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Proposal for data exchange standards and protocols

D5.5

EU-SysFlex

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ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
ACC	Aggregate Core Component
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
AS4	Applicability Statement 4
AT	Affordable Tool
BA	Business Application
BACnet	communication protocol for Building Automation and Control
BAIOP	Basic Application Interoperability Profiles (BAP Test Specifications)
BAN	Building Area Network
BAP	Basic Application Profiles
BIM	Business Information Model
BRP	Balance Responsible Party
BRS	Business Requirements Specification
BUC	Business Use Case
CEF	Connecting Europe Facility
CEM	Customer Energy Manager
CEN	French: French: Comité Européen de Normalisation; English: European Committee for Standardisation
CENELEC	French: Comité Européen de Normalisation Électrotechnique; English: European Committee for Electrotechnical Standardisation
CEP	Clean Energy Package
CG-SEG	Coordination Group on Smart Energy Grids of CEN-CENELEC-ETSI
CGMES	Common Grid Model Exchange Standard
CIM	Common Information Model
CLC	same as CENELEC
CMS	Charging Management System
COSEM	Companion Specification for Energy Metering
CPO	Charge Point Operator
CSIRT	Computer Security Incident Response Team
CSV	Comma Separated Values
DA	Distribution Automation
DC	Direct Current
DEP	Data Exchange Platform
DER	Distributed Energy Resources
DERMS	DER Management System
DLC	Digital Loop Carrier
DLMS	Device Language Message Specification; formerly Distribution Line Message Specification
DMS	Distribution Management System
DNP	Distributed Network Protocol
DoA	Description of Action
DR	Demand Response
DSF	Demand Side Flexibility
DSM	Demand Side Management
DSO	Distribution System Operator

E/E/PE, E/E/PES	Electrical/Electronic/Programmable Electronic Safety
e2e	end-to-end
ebIX	European forum for energy Business Information eXchange
EC	European Commission
EC-GA	Grant Agreement
EDI	Electronic Data Interchange of ENTSO-E
EEA	European Economic Area
EFET	European Federation of Energy Traders
EFI	Energy Flexibility Interface
EMS	Energy Management System
EN	European Norm (European standard)
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
ERRP	ENTSO-E Reserve Resource Process
ESB	Enterprise Service Bus
ESCO	Energy Service Company
ESPI	Energy Service Provider Interface
ETSI	European Telecommunications Standards Institute
EU	European Union
EU-SYSFLEX	Pan-European System with efficient, coordinated use of flexibilities for the integration of a large share of Renewable Energy Sources (RES)
EUC	Equipment Under Control
EURELECTRIC	The Union of the Electricity Industry
EV	Electric Vehicle
FAN	Flexible Power Alliance Network
FP	Flexibility Platform
FTP	File Transfer Protocol
FTPS	File Transfer Protocol Secure
GB	Green Button
GDPR	General Data Protection Regulation
HAN	Home Area Network
HEMRM	Harmonised Electricity Market Role Model
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
HVDC	High-Voltage Direct Current
IAN	Industrial Area Network
ICCP	Inter-Control Center Communications Protocol
ICT	Information and Communications Technology
ID	Identity Document; IDentifier
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEEE SA	IEEE Standards Association
IEM	Internal Electricity Market
inDEP	Layer for international Data Exchange Platform
IOP	Interoperability
IP	Internet Protocol

IRM	Interface Reference Model
IS	International Standard; Information System
ISMS	Information Security Management System
ISO	International Organisation for Standardisation
ISO CAB	ISO's Conformity Assessment Board
ISO CASCO	ISO's Committee on Conformity Assessment
IT	Information Technology
ITU	International Telecommunication Union
JMS	Java Message Service
JSON	Javascript Object Notation
kHz	Kilohertz
KORRR	Key Organisational Requirements, Roles and Responsibilities
KPI	Key Performance Indicator
KSI	Keyless Signature Infrastructure
LAN	Local Area Network
M&V	Measurement and Validation
MAC	Media Access Control
MADES	MArket Data Exchange Standard
MID	Directive on Measuring Instruments
MIME	Multipurpose Internet Mail Extensions
MMS	Manufacturing Message Specification
MQTT	Message Queuing Telemetry Transport
MSH	Message Service Handler
NAESB	North American Energy Standards Board
NAN	Neighbourhood Area Network
NCA	National Competent Authority
NIS Directive	Directive on Security of Network and Information systems
OA	Open Architecture
OBIS	Object Identification System
OCPP	Open Charge Point Protocol
OES	Operator of Essential Services
OIS	Open Systems Interworking
OPC	Open Platform Communications
OPC UA	OPC Unified Architecture
OSGP	Open Smart Grid Protocol
OSI model	Open Systems Interconnection model
PAS	Publicly Available Specification
PMB	Project Management Board
PPP	Point-to-Point Protocol
PV	Photovoltaics
RBAC	Role-Based Access Control
RDF	Resource Description Framework
RES	Renewable Energy Sources
REST	REpresentational State Transfer
RF	Radio Frequency
RPC	Remote Procedure Call

RTU	Remote Terminal Unit
S-FSK	Spread Frequency Shift Keying
SA	Substation Automation
SAREF	Smart Appliances Reference Ontology
SCADA	Supervisory Control and Data Acquisition
SCL	System Configuration description Language
SCP	Secure Copy Protocol
SDO	Standards Developing Organisation
SFTP	Secure File Transfer Protocol
SGAM	Smart Grid Architecture Model
SGCG	Smart Grid Coordination Group of CEN-CENELEC-ETSI
SGSM	Smart Grid Standards Map
SGTF	Smart Grids Task Force
SGTF EG	Expert Group of SGTF
SGUI	Smart Grid User Interface
SL	Security Level
SMCG	Smart Meters Coordination Group of CEN-CENELEC-ETSI
SOA	Service-Oriented Architecture
SPINE	Specification Smart Premises Interoperable Neutral Message Exchange
SQL DB	Structured Query Language DataBase
SRD	Systems Reference Deliverable
SRI	Smart Readiness Indicator
SSL	Secure Sockets Layer
SSO	Standards Setting Organisation
SUC	System Use Case
SyC	IEC System Committee
TC	Technical Committee
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TLS-PSK	Transport Layer Security pre-shared key cipher suites
TNO	Dutch: Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO); English: Netherlands Organisation for Applied Scientific Research
TP	Twisted Pair
TR	Technical Report
TS	Technical Specification
TSO	Transmission System Operator
UML	Unified Modelling Language
UN/CEFACT	The United Nations Centre for Trade Facilitation and Electronic Business
URL	Uniform Resource Locator
US	United States
USEF	Universal Smart Energy Framework
UXP	Unified eXchange Platform
V2G	Vehicle to Grid
VEN	Virtual End Node
VPP	Virtual Power Plant
VTN	Virtual Top Node

WAN	Wide Area Network
WP	Work Package
XML	Extensible Markup Language
XSD	XML Schema Definition
XSLT	eXtensible Stylesheet Language Transformations

EXECUTIVE SUMMARY

While this report investigates data exchange standards in general, part of the focus is specifically on data necessary for flexibility market functioning due to the general objectives of EU-SysFlex. The EU-SysFlex project aims to identify issues and solutions associated with integrating large-scale renewable energy and create a plan to provide practical assistance to power system operators across Europe. This plan should involve data exchange requirements, including needs for further standardisation. Data exchange has increasing importance for the liquid flexibility market involving various services and products, with many flexibility providers and a strong need for TSO-DSO coordination for acquiring flexibility.

Many organisations are trying to develop and establish standards for information exchange in the electricity sector. Broadly, there are limited international organisations that develop international standards as standards setting organisations (SSOs) and standards organisations that develop industry-specific standards as standards developing organisation (SDO).

As there are many different information exchange standards, interoperability seems to be of the most importance for building complex and reliable solutions where many market players are active. According to IEC TS 61850-2 interoperability can be defined as the ability of two or more devices to exchange information and use it for correct cooperation to perform the required functions. In other words, two or more systems (devices or components) are interoperable if they can perform a specific function cooperatively by using information that is exchanged.

Interoperability is in the explicit focus of EU-SysFlex as it enables exchange of any data type between multiple stakeholders and multiple systems. However, EU-SysFlex prioritises mutual understanding in terms of business processes, data exchange functionalities and data models rather than harmonising data formats and communication protocols.

CONTEXT

International standardisation organisation IEC provides a framework for standards' creation, management and use in smart grid domain. The elements of this framework involve Smart Grid Standards Map that allows easy identification of smart grid standards; Power System Reference Architecture that provides overview of all standards contributing to exchanges between business actors and system actors; Use Case based approach to standardisation and Use Case repository; and modelling of roles.

European standardisation organisations CEN-CENELEC-ETSI Smart Grid Coordination Group has developed Smart Grid Architecture Model (SGAM) that provides a systematic methodology for analysing smart grid architectures, coordination of standardisation activities, and coordination of products portfolio, development of architectures and custom solutions; Smart Grid Set of Standards that is one of the key deliverables produced in response to European Commission's mandate M/490 listing more than 500 standards; Interoperability Tool that enables to filter

relevant smart grid standards based on SGAM layers, zones and domains; and a report on Clean Energy Package (CEP) that addresses key legal propositions of CEP, which are considered most relevant for standardisation.

The Harmonised Electricity Market Role Model (HEMRM) developed by ENTSO-E, ebIX® and EFET facilitates cross-border communication between the market participants by attaching single name for each role and domain in the electricity market. It covers both the wholesale and retail electricity markets.

The central part of IEC standards for Smart Grid is covered by IEC 61850 and CIM (Common Information Model) packages. CIM data model is composed of IEC 61970-301, IEC 61968-11 and IEC 62325-301. CIM standards' current primary uses include facilitating the exchange of power system network data between organisations; allowing the exchange of data between applications within an organisation; and exchanging market data between organisations. CIM is the most recognised and widely used European electricity market standardised information model defined by the International Electrotechnical Commission's (IEC). CIM supports European regulation since 2010 with CGMES (Common Grid Model Exchange Standard) 1.0 profiles, and with ESMP (European Style Market Profile) profiles since 2011.

"CIMification" is the term proposed by EU-SysFlex to illustrate the need for and benefits of further interoperability through a single information model like CIM. Enlarging CIM usage makes sense in the context of European regulation and more precisely of Clean Energy Package. It is essential to consolidate CIM model, by defining new profiles. Moreover the methodology associated to CIM usage is well documented and well supported by some tools. Enhancing CIM will facilitate vendor adoption and support of CIM by vendors. It will also facilitate compliance testing and certification and facilitate organisation of interoperability tests between different vendors. Defining CIM canonical data model will facilitate cross-sector data exchange, e.g. by extending CIM and/or integrating other sectors' canonical data models with CIM.

European electricity sector has put in place a robust methodology based on system approach, which promotes interoperability by using standards (Use Case definition, Role Model, Canonical Data Model like CIM, Smart Grid Architecture Model). It would be valuable to extend this approach to other energy vectors and to cross-sector domain. In order to facilitate data exchange between sectors, it would make sense to develop cross-sector data models and profiles.

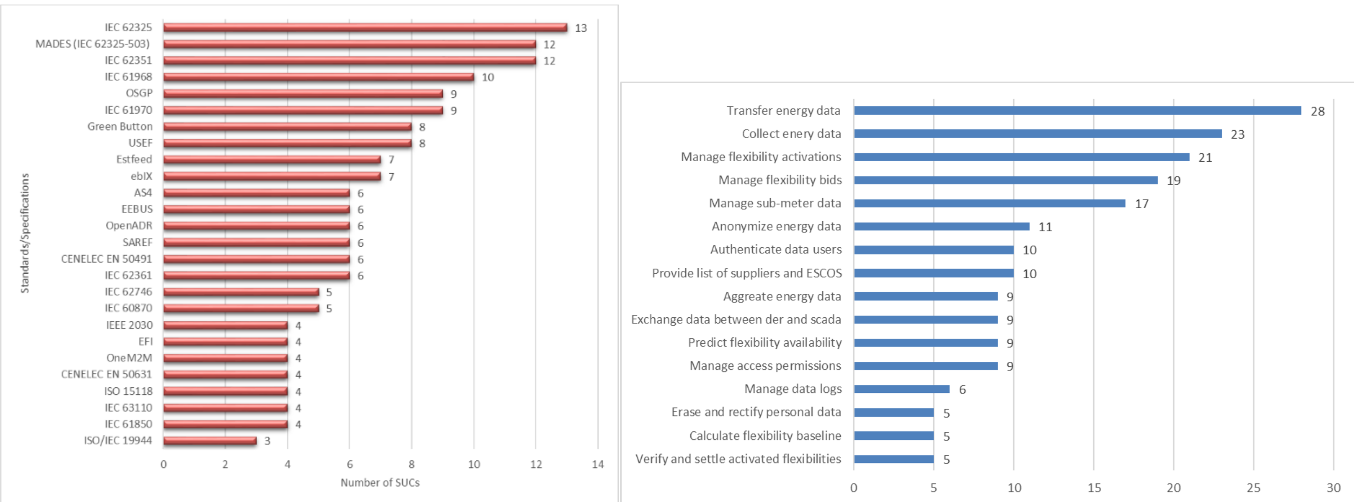
Demand side flexibility provided by end-consumers and prosumers may face barriers if there are too many and possibly contradictory standards and specifications for describing different interfaces between appliances providing flexibility, energy management systems and metering systems. European Commission promotes SAREF (Smart Appliances Reference Ontology) ontology to ensure alignment between the multitudes of approaches.

Due to the evolution of flexibility market and increasing awareness of consumers, there are issues to clarify in terms of data accessibility and shareability necessary for stakeholders to interact in different business processes (SGAM business layer). Private data has more importance than ever in the energy domain, and data management mechanisms need to focus more on cybersecurity exchange and handling of such data (SGAM function layer). Information models (like CIM) exist, creating different standards should be avoided, and complexity should be reduced (SGAM information layer). For data communication, sufficient tools already exist (SGAM communication layer).

There is quite some regulation regarding electricity domain's public data and some private (i.e. sensitive) data like grid data. However, explicit references to standards there are only a few. The new regulation is emerging for cybersecurity, handling of flexibility market data and meter data. There are still some areas not covered in European level legislation like management of sub-meter data and free but secure flow of any type of private data in general.

GAP ANALYSIS

In total, 42 standards and specifications have been evaluated against 16 system use cases (SUCs) identified in EU-SysFlex for data management functional processes. The results of the Evaluation based on use cases are presented in figures below. Most SUCs are covered by a few IEC family standards, such as IEC 62325 (13 SUCs), IEC 62351 and IEC 62325-503 (both 12 SUCs). Following non-IEC family standards there are ISGP, USEF and Green Button specifications, which can be applied in 8-9 SUCs. As depicted in the figure on right side, one of the most common SUC covered by the majority of standards is "Transfer energy data" – 28 standards and specifications are applicable to this use case.



NUMBER OF DATA EXCHANGE SYSTEM USE CASES PER EACH STANDARD AND SPECIFICATION, AND VICE VERSA

The objective of the standardisation gap analysis was to identify whether and which existing standards and specification there were at the time of assessment related to the data exchange system use cases identified in EU-SysFlex. The gap assessment was performed per each requirement of these SUCs. The gap analysis was based on Smart Grid Set of Standards and on expert assessment of EU-SysFlex partners. First, an assessment was performed for any standard/specification to see how extensively EU-SysFlex data exchange SUCs are covered by existing standards and specifications. Secondly, specific focus was put on CIM standards to see if the content of these SUCs is currently in the scope of CIM. Basically it means to assess whether there are missing attributes/classes in existing

CIM profiles. This may be, for example, because originally CIM was not designed for such data flows. Table below depicts simplified version of the coverage of data exchange system use cases by existing standards and specifications.

USE CASE	Covered in existing standards and specifications?	Further CIM coverage needed?
Collect energy data		May be needed
Transfer energy data		Recommended
Provide a list of suppliers and ESCOs		Not needed
Manage flexibility bids		May be needed
Manage flexibility activations		May be needed
Verify and settle activated flexibilities		May be needed
Manage access permissions		Recommended
Authenticate data users		Recommended
Manage data logs		Recommended
Calculate flexibility baseline		Recommended
Predict flexibility availability		May be needed
Manage sub-meter data		Recommended
Exchange data between DER and SCADA		Recommended
Anonymize energy data		May be needed
Aggregate energy data		May be needed
Erase, restrict and rectify personal data		Recommended

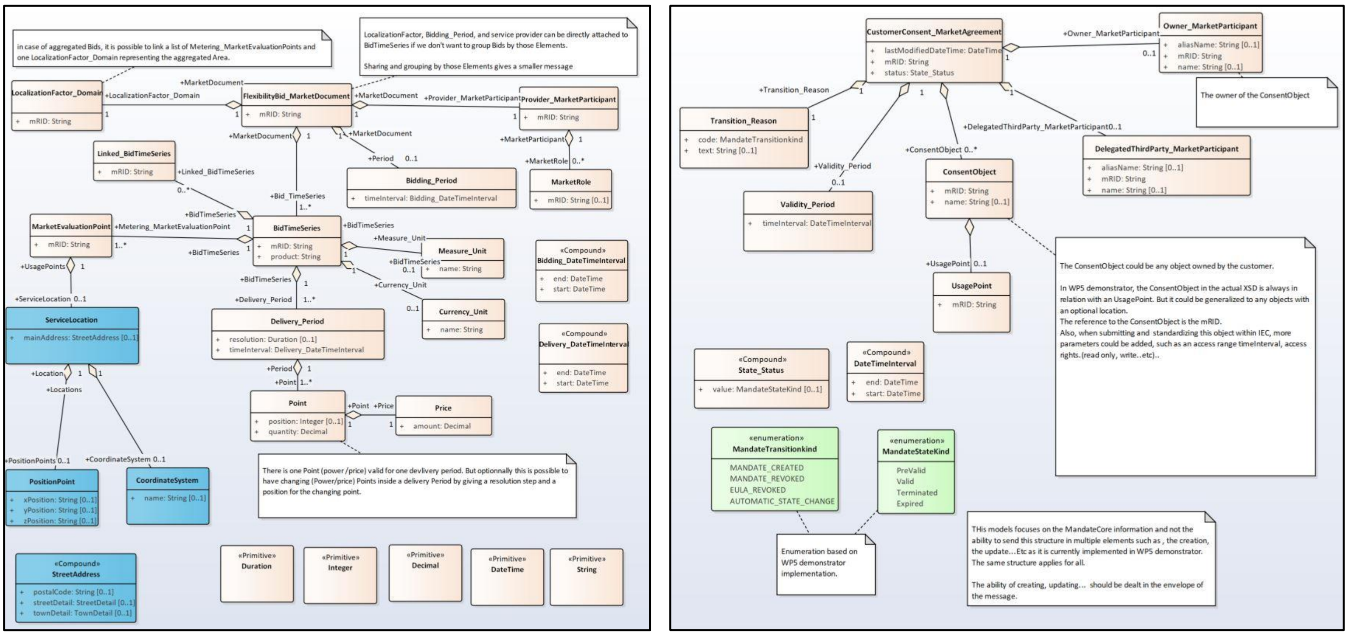
SUMMARY OF COVERAGE OF DATA EXCHANGE SYSTEM USE CASES BY EXISTING STANDARDS AND SPECIFICATIONS

"CIMification"

Beyond the gap analysis, data exchange system use cases were linked to business objects to evaluate further CIM profiling needs based on the identified CIM gaps. The profiles are grouped into two clusters – 'flexibility data' and 'private data'. This assessment is preliminary and can be confirmed by completing the profiling of all business objects. For this report the profiling process was performed for two business objects – 'Flexibility Bid' and 'Customer Consent'.

Based on these use cases and business objects, detailed specifications were written for many objects and implemented in data management demonstrators, however not compliant with CIM standards in their APIs (Application Programming Interfaces). Only then it was decided to realize a "CIMification" of some of these XSDs (XML Schema Definition). This CIMification started with comparing existing XSDs implemented demonstrators with CIM data model standards, such as ESMP (European Style Market Profile) based on IEC 62325. The objectives were to define CIM profiles based on CIM standards whenever it was possible and produce XSDs based on them; in case of gaps in CIM standards, define extensions to be proposed to IEC.

Figures below depict standardised CIM profiles, for 'Flexibility Bid' business object on the left side and for 'Customer Consent' object on the right side.

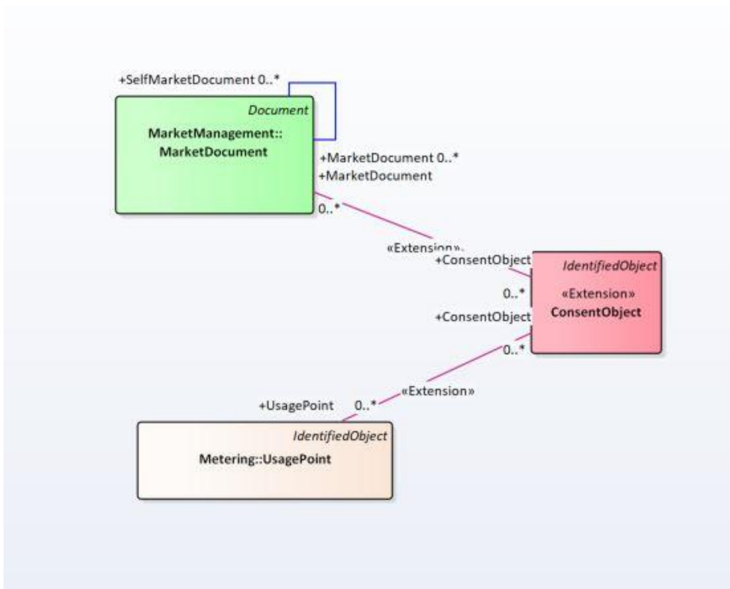


CIM PROFILES FOR 'FLEXIBILITY BID' AND 'CUSTOMER CONSENT' BUSINESS OBJECTS

The 'Flexibility Bid' business object does not require CIM extensions as all required data can be modelled when profiling CIM. This is true even if considering that ESMP was initially designed for balancing. As WP9 demonstrator aims to test data exchanges for joint balancing and congestion management product, which is mFRR[1] type of product, it was verified that ESMP already works for other products (at least for congestion management) beside balancing products and for joint products.

For the 'Customer Consent' business object it was necessary to extend the CIM by:

- Adding ConsentObject with a generalization association from IdentifiedObject in order to give the ability of uniquely identify it.
- Adding a relation between ConsentObject and MarketDocument in order to create a profile with a relation between the ConsentObject and MarketAgreement as it is a specialization of MarketDocument.
- Adding a relation between ConsentObject and UsagePoint in order to create a profile with a relation between those two classes.



CIM EXTENSIONS FOR 'CUSTOMER CONSENT' OBJECT

[1] mFRR – manual Frequency Restoration Reserve

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CONCLUSIONS AND PROPOSALS

General conclusions:

- Though data exchange system use cases include the concept of Data Exchange Platform[2], the standards and specifications investigated can and should in most cases be applied equally in different data exchange models – platform-based distributed data exchange, platform-based centralised data storage, bilateral data exchange.
- Requirements of data aggregation and data anonymization use cases are addressed in some specifications but not explicitly in standards.
- Regarding data user's authentication, the right to access own data as well as the ability to share information related to authentication and representation rights are addressed in some specifications but not explicitly in standards.
- Regarding consent management some specification exist but no explicit standards for giving and sharing access permissions.
- Regarding personal data management it is addressed in some specifications and standards but not explicitly about sharing erasure and rectification information.
- Ability to share information related to data logs has very limited coverage in standards.
- Energy data collection and energy data transfer use cases are fairly well covered in existing standards.
- Standardisation of easy access to sub-meter data by data owners and by other parties based on data owners consent could be improved.
- Direct DER[3]-SCADA[4] communication between small Distributed Energy Resources of prosumers and other end-users, their aggregators and system operators' SCADAs is not addressed in standards yet (though IEC 61850 could be extended towards that).
- Requirements for flexibility market baseline calculation, algorithm for prequalification of flexibility providers, selection of bids, calculation of grid impacts and computation of predictions are not addressed in standards specifically for increasingly complex flexibility market. Several other flexibility market requirements could benefit from CIM standards' extensions.
- Data management related to list of suppliers and ESCOs is well covered in existing standards.

CIM standards related conclusions:

- Additional CIM coverage may be needed for data hubs.
- Additional CIM coverage for private data portability, for access to own data, and for transfer of private data to other parties is recommended, incl. cross-border.
- CIM coverage is recommended for exchanging information related to authentication and representation rights between data users, Customer Portal and Authentication Service Provider.

[2] As defined in EU-SysFlex deliverable 5.2: Data exchange platform (DEP) is a communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g. data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g. cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs. Several DEPs may exist in different countries and inside one country.
[3] DER – Distributed Energy Resources
[4] SCADA – Supervisory Control and Data Acquisition

- ➢ CIM coverage is recommended for sharing access permissions (consent management) between data owners, concerned DEPs, applications and data sources. The CIM profiling of 'Customer Consent' business object confirmed the need for CIM extensions.
- ➢ CIM coverage is recommended for exchanging information related to erasure and rectification between data owners, concerned DEPs, applications and data sources
- ➢ CIM coverage is recommended for exchanging data logs related information between data owners, concerned DEPs, applications and data sources.
- ➢ Additional CIM coverage (possibly through COSEM) recommended for sub-meter data storing and exchange.
- ➢ For data aggregation and data anonymisation additional CIM coverage may be required for data exchange between data source and data user.
- ➢ For flexibility market data exchange use cases the current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing is not necessarily sufficient. However, the CIM profiling results for 'Flexibility Bid' business object presented in this report revealed that no CIM extensions are needed for the mFRR type product which can be used for both balancing and congestion management.
- ➢ Not all data flows necessary for baseline calculation are covered by CIM.
- ➢ CIM coverage is recommended for data exchange (real-time and near-real-time measurements, flexibility activation requests) between smaller DERs and system operators (possibly through harmonisation between CIM and IEC 61850 once the latter will be applied to DER-SCADA communication).

While methods on how to update and communicate changes in standards belong to the competence of standardisation organisations, the research and innovation projects like EU-SysFlex can contribute to 'pre-standardisation' activities. It is even powerful through combined efforts of many projects, one important platform being BRIDGE Initiative. While the focus of this report is on CIM standards, the identification and application of relevant CIM standards, incl. proposals for relevant CIM extensions are recommended to go through the concept of 'CIM repository' as described by BRIDGE. EU-SysFlex partners contributed heavily to this concept.

Four steps are proposed to structure a CIM repository, all steps can be considered also as stand-alone repositories with slightly different objectives:

- **STEP 1**: Based on the template proposed by BRIDGE information about business objects and CIM profiles and there links to SUCs, BUCs and demonstrators should be collected on project level.
- **STEP 2**: Based in inputs from individual projects a synthesised overview of business objects and CIM profiles can be produced to enable the comparison between projects and to identify the commonalities.
- **STEP 3**: A manageable UML repository for business objects and CIM profiles should be created allowing to produce reports and to use tools for defining profiles.
- **STEP 4**: Management of repository of instance files is needed. An instance file is a data set which is structured conformant with the profile.

1. INTRODUCTION

1.1 SCOPE AND STRUCTURE

According to the EU-SysFlex Description of Action (DoA), the objectives of Work Package (WP) 5 are to provide recommendations for data management in flexibility services when applied on a large scale (on an IT perspective) and to develop customer-centric data exchange model for flexible market design serving all stakeholders like TSOs (Transmission System Operators), DSOs (Distribution System Operators), suppliers, flexibility providers, ESCOs (Energy Service Companies) and enabling data exchange across the borders. Those recommendations have been tested in WP9 demonstrations and finally will be given to WP10 to elaborate the flexibility roadmap.

Task 5.5 of WP5 aimed to review current standards and protocols (EU, US, international) that could be applicable for WP5, such as standard data models or protocols. Data exchange models should be based on core standards like CIM (Common Information Model), IEC 61850 and COSEM (Companion Specification for Energy Metering). Standards used by EU-SysFlex demonstrators as well as several initiatives of European Commission and standardisation organisations were reviewed. The knowledge obtained was used for the gap analysis and recommendations. This report identifies what kind of standards evolutions are potentially necessary for flexibility services, incl. for private data management. Methods for updating and communicating changes in standards are recommended.

While this report investigates data exchange standards in general, part of the focus is specifically on data necessary for flexibility market functioning due to the nature of EU-SysFlex. The EU-SysFlex project aims to identify issues and solutions associated with integrating large-scale renewable energy and create a plan to provide practical assistance to power system operators across Europe. This plan should involve data exchange requirements, including needs for further standardisation. Data exchange has increasing importance for the liquid flexibility market involving various services and products, with many flexibility providers and a strong need for TSO-DSO coordination for acquiring flexibility.

The report is structured as follows:

- Second part of this introduction presents the standards implemented by EU-SysFlex demonstrators.
- Chapter 2 explains the general standardisation landscape and summarises the relevant existing standards and specifications, whereas:
    - Annexes I-V gives an overview of relevant IEC, CEN-CENELEC-ETSI, IEEE and ISO standards.
    - Annex VI gives an overview of several data exchange specifications like Green Button, MADES, USEF.
    - Deliverable of task 5.4 gives an overview of cybersecurity and data privacy standards (2021)[5].
- Chapter 3 provides the context, i.e. explains different standardisation related initiatives of EC, IEC, CEN-CENELEC-ETSI and ebIX®.

[5] To be published together with this deliverable.

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- Chapter 4 is the gap analysis of existing standards based on system use cases for data exchange developed by EU-SysFlex.
- Chapter 5 concludes by proposing future data exchange standards' development and methods for updating and communicating changes in standards.

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1.2 OVERVIEW OF STANDARDS IMPLEMENTED BY EU-SYSFLEX DEMONSTRATORS

Information layer

Inspired by the SGAM (Smart Grid Architecture Model) information layer describing information objects being exchanged and the underlying canonical data models, an analysis of EU-SysFlex demonstrators carried out as part of subtask 5.1.6 outlines the data models standards used to exchange data between systems (Table 1).

TABLE 1: STANDARDS AND SPECIFICATIONS USED FOR EU-SYSFLEX DATA MODELS

Data models	WP6 Germany	WP6 Italy	WP6 Finland	WP7 Portugal VPP	WP7 Portugal FlexHub	WP8 France	WP9
CIM							X
CIM CGMES	X						
ENTSO-E Reserve Resource Process (ERRP)	X						X
IEC 62325-503 (MADES)							X
IEC 60870-5 (101 or 104)	X	X	X			X	
IEC 61850		X	X			X	
IEC 60870-6 (TASE.2 ICCP)				X			
OPC UA			X	X			
Modbus						X	
Estfeed							X

Communication layer

Several EU-SysFlex documents describe the protocols used in EU-SysFlex demonstrators to exchange data between systems:

- "General description of processes and data transfer within three EU SysFlex demonstrators" (EU-SysFlex deliverable 6.4, 2019)[6],
- "Overall architectures for the VPP and Flexibility Hub" (EU-SysFlex deliverable 7.2, 2019)[7],
- "WP8 Demonstration Specification for Field Testing: Aggregation Approaches for Multi-services Provision from a Portfolio of Distributed Resources" (EU-SysFlex deliverable 8.1, 2018)[8].

These protocols are summarised in Table 2.

[6] http://eu-sysflex.com/wp-content/uploads/2019/05/Deliverable_6.4_v3.pdf
[7] Confidential
[8] http://eu-sysflex.com/wp-content/uploads/2019/02/D8.1-Demonstration-Specification-for-Field-Testing-Aggregation-Approaches-for-Multi-services-Provision-from-a-Portfolio-of-Distributed-Resources.pdf

TABLE 2: STANDARDS AND SPECIFICATIONS USED FOR EU-SYSFLEX COMMUNICATION PROTOCOLS

Data exchange protocols	WP6 Germany	WP6 Italy	WP6 Finland	WP7 Portugal VPP	WP7 Portugal FlexHub	WP8 France	WP9
IEC 60870-5 (101 ou 104)	X	X	X			X	
SCP	X						
FTP	X		X				
FTPS	X	X					
IEC 60870-6 (TASE.2 ICCP)	X						
IEC 61850		X	X			X	
RPC		X					
OPC UA			X				
SFTP				X	X		
SIEMENS WINCC OA				X			
REST						X	
Modbus						X	X
MQTT							X
JSON							X
TLS							X
Estfeed							X
HTTP							X
HTTPS							X

2. STANDARDISATION LANDSCAPE

2.1 INTERNATIONAL STANDARDISATION BODIES

Many organisations are trying to develop and establish standards for information exchange in the electricity sector. Broadly, there are limited international organisations that develop international standards as standards setting organisations (SSOs) and "thousands of industry- or sector-based standards organisations that develop and publish industry-specific standards" as standards developing organisation (SDO); "SDOs are differentiated from SSOs in that SDOs may be accredited to develop standards using open and transparent processes" [9]. International, regional, and national standards organisations exist.

Leading international standards organisations for electricity domain

IEC (the International Electrotechnical Commission)[10] is the largest and most well-established international standardisation organisation. IEC prepares and publishes international standards for all electrical, electronic and related technologies – collectively known as "electrotechnology". IEC standards cover a vast range of technologies from power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, solar energy, nanotechnology and marine energy, and many others. The IEC also manages four global conformity assessment systems that certify whether equipment, systems or components conform to its international standards. "IEC's fundamental mission is to make electrotechnology work for industries and countries throughout the world. Beyond the Smart Grid, the IEC is also deeply involved in improving the efficiency, safety and performance of all devices and systems containing electronics and generating, using, distributing, or storing electricity."[11]

IEC standards have numbers in the range 60000–79999, and their titles take a form such as *IEC 60417: Graphical symbols for use on equipment*. Standards of the 60000 series are also found preceded by EN (European Norm) to indicate that CENELEC also adopts the IEC standard as a European standard; for example, IEC 60034 is also available as EN 60034[12]. The IEC cooperates closely with the International Organisation for Standardisation (ISO) and the International Telecommunication Union (ITU). Besides, it works with several major standards development organisations, including the IEEE. Standards developed jointly with ISO carry the acronym of both organisations. The ISO/IEC prefix's use covers publications from ISO/IEC Joint Technical Committee 1 - Information Technology and conformity assessment standards developed by ISO CASCO (Committee on Conformity Assessment) and IEC CAB (Conformity Assessment Board). Other standards developed in cooperation between IEC and ISO are assigned numbers in the 80000 series, such as IEC 82045–1. IEC standards are also being adopted by other certifying bodies such as BSI (United Kingdom), CSA (Canada), U.L. & ANSI/INCITS (United States), SABS (South Africa), SAI (Australia),

[9] https://en.wikipedia.org/wiki/Standards_organisation
[10] https://www.iec.ch/
[11] http://smartgridstandardsmap.com/
[12] IEC and CENELEC cooperation is based on 'Frankfurt Agreement': https://ftp.cencenelec.eu/CENELEC/Guides/CLC/13_CENELECGuide13.pdf

SPC/GB (China) and DIN (Germany). IEC standards adopted by other certifying bodies may have some notable differences from the original IEC standard.

IEEE (The Institute of Electrical and Electronics Engineers)[13] is a professional association for electronic engineering and electrical engineering. IEEE produces over 30% of the world's literature in the electrical and electronics engineering and computer science fields, publishing journals and conference proceedings, tutorials, and standards produced by its standardisation committees. IEEE Standards Association (IEEE SA) is a leading consensus building organisation that nurtures, develops and advances global technologies through IEEE. "With an active portfolio of nearly 1,300 standards and projects under development, IEEE SA is a leading developer of industry standards in a broad range of technologies that drive the functionality, capabilities, and interoperability of a wide range of products and services, transforming how people live, work, and communicate." (IEEE website, see footnote 9)

ITU (The International Telecommunication Union)[14] is the United Nations agency for information and communication technologies (ICTs). The scope of ITU is to facilitate international connectivity in communications networks by allocating global radio spectrum and satellite orbits, developing the technical standards to interconnect networks and technologies, and striving to improve access to ICTs to underserved communities worldwide.

European (regional) standards organisations for electricity domain

CEN (French: Comité Européen de Normalisation; English: European Committee for Standardisation)[15] is a public standards organisation whose mission is to foster the economy of EU in global trading, the welfare of European citizens and the environment by providing an efficient infrastructure to interested parties for the development, maintenance and distribution of coherent sets of standards and specifications. Its thirty-four national members work together to develop European Standards (ENs) in various sectors to build a European internal market for goods and services and position Europe in the global economy. CEN is officially recognised as a European standards body by the European Union; the other official European standards bodies are CENELEC and ETSI. CEN and ISO signed the Vienna Agreement in 1991 and came into force in the mid-2000s. Its primary aim is to avoid duplication of (potentially conflicting) standards between CEN and ISO. CEN has adopted a number of ISO standards in the last decade, which replaced the corresponding CEN standards.

CENELEC (French: Comité Européen de Normalisation Électrotechnique; English: European Committee for Electrotechnical Standardisation)[16] is regional standardisation organisation responsible for European standardisation in the area of electrical engineering. Together with ETSI (telecommunications) and CEN (other technical areas), it forms the European system for technical standardisation. Although CENELEC works closely with

[13] https://www.ieee.org/
[14] https://www.itu.int/en/Pages/default.aspx
[15] https://www.cen.eu/Pages/default.aspx
[16] https://www.cenelec.eu/

the European Union, it is not an EU institution. Nevertheless, its standards are "EN" EU (and EEA) standards, thanks to EU Regulation 1025/2012[17].

ETSI (the European Telecommunications Standards Institute)[18] is an independent, not-for-profit standardisation organisation in the telecommunications industry (equipment makers and network operators) in Europe, with worldwide projection. ETSI produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies.

"In the European Union, only standards created by CEN, CENELEC, and ETSI are recognised as European standards (according to Regulation (EU) No 1025/2012), and member states are required to notify the European Commission and each other about all the draft technical regulations concerning ICT products and services before they are adopted in national law."[19]

Standards developing organisations for electricity domain

ENTSO-E (the European Network of Transmission System Operators for Electricity)[20] represents 43 electricity transmission system operators (TSOs) from 36 countries across Europe. ENTSO-E was established and given legal mandates by the EU's Third Package for the Internal energy market in 2009, aiming to liberalise the gas and electricity markets in the EU. To speed up the standardisation work in electronic data interchange (EDI) to meet the requirements from all member TSOs, ENTSO-E is leading the development of IEC Technical Specification (TS) that will be a basis for future International Standards (IS) of IEC.

ebIX®[21] is "a European platform in which TSO's, DSO's, suppliers and regulators work together. The purpose of ebIX®, the European forum for energy Business Information eXchange, is to advance, develop and standardise the use of electronic information exchange in the energy industry. Therefore, ebIX® provides standardised and harmonised processes for the liberalised downstream electricity and gas markets, focusing on information exchange, following EU rules and allowing national customisation. The ebIX® models are based on the Harmonised Electricity Market Role Model (see chapter 3.4). The main focus of the ebIX® modelling is on interchanging administrative data between different players on the internal European markets for electricity and gas. ebIX® covers the retail market's needs (downstream) and the wholesale market interface (upstream)."

[17] http://data.europa.eu/eli/reg/2012/1025/oj
[18] https://www.etsi.org/
[19] https://en.wikipedia.org/wiki/Standards_organization
[20] https://www.entsoe.eu/
[21] https://www.ebix.org/

2.2 TYPES OF STANDARDS

Following the Wikipedia there are:

- A **technical standard** is "an established norm[22] or requirement[23] for a repeatable technical task. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes, and practices. In contrast, a custom, convention, company product, corporate standard, and so forth that becomes generally accepted and dominant is often called a de facto standard[24]. A technical standard may be developed privately or unilaterally, for example, by a corporation, regulatory body, military. Standards can also be developed by groups such as trade unions and trade associations. Standards organisations often have more diverse input and usually develop voluntary standards: these might become mandatory if adopted by a government (i.e., through legislation), business contract." [25]
- A **specification** as a type of technical standard refers to documented requirements to be satisfied by a material, design, product, or service. Specifications may be developed by any organisation. "Example organisation types include a corporation, a consortium (a small group of corporations), a trade association (an industry-wide group of corporations), a national government (including its military, regulatory agencies, and national laboratories and institutes), a professional association (society), a purpose-made standards organisation such as ISO, or vendor-neutral developed generic requirements." [26]

Based on the example of IEC, standards and specifications can be split into even more specific categories. IEC has the following deliverables:

- International Standards (IS) is a document that has been developed through the consensus of experts from many countries and is approved and published by a globally recognized body. It comprises rules, guidelines, processes, or characteristics that allow users to achieve the same outcome time and time again.
- Technical Specification (TS) approaches an international standard in terms of detail and completeness but has not yet passed through all approval stages, either because consensus has not been reached or because standardisation is seen to be premature.
- Publicly Available Specification (PAS) is to speed up standardisation in areas of rapidly evolving technology and generally responds to an urgent market need. It is designed to bring the work of industry fora and consortia into the realm of the IEC. Competing publicly available specifications on the same subject are permitted.
- Technical Report (TR) focuses on a particular subject and contains for example data, measurement techniques, test approaches, case studies, methodologies and other types of information that is useful for standards developers and other audiences. It is never normative.

[22] https://en.wikipedia.org/wiki/Social_norm
[23] https://en.wikipedia.org/wiki/Requirement
[24] https://en.wikipedia.org/wiki/De_facto_standard
[25] https://en.wikipedia.org/wiki/Technical_standard
[26] https://en.wikipedia.org/wiki/Specification_(technical_standard)

- Systems Reference Deliverable (SRD) is a deliverable produced by Systems Committees (SyC) only. It is a guidance document on the use and application of specific standards in the SyC domain. It can be a normative document.
- Guides include rules, orientation, advice or recommendations relating to international standardisation and conformity assessment.

Many different standards and specifications exist for information exchange in the electricity industry. These standards are dedicated to:

- Device – to – Device communication
- IT System – to – IT System communication
- IT System – to – Device communication

Depending on the area of implementation and use cases, there are specific standards for:

- Real-time communication
- Message-based communication
- Offline information exchange

From the perspective of implementing reliable information exchange set of compliant specifications is required:

- PAYLOAD of the information (DATA MODEL)
- ENVELOPE of the MESSAGES to be exchanged
- COMMUNICATION STANDARDS between sender and receiver
- TRANSPORT standards for delivering the information on a distance

As there are many different information exchange standards, interoperability seems to be of the most importance for building complex and reliable solutions where many market players are active. Interoperability can be defined as the ability of two or more devices to exchange information and use it for correct cooperation to perform the required functions (IEC TS 61850-2, 2019)[27]. In other words, two or more systems (devices or components) are interoperable if they can perform a specific function cooperatively by using information that is exchanged.

The basis for interoperability of IT solutions and information exchange, as stated in the report of European Smart Grids Task Force Expert Group 1 (2019)[28], is formed by usage of:

- common role model (most common role model for the European energy market is presented in chapter 3.4),
- common information model (most common information model for the European energy market is presented in chapter 2.3),
- common process model,
- technology-neutral business requirements (business use cases).

[27] https://webstore.iec.ch/publication/59656
[28] https://ec.europa.eu/energy/sites/ener/files/documents/eg1_main_report_interop_data_access.pdf

It is assumed that most of the mentioned aspects are already covered in existing international or regional standards or specifications. However, detailed gap analysis of the standards (see chapter 4 for Gap analysis based on EU-SysFlex data exchange system use cases) will answer if the area of flexibility data and private data is also well covered by the existing standards and if they support business needs adequately.

2.3 COMMON INFORMATION MODEL

This deliverable covers the most important and most promising standards and specifications for flexibility information exchange. EU-SysFlex data management activities are interested in the various standards which can be used for managing information exchange for flexibility services on Internal Electricity Market (IEM) in the EU. The central part of IEC standards for Smart Grid is covered by IEC 61850 and CIM (Common Information Model) packages, as shown in Figure 1.

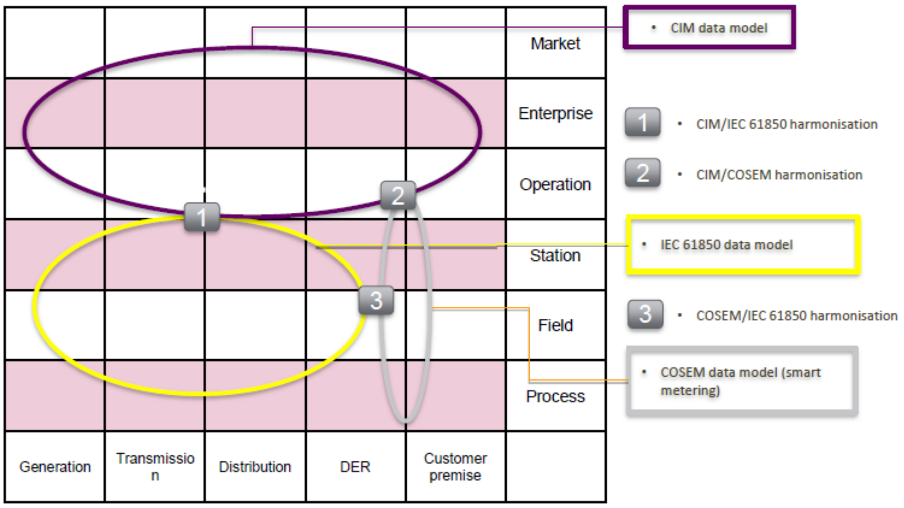

FIGURE 1: IEC CORE INFORMATION MODELS: CIM, IEC 61850, COSEM (IEC TR 62357-1, 2016[29])

CIM is an abstract model that represents all the major objects in an electricity utility enterprise, additional IEC CIM family standards (so-called "profiles") are defined to handle specific business processes. CIM data model is composed of IEC 61970-301, IEC 61968-11 and IEC 62325-301:

- The IEC 61970-301 (2020)[30] is a semantic model that describes the components of a power system at an electrical level and the relationships between each component.
- The IEC 61968-11 (2013)[31] extends this model to cover the other data aspects of power system software exchange such as asset tracking, work schedule, and customer billing.
- The IEC 62325-301 (2018)[32] caters to introducing the objects required for electricity markets' operation.

[29] Copyright © 2016 IEC Geneva, Switzerland. www.iec.ch
[30] https://webstore.iec.ch/publication/62698
[31] https://webstore.iec.ch/publication/6199
[32] https://webstore.iec.ch/publication/31487

These three standards are collectively known as the Common Information Model (CIM) for power systems and currently have three primary uses:

- to facilitate the exchange of power system network data between organisations;
- to allow the exchange of data between applications within an organisation;
- to exchange market data between organisations.

Many information exchanges in EU have been already defined for network planning (e.g. HVDC network development, interconnection development to tackle congestions), power system operation (e.g. real-time information on the generation output, balancing control), market operations (e.g. generation schedules, trades, balancing resource management, settlement). These processes require TSOs, DSOs, third parties and service providers to use commonly agreed and compatible data exchange standards.

CIM is the most recognised and widely used European electricity market standardised information model defined by the International Electrotechnical Commission's (IEC). CIM supports European regulation since 2010 with CGMES (Common Grid Model Exchange Standard) 1.0 profiles, and with ESMP (European Style Market Profile) profiles since 2011. As adopting and using one of the existing international reference models is the first recommendation of the European Smart Grids Task Force Expert Group 1 – 'Standards and Interoperability' and IEC CIM information model is pointed out as one of the most important for interoperability for electricity and gas data access and exchange within EU (2019)[33], CIM is also important as a reference model in EU-SysFlex data exchange demonstrations.

2.4 SUMMARY OF EXISTING DATA EXCHANGE STANDARDS AND SPECIFICATIONS

In total, 42 standards and specifications were evaluated against 16 EU-SysFlex system use cases (SUCs) identified in Task 5.2 for data management functional processes[34] (EU-SysFlex Deliverable 5.2, 2020)[35]. The results of the Evaluation based on use cases are presented in Figure 2. Most SUCs are covered by a few IEC standards, such as IEC 62325 (13 SUCs), IEC 62351 (12 SUCs) and IEC 62325-503 (12 SUCs). The following non-IEC standards can be applied in 8-9 SUCs: ISGP, USEF and Green Button specifications. Sixteen standards were excluded from the figure as they cover less than three SUCs.

[33] https://ec.europa.eu/energy/sites/ener/files/documents/eg1_main_report_interop_data_access.pdf

[34] System use cases describe in more detail the functionalities of a business process involving system roles like specific softwares (SGAM function layer), while business use cases describe the business process itself and the interactions between business roles only (SGAM business layer) (IEC 62913-1, 2019; IEC 63200, 2021).

[35] https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf

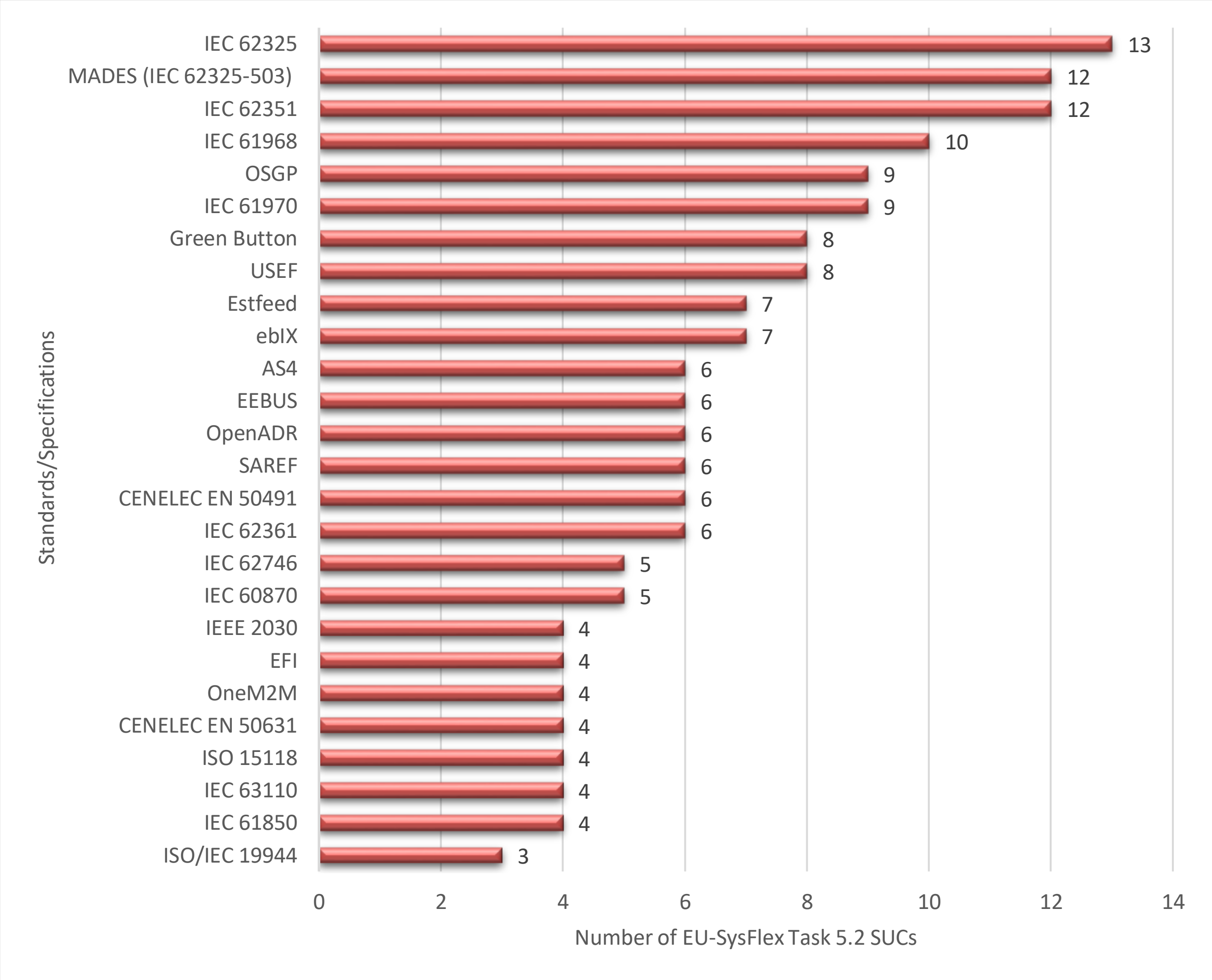

FIGURE 2: NUMBER OF EU-SYSFLEX TASK 5.2 SYSTEM USE CASES COVERED BY EACH STANDARD AND SPECIFICATION

Figure 3 presents the most frequently covered SUCs for 42 standards and specifications analysed in this study. One of the most common SUCs covered by the majority of standards and specifications is “Transfer energy data” – 28 standards and specifications are applicable to the use case. The next is “Collect energy data”, with 23 standards and specifications that can be applied for this SUC. The most rarely covered SUCs are “Erase and rectify personal data”, “Calculate flexibility baseline” and “Verify and settle activated flexibilities”.

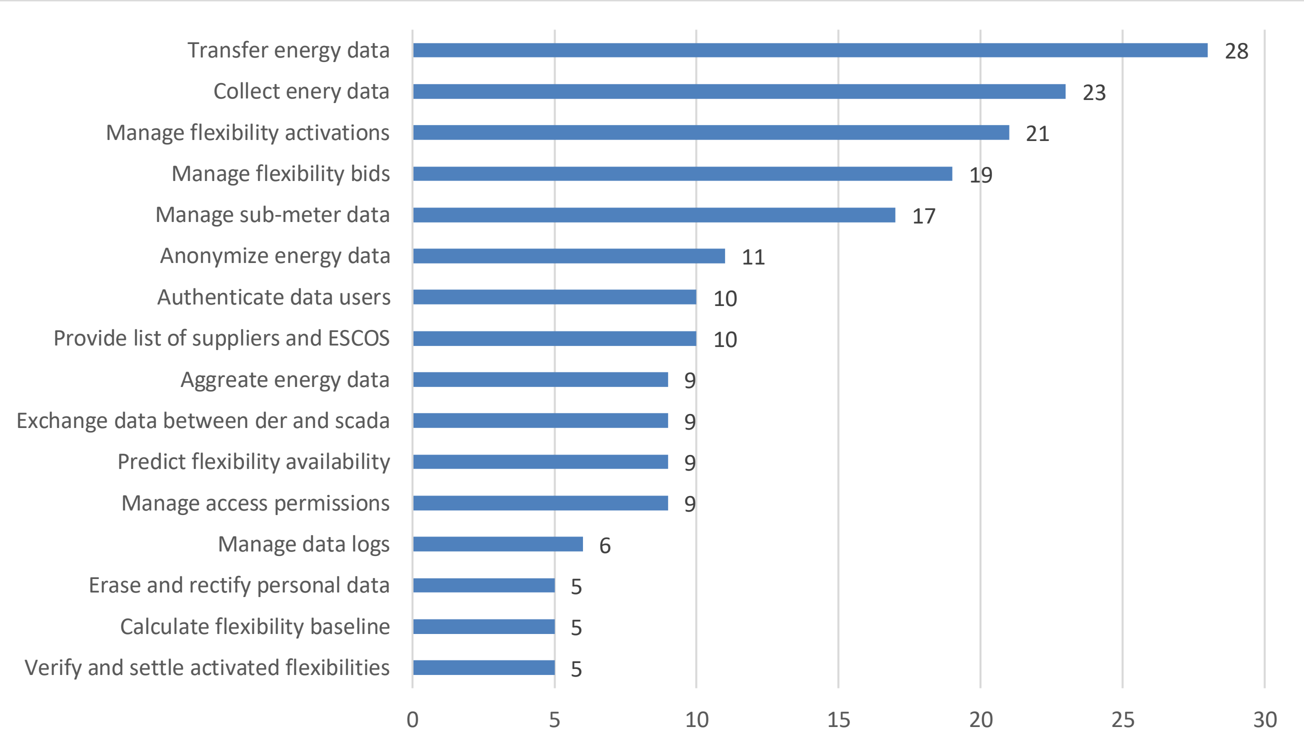

FIGURE 3: NUMBER OF STANDARDS AND SPECIFICATIONS PER EU-SYSFLEX TASK 5.2 SYSTEM USE CASE

A short description of each standard and specification follows, and longer descriptions for the majority of these are available in Annexes I-VI. See Figure 3 for the area of application of many IEC standards (IEC TR 62357-1, 2016).

IEC 61970

IEC 61970 deals with the application program interfaces of energy management systems. The series consists of several parts and specifies various components. One goal is to develop a data model which is agnostic to specific platforms and technologies. For this purpose, a comprehensive data model (Common Information Model) is defined in IEC 61970-301. CIM aims to create a data model that describes electrical grid and related data (e.g. generator models). Based on CIM profiles can be derived to model specific business processes. IEC 61970 covers 9 SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Calculate flexibility baseline", "Predict flexibility availability", "Manage sub-meter data", "Exchange data between DER and SCADA".

IEC 61968

IEC 61968 defines standards for the exchange of information between electrical distribution grids. The integration of different data from different applications is supported. IEC 61968 also defines interfaces for all essential elements for distribution management systems (DMS). It is to be implemented with middleware services that mediate messages between applications. IEC 61968 covers 10 SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Calculate flexibility baseline", "Predict flexibility availability", "Manage sub-meter data", "Exchange data between DER and SCADA", "Anonymise energy data", "Aggregate energy data".

IEC 62325

IEC 62325 is the set of standards for European energy market data modelling. IEC 62325 standards can potentially be used for 13 SUCs: "Collect energy data", "Transfer energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Verify and settle activated flexibilities", "Authenticated data users", "Calculate flexibility baseline", "Predict flexibility availability", "Manage sub-meter data", "Exchange data between DER and SCADA", "Anonymise energy data", "Aggregate energy data".

IEC 61850

The IEC 61850 standard aims to increase interoperability in the energy sector and is mainly used for communication to substations and other distribution systems. The standard defines the communication to the individual devices and a separate data model for different device types. IEC 61850, together with COSEM, complements CIM – harmonisation exists between these three core data models. The IEC 61850 standard satisfies the following list of SUCs: "Collect energy data", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data", "Predict flexibility availability".

IEC 62056

IEC 62056 is a series of standards specifying a language for data exchange with smart (meter) devices. It is an international version of DLMS/COSEM specification. COSEM (Companion Specification for Energy Metering) is the object model of the smart meter. DLMS (Device Language Message Specification) is the application layer protocol of smart meter messages. Originally, IEC 62056 standards have been developed for electricity metering. Now some parts of it can also be used for smart devices. Such meters have an increasing number of functionalities, including consumption management, near-real-time measurements, and therefore their communication capabilities become increasingly critical to ensure interoperability and secure data exchange. DLMS/COSEM does not cover collecting data into and storing in central data hubs/warehouses (except communication and data model part), nor does it cover head-end systems at data platforms or data brokers, nor does it cover centralised consent-based access to data. DLMS/COSEM supports gateways and services via SoaP. DLMS/COSEM has a very complete set of interface classes for handling data users' authorisation, and various levels of cyber security. IEC 62056 satisfies a few SUCs such as: "Collect energy data", "Transfer energy data", "Manage sub-meter data".

IEC 60870

The IEC 60870 standard defines systems used for supervisory control and data acquisition, also known as SCADA or telecontrol, for the electrical engineering and power system automation domain. Such systems are used for overseeing electric power transmission grids and other geographically widespread control systems. The IEC 60870 standard has six parts, defining general information related to the standard, operating conditions, electrical interfaces, performance requirements and data transmission protocols. IEC 60870 is one of the standards recommended for "Collect energy data", "Exchange data between DERs and System Operators", "Manage flexibility bids", "Manage flexibility activations", "Predict flexibility availability" SUCs.

IEC 61334

IEC 61334 enables distribution automation using distribution line carrier systems. It is a standard for low-speed reliable power line communications by electricity meters and SCADA (IEC 61334-5-1, 2001). IEC 61334 contains well researched documentation on physical environment of power lines, a well-adapted physical layer, a workable low-power media access layer, and a management interface. The IEC 61334 (entirely or partially) can be applied for the SUCs from Task 5.2 related to data transfer such as “Collect energy data”, “Transfer energy data”.

IEC 62051-62054/62058-62059

Physical construction requirements and testing of meters and metering equipment are covered in IEC 62051 (Electricity metering - Data exchange for meter reading, tariff and load control - Glossary of terms), IEC 62052 (Electricity metering equipment (AC) - General requirements, tests and test conditions), IEC 62053 (Electricity metering equipment - Particular requirements), IEC 62054 (Electricity metering (AC) - Tariff and load control), IEC 62058 (Electricity metering equipment (AC) - Acceptance inspection) and IEC 62059 (Electricity metering equipment – Dependability) standards. As these standards are not concerned with data privacy or data exchange, they are not relevant for this report. IEC 62051 has potential to be used in SUCs related to “Collect energy data”.

IEC 62746

IEC 62746 consists of many parts, and descriptions of two relevant sections follow. IEC TR 62746-2 (2015)[36] is a Technical Report that describes the “main pillars of interoperability to assist different Technical Committees in defining their interfaces and messages covering the whole chain between a smart grid and smart home/building/industrial area.” The “report focuses on the signals exchanged between the grid and the premise, which may go from simple signalling to integrated load management.” IEC TS 62746-3 (2015)[37] is a Technical Specification that establishes an architecture for interfaces between the Customer Energy Management System, including DER Management System, and the Power Management System. “The data model of IEC 62746 is based on the Common Information Model and IEC 61850. IEC 62746 is transport independent.” IEC 62746 has the potential to be used in SUCs related to “Collect energy data”, “Manage flexibility bids”, “Manage flexibility activations”, “Manage sub-meter data”, “Predict flexibility availability”.

IEC 62351

The IEC 62351 standard regulates power systems management and associated information exchange, focusing on data and communications security. The IEC 62351 standard covers 12 SUCs in total: “Collect energy data”, “Transfer energy data”, “Provide a list of suppliers and ESCOS”, “Manage flexibility bids”, “Manage flexibility activations”, “Manage access permission“, “Authenticate data users”, “Manage data logs”, “Predict flexibility availability”, “Manage sub-meter data”, “Exchange data between DER and SCADA”, “Aggregate energy data”.

[36] https://webstore.iec.ch/publication/22279
[37] https://webstore.iec.ch/publication/23488

IEC 62361

IEC 62361 (Power systems management and associated information exchange - Interoperability in the long term) is a set of documents (international standards, technical specification, technical report) that concerns interoperability issues between various IEC standards. For example, IEC 62361-2 (2013) “documents the quality codes used by existing IEC standards related to supervisory control and data acquisition (SCADA)”. IEC TS 62361-102 (2018) provides an approach for information exchange between electrical installations and systems using CIM standards, basically aiming at harmonisation between CIM and IEC 61850. IEC TR 62361-103 (2018) introduces standard profiling concepts for Common Information Model and the IEC 61850 standard series. “It serves as an introduction to profiling concepts and methodologies for the development of profiles for providing interoperability.” The IEC 62361 standard covers 6 SUCs in total: “Collect energy data”, “Manage flexibility bids”, “Manage flexibility activations”, “Verify and settle activated flexibilities”, “Calculate flexibility baseline”, “Predict flexibility availability”.

IEC 63110

The IEC 63110 standard is currently in the development phase and covers the management of electric vehicle charging and discharging infrastructure. It will address the requirements and information exchange to establish an electro-mobility ecosystem. IEC 63110 considers the communication flows between the different electro-mobility actors and data flows within the electric power system: energy transfer, grid usage, contractual and metering data, asset management of electric vehicle supply equipment, authentication, authorisation, payment of charging and discharging sessions. IEC 63110 is designed using the SGAM (Smart Grid Architecture Model) methodology considering cybersecurity, interoperability, grid integration and scalability. It has links with four EU-SysFlex system use cases (with some e-mobility adjustments): “Transfer energy data”, “Manage flexibility bids”, “Manage flexibility activations”, “Manage sub-meter data.”

CEN EN 13757

According to OMS Group (2014), “the standard series EN 13757 is the only communication standard for meters and related equipment which places the user into a position to cover measuring instruments of all media economically with one communication system”. EN 13757 references the DLMS/COSEM specification (see IEC 62056) for data exchange and communication as well as specifies requirements for layers of M-Bus communication. EN 13757 is applicable to use for electricity, heat meters, heat cost allocators, water meters and gas meters. CEN EN 13757 satisfies 2 SUCs from Task 5.2: “Collect energy data”, “Transfer energy data”.

CEN EN 16836

The EN 16836 standard contains a standardisation framework for the exchange of data from metering devices to other devices within a mesh network, such as in-home displays and communications hubs. The standard sets requirements for gas, heat, water meters, and also for electricity on the sub-meter level. The standard refers to the specifications by the ZigBee Alliance. CEN EN 16836 satisfies 2 SUCs from Task 5.2: “Collect energy data”, “Transfer energy data”.

CENELEC EN 50631

EN 50631-1 defines data models for Interoperable Connected Household Appliances. Standardised data models and neutral message structures need to be agnostic to communication technologies and any product specific layout. The standard specifies how sets of products from multiple manufacturers are able to interoperate with Home & Building / Customer Energy Management Systems (located in a home network or in the cloud), in the most interoperable manner. The CENELEC EN 50631 satisfies (entirely or partially) the following SUCs from Task 5.2: "Transfer energy data", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data".

CENELEC EN 50491

Relevant standards in the EN 50491 series cover general functional safety requirements for products intended to be integrated in Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS). EN 50491 includes application specifications of smart meters simple external consumer display, as well as general requirements and architecture for interface between the Customer Energy Manager (CEM) and Home/Building Resource manager. CENELEC EN 50491 is directly relevant for the following SUCs: "Collect energy data", "Transfer energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data".

CENELEC EN 50090

EN 50090 describes the KNX standard for commercial and domestic building automation. KNX enables access and security, remote meter reading, energy management and safety. The KNX standard covers the full scope of applications and communication media of integrated automation and control, including lighting, shading, shutters, blinds, household appliances, heating, cooling, ventilation and air-conditioning. KNX could potentially be used for device control, in place of other protocols like ZigBee, Modbus and OPC and covers 2 SUCs from Task 5.2: "Collect energy data", "Transfer energy data".

IEEE 2030

IEEE 2030.5 standard defines the application layer in the transport and internet layers "to enable utility management of the end user energy environment, including concepts like demand response, load control, time of day pricing, management of distributed generation, electric vehicles" (IEEE 2030.5, 2018). It is the standard for two-way communication between residential smart devices and utilities - system operators and power suppliers. The IEEE 2030 standard is directly related to 4 SUCs: "Manage sub-meter data," "Transfer energy data", "Manage flexibility bids", "Manage flexibility activation".

IEEE 802/1901

IEEE 802 series and IEEE 1901 series standards are used for smart grid communication. IEEE 802/1901 standards are relevant to SUCs such as: "Collect energy data", "Transfer energy data".

ISO/IEC 19944

ISO/IEC 19944 defines how data can be handled in a cloud system, including cross-border data transfer, data geolocation, data usage, data access, and data portability. Energy data (e.g., consumption data) can represent sensitive data. This standard could better regulate the handling of such data. The ISO/IEC 19944 standard covers 3 SUCs: "Transfer energy data", "Manage data logs", "Erase and rectify personal data".

ISO 15118

ISO 15118 is a standard that enhances communication between electric vehicles and the recharging infrastructure. It will become an international standard defining a Vehicle to Grid (V2G) communication interface for bi-directional charging/discharging of electric vehicles (future ISO 15118-20). The user-convenient and secure "Plug & Charge" feature that comes with ISO 15118 enables the electric vehicle to automatically identify (id and charging contract) and authorise itself to the charging station on behalf of the driver, to receive energy for recharging its battery. Another purpose of ISO 15118 is to integrate electric vehicle in the smart grid to enable flexible load control (reflecting for example a local or regional grid situation); this would enable valuable grid flexibility services. The ISO 15118 standard is related to the following SUCs: "Manage sub-meter data", "Manage flexibility activations", "Transfer energy data", "Provide a list of supplier and ESCOS".

MADES (IEC 62325-503)

MArket Data Exchange Standard (MADES) is "a specification for a decentralised common communication platform based on international IT protocol standards" (ENTSO-E, 2014). MADES specifies a standardised communication platform for TSOs to reliable and secure exchange of documents. Market participants like suppliers and DSOs can "benefit from a single, shared, harmonised, and secure platform for message exchange with the different TSOs, thus reducing the cost of building different IT platforms". It means that stakeholders can easily enter other markets in Europe. "The transported object is a "message" in which the sender document is securely repackaged in an envelope (i.e. a header) containing all the necessary information for tracking, transportation, and delivery." A standard relevant to MADES is IEC TS 62325-504 – Utilization of web services for electronic data interchanges on the European energy market for electricity (2015). MADES is relevant for the following SUCs: "Transfer energy data", "Manage access permissions", "Authenticate data users", "Manage data logs", "Anonymise energy data", "Aggregate energy data", "Collect energy data", "Provide a list of suppliers and ESCOS", Manage flexibility activations", "Verify and settle activated flexibilities", "Calculate flexibility baseline", "Manage sub-meter data".

OneM2M

OneM2M is a project to create a global technical standard for machine-to-machine interoperability. It is focused on architecture, application programming interface (API) specifications, security, and enrolment. It is independent of the technology used for the information transfer. OneM2M is relevant for the following SUCs: "Collect energy data", "Transfer energy data", "Manage sub-meter data", "Exchange data between DER and SCADA".

Energy Flexibility Interface

Energy Flexibility Interface (EFI) is a communication protocol that enables end-users to unlock flexible energy opportunities by controlling "various smart devices such as washing machines, air conditioning units, solar panels, and car chargers". It was established in 2013 by Flexible Power Alliance Network (FAN), bringing together Dutch market-leading partners and organisations to enable a controlled and reliable energy transition. EFI is specifically designed as a standard communication method between smart devices and demand-side management solutions. The EFI standard is related to the following SUCs: "Manage sub-meter data", "Manage flexibility activations", "Manage flexibility bids", "Transfer energy data".

SAREF

The Smart Applications REFerence (SAREF) is a reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT (Viola, 2015). It helps to define the concepts in the message data structures that are shared at the underlying technological level, regardless of the details of the underlying communication protocol, standard, or data model (Daniele, 2015). SAREF satisfies the following SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations," "Manage sub-meter data."

OpenADR

OpenADR is an emerging, open, two-way information model designed to facilitate information exchange between energy management systems (and the resources they control) and other energy system actors. OpenADR standardises the message format used for demand response. Dynamic price and reliability signals can be delivered in a uniform and interoperable fashion among energy management systems and buyers of demand response (e.g., system/network operators and balancing responsible parties). The current OpenADR specification (OpenADR 2.0) is being developed by the OpenADR alliance, "a mutual benefit corporation created to foster the development, adoption, and compliance of the OpenADR Smart Grid standard"[38]. OpenADR focuses on the connection of DERs to upstream actors (e.g., grid operators or balancing responsible parties who want to access the flexibility of DERs). Energy system actors may wish to communicate with such assets to modulate their operation for some network management or commercial purpose. OpenADR is relevant for the following SUCs: "Collect energy data," "Transfer energy data," "Manage flexibility bids," "Manage flexibility activations," "Manage sub-meter data," "Exchange data between DER and SCADA."

EEBUS

EEBUS is developed by the EEBUS initiative, founded in 2012 by Germany's Federal Ministry of Economics. The board and members of the EEBUS initiative are predominantly continental European. EEBUS is an open, two-way information model designed to facilitate information exchange between:

1. Demand response (DR)/distributed energy resources (DER)/smart devices and a gateway device/energy management system, and
2. Between the gateway/energy management system and other energy system actors. It also covers 'grid interactions'.

EEBUS architecture contains an 'information layer' (Specification Smart Premises Interoperable Neutral Message Exchange – SPINE) and a 'communication layer' (Smart Home IP – SHIP). This separation of layers follows the

[38] https://www.openadr.org/openadr-alliance-releases-20a

principles of the Smart Grid Architecture Model (SGAM). EEBUS is directly relevant for the following SUCs: "Collect energy data", "Transfer energy data", "Exchange data between DERs and SCADA", "Manage sub-meter data". Due to its general and modular design, it seems that EEBUS could be easily modified to satisfy the following SUCs: "Manage flexibility bids", "Manage flexibility activations".

AS4

AS4 is an Energy Market Profile for secure and reliable document exchange using AS4 messaging (NEDU, 2019). The profile is developed for interactions in both electricity and gas markets. The profile defines a minimum number of settings and configurable parameters to optimise communication and reduce the maintenance and management costs. Using the profile in AS4 communication produces a consistent, stable and interoperable communication between market parties. The profile is based on the international AS4 standard and the European eDelivery AS4 Profile (European Commission, 2018). AS4 is directly relevant for the following SUCs: "Transfer energy data", "Manage access permissions", "Authenticate data users", "Manage data logs", "Anonymise energy data", "Aggregate energy data".

ebIX®

Energy Business Information Exchange (ebIX®) is a European platform which aims to standardise electronic information exchange between energy providers (TSO's, DSO's, suppliers, and regulators) and users. ebIX® was founded in 2003 and developed as continuation of work started by Nordic Ediel Forum. ebIX® focuses on standardised and harmonised processes for the retail (upstream) and wholesale (downstream) electricity and gas markets (ebIX® website, 2017). The ebIX® information model can be mapped to CIM, and a description of this mapping is provided in IEC TR 62325-103 (2017). ebIX® satisfies (entirely or partially) the following SUCs from Task 5.2: "Collect energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Verify and settle activated flexibilities", "Manage access permissions", "Calculate flexibility baseline".

Estfeed

Estfeed is the first highly secure platform and protocol for distributed exchange of private energy metering data between Data Providers and Data Users with Data Owner's consent. Estfeed is designed and operated by Elering AS, the Estonian transmission system operator (TSO).

- Estfeed is compliant with EU regulations (Clean Energy Package and GDPR);
- It is secure, proven and scalable, and enables to save resources from developing the platform from scratch;
- Estfeed provides flexible ways to share energy data with energy services who want to access it.

Estfeed is directly relevant for the following SUCs: "Transfer energy data", "Manage access permissions", Authenticate data users, "Manage data logs, "Anonymise energy data", "Aggregate energy data", "Erase and rectify personal data".

USEF

The Universal Smart Energy Framework (USEF) is a collective initiative of top sector companies in the Netherlands to standardise smart grids. The USEF Foundation aims to create an open platform to boost development of smart energy services and facilitate access to the grid for stakeholders. The framework defines a modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message formats (USEF Foundation website, 2020). USEF is relevant for the following SUCs: “Manage flexibility bids”, “Manage flexibility activations”, “Verify and settle activated flexibilities”, “Manage access permissions”, “Authenticate data users”, “Calculate flexibility baseline”, “Predict flexibility availability”, “Anonymise energy data”.

OSGP

The Open Smart Grid Protocol (OSGP) is a family of specifications developed by OSGP Alliance. It was published by the European Telecommunications Standards Institute (ETSI). OSGP is designed to securely and efficiently provide command and control information for smart grid devices such as meters, solar panels, and direct load control modules. It is intended to support communication between large deployments of smart grid devices and utility companies for billing purposes, control users' consumption in case of an energy shortage, and provide consumption information to users (OSGP Alliance website, 2020). The OSGP satisfies the following SUCs from Task 5.2: “Collect energy data”, “Transfer energy data”, “Aggregate energy data”, “Manage flexibility bids”, “Manage flexibility activations”, “Authenticate data users”, “Manage sub-meter data”, “Exchange data between DER and SCADA”, “Anonymise energy data”.

Green Button

Green Button (GB) is a U.S. specification that helps utility companies share DSO time-series consumption data directly with customers. The sharing occurs via the utilities’ website or via third-party applications in a secure manner to keep the anonymity of the person behind the data. The ESPI (Energy Services Provider Interface) standard of NAESB (North American Energy Standards Board) defines the data exchange protocol. A detailed description of the GB standard is available on the Green Button website, which also contains technical implementation links (Green Button Data, 2020). In total, GB satisfies 8 SUCs defined in Task 5.2 such as “Transfer energy data”, “Provide a list of suppliers and ESCOs”, “Manage access permissions”, “Authenticate data users”, “Manage data logs”, “Anonymise energy data”, “Aggregate energy data”, and “Erase and rectify personal data”.

FIWARE

FIWARE is an open-source framework that provides access to an advanced application programming interface (API) named FIWARE NGSI (Next Generation Service Interface) for context data management. The FIWARE framework enables the development of a system that allows to capture data from multiple sources and analyse that information to implement desired outcomes and behaviour without being limited to specific standards. It facilitates the development of Smart Solutions for different domains such as Smart Cities, Smart Industry, and Smart Energy. FIWARE is directly relevant for the “Transfer energy data” SUC. Due to its general and modular design, with 3rd parties’ extensions, FIWARE could be easily modified to satisfy all SUCs.

3. CONTEXT

3.1 EUROPEAN COMMISSION'S INITIATIVES AND ACTIONS TOWARDS DATA INTEROPERABILITY

3.1.1 SMART METERING

In 2009 European Commission issued a mandate to CEN, CENELEC and ETSI to develop interoperability standards for electricity, gas, heat and water utility meters to facilitate customers' awareness of their actual consumption – Mandate M/441 (EC, 2009)[39]. According to the mandate, EC expected a software and hardware architecture for bidirectional communication through standardised interfaces and data formats, allowing remote data collection and control systems for both consumers and energy service providers.

Standardisation organisations responded to the mandate by producing a report from their Smart Meters Coordination Group (which involves other relevant stakeholders) describing the work undertaken at the end of 2012 (CEN-CENELEC-ETSI SMCG, 2012)[40]. One of the primary deliverables has been a technical report proposing functional reference architecture for communications in smart metering systems (CEN/CLC/ETSI/TR 50572, 2011)[41]. This technical report recognises few generic functionalities related to smart metering as listed below and visualises a reference architecture for smart metering as depicted in Figure 4:

- remote reading of metrological register(s) and provision to designated market organisations;
- two-way communication between the metering system and designated market organisation(s);
- to support advanced tariffing and payment systems;
- to allow remote disablement and enablement of supply and flow/power limitation;
- to provide secure communication enabling the smart meter to export metrological data for display and potential analysis to the end consumer or a third party designated by the end consumer;
- to provide information via a web portal/gateway to an in-home/building display or auxiliary equipment;
- to enable communication of AMI components with devices or gateways within the home/building used to provide energy efficiency and demand-side management services.

[39] https://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=421#
[40] ftp://ftp.cencenelec.eu/EN/EuropeanStandardisation/HotTopics/SmartMeters/CENCLCETSI_SMCG_end2012.pdf
[41] ftp://ftp.cen.eu/cen/Sectors/List/Measurement/Smartmeters/CENCLCETSI_TR50572.pdf

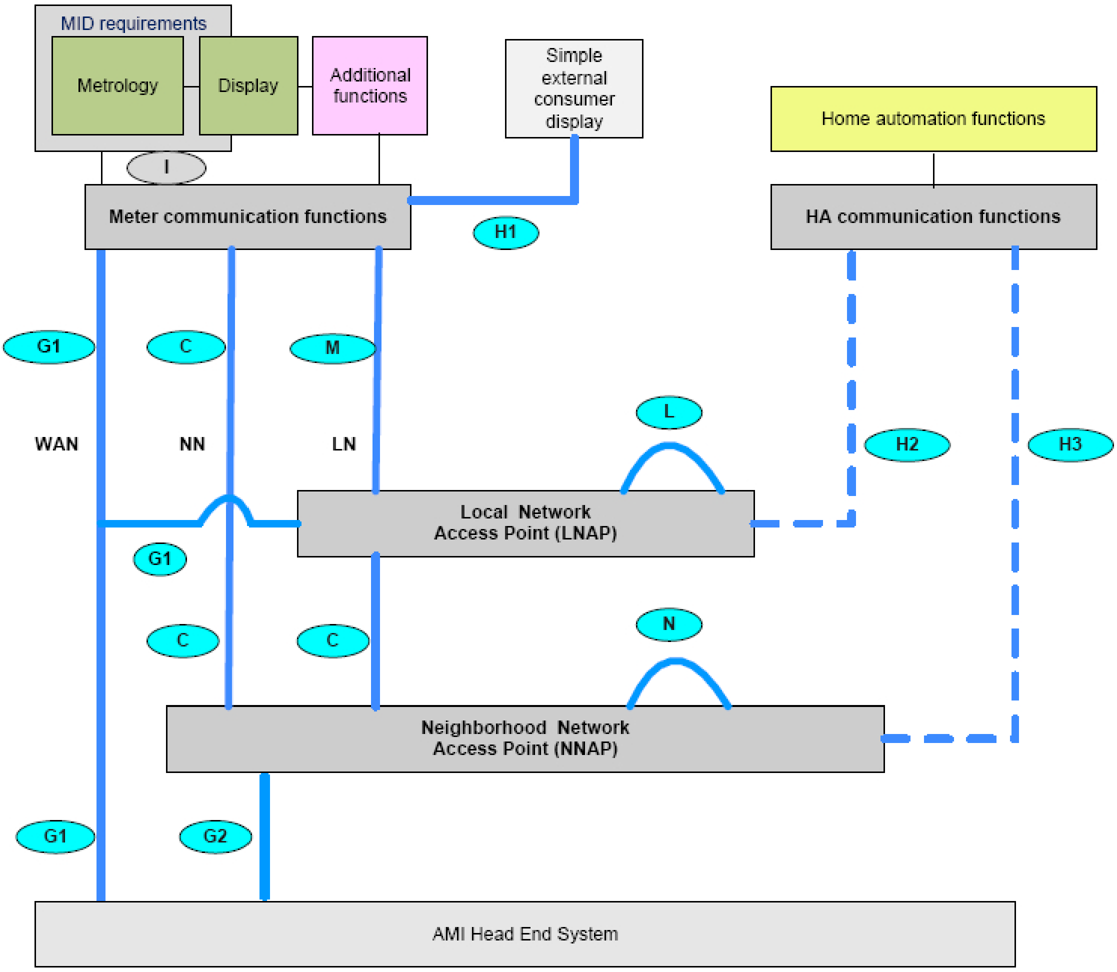

FIGURE 4: REFERENCE ARCHITECTURE DIAGRAM FOR SMART METERING COMMUNICATIONS (CEN/CLC/ETSI/TR 50572, 2011[42])

European Commission recommends ten standard minimum functional requirements for electricity smart metering systems (EC 2012/148/EU, 2012)[43]:

(a) Provide readings directly to the customer and any third party designated by the consumer.
(b) Update the readings referred to in point (a) frequently enough to allow the information to achieve energy savings.
(c) Allow remote reading of meters by the operator.
(d) Provide two-way communication between the smart metering system and external networks to maintain and control the metering system.
(e) Allow readings to be taken frequently enough for the information to be used for network planning.
(f) Support advanced tariff systems.
(g) Allow remote on/off control of the supply and flow or power limitation.
(h) Provide secure data communications.
(i) Fraud prevention and detection.
(j) Provide import/export and reactive metering.

[42] © CEN, reproduced with permission. © CENELEC, reproduced with permission. Reproduced with ETSI permission.
[43] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593168383796&uri=CELEX:32012H0148

<u>To conclude:</u>

- The scope in the area of smart metering' and 'smart meters' is limited to the meters addressed in the EU directive on measuring instruments (Directive, 2014/32)[44] – 'MID-compliant' energy meters[45]. This means that the 'sub-meters located beyond MID-compliant meters and providing measurements on individual device level (e.g. PV panel, heat pump, EV charger) are excluded.
- The requirements for smart metering and smart meters are rather of the nature of physical devices' technical capabilities and less related to the solutions for data exchange between multiple parties.

Therefore, standardisation in the field of smart meters is out of the scope of this report.

3.1.2 SMART GRID INTEROPERABILITY

In 2011, to take a step further, the European Commission issued another mandate to CEN, CENELEC and ETSI to develop an interoperable framework for standardisation in Smart Grids – Mandate M/490 (EC, 2011)[46]. A reference architecture was requested to address smart metering and other related domains like grid operation, grid automation, distributed energy resources management, industrial automation, building, and home automation. Also, "a set of consistent standards" for information exchange (communication protocols and data models) as well as "sustainable standardisation processes and collaborative tools" were expected.

As the response, CEN, CENELEC and ETSI have proposed the Smart Grid Architecture Model (see chapter 3.3.1), Smart Grid Set of Standards (see chapter 3.3.2) and an Interoperability Tool (see chapter 3.3.3).

European Commission has continued working in the field of interoperability through Smart Grids Task Force (SGTF).

SGTF focused on interoperability of interfaces 'H1' and 'H2' (see Figure 4 in chapter 3.1.1) of smart metering systems in its 2016 report (SGTF EG1, 2016-1)[47]. The report describes ensuring and maintaining interoperability through Basic Application Profiles (BAPs) and BAP Test Specifications – Basic Application Interoperability Profiles (BAIOPs), which help identify and utilise relevant standards and specifications.

Since then, data access and data sharing more broadly has been the focus of SGTF. The aim of "My Energy Data" report (SGTF EG1, 2016-2)[48] was "to identify possible obstacles for controlled data access and data management, and to explore at EU level the potential for and scope of a possible industrial initiative on a common format for energy data interchange". Few case studies in terms of meter data type, information model and file format were analysed (Table 3). The report recommended the services "download my data" and "share my data" to be specified from the perspective of functionality, protocols and data formats. IEC 62325-451-10 – Profiles for Energy Consumption Data ("My Energy Data") built on this work (2020)[49].

[44] https://eur-lex.europa.eu/eli/dir/2014/32/oj
[45] Terms used for 'MID-compliant meters' may also be 'validated meters' or 'certified meters'.
[46] https://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=475#
[47] https://ec.europa.eu/energy/sites/ener/files/documents/20160829_EG1_Final%20Report%20V1.1.pdf
[48] https://ec.europa.eu/energy/sites/ener/files/documents/report_final_eg1_my_energy_data_15_november_2016.pdf
[49] https://webstore.iec.ch/publication/61111

TABLE 3: SUMMARY OF MAIN STANDARDS IN USE IN MEMBER STATES CONSIDERED (SGTF EG1, 2016-2)

Member State	Meter Reading Data available	Information Model	File format
France	Indexes (day), Load curve	Specific	CSV (RFC 4180)
Spain	Load profile	Specific	CSV (RFC 4180), Excel, PDF
Germany	Load curve	Specific	JSON (RFC 7159, ECMA 404 & 262)
Estonia	Load curve	Specific	XML (W3C)
Italy	Indexes (day, month), Load curve	Specific	
The Netherlands	Load curve	Specific	P4 : XML (W3C)
	Load curve (direct access to the meter)	DLMS/COSEM IEC 62056-61	P1 : IEC 62056-21
Great Britain	Meter registers; 13 months of half hourly interval readings for imported energy	DLMS/ COSEM and ZigBee Smart Energy on the metering equipment	Zig Bee Smart Energy over the smart meter home area network; XML from DCC (remotely)
Belgium	load curve	specific	EDIEL - XML in preparation
Denmark	Load curve	specific	ebIX

SGTF report from 2019 makes several recommendations towards interoperability for data access and exchange (SGTF EG1, 2019)[50]. The closest ones concerning standardisation are as follows:

- Building on available role models, adopt and use a common European role model.
- To facilitate interoperability, adopt and use a common information model for semantics, for example, consider building on the available IEC CIM model.
- Adopt and use a core process model to allow for national specificities and stay open for further interoperability over time.
- Business requirements shall be the basis for interoperability and must remain technology-neutral.
- Adopt and use available European standards as a basis to improve interoperability.

In 2020 European Commission, through SGTF EG1, started to develop data interoperability implementing act as required in electricity market directive (Directive, 2019/944)[51] according to article 24(2): “The Commission shall

[50] https://ec.europa.eu/energy/sites/ener/files/documents/eg1_main_report_interop_data_access.pdf
[51] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593158348328&uri=CELEX:32019L0944

adopt, through implementing acts, interoperability requirements and non-discriminatory and transparent procedures for access to data referred to in Article 23(1)."

To conclude: Interoperability is in the explicit focus of EU-SysFlex as it enables exchange of any data type between multiple stakeholders and multiple systems. However, EU-SysFlex prioritises mutual understanding in terms of business processes, data exchange functionalities and data models rather than harmonising data formats and communication protocols.

3.1.3 INTEROPERABILITY FOR DEMAND SIDE FLEXIBILITY

European Commission considers Smart Appliances REFerence (SAREF) ontology[52] (see also Annex VI-4) as the necessary framework to model data exchange with prosumers assets providing flexibility. This concerns demand-side assets primarily but could be adapted to the prosumer's smaller-scale energy storage and generation facilities. SAREF was initially proposed by TNO (2015) and then standardised as ETSI Technical Specification (ETSI TS 103 264, 2020).

In the study prepared for the EC by PwC and Tractebel (2020), the action is recommended to promote the European wide adoption of "SAREF family of standards" by no later than 2023 to enable interoperability in the smart appliances' domain relevant for energy.

For participating in the flexibility market interoperability is needed between assets providing flexibility (smart appliances), smart meters and (home, building) energy management systems. This interoperability can be strengthened if based on standardised data semantics of communication interfaces.

Another study prepared for the EC by DNV GL, ESMIG, TNO (2018) focuses on data semantics under the assumption that if data elements specified by different standards are aligned, the information can seamlessly flow through the various interfaces of the DSF (Demand Side Flexibility) flow. Several standards addressing interfaces for DSF flow were reviewed: CEN 16836 (ZigBee SEP2), CENELEC EN 50491-11 Smart Metering, CENELEC EN 50631-1 (SPINE), ETSI TS 103 264 (SAREF), ETSI TS 103 410-1 (SAREF4ENER), IEC 61968-9 CIM for metering, IEC 61970 CIM, IEC/CENELEC 62056 COSEM, CENELEC EN 50090 (KNX), oneM2M TS 0012 Base Ontology (Figure 5).

The SAREF and SAREF4ENER ontologies were used as the overarching ontologies to alignments on the assumption that, if the considered standards could be aligned with SAREF/SAREF4ENER on the core data elements in the DSF domain, then these standards would be semantically interoperable also with each other. SAREF and SAREF4ENER themselves were also analysed for missing DSF core data elements. The conclusion was that a certain level of alignment already exists. SPINE and oneM2M are fully aligned with SAREF/SAREF4ENER. The study (DNV GL, ESMIG, TNO, 2018) concluded that alignment between standards for DSF is needed and that "SAREF/SAREF4ENER can be used as the overarching ontology to facilitate this alignment".

[52] https://en.wikipedia.org/wiki/Ontology_(information_science)

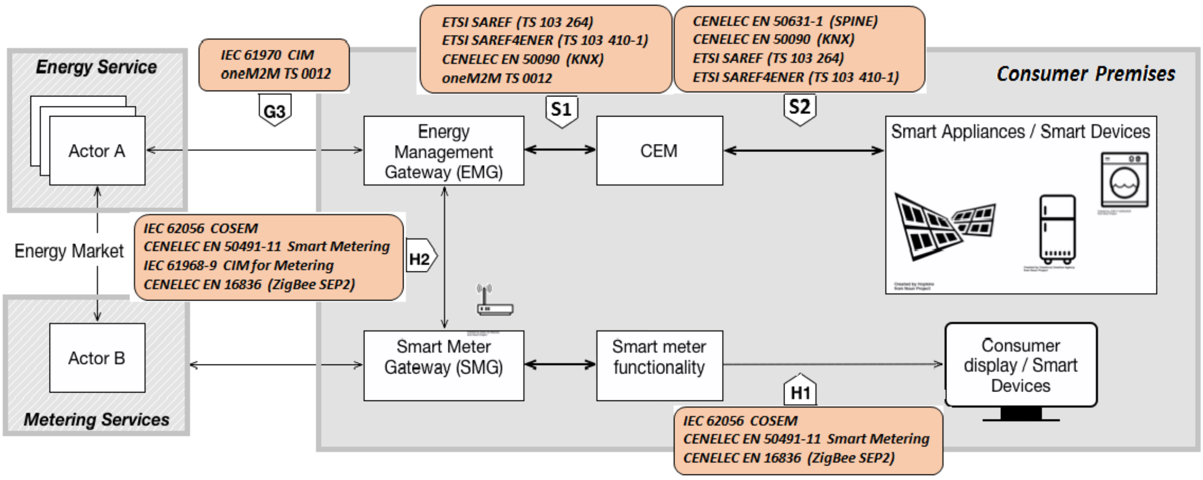

FIGURE 5: SELECTED STANDARDS CONCERNING DSF INTERFACES (DNV GL, ESMIG, TNO, 2018)

To conclude: Demand side flexibility provided by end-consumers and prosumers may face barriers if there are too many and possibly contradictory standards and specifications for describing different interfaces between appliances providing flexibility, energy management systems and metering systems. European Commission promotes SAREF ontology to ensure alignment between the multitude of approaches.

3.1.4 BRIDGE INITIATIVE

BRIDGE is a European Commission initiative that unites Horizon 2020 Smart Grid, Energy Storage, Islands, and Digitalisation Projects to facilitate the collaboration among the projects[53]. Projects come together in several working groups and in more ad-hoc working streams to discuss and draw conclusions and recommendations in common interest areas for projects themselves and relevant for EC. Working group on data management has recently produced several reports.

A report summarising findings and recommendations on some aspects of data handling (BRIDGE, 2019-2)[54] made few points related to standardisation:

- Regarding information model interoperability, “more standardisation does not appear to offer a solution. More standards would only exacerbate the problem. Pressuring parties and nudging people to use or support standards first requires a more in-depth understanding to be effective/beneficial”.
- Regarding information communication interoperability, “communication – its availability, support, ease-of-use – has improved significantly in recent years. Smart energy has enjoyed and benefited from this progress. To preserve this enjoyable situation, smart energy needs to speed up its adoption of widely available means of communication (e.g. MQTT, REST API) and avoid inventing its own solutions (which fail to recruit sufficient users)”.

[53] https://www.h2020-bridge.eu/
[54] https://www.h2020-bridge.eu/wp-content/uploads/2018/06/BRIDGE-Data-Management-WG-Findings-and-Reco-July-2019.pdf

- "Minimum requirements and standards for the security layer of a smart grid communication infrastructure or smart grid devices should be defined."

A joint report with a regulatory working group on TSO-DSO coordination (BRIDGE, 2019-3)[55] summarises recommendations for data management, all related to standardisation in a way:

- Develop a conceptual European data exchange model involving functionalities, governance, data access, open-source, and standardisation needs.
- Define "interoperability of platforms" and identify platforms with European ambition and potential for replicability and scalability.
- Ensure GDPR compliance and data owner's control over their data.
- Cooperate while developing use cases and an easily accessible use case repository.
- Elaborate new data roles, harmonise the approach to role definitions, and recommend them in HEMRM.
- Apply CIM standards in TSO-DSO coordination as well as cooperate in suggesting extensions to CIM.

These points were further elaborated by BRIDGE (2021-1) proposing high-level SGAM based reference architecture for European energy data exchange (Figure 6) and associated recommendations (only standardisation related recommendations are listed here):

- Leverage Smart Grid Architecture Model (SGAM) usage and study its extension to other sectors.
- Propose to ENTSO-E, ebIX® and EFET new roles and classes to be included and definitions to be adapted in existing HEMRM. Develop mechanism for proposing new roles by BRIDGE projects. Harmonise data roles across electricity and other energy domains by developing HERM – Harmonised Energy Role Model. Look for consistency with other domains outside energy based on this HERM – cross-sectoral roles.
- Define canonical data model facilitating cross-sector data exchange, e.g. by extending Common Information Model (CIM) and integrating other sectors' canonical data models with CIM. Study the benefit to use ontologies to support cross-sector interactions.
- Develop cross-sector data models and profiles.
- Ensure protocol agnostic approach to cross-sector data exchange.
- Ensure data format agnostic approach to cross-sector data exchange.
- Set up and manage a CIM repository for BRIDGE projects and beyond.
- Set up a European CIM User Group and eventually a Smart Energy Standard User Group.
- Define the strategy to disseminate advantages and benefits that CIM usage provides as well as develop a systematic approach in provision of education and consulting to all interested parties across Europe.
- Make CIM UML model(s) and associated profiles available following a clear procedure.
- Make DEPs (Data Exchange Platforms) interoperable by developing APIs (Application Programming Interfaces) which enable for data providers and data users easy connection to any European DEP but also create the possibility whereby connecting to one DEP ensures data exchange with any other stakeholder in Europe.

[55] https://www.h2020-bridge.eu/wp-content/uploads/2020/01/D3.12.f_BRIDGE-TSO-DSO-Coordination-report.pdf

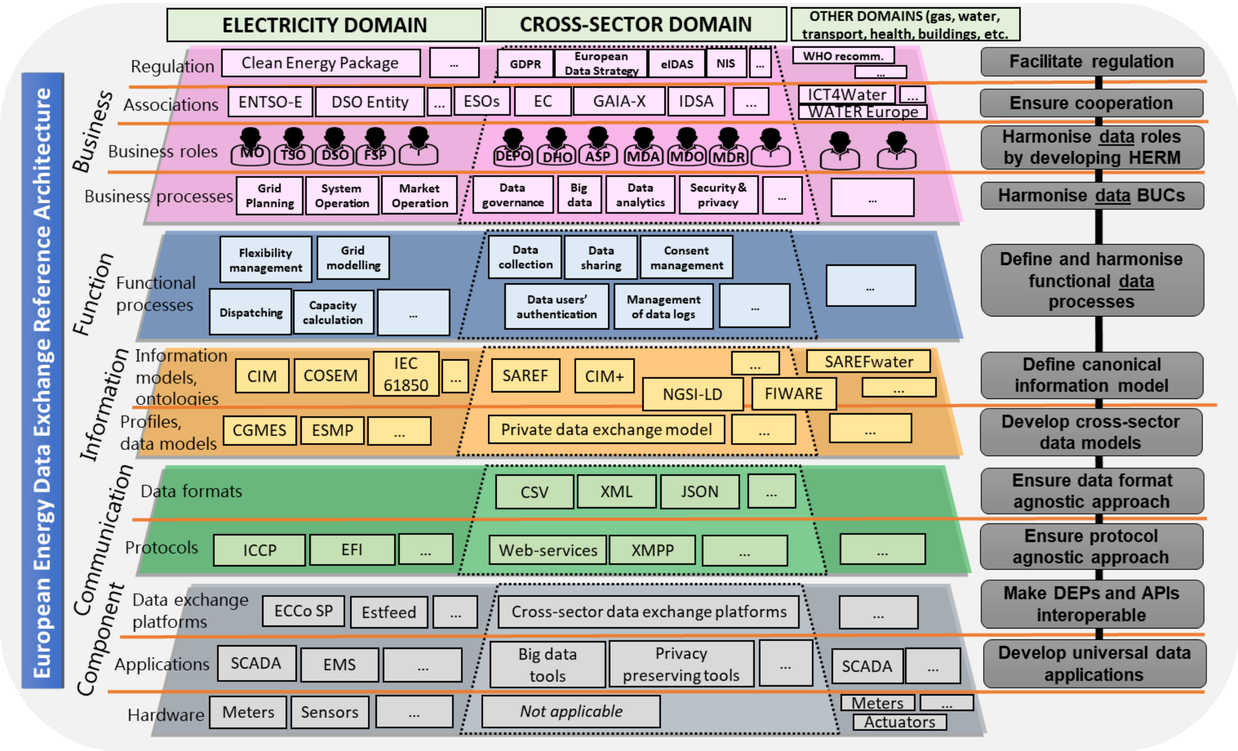

FIGURE 6: EUROPEAN ENERGY DATA EXCHANGE REFERENCE ARCHITECTURE (BRIDGE, 2021-1)

A different BRIDGE report (2021-2) looked at the interoperability of flexible assets by defining a methodology that allows to analyse the use cases by mapping them to a reference framework based on Generic Business Processes. Functions and interfaces of use cases could be mapped to relevant Generic Business Process. Relevant solutions/standards for each interface of the selected use cases were outlined. Regarding functions no standard definition of system functions has been identified, preventing to analyse functions as done for interfaces. Several gaps and propositions of standards' extensions/modifications were listed by the analysed projects.

<u>To conclude</u> the findings of Horizon 2020 projects:

- Due to the evolution of flexibility market and increasing awareness of consumers, there are issues to clarify in terms of data accessibility and shareability necessary for stakeholders to interact in different business processes (SGAM business layer).
- Private data has more importance than ever in the energy domain, and data management mechanisms need to focus more on cybersecurity exchange and handling of such data (SGAM function layer).
- Information models (like CIM) exist, creating different standards should be avoided, and complexity should be reduced (SGAM information layer).
- For data communication, sufficient tools already exist (SGAM communication layer).

3.1.5 EUROPEAN LEVEL LEGAL REQUIREMENTS FOR ELECTRICITY DATA

Whereas high-level data management principles are addressed in EU primary legislation (directives, regulations), including very few references to standards, there is an attempt to apply the more standardised approach in the secondary legislation in the form of implementing acts. Specifically, as referred to at the end of chapter 3.1.2, based on article 24 of the electricity market directive (Directive, 2019/944)[56] on interoperability requirements and procedures for access to data. However, this discussion will need to find a balance between subsidiarity and unnecessary administrative burden principles on one side and the free flow of data and customer empowerment principles on the other side.

An EU-SysFlex working document has reviewed ten EU level legal texts (network codes, other relevant regulations and directives) with the aim "to understand the legal requirements regarding data access and data exchange in more general which might be facilitated among other things by data exchange platforms (DEPs)" (EU-SysFlex, 2019)[57]. References to data management can be found relating to smart meters (articles 19 and 20 of Directive, 2019/944), to data management model (article 23 of Directive, 2019/944), and data exchange methodologies for balancing (article 18 of Regulation, 2017/2195)[58], for system operation (articles 40-53 of Regulation, 2017/1485)[59], for demand connection (article 18 of Regulation, 2016/1388)[60], for connections of some generation types (articles 14-15 of Regulation, 2016/631)[61] and generation and load data provision (article 16 of Regulation, 2015/1222)[62].

Obviously, in addition there are generic, 'non-energy' acts applicable to energy data management like General Data Protection Regulation (GDPR), regulation on electronic identification and trust services for electronic transactions (eIDAS), Network and Information Security directive (NIS), and upcoming Data Governance Act (see also EU-SysFlex deliverable 5.4, 2021).

To conclude:

- There is quite some regulation regarding electricity domain's public data and some private (i.e. sensitive) data like grid data. However, explicit references to standards there are only a few.
- The new regulation is emerging for cybersecurity, handling of flexibility market data and meter data.
- There are still some areas not covered in European level legislation like management of sub-meter data and free but secure flow of any type of private data in general.

[56] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593158348328&uri=CELEX:32019L0944
[57] https://eu-sysflex.com/wp-content/uploads/2019/10/EUSYSFLEX-5.1.5-Legal-requirements-to-data-exchange-2019.10-FINAL.pdf
[58] https://eur-lex.europa.eu/eli/reg/2017/2195/oj
[59] https://eur-lex.europa.eu/eli/reg/2017/1485/oj
[60] https://eur-lex.europa.eu/eli/reg/2016/1388/oj
[61] https://eur-lex.europa.eu/eli/reg/2016/631/oj
[62] https://eur-lex.europa.eu/eli/reg/2015/1222/oj

3.2 IEC FRAMEWORK

3.2.1 STANDARDISATION OF SMART GRID

There are many business domains (in Smart Grid Standards Map[63] so-called "clusters") for which information exchange standards are developed in IEC, resulting in different requirements for information (payload) exchanged as well as in different communication and transport standards:

- Energy management
- SCADA and network operation
- Substation protection, monitoring, and control
- Distribution automation
- Distributed Energy Resources (DER)
- Demand response and load control
- Meter reading and control
- Customers
- Work
- Network expansion planning
- Operational planning and optimization
- Maintenance and construction
- Records and asset management
- Market operations
- Reservations
- Financial
- Energy Scheduling

Many of the abovementioned clusters are also in the area of interest for flexibility domain as flexibility is the service provided by almost all smart grid users, starting from large industrial customers to individual household consumers. All of them have different installations and equipment supported by different information exchanges as defined in a dedicated cluster in SGSM (Smart Grid Standards Map)[63]. On the other hand, flexibility services can benefit from some use cases as already defined in IEC for other processes and services, i.e. energy scheduling, demand response and load control, DER, metering, financial.

3.2.2 SMART GRID STANDARDS MAP

Smart Grid Standards Map[63] is the tool that allows easy finding of and instantly identifies the "standards that are needed for any part of the Smart Grid". With this tool, anyone can identify any given standard within the smart grid. "Overall, the smart grid standards mapping tool defines relationships between components and standards of the Smart Grid." There are two main paths to find the smart grid standard, which is needed:

[63] http://smartgridstandardsmap.com/

- "Smart Grid Architecture View provides a pictorial overview of the grid. It includes clusters that form the generic Smart Grid landscape." Components of the grid are located in clusters (i.e. Distributed energy) and additionally are grouped into systems or so-called "functional clusters" (i.e. Advanced Metering Infrastructure).
- Mapping View provides a catalogue with a Components/Cluster view or Standards view. Choosing the Component/Cluster user will be given the list of applicable standards. Choosing the Standard user will be given the list of concerned Clusters/Components.

The overall scope of Smart Grid Standards Map[63], including all the Clusters and Components, is presented in Figure 7.

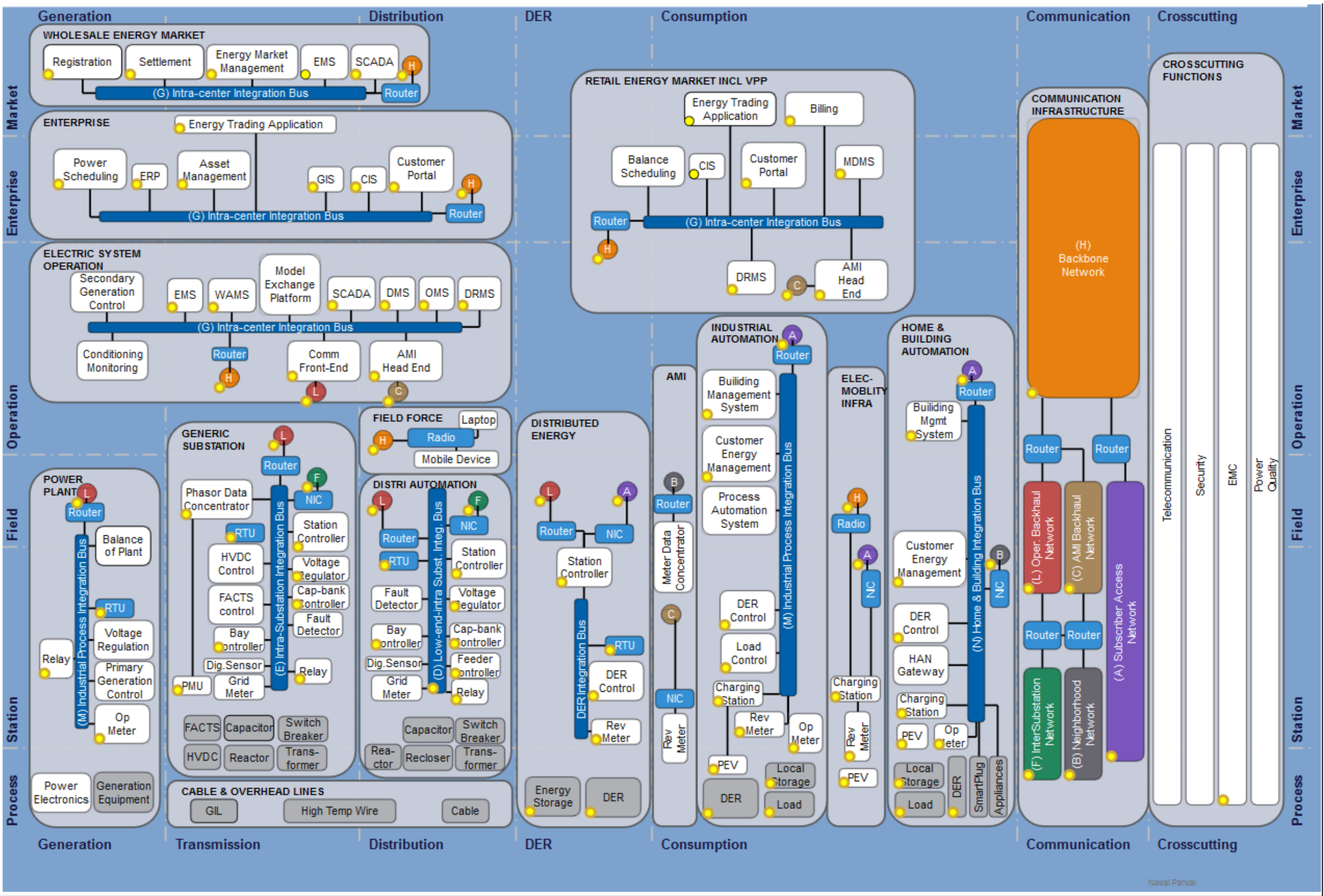

FIGURE 7: SMART GRID STANDARDS MAP OVERVIEW (IEC TR 62357-1, 2016[64]; IEC webpage, 2020)

[64] Copyright © 2016 IEC Geneva, Switzerland. www.iec.ch

3.2.3 POWER SYSTEM REFERENCE ARCHITECTURE, USE CASES AND ROLE MODEL

IEC TR 62357 series (Power systems management and associated information exchange) consists of technical reports (TR), i.e. it is not a standard *per se*. Significant parts of this series are IEC TR 62357-1 Reference architecture (2016)[65] and IEC TR 62357-2 Use Cases and Role Model (2019)[66].

IEC TR 62357-1: Reference architecture is a Technical Report that "provides a clear and comprehensive map of all standards which are contributing to support interactions, in an open and interoperable way, between actors, components and systems" in the field of electricity grids from generation to consumers, including transmission and distribution. The 2016 edition includes some new important technical changes:

- "Provides updates and defines layered Reference Architecture to help direct longer term goals and activities, specifically to ensure compatibility of all new standards developed in the IEC by benefitting from lessons learned during development of the current standards and their application to actual utility projects as well as through the application of other internationally recognized architecture standards."
- "Reflects the most recent editions of the IEC standards relating to power systems management and associated information exchange, including the IEC 61850 series and the IEC 61968[70], IEC 61970[67] and IEC 62325[68] Common Information Model (CIM) standards."

The document also brings "the vision of the path which will be followed by the concerned IEC technical committees and working groups in the coming years, to improve the global efficiency, market relevancy and coverage of this series of standards".

The area of application of the standards described in IEC TR 62357 is shown in Figure 8.

[65] https://webstore.iec.ch/publication/26251
[66] https://webstore.iec.ch/publication/28523
[67] https://webstore.iec.ch/publication/62698
[68] https://webstore.iec.ch/publication/31487

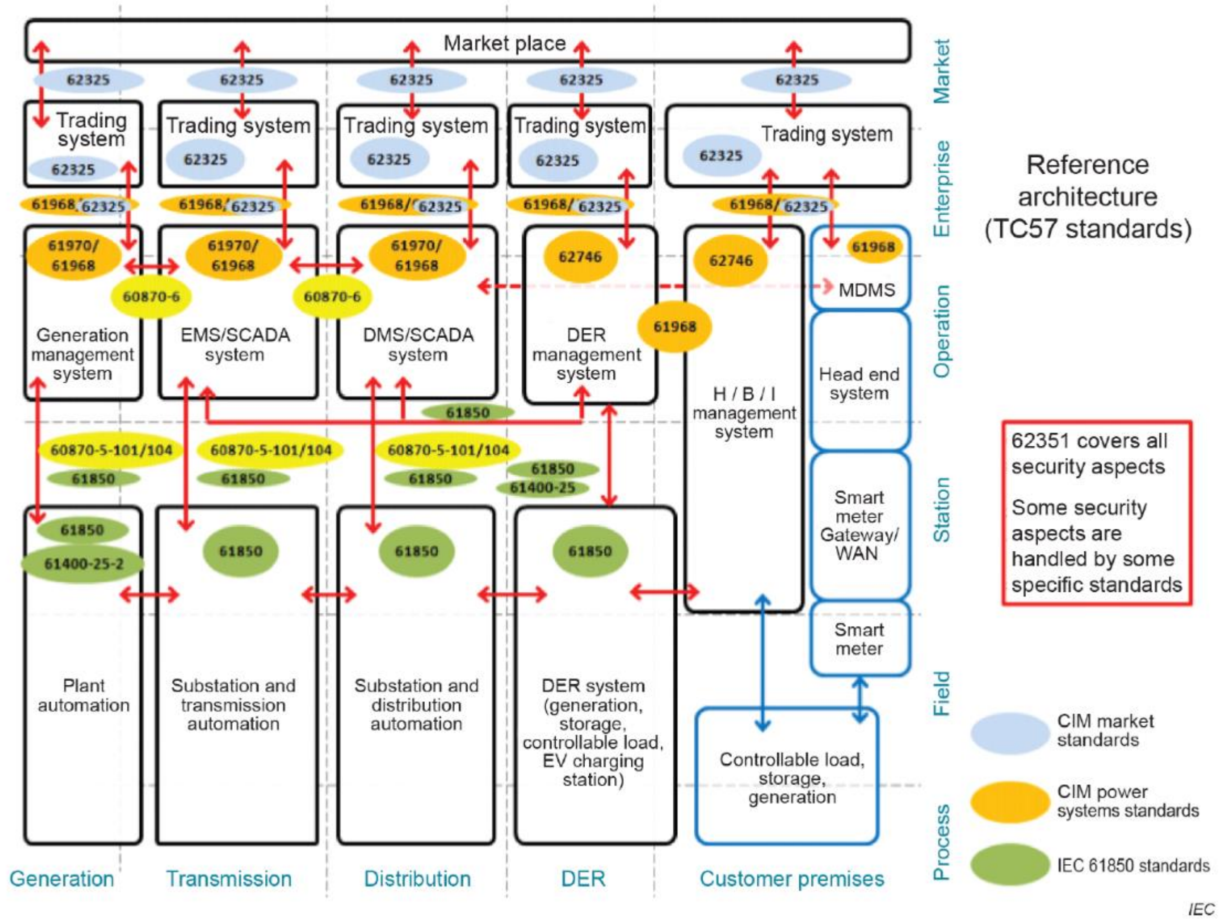

FIGURE 8: POWER SYSTEM MANAGEMENT AND INFORMATION EXCHANGE REFERENCE ARCHITECTURE (IEC TR 62357-1, 2016[69])

The enterprise communication between DER Management Systems (DERMS) falls into the IEC 61968[70] domain, while communication between DERMS and the actual DER (or specifically the smart inverters attached to the DER) within the IEC is the realm of IEC 61850. However, other standards and protocols are also used, such as IEEE 1815 (DNP), IEEE 2030.5, Sunspec Modbus and OpenFMB. CIM-based integration could also be accomplished, as documented in IEC 62325-301 and IEC 62361-100. IEC 62351 covers security aspects. However, some of them are handled by specific standards.

IEC TR 62357-2 on Use Cases and Role Model is a technical report that describes the list of Use Cases developed by TC 57 'Power systems management and associated information exchanges' to prepare International Standards, Technical Reports and Technical Specifications. This Technical Report:

- "Identifies in existing standards, technical specification, reports and in ongoing TC 57 work /…/ the Use Cases used as well as their links to standards, their status as Use Cases (level of description, standardisation of the description referring to IEC 62559[71]) and as IEC deliverables /…/."

[69] Copyright © 2016 IEC Geneva, Switzerland. www.iec.ch
[70] https://webstore.iec.ch/publication/32542
[71] IEC 62559 series is on Use case Methodology, https://webstore.iec.ch/searchform&q=62559

- "Helps System Committees consolidate Use Cases through terminology and term definition work (link with existing relevant standards on the TC Terminology) and building links between roles and modelling frameworks (Role Models). For example, in TC 57, building links between the Use Case methodology and the roles used in IEC 62913-2 with CIM Interface Reference Model (IRM – IEC 61968)."
- "Shares and promotes those Use Cases within TC 57 and outside it. TC 57 mainly describes System Use Cases in the standards it publishes. Business roles and Business Use Cases are mainly described within SyC SE (System Committee Smart Energy) deliverables (IEC 62559 series and IEC 62913 series)."
- "Explains the content of its Use Cases to potential users and providing support on using those Use Cases for standardisation (normative context, maturity of the Use Case, location in standardisation work, roles implied)."

Use Cases are central starting point in TC 57 publications. IEC TR 62357-2 explains how to use System Use Cases and System Roles. "Those Use Cases are aimed to be used as tools to identify requirements as input to further development of technical standards (whether TC 57 or not) and improve the consistency in this work and contribute to interoperability. Use Cases facilitate cooperation at a system level with TCs, other standards developing organisations, non-traditional players of electrotechnology, and regional organisations. Inside the IEC they provide a convergence platform with overall system level value for support of the Technical Committees and other standard development groups."

IEC TR 62357-2 "allows TC 57 to self-assess its work on Use Cases through KPIs (Key Performance Indicator) such as:

- % of Use Cases compliant with IEC 62559-2
- % of Business Use Cases (BUC) and System Use Cases (SUC)
- % of Business Roles and System Roles
- % of non-defined roles."

IEC TR 62357-2 also aims at providing use cases for TC 57 Use Case Repository.

3.2.4 GENERIC SMART GRID REQUIREMENTS

It is "necessary to achieve a consistent and homogeneous description of generic requirements for the different areas which make up the smart grid environment" (IEC SRD 62913-1, 2019)[72]. IEC SRD (systems reference deliverable) 62913 series delivers an applicable methodology to draft Use Cases (IEC SRD 62913-1), clarifying 'who does what' with regards to smart energy Use Cases, and it will also initiate the process of listing, organising and making available the Use Cases which carry the smart energy requirements which should be addressed by the IEC core technical standards (IEC SRD 62913-2 series). The IEC's systems approach will require adapted tools and processes to facilitate its implementation and should be understood as the first stepping stone towards implementing this systems approach. IEC SRD 62913-3[73] will be a roles database based on a harmonised naming

[72] https://webstore.iec.ch/publication/28019
[73] Not yet published.

methodology to ensure consistency when drafting smart energy Use Cases. As a result, this will provide a consistent and ready-to-use framework for all standardisation stakeholders.

Use Cases in the top-down approach of IEC SyC Smart Energy (C/1845/RV) are tools to identify smart grid requirements used to assess situations in standards (gaps or overlaps) and contribute to interoperability. These requirements may also be used further as input for interoperability profiles for the testing phase.

IEC SRD 62913-1 – 'Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach' "describes a common approach for IEC technical committees to define generic smart grid requirements for further standardisation work. It uses as input the Use Case methodology defined as part of the IEC 62559 series and provides a more detailed methodology for describing Use Cases and extracting requirements from these Use Cases." Use Case methodology helps to "achieve a consistent and homogeneous description of generic requirements for the different areas that make up the smart grid environment."

IEC SRD 62913-2 initiates and illustrates the IEC's systems approach based on Use Cases and identifies generic smart grid requirements for further standardisation work. Part 2 is composed of five subparts (four of them available currently) which refer to the clusters that group several domains:

- Part 2-1: Grid related domains
  The Grid management domain groups Use Cases and associated requirements common to the EHV, HV and MV/LV networks operations and the business analysis of the general electric network life cycle. Use Cases specific to parts of the general electric network are described in transmission grid management, distribution grid management, microgrids and smart substation automation clauses.
- Part 2-2: Market-related domain
  Market-related domain groups the generic smart grid requirements of the market activities.
- Part 2-3: Resources connected to the grid domains
  Resources connected to the grid domains groups the generic smart grid requirements of distributed energy resources, smart home/commercial/industrial/DR-customer energy management, energy storage, and bulk generation domains.
- Part 2-4: Electric transportation-related domain
  Electric transportation domain groups the generic smart grid requirements of electric vehicles.

These documents capture possible "common and repeated usage" of a smart grid system under the format of "Use Cases" to feed further standardisation activities. Use Cases can be described in different ways and can represent competing alternatives. These documents derive the common requirements to be considered by these further standardisation activities in terms of interfaces between actors interacting with the given system.

The documents for each domain are composed as follows.

- Purpose and scope.

- Business analysis: to address the domain's strategic goals and principles regarding its smart grid environment. It also lists business Use Cases, System Use Cases identified, their associated business roles and system roles (actors) and the simplified role model highlighting main interactions between actors.
- Generic smart grid requirements.
- Links between domains and technical committees.
- A complete description of Use Cases per domain based on IEC 62559-2.
- Bibliography.

3.3 CEN-CENELEC-ETSI INITIATIVES

3.3.1 SMART GRID ARCHITECTURE MODEL

Smart Grid Architecture Model developed by CEN-CENELEC-ETSI Smart Grid Coordination Group (2012)[74] provides a systematic methodology for analysing smart grid architectures, coordination of standardisation activities, and coordination of products portfolio, development of architectures and custom solutions. It can also help coordinate work packages between project groups, develop information and communication architecture, and a common view on project architecture. The main product is the SGAM framework, which merges interoperability layers with domains' and zones' dimensions as shown in Figure 9. SGAM model has been further developed and standardised by IEC recently (IEC 63200, 2021).

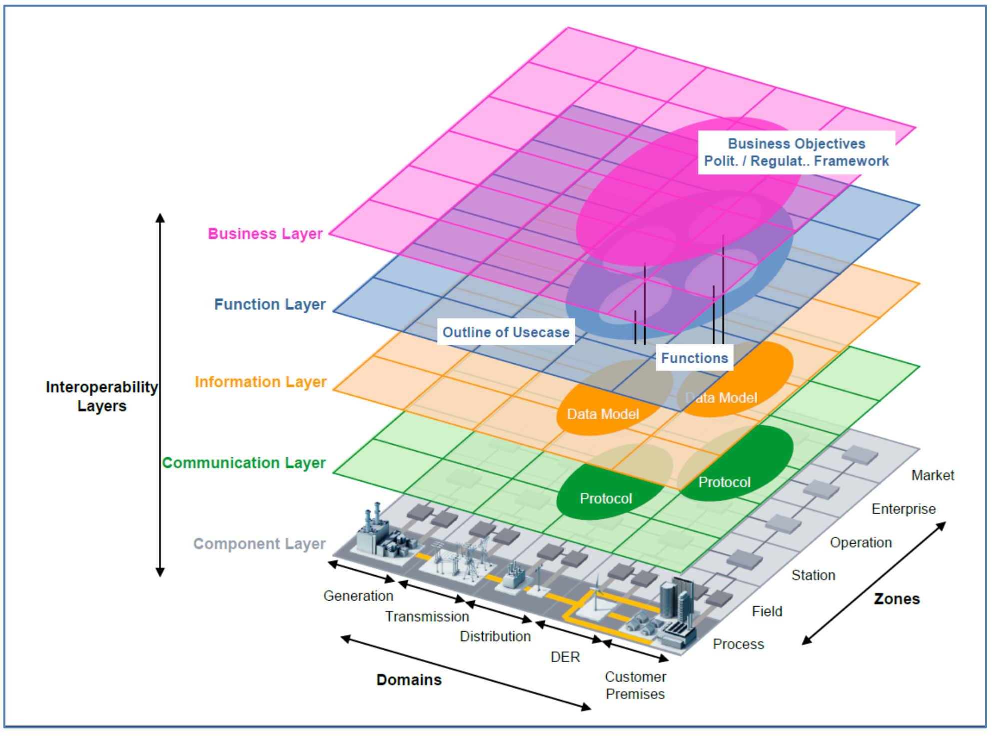

FIGURE 9: SGAM FRAMEWORK (CEN-CENELEC-ETSI SGCG, 2012[75])

[74] https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf
[75] © CEN, reproduced with permission. © CENELEC, reproduced with permission. Reproduced with ETSI permission.

The Domains and Zones dimensions create a smart grid plane. "According to this concept, those Domains, which are physically related to the electrical grid (Bulk Generation, Transmission, Distribution, DER, Customer Premises), are arranged according to the electrical energy conversion chain." (CEN-CENELEC-ETSI SGCG, 2012) The other dimension (Zones) represents hierarchical levels for the management of the electrical process.

The interoperability categories are aggregated into five abstract interoperability layers, as shown in Figure 10.

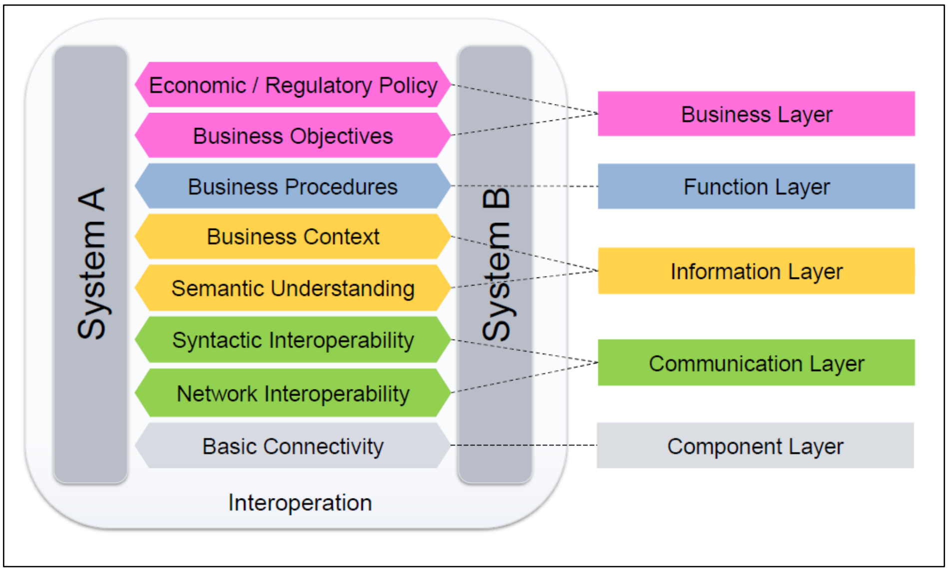

FIGURE 10: SGAM INTEROPERABILITY LAYERS (CEN-CENELEC-ETSI SGCG, 2012[76])

3.3.2 SMART GRID SET OF STANDARDS

CEN-CENELEC-ETSI Smart Grid Set of Standards (CEN-CENELEC-ETSI, 2017)[77] is one of the key deliverables produced in response to EC's mandate M/490 (see chapter 3.1.2). The document lists more than 500 standards and maps these to domains and systems (generation, transmission, distribution, DER, smart metering), high-level use cases and SGAM layers.

As a result of the work requested through the M/490 mandate, "this report intends to build a list of standards enabling or supporting the deployment of Smart Grid systems in Europe. It is based on CEN-CENELEC-ETSI experts' assessment. It is intended to depict the portfolio of European and/or international standards and to facilitate interoperable solutions based on standards."

CEN-CENELEC-ETSI lists some standards as core standards – "Core standards are standards that have an enormous effect on any Smart Grid application and solution. They are seen as a backbone of a future Smart Grid":

[76] © CEN, reproduced with permission. © CENELEC, reproduced with permission. Reproduced with ETSI permission.
[77] ftp://ftp.cencenelec.eu/EN/EuropeanStandardisation/Fields/EnergySustainability/SmartGrid/CGSEG_Sec_0042.pdf

- IEC 61970/61968: CIM (Common Information Model). Applying mainly to Generation management systems, EMS (Energy Management System); DMS (Distribution Management System); DA; SA; DER; AMI; DR; E-Storage
- IEC 62325: CIM (Common Information Model) based, energy market information exchange. Applying mainly to Generation management systems, EMS (Energy Management System); DMS (Distribution Management System); DER; AMI; DR; meter-related back-office systems; E-Storage
- IEC 61850: Power Utility Automation, Hydro Energy Communication, Distributed Energy Resources Communication. Applying mainly to Generation management systems, EMS; DMS; DA; SA; DER EStorage; E-mobility
- IEC 62056: COSEM. Applying mainly to: DMS; DER; AMI; DR; Smart Home; E-Storage; E-mobility Data exchange for meter reading, tariff and load control
- IEC 62351: Applying mainly to Security for all systems
- IEC 61508: Applying mainly to Functional safety of electrical/electronic/programmable electronic safety-related systems

Some others are considered as “highly important standards for Smart Grid”:

- IEC 62357: Power utilities Reference Architecture – SOA. Applying mainly to Energy Management Systems; Distribution Management Systems; DER operation systems, market & trading systems, DR[78] systems, meter-related back-office systems
- IEC 60870-5: Telecontrol. Applying mainly to EMS; DMS; DA; SA
- IEC 60870-6: TASE.2 Inter Control Centre Communication. Applying mainly to EMS; DMS
- IEC/TR 61334: “DLMS” Distribution Line Message Specification. Applying mainly to AMI
- IEC 61400-25: Wind Power Communication. Applying mainly to DER operation systems (Wind farms); EMS; DMS
- IEC 61851: EV-Communication. Applying mainly to: E-mobility; Home&Building management systems;
- IEC 62051-54/58-59: Metering Standards. Applying mainly to: DMS; DER; AMI; DR; Smart Home; E-Storage; E-mobility

Most of the above ‘core’ standards and ‘highly important’ standards are described in Annex I as these are potentially relevant for EU-SysFlex data exchange system use cases. Set of Standards is used as one of the starting points for gap analysis to link the use cases and existing standards. See detailed use case based mapping against existing standards in Chapter 4.2.

3.3.3 INTEROPERABILITY TOOL

Another deliverable under EC’s mandate M/490 (see Chapter 3.1.2) was the Interoperability (IOP) Tool (CEN-CENELEC-ETSI, 2014)[79].

[78] DR – Demand Response
[79] ftp://ftp.cencenelec.eu/EN/EuropeanStandardisation/HotTopics/SmartGrids/SGCG_Interoperability_Report.pdf

The IOP Tool enables to filter relevant smart grid standards based on SGAM layers, zones and domains (see a snapshot in Figure 11). The primary source was the CEN-CENELEC-ETSI Set of Standards (see Chapter 3.3.2).

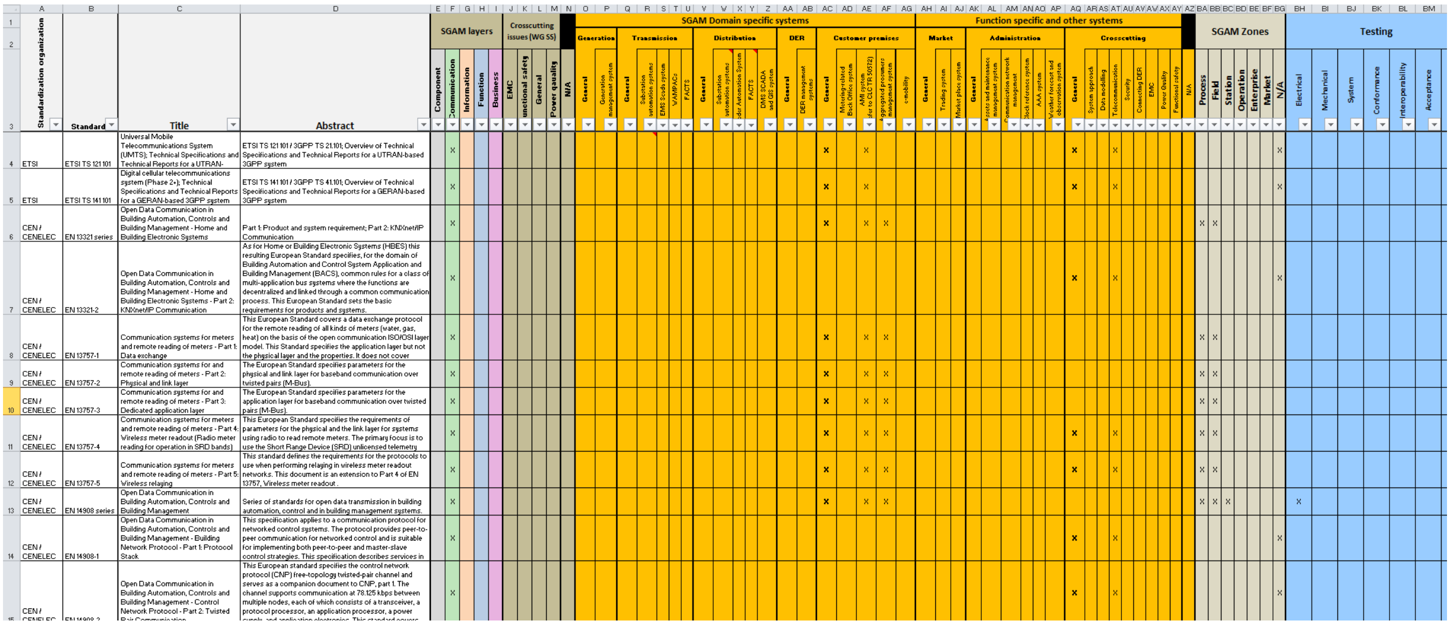

FIGURE 11: SNAPSHOT OF INTEROPERABILITY TOOL (CEN-CENELEC-ETSI, 2014[80])

3.3.4 ANALYSIS OF CLEAN ENERGY PACKAGE

On 13 December 2018 CEN-CENELEC-ETSI Coordination Group on Smart Energy Grids (CG-SEG) published the report on Clean Energy Package (CEP)[81] (CEN-CENELEC-ETSI, 2018). The report addresses key legal propositions of CEP, which are considered most relevant for standardisation and an initial assessment of priority topics with possible implications on the updated Set of Standards as a former deliverable M/490 (see chapter 3.3.2).

Table 4 presents the list of all identified priority topics, pointing on the ones relevant for EU-SysFlex project. Table 5 maps existing standards to relevant topics.

[80] © CEN, reproduced with permission. © CENELEC, reproduced with permission. Reproduced with ETSI permission.
[81] ftp://ftp.cencenelec.eu/EN/EuropeanStandardisation/Fields/EnergySustainability/SmartGrid/Final_report_WG_CEP.pdf

TABLE 4: CONSOLIDATED LIST OF PRIORITY TOPICS AND HIGH-LEVEL RECOMMENDATIONS (CEN-CENELEC-ETSI, 2018); COLOURS ADDED BY AUTHORS - GREEN INDICATES HIGH RELEVANCE FOR EU-SYSFLEX, YELLOW INDICATES PARTIAL RELEVANCE

Reference	**Priority topic** ***Recommended action (summary)***
CEP-EED-1	Energy Efficiency - New binding energy savings target at EU level by 2030 *Forward to CLC/TC 57 and CLC/TC 8, promote the role of standardisation for reporting*
CEP-EPBD-1	Development of new Smart Readiness Indicators (SRI) *Forward to CLC/TC 205 WG 18, CEN/TC 294 and IEC TC 13 to check the support of standards*
CEP-ECO-1	Eco-design Work Plan *Report eco-design related attributes back to IEC TC57 for CIM / IEC 61850 support and CEN/CENELEC for other ontology developments*
CEP-RED-1	DER management and connection to the grid *Forward to IEC TC 13 and TC 57 to consider different types of DER and to provide adequate data models and services*
CEP-RED-2	Phase-out of priority dispatch for RES *Forward to CLC/TC 57 in charge of providing market information exchange*
CEP-EMD-1	Data Management, format and interoperability *Align with EG1 and other stakeholders to promote the role of standardisation and ESO's interoperability methodology, coordinate with Horizon2020 projects*
CEP-EMD-2	Real-time access to consumption data and connectivity to the smart metering infrastructure *Forward to CG-SM, dissemination to the market and consideration of new use cases*
CEP-EMD-3	Interoperability with Consumer Energy Management systems *Align ongoing work with IEC TC 205 and TC 57, coordinate with Horizon2020 projects*
CEP-EMD-4 CEP-EMR-1	Demand Response, congestion mechanism and market solutions for balancing *Alignment with EG3 and IEC TC 57 WG21, coordinate with Horizon2020 projects*
CEP-EMD-5	Microgrid management – Local energy community (LEC) Check new/boost previous microgrid use cases and align with IEC TC 57 WG 17
CEP-EMD-6	Dynamic electricity price contract for customers Follow-up with work outcomes of SAREF, process further gaps by CG-SM and CG-SEG
CEP-EMD-7	Neutrality and transparency of grid operators Identify acceptable standard practices ensuring neutrality and transparency and identify whether and which harmonised processes on a European level would be needed
CEP-EMR-2	Management of storage and integration into the grid Check for new use cases drafted in 62913-2-3
CEP-EMR-3	Operational data exchange between grid operators and grid users Check requirements with NC SO Guideline and KORRR, coordinate with Horizon2020 projects
CEP-EMR-4	Compliance with new network codes (also on DSO level) Action to be explored with the EC depending on mandate decision
CEP-EMR-5	Compliance with new cybersecurity network codes Action to be explored with the EC depending on mandate decision

TABLE 5: MAPPING EXISTING STANDARDS TO RELEVANT PRIORITY CEP TOPICS (TABLE PRODUCED BY AUTHORS BASED ON CEN-CENELEC-ETSI, 2018)

Relevant priority topics	Standard coverage
DER management and connection to the grid	IEC 61970, IEC 61968, IEC 61850, IEC 62361-102 (harmonisation of CIM and 61850), TC205 standards, smart home and buildings (auto consumption)
Data Management, format and interoperability	ETSI TS 103 264 (SAREF), ETSI TS 103 410-1 (SAREF4ENER), IEC 62056, IEC 61970, IEC 61968, IEC 62325
Real-time access to consumption data and connectivity to the smart metering infrastructure	Mainly standards for H1/H2 interface on smart meter reference architecture including standards of TC57, TC13, TC294 and TC205
Interoperability with Consumer Energy Management systems	Mainly standards for H2 interface on smart meter reference architecture including standards of TC57, TC13, TC294 and TC205
Demand Response, congestion mechanism and market solutions for balancing	IEC 61850, IEC 62746, current work of TC 57 WG 16 on market places (IEC 62325)
Microgrid management – Local energy community (LEC)	IEC TS 62898, IEC 61850, EN 50438, EN 50549, IEC 62786, IEC 62746, IEC 60364, IEC 62325, IEC 61968, IEC 61970
Management of storage and integration into the grid	IEC 61970, IEC 61968, IEC 61850, IEC 62913-2-3, IEC 62786, EN 50549
Operational data exchange between grid operators and grid users	IEC 61970, IEC 61968, IEC 61850 to System Operation Guideline and KORRR

3.4 HARMONISED ELECTRICITY MARKET ROLE MODEL

The Harmonised Electricity Market Role Model (HEMRM)[82] has been developed by ENTSO-E, ebIX® and EFET (2020) to facilitate “dialogue between the market participants from different countries” by attaching a single name for each role and domain in the electricity market. The role model provides a universal terminology for IT development.

“This document describes the roles that can be played for given objects within the European electricity market. It covers both the wholesale and retail electricity markets. Roles are of logical nature, which act within or upon a given domain. The document covers the roles as identified in current development being carried out in information exchange.”

“A role model of this nature shall be the formal means of identifying roles and objects that are used in information exchange. It is important to stress that it is not a model of the electricity market but rather a model of the roles related to the information interchange.” Beside roles the HEMRM identifies relevant ‘objects’ where these are

[82] https://www.entsoe.eu/digital/cim/role-models/; https://www.ebix.org/artikel/role_model

necessary to describe information exchange. “The term *Object* is a generic term covering domains, points, resources, CIM objects and accounts.”

The primary product of the HEMRM, i.e. the model covering all the roles, the main relationships between them and the related objects, is presented in Figure 12 (Copyright © ebIX®, EFET and ENTSO-E. All Rights Reserved)**Error! Reference source not found.**.

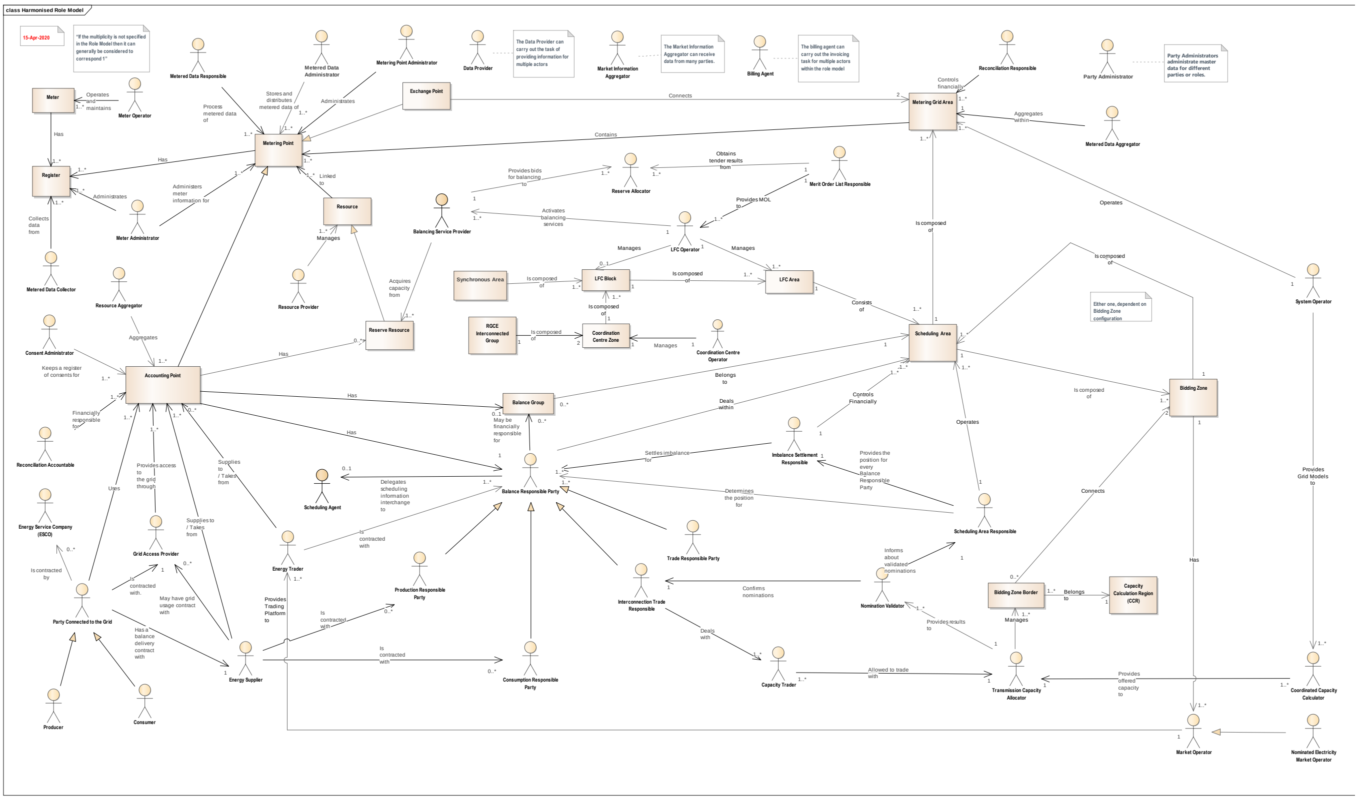

FIGURE 12: THE HARMONISED EUROPEAN ELECTRICITY MARKET ROLE MODEL (EBIX®, EFET AND ENTSO-E, 2020)

4. GAP ANALYSIS BASED ON EU-SYSFLEX DATA EXCHANGE SYSTEM USE CASES

4.1 OBJECTIVE AND SUMMARY OF GAP ANALYSIS

The objective of the gap analysis was to identify whether and which existing standards and specification there were at the time of assessment related to the data exchange system use cases from EU-SysFlex deliverable 5.2 (2020)[83]. The gap assessment was performed per each requirement of these SUCs, the requirements had been previously identified in EU-SysFlex deliverable 5.3 (2020)[84]. The descriptions of most prevalent standards and specifications are provided in annexes.

The gap analysis was based on Smart Grid Set of Standards (CEN-CENELEC-ETSI, 2017) and on expert assessment of EU-SysFlex partners. First, an assessment was performed for any standard/specification to see how extensively EU-SysFlex data exchange SUCs are covered by existing standards and specifications. Secondly, specific focus was put on CIM standards to see if the content of these SUCs is currently in the scope of CIM. Basically it means to assess whether there are missing attributes/classes in existing CIM profiles. This may be, for example, because originally CIM was not designed for such data flows. More detailed CIM assessment would require actual profiling of SUCs, two examples of this exercise can be found in chapter 5.2.

Table 6 describes the coverage of data exchange system use cases by existing standards and specifications. Tables 7 and 8 list specific requirements of these SUCs for which gaps where identified, whereas use cases are clustered into 'flexibility data exchange' and 'private data exchange' use cases. Each use case is then evaluated in detail in chapter 4.2.

Not all the possible standards and specifications were analysed, only the ones relevant for data exchange from the perspective of EU-SysFlex consortium were addressed. For example, some standards refer to others in which case the inclusion of these would mean quite a repetition. Also, specific standards for data communications were not included. The overview of standards analysed in more detail is presented in Annexes I-VI.

[83] https://eu-sysflex.com/description-of-data-exchange-use-cases-based-on-iec-62559-methodology-published/
[84] https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex_Task53_deliverable_v1_FINAL.pdf

TABLE 6: COVERAGE OF DATA EXCHANGE SYSTEM USE CASES BY EXISTING STANDARDS AND SPECIFICATIONS

USE CASE	Covered in existing standards and specifications?	Further CIM coverage needed?
Collect energy data	Well covered.	Additional CIM coverage may be needed for data hubs.
Transfer energy data	Further standardisation for some requirements.	Additional CIM coverage for private data transfer recommended, incl. cross-border.
Provide a list of suppliers and ESCOs	Well covered.	Not needed
Manage flexibility bids	Further standardisation for some requirements, especially for grid impact assessment, bid selection.	Current CIM coverage for any flexibility service/product not necessarily sufficient.
Manage flexibility activations	Further standardisation for some requirements.	Current CIM coverage for any flexibility service/product not necessarily sufficient.
Verify and settle activated flexibilities	Further standardisation for some requirements.	Current CIM coverage for any flexibility service/product not necessarily sufficient.
Manage access permissions	Addressed in some specifications but not explicitly in standards.	CIM coverage recommended for exchanging access permissions related information.
Authenticate data users	Addressed in some specifications but not explicitly in standards.	CIM coverage recommended for exchanging authentication and representation rights related information.
Manage data logs	Very limited coverage in standards.	CIM coverage recommended for exchanging data logs related information.
Calculate flexibility baseline	Further standardisation for some requirements.	All data flows necessary for baseline calculation not covered by CIM.
Predict flexibility availability	Computation of predictions for different flexibility needs not covered in standards.	Current CIM coverage for any flexibility service/product not necessarily sufficient.
Manage sub-meter data	Standardisation of easy access to sub-meter data by data owners and by other parties based on data owners consent could be improved.	Additional CIM coverage (possibly through COSEM) recommended for sub-meter data storing and exchange.
Exchange data between DER and SCADA	Direct communication between small end-users (e.g. prosumers) DERs, their aggregators and system operators' SCADAs not yet addressed sufficiently in standards.	CIM coverage (possibly through harmonisation with IEC 61850 if it will be extended to small DER) recommended for data exchange between smaller DERs and system operators.
Anonymize energy data	Addressed in some specifications but not explicitly in standards.	Additional CIM coverage may be required for data exchange between data source and data user.
Aggregate energy data	Addressed in some specifications but not explicitly in standards.	Additional CIM coverage may be required for data exchange between data source and data user.
Erase, restrict and rectify personal data	Addressed in some specifications and standards but not explicitly about sharing erasure and rectification information.	CIM coverage recommended for exchanging erasure and rectification related information.

TABLE 7: REQUIREMENTS OF 'FLEXIBILITY' DATA EXCHANGE SYSTEM USE CASES WITH CIM GAPS

USE CASE	REQUIREMENT	COMMENT
Manage flexibility bids	➢ Ability to exchange information on System Operators' flexibility need and FSPs' flexibility potential through flexibility platform (and DEP)	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
	➢ Flexibility platform's ability to collect bids from FSPs	
	➢ Flexibility platform's ability to collect grid validation results from SOs	
	➢ Auction process supervised by Market Operator	
	➢ Automated exchange of bids is possible	
Manage flexibility activations	➢ Exchange of activation requests through DEP and flexibility platform	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
Verify and settle activated flexibilities	➢ Calculation of actually delivered flexibility as response to activation request	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
	➢ Verification that flexibility delivered matches with flexibility requested	
	➢ Calculation of the penalty if flexibility delivered is less than flexibility requested	
Calculate flexibility baseline	➢ Ability of flexibility platform to collect input for baseline calculation, incl. through DEP	All data flows necessary for baseline calculation not covered by CIM.
Predict flexibility availability	➢ Collection of data for prediction (long term - years)	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
	➢ Collection of data for prediction (medium term - days to years ahead)	
	➢ Collection of data for prediction (short term - intraday operation)	
Exchange data between DER and SCADA	➢ Ability of DEP to forward real-time data from DER's to System Operators	Direct communication between small DERs and SO SCADAs not addressed in standards. CIM coverage recommended.
	➢ Ability of DEP to forward very-near-real-time (up to 1 minute) data from DER's to System Operators	
	➢ Ability of DEP to forward near-real-time (up to 1 hour) data from DER's to System Operators	
	➢ Ability of DEP to forward activation requests from System Operators to DER	
Manage sub-meter data	➢ Storing sub-meter data in data hub	Storing of sub-meter data in an easily accessible way not available. CIM coverage recommended.
	➢ Ability of DEP to forward sub-meter data from data hub to customer (data owner) and application (energy service provider)	CIM coverage for access to and sharing of sub-meter data recommended.

TABLE 8: REQUIREMENTS OF 'PRIVATE' DATA EXCHANGE SYSTEM USE CASES WITH CIM GAPS

USE CASE	REQUIREMENT	COMMENT
Manage access permissions	➢ Ability to share access permissions between data owners, concerned DEPs, applications and data sources	CIM coverage recommended.
Erase, restrict and rectify personal data	➢ Ability to share information related to erasure of personal data between data owners, concerned DEPs, applications and data sources	CIM coverage recommended.
	➢ Ability to share information related to rectification of personal data between data owners, concerned DEPs, applications and data sources	CIM coverage recommended.
Authenticate data users	➢ Ability to share information related to representation rights between data users and concerned Customer Portals	CIM coverage recommended.
	➢ Ability to share authentication information between data users, Customer Portal and Authentication Service Provider	CIM coverage recommended.
Manage data logs	➢ Ability to share information related to data logs between data owners, concerned DEPs, applications and data sources	CIM coverage recommended.
Collect energy data	➢ Store data in meter data hub	Additional CIM coverage may be required.
Transfer energy data	➢ Data portability (applies to personal data - Article 20 of the GDPR)	Additional CIM coverage for private data portability recommended, incl. cross-border.
	➢ Data owner's access to data through DEP (and foreign DEP)	Additional CIM coverage for access to own data recommended, incl. cross-border.
	➢ Application's access to data through DEP (and foreign DEP)	Additional CIM coverage for transfer of private data to other parties recommended, incl. cross-border.
Anonymize energy data	➢ DEP ability to forward anonymized data from data source to data user	Additional CIM coverage may be required.
Aggregate energy data	➢ DEP ability to forward aggregated data from data source to data user	Additional CIM coverage may be required.

4.2 EVALUATION BASED ON USE CASES

4.2.1 COLLECT ENERGY DATA

Description of SUC

Collection of different types of meter, market and grid data to be made available through a data exchange platform to interested parties. Users of the data exchange platform can receive data directly from the data provider (data source) or from a data hub that collects (and stores) data. This use case focuses on the data necessary for flexibility trading.

<u>Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases</u>

- AMI system; Metering-related Back Office systems
  - Billing
    - Obtain meter reading data
- Substation automation system
  - Provide and collect contractual measurements
    - Measuring and exposing energy flows for revenue purpose (smart meter); Measuring and exposing power quality parameters for revenue purpose (smart meter)
- Generation management; TSO EMS/SCADA system; Advanced Distribution Management System (ADMS); DER Operation System; Demand and production flexibility systems
  - Demand and production (generation) flexibility
    - Receiving metrological or price information for further action by consumer or CEM (Customer Energy Manager)
- AMI system; Generation management system; FACTS (Distribution); EMS SCADA system; Advanced Distribution Management System; DER Operation System
  - (AMI) Collect events and status information; Grid stability; Maintaining grid assets; Asset and Maintenance Management system
    - Manage supply quality; Monitoring and reduce harmonic mitigation; Monitoring and reduce power oscillation damping; Monitoring and reduce voltage flicker; Stabilizing network by reducing sub-synchronous resonance (Sub synchronous damping); Archive maintenance information; Monitoring assets conditions; Optimize field crew operation; Supporting periodic maintenance (and planning)

<u>List of associated standards and specifications</u>

- IEC 61968: distribution management based on CIM, incl.:
  - IEC 61968-11: CIM Extensions for Distribution (has a data model for meter data);
  - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 61970: Energy management system application program interface, incl.:
  - IEC 61970-301: Data model that describes electrical grids as well as related data;
- IEC 62325: set of standards for energy market based on CIM, incl.:
  - IEC 62325-504: Use of web services for market data exchange;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- IEC 61850: Communication networks and systems for power utility automation. Describes a general transmission protocol for the protection and control technology in medium and high voltage electrical switchgear;
- IEC 60870: Telecontrol equipment and systems;

- IEC 62056: Electricity metering data exchange - The DLMS/COSEM suite;
- IEC 61334: Distribution automation using distribution line carrier systems;
- IEC 62051-62054/62058-62059: Metering standards, incl. for meter reading;
- IEC 62746: Systems interface between customer energy management system and the power management system;
- IEC 62361: Power systems management and associated information exchange - Interoperability in the long term;
- CEN EN 13757: Communication systems for meters;
- CEN EN 16836: Communication systems for meters - Wireless mesh networking for meter data exchange;
- CENELEC EN 50090: Home and Building Electronic Systems (HBES);
- CENELEC EN 50491: General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS);
- IEEE 802 series and IEEE 1901 series for smart grid communication;
- SAREF (ETSI 103 series): reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT;
- OneM2M: communication ontology for machine-to-machine interoperability, focusing on architecture, API specifications, security and enrolment;
- OpenADR: open, two-way information model designed to facilitate information exchange between energy management system and other energy system actors;
- EEBUS: open, two-way information model designed to facilitate information exchange primarily in-home (between devices and an energy management system/gateway) but also with external stakeholders;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- ebIX®: Business Requirements and Business Information Model for Measure Collected Data;
- ebIX®: Business Requirements and Business Information Model for Measure Determine Meter Read;
- ebIX®: Business Requirements for Alignment of metering configuration characteristics;
- ebIX®: Business Requirements for Manage Accounting Points;
- ebIX®: overview of energy flexibility services;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents

TABLE 9: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'COLLECT ENERGY DATA'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Collect energy data							
DC-REQ1	o Collection of meter data						
DC-REQ1.1	- Get near-real-time data (up to 1 hour) from meters	V	V	V	V		
DC-REQ1.2	- Get historical data (monthly) from conventional meters	V	V	V	V		
DC-REQ1.3	- Store data in meter data hub		V			V	Additional CIM coverage may be required.
DC-REQ2	o Collection of market data						
DC-REQ2.1	- Get near-real-time (up to 1 hour) data from market	V	V	V	V		
DC-REQ2.2	- Get historical data from market	V	V	V	V		
DC-REQ2.3	- Store data in market data hub		V			V	
DC-REQ3	o Collection of grid data						
DC-REQ3.1	- Get very-near-real-time (up to 1 minute) data from grid	V	V		V		
DC-REQ3.2	- Get near-real-time (up to 1 hour) data from grid	V	V		V		
DC-REQ3.3	- Get historical data from grid	V	V		V		
DC-REQ3.4	- Store data in grid data hub		V			V	

4.2.2 TRANSFER ENERGY DATA

<u>Description of SUC</u>

The granularity of data and frequency of data transfer could be different depending on the business use case, but the purpose is the same: ensuring the needed data in order to support business processes. Some other system use cases (data collection, authentication of data users, anonymization of data, aggregation of data) are strongly connected to this use case, which is considered as preconditions.

<u>Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases</u>

- AMI system; Metering-related Back Office systems
    - (AMI) Customer information provision; Monitor AMI event
        - Provide information to consumer; Facilitate DER for network operation; Facilitate demand response actions; Interact with devices at the premises; Manage efficiency measures at the premise using metering system data; Demand side management

List of associated standards and specifications

- IEC 61968-11: CIM Extensions for Distribution, incl.:
    - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 62056: Electricity metering data exchange - The DLMS/COSEM suite;
- IEC 61334: Distribution automation using distribution line carrier systems;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- IEC 61970-301: Data model that describes electrical grids as well as related data (CIM - Common Information Model);
- IEC 62325 series, incl.:
    - IEC 62325-301: CIM extensions for markets;
    - IEC 62325-451-10 (draft): profiles for energy consumption data (“My Energy Data”);
- IEC 63110: Protocol for Management of Electric Vehicles charging and discharging infrastructures;
- ISO/IEC 19941:2017 specifies the types of interoperability and portability of cloud computing. This standard could also be used to exchange energy data between different cloud applications in the energy sector;
- ISO/IEC 19944: how data can be handled in a cloud system, such as cross-border data transfer, data geolocation, data usage, data access and data portability. Energy data (like consumption data) can represent sensitive data. This standard could better regulate the handling of such data;
- CEN EN 13757: Communication systems for meters;
- CEN EN 16836: Communication systems for meters - Wireless mesh networking for meter data exchange;
- CENELEC EN 50090: Home and Building Electronic Systems (HBES);
- CENELEC EN 50491: General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS);
- CENELEC EN 50631: Household appliances network and grid connectivity;
- ISO 15118: Road vehicles — Vehicle to grid communication interface;
- IEEE 2030: Series for Smart Grid Interoperability;
- IEEE 802 series and IEEE 1901 series for smart grid communication;
- SAREF (ETSI 103 series): reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT;
- Green Button: specification developed in US that helps utility companies provide consumption time-series data to the customer directly from utility website in a secure manner;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- AS4: Energy Market Profile for secure and reliable document exchange;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- Estfeed: protocol and platform for secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner;

- FIWARE: framework of open source platform components which can be assembled and with other third-party platform components, API that enables the integration of components;
- EFI: a communication protocol that enables end-users to control various smart devices;
- OneM2M: communication ontology for machine-to-machine interoperability, focusing on architecture, API specifications, security and enrolment;
- OpenADR: open, two-way information model designed to facilitate information exchange between energy management system and other energy system actors;
- EEBUS: open, two-way information model designed to facilitate information exchange primarily in-home (between devices and an energy management system/gateway) but also with external stakeholders

TABLE 10: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'TRANSFER ENERGY DATA'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Transfer energy data							
DT-REQ1	o Transfer of data must be secured, employing encryption or communication protocol	V	V	V	V		
DT-REQ2	o Data portability (applies to personal data - Article 20 of the GDPR)					V	Additional CIM coverage for private data portability recommended, incl. cross-border.
DT-REQ3	o Data owner's access to data through DEP (and foreign DEP)		V	V	V	V	Additional CIM coverage for access to own data recommended, incl. cross-border.
DT-REQ4	o Application's access to data through DEP (and foreign DEP)		V	V	V	V	Additional CIM coverage for transfer of private data to other parties recommended, incl. cross-border.

4.2.3 PROVIDE LIST OF SUPPLIERS AND ESCOS

Description of SUC

Set up and share the list of suppliers and service providers to be made available through a data exchange platform for the interested parties. The list is available for authorised parties who can contact suppliers and service providers for any kind of business purpose.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Metering-related Back Office systems
  - Billing
    - Supplier change; Consumer move-in/move-out

List of associated standards and specifications

- IEC 61968 series:
    - IEC 61968-11: CIM Extensions for Distribution (has a data model for meter data);
    - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 61970-301: Data model that describes electrical grids as well as related data (CIM - Common Information Model);
- IEC 62325-301: CIM extensions for markets;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- Green Button: specification developed in US that helps utility companies provide consumption time-series data to the customer directly from utility website in a secure manner;
- ebIX®: Business Requirements and Business Information Model for change of Supplier;
- ebIX®: Business Requirements and Business Information Model for End of supply;
- ebIX®: Business Requirements for Customer Move;
- ebIX®: Business Requirements for end of supply

TABLE 11: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'PROVIDE LIST OF SUPPLIERS AND ESCOS'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Provide a list of suppliers and ESCOs							
ESCO-REQ1	o List of suppliers and ESCOs is available through DEP; List of aggregators is available through flexibility platform additionally					V	

4.2.4 MANAGE FLEXIBILITY BIDS

Description of SUC

The use case describes the process of pre-qualification of the flexibility bids provided by market participants (aggregators and individual consumption, generation and storage units) and the bidding process ending with the selection of flexibility bids, which will then be activated by the primary network operator (see separate system use case for flexibility activation). Implementation of these processes takes place on the flexibility platform (flexibility register), which on the one hand gathers all information regarding the needs of operators and on the other hand registers all bids of flexibility service providers.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Generation management; Advanced Distribution Management System (ADMS); DER Operation System
    - Demand and production (generation) flexibility
        - Participating to the electricity market
- Generation management; DER Operation System
    - Demand and production (generation) flexibility
        - Registration/deregistration of customers in DR program
- Advanced Distribution Management System (ADMS); DER Operation System
    - Operate DER(s)
        - Registration/deregistration of DER in VPP; Aggregate DER as technical VPP; Aggregate DER as commercial VPP
- Demand and production flexibility systems
    - System and security management
        - Registration/de-registration of smart devices
- Market places
    - Grid reliability using market-based mechanisms
        - Operate (register / bidding / clearing / publishing) Ancillary Services Markets; Solve balancing issues through Balancing Market; Solve grid congestion issues through Balancing Market; Manage (auction / resale / curtailment) transmission capacity rights on interconnectors
    - Flexibility Markets
        - Register Flexibility Markets
    - Operate wholesale electricity market
        - Receive energy offers and bids; Clear real-time market; Publish market results
- Trading systems
    - Trading front office operation
        - Bid into ancillary services markets

List of associated standards and specifications

- IEC 61968-11: CIM Extensions for Distribution, incl.:
    - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 61970-301: Data model that describes electrical grids as well as related data (CIM - Common Information Model);
- IEC 62325: set of standards for energy market based on CIM, incl.:
    - IEC 62325-301: CIM extensions for markets;
    - IEC 62325-351: CIM European market model exchange profile;

    - IEC 62325-450: methodology applied to develop the conceptual and assembly models of ENTSO-E Reserve Resource Planning (ERRP);
    - IEC 62325-451-1: acknowledgement business process and contextual model for CIM European market;
    - IEC 62325-451-2: scheduling business process and contextual model for CIM European market;
    - IEC 62325-451-5: problem statement and status request business processes, contextual and assembly models for European market;
    - IEC 62325-451-6: publication of information on market, contextual and assembly models;
    - IEC 62325-451-7 (draft): balancing processes, contextual and assembly models;
    - IEC 62325-504: Use of web services for market data exchange;
- IEC 61850: Communication networks and systems for power utility automation;
- IEC 60870: Telecontrol equipment and systems;
- IEC 62746: Systems interface between customer energy management system and the power management system;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- IEC 62361: Power systems management and associated information exchange - Interoperability in the long term;
- IEC 63110: Protocol for Management of Electric Vehicles charging and discharging infrastructures;
- CENELEC EN 50491: General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS);
- CENELEC EN 50631: Household appliances network and grid connectivity;
- ISO 15118: Road vehicles — Vehicle to grid communication interface;
- IEEE 2030: Series for Smart Grid Interoperability;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- OpenADR: open, two-way information model designed to facilitate information exchange between energy management system and other energy system actors;
- EEBUS: open, two-way information model designed to facilitate information exchange primarily in-home (between devices and an energy management system/gateway) but also with external stakeholders;
- ebIX®: overview of energy flexibility services;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- EFI: a communication protocol that enables end-users to control various smart devices;
- SAREF (ETSI 103 series): reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT

TABLE 12: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'MANAGE FLEXIBILITY BIDS'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Manage flexibility bids							
FBIDS-REQ2	o Ability to exchange information on System Operators' flexibility need and FSPs' flexibility potential through flexibility platform (and DEP)	V	V	V	V	V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FBIDS-REQ4	o Algorithm for prequalification of flexibility providers		V			V	Not addressed specifically in standards for increasingly complex flexibility market. However, not subject to CIM.
FBIDS-REQ6	o Flexibility platform's ability to collect bids from FSPs		V	V	V	V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FBIDS-REQ7	o Selection of successful bids		V			V	Not addressed specifically in standards for increasingly complex flexibility market. However, not subject to CIM.
FBIDS-REQ8	o Flexibility platform's ability to collect grid validation results from SOs	V		V		V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FBIDS-REQ9	o Calculation of grid impacts (congestion, imbalance)		V		V	V	Not addressed specifically in standards for increasingly complex flexibility market. However, not subject to CIM.
FBIDS-REQ3	o Auction process supervised by Market Operator					V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FBIDS-REQ5	o Automated exchange of bids is possible					V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.

4.2.5 MANAGE FLEXIBILITY ACTIVATIONS

<u>Description of SUC</u>

Delivery of notification of activated bids or set points to the FSP which have been previously selected to provide the service, in a reliable and timely manner according to the relevant terms and conditions applicable for FSP.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Generation management
    - Generation Operation Scheduling
        - Ancillary services and reserve products control
- Substation automation system; TSO EMS/SCADA system; DSO feeder automation system; Advanced Distribution Management System (ADMS); DER Operation System
    - Managing power quality
        - Voltage regulation; VAR regulation
- Substation automation system; Advanced Distribution Management System (ADMS)
    - Controlling the grid (locally/ remotely) manually or automatically
        - Feeder load balancing
- TSO EMS/SCADA system; DER Operation System
    - Operate DER(s)
        - DER remote control (dispatch)
- Market places
    - Grid reliability using market-based mechanisms
        - Operate (register / bidding / clearing / publishing) Ancillary Services Markets; Solve balancing issues through Balancing Market; Solve grid congestion issues through Balancing Market
    - Flexibility Markets
        - Register Flexibility Markets
- Demand and production flexibility systems
    - Demand and production (generation) flexibility; System and security management
        - Direct load/generation control signals; Enabling remote control of smart devices

List of associated standards and specifications

- IEC 61968: distribution management based on CIM, incl.:
    - IEC 61968-11: CIM Extensions for Distribution;
    - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 61970: Energy management system application program interface, incl.:
    - IEC 61970-301: Data model that describes electrical grids as well as related data (CIM - Common Information Model);
- IEC 62325: set of standards for energy market based on CIM, incl.:
    - IEC 62325-301: CIM extensions for markets;
    - IEC 62325-351: CIM European market model exchange profile;
    - IEC 62325-450: methodology applied to develop the conceptual and assembly models of ENTSO-E Reserve Resource Planning (ERRP);

  - IEC 62325-451-1: acknowledgement business process and contextual model for CIM European market;
  - IEC 62325-451-5: problem statement and status request business processes, contextual and assembly models for European market;
  - IEC 62325-451-6: publication of information on market, contextual and assembly models;
  - IEC 62325-451-7 (draft): balancing processes, contextual and assembly models;
  - IEC 62325-504: Use of web services for market data exchange;
- IEC 60870: Telecontrol equipment and systems;
- IEC 62746: Systems interface between customer energy management system and the power management system;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- IEC 61850: Communication networks and systems for power utility automation. Describes a general transmission protocol for the protection and control technology in medium and high voltage electrical switchgear;
- IEC 62361: Power systems management and associated information exchange - Interoperability in the long term;
- IEC 63110: Protocol for Management of Electric Vehicles charging and discharging infrastructures;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- CENELEC EN 50491: General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS);
- CENELEC EN 50631: Household appliances network and grid connectivity;
- ISO 15118: Road vehicles — Vehicle to grid communication interface;
- IEEE 2030: Series for Smart Grid Interoperability;
- OpenADR: open, two-way information model designed to facilitate information exchange between energy management system and other energy system actors;
- EEBUS: open, two-way information model designed to facilitate information exchange primarily in-home (between devices and an energy management system/gateway) but also with external stakeholders;
- EFI: a communication protocol that enables end-users to control various smart devices;
- SAREF (ETSI 103 series): reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT;
- ebIX®: overview of energy flexibility services;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format;
- OSGP: supports communication between large deployments of smart grid devices and utility companies

TABLE 13: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'MANAGE FLEXIBILITY ACTIVATIONS'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Manage flexibility activations							
FA-REQ2	o Exchange of activation requests through DEP and flexibility platform	V	V		V	V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FA-REQ1	o Automated activation of devices is possible					V	

4.2.6 VERIFY AND SETTLE ACTIVATED FLEXIBILITIES

Description of SUC

All market participants have to respect a power schedule generated by the market sessions and by the dispatching orders received in real-time. If the participant has taken part to the Energy Market session (Day-ahead or Intraday), the schedule is equal to the market outcome as modified in the Ancillary Service Market (ASM); if the participant bids flexibility directly in the ASM (without participation in the Energy Market session) the schedule is equal to the Baseline (please refer to the SUC named "Baseline calculation") as modified in the ASM. Failure to comply with this schedule causes an imbalance in the electrical system, which involves a settlement process associated with it.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Market places
  - Market Settlements
    - Perform M&V[85]; Perform settlements

List of associated standards and specifications

- IEC 62325 series:
  - IEC 62325-301: CIM extensions for markets;
  - IEC 62325-351: CIM European market model exchange profile;
  - IEC 62325-450: methodology applied to develop the conceptual and assembly models of ENTSO-E Reserve Resource Planning (ERRP);
  - IEC 62325-451-1: acknowledgement business process and contextual model for CIM European market;
  - IEC 62325-451-2: scheduling business process and contextual model for CIM European market;

[85] M&V – Measurement and Validation

- IEC 62325-451-4: settlement and reconciliation business process, contextual and assembly models for European market;
- IEC 62325-451-5: problem statement and status request business processes, contextual and assembly models for European market;
- IEC 62325-451-6: publication of information on market, contextual and assembly models;
- IEC 62325-451-7 (draft): balancing processes, contextual and assembly models;
- IEC 62325-504: Use of web services for market data exchange;

- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- IEC 62361: Power systems management and associated information exchange - Interoperability in the long term;
- ebIX®: overview of energy flexibility services;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format

TABLE 14: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'VERIFY AND SETTLE ACTIVATED FLEXIBILITIES'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Verify and settle activated flexibilities							
FVERIF-REQ1	o Calculation of actually delivered flexibility as response to activation request		V			V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FVERIF-REQ2	o Verification that flexibility delivered matches with flexibility requested		V			V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FVERIF-REQ3	o Calculation of the penalty if flexibility delivered is less than flexibility requested					V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.

4.2.7 MANAGE ACCESS PERMISSIONS

Description of SUC

The party who is the data owner (e.g. electricity consumer is the owner of its consumption data) can authorise an application to have access to its data. Cross-border acknowledgement of authorisations shall be enabled.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Authentication, Authorisation, Accounting Systems
    - System and security management
        - Rights/Privileges Management; Certificate Management

List of associated standards and specifications

- IEC 62351: Power systems management and associated information exchange – Data and communications security ;
- ISO/IEC 14908-1: specifies a communication protocol for local area control networks. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies;
- IEC 9798: defines information technology mechanisms for authentication of instances. These are used to confirm that an instance is indeed who it claims to be. An instance to be authenticated proves its identity by showing that it knows a secret authentication key;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format;
- ebIX®: Business Requirements for Consented request for Accounting Point Characteristics;
- ebIX®: Business Requirements for administration of consent;
- Green Button: specification developed in US that helps utility companies provide consumption time-series data to the customer directly from utility website in a secure manner;
- AS4: Energy Market Profile for secure and reliable document exchange;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- Estfeed: protocol and platform for secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner

TABLE 15: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'MANAGE ACCESS PERMISSIONS'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Manage access permissions							
AUTHZN-REQ1	o Every person needs access permission			V	V		Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
AUTHZN -REQ2	o Valid identity of the person receiving access permissions					V	Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
AUTHZN -REQ3	o Ability to share access permissions between data owners, concerned DEPs, applications and data sources	V	V			V	Addressed in some specifications but not explicitly in standards. CIM coverage recommended.

4.2.8 AUTHENTICATE DATA USERS

Description of SUC

All data users need to be authenticated before accessing the data exchange platform (DEP) containing individual metering data (private data) or any other information with restricted access.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Authentication, Authorisation, Accounting Systems
    - System and security management
        - User Management; Role Management

List of associated standards and specifications

- IEC 62351: Power systems management and associated information exchange – Data and communications security ;
- IEC 62325-451-10 (draft): profiles for energy consumption data ("My Energy Data");
- IEC 9798: defines information technology mechanisms for authentication of instances. These are used to confirm that an instance is indeed who it claims to be. An instance to be authenticated proves its identity by showing that it knows a secret authentication key;
- ISO/IEC 14908-1: specifies a communication protocol for local area control networks. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format;
- Green Button: specification developed in US that helps utility companies provide consumption time-series data to the customer directly from utility website in a secure manner;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- AS4: Energy Market Profile for secure and reliable document exchange;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- Estfeed: protocol and platform for secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner

TABLE 16: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'AUTHENTICATE DATA USERS'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Authenticate data users							
AUTH-REQ-1	o Right to access own data			V			Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
AUTH-REQ-2	o Authentication tools					V	
AUTH-REQ-3	o Ability to share information related to representation rights between data users and concerned Customer Portals	V	V			V	Addressed in some specifications but not explicitly in standards. CIM coverage recommended.
AUTH-REQ-4	o Ability to share authentication information between data users, Customer Portal and Authentication Service Provider	V	V			V	Addressed in some specifications but not explicitly in standards. CIM coverage recommended.

4.2.9 MANAGE DATA LOGS

Description of SUC

Data owner's access to security logs contributes to personal data protection. This concerns both logs of actual data (e.g. who and when has accessed person's consumption data) and information about authorisations (e.g. who and when has issued a new authorisation).

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Authentication, Authorisation, Accounting Systems
  - System and security management
    - Events Management

List of associated standards and specifications

- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- ISO/IEC 19944: how data can be handled in a cloud system, such as cross-border data transfer, data geolocation, data usage, data access and data portability. Energy data (like consumption data) can represent sensitive data. This standard could better regulate the handling of such data;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- Green Button: specification developed in US that helps utility companies provide consumption time-series data to the customer directly from utility website in a secure manner;
- AS4: Energy Market Profile for secure and reliable document exchange;

- Estfeed: protocol and platform for secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner

TABLE 17: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'MANAGE DATA LOGS'

SUCs / Requirements		**TYPE OF REQUIREMENT**					**Gaps, with focus on CIM**
		Performance	**Big data**	**Personal data**	**Security**	**Functional**	
SUC: Manage data logs							
LOGS-REQ1	o Ability to share information related to data logs between data owners, concerned DEPs, applications and data sources		V	V	V	V	Addressed in some specifications but not much in standards. CIM coverage recommended.

4.2.10 CALCULATE FLEXIBILITY BASELINE

Description of SUC

If a market participant bids flexibility in the ASM (without participating in the Energy Market session), it has to declare its power schedule (baseline) in such a way to permit to the TSO to implement the settlement processes. Such player (BSP) usually declares the baseline directly, but the TSO could provide specific tools to help market participants in the baseline definition, promoting market participation. The baseline cannot be measured directly, so it must be calculated based on other available measured data, using an agreed, robust methodology. When choosing the suitable baseline methodology, it is crucial to understand the most important baseline characteristics. In essence, these are accuracy, simplicity, integrity and alignment. It means that at the same time the accuracy of the methodology is important but also it should be simple enough for all stakeholders to calculate and understand. Additionally to that, a suitable methodology should minimize the availability of data manipulation as well as minimize unintended consequences.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Market places
    - Grid reliability using market-based mechanisms
        - Consolidate and verify energy schedules

List of associated standards and specifications

- IEC 62325 series:
    - IEC 62325-301: CIM extensions for markets;
    - IEC 62325-351: CIM European market model exchange profile;

- IEC 62325-450: methodology applied to develop the conceptual and assembly models of ENTSO-E Reserve Resource Planning (ERRP);
- IEC 62325-451-1: acknowledgement business process and contextual model for CIM European market;
- IEC 62325-451-2: scheduling business process and contextual model for CIM European market;
- IEC 62325-451-5: problem statement and status request business processes, contextual and assembly models for European market;
- IEC 62325-451-6: publication of information on market, contextual and assembly models;
- IEC 62325-451-7 (draft): balancing processes, contextual and assembly models;
- IEC 62325-504: Use of web services for market data exchange;

- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- IEC 62361: Power systems management and associated information exchange - Interoperability in the long term;
- ebIX®: overview of energy flexibility services;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format

TABLE 18: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'CALCULATE FLEXIBILITY BASELINE'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Calculate flexibility baseline							
FB-REQ1	o Ability of flexibility platform to collect input for baseline calculation, incl. through DEP	V	V	V	V	V	All data flows necessary for baseline calculation not covered by CIM.
FB-REQ2	o Ability of flexibility platform to compute baseline		V			V	Not addressed specifically in standards. However, not subject to CIM.

4.2.11 PREDICT FLEXIBILITY AVAILABILITY

Description of SUC

This use case describes how the prediction of flexibility availability is undertaken. Flexibility products are described as either slow (e.g. mFRR and STOR) or semi-fast (aFRR) or fast (e.g. FCR). They can provide services for balancing and congestion management at local and national levels for TSOs and DSOs. The assessment of flexibility available in this use case is split over three timeframes:

- Investment planning (3+ years ahead) aims to understand future availability and if the predictions highlight insufficient capacity that needs addressing.

- Operation planning (days to years ahead) aims to predict the short and medium-term availability of flexible products that have committed to providing service.
- Real-time planning (on-the-day operation) aims to predict the current availability of flexible products to balancing requirements for that day.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Generation management; TSO EMS/SCADA system; Advanced Distribution Management System (ADMS); DER Operation System
  - Demand and production (generation) flexibility
    - Generation forecast; Load forecast

List of associated standards and specifications

- IEC 61968 series:
  - IEC 61968-11: CIM Extensions for Distribution;
  - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 61970-301: Data model that describes electrical grids as well as related data (CIM - Common Information Model);
- IEC 62325-301: CIM extensions for markets;
- IEC 61850: Communication networks and systems for power utility automation;
- IEC 60870: Telecontrol equipment and systems;
- IEC 62746: Systems interface between customer energy management system and the power management system;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- IEC 62361: Power systems management and associated information exchange - Interoperability in the long term;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format

TABLE 19: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'PREDICT FLEXIBILITY AVAILABILITY'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Predict flexibility availability							
FPRED-REQ1	o Collection of data for prediction (long term - years)	V	V			V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FPRED-REQ2	o Computation of predictions (long term - years)	V	V			V	Computation of predictions for different flexibility needs not covered in standards. However, not subject to CIM.
FPRED-REQ3	o Collection of data for prediction (medium term - days to years ahead)	V	V			V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FPRED-REQ4	o Computation of predictions (medium term - days to years ahead)	V	V			V	Computation of predictions for different flexibility needs not covered in standards. However, not subject to CIM.
FPRED-REQ5	o Collection of data for prediction (short term - intraday operation)	V	V			V	Current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing not necessarily sufficient.
FPRED-REQ6	o Computation of predictions (long term - intraday operation)	V	V			v	Computation of predictions for different flexibility needs not covered in standards. However, not subject to CIM.

4.2.12 MANAGE SUB-METER DATA

Description of SUC

Communication with different energy consuming and producing devices should be enabled in an organised way to satisfy the needs of different stakeholders. Customers need to monitor and control their devices. Flexibility service providers (flexibility aggregators) and other energy service providers need access for service providers based on these devices. TSOs and DSOs need information for flexibility settlement.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- DER Operation System; Demand and production flexibility systems
    - Demand and production (generation) flexibility; System and security management

- Direct load/generation control signals; Managing energy consumption or generation of DERs via local DER energy management system bundled in a DR program; Enabling remote control of smart devices

List of associated standards and specifications

- IEC 61970-301: Data model that describes electrical grids as well as related data (CIM - Common Information Model);
- IEC 62325: set of standards for energy market based on CIM, incl.:
  - IEC 62325-301: CIM extensions for markets;
  - IEC 62325-351: CIM European market model exchange profile;
  - IEC 62325-504: Use of web services for market data exchange;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- IEC 61968: distribution management based on CIM, incl.:
  - IEC 61968-11: CIM Extensions for Distribution;
  - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 62746: Systems interface between customer energy management system and the power management system;
- IEC 62351: Power systems management and associated information exchange – Data and communications security;
- IEC 63110: Protocol for Management of Electric Vehicles charging and discharging infrastructures;
- IEC 62056: Electricity metering data exchange - The DLMS/COSEM suite, incl.:
  - IEC TS 62056-6-9:2016: Mapping between the Common Information Model message profiles (IEC 61968-9) and DLMS/COSEM (IEC 62056) data models and protocols
- CENELEC EN 50491: General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS);
- CENELEC EN 50631: Household appliances network and grid connectivity;
- ISO 15118: Road vehicles — Vehicle to grid communication interface;
- IEEE 2030: Series for Smart Grid Interoperability;
- EFI: a communication protocol that enables end-users to control various smart devices;
- SAREF (ETSI 103 series): reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT;
- OpenADR: open, two-way information model designed to facilitate information exchange between energy management system and other energy system actors;
- EEBUS: open, two-way information model designed to facilitate information exchange primarily in-home (between devices and an energy management system/gateway) but also with external stakeholders;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;

- OneM2M: communication ontology for machine-to-machine interoperability, focusing on architecture, API specifications, security and enrolment

TABLE 20: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'MANAGE SUB-METER DATA'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Manage sub-meter data							
SUBMET-REQ1	o Collection of data from sub-meters	V	V	V	V		
SUBMET-REQ3	o Storing sub-meter data in data hub		V	V	V	V	Additional CIM coverage (possibly through harmonisation with COSEM) for central sub-meter data storing recommended.
SUBMET-REQ2	o Ability of DEP to forward sub-meter data from data hub to customer (data owner) and to application (energy service provider)	V	V	V	V	V	Additional CIM coverage (possibly through harmonisation with COSEM) for access to and sharing of sub-meter data recommended.
SUBMET-REQ4	o Data format of sub-metering	V	V				
SUBMET-REQ5	o Transmission protocols of sub-metering	V	V	V	V		
SUBMET-REQ6	o SLA between customer and energy service provider	V				V	

4.2.13 EXCHANGE DATA BETWEEN DER AND SCADA

Description of SUC

The use case includes data exchange between generators, DR resources and energy storage devices, and a data exchange platform that provides further real-time communication with SCADA TSO and DSO systems. The data range includes real-time data on the setpoints of devices providing services. It is assumed that the SCADA systems do not require schedule data but require structural data (including connection diagrams) each time they are changed. The purpose of this SUC is to describe the situation where DEP could be used for secure data exchange between FSPs and SOs instead of direct SCADA-to-SCADA communication based on ICCP protocol. The reason is to provide alternative approach to smaller flexibility providers who cannot afford relatively expensive ICCP connection. Obviously, the balance between the affordability and security should be considered in each individual case. Where DEP based approach is acceptable for a system operator it should be considered. Additional standardisation would be needed to cover this case and additional CIM profiling might be needed.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- TSO EMS/SCADA system
    - Operate DER(s)
        - DER remote control (dispatch)

List of associated standards and specifications

- IEC 61970: Energy management system application program interface;
- IEC 62325: set of standards for energy market based on CIM;
- IEC 61968: distribution management based on CIM, incl.:
    - IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 60870: Telecontrol equipment and systems, incl.:
    - IEC 60870-6: The TASE.2 protocol is used to interconnect different SCADA systems;
- IEC 62351: Power systems management and associated information exchange – Data and communications security, incl.:
    - IEC 62351-4: Security measure for MMS-based protocols (e.g. ICCP-based IEC 60870-6) by securing the transport layer and defining an authentication mechanism at the application layer for MMS associations using X.509 certificates;
- IEC 61850: standard defining communication protocols for intelligent electronic devices at electrical substations, as well as abstract data models;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- OpenADR: open, two-way information model designed to facilitate information exchange between an energy management system and other energy system actors;
- EEBUS: open, two-way information model designed to facilitate information exchange primarily in-home (between devices and an energy management system/gateway) but also with external stakeholders;
- OneM2M: communication ontology for machine-to-machine interoperability, focusing on architecture, API specifications, security and enrolment

TABLE 21: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'EXCHANGE DATA BETWEEN DER AND SCADA'

SUCs / Requirements		**TYPE OF REQUIREMENT**					**Gaps, with focus on CIM**
		Performance	**Big data**	**Personal data**	**Security**	**Functional**	
SUC: Exchange data between DER and SCADA							
DER-SCADA-REQ4	o Ability of DEP to forward real-time data from DER's to System Operators	V	V	V	V		Direct communication between small DERs and SO SCADAs not addressed in standards. CIM coverage recommended.
DER-SCADA-REQ5	o Ability of DEP to forward very-near-real-time (up to 1 minute) data from DER's to System Operators	V	V	V	V		Direct communication between small DERs and SO SCADAs not addressed in standards. CIM coverage recommended.
DER-SCADA-REQ6	o Ability of DEP to forward near-real-time (up to 1 hour) data from DER's to System Operators	V	V	V	V		Direct communication between small DERs and SO SCADAs not addressed in standards. CIM coverage recommended.
DER-SCADA-REQ7	o Ability of DEP to forward activation requests from System Operators to DER	V	V	V	V		Direct communication between small DERs and SO SCADAs not addressed in standards. CIM coverage recommended.
DER-SCADA-REQ2	o Communication link between DEP and SO's SCADA					V	Direct communication between small DERs and SO SCADAs not addressed in standards. However, not subject to CIM.
DER-SCADA-REQ1	o Encrypted data exchange		V		V		
DER-SCADA-REQ3	o Safety of DER's IT infrastructure				V		

4.2.14 ANONYMIZE ENERGY DATA

Description of SUC

Private data without identifying the person behind may be useful for some applications and services – e.g., for academic studies, benchmarking, reporting. Using techniques to anonymize data makes access to data easier for these parties as no consent is needed from every individual consumer.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

N/A

List of associated standards and specifications

- IEC 61968-100: This standard defines how energy data (also for market information) modulated in CIM can be exchanged. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose;
- IEC 29100:2011 standard is a framework on privacy and data protection. Its defines the relevant terminology specifies the actors and their roles in the processing of personal data.;
- IEC 20889: This document describes privacy-enhancing de-identification techniques for the privacy principles in ISO/IEC 29100. In particular, this document specifies terminology, a classification of de-identification techniques according to their characteristics and their applicability to reduce the risk of re-identification;
- IEC 62325-451-10 (draft): profiles for energy consumption data ("My Energy Data");
- ISO/TS 25237: more used in the Healthcare sector, contains principles and requirements for privacy protection using pseudonymization services for the protection of personal health;
- Green Button: specification developed in the US that helps utility companies provide consumption time-series data to the customer directly from the utility website in a secure manner;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- AS4: Energy Market Profile for secure and reliable document exchange;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- Estfeed: protocol and platform for the secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner;
- USEF: framework defining modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format

TABLE 22: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'ANONYMIZE ENERGY DATA'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Anonymize energy data							
ANO-ED-REQ-1	o Standard rules to anonymize data not to enable the identification of persons behind data			V	V		Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
ANO-ED-REQ-2	o Standard rules to anonymize data in order to ensure the comparability of anonymized data sets					V	Addressed in some specifications but not explicitly in standards. However, not subject to CIM.'
ANO-ED-REQ-3	o Data source (e.g. meter data hub) ability to anonymize data	V	V			V	Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
ANO-ED-REQ-4	o DEP ability to forward anonymized data from data source to data user	V	V			V	Addressed in some specifications but not explicitly in standards. Additional CIM coverage may be required.

4.2.15 AGGREGATE ENERGY DATA

Description of SUC

Data exchange platform can support data aggregation. Aggregated data may be useful for different applications (services) – e.g. related to benchmarking, national statistics, imbalance reporting. Also, aggregated data would not require consent for personal data or commercially sensitive data.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

- Metering-related Back Office systems; Substation automation system; EMS SCADA system; Distribution management systems; Advanced Distribution Management System; DER Operation System
    - Monitor AMI event; Monitoring the grid flows; Operate DER(s)
        - Manage power quality data; Manage outage data; Manage the network using metering system data; Manage efficiency measures at the premise using metering system data; Monitoring electrical flows

List of associated standards and specifications

- IEC 62325: a set of standards for energy market based on CIM, incl.:
    - IEC 62325-351: CIM European market model exchange profile;
    - IEC 62325-504: Use of web services for market data exchange;
    - IEC 62325-451-6: Publication of information on market, contextual and assembly models;
- IEC 61968: distribution management based on CIM;
- IEC 61970: Energy management system application program interface;
- IEC 62351: Power systems management and associated information exchange – Data and communications security
- Green Button: specification developed in the US that helps utility companies provide consumption time-series data to the customer directly from the utility website in a secure manner;
- MADES (IEC 62325-503): profile for a communication platform which European TSOs may use to reliably and securely exchange documents;
- OSGP: supports communication between large deployments of smart grid devices and utility companies;
- AS4: Energy Market Profile for secure and reliable document exchange;
- Estfeed: protocol and platform for the secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner

TABLE 23: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'AGGREGATE ENERGY DATA'

SUCs / Requirements		TYPE OF REQUIREMENT					Gaps, with focus on CIM
		Performance	Big data	Personal data	Security	Functional	
SUC: Aggregate energy data							
AGG-ED-REQ-1	o Standard rules to aggregate data in order not to enable the identification of persons behind data			V	V		Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
AGG-ED-REQ-2	o Standard rules to aggregate data in order to ensure the comparability of aggregated data sets					V	Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
AGG-ED-REQ-3	o Data source (e.g. meter data hub) ability to aggregate data	V	V			V	Addressed in some specifications but not explicitly in standards. However, not subject to CIM.
AGG-ED-REQ-4	o DEP ability to forward aggregated data from data source to data user	V	V			V	Addressed in some specifications but not explicitly in standards. Additional CIM coverage may be required.

4.2.16 ERASE AND RECTIFY PERSONAL DATA

Description of SUC

According to data protection rules, any person has the right (unless not stated otherwise in law) to execute control over its data – to erase it, restrict access to it, and rectify it.

Related CEN-CENELEC-ETSI (2017) major systems/functions, use cases cluster and high-level use cases

N/A

List of associated standards and specifications

- ISO/IEC 19944: how data can be handled in a cloud system, such as cross-border data transfer, data geolocation, data usage, data access and data portability. Energy data (like consumption data) can represent sensitive data. This standard could better regulate the handling of such data;
- ISO/IEC 27001: a baseline for handling personal data and deal with privacy topics;
- ISO/IEC 27000: establishes commonly accepted control objectives, controls and guidelines for implementing measures to protect personally identifiable information (PII) following the privacy principles in ISO/IEC 29100 for the public cloud computing environment;
- Green Button: specification developed in the US that helps utility companies provide consumption time-series data to the customer directly from the utility website in a secure manner;
- Estfeed: protocol and platform for the secure exchange of private energy metering data between Data Providers and Data Users with the consent of Data Owner

TABLE 24: REQUIREMENTS AND STANDARDISATION GAPS OF SUC 'ERASE AND RECTIFY PERSONAL DATA'

SUCs / Requirements		**TYPE OF REQUIREMENT**					**Gaps, with focus on CIM**
		Performance	**Big data**	**Personal data**	**Security**	**Functional**	
SUC: Erase, restrict and rectify personal data							
PERSO-DATA-REQ1	o Ability to share information related to erasure of personal data between data owners, concerned DEPs, applications and data sources			V		V	Addressed in some specifications and standards but not explicitly about sharing rectification information. CIM coverage recommended.
PERSO-DATA-REQ2	o Ability to share information related to rectification of personal data between data owners, concerned DEPs, applications and data sources			V		V	Addressed in some specifications and standards but not explicitly about sharing erasure information. CIM coverage recommended.

5. FUTURE DATA EXCHANGE STANDARDS' DEVELOPMENT

5.1 RATIONALE FOR "CIMIFICATION"

"CIMification" is the term proposed by EU-SysFlex to illustrate the need for and benefits of further interoperability through a single information model like CIM.

Some key standardisation elements which justify the choice of "CIMification" should be reminded. IEC CIM (IEC 61970, IEC 61968, IEC 62325 series) is identified as a core smart grid standard in IEC TR 63097 *Smart grid standardization roadmap* (2017)[86]. Three data models CIM, 61850, COSEM are identified as core information models as described in Figure 1. It has to be pointed out that these standard data models are also supported by harmonisation documents.

IEC TR 62357-1 (2016)[87] "provides a clear and comprehensive map of all standards which are contributing to support interactions, in an open and interoperable way, between actors, components and systems" in the field of electricity grids from generation to consumers, including transmission and distribution systems (see also chapter 3.2.3). It leverages SGAM domains and zones as described in Figure 8.

[86] https://webstore.iec.ch/publication/27785
[87] https://webstore.iec.ch/publication/26251

IEC CIM is also the information model chosen to support information exchanges in the Utility domain. Thus, another IEC valuable framework provided by IEC is defined in 61968-1 Interface Reference Model (IRM) (2020)[88] which helps to define which business objects will be exchanged between business functions (Figure 13).

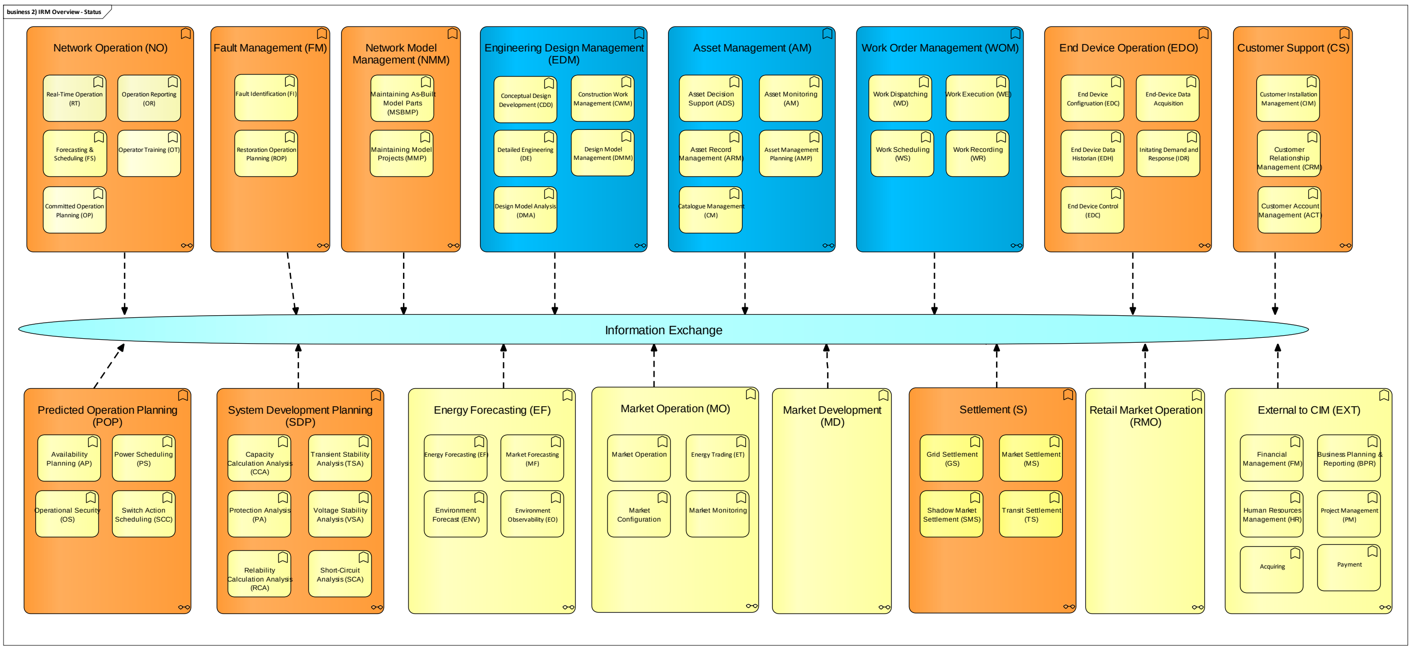

FIGURE 13: IEC INTERFACE REFERENCE MODEL (IEC 61968-1, 2020[89])

IEC CIM is the data model chosen to support Business Object definitions which are defined during Use Case definitions.

Last but not least, IEC CIM is already supporting EU regulation as illustrated in Figure 14.

[88] https://webstore.iec.ch/publication/32542
[89] Copyright © 2020 IEC Geneva, Switzerland. www.iec.ch

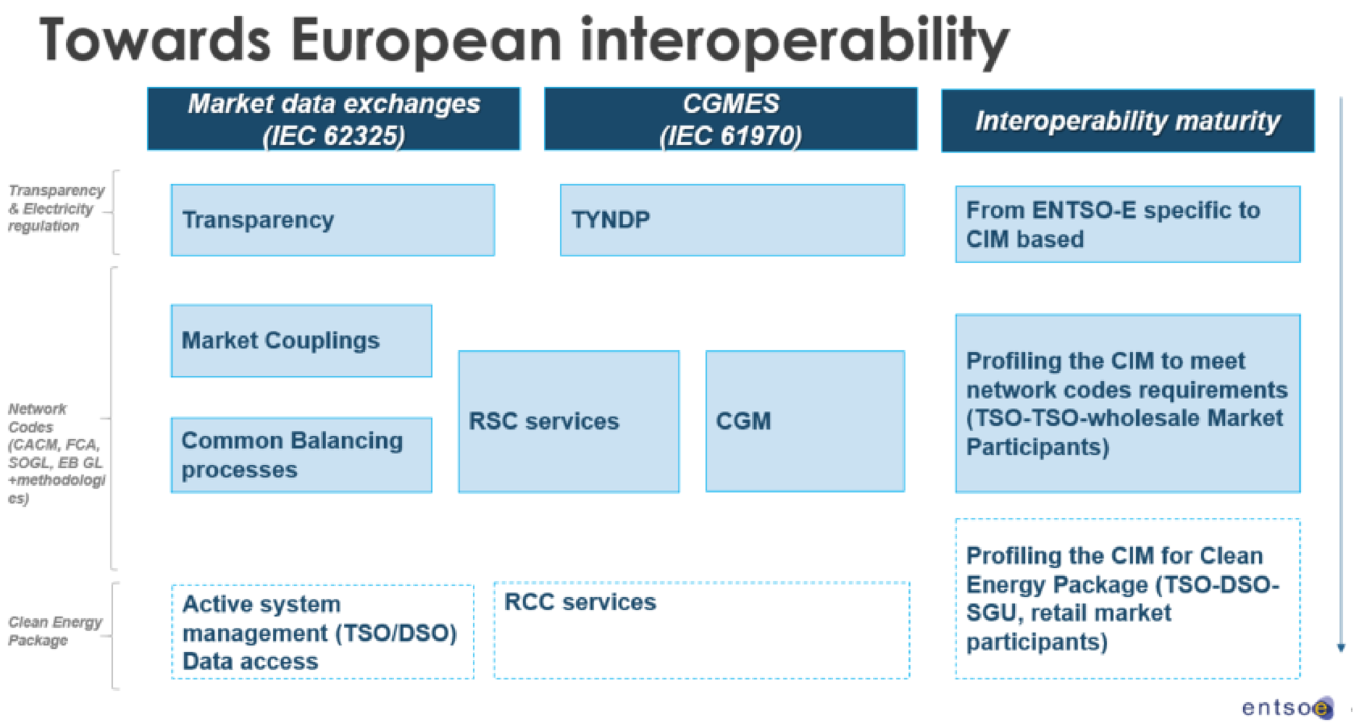

FIGURE 14: IEC CIM SUPPORTING EU REGULATION (ENTSO-E, NOT PUBLISHED)

Therefore enlarging CIM usage makes sense in the context of European regulation and more precisely of Clean Energy Package. It is essential to consolidate CIM model, by defining new profiles. Moreover the methodology associated to CIM usage is well documented and well supported by some tools. The overall profiling methodology is illustrated in Figure 15.

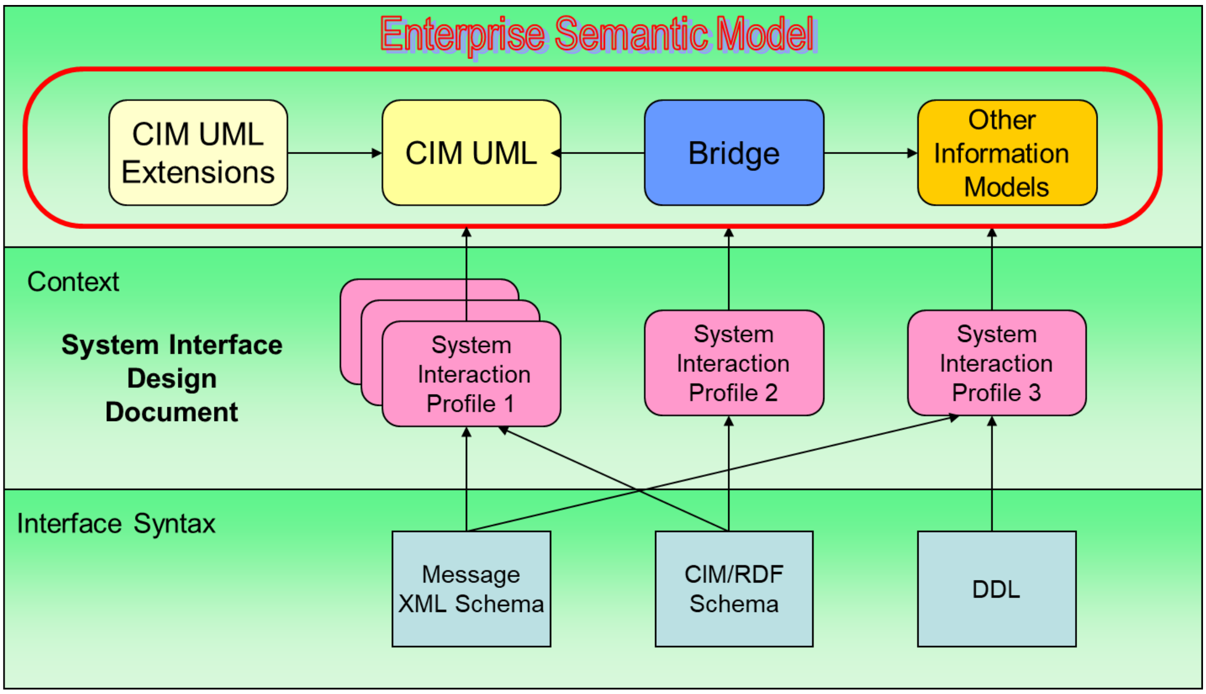

FIGURE 15: CIM RELATED PROFILING METHODOLOGY AND BRIDGE TO OTHER INFORMATION MODELS (SAXTON, 2016)

Enhancing CIM will facilitate vendor adoption and support of CIM by vendors. It will also facilitate compliance testing and certification and facilitate organisation of interoperability tests between different vendors.

Using CIM in electricity sector can also facilitate cross-sector interoperability as illustrated by BRIDGE reference architecture proposal in Figure 6 to support European energy data exchange (BRIDGE, 2021-1). Defining canonical data model will facilitate cross-sector data exchange, e.g. by extending CIM and/or integrating other sectors' canonical data models with CIM.

European electricity sector has put in place a robust methodology based on system approach, which promotes interoperability by using standards (Use Case definition, Role Model, Canonical Data Model like CIM, Smart Grid Architecture Model). It would be valuable to extend this approach to other energy vectors and to cross-sector domain. In order to facilitate data exchange between sectors, it would make sense to develop cross-sector data models and profiles.

It also has to be noticed that some CIM extensions can be kept at a regional level and not be part of IEC CIM model. It is the case of few extensions proposed by ENTSO-E which are kept at the European level and managed by ENTSO-E. Nevertheless the main objective is to consolidate IEC CIM model by raising CIM issues and discuss these issues at the level of IEC TC57 working groups in order to consolidate and improve IEC CIM model.

This "CIMification" process helps also to set up CIM repositories (see chapter 5.4) and share CIM knowledge among European community. It will definitely improve interoperability between smart grid applications.

5.2 CIM PROFILING FOR DATA EXCHANGE DEMONSTRATORS

5.2.1 USE CASES AND BUSINESS OBJECTS FOR "CIMIFICATION"

Beyond the gap analysis between Task 5.2 data exchange System Use Cases and existing standards/specifications explained in chapter 4, a finer grained analysis yielded table 25 showing the links between data exchange system use cases from Task 5.2 and business objects associated with these with further CIM profiling needs based on the identified CIM gaps in chapter 4.1 (tables 7 and 8). The profiles are grouped into two clusters – 'flexibility data' and 'private data'. Some profiles could be classified into both but more dominant was selected for presentation (e.g. 'Flexibility Bid' is considered as flexibility data, even though it is also private data by nature. This assessment is preliminary and can be confirmed by completing the profiling of all business objects listed in the table. As part of Task 5.5 and this report the profiling process was performed for two business objects – Flexibility Bid (chapter 5.2.2) and Customer Consent (chapter 5.2.3).

TABLE 25: PRELIMINARY ASSESSMENT OF NEED FOR FURTHER 'CIMIFICATION'

SUCs	Business Objects	Need for further CIM profiling? Profiling of flexibility data	Need for further CIM profiling? Profiling of private data
Authenticate data users	Authenticate Information		X
	Representation Rights		X
Calculate flexibility baseline	Baseline	X	
	Flexibility Bid	X	
Collect energy data	Authenticate Information		X
	Metering Data	No action needed	
	Market Data (e.g. Flexibility Bid)	X	
	Request on Market Data	X	
	Congestion Matrix (same as Results of Grid Validation or Grid Impact Assessment Result)	X	
Exchange data between DERs and System Operators	DER Structural Data	X	
	DER Real Time Data	X	
	DER Activation	X	
Manage access permissions	Authorisation information		X
	Customer Consent		X
Manage data logs	Data log request		X
	Data log		X
Manage flexibility activations	Flexibility Bid	X	
	Flexibility Activation Request (involves Flexibility Activation Order)	X	
	Congestion Matrix (same as Results of Grid Validation or Grid Impact Assessment Result)	X	
	Counter Action	X	
	Activated Flexibility (same as Activation Confirmation)	X	
	Flexibility Potential	X	
Manage flexibility bids	Flexibility Need	X	
	Flexibility Potential	X	
	Congestion Matrix (same as Results of Grid Validation or Grid Impact Assessment Result)	X	
	Network Restriction	X	
	Flexibility Call for Tenders	X	
	Flexibility Bid	X	
Manage sub-meter data	Sub-Meter Data		X
	Request on Sub-Meter Data		X
	Customer Consent		X
	Control Signal	X	
Predict flexibility availability	Flexibility Need	X	
	Flexibility Potential	X	
Provide list of suppliers and ESCOs	ESCO Information	X	
	Authenticate Information		X
	Aggregator Information	X	
Transfer energy data	Authenticate Information		X
Verify and settle activated flexibilities	Metering Data	No action needed	
	Baseline	X	
	Activated Flexibility	X	
	Flexibility Settlement	X	

Based on these use cases and business objects, detailed specifications were written for many objects and implemented in Work Package (WP) 9 demonstrators, however not compliant with CIM standards in their APIs (Application Programming Interfaces). Central element for all data exchanges is Estfeed DEP. These detailed specifications are based in particular on:

- Estfeed services description Flexibility Platform,
- Estfeed services description SO Simulator,
- Estfeed Service Payload Formats. Technical Specification (Cybernetica, 2018)[90].

For instance, the SubmitFlexibilityBid API consists in the custom-made XSD (XML Schema Definition) as depicted in Figure 16.

FIGURE 16: ‘FLEXIBILITY BID’ XSD (NON-COMPLIANT TO CIM)

This XSD is correct syntactically speaking but leaves out precisions, such as measure units for measures, currency units for prices, strongly typed values (instead of just strings) or enumerated values. These precisions are expected in XSDs based on CIM standards.

WP5 decided to realize a “CIMification” of some of these XSDs. This CIMification started with comparing existing XSDs implemented in Work Package 9 demonstrators with CIM data model standards, such as ESMP (European Style Market Profile) based on IEC 62325. The objectives were to:

- Define CIM profiles based on CIM standards whenever it was possible and produce XSDs based on them,
- In case of gaps in CIM standards, define extensions to be proposed to IEC.

The CIMification process was carried out after XSDs have been defined in WP9. In order to minimize the impact on the APIs of already implemented systems (i.e. the Flexibility Platform and the Affordable Tool), XSLT (eXtensible

[90] https://elering.ee/sites/default/files/attachments/estfeed_service_payload_formats_2.8_Y-1028-8.pdf

Stylesheet Language Transformations) codes were produced to map XML documents compliant with actual XSDs into XML documents compliant with CIMified XSDs, as well as other XSLT codes that map XML documents in the other way around.

The CIMification process could have been carried out earlier, i.e. before the definition of the actual XSDs. It would have led to reflections on subjects that were left out initially (such as ID managements of Bids, Linked Bids) because not considered important for demonstration purpose. But a CIMification of existing XSDs carried out at this stage of the development process avoided the tunnelling effect of time-consuming specifications.

The CIMification process started with an inventory of XSDs implemented in WP9 demonstrators and an analysis of related business objects mentioned in Task 5.2 data exchange system use cases. This analysis yielded in Table 26.

TABLE 26: APIS AND RELATED BUSINESS OBJECTS

Systems[91]	APIs	Data Type	Business Objects
FP	GetProducts	Flexibility Data	Flexibility Product
FP	SubmitFlexibilityPotential	Flexibility Data	Flexibility Potential
FP	GetPotentialPrequalificationStatus	Flexibility Data	Flexibility Potential
FP	GetCallsForTenders	Flexibility Data	Flexibility Call for Tenders
FP	SubmitFlexibilityBid	Flexibility Data	Flexibility Bid
FP	GetFlexibilityBids	Flexibility Data	Flexibility Bid
FP	SendActivationOrder	Flexibility Data	Flexibility Activation Order
FP	GetVerificationResults	Flexibility Data	Flexibility Settlement
FP	SubmitSchedule	Flexibility Data	Flexibility Baseline
SO	SubmitProductProposal	Flexibility Data	Flexibility Product
SO	SubmitFlexibilityNeed	Flexibility Data	Flexibility Need
SO	PotentialGridImpactAssessment	Flexibility Data	Congestion Matrix
SO	BiddingGridImpactAssessment	Flexibility Data	Congestion Matrix
SO	SubmitCallForTenders	Flexibility Data	Flexibility Call for Tenders
SO	SendActivationRequest	Flexibility Data	Flexibility Activation Request
Estfeed	GetElectricityUsagePoints	Private Data	Usage Point
Estfeed	GetElectricityConsumptionHistory	Private Data	Metering Data
Estfeed	GetGasUsagePoints	Private Data	Usage Point
Estfeed	GetGasConsumptionHistory	Private Data	Metering Data
Estfeed	WeatherForecast	Private Data	Weather Forecast
Estfeed	WeatherObservation	Private Data	Weather Observation
Estfeed	ElectricityPrice	Private Data	Electricity Price
Estfeed	ConsumptionData	Private Data	Metering Data
Estfeed	ElectricityUsagePoints	Private Data	Usage Point
Estfeed	GasUsagePoints	Private Data	Usage Point
Estfeed	MeasurementData	Private Data	Metering Data
Estfeed	MandateData	Private Data	Customer Consent Representation Rights

[91] FP – Flexibility Platform, SO – System Operator Simulator.

Then, the CIMification process consisted in:

- Establishing standardised data models of business objects. This task was realized with the Sparx Enterprise Architect UML tool and the EDF Modsarus plugin for helping the elaboration of the data models. The data models were built on data model standards (such as ESMP) and were structured by means of dedicated CIM profiles. Modsarus was also used to generate standardised XSDs.
- Mapping actual XSDs and standardised XSDs with each other, so that correspondences could be drawn between XML documents compliant with them. This task was realized with the Altova MapForce XML tool. This tool generated the XSLT codes mentioned above.

5.2.2 PROFILING OF FLEXIBILITY DATA EXCHANGE (BASED ON EXAMPLE OF FLEXIBILITY BID SUBMISSION)

The CIMification process was applied to one of the core business APIs for flexibility management: SubmitFlexibilityBid. This API is implemented in the Flexibility Platform to submit Flexibility Bids.

The standardised CIM profile illustrated in Figure 17 was elaborated for 'Flexibility Bid' business object with Sparx Enterprise Architect and Modsarus.

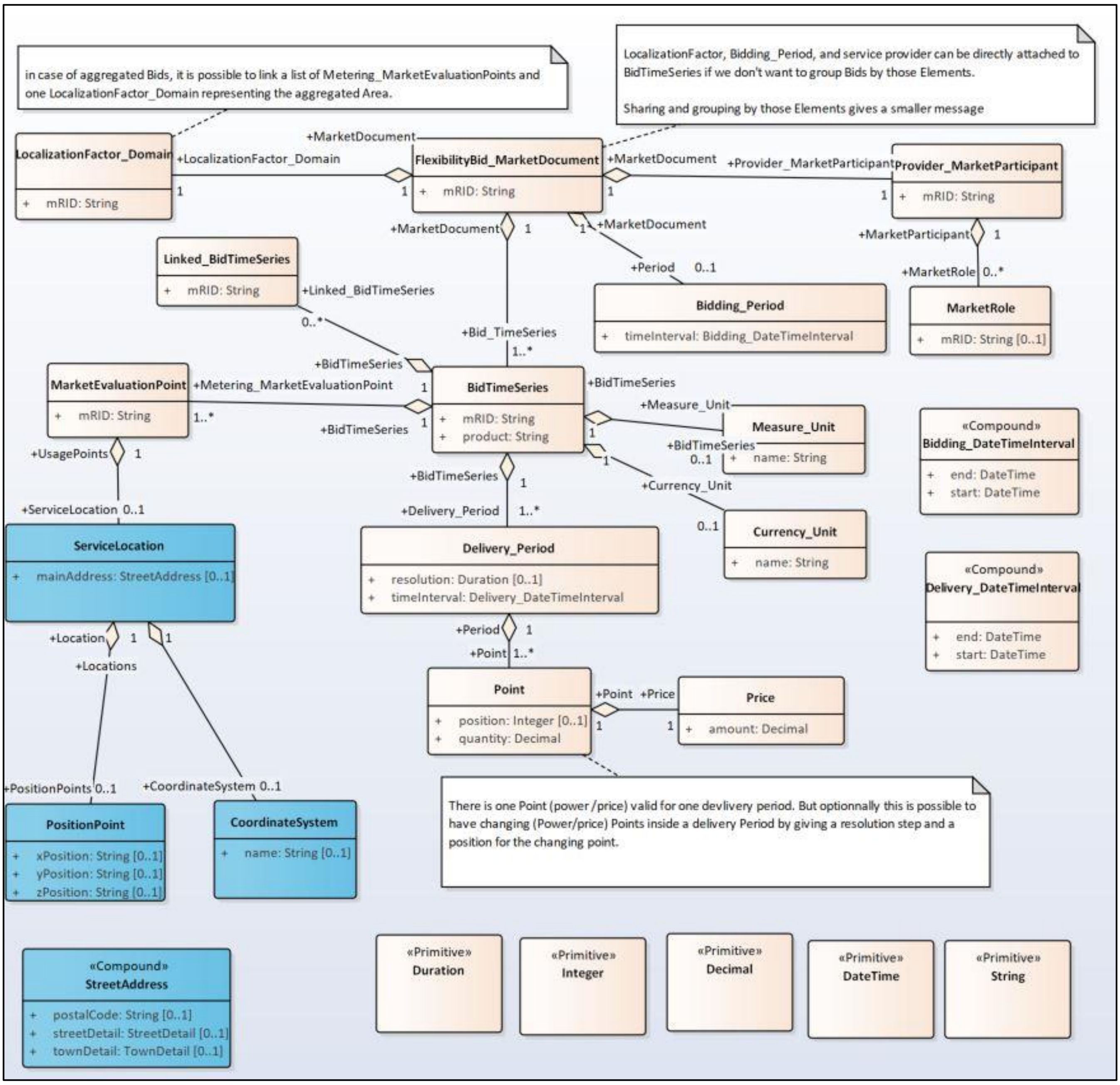

FIGURE 17: STANDARDISED CIM PROFILE FOR 'FLEXIBILITY BID' BUSINESS OBJECT

This standardised data model was used to produce the standardised XSD depicted in Figure 18.

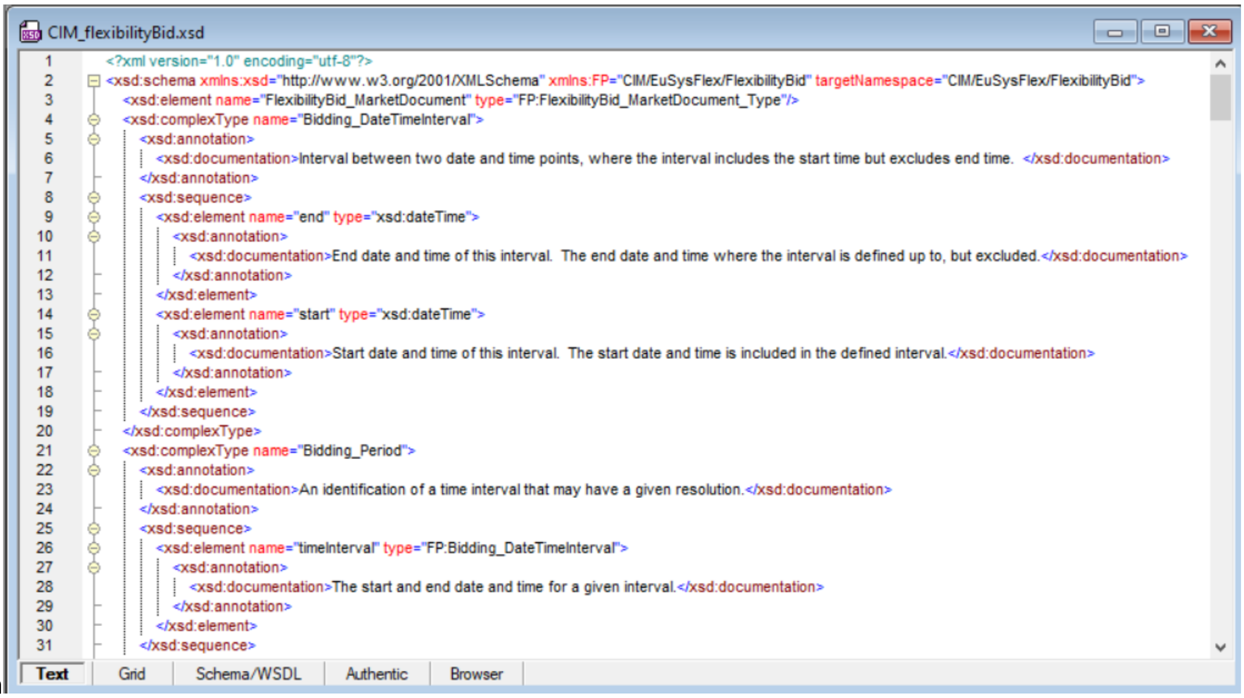

FIGURE 18: STANDARDISED XSD FOR 'FLEXIBILITY BID' BUSINESS OBJECT

The mapping between the actual XSD and the standardised XSD is illustrated in the diagram in Figure 19 where attributes on both sides are linked, with algebraic relations when needed.

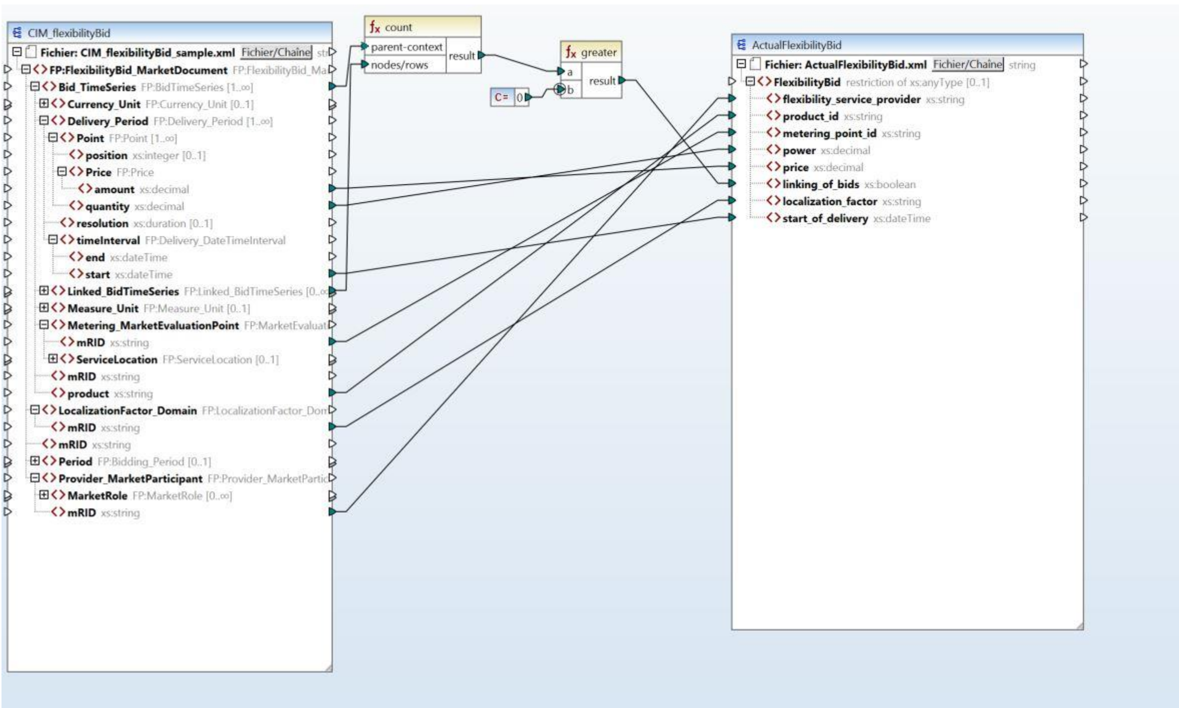

FIGURE 19: 'FLEXIBILITY BID' BUSINESS OBJECT - XSLT TRANSFORMATION FROM CIM COMPLIANT FORMAT TO EU-SYSFLEX FORMAT

The XSLT codes generated with Altova MapForce were integrated in the Flexibility Platform, by means of a Saxon library, without any other inner changes. In particular, the internal data model did not need any changes. The illustration in Figure 20 gives the first lines of the XSLT code that maps an XML document compliant with the CIMified XSD with an XML document compliant with the actual XSD.

FlexibilityBid CIM2Sys.xslt *

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="2.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:ns0="CIM/EuSysFlex/FlexibilityBid" xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:fn="http://www.w3.org/2005/xpath-functions" exclude-result-prefixes="ns0 xs fn">
  <xsl:output method="xml" encoding="UTF-8" byte-order-mark="no" indent="yes"/>
  <xsl:template match="/">
    <xsl:variable name="var1_FlexibilityBid_MarketDocument" as="node()?" select="ns0:FlexibilityBid_MarketDocument"/>
    <FlexibilityBid>
      <xsl:attribute name="xsi:noNamespaceSchemaLocation" namespace="http://www.w3.org/2001/XMLSchema-instance" select="
'file:///C:/Users/d93057/Documents/OneDrive%20-%20EDF/Espace%20de%20travail/Projets%20europ%C3%A9ens/EUSysFlex/WP5/CIM%20Profiling/ActualFlexibilityBid.xsd'"/>
      <xsl:for-each select="$var1_FlexibilityBid_MarketDocument">
        <flexibility_service_provider>
          <xsl:sequence select="fn:string(Provider_MarketParticipant/mRID)"/>
        </flexibility_service_provider>
      </xsl:for-each>
      <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries">
        <product_id>
          <xsl:sequence select="fn:string(product)"/>
        </product_id>
      </xsl:for-each>
      <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Metering_MarketEvaluationPoint">
        <metering_point_id>
          <xsl:sequence select="fn:string(mRID)"/>
        </metering_point_id>
      </xsl:for-each>
      <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Delivery_Period/Point">
        <power>
          <xsl:sequence select="xs:string(xs:decimal(fn:string(quantity)))"/>
        </power>
      </xsl:for-each>
      <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Delivery_Period/Point">
        <price>
```

Text | Grid | Schema/WSDL | Authentic | Browser

FIGURE 20: XSLT CODE FOR THE MAPPING BETWEEN 'FLEXIBILITY BID' BUSINESS OBJECT XSDS

Finally, a new CIMSubmitFlexibilityBid API was created and published on the Estfeed platform. This way, the Flexibility Platform similarly accepts Flexibility Bids submitted by means of the former API or the standardised (CIM compliant) API.

Also, as a proof-of-concept, XSLT transformations were provided and tested on sample data in both ways:

- From CIM to actual EU-SysFlex format as described previously,
- From EU-SysFlex format to CIM: for this transformation (see Figure 21), as the CIMified XSD contains more data than the actual EU-SysFlex XSD, arbitrary values have been set for the following objects: IDs of CIM Objects, endTime for bidding and delivery periods. Moreover, as LinkedBids IDs are not managed in the actual implementation of systems used in WP9 demonstrators, the information is not initialized by the transformation.

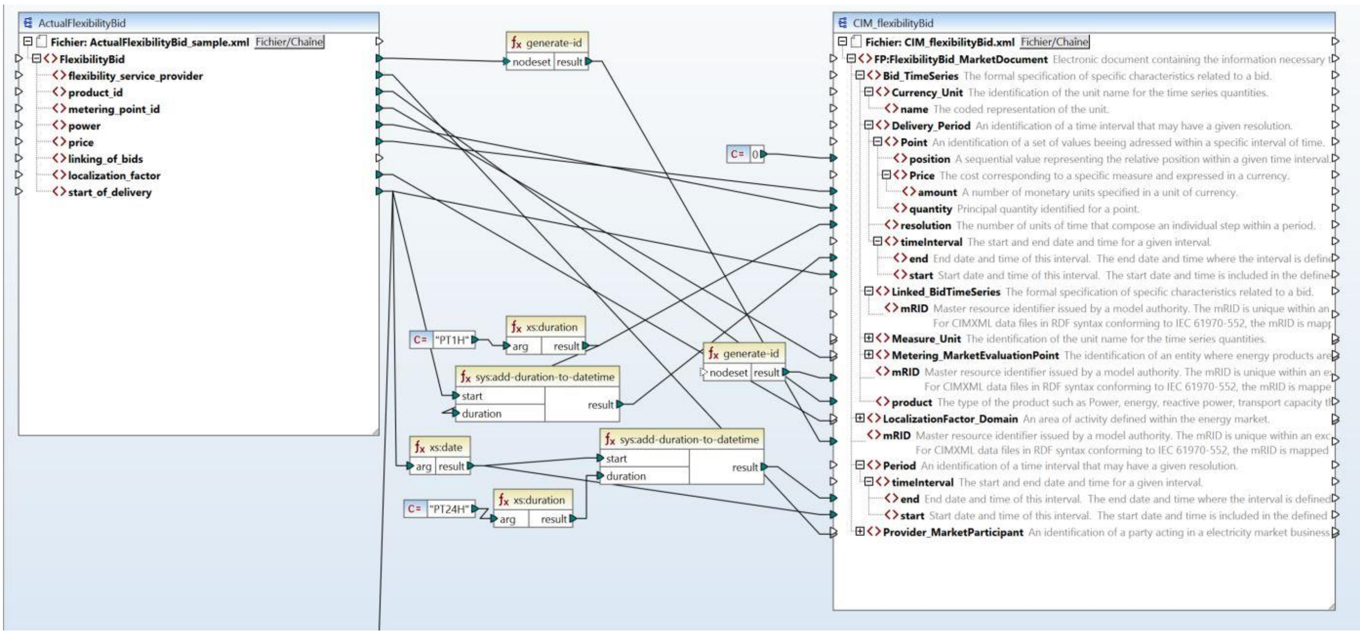

FIGURE 21: 'FLEXIBILITY BID' BUSINESS OBJECT - XSLT TRANSFORMATION FROM EU-SYSFLEX FORMAT TO CIM COMPLIANT FORMAT

Annex VII provides the full code for XSD and XSLTs of 'Flexibility Bid' business object.

As a conclusion, the 'Flexibility Bid' business object does not require CIM extensions as all required data can be modelled when profiling CIM. This is true even if considering that ESMP was initially designed for balancing. As WP9 demonstrator aims to test data exchanges for joint balancing and congestion management product (mFRR type of product) it was verified that ESMP already works for other products (at least for congestion management) and for joint products.

5.2.3 PROFILING OF PRIVATE DATA EXCHANGE (BASED ON EXAMPLE OF CONSENT MANAGEMENT)

The work focused on the 'Customer Consent' business object implemented in Estfeed as the 'Mandate Data' message and also consisted in analysing two SUCs published in WP5 (Authenticate data users and Manage access permissions). The 'Customer Consent' message deals with the ability to delegate access permissions to another player, in order the other player to have access to customer's data (e.g. consumption data).

The Estfeed XSD for this 'Mandate Data' message is shown in Figure 22.

```xml
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified" attributeFormDefault="unqualified">
    <xs:element name="MandateData">
        <xs:complexType>
            <xs:sequence>
                <xs:element name="addMandate" type="MandateType" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element name="updateMandate" type="UpdateMandateType" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element name="mandate" type="MandateType" minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <!-- Types -->
    <xs:complexType name="MandateType">
        <xs:sequence>
            <xs:element name="mandateId" type="xs:string"/>
            <xs:element name="mandateObject" type="MandateObjectType"/>
            <xs:element name="person" type="PersonType"/>
            <xs:element name="validFrom" type="xs:dateTime"/>
            <xs:element name="validTo" type="xs:dateTime"/>
            <xs:element name="state" type="xs:string"/>
            <xs:element name="lastTransitionDatetime" type="xs:dateTime"/>
            <xs:element name="transitionComment" type="xs:string"/>
            <xs:element name="contactEmail" type="xs:string" minOccurs="0"/>
            <xs:element name="contactPhone" type="xs:string" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="UpdateMandateType">
        <xs:sequence>
            <xs:element name="mandateId" type="xs:string"/>
            <xs:element name="state" type="xs:string"/>
            <xs:element name="lastTransitionDatetime" type="xs:dateTime"/>
            <xs:element name="transitionComment" type="xs:string"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="MandateObjectType">
        <xs:sequence>
            <xs:element name="code" type="xs:string"/>
            <xs:element name="kind" type="xs:string"/>
            <xs:element name="location" type="xs:string"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="PersonType">
        <xs:sequence>
            <xs:element name="ETSI" type="xs:string"/>
            <xs:element name="givenName" type="xs:string"/>
            <xs:element name="surname" type="xs:string" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
</xs:schema>
```


FIGURE 22: ‘MANDATE DATA’ XSD IMPLEMENTED IN WP9 DEMONSTRATORS (NON-COMPLIANT TO CIM)

As for 'Flexibility Bid' business object, the CIMification used also ESMP classes to produce the equivalent in CIM. Besides, the CIMified 'Customer Consent' message is really generic as any CIM consent objects can be associated by giving its identifier in the consent agreement.

For 'Flexibility Bid' business object, no CIM extensions were needed, but for 'Customer Consent' object this generic approach needed CIM extensions as shown in Figure 23. In order to model a customer consent as a MarketAgreement with the ability to link a ConsentObject identifier and eventually an identifier of an UsagePoint, it was necessary to extend the CIM by:

- Adding ConsentObject with a generalization association from IdentifiedObject in order to give the ability of uniquely identify it.
- Adding a relation between ConsentObject and MarketDocument in order to create a profile with a relation between the ConsentObject and MarketAgreement as it is a specialization of MarketDocument.
- Adding a relation between ConsentObject and UsagePoint in order to create a profile with a relation between those two classes.

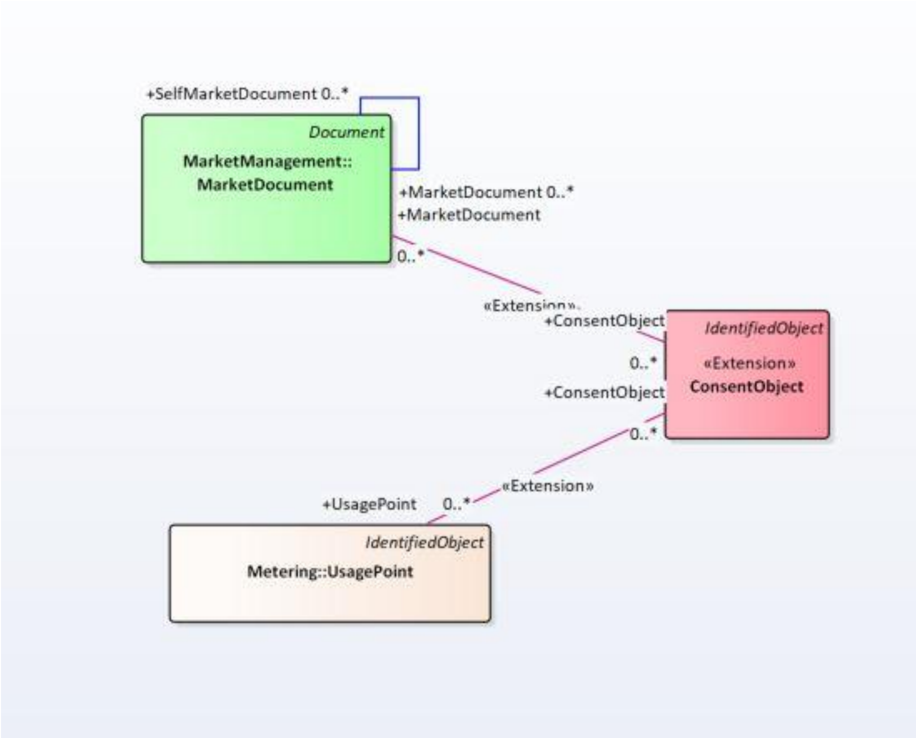

FIGURE 23: CIM EXTENSIONS FOR 'CUSTOMER CONSENT' BUSINESS OBJECT

Once extended, the CIM profile for the 'Customer Consent' message can be defined as shown in Figure 24.

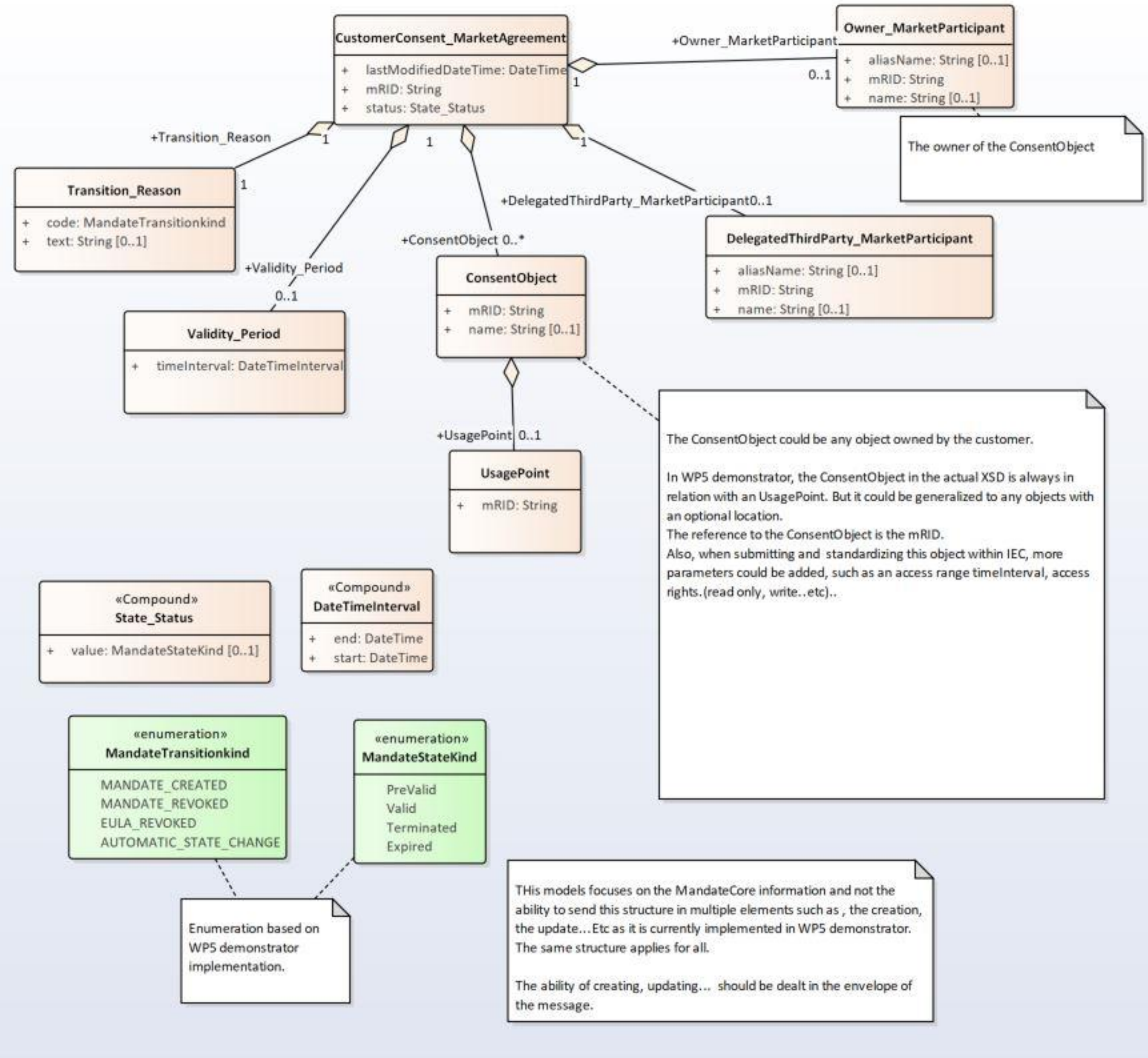

FIGURE 24: STANDARDISED CIM PROFILE FOR 'CUSTOMER CONSENT' BUSINESS OBJECT

In WP9 demonstrators, the ConsentObject is always in relation with a UsagePoint. But it could be generalized to any objects with an optional location. Also, when standardising this object within IEC, more parameters could be added, such as an access range timeInterval and access rights (read only, write…).

Finally, the XSD for this message can be generated from the CIM profile and is shown in Annex VIII.

5.3 CONCLUSIONS RELATED TO DATA EXCHANGE STANDARDS

The following conclusions are based on gap analysis (chapter 4) and on "CIMification" process of two sample business objects (chapter 5.2).

General conclusions:

- Though data exchange system use cases include the concept of Data Exchange Platform[92], the standards and specifications investigated can and should in most cases be applied equally in different data exchange models – platform-based distributed data exchange, platform-based centralised data storage, bilateral data exchange.
- Requirements of data aggregation and data anonymization use cases are addressed in some specifications but not explicitly in standards.
- Regarding data user's authentication, the right to access own data as well as the ability to share information related to authentication and representation rights are addressed in some specifications but not explicitly in standards.
- Regarding consent management some specification exist but no explicit standards for giving and sharing access permissions.
- Regarding personal data management it is addressed in some specifications and standards but not explicitly about sharing erasure and rectification information.
- Ability to share information related to data logs has very limited coverage in standards.
- Energy data collection and energy data transfer use cases are fairly well covered in existing standards.
- Standardisation of easy access to sub-meter data by data owners and by other parties based on data owners consent could be improved.
- Direct DER-SCADA communication between small Distributed Energy Resources of prosumers and other end-users, their aggregators and system operators' SCADAs is not addressed in standards yet.[93]
- Related to flexibility market baseline calculation, algorithm for prequalification of flexibility providers, selection of bids, calculation of grid impacts, computation of predictions are not addressed in standards specifically for increasingly complex flexibility market. Several other flexibility market requirements could benefit from CIM standards' extensions.
- Data management related to list of suppliers and ESCOs is well covered in existing standards.

CIM standards related conclusions:

- Additional CIM coverage may be needed for data hubs.
- Additional CIM coverage for private data portability, for access to own data, and for transfer of private data to other parties is recommended, incl. cross-border.
- CIM coverage is recommended for sharing access permissions (consent management) between data owners, concerned DEPs, applications and data sources. The CIM profiling of 'Customer Consent' business object confirmed the need for CIM extensions.

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[92] As defined in EU-SysFlex deliverable 5.2: Data exchange platform (DEP) is a communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g. data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g. cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs. Several DEPs may exist in different countries and inside one country.

[93] Proposal has been made to enhance IEC 61850 by including system operator's communication with distributed devices (Fries et al., 2016): https://www.researchgate.net/publication/305207018_Decentralised_Energy_in_the_Smart_Energy_Grid_and_Smart_Market_-_How_to_master_reliable_and_secure_control

- CIM coverage is recommended for exchanging information related to erasure and rectification between data owners, concerned DEPs, applications and data sources
- CIM coverage is recommended for exchanging information related to authentication and representation rights between data users, Customer Portal and Authentication Service Provider.
- CIM coverage is recommended for exchanging data logs related information between data owners, concerned DEPs, applications and data sources.
- Additional CIM coverage (possibly through COSEM) recommended for sub-meter data storing and exchange.
- For data aggregation and data anonymisation additional CIM coverage may be required for data exchange between data source and data user.
- For flexibility market data exchange use cases the current CIM coverage for other flexibility services/products (e.g. congestion management, voltage control) besides balancing is not necessarily sufficient. However, the CIM profiling results for 'Flexibility Bid' business object presented in this report revealed that no CIM extensions are needed for the mFRR type product which can be used for both balancing and congestion management.
- Not all data flows necessary for baseline calculation are covered by CIM.
- CIM coverage is recommended for data exchange (real-time and near-real-time measurements, flexibility activation requests) between smaller DERs and system operators (possibly through harmonisation between CIM and IEC 61850 once the latter will be applied to DER-SCADA communication).

5.4 APPROACH TO 'PRE-STANDARDISATION' CHANGE MANAGEMENT

While methods on how to update and communicate changes in standards belong to the competence of standardisation organisations, the research and innovation projects like EU-SysFlex can contribute to 'pre-standardisation' activities. It is even powerful through combined efforts of many projects, one important platform being BRIDGE Initiative[94].

In 2021 some BRIDGE projects produced three relevant reports on use case repository (2021-3), flexibility assets' interoperability (2021-2) and data exchange reference architecture (2021-1) – all these address the elements of achieving higher degree of interoperability through standardisation. The way use cases are developed and described, roles defined and modelled, information exchange structured and modelled, and individual practices evaluated against 'reference' models requires standardised approach, incl. across country borders and across different sectors.

Since the focus of this report is on CIM standards, the rest of this sub-chapter is dedicated to identifying and applying relevant CIM standards, incl. to proposing relevant CIM extensions where required. This is recommended through the concept of 'CIM repository' and as described in one of the BRIDGE reports. EU-SysFlex partners contributed heavily to this concept (and to BRIDGE reports in general). However, governance-wise CIM repository

[94] https://www.h2020-bridge.eu/

should addressed jointly with other recommendations made in BRIDGE reports – use case repository, role repository, mapping methodology, reference architecture.

Four steps are proposed to structure a CIM repository, all steps can be considered also as stand-alone repositories with slightly different objectives (BRIDGE, 2021-1).

STEP 1: Based on the template proposed by BRIDGE information about business objects and CIM profiles and there links to SUCs, BUCs and demonstrators should be collected on project level (Figure 25).

Updated CIM profile			Use Case Background			Demo	
Profile name	CIM extension (UML package name)	Profile is based on	BO (Business Object)	SUC (System Use case)	BUC (Business Use case)	Profile was used in demo	CIM was used in demo
Name of the profile	Is an extension required or not? If yes a UML Package name can be provided.	Profile can be based on an existing CIM profile.	Name of the business object (semantic of data that has to be exchanged)	To which SUC the BO is associated?	To which BUC the BO is associated?	Has the profile been implemented?	Was CIM also used in the demo for this profile? If not, just justify (other information model, proprietary format was used).

FIGURE 25: TEMPLATE FOR COLLECTING INFORMATION ON CIM PROFILES, BUSINESS OBJECTS AND USE CASES (BRIDGE, 2021-1)

STEP 2: Based in inputs from individual projects a synthesised overview of business objects and CIM profiles can be produced to enable the comparison between projects and to identify the commonalities. Figure 26 depicts the early approach initiated by EU-SysFlex (contains business objects but not CIM profiles yet).

EU-SysFlex		INTERRFACE		TDX ASSIST	
SUCs	Business Objects	SUCs	Business Objects	SUCs	Business Objects
Authenticate data users	Authenticate Information				
	Representation Rights				
Calculate flexibility baseline	Baseline				
	Flexibility Bid				
Collect energy data	Authenticate Information				
	Metering Data				
	Market Data (e.g. Flexibility Bid)				
	Request on market data				
	Congestion Matrix (same as Results of Grid Validation or Grid Impact Assessment Result)				
Exchange data between DERs and System Operators	DER Structural Data				
	DER Real Time Data				
	DER Activation				
Manage access permissions	Authorization information				
	Customer Consent				
Manage data logs	Data log request				
	Data log				
	Flexibility Bid				

Mapping objects to use cases | Mapping profiles to objects

FIGURE 26: GLOBAL BUSINESS OBJECT TEMPLATE (EXAMPLE BASED ON EU-SYSFLEX DELIVERABLE 5.2, 2020)

STEP 3: A manageable UML repository for business objects and CIM profiles should be created allowing to produce reports and to use tools for defining profiles. Figure 27 depicts the UML repository of business objects based on example from EU-SysFlex project and Figure 28 illustrates a UML CIM profile repository based on example from TDX-ASSIST project.

FIGURE 27: UML REPOSITORY FOR BUSINESS OBJECTS (EXAMPLE FROM EU-SYSFLEX DELIVERABLE 5.2, 2020)

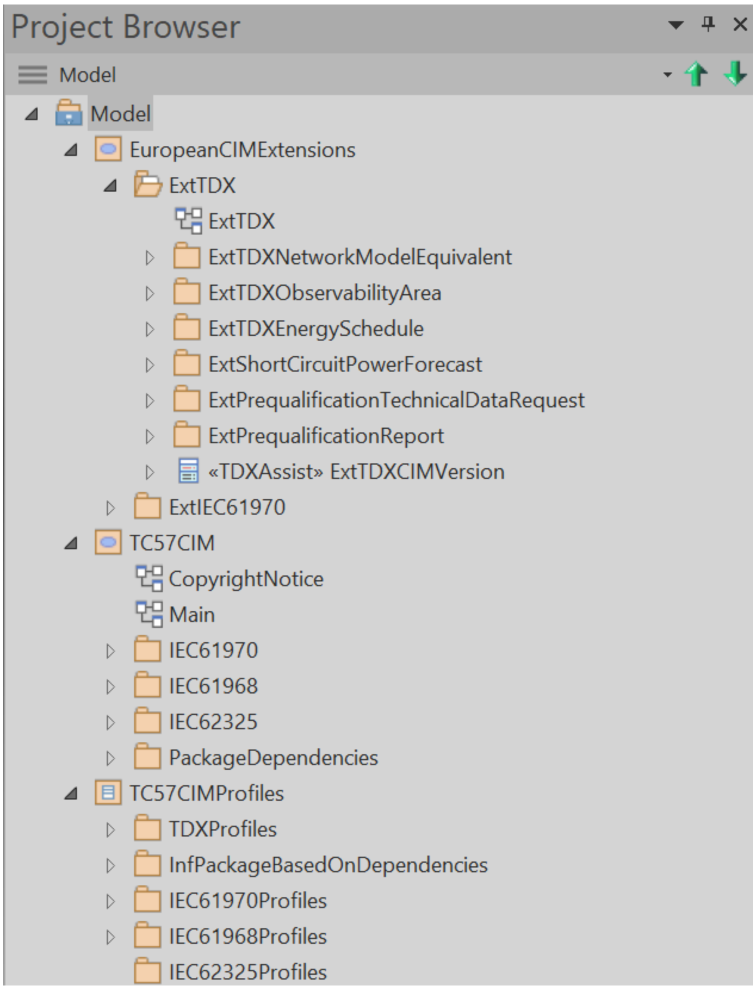

FIGURE 28: UML REPOSITORY FOR CIM PROFILES, INCL. EXTENSIONS' PROPOSALS (EXAMPLE FROM TDX-ASSIST UML REPOSITORY, REPRODUCED FROM BRIDGE, 2021-1)

STEP 4: Management of repository of instance files is needed. An instance file is a data set which is structured conformant with the profile.

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ANNEX I. IEC STANDARDS

I-1. IEC 61970 ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API)

High-level description

IEC 61970 deals with the application program interfaces of energy management systems[95] and is maintained by IEC TC 57 WG 13. The series consists of several parts and specifies various components. One goal is to develop a data model which is agnostic to specific platforms and technologies. For this purpose a comprehensive data model (Common Information Model) is defined in IEC 61970-301 (2020)[96]. The aim of CIM is to create a data model that describes both electrical grid and related data (e.g. generator models). CIM enables the user to define profiles that form a subset of the model (Uslar, 2012a).

Location/area of application

CIM data can be provided by some grid control centres, e.g. to forward data from the distribution system operator to the transmission system operator. However, CIM is also used in the meantime to modulate other data (e.g. forecast data). In Europe, CGMES has established itself as a CIM profile.

Technical overview

CIM uses RDF files for data exchange and serialization. RDF model uses statements about resources in the form of subject-predicate-object expressions (triples), e.g. the PV plant produces three MW. Here, "the PV plant" is the subject, "produces" the predicate and "three MW" the object. Each CIM object in the RDF has a unique ID and can be referenced. RDF/ files are saved in XML format by default.

Link to EU-SysFlex System Use Cases

IEC 61970 covers 9 SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Provide list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Calculate flexibility baseline", "Predict flexibility availability", "Manage sub-meter data", "Exchange data between DER and SCADA".

I-2. IEC 61968 APPLICATION INTEGRATION AT ELECTRIC UTILITIES – SYSTEM INTERFACES FOR DISTRIBUTION MANAGEMENT

High-level description

IEC 61968 is an IEC standard that defines standards for the exchange of information between electrical distribution grids[97]. These standards are developed by Working Group 14 of the IEC Technical Committee 57 (IEC TC 57 WG14). The integration of different data from different applications is to be supported. IEC 61968 defines interfaces for all essential elements for distribution management systems (DMS). It is to be implemented with middleware services

[95] https://webstore.iec.ch/searchform&q=61970
[96] https://webstore.iec.ch/publication/62698
[97] https://webstore.iec.ch/searchform&q=61968

that mediate messages between applications. The standard is based on the CIM standard and represents a data model extension for distribution grid (M. Uslar, 2012a).

Location/area of application

The extension for CIM can be provided by some grid control centres, e.g. to forward data from the distribution system operator to the transmission system operator.

Technical overview

The extensions for CIM are also based on UML. In part 11 the data model for CIM is extended for distribution system (IEC 61968-11, 2013)[98] and in part 13 the RDF model for data exchange is defined (IEC 61968-13, 2021)[99]. Different technologies like ESB (Enterprise Service Bus) or JMS (Java Message Service) are used for this purpose.

Link to EU-SysFlex System Use Cases

IEC 61968 covers 10 SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Provide list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Calculate flexibility baseline", "Predict flexibility availability", "Manage sub-meter data", "Exchange data between DER and SCADA", "Anonymize energy data", "Aggregate energy data".

I-3. IEC 62325 FRAMEWORK FOR ENERGY MARKET COMMUNICATIONS

High-level description

IEC 62325[100] defines standards for European energy market data exchanges (M. Uslar, 2012a).

Location/area of application

European market participants (such as traders, distribution companies) could use this standard to exchange data with a transmission system operator (TSO).

Technical overview

It is based on the CIM standard and also uses UML. IEC 62325 consists of the set of standards relevant for European electricity markets. There are e.g.:

- IEC 62325-301 (2018)[101] – Common information model (CIM) extensions for markets; specifies the object classes required for the operation of electricity markets
- IEC 62325-351 (2016)[102] – CIM European market model exchange profile; specifies a UML package which provides a logical view of the functional aspects of European style electricity market information exchanges i.e. aggregate core components (ACCs)

98 https://webstore.iec.ch/publication/6199
99 https://webstore.iec.ch/publication/34213
100 https://webstore.iec.ch/searchform&q=62325
101 https://webstore.iec.ch/publication/31487
102 https://webstore.iec.ch/publication/25128

- IEC 62325-450 – Profile and context modelling rules; defines how to create a profile from the common information model and the context modelling rules related to this task

Set of profiles that specify UML packages and their associated document contextual models, assembly models and XML schemas for use within the European style electricity markets:

- IEC 62325-451-1: Acknowledgement business process
- IEC 62325-451-2: Scheduling business process
- IEC 62325-451-3: Transmission capacity allocation business process (explicit or implicit auction)
- IEC 62325-451-4: Settlement and reconciliation business process
- IEC 62325-451-5: Problem statement and status request business processes
- IEC 62325-451-6: Publication of information on market

There are ongoing standardisation procedures for:

- IEC 62325-451-7: Balancing business process
- IEC 62325-451-8: HVDC scheduling business process
- IEC 62325-451-10: Profiles for energy consumption data ("My Energy Data")

The IEC 62325 profiles are created according to the methodology as presented in Figure 29.

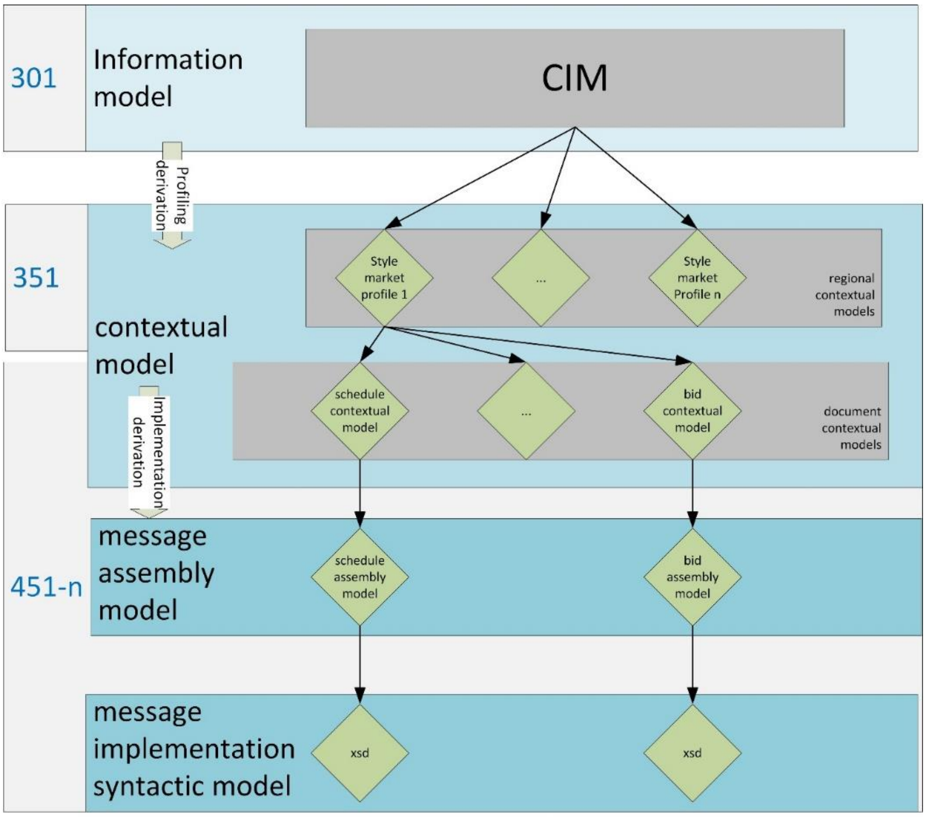


FIGURE 29: IEC 62325 METHODOLOGY FOR CREATING COMMUNICATION PROFILES (BASED ON ENTSO-E PRESENTATION)

Link to EU-SysFlex System Use Cases

IEC 62325 standards can potentially be used for 13 SUCs: "Collect energy data", "Transfer energy data", "Provide list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Verify and settle activated flexibilities", "Authenticated data users", "Calculate flexibility baseline", "Predict flexibility availability", "Manage sub-meter data", "Exchange data between DER and SCADA", "Anonymize energy data", "Aggregate energy data".

I-4. IEC 61850 COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION

High-level description

IEC 61850 is used for communication to substations, but can also be used for other devices[103]. IEC 61850 aims to increase interoperability between electronic devices in the energy sector from different manufacturers. The standard defines the communication to the individual devices and a separate data model for different device types (M. Uslar, 2012a).

Location/area of application

The IEC 61850 standard is now widely used in station automation. Well-known protection device manufacturers have implemented this standard.

Technical overview

The data model and the communication parameters are provided by a server in an SCL file (SCL: System Configuration description Language). A client can download this file and thus obtain information on how to obtain the data and how to interpret it. Within the SCL file physical devices are defined. Each device can be divided into logical nodes that based on predefined classes within standard and sub standards. Those classes can consist of several objects with different attributes.

The communication protocol used is MMS (Manufacturing Message Specification). This uses TCP/IP. IEC 61850 also defines its own protocol (GOOSE) on the bit transmission and security layer. In GOOSE the data can be transmitted in real time.

Link to EU-SysFlex System Use Cases

IEC 61850 standards satisfies the following list of SUCs: “Collect energy data”, “Manage flexibility bids”, “Manage flexibility activations”, “Manage sub-meter data”, “Predict flexibility availability”.

[103] https://webstore.iec.ch/searchform&q=61850

I-5. IEC 62056 ELECTRICITY METERING DATA EXCHANGE (DLMS/COSEM SUITE)

High-level description

DLMS/COSEM is a series of standards specifying a language for data exchange with smart (meter) devices[104]. Such meters have increasing number of functionalities, incl. consumption management, near-real-time measurements, and therefore their communication capabilities become increasingly critical to ensure interoperability and secure data exchange. COSEM (Companion Specification for Energy Metering) is the object model of smart meter. DLMS (Device Language Message Specification) is the application layer protocol of smart meter messages[105]. Though the IEC 62056 standards have been developed for electricity metering, some parts of it like the COSEM data model are and can also be used for non-electricity metering. DLMS/COSEM does not cover collecting data into and storing in central data hubs/warehouses (except communication and data model part), nor does it cover head-end systems at data platforms or data brokers, nor does it cover centralised consent-based access to data. However, it does support gateways and soon services via SoaP. DLMS/COSEM has a very complete set of interface classes for handling data users' authorisation, and various levels of cyber security.

Location/area of application

According to www.dlms.com DLMS/COSEM standards are used in more than 60 countries and implemented by more than 150 vendors. More than 1000 device (meter) types have been certified based on these standards. DLMS/COSEM compliant devices range over a variety of communication networks and enable monitoring and control in different sectors (electricity, gas, heat energy, water). List of products certified to be DLMS/COSEM compliant: https://www.dlms.com/certification-scheme/certificates-list.

Technical overview

DLMS/COSEM consists of data model (application model), the messaging protocol and media-specific communication profiles to ensure the interoperability between applications who need meter data for different services and utilities that can provide these data (Figure 30).

[104] https://webstore.iec.ch/searchform&q=62056
[105] Initially DLMS stood for Distribution Line Message Specification coming from IEC 61334.

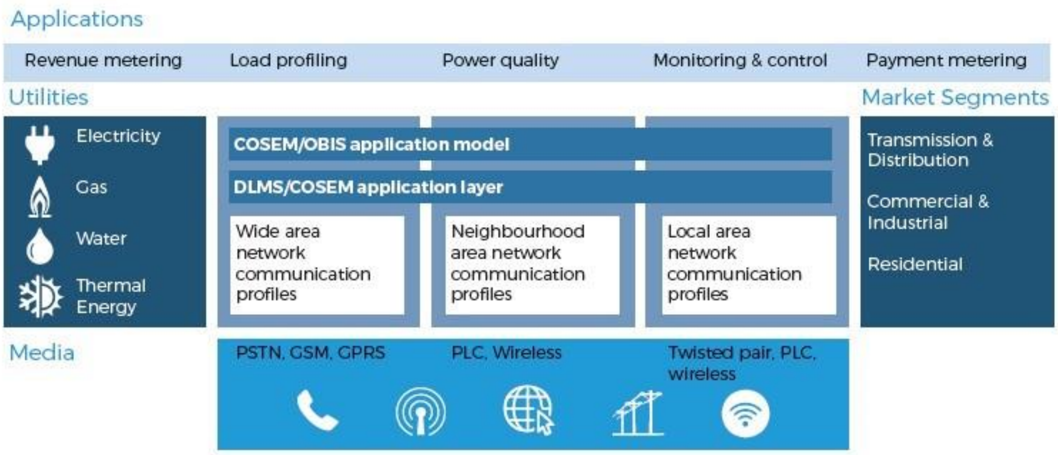


FIGURE 30: DLMS/COSEM USED FOR ALL UTILITIES, ALL MARKET SEGMENTS, ALL APPLICATIONS AND OVER VARIETY OF COMMUNICATION MEDIA[106]

Semantics of the data is described in a model of a meter and its functionalities "using object-oriented methods, in the form of interface classes" (IEC 62056-6-2, 2017)[107]. COSEM does not make "any assumptions about which functions need to be supported, how those functions are implemented, and how the data are transported". OBIS (Object Identification System) enables to identify all data items in a manufacturer-independent way uniquely. COSEM models the utility meter as a server application which the client applications representing market participants exchange information with. Interface classes form an extensible library for different use cases to be used by manufacturers for developing their products and by applications for their business processes. IEC 62056-1-0 (2014)[108] "provides information on the smart metering use cases and on supported architectures". DLMS/COSEM application layer specifies the structure, services, and protocols for DLMS/COSEM clients and servers, and defines rules to specify the DLMS/COSEM communication profiles. Specific parts of IEC 62056 describe a variety of communication profiles, e.g. use of local area networks on twisted pair with carrier signalling, DLMS/COSEM transport layer for IP networks, wired and wireless M-Bus communication profiles for local and neighbourhood networks. In addition, mapping between the Common Information Model message profiles and DLMS/COSEM data models and protocols is provided.

<u>Link to EU-SysFlex System Use Cases</u>

IEC 62056 is applicable for "Collect energy data" and "Transfer energy data" SUCs.

[106] https://www.dlms.com/dlms-cosem/overview
[107] https://webstore.iec.ch/publication/34317
[108] https://webstore.iec.ch/publication/6397

I-6. IEC 60870 TELECONTROL EQUIPMENT AND SYSTEMS

High-level description

In electrical engineering and power system automation, IEC 60870 standard defines systems used for telecontrol (supervisory control and data acquisition, also known as SCADA)[109]. Such systems are used for controlling electric power transmission grids and other geographically widespread control systems. By use of standardised protocols, equipment from many different suppliers can be made to interoperate. The IEC 60870 standard has six parts, defining general information related to the standard, operating conditions, electrical interfaces, performance requirements and data transmission protocols. ADAs are used by System Operators to collect data from OPC, IEC 60870-6 (TASE.2/ICCP), IEC 61850, IEC 60870-5, DNP3 or Modbus Server/Slave devices and then supply this data to other control systems supporting these protocols.

Location/area of application

The areas of application of the standards are mentioned in IEC TR 62357 represented in chapter 3.2.3: monitoring of plants, substations and DERs and data exchanges between energy management systems.

Technical overview

IEC 60870 part 5 provides a communication profile for sending basic telecontrol messages between two systems using permanent directly connected data circuits. IEC 60870-5-104 (2016)[110] (IEC 104) protocol is an extension of IEC 60870-5-101 (2015)[111] protocol with changes in transport, network, link & physical layer services to suit the complete network access. The standard uses an open TCP/IP interface to the network to have connectivity to the LAN (Local Area Network) and routers with different facility (ISDN, X.25, Frame relay) can be used to connect to the WAN (Wide Area Network). The standard defines two separate link layers, which is suitable for data transfer over Ethernet & serial line (PPP - Point-to-Point Protocol). The control field data of IEC 104 contains various types of mechanisms for effective handling of network data synchronization.

The security of IEC 104 had to be changed, due to many other SCADA protocols developed around the same time. IEC Technical Committee (TC) 57 have published IEC 62351, a security standard which implements end-to-end encryption and would prevent such attacks as replay, man-in-the-middle and packet injection. IEC 60870 part 6 provides a communication profile for sending basic telecontrol messages between two systems which is compatible with ISO standards and ITU recommendations. Inter-Control Centre Communications Protocol (ICCP or IEC 60870-6/TASE.2) is used by utility organisations throughout the world to provide data exchange over WANs between utility control centres, utilities, power pools, regional control centres and non-utility generators.

Link to EU-SysFlex System Use Cases

IEC 60870 is one of the standards recommended for “Collect energy data”, “Exchange data between DERs and System Operators”, “Manage flexibility bids”, “Manage flexibility activations”, “Predict flexibility availability” SUCs.

[109] https://webstore.iec.ch/searchform&q=60870
[110] https://webstore.iec.ch/publication/25035
[111] https://webstore.iec.ch/publication/23822

I-7. IEC 61334 DISTRIBUTION AUTOMATION USING DISTRIBUTION LINE CARRIER SYSTEMS

High-level description

The IEC 61334 is a series of standards describing the researched physical environment of power lines, a well-adapted physical layer, a workable low-power media access layer, and a management interface[112]. IEC 61334 enables distribution automation using distribution line carrier systems. It is a standard for low-speed reliable power line communications by electricity meters and SCADA (IEC 61334-5-1, 2001).

Location/area of application

Targeted to DLMS/COSEM (IEC 62056) EU based standard. Applied outside of North America (Cleveland, 2012).

Technical overview

The application area of the standards series contains the communication by carrier systems on the middle-voltage layer as well as on the low-voltage layer. Thereby, the digital loop carrier (DLC) systems enable bidirectional communication for various devices and functions such as control centres, data concentrators, load management, or streetlights. ASN.1, enhanced by IEC 61334-6 coding possibilities, is used to describe the protocol data units of the application protocol of the model. Currently, it is primarily used for retrieving metering information using the IEC 62056 metering standard (Gillerman, Falk, Mackiewicz, 2005). IEC 61334-3-21 and 61334-3-22 define requirements to feed DLC signals into middle-voltage lines without violating security issued. The substandard IEC 61334-4-1, which is also known as the Distribution Line Message Specification (DLMS), defines a reference architecture and provides an abstract and object-oriented server model. The server model explicitly takes limited hardware resources and the low bandwidth of distribution equipment into consideration. IEC 61334-4-511 and 61334-4-512 define a management framework and techniques that are aligned to IEC 61334-5-1 (2001). The sub-standards IEC 61334-5-1 to 61334-5-5 represent different physical and Media Access Control (MAC) layers with varying technologies of modulation that are applicable for both low- and medium-voltage grids (Xiao, 2013). The IEC 61334-5-1 standard itself defines low-speed power line communications in the 60-76 kHz band. IEC 61334-5-1 is also known as S-FSK (Spread Frequency Shift Keying). (Varadarajan, Dabak, Kim, Shaver, 2014). IEC 61334–5–1 specifies that the maximum length of a MAC layer frame is only 38 bytes (Duplex, 2009).

Link to EU-SysFlex System Use Cases

The IEC 61334 (entirely or partially) can be applied for the SUCs from Task 5.2 related to data transfer such as "Collect energy data", "Transfer energy data".

[112] https://webstore.iec.ch/searchform&q=61334

I-8. IEC 62051-62054/62058-62059 METERING STANDARDS

IEC 62051 (Electricity metering - Data exchange for meter reading, tariff and load control - Glossary of terms)[113], 62052 (Electricity metering equipment (AC) - General requirements, tests and test conditions)[114], 62053 (Electricity metering equipment - Particular requirements)[115], 62054 (Electricity metering (AC) - Tariff and load control)[116], 62058 (Electricity metering equipment (AC) - Acceptance inspection)[117] and 62059 (Electricity metering equipment – Dependability)[118] standards are predominantly concerned about physical construction requirements and testing of meters and metering equipment. With the exception of IEC 62053-31 which defines the behaviour of pulse outputs of energy meters. Pulse outputs are a way for third party equipment to record energy consumption from an energy meter/sub-meter, i.e. not something that is used by the grid to record the consumption of a registered meter. Pulses are something that electric meters (specifically sub-meters) often support but is seldom used outside bridging to legacy equipment. Generally, nowadays Modbus RTU/TCP, M-Bus or BACnet are used. As these standards are not concerned with data privacy or data exchange they are not relevant for this report.

Link to EU-SysFlex System Use Cases

IEC 62051 has potential to be used in SUCs related to “Collect energy data”

I-9. IEC 62746 SYSTEMS INTERFACE BETWEEN CUSTOMER ENERGY MANAGEMENT SYSTEM AND THE POWER MANAGEMENT SYSTEM

High-level description

“The success of the Smart Grid and Smart Home/Building/Industrial approach is very much related to interoperability, which means that Smart Grid and all smart devices in a Home/Building/Industrial environment have a common understanding of messages and data in a defined interoperability area (in a broader perspective, it does not matter if it as an energy related message, a management message or an informative message). In contradiction, today’s premises are covered by different networks and standalone devices.” IEC TR 62746-2 (2015)[119]

IEC TR 62746-2 Technical Report describes the “main pillars of interoperability to assist different Technical Committees in defining their interfaces and messages covering the whole chain between a smart grid and smart home/building/industrial area”. The “report focuses on the signals exchanged between the grid and the premise, which may go from simple signalling to integrated load management”. The main topics covered by this technical report are: architecture model from a logical point of view; set of user stories describing a number of situations related to energy flexibility and demand side management; set of use cases based on the user stories and

[113] https://webstore.iec.ch/searchform&q=62051
[114] https://webstore.iec.ch/searchform&q=62052
[115] https://webstore.iec.ch/searchform&q=62053
[116] https://webstore.iec.ch/searchform&q=62054
[117] https://webstore.iec.ch/searchform&q=62058
[118] https://webstore.iec.ch/searchform&q=62059
[119] https://webstore.iec.ch/publication/22279

architecture; details of the communication; identified in the use cases, by describing the requirements for messages and information to be exchanged.

“This technical report can also be used as a blue print for further smart home solutions like remote control, remote monitoring, ambient assistant living and so forth.”

IEC TS 62746-3 (2015)[120] Technical Specification establishes an architecture for interfaces between the Customer Energy Management System, including DER Management System, and the Power Management System. “The focus of this architecture is to leverage the internet for communications between grid operators, market operators, distribution system operators, electricity suppliers, aggregators, service providers and energy resources. This Technical Specification leverages existing IEC standards. The data model of IEC 62746 is based on the Common Information Model and IEC 61850. IEC 62746 is transport independent.”

Technical overview

IEC 62746-10-1 (2018)[121] “specifies a minimal data model and services for demand response (DR), pricing, and distributed energy resource (DER) communications. This document can be leveraged to manage customer energy resources, including load, generation, and storage, via signals provided by grid and/or market operators. These resources can be identified and managed as individual resources with specific capabilities, or as virtual resources with an aggregated set of capabilities.” It “specifies how to implement a two-way signalling system to facilitate information exchange between electricity service providers, aggregators, and end users. The DR signalling system is described in terms of servers (virtual top nodes or VTNs), which publish information to automated clients (virtual end nodes, or VENs), which in turn subscribe to the information.”

“This document is a communications data model, along with transport and security mechanisms, which facilitate information exchange between two end-points: the electricity service provider or DR program operator, and a customer-side resource. It is not a protocol that specifies "bit-structures" as some communication protocols do, but instead relies upon existing open standards such as Extensible Markup Language (XML) and internet protocol (IP) as the framework for exchanging DR signals. In some references, the term "system," "technology," or "service" is used to refer to the features of this document.”

“IEC 62746-10-1 is designed to facilitate automation of DR actions at the customer location, whether it involves electric load decreases, load increases, or load shifting for various demand response markets. Many emergency or reliability DR events occur at specific times when the electricity grid is strained. The communications are designed to coordinate such signals with facility control systems (commercial, industrial, and residential). This document is also designed to provide continuous dynamic price signals, such as hourly, day-ahead, or day-of real-time pricing. With such price information, an automated client can be configured to continuously monitor these prices and translate this information into continuous automated control and response within a facility. /…/ This document

120 https://webstore.iec.ch/publication/23488
121 https://webstore.iec.ch/publication/26267

covers the signalling data models for price and reliability signals to both wholesale and retail markets and can act as a complementary standard to a CIM-based grid control system."

"The services make no assumption on specific DR electric load control strategies that can be used within a DR resource or of any market-specific contractual or business agreements between electricity service providers and their customers."

IEC 62746-10-3 (2018)[122] "defines and describes methods and example XML artefacts that can be used to build a conformant adapter to enable interoperation between a utility distributed automation or demand response (DR) system based on the IEC common information model (CIM) and a utility smart grid user interface (SGUI) bridge standard (e.g. IEC 62746-10-1) to a customer facility. Such interoperation is two-way, applying a conformant adapter, a facility system may present itself to grid systems as if it implemented CIM demand response; likewise, a CIM system may present itself to facility systems as if it implemented an SGUI bridge standard."

"The scope is restricted to a method to define payload mappings between any specific CIM profile that contains DR/DER information models and the SGUI bridge standards including IEC 62746-10-1.This document provides a standard method to achieve interoperability for the semantics and mapping of message payloads, and does not address broader system issues including but not limited to transport protocols, message envelopes, cybersecurity and business model differences."

Link to EU-SysFlex System Use Cases

It has potential to be used in SUCs related to "Collect energy data", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data", "Predict flexibility availability".

I-10. IEC 63110 PROTOCOL FOR MANAGEMENT OF ELECTRIC VEHICLES CHARGING AND DISCHARGING INFRASTRUCTURES

High-level description

Once the electric vehicle has sent the energy data to the charging station, the Charge Point Operator (CPO) still needs to send data to centralised Charging Management Systems (CMS). The majority of charging stations nowadays support OCPP (Open Charge Point Protocol). OCPP is a protocol for communication between an EV charging station and a central back-office system. Similar to many IoT protocols, OCPP describes the messages that charging stations and IT backend send to each other to authenticate new EV users, track energy meter values or give charging commands. OCPP is still evolving (versions of OCPP 2.0 are released) and will soon be integrated into a future international standard IEC 63110.

IEC 63110 will cover the management of charging and discharging infrastructure. It will address the requirements and information exchange for the establishment of electro-mobility ecosystem. IEC 63110 will take into account

[122] https://webstore.iec.ch/publication/59771

the communication flows between the different electro mobility actors as well as data flows with the electric power system: energy transfer, grid usage, contractual and metering data, asset management of EV supply equipment, authentication / authorisation / payment of charging and discharging sessions. IEC 63110 is currently designed using the SGAM (Smart Grid Architecture Model) methodology and will integrate cybersecurity, interoperability, grid integration and scalability.

Location/area of application

OCPP is used worldwide in more than 100 countries.

Technical overview

OCPP 2.0 specifications are divided into 16 Functional Blocks and define the following points: 59 Use Cases and Requirements, Messages, Data Types and Referenced Components and Variables and an Implementation Guide JSON (OCPP 2.0 no longer supports SOAP as a transport protocol). In contrast to OCPP 1.6, the OCPP 2.0 specification is written in a different structure, based on IEC62559-2 (2015): "Use case methodology - Part 2: Definition of the template for use cases, actor list and requirements list". OCPP 2.0 supports the ISO 15118 standard. IEC63110 is being established.

Link to EU-SysFlex System Use Cases

We find in the OCPP functional blocks a thematic structure close to 4 used for EU-SysFlex use cases (with some e-mobility adjustments): "Transfer energy data", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data"

I-11. IEC 62361 POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE - INTEROPERABILITY IN THE LONG TERM

IEC 62361 is a set of documents (International standards, technical specification, technical report) that concerns mainly interoperability issues between various IEC standards. IEC 62361-2 (2013) "documents the quality codes used by existing IEC standards related to supervisory control and data acquisition (SCADA). /…/ The identified standards to be dealt with in this document are: IEC 60870-5, IEC 60870-6 TASE.2, IEC 61850, IEC 61970, DAIS DA, OPC DA and OPC UA. The scope of IEC 62361-2 is to create a common list of SCADA quality codes for reference by other standards to avoid embedding quality code lists in other standards."[123]

IEC 62361-100 (2016) describes a mapping from CIM profiles to W3C XML Schemas, intended "to facilitate the exchange of information in the form of XML documents whose semantics are defined by the IEC CIM and whose syntax is defined by a W3C XML schema".[124] IEC TS 62361-102 (2018) "outlines a technical approach for achieving effective information exchange between power system installations governed by IEC 61850 and business systems

[123] https://webstore.iec.ch/publication/6923
[124] https://webstore.iec.ch/publication/25114

integrated with IEC CIM standard data exchanges, based on a selected specific set of use cases, but also with the goal of creating a framework that will extend successfully to other use cases in the future."[125] The report will consider existing standards for semantics, services, protocols, system configuration language, and architecture. IEC TR 62361-103 (2018) is the introduction to concepts of standard profiling and profile development for Common Information Model and IEC 61850 standard series for providing interoperability. "It describes the specific needs and requirements of the standard application domains and derives profiling concepts respectively."[126]

Link to EU-SysFlex System Use Cases

IEC 62351 standard covers 6 SUCs in total: "Collect energy data", "Manage flexibility bids", "Manage flexibility activations", "Verify and settle activated flexibilities", "Calculate flexibility baseline", "Predict flexibility availability".

[125] https://webstore.iec.ch/publication/27417
[126] https://webstore.iec.ch/publication/61296

ANNEX II. CEN STANDARDS

II-1. CEN EN 13757 COMMUNICATION SYSTEMS FOR METERS

High-level description

The DLMS/COSEM specification (see IEC 62056 in chapter 3.1.6) is referenced in EN 13757-1 which specifies data exchange and communications for meters and remote reading of meters in a generic way. It establishes a protocol specification for the Application Layer for meters and establishes several protocols for meter communications which may be applied depending on the application being fulfilled. Some other parts of the standard series specify the requirements for the physical and the link layer of wired M-Bus communication (baseband communication over twisted pair) and of wireless M-Bus communication (using radio). These are usable not only for electricity meters but also for others like heat meters, heat cost allocators, water meters and gas meters. According to OMS Group (2014), "the standard series EN 13757 is the only communication standard for meters and related equipment, which places the user into a position to cover measuring instruments of all media economically with one communication system." [127]

Location/area of application

Most electricity, gas, heat and water meters.

Technical overview

EN 13757 is a modular kit where various physical interface characteristics and protocol applications are described. "These may be combined with one another in each case, so that a very flexible protocol stack is created." (OMS Group, 2014) (See Figure 31.)

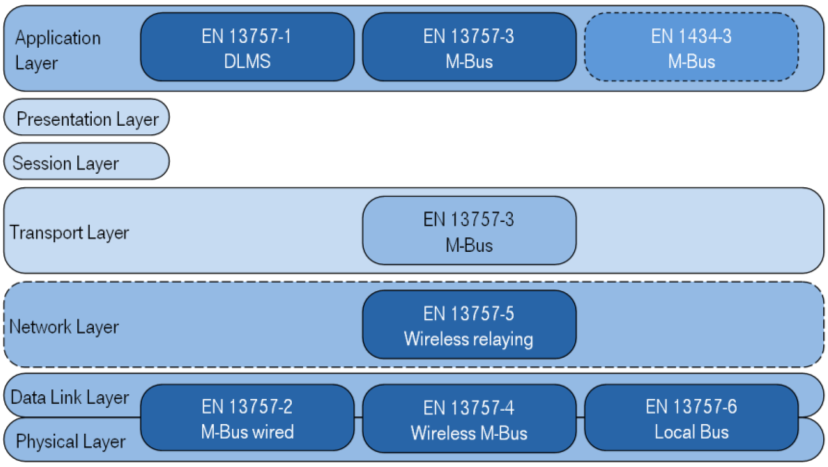


FIGURE 31: PROTOCOL STACK OF EN 13757 (OMS GROUP, 2014)

Link to EU-SysFlex System Use Cases

CEN EN 16836 satisfies 2 SUCs from Task 5.2: "Collect energy data", "Transfer energy data".

[127] https://oms-group.org/fileadmin/files/download4all/specification/Vol2/4.1.2/OMS-Spec_Vol1_General_v201_RELEASE.pdf

II-2. CEN EN 16836 COMMUNICATION SYSTEMS FOR METERS - WIRELESS MESH NETWORKING FOR METER DATA EXCHANGE

High-level description

This standard provides standardisation framework, physical layer specification, medium access layer specification, network layer specification and application layer specification of communication systems applicable to the exchange of data from metering devices to other devices within a mesh network. It means messaging and networking between a meter or multiple meters and other devices in a mesh network, such as in home displays and communications hubs. While the standard sets requirements for gas, heat and water meters, but also for electricity on sub-meter level. The standard refers to the specifications by ZigBee Alliance[128].

Location/area of application

Zibgee is IoT solution for residential and commercial markets. In the smart home domain ZigBee is the full-stack solution for a majority of smart home ecosystem providers, such as Amazon's Echo Plus, Samsung SmartThings, Signify (Philips Hue) and more[129].

Technical overview

The referenced documents in this European Standard contain specifications, interface descriptions, object descriptions, protocols and algorithms pertaining to this protocol standard, the device objects, device profile, the application framework, the network layer, and security services. "The ZigBee Alliance has developed a very low-cost, very low-power-consumption, two-way, wireless communications standard." (ZigBee Alliance, 2015)[130] ZigBee standard can be applied "in consumer electronics, home and building automation, industrial controls, PC peripherals, medical sensor applications, toys, and games". Its architecture stack consists of layers as – "Each layer performs a specific set of services for the layer above."

Link to EU-SysFlex System Use Cases

CEN EN 16836 covers 2 SUCs from Task 5.2: "Collect energy data", "Transfer energy data".

128 https://zigbeealliance.org/
129 https://zigbeealliance.org/market-uses/smart-home/
130 https://zigbeealliance.org/wp-content/uploads/2019/11/docs-05-3474-21-0csg-zigbee-specification.pdf

ANNEX III. CENELEC STANDARDS

III-1. CENELEC EN 50491 GENERAL REQUIREMENTS FOR HOME AND BUILDING ELECTRONIC SYSTEMS (HBES) AND BUILDING AUTOMATION AND CONTROL SYSTEMS (BACS)

High-level description

Relevant standards in EN 50491 series cover general functional safety requirements for products intended to be integrated in HBES/BACS, application specifications of smart meter's simple external consumer display, general requirements and architecture for interface between the customer energy Manager (CEM) and Home/Building Resource manager.

Link to EU-SysFlex System Use Cases

CENELEC EN 50491 is directly relevant for the following SUCs: "Collect energy data", "Transfer energy data", "Provide list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data".

III-2. CENELEC EN 50631 HOUSEHOLD APPLIANCES NETWORK AND GRID CONNECTIVITY

High-level description

EN 50631-1 defines data models for Interoperable Connected Household Appliances. Standardised data models and neutral message structures need to be agnostic to communication technologies and any product specific layout. The standard specifies how sets of products from multiple manufacturers are able to interoperate with Home & Building / Customer Energy Management Systems, located in a home network or in the cloud, in the most interoperable manner. This standard focuses on interoperability of household appliances and describes the necessary control and monitoring. Upcoming part 4 of this series will define the mapping of neutral messages to examples of typical communication protocols such as ZigBee, KNX, OIC, SHIP, Echonet light, Thread.

Link to EU-SysFlex System Use Cases

The CENELEC EN 50631 satisfies (entirely or partially) the following SUCs from Task 5.2: "Transfer energy data", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data".

III-3. CENELEC EN 50090 HOME AND BUILDING ELECTRONIC SYSTEMS (HBES)

High-level description

EN 50090 describes the open standard KNX, a standard for commercial and domestic building automation. The KNX specification covers the full scope of applications and communication media of integrated automation and control, including lighting, shading, shutters and blinds, household appliances, heating, cooling, ventilation and air-conditioning, access and security, remote meter reading, energy management and safety.

Location/area of application (if possible)

KNX is used worldwide in 190 countries for home and commercial automation projects. In addition to the European standard, it is also a international standard (ISO/IEC 14543-3), US standard (ANSI/ASHREA 135) and Chinese standard (GB/T 20965).

Technical overview

KNX is a OSI-communication model compliant bus, supporting 4 different physical layers, twisted pair (TP1), power line (PL110), radio (RF) and TCP/IP (IP). Encryption and security was added to the standard in 2018 (EN 50090-3-4) for IP, TP and RF.

Link to EU-SysFlex System Use Cases

KNX could potentially be used for device control, in place of other protocols like ZigBee, Modbus and OPC and covers 2 SUCs from Task 5.2: "Collect energy data", "Transfer energy data".

ANNEX IV. IEEE STANDARDS

IV-1. IEEE 2030 SERIES FOR SMART GRID INTEROPERABILITY

High-level description

IEEE 2030 series consists of relevant standards in smart grid domain:

- IEEE 2030.1.1 Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles
- IEEE P2030.2 Guide for Energy Storage Systems Integrated with the Electric Power Infrastructure
- IEEE P2030.2.1 Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems
- IEEE P2030.3 Standard for Test Procedures for Electric Energy Storage Equipment and Systems
- IEEE P2030.4 Guide for Control and Automation Installations Applied to the Electric Power Infrastructure
- IEEE 2030.5 Standard for Smart Energy Profile 2.0 Application Protocol
- IEEE P2030.6 Guide for the Benefit Evaluation of Electric Power Grid Customer Demand Response
- IEEE P2030.7 Standard for the Specification of Microgrid Controllers
- IEEE P2030.8 Standard for the Testing of Microgrid Controllers
- IEEE P2030.9 Recommended Practice for the Planning and Design of the Microgrid
- IEEE P2030.10 Standard for DC Microgrids for Rural and Remote Electricity Access Applications
- IEEE P2030.100 Recommended Practice for Implementing an IEC 61850 Based Substation Communications, Protection, Monitoring and Control System
- IEEE P2030.101 Guide for Designing a Time Synchronization System
- IEEE P2030.102.1 Standard for Interoperability of Internet Protocol Security (IPsec) Utilized within Utility Control Systems

IEEE 2030.5 standard defines the "application layer with TCP/IP providing functions in the transport and internet layers to enable utility management of the end user energy environment, including concepts like demand response, load control, time of day pricing, management of distributed generation, electric vehicles" (IEEE 2030.5, 2018)[131]. It is the standard for two-way communication between residential smart devices and utilities (system operators, power suppliers).

Location/area of application

Smart Energy Profile of IEEE 2030.5 has been developed by the ZigBee Alliance[132]. See more about Zigbee in chapter 3.2.2 for CEN EN 16836 standard which addresses ZigBee specifications in an European standard while IEEE standards are more common in US.

Figure 32 illustrates the application of IEEE 2030.5 standard for the "Rule 21" based communications[133].

[131] https://ieeexplore.ieee.org/document/8608044
[132] https://zigbeealliance.org/
[133] "Rule 21" is a set of specifications enacted by State of California on residential and commercial solar inverters in 2017.

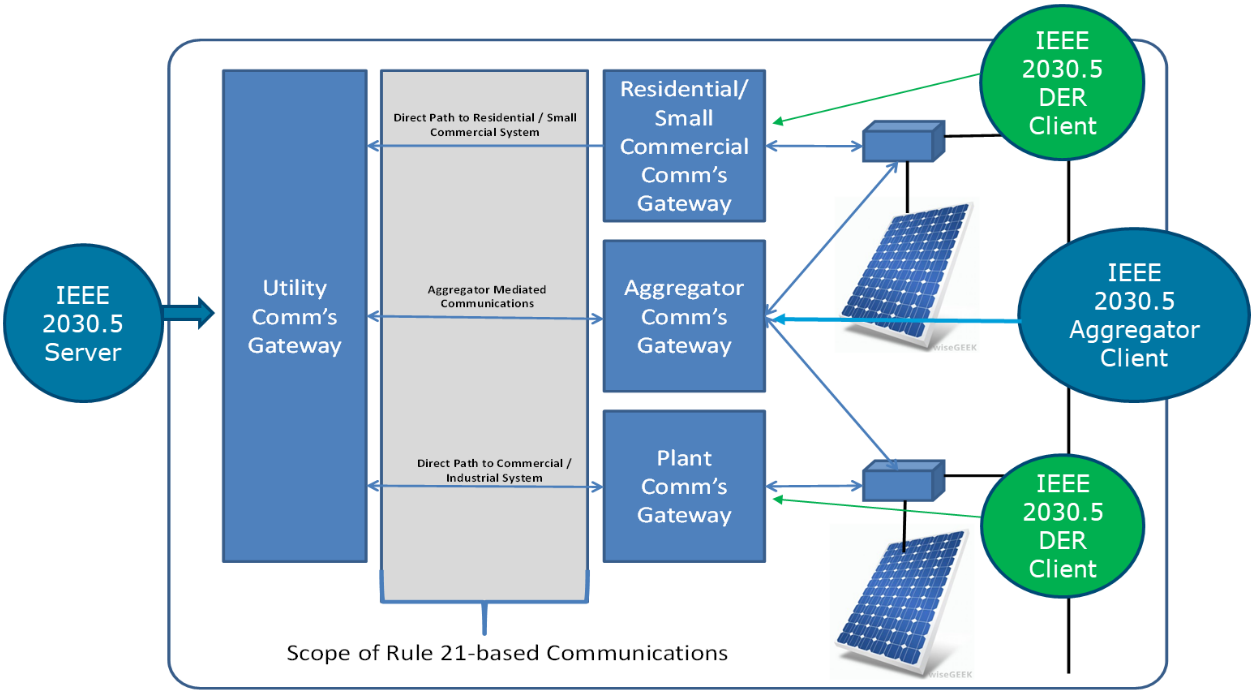


FIGURE 32: DER USE CASES IN CALIFORNIA "RULE 21" (IEEE webinar, 2017)

Technical overview

IEEE 2030.5 facilitates the integration of smart home devices into the grid via two main functionalities:

- give information to the consumers about energy consumption, prices;
- enable consumers to receive orders for device control (e.g. control of heat pumps, EV charging, PV control, storage control).

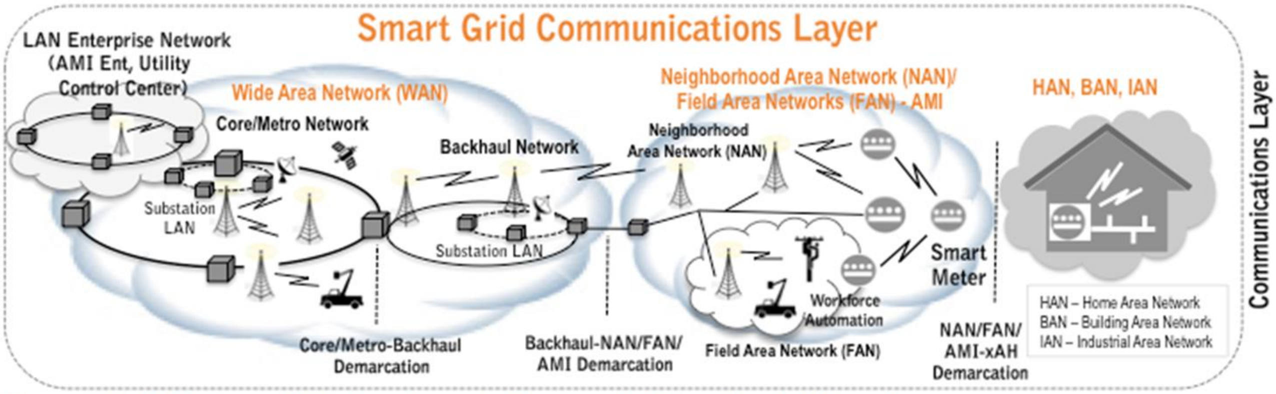
IEEE 2030.5 standard defines the mechanisms for exchanging application messages and the security features used to protect those messages. The standard is based on four layers of Open Systems Interconnection (OSI) network model. The application profile refers to other standards like IEC 61968 and IEC 61850, and follows a RESTful architecture using internet protocols like HTTP.

Link to EU-SysFlex System Use Cases

IEEE 2030 standard is directly related to 4 SUCs: "Manage sub-meter data", "Transfer energy data", "Manage flexibility bids", "Manage flexibility activation".

IV-2. IEEE STANDARDS FOR SMART GRID COMMUNICATION

IEEE standards for smart grid communication mostly concern IEEE 802 series and IEEE 1901 series and present in Figure 33.



Smart Grid Network Technology & Protocols Standards Mapping

Wide Area Network (WAN)			NAN/FAN			Smart Meters	HAN, BAN, IAN		
Substation	Core/Metro Network/Backhaul Network		Substaion						
	Wireline	Wireless		Wireline	Wireless		Wireline	Wireless	
LAN IEEE 1815/IEC 61850 Several Options	IEEE 802.1 IEEE 802.3	IEEE 802.16d/e IEEE 802.20 IEEE 802.22	LAN IEEE 1815/IEC 61850 Several Options	IEEE 802.1 IEEE 802.3 IEEE 1901	IEEE 802.11 IEEE 802.15.4 IEEE 802.16	IEEE SC31 (1377, 1701, 1703, P1704)	IEEE 802.1 IEEE 802.3 IEEE 1901 IEEE 1901.2 IEEE P1905.1	IEEE 802.11 IEEE 802.15.4	Technology Standards

FIGURE 33: IEEE STANDARDS FOR SMART GRID COMMUNICATIONS (DE OLIVEIRA,, FONSECA,, 2011)

<u>Link to EU-SysFlex System Use Cases</u>

IEEE standards are relevant to SUCs such as: “Collect energy data”, “Transfer energy data”.

ANNEX V. ISO STANDARDS

V-1. ISO 15118 ROAD VEHICLES — VEHICLE TO GRID COMMUNICATION INTERFACE

High-level description

ISO 15118 is one of the standards enhancing communication between electric vehicles and the recharging infrastructure. It will soon enable bi-directional charging/discharging of electric vehicles. The user-convenient and secure "Plug & Charge" feature that comes with ISO 15118 enables the electric vehicle to automatically identify (id and charging contract) and authorise itself to the charging station on behalf of the driver to receive energy for recharging its battery. The only action required by the driver is to plug the charging cable into the EV and charging station. ISO 15118 will enable smart charging: optimization of charge planning taking into account constraints of electric vehicles (V1G or unidirectional power flow), charging stations and power grid and the needs of the driver. ISO 15118 will soon become an international standard defining a Vehicle to Grid (V2G) communication interface for bi-directional charging/discharging of electric vehicles (future ISO 15118-20).

Location/area of application (if possible)

EV charging stations and personal EVs parked at customer premises are controllable loads. They are opportunities for flexibilities to be gathered by aggregators and provided to TSOs and DSOs.

Technical overview

ISO 15118 defines a digital, IP-based protocol applied in the communication between EV and charging station. The idea is to enable a user-friendly mechanism for authentication, authorisation and billing without the need for further user interaction (Plug and Charge). Technically ISO15118 uses XSD schema files to define the messages structure (XML and JSON messages) and describes security concepts needed to ensure confidentiality, integrity and authenticity: 256 bits keys cryptography, Hash function SHA-256, X500 digital certificates and more.

Link to EU-SysFlex System Use Cases

Another purpose of ISO 15118 is the integration of EV in the smart grid to enable flexible load control (reflecting for example a local or regional grid situation) and thus to provide valuable grid flexibility services. This standard is related to the following SUCs: "Manage sub-meter data", "Manage flexibility activations", "Transfer energy data", "Provide list of supplier and ESCOs".

ANNEX VI. OTHER EXISTING SPECIFICATIONS/IMPLEMENTATIONS

VI-1. EBIX® DISTRIBUTED FLEXIBILITY

High-level description

ebIX®[134] is a platform that primary purpose is to standardise electronic information exchange between energy providers (TSO's, DSO's, suppliers, and regulators) and users in Europe. ebIX® was founded in 2003 and developed as continuation of work started by Nordic Ediel Forum[135]. ebIX® focuses on standardised and harmonised processes for the retail (upstream) and wholesale (downstream) electricity and gas markets (ebIX® website, 2017).

Location/area of application

ebIX® follows EU rules and regulations and continuously collaborates with standardisation like IEC, EFET, ENTSO-E, and EURELECTRIC. It also allows customization based on the country where it is applied. The ebIX® standard is implemented in Austria, Belgium, Denmark, Finland, Germany, the Netherlands, Norway, Sweden, and Switzerland (Uslar et al., 2012b)

Technical overview

"The modelling process ebIX® uses includes setting up Business Requirements Specifications (BRS's) for the different intercompany market processes and associated information exchange /…/." The ebIX® Technical Committee (ETC) developed Business Information Models (BIMs) based on business needs. The resulting information exchange can be generated into XML schema. The ebIX® core UML model is used to generate all documents and messages.

The BRS and BIM consist of the following three main parts that are in line with the UN/CEFACT Modelling Methodology version 2.0 (UMM-2) that uses UML notation (Hiekka, 2019):

- **Elements of Business Requirement View.** The business requirements are determined by business user groups that follow the ebIX® methodology rules.
- **Business process use case** defines various activities happening between business partners. Business process use-case might happen between the business partners or internally inside one business partner.
- **Business process** defines the behaviour of business process use cases among partners. Business process helps to determine the business requirements for the partners to cooperate.

Link to EU-SysFlex System Use Cases

The ebIX® satisfies (entirely or partially) the following SUCs from Task 5.2: "Collect energy data", "Provide list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Verify and settle activated flexibilities", "Manage access permissions", "Calculate flexibility baseline".

[134] https://www.ebix.org/
[135] https://ediel.org/purpose/

VI-2. ENERGY FLEXIBILITY INTERFACE

High-level description

EFI[136] is a "communication protocol that enables end users to control various smart devices, such as washing machines, air conditioning units, solar panels, and car chargers, and thus unlock the opportunities of flexible energy". It was created by the FAN established in 2013 and brings together Dutch market-leading partners[137] and organisations to enable a controlled and reliable energy transition. The Energy Flexibility Interface, for short EFI, is specifically designed as a standard communication method between smart devices and DSM solutions. TNO developed EFI to deal with interoperability issues encountered while experimenting and researching energy flexibility in field trials (FAN website, 2019).

FAN projects[138]:

- **ReFlex.** It is a software solution that enables aggregators to create a powerful Virtual Power Plant[139] that provides a detailed understanding of the flexible power available within a cluster of connected assets (devices) and calculate the consequences of the various dispatch options.
- **Interflex.** Enexis, TNO, and ElaadNL are testing a local marketplace where grid operator Enexis can negotiate with service providers who can steer energy consumption (such as providing an app for low-cost charging of electric cars) to reduce the daily peaks in energy demand.
- **Heerhugowaard.** Grid operator Liander conducted a 3-year study among households in Heerhugowaard, Netherlands. The study examined the possibilities of aligning supply and demand through a flexible market.
- **Lochem.** In 2015 researchers tested the power grid's maximum capacity until overload time and consequences of such overload.

Location/area of application

EFI focuses on Smart Grid, Demand Response, Flexible Energy, Smart Energy, Smart Home, Smart charging, Renewables, Peak shaving, and Grid balancing. Currently, EFI concepts are being standardised within the European standardisation organisation CENELEC to become a European Standard for modelling energy flexibility (FAN website, 2019).

Technical overview

EFI is a communication protocol with a common language for energy, allowing any combination of device and DSM-solution. It only provides an abstraction of the device for modelling energy flexibility**.** EFI is an open-source standard that enables bidirectional communication between smart devices and smart grids .The EFI has four flexibility types for an appliance or device. They provide an abstraction of the devices regarding energy flexibility and are device and DSM independent (Werkman et al., 2019).

136 https://flexible-energy.eu/efi-energy-flexibility-interface/
137 https://flexible-energy.eu/fan-partners/
138 https://flexible-energy.eu/portfolio/
139 A virtual power plant is cloud-based distributed power plant that aggregates the capacities of heterogeneous distributed energy resources for the purposes of enhancing power generation, as well as trading or selling power on the electricity market.

Flexibility types:

- **Inflexible.** It cannot be controlled and has no actual flexibility but is measurable and may provide forecasts. For example, solar collectors.
- **Shiftable.** Time-shiftable processes e.g. has a deadline. For example, dryers.
- **Storage.** Flexible in production and consumption level with a buffer limits. Limits are required to be fill to levels constrain. For example, electric vehicles.
- **Adjustable.** Flexible in production and consumption level without buffer. They have a wide range of control and usually offers better flexibility. For example, diesel generators.

Link to EU-SysFlex System Use Cases

The EFI standard is related to the following SUCs: “Manage sub-meter data”, “Manage flexibility activations”, “Manage flexibility bids”, “Transfer energy data”.

VI-3. GREEN BUTTON

High-level description

Green Button (GB)[140] is US developed specification that helps utility companies provide consumption time-series data published by DSO (electricity, gas, water data) to the customer directly from the utility website (in CSV or XML format) or indirectly (via sharing data with third-party applications) in a secure manner to keep the anonymity of the person behind the data. Although it is called the “Green Button standard”, based on the definition given in this document, it falls under the “specification” category. A detailed description of the Green Button standard is available on the Green Button website, which also contains technical implementation links (Green Button Data, 2020).

Location/area of application

At the moment, GB has been implemented in Ontario, Canada and 12 states within the United States, including California, New York, Arkansas, North Carolina, and others (Green Button Alliance, 2020).

Technical overview

GB falls under international standards (potentially complies with GDPR) and works at different scales (industrial and residential). Metered data is not currently transmitted or collected using the GB Energy Usage Information schema, although possible. The Green Button standard requires utilities to implement “The OAuth 2.0 Authorisation Framework” (RFC 6749) standard’s “Client Credential”, “Authorisation Code”, and “Refresh Token” Grant flows, which generate OAuth 2.0 access tokens. The OAuth 2.0 access tokens are then required to access the utilities customer’s data by the Third Party. Green Button does not participate in the wholesale market bidding and contract process. All GB transmissions require the data to be sent using SSL encryption via the HTTPS protocol, and both the utility and Third Party are required to use SSL certificates issued by fully audited Certificate Authorities. Customers

[140] https://www.energy.gov/data/green-button

are allowed to request authorised access to their data by Third Parties be revoked. The ESPI (Energy Services Provider Interface) standard of NAESB (North American Energy Standards Board) defines the data exchange protocol and authorisation process, including controlling what data can be provided to Third Parties by the utilities when implementing the standard. How a utility performs authentication, data access, authentication and authorisation logging is beyond the standard's scope (Green Button Developer, 2020).

Link to EU-SysFlex System Use Cases

The GB satisfies (entirely or partially) the following SUCs from Task 5.2: “Transfer energy data”, “Provide a list of suppliers and ESCOS”, “Manage access permissions”, “Authenticate data users”, “Manage data logs”, “Anonymise energy data”, “Aggregate energy data”, “Erase and rectify personal data”.

VI-4. SMART APPLIANCES REFERENCE (SAREF) ONTOLOGY

High-level description

SAREF[141] ontology is a reference ontology for smart appliances that focuses on the smart home environment and enables semantic interoperability in the IoT *(Viola, 2015).* It helps to define the concepts in the message data structures that are shared at the underlying technological level, regardless of the details of the underlying communication protocol, standard, or data model. *(Daniele, 2015)*

Location/area of application

TNO develops the SAREF in close interaction with the industry and with the support of the EC. It is published as a technical specification by ETSI (ETSI TS 103 410-1, 2020). CENELEC, W3C Linked building Data community, and the Alliance for the Internet of Things Innovation (AIOTI) have acknowledged and adopted SAREF in their standardisation activities (Daniele, Solanki, den Hartog, Roes, 2016).

Technical overview

SAREF is a reference ontology that explicitly defines the core concepts for the participants in the smart appliances domain. It also provides a mechanism to map different existing solutions (i.e., data models, protocols, standards) to one another set constraints for the application and built a relationship. SAREF was created to be used as a basis for the creation of more specialized ontologies. Specialized ontologies that based on the same reference ontology are (semantically) interoperable. The SAREF ontology provides building blocks that can be recombined depending on specific needs. SAREF is desined using OWL-DL and contains 110 classes, 31 object properties, and 11 datatype properties (Daniele, Solanki, den Hartog, Roes, 2016).

Its mapping of other concepts used by different assets/standards/models allows the transformation from reference ontology to specific assets. It reduces the resources to translate one asset to another since the reference ontology requires one set of mappings for each asset, rather than a specific collection of mappings for each pair of assets (ETSI TS 103 264, 2020).

[141] https://saref.etsi.org/

SAREF4EE is an extension of SAREF developed in collaboration with EEBus and Energy@Home, Germany- and Italy-based industry associations, to enable their different data models' interconnection (ETSI TS 103 410-1, 2020).

Link to EU-SysFlex System Use Cases

The SAREF satisfies the following SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Provide a list of suppliers and ESCOS", "Manage flexibility bids", "Manage flexibility activations", "Manage sub-meter data".

VI-5. OPEN SMART GRID PROTOCOL

High-level description

The Open Smart Grid Protocol (OSGP) is a family of specifications developed by OSGP Alliance which consists of industry market participants, utilities, hardware manufacturers, service providers and system integrators. It was published by the European Telecommunications Standards Institute (ETSI). These specifications used alone with the ISO/IEC 14908 control networking standard to provide state-of-art high-performance, scalable infrastructure for smart grid applications. These standard enables flexibility to address new challenges by extending network with new devices or applications[142]. OSGP is designed to provide command and control information for smart grid devices (such as meters, solar panels, direct load control modules) securely and efficiently. It supports communication between large deployments of smart grid devices and utility companies for use cases such as billing, user's consumption control consumption for energy shortage, and supply consumption data to the user (OSGP Alliance website, 2020).

Location/area of application

According to OSGP website, there are around 5 million smart meters and devices worldwide that use OSGP protocol. Mainly OSGP is used in Europe in such countries as Sweden, Denmark, Finland, Germany, and Austria. Standard was also applied in Turkey, Egypt, Russia, Republic of South Africa, South Korea, United States (Kansas, California), Malaysia, New Zeeland, Brazil (Porto Alegre).[143]

Technical overview

A core feature of the protocol over power line channels is a repeat function that allows the application layer flexibility and responsibility for forwarding packets between machines, irrespective of the routing protocol or underlying layer limitations (Dansk Standard, 2019).

Application Layer

For the Applications Layer, OSGP employes ANSI C 12 table structure for a networking protocol for utility-related devices. Applications Layer utilises ETSI TS 104 001 which has table-oriented data storage and command system for smart meters as well as for general-purpose extensions of various smart grid devices. The OSGP data interface uses a representation-oriented model (procedures and tables). It requires low overhead and enables it to be very

[142] https://osgp.org/en/technical
[143] https://osgp.org/en/successful_deployments

bandwidth efficient. OSGP includes both authentication and encryption for all data transfers to secure integrity and privacy (ETSI TS 104 001, 2019).

Networking Layers

In Networking Layer, OSGP uses EN14908-1 with extensions for security, authentication, and encryption. The intermediate layers of the OSGP stack use the ISO/IEC 14908 control networking specification. The low overhead of ISO/IEC 14908 does not require high bandwidth to achieve high performance (OSGP Alliance website, 2020).

Physical Layer

In physical layer, OSGP utilises ETSI TS 103 908 specification. ETSI TS 103 908 has a high power line link budget related to packets' capability. It can transmit and receive information over extended distances under very harsh conditions and manage the volumes of useful work performed via single channel. (OSGP Alliance website, 2020).[144]

Link to EU-SysFlex System Use Cases

The OSGP satisfies the following SUCs from Task 5.2: "Collect energy data", "Transfer energy data", "Aggregate energy data", "Manage flexibility bids", "Manage flexibility activations", "Authenticate data users", "Manage sub-meter", "Exchange data between DER and SCADA", "Anonymize energy data".

VI-6. USEF

High-level description

The USEF is an initiative in the Netherlands by the collective of top sector companies to standardise smart grids. They aim to create an open platform that facilitates access to the grid for stakeholders and smart energy services development. The framework defines a modular design for flexible smart energy systems, including the definition of flexibility value chains, roles, interaction models, programmatic interfaces and message format (USEF Foundation website, 2020).

Location/area of application

USEF framework is mainly applied in Europe for in smart energy projects and solutions.[145] (USEF Foundation website, 2020)

Technical overview

USEF creates value by introducing flexibility, the time-shiftable load of smart devices, to the electricity grid. Flexibility can be invoked for grid capacity management to avoid or reduce peak loads. It allows for active balancing through optimisation between supply and demand. Stakeholders in USEF are organised in a hierarchical tree structure, BRP, aggregators, prosumers, and the DSO. Electricity is traded between the suppliers and the BRPs over the wholesale energy market (day-ahead) or imbalance market (operation time). The BRPs dispatch the electricity

[144] https://osgp.org/en/technical
[145] https://www.usef.energy/implementations/

to the aggregators, which in turn deliver to the prosumers. The aggregator groups the prosumers into clusters. Its primary purpose is to accumulate and offer flexibility on behalf of the connected prosumers. The DSO acts as a supervisor for the grid. It resolves detected congestion that might occur in the distribution lines (Nguyen et al., 2017).

USEF employs a market-based control mechanism that consists of four phases: planning, validation, operation and settlement. In the planning phase, a day-ahead forecast of the energy consumption is made, which needs to be validated by the DSO. The planning and validation phases are iterated until an agreement is reached on the forecast. In the operation phase, the system aims balances between the forecast and actual electricity load by procuring flexibility to comply with a predefined plan. Settlement phase includes financial reconciliation (Backers et al., 2014).

Link to EU-SysFlex System Use Cases

USEF is relevant for the following SUCs: "Manage flexibility bids", "Manage flexibility activations", "Verify and settle activated flexibilities", "Manage access permissions", "Authenticate data users", "Calculate flexibility baseline", "Predict flexibility availability", "Anonymise energy data".

VI-7. ONEM2M

High-level description

OneM2M is a project to create a global technical standard for machine-to-machine interoperability. It is focused on architecture, API specifications, security and enrolment. It is independent of the technology used for the transport of information.

Location/area of application

OneM2M was constituted by eight ICT standards development organisations (ARIB (Japan), ATIS (United States), CCSA (China), ETSI (Europe), TIA (USA), TSDSI (India), TTA (Korea) and TTC (Japan)). The membership[146] (via the partner standards development organisations) has a similarly global constitution. The list of OneM2M deployments[147] is similarly global, with a slight bias to the Far East.

Technical overview

OneM2 M specifies only one ontology, the OneM2M Base Ontology. The oneM2M Base Ontology has the minimum number of conventions required so that other ontologies can be mapped into oneM2M. Those other external ontologies might describe specific types of devices, or other, general 'things' (e.g., buildings, rooms, cars) that require representation. Mapping of properties and classes between the ontologies enables external usage of ontologies with the OneM2M Base Ontology. Some external ontologies are already specifically supported, i.e., OneM2M supports interworking with several specific non-oneM2M solutions (e.g., SAREF).

[146] https://onem2m.org/membership/current-members
[147] https://onem2m.org/membership/list-of-deployments

Link to EU-SysFlex System Use Cases

OneM2M is relevant for the following SUCs: "Collect energy data",, "Transfer energy data", "Manage sub-meter data", "Exchange data between DER and SCADA".

VI-8. OPENADR

High-level description

OpenADR is an emerging, open, two-way information model designed to facilitate information exchange between energy management systems (and the resources they control) and other energy system actors). Aimed initially at facilitating demand response, it is flexible and has been adapted to other use cases, including control of smart inverters and distributed energy resources (DERs). Energy system actors may wish to communicate with such assets to modulate their operation for some network management or commercial purpose. OpenADR standardises the message format used for demand response. Dynamic price and reliability signals can be delivered in a uniform and interoperable fashion among energy management systems and buyers of demand response (e.g., system/network operators and balancing responsible parties. The current OpenADR specification (OpeADR 2.0) is being developed by the OpenADR alliance, "a mutual benefit corporation created to foster the development, adoption, and compliance of the OpenADR Smart Grid standard"[148]. OpenADR focuses on the connection of DERs to upstream actors (e.g., grid operators or balancing responsible parties who want to access the flexibility of DERs).

Location/area of application

The OpenADR Alliance is primarily North-American[149]. According to the OpenADR Alliance, there are over sixty deployments of OpenADR-based systems across the US and internationally.

Technical overview

OpenADR 2.0 specifies the signalling data models between a virtual top node (VTN, which publishes information to automated clients) and a virtual end node (VEN, which subscribe to that information). Services covered include:

1. **Registration** of actors to roles of VENs or VTNs.
2. **Enrolment** of resources for participation in flexibility/demand response programs
3. **Market contexts.** It is used to discover rules or standard reports, i.e., information that does not change frequently and appended to every message.
4. **Event.** Used to instruct the required behaviour given a transaction (e.g., committing a resource to provide demand response under some conditions).
5. **Quote or dynamic prices.** For distributing complex dynamic prices (e.g., block or tier tariffs).
6. **Reporting or feedback,** to set the state of a resource (i.e., its response to a signal)
7. **Availability.** Constraints on the availability of a device.
8. **Opt or override.** Enables short notice changes to availability of a VEN (i.e., opting in or out).

[148] https://www.openadr.org/openadr-alliance-releases-20a
[149] https://www.openadr.org/members

Link to EU-SysFlex System Use Cases

OpenADR is relevant for the following SUCs: “Collect energy data”, “Transfer energy data”, “Manage flexibility bids”, “Manage flexibility activations”, “Manage sub-meter data”, “Exchange data between DER and SCADA”.

VI-9. EEBUS

High-level description

Like Open ADR, EEBUS is an emerging, open, two-way information model designed to facilitate information exchange between:

1. demand response (DR)/distributed energy resources (DER)/smart devices and a gateway device/energy management system, and
2. between the gateway/energy management system and other energy system actors.

Whereas OpenADR is more focused on exchanges between DERs and upstream actors, EEBUS is more focused on interactions within a home, i.e., between devices and an energy management system/gateway (though it does also cover ‘grid interactions’). Within the EEBUS architecture is an ‘information layer’ (Specification Smart Premises Interoperable Neutral Message Exchange – SPINE) and a ‘communication layer’ (Smart Home IP – SHIP). This separation of layers follows the principles of the Smart Grid Architecture Model (SGAM). EEBUS is developed by the EEBUS initiative, founded in 2012 by Germany’s Federal Ministry of Economics. The board and members[150] of the EEBUS initiative are predominantly continental European.

Location/area of application

According to the EEBUS website, more than sixty companies are already ‘speaking’ EEBUS. Most of the companies cited are based in continental Europe or have a significant subsidiary in continental Europe, reflecting the EEBUS initiative's membership.

Technical overview

The critical aspect of EEBUS is that the main components (SPINE and SHIP) are independent. SPINE defines messages and procedures on the application level and can be used with any transport protocol, although the SPINE documentation emphasises that integration with SHIP is effortless).

The SPINE data model and protocol specifications have a more general design compared to OpenADR. This general and modular design are deliberate to facilitate extension to cover new requirements with different data points. That said, the SPINE documentation does define a ‘resource model’ which defines a description of a resource (e.g., a smart fridge/freezer) and how information included in that description (e.g., device type, entity type, feature type and feature data) should be mapped into the data model.

[150] https://www.eebus.org/about-us/

Link to EU-SysFlex System Use Cases

EEBUS is directly relevant for the following SUCs: “Collect energy data”, “Transfer energy data”, “Exchange data between DERs and SCADA”, “Manage sub-meter data”. Besides, due to its general and modular design, it seems that EEBUS could be easily modified to satisfy the following use cases: “Manage flexibility bids”, “Manage flexibility activations”.

VI-10. MADES (IEC 62325-503)

High-level description

The MADES initiative specifies a standard for a “communication platform that every Transmission System Operator (TSO) in Europe may use to reliably and securely exchange documents” (ENTSO-E, 2014)[151]. Market participants like suppliers and DSOs can “benefit from a single, common, harmonised and secure platform for message exchange with the different TSOs, thus reducing the cost of building different IT platforms to interface with all the parties involved”. It means that stakeholders can easily enter other markets in Europe.

The “MADES” acronym is short for **MArket Data Exchange Standard**. MADES is “a specification for a decentralised common communication platform based on international IT protocol standards:

- From a business application (BA) perspective, MADES specifies software interfaces to exchange electronic documents with other BAs. Such interfaces mainly provide means to send and receive documents using a so-called “MADES network”. Every step of the delivery process is acknowledged, and the sender can request a document's delivery status. This is done through acknowledgement, which are messages returned to the sender. This makes MADES networks usable for exchanging documents in business processes requiring reliable delivery.
- MADES also specifies all services for the business application (BA); the complexities of recipient localisation, recipient connection status, message routing and security are hidden from the connecting BA. MADES services include directory, authentication, encryption, signing, message tracking, message logging and short-term message storage.”

“The purpose of MADES is to create a data exchange standard comprised of standard protocols and utilizing IT best practices to create a mechanism for exchanging data over any TCP/IP communication network in order to facilitate business to business information exchanges as described in IEC 62325-351 and the IEC 62325-451 series. A MADES network acts as a post-office organisation. The transported object is a “message” in which the sender document is securely repackaged in an envelope (i.e. a header) containing all the necessary information for tracking, transportation and delivery.” MADES has been standardised through ESMP – IEC 62325-503: Market data exchanges guidelines for the IEC 62325-351 profile. Relevant related standard is IEC TS 62325-504 – Utilization of web services for electronic data interchanges on the European energy market for electricity (2015).

[151] https://eepublicdownloads.azureedge.net/clean-documents/EDI/Library/depreciated/503_mades-v1r1.pdf

Location/area of application

"The MADES initiative has been adopted by the ENTSO-E Electronic Data Interchange (EDI) Working Group (WG) to facilitate communication between TSOs and European electricity market participants."

"MADES is a generic way to exchange information. It is not limited in usage to market data or the electricity industry and can be used more widely for any non-real-time data exchange application. The MADES enables each party to implement MADES access points (referred to as endpoints) connected to his information system (IS), where he may securely send and receive documents to and from other parties. MADES is not concerned with specific business functionality, neither creating a new IT standard, nor building communication infrastructure. For the market to operate correctly, parties must exchange electronic documents conforming to predefined business logic and in a cost-effective way, namely by using existing IT standards and protocols over existing communication infrastructures."

Technical overview

Message delivery

"The main feature of MADES is the message delivery function /…/. A message is transferred from a sender to a recipient. Both sender and recipient are business applications (BAs). A BA connects to a MADES endpoint using a programming interface. The sender and recipient view the MADES system only through the defined interface. The document transported between sender and recipient can be any text or binary data. Alongside with the document, a MADES message contains additional information in a header (or envelope), including information to securely identify, transport and route the message such as a unique message ID, the identities of the sender and of the recipient, a business-type." (See Figure 34.)

FIGURE 34: MADES MESSAGE DELIVERY OVERVIEW (ENTSO-E, 2014)

Transparency

From the sender's to the recipient's endpoint, the message passes some MADES components. "When a message traverses a component, the latter notifies the event, and a new message (referred to as an acknowledgement) is sent back to the sender's endpoint. All the events notified during the message delivery can be retrieved by the sender's BA."

Security and reliability

"MADES ensures a secure message transfer and a fully tracked delivery /…/." (See Figure 35.)

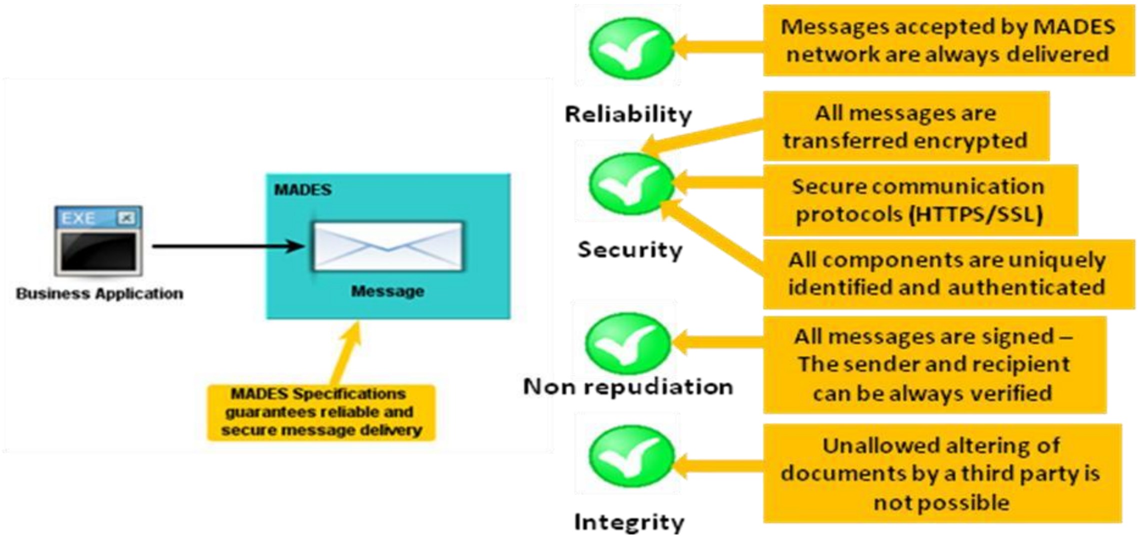


FIGURE 35: MADES SECURITY AND RELIABILITY (ENTSO-E, 2014)

A MADES communication system guarantees that any message accepted by the system will not be lost. The sender can at any time check the delivery status of the messages (delivering, delivered or failed). The standard describes a logging mechanism to be implemented in all message handling components to provide information about the message transfers; MADES describes nonrepudiation features, allowing the verification of a message and its header, which includes the sender, the recipient, the sending time, the delivery time, etc. MADES defines the way to sign and encrypt the transported messages. For the communication layer, the MADES cohmponents use secure communication protocols HTTPS. Information is transported encrypted. Moreover, both sides of communication are authenticated using industry-standard PKI certificates."

Link to EU-SysFlex System Use Cases

MADES is relevant for the following SUCs: "Transfer energy data", "Manage access permissions", "Authenticate data users", "Manage data logs", "Anonymize energy data", "Aggregate energy data", "Collect energy data", "Provide a list of suppliers and ESCOS", Manage flexibility activations", "Verify and settle activated flexibilities", "Calculate flexibility baseline", "Manage sub-meter data".

VI-11. AS4

High-level description

AS4 is Energy Market Profile for secure and reliable document exchange using AS4 messaging (NEDU, 2019). "The profile is developed for interactions in both the electricity and the gas market. The profile defines a number of settings and configurable parameters for optimal use in AS4 communication." Profiles produce "consistent, stable and interoperable communication between market parties". The profile is based on the international AS4 standard[152] and the European eDelivery AS4 Profile (European Commission, 2018)[153].

The Energy Market Profile primes to be practically ease to use, therefore the number of configurable parameters is kept to the minimum. This will ease communication in setting up the profile and will reduce maintenance and management costs. The profile will have enough information to ensure interoperability to exchange AS4 messages securely and reliably between actors and pass the documents on to the back-end systems."

Location/area of application

The European Commission maintains the eDelivery AS4 Common Profile for the Connecting Europe Facility (CEF). The ENTSOG uses AS4 profile for operating European gas market (ENTSOG, 2017)[154]. "The profile aims for synergy improvement in the electricity and gas sector for the exchange of business documents in the energy market. Although the AS4 Energy Market Profile was developed for the Dutch energy market the profile is certainly intended for use in the EU energy market."

Technical overview

Demand for the profile is the exchange of exactly one business document. A business document in this context is a structured set of data, usually presented in XML. Next to the business document, the AS4 message may contain multiple structured and unstructured additions.

"The *Four Corner Topology Profile Enhancement* is a mandatory extension of the *AS4 Energy Market Profile*, although it is an optional extension of the eDelivery AS4. The *Four Corner Topology Profile Enhancement* offers a uniform and consistent model for optionally using third parties in the chain between the (original) sender and addressee (final receiver) of an exchanged business document. It logs in a consistent way the routing information of the exchange. A third party may offer the service for AS4 message exchange, where the original sender or addressee (final receiver) still do the functional processing of the data exchanged. In such cases it needs to be clear under what conditions the data has to be exchanged between the third party (front-end) and the processing systems (back-end). The *Four Corner Topology* specifies a uniformed approach for this /…/ by making an explicit distinction between the original (business) sender, the business addressee (final receiver) and the intermediate parties in the AS4 exchange." (See Figure 36.)

"The *Four Corner Topology* defines a standard way of tracking the identity of the original sender and the ultimate addressee (final receiver) of the message by registering these in the AS4 message properties *originalSender* and *finalRecipient*. Using the *finalRecipient* of a message, an MSH [Message Service Handler] is able to route the content to the intended back-end business application. The *originalSender* always discloses the original sending business party that triggered the data exchange to the final business recipient."

[152] https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/2020/07/24/ISO+approves+eDelivery+message+exchange+protocol+as+International+Standard
[153] https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/eDelivery+AS4+-+1.14
[154] https://entsog.eu/sites/default/files/files-old-website/as4/pdf/INT0488-170328%20AS4%20Usage%20Profile_Rev_3.5.pdf

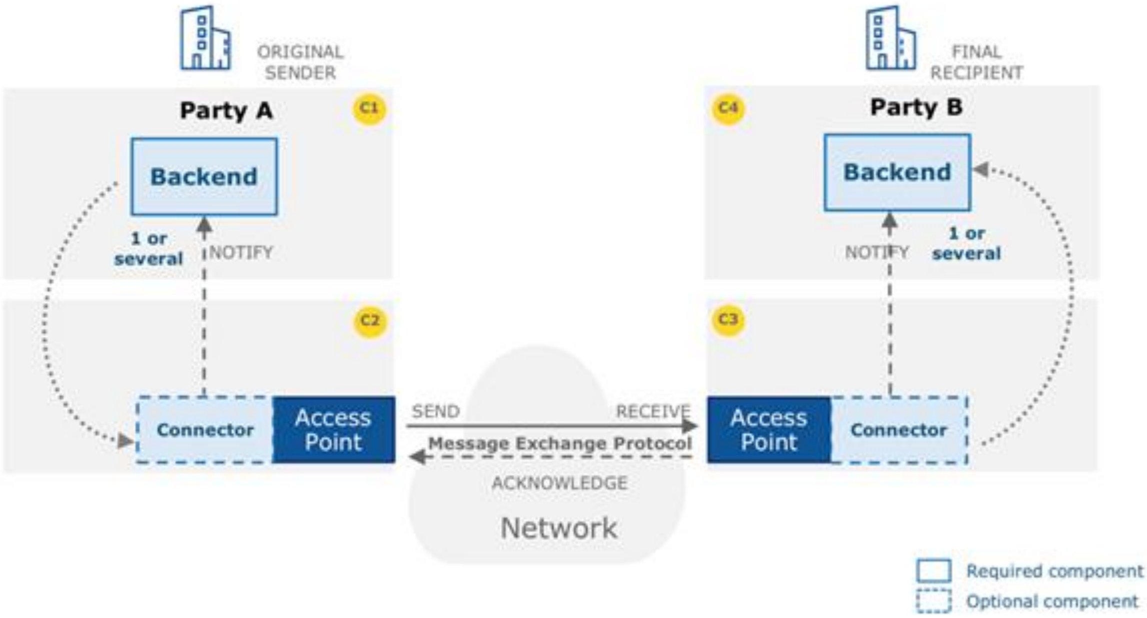


FIGURE 36: FOUR CORNER TOPOLOGY (NEDU, 2019)

Link to EU-SysFlex System Use Cases

AS4 is directly relevant for the following SUCs: “Transfer energy data”, “Manage access permissions”, “Authenticate data users”, “Manage data logs”, “Anonymize energy data”, “Aggregate energy data”.

VI-12. ESTFEED

High-level description

Estfeed[155] is a distributed message bus with additional controls for the use of private information. The platform connects data sources (providing data on a *publish* or *request* basis) to applications (information systems using data). The applications receive data either via a push method or pull method.

Estfeed is the first highly secure platform for exchanging private energy metering data between Data Providers and Data Users with Data Owner's consent. Estfeed is designed and operated by Elering AS, the Estonian transmission system operator (TSO).

- Estfeed is compliant with EU regulations (Clean Energy Package and GDPR)
- It is secure, proven and scalable, and enables to save from developing the platform from scratch
- Estfeed provides flexible ways to share energy data with energy services who want to access it

[155] https://elering.ee/en/smart-grid-development#tab0

Location/area of application

Different Data Providers can share data through Estfeed. Everyone who stores or provides access to energy data, both public (like energy price) and private data (like metering data), e.g. TSOs, DSOs and other meter data management companies and organisations providing public energy data.

Different Data Users can use this data: energy service providers, e.g. energy sales, smart home, flexibility services, electricity price comparison tools:

- to create new and innovate energy products and services that save energy and money;
- to develop and provide personalized energy services based on real metering data history;
- to save money from making one integration instead of many.

Estfeed has been proven in Estonia – it provides access to all Estonian electricity and gas metering data from 2017. It can be scaled all over Europe to facilitate the integration of the European energy market. If Data Owners (like consumers) are in control of sharing their metering data, they can use novel energy services that save and use energy more sustainably.

Technical overview

Data exchange involves three parties (Cybernetica, 2017)[156] (Figure 37):

- Application information system (application IS) – a consumer of data and services; communicates with the Estfeed system (application adapter) using Estfeed protocol;
- Source information system (data source IS) – a provider of data and services; communicates with the Estfeed system (source adapter) using Estfeed protocol;
- Estfeed system – mediator of data and services between applications and data sources.

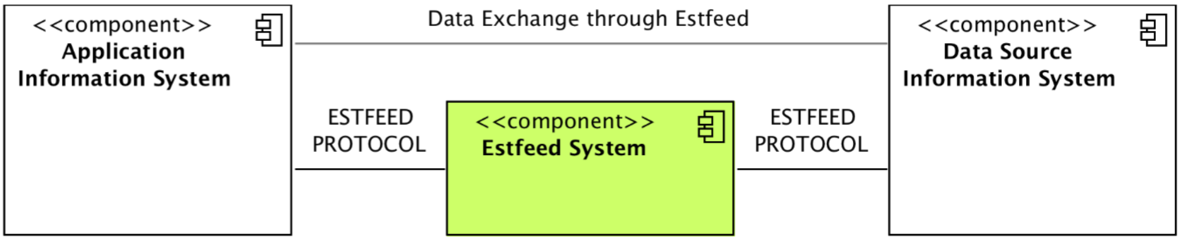


FIGURE 37: ESTFEED PROTOCOL OVERVIEW (CYBERNETICA, 2017)

The end-to-end data exchange uses multipart Multipurpose Internet Mail Extensions (MIME) messages. The first part of the multipart message contains message metadata in XML format, and the following parts of the message are service-specific payloads. Between individual systems, using HTTP for the transfer of the messages. "Application information system and source information system exchange data with the Estfeed system over mutually authenticated TLS (HTTPS) connections. Certificates are exchanged between interconnected systems to achieve the mutual authentication (certificate pinning). In deployment cases, where the information system is deployed to the

[156] https://elering.ee/sites/default/files/attachments/estfeed_protocol_1.13_Y-1029-1.pdf

same host together with the Estfeed system endpoint (Estfeed adapter), regular HTTP can be used for data exchange."

The standard HTTP method is HTTP POST in both directions, where both the Estfeed adapter and the information system call an URL to push data. For an application, an optional pull method is also supported. In this case, the application will periodically poll the Estfeed adapter for incoming messages. "In publish data exchange, the data sources periodically publish messages (e.g. measurement data) to the Estfeed system. Applications are subscribed to the services publishing the data (note: the subscription process is not part of the Estfeed protocol). When a data source publishes data, the Estfeed system automatically forwards it to all applications that are subscribed to the service provided by the data source and are permitted to receive the data."

"The request-response protocol can be used to invoke services offered by data sources. One service can be provided by multiple data sources. Estfeed automatically sends the request to all involved data sources. Request is initiated by an application that sends a request to the Estfeed system. The Estfeed system immediately responds with an acknowledgement message containing a transaction identifier and a list of responder source identifiers. The Estfeed system then forwards the request to data sources that provide the specified service.

Link to EU-SysFlex System Use Cases

Estfeed is directly relevant for the following SUCs: "Transfer energy data", "Manage access permissions", Authenticate data users, "Manage data logs, "Anonymize energy data", "Aggregate energy data", "Erase and rectify personal data".

VI-13. FIWARE

High-level description

FIWARE[157] is an open-source components framework and set of API (FIWARE NGSI) for context data management. It facilitates Smart Solutions' development for different domains such as Smart Cities, Smart Industry, and Smart Energy. FIWARE framework enables the development of a system that allows to capture data from multiple sources (not only IoT) and analyse that information to implement desired outcomes and behaviour without limiting to specific standards.

Location/area of application

FIWARE has a large community, actively cooperates with industry partners, and built a great community in 150 cities. FIWARE Mundus project iswith a focus on Latin and North America, Africa and Asia. FIWARE iHubs aims to help with the integration and implementation of FIWARE technologies in business. FIWARE also has 16 accelerators for funding teams which solutions are based on FIWARE technology. FIWARE has been approved by GSMA, CEF, and ETSI standards bodies.

[157] https://www.fiware.org/

Technical overview

FIWARE Platform Architecture consists of five blocks presented in Figure 38. The core and only mandatory component is the FIWARE Context Broker. Other FIWARE components can be assembled with third-party platform components to accelerate Smart Solutions' development.

The FIWARE Context Broker holds the current state of the whole smart system. It enables Context Information Management via FIWARE NGSI RESTful API to actuate and alter or enrich the current context. It follows the Publish/Subscribe paradigm, allowing data communication to be standard communication protocol based on Restful over HTTP. NGSI-LD has linked data concepts that allow one entity to share information about other entities.

The Context Broker can be enhanced by a suite of additional platform components, also called Generic enablers (GEs). They serve as software components of different applications and architectures. They help supply context data (e.g. from diverse sources such as a CRM system, social networks, mobile apps or IoT sensors), supporting processing, analysis and visualisation of data or bringing support to data access control, publication or monetisation. Moreover, it includes security protocols, such as OAuth2, when the information is interchanged since it is necessary to ensure the involved agents' privacy.

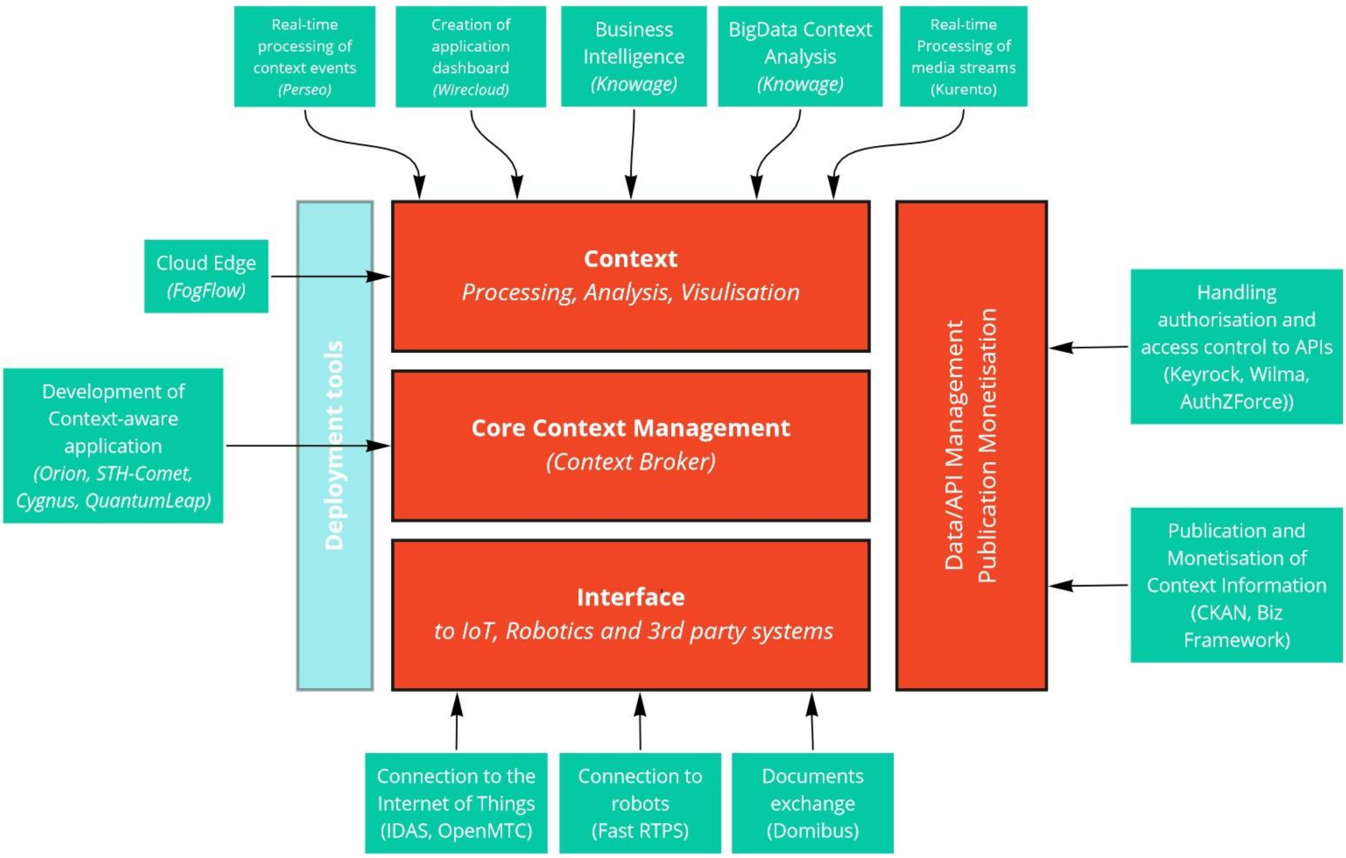


FIGURE 38: FIWARE PLATFORM ARCHITECTURE OVERVIEW WITH GES (FIWARE, 2018)[158]

[158] https://www.slideshare.net/FI-WARE/fiware-global-summit-fiware-overview

Apart from the Context Broker, a few elements are used for data uploading into databases and retrieval information. Short term history Comet provides MongoDB context data storage for short term information history. Cygnus enables the persistence of historical context information in a variety of databases.

Link to EU-SysFlex System Use Cases

FIWARE is directly relevant for the following “Transfer energy data” SUC. Due to its general and modular design, with 3rd parties’ extensions, it seems that FIWARE could be easily modified to satisfy all SUCs.

ANNEX VII. XSD AND XSLT CODES FOR CIM 'FLEXIBILITY BID'

CIM Flexibility BID XSD

```
<?xml version="1.0" encoding="utf-8"?>
<xsd:schema targetNamespace="CIM/EuSysFlex/FlexibilityBid" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:FP="CIM/EuSysFlex/FlexibilityBid">
    <xsd:element name="FlexibilityBid_MarketDocument" type="FP:FlexibilityBid_MarketDocument_Type"/>
    <xsd:complexType name="Bidding_DateTimeInterval">
        <xsd:annotation>
            <xsd:documentation>Interval between two date and time points, where the interval includes the start time but excludes end time.
</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="end" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>End date and time of this interval.  The end date and time where the interval is defined up to, but
excluded.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="start" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Start date and time of this interval.  The start date and time is included in the defined
interval.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="Bidding_Period">
        <xsd:annotation>
            <xsd:documentation>An identification of a time interval that may have a given resolution.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="timeInterval" type="FP:Bidding_DateTimeInterval" minOccurs="1" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>The start and end date and time for a given interval.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="BidTimeSeries">
        <xsd:annotation>
            <xsd:documentation>The formal specification of specific characteristics related to a bid.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="Currency_Unit" type="FP:Currency_Unit" minOccurs="0" maxOccurs="1"/>
            <xsd:element name="Delivery_Period" type="FP:Delivery_Period" minOccurs="1" maxOccurs="unbounded"/>
            <xsd:element name="Linked_BidTimeSeries" type="FP:Linked_BidTimeSeries" minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element name="Measure_Unit" type="FP:Measure_Unit" minOccurs="0" maxOccurs="1"/>
            <xsd:element name="Metering_MarketEvaluationPoint" type="FP:MarketEvaluationPoint" minOccurs="1" maxOccurs="unbounded"/>
            <xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
```

```
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="product" type="xsd:string" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The type of the product such as Power, energy, reactive power, transport capacity that is the subject of the time series.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="CoordinateSystem">
            <xsd:annotation>
                <xsd:documentation>Coordinate reference system.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="name" type="xsd:string" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The name is any free human readable and possibly non unique text naming the object.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="Currency_Unit">
            <xsd:annotation>
                <xsd:documentation>The identification of the unit name for the time series quantities.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="name" type="xsd:string" minOccurs="1" maxOccurs="1" default="€/MWh">
                    <xsd:annotation>
                        <xsd:documentation>The coded representation of the unit.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="Delivery_DateTimeInterval">
            <xsd:annotation>
                <xsd:documentation>Interval between two date and time points, where the interval includes the start time but excludes end time.
</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="end" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>End date and time of this interval.  The end date and time where the interval is defined up to, but excluded.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="start" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>Start date and time of this interval.  The start date and time is included in the defined interval.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
```

```
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="Delivery_Period">
		<xsd:annotation>
			<xsd:documentation>An identification of a time interval that may have a given resolution.</xsd:documentation>
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="Point" type="FP:Point" minOccurs="1" maxOccurs="unbounded"/>
			<xsd:element name="resolution" type="xsd:duration" minOccurs="0" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>The number of units of time that compose an individual step within a period.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="timeInterval" type="FP:Delivery_DateTimeInterval" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>The start and end date and time for a given interval.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="FlexibilityBid_MarketDocument_Type">
		<xsd:annotation>
			<xsd:documentation>Electronic document containing the information necessary to satisfy a given business process set of requirements.
</xsd:documentation>
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="Bid_TimeSeries" type="FP:BidTimeSeries" minOccurs="1" maxOccurs="unbounded"/>
			<xsd:element name="LocalizationFactor_Domain" type="FP:LocalizationFactor_Domain" minOccurs="1" maxOccurs="1"/>
			<xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="Period" type="FP:Bidding_Period" minOccurs="0" maxOccurs="1"/>
			<xsd:element name="Provider_MarketParticipant" type="FP:Provider_MarketParticipant" minOccurs="1" maxOccurs="1"/>
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="Linked_BidTimeSeries">
		<xsd:annotation>
			<xsd:documentation>The formal specification of specific characteristics related to a bid.</xsd:documentation>
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
		</xsd:sequence>
```

```
		</xsd:complexType>
		<xsd:complexType name="LocalizationFactor_Domain">
			<xsd:annotation>
				<xsd:documentation>An area of activity defined within the energy market.</xsd:documentation>
			</xsd:annotation>
			<xsd:sequence>
				<xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
					<xsd:annotation>
						<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.</xsd:documentation>
					</xsd:annotation>
				</xsd:element>
			</xsd:sequence>
		</xsd:complexType>
		<xsd:complexType name="MarketEvaluationPoint">
			<xsd:annotation>
				<xsd:documentation>The identification of an entity where energy products are measured or computed.</xsd:documentation>
			</xsd:annotation>
			<xsd:sequence>
				<xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
					<xsd:annotation>
						<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.</xsd:documentation>
					</xsd:annotation>
				</xsd:element>
				<xsd:element name="ServiceLocation" type="FP:ServiceLocation" minOccurs="0" maxOccurs="1">
					<xsd:annotation>
						<xsd:documentation>Service location where the service delivered by this usage point is consumed.</xsd:documentation>
					</xsd:annotation>
				</xsd:element>
			</xsd:sequence>
		</xsd:complexType>
		<xsd:complexType name="MarketRole">
			<xsd:annotation>
				<xsd:documentation>The external intended behavior played by a party within the electricity market.</xsd:documentation>
			</xsd:annotation>
			<xsd:sequence>
				<xsd:element name="mRID" type="xsd:string" minOccurs="0" maxOccurs="1">
					<xsd:annotation>
						<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object elements.</xsd:documentation>
					</xsd:annotation>
				</xsd:element>
			</xsd:sequence>
		</xsd:complexType>
		<xsd:complexType name="Measure_Unit">
			<xsd:annotation>
				<xsd:documentation>The identification of the unit name for the time series quantities.</xsd:documentation>
```

```xml
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="name" type="xsd:string" minOccurs="1" maxOccurs="1" default="MW">
				<xsd:annotation>
					<xsd:documentation>The coded representation of the unit.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="Point">
		<xsd:annotation>
			<xsd:documentation>An identification of a set of values beeing adressed within a specific interval of time.</xsd:documentation>
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="position" type="xsd:integer" minOccurs="0" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>A sequential value representing the relative position within a given time interval.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="Price" type="FP:Price" minOccurs="1" maxOccurs="1"/>
			<xsd:element name="quantity" type="xsd:decimal" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Principal quantity identified for a point.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="PositionPoint">
		<xsd:annotation>
			<xsd:documentation>Set of spatial coordinates that determine a point, defined in the coordinate system specified in
'Location.CoordinateSystem'. Use a single position point instance to desribe a point-oriented location. Use a sequence of position points to describe a
line-oriented object (physical location of non-point oriented objects like cables or lines), or area of an object (like a substation or a geographical zone - in
this case, have first and last position point with the same values).</xsd:documentation>
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="xPosition" type="xsd:string" minOccurs="0" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>X axis position.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="yPosition" type="xsd:string" minOccurs="0" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Y axis position.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="zPosition" type="xsd:string" minOccurs="0" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>(if applicable) Z axis position.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="Price">
		<xsd:annotation>
```

```
            <xsd:documentation>The cost corresponding to a specific measure and expressed in a currency.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="amount" type="xsd:decimal" minOccurs="1" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>A number of monetary units specified in a unit of currency.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="Provider_MarketParticipant">
        <xsd:annotation>
            <xsd:documentation>An identification of a party acting in a electricity market business process. This class is used to identify organisations
that can participate in market management and/or market operations.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="MarketRole" type="FP:MarketRole" minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object
elements.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="ServiceLocation">
        <xsd:annotation>
            <xsd:documentation>A real estate location, commonly referred to as premises.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="CoordinateSystem" type="FP:CoordinateSystem" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Coordinate system used to describe position points of this location.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="mainAddress" type="FP:StreetAddress" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Main address of the location.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="PositionPoints" type="FP:PositionPoint" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Sequence of position points describing this location, expressed in coordinate system
'Location.CoordinateSystem'.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="StreetAddress">
        <xsd:annotation>
            <xsd:documentation>General purpose street and postal address information.</xsd:documentation>
        </xsd:annotation>
```

```
        <xsd:sequence>
            <xsd:element name="postalCode" type="xsd:string" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Postal code for the address.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="streetDetail" type="FP:StreetDetail" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Street detail.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="townDetail" type="FP:TownDetail" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Town detail.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="StreetDetail">
        <xsd:annotation>
            <xsd:documentation>Street details, in the context of address.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="addressGeneral" type="xsd:string" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>First line of a free form address or some additional address information (for example a mail
stop).</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="buildingName" type="xsd:string" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>(if applicable) In certain cases the physical location of the place of interest does not have a direct point of
entry from the street, but may be located inside a larger structure such as a building, complex, office block, apartment, etc.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="name" type="xsd:string" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Name of the street.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
            <xsd:element name="number" type="xsd:string" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
                    <xsd:documentation>Designator of the specific location on the street.</xsd:documentation>
                </xsd:annotation>
            </xsd:element>
        </xsd:sequence>
    </xsd:complexType>
    <xsd:complexType name="TownDetail">
        <xsd:annotation>
            <xsd:documentation>Town details, in the context of address.</xsd:documentation>
        </xsd:annotation>
        <xsd:sequence>
            <xsd:element name="country" type="xsd:string" minOccurs="0" maxOccurs="1">
                <xsd:annotation>
```

```
                <xsd:documentation>Name of the country.</xsd:documentation>
            </xsd:annotation>
        </xsd:element>
        <xsd:element name="name" type="xsd:string" minOccurs="0" maxOccurs="1">
            <xsd:annotation>
                <xsd:documentation>Town name.</xsd:documentation>
            </xsd:annotation>
        </xsd:element>
        <xsd:element name="stateOrProvince" type="xsd:string" minOccurs="0" maxOccurs="1">
            <xsd:annotation>
                <xsd:documentation>Name of the state or province.</xsd:documentation>
            </xsd:annotation>
        </xsd:element>
    </xsd:sequence>
  </xsd:complexType>
</xsd:schema>
```

XSLT Code: From CIM to EU-SysFlex format

```
<xsl:stylesheet version="2.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:ns0="CIM/EuSysFlex/FlexibilityBid"
xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:fn="http://www.w3.org/2005/xpath-functions" exclude-result-prefixes="ns0 xs fn">
  <xsl:output method="xml" encoding="UTF-8" byte-order-mark="no" indent="yes"/>
  <xsl:template match="/">
    <xsl:variable name="var1_FlexibilityBid_MarketDocument" as="node()?" select="ns0:FlexibilityBid_MarketDocument"/>
    <FlexibilityBid>
        <xsl:attribute name="xsi:noNamespaceSchemaLocation" namespace="http://www.w3.org/2001/XMLSchema-instance"
select="'file:///C:/Users/cyril/Downloads/EuSysFlex/ActualFlexibilityBid.xsd'"/>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument">
            <flexibility_service_provider>
                <xsl:sequence select="fn:string(Provider_MarketParticipant/mRID)"/>
            </flexibility_service_provider>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries">
            <product_id>
                <xsl:sequence select="fn:string(product)"/>
            </product_id>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Metering_MarketEvaluationPoint">
            <metering_point_id>
                <xsl:sequence select="fn:string(mRID)"/>
            </metering_point_id>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Delivery_Period/Point">
            <power>
                <xsl:sequence select="xs:string(xs:decimal(fn:string(quantity)))"/>
            </power>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Delivery_Period/Point">
            <price>
                <xsl:sequence select="xs:string(xs:decimal(fn:string(Price/amount)))"/>
            </price>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries">
            <linking_of_bids>
```

```
                <xsl:sequence select="xs:string((fn:count(Linked_BidTimeSeries) &gt; xs:decimal('0')))"/>
            </linking_of_bids>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument">
            <localization_factor>
                <xsl:sequence select="fn:string(LocalizationFactor_Domain/mRID)"/>
            </localization_factor>
        </xsl:for-each>
        <xsl:for-each select="$var1_FlexibilityBid_MarketDocument/Bid_TimeSeries/Delivery_Period">
            <start_of_delivery>
                <xsl:sequence select="xs:string(xs:dateTime(fn:string(timeInterval/start)))"/>
            </start_of_delivery>
        </xsl:for-each>
    </FlexibilityBid>
  </xsl:template>
</xsl:stylesheet>
```

XSLT Code from EU-SysFlex format to CIM

```
<xsl:stylesheet version="2.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:sys="http://sysFlex/Lib"
xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:fn="http://www.w3.org/2005/xpath-functions" exclude-result-prefixes="sys xs fn">
  <xsl:include href="EuSysFlex_Lib.xsl"/>
  <xsl:output method="xml" encoding="UTF-8" byte-order-mark="no" indent="yes"/>
  <xsl:template match="/">
    <xsl:variable name="var2_PT_H_as_duration" as="xs:duration" select="xs:duration('PT1H')"/>
    <xsl:variable name="var1_FlexibilityBid" as="node()?" select="FlexibilityBid"/>
    <FlexibilityBid_MarketDocument xmlns="CIM/EuSysFlex/FlexibilityBid">
        <xsl:attribute name="xsi:schemaLocation" namespace="http://www.w3.org/2001/XMLSchema-instance"
select="'CIM/EuSysFlex/FlexibilityBid file:///C:/Users/cyril/Downloads/EuSysFlex/CIM_flexibilityBid.xsd'"/>
        <Bid_TimeSeries xmlns="">
            <Delivery_Period>
                <Point>
                    <position>
                        <xsl:sequence select="xs:string(xs:integer(xs:decimal('0')))"/>
                    </position>
                    <Price>
                        <xsl:for-each select="$var1_FlexibilityBid">
                            <amount>
                                <xsl:sequence select="xs:string(xs:decimal(fn:string(price)))"/>
                            </amount>
                        </xsl:for-each>
                    </Price>
                    <xsl:for-each select="$var1_FlexibilityBid">
                        <quantity>
                            <xsl:sequence select="xs:string(xs:decimal(fn:string(power)))"/>
                        </quantity>
                    </xsl:for-each>
                </Point>
                <resolution>
                    <xsl:sequence select="xs:string($var2_PT_H_as_duration)"/>
                </resolution>
                <timeInterval>
                    <xsl:for-each select="$var1_FlexibilityBid">
```

```
                            <end>
                                <xsl:sequence select="xs:string(sys:add-duration-to-datetime(xs:dateTime(fn:string(start_of_delivery)),
$var2_PT_H_as_duration))"/>
                            </end>
                        </xsl:for-each>
                        <xsl:for-each select="$var1_FlexibilityBid">
                            <start>
                                <xsl:sequence select="xs:string(xs:dateTime(fn:string(start_of_delivery)))"/>
                            </start>
                        </xsl:for-each>
                    </timeInterval>
                </Delivery_Period>
                <Metering_MarketEvaluationPoint>
                    <xsl:for-each select="$var1_FlexibilityBid">
                        <mRID>
                            <xsl:sequence select="fn:string(metering_point_id)"/>
                        </mRID>
                    </xsl:for-each>
                </Metering_MarketEvaluationPoint>
                <mRID>
                    <xsl:sequence select="generate-id()"/>
                </mRID>
                <xsl:for-each select="$var1_FlexibilityBid">
                    <product>
                        <xsl:sequence select="fn:string(product_id)"/>
                    </product>
                </xsl:for-each>
            </Bid_TimeSeries>
            <LocalizationFactor_Domain xmlns="">
                <xsl:for-each select="$var1_FlexibilityBid">
                    <mRID>
                        <xsl:sequence select="fn:string(localization_factor)"/>
                    </mRID>
                </xsl:for-each>
            </LocalizationFactor_Domain>
            <xsl:for-each select="$var1_FlexibilityBid">
                <mRID xmlns="">
                    <xsl:sequence select="generate-id(.)"/>
                </mRID>
            </xsl:for-each>
            <Period xmlns="">
                <timeInterval>
                    <xsl:for-each select="$var1_FlexibilityBid">
                        <end>
                            <xsl:sequence select="xs:string(sys:add-duration-to-
datetime(xs:dateTime(xs:date(xs:dateTime(fn:string(start_of_delivery)))), xs:duration('PT24H')))"/>
                        </end>
                    </xsl:for-each>
                    <xsl:for-each select="$var1_FlexibilityBid">
                        <start>
                            <xsl:sequence select="xs:string(xs:dateTime(xs:date(xs:dateTime(fn:string(start_of_delivery)))))"/>
                        </start>
                    </xsl:for-each>
                </timeInterval>
```

```
            </Period>
            <Provider_MarketParticipant xmlns="">
                <xsl:for-each select="$var1_FlexibilityBid">
                    <mRID>
                        <xsl:sequence select="fn:string(flexibility_service_provider)"/>
                    </mRID>
                </xsl:for-each>
            </Provider_MarketParticipant>
        </FlexibilityBid_MarketDocument>
    </xsl:template>
</xsl:stylesheet>
```

Used Library : EuSysFlex_Lib.XSL

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="2.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:fn="http://www.w3.org/2005/xpath-functions" xmlns:r="http://schemas.openxmlformats.org/package/2006/relationships"
xmlns:w="http://schemas.openxmlformats.org/spreadsheetml/2006/main"
xmlns:rD="http://schemas.openxmlformats.org/officeDocument/2006/relationships" xmlns:sys="http://sysFlex/Lib"
xmlns:m="http://schemas.openxmlformats.org/spreadsheetml/2006/main">



    <xsl:function as="xs:dateTime" name="sys:add-duration-to-datetime">
        <xsl:param as="xs:dateTime" name="start"/>
        <xsl:param as="xs:duration" name="duration"/>

        <xsl:variable name="dur" as="xs:dayTimeDuration" select="xs:dayTimeDuration( $duration )"/>
        <xsl:value-of select="$start+$dur"/>
    </xsl:function>

</xsl:stylesheet>
```

ANNEX VIII. XSD FOR CIM 'CUSTOMER CONSENT'

XSD for CIM Customer Consent

```
<?xml version="1.0" encoding="utf-8"?>
<xsd:schema targetNamespace="http://EuSysFlex/WP5/ConsentObject.xsd" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:CO="http://EuSysFlex/WP5/ConsentObject.xsd">
	<xsd:element name="CustomerConsent_MarketAgreement" type="CO:CustomerConsent_MarketAgreement_Type"/>
	<xsd:simpleType name="MandateStateKind">
		<xsd:restriction base="xsd:string">
			<xsd:enumeration value="PreValid"/>
			<xsd:enumeration value="Valid"/>
			<xsd:enumeration value="Terminated"/>
			<xsd:enumeration value="Expired"/>
		</xsd:restriction>
	</xsd:simpleType>
	<xsd:simpleType name="MandateTransitionkind">
		<xsd:restriction base="xsd:string">
			<xsd:enumeration value="MANDATE_CREATED"/>
			<xsd:enumeration value="MANDATE_REVOKED"/>
			<xsd:enumeration value="EULA_REVOKED"/>
			<xsd:enumeration value="AUTOMATIC_STATE_CHANGE"/>
		</xsd:restriction>
	</xsd:simpleType>
	<xsd:complexType name="ConsentObject">
		<xsd:sequence>
			<xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object
elements.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="name" type="xsd:string" minOccurs="0" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>The name is any free human readable and possibly non unique text naming the object.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="UsagePoint" type="CO:UsagePoint" minOccurs="0" maxOccurs="1"/>
		</xsd:sequence>
	</xsd:complexType>
	<xsd:complexType name="CustomerConsent_MarketAgreement_Type">
		<xsd:annotation>
			<xsd:documentation>An identification  or eventually the contents of an agreement between two or more parties.</xsd:documentation>
		</xsd:annotation>
		<xsd:sequence>
			<xsd:element name="ConsentObject" type="CO:ConsentObject" minOccurs="0" maxOccurs="unbounded"/>
			<xsd:element name="DelegatedThirdParty_MarketParticipant" type="CO:DelegatedThirdParty_MarketParticipant" minOccurs="0"
maxOccurs="1"/>
			<xsd:element name="lastModifiedDateTime" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Date and time this document was last modified. Documents may potentially be modified many times during
their lifetime.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object
elements.</xsd:documentation>
				</xsd:annotation>
			</xsd:element>
			<xsd:element name="Owner_MarketParticipant" type="CO:Owner_MarketParticipant" minOccurs="0" maxOccurs="1"/>
			<xsd:element name="status" type="CO:State_Status" minOccurs="1" maxOccurs="1">
				<xsd:annotation>
					<xsd:documentation>Status of subject matter (e.g., Agreement, Work) this document represents. For status of the document itself,
use 'docStatus' attribute.</xsd:documentation>
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                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="Transition_Reason" type="CO:Transition_Reason" minOccurs="1" maxOccurs="1"/>
                <xsd:element name="Validity_Period" type="CO:Validity_Period" minOccurs="0" maxOccurs="1"/>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="DateTimeInterval">
            <xsd:annotation>
                <xsd:documentation>Interval between two date and time points, where the interval includes the start time but excludes end time.
</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="end" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>End date and time of this interval.  The end date and time where the interval is defined up to, but
excluded.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="start" type="xsd:dateTime" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>Start date and time of this interval.  The start date and time is included in the defined
interval.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="DelegatedThirdParty_MarketParticipant">
            <xsd:annotation>
                <xsd:documentation>An identification of a party acting in a electricity market business process. This class is used to identify organisations
that can participate in market management and/or market operations.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="aliasName" type="xsd:string" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The aliasName is free text human readable name of the object alternative to IdentifiedObject.name. It may
be non unique and may not correlate to a naming hierarchy.
The attribute aliasName is retained because of backwards compatibility between CIM relases. It is however recommended to replace aliasName with the
Name class as aliasName is planned for retirement at a future time.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object
elements.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="name" type="xsd:string" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The name is any free human readable and possibly non unique text naming the object.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="Owner_MarketParticipant">
            <xsd:annotation>
                <xsd:documentation>An identification of a party acting in a electricity market business process. This class is used to identify organisations
that can participate in market management and/or market operations.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="aliasName" type="xsd:string" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The aliasName is free text human readable name of the object alternative to IdentifiedObject.name. It may
be non unique and may not correlate to a naming hierarchy.
The attribute aliasName is retained because of backwards compatibility between CIM relases. It is however recommended to replace aliasName with the
Name class as aliasName is planned for retirement at a future time.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
```

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                    <xsd:annotation>
                        <xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object
elements.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="name" type="xsd:string" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The name is any free human readable and possibly non unique text naming the object.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="State_Status">
            <xsd:annotation>
                <xsd:documentation>Current status information relevant to an entity.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="value" type="CO:MandateStateKind" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>Status value at 'dateTime'; prior status changes may have been kept in instances of activity records
associated with the object to which this status applies.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="Transition_Reason">
            <xsd:annotation>
                <xsd:documentation>The motivation of an act.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="code" type="CO:MandateTransitionkind" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The motivation of an act in coded form.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
                <xsd:element name="text" type="xsd:string" minOccurs="0" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The textual explanation corresponding to the reason code.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="UsagePoint">
            <xsd:annotation>
                <xsd:documentation>Logical or physical point in the network to which readings or events may be attributed. Used at the place where a
physical or virtual meter may be located; however, it is not required that a meter be present.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="mRID" type="xsd:string" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>Master resource identifier issued by a model authority. The mRID is unique within an exchange context.
Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended.
For CIMXML data files in RDF syntax conforming to IEC 61970-552, the mRID is mapped to rdf:ID or rdf:about attributes that identify CIM object
elements.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
        <xsd:complexType name="Validity_Period">
            <xsd:annotation>
                <xsd:documentation>An identification of a time interval that may have a given resolution.</xsd:documentation>
            </xsd:annotation>
            <xsd:sequence>
                <xsd:element name="timeInterval" type="CO:DateTimeInterval" minOccurs="1" maxOccurs="1">
                    <xsd:annotation>
                        <xsd:documentation>The start and end date and time for a given interval.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
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        </xsd:sequence>
    </xsd:complexType>
</xsd:schema>
```