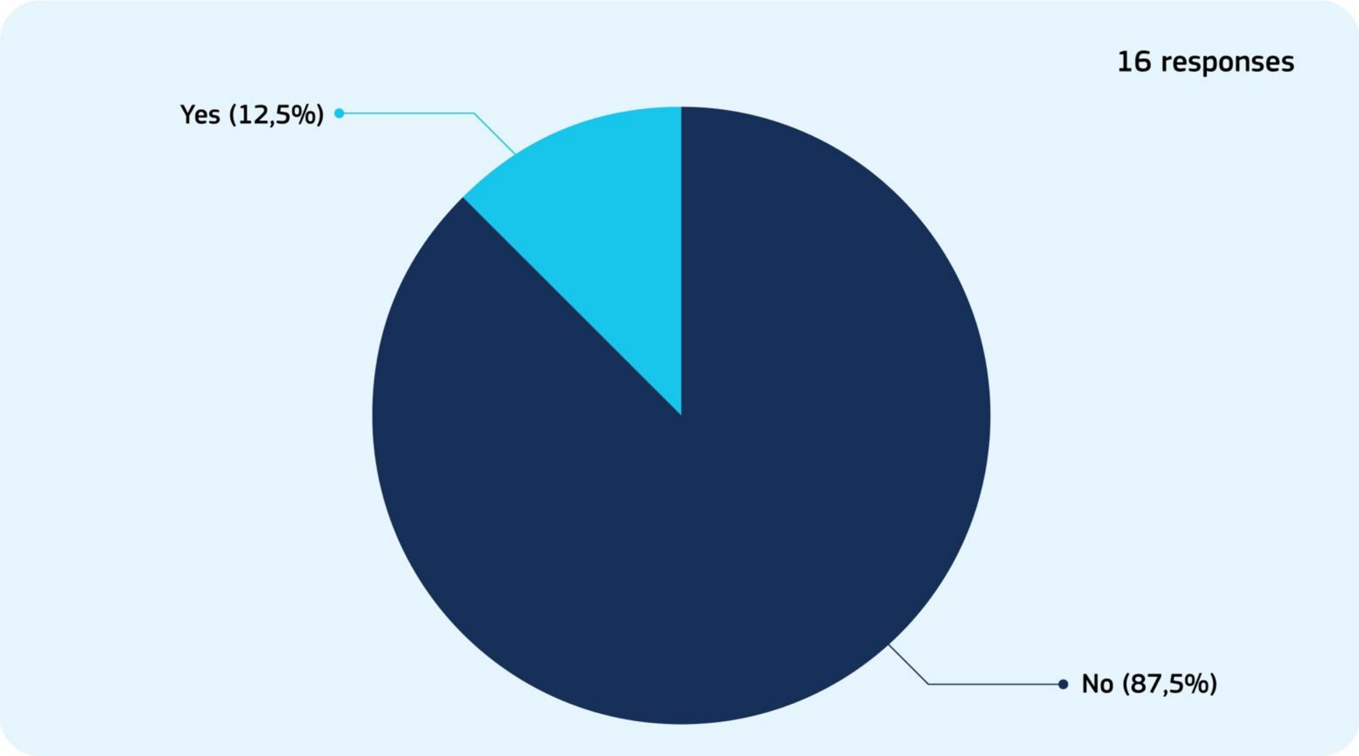

Figure 4 - Results of the question, " Did you face any difficulties in using/understanding the framework? "

Most projects surveyed did not face any difficulties in understanding the framework. Two comments indicated issues with the clarity of the framework:

- Based on use cases the technical demands are different. Some techniques support the different demands better than others.
- Well, it requires some deeper knowledge how to translate the projects UCs in the context of settlement sub-process

1.3.2.1.3 Q3: Do you see inconsistencies between BRIDGE Reference Framework and other frameworks?

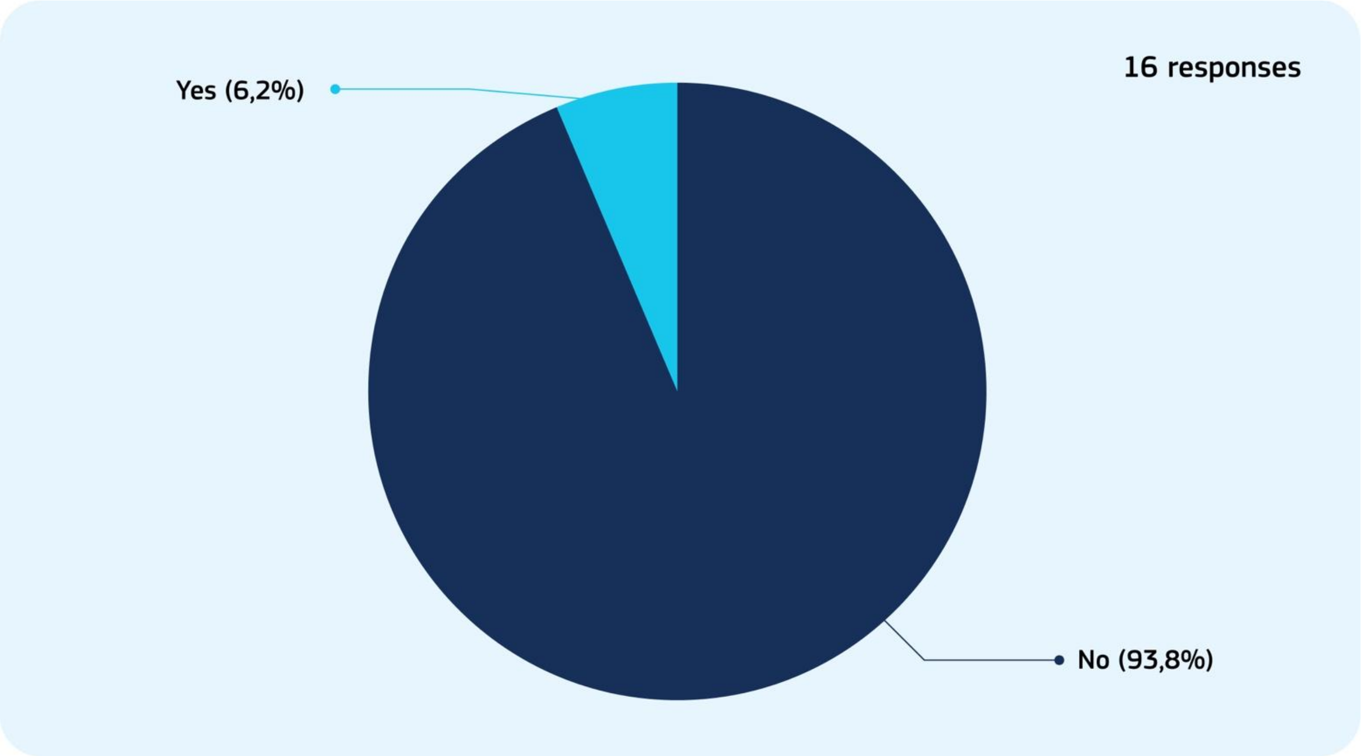

Figure 5 - Do you see inconsistencies between BRIDGE Reference Framework and other frameworks? "

Most projects did not find any inconsistencies between BRIDGE reference framework and other frameworks. One project indicated that:

- Some solutions which are already implemented at large in the energy market, such as Opentherm, are not a part of the framework

1.3.2.2 Generic Business Process Section

1.3.2.2.1 Q4: Please indicate which GBPs are relevant for your project(s)

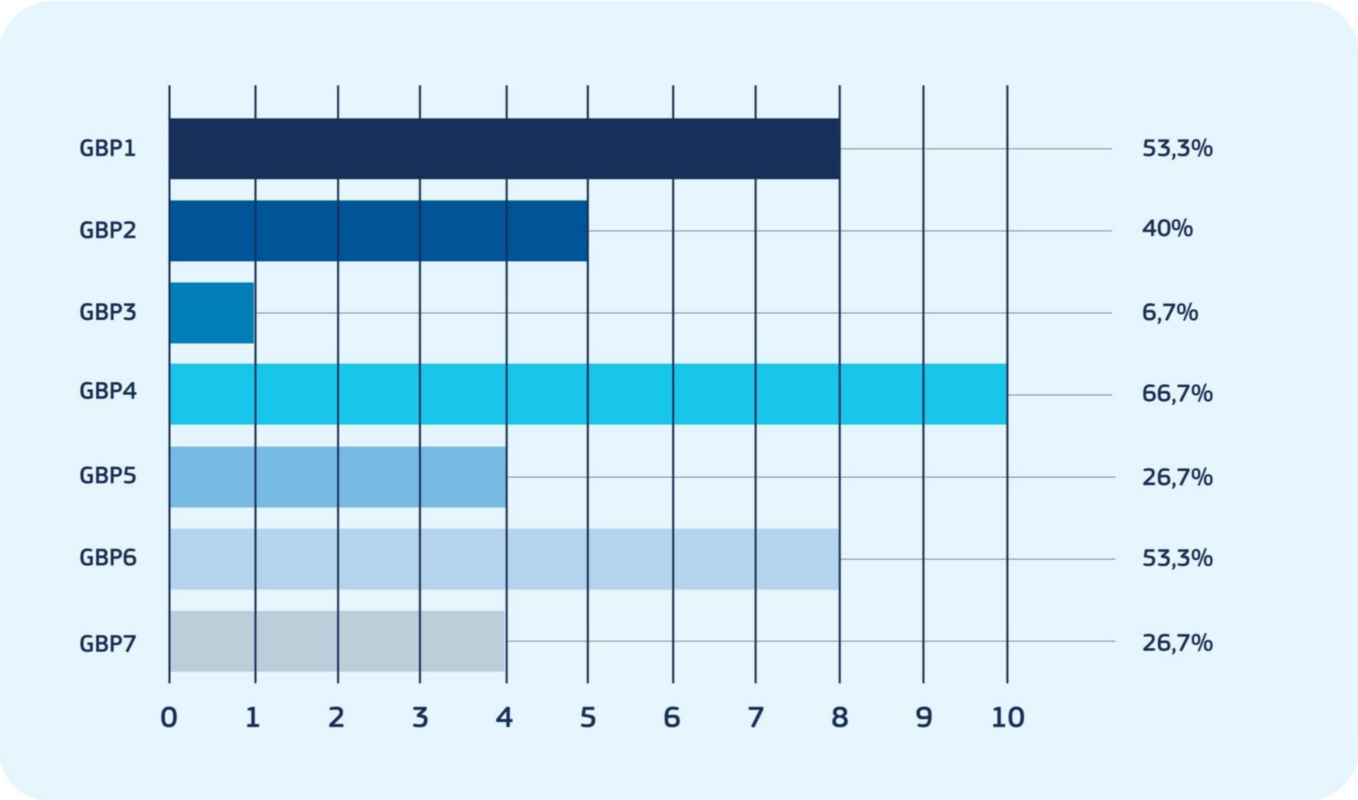

Figure 6 - Results of the question, " Please indicate which GBPs are relevant for your project(s)? "

The GBP 4 (Flexibility for energy community optimisation) has been the most implemented with 10 projects implementing it, and the GBP 3 (Flexibility for BRP portfolio optimisation, GBP4 – Flexibility for energy community optimisation) has been the least implemented with one project implementing it.

1.3.2.2.2 Q5: Please rate the level of alignment of your UC with GBPs

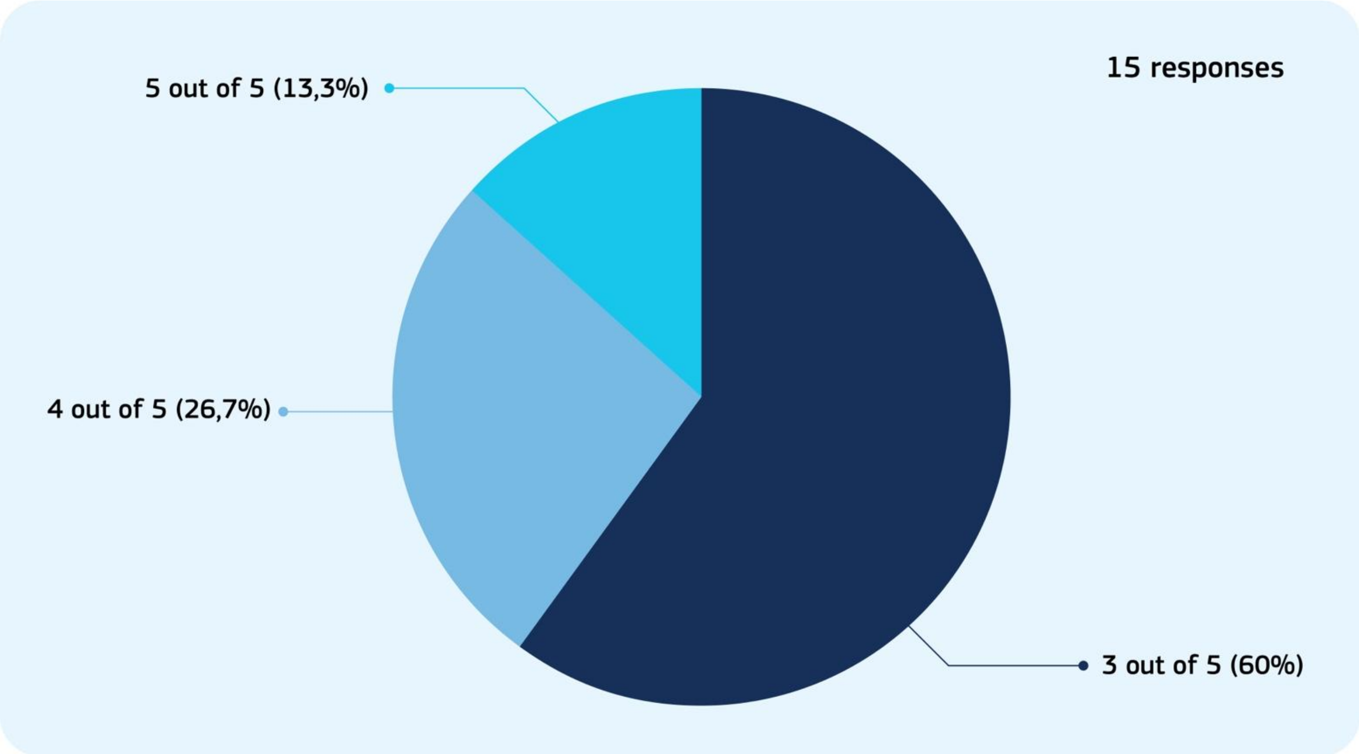

Figure 7 - Results of the question, " Please rate the level of alignment of your UC with GBPs? "

Ratings on alignment ranged 3 (partially aligned) to 5 (very aligned). No project indicated not being aligned at all or poorly aligned. The GBPs can therefore be considered to be generally aligned to the needs of the projects. However, the following misalignment points were listed:

- We are combining some of the models, since we are both trying to optimise within the local community, but at the same time providing flexibility to the electricity market as well as trying to enhance capacity of local grid.
- The settlement part was not defined
- The WEDUSEA project is currently in a pre-deployment phase. During the deployment, the baseline device will generate in excess of 1,650 MWh. During the deployment phase we will review the GBPs that have been developed to compare the use cases from other projects.
- Data Cellar aims to collect any relevant to local energy communities and to support data driven related services also through advanced AI models, so in this sense it is not aligned with a specific GBP although potentially the data collected and available through the Data Cellar market place could support partially the adoption or implementation of the majority of the GBP.

1.3.2.2.3 Q6: Please indicate how satisfied you are with the level of detail of the GBP analysis

The respondents rated the level of detail of the GBPs:

- 2 respondents did not know whether the level of detail is sufficient
- 7 respondents indicated they were satisfied with the level of detail
- 3 respondents indicated the level of detail to be very satisfactory
- 1 respondent indicated that the level of detail was confusing due to a number of concepts needing to be understood

1.3.2.2.4 Q7: Please indicate any suggestions for improvement of the GBP analysis

The following suggestions towards the improvement of the GBPs were made:

- Per country the situation and assumptions are different, maybe we can make add the importance of the GBP based on different contexts
- Maybe an extra table below the diagrams which shows in each box described in the settlement subprocess which actors (e.g. DSO, consumers, community) participate. In this way it is easier to match the diagram info with the text below which explains these concepts
- we need maybe a set up where we have several price inputs from different stakeholders, if for instance we need to provide flexibility both for overall day ahead market but also control the system according to local tariffs from the DSO
- Should be instantiated to address specific flexibility assets such as EVs and new roles such as CPOs (Charging Point Operators)
- We may have suggestions in the deployment phase of the project.

1.3.2.2.5 Q8: Are there any GBPs that you would like to see added in the Framework? Please, briefly describe them

The following GBP additions were suggested:

- The support of the OpenTherm protocol
- We need maybe a set up where we have several price inputs from different stakeholders, if for instance we need to provide flexibility both for overall day ahead market but also control the system according to local tariffs from the DSO.
- Consider flexibility of heat sector and cross-sectorial collaboration
- As mentioned before, specific GBPs addressing the integration with the mobility sector
- We may have suggestions in the deployment phase of the project.

1.3.2.3 Settlement sub-processes section

1.3.2.3.1 Q9: Has settlement been performed in your project?

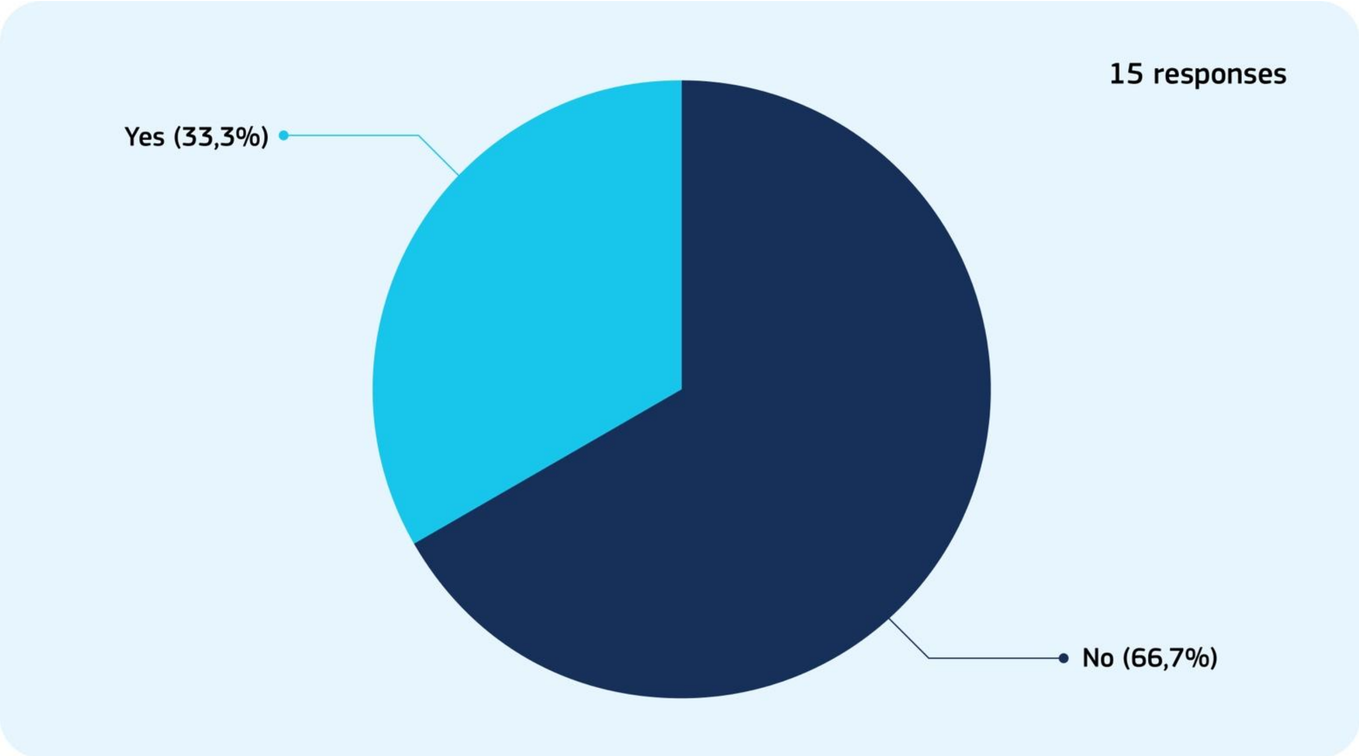

Figure 8 - Results of the question, "Has settlement been performed in your project? "

5 projects (ENFLATE, Hedge-IoT, ACCEPT, RESONANCE, SYNERGIES) have implemented settlement.

1.3.2.3.2 Q10: Did you use the settlement sub-process to implement it?

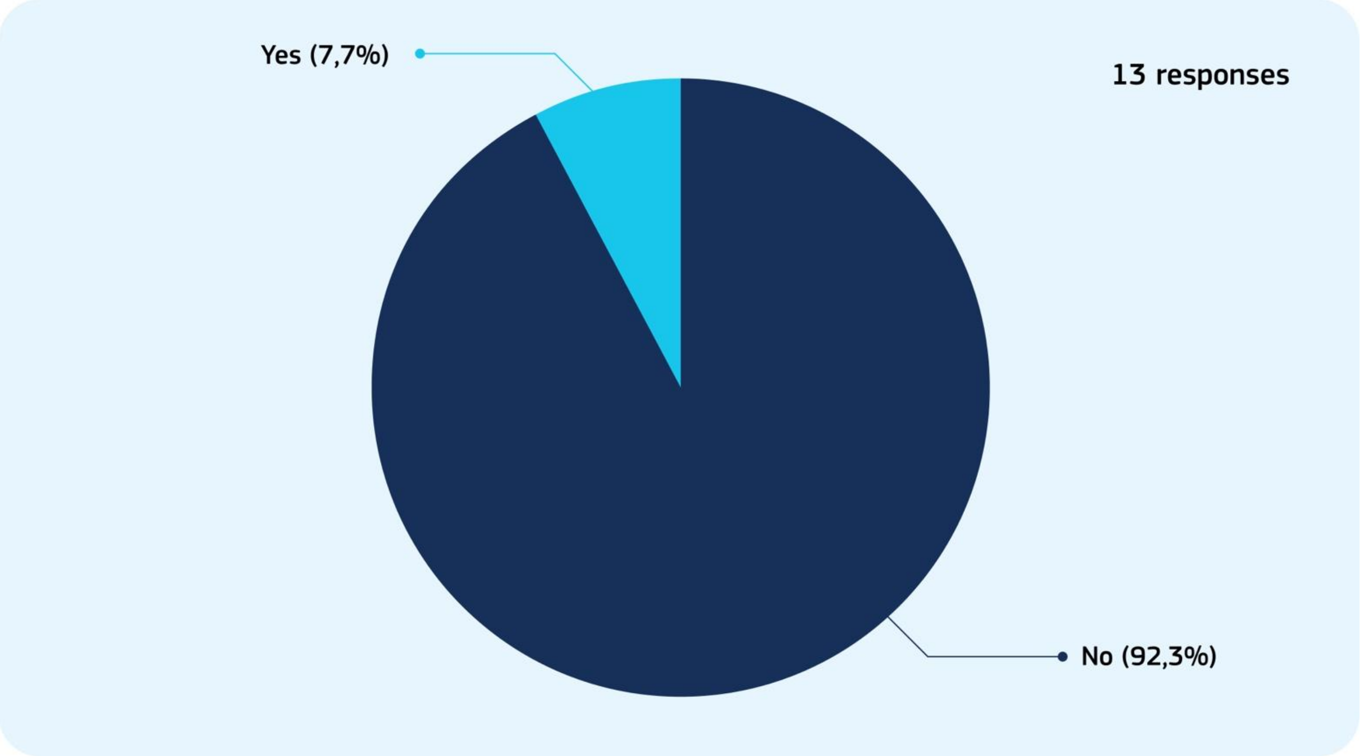

Figure 9 - Results of the question, " Did you use the settlement sub-process to implement it?"

The project SYNERGIES has used the settlement sub-process.

Thise project found it easy to understand and use, while the project ACCEPT, that implemented settlement but not the settlement sub-process, did not.

The projects that did not use the settlement sub-process for their implementation of settlement included the following comments related to the alignment of their project to the settlement sub-process:

- Settlement described as a system use case in the project for one pilot.
    - Yes the project is aligned.
    - The settlement process includes the following steps:
        - The delivered flexibility is calculated as the difference between the baseline and meter data provided by the BSP (or distribution system operator (DSO)).
        - Verify that the delivered flexibility matches the requested flexibility by comparing the actual delivered flexibility and the requested flexibility by the TSO.
        - Calculate reconciliation values for the BSP.
- Well it is in terms of UCs, however it is a bit confusing when you try to match the project's UCs with particular GBPs, as they are many actors involved and processes, so it's difficult to clarify in which GBP it fits better
- We have not analysed yet the settlement process.
- The pilots of the RESONANCE project who needed it implemented the settlement sub-process in their own way, and didn't detail all the steps in their Business Use Cases or System Use cases. But the main ideas are the same as the ones described in the settlement sub-process from the Reference framework indeed.
- The project is aligned with the settlement subprocess
- We will look at the projects where they shared how they are implementing the settlement sub-process. We will analyse the approaches followed by different projects implementing the settlement sub-process.

1.3.2.4 Conclusion Section

1.3.2.4.1 Q11: Do you have suggestions on how to make the Reference Framework more practical?

The following suggestions were indicated:

- Find an easy way probably using tables and key words in order to match easily your project's UCs to the different GBP
- We may have suggestions in the deployment phase of the project.
- Since many reference frameworks (with overlapping concepts and principles) it would be very much helpful for incumbents to data spaces to adopt same terminologies for same components/roles/functionalities and services.

1.3.3 Conclusions from the Feedback Survey

As a conclusion to the reference framework , some actionable points have been identified for the coming year.

With regards to the understandability and consistency of the framework:

- Translating projects use cases into the GBPs, and in particular the settlement sub-process has been identified as a difficulty. The drafting of guidelines to help with this translation could therefore prove useful. In particular, the use of key words search could be facilitated.
- A study of solutions already implemented at large in the energy market (such as Opentherm) has been recommended to check the alignment of the framework with existing solutions.

With regards to the relevance of the GBPs:

- The possibility to combine GBPs to define a use case should be mentioned.
- The fact that the GBPs may present with variations based on different contexts (countries for instance) should be mentioned.
- An extra table below the diagrams showing, for each box described in the settlement subprocess, which actors (e.g. DSO, consumers, community) participate could be added.
- A set-up where several price inputs from different stakeholders could be described (if for instance there is a need to provide flexibility both for overall day-ahead market and to control the system according to local tariffs from the DSO)
- New GBP suggestions:
  - Flexibility of heat sector and cross-sectorial collaboration
  - The integration of the mobility sector
  - The inclusion of new roles such as CPOs

With regards to the application of settlement guidelines:

- An extra table below the diagrams showing, for each box described in the settlement subprocess, which actors (e.g. DSO, consumers, community) participate could be added to the sub-process.
- Additionally, since the number of responding projects which implemented settlement or used the settlement guidelines is rather low, the action should aim to collect additional feedback in the coming years.

1.3.4 Reference Framework Survey on Standards

A survey on the use of standards in relation to the reference framework was performed in January and February 2025. It received 22 answers from 20 projects (SUSTENANCE, SENDER, i-STENTORE, Hedge-IoT, eFORT, ODEON, kr nei, OneNet, EU-DREAM, RESCHOOL, R2D2, TIGON, HYNET, ECHO, InterPED, OMEGA-X, PEDvolution, DECODIT, RESONANCE and int:net)

The survey invited the participants to indicate:

- The implementation status of the project
- For each generic business process:
  - Whether the GBP is implemented in the project
  - For each interface, which standards were used to implement it
- Implementation of standards section
  - Did you encounter any issues in implementing the standards that you mentioned previously? If yes, could you describe these issues and how you solved them?
  - Have any of the implementations of standards been released as code components? If yes, please describe them and provide a link?
  - Did you document the implementation of a standard in a webinar available online? If yes, please provide a link and a description
- Conclusion section.
  - Are there any additional remarks about the implementation of standards in flexibility processes that you would like to add?

1.3.5 Answers to the Standards Survey

1.3.5.1 Q1: What is the implementation status of your project?

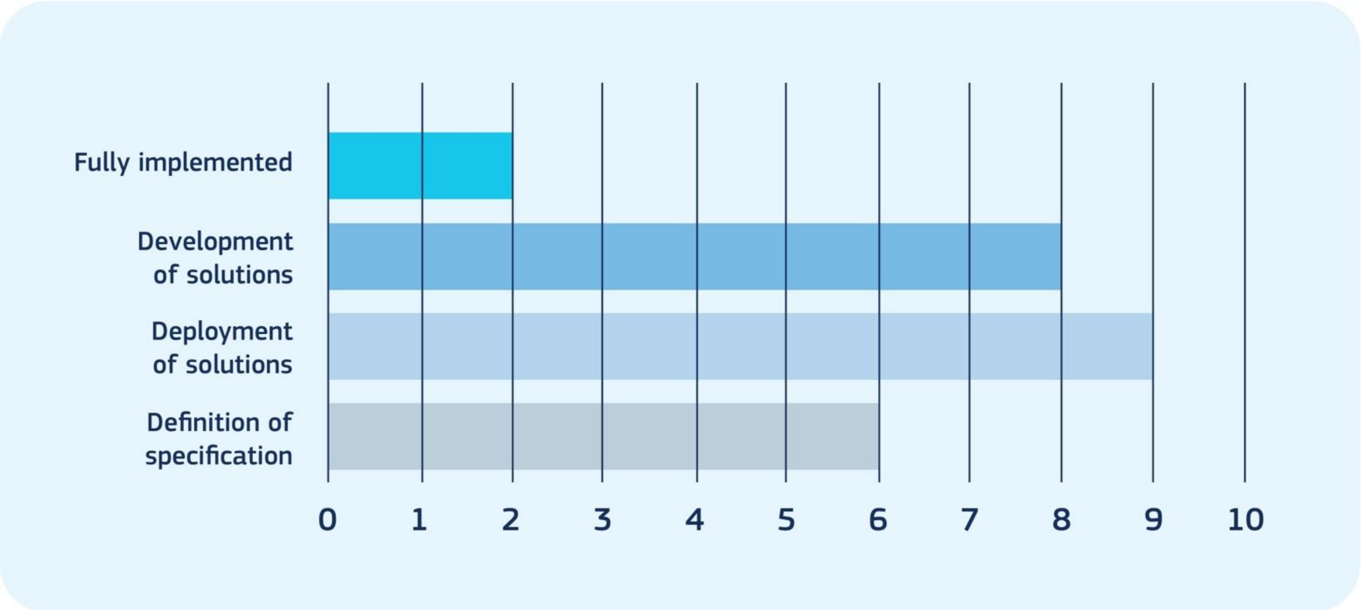

Figure 10 - Standards survey Q1: What is the implementation status of your project?

Projects at all implementation stages answered the survey.

1.3.5.2 Q2-Q10: Are the GBPs implemented in your project?

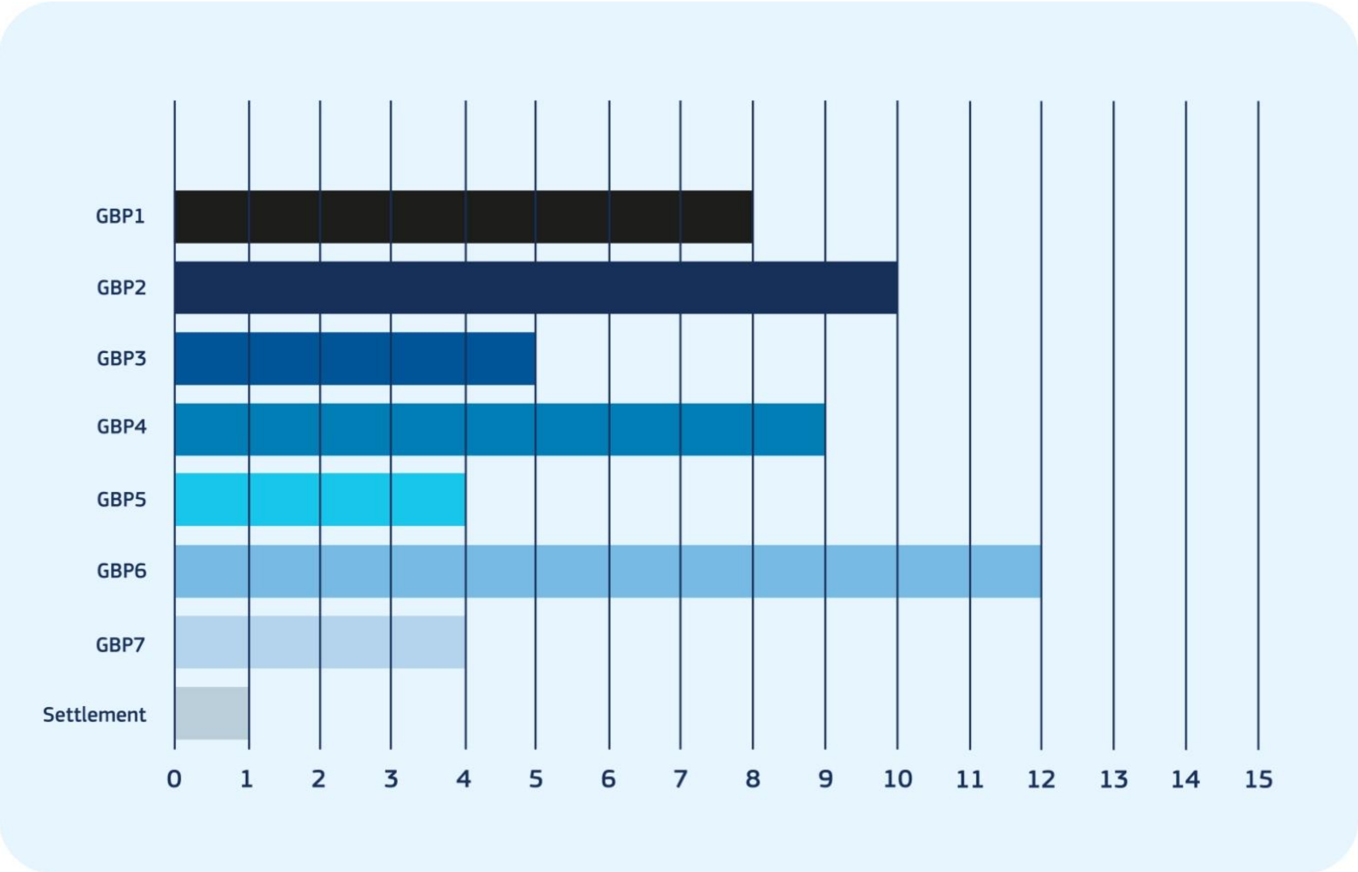

Figure 11 - Standards survey Q2-Q10: For each of the GBPs, is the GBP implemented in your project?

The answers are summarised in the table above.

8 of the responding projects implemented GBP 1.
8 of the responding projects implemented GBP 2.
5 of the responding projects implemented GBP 3.
7 of the responding projects implemented GBP 4.
4 of the responding projects implemented GBP 5.
10 of the responding projects implemented GBP 6.
4 of the responding projects implemented GBP 7.
1 of the responding projects implemented the settlement sub-process.

1.3.5.3 Q11: Have any of the implementations of standards been released as code components? If yes, please describe them and provide a link.

The project Odeon answered no.

1.3.5.4 Q12: Did you document the implementation of a standard in a webinar available online? If yes, please provide a link and a description.

The project Odeon answered no.

1.3.5.5 Q13: Are there any additional remarks about the implementation of standards in flexibility processes that you would like to add?

The project ODEON answered, “Not for the moment”.

The project EU-DREAM answered: “The EU-DREAM project is currently in its initial phase, and use cases have not yet been defined. Therefore, our responses are based on preliminary assessments and may change significantly as the project progresses.”

The project InterPED answered : “We are just starting to implement, standards to come later.”

The standards indicated for each interface have been included in the next section.

1.3.6 Updated List of Standards

The list of standards used for each of the GBPs' interfaces from the 2021 survey has been updated below based on the answers from the survey. The new standards and updated results have been coloured in green in the table.

Interface	List of solutions/standards (occurrence)	Number of internal or proprietary[2]
GBP1: Flexibility for SO through open market		
P1 - A1	FlexOffer (7) USEF (4) Modbus (3) OCPP (2) IEC 60870-5-104 (3) DLMS/COSEM (1) IEC 61850 (1) HTTP/JSON (1)	3
A1 - A2	ERRP (2) EQUIGY (2) OpenADR (2) FlexOffer (3) CIM (1) IEC 61850 (1) USEF (1)	7
P1-A2	Modbus (2) xEMS (2) OpenADR (1) FlexOffer (1) USEF (1)	2
A2-M2	FlexOffer (4) USEF (3) ERRP (1) EQUIGY (2) OpenADR (2) IEC CIM EUMED Metering profile (1)	4
S1-B2	FlexOffer (1) HTTP/JSON (1) UFTP (USEF Flex trading Protocol) (1) GOPACS (1)	

B2-M2	FlexOffer (1)	
S1-M2	CIM (4) OpenADR (1) USEF (2) FlexOffer (2) IEC CIM EUMED Metering profile (1)	4
M2-B3	– (not implemented)	
B3-S3	FlexOffer (1)	
M2-S3	USEF (2) FlexOffer (2)	2
M2-A8	FlexOffer (4) USEF (3) ERRP (2) EQUIGY (2) OpenADR (2)	4
A8-A3	FlexOffer (5) USEF (3) ERRP (2) EQUIGY (2) OpenADR (2)	8
A3-P2	FlexOffer (7) USEF (5) Modbus (3) OCPP (2) IEC 60870-5-104 (2) OpenADR (1) IEC 61850 (1)	2
A8-P2	xEMS (2) Modbus (2) OpenADR (2) FlexOffer (1) USEF (1)	1
S3-SS	FlexOffer (2) USEF (1)	3

	IEC CIM EUMED Metering profile (1)	
P2-SS	Z-Wave (1) FlexOffer (2) IEC 61850 (1) USEF (1)	6
S1-ext	CIM (5) IEC 60870-5-104 (1) FlexOffer (1) USEF (1)	0
M2-ext	– (not implemented)	
P1-Ext	xEMS (1) Modbus (1) FlexOffer (1) USEF (1)	2
P2-Ext	Modbus (4) OCPP (2)	3
GBP2: Flexibility for SO via prior bilateral agreement		
P1-A1	FlexOffer (6) USEF (4) Modbus (3) OCPP (2) IEC 60870-5-104 (3) DLMS/COSEM (1) IEC 61850 (1) HTTPS / JSON (1)	3
A1-A5	IEC 60870-5-101 (1) DLMS/COSEM (1) IEC 60870-5-104 (1) USEF (1)	4
P1-A5	DLMS/COSEM (1) IEC 60870-5-104 (1) ProfiNET (1) USEF (1) IEC CIM EUMED Metering profile (1)	1
A5-S5	IEC 60870-5-104 (2) USEF (1)	3

	IEC CIM EUMED Metering profile (1)	
S6-A6	IEC 60870-5-104 (2) Open ADR (1) USEF (2) MQTT, Kafka messages (1) HTTP/JSON (1) GOPACS (1) IEC CIM EUMED Metering profile (1)	3
A6-S7	IEC 60870-5-104 (2) USEF (2) MQTT, Kafka messages (1) HTTP/JSON (1) GOPACS (1)	2
A6-A7	IEC 60870-5-104 (2) Modbus (1) USEF (1)	1
A7-P2	OpenHAB (1) ProfiNET (1) IEC 60840-5-104 (1) Modbus (1) USEF (1)	1
A6-P2	ProfiNET (1) IEC 60840-5-104 (1) USEF (1) HTTP/JSON (1)	2
P2-SS	Z-Wave (1) FlexOffer (2) IEC 61850 (1) USEF (1) HTTP/JSON (1) IEC CIM EUMED Metering profile (1)	6
S1-Ext	CIM (5) IEC 60870-5-104 (1) USEF (1) HTTP/JSON (1)	0
M2-Ext	– (not implemented)	
P1-Ext	xEMS (1) Modbus (1)	2

P2-Ext	Modbus (4) OCPP (2) USEF (1) HTTP/JSON (1) KNX (1) MQTT(S) (1)	3
GBP3: Flexibility for BRP portfolio optimisation		
P1 - A1	FlexOffer (7) USEF (3) Modbus (3) OCPP (2) IEC 60870-5-104 (3) DLMS/COSEM (1) IEC 61850 (1)	3
A1-A2	ERRP (2) EQUIGY (2) OpenADR (2) FlexOffer (3) CIM (1) IEC 61850 (1)	7
P1-A2	Modbus (2) xEMS (2) OpenADR (1) FlexOffer (1) IEC CIM EUMED Metering profile (1)	2
A8-A3	FlexOffer (5) ERRP (2) EQUIGY (2) OpenADR (2)	8
A3-P2	FlexOffer (7) USEF (4) Modbus (3) OCPP (2) IEC 60870-5-104 (2) OpenADR (1) IEC 61850 (1) FlexOffer (1)	2

A8-P2	xEMS (2) Modbus (2) OpenADR (2) FlexOffer (1)	1
A2-M1	USEF (1) FlexOffer (2)	1
B1 - B2	FlexOffer (1) IEC CIM EUMED Metering profile (1)	
B2-M1	USEF (1) FlexOffer (2) IEC CIM EUMED Metering profile (1)	0
M1-S2	USEF (1) FlexOffer (1) IEC CIM EUMED Metering profile (1)	0
M1-B3	USEF (1) FlexOffer (1)	1
M1-A8	USEF (1) FlexOffer (2)	0
P2-SS	Z-Wave (1) FlexOffer (3) IEC 61850 (1)	6
B3-SS	FlexOffer (2) IEC CIM EUMED Metering profile (1)	0
S2-Ext	– (not implemented)	
M1-Ext	– (not implemented)	
P1-Ext	xEMS (1) Modbus (1) FlexOffer (1)	2
P2-Ext	Modbus (4) OCPP (2)	3
GBP 4 - Flexibility for energy community optimisation		
P4-A9	USEF (2) S2 (1) HTTPS /JSON (1)	3

	MQTT (1) OCPP (1) IEC CIM EUMED Metering profile (1)	
A9-A10	USEF (1) IEC CIM EUMED Metering profile (1)	3
A10-P5	Modbus (1) USEF (1) HTTPS /JSON (1) S2 (1) IEC CIM EUMED Metering profile (1)	0
A10-A3	USEF (1) S2 (1)	1
P2-SS	Z-Wave (1) FlexOffer (2) IEC 61850 (1) USEF (1) HTTPS /JSON (1) S2 (1)	6
A3-SS	USEF (1) S2 (1)	
P4-Ext	S2 (1) USEF (1) HTTPS / JSON (1) KNX (1) MQTT (1)	1
A10-Ext	USEF (1) S2 (1)	
GBP 5: Implicit flexibility using dynamic steering signals		
S1-I1	–	2
I1-P6	FlexOffer (1) HTTPS / JSON (1)	1
P6-P2	OCPP (2) HTTPS / JSON (1)	2
P2-SS	Z-Wave (1) FlexOffer (2) IEC 61850 (1)	6
I1-SS	– (not implemented)	

GBP 6 - Energy monitoring and energy management		
P7-E1	Dutch DSMR standard (P1) (1) MQTT Eclipse Sparkplug B (1) SAREF(1) HTTPS / JSON (1) IEC CIM EUMED Metering profile (1)	Custom IoT infrastructure (1)
E1-E2	IECON Framework (1) MQTT Eclipse Sparkplug B (1) SAREF(1) HTTPS / JSON (1)	Custom IoT infrastructure (1)
E2-P8	MQTT Eclipse Sparkplug B (1) SAREF(1) HTTPS / JSON (1)	Custom IoT infrastructure (1)
P8-B	MQTT Eclipse Sparkplug B (1) SAREF(1) HTTPS / JSON (1)	Custom IoT infrastructure (1)
P7-Ext	SAREF(1) HTTPS / JSON (1) MQTT (2) MQTT Eclipse Sparkplug B (1)	Custom IoT infrastructure (1)
GBP 7 - P2P Trading in energy community		
P9-P10	SAREF (1)	
P10-P2M1	SAREF (1)	
P2M1-P11	SAREF (1)	
P2M1-SS	SAREF (1)	
P9-Ext	SAREF (1)	
P10-Ext	Not implemented	
P11-Ext	Not implemented	
Settlement Subprocess		
SP1-SP2	USEF (4) IEC 60870-5-104 (2) IEC 60870-5-101 (1)	6
SP2-SP3	USEF (4) IEC 60870-5-104 (1)	3

SC1-SC2	USEF (4) IEC 60870-5-104 (1)	3
SC2-SP3	USEF (4) IEC 60870-5-104 (2) IEC 60870-5-101 (1)	1
SP3-SP4	IEC 60870-5-104 (2) IEC 60870-5-101 (1) USEF (1)	3
SP4-SC3	USEF (4) IEC 60870-5-104 (2)	0
SP1-Ext	Z-Wave (3) USEF (1)	0

1.4 Contribution to the BRIDGE Use Case Repository

1.4.1 Generic Actor List

The generic actor List is a concept defined in IEC 62559-2 [8] Section 6. In particular, it has the following objective: "[with a] a generic actor list […], only actors of this generic actor list should be used as far as possible in the use case". It is also stated that a generic actor list includes: "(1) System actors [that] are covering functions or devices (for example in the energy system area, system actors are defined in the interface reference model (IEC 61968-1); (2) business actors [that] specify in fact a "role" (roles can be taken by diverse entities)"

The supporting materials of the SGTF EG1 report of 2019 [10] emphasize the need for a generic actors list. In particular, an existing list is referenced: "A list of actors provided by CENCENELEC-ETSI SG-CG in the Sustainable Processes report as well as the actors defined in the Harmonised Electricity Market Role Model can be used here".

Indeed, in the CEN/CENELEC/ETSI Sustainable Processes report [11], a generic list of actors is detailed in Annex A (12 pages of actors' description). This list is mostly based on IEC Interface Reference Model (61968-1:2012) and the Harmonized Electricity Market Role Model (HEMRM) available at that time (named "ENTSO-E role model" in the document). Other sources are referenced such as "SGTF EG3", "AhG Charging", "GUC". This list contains 170 entries and for sure requires updating.

The IEC 62559-2 [8] documents list the expected information for each actor:

Table 3 - List of relevant fields for each of the actors in a generic actor list

Field	Example / Comment
Area	Example: Smart Grid/energy systems
Mapping to grouping	Example: To sort requirements for "smart metering" within the area "energy system"
Name of the actor	Example: Distribution system operator (DSO)
Abbreviation for the actor's name	Example: DSO
Actor type (e.g. roles, application, …)	Example: DSO is a role, an energy management system (EMS) is an application
Definition of actor	Here the actor will be described. Usually, the actor is taken from an existing actor list so that the definition already exists.
Possible actors fulfilling this role	Example: For the actor "meter operator" it might be a DSO or an independent meter operator, depending on the national background or the specific project
International, regional or national relevance	Actors might differentiate in definition depending on regional or national legislation or markets
Source of the definition	Actors should be based as far as possible on existing data models in the relevant area or domain Example: Data models like CIM common information model (IEC

	61968/61970) or COSEM in the metering domain (IEC 62056)
Parent	This column is used to build up a kind of hierarchy of actors Example: A grid operator as parent of transmission or distribution system operator (TSO or DSO)
Further comments	

Considering the current scope and purpose of the new generic actor list, the action #3 proposes to focus on the following fields: Area, Name of the actor, Actor type, Definition of actor, Source of the definition.

1.4.2 Update of the Generic Actor List

As mentioned above, the generic actor list defined by CEN/CENELEC/ETSI in 2012 is based on outdated sources. Therefore, an update is planned, based on updated references and new sources, in particular:

- IEC Interface Reference Model (IRM) as defined in IEC 61968-1:2020 [12];
- Harmonized Electricity Market Role Model (HEMRM) as defined in its release of January 2022 [9].

In order to perform this update, the following approach has been defined:

1. A first analysis is performed by the leader of this task (Trialog, on behalf of InterConnect and RESONANCE)
2. Groups of experts, clustered by area, are set up to further analyse each actor and build the updated list
3. The updated list will be submitted to CEN/CLC/ETSI Coordination Group on Smart Grids (CG-SG) for validation and approval.
4. The updated list will be included in the BRIDGE use case repository as a library of actors
5. If relevant, this updated list will also be pushed to IEC standardisation

1.4.3 Plan for the Generic Actor List Update

Step 1 has been performed by Trialog, on behalf of InterConnect and RESONANCE. The first analysis contains about 200 entries. The list of actors has been clustered depending on the area, and priorities have been determined:

Table 4 - List of areas for the update of the Generic Actor List

Area	Number of items	Priority
Grid Management	68	1 (high)
Smart Metering	15	1 (high)
Electric Mobility	12	1 (high)
Market Operation	31	1 (high)
Power Generation / DER	7	2 (medium)
Smart Home / Smart Building / Smart City	23	2 (medium)
Data Management	5	2 (medium)
Customer Relationship	15	3 (low)
Third parties / Other	23	3 (low)

For Step 2, a call for participation was circulated in the Data Management WG and Regulation WG in January/February 2024. Based on the 23 received answers, a list of 16 contributors was identified and a few additional reviewers were designated.

The Step 3 was started in February 2024 and is still in progress. The lists of the 4 first topics (Grid Management, Smart Metering, Electric Mobility and Market Operation) have been updated by the relevant expert groups. Trialog is currently finalising these lists in order to be able to send then to CEN/CLC/ETSI CG-SG for review. Step 2 and Step 3 will continue in parallel until the end of 2025. Step 4 will start when the first lists are fully validated and when the new version of the BRIDGE use case repository is available. Step 5 (if relevant) will start when the whole list is completely validated.

Conclusion and Perspectives

1.5 Main Findings and Recommendations

This section describes the main findings and recommendations regarding the reference framework.

Topic	Feedback survey – Understandability and usability of the framework
Findings	• Translating project's use cases into the GBPs, and in particular the settlement sub-process has been identified as a difficulty. In particular, the use of key words search could be facilitated. • A study of solutions already implemented at large in the energy market (such as Opentherm) has been recommended in order to check the alignment of the framework with existing solutions.
Recommendation	The drafting of guidelines to help with the translation of project use cases into GBPs could help with the usability of the framework. Additionally, the consistency of the framework with industrial solutions should be checked.

Topic	Feedback survey – relevance of the generic business processes

Findings	The following findings have been identified in the analysis of the answers on the feedback survey:
	• The possibility to combine GBPs to define a use case should be mentioned.
	• The fact that the GBPs may show variations based on different contexts (countries for instance) should be mentioned.
	• An extra table below the diagrams showing, in each box described in the settlement subprocess, which actors (e.g. DSO, consumers, community) participate could be added.
	• A set-up where several price inputs from different stakeholders could be described (if for instance there is a need to provide flexibility both for overall day ahead market and to control the system according to local tariffs from the DSO)
	• New GBPs suggestions:
	  ○ Flexibility of heat sector and cross-sectorial collaboration
	  ○ The integration of the mobility sector
	  ○ The inclusion of new roles such as CPOs

Recommendation	The above-mentioned improvements should be analysed in order to see how they could be integrated into the reference framework and increase its relevance.

	Additionally, the scope of the reference framework should be made clear. The above-mentioned improvements should be analysed in order to see how they could be integrated into the reference framework and increase its relevance.

Topic	Feedback survey - Settlement sub-process
Findings	The following findings related to the settlement sub-process have been identified: • An extra table below the diagrams showing, in each box described in the settlement subprocess, which actors (e.g. DSO, consumers, community) participate could be added to the sub-process. • Additionally, the number of responding projects implemented settlement or used the settlement guidelines being rather low, the action should aim to collect additional feedback in the upcoming years.
Recommendation	The settlement sub-process should be completed to improve its usability. More feedback should be collected in the coming years in order to improve the settlement sub-process and keep it accurate, as more projects start implementing settlement.

Topic	Standards mapping
Findings	The survey on standards conducted in 2020 and 2021, identifying relevant standards for each interface of the GBPs, was assessed as useful by projects participating in the survey. An update has been performed in 2025.
Recommendation	The framework should be updated every few years in line with the latest project developments.

1.6 Perspective and Next Steps

The activities of the Action #3 should be continued in 2025 and beyond.

Based on the recommendations, several actions have been identified:

1. Further improve the reference framework: align GBPs with project use cases, provide guidelines to compare GBPs with project use cases, extend the list of GBPs, improve alignment with other frameworks.
2. Set out the scope and boundaries of the reference framework
3. Reinforce the reference framework to support practical implementation: use-case harmonisation (incl. generic actor list), list of relevant protocols/standards, …
4. Follow up on the application of the settlement guidelines to current and future projects.
5. Get regular updates on the implementation of standards related to the reference framework

A detailed plan has been produced to achieve most of these actions by the 2025 BRIDGE General Assembly.

Annex 1: Reference framework

In this chapter, the reference framework is described. As defined in §1.2, it is made of generic business processes, functions and interfaces.

1.7 Definition of Terms

1.7.1 Flexibility

For the sake of clarity in the following discussion, it is helpful to define the terms and relations used in the latter context.

The first term to be defined is the flexibility itself. According to [17] flexibility can be defined as follows:

"On an individual level, flexibility is the modification of generation injection and/or consumption patterns in reaction to an external (signal or activation) in order to provide services within the energy system."

This generic definition was further extended to a definition that is already touching some details related to the relations between system components and the implementation of flexibility, what might in the end limit the generality of the definition. But what is more important is that it also defines parameters to describe the flexibility. Such parameters are very important to define and measure flexibility and it is crucial for the operations related to flexibility to be able to do that. It is important in order to be able to define the flexibility offer (or request) and its respective value, but also for the verification process that the flexibility was indeed released.

Thus, to summarise in a generic way, we can say that:

"Flexibility is a service based on measurable and verifiable modification of energy production and/or consumption behaviour in reaction to external signal (request or activation)."

1.7.2 Flexibility Stakeholders

Further, in order to discuss processes based on this service, we can define a set of generic stakeholders related to providing and consuming flexibility. These can be as follows:

Flexibility Provider – is a party that is able and willing to adapt or modify its energy-related behaviour in exchange for some compensation. This party operates in its own name and is not representing anyone else. It can be a private and small energy grid stakeholder, but it can also be industrial and large stakeholder. In general, it is an energy prosumer.

Flexibility Consumer – is a party that needs the flexibility, i.e., it is willing to provide some compensation for the flexibility providers in order to achieve (or avoid) a specific condition in the energy grid. This role can be representing a TSO, DSO, BRP and other energy grid stakeholders that may require the change of energy grid parameters.

Flexibility Service Provider (incl. aggregator) – is a party that is (mainly) not offering flexibility on its own, but it rather represents the individual flexibility providers to make them access the market, in exchange for some fraction of the compensation they get for the flexibility. It bundles (aggregates) the flexibility offered by its clients and, by that, may offer more flexibility to larger flexibility consumers. It needs to handle the individual flexibility providers.

Flexibility Facilitator – is a party that represents one or several flexibility consumers to make them access the market. Depending on the local regulation and market model, this party might not be necessary or might part of the BRP scope.

Flexibility Market Operator – is a party that connects the flexibility providers and flexibility consumers. It may require these parties to have specific features or parameters to be able to participate in the service processes, e.g. minimum amount of flexibility that may be provided or only industrial parties. It provides means to announce flexibility requests and/or offers allowing the providers/aggregators and consumers to find each other to use and provide the service.

Depending on the GBPs, these stakeholders can be mapped to one party or another, e.g. in GBP1 the Flexibility consumer is the SO, while in GBP3 it is the BRP.

1.7.3 Energy Services Stakeholders

In addition, we define a set of stakeholders related to energy services:

Energy Service Company – Based on the HEMRM [9], a party offering energy-related services to the party connected to grid, but not directly active in the energy value chain or the physical infrastructure itself. The energy service company (ESCO) may provide insight services as well as energy management services.

Energy Supplier – Based on the HEMRM, an energy supplier supplies electricity to or takes electricity from a party connected to the grid at an accounting point.

P2P Market Operator – Responsible for the maintenance and operation of a peer-to-peer (P2P) energy market, including management of participants (peers).

Electrical Vehicle Charge Point Operator (EV CPO) – Owner/operator/manager of EV charging infrastructure.

1.8 Generic Business Processes

1.8.1 GBP1 – Flexibility for SO Through Open Market

The generic business process for the case of SOs (i.e. DSO or TSO) utilising flexibility through open market mechanism – mapping mostly to the case of grid normal operation – is presented in the following figure. The diagram depicts the different subprocesses/functions of each stakeholder in the flexibility lifecycle. In the open market scenario, the process may involve all the relevant stakeholders in the flexibility market:

- System Operator (SO) as a flexibility consumer, aiming to optimise the operation of the grid via the use of flexibility. This SO initiates the process of flexibility activation lifecycle (function S1), assesses the flexibility offered by the market (function S3) and handles the settlement process (function S).
- Balance Responsible Party (BRP), acting as a flexibility facilitator for flexibility procurement, placing a buying offer in the flexibility market (function B2), processing the results (function B3) and handling some part of the settlement process (function B4). In some cases, the BRP is skipped and the SO goes directly to the market.
- Flexibility Market Operator (FMO), enabling the flexibility trading by operating a market (function M2).
- Flexibility Service Provider (e.g. Aggregator), facilitating the pooling of flexibility from various sources (function A1), participating in the market (function A2) and optimally managing its portfolio (function A3) to provide the contracted flexibility. It also provides a settlement function for the utilised flexibility source.
- Prosumer, the flexibility provider, which is offered to the market via the aggregator (function P1), activated taking into account preferences and constraints (function P2) and properly remunerated or penalised (function S).

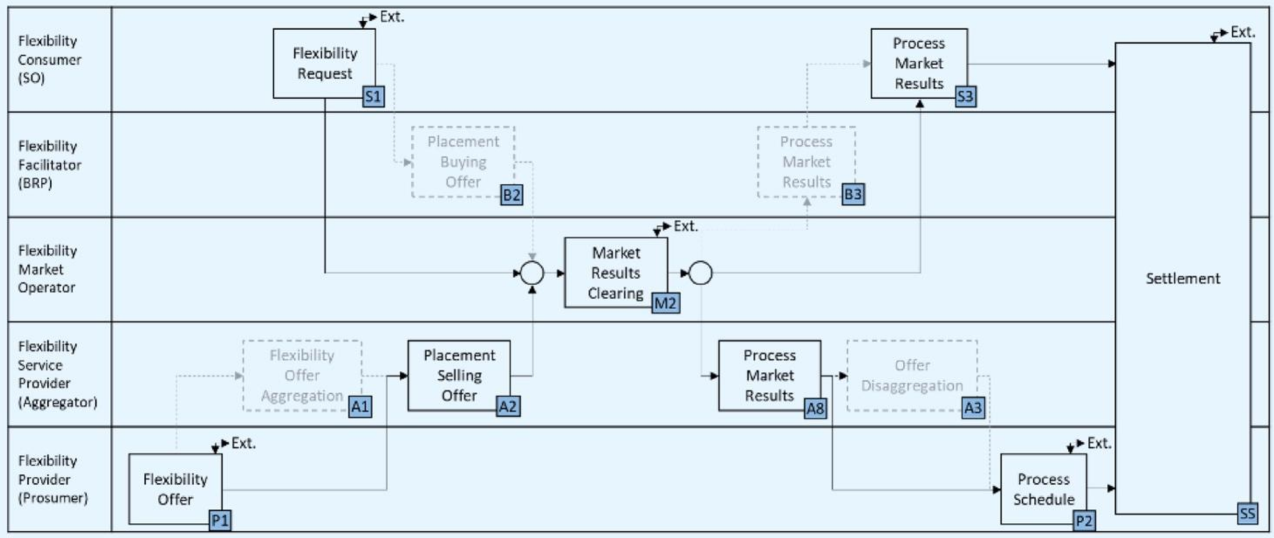

Figure 12 - Business process diagram – GBP1 “SO flexibility through open market”

1.8.2 GBP2 – Flexibility for SO via Prior Bilateral Agreement

The SO (i.e. DSO or TSO) business process for flexibility via prior bilateral agreement (**Errore. L'origine riferimento non è stata trovata.**) is quite different from the one described above, even though flexibility is offered to SO in this case as well. The purpose of this case is to provide near real-time flexibility activation after a SO request, in particular for the SO to deal with an emerging network congestion/load balancing problem. Delivery of flexibility is not expected to be performed through a market; therefore, no market operator is involved in order to simplify and speed up the process. The highest priority must be given due to the emergency status. Therefore, if there are other flexibility offers and requests available in a market (e.g., local flexibility market), these planned transactions could be temporarily disregarded.

The roles that are involved in this process are the SO, the flexibility providers (prosumers) and the flexibility service provider (prosumers, aggregator). The SO flexibility via prior bilateral agreement process comprises two distinct phases:

- In the first phase, a bilateral agreement between the SO and the aggregator is made in order to determine details such as minimum/maximum amount of flexibility, pricing of the service that aggregator provides to the SO, and estimated amount of aggregated flexibility that can be provided. The amount of flexibility that can be delivered to SO is determined dynamically by the flexibility service provider, who continuously estimates aggregated flexibility within a rolling horizon T, based on the flexibility offers that are received by the participating prosumers. Flexibility is being updated within T, however, it is usually considered fixed for a period of time set by a fixed timestep (current time + timestep).
- The second phase is initiated when the SO effectively requires flexibility, for example, when detecting or predicting a critical network problem and, therefore, requests flexibility from the Flexibility Service Provider based on the bilateral agreement. The amount of flexibility that will be provided to SO is calculated dynamically by the flexibility service provider.
- During runtime, flexibility providers provide the information on the availability of flexibility (directly or through an aggregator, including amount of flexibility, duration, time span, etc. The set of parameters should include the amount of available flexibility, the time span and the conditions, under which the flexibility offer is valid to enable the evaluation of the availability of flexibility at a specific time and classify it according to the different needs of the SO (immediate actions in case of time-critical emergency events and planning to compensate for predicted forecast deviations).

- Under normal conditions, the process ends with the generation of asset control schedules on the prosumer side, flexibility activation, and settlement.
- The applied rules are defined by the regulator, however, the regulator does not participate actively in the process during runtime. However, the regulator is expected to perform control/audit to assure that the agreement is in line with the set rules.

Regarding the settlement process, a separate "settlement subprocess" is set out, whose process is discussed in further detail in section 1.8.6 The established settlement subprocess is common for all GBPs.

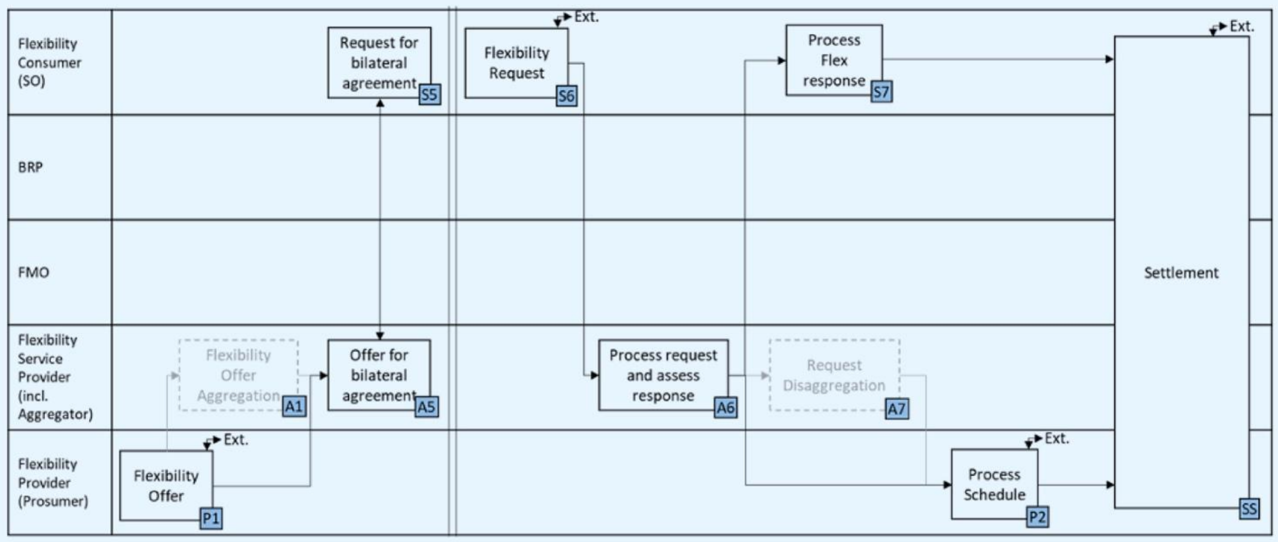

Figure 13 - Business process diagram for GBP2 "SO flexibility via prior bilateral agreement"

1.8.3 GBP3 – Flexibility for BRP Portfolio Optimisation

The main objective of balancing markets is to ensure grid stability and security of supply. The flexibility can be used to optimise trading portfolios and reduce balancing cost resulting from deviations between scheduled and actual inflow/off-take. The costs for this balancing mechanism are charged to BRPs with an imbalance in their portfolio. The BRPs optimise their portfolio so that instantaneous deviations between predicted and actual production and consumption are kept as low as possible to avoid imbalance costs and prevent the power system to enter the emergency mode. The flexibility services are offered to energy suppliers/BRPs from the aggregator flexibility asset pools comprising the flexibilities services offered by customers or network users to balance the flexibility assets in the grid or energy markets. The responsibility might be carried out by existing bundled roles in the energy market, like energy suppliers with variable prices, aggregators.

It is worth emphasising that the BRP defines its optimisation strategy by undertaking roles of an aggregator and using the received flexibility offer. Moreover, the BRP can participate in new or existing balancing power markets and energy services. The difference between the DSO leveraging flexibility through open market and portfolio optimisation is that the market settlement is undertaken by the BRP. Market settlement is analysed further in section 1.8.6, entitled 'Settlement subprocess', and is common to all GBPs, incl. GBP3.

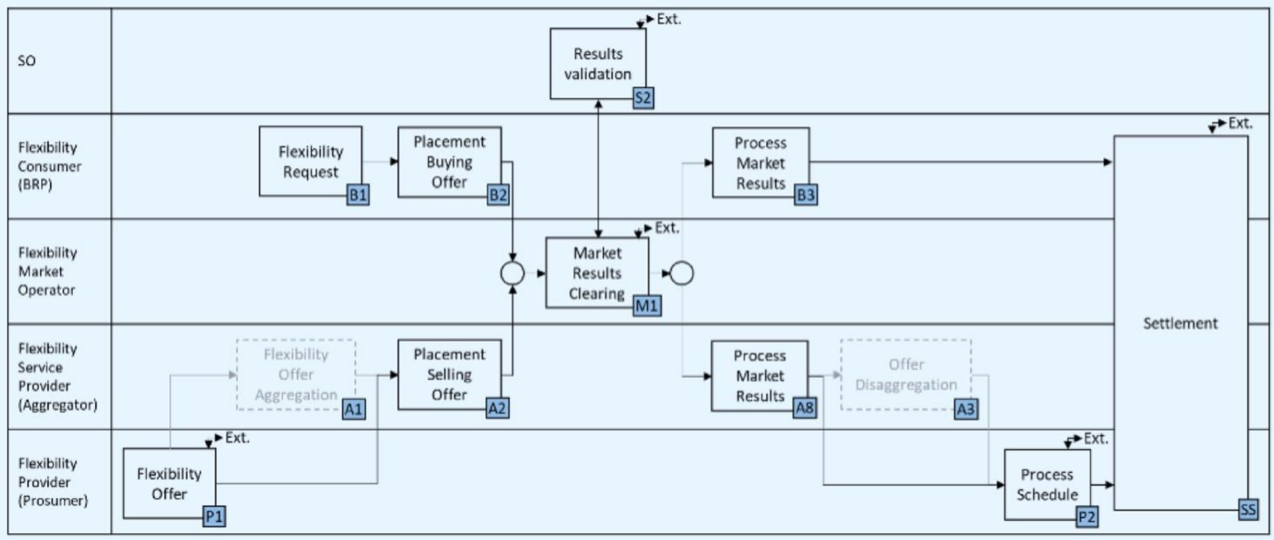

Figure 14 - Business process diagram for GBP3 “BRP portfolio optimisation”

1.8.4 GBP4 – Flexibility for Energy Community Optimisation

The main objective of an energy community is to optimise the energy flows within the community. This optimisation can follow different strategies, e.g. the goal may be to maximise the collective self-consumption (i.e. adapt consumption to be equal to production so there is no energy exchange with the grid outside the community). The energy community is managed by a flexibility service provider, or aggregator. Regardless of the goal and the participation in the market, there are some actions related to the internal optimisation within the energy community as shown in the **Errore. L'origine riferimento non è stata trovata.**. If the optimisation process is not done by a central entity, but by some distributed approach involving the community members, the flexibility service provider, or aggregator, is virtually present. The energy community as a whole can also participate in the above GBPs, either as an active participant (the aggregator/flexibility service provider has access to market) or as a prosumer represented by another (external) aggregator/flexibility service provider. The GBP covers scenarios related to energy communities, virtual power plants and similar.

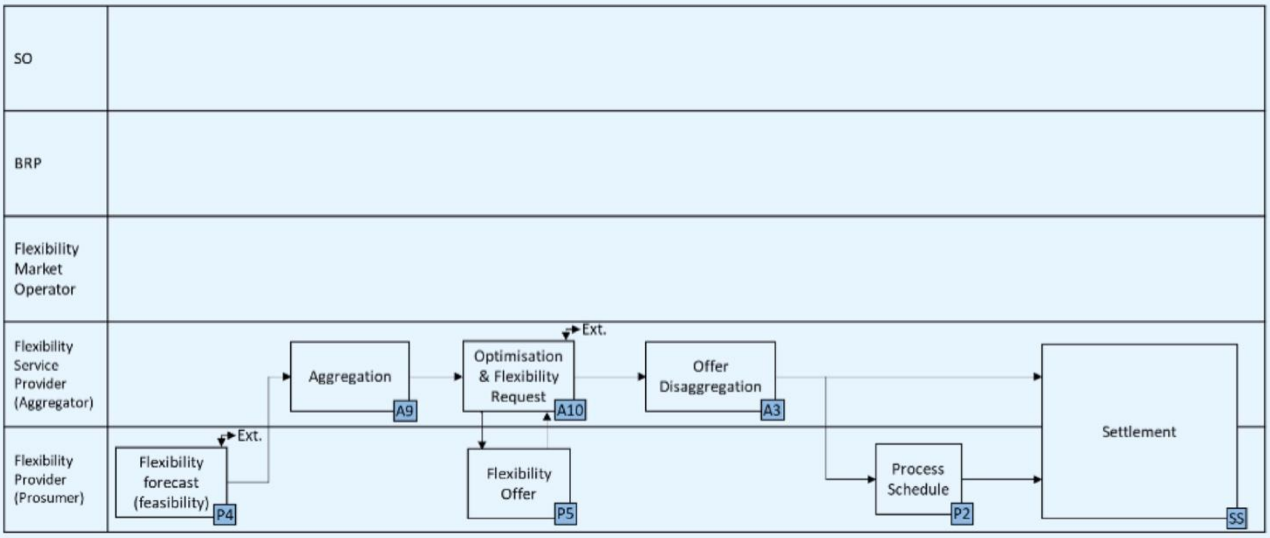

Figure 15 - Business process diagram for GBP4 "Energy community optimisation"

1.8.5 GBP5 – Implicit Flexibility Using Dynamic Steering Signals

The flexibility offering and buying can be realised in an implicit way. The demand for adapting energy production and consumption can be triggered by issuing adequate signals (e.g. price signal, CO_2/kWh indicator or other grid notifications) that should indicate if there is too much or too less energy in the grid and the Prosumers should adapt. This approach is usually applied with emphasis on active energy, but extending the trigger can also cause this approach to be useful in other areas of flexibility (power factor, etc.). Mainly in this GBP there exists no bidding phase, the flex consumer defines the signal parameters (e.g. price table or peak notice) with the hope to have enough prosumers reacting according to the wish of the buyer. The accounting is done according to the measured amount of flexibility provided with respect to potential additional parameters (like power factor).

This approach actually does not need to involve the market nor the aggregator. But variations are possible in different scenarios. In the basic approach the flex consumer takes the risk of being exploited by the flex providers, i.e., if they are very flexible, they can become speculators, they can consume only cheap energy, while producing energy while it is expensive. Here it is necessary to be supported by regulations.

This GBP is still under construction. A tentative business process diagram for the "price signal" scenario is provided below:

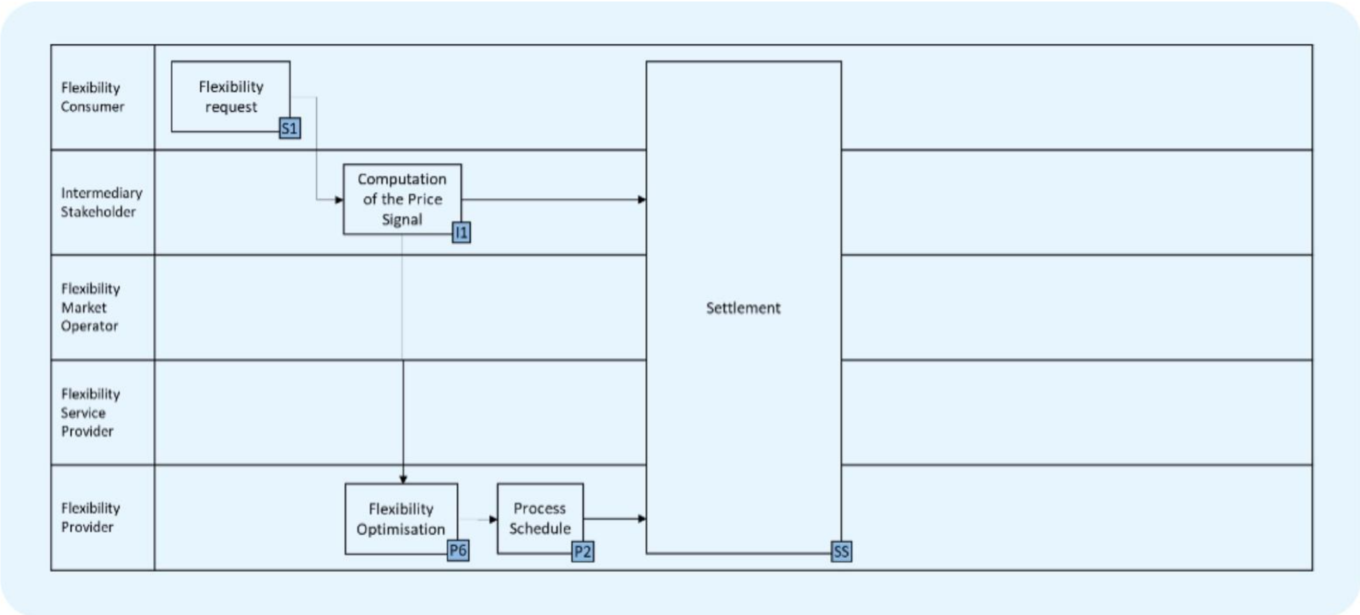

Figure 16 - Tentative business process diagram for GBP5 "Implicit flexibility using dynamic steering signals" ("price signal" scenario)

1.8.6 GBP6 – Energy Monitoring and Energy Management

A key enabler of the energy transition is the management of energy at individual premises level. This involves energy monitoring and optimisation of asset operation in respect to the end-consumer preferences, local production, and to external factors such as energy prices, CO2 equivalent of the energy generation mix, weather conditions and forecasts, etc. Such solutions can be offered by energy service companies (ESCOs), who provide the infrastructure and/or support the prosumer in achieving an efficient operation of its premises.

The aim of this GBP is to model the feedback to the prosumer with regards to energy monitoring and management based on detailed energy and external data. The form of the feedback can range from actions that need to be applied manually by the end user to automatic operation that is transparently applied to home appliances with dedicated control signals.

Further, the ESCO can perform these operations on a prosumer basis or for a group of prosumers in a larger context involving aggregation and extended processing.

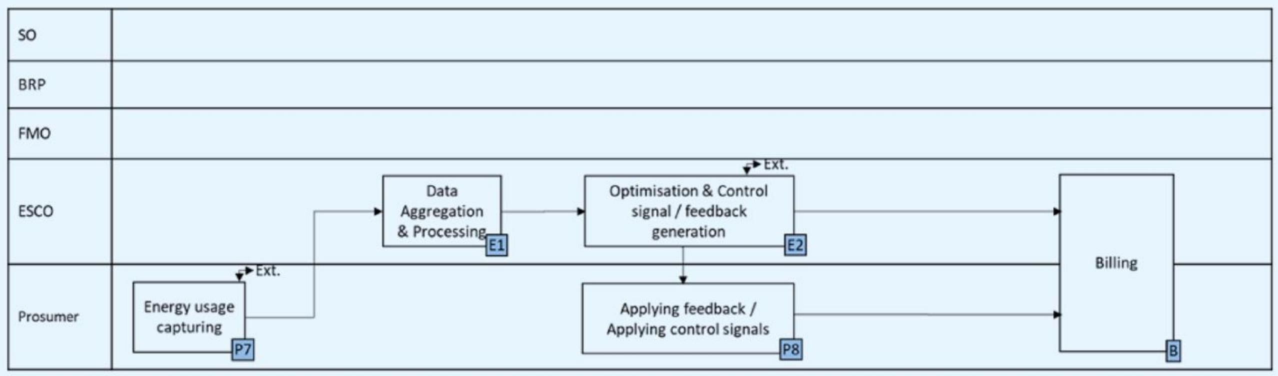

Figure 17 - Energy Monitoring and Management GBP

1.8.7 GBP7 – P2P Trading in an Energy Community

Extending the description provided in GBP 4, this GBP aims to describe the trading of energy among peers / members of an energy community. This can be enabled via a local energy market (aka P2P market), which will be managed by an operator, responsible for its maintenance, monitoring of transactions as well as for the management of participants. The following diagram depicts the different sub-processes/ functions of each stakeholder in the P2P trading lifecycle.

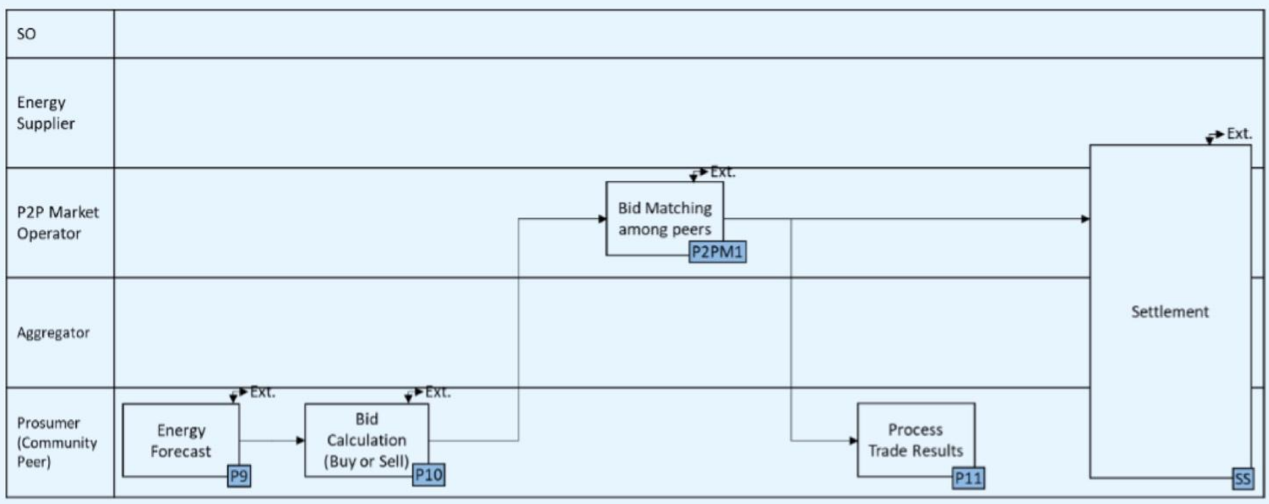

Figure 18 - P2P Trading in energy community GBP

1.8.8 Settlement Subprocess

1.8.8.1 Generic Process

The purpose of the settlement is to prepare the billing process by determining the delivered flexibility and computing the flexibility fee based on the contractual agreement between the flexibility service provider (e.g. aggregator) and the flexibility consumer (e.g. SO or BRP). It relies first on the quantification of the flexibility provided, and then on the comparison/reconciliation of the flex fee between the flexibility provider and the flexibility consumer.

As this phase is similarly structured for all the flexibility GBPs, it is described in a common subprocess.

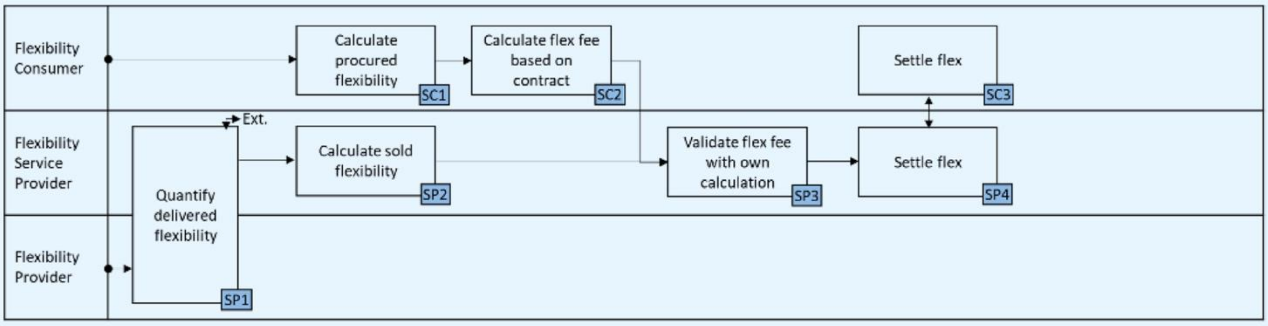

Figure 19 - Business process diagram for the settlement subprocess

1.8.8.2 Comparative Analysis with Projects Implementing the Settlement

In 2024, the WG collected feedback on how the different projects approach the implementation of the settlement. One intended to understand if they are considering a similar sub-process to the one depicted in **Errore. L'origine riferimento non è stata trovata.**.

For that purpose, seven projects (PARITY, ACCEPT, OneNet -Northern Demo Cluster, X-Flex, Platone, BRIGHT and IANOS) shared how they are implementing the settlement subprocess of the flexibility procurement. Based on their feedback, this section provides an indepth analysis of the approaches followed by different projects implementing the settlement sub-process. It then provides a brief explanation of each project concerning the settlement subprocess.

1.8.8.2.1 PARITY

In PARITY local energy market / local flexibility market, settlement is done automatically via the help of software (named Oracle) which runs per each prosumer. It communicates with the blockchain platform and checks the rules that are defined within the smart contracts (these rules are referred to as service level agreements). It calculates the sold flexibility by directly accessing the corresponding measurement data, i.e. power consumption and production, per consumer or prosumer involved. According to this description, this project adopts the sequence diagram presented in **Errore. L'origine riferimento non è stata trovata.**.

For the delivery of aggregated flexibility to the distribution system operator or external markets (e.g. ancillary services market), the Aggregator Toolset, which is software that assumes the role of the aggregator within the

PARITY framework, acts as the aggregated flexibility provider and performs the settlement and remuneration. It then distributes the corresponding tokens of the energy/flexibility transaction to each participating prosumer.

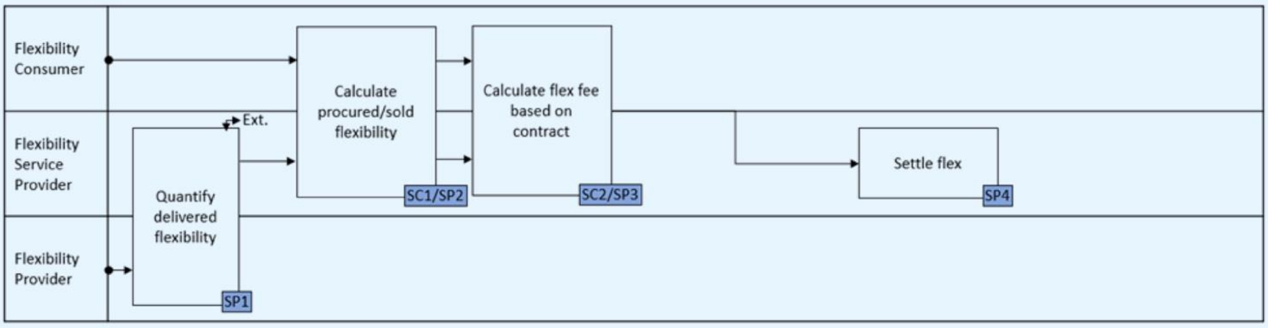

Figure 20 - Business process diagram for the Settlement subprocess in the PARITY project

1.8.8.2.2 ACCEPT

Within the ACCEPT project, the flexibility provider role is assumed by the prosumer/ consumer (in our case, this is an energy community member). The main scenarios in which the prosumer/consumer is asked to provide flexibility to a third party are:

i. the P2P trading scenario among members of the same energy community,
ii. the explicit demand response scenario, and
iii. the implicit (i.e., price-based) demand response scenario. In all three scenarios, the settlement process, based on the outputs of which the prosumer/consumer is remunerated for their provided flexibility, is carried out automatically by a software component called P2P Exchange Platform.

The P2P Exchange Platform performs the remuneration based on consumption measurements gathered from the consumer/prosumer (this is the external input depicted in the GBP diagram of **Errore. L'origine riferimento non è stata trovata.**) and a set of rules agreed between the consumer/prosumer and the flexibility service provider (within ACCEPT, this role could be assumed by either an ESCO, a retailer or an aggregator, based on the scenario implemented at any given time). The consumption measurements, post-flexibility provision, are compared to the previously calculated baseline consumption of the user to estimate the delivered flexibility (verification of response estimation) of the prosumer/consumer.

It should be noted that the set of rules mentioned before, referred to as service level agreements, are included in smart contracts between the flex service provider and the flex provider. Among those rules, for the i) and iii) scenarios, the remuneration price for the flexibility provision is calculated based on a P2P trading mechanism which is executed on a smart contract. For the ii) scenario, the price is provided by the flex service provider on a day-ahead basis (this price is calculated by the flex service provider, here the retailer, with inputs from the DSO and the wholesale market, and the demand elasticity calculated by ACCEPT software).

The flexibility service provider has, in turn, a bilateral agreement with the flexibility consumer (in our case, this is the DSO, whose functions are performed by software called ACCEPT System Emulator), where the commercial terms under which flexibility is procured and then settled are described (i.e., the price per kWh that the flexibility consumer is willing to pay for procuring flexibility). How the agreement between the two parties was achieved (either through a tender or through the energy flex market) is beyond the scope of the project. Once all flexibility providers send their verification of response (i.e., their provided flexibility calculated based on the baseline consumption and the measured actual consumption) to the flexibility service provider, the latter aggregates these responses to calculate the actual sold flexibility. The remuneration is then carried out by the DSO to the community, which then distributes the revenue to the participating members according to the agreed bilateral agreements.

Therefore, the business process diagram adopted in the ACCEPT projects is adapted from **Errore. L'origine riferimento non è stata trovata.** and depicted in **Errore. L'origine riferimento non è stata trovata.**.

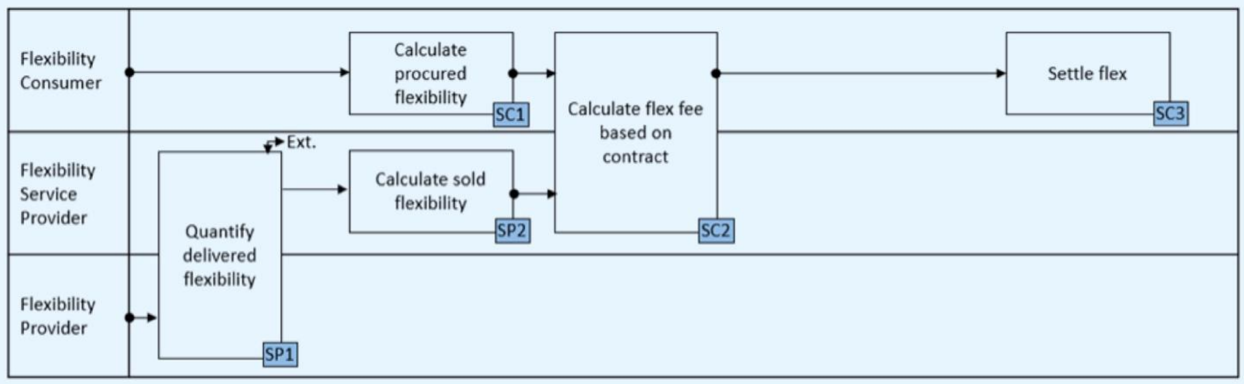

Figure 21 - Business process diagram for the settlement subprocess in the ACCEPT project

1.8.8.2.3 X-FLEX

In the XFLEX project, no BRP role and thus the market clearing is performed at the MO level. The overall settlement process is centralised as the MO is responsible for the market clearing and thus the settlement of the amount of the flex offered by flex providers (aggregators) to the flex consumers (SOs). Therefore (SC1= SP2) and (SC2=SP3) are performed towards the valuation of the flexibility offered by the flex service provider to the system operator and then the remuneration for the provided flexibility (based on the financial terms defined in the offer).

The remuneration is performed based on flexibility availability and use. Different scenarios are examined in the XFLEX project taking into account the settlement parameters for both availability and use. The flex settlement approach applies also at the level of flexibility provider (consumer/flexibility asset owner) and flexibility service provider (aggregator). In this case, the aggregator is responsible for the settlement of flexibility offered. The approach is similar to what was presented in generic business process definition. More specifically:

- **SC1:** Flex Service Provider is responsible for the calculation of the flex offered (vs flex potential) from the different flex providers;
- **SC2=SP3:** Flex Service Provider get from the MO the information about flex offered to SO and validate the amount of flex provided. Then the settlement disaggregation to flex providers is performed on the basis of the contractual terms agreed between flex service provided and flex providers;
- **SP4/SC3**: is performed by default by both entities (Flex Service Provider AND Flex Provider) to perform the flexibility settlement validation.

Taking into account the explanation described above for the X-Flex project, the sequence diagram for the settlement subprocess in the project is represented below.

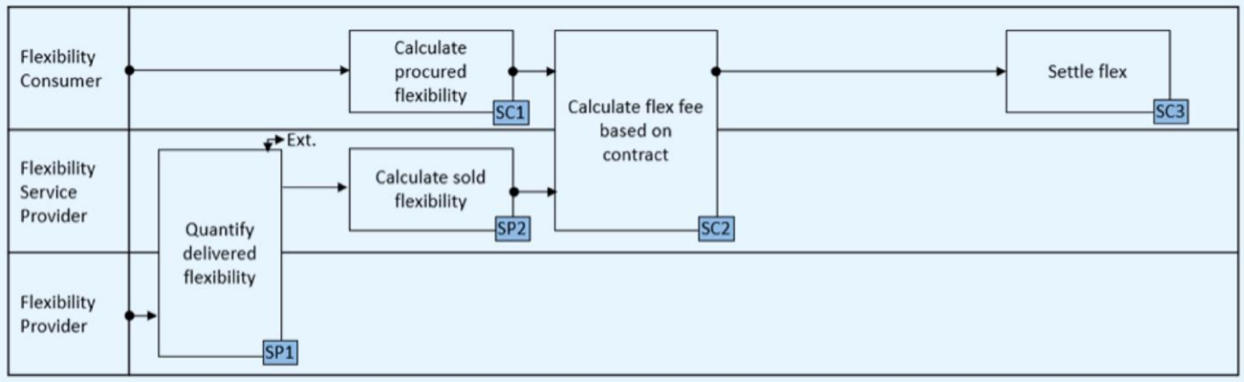

Figure 22 - Business process diagram for the settlement subprocess in the X-Flex project

1.8.8.2.4 Platone

The settlement process in the Italian use case of the Platone Project is implemented by the Platone Market Platform, which is also in charge of collecting the flexibility requests and offers, matching them and providing the market results for the flexibility activation. The settlement process is divided into two phases: validation and remuneration. In order to validate the flexibility provided by the resources, the market platform acquires the certified measurements (using blockchain) from the shared customer database at the end of the activation phase.

The Platone Market Platform is able to calculate the settlement for each resource and to enable the remuneration process through the smart contract and Platone tokens, using blockchain technology. More in detail, the Platone Market Platform implements two different smart contracts for the settlement remuneration:

- Settlement Agreement, a dynamic smart contract able to manage multiple agreements between the aggregator and its own customers. This smart contract is used for the settlement management.
- Platone Token, an ERC-20 based token is used for the payment of the flexibility provisioning to the end customers. Each customer has its own wallet linked to its own point of delivery (PoD) and Platone tokens are provided to the customer wallet at the end of the settlement phase.

Below a step-by-step sequence diagram for the settlement process:

1) Market platform receives measurements for market data verification and settlement.
2) Market platform verifies on the blockchain services layer the agreement between aggregator and customer
3) Market platform performs settlement based on measurement, market outcomes and agreements.
4) Market platform assigns the Platone tokens to the respective customers.
5) Market platform shares the settlement data with all the market participants (with specific access permission)
6) Aggregator, TSO, and DSO can visualise all the data via web user interface (UI).

1.8.8.2.5 OneNet (Northern Cluster)

In turn, for the Northern Cluster of the OneNet project, the settlement process is conducted in a component called the flexibility register (FR). The Northern Demonstrator implemented a software system for the needs of the demo. The FR receives information about the trade made on the market (for congestion management) and does the verification process first. In this process the metering data is compared to either schedules (plans) sent by the flexibility service provider, or alternatively the FR calculates a baseline from based on historical data. These results are then communicated to relevant parties.

The verification process quantifies the delivered flexibility and the settlement process uses this information to conclude financial and imbalance settlement done partly outside of the FR. The sequence diagram for the use case can be found in Figure 2.7. The objective of this use case is to quantify the delivered flexibility volumes and support the financial and imbalance settlement based on the results in the context of OneNet Northern demonstration scope. This is one of the FR's core functionalities.

This process also includes the calculation of a baseline, which is conducted by the FR based on historical metering data. The Northern Demonstration concept presented two alternatives for establishing the reference value for metering data of resources, against which the behaviour of the resources is evaluated in the verification process. These two are the baseline calculated by the FR and schedules sent by the FSP operating the respective resources. In this demo cluster, an optimisation model for SOs is also implemented to procure flexibility together for congestion management. It is reported that, in this case, it is not trivial to make the financial settlement.

1.8.8.2.6 BRIGHT

In BRIGHT project, demand response (DR) programs are implemented at the community level using peer-to-peer flexibility trading to determine the DR signals.

The implementation is done on top of the blockchain energy ledger that stores, in a tamper-proof manner, the energy (and non-energy) information collected by smart devices. The DR signals are injected into the blockchain self-enforcing smart contracts managing the community's flexible entities to programmatically determine the expected energy flexibility to be delivered by each local prosumer as well as the associated remuneration. The commitments for energy flexibility delivery are saved in blockchain as transactions for each flexible entity participant. They are processed and compared to the real-time monitored values during delivery time.

The DR programs settlement is based on the monitored data to activate the appropriate financial remuneration for the community flexibility providers. During flexibility delivery, energy transactions are generated and stored in the blockchain based on the energy data monitoring gathered from the smart meters associated with each flexible entity. The new data triggers the execution of smart contracts that are associated with the flexibility entities. The smart contracts check and compare the monitoring data with the corresponding commitments, and based on these values, the actual settlement is generated.

The payments are represented by tokens transfer associated with energy flexibility delivery.

1.8.8.2.7 IANOS

In the IANOS project the application of a P2P market platform enables prosumers in a local network to directly trade energy with each other, by avoiding RES curtailment and future grid transport costs.

The settlement process is implemented using smart contracts by considering both the energy and financial aspects of trading management and the energy data acquired by smart meters.

During delivery based on the energy, monitoring data gathered from the smart meters associated with each prosumer energy transactions are generated and stored in the blockchain. The new data triggers the execution of the smart contracts associated with the prosumers. The smart contract will check and compare the monitoring with the corresponding commitments and the actual settlement will be made based on these values. Fungible tokens based on ERC-20 standard are exploited as a payment for the purchase of energy between prosumers.

1.9 Functions and Interfaces

This section describes the functions and interfaces used in the generic business processes. To enable an easy comparison with the previous version of the Reference Framework [3], all the changes and additions are marked in red.

1.9.1 Functions

1.9.1.1 Summary of Relevant Functions per Generic Business Process

Function	GBP1	GBP2	GBP3	GBP4	GBP5	GBP6	GBP7
S1 / Flexibility Request	✓				✓		
S2 / Results validation			✓				
S3 / Process Market Results	✓						
~~S4 / Process Settlement~~							
S5 / Request for bilateral agreement		✓					
S6 / Flexibility request		✓					
S7 / Process Flex response		✓					
B1 / Flexibility request			✓				
B2 / Placement of Buying Offer	(✓)		✓				
B3 / Process Results	(✓)		✓				
~~B4 / Process Settlement~~							
M1 / Market Results Clearing (BRP)			✓				
M2 / Market Results Clearing (SO)	✓						
A1 / Flexibility Offer Aggregation	(✓)	(✓)	(✓)				

A2 / Placement Selling Offer	✓		✓				
A3 / Offer Disaggregation	(✓)		(✓)	✓			
~~A4 / Settlement Disaggregation~~							
A5 / Offer for bilateral agreement		✓					
A6 / Process request and assess response		✓					
A7 / Request disaggregation		(✓)					
A8 / Process market results	✓		✓				
A9 / Aggregation				✓			
A10 / Optimisation & Flexibility request				✓			
P1 / Flexibility offer	✓	✓	✓				
P2 / Process schedule	✓	✓	✓	✓	✓		
~~P3 / Process Settlement~~							
P4 / Flexibility forecast (feasibility)				✓			
P5 / Flexibility offer (energy community)				✓			
P6 / Flexibility optimisation					✓		
P7 / Energy usage capturing						✓	

P8 / Applying the feedback						✓	
P9 / Energy Forecast							✓
P10 / Bid Calculation							✓
P11 / Process Trading Result							✓
I1 / Computation of Price Signal					✓		
E1 / Data Aggregation & Processing						✓	
E2 / Optimisation & Control signal / feedback generation						✓	
P2PM1 / Bid Matching among peers							✓
B / Billing						✓	
SS / Settlement subprocess: • SP1 / Quantify delivered flexibility • SP2 / Calculate sold flexibility • SP3 / Validate flex fee with own calculation • SP4 / Settle flex • SC1 / Calculate procured flexibility • SC2 / Calculate flex fee based on contract • SC3 / Settle flex	✓	✓	✓	✓	✓		✓

1.9.1.2 S functions

S1 / Flexibility Request	
Description	The Flexibility Consumer sends a flexibility request to the market or to the Flexibility Facilitator, specifying volume, date(s), location, expiration date (and

	price in the case of market bid).
Inputs	
Outputs	Flexibility request
External required data	Flexibility pool, Grid Operational Status, Flexibility availability
Breakdown into functions/subfunctions	

S2 / Results Validation	
Description	The foreseen result of the market cycle is provided by the Flexibility Market Operator to the SO, so the SO can validate that the proposed plan is acceptable from the grid perspective.
Inputs	Flexibility offers and offer results (what, when, where, how much, …)
Outputs	Acceptance or refusal of the proposed plan
External required data	Grid operational status
Breakdown into functions/subfunctions	

S3 / Process Market Results	
Description	The SO receives information on activated flexibility. It processes the result and in case of inadequate volumes, corrective actions are taken (e.g. new request). It also informs about the corresponding flexibility transaction/agreement to enable the settlement.

Inputs	Flexibility order
Outputs	Corrective actions Flexibility transaction/agreement
External required data	
Breakdown into functions/subfunctions	

~~S4 / Process Settlement~~
Deprecated

S5 / Request for Bilateral Agreement	
Description	The Flexibility Consumer makes a request to the Flexibility Service Provider to make bilateral agreement regarding the flexibility that can be provided
Inputs	Special flag to indicate an emergency operation scenario Desirable amount of flexibility
Outputs	Start iterative negotiation process with the Flexibility Service Provider
External required data	
Breakdown into functions/subfunctions	

S6 / Flexibility Request	
Description	Flexibility Consumer makes a flexibility request to the Flexibility Service Provider to deal with a predicted grid issue (e.g. emergency situation)
Inputs	
Outputs	Time period Amount of energy Location information
External required data	Grid network area status (emergency state)
Breakdown into functions/subfunctions	

S7 / Process Flex Response	
Description	Flexibility Consumer processes the flexibility response received. It also informs about the corresponding flexibility transaction/agreement to enable the settlement.
Inputs	Flexibility response
Outputs	Selected flexibility response Flexibility transaction/agreement
External required data	
Breakdown into functions/subfunctions	

1.9.1.3 B functions

B1 / Flexibility Request	
Description	The Flexibility Consumer prepares a flexibility request, specifying volume, date(s), location, expiration date (and price in the case of market bid).
Inputs	
Outputs	Flexibility request
External required data	Production/Consumption forecast, Portfolio status, Flexibility availability
Breakdown into functions/subfunctions	

B2 / Placement of Buying Offer	
Description	Flexibility Facilitator places a flexibility bid in the market, specifying volume, date(s), location, expiration date and price.
Inputs	Flexibility request by Flexibility Consumer
Outputs	Flexibility request to the market
External required data	
Breakdown into functions/subfunctions	

B3 / Process Results

Description	Flexibility Facilitator receives information on activated flexibility. It forwards relevant information to Flexibility Consumer. It also informs about the corresponding flexibility transaction/agreement to enable the settlement.
Inputs	Flexibility order (s) from market
Outputs	Flexibility order(s) to Flexibility Consumer Flexibility transaction/agreement
External required data	
Breakdown into functions/subfunctions	

~~B4 / Process Settlement~~
Deprecated

1.9.1.4 M Functions

M1 / Market Results Clearing (BRP)	
Description	Matching of the buying requests and the selling offers from the Flexibility Service Provider
Inputs	Flexibility request from Flexiblity Consumer Selling offer(s) from Flexibility Service Provider Validated Results
Outputs	Market Results clearing

External required data	Flexibility pool
Breakdown into functions/subfunctions	

M2 / Market Results Clearing (SO)	
Description	Matching of the request (buy) and offers (sell) of flexibility.
Inputs	Flexibility request from Flexiblity Consumer Selling offer(s) from Flexiblity Service Provider
Outputs	Flexibility order(s)
External required data	Flexibility pool
Breakdown into functions/subfunctions	

1.9.1.5 A Functions

A1 / Flexibility Offer Aggregation	
Description	Flexibility Service Provider collects flexibility offers of all Flexibility Providers and calculates the available flexibility for its portfolio.
Inputs	Flexibility offer of Flexibility Providers (incl. consumers, prosumers, electric vehicle charging point operators, etc.)
Outputs	Aggregated flexibility
External required data	

Breakdown into functions/subfunctions	

A2 / Placement Selling Offer	
Description	Flexibility Service Provider places a bid of flexibility in the market. The bid has an expiration date and the location of the grid. Location can relate to physical infrastructure (e.g. substation, feeder) or logical segment (area of the grid).
Inputs	Aggregated flexibility
Outputs	Flexibility offer (market level)
External required data	
Breakdown into functions/subfunctions	

A3 / Flexibility Offer Disaggregation	
Description	Flexibility Service Provider receives flexibility schedule from the market. It activates flexibility of Flexibility Providers following internal process of optimisation.
Inputs	Flexibility order from market or optimisation process
Outputs	Flexibility order(s) of Flexibility Provider(s)
External required data	
Breakdown into	

functions/subfunctions	

~~A4 / Settlement Disaggregation~~
Deprecated

A5 / Offer for Bilateral Agreement	
Description	The Flexibility Service Provider provides an offer for bilateral agreement with the Flexibility Consumer
Inputs	Aggregated flexibility (calculated from previous step)
Outputs	Min/Max amount of flexibility that can be used after a Flexibility Consumer flexibility request Price per flexibility unit to be paid for providing the service to the Flexibility Service Provider
External required data	
Breakdown into functions/subfunctions	

A6 / Process Request and Assess Response	
Description	Flexibility Service Provider receives the flexibility request and checks if it is valid according to the bilateral agreement. If yes, highest priority is given to respond to the flexibility request.
Inputs	Flexibility request information (time period, amount of energy, location)

Outputs	Flexibility schedule returned as response
External required data	
Breakdown into functions/subfunctions	

A7 / Request Disaggregation	
Description	Flexibility Service Provider performs disaggregation of the selected flexibility response to the appropriate Flexibility Providers, by applying optimisation methods
Inputs	Flexibility that can be provided to Flexibility Consumer after its request
Outputs	Flexibility schedule(s) of prosumer(s)
External required data	
Breakdown into functions/subfunctions	

A8 / Process Market Results	
Description	Flexibility Service Provider receives information on activated flexibility. It forwards relevant information to disaggregation or directly to the Flexibility Provider.
Inputs	Flexibility order(s) from market
Outputs	Flexibility order(s) to disaggregation or Flexibility Provider

External required data	
Breakdown into functions/subfunctions	

A9 / Aggregation	
Description	The Flexibility Service Provider aggregates all available flexibility forecasts received from the flexibility providers within their portfolio. This Function is very similar to A1. It is to be investigated if there are major differences stemming from the different GBPs or if these two can be merged.
Inputs	Flexibility forecast per flexibility provider (prosumer)
Outputs	Aggregated flexibility forecast (i.e., community/portfolio-level flexibility forecast, where portfolio here comprises all available and eligible flexibility providers).
External required data	None
Breakdown into functions/subfunctions	

A10 / Optimisation & Flexibility Request	
Description	The Flexibility Service Provider receives (in a dynamic or static way) an optimisation request/task (depending on the optimisation scenario/use case) and performs an iterative optimisation process. Based on the initial flexibility offers by the Flexibility Providers, the Flexibility Service Provider may send an individual flexibility request to eligible Flexibility Providers and receive a reassessed flexibility offer from them. Based on the available offers, the optimisation engine calculates and produces the flexibility profile at the cumulated level.

Inputs	Aggregated flexibility forecast Flexibility offer per flexibility provider (prosumer)
Outputs	Flexibility request to each prosumer Aggregated flexibility profile (flexibility profile at community or portfolio level based on the aggregation of available flexibility offers per prosumer)
External required data	Optimisation constraints and goals (the optimisation scenario driving the optimisation and calculation of the required flexibility, translated into optimisation constraints)
Breakdown into functions/subfunctions	

1.9.1.6 P functions

P1 / Flexibility Offer	
Description	Flexibility Provider’s flexibility is provided to the Flexibility Service Provider. Flexibility Provider is aware and agrees that provided flexibility can be procured via market transactions or based on bilateral agreement between the Flexibility Consumer and the Flexibility Service Provider (incentives for prosumer involvement can be provided in the latter case).
Inputs	Flexibility calculation from individual assets: P2H, EV charging, etc. Flexibility time period
Outputs	Flexibility offer
External required data	Any data required for calculating flexibility that can be offered dynamically based on current and forecasted parameters’ values: usage patterns, types of devices, set-points preferences, weather data (including forecasts), calendar, state of charge (SoC), etc.

Breakdown into functions/subfunctions	1 Calculation of flexibility per controllable, flexible asset 2 Aggregated flexibility at the level of the flexibility provider The calculation of the flexibility per controllable, flexible asset may require an extra step for the creation of certain profiles (e.g., EV charging profile, occupancy profile, thermal comfort profiling, etc.).

P2 / Process Schedule	
Description	Flexibility Provider receives flexibility schedule from the Flexibility Service Provider. Assets are activated following the schedule received. It also informs about the corresponding flexibility transaction/agreement to enable the settlement.
Inputs	Disaggregated Flexibility order/request/offer (from Flexibility Service Provider to Flexibility Provider)
Outputs	Control actions (to controllable assets) based on flexibility request Verification of response to flexibility request Flexibility transaction/agreement
External required data	• Control of assets – specific setpoints • Response from controllable assets
Breakdown into functions/subfunctions	1 Create process schedule per asset 2 'Translation' of process schedule to specific control actions/asset setpoints

~~**P3 / Process Settlement**~~
Deprecated

P4 / Flexibility Forecast (feasibility)	
Description	The Flexibility Provider (prosumer) generates flexibility forecasts based on data from available IoT infrastructure (meters, sensors, etc.) and available EV infrastructure. This Function is very similar to P1. It is to be investigated if there are major differences stemming from the different GBPs or if these two can be merged.
Inputs	Metering and sensoring IoT data / Request for provision of flexibility forecast / profiling data (e.g., occupancy profiling, thermal comfort profiling, thermal building profile, etc.) / data from EV infrastructure (e.g., SoC, EV charging pattern, etc.)
Outputs	Prosumer-level flexibility forecast
External required data	Metering and sensor IoT data, weather data (including forecasts), data from EV infrastructure
Breakdown into functions/subfunctions	1 Calculation of available flexibility per asset 2 Aggregation of asset-level flexibility forecasts into provider-level flexibility forecast

P5 / Flexibility Offer (energy community)	
Description	The Flexibility Provider receives a flexibility request by the Flexibility Service Provider, assesses it and returns their flexibility offer (i.e., the flexibility profile that they can offer in response to the request made by the Service Provider)
Inputs	Flexibility request by the Flexibility Service Provider
Outputs	Flexibility offer per flexibility provider (incl. prosumers, consumers, EV charging points operators, etc.)
External required data	None

Breakdown into functions/subfunctions	

P6 / Flexibility optimisation	
Description	The Flexibility Provider receives the implicit steering signal (dynamic energy price, CO2/kWh indicator, etc.) and decides on the activation of available assets.
Inputs	The implicit steering signal
Outputs	Schedule for activating the available assets
External required data	
Breakdown into functions/subfunctions	

P7 / Energy Usage Capturing	
Description	This function is realised at the prosumer household and covers the collection of energy usage data and any data related to energy usage. This can cover the summarised usage, but also the energy usage of individual appliances as well as other data collected by relevant sensors. There might also be diversity in the temporal resolution of the data.
Inputs	• Smart Meter data • Appliance status (on/off, mode of operation) • Appliance Schedule • Temperature/Humidity/Occupancy/Luminance Sensor data
Outputs	Energy usage and related data (diverse temporal and spatial resolutions possible)

External required data	External data that can influence the energy monitoring (weather, time, etc.)
Breakdown into functions/subfunctions	

P8 / Applying the Feedback	
Description	The prosumer receives the feedback that covers the suggestions on how to improve the energy usage and can apply these to improve efficiency in the household. This feedback can be applied manually by the end user or in automated manner.
Inputs	• Energy related feedback • Appliance operation schedule
Outputs	Steering signals to control the appliances
External required data	
Breakdown into functions/subfunctions	

P9 / Energy Forecast	
Description	Execution of energy forecasting algorithms at the level of the prosumer in order to identify the energy to be exported or imported from other peers of the energy community or from the contracted Retailer.
Inputs	Energy Data (data on energy demand and generation – if available)
Outputs	Forecasts

External required data	Weather Historic and Forecast Data
Breakdown into functions/subfunctions	

P10 / Bid Calculation	
Description	Based on the energy forecasts and the prosumer's preference the energy to be exported or imported from other peers of the energy community or from the contracted Retailer is identified.
Inputs	Forecast Data, Prosumer Preferences
Outputs	Bid
External required data	
Breakdown into functions/subfunctions	

P11 / Process Trading Result	
Description	The outcome of the trading mechanism is communicated in this step.
Inputs	Traded Quantity/Price
Outputs	
External required data	

Breakdown into functions/subfunctions	

1.9.1.7 I functions

I1 / Computation of Price Signal	
Description	The explicit flexibility request is translated into an implicit steering signal to be distributed among the interested Flexibility Providers
Inputs	Explicit Flex Request
Outputs	Implicit steering signal (energy price)
External required data	
Breakdown into functions/subfunctions	

1.9.1.8 E Functions

E1 / Data Aggregation & Processing	
Description	If the prosumer (or many prosumers) need to be considered in a larger context, their energy usage data can be aggregated and all the data related to their energy usage (sensor data, IoT data) can be processed for the main optimisation.
Inputs	Energy usage and related data from the prosumers
Outputs	Aggregated and pre-processed data
External required data	

Breakdown into functions/subfunctions	

E2 / Optimisation & Control Signal / Feedback Generation	
Description	The energy usage and related data are processed here, and optimisation processes are executed. This might also involve training of Digital Twins. The output of these is a summary that covers the improvement suggestions (feedback) or directly applicable steering signals that can be executed on the appliances within the households.
Inputs	The pre-processed or aggregated energy usage and related data from the monitored prosumers.
Outputs	The feedback (suggestion on the energy usage change) or direct steering signals to be applied on the appliances
External required data	The optimisation process may use external data on energy price, CO2 generation, weather, etc., as additional drivers.
Breakdown into functions/subfunctions	

1.9.1.9 P2PM Functions

P2PM1 / Bid Matching Among Peers	
Description	Based on the energy forecasts and the prosumer's preference, the energy to be exported or imported from other peers in the energy community or from the contracted Retailer is identified.
Inputs	Bids
Outputs	Traded Quantities/Prices

External required data	
Breakdown into functions/subfunctions	

1.9.1.10 Billing Function

B / Billing	
Description	In this process the service provider gets the payment for the service, the results are evaluated and their value is defined.
Inputs	Energy Usage data
Outputs	
External required data	
Breakdown into functions/subfunctions	

1.9.1.11 Settlement Functions

SP1 / Quantify Delivered Flexibility	
Description	The Flexibility Provider and/or the Flexibility Service Provider quantify the flexibility that has been indeed provided/delivered by the Flexibility Provider, based on appropriate measurements and monitoring.
Inputs	Flexibility transaction/agreement
Outputs	Delivered flexibility (how much, when, …)

External required data	Metering data
Breakdown into functions/subfunctions	

SP2 / Calculate Sold Flexibility	
Description	The Flexibility Service Provider maps the delivered flexibility with the flexibility contract(s) to characterise the sold flexibility.
Inputs	Delivered flexibility (how much, when, …)
Outputs	Sold flexibility (contract reference, quantity, time period, …)
External required data	
Breakdown into functions/subfunctions	

SP3 / Validate Flex Fee with Own Calculation	
Description	The Flexibility Service Provider validates the compensation fee for the sold flexibility by comparing the flex fee claimed by the Flexibility Consumer and the flex fee computed by itself, based on the contract and sold flexibility.
Inputs	Sold flexibility Compensation fee for the procured flexibility (from Flexibility Consumer)
Outputs	Compensation fee for the sold flexibility
External required data	

Breakdown into functions/subfunctions	

SP4 / Settle Flex	
Description	The flexibility transactions are validated and the payment information for settlement is agreed between the Flexibility Consumer and the Flexibility Service Provider.
Inputs	Compensation fee for the sold flexibility
Outputs	
External required data	
Breakdown into functions/subfunctions	

SC1 / Calculate Procured Flexibility	
Description	The Flexibility Consumer calculates the amount (and time period) of procured flexibility, based on the existing contracts and past Flexibility requests
Inputs	Flexibility transaction/agreement Price signals (for GBP5)
Outputs	Procured flexibility
External required data	
Breakdown into	

functions/subfunctions	

SC2 / Calculate Flex Fee Based on Contract	
Description	The Flexibility Consumer computes the compensation fee for the sold flexibility based on the contract and procured flexibility
Inputs	Procured flexibility
Outputs	Compensation fee for the procured flexibility
External required data	
Breakdown into functions/subfunctions	

SC3 / Settle Flex	
Description	The flexibility transactions are validated and the payment information for settlement is agreed between the Flexibility Consumer and the Flexibility Service Provider.
Inputs	Compensation fee for the sold flexibility
Outputs	
External required data	
Breakdown into functions/subfunctions	

1.9.2 Arrows (information flows)

1.9.2.1 Summary of Relevant Interfaces per Generic Business Process

	GBP						
Interface	**1**	**2**	**3**	**4**	**5**	**6**	**7**
P1 → A1	(✓)	(✓)	(✓)				
A1 → A2	(✓)		(✓)				
P1 → A2	✓		✓				
A1 → A5		(✓)					
P1 → A5		✓					
A2 → M2	✓						
S1 → B2	(✓)						
B2 → M2	(✓)						
S1 → M2	✓						
M2 → B3	(✓)						
B3 → S3	(✓)						
M2 → S3	✓						
~~S3 → B4~~							

	GBP						
Interface	**1**	**2**	**3**	**4**	**5**	**6**	**7**
M1 → B3			✓				
M1 → A8			✓				
~~B3 → B4~~							
~~B4 → A4~~							
P4 → A9				✓			
A9 → A10				✓			
A10 ↔ P5				✓			
A10 → A3				✓			
S1 → I1					✓		
I1 → P6					✓		
P6 → P2					✓		
S3 → SS	✓						
P2 → SS	✓	✓	✓	✓	✓		

~~B4 → A4~~							
~~S3 → S4~~							
~~S4 → A4~~							
M2 → A8	✓						
A8 → A3	(✓)		(✓)				
A3 → P2	(✓)		(✓)	✓			
A8 → P2	✓		✓				
~~P2 → P3~~							
~~A4 → P3~~							
A5 ↔ S5		✓					
S6 → A6		✓					
A6 → S7		✓					
A6 → A7		(✓)					
A7 → P2		(✓)					
A6 → P2		✓					
~~S7 → S4~~							
A2 → M1			✓				

S7 → SS		✓					
B3 → SS			✓				
A3 → SS				✓			
I1 → SS					✓		
P2PM1 → SS							✓
S1 ↔ Ext	✓						
S2 ↔ Ext			✓				
S6 ↔ Ext		✓					
M1 ↔ Ext			✓				
M2 ↔ Ext	✓						
~~A4 ↔ Ext~~							
P1 ↔ Ext	✓	✓	✓				
P2 ↔ Ext	✓	✓	✓				
P4 ↔ Ext				✓			
P7 ↔ Ext						✓	
P9 ↔ Ext							✓

B1 → B2			✓				
B2 → M1			✓				
M1 ↔ S2			✓				
P7 → E1						✓	
E1 → E2						✓	
E2 → P8						✓	
P8 → B						✓	
P9 → P10							✓
P10 → P2M1							✓
P2PM1 → P11							✓

P10 ↔ Ext							✓
P11 ↔ Ext							✓
A10 ↔ Ext				✓			
SP1 → SP2	✓	✓	✓	✓	✓		✓
SP2 → SP3	✓	✓	✓	✓	✓		✓
SC1 → SC2	✓	✓	✓	✓	✓		✓
SC2 → SP3	✓	✓	✓	✓	✓		✓
SP3 → SP4	✓	✓	✓	✓	✓		✓
SP4 ↔ SC3	✓	✓	✓	✓	✓		✓
SP1 ↔ Ext	✓	✓	✓	✓	✓		✓

1.9.2.2 Internal Interfaces

P1 → A2

Option 1: with aggregation

P1 → A1	
Purpose	Inform Flexibility Service Provider about possible flexibility on Flexibility Provider side for the next hour/day/…
Roles Involved	Flexibility Provider Flexibility Service Provider

P1 → A2	
List of exchanged data	Flexibility offer (what, when, where, how much, …) Could be: • A set of Timeseries of flexibility (tolerance) including *baseline* (estimation of desired power consumption considering only Flexibility Provider's comfort), *upper bound* (maximum energy that can absorb) *lower bound* (minimum energy required). • *Granularity* of the timeseries, its *length* (horizon) and *unit* is also contained in message description. • Location: geographical (latitude and longitude) or grid-related (substation ID or connection point) • Communication endpoints for central EMS (or individual assets) Other information: e.g. flexibility timeseries are valid till are not exploited, once the flexibility is used, Flexibility Service Provider needs to consider a rate of flexibility adjustment or make frequent queries to get latest updates from Flexibility Provider. Or data about rebound effects of storage-like flexibility.

A1 → A2	
Purpose	Inform about aggregated flexibility that can be offered to the market
Roles Involved	Flexibility Service Provider
List of exchanged data	Flexibility offer (what, when, where, how much, …)

Option 2: no aggregation

P1 → A2	
Purpose	Inform Flexibility Service Provider about possible flexibility on Flexibility Provider side for the next hour/day/…
Roles Involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Flexibility offer (what, when, where, how much, …) Could be: • A set of Timeseries of flexibility (tolerance) including *baseline* (estimation of desired power consumption considering only Flexibility Provider's comfort), *upper bound* (maximum energy that can absorb)

P1 → A2	
	lower bound (minimum energy required). • *Granularity* of the timeseries, its *length* (horizon) and *unit* is also contained in message description. • Location: geographical (latitude and longitude) or grid-related (substation ID or connection point) • Communication endpoints for central EMS (or individual assets) Other information: e.g. flexibility timeseries are valid till are not exploited, once the flexibility is used, Flexibility Service Provider needs to consider a rate of flexibility adjustment or make frequent queries to get latest updates from Flexibility Provider. Or data about rebound effects of storage-like flexibility.

P1 → A5

Option 1: with aggregation

P1 → A1	
Purpose	Inform Flexibility Service Provider about possible flexibility on Flexibility Provider side for the next hour/day/…
Roles Involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Flexibility offer (what, when, where, how much, …) Could be: • A set of Timeseries of flexibility (tolerance) including *baseline* (estimation of desired power consumption considering only Flexibility Provider's comfort), *upper bound* (maximum energy that can absorb) *lower bound* (minimum energy required). • *Granularity* of the timeseries, its *length* (horizon) and *unit* is also contained in message description. • Location: geographical (latitude and longitude) or grid-related (substation ID or connection point) • Communication endpoints for central EMS (or individual assets) Other information: e.g. flexibility timeseries are valid till are not exploited, once the flexibility is used, Flexibility Service Provider needs to consider a rate of flexibility adjustment or make frequent queries to get latest updates from Flexibility Provider. Or data about rebound effects of storage-like flexibility.

P1 → A5	
A1 → A5	
Purpose	Communication of the available aggregated flexibility for the horizon of interest, to be processed with an offer optimisation function (regarding portfolio of clients, and estimation of the bids/imbalance fees).
Roles Involved	Flexibility Service Provider
List of exchanged data	Aggregated flexibility offers per zone

<u>Option 2: no aggregation</u>

P1 → A5	
Purpose	Inform Flexibility Service Provider about possible flexibility on Flexibility Provider side for the next hour/day/...
Roles Involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Flexibility offer (what, when, where, how much, ...) Could be: • A set of Timeseries of flexibility (tolerance) including *baseline* (estimation of desired power consumption considering only Flexibility Provider's comfort), *upper bound* (maximum energy that can absorb) *lower bound* (minimum energy required). • *Granularity* of the timeseries, its *length* (horizon) and *unit* is also contained in message description. • Location: geographical (latitude and longitude) or grid-related (substation ID or connection point) • Communication endpoints for central EMS (or individual assets) Other information: e.g. flexibility timeseries are valid till are not exploited, once the flexibility is used, Flexibility Service Provider needs to consider a rate of flexibility adjustment or make frequent queries to get latest updates from Flexibility Provider. Or data about rebound effects of storage-like flexibility.

A2 → M2	
Purpose	Submit flexibility offer to the market
Roles Involved	Flexibility Service Provider MO
List of exchanged data	Flexibility offer (what, when, where, how much, …)

S1 → M2

Option 1: through Flexibility Facilitator

S1 → B2	
Purpose	Inform about flexibility need that should be placed to the market
Roles Involved	Flexibility Consumer Flexibility Facilitator
List of exchanged data	Flexibility request (what, when, where, how much, …)
B2 → M2	
Purpose	Place flexibility request
Roles Involved	Flexibility Facilitator MO
List of exchanged data	Flexibility request (what, when, where, how much, …)

Option 2: direct

S1 → M2	
Purpose	Place flexibility request
Roles Involved	Flexibility Consumer

S1 → M2	
	MO
List of exchanged data	Flexibility request (what, when, where, how much, …)

M2 → S3

Option 1: through Flexibility Facilitator

M2 → B3	
Purpose	Inform about flexibility transaction/agreement
Roles Involved	MO Flexibility Facilitator
List of exchanged data	Flexibility order (what, when, where, how much, …)

B3 → S3	
Purpose	Inform about flexibility transaction/agreement
Roles Involved	Flexibility Facilitator Flexibility Consumer
List of exchanged data	Flexibility order (what, when, where, how much, …)

Option 2: direct

M2 → S3	
Purpose	Inform about flexibility transaction/agreement

M2 → S3	
Roles Involved	MO Flexibility Consumer
List of exchanged data	Flexibility order (what, when, where, how much, …)

M2 → A8	
Purpose	Inform about flexibility transaction/agreement
Roles Involved	MO Flexibility Service Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)

A8 → P2

Option 1: with aggregation

A8 → A3	
Purpose	Inform about flexibility transaction/agreement
Roles Involved	Flexibility Service Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)
A3 → P2	
Purpose	Inform about flexibility activation to be scheduled (disaggregated)
Roles Involved	Flexibility Service Provider Flexibility Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)

A8 → P2

Option 2: no aggregation

A8 → P2	
Purpose	Inform about flexibility activation to be scheduled
Roles Involved	Flexibility Service Provider Flexibility Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)

A3 → P2 (for GBP4)	
Purpose	Inform about flexibility activation to be scheduled (disaggregated)
Roles Involved	Flexibility Service Provider Flexibility Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)

A5 → S5	
Purpose	Bid/offer for bilateral agreement (iterative phase) Note: As a prerequisite, bilateral agreements between Flexibility Consumer and Flexibility Service Provider (and/or Flexibility Provider) must be foreseen in the regulation. Parties involved (Flexibility Consumer, Flexibility Service Provider) have to proceed with the bilateral agreement in fully compliance with the regulation dictates.
Roles Involved	Flexibility Consumer Flexibility Service Provider

A5 → S5	
List of exchanged data	Imbalance Settlement period and its duration. Hourly table of flexibility and corresponding offer request/bid for flexibility in specific slot(s) of time Validation/refusal message Reconsider offers until all the forecasted energy requirement is safely satisfied. Lead time; Time before the (recurring) flexibility option expires. Problematic point (node) Remuneration scheme Others: • Maximum number of activations • Minimum time between activation • Penalties for deviation from contract

S6 → A6	
Purpose	Flexibility request in operation phase (once the agreements are settled)
Roles involved	Flexibility Consumer Flexibility Service Provider(s)
List of exchanged data	Amount of flexibility and timing Location (geocoding or node specification) of the points in which flexibility is required

A6 → S7	
Purpose	Flexibility response
Roles involved	Flexibility Consumer Flexibility Service Provider
List of exchanged data	Response; Validation, rejection

A6 → P2

Option 1: with aggregation

A6 → A7	
Purpose	Inform about flexibility agreement
Roles involved	Flexibility Service Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)
A7 → P2	
Purpose	Inform about flexibility activation to be scheduled
Roles involved	Flexibility Service Provider Flexibility Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)

Option 2: no aggregation

A6 → P2	
Purpose	Inform about flexibility activation to be scheduled
Roles involved	Flexibility Service Provider Flexibility Provider
List of exchanged data	Flexibility order (what, when, where, how much, …)

A2 → M1	
Purpose	Submit flexibility offer to the market

Roles involved	Flexibility Service Provider MO
List of exchanged data	Flexibility offer (what, when, where, how much, …)

B1 → B2	
Purpose	Inform about flexibility need that should be placed to the market
Roles involved	Flexibility Consumer
List of exchanged data	Flexibility request (what, when, where, how much, …)

B2 → M1	
Purpose	Place flexibility request
Roles involved	MO Flexibility Consumer
List of exchanged data	Flexibility request (what, when, where, how much, …)

M1 ↔ S2	
Purpose	Exchange between market and SO to ensure a harmless and efficient bid selection from the grid perspective
Roles involved	SO MO
List of exchanged data	Flexibility offers and offer results (what, when, where, how much, …) Acceptance or refusal of the proposed plan of the MO and/or selection of most relevant offers from SO perspective

M1 → B3	
Purpose	Inform about market results to Flexibility Consumer
Roles involved	MO Flexibility Consumer
List of exchanged data	Market results (what, when, where, how much, …)

M1 → A8	
Purpose	Inform about market results to Flexibility Service Provider
Roles involved	MO Flexibility Service Provider
List of exchanged data	Market results (what, when, where, how much, …)

P4 → A9	
Purpose	Inform the Flexibility Service Provider of available flexibility at prosumer level.
Roles involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Flexibility forecasts per flexibility provider

A9 → A10	
Purpose	Provide the optimisation engine of the aggregator with data on the available community- or portfolio-level flexibility.
Roles involved	Flexibility Service Provider
List of exchanged data	Aggregated flexibility forecast

A10 → P5	

Purpose	Inform Flexibility Provider of a request for the provision of flexibility
Roles involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Request for flexibility

A10 → A3	
Purpose	Inform aggregator about the actual flexibility that can be offered by the Flexibility Provider
Roles involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Prosumer flexibility offer

S1 → I1	
Purpose	Provide the flexibility need by the Intermediary Stakeholder so it can compute the Price Signal to be transmitted to the potential Flexibility Providers
Roles involved	Flexibility Consumer Intermediate Stakeholder
List of exchanged data	Flexibility request

I1 → P6	
Purpose	Inform the prosumer about the energy price for the upcoming periods
Roles involved	Intermediate Stakeholder Flexibility Provider
List of exchanged data	Implicit steering signal (energy price)

P6 → P2

Purpose	Inform the Flexibility Provider about the flexibility to schedule
Roles involved	Flexibility Provider
List of exchanged data	Schedule for activating the available assets

P7 → E1	
Purpose	Share all the data necessary to provide the prosumer with feedback
Roles involved	
List of exchanged data	Energy usage data, data related to energy usage (many options possible, including sensor data and IoT data)

E1 → E2	
Purpose	Provide necessary near real-time and historical data to train the necessary models used by the optimisation engine of the ESCo.
Roles involved	Prosumer and ESCo
List of exchanged data	1 Metering data (total consumption, consumption of individual appliances) 2 Sensoring data (indoor temperature, occupancy, humidity, luminance, etc.) 3 Weather data 4 Monitoring data (appliances status (on/off), appliances mode of operation)

E2 → P8	
Purpose	Send optimised operational schedule to the prosumer for achieving the desired goal (e.g., save energy, save money from energy bills, maximise their self-consumption, etc.)
Roles involved	Prosumer, ESCo
List of exchanged data	1 Recommendations on optimum operation of controllable appliances for implementation of manual actions by the prosumer 2 Control signals to gateway of prosumer for automatic implementation of optimal operational schedule by applicable controllable devices.

E2 → B

Purpose	Estimate of the process results from the ESCO
Roles involved	ESCO
List of exchanged data	To be defined how these results are estimated

P8 → B	
Purpose	Process results from the prosumer
Roles involved	Prosumer
List of exchanged data	To be defined how these results are provided

P9 → P10	
Purpose	Realise the actual needs of the prosumer (to either buy energy to cover demand or sell surplus generation). Should flexibility be considered, the purpose is to realise the needs of the prosumer while respecting their comfort and convenience and achieving certain optimisation goals, such as maximising the consumption of local generation.
Roles involved	Prosumer
List of exchanged data	1 Demand forecast or flexibility forecast (baseline demand forecast plus upwards/downwards available flexibility) 2 Generation forecast

P10 → P2PM1	
Purpose	Matches the available generation, as well as the total demand at community/local market level. Meet the needs of each prosumer within the community/local market (incl. energy needs and needs relating to comfort and convenience).
Roles involved	Prosumer, P2P Market Operator
List of exchanged data	1 Selling bid: Prosumer-level generation surplus 2 Buying bid: Prosumer-level demand needs

P2PM1 → P11

Purpose	Provide result of trading
Roles involved	P2P Market Operator, Prosumer
List of exchanged data	Traded Quantity/Price

S3 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Roles involved	Flexibility Consumer
List of exchanged data	Flexibility transaction/agreement

P2 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Roles involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Flexibility transaction/agreement

S7 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Roles involved	Flexibility Consumer
List of exchanged data	Flexibility transaction/agreement

B3 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Roles involved	Flexibility Consumer

List of exchanged data	Flexibility transaction/agreement

A3 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Roles involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Flexibility transaction/agreement

I1 → SS	
Purpose	Inform about the past price signals to enable the settlement
Roles involved	Intermediary Stakeholder Flexibility Consumer
List of exchanged data	Price signals

P2PM1 → SS	
Purpose	Trade settlement
Roles involved	P2P Market Operator
List of exchanged data	Traded Quantity/Price

1.9.2.3 External Interfaces

S1 ↔ Ext	
Purpose	Exchange data for Flexibility Request

Roles involved	Flexibility Consumer, External
List of exchanged data	Flexibility pool, Grid Operational Status, Flexibility availability

S2 ↔ Ext	
Purpose	Exchange data for Results validation
Roles involved	SO, External
List of exchanged data	Grid operational status

S6 ↔ Ext	
Purpose	Exchange data for Flexibility request
Roles involved	Flexibility Consumer, External
List of exchanged data	Grid network area status (emergency state)

M1 ↔ Ext	
Purpose	Exchange data for Market Results Clearing (BRP)
Roles involved	MO, External
List of exchanged data	Flexibility pool

M2 ↔ Ext	
Purpose	Exchange data for Market Results Clearing (SO)
Roles involved	MO, External
List of exchanged data	Flexibility pool

P1 ↔ Ext	
Purpose	Exchange data for Flexibility offer
Roles involved	Flexibility Provider, External
List of exchanged data	Any data required for calculating flexibility that can be offered dynamically based on current and forecasted parameters' values: usage patterns, types of devices, set-points preferences, weather data, calendar.

P2 ↔ Ext	
Purpose	Exchange data for Process Schedule
Roles involved	Flexibility Provider, External
List of exchanged data	Control of assets

P4 ↔ Ext	
Purpose	Trigger received by third party or the community to provide flexibility forecast
Roles involved	Flexibility Provider
List of exchanged data	Request for flexibility forecast

P7 ↔ Ext	
Purpose	Gather all necessary prosumer-level data required by the ESCo for optimising the operation / use of household appliances of the prosumer
Roles involved	Prosumer
List of exchanged data	1 Total consumption 2 Consumption of individual (controllable) appliances 3 Status and mode of operation of individual (controllable) appliances 4 Indoor ambient conditions

P9 ↔ Ext	
Purpose	Calculate the energy demand and energy generation (where applicable) forecasts required for understanding the bid needs of a prosumer.
Roles involved	Prosumer
List of exchanged data	1. Energy measurements (generation and consumption) 2. Weather conditions

P10 ↔ Ext	
Purpose	Retrieve energy price data from the market enabling the proper calculation of the bids.
Roles involved	Prosumer
List of exchanged data	Energy Prices

P11 ↔ Ext	
Purpose	Decide on the P2P transactions to take place among peers of the community/local energy market based on prosumer-level needs and energy prices.
Roles involved	P2P Market Operator
List of exchanged data	1. Energy Prices for local energy market 2. Grid energy prices

A10 ↔ Ext	
Purpose	Trigger the optimisation engine of the aggregator to request flexibility offers from available prosumers
Roles involved	Flexibility Service Provider
List of exchanged data	Request for flexibility

1.9.2.4 Settlement Subprocess Interfaces

SP1 → SP2	
Purpose	Provide the characteristics (amount, time, …) of the provided/delivered flexibility to the Flexibility Service Provider
Roles involved	Flexibility Service Provider Flexibility Provider
List of exchanged data	Delivered flexibility (how much, when, …)

SP2 → SP3	
Purpose	Provide the information about the sold flexibility (contract, amount, time, …)
Roles involved	Flexibility Service Provider
List of exchanged data	Sold flexibility (contract reference, quantity, time period, …)

SC1 → SC2	
Purpose	Inform about the procured flexibility
Roles involved	Flexibility Consumer
List of exchanged data	Procured flexibility (contract reference, quantity, time period, …)

SC2 → SP3	
Purpose	Inform the Flexibility Service Provider about the calculated compensation fees for the procured flexibility
Roles involved	Flexibility Consumer Flexibility Service Provider
List of exchanged data	Compensation fee for the procured flexibility

SP3 → SP4	
Purpose	Inform about the compensation fee to be paid for the sold flexibility
Roles involved	Flexibility Service Provider
List of exchanged data	Compensation fee for the sold flexibility

SP4 ↔ SC3	
Purpose	Validate the flexibility transactions and agree on the payment information for settlement
Roles involved	Flexibility Consumer Flexibility Service Provider
List of exchanged data	Flexibility transaction data Payment information

SP1 ↔ Ext	
Purpose	Collect metering data to characterise the provided/delivered flexibility
Roles involved	Flexibility Provider Flexibility Service Provider
List of exchanged data	Metering data

1.10Guidelines for Settlement Implementation

1.10.1 Settlement

Settlement in flexibility procurement processes refers to the finalisation of transactions and agreements between parties involved in the procurement of flexibility services within the energy sector. It involves the financial and contractual aspects of acquiring flexibility resources to balance supply and demand in the energy grid. Settlement in flexibility procurement processes aligns closely with the generic business process framework established by the BRIDGE WG. In the context of electricity grids, settlement occurs after a flexibility service provider has delivered the contracted amount of flexibility, which could include adjusting energy production or consumption levels in response to grid needs. The settlement process ensures that the provider is compensated appropriately for the services rendered. Key components of settlement processes typically include:

- **Metering and Measurement:** Accurate measurement of the flexibility provided is essential for settlement. This involves metering the relevant parameters, such as energy production and/or consumption, to determine the quantity of flexibility delivered.
- **Validation and Verification:** Before settlement occurs, there is often a validation and verification process to ensure that the flexibility services meet the requirements specified in the procurement agreement. This may involve checking the quality, accuracy, and timeliness of the provided flexibility.
- **Calculation of Payments:** Settlement involves calculating the payments owed to the flexibility service provider based on the agreed-upon terms and conditions outlined in the procurement contract. Payments may be structured based on various factors, including the quantity and quality of flexibility delivered, as well as any performance incentives or penalties.
- **Invoicing and Payment Processing:** Once the settlement calculations are completed, invoices are issued to the relevant parties, detailing the amount owed for the flexibility services. Payment processing involves the transfer of funds from the procuring entity to the flexibility service provider in accordance with the agreed-upon payment terms.
- **Reporting and Documentation:** Settlement processes often require comprehensive reporting and documentation to ensure transparency and accountability. This includes maintaining records of transactions, metering data, validation results, and payment documentation for auditing and regulatory compliance purposes.

1.10.2 Lessons Learned from EU-Funded Projects

This section presents insights gathered from various EU-funded projects regarding the implementation of the settlement subprocess in the provision of flexibility. As the transition towards more flexible and sustainable energy systems accelerates, and with the deployment of flexibility markets, the efficient settlement of transactions between market participants becomes increasingly crucial. In this context, understanding the challenges, best practices and emerging trends in settlement processes is paramount for ensuring the smooth operation of energy markets. The feedback provided encompasses a range of perspectives and experiences from stakeholders involved in EU-funded projects:

- **Clarity in Contractual Agreements:** The terms used in agreements should be well defined upfront. This applies particularly to terms related to pricing mechanisms, service levels, performance metrics, and settlement procedures.
- **Standardisation of Data Formats:** Standardising data formats and communication protocols for reporting flexibility service delivery is crucial for streamlining the settlement process. Consistent data formats enable automated metering, validation, and reconciliation, reducing manual intervention and potential errors.
- **Automated Metering and Validation:** Implementing automated metering and validation processes helps ensure the accuracy and reliability of data used for settlement. Automated systems can detect discrepancies or anomalies in reported data more efficiently, facilitating faster resolution and reducing the risk of disputes.
- **Transparent and Timely Reporting:** Establishing transparent and timely reporting mechanisms for flexibility service delivery enables stakeholders to track performance and monitor compliance with contractual obligations. Real-time or near-real-time reporting allows for proactive management of settlement-related issues and enhances trust between parties.
- **Robust Dispute Resolution Mechanisms:** Despite efforts to standardise processes and ensure accuracy, disputes may still arise during the settlement process. Having robust dispute resolution mechanisms in

place, such as arbitration or mediation procedures, helps address disagreements promptly and fairly, minimising disruptions to ongoing operations.
- **Continuous Monitoring and Improvement:** Continuous monitoring of the settlement process is essential for identifying inefficiencies, bottlenecks, or areas for improvement. Regular evaluations and feedback loops enable stakeholders to refine procedures, enhance system performance and adapt to evolving requirements.
- **Collaboration and Knowledge Sharing:** Stakeholders involved in flexibility procurement and settlement processes should work together and share knowledge as this is vital for promoting best practices and driving innovation.
- **Harmonisation of Telemetry and Time-Granularity Requirements:** Guidelines for telemetry and time-granularity requirements should be harmonised at the European level, considering the time characteristics of flexibility products to ensure broader harmonisation of settlement processes in European flexibility markets. Real-time telemetry harmonisation, addressing factors such as data quality and granularity of measurements, is essential.
- **Attributes of Flexibility Products:** Flexibility products are characterised by attributes, including preparation time and time activations, which clearly determine the telemetry requirements. Fast flexibility products that should be activated in seconds have different time-granularity requirements than those activated in hours.
- **Independent Aggregation and Data Collection:** Enabling independent aggregation while managing the responsibilities of different actors entails complexity in data collection. Developing strategies to address this is crucial for ensuring accurate and reliable settlement processes.
- **Best Practices for Verification and Compensation:** Drafting of a set of best practices for verification and compensation processes is necessary. These practices should address both information exchange needs among market players (e.g., BRPs access to FSP resource information) and means of verification of actual flexibility delivery for SOs.

1.10.3 Guidelines for Settlement Implementation

1.10.3.1 Measurement and Verification

For flexibility services, measurement and verification (M&V) needs are typically more stringent compared to traditional DR programs. This is because distribution services involve the direct management and control of DER within the distribution grid. These resources, which can include solar panels, battery storage systems, electric vehicles and demand response-enabled appliances, are located closer to end users and are often interconnected with the distribution grid. As a result, M&V processes for flexibility services require accurate and granular data collection to measure the performance of individual DER and their collective impact on grid operations. This may involve real-time monitoring of energy consumption, generation, voltage levels, frequency and other grid parameters at the distribution level. Sophisticated metering, telemetry and data analytics technologies are often deployed to capture and analyse this data effectively. In contrast, traditional DR programs typically focus on aggregating flexible loads or generation from a diverse portfolio of participants to provide a statistical response to grid events. The M&V requirements for these programs may be less stringent, as they rely on aggregated measurements and statistical methods to estimate overall program performance rather than individual resource performance.

Similarly, settlement processes for flexibility services tend to be more complex and detailed compared to traditional DR programs. Flexibility services involve active participation in grid operations and may require bidirectional energy flows, dynamic pricing mechanisms and flexible contracting arrangements between SOs and DER owners. Settlement for flexibility services involves accurately quantifying the energy exchanged between the grid and individual DERs, accounting for bidirectional energy flows, time-of-use pricing and any ancillary services provided. This requires robust billing systems, metering infrastructure, and contractual frameworks to ensure fair and transparent compensation for DER participation in grid services. In contrast, settlement for traditional DR programs may be based on predetermined payment structures, capacity commitments or incentive-based mechanisms that do not necessarily require detailed energy accounting or bidirectional transactions.

Overall, the greater stringency of M&V requirements for distribution services reflects the evolving nature of grid operations and the increasing role of distributed energy resources in supporting grid reliability, resilience, and efficiency. As distribution systems become more dynamic and interconnected, accurate measurement, verification and settlement processes become essential for effective grid management and DER integration.

1.10.3.2 M&V Methods

M&V methods play a critical role in the procurement of flexibility services within the energy sector. These methods are essential for ensuring the accuracy, reliability and transparency of flexibility service delivery, as well as for verifying compliance with contractual agreements and regulatory requirements. One key aspect of M&V methods is the measurement of actual flexibility provided by market participants. This involves collecting and analysing data related to energy consumption, generation or demand response activities in real-time or near-real-time. Advanced metering infrastructure, telemetry systems, and data analytics tools are often utilised to capture and process this data efficiently.

Verification of flexibility delivery entails comparing the measured performance against predefined benchmarks, targets or service level agreements (SLAs). This verification process may involve validating the timing, duration and magnitude of flexibility responses, as well as ensuring adherence to quality standards and operational constraints. Various methodologies for M&V exist to facilitate the provision of grid services by DERs, ranging from straightforward schemes to more intricate verification processes. This section offers an outline of five prevalent approaches, each differing in complexity, as summarised in **Errore. L'origine riferimento non è stata trovata.**. To determine the most suitable M&V approach(es) for verifying the performance of service providers delivering specific grid services, several factors need to be taken into account. These encompass the nature of the service requirements under scrutiny, the positioning of the DER(s) delivering the service (front-of-the-meter or behind-the-meter), whether the service is delivered by an individual DER or a grouped aggregation, and the availability and granularity of existing metering equipment, along with the associated data.

Table 5 - Comparison of common M&V approaches (based [13])

M&V Approach	Principle	Time Horizon of Assessment	Metering Requirements	Relative Complexity
(1) System of notifications	No explicit performance assessment or limited to receipt of basic messages.	None, or limited to receipt of basic messages.	No meter required.	Lower
(2) Measurements before/ after service activation	Verify that response trend is consistent with expected response.	Period of time before/ after service activation.	Meter upstream of resource providing service, with sufficient data granularity.	Medium
(3) Evaluation against comparable service providers	Compare performance of service provider against other similar service providers.	Service delivery window.	Meter upstream of resource providing service, with sufficient data granularity.	Medium
(4) Use of historical baselines	Compare performance of service provider against its own behaviour when	Service delivery window.	Meter upstream of resource providing service, with sufficient	Higher

	not delivering service.		data granularity.	
(5) Dedicated Meter	Assess DER response through dedicated metering data.	Service delivery window.	Dedicated meter required to monitor resource providing service, with sufficient data granularity.	Higher

1.10.3.2.1 System of Notifications

According to **Errore. L'origine riferimento non è stata trovata.**, this method, commonly employed in demand response (DR) programs, entails dispatching activation signals to enrolled resources, such as extensive collections of small-scale flexible loads (e.g., water heaters). Each activation signal is dispatched either directly by the entity requesting the service or through a third-party aggregator. Upon receiving an activation signal, each resource is required to engage local controls to adjust its operation. The activation signal may specify a start time and/or the desired level of response ("normal," "critical," etc.). In certain DR programs, this "open loop" notification system suffices, while in others, the resource is supposed to transmit a message to acknowledge receipt of the activation signal. In this initial approach, individual resources are not expected to provide detailed reports on their performance (e.g., kW reduction).

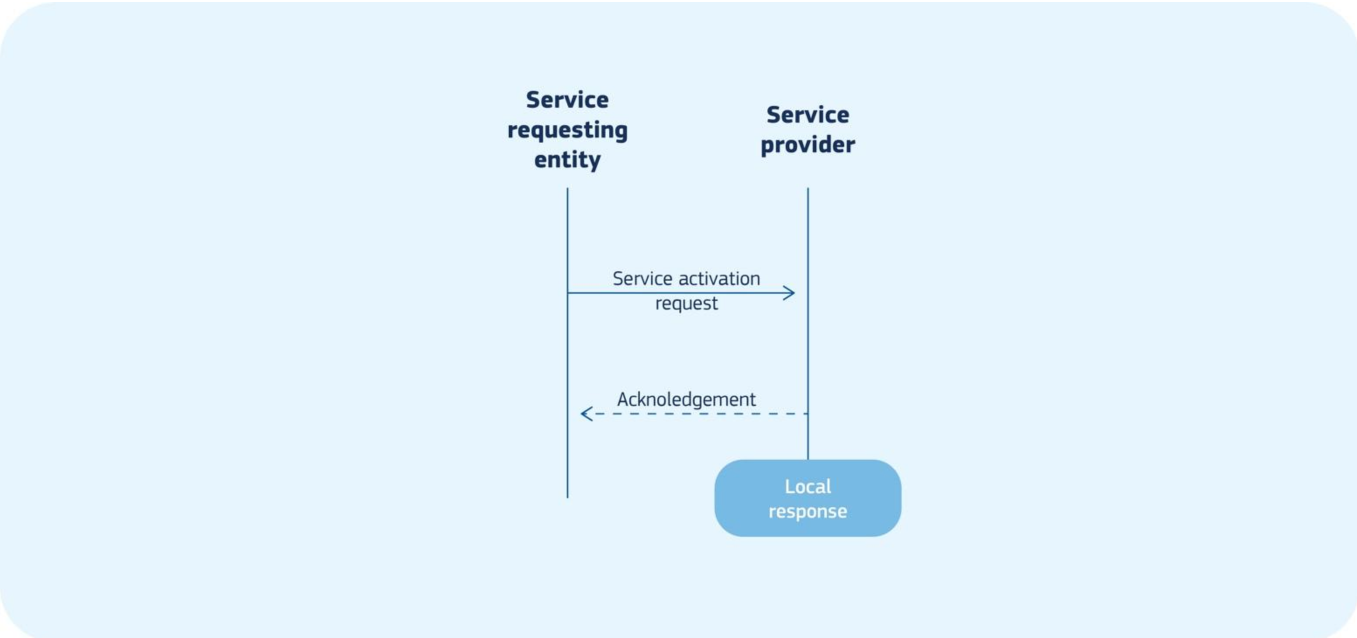

Figure 23 - System of Notifications (based on [13])

Advantages – Implementation simplicity: No specialised metering equipment is necessary for evaluating performance, and communication requirements are minimal. This method is applicable to all types of distributed energy resources (DERs) as long as the predetermined local response to be triggered upon receiving an activation request is specified (e.g., for a water heater, ceasing consumption until the water heater's energy content reaches a specific threshold).

Disadvantages – Lack of detailed performance verification: A resource that receives an activation request may only partially adjust its behaviour or not modify it at all, even after sending a signal to acknowledge receipt of the request. Additionally, two resources exhibiting different performance levels would likely receive the same financial compensation since detailed performance assessment is not conducted, potentially leading to fairness and free-riding issues.

1.10.3.2.2 Measurement Before/After Service Activation

This method, depicted in **Errore. L'origine riferimento non è stata trovata.**, acknowledges that all DERs supplying a grid service are consistently linked downstream of a revenue-grade meter, either individually or alongside other co-located resources. Its objective is to utilise existing metering apparatus to verify that the observed "trend" in metering data immediately following service activation aligns with the anticipated response. The goal is not to conduct a thorough evaluation over the entire service delivery duration but rather to evaluate the coherence of the initial response trend.

Advantages – Ease of implementation: Utilises existing metering infrastructure to confirm that the response trend immediately after activation aligns with anticipated behaviour; eliminates the need for comprehensive baseline calculations at the service provider level to establish historical baselines.

Disadvantages – Potential for manipulation: Customers might attempt to artificially boost their consumption before receiving an activation request, particularly those with low load factors; the granularity of data from existing revenue meters may be inadequate for accurately assessing the response trend, and accessing the data may be challenging; overall, performance evaluation is conducted with limited detail.

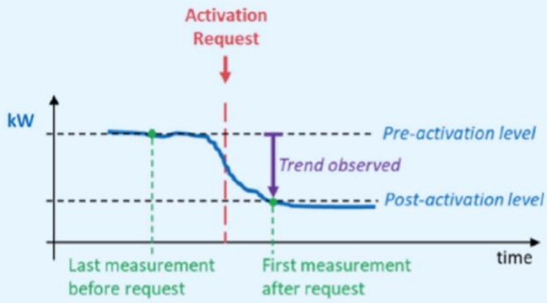

Figure 24 - Measurements before/after service activation request (based on [13])

1.10.3.2.3 Evaluation Against Comparable Service Providers

This method operates under the assumption that service providers can be categorised into groups based on similarities, such as water heaters or AC systems of comparable sizes. It evaluates the effectiveness of each individual response by comparing it to the average response achieved by similar service providers (refer to Figure 4). This approach is especially pertinent for extensive collections of service providers with shared characteristics.

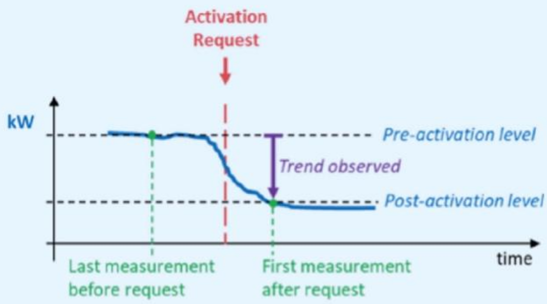

Figure 25 - Performance evaluation against group of similar providers (based on [13])

Advantages – Implementation is relatively simpler than Approach 4 outlined below, as it doesn't necessitate historical baselines, yet it still quantifies the observed performance level. Consequently, financial compensation could potentially be linked to the quantified performance level. This method also enables consideration of independent variables, such as weather-related factors, which might affect performance across a group of similar providers.

Disadvantages – Like Approach 2 (measurement before/after service activation), this method requires sufficiently granular metering data, which may not be available from existing meters. Additionally, it doesn't evaluate performance against what the service provider would have done if not responding to the service request, which may be desirable for certain services. Instead, it assesses how effectively the provider delivers a particular service compared to similar providers.

1.10.3.2.4 Use of Historical Baselines

This method evaluates the actual behaviour of each service provider throughout the service delivery period. It compares the observed behaviour against a baseline, which represents what the resource would have done if it hadn't been delivering the service. Performance is determined by the variance between 1) the actual behaviour of the resource when providing the service, and 2) the anticipated behaviour indicated by the baseline. The baseline can be established at different levels, depending on the service under consideration. For instance, it might be set at an end-user meter that measures multiple co-located resources, including the ones providing the service. Alternatively, it could be set at a meter (or sub-meters) dedicated solely to monitoring the DER(s) delivering the service.

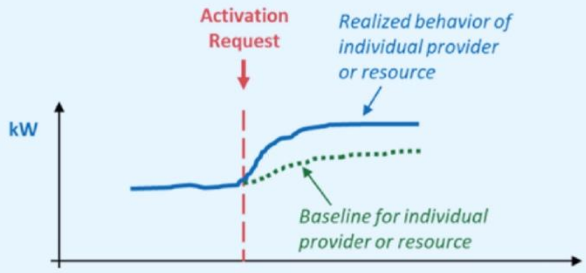

Figure 26 - Performance assessment against baseline (based on [13])

Advantages — Similar to Approach 3 (evaluation against comparable service providers), this method allows for the quantification of performance and the consideration of independent factors (e.g., weather) when calculating the baseline. However, unlike Approach 3, this approach assesses the provider's response against what it would have done if it were not delivering the service.

Disadvantages — Sufficient granularity in the metering data is necessary, which may not be provided by existing meters. Additionally, establishing meaningful baselines can be challenging for small-size resources, particularly flexible loads with a low load factor, as their discrete behaviour is more difficult to represent using baselines.

1.10.3.2.5 Dedicated Meter

This approach necessitates individual metering for each resource delivering a grid service, whether through a dedicated meter for Front-of-the-Meter (FTM) resources or a dedicated sub-meter for behind-the-meter (BTM) resources. For DERs providing a mix of grid and customer services, dedicated metering may be coupled with baseline comparisons.

Advantages — This method offers resource-specific metering data for every grid service provider, enabling detailed performance evaluation and providing operational advantages like load unmasking.

Disadvantages — Costs pose a significant challenge with this approach, related to metering equipment and communication infrastructure needed for data transmission. Also, end users sometimes object to install additional sub-metering equipment in their households/buildings, especially when these are visible. Additionally, for BTM DERs, there are concerns about potential tampering with third party-owned sub-meters, along with privacy and security issues associated with data transmission from these endpoints.

1.10.4 Baselining Methodologies

Baselining methodologies for flexibility services are essential for accurately evaluating the performance of resources that provide flexibility services. These methodologies establish a reference point against which the actual behaviour of resources is compared during service delivery. One common approach involves using historical data to create historical baselines, reflecting the typical behaviour of resources when not delivering the service. Statistical methods are often employed to develop baselines based on historical data, such as averaging historical performance over a specific period or using statistical models to predict resource behaviour. Some baselining methodologies are described as follows:

- **High X of Y:** This method selects the highest value (X) from a set of historical data points (Y) within a specified time frame to establish the baseline.
- **Regression:** Regression analysis is used to model the relationship between relevant factors (such as time, weather conditions) and energy consumption, enabling the prediction of expected consumption levels.
- **Comparable Day:** The baseline is determined by comparing the energy consumption of the current day with that of similar days in the past, adjusted for relevant factors like weather conditions and day type.
- **Rolling Average:** This method calculates the baseline by averaging energy consumption over a defined historical period, such as the past few days or weeks, to smooth out short-term fluctuations.
- **Statistical Sampling:** A subset of historical data points is randomly selected to represent typical energy consumption patterns, providing a simplified baseline estimation.
- **Meter Before/Meter After:** The baseline is established by comparing energy consumption before and after a specific intervention or change, such as the activation of a demand response event.
- **Maximum Base Load:** This method sets the baseline as the maximum energy consumption observed during a specified historical period, representing the highest expected demand level.
- **Metering Generator Output:** The baseline is determined by monitoring the output of a generating source (e.g., solar panels, wind turbines) under normal operating conditions, providing a reference for expected energy production.
- **Machine Learning:** Machine learning algorithms analyse historical energy consumption data to identify patterns, trends, and anomalies, enabling the prediction of future consumption levels.
- **Control Groups:** A baseline is established by comparing the energy consumption of a group receiving the service with that of a control group not receiving the service, allowing for the isolation of the service's impact.
- **Self-declared Baseline:** Participants declare their expected energy consumption levels based on historical usage patterns or other relevant factors, providing a simple and flexible baseline estimation method.

The selection of baseline methodologies for different flexibility products in the demonstration, as well as the factors influencing this choice, is addressed in the deliverable D3.4 of the OneNet project [14]. The demonstration experience highlights that only a subset of available baselining methodologies is practically utilised, reflecting the complexity of decision-making in this context. Furthermore, the absence of a distinct preference for any specific methodology underscores the importance of accommodating diverse approaches, echoing the principles outlined in D3.4. The decision-making process for selecting a methodology is contingent upon various factors, including stakeholder expertise, regulatory requirements and available resources, which aligns with the considerations discussed in the OneNet project. Moreover, the need for alternative solutions and robust verification measures to ensure accuracy and integrity, as suggested in the demonstration, corresponds to the recommendations put forth in D3.4 of the OneNet project for establishing a reliable regulatory framework for baselining. This example from the OneNet project serves as a valuable example for determining the appropriate baseline methodology to apply to various flexibility products.

Table 6 - Overview of baseline methodology per product used in the OneNet demonstrators [15]

Product	High X to Y	Comparable day	Meter before / Meter after	Self-declared FSP
aFRR	Greece			
mFRR	Northern Cluster,		Poland	Northern Cluster

	Greece			
RR			Poland	
Corrective local active power	Northern Cluster	Spain	Slovenia	Northern Cluster, Cyprus, Spain
Corrective local reactive power	Greece			Cyprus
Predictive short-term active power	Northern Cluster, Greece	Spain	Poland	Northern Cluster, Spain, Poland
Predictive long-term local active power	Northern cluster	Spain		Northern Cluster, Spain

The conclusions extracted from the analysis presented in D3.4 of the OneNet project offer valuable insights into various aspects of baselining methodologies and their application in the context of flexibility services. As the energy sector transitions towards greater flexibility and decentralisation, understanding the intricacies of baselining becomes increasingly crucial, particularly within the settlement subprocess of flexibility procurement. Through a comprehensive examination of key questions surrounding baselining, informed by both literature review and OneNet demonstrator experiences, a nuanced understanding emerges regarding the principles of simplicity, accuracy and integrity. These insights provide valuable guidance for policymakers, regulators and industry stakeholders navigating the evolving landscape of energy markets and seeking to develop effective frameworks for the deployment of flexibility services. The following questions were analysed in the OneNet project, [15]:

1. **Which relationship is the baseline methodology applied to?**
   a. When considering the relationship, baselining methodologies can be broadly categorised into two fields: contractual relationships between customers and intermediaries, and relationships between aggregators and system operators (SOs). Upholding principles of simplicity, accuracy, and integrity is crucial for both relationships, given the public interest in maintaining trust and reliability in the energy system.

2. **In which grid operational state is the baseline methodology used?**
   a. The choice of baseline methodology may vary depending on the operational state of the grid. While simplicity and transparency are vital during normal grid operation, accuracy and integrity become more critical during emergency states to maintain trust in the system. Balancing these requirements requires careful consideration and may necessitate separate baselines for different operational states.
3. **Who is responsible for setting the baseline?**
   a. Four actors are typically considered for setting the baseline: the SO, independent market operator (IMO), flexible service provider (FSP), or an independent third party like the regulator. Each allocation presents trade-offs, such as simplicity versus information asymmetry. Demos often assign this responsibility to FSPs or SOs, with fallback options and monitoring measures in place to ensure accuracy and compliance.
4. **Which type of customer is baselining applied to?**
   a. Baselining methodologies are tailored to different customer types. Non-professional customers, such as households, prefer simple baselines for transparency, while professional customers, like commercial entities, prioritise accuracy without excessive complexity. This preference influences the choice of baseline methodology in OneNet demos, with a focus on simplicity and medium accuracy.
5. **Which type of DER is baselining applied to?**
   a. Baselining approaches differ for various types of distributed energy resources (DERs) based on their participation and aggregation levels. While accuracy is crucial for isolated DERs in electricity markets, combined DERs require baselines that accurately reflect their contributions while maintaining simplicity. The choice between aggregated or individual baselines depends on factors like technology type and portfolio composition.
6. **Which product is baselining applied to?**
   a. Different flexibility products necessitate distinct baselining methodologies, primarily determined by product characteristics such as capacity, activation duration and preparation time. While simplicity remains consistent across methodologies, accuracy and integrity are influenced by product-specific requirements. While demo experiences often employ a single methodology across all products, the choice is influenced by regulatory frameworks and existing tools and information.

DERs, including heat pumps, PV/wind, back-up generation, combined heat and power, or storage/batteries, offer diverse participation possibilities in flexibility markets. They can operate independently or be combined with demand reduction actions of an active consumer behind the main meter. Alternatively, they may be aggregated into a larger portfolio managed by an aggregator. Baseline methodologies for isolated DERs vary in terms of simplicity, accuracy and integrity, depending on the DER type. For combined DERs, accuracy is crucial to avoid over- or under-incentivisation, especially when both demand reduction and generation assets are involved. Submetering is advocated to improve accuracy, particularly for combined DERs, enabling better performance quantification and supplier accountability. Aggregated baselines may be calculated for the same or different types of DERs, each requiring tailored methodologies. Simpler baseline approaches may enhance accuracy when aggregating DERs of the same type, while transparent and consistent calculation methods are vital for integrity, especially in aggregated baselines, to prevent manipulation and ensure fairness and reliability.

Assessing selected baseline methodologies in accordance with the type of DER against the baselining principles of accuracy (A), simplicity (S), integrity (I), and efficacy (E) draws upon the research conducted within the CoordiNet project as outlined in deliverable D2.1 [16]. This evaluation involves scrutinising different baseline approaches to determine their effectiveness in accurately quantifying the contribution of DERs (accuracy), minimising complexity for market participants (simplicity), ensuring the reliability and robustness of baseline calculations (integrity), and ultimately achieving the desired outcomes of flexibility provision and grid stability (efficacy).

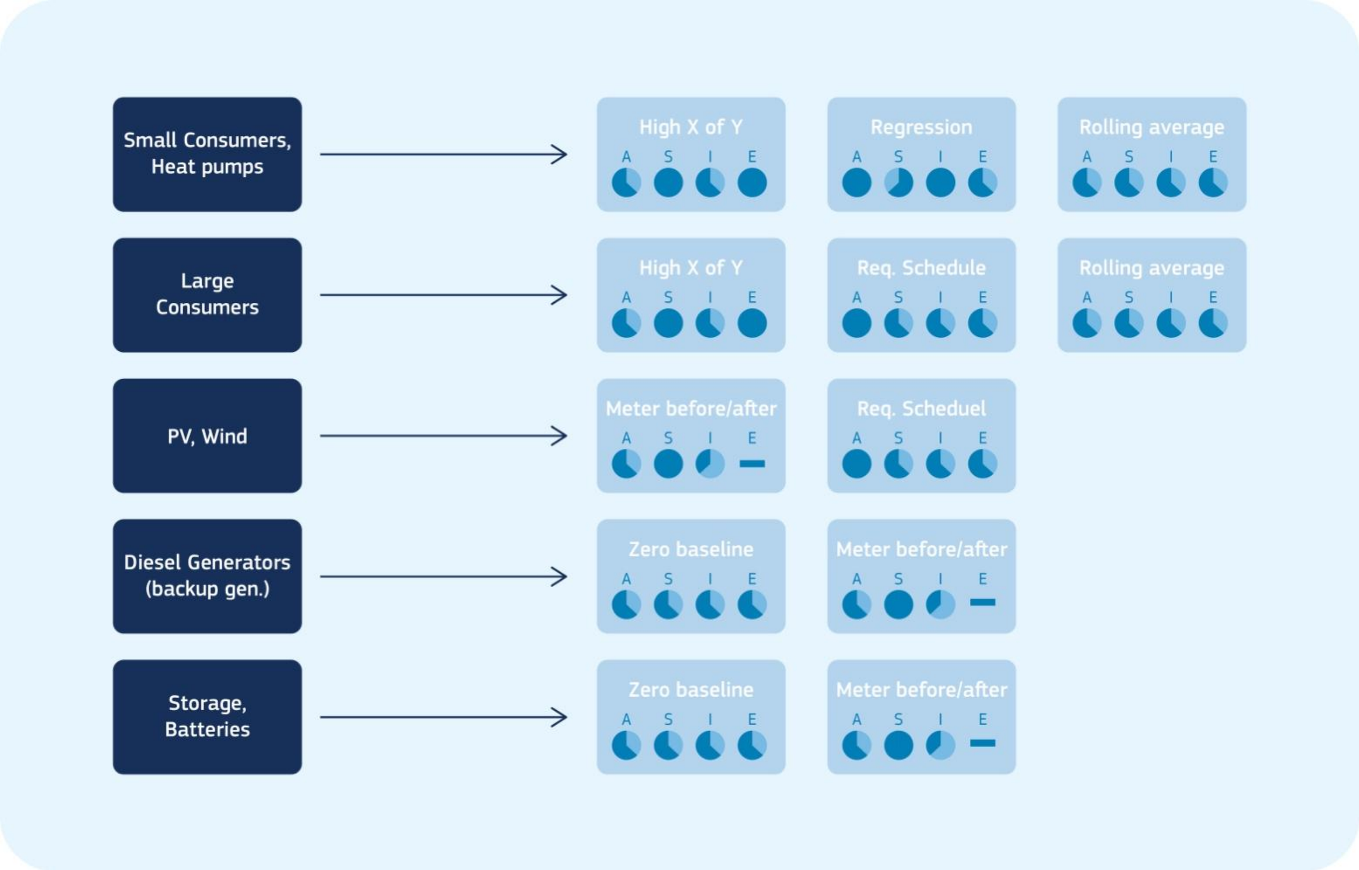

Figure 27 - Baseline decision framework adopted in the CoordiNet project [16]

1.10.5 Data Requirements

There are two categories of metering data that are integral to the M&V process. Firstly, there is revenue-grade meter data, which has conventionally been utilised for retrospective verification and settlement purposes. Secondly, there is real-time operational data, the usage of which depends on factors such as the nature of the flexibility service, the available metering resolution and the frequency of data streaming to the entity requiring the service. For instance, operational data can be employed to promptly identify instances where a DER service provider fails to fulfil their contractual commitments, allowing for immediate action to be taken if necessary. Both types of metering data may originate from a single or multiple metering infrastructure.

DERs are typically smaller in size than traditional resources, which can result in higher costs for conventional metering and telemetry solutions when applied to DER projects. Additionally, DERs often deliver services to multiple entities, such as DSOs and TSOs, introducing new challenges in terms of "accounting" for these services. This is in contrast to conventional resources, which typically operate within a single service domain. Moreover, geographically dispersed DERs may offer services as part of an aggregated group, unlike conventional resources that are usually standalone assets. However, despite these differences, the fundamental objective of M&V remains consistent: to ensure that each service provider adheres to the service requirements outlined in their contracts.

The positioning of DERs in the grid, whether they are "behind-the-meter" (BTM) or "front-of-the-meter" (FTM), is crucial for effective M&V planning, especially in the context of settlement processes. BTM DERs are situated on the customer's side of the electric meter, allowing on-site energy consumption without metering, while FTM DERs deliver energy off-site, necessitating metered passage through the end-user meter. This distinction significantly impacts settlement procedures, with BTM resources typically operating under retail tariffs and FTM resources subject to retail or wholesale tariffs, depending on various factors such as DER type and service offerings.

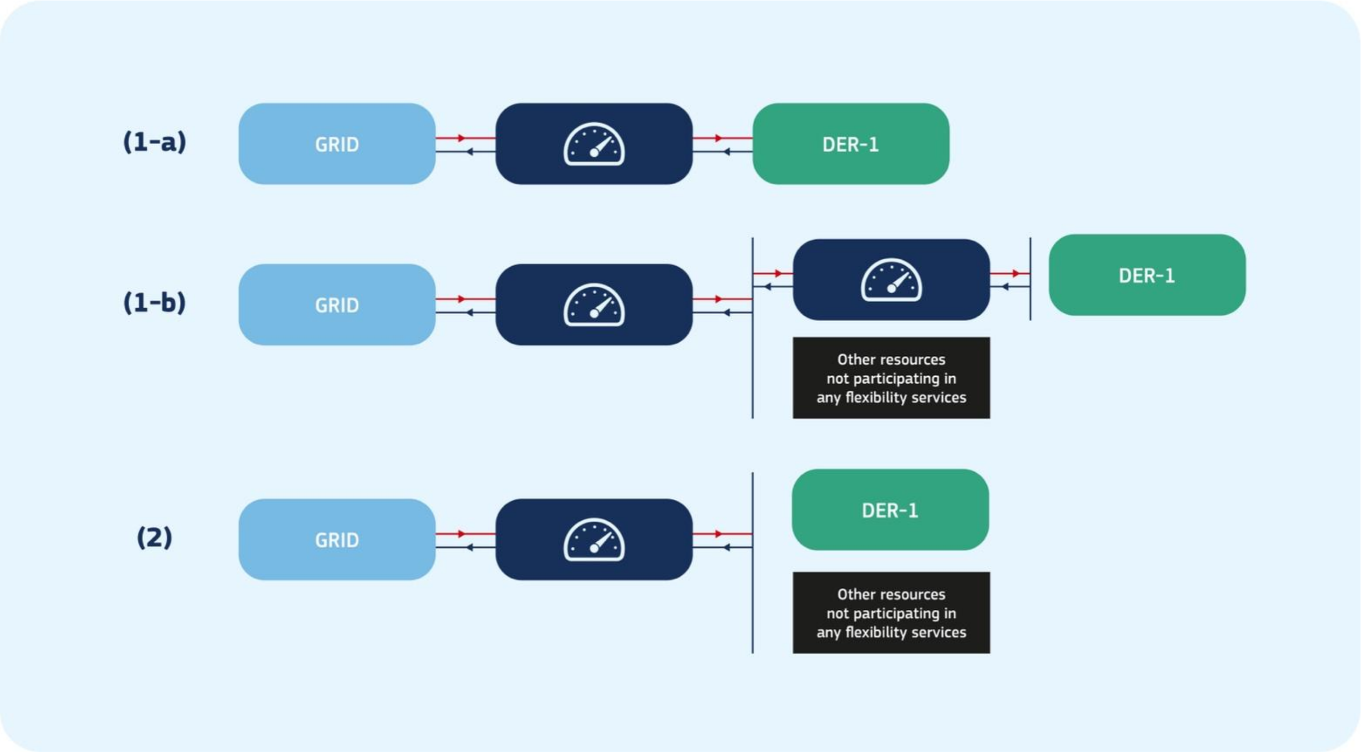

Figure 28 - *Metering configurations: dedicated meter (1-a) or sub-meter (1-b), vs. meter shared between participating and non-participating resources (2)*

The majority of prevalent M&V methodologies outlined in **Errore. L'origine riferimento non è stata trovata.** rely on metering data to evaluate the effectiveness of the grid services rendered. These data configurations can generally be classified into two primary categories. In the first category, DERs delivering grid services are equipped with their own dedicated metering infrastructure (Configuration 1-a in **Errore. L'origine riferimento non è stata trovata.**) or sub-meter (Configuration 1-b in **Errore. L'origine riferimento non è stata trovata.**). Alternatively, in the second category, DERs are metered alongside loads and other resources that may not provide the same grid services or may offer different ones (Configuration 2 in **Errore. L'origine riferimento non è stata trovata.**). Configuration 1-a is typically utilised for FTM DERs engaged in grid services provision, while Configuration 1-b becomes pertinent when individual metering of BTM DERs is mandated within the M&V framework. Configuration 2 is commonly observed in M&V methodologies employed in demand response (DR) programs; wherein baseline establishment relies on data obtained from the existing end-user meter.

In addition to DER location and data granularity, the aggregation of DERs and the potential for submetering play crucial roles in M&V planning, particularly concerning settlement processes. Aggregating DERs allows for the collective assessment of multiple distributed resources, providing a comprehensive view of their combined impact on the grid. This aggregation can streamline settlement procedures by consolidating data from various sources and simplifying the calculation of payments or credits for grid services. Submetering offers a valuable tool for M&V, enabling the isolation and measurement of specific components within a larger system. It allows for the precise monitoring of individual DERs or subsets of DERs, facilitating accurate assessment of their performance and contribution to grid services. By submetering, the granularity of data collection can be enhanced, providing detailed insights into the operation and efficiency of each DER unit.

The granularity of data required varies across different flexibility services, reflecting the diverse operational needs and objectives of each service. For instance, services involving real-time response to grid conditions, such as frequency regulation or voltage support, demand highly granular data with rapid sampling rates to capture fluctuations in supply and demand. On the other hand, services focused on longer-term optimisation, such as capacity provision or energy arbitrage, may require less frequent data sampling but still necessitate detailed information on energy consumption and generation patterns. Furthermore, the granularity of data may differ based on the specific characteristics of the flexibility service and the underlying technologies involved. For example, services utilising fast-responding resources like battery storage or fast-acting demand response may require sub-second granularity to capture rapid changes in output or consumption. In contrast, services relying on slower-responding resources such as thermal storage or distributed generation may tolerate coarser data granularity but still require sufficient resolution to capture relevant operational parameters.

As an illustrative example, the needs for explicit DR in the ACCEPT project are identified as presented below:

- **Quantify delivered flexibility**
  - Power and energy consumption data from eligible prosumers and district level assets respectively
  - Data granularity – 15 minutes
  - Flexibility provided period (specific hours during the day)
  - Power/energy from controllable loads (i.e. dhw,hvac)
  - Power/energy from building-level PVs (generation)
  - Power/energy from district-level PVs (generation)
- **Quantify procured flexibility**
  - Data granularity – 15 minutes
  - Baseline power/energy from each consumer (W/kWh)
  - Actual power/energy from each consumer (W/kWh)
- **Flexibility sold**
  - Data granularity – 15 minutes
  - quantify delivered flexibility
  - Remuneration price in €/kWh based on the SLAs
- **SC2 – flexibility fee calculation**
  - Data granularity – 15 minutes
  - quantify procured flexibility (W/kWh)
  - price in €/kWh specified by the provider
- **SP3 – flexibility fee validation**
  - Data granularity – 15 minutes
  - Flexibility fee calculated (€/kWh)
  - dynamic pricing factors (such as electricity market prices, network constraints, weather conditions, etc.)
- **SP4 – settle flex**
  - Data granularity – 15 minutes
  - Flexibility fee validation (€/kWh)
  - Actual Consumption and Generation Data (W/kWh)
  - Baseline Consumption and Generation Data (W/kWh)
  - Flexibility Fee Rates (€/kWh)
  - Dynamic Pricing Data (€/kWh)

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