IDTA 02076 Energy Flexibility Data Model

Version 1.0

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SPECIFICATION

Submodel Template of the Asset Administration Shell

Imprint

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1 General

1.1 About this document

This document is a part of a specification series. Each part specifies the contents of a Submodel template for the Asset Administration Shell (AAS). The AAS is described in [1], [2], [3] and [6]. First exemplary Submodel contents were described in [4], while the actual format of this document was derived by the "Administration Shell in Practice" [5]. The format aims to be very concise, giving only minimal necessary information for applying a Submodel template, while leaving deeper descriptions and specification of concepts, structures and mapping to the respective documents [1] to [6].

The target group of the specification are developers and editors of technical documentation and manufacturer information, which are describing assets in smart manufacturing by means of the Asset Administration Shell (AAS) and therefore need to create a Submodel instance with a hierarchy of SubmodelElements. This document especially details on the question, which SubmodelElements with which semantic identification shall be used for this purpose.

1.2 Scope of the Submodel

Energy flexibility is the ability of a system, particularly in industrial settings, to adjust its electricity consumption in response to external signals, such as price fluctuations or grid stability requirements. This adaptability allows production systems to align their energy usage with market conditions, contributing to both grid stability and operational efficiency.

In this context, the Submodel Energy Flexibility Data Model (EFDM) serves as a standardized information model in the form of AAS. EFDM is designed to enable automated and streamlined communication between various entities, including production systems, energy market participants, and service providers. By providing a unified framework for describing energy flexibility, the EFDM facilitates efficient data exchange, reduces the need for customized integrations, and minimizes translation errors. This standardization ultimately supports a more resilient, flexible, and economically optimized energy system.

Energy flexibility is modeled within EFDM in terms of flexibility potential and specific flexibility measures. However, Instead of constructing a complete digital twin, the EFDM prioritizes key properties necessary to describe energy flexibility effectively, minimizing data complexity and protecting sensitive operational data. The EFDM has been implemented in JSON format, which is publicly accessible through the provided link [9]. Additionally, a web application for creating EFDM JSON instances is available at the link [10]. This document describes its AAS implementation.

1.3 Relevant standards for the Submodel template

List of relevant standards

- VDI-Richtlinie 5207 Blatt 1, 2020-07: VDI-Richtlinie 5207 Blatt 1, Energieflexible Fabrik - Grundlagen. [7]
- RECOMMENDATION No 01/2025 OF THE EUROPEAN UNION AGENCY FOR THE COOPERATION OF ENERGY REGULATORS of 7 March 2025 [8]

In addition to the relevant standards, the current AAS implementation of EFDM (SMT EFDM v1.0) is based on the original EFDM v1.1, which is implemented as a JSON schema [9].

1.4 Use cases

EFDM can be utilized within a factory to support internal optimization, such as reducing energy costs and production processes. Furthermore, energy flexibility can be monetized by participating in external electricity markets. The following sections detail two typical use cases of EFDM: optimized production scheduling and electricity trading.

To realize these use cases, the EFDM serves as a semantic interoperability layer. In a real-world factory environment, flexibility data originates from heterogeneous sources ranging from rigid ERP and MES systems (e.g., production plans, shift schedules) to physical assets (e.g., heat Pumps, batteries). Since the data structures, syntax, and cardinality of proprietary ERP/MES systems vary significantly between vendors, the EFDM does not attempt to mirror a specific legacy schema. Instead, it applies the EFDM approach [9] to provide a technology-agnostic standard. Therefore, the usage of EFDM implies an architecture where connectors are employed, as shown in Figure 1. These connectors map the specific syntax and logic of the source system (e.g., an SAP production order or a specific MES job list) into the standardized EFDM structure. This abstraction allows the energy optimization algorithms to function uniformly, regardless of whether the flexibility constraint comes from a complex production schedule or a simple hardware device.

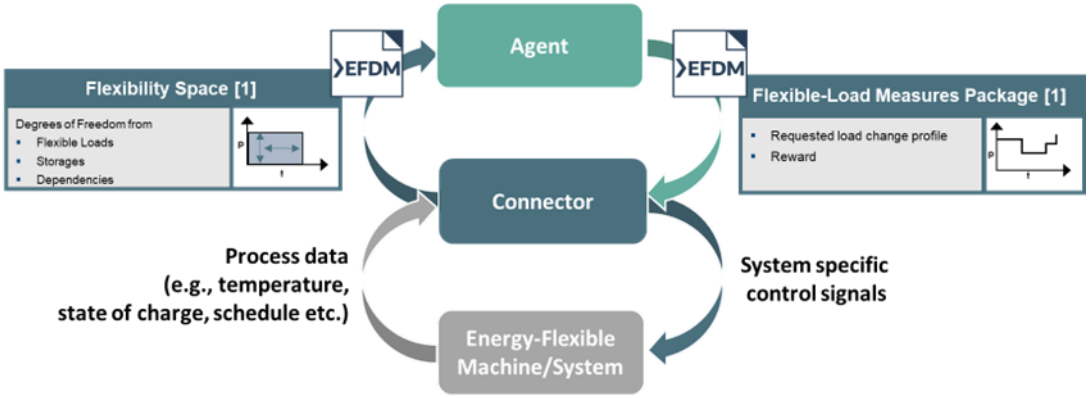

Figure 1 Exemplary system architecture for integrating external data into the EFDM using Connectors.

1.4.1 UC: Scheduling Problem for Optimal Energy Cost in a Manufacturing Process

This use case focuses on optimizing the scheduling of a manufacturing process to reduce electricity costs by aligning machine operations with periods of favorable electricity prices. Figure 2 shows an exemplary scheduling task. This scenario involves a manufacturing setup where parts need to be machined sequentially using two machines: a machine tool (MT) and a cleaning machine (CM). The process requires an initial grinding operation on MT, followed by a cleaning process on CM. To ensure flexibility and optimal energy costs, the system must schedule these tasks within a designated time frame, from the earliest start time of 7:00 am to the latest end time of 12:00 pm.

- Objective: The primary objective is to determine optimal run times for the machines to minimize electricity costs while meeting production requirements.
- Requirements: The process relies on two main data points, i.e. the average power consumption and duration of each manufacturing step, and the availability of real-time, fluctuating electricity prices.
- Restrictions: 1. A fixed sequence must be followed: grinding on MT first, then cleaning on CM. 2. Both machines operate within a restricted time window from 7:00 am to 12:00 pm.

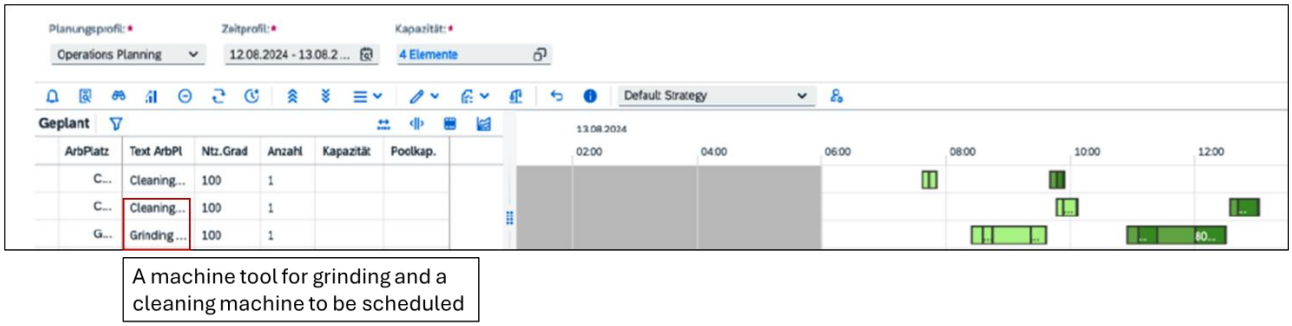

Figure 2 Dashboard of an ERP/MES System with exemplary manufacturing order

Figure 3 shows how the EFDM is used in this use case for achieving optimal energy costs. The EFDM is used to represent flexibility potentials and specific measures for each machine. Each machine's flexibility, including operational timing constraints and dependencies, is defined within the EFDM Flexibility Space. For example:

- *Machine Tool (MT)* and *Cleaning Machine (CM)* each have defined periods of validity (7:00 am - 12:00 pm) within the flexibility space.
- MT must complete its task before CM starts, as indicated by their dependency relationship.

The EFDM Service uses a scheduling algorithm that integrates data from the ERP/MES system (Enterprise Resource Planning / Manufacturing Execution System) and real-time electricity market prices:

- The scheduling algorithm identifies the most cost-effective times to run each machine, aligning operation schedules with periods of lower electricity prices.
- Reward structures are calculated for each machine based on energy savings achieved through optimal scheduling. For instance, MT might receive a reward for operating between 8:00 am and 9:00 am, while CM's reward is calculated for an optimal time slot from 9:00 am to 10:00 am.

By leveraging EFDM and the scheduling algorithm, the manufacturing process can adapt to energy price fluctuations, thus reducing operational costs while meeting production requirements.

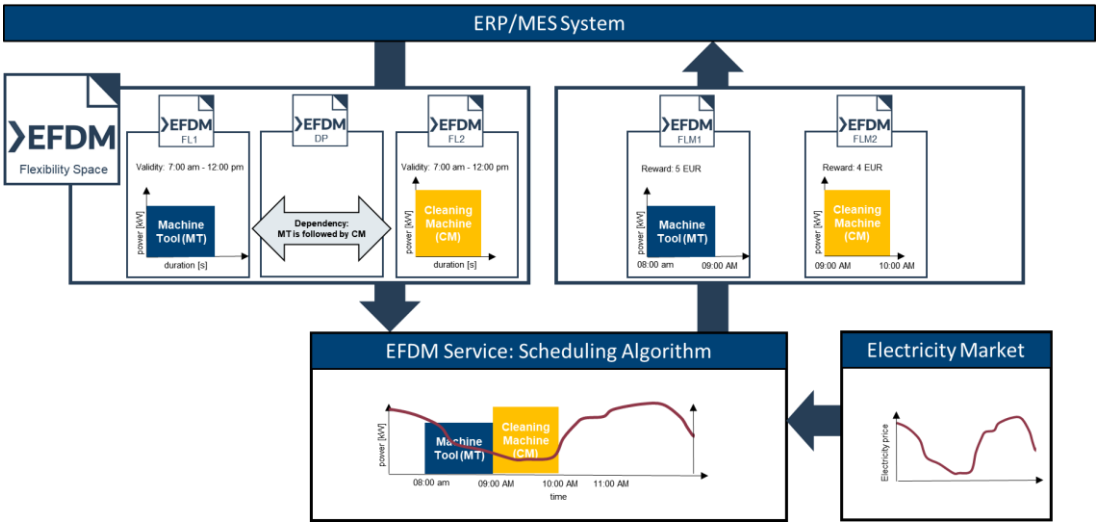

Figure 3 Using EFDM in the scheduling problem for optimal energy cost

1.4.2 UC: Trading energy flexibility on the electricity market

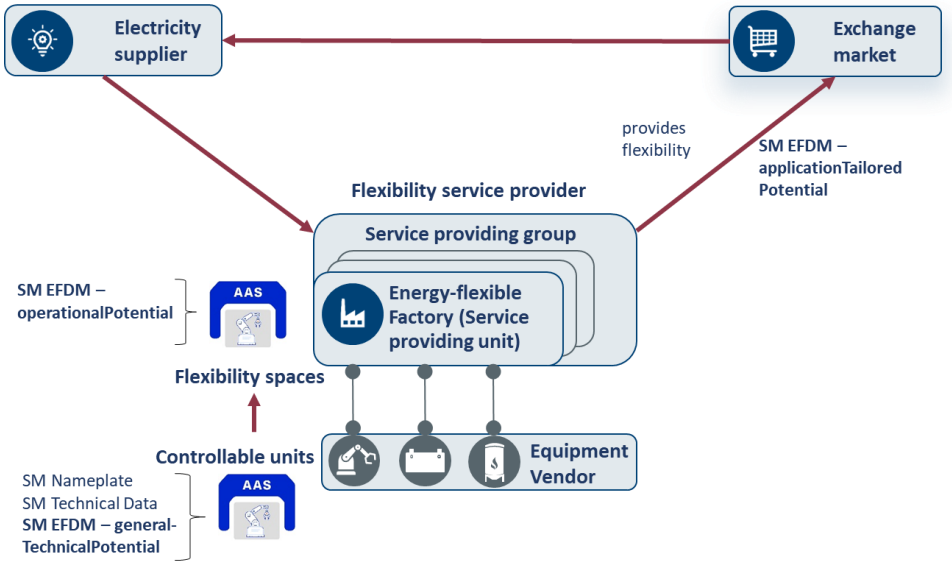

Figure 4 Interaction between different stakeholders in the electricity market for trading energy flexibility

Figure 4 illustrates the interaction between different stakeholders in an energy flexibility framework for trading electricity and energy flexibility on the electricity exchange market. This system enables optimized electricity usage and trading based on real-time market conditions and factory load flexibility.

In a conventional energy market without flexibility mechanisms, the Balancing Responsible Party, who maintains the balance between electricity supply and demand, coordinates electricity generation and provides electricity on the exhange market. Electricity suppliers, in turn, purchase energy from generators or through exchange markets and offer it to consumers, such as production factories, at competitive rates. In this setup, a production factory functions solely as a passive end-consumer, purchasing electricity to power its operations.

However, the integration of energy flexibility transforms this dynamic. A factory, which manages energy-adaptable production assets (as flexible loads in EFDM), can become an active participant in the electricity market. Annex 1 Amended Demand Response Network Code of Recommendation No. 01/2025 of the European Union Agency for the Cooperation of Energy Regulators [8] defines several terminologies and participants' roles.

- **Controllable unit**: a single power-generating module or demand unit, which has the flexibility potential and is modelled as a single **flexible space** in EFDM
- **Service providing unit**: a single controllable unit or an ensemble of controllable units connected to a single connection point. It commonly refers to the energy-flexible factory in Figure 4, which is connected to one electrical connection point
- **Service providing group**: an aggregation of controllable units or service providing units connected to more than one connection point within the same scheduling area.
- **Service provider**: a market participant with service providing units or service providing groups able to provide system operator services in a balancing or local market;

In addition, controllable units are provided by the **Equipment Vendor** (**EquipVendor**), who is not a direct participant in the electricity market. However, EquipVendor supplies technical specifications, operational constraints, and performance data in form of AAS for the physical assets (i.e. controllable units in the context of EFDM), from which the technical flexibility potential of equipment can be derived. The relevant properties are stored within a SubmodelElement Collection (SMC) *flexibilitySpace_generalTechnicalPotential* of SM EFDM, as shown in Figure 5. EFDM models the energy flexibility of a controllable unit mainly through SMC flexbilitySpace. The data that EquipVendor delivers in SMC *flexibilitySpace_generalTechnicalPotential* merely includes universally valid technical characteristics and restrictions of controllable units, regardless operational or use-case specific conditions and restrictions.

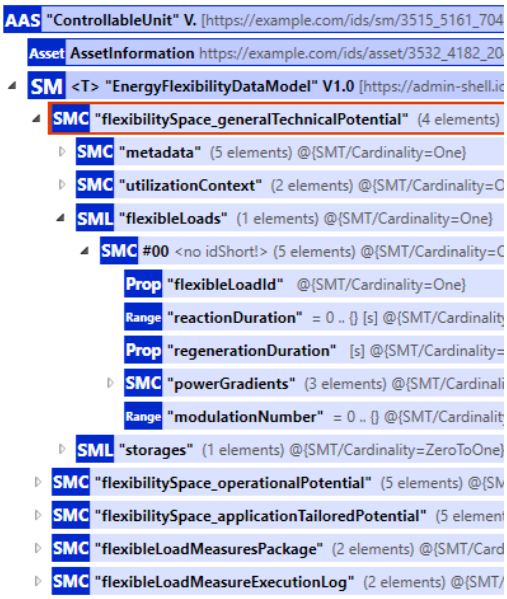

Figure 5 Example AAS of a controllable unit

Once a controllable unit is installed in the flexible factory and connected to the electricity network, it (or a set of aggregated controllable units at a single connection point) becomes a **service providing unit**. Multiple service providing units can, in turn, be aggregated into a **service providing group**. At this stage, the flexibility of the assets becomes **operationally usable**. From an information modelling perspective, this transition is represented by initiating a new EFDM SM instance with SMC *flexibilitySpace_operationalPotential*, where flexibility is fully considered within the context of the production environment and includes all necessary properties required to make use of the flexibility. This SMC describes the maximum feasible potential, and independent of the specific use case. The values of properties should be calculated based on those in SMC *flexibilitySpace_generalTechnicalPotential* delivered by EquipVendor.

Energy flexibility is achieved through individual controllable units within the factory, which are aggregated by a **service provider** and offered on the electricity market. At this moment, the SMC *applicationTailoredPotential* is used. Application-specific conditions and restrictions will be applied when calculating the values of flexibility properties. At the conclusion of the data process, the EFDM instance with SMC *applicationTailoredPotential* provides a standardized description of the flexibility, enabling its use in the marketplace for flexibility trading.

This mechanism enables the factory not only to optimize its internal energy costs but also to provide surplus flexibility as a service, which can contributes to grid stability and unlocks new revenue streams within the energy market. The energy flexibility offered by the service provider is encouraged to be described using the EFDM, which provides a standardized framework for representing the required information of each flexible load.

2 Submodel template

2.1 Modeling concept

Energy flexibility is the capability of a technical system (such as a production machine) to adjust its power consumption in response to an initiating event (T_0) within defined time periods, enabling participation in demand-side energy management. The initiating event T_0 can be triggered by various factors, such as:

- Price Signal from the Energy Market: A sudden drop or spike in electricity prices in real-time or day-ahead markets. For example, during periods of low energy prices caused by a surplus of renewable generation, a factory may ramp up energy-intensive processes to capitalize on cheaper electricity.
- Demand Response Request: A signal from a utility or grid operator requesting a reduction in energy consumption during peak load periods or grid constraints. This commonly occurs on hot summer days when electricity demand surges due to widespread air conditioning use.
- Grid Congestion Alert: A request from the transmission system operator (TSO) or distribution system operator (DSO) to decrease power consumption or shift loads to prevent grid overloading.
- Production Process Trigger: A planned production activity that requires synchronization with off-peak electricity availability to reduce costs. For instance, operating large industrial machines during low-demand hours can optimize energy expenses.

According to VDI 5207 Part 1, the energy adjustment is modeled as depicted in Figure 6. This diagram illustrates key time-related data in the form of distinct time periods that follow an initiating event T_0. The event T_0 triggers a change in the system's previous power consumption level, leading to a relative shift in electrical power usage. The duration of these time intervals varies and can sometimes be negligible. The defined time periods are as follows:

- Perception Time: The time from the occurrence of T_0 to its perception.
- Decision-Making Time: The period that elapses from the perception of T_0 to the decision for a flexibility measure.
- Planning Time: The required duration from the decision to implement a flexibility measure to the completion of all planning activities entailed in the process flow and production process.
- Rise Time: The period from the initiation of a load change to the point where the desired load change level is achieved.
- Request Time: The duration from when a fully developed load change begins until the deactivation of the flexibility measure starts.
- Deactivation Time: The time from the start of deactivation of a fully developed flexibility measure to the recovery of the initial level of power consumption. (If there is no need to return to the original level of power consumption, the deactivation time is 0 seconds.)
- Regeneration Time: The time needed to enable the repeat implementation of a flexibility measure after it has been deactivated.

The period before the rise time is collectively referred to as the reaction duration in EFDM. This duration specifies the time required by a technical system between the call-up of a flexibility measure and the initiation of the actual load change (which begins at the start of rise time in Figure 6). The curve representing load changes between rise time and deactivation time is described using a combination of SMC powerState and powerGradient parameters.

To achieve flexibility, flexibility measures should be applied. Different types and possible flexibility measures are described in VDI 5207, as shown in Figure 7. In EFDM, SMC flexibleLoadMeasure aims to represent a flexibility measure in terms of load change profiles without describing concrete physical systems.

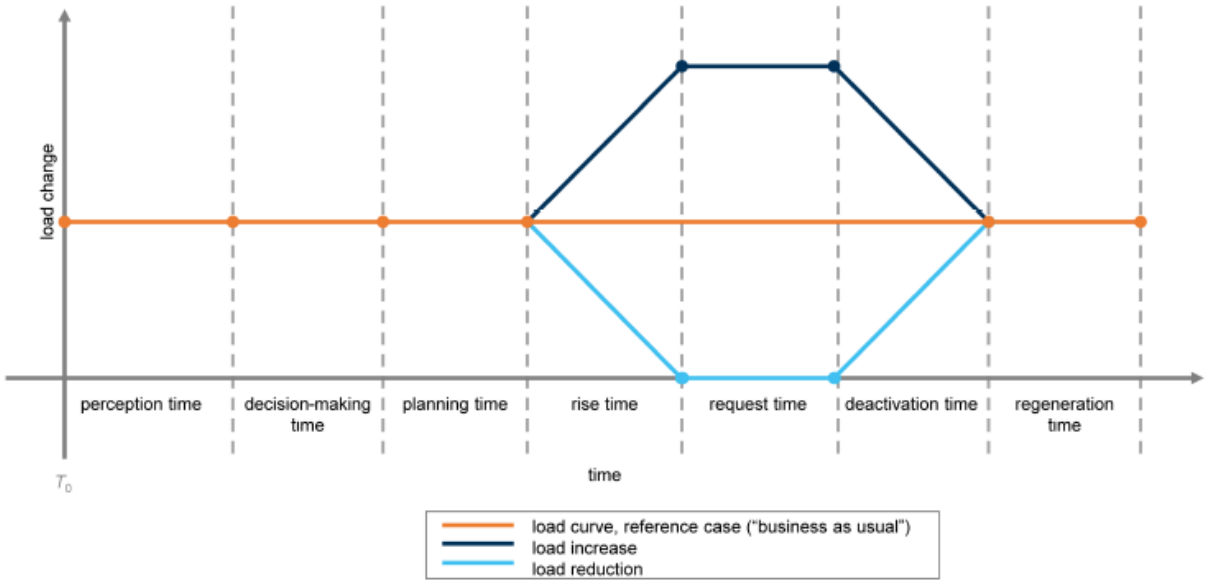

Figure 6 Key time-related data for describing energy flexibility [7]

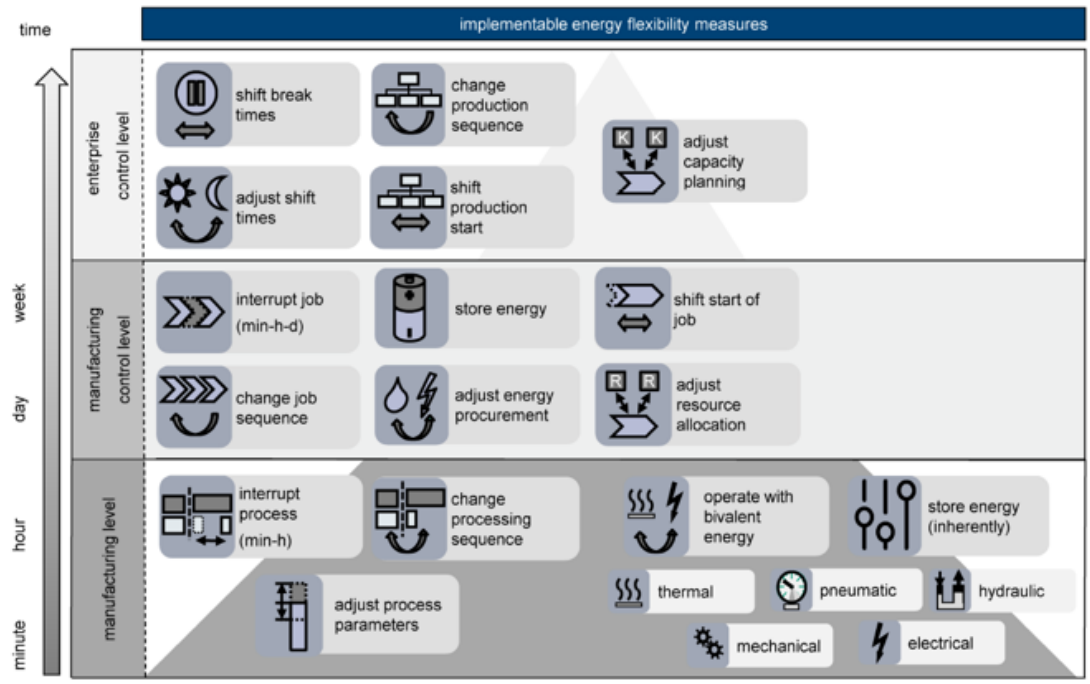

Figure 7 Exemplary flexibility measures described in VDI 5207 Part-1 [7]

In summary, energy flexibility in EFDM is represented as the adjustment curve of a system's power consumption in response to an initiating event within defined time periods. This adjustment is modeled as a flexible load, which can be linked to other flexible loads or energy storage devices. These interconnected elements form the SMC **Flexibility Space (FS)**. The associated metadata and the potential consequences of flexibility measures are captured separately in an SMC **Flexible-Load Measures Package (FLMP)**. To record the actual execution of a flexibility measure, EFDM introduces the SMC **Flexible-Load Measure Execution Log (FLMEL)** in addition. Together, these three components, i.e., FS, FLMP, and FLMEL, constitute the core structure of EFDM's flexibility modeling approach.

Depending on the modeling scope, the FS in EFDM is classified into three types, as shown in Figure 8. All three share a common property space, meaning they are described using the same set of flexibility properties.

- **flexibilitySpace_generalTechnicalPotential** (FS_TP) contains the minimum collection of properties expected to be provided by the EquipVendor. It models flexibility based solely on universally valid

technical characteristics and restrictions, without considering operational strategies, production plans, or application-specific constraints. This potential is not directly implementable.

- **flexibilitySpace_operationalPotential** (FS_OP) uses the same property set as FS_AP but describes flexibility in the context of the actual production environment, including all necessary information to make the flexibility usable. It reflects the maximum feasible potential, independent of a specific market or application. It is typically created by the factory operator or the flexibility service provider based on the values from FS_TP.
- **flexibilitySpace_applicationTailoredPotential** (FS_AP) uses the same property set as FS_OP but calculates the property values under conditions and restrictions of a specific application. For example, if an energy market only accepts Flexible Load with holding durations in 15-minute intervals, the potential and dependencies are transformed accordingly. It should be created by the flexibility service provider based on the values from FS_OP.

The key difference among these three types of FS lies in how the property values are determined based on the relevant operating conditions and constraints, rather than in the properties themselves.

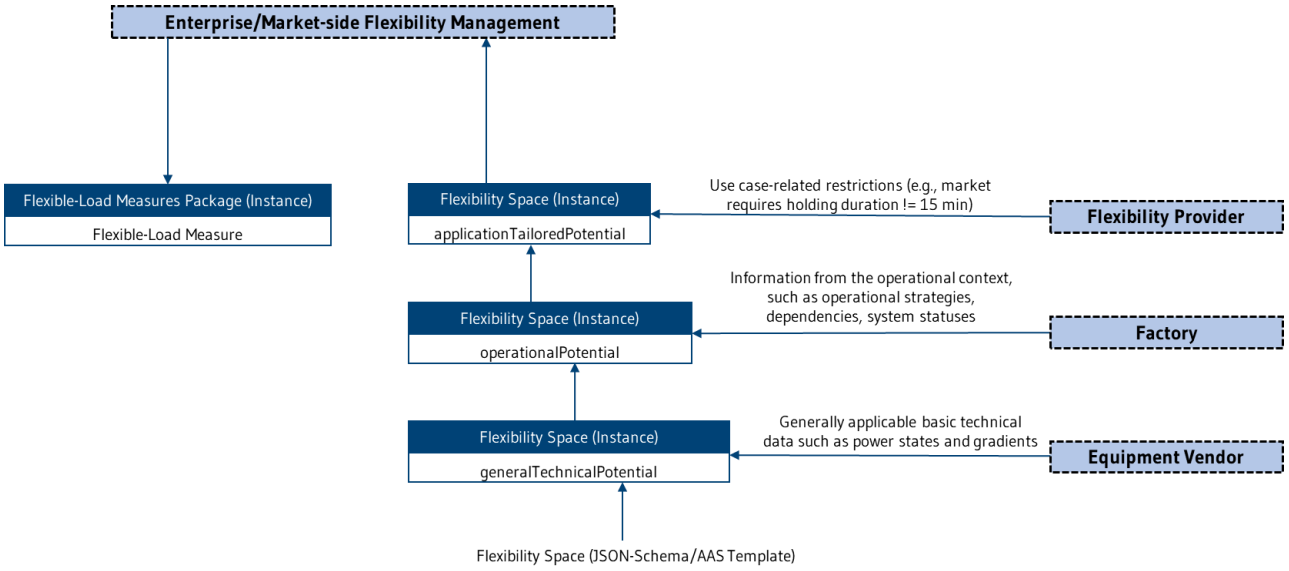

Figure 8 Different modeling scope leads to three types of flexibility spaces, namely “flexibility space_generaltechnicalpotential”, “flexibility space_operationalpotential”, and “flexibility space_applicationspecificpotential”.

2.2 Model architecture

In summary, Figure 9 depicts the overall model architecture of EFDM. The three types of FS are modelled by the individual SMC, respectively. One of them should be populated when initializing the EFDM instance. FS_TP is typically populated by the EquipVendor, providing the minimum technical property set for the system. FS_OP and FS_AP are typically created by the flexible factory operator or a service provider to describe flexibility in the context of specific operational or trading scenarios. Importantly, each of the SMC FLMP, FLMEL, FS_TP, FS_OP, and FS_AP may be created by different organizations. To document metadata about the created model instance, each of these SMCs contains its own SMC **metadata**, ensuring traceability of the source, creation context, and relevant descriptive information.
An *FS* describes the degrees of freedom of an energy-flexible system via the energy-relevant, subordinate classes of *Flexible Load*, *Dependency* (optional), and *Storage* (optional). The number of instances of these subordinate classes varies according to the complexity of the energy-flexible system.

- **Flexible Loads** models changes in power consumption.
- **Storages** models an energy storage unit.
- **Dependencies** captures restrictions and interdependencies between multiple flexible loads within a flexibility space.

These subordinate elements are collectively represented as SubmodelElement Lists (SML), where each SML entry is an SMC corresponding to a single Flexible Load, Storage, or Dependency instance.

Additionally, the FLMP in EFDM defines planned measures targeting a specific FS. The FLMP contains one or more *Flexible-Load Measures (*FLM*),* each describing an intended change in the performance of a designated *Flexible Load*. The actual execution states of these measures are recorded in the FLMEL. In other

words, FLMP represents the planned values, while FLMEL captures the actual values once the flexibility measures have been carried out. Similarly, FLM and FLMEL are modelled as SML, where each SML entry is an SMC corresponding to a single FLM or FLME.

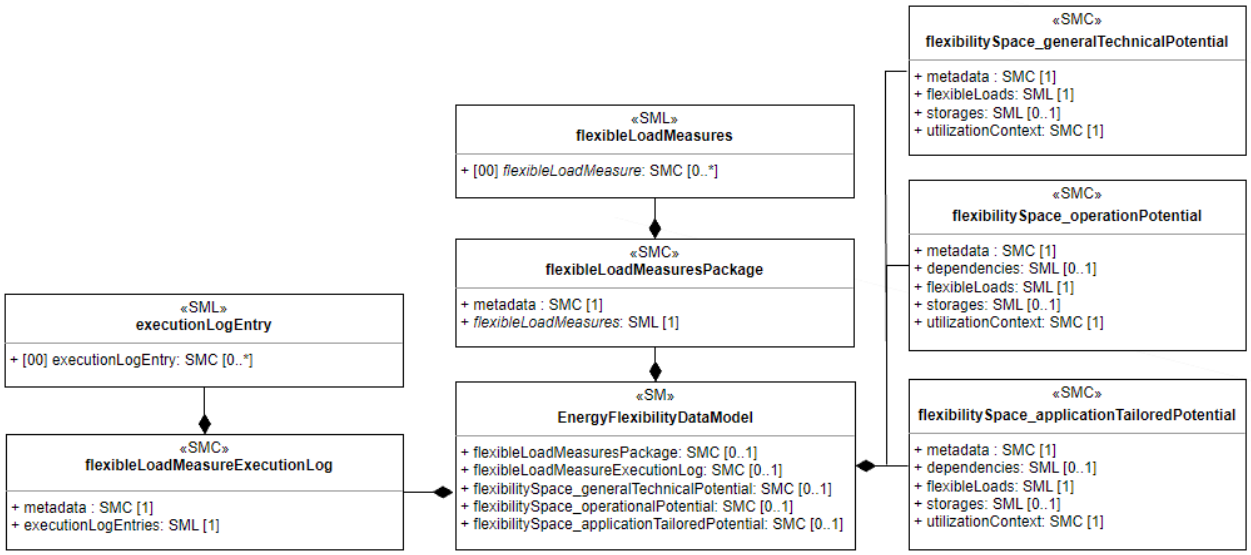

Figure 9 UML diagram of EFDM

2.3 SubmodelElement of the Submodel

In the following, the Submodel Elements (SMEs) defined within the EFDM are described in detail.

Table 1 SMC and SME of SM EFDM

idShort:	EnergyFlexibilityDataModel Note: a different idShort might be used for each SM instance, as long as it is unique.		
Class:	Submodel (SM)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/EnergyFlexibilityDataModel		
Parent:			
Explanation:	The Submodel Energy Flexibility Data Model (EFDM) provides a unified framework for describing energy flexibility.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] flexibilitySpace_operationalPotential	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibilitySpace_operationalPotential This SMC describes the degrees of freedom of an energy-flexible system within its actual operational environment. It includes all relevant conditions, resources, and constraints of the production context, enabling a realistic representation of the maximum feasible flexibility potential, regardless of a specific application. One of the three flexibilitySpace types should be populated.	n/a	0..1

[SMC] flexibilitySpace_applicationTailoredPotential	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibilitySpace_applicationTailoredPotential This SMC describes the degrees of freedom of an energy-flexible system tailored to the requirements and restrictions of a specific application or market. Property values are derived from the operational potential but adjusted to meet the defined application conditions, such as market rules, technical standards, or contractual obligations. One of the three flexibilitySpace types should be populated.	n/a	0..1
[SMC] flexibilitySpace_generalTechnicalPotential	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibilitySpace_generalTechnicalPotential This SMC describes the degrees of freedom of an energy-flexible system based solely on its general technical characteristics. It focuses on the inherent flexibility potential of the system, independent of any operational strategies, specific conditions, or application-related constraints. One of the three flexibilitySpace types should be populated.	n/a	0..1
[SMC] flexibleLoadMeasuresPackage	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasuresPackage The flexibleLoadMeasuresPackage contains one or more Flexible-Load Measures that describe a specific change in the performance of a dedicated Flexible Load	n/a	0..1
[SMC] flexibleLoadMeasureExecutionLog	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasureExecutionLog The flexibleLoadMeasureExecutionLog contains one or more Execution Log Entries that record an implemented flexible load measure.	n/a	0..1

2.4 SubmodelElement of flexibilitySpace

flexibilitySpace_operationalPotential and flexibilitySpace_applicationTailoredPotential share the same property set and are introduced below. flexibilitySpace_generalTechnicalPotential contains only a minimum collection of properties and will be introduced separately in Section 2.5.

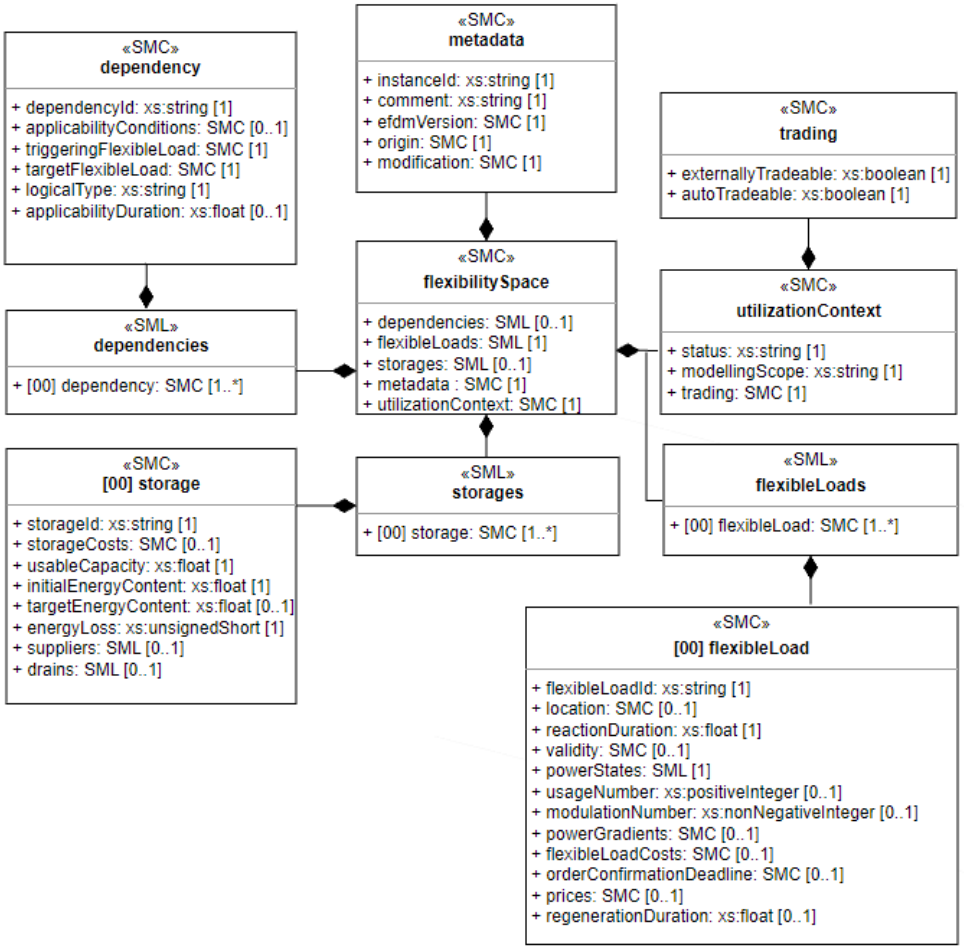

Figure 10 UML diagram of SMC flexibilitySpace

Table 2 SMC and SME of SMC flexibilitySpace_operationalPotential and SMC flexibilitySpace_applicationTailoredPotential. Both contain the same SMEs, but should be populated in different use cases.

idShort:	flexibilitySpace_operationalPotential / flexibilitySpace_applicationTailoredPotential		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibilitySpace_operationalPotential https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibilitySpace_applicationTailoredPotential		
Parent:	Submodel EnergyFlexibilityDataModel		
Explanation:	flexibilitySpace_operationalPotential/flexibilitySpace_applicationTailoredPotential describes the degrees of freedom of an energy-flexible system		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	

[SMC] metadata	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/metadata The metadata provides essential information for tracking and tracing the model instances.	n/a	1
[SMC] utilizationContext	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/utilizationContext Containing metainformation, describing the model status and scope	n/a	1
[SML] flexibleLoads	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoads flexibleLoads may contain multiple flexibleLoad.	n/a	1
[SML] storages	IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storages Storages may contain multiple storage.	n/a	0..1
[SML] dependencies	IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/dependencies dependencies may contain multiple dependencies.	n/a	0..1

2.4.1 SubmodelElement of metadata

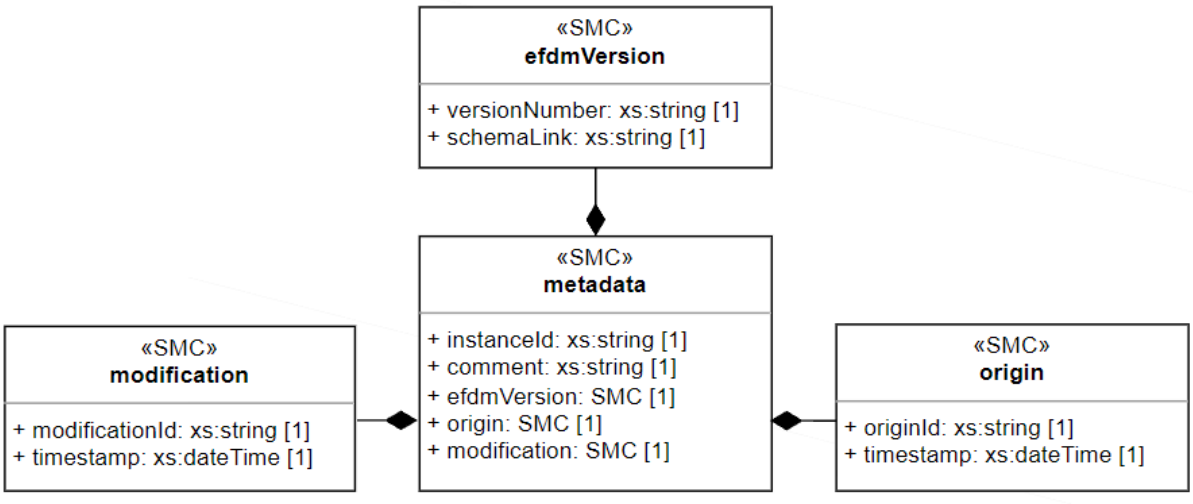

Figure 11 UML diagram of SMC metadata

Table 3 Elements of SMC metadata

idShort:	metadata
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/metadata
Parent:	Submodel flexibilitySpace
Explanation:	The metadata provides essential information for tracking and tracing the model instances.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] instanceId	[IRI] https://adminshell.io/idta/EnergyFlexibilityDataModel/1/0/instanceId The UUID of a Flexibility Space or Flexible-Load Measure Package for unique identification. The *Universally Unique Identifier (UUID)* is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-facing services.	f3e12b90-7c2a-4d97-b7c6-62c0e1a7d426	1
[MLP] comment	[IRI] https://adminshell.io/idta/EnergyFlexibilityDataModel/1/0/comment Free text to comment on the EFDM object.	This is an example instance	0..1
[SMC] efdmVersion	[IRI] https://adminshell.io/idta/EnergyFlexibilityDataModel/1/0/efdmVersion Specification of the EFDM version and hyperlink to the corresponding scheme.		1
[SMC] origin	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/origin It contains the UUID of the creating service and the point in time of creation. By means of the automated filling in of the Element, conclusions about the origin and an allocation to executing agencies are made possible. In the case of communication with external services, this Element is replaced by an ID that is intended for external communication.		1
[SMC] modification	IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/modification It contains the UUID of the service instance that last processed this object and the point in time of last processing. In the case of communication with external services, this Element can be replaced by an ID that is intended for external communication.		1

Table 4 Elements of SMC efdmVersion

idShort:	efdmVersion
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/efdmVersion
Parent:	SMC metadata
Explanation:	Specification of the EFDM version and hyperlink to the corresponding scheme.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] versionNumber	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/versionNumber the EFDM version (e.g., 1.1).	1.1	1
[Property] schemaLink	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/schemaLink hyperlink to the corresponding scheme.	https://git.ptw.maschinenbau.tu-darmstadt.de/eta-fabrik/public/energy_flexibility_data_model/-/tree/main/efdm_v1.1/JSON_schema?ref_type=heads	1

Table 5 Elements of SMC origin

idShort:	origin
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/origin
Parent:	SMC metadata
Explanation:	UUID of the creating service and the point in time of creation

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] originId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID UUID of the creating service and the point in time of creation	d7f1a204-64cf-4ec5-8ad0-35b06d9a9f41	1
[Property] timestamp	[IRDI] 0173-1#02-ABF198#001 timestamp of the creating service.	2023-10-01T14:30:00Z	1

Table 6 Elements of SMC modification

idShort:	modification
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/modification
Parent:	SMC metadata

Explanation:	It contains the UUID of the service instance that last processed this object and the point in time of last processing. In the case of communication with external services, this Element can be replaced by an ID that is intended for external communication		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] modificationId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID UUID of the service instance that last processed this object	0a3f6f3b-7f7e-4c3b-8a12-2e6d6c3a0d21	1
[Property] timestamp	[IRDI] 0173-1#02-ABF198#001 timestamp of last processing.	2025-07-01T00:00:00+09:00	1

2.4.2 SubmodelElement of utilizationContext

Table 7 Elements of SMC utilizationContext

idShort:	utilizationContext		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/utilizationContext		
Parent:	SMC flexibilitySpace		
Explanation:	It contains metainformation, describing the model status and scope.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] status	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/status enum: draft, available, offered, reserved, measuresRequest, finalized. The status of a Flexibility Space describes its current condition within the overall process of applying energy-flexible measures. The objective is to make the progression and individual phases of each Flexibility Space transparently traceable.	draft	1
[Property] modellingScope	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/modellingScope Enum: generalTechnicalPotential, operationalPotential, applicationTailoredPotential. The modelling scope places individual EFDM instances and their key figures into context. operationalPotential: Flexibility is fully considered within the context of the production environment and includes all necessary information required to make use of the flexibility. The model describes the maximum feasible potential—independent of the specific use case.	generalTechnicalPotential	1

	applicationTailoredPotential: The model describes a potential tailored to a specific application. For example, an energy market may only allow the use of the Flexible Load class with holding durations in 15-minute intervals. In such a case, the potential of storage units and dependencies would need to be transformed so that they can be represented as Flexible Load.		
[SMC] trading	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/trading The *Trading* of a *Flexibility Space* comprises configurable properties that determine its feasibility and operational implementation	n/a	1

Table 8 Elements of SMC trading

idShort:	trading		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/trading		
Parent:	SMC utilizationContext		
Explanation:	The Trading of a Flexibility Space comprises configurable properties that determine its feasibility and operational implementation		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] externallyTradeable	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/externallyTradeable Indicates whether the Flexibility Space is intended to participate in external energy markets (true) or is to be used exclusively for internal optimization purposes (false).	true	1
[Property] autoTradeable	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/autoTradeable Specifies whether the trading process can be executed automatically (true) or if additional manual preparations or reviews and verification procedures are required (false).	false	1

2.4.3 SubmodelElement of flexibleLoad

Table 9 Elements of SML flexibleLoads

idShort:	flexibleLoads
Class:	SubmodelElementList (SML)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoads

Parent:	SMC flexibilitySpace		
Explanation:	flexibleLoads may contain multiple flexibleLoad.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] flexibleLoad	[IRI]https://adminshell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoad Each flexibleLoad is described as a technical system or a combination of systems that can adjust its power consumption or generation in response to external conditions or requirements. It focuses on the limitations and possibilities (degrees of freedom) of changing power outputs of a technical system.	n/a	1..*

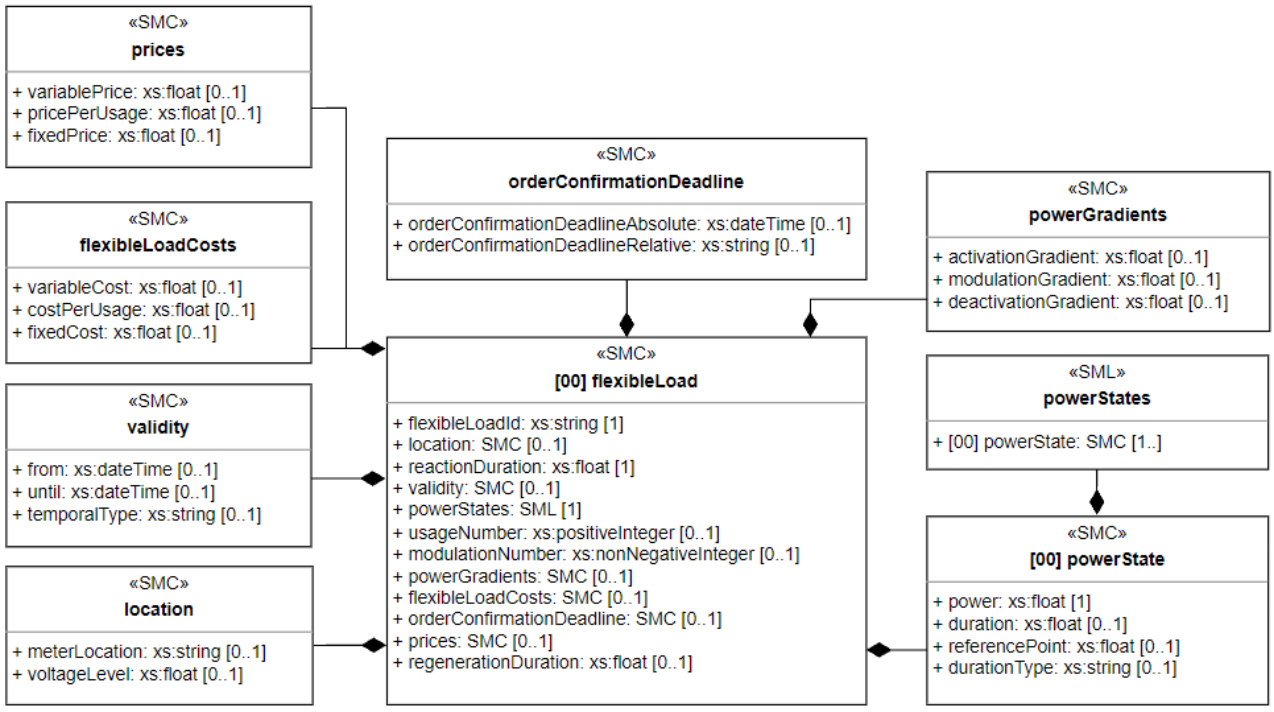

Figure 12 UML diagram of SMC [00] flexibleLoad

Table 10 Elements of SMC flexibleLoad

idShort:	flexibleLoad
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoad
Parent:	SML flexibleLoads
Explanation:	Each flexibleLoad is described as a technical system or a combination of systems that can adjust its power consumption or generation in response to external conditions or requirements. It focuses on the limitations and possibilities (degrees of freedom) of changing power outputs of a technical system.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] flexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a Flexible Load for unique identification. The Universally Unique Identifier (UUID) is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services. String Format: UUID	10edb7e5-a894-4ce7-a09d-138f0841fcaf	1
[Range] reactionDuration	[IRDI] 0173-1#02-AAV535#002 Time (seconds) required by a technical system between the receipt of a call-up and the initiation of a *Flexible-Load Measure* within the enterprise. The call must be issued with at least this lead time before the *Flexible-Load Measure* starts. This duration includes not only the technical ramp-up time of the machine but also additional time needed due to operational and organizational factors, such as internal communication delays, decision-making processes, and coordination through upstream IT systems. Therefore, the call-up must be issued at least this amount of time in advance to ensure proper and timely execution of the flexibility measure. Uncertainty in Reaction Duration can be represented by specifying a range, rather than a value.	[300, 400]	0..1
[SMC] validity	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/validity A subset of the company-internal planning horizon in which the Flexible Load is available. The beginning and end of this validity period are specified with the attributes from and until. If this period is not specified, continuous availability of the Flexible Load is assumed.	n/a	0..1
[SML] powerStates	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerStates A set of *Power States* available to the *Flexible Load* during each of the (number of changes + 1) holding periods.	n/a	1
[Range] usageNumber	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/usageNumber The permitted number of activations of the Flexible Load within the Validity Period. A specified minimum value of the range defines a required number of activations; a specified maximum value sets an upper limit on activation frequency.	[1, 10]	0..1
[Range] modulationNumber	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/modulationNumber The maximum number of Power State changes (modulations) allowed within one use of a Flexible Load. The two modulations	[0, 2]	0..1

	corresponding to the initial activation and the final deactivation are not counted.		
[SMC] powerGradients	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerGradients The absolute value of the *Power Gradient* of a *Flexible Load* indicates the maximum rate at which its power can be increased or decreased.	n/a	0..1
[Property] regenerationDuration	[IRDI] 0173-1#02-ABF201#002 The required regeneration time during which no other measure of the same *Flexible Load* may be activated following the deactivation of a previous measure. This time constraint applies only if an actual deactivation occurs. If another measure follows without interruption, no deactivation takes place between them; this does not constitute a violation of the defined regeneration period. This duration accounts for both the technical recovery time of the machine (e.g., cooling down, resetting, stabilization) and any additional time required due to operational or organizational factors—such as internal coordination, safety checks, or scheduling constraints.	20	0..1
[SMC] flexibleLoadCosts	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadCosts The costs associated with the use of the Flexible Load, excluding electricity costs. The Costs of a Flexible Load consist of variable cost, usage cost and fixed cost.	n/a	0..1
[SMC] orderConfirmationDeadline	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/orderConfirmationDeadline Latest possible time by which confirmation of an accepted offer of the Flexible Load must have been received. By this time, the flexibility provider needs to know whether the Flexible Load must be held ready. After the Booking Confirmation Deadline is exceeded, the Flexible Load offer is removed from the market. The Order Confirmation Deadline can be specified EITHER absolutely with a fixed time OR relative to the start time of the Flexible-Load Measure (e.g. 100 seconds before the start of a FLM). If no value is specified, constant availability for offering is assumed until the latest possible start time within the Validity Period minus the Reaction Duration.	n/a	0..1
[SMC] prices	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/prices Prices to be realized on the market as a minimum for offering the Flexible Load. The Prices of a Flexible Load are composed of a variable price, a usage price, and a fixed price analogous to the Costs. Prices are only needed if the Flexible Load is to be actively offered on the market.	n/a	0..1
[SMC] location	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/location	n/a	0..1

	Meter point designation for the geographical and power grid topological location of a Flexible Load.		

Table 11 Elements of SMC validity

idShort:	validity		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/validity		
Parent:	SMC flexibleLoad		
Explanation:	A subset of the company-internal planning horizon in which the Flexible Load is available. The beginning and end of this validity period are specified with the attributes from and until. If this period is not specified, continuous availability of the Flexible Load is assumed.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] from	[IRDI] 0173-1#02-ABF198#001 from time. If this period is not specified, continuous availability of the Flexible Load is assumed. includes a communication chain via several upstream IT systems.	2025-04-01T00:00:00	0..1
[Property] until	[IRDI] 0173-1#02-ABF198#001 until time. If this period is not specified, continuous availability of the Flexible Load is assumed.	2025-04-08T00:00:00	0..1
[Property] temporalType	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/temporalType enum: start, total, end. The temporalType start specifies that the start of each Flexible-Load Measure belonging to this Flexible Load must lie within the Validity Period. end specifies that the end of each Flexible-Load Measure belonging to this Flexible Load must lie within the Validity Period. total specifies that the total duration of each Flexible-Load Measure belonging to this Flexible Load must lie within the Validity Period.	total	0..1

Table 12 Elements of SML powerStates

idShort:	powerStates
Class:	SubmodelElementList (SML)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerStates
Parent:	SMC flexibleLoad
Explanation:	A set of *Power States* available to the *Flexible Load* during each of the (number of changes + 1) holding periods.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[SMC] powerState	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerState A powerState collection contains the value of this power state and its duration.	n/a	1..*

Table 13 Elements of SMC powerState

idShort:	powerState
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerState
Parent:	SML powerStates
Explanation:	A powerState collection contains the value of this power state and its duration.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Range] power	[IRDI] 0173-1#02-AAZ820#001 A positive sign means that the *Flexible Load* can increase its power consumption. Negative Power States represent a possible decrease in power consumption. Uncertainty can be represented by specifying a range.	[100, 120]	1
[Range] duration	[IRDI] 0173-1#02-ABF201#002 The time period during which the Flexible Load can run in its corresponding Power States. Uncertainty can be represented by specifying a range.	[600, 640]	0..1
[Property] referencePoint	[IRDI] 0173-1#02-AAZ820#001 the scheduled baseline load	0	0..1
[Property] durationType	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/durationType enum: deliveryDuration, holdingDuration. Duration either corresponds to the time of a constant Power State (holdingDuration) OR a constant Power State WITH initial power modulation (deliveryDuration).	holdingDuration	0..1

Table 14 Elements of SMC powerGradients

idShort:	powerGradients
Class:	SubmodelElementCollection (SMC)

semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerGradients		
Parent:	SMC flexibleLoad		
Explanation:	The absolute value of the *Power Gradient* of a *Flexible Load* indicates the maximum rate at which its power can be increased or decreased.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] activationGradient	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PowerGradient Activation Gradient specifies the power gradient applicable during the initial activation of the Flexible Load.	[10, 20]	0..1
[Property] modulationGradient	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PowerGradient The Modulation Gradient specifies the power gradient during a change of power states.	[50, 60]	0..1
[Property] deactivationGradient	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PowerGradient The Deactivation Gradient specifies the power gradient during the final deactivation phase.	[10, 20]	0..1

Table 15 Elements of SMC flexibleLoadCosts

idShort:	flexibleLoadCosts		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadCosts		
Parent:	SMC flexibleLoad		
Explanation:	The costs associated with the use of the Flexible Load, excluding electricity costs. The Costs of a Flexible Load consist of variable cost, usage cost and fixed cost.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] variableCost	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/CostPerEnergyConverted Variable costs refer to the total amount of energy converted.	0.1	0..1
[Property] costPerUsage	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/CostPerUsage Usage costs are incurred per use of a Flexible-Load.	50	0..1

[Property] fixedCost	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/fixedCost Fixed costs incurred during the Validity Period regardless of the call of a Flexible Load (example: standby costs of a power generation plant).	100	0..1

Table 16 Elements of SMC prices

idShort:	prices		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/prices		
Parent:	SMC flexibleLoad		
Explanation:	Prices to be realized on the market as a minimum for offering the Flexible Load. The Prices of a Flexible Load are composed of a variable price, a usage price, and a fixed price analogous to the Costs. Prices are only needed if the Flexible Load is to be actively offered on the market.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] variablePrice	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PricePerEnergyConverted Variable price refers to the total amount of energy converted.	0.2	0..1
[Property] pricePerUsage	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/pricePerUsage Usage prices are incurred per use of a Flexible-Load.	100	0..1
[Property] fixedPrice	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/fixedPrice Fixed price	200	0..1

Table 17 Elements of SMC orderConfirmationDeadline

idShort:	orderConfirmationDeadline
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/orderConfirmationDeadline
Parent:	SMC flexibleLoad
Explanation:	Latest possible time by which confirmation of an accepted offer of the Flexible Load must have been received. By this time, the flexibility provider needs to know whether the Flexible Load must be held ready. After the Booking Confirmation Deadline is exceeded, the

	Flexible Load offer is removed from the market. The Order Confirmation Deadline can be specified EITHER absolutely with a fixed time OR relative to the start time of the Flexible-Load Measure (e.g. 100 seconds before the start of a FLM). If no value is specified, constant availability for offering is assumed until the latest possible start time within the Validity Period minus the Reaction Duration.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] orderConfirmationDeadlineAbsolute	[IRDI] 0173-1#02-ABF198#001 absolute deadline	2025-08-01T00:00:00Z	0..1
[Property] orderConfirmationDeadlineRelative	[IRDI] 0173-1#02-ABF198#001 relative to the start time of the Flexible-Load Measure (e.g., 100 seconds before the start of a FLM)	18000	0..1

Table 18 Elements of SMC location

idShort:	location		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/location		
Parent:	SMC flexibleLoad		
Explanation:	Meter point designation for the geographical and power grid topological location of a Flexible Load.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] meterLocation	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/MeterPointDesignation The unambiguous allocation is made by means of the meter point designation known in the energy industry / in market communication. In Germany, it corresponds to a 33-digit alphanumeric code number.	DE012345678901234567890	0..1
[Property] voltageLevel	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/GridVoltageLevel The specification of the Grid Voltage Level to which the Flexible Load is connected. The voltage level at the grid connection point is to be used, independent of deviating voltage levels in any company grid.	22	0..1

2.4.4 SubmodelElement of storage

Table 19 Elements of SML storages

idShort:	storages		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storages		
Parent:	SMC flexibilitySpace		
Explanation:	Storages may contain multiple storages, each of which represents a technical system or a combination of systems that has the potential to store energy		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] storage	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storage A Storage represents a technical system or a combination of systems that has the potential to store energy.	n/a	1..*

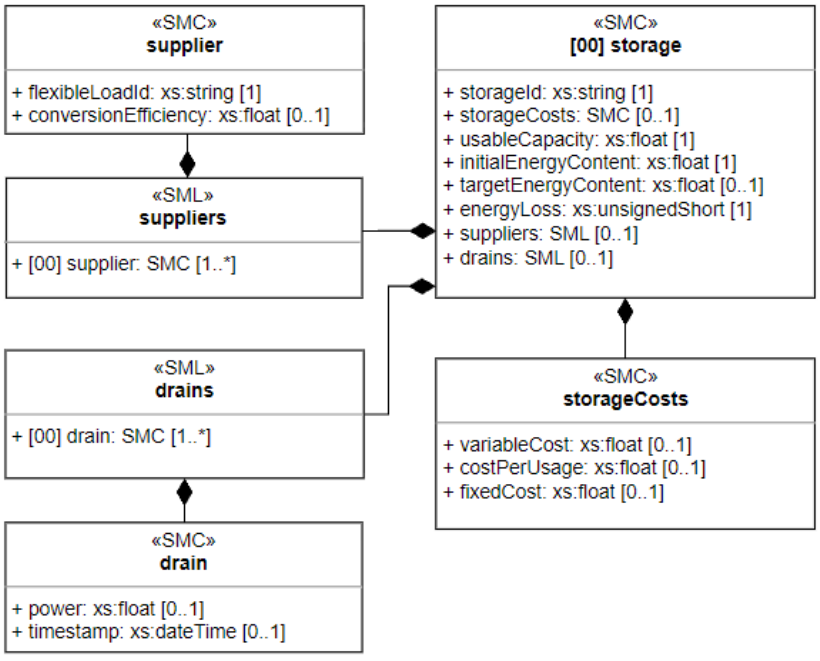

Figure 13 UML diagram of SMC [00] storage

Table 20 Elements of SMC storage

idShort:	storage
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storage
Parent:	SML storages

Explanation:	A Storage represents a technical system or a combination of systems that has the potential to store energy.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] storageId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a storage for unique identification. The *Universally Unique Identifier (UUID)* is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services.	550e8400-e29b-41d4-a716-446655440000	1
[Range] usableCapacity	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/ElectricalEnergyStorageContent Lower and upper limits of the storage energy content. These limits must never be exceeded or fallen short of. Depending on the choice of reference point, it is also possible to specify negative storage capacities, e.g., if it needs to be possible to either exceed or fall below storage limits. It includes two important aspects: The initial capacity specification provided by the Equipment Vendor, representing the theoretical or design limits of the system The actual usable capacity, which may be lower due to operational constraints, system aging, or integration with other enterprise processes Depending on the use case of EFDM, this distinction should be noticed.	[200, 1000]	1
[Range] initialEnergyContent	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/ElectricalEnergyStorageContent Energy content of the storage at the start time of the Validity Period of the associated Flexible Load (Suppliers). If the storage is connected to several Flexible Loads, the Initial Energy Content refers to the earliest start time of the Validity Periods of all Flexible Loads. If the initial energy content cannot be quantified exactly, the predicted range can be specified via min and max.	[450, 550]	1
[Range] targetEnergyContent	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/ElectricalEnergyStorageContent Energy content that the storage must have at the end of the Validity Period of the associated Flexible Loads (Suppliers). If the storage is connected to several Flexible Loads, the Target Energy Content refers to the latest end time of the Validity Periods of all Flexible Loads. If the target energy content is flexible, the desired target range can be specified via min and max.	[800, 900]	0..1

[Property] energyLoss	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/EnergyContentLossPerHour Proportion of the energy content that is continuously lost, e.g., through exchange with the environment. The percentage refers to the actual energy content and not to the storage capacity.	50	0..1
[SML] suppliers	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/suppliers One or more Flexible Loads supplying the storage. The Flexible Loads must be defined in the same Flexibility Space. The conversion efficiency is specified for each supply system.	n/a	0..1
[SML] drains	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/drains Non-influencable energy demands in the form of a load profile that must be met. The interpolation between the Power States is linear.	n/a	0..1
[SMC] storageCosts	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storageCosts The costs associated with the use of the energy storage. The Costs of a storage facility consist of variable cost, usage cost, and fixed cost. Variable costs refer to the total amount of energy converted. Usage costs arise per use of a storage tank. Fixed costs arise from keeping a storage facility on standby.	n/a	0..1

Table 21 Elements of SMC storageCosts

idShort:	storageCosts		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storageCosts		
Parent:	SMC storage		
Explanation:	The costs associated with the use of the energy storage. The Costs of a storage facility consist of variable cost, usage cost, and fixed cost. Variable costs refer to the total amount of energy converted. Usage costs arise per use of a storage tank. Fixed costs arise from keeping a storage facility on standby.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] variableCost	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/CostPerEnergyConverted Variable costs refer to the total amount of energy converted.	0.1	0..1
[Property] costPerUsage	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/CostPerUsage	50	0..1

	Usage costs are incurred per use of a Flexible-Load.		
[Property] fixedCost	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/fixedCost Fixed costs incurred during the Validity Period regardless of the call of a Flexible Load (example: standby costs of a power generation plant).	100	0..1

Table 22 Elements of SML suppliers

idShort:	suppliers		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/suppliers		
Parent:	SMC storage		
Explanation:	One or more Flexible Loads supplying the storage. The Flexible Loads must be defined in the same Flexibility Space. The conversion efficiency is specified for each supply system.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] supplier	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/supplier Indicating a single supply	n/a	1..*

Table 23 Elements of SMC supplier

idShort:	supplier		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/supplier		
Parent:	SML suppliers		
Explanation:	Indicating a single supply		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] flexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a Flexible Load for unique identification. The Universally Unique Identifier (UUID) is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services. String Format: UUID.	10edb7e5-a894-4ce7-a09d-138f0841fcaf	1

	This ID identifies the Flexible Load supplying the storage.		
[Property] conversionEfficiency	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/EnergyConversionEfficiency Energy conversion efficiency of the supplier.	80	0..1

Table 24 Elements of SML drains

idShort:	drains		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/drains		
Parent:	SMC storage		
Explanation:	Non-influenceable energy demands in the form of a load profile that must be met. The interpolation between the Power States is linear.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] drain	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/drain Indicating a single non-influencable energy demand	n/a	1..*

Table 25 Elements of SMC drain

idShort:	drain		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/drain		
Parent:	SML drains		
Explanation:	Indicating a single non-influencable energy demand		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] power	[IRDI] 0173-1#02-AAZ820#001 power drained.	200	0..1
[Property] timestamp	[IRDI] 0173-1#02-ABF198#001 timestamp of power drain.	2025-05-15T00:00:00	0..1

2.4.5 SubmodelElement of dependency

Table 26 Elements of SML dependencies

idShort:	dependencies
Class:	SubmodelElementList (SML)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/dependencies
Parent:	SMC flexibilitySpace
Explanation:	dependenciesmay contain multiple dependencies, each of which can be used to describe a restriction or dependency for the interaction of several Flexible Loads within an Flexibility Space. This allows the permissible operating options of an overall system to be mapped in greater detail so that Flexible-Load Measures do not have a negative impact on the system, the production processes or the product quality.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[SMC] dependency	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/dependency Each dependency can be used to describe a restriction or dependency for the interaction of several Flexible Loads within an Flexibility Space. This allows the permissible operating options of an overall system to be mapped in greater detail so that Flexible-Load Measures do not have a negative impact on the system, the production processes or the product quality	n/a	1..*

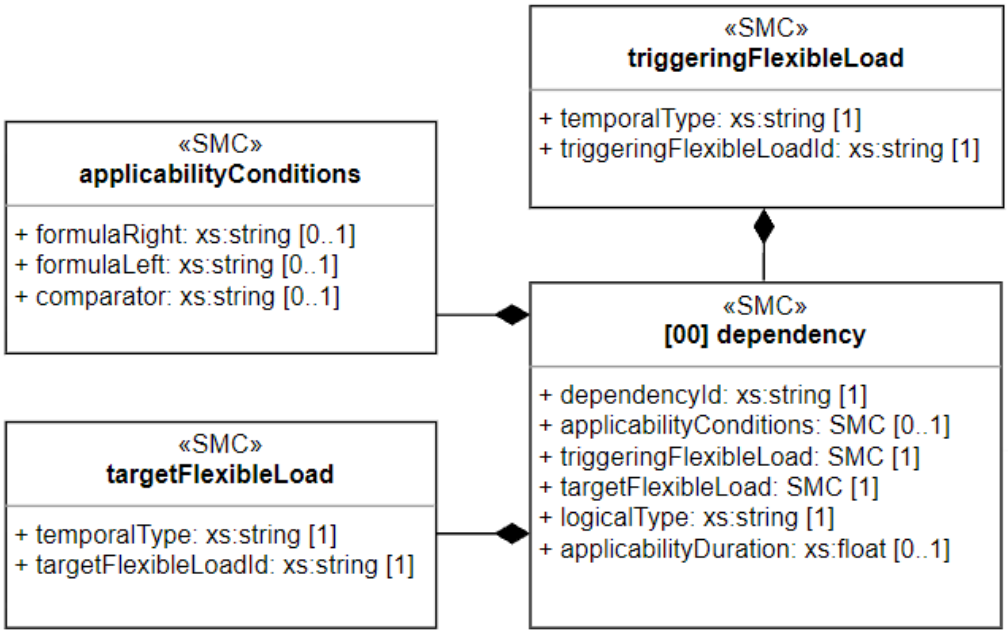

Figure 14 UML diagram of SMC [00] dependency

Table 27 Elements of SMC dependency

idShort:	dependency
Class:	SubmodelElementCollection (SMC)

semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/dependency
Parent:	SML dependencies
Explanation:	Each dependency can be used to describe a restriction or dependency for the interaction of several Flexible Loads within an Flexibility Space. This allows the permissible operating options of an overall system to be mapped in greater detail so that Flexible-Load Measures do not have a negative impact on the system, the production processes or the product quality.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] dependencyId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a dependency for unique identification. The *Universally Unique Identifier (UUID)* is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services.	9b2c4f94-1a2b-4a6f-9bce-2c8f3ddad4b7	1
[SMC] triggeringFlexibleLoad	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/triggeringFlexibleLoad The Flexible Load that triggers the dependency. The Flexible Load must be defined in the same Flexibility Space, and is referenced by its ID. In addition, one time parameter (start, total or end) of the Triggering Flexible-Load affected by the dependency is to be indicated.	n/a	1
[SMC] targetFlexibleLoad	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/targetFlexibleLoad The target flexible load that is affected by the *Triggering Flexible-Load*.	n/a	1
[Property] logicalType	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/logicalType enum: implies, excludes. Specifies whether a use of the Triggering Flexible-Load requires (implies) or prevents (excludes) the activation of the Target Flexible-Load within the Applicability Duration.	implies	1
[Range] applicabilityDuration	[IRDI] 0173-1#02-ABF201#002 The time period following the activation of the*Triggering Flexible-Load* during which the *Target Flexible-Load* must be activated at least once (*Logical Type*: *implies*) or must not be activated at all (*Logical Type*: *excludes*). The values specified for *min* and *max* define the *Applicability duration* relative to: -...the start of of the *Triggering Flexible-Load* (in case of the usage of the temporal parameter *start*), -...the end of the *Triggering Flexible-Loads* deactivation (in case of the usage of the temporal parameter *end*), -...the total duration of the *Triggering Flexible-Load* (in case of the usage of the temporal parameter *total*).	[100, 1000]	0..1

[SML] applicabilityConditions	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/applicabilityConditions Additional conditions that must be met for the dependency to be considered fulfilled. In other words, an activation of the Triggering Flexible-Load implies or excludes a corresponding activation of the Target Flexible-Load in a configuration (measure), so that the applicability conditions are fulfilled. The Triggering Flexible-Load metrics are incorporated on the left side of the formula. The Target Flexible-Load metrics are incorporated on the right side.	n/a	0..1

Table 28 Elements of SML applicabilityConditions

idShort:	applicabilityConditions		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/applicabilityConditions		
Parent:	SMC dependency		
Explanation:	Additional conditions that must be met for the dependency to be considered fulfilled. In other words, an activation of the Triggering Flexible-Load implies or excludes a corresponding activation of the Target Flexible-Load in a configuration (measure), so that the applicability conditions are fulfilled. The Triggering Flexible-Load metrics are incorporated on the left side of the formula. The Target Flexible-Load metrics are incorporated on the right side.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] applicabilityCondition	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/applicabilityCondition	n/a	1..*

Table 29 Elements of SMC applicabilityCondition

idShort:	applicabilityCondition		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/applicabilityCondition		
Parent:	SML applicabilityConditions		
Explanation:	Indicating a single condition		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	

[Property] formulaLeft	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/formulaLeft The Triggering Flexible-Load metrics are incorporated on the left side of the formula.	power consumption of Triggering Flexible Load	0..1
[Property] formulaRight	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/formulaRight The Target Flexible-Load metrics are incorporated on the right side.	100	0..1
[Property] comparator	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/comparator enum: equals, less, lessEqual, greater, greaterEqual.	greaterEqual	0..1

Table 30 Elements of SMC triggeringFlexibleLoad

idShort:	triggeringFlexibleLoad		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/triggeringFlexibleLoad		
Parent:	SMC dependency		
Explanation:	The Flexible Load that triggers the dependency. The Flexible Load must be defined in the same Flexibility Space, and is referenced by its ID. In addition, one time parameter (start, total or end) of the Triggering Flexible-Load affected by the dependency is to be indicated.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] temporalType	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/temporalType enum: start, total, end. The temporalType start specifies that the start of each Flexible-Load Measure belonging to this Flexible Load must lie within the Validity Period. end specifies that the end of each Flexible-Load Measure belonging to this Flexible Load must lie within the Validity Period. total specifies that the total duration of each Flexible-Load Measure belonging to this Flexible Load must lie within the Validity Period.	start	0..1
[Property] triggeringFlexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of the *Flexible Load* that is affected by the *Triggering Flexible-Load*. The *Flexible Load* must be defined in the same *Flexibility Space*, and is referenced by its ID.	10edb7e5-a894-4ce7-a09d-138f0841fcaf	1

Table 31 Elements of SMC targetFlexibleLoad

idShort:	targetFlexibleLoad

Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/targetFlexibleLoad		
Parent:	SMC dependency		
Explanation:	The target flexible load that is affected by the *Triggering Flexible-Load*.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] temporalType	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/temporalType enum: start, total, end. The temporalType *start* specifies that the start of a *Flexible-Load Measure* of the *Target Flexible-Load* is affected by the dependency *Applicability Duration*. *end* specifies that the deactivation end of a *Flexible-Load Measure* of the *Target Flexible-Load* is affected by the dependency *Applicability Duration*. *total* specifies that the *Flexible-Load Measure* of the *Target Flexible-Load* is affected by the dependency *Applicability Duration* starting at activation until the end of deactivation	start	0..1
[Property] targetFlexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The UUID of the Flexible Load that is affected by the Triggering Flexible-Load. The Flexible Load must be defined in the same Flexibility Space, and is referenced by its ID.	a78c2e1b-1d47-4e57-95df-8d32925f0f59	1

2.5 SubmodelElement of flexibilitySpace_generalTechnicalPotential

flexibilitySpace_generalTechnicalPotential contains only a minimum collection of properties. Its SMC metadata is the same as FS_OP and FS_AP and thus will not be introduced. It does not have dependencies- EquipVendor delivers the single controllable units, modeled as flexible loads that may be accompanied by storage. At this stage, these are the system's components. Dependencies become relevant only when multiple controllable units (flexible loads) are aggregated to form a technical system. This arises during the operational integration stage.

Table 32 Elements of SMC flexibilitySpace_generalTechnicalPotential

idShort:	flexibilitySpace_generalTechnicalPotential
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibilitySpace_generalTechnicalPotential
Parent:	Submodel EnergyFlexibilityDataModel
Explanation:	flexibilitySpace_generalTechnicalPotential describes the degrees of freedom of an energy-flexible system based solely on its general technical characteristics. It focuses on the inherent flexibility potential of the system, independent of any operational strategies, specific conditions, or application-related constraints.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[SMC] metadata	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/metadata The metadata provides essential information for tracking and tracing of the model instances.	n/a	1
[SMC] utilizationContext	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/utilizationContext Containing metainformation, describing the model status and scope	n/a	1
[SML] flexibleLoads	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoads flexibleLoads may contain multiple flexibleLoad.	n/a	1
[SML] storages	IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storages Storages may contain multiple storage.	n/a	0..1
[SML] dependencies	IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/dependencies dependencies may contain multiple dependencies.	n/a	0..1

2.5.1 SubmodelElement of utilizationContext

Table 33 Elements of SMC utilizationContext under SMC flexibilitySpace_generalTechnicalPotential

idShort:	utilizationContext
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/utilizationContext
Parent:	SMC flexibilitySpace_generalTechnicalPotential
Explanation:	Containing metainformation, describing the model status and scope

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] status	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/status Status of the model instance in case of generalTechnicalPotential should be "draft"	draft	1
[Property] modellingScope	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/modellingScope	generalTechnicalPotential	1

	generalTechnicalPotential: modelling of flexibility includes universally valid technical characteristics and restrictions. The model does not contain information on operational strategies, production plans, or other limitations arising from the specific use of the plant or system. In this case, the energy flexibility potential is not directly implementable.		

2.5.2 SubmodelElement of flexibleLoad

Table 34 Elements of SML flexibleLoads under SMC flexibilitySpace_generalTechnicalPotential

idShort:	flexibleLoads		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoads		
Parent:	SMC flexibilitySpace		
Explanation:	flexibleLoads may contain multiple flexibleLoad.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] flexibleLoad	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoad Each flexibleLoad is described as a technical system or a combination of systems that can adjust its power consumption or generation in response to external conditions or requirements. It focuses on the limitations and possibilities (degrees of freedom) of changing power outputs of a technical system.	n/a	1..*

Table 35 Elements of SMC flexibleLoad under SMC flexibilitySpace_generalTechnicalPotential

idShort:	flexibleLoad		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoad		
Parent:	SML flexibleLoads		
Explanation:	Each flexibleLoad describes the energy flexibility of a technical system (i.e. controllable unit) or a combination of systems (i.e. an ensemble of controllable units) that can adjust its power consumption or generation in response to external conditions or requirements. It focuses on the limitations and possibilities (degrees of freedom) of changing power outputs of a technical system.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	

[Property] flexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a Flexible Load for unique identification. The Universally Unique Identifier (UUID) is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services. String Format: UUID	10edb7e5-a894-4ce7-a09d-138f0841fcaf	1
[Range] reactionDuration	[IRDI] 0173-1#02-AAV535#002 Start-up time of the technical system in time (seconds) Uncertainty in Reaction Duration can be represented by specifying a range, rather than a value.	[300, 400]	1
[SMC] powerGradients	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerGradients The absolute value of the *Power Gradient* of a *Flexible Load* indicates the maximum rate at which its power can be increased or decreased.	n/a	0..1
[Property] regenerationDuration	[IRDI] 0173-1#02-ABF201#002 technical recovery time of the technical system in time (seconds)	800	1
[Range] modulationNumber	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/modulationNumber The maximum number of Power State changes (modulations) allowed within one use of a Flexible Load. The two modulations corresponding to the initial activation and the final deactivation are not counted.	[0, 5]	0..1
[SML] powerStates	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerStates A set of *Power States* available to the *Flexible Load* during each of the (number of changes + 1) holding periods. Positive signs indicate an increase in power consumption, while negative signs represent a possible reduction. Depending on the modeling perspective, *Power States* may be defined as absolute power values (reference "zero") or as deviations from the scheduled baseline load.	n/a	1

Table 36 Elements of SML powerStates

idShort:	powerStates
Class:	SubmodelElementList (SML)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerStates
Parent:	SMC flexibleLoad
Explanation:	A set of *Power States* available to the *Flexible Load* during each of the (number of changes + 1) holding periods.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[SMC] powerState	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerState A powerState collection contains the value of this power state and its duration.	n/a	1..*

Table 37 Elements of SMC powerState

idShort:	powerState
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerState
Parent:	SML powerStates
Explanation:	A powerState collection contains the value of this power state and its duration.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Range] power	[IRDI] 0173-1#02-AAZ820#001 A positive sign means that the *Flexible Load* can increase its power consumption. Negative Power States represent a possible decrease in power consumption. Uncertainty can be represented by specifying a range.	[100, 120]	1

Table 38 Elements of SMC powerGradients

idShort:	powerGradients
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/powerGradients
Parent:	SMC flexibleLoad
Explanation:	The absolute value of the *Power Gradient* of a *Flexible Load* indicates the maximum rate at which its power can be increased or decreased.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] activationGradient	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PowerGradient Activation Gradient specifies the power gradient applicable during the initial activation of the Flexible Load.	[10, 20]	0..1

[Property] modulationGradient	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PowerGradient The Modulation Gradient specifies the power gradient during a change of power states.	[50, 60]	0..1
[Property] deactivationGradient	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/PowerGradient The Deactivation Gradient specifies the power gradient during the final deactivation phase.	[10, 20]	0..1

2.5.3 SubmodelElement of storage

Table 39 Elements of SML storages under SMC flexibilitySpace_generalTechnicalPotential

idShort:	storages		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storages		
Parent:	SMC flexibilitySpace		
Explanation:	Storages may contain multiple storages, each of which represents a technical system or a combination of systems that has the potential to store energy		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] storage	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storage A Storage represents a technical system or a combination of systems that has the potential to store energy.	n/a	1..*

Table 40 Elements of SMC storage under SMC flexibilitySpace_generalTechnicalPotential

idShort:	storage		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/storage		
Parent:	SML storages		
Explanation:	A Storage represents a technical system or a combination of systems that has the potential to store energy.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	

[Property] storageId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a storage for unique identification. The *Universally Unique Identifier (UUID)* is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services.	550e8400-e29b-41d4-a716-446655440000	1
[Range] usableCapacity	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/ElectricalEnergyStorageContent Lower and upper limit of the storage energy content. These limits must never be exceeded or fallen short of. Depending on the choice of reference point, it is also possible to specify negative storage capacities, e.g. if it needs to be possible to either exceed or fall below storage limits. It includes two important aspects: The initial capacity specification provided by the Equipment Vendor, representing the theoretical or design limits of the system The actual usable capacity, which may be lower due to operational constraints, system aging, or integration with other enterprise processes Depending on the use case of EFDM, this distinction should be noticed.	[200, 1000]	1
[Range] initialEnergyContent	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/ElectricalEnergyStorageContent Energy content of the storage at the start time of the Validity Period of the associated Flexible Load (Suppliers). If the storage is connected to several Flexible Loads, the Initial Energy Content refers to the earliest start time of the Validity Periods of all Flexible Loads. If the initial energy content cannot be quantified exactly, the predicted range can be specified via min and max.	[450, 550]	1
[Property] energyLoss	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/EnergyContentLossPerHour Proportion of the energy content that is continuously lost, e.g. through exchange with the environment. The percentage refers to the actual energy content and not to the storage capacity.	50	0..1
[SML] suppliers	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/suppliers One or more Flexible Loads supplying the storage. The Flexible Loads must be defined in the same Flexibility Space. The conversion efficiency is specified for each supply system.	n/a	0..1

Table 41 Elements of SML suppliers

idShort:	suppliers

Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/suppliers		
Parent:	SMC storage		
Explanation:	One or more Flexible Loads supplying the storage. The Flexible Loads must be defined in the same Flexibility Space. The conversion efficiency is specified for each supply system.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] supplier	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/supplier Indicating a single supply	n/a	1..*

Table 42 Elements of SMC supplier

idShort:	supplier		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/supplier		
Parent:	SML suppliers		
Explanation:	Indicating a single supply		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] flexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of a Flexible Load for unique identification. The Universally Unique Identifier (UUID) is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services. String Format: UUID. This ID identifies the Flexible Load supplying the storage.	10edb7e5-a894-4ce7-a09d-138f0841fcaf	1
[Property] conversionEfficiency	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/EnergyConversionEfficiency Energy conversion efficiency of the supplier.	80	0..1

2.6 SubmodelElement of flexibleLoadMeasuresPackage

Table 43 Elements of SMC flexibleLoadMeasuresPackage

idShort:	flexibleLoadMeasuresPackage

Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasuresPackage
Parent:	Submodel EnergyFlexibilityDataModel
Explanation:	The flexibleLoadMeasuresPackage contains one or more Flexible-Load Measures that describe a specific change in the performance of a dedicated Flexible Load

[SME type]	**semanticId = [idType]value**	**[valueType]**	**Data Source**	**card.**
idShort	**Description@en**	**example**		
[SMC] metadata	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/metadata The metadata provides essential information for tracking and tracing of the model instances. (It has the same properties as presented in Section 2.4.1)	n/a	n/a	n/a
[SML] flexibleLoadMeasures	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasures flexibleLoadMeasures contains one or more flexibleLoadMeasure.	n/a	n/a	1

2.6.1 SubmodelElement of flexibleLoadMeasure

Table 44 Elements of SML flexibleLoadMeasures

idShort:	flexibleLoadMeasures
Class:	SubmodelElementList (SML)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasures
Parent:	SMC flexibleLoadMeasuresPackage
Explanation:	flexibleLoadMeasuresmay contain multiple flexibleLoadMeasure.

[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] flexibleLoadMeasure	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasure Each flexibleLoadMeasure describes a specific load change profile of a dedicated Flexible Load within an Flexibility Space. In addition, the revenue resulting from the execution of the flexibleLoadMeasure is specified in this class.	n/a	1..*

Table 45 Elements of SMC flexibleLoadMeasure

idShort:	flexibleLoadMeasure		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasure		
Parent:	SMC flexibleLoadMeasures		
Explanation:	Each flexibleLoadMeasure describes a specific load change profile of a dedicated *Flexible Load* within an *Flexibility Space*. In addition, the revenue resulting from the execution of the flexibleLoadMeasure is specified in this class.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] flexibleLoadMeasureId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of the load measure for unique identification. The Universally Unique Identifier (UUID) is generated automatically and is used for identification and assignment within an IT system in a company and for further processing by external, market-side services.	d7f1a204-64cf-4ec5-8ad0-35b06d9a9f41	1
[Property] flexibleLoadId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of the Flexible Load to which the Flexible-Load Measure is directed.	10edb7e5-a894-4ce7-a09d-138f0841fcaf	1
[Property] status	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/status The *status* of a *Flexible-Load Measure* indicates its current progress within the process of providing energy flexiblity. The goal is to enable clear tracking of each measure across defined phases: - *draft*: The *Flexible-Load Measure* is in the drafting phase and is currently being created or edited. - *toExecute*: The measure is fully prepared and ready for execution. - *inExecution*: The measure is currently being executed. - *executed*: The measure has been fully implemented as planned. - *partiallyExecuted*: The measure was executed, but the resulting *Load Change Profile* deviated from the originally rewuired profile or could only be partially realized. - *failed*: An error occurred during execution that prevented the measure from being carried out. - *canceled*: The measure was canceled by the flexibility requester before execution.	draft	0..1
[Property] reward	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/reward	10000	0..1

	Total revenue received by a company for executing the *Flexible-Load Measure*.		
[SML] loadChangeProfiles	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfile loadChangeProfiles may contain multiple loadChangeProfile.	n/a	1
[SMC] loadChangeProfile	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfile Load profile that represents the power reduction or increase of the Flexible Load.	n/a	1..*

Table 46 Elements of SML loadChangeProfiles

idShort:	loadChangeProfiles		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfiles		
Parent:	SMC flexibleLoadMeasure		
Explanation:	loadChangeProfiles may contain multiple loadChangeProfile.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] loadChangeProfile	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfile Load profile that represents the power reduction or increase of the Flexible Load.	n/a	1..*

Table 47 Elements of SMC loadChangeProfile

idShort:	loadChangeProfile		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfile		
Parent:	SML loadChangeProfiles		
Explanation:	Load profile that represents the power reduction or increase of the Flexible Load.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] power	[IRDI] 0173-1#02-AAZ820#001 Positive power states mean that the Flexible-Load Measure requests an increase in power consumption from the Flexible	160	1

	Load. Negative power states require a decrease in power consumption. Interpolation between Power States is linear; a step change in power can be mapped by specifying two equal timestamps with different power values.		
[Property] timestamp	[IRDI] 0173-1#02-ABF198#001 timestamp of a power state.	2025-08-15T00:00:00	1

2.7 SubmodelElement of flexibleLoadMeasureExecutionLog

Table 48 Elements of SMC flexibleLoadMeasureExecutionLog

idShort:	flexibleLoadMeasureExecutionLog		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/flexibleLoadMeasureExecutionLog		
Parent:	Submodel EnergyFlexibilityDataModel		
Explanation:	The flexibleLoadMeasureExecutionLog contains one or more Execution Log-Entry that records an implemented flexible load measure.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] metadata	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/metadata The metadata provides essential information for tracking and tracing of the model instances. (It has the same properties as presented in Section 2.4.1)	n/a	n/a
[SML] executionLogEntries	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/executionLogEntries executionLogEntries contains one or more executionLogEntry.	n/a	1

2.7.1 SubmodelElement of flexibleLoadMeasure

Table 49 Elements of SML executionLogEntries

idShort:	executionLogEntries
Class:	SubmodelElementList (SML)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/executionLogEntries
Parent:	SMC flexibleLoadMeasureExecutionLog
Explanation:	executionLogEntries contains one or more executionLogEntry, each of which describes an implemented flexibleLoadMeasure.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[SMC] executionLogEntry	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/executionLogEntry Each executionLogEntry describes an implemented flexibleLoadMeasure.	n/a	1..*

Table 50 Elements of SMC executionLogEntry

idShort:	executionLogEntry
Class:	SubmodelElementCollection (SMC)
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/executionLogEntry
Parent:	SML executionLogEntries
Explanation:	Each executionLogEntry describes an implemented flexibleLoadMeasure.

[SME type]	semanticId = [idType]value	[valueType]	card.
idShort	**Description@en**	**example**	
[Property] flexibleLoadMeasureId	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/UUID The ID of the Flexible-Load Measure for which the log entry is created.	d7f1a204-64cf-4ec5-8ad0-35b06d9a9f41	1
[Property] reward	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/reward Realized revenue from implementing the *Flexible-Load Measure*. The sign indicates the direction of the cash flow.	10000	0..1
[Property] exceptions	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/exceptions Error objects that occurred during the execution of the *Flexible-Load Measure*.	none	0..1
[SML] loadChangeProfiles	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfiles Load profiles that record the actual power reduction or increase of the Flexible load during execution. The Power values are refer to the same referencePoint as the associated Flexible-Load Measure.	n/a	1

Table 51 Elements of SML loadChangeProfiles under SMC executionLogEntry

idShort:	loadChangeProfiles

Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfiles		
Parent:	SMC executionLogEntry		
Explanation:	Load profiles that record the actual power reduction or increase of the Flexible load during execution. The Power values are refer to the same referencePoint as the associated Flexible-Load Measure.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] loadChangeProfile	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfile A single Load profile that records the actual power reduction or increase of the Flexible load during execution.	n/a	1..*

Table 52 Elements of SMC loadChangeProfile

idShort:	loadChangeProfile		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/loadChangeProfile		
Parent:	SML loadChangeProfiles		
Explanation:	A single Load profile that records the actual power reduction or increase of the Flexible load during execution.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] power	[IRDI] 0173-1#02-AAZ820#001 Positive power states mean that the Flexible-Load Measure requests an increase in power consumption from the Flexible Load. Negative power states require a decrease in power consumption. Interpolation between Power States is linear; a step change in power can be mapped by specifying two equal timestamps with different power values.	500	1
[Property] timestamp	[IRDI] 0173-1#02-ABF198#001 timestamp of a power state.	2025-09-15T00:00:00+09:00	1
[Ref] referencePoint	[IRDI] https://admin-shell.io/idta/EnergyFlexibilityDataModel/1/0/referencePoint Refers to the associated Flexible-Load Measure as planed value.		1

Annex A. Explanations on used table formats

1. General

The used tables in this document try to outline information as concise as possible. They do not convey all information on Submodels and SubmodelElements. For this purpose, the definitive definitions are given by a separate file in form of an AASX file of the Submodel template and its elements.

2. Tables on Submodels and SubmodelElements

For clarity and brevity, a set of rules is used for the tables for describing Submodels and SubmodelElements.

- The tables follow in principle the same conventions as in [5].
- The table heads abbreviate 'cardinality' with 'card'.
- The tables often place two informations in different rows of the same table cell. In this case, the first information is marked out by sharp brackets [] form the second information. A special case are the semanticIds, which are marked out by the format: (type)(local)[idType]value.
- The types of SubmodelElements are abbreviated:

SME type	SubmodelElement type
Property	Property
MLP	MultiLanguageProperty
Range	Range
File	File
Blob	Blob
Ref	ReferenceElement
Rel	RelationshipElement
SMC	SubmodelElementCollection
SML	SubmodelElementList

- If an idShort ends with '__00__', this indicates a suffix of the respective length (here: 2) of decimal digits, in order to make the idShort unique. A different idShort might be choosen, as long as it is unique in the parent's context.
- The Keys of semanticId in the main section feature only idType and value, such as: [IRI]https://admin-shell.io/vdi/2770/1/0/DocumentId/Id. The attributes "type" and "local" (typically "ConceptDescription" and "(local)" or "GlobalReference" and (no-local)") need to be set accordingly; see [6].
- If a table does not contain a column with "parent" heading, all represented attributes share the same parent. This parent is denoted in the head of the table.
- Multi-language strings are represented by the text value, followed by '@'-character and the ISO 639 language code: example@EN.
- The [valueType] is only given for Properties.

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