GDBN, a Customer-centric Digital Platform to Support the Value Chain of Flexibility Provision

Fábio Coelho[1,2], Luís Rodrigues[1], João Mello[1,3], José Villar[1], Ricardo Bessa[1]
[1] INESC TEC - Institute for Systems and Computer Engineering, Technology and Science
[2] Universidade do Minho
[3] Faculdade de Engenharia da Universidade do Porto
Portugal
fabio.a.coelho@inesctec.pt

***Abstract*— This paper proposes an original framework for a flexibility-centric value chain and describes the pre-specification of the Grid Data and Business Network (GDBN), a digital platform to provide support to the flexibility value chain activities. First, it outlines the structure of the value chain with the most important tasks and actors in each activity. Next, it describes the GDBN concept, including stakeholders' engagement and conceptual architecture. It presents the main GDBN services to support the flexibility value chain, including, matching consumers and assets and service providers, assets installation and operationalization to provide flexibility, services for energy communities and services, for consumers, aggregators, and distribution systems operators, to participate in flexibility markets. At last, it details the workflow and life cycle management of this platform and discusses candidate business models that could support its implementation in real-life scenarios.**

***Index Terms*— digital platforms, distributed energy resources, distribution grids, flexibility, interoperability**

I. Introduction

The European Union (EU) is urging member states to formulate regulatory frameworks that allow and incentivize distribution system operators (DSOs) to procure flexibility to operate and develop their grids. In addition, whenever possible, flexibility shall be procured through a transparent, non-discriminatory, and market-based procedure [1].

The deployment of flexibility, particularly demand-side flexibility, requires digital infrastructures capable of ensuring a secure and reliable data access and exchange between parties [2]. Thus, over the last few years, multiple flexibility market platforms have been conceptualized and deployed to support DSOs in procuring and leveraging flexibility [3], [4], most of emerging in pilots or regulatory sandboxes.

More recently, in 2023, the EU DSO Entity and ENTSO-E set out a proposal for a Network Code on Demand Response which compels Member States to require System Operators (SOs) to publish information related to flexibility procurement on a single platform at national level [5].

This paper proposes a flexibility-centric value chain (FCVC), depicting the main stages needed for final consumers to become direct flexibility providers, catering to system operator's needs, and introduces the Grid Data and Business Network (GDBN), a multi-tenant cloud-based platform designed for that purpose. The GDBN aims to be a low-cost and low-complexity solution, supporting small and large DSOs in leveraging available flexibility capacity, and to engage final consumers to unlock their flexibility potential by creating additional value for them. The GDBN links the key actors of the FCVC, including consumers, service providers (SPs) and DSOs, supporting the main FCVC activities and creating new value streams. Moreover, it facilitates and promotes new activities such as pairing SPs with potential clients via interoperable protocols, enable various flexibility service providers (FSPs) to interact with different flexibility market platforms by providing interoperable interfaces to these platforms, enables flexibility activation and settlement of DSOs, and support new business models related to consumer data processing by properly marketing this data to software companies, unlocking value to consumers engaged in flexibility provision. These potential models were already identified in [6] as a preliminary step to build the FCVC.

The main contributions of this paper include:

- A comprehensive proposal for a FCVC designed to boost the flexibility from final consumers. This renders a complete description of the FCVC's stages, main activities, and primary and secondary actors involved. The FCVC reveals the mechanisms required to deploy and integrate consumer into the FCVC and emphasises the collaboration between stakeholders such as consumers, SPs, and DSOs.
- The pre-specification of the GDBN as an innovative, multi-stakeholder digital platform to support the proposed FCVC. This includes the conceptual architecture of the GDBN, its relationship with the FCVC, an assortment of supported services, key deployment and life cycle options, and business models (BMs) for its operation.

Section II describes the FCVC and its stages and activities, section III presents the GDBN, including stakeholders,

architecture and functionalities, section IV describes the main services implemented so far, section V focus in the GDBN deployment and BM, and section VI provides concluding remarks.

II. Flexibility-Centric Value Chain

The FCVC, introduced in [7], describes the stages and activities for the enrolment of new participants in the provision of flexibility. It eases the participation in flexibility markets, while ensuring that distributed energy resources (DERs) are easily accessible to all parties, thereby unlocking the potential flexibility of consumer-side assets.

The core value of the FCVC is in its ability to pair stakeholders and link them with profitable BMs. This can be supported by digital tools and platforms, such as the GDBN and the services it provides, to coordinate and exchange data between flexible assets, FSPs and SOs who join the FCVC. Moreover, the interoperability enablers in the GDBN link each FCVC stage, supporting the interoperable data exchange requirements and future proofing the concept. Finally, the FCVC presents a framework for all flexibility stakeholders to acquire flexible assets, find attractive BMs, and handle asset control and mobilisation. For consumers it provides a low-cost and simple solution. For businesses, it helps to find and match clients and partners, and to explore the intrinsic value of flexibility data within them, while promoting sustainable BMs to reduce shortage of flexibility in the power system due to unattractive value propositions. This FCVC is a result of the BMs and role model identified and described in [6], departing from [7] and [8].

The FCVC includes 6 primary stages: flexibility capacitation, integration/enablement, aggregation, negotiation preparation, market operation, and activation & settlement, as depicted in Fig. 1. For each stage, the primary and secondary activities and the main roles involved are identified. While the first two activities of the FCVC (acquiring new or retrofitting existing assets and enabling them to provide flexibility) are occasional activities, the remainder ones execute periodically, as depicted in Figure 1. Nonetheless, specific activities of the periodic stages may also run occasionally.

	Flexibility capacitation	Integration /Enablement	Aggregation	Negotiation preparation	Market operation	Activation & Settlement
Main activities (regular operation)	• Asset provision and installation or retrofit	• Assets OM • HEMS/EMS (cross-sector and local Aggregator constraints) • (Sub)Metering	• Aggregator/EC DP management • Bidding • Activation • Verification (baseline) • Settlement	• Flexibility needs • Flexibility zones • Bids preparation • TSO-DSO coordination	• Market DP operation • Bids selection	• TSO-DSO coordination • Activation • Monitoring • Verification (baseline) • Settlement • Billing
Main activities (done once)	• Registration • Contracting support • Financing	• Aggregator DP integration • Financing	• Market registration • Aggregator/EC DP algorithm development • Aggregator pre-qualification • Contracting support	• DSO pre-qualification • Market DP integration • Baseline computation	• Contracting support	
Secondary activities	• Energy services: sizing, efficiency, diagnostics, optimal aggregation, EC creation support, education • Maintenance and support services	• Links with cross-sector services • Maintenance and support services	• Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education	• Market analysis • Market simulation • Bidding strategies • Forecasting • Grid analysis	• Market analysis and reporting	• Statistics
Main roles	• Consumer • DER Provider • ICT Provider • Manufacturer • ESCo, SCo	• DER Manager • Consumer	• Resource Aggregator • EC manager	• Resource Aggregator • BRP • DSO • TSO	• Flexibility Market Operator	• Resource Aggregator • DER Manager • Meter Data Collector • DSO and TSO • Billing Agent

Figure 1. Flexibility FCVC stages, activities, and main roles

A. *Flexibility capacitation*

This activity identifies available and untapped consumers' side flexibility, and refers to the acquisition and/or retrofit of flexible assets under different BMs [6]. Electricity and cross-sector (such as heating and mobility assets) build part of the asset mix. It is at this stage that consumers onboard the FCVC, guiding them through the process of finding asset providers that can install and/or finance assets, to engage them in the flexibility business [10], [11]. Secondary activities include asset sizing, efficiency improvement, energy behaviour diagnostics, renewable energy communities (RECs) creation support, or education services to foster the adoption of sustainable energy consumption.

B. *Integration/Enablement*

This activity allows the integration of the flexible assets with digital platforms (i.e., an EMS or an FSP or aggregator operational platform, submetering and metering data processing) required to control and operate them for the

provision of flexibility. This stage also includes the integration with SPs offering energy and cross-sector services, such as energy service companies (ESCo) and service companies (SCo) as described in [6] that can provide additional value to the provision of flexibility, such as profiting from metering data to improve energy forecasts.

C. Aggregation

In this activity the aggregator operates its DP to respond to flexibility requests in the LFM where it operates. The aggregator manages its portfolio of consumers and assets registered in its DP to bid flexibility to the LFM, and activates it, in case its selected, controlling the corresponding assets. Aggregators also need to pre-qualify their consumers and assets to ensure they can offer the flexibility committed.

D. Negotiation Preparation

This activity determines flexibility needs by the flexibility procurers (such as DSOs) and identifies flexibility zones to allow aggregation, the computation of the aggregator portfolio baselines, and the preparation of flexibility bids to be submitted to the LFM. Integration of the aggregator or FSP with the LFM platform, and the pre-qualified by the DSO and the local market operator (LMO) to be allowed to participate in the LFM with the appropriate technical and financial guarantees, are occasional activities. Extra activities include, e.g., market analysis and simulation, energy, and grid forecasting (anticipating future scenarios), which, combined with strategic bidding, allow to optimize the flexibility bids.

E. Market Operation

This activity comprehends the LFM operation, usually through an LFM digital platform, to publish flexibility needs, collect bids, and support bid selection (or partial selection by elaborating a merit order list). They may also support the formalization of the flexibility contracts between FSPs and flexibility procurers.

F. Activation & Settlement

The last activity of the FCVC refers to the flexibility activation and settlement. It includes sub-activities, such as flexibility activation, usually not supported by the LFM platforms, but supported by the GDBN, verification of delivered flexibility, and settlement according to the pre-defined rules and contractual agreements. From the selected bids, SOs decide those that should be activated, and inform the corresponding FSPs, who can either directly control the aggregated assets, or forward these signals to DER managers [6]. The verification process determines the flexibility delivered according to the pre-agreed baselines and metering data. The settlement computes FSP's financial compensations for the flexibility delivered, and penalties for non-delivered flexibility. Aggregators pass these compensations to consumers in their portfolio. As a support activity, statistics of the LFM performance including the cost of the flexibility activated, or FSP reliability in providing committed flexibility are included.

III. GDBN Concept

The GDBN platform supports the main stages and enables secondary activities for stakeholders of the FCVC, facilitating the different processes and contractual agreements involved, as an engagement driver to unlock flexibility provision. The GDBN can integrate third parties' services and digital platforms, such as commercial LFM platforms already available, and provide services such as the flexibility activation, often not part of LFM platforms.

A. Stakeholders

The GDBN comprehends unique value propositions for the FCVC stakeholders. For instance, consumers aiming to reduce energy consumption and bills might choose to invest in flexible assets or use their pre-existing flexibility to profit from implicit or explicit flexibility schemes [9]. Thus, they can join the GDBN and search for SPs offering BMs suiting their needs.

SPs, including aggregators, can also join the GDBN to find consumers willing to contract their services, such as appliances retrofit or flexible assets installation, or to build a significant flexibility assets portfolio for participating in a LFM. The GDBN allows SPs to identify new clients in competition with other SPs already on board the platform. More importantly, the GDBN allows SPs to explore the flexibility potential of the regions in which they intend to operate and enables them to sound out the existence of available consumers and competing SPs in regions where they might be willing to expand.

DSOs also benefit from the GDBN, namely smaller or regional sized. Indeed, according to the new EU regulation, DSOs will need to integrate local flexibility in their grid operation and planning process, as well as to help TSOs to also profit from distributed flexibility. The GDBN integrates existing LFM platforms and provides additional support to those complementary activities, e.g., flexibility activation is usually missing from LFM platforms. The growing number of flexible consumers and SPs requires a direct way to command the activation of flexibility toward the operational platforms of the SPs or, when applicable, to consumers able to directly participate in the GDBN and LFM. The GDBN assists in this process by holding a catalogue (or pool) of flexible assets available in different regions. In addition, the GDBN can also assist small or regional DSOs in the process of procuring flexibility along the flexibility FCVC and provide them verification and settlement services in case they have limited resources to invest in their own tools. Note that SAP is one of the main partners of BeFlexible project [12], with the objectives of integrating their tools for assets management and billing processes into the GDBN.

B. Conceptual Architecture

The GDBN architecture is built from a series of modules that ensure the operation of the FCVC (Figure 2).

The **flexibility-centric services module** sets the service for the core stages of the value-chain to capacitate consumers to leverage their flexibility potential, to integrate, aggregate and take the flexibility offers to market and afterwards receive activation requests from DSO.

The **flexibility products module** if for installing a tiered service proposal for adopters of the GDBN solution, including the short-term scheduled and the short-term dispatched.

The **value-chain services module** includes basic services such as user accounting for all stakeholders, but also consent management over all flexibility related data exchanges, and

most importantly, the repositories of flexibility bids, activations, and the assets available in the flexibility zones where the GDBN actively provides services.

The **interoperability and data spaces module** accounts for the interoperable and standard data interfaces available for the inclusion of stakeholders' digital platforms and external market platforms considered in each stage. Besides standard interfaces as CIM for metering data communication, this module future proofs the GDBN, enabling it to collect and provide flexibility related data according to the data spaces initiative [13], [14], a collaborative reference architecture supporting components in an energy data space. The energy data space allows organisations to hold data sovereignty and motivates data exchanges from domain sensitive information.

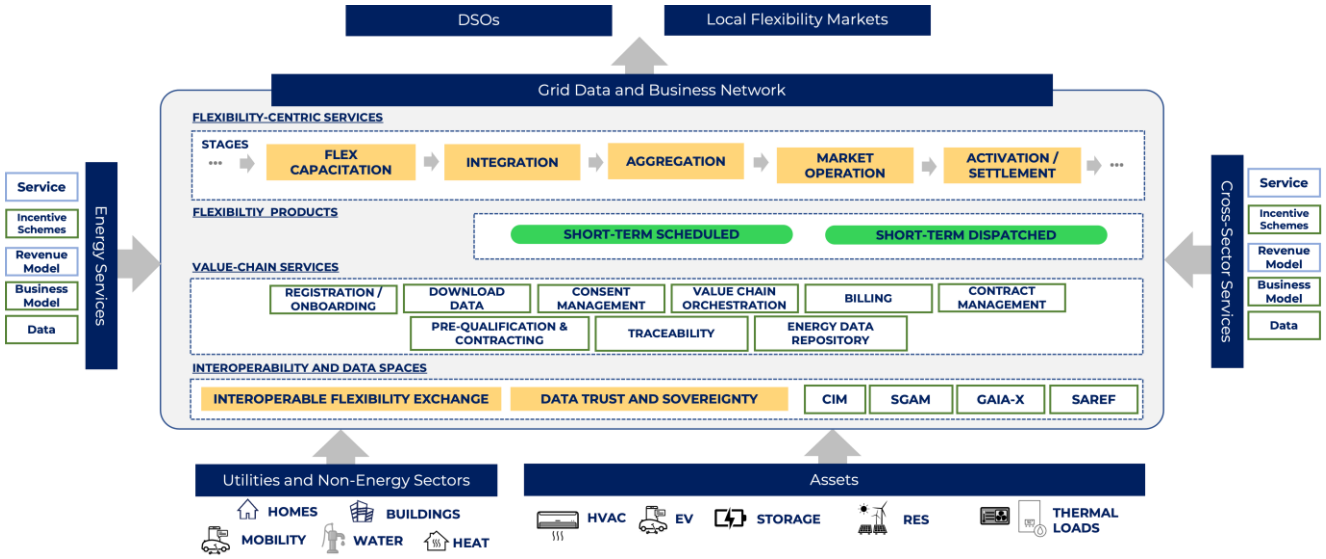

Figure 2. GDBN architecture

IV. GDBN SERVICES

The GDBN facilitates services that ease the participation of key stakeholders in the FCVC, including current services, but most importantly establishing an ecosystem to foster the conceptualization and validation of innovative flexibility-centric services.

A. Install flexible assets in candidate consumers through service subscriptions

This service assists SPs, including aggregators, in expanding their flexible assets portfolio. It supports SPs in providing flexible assets to consumers in return for their participation in the FCVC, offering them incentives like the absence of up-front investment costs. SPs can use the GDBN to announce when they are looking for new candidates, such as consumers, allowing them to set participation limits per enrolment campaign or maintain an open offer. This service resembles a marketplace where stakeholders forge Business-to-Clients (B2C) or (Business-to-Business) B2B relationships, involving SPs and consumers as primary actors. Regarding the conditions for deployment, SPs must have a BM with clearly defined incentives, and there must be consumers who do not own flexible assets or have them but want to increase their number. The FCVC stages are Flexibility Capacitation and Integration/Enablement.

B. Pair consumers with flexible assets and SPs exploiting flexibility BMs

This service matches SPs with consumers who own flexible assets to increase flexibility potential. It aligns consumers with SPs offerings based on location or specific objectives, enhancing service subscriptions, and maximizing available flexibility utilisation. SPs determine the frequency of matching cycles, with a daily match being the default setting. This ensures that SPs are not short on subscribers when engaging with the FCVC and facilitates asset monetization or service subscription for consumers. SPs and consumers are the primary stakeholders, and the only condition is to have registered consumers in the SPs' operational regions. The FCVC stages are Flexibility Capacitation and Integration/Enablement.

C. REC Planning and Sizing

This service supports the strategic planning and sizing of RECs under different BMs, considering various asset ownership scenarios, and assessing flexibility potential. Thus, this service introduces REC managers as primary actors, alongside with SPs and Consumers. The conditions for its implementation include the availability of registered consumers within the SPs' operational regions and consent for data usage, including historical metering data of the REC. The relevant FCVC stages are Flexibility Capacitation and Aggregation.

D. Operation and Management of RECs

This service operates and manages RECs able to provide explicit flexibility. Operation modes include a market-based approach, where decisions are decentralized to REC members as market participants, and a centralized approach aligning with market principles, where flexible asset schedules are computed with an optimization algorithm, and the collective benefits shared according to market-like principles based on a set of selected pricing mechanisms. The primary actors are SPs, REC manager, and Consumers, and the conditions that must be met

include registered consumers the availability of registered consumers within the SPs' operational regions, consent for data usage, including historical metering data of the REC, and flexible assets' data. The FCVC stages are Flexibility Capacitation and Aggregation.

E. Consumer Education

This service gears consumers to sustainable energy choices, guiding them towards informed decisions based on the available services on the GDBN. For instance, it can inform them about the possibility of using roof space to install PV panels, or that there are SPs in their area currently offering such services. The only primary actors are consumers, and the only conditions are to have consumers within the SPs' operational regions and consent for data usage. The relevant FCVC stage is flexibility Capacitation.

V. GDBN DEPLOYMENT AND BMS

A. Deployment and life cycle

The GDBN is designed as a cloud-based, multi-tenant application, using SAP's ecosystem. Its lifecycle is depicted in Figure 3 and has 2 main parts.

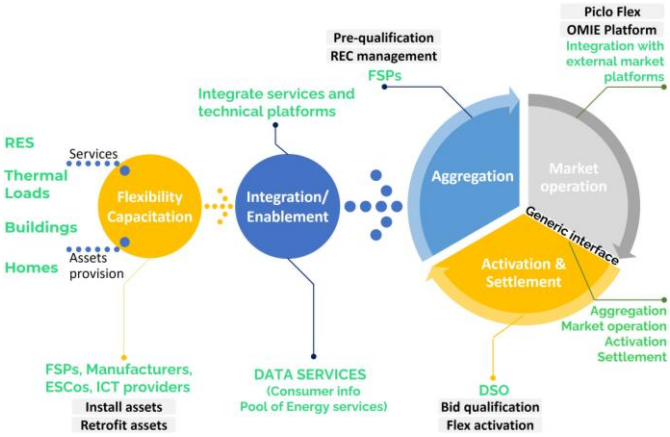

Figure 3. GDBN lifecycle

The first part is composed by the Flexibility Capacitation and the Integration/Enablement stages of the FCVC, while the second includes the Aggregation, Market Operation, and Activation & Settlement stages.

While the first part is a one-time onboarding process, the second part involves the operational dimension of the GDBN. This includes occasional or periodic pre-qualification, and periodic aggregation, flexibility needs estimation, bids preparation, bids selection, and flexibility activation, verification, and settlement. Stakeholders interact with the services available leveraging from the FCVC integration and orchestration and seamless data exchange. Each stage, benefits from standard, interoperable interfaces to link with external systems (e.g., market platforms or DSO IT systems), whose design extends results from other initiatives, namely: the representation of flexibility and flexibility zones from the EUniversal H2020 project UMEI API Specification [15]; or the data connectors for interoperable data exchange in the data spaces initiatives approach and OMIE interfaces developed in the OneNet project [16].

B. Candidate BM

A possible BM for the GDBN can involve a co-ownership agreement in a consortium of DSOs and a software provider.

As a multi-stakeholder platform, revenue streams targeting B2B interactions can be explored, through admission fees or an API and Development Ecosystem fee for SPs to gain access to the platform. Profits from data insights from anonymized flexibility data as the history of flexibility dispatch or participation are in scope, with value for aggregators. Also, in line is a flat-rate fee charged to SPs based on the number of customers discovered through the platform who subsequently subscribes their services. Finally, a franchise model to distribute the GDBN can be considered, addressing country-specific / local conditions and coping with the level of maturity of the market. In Europe, two types of markets are in scope: a) low maturity market: few actors or experiments are currently involved in the flexibility market, the amount of flexibility traded is relatively low, e.g., France, Spain or Italy b) medium maturity market: some actors, largely existing utilities, their spin-off and few "*flexible native*" actors, are involved and the amount of flexibility traded is average, e.g., UK, The Netherlands or Germany.

VI. CONCLUSION

This paper introduces the GDBN, a new digital platform designed to embody the FCVC in the provision of flexibility in modern energy systems, detailing its role in linking stakeholders, promoting data exchange to support the FCVC.

The GDBN aligns with European regulations which guide SOs to publish flexibility procurement information on a common platform at national level, a key factor given the increasing number of emerging flexibility market platforms.

A successful implementation of the GDBN platform represents a significant advancement in the digitalization of energy systems focusing on flexibility provision. Its customer-centric approach not only facilitates the engagement of varied market participants but also aligns with the changing regulatory setting and market shift towards the integration of more renewable energy sources.

Future developments should focus on expanding the platform's functionalities, exploring different BMs, and ensuring its adoption by stakeholders e.g., DSOs of different sizes and regions.

ACKNOWLEDGMENTS

The research leading to this work is being carried out as a part of the BeFlexible project (European Union's Horizon 2020, No. 101075438). The sole responsibility of this publication lies with the author. The European Union is not responsible for any use that may be made of the information contained therein.

REFERENCES

[1] European Union, *Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast)*, vol. 158. 2019. Accessed: Jan. 02, 2024.

[Online]. Available: https://eur-lex.europa.eu/eli/dir/2019/944/oj/eng
[2] S. Chondrogiannis, J. Vasiljevska, A. Marinopoulos, I. Papaioannou, and G. Flego, 'Local electricity flexibility markets in Europe', *JRC Publications Repository*, Oct. 2022, doi: 10.2760/9977.
[3] O. Valarezo *et al.*, 'Analysis of New Flexibility Market Models in Europe', *Energies*, vol. 14, no. 12, Art. no. 12, Jan. 2021, doi: 10.3390/en14123521.
[4] ENTSO-E, 'Review of Flexibility Platforms'. 2021. Accessed: Apr. 11, 2023. [Online]. Available: https://eepublicdownloads.azureedge.net/clean-documents/SOC%20documents/SOC%20Reports/210957_entso-e_report_neutral_design_flexibility_platforms_04.pdf
[5] EU DSO Entity and ENTSO-E, 'EUDSO Entity and ENTSO-E DRAFT Proposal for a Network Code on Demand Response'. Accessed: Dec. 12, 2023. [Online]. Available: https://consultations.entsoe.eu/markets/public-consultation-networkcode-demand-response/supporting_documents/Network%20Code%20Demand%20Response%20v1%20draft%20proposal.pdf
[6] L. Rodrigues *et al.*, 'Analysis of Flexibility-centric Energy and Cross-sector Business Models', in *2023 19th International Conference on the European Energy Market (EEM)*, Jun. 2023, pp. 1–6. doi: 10.1109/EEM58374.2023.10161816.
[7] BeFlexible, 'D1.2: Framework for a Flexibility-Centric Energy and Cross-sector Value Chain, Business Use Cases and KPI Definition'. [Online]. Available: https://beflexible.eu/wp-content/uploads/2024/04/BeFlexible-D1.2-Framework-for-Flexibility-Centric-Energy.pdf
[8] Cleantech Group, 'Cleantech Research Agenda Update – Q1 2021'. Accessed: Jan. 04, 2024. [Online]. Available: https://www.cleantech.com/cleantech-research-agenda-update-q1-2021/
[9] USEF, 'Flexibility Value Chain'. 2018. Accessed: Jan. 04, 2024. [Online]. Available: https://www.usef.energy/app/uploads/2018/11/USEF-White-paper-Flexibility-Value-Chain-2018-version-1.0_Oct18.pdf
[10] SmartEn, 'Scalable Innovative Financing for Smart Buildings'. 2018. [Online]. Available: https://www.smarten.eu/wp-content/uploads/2018/10/Smart-Financing_final_with-date-1.pdf
[11] e-SAFE, 'D6.2 Business Models and Financial Schemes: identification and development'. 2022. [Online]. Available: https://zenodo.org/records/6497154
[12] BeFlexible, 'BeFlexible project'. Accessed: Feb. 26, 2024. [Online]. Available: https://beflexible.eu/
[13] International Data Spaces Association, 'IDS RAM 4'. Mar. 15, 2024. Accessed: Mar. 20, 2024. [Online]. Available: https://github.com/International-Data-Spaces-Association/IDS-RAM_4_0
[14] A. Dognini *et al.*, 'Blueprint of the Common European Energy Data Space'. Interoperability Network for the Energy Transition (int:net), Munich, Germany, Mar. 2024. doi: 10.5281/zenodo.10789975.
[15] EUniversal, 'UMEI OpenAPI Specification'. Accessed: Feb. 22, 2024. [Online]. Available: https://euniversal.github.io/umei-api-specification/swagger-ui.html
[16] OneNet, 'OneNet project'. Accessed: Feb. 20, 2024. [Online]. Available: https://onenet-project.eu/