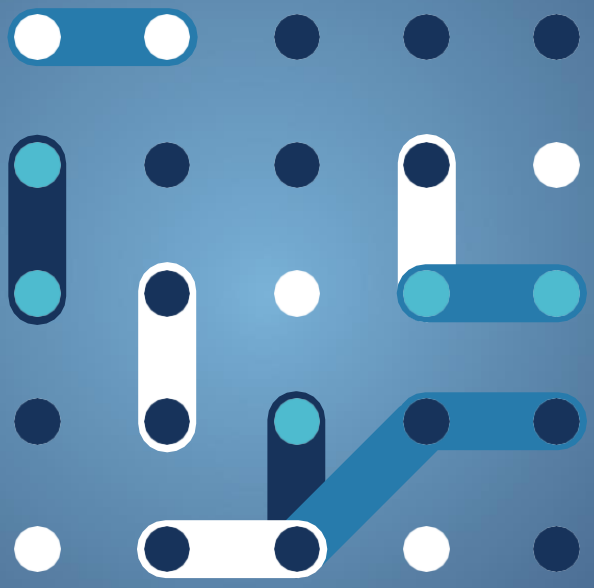
European Commission

bridge

Reference Framework

1.0

Data Management Working Group



June - 2023

AUTHORS

Olivier Genest, *Trialog*

Isidoros Kokos, *Intracom Telecom*

Mário Couto, *EPRI*

Ismini Dimitriadou, *Hypertech*

Krzysztof Piotrowski, *IHP Microelectronics*

Stelios Zikos, *CERTH/ITI*

OTHER CONTRIBUTORS

Members: Ferdinando Bosco of *Engineering,* Marjolaine Farre & Dune Sebilleau of *Trialog,* Kostas Tsatsakis of *Suite5,* Dimitra Tsirigoti of *isZEB,* Denisa Ziu & Vincenzo Croce of *Engineering,* Joaquim Meléndez i Frigola of *Universitat de Girona,* Elena Boskov Kovacs of *Blueprint Energy,* Jukka Rinta-Luoma of *Fingrid.*

Projects: ACCEPT, ebalance-plus, FEVER, GIFT, InterConnect, MAESHA, OneNet, PARITY, PlatOne, X-FLEX, BRIGHT, IANOS, RESCHOOL

SUPPORT FROM BRIDGE SECRETARIAT

BRIDGE Secretariat: Savvas Symeonidis & Ioannis Vlachos, ICCS (NTUA), Martin Bracken, CLERENS, Niclette Zampata & Agnieszka Gierej, ZABALA. BRIDGE Secretariat coordinator: Marcos Jareño, ZABALA.

BRIDGE WG/TF CHAIRMANSHIP

Olivier Genest – *Chair*

ACKNOWLEDGEMENTS

The editors would like to acknowledge the valuable inputs from BRIDGE projects and Data Management WG who participated in the meetings and consultation rounds as well as members of the SPRING team, all contributing to this BRIDGE Reference Framework Report.

EUROPEAN COMMISSION

Directorate-General for Energy
Directorate B – Just Transition, Consumers, Energy Efficiency and Innovation
Unit B5 – Innovation, Research, Digitalisation, Competitiveness

European Climate, Infrastructure and Environment Executive Agency – CINEA
Department Green Research and Innovation
Unit C2 Horizon Europe Energy

Contact: Mugurel-George Păunescu (DG ENER), Mariana Stantcheva (CINEA)

E-mail: mugurel-george.paunescu@ec.europa.eu ; mariana.stantcheva@ec.europa.eu

European Commission

B-1049 Brussels

Reference Framework

Data Management Working Group

June 2023

Directorate General for Energy 2023

bridge

LEGAL NOTICE

BOOK	ISBN 978-92-68-07475-6	Doi: 10.2833/646224	MJ-04-23-846-EN-C
PDF	ISBN 978-92-68-07474-9	Doi: 10.2833/475006	MJ-04-23-846-EN-N

Luxembourg: Publications Office of the European Union, 2023

Manuscript completed in June 2023

First edition

INDEX

Executive Summary

Initially, the topic of "Interoperability of flexibility assets" was discussed and its scope defined during the BRIDGE General Assembly held on March 11th and 12th 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 has been 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.

Following the BRIDGE General Assembly of March 2022 [4], it was decided to focus the activities on the further development of the Reference Framework, in particular:

- To refine the existing GBPs based on the feedback from new projects;
- To extend the Reference Framework to include new GBPs beyond flexibility;
- To improve the Settlement subprocess based on the BRIDGE projects that are effectively implementing settlement.

This report presents an update of the Reference Framework, now describing 7 Generic Business Processes and detailing the Settlement subprocess. It also highlights 3 main findings and recommendations (see §4.1):

- *Consistency with existing standards and on-going initiatives*: activities like the Reference Framework are performed in parallel to BRIDGE activities, in IEC with 62913 series and in SGTF EG1 with a set of Implementing Acts for the Electricity Directive Article 24. Cooperation with these initiatives should be established to ensure consistency.
- *Expectations and benefits from the Generic Business Processes*: seven GBPs are now defined, covering flexibility, energy monitoring and P2P trading. The expectations from the BRIDGE projects and potential benefits should be studied to increase the impact of the Reference Framework.
- *Further understanding of implementing the Settlement sub-process*: the Settlement sub-process has been compared with its effective implementation in five on-going projects. Barriers and challenges should be identified, and guidelines provided to ease the implementation of settlement in future projects.

1 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 definition 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 fits into the 3rd area "Data Handling" and is covering 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 March 11th and 12th 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 has been 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.

Following the BRIDGE General Assembly of March 2022 [4], it was decided to focus the activities on the further development of the Reference Framework, in particular:

- To refine the existing GBPs based on the feedback from new projects;
- To extend the Reference Framework to include new GBPs beyond flexibility;
- To improve the Settlement subprocess based on the BRIDGE projects that are effectively implementing settlement.

This report presents an update of the Reference Framework, now describing 7 Generic Business Processes and detailing the Settlement subprocess.

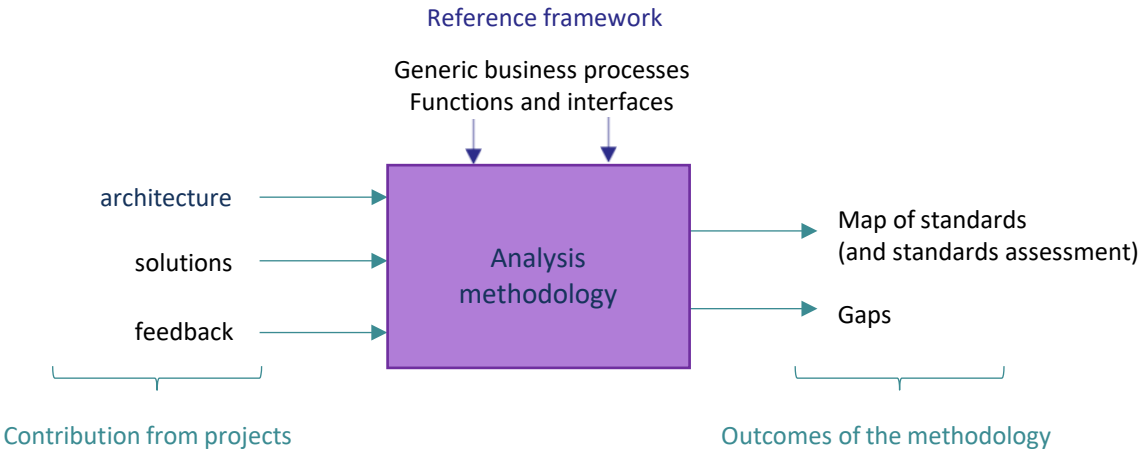
2 General approach

2.1 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 define some generic business processes, which are agnostic to any specific technical solution, enabling to map each of the projects' specific solutions to these Generic Business Processes to enable cross-projects comparison and analysis.

This 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 gaps identification.



Color legend: stable – update in case of novel use-cases – regular update to include inputs from new projects.

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 harmonize use-cases descriptions between projects (e.g. via the BRIDGE use-case repository).

2.2 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 Generic Business Processes (GBPs), made of functions and interfaces, with which each project's use-cases and architecture can be mapped.

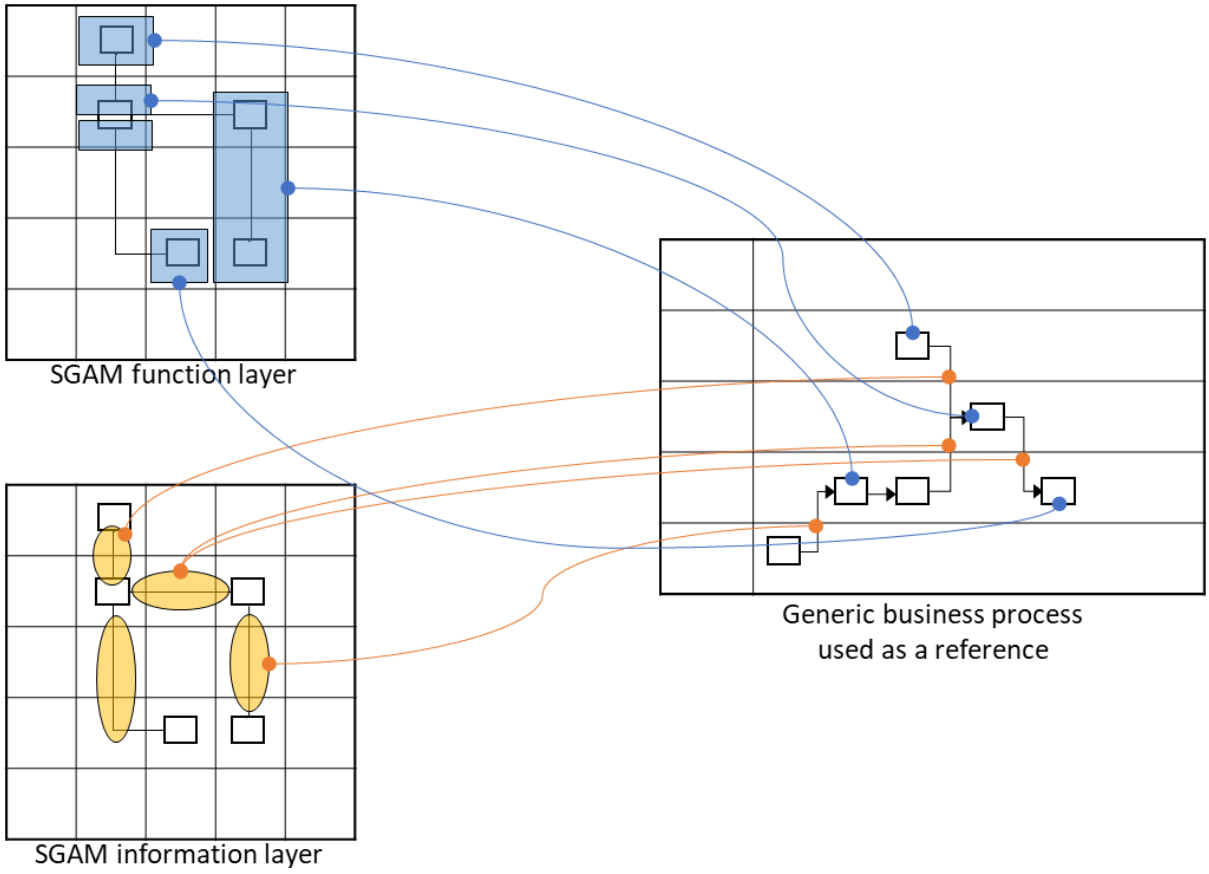


Figure 2: Example mapping between the SGAM layers of a specific solution/use-case, and a Generic BusinessProcess used as a reference.

2.2.1 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 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 generic business processes 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. In case several paths are possible, the alternative path is drawn with dotted lines.

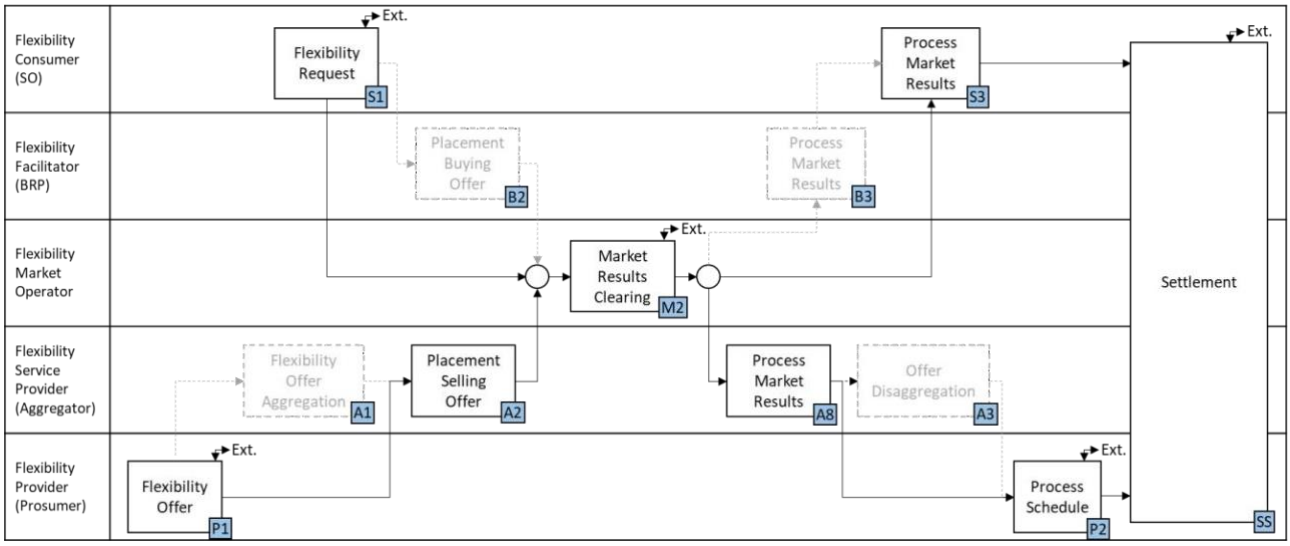


Figure 3. Example of business process diagram

2.2.2 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 command, and finally provide outputs to the following function. They can be decomposed into "subfunctions", which might be useful for more detailed mapping with some specific architecture.

They are defined with the following table:

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 realise the function. An example of external data could be "weather data", "metering data", … An example of command could be "control of flexible loads".
Decomposition into functions/subfunctions	This cell describes the decomposition of the function into subfunctions.

Table 1. Template for function description

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

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

Table 2. Template for interface description

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

2.2.3 Extension of the Reference Framework

A survey was performed in January 2023 (see Annex 1: Consultation of BRIDGE Action #3 on Reference Framework extension) to identify relevant Generic Business Processes to be added, based on use-cases from contributing projects. The main areas of interest express in the survey answers, as well as the corresponding projects, are listed below:

- Cross Sector use-cases
  - **Mobility**: FEVER, Interconnect, XFLEX, Re-empowered
  - Power2Heat: Re-empowered
  - Water (Pumping stations): GIFT
  - Smart Buildings: Parity, Interconnect, etc.
- Prosumer Services
  - **Energy management of households**: MAESHA, iFLEX, ACCESS
  - Energy Markets
- **P2P Trading**: FEVER, ACCESS, PARITY

In **bold** are highlighted the topics with the most concerned projects.

Therefore, the work focused on three possible Generic Business Processes:

- E-mobility-based flexibility: after deeper analysis, it was concluded that this GBP is mostly a variation of GBP #1 “Flexibility for SO via open market” with e-mobility specific actors. The associated functions and interfaces have been adapted accordingly.
- P2P energy trading: this GBP has been developed as described in §3.2.7.
- Energy monitoring and energy management in households: this GBP has been developed as described in §3.2.6.

2.2.4 Settlement implementation

The BRIDGE projects implementing settlement have been identified and then contacted between November and February 2023 to ask for details about how settlement is handled within the project and if their implementation can be mapped to the settlement subprocess currently defined in the Reference Framework. Answers from 5 projects were received and are analysed in §3.2.8.2.

3 Reference framework

In this chapter, the reference framework is described. As defined in §2.2, it is made of generic business processes, functions and interfaces.

3.1 Definition of terms

3.1.1 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 [5] 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 into 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 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 behavior in reaction to external signal (request or activation)."

3.1.2 Flexibility stakeholders

Further, 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 behavior 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 be also 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 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 by its own, but it rather represents the individual flexibility providers to make them access the market, in exchange for some fraction of the compensations 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 represent 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 Generic Business Processes, 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.

3.1.3 Energy services stakeholders

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

Energy Service Company – Based on the HEMRM [5], 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.

3.2 Generic business processes

3.2.1 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 stakeholder 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 care modelled preferences and constraints (function P2) and properly remunerated or penalised (function S).

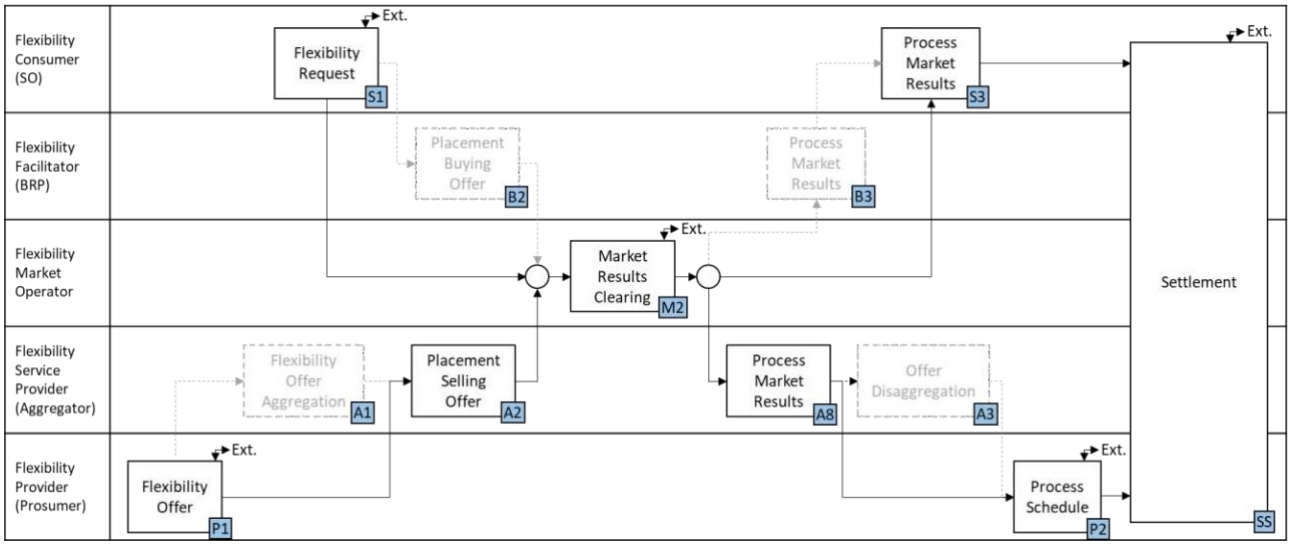


Figure 4 Business process diagram – GBP1 "SO flexibility through open market"

3.2.2 GBP2 – Flexibility for SO via prior bilateral agreement

The SO (i.e. DSO or TSO) business process for flexibility via prior bilateral agreement (Figure 5) 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, 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 to simplify and speed up the process. The highest priority must be given due to the emergency status. Therefore, in case 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 to define 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 defined 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 at the prosumers' 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 defined, which this process is discussed in further detail in section 3.2.6 The defined settlement subprocess is common for all GBPs.

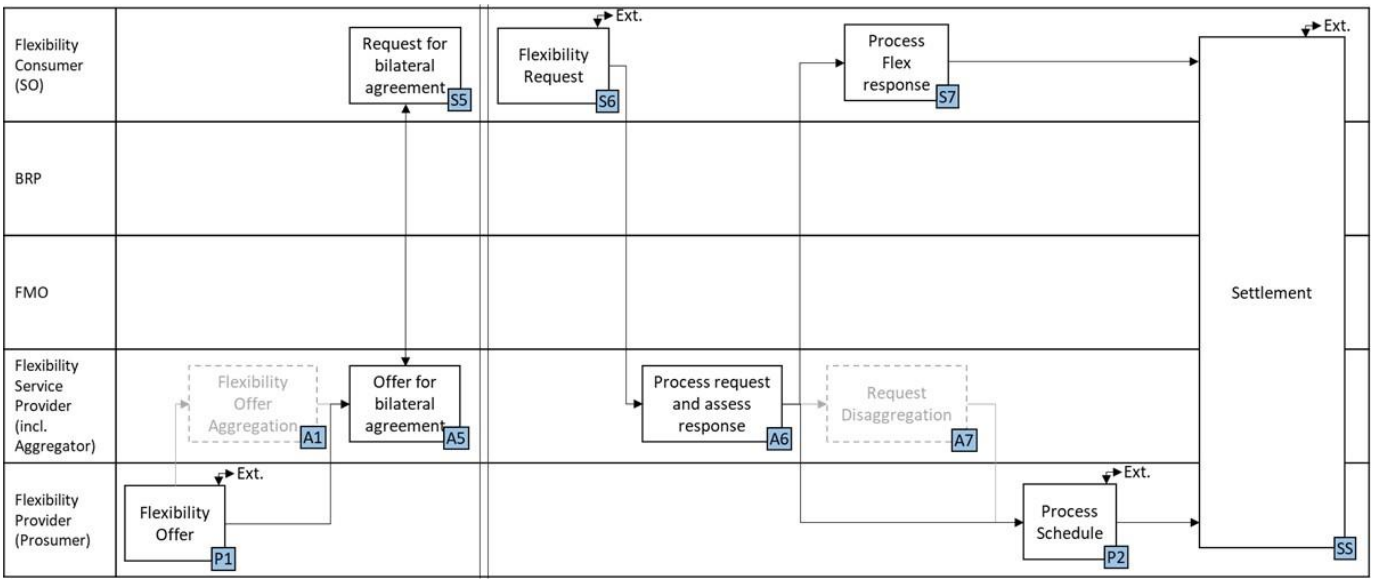


Figure 5. Business process diagram for GBP2 "SO flexibility via prior bilateral agreement"

3.2.3 GBP3 – Flexibility for BRP portfolio optimisation

The main objective of balancing markets is to deal with the power system's temporary imbalances 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 the market settlement is undertaken by the BRP. Market settlement is analysed further in section 3.2.6, entitled 'Settlement subprocess', and is common across all GBPs, incl. GBP3.

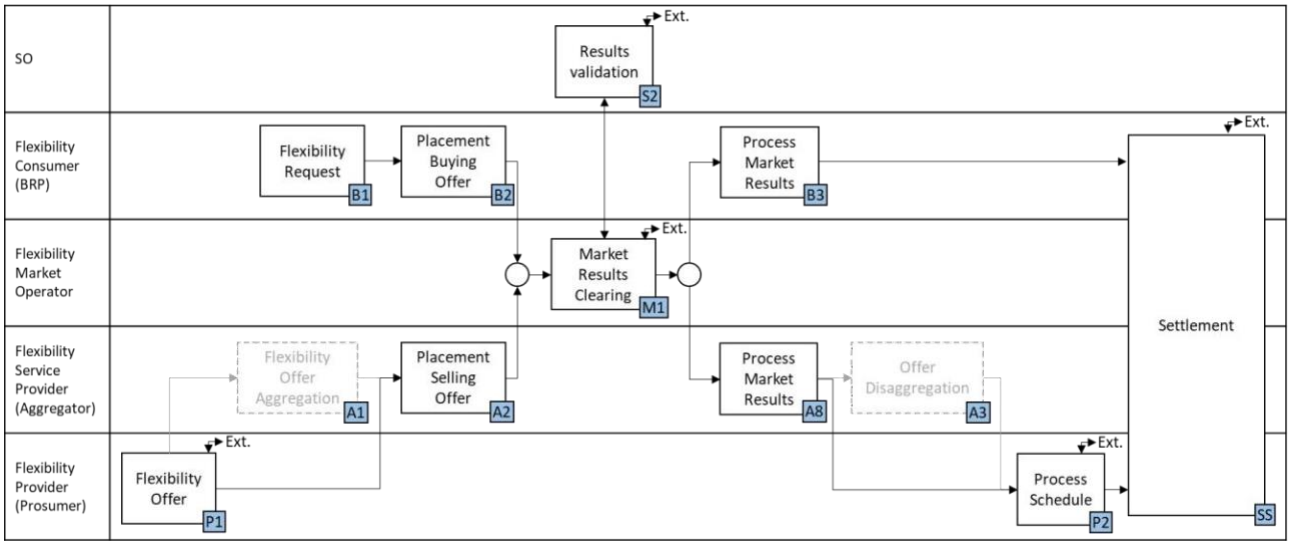


Figure 6: Business process diagram for GBP3 “BRP portfolio optimisation”

3.2.4 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. Independent from the goal and from the participation to the market, there are some actions related to the internal optimisation within the energy community as shown in the Figure 7. In case 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 can also participate to 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.

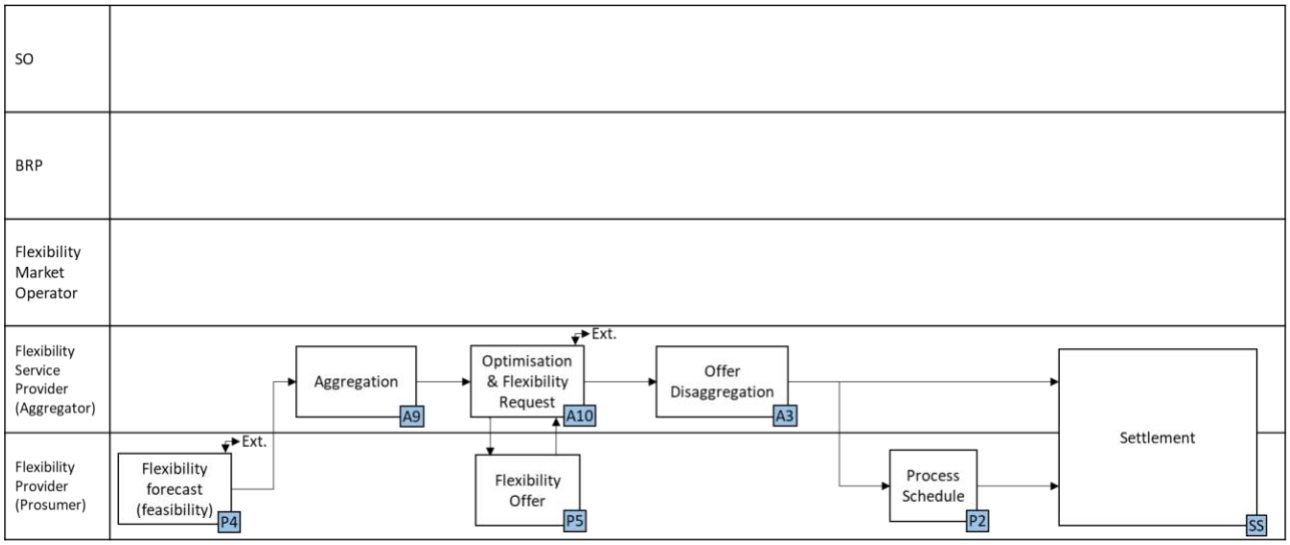


Figure 7. Business process diagram for GBP4 "Energy community optimisation"

3.2.5 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 focus 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 does not need to involve the market nor the aggregator. But variations are possible in different realisations. 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:

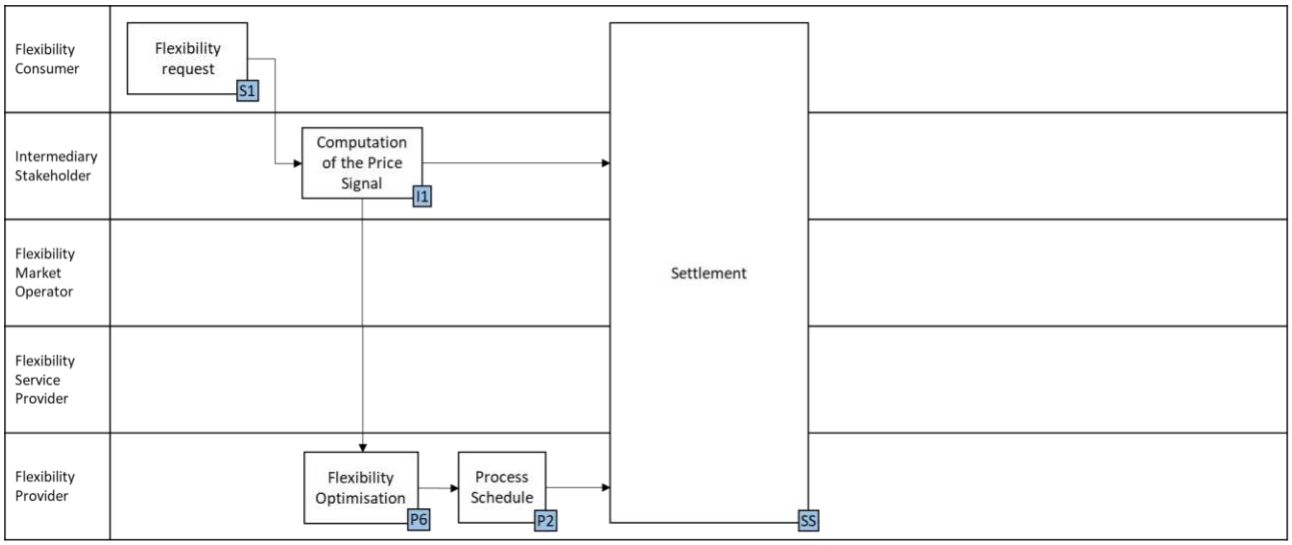


Figure 8. Tentative business process diagram for GBP5 "Implicit flexibility using dynamic steering signals" (“price signal” scenario)

3.2.6 GBP6 – Energy monitoring and energy management

A key enabler of the energy transition is the management of energy at individual premise level, enabled though energy monitoring and optimisation of asset’s operation in respect to the end-consumer preferences, local production, as well as considering 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 are 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.

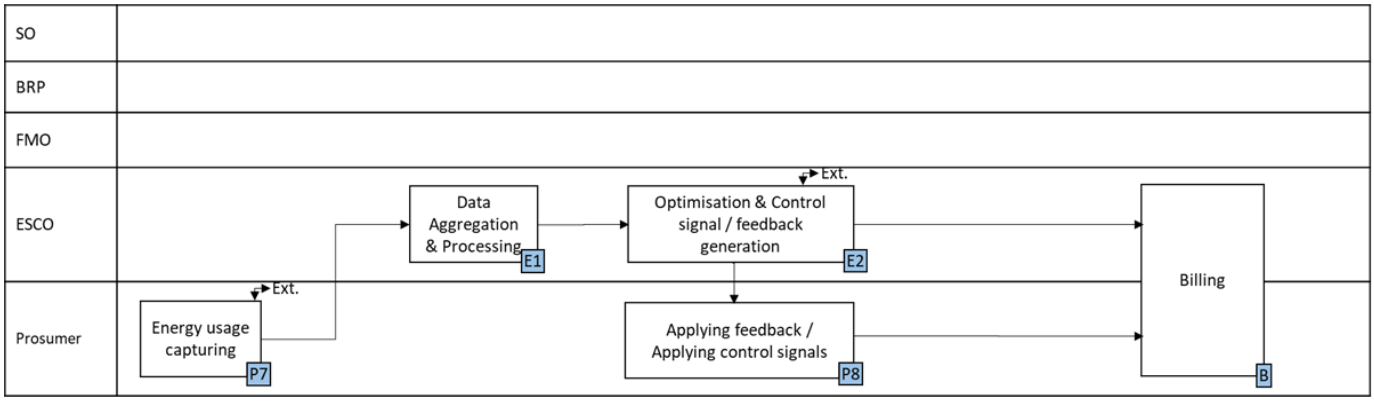


Figure 9. Energy Monitoring and Management GBP

3.2.7 GBP7 – P2P Trading in 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.

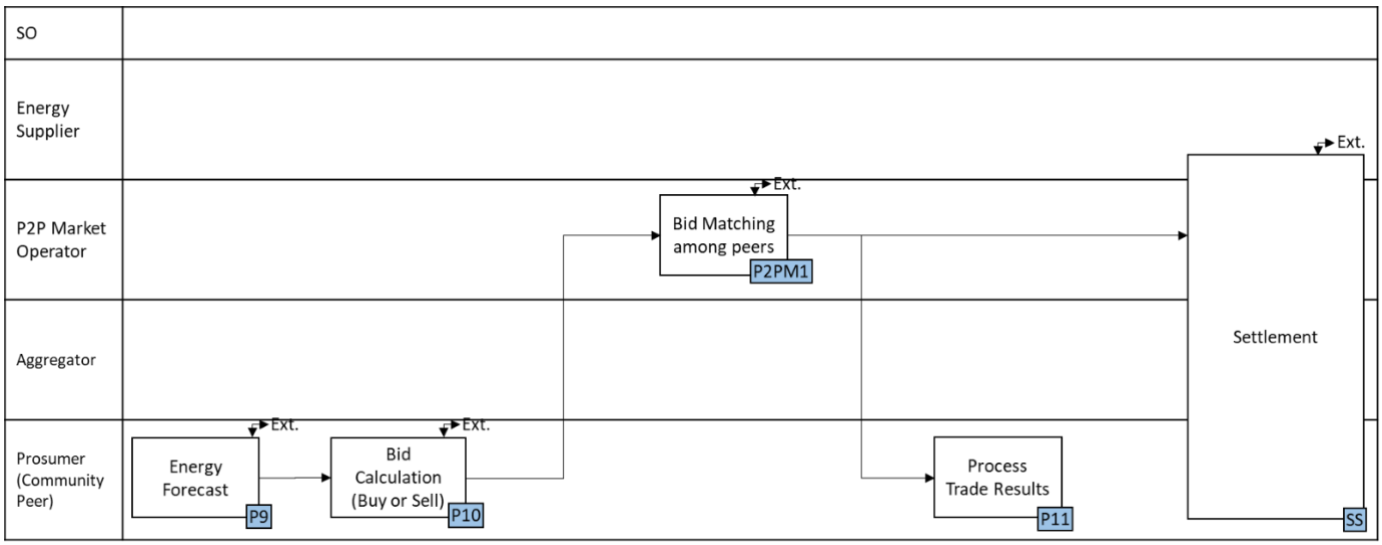


Figure 10. P2P Trading in energy community GBP

3.2.8 Settlement subprocess

3.2.8.1 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 provided flexibility, 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.

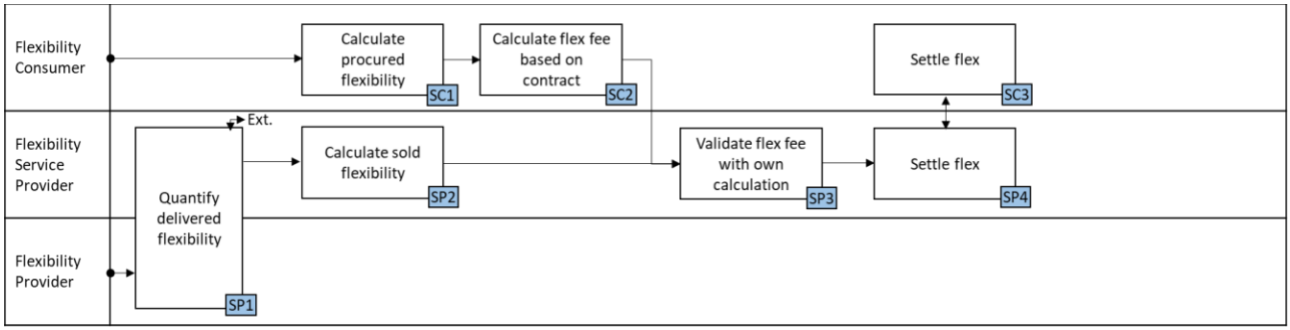


Figure 11. Business process diagram for the Settlement subprocess

3.2.8.2 Comparative analysis with projects implementing the settlement

This year, one intended to collect feedback on implementing the settlement to understand how the different projects are approaching it. One intended to understand if they are considering a similar sub-process to the one depicted in Figure 11.

For that purpose, 7 projects (PARITY, ACCEPT, OneNet -Northern Demo Cluster, X-Flex, Platone, BRIGHT and IANOS) share how they are implementing the settlement sub-process of the flexibility procurement. Based on their feedback, this section intends to provide a deep-dive analysis of the approaches followed by different projects implementing the settlement sub-process. Afterwards, it is provided with a brief explanation of each project concerning the settlement subprocess.

3.2.8.2.1 PARITY

In PARITY Local Energy Market / Local Flexibility Market, settlement is done automatically via the help of a software component (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 involved consumer or prosumer. According to this description, this project adopts the sequence diagram presented in Figure 11. Business process diagram for the Settlement subprocess.

For the delivery of aggregated flexibility to the Distribution System Operator or external markets (e.g. ancillary services market), the Aggregator Toolset, which is a software component that assumes the role of the Aggregator within the PARITY framework, acts as the aggregated flexibility provider and performs the settlement and remuneration. Then, it distributes the corresponding tokens of the energy/flexibility transaction to each participating prosumer.

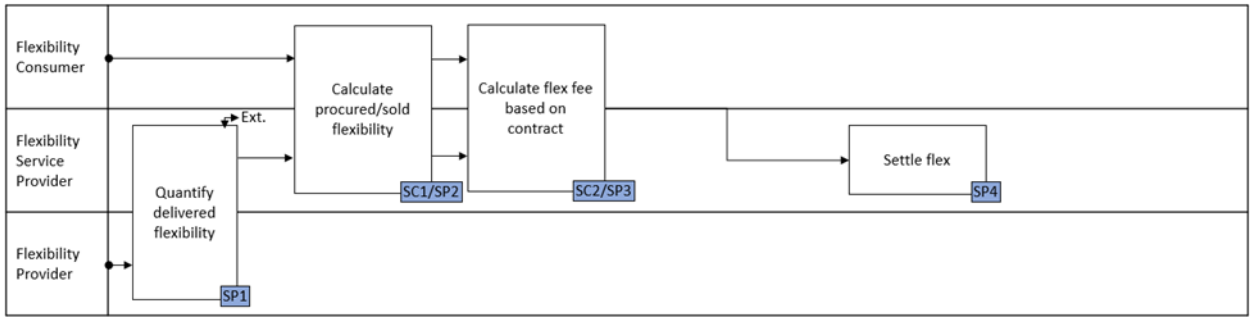


Figure 12. Business process diagram for the Settlement subprocess in the PARITY project

3.2.8.2.2 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 under which the prosumer/consumer is requested 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 Figure 11) 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 Provide, here the Retailer, with inputs from the DSO and the Wholesale Market, and the demand elasticity calculated by a relevant ACCEPT software component).

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 a software component 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 out of scope for 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 revenues to the participating members according to the agreed bilateral agreements.

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 Provide, here the Retailer, with inputs from the DSO and the Wholesale Market, and the demand elasticity calculated by a relevant ACCEPT software component).

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 a software component 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 out of scope for 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 revenues to the participating members according to the agreed

bilateral agreements. Therefore, the business process diagram adopted in the ACCEPT projects is adapted from Figure 11 and depicted in Figure 13.

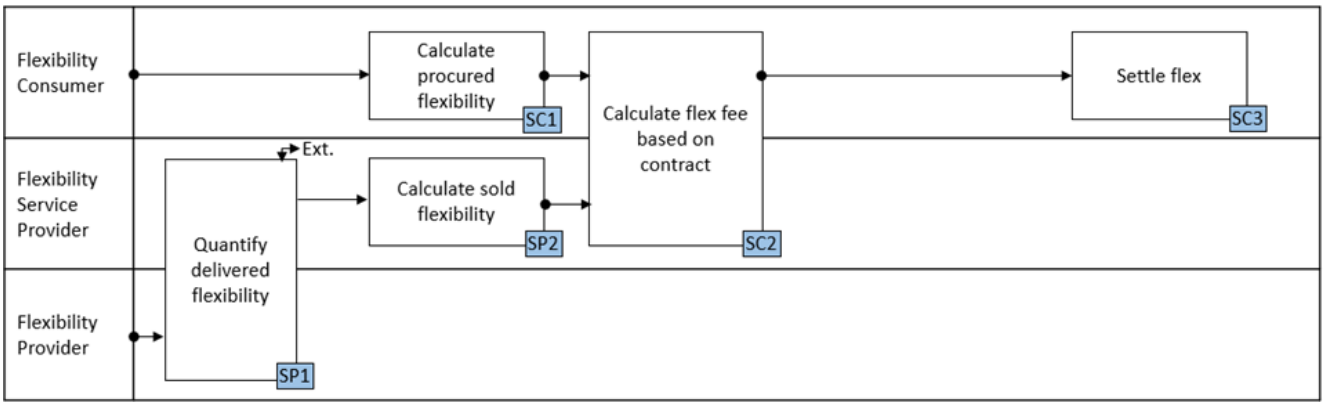


Figure 13. Business process diagram for the Settlement subprocess in the ACCEPT project.

3.2.8.2.3 X-FLEX

In XFLEX project, no BRP role and thus the market clearing is performed at the MO level. The overall settlement process is centralized 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) 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 utilization. Different scenarios are examined in XFLEX project considering the settlement parameters for both availability and utilization. The flex settlement approach applies also at the level of flexibility provider (consumer/flexibility asset owner) and flexibility service provider (Aggregator). In that case, the Aggregator is responsible for the settlement of flexibility offered. The approach is like 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 based onthe 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;

Considering the explanation described above for the X-Flex project, the sequence diagram for the settlement sub-process in the X-Flex project is represented in.

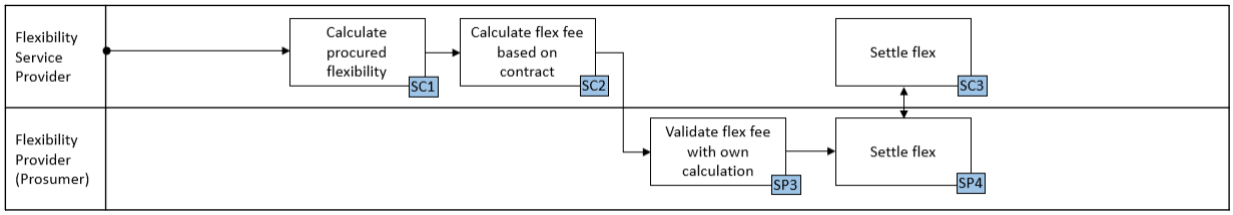


Figure 14 Business process diagram for the Settlement subprocess in the X-Flex project

3.2.8.2.4 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 to collect the flexibility requests and offers, match them and provide the market

results for the flexibility activation. The settlement process is divided into two phases: validation and remuneration. 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 can 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 to all the market participants (with specific access permission);
6) Aggregator, TSO, and DSO can visualise all the data via web User Interface (UI).

3.2.8.2.5 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 trades made on the market (for congestion management) and does first the verification process. 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 settlement process uses this information to conclude financial and imbalance settlement done partly outside of 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 optimization model for SOs is also implemented to procure flexibility together for congestion management. It is reported that in this case doing the financial settlement is not trivial.

3.2.8.2.6 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 define 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 will be 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 represent tokens transfer associated with energy flexibility delivery.

3.2.8.2.7 IANOS

In 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.

3.3 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.

3.3.1 Functions

3.3.1.1 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		✓					

Function	GBP1	GBP2	GBP3	GBP4	GBP5	GBP6	GBP7
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)				✓			

Function	GBP1	GBP2	GBP3	GBP4	GBP5	GBP6	GBP7
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	✓	✓	✓	✓	✓		✓

3.3.1.2 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	

S1 / Flexibility Request	
Outputs	Flexibility request
External required data	Flexibility pool, Grid Operational Status, Flexibility availability
Decomposition 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
Decomposition 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	
Decomposition 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	
Decomposition 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

S6 / Flexibility request	
	Location information
External required data	Grid network area status (emergency state)
Decomposition 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	
Decomposition into functions/subfunctions	

3.3.1.3 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
Decomposition 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	
Decomposition 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	
Decomposition into functions/subfunctions	

~~B4 / Process Settlement~~
Deprecated

3.3.1.4 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
Decomposition 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
Decomposition into functions/subfunctions	

3.3.1.5 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.

A1 / Flexibility Offer Aggregation	
Inputs	Flexibility offer of Flexibility Providers (incl. consumers, prosumers, electric vehicle charging point operators, etc.)
Outputs	Aggregated flexibility
External required data	
Decomposition 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	
Decomposition 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	

A3 / Flexibility Offer Disaggregation	
Decomposition 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	
Decomposition 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	

A6 / Process request and assess response	
Decomposition 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	
Decomposition 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	
Decomposition 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
Decomposition into functions/subfunctions	

A10 / Optimisation & Flexibility request	
Description	The Flexibility Service Provider receives (on 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)

A10 / Optimisation & Flexibility request	
Decomposition into functions/subfunctions	

3.3.1.6 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.
Decomposition 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 received schedule. It also informs about the corresponding flexibility transaction/agreement to enable the settlement.

P2 / Process schedule	
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
Decomposition 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
Decomposition into functions/subfunctions	1 Calculation of available flexibility per asset

P4 / Flexibility forecast (feasibility)	
	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
Decomposition 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	
Decomposition into functions/subfunctions	

P7 / Energy usage capturing	
Description	This function is realized at the prosumer household and covers the collection of energy usage data and any data related to energy usage. This can cover the summarized usage, but also the energy usage of individual appliances as well as other data collected by relevant sensors. There might also be a 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.)
Decomposition 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	
Decomposition 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 peer 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
Decomposition 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 peer of the energy community or from the contracted Retailer is identified.
Inputs	Forecast Data, Prosumer Preferences
Outputs	Bid
External required data	
Decomposition 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	

P11 / Process Trading Result	
Decomposition into functions/subfunctions	

3.3.1.7 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	
Decomposition into functions/subfunctions	

3.3.1.8 E functions

E1 / Data Aggregation & Processing	
Description	If needed to consider the prosumer (or many prosumers) 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 optimization.
Inputs	Energy usage and related data from the prosumers
Outputs	Aggregated and pre-processed data
External required data	
Decomposition into functions/subfunctions	

E2 / Optimisation & Control signal / feedback generation	
Description	The energy usage and related data are here processed, and optimisation processes are executed. This might involve also training of Digital Twins. The output of these is a summary that covers the improvement suggestions (feedback) or directly applicable steering signals that can beexecuted 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.
Decomposition into functions/subfunctions	

3.3.1.9 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 peer of the energy community or from the contracted Retailer is identified.
Inputs	Bids
Outputs	Traded Quantities/Prices
External required data	
Decomposition into functions/subfunctions	

3.3.1.10 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	
Decomposition into functions/subfunctions	

3.3.1.11 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
Decomposition 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, …)

SP2 / Calculate sold flexibility	
Outputs	Sold flexibility (contract reference, quantity, time period, …)
External required data	
Decomposition 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	
Decomposition 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	
Decomposition 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	
Decomposition 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	
Decomposition 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

SC3 / Settle flex	
Outputs	
External required data	
Decomposition into functions/subfunctions	

3.3.2 Arrows (information flows)

3.3.2.1 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			✓			
B1 → B2			✓			
B2 → M1			✓			
M1 ↔ S2			✓			
P7 → E1					✓	
E1 → E2					✓	
E2 → P8					✓	

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						✓
P10 ↔ Ext						✓
P11 ↔ Ext						✓
A10 ↔ Ext				✓		
SP1 → SP2	✓	✓	✓	✓	✓	✓
SP2 → SP3	✓	✓	✓	✓	✓	✓

P8 → B		✓
P9 → P10		✓
P10 → P2M1		✓
P2PM1 → P11		✓

SC1 → SC2	✓	✓	✓	✓	✓	✓
SC2 → SP3	✓	✓	✓	✓	✓	✓
SP3 → SP4	✓	✓	✓	✓	✓	✓
SP4 ↔ SC3	✓	✓	✓	✓	✓	✓
SP1 ↔ Ext	✓	✓	✓	✓	✓	✓

3.3.2.2 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/…
Involved roles	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 → A2	
A1 → A2	
Purpose	Inform about aggregated flexibility that can be offered to the market
Involved roles	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/…
Involved roles	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* are 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/…
Involved roles	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* are 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 → 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).
Involved roles	Flexibility Service Provider
List of exchanged data	Aggregated flexibility offers per zone

Option 2: no aggregation

P1 → A5	
P1 → A5	
Purpose	Inform Flexibility Service Provider about possible flexibility on Flexibility Provider side for the next hour/day/…
Involved roles	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
Involved roles	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
Involved roles	Flexibility Consumer Flexibility Facilitator
List of exchanged data	Flexibility request (what, when, where, how much, …)
B2 → M2	
Purpose	Place flexibility request
Involved roles	Flexibility Facilitator MO
List of exchanged data	Flexibility request (what, when, where, how much, …)

Option 2: direct

S1 → M2	
Purpose	Place flexibility request
Involved roles	Flexibility Consumer MO
List of exchanged data	Flexibility request (what, when, where, how much, …)

M2 → S3

Option 1: through Flexibility Facilitator

M2 → S3	

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

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

M2 → A8

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

Option 2: no aggregation

A8 → P2	
Purpose	Inform about flexibility activation to be scheduled
Involved roles	Flexibility Service Provider Flexibility Provider

A8 → P2	
List of exchanged data	Flexibility order (what, when, where, how much, …)

A3 → P2 (for GBP4)	
Purpose	Inform about flexibility activation to be scheduled (disaggregated)
Involved roles	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. Involved parties (Flexibility Consumer, Flexibility Service Provider) have to proceed with the bilateral agreement in fully compliance with the regulation dictates.
Involved roles	Flexibility Consumer Flexibility Service Provider
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 Re-consider offers until all the forecasted energy requirement is safely satisfied. Lead time; Time before the (recurring) flexibility option expires. Problematic point (node)

A5 → S5	
	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)
Involved roles	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
Involved roles	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

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

B2 → M1	
Purpose	Place flexibility request
Involved roles	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
Involved roles	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
Involved roles	MO Flexibility Consumer

M1 → B3	
List of exchanged data	Market results (what, when, where, how much, …)

M1 → A8	
Purpose	Inform about market results to Flexibility Service Provider
Involved roles	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.
Involved roles	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.
Involved roles	Flexibility Service Provider
List of exchanged data	Aggregated flexibility forecast

A10 → P5	
Purpose	Inform Flexibility Provider of a request for the provision of flexibility

Involved roles	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
Involved roles	Flexibility Provider Flexibility Service Provider
List of exchanged data	Prosumer flexibility offer

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

I1 → P6	
Purpose	Inform the prosumer about the energy price for the upcoming periods
Involved roles	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
Involved roles	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
Involved roles	
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.
Involved roles	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.)
Involved roles	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
Involved roles	ESCO
List of exchanged data	To be defined how these results are estimated

P8 → B	
Purpose	Process results from the prosumer
Involved roles	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.
Involved roles	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	Realise the available generation, as well as the total demand at community/local market level. Realise the needs of each prosumer within the community/local market (incl. energy needs and needs relating to comfort and convenience).

Involved roles	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
Involved roles	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
Involved roles	Flexibility Consumer
List of exchanged data	Flexibility transaction/agreement

P2 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Involved roles	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

Involved roles	Flexibility Consumer
List of exchanged data	Flexibility transaction/agreement

B3 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Involved roles	Flexibility Consumer
List of exchanged data	Flexibility transaction/agreement

A3 → SS	
Purpose	Inform about the past flexibility transaction/agreement to enable the settlement
Involved roles	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
Involved roles	Intermediary Stakeholder Flexibility Consumer
List of exchanged data	Price signals

P2PM1 → SS

Purpose	Trade settlement
Involved roles	P2P Market Operator
List of exchanged data	Traded Quantity/Price

3.3.2.3 External interfaces

S1 ↔ Ext	
Purpose	Exchange data for Flexibility Request
Involved roles	Flexibility Consumer, External
List of exchanged data	Flexibility pool, Grid Operational Status, Flexibility availability

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

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

M1 ↔ Ext

Purpose	Exchange data for Market Results Clearing (BRP)
Involved roles	MO, External
List of exchanged data	Flexibility pool

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

P1 ↔ Ext	
Purpose	Exchange data for Flexibility offer
Involved roles	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
Involved roles	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
Involved roles	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
Involved roles	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.
Involved roles	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.
Involved roles	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.
Involved roles	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
Involved roles	Flexibility Service Provider
List of exchanged data	Request for flexibility

3.3.2.4 Settlement subprocess interfaces

SP1 → SP2	
Purpose	Provide the characteristics (amount, time, …) of the provided/delivered flexibility to the Flexibility Service Provider
Involved roles	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, …)
Involved roles	Flexibility Service Provider

List of exchanged data	Sold flexibility (contract reference, quantity, time period, …)

SC1 → SC2	
Purpose	Inform about the procured flexibility
Involved roles	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
Involved roles	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
Involved roles	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
Involved roles	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
Involved roles	Flexibility Provider Flexibility Service Provider
List of exchanged data	Metering data

4 Conclusion and perspectives

4.1 Main findings and recommendations

This sections descriptions the main findings and recommendations regarding the Reference Framework.

Topic	Consistency with existing standards and on-going initiatives
Findings	Activities like the Reference Framework are performed in parallel to BRIDGE activities, in particular: • IEC has developed the IEC 62913 series defining several reference use-cases for 4 domains: Grid; Market; Resources connected to the grid; Electric transportation. Compared to BRIDGE Reference Framework, the described use-cases are less high-level and less generic. • The Smart Grid Task Force (SGTF) Expert Group 1 (EG1) is currently defining a set of Implementing Acts for the Electricity Directive EU 2019/944 Article 24. The IAs for "metering and consumption data" has been released in 2022. The IAs for "customer switching" and "demand response" are under development with a first draft in 2023 and a final release in early 2024. It must be noted that these two initiatives are more "top-down" while the BRIDGE Reference Framework is "bottom-up", i.e. based on what is effectively implemented in the BRIDGE projects.
Recommendation	1. While they cannot be directly compared, check the consistency between BRIDGE Reference Framework and IEC 62913 series. It may also help to identify new Generic Business Processes to be added to the BRIDGE Reference Framework. 2. Push the BRIDGE Reference Framework as an input to the on-going SGTF Implementing Acts on "demand response". 3. Check the consistency between the Implementing Act on "metering and consumption data" and the BRIDGE Reference Framework. BRIDGE Standards User Group can provide support to establish contact with IEC SyC Smart Energy and SGTF EG1, and implement these three recommendations.

Topic	Expectations and benefits from the Generic Business Processes
Findings	The reference framework for flexibility has been updated and extended based on the real use-cases and systems implemented by BRIDGE projects. It now describes seven Generic Business Processes (GBPs): • 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: Flexibility with the use of price signals • GBP6: Energy monitoring and energy management • GBP7: P2P trading in energy community

Topic	Expectations and benefits from the Generic Business Processes
	Each GBP defines both the functions and the interfaces of which it is composed. These GBPs are the common denominators between use-cases from different projects aiming the same business objectives. Their objective is to support interoperability and to harmonize use-cases descriptions between projects (e.g. via the BRIDGE use-case repository).
Recommendation	1. Keep improving the existing GBPs and developing new GBPs based on the use-cases implemented in the BRIDGE projects. 2. Analyse how the Reference Framework is already supporting BRIDGE projects for use-cases development and identify ways to increase its impact and associated benefits. 3. Consider using this Reference Framework as templates or library for BRIDGE use-case repository, e.g. to harmonize use-cases definition

Topic	Further understanding of implementing the Settlement Sub-process
Findings	According to the projects that contributed this year, some variations may be introduced to the GBP for the settlement sub-process. These variations may rely on the type of use cases for flexibility services tested in each project. For example, when flexibility is tested from a P2P perspective, decentralized techniques (e.g., based on blockchain are preferably applied to perform the settlement. On the other hand, the settlement process can be performed following a centralized approach by a market platform (although smart contracts using blockchain can also be used in this case). Some variations of the GBP for the settlement subprocess are described in this report. However, the number of projects implementing the settlement subprocess is reduced, being needed to have more projects doing that to get a better characterization of the different ways to implement the settlement sub-process. The projects also report some barriers regarding the implementation of the settlement, namely determining the reference value for verification (schedule or baseline. In many cases, it is challenging, especially when the resources differ significantly (power plant, battery, electric vehicle, heat pump). It is also stated that the roles in conducting the settlement are unclear.
Recommendation	1. Identify a set of common barriers and challenges in implementing the settlement sub-process to support new projects to implement it by collecting the lessons learned from the finished and ongoing projects; 2. Identify the solutions already adopted in finished or ongoing projects to implement the settlement sub-process; 3. Review the GBP for the settlement sub-process based on the feedback provided by the projects and adjust it if needed; 4. Further research and discussion on the different roles and responsibilities for the settlement sub-process. For such, it should be considered different scenarios such as acquiring flexibility from DSOs and TSOs, flexibility

Topic	Further understanding of implementing the Settlement Sub-process
	trading under the P2P environment, trading and provision of flexibility in the framework of energy communities, and cross-sector flexibility.

4.2 Perspective and next steps

The activities of the Action #3 should be continued in 2023 and beyond.

Based on the recommendations, several actions have been identified:

1. Cooperate with similar initiatives, in particular SGTF EG1 Implementing acts and IEC 62913 series, to check consistency and feed future developments;
2. Investigate expected / potential benefits of BRIDGE GBPs for projects and identify ways of improvement.
3. As a continuation, develop new GBPs or enhance the existing GBPs;
4. Explore potential contribution to the use-case repository, e.g. by providing references (template / libraries);
5. Develop a guideline about settlement implementation.

A detailed plan will be defined to achieve most of these actions by the BRIDGE General Assembly of 2024.

5 Annex 1: Consultation of BRIDGE Action #3 on Reference Framework extension

A consultation of BRIDGE projects has been performed between January 9th and 20th 2023, to collect use-cases of interest to be analysed via the Reference Framework.

This annex details the content of the questionnaire and the received answers.

Based on the outcome of the questionnaire it was decided to focus the extension of the GBP's analysis to e-mobility, P2P trading and energy monitoring/management.

Questionnaire

PLEASE INDICATE FOR WHICH OF THE FOLLOWING AREAS OF INTEREST, YOU HAVE MODELED USE CASES IN YOUR PROJECT (INDICATE THE NUMBER OF USE CASES IN COLUMN B):

E-MOBILITY	
POWER2HEAT	
WATERSECTOR	
SMART BUILDINGS	
ENERGY ACCESS (IMPROVING QUALITY OF SUPPLY)	
ENERGY MONITORING/MANAGEMENT OF HOUSEHOLDS	
P2P TRADING	

ARE THERE ANY OTHER AREAS OF INTEREST THAT COULD BE CONSIDERED FOR THE EXTENSION OF THE REFERENCE FRAMEWORK?

PLEASE ELABORATE...

USE CASE #	
NAME OF USE CASE	
AREA OF INTEREST	
OBJECTIVES	
SHORT DESCRIPTION	
SPECIFICITIES (IF ANY)	

TECHNICAL DETAILS

ACTOR NAME	
ACTOR TYPE	
ACTOR DESCRIPTION	

DIAGRAMS OF USE CASE

E.G. SEQUENCE DIAGRAM	

Summary of results

USE CASE SCOPE	#
E-MOBILITY	**4**
POWER2HEAT	1
WATERSECTOR	1
SMART BUILDINGS	1
ENERGY ACCESS (IMPROVING QUALITY OF SUPPLY)	1
ENERGY MONITORING/MANAGEMENT OF HOUSEHOLDS	**2**
P2P TRADING	**4**
TOTAL	**14**

6 Annex 2: Contribution of BRIDGE Action #3 contributors on settlement

A consultation of BRIDGE projects has been performed between January 1st and January 15th, 2023, to collect information on settlement implementation.

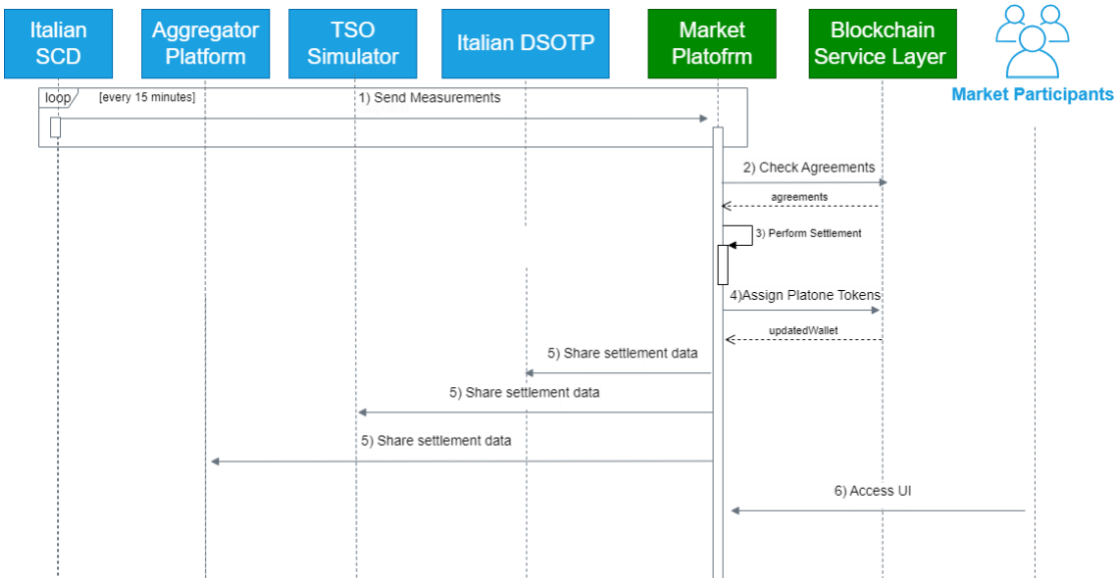


Figure 15 Business process diagram for the Settlement subprocess in the Platone project (Italian use case)

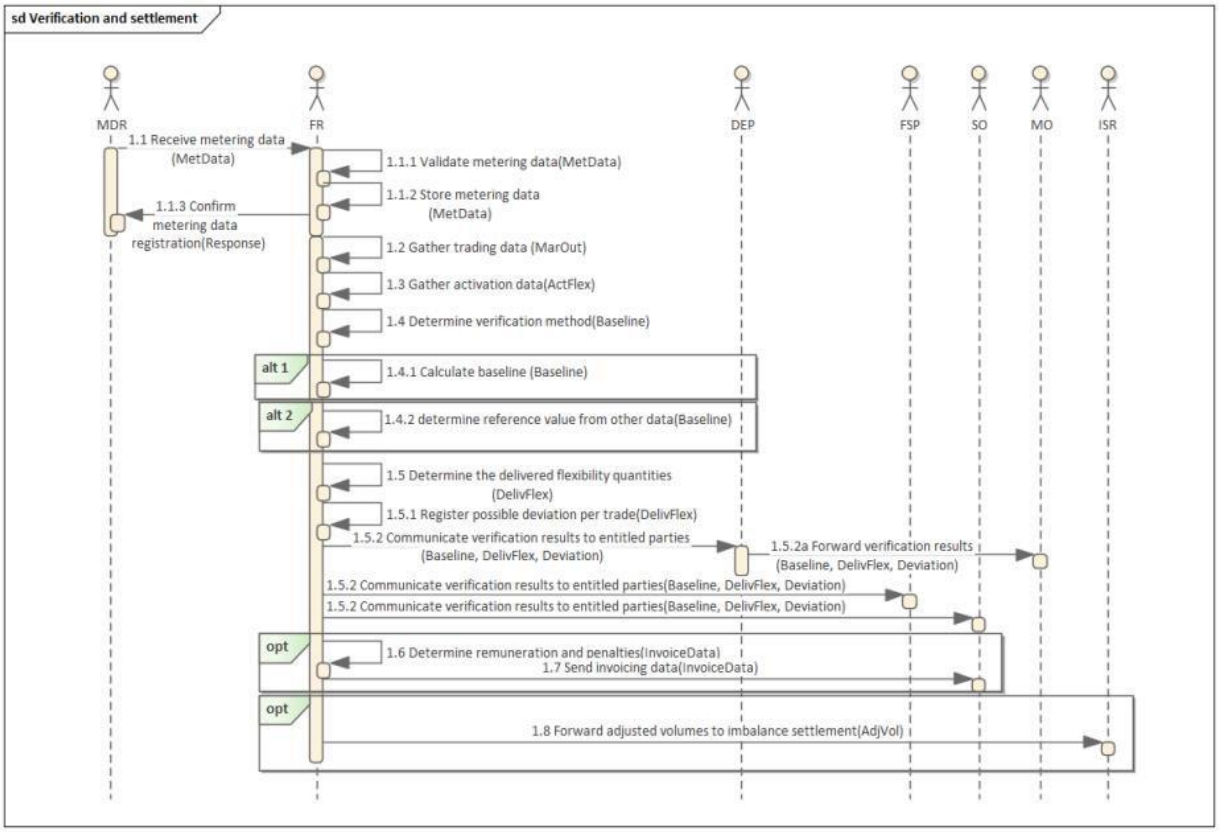


Figure 16 Business process diagram for the Settlement subprocess in the OneNet project (Northern demo cluster)

List of Acronyms and Abbreviations

BPMN	Business Process Model and Notation
BRP	Balance Responsible Party
DER	Distributed Energy Resources
DSO	Distribution System Operator
EMS	Energy Management System
EV	Electrical Vehicle
FO	Flexibility Offer
FSP	Flexibility Service Provider
GBP	Generic Business Process
HEMRM	Harmonized Electricity Market Role Model [5]
IEC	International Electrotechnical Commission
LEC	Local Energy Community
MO	Market Operator
P2P	Peer-to-peer
SGAM	Smart Grid Architecture Model
SO	System Operator (i.e. TSO or DSO)
TSO	Transmission System Operator
UC	Use-Case
WG	Working Group

List of references

[1] BRIDGE, «BRIDGE General Assembly February 2020 – Conclusions & Next Steps» [En ligne]. Available: https://www.h2020-bridge.eu/wp-content/uploads/2020/03/BRIDGE-GA2020_Conclusions-and-next-steps.pdf.

[2] BRIDGE, «BRIDGE – Interoperability of flexibility assets – April 2021» [En ligne]. Available: https://ec.europa.eu/energy/sites/default/files/documents/bridge_wg_data_management_interoperability_of_flexibility_assets_report_2020-2021.pdf.

[3] BRIDGE, «Interoperability of flexibility assets - Version 2.0» 2022. [En ligne]. Available: https://op.europa.eu/en/publication-detail/-/publication/a00be176-ac1f-11ed-b508-01aa75ed71a1/language-en.

[4] BRIDGE, «BRIDGE General Assembly March 2022 – Conclusions & Next Steps» [En ligne]. Available: https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu/sites/default/files/download/BRIDGE%202022%20GA%20-%20Conclusions.pdf.

[5] ebIX, EFET, ENTSO-E, «Harmonised Electricity Market Role Model» [En ligne]. Available: https://www.ebix.org/artikel/role_model.

[6] IEC, «IEC TR 63097:2017 Smart grid standardization roadmap» [En ligne]. Available: webstore.iec.ch/publication/27785.

List of figures

List of Tables

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centers. You can find the address of the center nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

– at the following standard number: +32 22999696, or

– by email via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from: https://op.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information center (see https://europa.eu/european-union/contact_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

Open data from the EU

The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

MJ-04-23-846-EN-N

Publications Office
of the European Union

ISBN 978-92-68-07474-9