

Deliverable 2.2: Standardization Landscape and Socioeconomic Context

27 September 2023

opentunity



[OPENTUNITYproject.eu](https://opentunityproject.eu)



**Funded by
the European Union**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Horizon Europe Grant agreement N° 101096333.

Deliverable Details

Title	WP	Version
Standardization Landscape and Socioeconomic Context	2	1.0

Contractual delivery date	Actual delivery date	Delivery type*	Dissemination**
September 2023 (M9)	September 2023 (M9)	R	PU

Author(s)	Organization
Stephan Schwarzinger	JOANNEUM Research Forschungsgesellschaft mbH (JR)
Camilla Neumann	JOANNEUM Research Forschungsgesellschaft mbH (JR)
Andreas Türk	JOANNEUM Research Forschungsgesellschaft mbH (JR)
Michael Brenner-Fließer	JOANNEUM Research Forschungsgesellschaft mbH (JR)
Iker Iñigo Ochandorena	Asociación Española de Normalización (UNE)

Version	Date	Person	Action	Status***
0.1	04/09/2023	Camilla Neumann (JR) Stephan Schwarzinger (JR) Michael Brenner-Fließer (JR) Iker Iñigo Ochandorena (UNE)	1 st Version	Draft
0.2	15/09/2023	Camilla Neumann (JR) Stephan Schwarzinger (JR)	Ready for peer review	Draft
0.3	25/09/2023	Sheila Sánchez Mínguez (ETRA) Álvaro Nofuentes Prieto (ETRA) Janez Gregor Golja (UL) Camilla Neumann (JR) Stephan Schwarzinger (JR)	Feedback from peer reviewing (ETRA & UL) is integrated	Approved
1.0	26/09/2023	Camilla Neumann (JR) Stephan Schwarzinger (JR)	Last check and document ready	Submitted

*Delivery type: R: Document, report; DEM: Demonstrator, pilot, prototype; DEC: Websites, patent fillings, videos, etc; OTHER; ETHICS: Ethics requirement; ORDP: Open Research Data Pilot.

**Dissemination Level: PU: Public; CO: Confidential, only for members of the consortium (including the Commission Services)

***Status: Draft, Final, Approved, Submitted (to European Commission).

Contributors

In the course of the work that led to this Deliverable, several contributions were received by members of all partner organizations. As some of the work was done in a collaborative online setting (e.g. the consolidation of topics list for User Acceptance and User Experience) and the ranking of the high-priority topics was done in an anonymous online survey among members of all partner organizations, we cannot name all individual contributors and would therefore like to thank all colleagues of the project for their detailed feedback and their participation in the work described in this report.

Keywords

Electricity Ecosystem, Decarbonization, Flexibility Market, Business Models, Standardization, User Experience

Executive summary

This report presents a preliminary analysis of the current status of standardization, business models, and user engagement regarding the OPENTUNITY tools and demo sites.

The first part of this report identifies applicable standards for OPENTUNITY. As a starting point, a list of key topics was created by the consortium for which standards were identified. The main topics are: smart grids, smart meters, power systems management, and associated information exchange, Information security, cybersecurity and privacy protection, Internet of Things (IoT), artificial intelligence and machine learning, electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks, automatic identification and data capture techniques, power quality and GIS. Already established as well as standards under development are considered and a link towards the respective standardization Technical Committees was made. Relevant European Directives and Regulations are highlighted and the relation between national, European and international codes is introduced. Identified standards will be the basis on which the project results will build on to ensure compatibility and interoperability, and address risk 9 as identified by OPENTUNITY as “project outcomes not compatible with existing market procedures expressed through standards”. Current areas without applicable standards were identified, namely “flexibility market and market design” as well as “remuneration schemes for local energy and flexibility markets”. These gaps are aimed to be addressed as the project moves along under T7.5 “Contribution to standardization”. Moreover, IEC 62746 “Systems interface between customer energy management system and the power management system” (Energy Management Systems) contains several parts (both published and under development), where OPENTUNITY contributions might be valuable. OPENTUNITY results might also be useful to contribute to a future review of the Technical Report (TR) or new Standards on the topic of ISO/IEC TR 30176:2021 ED1 “Internet of Things (IoT) - Integration of IoT and DLT/blockchain”. The next steps include the selection of technical committees to be contacted under T8.1.1 “Communication with technical standardization bodies”.

The second part of the report presents the boundary conditions for the creation of business models. A literature review was conducted to analyze current business models for flexibility provision. Existing business models focus mostly on internal optimization or for bigger entities participation on existing auxiliary service markets while local valorization is not yet considered. Barriers to the implementation of the identified business models were also highlighted referring to technical ones (standardization, lack of data etc.) and regulatory ones (e.g. high limits for minimum flexibility to be offered or a lack of regulation). As part of a market analysis, the increasing need for the OPENTUNITY solutions was underlined. Actors involved in the OPENTUNITY business models were introduced and their activities were presented. For each OPENTUNITY demo site, a preliminary business model canvas was created with the support of the demo leaders, which will serve as a basis for further economic assessment as part of T7.2 “Socioeconomic impact assessment”. Topics for further analysis as part of OPENTUNITY were defined, more precisely, the financial settlement between the aggregator and end-users as well as actual economic remuneration for offering flexibility to the DSO/TSO.

The last part of the report presents theories, methods and topics in the area of User Acceptance and User Experience (UX) considered most relevant for OPENTUNITY. The method for identifying these topics was fourfold:

- I. An initial literature review was conducted, resulting in 32 potentially relevant topics.
- II. An open feedback loop aimed at a better understanding led to a consolidated list of 26 potentially relevant topics.
- III. A consortium-wide survey for the identification of high-priority topics led to the selection of the 10 highest-ranked topics.
- IV. Expert interviews with the representatives of the tool developers were held to gain further insights into the roles of the topics during the user engagement research in OPENTUNITY.

The top 10 topics are: Economic benefits through usage, comfort during usage, privacy concerns, environmental benefits of usage, time savings through usage, interoperability of technologies, trust in technology providers or platform operators, safety during set-up and usage, business model transparency and knowledge gain through usage. Based on the results it was decided that a strong focus will be on aspects closely linked to the concrete use of the technologies. The goal of User Acceptance und UX related research during OPENTUNITY is to deliver a comprehensive understanding of the role and relevance of the high-priority topics in different use cases and user groups, and to develop an actionable and replicable strategy that supports the development and rollout of smart energy solutions. The findings outlined in this report will serve as a guidance for the respective activities.

INDEX

1	Introduction.....	10
1.1	Purpose of the Deliverable	10
1.2	Scope of the deliverable.....	10
1.3	Structure of the deliverable.....	11
1.4	Abbreviations and acronyms	11
2	Introduction to “Standardization Landscape Analysis” (T2.2)	12
2.1	Summary and Scope.....	12
2.1.1	Short Introduction about Standardization	12
2.1.2	Methodology and Topics for Standardization Landscape Analysis	15
2.2	European Union Regulations and Directives on Standardization	16
2.3	European Commission Standardization Requests.....	20
2.3.1	Harmonized Standards	21
2.3.2	TCs Relation to Topics, WPs and Tasks.	21
2.4	Conclusions/Key Takeaways.....	25
3	Business Models for Flexibility Services (as part of T2.3)	27
3.1	Overview of current business models for flexibility opportunities	27
3.2	Gaps in current business models	30
3.2.1	Technical gaps.....	30
3.2.2	Regulatory gaps.....	33
3.3	Market trends	36
3.3.1	Role of prosumers and operators in using OPENTUNITY solutions	36
3.3.2	Market environment	37
3.4	Business models of OPENTUNITY demo sites	39
3.4.1	Business models for the Greek demo site	39
3.4.2	Business model for the Slovenian demo site	41
3.4.3	Business Model for the Spanish Demo Site.....	43
3.4.4	Business Model for the Swiss Demo Site	46
3.5	Outlook on OPENTUNITY business models.....	49
4	User Acceptance and User Experience (as part of Task 2.3).....	50
4.1	Identification of most relevant Theories, Methods, and Topics	51
4.1.1	Theories on Adoption and Diffusion of new Technologies	51
4.1.2	Literature Review and first Identification of potential Topics	54
4.1.3	Consolidation of potentially relevant Topics.....	58
4.1.4	Identification of High-Priority Topics	59
4.2	Literature Insights into Top-10 Topics	60
4.2.1	Economic Benefits	60
4.2.2	Comfort	61

4.2.3	Privacy Concerns	61
4.2.4	Environmental Benefits	62
4.2.5	Time Savings	62
4.2.6	Interoperability	63
4.2.7	Trust in Technology Providers or Platform Operators.....	63
4.2.8	Safety during Setup and Usage.....	63
4.2.9	Business Model Transparency	63
4.2.10	Knowledge Gain through Usage.....	64
4.3	Enrichment of Literature Insights with OPENTUNITY Solution Providers	65
4.3.1	OPENTUNITY Energy Blockchain (WP3).....	65
4.3.2	Technologies for Flexibility in Prosumer's Environment (WP4).....	66
4.3.3	Technologies for Grid Operators (WP5)	67
4.4	Outlook on User Acceptance and User Experience related Work in OPENTUNITY	68
5	Discussion and Conclusion.....	69
6	References	70
6.1	Norms and Regulations.....	70
6.2	Business Models and User Experience related References	70
7	Annex 1 List of identified Standards (CEN-CLC-ETSI-ISO-IEC-ITU).....	74
7.1	Smart Grids.....	74
7.1.1	List of Standards	74
7.1.2	Standards under development	77
7.2	Smart Meters	77
7.2.1	List of Standards	77
7.2.2	Standards under development	80
7.3	Power systems management and associated information exchange.....	81
7.3.1	List of Standards	81
7.3.2	Standards under development	91
7.4	Information security, cybersecurity and privacy protection.....	95
7.4.1	List of Standards	95
7.4.2	Standards under development	97
7.5	Internet of Things (IoT).....	98
7.5.1	List of Standards	98
7.6	Artificial Intelligence and machine learning.....	98
7.6.1	List of Standards	98
7.6.2	Standards under development	98
7.7	Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks	99
7.7.1	List of Standards	99
7.8	Automatic identification and data capture techniques.....	99
7.8.1	List of Standards	99

7.8.2	Standards under development	99
7.9	Power quality	100
7.9.1	List of Standards	100
7.10	GIS	100
7.10.1	List of Standards	100
7.10.2	Standards under development	100
8	Annex 2 Standards from other organizations	102
8.1	W3C.....	102
8.2	IEEE.....	102
8.3	Connectivity Standards Alliance	103
9	Annex 3 Other documents/protocols of interest	103
10	Annex 4 Related Standardization Committees/Groups	105
10.1	CEN/CENELEC/ETSI (European level)	105
10.2	ISO/IEC/ITU (International level).....	111

List of tables

Table 1 Characteristics of different Standardization Documents	13
Table 2 Topics for Standardization Landscape Analysis	15
Table 3 TCs Relation to Topics, WPs and Tasks	21
Table 4 Value proposition of market actors [3]	28
Table 5 BMC for a flexibility market operation, adapted from Farrukh and Pellerin [6].....	29
Table 6 BMC for offering flexibility services / tools adapted from Farrukh and Pellerin [6].....	30
Table 7 Overview of technical barriers to business models	31
Table 8 Overview of regulatory barriers for business models	33
Table 9 BMC of the Greek demo site: grid operator perspective	40
Table 10 BMC of the Greek demo site: aggregator perspective	40
Table 11 BMC of the Slovenian demo site: aggregator perspective	42
Table 12 BMC of the Slovenian demo site: DSO perspective.....	42
Table 13 BMC for the Spanish demo site: perspective of Estabanell Impulsa	44
Table 14 BMC for the Spanish demo site: perspective of Anell	45
Table 15 BMC for the Swiss demo site – UC 5.1	47
Table 16 BMC for the Swiss demo site – UC5.2	48
Table 17 Performance Expectancy related Topics	55
Table 18 Effort Expectancy related Topics	56
Table 19 Facilitating Conditions related Topics	56
Table 20 Sociodemographics related Topics	56
Table 21 Experience related Topics.....	57
Table 22 Topics considered (potentially) Moderating Variables	57
Table 23 Top-10 (and selected lower ranked) User Acceptance and User Experience related Topics.....	60
Table 24 Energy Blockchain related Expert Interview Insights on High-Priority Topics.....	65
Table 25 Prosumer Technologies related Expert Interview Insights on High-Priority Topics.....	66
Table 26 Grid Operator Technology related Expert Interview Insights on High-Priority Topics..	67

List of figures

Figure 1 Possible tracks of Standards adoption	14
Figure 2 Example of identification of elements in the code of a standard	14
Figure 3 Possible Tracks for Standardization of OPENTUNITY Results	26
Figure 4 Value chain Greek demo site	39
Figure 5 Value chain Slovenian demo site	41
Figure 6 Value chain of the Spanish demo site	43
Figure 7 Value chain analysis for the Swiss demo site.....	46
Figure 8 Screenshot of the ranking exercise in the expert survey	59

1 Introduction

1.1 Purpose of the Deliverable

This deliverable is based on the work of two tasks in Work Package 2 (WP2) "Project Foundations". It reports the results of the Standardisation Landscape Analysis in Task 2.2 (T2.2) and of the Stocktaking of Business Models and User Acceptance (T2.3).

The analysis of the standardization aims to identify the relevant **Standardization Landscape** together with applicable standards. It identifies the standardization Technical Committees (TCs) related with the project and standards (both published and under development) potentially useful and relevant for the project activities. It thereby sets the basis for the next standardization related tasks (i.e. "Contribution to Standardization" in T7.5).

The **Stocktaking of Business Models** represents a review of current and/or innovative business models for flexibility services. Focus is firstly on the identification of barriers hindering the actual implementation of the proposed business models. Secondly, it describes the market environment and need for the use of electricity flexibility, including the roles of different actors in OPENTUNITY, as well as market developments relevant for OPENTUNITY solutions. Finally, preliminary business models for each of the OPENTUNITY demo sites are developed.

The **Stocktaking of User Acceptance and User Experience** provides the basis (in terms of most relevant theories and topics) for the further analysis and a comprehensive understanding about the role and relevance of driving factors behind high User Acceptance and a positive User Experience. During the user research at the OPENTUNITY demo sites, special emphasis will be on the question how the high-priority topics are perceived across different user groups and contexts to enable a just, successful, and broad rollout/replication of OPENTUNITY solutions.

1.2 Scope of the deliverable

In line with the "Project Foundations" ambition of WP2, the scope of this report is to provide better orientation for further work in OPENTUNITY. This requires narrowing down the theoretically endless number of interesting topics and research questions to the most relevant selection to obtain a manageable number of foci. This narrowing down implies that the selected topics in the deliverable are explored with strong emphasis on their prospective relevance for the OPENTUNITY solutions. The Deliverable therefore does not yet contain empirical findings from practice. The actual relevance and role of the topics will be quantified and analyzed during the empirical work of the project.

An essential aspect in the work reported in D2.2 was to involve the project team intensively in order to make the best possible use of the expertise in science and practice available in the consortium. Therefore, the deliverable is both an operationally useful "guiding document", and a reflection of essential work steps and discussions during the initial phase of the project that led to a common understanding of the terms and concepts used and facilitated a sense of "shared ownership".

1.3 Structure of the deliverable

The first chapter of this report presents insights regarding the purpose and scope of this deliverable. This is followed by the three main chapters “Introduction to “Standardization Landscape Analysis” (Chapter 2), Business models for flexibility services (Chapter 3) and User Acceptance and User Experience (Chapter 4). Chapter 5 presents the discussion and conclusions. More detailed information regarding standardization codes is given in Annex 1, Annex 2, Annex 3 and Annex4.

1.4 Abbreviations and acronyms

In this document the following abbreviations and acronyms are used:

BEMS	Building energy management systems
BMC	Business model canvas
BT	CEN/CLC Technical Board
CAPEX	Capital expenditure
CEN	European Committee for Standardization
CENELEC (CLC)	European Committee for Standardization in the Electrical field
CG	Coordination Group
CWA	CEN or CENELEC Workshop Agreement
DR	Demand response
DSO	Distribution system operator
EC	European Commission
EFTA	European Free Trade Association
EN	European Standard
ESO	European Standardization Organisation (CEN, CLC & ETSI)
ETSI	European Telecommunications Standards Institute
EV	Electric vehicle
FSPp	Flexibility service provider
HEMS	Home energy management system
hEN	Harmonized European Standard
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization; International Standard
ITU	International Telecommunication Union
JTC	Joint Technical Committee
JWG	Joint Working Group
NILM	Non-intrusive load monitoring
NMC	National Mirror Committee
NSB	National Standardization Body
OPEX	Operational expenditure
SC	Subcommittee
SG	Smart Grid(s)
SMB	IEC Standardization Management Board
SRD	Systems Reference Deliverable
TC	Technical Committee
TOTEX	Total expenditure
TR	Technical Report
TS	Technical Specification
TSO	Transmission system operator
UNE	Spanish Association for Standardization
UX	User Experience
WG	Working Group
WI	Work Item

2 Introduction to “Standardization Landscape Analysis” (T2.2)

2.1 Summary and Scope

The purpose of Task 2.2 (T2.2) “Standardization landscape analysis” is to identify the relevant standardization landscape together with applicable standards. The results of this subtask will be part of the Deliverable D2.2 together with the “socioeconomic context” (T2.3).

The Spanish Association for Standardization (UNE), as a European Standardization Body, is a partner of the OPENTUNITY project and provides support regarding the standardization tasks of the project. This part of deliverable D2.2 *“Standardization landscape and socioeconomic context”* has been prepared in order to guide the partners about the published Standards and Standards under development that can be applicable to OPENTUNITY.

Deliverable D2.2 contains the fields of interest related to OPENTUNITY project, given by its consortium. It identifies the standardization Technical Committees (TCs) related with the project and published standards and standards under development that can be useful and relevant for the project activities. Furthermore, it will help in the next stages of the standardization task “Contribution to standardization” (T7.5) to identify standardization gaps that can be covered by the results of the project.

It covers European standardization developed by the European Committee for Standardization (CEN), the European Committee for electrotechnical Standardization (CENELEC), the European Telecommunications Standards Institute (ETSI) and International Standardization developed by the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and International Telecommunication Union (ITU). Other relevant private Standards organizations such as W3C, IEEE, etc. have also been considered.

The study is structured in Standardization areas for which relevant Standardization Technical Committees (TCs) and other technical bodies within them, have published Standards or are developing them. The relationship with the project found for each of the identified areas is identified, as well as the relevant European Directives or Regulations.

2.1.1 Short Introduction about Standardization

Standards are voluntary technical documents that set out requirements for a specific item, material, component, system or service, or describe in detail a particular method, procedure or best practice. Standards are developed and defined through a process of sharing knowledge and building consensus among technical experts nominated by interested parties and stakeholders, including businesses, consumers and environmental groups, among others. These experts are organized in Technical Committees (TCs), which are subdivided in Subcommittees (SCs) or Working Groups (WGs). These TCs are included in the structure of the Standardization Organizations (National, European and International, with their respective mirror committees) and follow their internal regulations.

The Standardization bodies operate at National (UNE, AFNOR, BSI, DIN, etc.), Regional (CEN, CENELEC, ETSI) or International (ISO, IEC, ITU) level. Sometimes there are different Standardization bodies at the same level but covering different fields. This is the case of ISO (general), IEC (electrical) and ITU (telecommunications) at international level, or CEN (general), CENELEC (electrical) and ETSI (telecommunications) at European level.

There are different kinds of Standardization documents. The most widespread is the Standard, which has a different code depending on the organization under it was developed; e.g., EN for European Standards, ISO or IEC for International standards. Other types of documents are Technical Specifications (TS), Technical Reports (TR) and Workshop Agreements (CWA). Further Amendments to the standards are identified by adding A1, A2, etc. at the end of the Standard code.

At European level, all the members of CEN and CENELEC shall adopt EN Standards as national Standards and must withdraw any existing national Standard which could conflict with them. A summary of the characteristics of the different Standardization documents could be found in the following *Table 1*.

Table 1 Characteristics of different Standardization Documents

Type	International code	European code	National code	Main characteristics
Standard	ISO IEC	EN	UNE, NF, BS, DIN, etc. When adopting: UNE-EN, NF-EN, UNE-ISO, NF-ISO, etc.	<ul style="list-style-type: none"> • Elaboration: 3 years • 2 steps of member approval • European: compulsory national adoption Revision: every 5 years
Technical Specification	ISO/TS IEC/TS	CEN/TS CLC/TS	When adopting: UNE-CEN/TS, NF- CEN/TS, UNE- ISO/TS, NF- ISO/TS, etc.	<ul style="list-style-type: none"> • Elaboration: 21 months • 1 step of member approval or internal approval in TC • European: optional national adoption Revision: at 3 years (upgrading to EN, confirmation or deletion)
Technical Report	ISO/TR IEC/TR	CEN/TR CLC/TR	When adopting: UNE-CEN/TR, NF- CEN/TR, UNE- ISO/TR, NF- ISO/TR, etc.	<ul style="list-style-type: none"> • Elaboration: free timeframe • Internal approval in TC • European: optional national adoption No revision required
Workshop Agreement	IWA	CWA	Variable	<ul style="list-style-type: none"> • Elaboration: free timeframe (usually few months) • Internal approval in the Workshop • European: optional national adoption Revision: at 3 years (upgrading to EN, confirmation or deletion, maximum life of 6 years)

There is also an agreement established between European and International Organizations (e.g., CEN and ISO) to avoid duplication of efforts and promote global relevance of Standards, which allows to adopt or develop in parallel each other's Standards with the same content and code. National Standards could also be proposed as a base for new European or International Standards. The following *Figure 1* shows the tracks of the Standards.

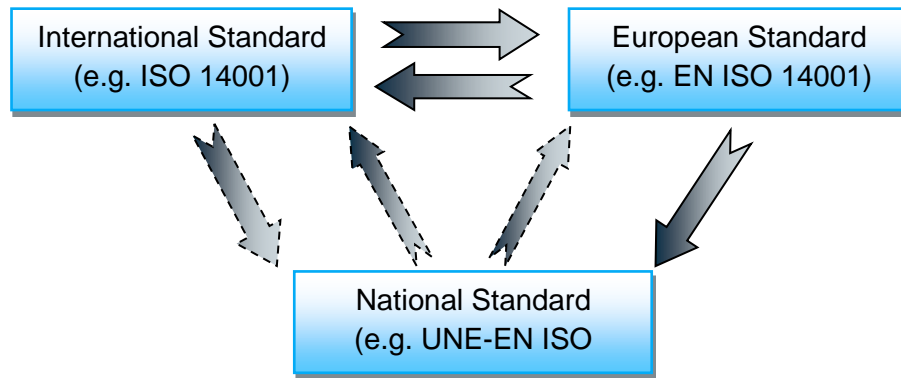


Figure 1 Possible tracks of Standards adoption

Therefore, the code of any Standard is the combination of the above-mentioned issues and could be explained as shown in *Figure 2*.

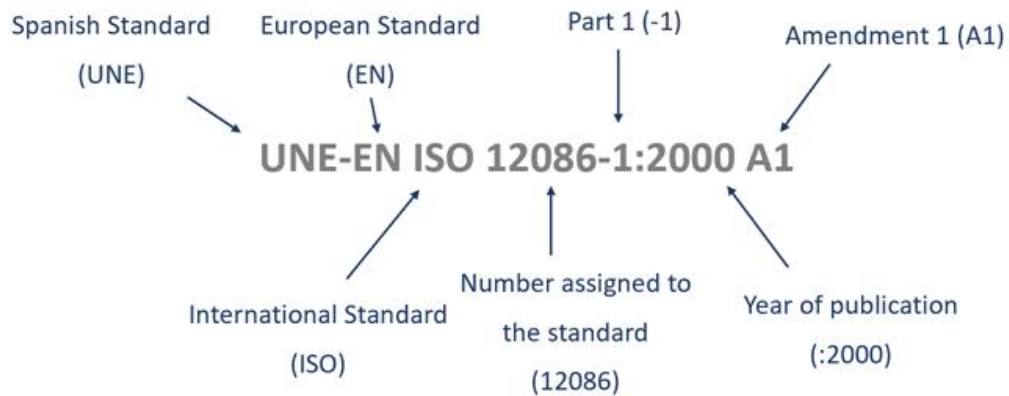


Figure 2 Example of identification of elements in the code of a standard

2.1.2 Methodology and Topics for Standardization Landscape Analysis

This document presents the Standardization activity found relevant for the OPENTUNITY project. For the research, a list of key topics was elaborated by UNE as a starting point for the identification of Standardization areas. Several topics have been identified, into which other sub-topics have been grouped. These topics were suggested and filtered by the Consortium and have been compiled in Table 2:

Table 2 Topics for Standardization Landscape Analysis

Main topics	Subtopic 1	Subtopic 2	Subtopic 3	Subtopic 4	Subtopic 5
Smart Grids	SGAM	Baseline Calculation	Prosumers electrical installations	Household appliances network and grid connectivity	Home and Building Electronic Systems (HBES)
Smart Meters	Meter data management	Sensing devices for non-intrusive load monitoring (NILM) systems			
Power systems management and associated information exchange.	Communication networks and systems for power utility automation	Framework for energy market communications	Energy Management systems		
Information security, cybersecurity and privacy protection.	Blockchain and distributed ledger technologies	Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs)	Data anonymisation and data security		
Internet of Things (IoT)	Integration of IoT and DLT/blockchain				
Artificial Intelligence and machine learning	Deep learning/Deep Neural Networks				
Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks	Protocol for management of electric vehicles (EVs) charging and discharging infrastructures	Management of Distributed Energy Storage Systems based on Electrically Chargeable Vehicles (ECV-DESS)			
Automatic identification and data capture techniques	QR	RFID	Plug and play recognition of devices		
Power quality	Power quality				
GIS	GIS				

2.2 European Union Regulations and Directives on Standardization

Some European Union Regulations and Directives have been identified as related to the project:

- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

This Directive establishes a common framework of measures to promote energy efficiency within the Union in order to ensure that the Union's 2020 headline targets on energy efficiency of 20 % and its 2030 headline targets on energy efficiency of at least 32,5 % are met and paves the way for further energy efficiency improvements beyond those dates.

This Directive lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy and provides for the establishment of indicative national energy efficiency targets and contributions for 2020 and 2030.

This Directive contributes to the implementation of the energy efficiency first principle.

The requirements laid down in this Directive are minimum requirements and shall not prevent any Member State from maintaining or introducing more stringent measures. Such measures shall be compatible with Union law. Where national legislation provides for more stringent measures, the Member State shall notify such legislation to the Commission.

- Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits.

The purpose of this Directive is to ensure that electrical equipment on the market fulfils the requirements providing for a high level of protection of health and safety of persons, and of domestic animals and property, while guaranteeing the functioning of the internal market.

This Directive shall apply to electrical equipment designed for use with a voltage rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current, other than the equipment and phenomena listed in Annex II.

- Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure

This Directive establishes a common framework of measures for the deployment of alternative fuels infrastructure in the Union in order to minimise dependence on oil and to mitigate the environmental impact of transport. This Directive sets out minimum requirements for the building-up of alternative fuels infrastructure, including recharging points for EVs and refuelling points for natural gas (LNG and

CNG) and hydrogen, to be implemented by means of Member States' national policy frameworks, as well as common technical specifications for such recharging and refuelling points, and user information requirements.

- Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of Personal Data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)

1. This Regulation lays down rules relating to the protection of natural persons with regard to the processing of personal data and rules relating to the free movement of personal data.

2. This Regulation protects fundamental rights and freedoms of natural persons and in particular their right to the protection of personal data.

3. The free movement of personal data within the Union shall be neither restricted nor prohibited for reasons connected with the protection of natural persons with regard to the processing of personal data.

- Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union

This Directive lays down measures with a view to achieving a high common level of security of network and information systems within the Union so as to improve the functioning of the internal market.

2. To that end, this Directive:

(a) lays down obligations for all Member States to adopt a national strategy on the security of network and information systems;

(b) creates a Cooperation Group in order to support and facilitate strategic cooperation and the exchange of information among Member States and to develop trust and confidence amongst them;

(c) creates a computer security incident response teams network ('CSIRTs network') in order to contribute to the development of trust and confidence between Member States and to promote swift and effective operational cooperation;

(d) establishes security and notification requirements for operators of essential services and for digital service providers;

(e) lays down obligations for Member States to designate national competent authorities, single points of contact and CSIRTs with tasks related to the security of network and information systems.

3. The security and notification requirements provided for in this Directive shall not apply to undertakings which are subject to the requirements of Articles 13a and

13b of Directive 2002/21/EC, or to trust service providers which are subject to the requirements of Article 19 of Regulation (EU) No 910/2014.

4. This Directive applies without prejudice to Council Directive 2008/114/EC (14) and Directives 2011/93/EU (15) and 2013/40/EU (16) of the European Parliament and of the Council.

5. Without prejudice to Article 346 TFEU, information that is confidential pursuant to Union and national rules, such as rules on business confidentiality, shall be exchanged with the Commission and other relevant authorities only where such exchange is necessary for the application of this Directive. The information exchanged shall be limited to that which is relevant and proportionate to the purpose of such exchange. Such exchange of information shall preserve the confidentiality of that information and protect the security and commercial interests of operators of essential services and digital service providers.

6. This Directive is without prejudice to the actions taken by Member States to safeguard their essential State functions, in particular to safeguard national security, including actions protecting information the disclosure of which Member States consider contrary to the essential interests of their security, and to maintain law and order, in particular to allow for the investigation, detection and prosecution of criminal offences.

7. Where a sector-specific Union legal act requires operators of essential services or digital service providers either to ensure the security of their network and information systems or to notify incidents, provided that such requirements are at least equivalent in effect to the obligations laid down in this Directive, those provisions of that sector-specific Union legal act shall apply.

- Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources

This Directive establishes a common framework for the promotion of energy from renewable sources. It sets a binding Union target for the overall share of energy from renewable sources in the Union's gross final consumption of energy in 2030. It also lays down rules on financial support for electricity from renewable sources, on self-consumption of such electricity, on the use of energy from renewable sources in the heating and cooling sector and in the transport sector, on regional cooperation between Member States, and between Member States and third countries, on guarantees of origin, on administrative procedures and on information and training. It also establishes sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels.

- Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC.

This Regulation lays down rules relating to the protection of natural persons with regard to the processing of personal data by the Union institutions and bodies and rules relating to the free movement of personal data between them or to other recipients established in the Union. This Regulation protects fundamental rights and freedoms of natural persons and in particular their right to the protection of personal data. The European Data Protection Supervisor shall monitor the application of the provisions of this Regulation to all processing operations carried out by a Union institution or body.

- Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity

This Regulation aims to:

(a) set the basis for an efficient achievement of the objectives of the Energy Union and in particular the climate and energy framework for 2030 by enabling market signals to be delivered for increased efficiency, higher share of renewable energy sources, security of supply, flexibility, sustainability, decarbonisation and innovation;

(b) set fundamental principles for well-functioning, integrated electricity markets, which allow all resource providers and electricity customers non-discriminatory market access, empower consumers, ensure competitiveness on the global market as well as demand response (DR), energy storage and energy efficiency, and facilitate aggregation of distributed demand and supply, and enable market and sectoral integration and market-based remuneration of electricity generated from renewable sources;

(c) set fair rules for cross-border exchanges in electricity, thus enhancing competition within the internal market for electricity, taking into account the particular characteristics of national and regional markets, including the establishment of a compensation mechanism for cross-border flows of electricity, the setting of harmonised principles on cross-border transmission charges and the allocation of available capacities of interconnections between national transmission systems;

(d) facilitate the emergence of a well-functioning and transparent wholesale market, contributing to a high level of security of electricity supply, and provide for mechanisms to harmonise the rules for cross-border exchanges in electricity.

- Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

This Directive establishes common rules for the generation, transmission, distribution, energy storage and supply of electricity, together with consumer protection provisions, with a view to creating truly integrated competitive, consumer-centred, flexible, fair and transparent electricity markets in the Union. Using the advantages of an integrated market, this Directive aims to ensure affordable, transparent energy prices and costs for consumers, a high degree of

security of supply and a smooth transition towards a sustainable low-carbon energy system. It lays down key rules relating to the organisation and functioning of the Union electricity sector, in particular rules on consumer empowerment and protection, on open access to the integrated market, on third-party access to transmission and distribution infrastructure, unbundling requirements, and rules on the independence of regulatory authorities in the Member States.

This Directive also sets out modes for Member States, regulatory authorities and transmission system operators (TSO) to cooperate towards the creation of a fully interconnected internal market for electricity that increases the integration of electricity from renewable sources, free competition and security of supply.

2.3 European Commission Standardization Requests

A Standardization Request (Mandate) is a demand from the European Commission to the European Standardization organisations (ESOs), such as CEN or CENELEC, to draw up and adopt European standards in support of European policies and legislation, such as Directives and Regulations. Draft mandates are drawn up by the Commission services through a process of consultation with a wide group of interested parties (social partners, consumers, relevant industry associations, etc.). The European Standards, even developed under a mandate and for European legislation, remain voluntary in their use.

A database of Standardization Requests may be found in the European Commission webpage. Some of the Standards compiled in this document have been developed after the following Standardization Requests:

- M/441 (March 2009):

Standardization mandate to CEN, CENELEC and ETSI in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability.

- M/490 (March 2011):

Standardization Mandate to European Standardization Organisations (ESOs) to support European Smart Grid deployment.

- M/511 (November 2012)

Standardization mandate to CEN, CENELEC and ETSI relating to harmonised Standards in the field of the Low Voltage Directive.

- M/581 (March 2022)

Standardization Request as regards communication exchange, electricity, and hydrogen supply for road, maritime transport and inland navigation in support of Directive 2014/94/EU and its planned revision under the 'Fit for 55' package.

Some other Standardization Requests that could be related to OPENTUNITY project are:

- M/593 in support of Union policy on artificial intelligence.
- M/585 as regard radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council and Commission Delegated Regulation (EU) 2022/30.
- M552 as regards harmonised standards in support of Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.
- M/543 regards ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council.
- M/541 pursuant to Regulation (EU) No 1025/2012 of the European Parliament and of the Council as regards certain measuring instruments.
- M/536 as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the council.
- M/530 pursuant to Article 10(1) of Regulation (EU) No 1025/2012 of the European Parliament and of the Council in support of Directive 95/46/EC of the European Parliament and of the Council and in support of Union's security industrial policy.

2.3.1 Harmonized Standards

Harmonised European Standards (hENs) are developed by CEN or CENELEC following the mandates given by the European Commission. The Harmonised European Standards are identified by the inclusion of an Annex showing the relationship between the European Standard and the essential requirements of the legislation (Annex ZA -CEN- or Annex ZZ -CENELEC-). Manufacturers, other economic operators, or conformity assessment bodies can use harmonised standards to demonstrate that products, services, or processes comply with relevant EU legislation. The references of harmonised standards must be published in the Official Journal of the European Union (OJEU).

2.3.2 TCs Relation to Topics, WPs and Tasks.

Table 3 TCs Relation to Topics, WPs and Tasks

Main Topics	Subtopics	WP	Tasks	European level	International level
Smart Grids	SGAM	WP2	T2.4	CEN/CLC/ETSI CG-SG	IEC/SyC Smart Energy
	Baseline Calculation	WP4, WP5	T4.1, T4.4, T5.3	CEN/CLC/ETSI CG-SG	IEC/SyC Smart Energy ISO/TC 301 Energy management and energy savings
	Prosumers electrical installations	WP3, WP4	T3.3, T4.1, T4.2, T4.3, T4.4, T4.5	CEN/CLC/ETSI CG-SG CLC/TC 121A Low-voltage switchgear and control gear CLC/TC 16 Basic and safety principles	IEC/TC 121/SC 121A Low-voltage switchgear and control gear IEC/TC 3 Documentation, graphical symbols and

D2.2 Standardization landscape and socioeconomic context

				<p>for man-machine interface, marking and identification</p> <p>CLC/TC 23BX Switches, boxes and enclosures for household and similar purposes, plugs and socket outlet for D.C.</p> <p>CLC/TC 23E Circuit breakers and similar devices for household and similar applications</p> <p>CLC/TC 64 Electrical installations and protection against electric shock</p> <p>CLC/TC 64/WG 30 Low-voltage electrical installations - Part 8-2: Smart Low-Voltage Electrical Installations</p> <p>CLC/TC 70 Degrees of protection provided by enclosures</p>	<p>representations of technical information</p> <p>IEC/TC 23 Electrical accessories</p> <p>IEC/TC 23/SC 23B Plugs, socket-outlets and switches</p> <p>IEC/TC 23/SC 23E Circuit-breakers and similar equipment for household use</p> <p>IEC/TC 64 Electrical installations and protection against electric shock</p> <p>IEC/TC 70 Degrees of protection provided by enclosures</p> <p>IEC/TC 8 System aspects of electrical energy supply</p> <p>IEC/SyC Smart Energy</p>
	Household appliances network and grid connectivity	WP3, WP4	T3.3, T4.1, T4.2, T4.3, T4.4, T4.5	<p>CEN/CLC/ETSI CG-SG</p> <p>CLC/TC 59X Performance of household and similar electrical appliances</p> <p>CLC/TC 59X/WG 07 Smart household appliances</p>	IEC/SyC Smart Energy
	Home and Building Electronic Systems (HBES)	WP3, WP4	T3.3, T4.1, T4.2, T4.3, T4.4, T4.5	<p>CEN/CLC/ETSI CG-SG</p> <p>CLC/TC 205 Home and Building Electronic Systems (HBES)</p> <p>CEN/TC 247 Building Automation, Controls and Building Management</p>	<p>IEC/SyC Smart Energy</p> <p>ISO/TC 205 Building environment design</p>

Smart Meters	Meter data management	WP4	T4.1, T4.3	CEN/CLC/ETSI CG-SG CLC/TC 13 Electrical energy measurement and control ETSI/e Smart Machine-to-Machine communications (SmartM2M)	IEC/TC 13 Electrical energy measurement and control
	Sensing devices for NILM systems	WP4	T4.3	CEN/CLC/ETSI CG-SG CEN/TC 294 Communication systems for meters CEN/TC 294/WG 2 Data exchange for meters on DLMS/COSEM systems CEN/TC 294/WG 4 Data exchange for meters on M-Bus systems CEN/TC 294/WG 5 Data exchange for meters on wireless M-Bus systems CEN/TC 294/WG 7 Adaptation layer	IEC/TC 85 Measuring equipment for electrical and electromagnetic quantities
Power systems management and associated information exchange.	Communication networks and systems for power utility automation	WP5	T5.3, T5.4	CLC/TC 57 Power systems management and associated information exchange	IEC/TC 57 Power systems management and associated information exchange
	Framework for energy market communications	WP3, WP4	T3.4, T4.5	CLC/TC 57 Power systems management and associated information exchange	IEC/TC 57 Power systems management and associated information exchange
	Energy Management Systems	WP5	T5.2, T5.3, T5.4	CLC/TC 57 Power systems management and associated information exchange CEN/CLC/JTC 14 Energy management and energy efficiency in the framework of energy transition	IEC/TC 57 Power systems management and associated information exchange IEC/PC 118 Smart grid user interface ISO/IEC JTC 1/SC 25 Interconnection of information technology equipment ISO/TC 301 Energy management and energy savings

Information security, cybersecurity and privacy protection.	Blockchain and distributed ledger technologies	WP3	T3.1	CEN/CLC/JTC 19 Blockchain and Distributed Ledger Technologies	ISO/TC 307 Blockchain and distributed ledger technologies ISO/TC 184 Automation systems and integration ISO/TC 184/SC 4 Industrial data
	Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs)	WP3	T3.1, T3.4		ISO/IEC JTC 1/SC 6 Telecommunications and information exchange between systems
	Data anonymisation and data security	WP3	T3.1, T3.2	CEN/CLC/JTC 13 Cybersecurity and Data Protection	ISO/IEC JTC 1 Information technology ISO/IEC JTC 1/SC 27 Information security, cybersecurity and privacy protection
Internet of Things (IoT)	Integration of IoT and DLT/blockchain	WP3	T3.4		ISO/IEC JTC 1/SC 41 Internet of Things and Digital Twin
Artificial Intelligence and machine learning	Deep learning/Deep Neural Networks	WP4, WP5	T4.3, T5.2, T5.3, T5.4,	CEN/CLC/JTC 21 Artificial Intelligence	ISO/IEC JTC 1/SC 42 Artificial Intelligence
Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks	Protocol for management of EVs charging and discharging infrastructures	WP3, WP4	T3.4, T4.4	CLC/TC 69X Electrical systems for electric road vehicles	IEC/TC 69 Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks IEC/TC 23/SC 23H Plugs, Socket-outlets and Couplers for industrial and similar applications, and for Electric Vehicles
	Management of Distributed Energy Storage Systems based on Electrically Chargeable Vehicles (ECV-DESS)	WP3, WP4	T3.4, T4.4	CLC/TC 69X Electrical systems for electric road vehicles	IEC/TC 69 Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks
Automatic identification and data capture techniques	QR	WP3	T3.3		ISO/IEC JTC 1/SC 31 Automatic identification and data capture techniques
	RFID	WP3	T3.3		ISO/IEC JTC 1/SC 31 Automatic identification and data capture techniques
	Plug and play recognition of devices	WP3	T3.3		Connectivity Standards Alliance
Power quality	Power quality	WP4, WP5	T4.4, T5.3, T5.4	CLC/TC 8X System aspects of electrical energy supply	IEC/TC 8 System aspects of electrical energy supply

GIS	GIS	WP5	T5.1, T5.2, T5.3, T5.5	CEN/TC Geographic Information	287	ISO/TC 211 Geographic information/Geomatics
-----	-----	-----	---------------------------	-------------------------------------	-----	------------------------------------------------

2.4 Conclusions/Key Takeaways

As a result of the Standardization Landscape Analysis (T2.2) a list of Standards and Standards under development related to OPENTUNITY project have been identified as useful for the project development and its dissemination.

These Standards will be considered by the Consortium allowing the compatibility and interoperability of the project results with the already existing standards and standards under development. On the list of critical risks of OPENTUNITY Grant Agreement, number 9 is “Project outcomes not compatible with existing market procedures expressed through Standards”, and its mitigation measure involves considering this list during the development of the tools and processes. Moreover, the analysis of these Standards by the OPENTUNITY partners will not only allow compatibility but also will show the Standardization Gaps that may be covered by the results of the project (WP7 objectives).

“Flexibility market and market design” and “Remuneration schemes for local energy and flexibility markets” were initially proposed as search topics and no standards were found in direct relation to them. Although standardization gaps that can be covered by the results of the project will be analysed on task T7.5 “Contribution to standardization”, these 2 topics are highlighted on the conclusions of this deliverable as they should be considered on the next steps as a possible gap.

Relating to already existing Standards or Standards under development, IEC 62746 “Systems interface between customer energy management system and the power management system” (Energy Management Systems) contains several published and under development parts, where OPENTUNITY contribution might be valuable. Although ISO/IEC TR 30176:2021 ED1 “Internet of Things (IoT) - Integration of IoT and DLT/blockchain: Use cases” (Integration of IoT and DLT/blockchain) is not a normative document, but a Technical Report, OPENTUNITY results might also be useful to contribute to a future review of the TR or new Standards on the topic.

The list will be in any case analysed in detail by the consortium on task T7.5 (Contribution to Standardization) to determine whether a contribution can be made either on these or on any other listed Standard. Relevant European and International TCs have been also identified as a result of the Task T2.2. These results together with the relevant Standards list, will be used as the basis for the following tasks T8.1.1 “Communication with technical Standardization bodies”, and T7.5 “Contribution to Standardization”.

According to the interest for OPENTUNITY project, next steps will include a selection of the TCs that will be finally contacted, the determination of the content to be disseminated with the TCs (agreed with the Consortium) and making a first contact with them to raise awareness about OPENTUNITY project and ease future contacts. Implication of OPENTUNITY in the relevant TCs should be managed on different ways according to the impact or relevance of the standardization works of the TCs and the feasibility of initiating a standardization process within them (instead of initiating the standardization process within a Standardization workshop). Accordingly, the Standardization activity of the TC will be followed up and reported either by UNE, the joining and

participation of OPENTUNITY partners on the TC, or through establishing a project Liaison with the TC.

The most relevant TCs will imply the need of a bigger implication of the partners on the TC. Since standardization is an open activity, all interested parties may participate in the Technical Committees through the designation of their National Standardization Body. This option allows for a deeper follow-up of the activity of a Standardization committee and is valuable if the Standardization process is going to be initiated within the TC. Under the figure of a project Liaison, the consortium may as well participate as an entity in the TC works, but without voting rights. This is recommended only when the work of the standardization committee is closely linked with the main goals of the project and a direct technical contribution from the project is expected.

In the other way, relevant TCs will be informed of the project progress, in order to involve them and take into account their inputs. This will be done either by delivering reports on the progress of the project to the TC secretary or attending relevant TC meetings to show the project progress. In this case the presence of the project coordinator and partners will be very important to present the technical aspects of the project.

Based both on the information provided by the evaluation of the relevant TCs and OPENTUNITY results that could be standardized, it will be necessary to decide regarding further steps in the standardization process (see Figure 3)

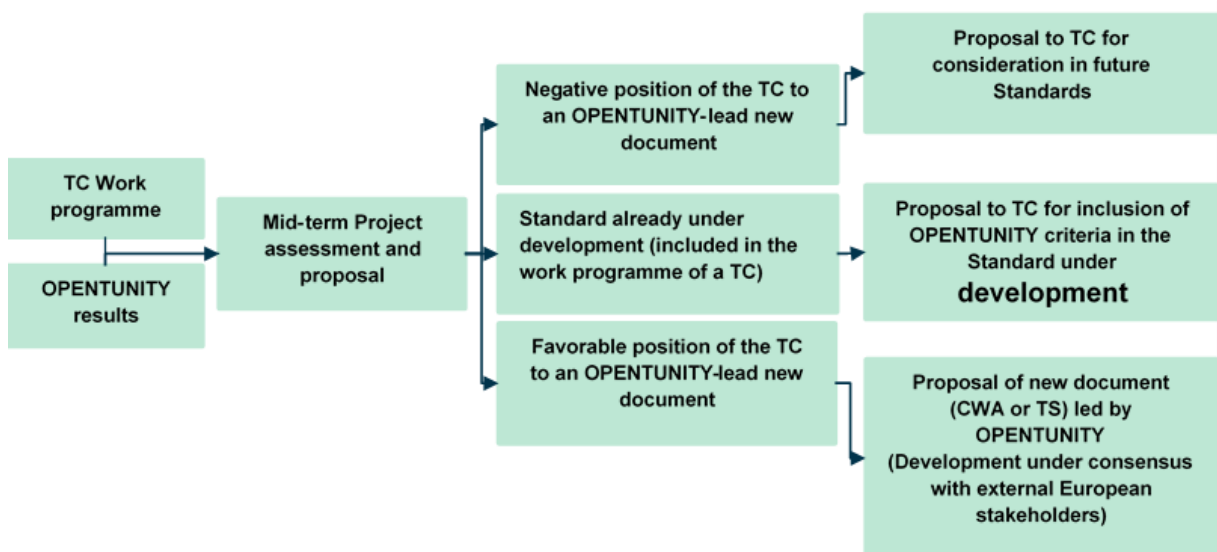


Figure 3 Possible Tracks for Standardization of OPENTUNITY Results

Next tasks regarding standardization aspects are Task 8.1.1 (Communication with technical standardization bodies) which will start immediately after Task T2.2, and Task T7.5 “Contribution to Standardization” (which will cover the development of new standards, CWAs, or other contribution to Standardization), which is scheduled from M37 to M48.

3 Business Models for Flexibility Services (as part of T2.3)

3.1 Overview of current business models for flexibility opportunities

This chapter presents insights into business models for flexibility opportunities enabled by interoperable ICT solutions as found in other projects.

Business models for DR for different actors have been created by several projects. BestRES [1] for example focuses on the role of the aggregator and describes which entities (supplier, balance responsible party, distribution system operator (DSO), independent aggregator, prosumer...) can take over the role of the aggregator and how the respective business model could look like. The value proposition includes retailing electricity, scheduling generation, trading and consumption, offering balancing services, participation in reserve markets, ensuring grid stability, energy autarky, energy service provision, and market aggregation/flexibility provision. Next to the physical key resources such as PV, intellectual resources like computer models, forecasting algorithms, and control algorithms are mentioned.

As part of SmartSPIN an innovative business model for energy service companies is presented to provide energy savings and DR services. The idea is that with an upgrade of equipment (efficiency / smartness) demand flexibility can be increased as well as the ability to respond to DR signals can be incorporated. This allows that flexibility can be utilized by the grid reducing the payback period of the investment. Such a concept is also tested in the project sensei [2].

A good summary of business models and more precise value propositions for DR is given in Hamwi et al. [3]. The following value propositions for DR are mentioned, and presented in further detail in Table 4:

- Capacity provision
- System reliability
- Market efficiency
- Congestion management
- Procurement improvement
- Load shaping
- Valorisation of customer flexibility
- DR markets
 - Electricity wholesale
 - Ancillary service marker
 - Price responsive markets

Table 4 Value proposition of market actors [3]

Value proposition / power system actors	System Operation	Generation	Transmission & distribution	Retailer	Consumer
Capacity provision	Meeting the demand, the future and current power capacity			Ensuring not to go over the provided capacity and mitigating future capacity procurement	
System reliability	Maintaining power system balancing in short-term				
Market efficiency	Neutralize the exercise of market power and eliminate price spikes				
Congestion management			Reduction in infrastructure reinforcement and delay in network investment		
Procurement improvement				Avoiding purchasing from spot market during supply shortfall or forecast error	
Load shaping			Reducing imbalance cost especially for renewable energy resources	Increase load in some period and decrease in another period to decrease procurement cost	
Valorising customer flexibility					Having financial incentives from selling load flexibility to the TSO e.g. large industrial consumers

The project V2Market [4] proposes value proposition canvases for different actors in the area of EV owners, fleet and car-sharing operators, utility companies facility managers, charging point operators, DSOs, energy service companies, energy communities and aggregators) with the aim to not only reduce charging costs but also offer flexibility services to the grid.

Fioretti et al. focus precisely on business models for energy communities. Demand-response services such as implicit DR programs via retailers, explicit DR directly or via an aggregator, or participation in energy markets via virtual power plant aggregators are mentioned [5].

In general, the above-mentioned projects mostly focus on business models for actors of the electricity system such as DSOs, prosumers, or aggregators, and less on the ICT solutions enabling the proposed business model. On the contrary, Farrukh and Pellerin [6] provide an overview of the business models associated with innovative ICT tools and corresponding business cases for important actors of flexibility markets. It is mentioned that challenges such as a high RES penetration can be addressed by smart grid solutions incentivizing the flexible use of DER, demand side management, improved planning and operation of storage, and RES forecasting. Several advanced tools have been developed in European research projects enabling local flexibility markets and providing value to its customers. Two tools that were created as part of the FLEXIGRID project are introduced:

- a. An automated trading platform, called FLEXIGRID ATP, for enabling an efficient local flexibility market. This market platform allows to integrate and operate flexibility markets in real-time and improves services for flexibility providers as well as grid operators.
- b. FLEXIGRID flexibility market clearing toolkit (FMCT) enables more efficient operation for a DSO with flexibility needs.

Table 5 and

Table 6 present business model canvases (BMC) for offering flexibility services by means of innovative ICT tools.

Table 5 BMC for a flexibility market operation, adapted from Farrukh and Pellerin [6]

Key Partners	Key Activities	Value Proposition	Customer relationship	Customer Segments
Algorithm developers	Software development & maintenance	Increase service offers to FlexBuyers and FlexSuppliers	Customer support	Flexibility Market Operator
DSOs				Market operator
	Customer support	Improved market clearing process	Channels Direct sales Pilot projects	
	Key resources	Network-aware market clearing		
	FLEXGRID automated trading platform			
	FMCT			
Cost structure		Revenue structure		
Product development		Software as a service		
Product maintenance		Licensing		

Table 6 BMC for offering flexibility services / tools adapted from Farrukh and Pellerin [6]

Key Partners	Key Activities	Value Proposition	Customer relationship	Customer Segments
Algorithm developers Flexibility market operator	Software development & maintenance	Identify congestion & voltage issues in grid	Customer support	DSOs
	Customer support Automated trading platform FMCT	Market-based flexibility service procurement Automatically generate FlexRequests TSO-DSO coordinate through fine-grained API Peak shaving	Channels Pilot projects	
Cost structure		Delay or avoid investment in network reinforcement	Revenue structure	
Product development			Software as a service	
Computational costs			Licensing	

Most projects make use of a BMC for the presentation of the specific business model. While a BMC is a good starting point for identifying certain parameters of business models for smart grid projects, it was highlighted as part of the BRIDGE business model working group that currently the quantification of the proposed business model is lacking in the majority of projects [7]. To address this issue, it is planned that as part of OPENTUNITY *T7.2 Socioeconomic impact assessment*, quantified business models for all demo sites will be created. This will be based on the preliminary business model canvases presented in this report, fine-tuned and supported by data throughout the project's lifetime. As the developed tools are the main focus of OPENTUNITY as well as of the demo sites a focus will lay on the quantification of ICT tools.

3.2 Gaps in current business models

In the following section, identified technical and regulatory gaps of current business models are presented.

3.2.1 Technical gaps

Business models for enabling the participation of small prosumers in the energy markets should consider the existing technical gaps and barriers that restrict the exploitation of their untapped flexibility by DR services. These barriers and technical gaps mainly refer to:

- I. standardization gaps that will ensure end-to-end interoperability between the markets/DR services and the prosumers
- II. no access to smart metering data (even lack of smart meters in some countries), and finally
- III. technical modalities among the EU countries.

Table 7 presents the main identified technical barriers affecting business models of flexibility provision. These barriers are further elaborated on in the following paragraphs.

Table 7 Overview of technical barriers to business models

	Barrier	Recommendations
Standardization & interoperability	Complexity of integrating different devices → high transaction costs	Standards and protocols
Smart meters	DSOs are not allowed to use smart metering data	Grant access to DSOs to allow proper simulations
	Data is not accessible to consumers/aggregators	Grant access to service providers to make use of DR benefits without additional costs for smart meters

Standardization & interoperability

The success of flexibility services and DR depends heavily on how well consumers accept and engage with the program. To achieve this, technical solutions must be user-friendly and provide a decent return on investment. Standardization and interoperability are crucial factors to ensure that various devices in the market can provide flexibility and work seamlessly with each other. This is especially important for gateways like building energy management systems (BEMS) and smart home gateways, which require standardized communication protocols. However, the current market for "smart" devices is still in its early stages and not all conditions are met.

To prevent platform fragmentation, which can hinder the uptake of DR by small- and medium-sized prosumers, a reliable Internet of Things communication strategy must be developed. Mature DR markets in the United States have established standards and protocols for data communication and device control, as exemplified by PJM's DR programs.

Smart electric devices that can be remotely controlled are essential for DR in households. However, with numerous smart home solutions available, each using different communication protocols, there is a risk of a lock-in effect. Manufacturers may have an incentive to create products that are not interoperable with other brands, giving big players an advantage and leading to a fragmentation of communication standards. While efforts are being made to address this issue, such as through SAREF [8] and oneM2M [9], there remains a need to encourage manufacturers to provide interoperable solutions. Achieving interoperability is particularly important for DR business models, as the complexity of integrating different devices can result in high transaction costs. For instance, solutions that aim to promote interoperability are often difficult to install on end-user premises, requiring technical support and resulting in additional costs.

Smart Meters

Smart meters are being rolled out or planned for all consumers in most EU member states. However, in some cases, although smart meters are already widely installed and provide suitable data, the data is not accessible to consumers or third parties such as aggregators. To promote non-discriminatory access to smart meter data, any consumer and third party should be granted access with the consent of the consumer. Real-time data could be measured by the smart meter, but a smart meter gateway needs to be purchased and installed to retrieve the data through the DSO's online portal. A communication channel also needs to be established to retrieve data from the gateway, requiring additional internet connection.

Large energy-intensive devices such as central heat pumps or EV charging stations can pose installation and operation problems as they may not be directly in the area of domestic Wi-Fi.

To address this, DSOs should provide data through their existing portal in real-time rather than only once a day, as is currently the situation in many member states. Real-time access to data from the DSO can facilitate the implementation of cost-efficient smart systems for DR. Improved data access is important as it reduces investment costs for prosumers participating in DR programs. Without access to smart meter data, additional metering devices would be required, raising investment and transaction costs, and possibly making DR business models infeasible for small-sized prosumers. Currently, also DSOs are not allowed to use smart metering data, which makes proper simulations impossible.

Moreover, the rollout of smart meters with improved capabilities, providing more information about the grid and consumption, and enabling switching on and off specific connection points, would benefit the market uptake of DR solutions and programs. Basic functionalities necessary for activating DR could be provided by the smart meter, reducing investment costs for consumers participating in DR programs.

Standardization of smart meter platforms and technologies across the EU is necessary, and a common data format and framework is essential for interoperability and data access among EU member states.

Technical modalities in different EU countries

Several technical modalities exist in many of the EU countries and limit the flexibility opportunities of small- and medium-sized prosumers. To mention just a few:

- Technical limitations imposed on DR programs, including mandatory availability periods and control requirements. For instance, residential DR systems that operate through automated electrical heating have the potential to help alleviate capacity issues during peak periods. However, the requirement for availability throughout large periods poses a significant barrier for such programs, as it increases the operational costs for residential consumers.
- Technical requirements in the current energy system markets are heavily focused on generation and do not take into account the potential of demand-side resources [10].

3.2.2 Regulatory gaps

The subsequent section highlights regulatory gaps observed in business models for DR opportunities and interoperable ICT solutions as summarized in Table 8.

Table 8 Overview of regulatory barriers for business models

	Barrier	Recommendations
Flexibility services by DSOs	Increased costs due to improved need for grid observability	Financial support
	Regulatory lock-in → decisions based on CAPEX and OPEX	TOTEX approach should be considered
	No revenues from local markets for DR providers	Regulatory framework for local markets is needed
Flexibility services by TSOs	Existing network codes impeding DSF	Need for harmonized/clearly define regulatory framework
	Higher costs due to diverse national regulatory frameworks	
General observations		Regulatory sandboxes are very helpful National targets for demand-side flexibility (renewable support schemes with distributed flexibility)

In addition to the absence of a well-defined framework and inconsistencies in market rules, various barriers have been identified in the existing literature and are outlined below:

The Joint Research Centre's technical report provides an overview of some of the most important flexibility market development projects in Europe. The analysis focuses on projects that prioritise the provision of local flexibility services to DSOs through market-based approaches and addresses the impact of regulatory measures to promote the deployment of flexibility solutions. National regulatory frameworks play an important role in enabling DSOs to take a more active role, both as buyers of distributed flexibility and in facilitating the use of flexibility resources on their own networks by others to enable system-wide benefits. The regulatory framework for DSO revenues and the national distribution network situation contribute to the scope of flexibility procurement and the preferred methods. Market-based procurement of flexibility services by DSOs is still a niche activity in most countries [11].

The development of the flexibility market encountered a hurdle related to congestion forecasting at the DSO level. To overcome this challenge, significant efforts were made to improve the observability of the distribution network by installing sensors. In general, technological solutions already exist for various systems, such as grid forecasting and aggregator optimisation tools. However, these solutions are currently expensive, which has a negative impact on the viability of the business model. Respondents expressed the view that financial support should be offered to provide the necessary intelligence for flexibility provision, similar to the support provided for renewable energy development [11].

In terms of market architecture and design of flexibility products, long-term contracts (seasonal and longer) seem better suited to provide grid shifts and reliability services, while short-term markets seem suitable for operational support, e.g. congestion management [11].

The analysis of Chondrogiannis et al. also showed that innovation incentives, including regulatory experiments, e.g. in the form of sandboxes, can be very helpful in the first steps of local flexibility markets [11].

The Smart Energy Europe Position Paper, published in December 2022, primarily concentrates on presenting recommendations for the EU electricity market design (EMD). It is advised that EU Member States expedite the adoption of EMD regulations and policies to facilitate the utilization of demand-side flexibility. SmartEn additionally advocates for the establishment of national targets aimed at activating demand-side flexibility. This objective can be realized by making DR a permanent, structural obligation of the new market design [12].

Recommendations mentioned in the positioning paper are:

- Strengthening consumer empowerment.
- Maximising district self-balancing.
- Unlocking the value of demand-side resources in wholesale energy and ancillary services markets.
- Supporting investments with capacity remuneration arrangements.
- Combining renewables support schemes with distributed flexibility [12].

The ASSET study on "Regulatory priorities to enable demand side flexibility" distinguishes between regulatory barriers at the transmission and distribution level. At the transmission level, the existing network codes impose system requirements that potentially impede the participation of demand-side flexibility (DSF), especially for small providers. The limited scope of the prequalification process and technical requirements create entry barriers. Additionally, the prequalification process does not consider the evolving role of DSOs and constraints in the distribution network. Furthermore, the current lack of standardized and harmonized framework conditions, particularly in the aggregation framework, presents challenges. Varying requirements across member states increase costs for aggregator participation and hinder multi-jurisdictional interconnected networks. Addressing these barriers would involve expanding guidelines such as the Grid Operation Guideline, Energy Balancing Guideline, and Capacity Allocation and Congestion Management Guideline to ensure a harmonized aggregation framework covering aspects like baseline methodology, measurement, validation, and verification [13]. Therefore, in terms of consistency with existing network codes and guidelines, and from a timing and resource perspective, it should be sufficient to adjust existing network codes to remove barriers at the wholesale level, depending on the evolving role of DSOs, increasing constraints on the distribution network, and the need for aggregation.

European legislation prioritizes market-based approaches to address these challenges, where prices play a crucial role in guiding efficient consumption, production, and investment decisions, rather than relying on pre-defined tariffs and rules. However, the specific details of such a market-based framework are not clearly outlined in the EU framework. Consequently, the absence of a well-defined congestion management market at the distribution level is considered a significant barrier to the development of DSF.

The regulatory gaps Küpper et al. have identified relate to the fundamental design features of a congestion management market at the distribution level. These key design elements include the establishment of products that cater to emerging needs, determining the geographical boundaries of such markets, defining the entity responsible for operating the market platform, establishing a coordination scheme between TSOs and DSOs, and ensuring proper integration with existing wholesale markets such as day-ahead, intraday, and balancing markets.

At the moment, DSOs are in a regulatory lock-in where they have to make their investment choices based on capital expenditures (CAPEX) and operational expenditures (OPEX) as provided by the National Regulatory Agency.

A push towards a total expenditure (TOTEX) approach [14] is needed as well as the most utilised power lines should be rewarded instead of increasing the grid capacities. Such a regulatory push could also solve problems regarding public acceptance. Moreover, regulatory frameworks for local markets are needed.

As part of the BRIDGE regulatory working group, the importance of finding a balance between EU harmonization and local solutions (e.g. prequalification, local market design, products for local congestion management) is highlighted. The main barriers to flexibility provision are related to the low voltage level (min. bid size, baselining, settlement). Regulatory Sandboxes were identified as an important enabler for new solutions. Lastly, regulatory frameworks should be consumer-centric from the start of the initiative [15].

Regulatory barriers in different EU countries

In numerous countries within the EU, various regulatory and legal barriers exist that restrict the range of available flexibility options. Here are just a few examples:

- Lack of national legislation and regulations for DR that enable prosumers participation in the electricity energy markets (e.g. Spain).
- High limits for the minimum flexibility that a single user can bid in the energy markets. This might not be applicable for small- and medium-sized prosumers (especially for the residential building sector) even in an aggregated manner.
- In most cases, the current way of charging EVs or storage systems does not accurately reflect fluctuations in market prices. This can result in overcharging for consumers and aggregators, or inadequate compensation for retailers. The issue is particularly relevant for residential consumers who often have smaller profit margins than industrial consumers, despite typically saving cumulatively more energy. This highlights the need for a more equitable distribution of revenues in the DR market.
- In some cases, pre-qualification tests are required at an individual asset/prosumer level. This is a significant barrier to the participation of as many loads/assets that could provide valuable contributions since they are unable to pass the pre-qualification stage on their own (especially household assets).

3.3 Market trends

This chapter describes the roles of different actors in using OPENTUNITY solutions – these are also the main actors as part of the value chain for the different demo sites. Moreover, current market trends in the area of OPENTUNITY solutions are touched upon.

3.3.1 Role of prosumers and operators in using OPENTUNITY solutions

DSO / TSO

The role of grid operators in using OPENTUNITY solutions is crucial for the reliable and efficient operation of an electrical grid. A flexibility ecosystem refers to the network of resources and technologies that can help balance electricity supply and demand in real-time, especially in the context of increasing renewable energy integration and the need for grid resilience. The grid operators, often referred to as a TSO or DSO, play several key roles in this ecosystem, as they are responsible for managing and optimizing the grid's operation, integrating renewable energy sources, procuring flexibility services, ensuring grid security, and planning for the future needs of the grid. DSOs and TSOs will need to solve grid problems using DR campaigns, and OPENTUNITY will provide various tools and methodologies to help them do so, including topology identification and estate estimation using historical data and Machine Learning algorithms, indirect real-time thermal rating, a seamless methodology to integrate GIS, SCADA and topology into different platforms, a gateway to communicate with local flexibility market operators, advanced asset management, and new grid planning methodologies.

Prosumers

OPENTUNITY aims to empower prosumers by providing them with innovative technologies and tools that can increase flexibility in their energy usage. With these solutions, prosumers can actively participate in the energy market and support grid stability. By optimizing their energy usage, prosumers can reduce their carbon footprint and potentially earn revenue by selling excess energy back to the grid. Through OPENTUNITY's solutions, consumers and prosumers can access energy and flexibility markets and monetize their flexibility. Increasing consumers' knowledge about their energy consumption is one of the most cost-effective and environmentally friendly ways to encourage energy efficiency, and OPENTUNITY's solutions enable prosumers to easily use them.

Prosumers, for example, that are using a Home Energy Management System (HEMS) or BEMS, will be able to register their assets such as electrical appliances and energy meters by scanning the QR codes to register their devices. By providing all the necessary information of the flexibility devices to the OPENTUNITY platform, the software understands their DR capabilities, desired level of involvement in DR campaigns, and preferred conditions. The Energy Management Systems will take into account different energy assets, such as EVs, batteries, and heaters, to optimize energy management.

OPENTUNITY's solutions include an initial settings algorithm to automatically generate a DR profile for prosumers, reducing their worries about how to react to DR signals.

The consortium also provides different HEMS and BEMS options with different energy management optimizations and management according to the development of different vendors. The user's main information is stored in the blockchain, so switching from one HEMS/BEMS to another does not require a new initial configuration. OPENTUNITY also uses NILM algorithms to obtain real-time measurements from energy assets that are not sensed, saving prosumers on expenditures in that field.

Overall, OPENTUNITY's solutions can help businesses improve their energy efficiency, reduce greenhouse gas emissions and energy costs, track and measure environmental impact, gain a competitive advantage, streamline processes, increase efficiency, and gain insights into operations and performance through data analytics.

3.3.2 Market environment

The section describes current market developments in the area of European Smart Grids, with the aim to supply more flexibility and balance the grid as envisaged in OPENTUNITY.

In recent years, there has been a growing demand for flexibility in the electricity grid, as it has the potential to optimize the operation of the electricity grid, integrate renewable energy, and manage demand effectively. This trend is pushed by the following factors:

- Integration of renewable energy sources: Due to the variability and intermittency of RES, flexibility is needed to better match supply and demand and decrease the reliance on fossil fuel backup generation.
- Grid stability: flexibility allows to stabilize the grid (e.g. reduced consumption during peak hours) and therefore prevents blackouts and voltage deviations.
- Infrastructure optimization: Flexibility can be used to defer grid investment and improve grid efficiency.
- Reduction of costs: Flexibility allows consumers to adjust to electricity price fluctuation and generate savings.
- Market efficiency: By including flexibility in energy markets, competition as well as innovations and the development of new services and technologies are fostered. Moreover, new market actors such as aggregators, service providers and technology providers, promote an efficient market – which is also foreseen as part of the European Electricity Market design.
- Environmental sustainability: By shifting demand to times with a high percentage of RES in the electricity grid, carbon emissions can be reduced.

In general, the market needs for flexibility aim at accomplishing a more resilient, sustainable, cost-effective and efficient electricity system.

Tools for the optimized use of flexibility assets are of high relevance not only for aggregators but also for energy communities, EV charging point managers and commercial/industrial customers as well as residential customers. Tools to increase grid observability/controllability in the distribution management grid are likely to record a compound annual growth rate of almost 20% until 2028 worldwide [16]. This is due to the increasing energy demand and efficiency as well as improved customer service.

- The global market is expanding primarily due to the growing worldwide demand for efficient energy resources. The optimization of distribution grid performance and the automation of outage restoration are facilitated by grid management tools. Additionally, the market is experiencing growth driven by the rising adoption of advanced metering infrastructure. Technological enhancements, such as the integration of connected devices with the Internet of Things and the utilization of modern components and control systems to enhance security while decreasing overall costs and electricity loss, are driving the expansion of the market.
- It is estimated that approximately 584 billion euros will be invested in the electricity grid between 2020 and 2030, with a main focus on the distribution grid. A considerable part thereof will be invested in digital tools. The International Energy Agency further expects that DR could avoid 270 billion USD in electricity infrastructure [17]. As part of the ENTEC report, it is mentioned that by 2050 distributed energy resources management systems will provide 3GW of flexibility capacity and 23 TWh. The expansion potential of these tools is estimated to be approximately 30% [18].

3.4 Business models of OPENTUNITY demo sites

This chapter presents the value chains of the OPENTUNITY demo sites as well as preliminary business models, by means of a business model canvas, for different actors (aggregators/DSOs) of the demo sites. The business models are linked to the use case defined in Task 2.1 - Use Cases, requirements and KPIs definition.

3.4.1 Business models for the Greek demo site

The Greek demo site includes the TSO IPTO, the DSO HEDNO as well as ICCS and HYPERTECH as the aggregators and technical support. Flexibility will be offered over the NODES market platform as presented in Table 7.

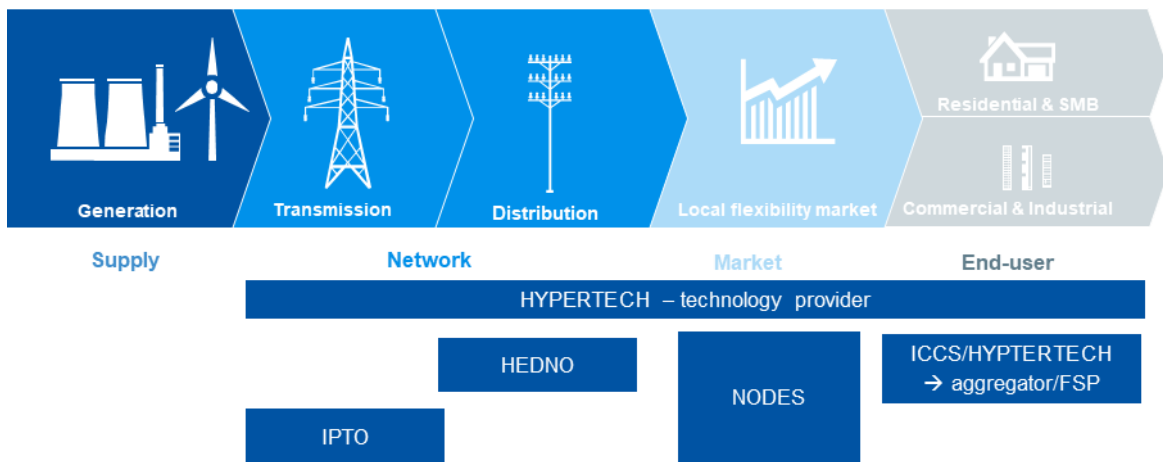


Figure 4 Value chain Greek demo site

The first business model canvas (Table 9) considers the business model from the perspective of the grid operators. IPTO and HEDNO will make use of flexibility for grid management and potentially defer grid investments. Key activities include the identification of grid issues, sending flexibility requests as well as payment for the activated flexibility. Key resources include access to the NODES market platform. Partners are the flexibility market operator, regulators and technology providers. Customers are aggregators. Costs include costs for flexibility activation on the local market as well as the cost for the access of NODES. Revenues are reduced costs for grid management, however, there will be no actual monetary exchange between the grid operator and the aggregator provider as part of the demo set-up.

Table 9 BMC of the Greek demo site: grid operator perspective

Key activities	Key resources	Key partners
<ul style="list-style-type: none"> • Identification of grid issues • Sending flexibility requests • Payment for flexibility activation 	<ul style="list-style-type: none"> • Access to NODES 	<ul style="list-style-type: none"> • Flexibility market platform operator • Regulators • Technology providers
Competing solutions	Customers	Value propositions

<ul style="list-style-type: none"> Grid reinforcement 	<ul style="list-style-type: none"> Aggregator 	<ul style="list-style-type: none"> Investment deferral Cheaper/more efficient grid management
Cost structure <ul style="list-style-type: none"> Costs for flexibility activation on the local market Costs for access to NODES 		Revenue structure <ul style="list-style-type: none"> Reduced costs for grid management → not planned as part of the demo set-up

The second business model canvas (Table 10) considers the perspective of the aggregators, which as part of the Greek demo site are ICCS and Hypertech. They will use the flexibility they own themselves and offer them on the NODES market platform to create revenues for flexibility providers. Key activities include the aggregation and control of flexible assets, local market participation, and financial settlement. Key resources are the ICT infrastructure to control flexible assets as well as access to NODES. Partners are regulators, NODES, and technology providers. Customers are HEDNO, IPTO, and potentially residential households. Flexibility could also be used for internal optimization according to price signals. Costs include costs for access to the NODES platform as well as for the software for flexibility management. In the future payments to flexibility providers could be conducted however as mentioned above there will be no actual monetary exchange between the grid operators and the aggregators as part of the demo set-up.

Table 10 BMC of the Greek demo site: aggregator perspective

Key activities Aggregation of flexibility Controlling flexible assets Local market participation Financial settlement	Key resources Access to NODES ICT infrastructure to control flexible assets	Key partners Regulators Local flexibility platform operator / NODES Technology providers
Competing solutions Internal optimization according to price signals	Customers HEDNO (DSO) IPTO (TSO) Residential households	Value propositions Aggregate flexibility from ICCS/households and offer them through NODES to create revenues for flexibility providers
Cost structure Costs for access to NODES Payments to flexibility providers Software for flexibility management		Revenue structure Remuneration from the local flexibility market → not planned as part of demo set-up

3.4.2 Business model for the Slovenian demo site

The Slovenian pilot consists of a network area of two Slovenian DSOs, namely Elektro Ljubljana and Elektro Primorska. Moreover, several buildings with HEMS/BEMS as well as vehicle charging stations are part of these grid sections. Avantcar provides more than 140 EV charging points. The aim of the demo site is the optimal selection of available flexibility as well as to enable building users to optimize their energy consumption.

Figure 5 presents the value chain for the Slovenian demo site. SETUP takes the role of the aggregator and Avantcar is the mobility service provider. Amibit is a technology developer and integrator and the University of Ljubljana (UL) is the demo leader as well as a technology provider.

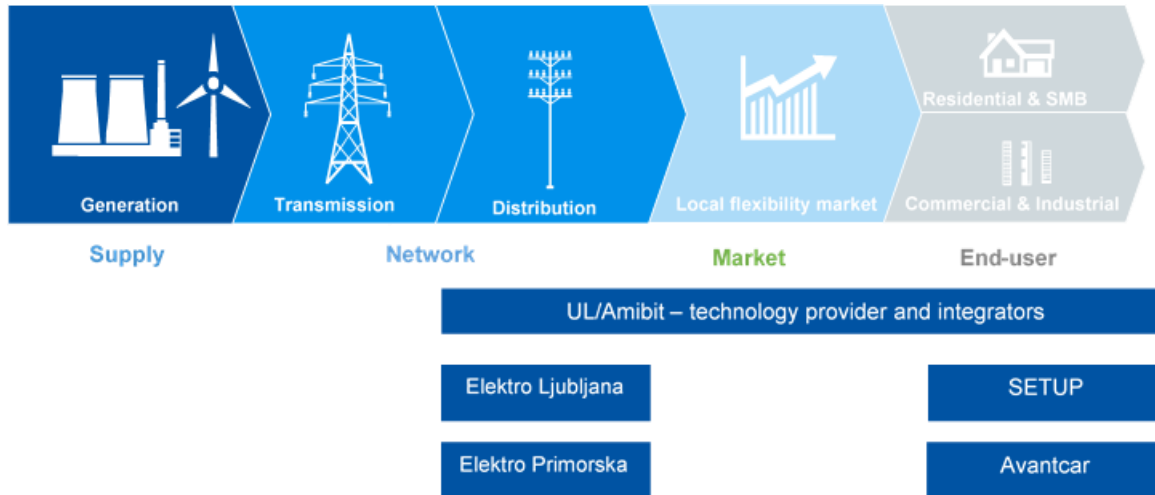


Figure 5 Value chain Slovenian demo site

The business model canvases for the Slovenian pilot site were completed once from the perspective of SETUP (aggregator - Table 11) and once from the perspective of the DSOs (Elektro Ljubljana/Elektro Primorska -

Table 12). The main activity for SETUP as part of the OPENTUNITY project is the integration of assets, as well as contribution to the development of the demand forecast and optimal selection of available flexibility algorithms. The value proposition includes revenues for EV fleet and HEMS fleet providers and grid investment deferral, as flexibility can improve or (even completely remove) the voltage/utilization bottlenecks on the grid and consequently grid investment is needed later or not at all. Key resources are the flexibility assets, the optimal flexibility selection algorithm and the demand forecast algorithms. Key partners are DSOs/TSOs, users, aggregators, EV charging fleet providers and HEMS providers. Customers are on the one hand DSOs and TSOs and on the other hand users. Revenues include revenues for capacity services as well as energy services.

Table 11 BMC of the Slovenian demo site: aggregator perspective

Key activities	Key resources	Key partners
Integration of assets with aggregators/DSO/TSO Contribution to the development of the demand forecast algorithm Contribution to the development of the optimal selection of available flexibility algorithm	Integrated flexibility assets Optimal flexibility selection algorithm Demand forecast algorithm	DSO/TSO Users Aggregator EV charging fleet provider HEMS provider
Competing solutions	Customers	Value propositions
Installations of batteries, smart components	DSO/TSO Users	Revenues for EV fleet and HEMS fleet provider Grid investment deferral
Cost structure	Revenue structure	

Cost for integration of the assets to the aggregator platform (measurement devices, connection devices, paperwork for registration) Maintenance costs for the measurement and connection equipment Aggregator platform User costs	Revenue for capacity services (already defined on the TSO level) Revenue for energy services (already defined on the TSO level) Revenue for other services potentially needed by DSO
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

The other business model canvas considers the view of the DSO. Created value includes investment deferral as well as quality and reliability of electricity supply. Key activities include the registration of FSP (flexible service providers) (with flexible assets), integration of flexibility assets with the aggregator, DSO, TSO and the creation of a flexibility market for DSO ancillary services (congestion management, voltage control). Key resources are a functional flexibility market, traffic light system, grid topology information/data and state estimation and grid planning optimization. Partners are the TSO and customers include FSP and charging point operators. Competing solutions include classical investment into the grid, contracted grid connection power and installation of batteries in combination with renewables (e.g. solar PV, small wind turbines). Costs include costs for the aggregator platform, and operational / information (IT/OT) system costs.

Table 12 BMC of the Slovenian demo site: DSO perspective

Key activities	Key resources	Key partners
Registration of FSP (with flexible assets) Integration of flexibility assets with agg./DSO/TSO → OPENTUNITY Creation of flexibility market for DSO ancillary services (CM, voltage control)	Functional flexibility market Traffic light system Grid Topology Information/data and state estimation Grid planning optimization	TSO
Competing solutions	Customers	Value propositions
Classical investment into the grid Contracted grid connection power Installations of batteries in combination with renewables (e.g. solar PV, small wind turbines)	Aggregators FSPs Charging point operators	Investment deferral Quality and reliability of electricity supply
Cost structure	Revenue structure	
Operation and maintenance costs DSO flexibility (aggregation) platform IT/OT system costs	/	

3.4.3 Business Model for the Spanish Demo Site

The goal of the Spanish demo site within OPENTUNITY is to increase the grid observability as well as the settlement of a local flexibility market to enable the efficient and effective use of energy resources. The Spanish pilot site includes residential and industrial end-users as well as the Santa Eulalia energy community. Part of the pilot site is also ANELL as the DSO, ETRA and Hypertech as the technology providers and IMPULSA, who will take the role of the aggregator within the project as shown in Figure 6.

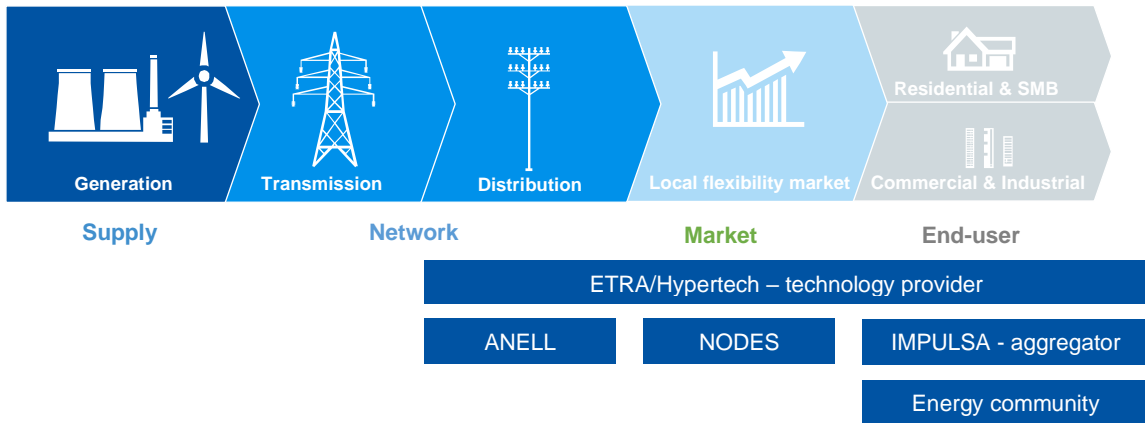


Figure 6 Value chain of the Spanish demo site

The first business model canvas considers the business model from the perspective of IMPULSA, the aggregator (

Table 13). Key activities include the control of the flexible assets, the participation in the local flexibility market as well as the financial settlement with end-consumers. Created value includes increased revenues for flexibility assets providers, as well as support for the energy communities. The created value can be offered to DSO – as flexibility products and as additional revenues to Estabanell Impulsa’s retail customers as well as other residential buildings, businesses with flexibility assets and the energy community. Competitors offering similar value to the customers are other aggregators, retailers with in-house solutions, independent flexibility providers as well as technology vendors specializing in grid management systems. Partners are regulators, local flexibility platform operators, technology providers, consumers, energy market operators and distributed energy resource owners. Costs include payments to residential buildings for providing flexibility and ICT costs for controlling flexible assets. Revenues include revenues from the local market (capacity/energy), service fees for energy forecasting, optimization and market participation as well as potential revenues from demand-side flexibility services and energy community support. It should be pointed out that at this point of the project, the distribution between the aggregator and the flexibility providers (e.g. end-users) is not yet defined, but this will be further explored as part of OPENTUNITY.

Table 13 BMC for the Spanish demo site: perspective of Estabanell Impulsa

<p>Key activities</p> <p>Control flexible assets / energy forecasting and optimization Local market participation Financial settlement</p>	<p>Key resources</p> <p>Local market access ICT infrastructure to control flexible assets</p>	<p>Key partners</p> <p>Regulators Local flex. platform operators Technology providers Consumers Energy market operators DER owners</p>
<p>Competing solutions</p> <p>Other energy aggregators offering grid management assistance and</p>	<p>Customers</p> <p>ANELL (DSO) Estabanell Impulsa's Retail Customers</p>	<p>Value propositions</p> <p>Increased revenues for flex. assets provider</p>

flexibility services to DSOs and retailers Retailers with in-house solutions Independent flexibility providers Technology vendors specializing in grid management systems	Residential buildings / businesses with flexible assets Energy communities	
Cost structure		Revenue structure
Payments to residential buildings for providing flexibility ICT costs for controlling flex. Assets Costs for access to NODES		Revenues from a local market (capacity/energy) Service fees (energy forecasting, optimization, and market participation)

The second BMC considers the perspective of Anell, the DSO (Table 14). Key activities include the following activities:

- Identification of grid issues
- Sending flex. requests
- Payment for flexibility activation
- Promoting demand-side flexibility
- Local market platform operation

These activities allow for cheaper/more efficient grid management, potential investment deferral and better quality of services, such as less voltage volatility and potentially fewer interruptions. Customers are aggregators, DR service providers and energy communities. Key resources include access to the local market, Anell's power grid infrastructure and flexibility assets. Competing solutions refer to the traditional way DSOs deal with grid congestion which is usually grid reinforcement. Partners are the local market platform operator, regulators as well as technology providers. Costs refer to costs for the flexibility activation on the local market as well as access to the local market platform. Revenues could come from reduced costs for grid management.

Table 14 BMC for the Spanish demo site: perspective of Anell

Key activities Identification of grid issues Sending flex. requests Payment for flex activation Promoting demand-side flexibility Platform operation	Key resources Local market access Anell's power grid infrastructure Flexibility assets of end-users	Key partners Local market platform operator Regulators Technology providers
Competing solutions Grid reinforcement	Customers Aggregators DR service providers Energy communities	Value propositions Investment deferral Cheaper/more efficient grid management Support for energy communities and promotion of demand-side flexibility Better quality of services
Cost structure Costs for flexibility activation on local market Costs for access to NODES		Revenue structure Reduced costs for grid management → to be analysed as part of the project

3.4.4 Business Model for the Swiss Demo Site

Part of the Swiss demo is an energy community with residential flats and single houses. The aim within OPENTUNITY is the establishment of a local flexibility market to allow DSO to start DR campaigns and take advantage of the flexibility available from the prosumers from its grid. The local flexibility market will be done over the NODES platform. AEM acts as the DSO as well as the aggregator for the EC. HIVE and SUPSI are the technology provider as shown in Figure 7. The business models relate to *UC 5.1 Improve congestion management to facilitate DER penetration* and *UC 5.2 Integrate flexibility with the distribution grid to provide balancing services*.

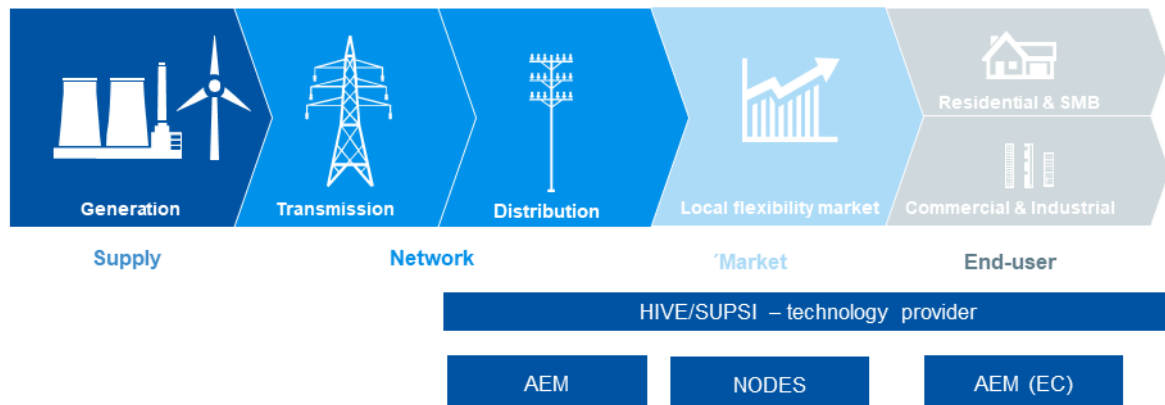


Figure 7 Value chain analysis for the Swiss demo site

The first business model canvas describes UC 5.1 Improve congestion management to facilitate DER penetration (

Table 15). Value created includes congestion and overvoltage reduction, deferral of grid investment for the DSO, improving grid efficiency and RES exploitation. Key activities are the identification of the local grid topology, prediction of local consumption and production, transformer stations and grid rating, congestion and overloading, estimation of local available flexibility, development and integration of tools and the establishment of efficient communication with the key partners (measurement and verification (M&V) process after service delivery). Key resources are smart meters, a smart communication infrastructure, power-to-X & flexible assets, expertise in DR services and machine learning, as well as software development and optimization of tools. Key partners are energy management system providers, FSP as well as energy community members (consumers and prosumers). The customer of this service is the DSO. Costs refer to production costs (hardware & software), operational costs for service provision, partnership and collaboration costs between key partners, end-users engagement costs as well as costs for access to the NODES market platform. Revenues stem from services provided to the DSO, maintenance services, potential governmental incentives or grants and revenue-sharing agreements with FSP for utilizing their resources.

Table 15 BMC for the Swiss demo site – UC 5.1

Key activities	Key resources	Key partners
Identify local grid topology Predict of local consumption and production Predict transformer stations and grid ratings Predict congestions and overloading Estimate local available flexibility Tools development and integration Establish efficient communication with the key partners (M&V process after service delivery)	Smart Meters (SM) SMs communication infrastructure Power-to-X & flexible assets Expertise in services Expertise in Machine learning Software development and optimization tools	Energy Management System (EMS) (Grid Energy Management System or BEMS) providers FSPs Energy Community members: Consumers and Prosumers
Competing solutions	Customers	Value propositions
Incentive tariffs for indirect DSM Grid expansion and reinforcement Traditional voltage regulations (Transformer tap Changers)	DSOs	Congestions and overloading reduction Defer grid investments for the DSO Improve grid efficiency Improve RES exploitation
Cost structure	Revenue structure	
Production costs (hardware & software) Operational costs for service provision Partnership and collaboration costs between key partners End-users' engagement costs Costs for access to NODES	Service provided to the DSO Maintenance services Potential government incentives or grants Revenue-sharing agreements with FSP for utilizing their resources	

The second business model canvas considers *UC 5.2 - Integrate flexibility with the distribution grid to provide balancing services* (Table 16). Value is created by amortizing DERs investments, enabling flexibility market access for small DERs, providing a cost-effective solution for local grid management, efficiently managing energy surplus in the EC and improving the overall grid efficiency. Key activities include identifying and onboarding small DER owners, the local grid topology, predicting local consumption and production, estimating local available flexibility, aggregating flexibility to meet the request, clearing the flexibility market to match bids/offers and controlling flexible assets to deliver the service. Key resources are smart meters, a smart communication infrastructure, power-to-X & flexible assets, expertise in DR services and machine learning, the flexibility market platform, as well as software development and optimization of tools and AI algorithms for NILM. Key partners are FSP, flexibility market operators, energy management systems and energy community members (prosumers/consumers). Competing solutions are traditional, centralised or decentralised solutions centred on larger energy generators or storage systems, which do not involve the end-users. Customers are the DSO (main validation case). Competing solutions are traditional, centralised or decentralised solutions centred on large energy generators or storage systems, which do not involve the end-user. Costs include production costs (hardware & software), operational costs for service provision and the flexibility market management and access to NODES. Revenues refer to services provided to the DSO (main validation case) or the BSP (optional validation case), as well as maintenance services, potential government incentives or grants and revenues from flexibility trading on local flexibility markets.

Table 16 BMC for the Swiss demo site – UC5.2

Key activities	Key resources	Key partners
Identify and onboard small DER owners Identify local grid topology Predict of local consumption and production Estimate local available flexibility Aggregate flexibility to meet the request Clear the flexibility market to match bids/offers Control flexible assets to deliver the service	Smart Meters SMs communication infrastructure Power-to-X & flexible assets Expertise in DR services Expertise in Machine learning Flexibility market platform Software development and optimization tools AI algorithm for NILM	FSPs Flexibility Market Operator Energy Management System (Grid Energy Management System or BEMS) Energy Community members: Consumers and Prosumers
Competing solutions	Customers	Value propositions
Traditional, centralised or decentralised solutions centred on large energy generators or storage systems, which do not involve the end-user.	DSO Balancing Service Providers or aggregators (Optional Validation Case)	Amortize DER's investments Enabling flexibility market access for small DERs Provide a cost-effective solution for local grid management Efficiently manage energy surplus in the energy community Improve the overall grid efficiency
Cost structure	Revenue structure	
Production costs (hardware & software) Operational costs for service provision and flexibility market management/access to NODES Partnership and collaboration costs between key partners End-users' engagement costs	Service provided to the DSO or BSP Maintenance services Potential government incentives or grants Flexibility trading: revenue sharing through local flexibility market	

3.5 Outlook on OPENTUNITY business models

This part of the report presents first insights into the economic environment of the OPENTUNITY solutions. It is pointed out that most of the current business models for flexibility services found in the literature focus on DR opportunities (internal optimization or offering flexibility on existing electricity markets such as mFRR or aFRR) and less on the possible value created by local (flexibility) markets. Contrary to this observation, as part of OPENTUNITY a focus will be laid on the local flexibility market as highlighted in Chapter 3.4. For flexibility markets to take off in the future an enabling legislative framework is essential, which is currently lacking and therefore hampering further deployment of flexibility and value creation. In general, it was also observed in the literature that business models take into consideration already existing actors of the electricity system and zoom in less on the ICT solutions enabling the proposed business model. Regarding actors, it should also be noted that the role of actors in the value chain might change due to using the OPENTUNITY solutions.

Barriers that hinder the actual implementation of business cases in the area of flexibility are standardization gaps, where the first chapter of this report presents a more detailed overview. Secondly, the lack of access to smart metering data or smart meters in general for prosumers as well as DSOs is mentioned. Moreover, current network codes/regulatory frameworks hamper demand side flexibility such as high limits for minimum flexibility, lack of regulation for DR or prequalification rests for each individual.

Several topics of interest have been identified which will be further analysed as part of OPENTUNITY. Further research is needed regarding the financial settlement for aggregators (how to do it? Who gets how much ...?). Moreover, the actual monetary exchange between the aggregator and the TSO/DSO should be investigated. Lastly, the BMC proved to be a good starting point for the creation of business models, however, quantification of costs and revenues is needed which will be addressed as part of *T7.2 "Socioeconomic impact assessment"*.

4 User Acceptance and User Experience (as part of Task 2.3)

The goals of the research on User Acceptance and User Experience in OPENTUNITY are the following:

- Deliver a comprehensive understanding about the role and relevance of driving factors behind User Acceptance and User Experience of OPENTUNITY solutions in different contexts, use cases and user groups.
- Develop an actionable and replicable strategy that supports User Acceptance and enables a positive User Experience in the rollout of OPENTUNITY solutions.

As the scope of User Acceptance and User Experience related theories and methods is extremely broad, we had to identify the most important topics to create a selection that guides the way for further research during the project. To identify and investigate the topics of particular relevance for the technologies and tools developed within OPENTUNITY, we conducted the following procedure:

1. We started with the identification of theories, about what might influence the adoption or non-adoption of new technologies. This resulted in the list of theories outlined in 4.1.1.
2. The list of theories informed the search for empirical literature on the adoption of smart-energy solutions in private households. The result was an initial list of topics with potential relevance for the activities in OPENTUNITY, which is presented in 4.1.2.
3. The initial list was presented to the project partners, and they were invited to incorporate their knowledge (e.g. with regards to overlapping topics that could be summarized, topics considered not relevant for OPENTUNITY technologies, or additional topics that might play a role for OPENTUNITY technologies). This step resulted in an updated list, which is presented in 0
4. For the updated list, we asked all project partners to prioritize the topics according to how important they consider them against the backgrounds of their respective expert knowledge and prior experiences. This prioritization by the OPENTUNITY partners resulted in a selection of 10 high-priority topics, which is presented in 4.1.4.
5. For the 10 high-priority topics, we conducted an additional literature research to understand in more detail how these topics relate to user acceptance and how they can feed into the development of tools and technologies in OPENTUNITY. The results from this literature research (presented in 4.2) were used to develop a thematic outline to be used in expert interviews with representatives of the lead partners in the WPs in which technologies and tools are developed (WPs 3-6).
6. Against the background of the broadened knowledge derived from literature, we conducted discussion-like expert interviews with the tool- and technology developers to collect their perspectives on the high-priority topics. Special attention was on how these aspects can and should be best incorporated into the tools and technologies developed in OPENTUNITY. The experts' perspectives are presented in 4.3.

4.1 Identification of most relevant Theories, Methods, and Topics

4.1.1 Theories on Adoption and Diffusion of new Technologies

There exist several theories concerned with identifying mechanisms relevant for the adoption and the diffusion of new technologies. A few prominent examples are the following:

Diffusion of Innovation Theory: The Diffusion of Innovation Theory, developed by sociologist Everett Rogers in 1962 [19], seeks to explain how new ideas, products, or technologies are adopted and spread within a social system. It provides a framework to understand the process of innovation adoption by different target groups and the factors that influence the rate of adoption.

According to Rogers, the adoption of innovations typically follows a bell-shaped curve, and he classifies individuals into five adopter categories based on their readiness to adopt new ideas:

- **Innovators:** These are the adventurous, risk-taking individuals, who embrace new ideas and technologies very early on. They are willing to take risks and are thus crucial in the early stages of an innovation's diffusion.
- **Early Adopters:** These are opinion leaders and influencers within their social circles. They adopt new ideas relatively quickly and are perceived by others as role models.
- **Early Majority:** The early majority represents the pragmatic, deliberate individuals who adopt an innovation after it has been proven successful by early adopters. They seek more evidence and assurance before embracing change.
- **Late Majority:** The late majority is more sceptical and conservative. They adopt innovations only after they have become mainstream and widely accepted.
- **Laggards:** Laggards are the last to adopt an innovation. They are resistant to change and tend to stick to traditional practices even when the majority has moved on.

The diffusion process is influenced by several factors, including:

- **Relative Advantage:** The perceived improvement an innovation offers over existing alternatives.
- **Compatibility:** The degree to which the innovation is perceived to be consistent with the values, needs, and experiences of potential adopters.
- **Complexity:** The level of difficulty involved in understanding and using the innovation.
- **Trialability:** The ability to experiment with the innovation on a limited basis before committing to full adoption.
- **Observability:** The extent to which the results and benefits of the innovation are visible to others.
- **Communication Channels:** The methods and channels through which information about the innovation is disseminated.
- **Social System:** The social structure and norms that can either facilitate or hinder the diffusion of an innovation.

The Diffusion of Innovation theory has been widely applied in various fields, such as marketing, technology adoption, public health, and social change, to understand and promote the adoption of new ideas and practices [20]-[22].

Technology Acceptance Model: The Technology Acceptance Model (TAM) is a theoretical framework in the field of information systems and technology management. It was developed by Fred Davis in the late 1980s to explain and predict users' acceptance and adoption of new information technologies [23].

The model is based on the assumption that perceived usefulness and perceived ease of use are the primary determinants of a user's intention to use a technology, which, in turn, influences their actual technology usage.

The TAM consists of two main constructs:

1. Perceived Usefulness (PU): Perceived usefulness refers to the degree to which a user believes that using a particular technology will enhance their job performance or make their tasks easier and more effective. If users perceive the technology as useful, they are more likely to adopt it.
2. Perceived Ease of Use (PEOU): Perceived ease of use refers to the extent to which a user believes that using the technology will be effortless and free from complexity. If users find the technology easy to use, they are more likely to have a positive attitude towards using it.

The TAM posits that these two factors (PU and PEOU) directly influence an individual's behavioural intention to use a technology. In other words, if users perceive a technology as useful and easy to use, they are more likely to express an intention to use it.

Beyond the direct effects on behavioural intention, TAM also suggests that external factors may indirectly influence users' acceptance of technology through their impact on perceived usefulness and perceived ease of use. Some of these external factors include:

1. External Variables: External variables could be external pressure or influence from colleagues, superiors, or external stakeholders that may affect users' perceptions of the technology.
2. Experience: Previous experience with similar technologies or related tasks can influence users' perceptions of ease of use and usefulness.
3. Training and Support: Adequate training and user support can positively affect users' perception of ease of use, thereby influencing their intention to use the technology.
4. System Characteristics: System characteristics, such as system performance, reliability, and security, can influence users' perceptions of usefulness and ease of use.

The TAM has been widely used and validated across various contexts and technology adoption scenarios. It exists in two extensions TAM2 and TAM 3 [21], [24].

Task-Technology Fit Model

The Task-Technology Fit (TTF) model is a theoretical framework developed to understand the relationship between the characteristics of a task and the appropriateness of the technology used to accomplish that task. It is commonly used in the field of information systems and technology management to assess how well a particular technology aligns with the requirements and demands of a specific task or job.

Goodhue and Thompson first introduced the TTF model in 1995 [25] as an extension of the Technology Acceptance Model (TAM). The core idea of the TTF model is that the effectiveness and performance of a task depend on how well the technology supports the task requirements. When there is a good fit between the two, the technology is more likely to be adopted and used effectively, resulting in improved outcomes.

The TTF model consists of three main components:

1. Task Characteristics: These are the specific attributes and requirements of the task. It includes factors such as complexity, interdependence, uncertainty, time sensitivity, and the nature of information processing involved.
2. Technology Characteristics: These refer to the features and capabilities of the technology to be used. It includes aspects such as usability, functionality, compatibility, flexibility, and overall performance of the technology.
3. Fit: The fit represents the degree of alignment or match between the task characteristics and the technology characteristics. The better the alignment, the higher the task-technology fit.

The TTF model proposes that a good task-technology fit can lead to several positive outcomes:

1. Increased Efficiency: When technology complements the task, it can streamline processes, and make them more efficient, leading to time and cost savings.
2. Enhanced Effectiveness: Appropriate technology can improve the quality and accuracy of task outcomes, leading to better overall performance.
3. Higher User Acceptance: Users are more likely to accept and adopt technology that fits well with their tasks, reducing resistance to change.
4. Improved Job Satisfaction: When the technology supports a job related task effectively, it can lead to higher job satisfaction for users.

The TTF model can help organizations in selecting appropriate technologies for specific tasks, understanding potential challenges and barriers to adoption, and identifying areas for improvement in the existing technology-task alignment [21], [26].

Unified Theory of Acceptance and Use of Technologies: (UTAUT) was introduced 2003 [27]. The UTAUT consolidates and extends various existing technology acceptance models, including the Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), and the Diffusion of Innovation Theory, among others. It aims to provide a comprehensive understanding of the factors that influence individuals' decisions to adopt and use technology in different contexts.

The model identifies four key constructs that influence technology acceptance and usage:

1. Performance Expectancy: Refers to the degree to which an individual believes that using the technology will make tasks easier.
2. Effort Expectancy: Relates to the perception of how easy or difficult it is for an individual to use the technology.
3. Social Influence: Refers to the influence of others, such as peers, colleagues, or supervisors, on an individual's intention to use technology.
4. Facilitating Conditions: Encompasses the external factors and resources that support or hinder the use of technology, including technical support, training, and infrastructure.

Additionally, UTAUT also considers four moderating variables that can influence the relationships between the constructs and technology adoption:

1. Gender: Differences in technology acceptance between males and females.
2. Age: How age influences individuals' attitudes and beliefs towards technology adoption.
3. Experience: The level of prior experience and exposure to technology.
4. Voluntariness: Whether the use of technology is mandatory or voluntary for the individual.

The UTAUT model proposes that technology adoption and usage behaviour are influenced by the interplay of these constructs and moderating variables. By understanding these factors, researchers and practitioners can better predict and explain technology adoption patterns, design more effective technology interventions, and encourage broader technology usage in different settings [21], [28].

Since the UTAUT claims to consolidate and expand most of the theories named beforehand, we will use this framework as a guidance for the following steps of analysis in OPENTUNITY. From the topics identified in the theory, for the purpose of tailoring the tools (and accompanying information), all of the named topics are relevant, apart from social influence (which realistically cannot be influenced neither by the tool design itself nor by accompanying information) and voluntariness (since the adoption of the OPENTUNITY tool is generally voluntary). Gender and age, we summarize into sociodemographic background¹. Furthermore, we add an open category for the case that other variables come into play that do not fit into the theoretical framework, but still seem to be important.

4.1.2 Literature Review and first Identification of potential Topics

In this step, we conducted a search for empirical literature on the adoption of smart-energy solutions in private households. With the results at hand, we conducted a narrative literature review, using the method of thematic saturation [29]. This method proposes to continue with the identification of new literature until no new topics emerge anymore (and the research is considered "saturated"). The following search string guided the research in Google Scholar and Web of Knowledge: "smart home tools" OR "smart energy tools" OR "wireless personal area network" OR "wireless sensor network" OR "smart home network" OR "smart energy management" OR "Smart Light Control system" OR "Load Control" AND "user acceptance" OR "consumer acceptance" OR "User experience" OR "Consumer experience". Research results were restricted to peer-reviewed empirical articles, meta-analyses and reviews published after 2010 and only included, if they make a statement about a feature users might demand for from smart home applications. In the following tables, we show the results ordered according to the general categories of UTAUT and an additional category for (potentially) moderating variables:

¹ Of course, sociodemographic characteristics also cannot be changed, but what we can do, if that variables are identified as relevant for our purposes, is to tailor the tools towards a direction that might reduce the inhibition threshold for certain groups.

Table 17 Performance Expectancy related Topics

Performance Expectancy			
Variable	Explanation	Literature	No.
Financial gains/burdens	Expectation that device saves or generates money	[30]-[36]	7
Energy savings	Expectation that device saves energy	[30], [31], [33]-[36]	6
Autonomy/Controllability	Expectation that users have full control over the device and its actions	[31], [33], [35], [36]	4
Safety	Expectations that device informs police of emergencies or prevents fires or severe accidents.	[33], [35]	2
Wasteful consumption	Expectation that device prioritizes luxury and comfort and leads to higher consumption patterns.	[33], [35]	2
Health Benefits	Expectations that device has ability to alert relatives or health professionals to emergency events, aiding health diagnosis, and enabling aggregate level health analytics	[33], [35]	2
Greenhouse gas emissions	Expectations that device reduces Greenhouse Gas emissions	[33], [35]	2
Environmental Benefits	Expectations that device brings environmental benefits	[33], [35]	2
Social Benefits	Expectations that device leads to inclusion—adopters feeling like they belonged to a community—or networking with others for professional or personal reasons	[35]	1
Educational Benefits	Expectations that device relates to the enhanced learning opportunities smart home technologies can bring, whether accessing new forms of knowledge, undertaking digital training, or simply new ways of receiving information or developing new skills	[35]	1
Social isolation	Expectation that device reduces social interactions	[35]	1
Exclusiveness/Elitism	Expectation that device is only available for certain groups in society	[35]	1
Appliances lifetime	Expectation that the device will last for a long period of time and does not need to be replaced regularly	[35]	1
System resilience	Expectation that a system is more resilient against outside changes	[34]	1

Table 18 Effort Expectancy related Topics

Effort Expectancy			
Variable	Explanation	Literature	No.
Comfort	Users don't need to change their lifestyle strongly to use the devices	[30]-[34], [36]	6
Time savings	Expectation that device saves time	[30]-[34], [36]	4
Usability	Expectation that device is easy and intuitive to use	[33], [35]	2

Table 19 Facilitating Conditions related Topics

Facilitating Conditions			
Variable	Explanation	Literature	No.
Privacy	Expectation that data generated through the device isn't unnecessary observed to find out more about the user or shared with third parties if the user doesn't agree to that	[30], [31], [33]-[39]	8
Transparency	Expectation that companies are transparent toward the users about their goals, the functions of the tools and what happens with the generated data.	[33]	1

Table 20 Sociodemographics related Topics

Sociodemographics			
Variable	Explanation	Literature	No.
Household size and constellation	Number of household members and who they are (e.g. small children, elderly people)	[31], [32]	2
Age	Age of a person	[30]	1
Gender	Gender of a person	[30]	1
Education	Highest education of a person	[30]	1
Social class	Group of people within a society who possess the same socioeconomic status	[30]	1
Employment status	Legal status at work	[30]	1

Table 21 Experience related Topics

Experience			
Variable	Explanation	Literature	No.
(Dis-)Trust	Amount to which users think that they can trust those offering the device	[32], [33]	2
Fear of new technologies	Fear of using new technologies	[33], [35]	2
Knowledge	Knowing about a certain technology and how it can be used	[30], [34]	2
Self Efficacy	Individual's belief in their capacity to act in the ways necessary to reach specific goals	[30]	1

Table 22 Topics considered (potentially) Moderating Variables

(Potential) Moderating Variables			
Variable	Explanation	Literature	No.
Aesthetics	Assessment of device looks, is designed, and adds symbolic value to a house as an item of fashion or style	[35]	1
Personal Innovativeness	Degree how strong someone is willing to try out new things	[30]	1
Environmental awareness	Being aware of the impact the own actions have on the environment/climate	[30]	1

4.1.3 Consolidation of potentially relevant Topics

After the creation of the initial list, we asked all partners involved in WP2 to comment on the presented topics. This could be comments about how the OPENTUNITY tools and technologies as well as suggestions for additional topics or considerations about excluding certain topics due to lack of relevance for aims of OPENTUNITY. The comments of the partners primarily related to the conceptual understanding of the collected topics. There were also some suggestions for treating closely related topics together (e.g., “wasteful consumption” and “environmental benefits” treated together under “environmental benefits through usage”). The result was a consolidated list of topics potentially relevant for the tools and technologies developed in OPENTUNITY, as presented in the next section.

The topics from the consolidated list grouped according to the extended UTAUT framework (as with the initial list presented above):

Performance expectancy:

- Economic benefits through usage
- Environmental Benefits of Usage
- Health Benefits through Usage
- Social Benefits through Usage
- Time Savings through Usage
- Knowledge Gain through Usage
- Safety during Setup and Usage
- Rebound Effects
- Autonomy of Users
- Isolation and other negative Consequences of Usage and Market Participation
- Inclusiveness
- Exclusiveness / Elitism
- Appliances Lifetime Concerns
- Sovereignty & Efficacy of Users

Effort Expectancy:

- Usability in unforeseen (but real) Scenarios
- Comfort during Usage

Facilitating Conditions:

- Business Model Transparency
- Privacy Concerns
- Interoperability of Technologies

Sociodemographics:

- Social Status & Characteristics of Users
- Differences between User Groups

Experience:

- Trust in Technology Providers or Platform Operators
- Fear of new Technologies
- Brand Awareness and Market Share

(Potentially) Moderating variables:

- Aesthetics of Technologies
- Users' Personal Norms and Values

4.1.4 Identification of High-Priority Topics

The final prioritization of topics aimed to identify the high-priority topics from the perspective of the OPENTUNITY team. It was needed as the consolidated list of potentially relevant topics (see 4.1.3) contains too many topics to cover all of them in sufficient detail during the course of the accompanying User Acceptance and User Experience related research in the project. For the prioritization, an online survey was used (based on the open-source tool LimeSurvey, installed on the servers of Joanneum Research, and hosted in Graz, Austria). The participants were presented the topics included in the consolidated topics list in a random order and were asked to rank them according to what they perceived as most important for the User Acceptance and User Experience of technologies developed in the project (see Figure 8). As the ranking aimed to identify the top 10 topics (a reasonably manageable number), the topic ranked highest by a participant scored 10 points, the topic on the 10th position scored 1 point. Topics ranked below position 10 by a participant were not assigned any points in the respective response. All OPENTUNITY partner organizations were asked to participate, and all responses were given the same weight. If more than one representative of a partner organization participated in the survey, the average rankings informed the calculation of the final topics list.

Please sort the following topics according to **what you think is most relevant** for the **User Acceptance** and **User Experience** of OPENTUNITY Technologies.

Note: The results of this item will be used to identify the priority-topics, which will be explicitly covered in the User Acceptance and User Experience related research at the demo sites.

Double-click or drag-and-drop items in the left list to move them to the right - your highest ranking item should be on the top right, moving through to your lowest ranking item.

Please select from 10 to 26 answers.

Your choices	Your ranking
Sovereignty & Efficacy of Users (e.g. ability to override the settings if needed)	Brand Awareness and Market Share
Isolation and other negative Consequences of Usage and Market Participation	Autonomy of Users (i.e. independence from service staff)
Comfort during Usage	Time Savings through Usage
Rebound Effects (i.e. extra consumption due to lower prices or more comfortable usage)	Privacy Concerns
Health Benefits through Usage (e.g. reduced stress due to easier workflows)	
Trust in Technology Providers or Platform Operators	
Interoperability of Technologies	
Appliances Lifetime Concerns (e.g. damage to legacy devices through switching on and off)	
Safety during Setup and Usage (e.g. risk of injury or damaged devices)	
Inclusiveness (i.e. accessible to "everyone")	
Economic Benefits through Usage	

Figure 8 Screenshot of the ranking exercise in the expert survey

The final ranking and the respective points assigned (sum of all participating organizations, according to calculation outlined above) are shown in Table 23.

All prioritized topics focus very strongly on the direct interaction between technologies and their users and the users' perceptions of the technologies, while e.g. more society-oriented topics like “Social Benefits” and marketing-related topics like “Brand Awareness and Market Share” ranked clearly lower with 18 and 11 points, respectively.

Table 23 Top-10 (and selected lower ranked) User Acceptance and User Experience related Topics

Rank	Topic	Points assigned
1	Economic Benefits through Usage	108
2	Comfort during Usage	107
3	Privacy Concerns	92
4	Environmental Benefits of Usage	85
5	Time Savings through Usage	82
6	Interoperability of Technologies	61
7	Trust in Technology Providers or Platform Operators	49
8	Safety during Setup and Usage	45
9	Business Model Transparency	43
10	Knowledge Gain through Usage	38
...
17	Social Benefits through Usage	18
...
23	Brand Awareness and Market Share	11
...

4.2 Literature Insights into Top-10 Topics

After identifying the top ranked topics, we conducted an in-depth literature analysis of the selected topics, focusing solely on applications closely related to the tools and technologies to be developed in OPENTUNITY. These are:

- Smart Metering
- BEMS
- HEMS
- Demand-Response Applications
- NILM Applications

In the following, we present the findings of the focused review of scientific literature on the selected topics, paying special attention to **push- and pull-factors** for the acceptance of technologies and drivers for a positive user experience.

4.2.1 Economic Benefits

Bertoldo and colleagues showed that the ability to save money through closer monitoring (and adjustment) of energy behavior by using smart meters was an attractive feature for their study participants. [31]

Similar findings were reported by Sovacool and Furszyfer Del Rio. [31], similar: [35]. On the other hand, a higher electricity price at a time point where they want to consume more electricity (e.g. after coming home after work) was seen critical and disapproved. Similarly, the participants of a study by Goulden confirmed financial advantages as dominant incentive for adopting response-demand technologies. However, they also indicated that this only accounts if the financial incentives are considerably high and the adopted technology does not interfere too much with their everyday habits [32]. Similarly, Li and colleagues indicate, that the motivation for the adoption of smart home technology becomes more positive with an increase in anticipated savings and a decrease in the investment payback period [33]. In a study on smart home technologies by Wilson and colleagues, saving money was considered the fourth most important potential benefit of these technologies, after saving energy, making things less effort and saving time [36]. Verbong and colleagues also indicate, that financial benefits might be a relevant benefit to gain more users, but they emphasize limited effects [40].

Generally, the literature reveals that financial benefits are an important argument for the adoption of smart energy tools and therefore should be explicitly considered during OPENTUNITY. Nevertheless, the literature implies that financial arguments alone might not be sufficient to convince potential users to adopt a certain technology.

4.2.2 Comfort

The participants in a study by Bertoldo et al. mentioned a loss in comfort as one of the main barriers for the adoption of smart demand-response systems. Examples of comfort loss were being forced to lower room temperatures below the comfort-threshold, or not being able to perform energy intensive housework like washing dishes or clothes at any time [31]. The same issue was raised by participants of the study of Goulden et al., who expressed that flexibility restrictions might be an even greater issue, if children live in the household [32]. The potential disruption of daily routines was also shown to pose a potential (but relatively low) risk for the adoption of smart home technologies in a study by Wilson and colleagues, [36]. Li and colleagues identified convenience and comfort provided as the most important single motive for the adoption of smart home technologies [33].

Generally, the results indicate that consumers value comfort very highly, potentially even higher than e.g. financial gains. For the adoption of OPENTUNITY technologies, this means that it must be assured, that a disruption of the routines and potential comfort loss perceived by the recipients is kept to a minimum. Furthermore, it might be beneficial if the users get the easy possibility to overrule every decision taken automatically.

4.2.3 Privacy Concerns

Alkawsu and colleagues show that privacy concerns are negatively correlated to the intention to use smart-meters. Similar findings are reported by Raimi and Corrico [30], similar: [41]. Relatedly, Bertoldo reveals that energy consumption is still seen as something that is private and should not be monitored by the government or other agencies [31].

In the course of a study with experts, Sovacool and Furszyfer Del Rio identified privacy, security and hacking as the most articulated risks [35]. However, while acknowledging that privacy

concerns are seen as barrier towards the adoption of smart solutions, Li and colleagues also presented studies that conclude that privacy and security risks do not significantly affect smart home adoption intention. One reason they give is that users typically believe that they can control privacy problems. They also see potential cultural influences: Cultures that are dominated by a masculine and collectivistic culture (like Tokyo) might tend more strongly to down-play privacy risks in contrast to more feminine and individualistically dominated cultures (like New York) [33]. Rottondi and colleagues identified the following privacy architecture as basic requirement to ensure a maximum of perceived privacy [39]:

- Clear identification of the business entities that have access to the user data.
- The data must be collected with the minimum granularity necessary for proper smart grid operations; in particular, data should be aggregated or anonymized unless it is strictly necessary to do differently.
- Collected data shall be associated to customer identities only when and where it is strictly necessary.

Also, in the case of OPENTUNITY, a focus should be on securing as much privacy as possible for the users. As a minimum requirement, the rules by Rottondi and colleagues can be applied.

4.2.4 Environmental Benefits

Despite being one of the main arguments for the promoted distribution of smart home technologies, environmental benefits are not yet drivers that lead to the adoption of such technologies by large numbers of end consumers. For example, Sovacool and Furszyfer Del Rio critically discuss the demographics and motivations of early adopters as not representative for general populations [35], and Li and colleagues mention environmental benefits more as a general remark than as a key feature [33]. So, while the amount of saved energy/CO₂ is very important to determine the overall impact of tools and applications, it does not yet seem to play a crucial role from an end-user's point of view.

4.2.5 Time Savings

Alkawsy and colleagues used time saving as part of the superordinate factor of performance expectancy and found a positive correlation with smart-meter use [30]. In the survey of Wilson and colleagues, saving time was named as the third most important potential benefit of smart home tools [36]. On the other hand, Bertoldo and colleagues as well as Goulden and colleagues identified time required to monitor the own energy consumption and the time needed to familiarize oneself with the smart tools as potential barriers to the adoption [31], [32].

For the development of OPENTUNITY tools and technologies, this means that from an end-user perspective the tools should be designed in a way that they should (I) allow a high degree of automation (freeing the end-user from the task of manually setting up devices) and (II) require a minimum of effort during familiarization.

4.2.6 Interoperability

Wilson and colleagues, Sovacool and Furszyfer Del Rio, as well as Li and colleagues identified missing interoperability of different devices as potential barriers of smart-home adoption [33], [35], [36].

For the work conducted in OPENTUNITY, this means that the tools and technologies should be designed in a way that allows for the easy integration of different smart household applications wherever possible (which is anyway one of the key goals of the project).

4.2.7 Trust in Technology Providers or Platform Operators

Goulden and colleagues found that distrust with regard to energy-companies (and to a lesser degree in governments) can be a relevant barrier for the adoption of smart-technologies. End-users on the one hand doubt that companies offer them something that is beneficial for them but not for the companies, and on the other hand fear that the data generated by the tools are either used for purposes not agreed upon or to monitor their behavior [32]. Additionally, the distrust in the device itself might be a barrier to the adoption, as Li and colleagues revealed. Main issues were reliability, performance, and controllability of the devices [33].

For the OPENTUNITY tools and technologies this means firstly that the end-users should always be informed about which data are generated and collected, and for which purposes the data are used. Wherever possible, data should be collected without personal identifiers (explicit and implicit). An early and full anonymization of personal identifiers (where they are technically required), and the exclusion of data sharing with third parties are further important aspects of successful trust building. Secondly, as already stated in relation to comfort, the end-users should get the possibility to override every automated decision made by the tools.

4.2.8 Safety during Setup and Usage

In the context of smart technologies, safety is mainly discussed in relation to surveillance and health monitoring tools that can increase the safety of residents [33], [35]. Surprisingly, safety does not seem to be considered an issue when it comes to end-users needs; probably because safe operations during the installation and running of tools is generally assumed.

This accounts also for the tools developed in OPENTUNITY. The end-user should only be involved, after rigorous testing of all tools and technologies. Furthermore, the end-user should have the opportunity to manually override the actions initiated by the tools at any time if they concern something within the power of the end users' disposition.

4.2.9 Business Model Transparency

Transparency is mainly discussed within the context of trust towards the technology provider (see also chapter 4.2.7) [33].

The main point for OPENTUNITY in this regard is that the end-users should be informed as rigorous as possible about how the user-data generated by the tools are stored, processed and who gets access to it (and that access to data by third parties is ruled out). Furthermore, data should always be anonymized as soon as possible and data control should remain under the control of the end-users wherever possible.

Apart from data usage related transparency, it might be also beneficial to indicate how a business (if it is associated with a certain tool or technology) makes profit out of the provision of the tool.

4.2.10 Knowledge Gain through Usage

Knowledge gains refer to a better understanding of the own energy use but can also go beyond that. An example is imparting the end-users new skills, like how to effectively interact with smart-technologies [35]. On the other hand, it needs to be taken into account, that learning and (potential) knowledge gain requires effort and might therefore collide with the wish for comfort. Accordingly, Verbong and colleagues stated that most people will not be very interested into analyzing their energy usage data [40].

For the OPENTUNITY-project, this ideally means that the end-users should be given this learning opportunity (for example by providing additional material with the tools and visualizing data for end-users), but at the same time the use of the tools should also be possible with a minimum of effort required.

4.3 Enrichment of Literature Insights with OPENTUNITY Solution Providers

The enrichment of literature insights was based on interviews with the leaders of the work packages in which the respective tools and technologies are going to be developed during OPENTUNITY. Representatives of Energy Web, Hypertech, and ETRA detailed what role the prioritized topics play in their developments and how they take into account the associated challenges. The generated insights foster the project-wide orientation and will guide the research design for the user research at the demo sites.

4.3.1 OPENTUNITY Energy Blockchain (WP3)

The aim of the OPENTUNITY Energy Blockchain to be developed under the lead of Energy Web Devhub GmbH in WP3 is to facilitate data exchange in a decentralized manner among the project partners (and later: within the flexibility market) by providing a data exchange infrastructure. The interview partner was a project manager with three years of experience from different customer projects on energy solutions.

Table 24 Energy Blockchain related Expert Interview Insights on High-Priority Topics

Topic	Key statements (condensed and/or paraphrased)
Comfort in Setup and Usage	In exchange with end users, it might be important to not emphasize how it works, but which problems it solves and what are the benefits from a user's perspective. Provide documentation and step-by-step guidelines for companies to deploy their technologies.
Economic Benefits	Solution avoids risk of vendor-lock-in effect, and benefits from network effect (community). Coordinated by a non-profit organization.
Environmental Benefits	Compared to other Blockchains relatively low energy demand. Activities to incentivize the use of renewable energy sources by the validators and participants.
Privacy Concerns	Handling of potential concerns: Encryption for personal data, zero-knowledge proofs, encrypted data messaging.
Trust in Providers/Operators	Driven by maturity of offered technology, and how well documented and maintained the technology is.
Time Savings	Re-use of components prevents from developing everything from the start.
Interoperability	Trying to make technology standard agnostic and independent from specific data schemes and architectures. Can run both on local servers and in a cloud architecture.
Safety during Setup/Usage	Provides opportunity to gain experience in experimenting within a controlled environment, conduct quality assurance (QA) testing, use dummy data etc.
Business Model Transparency	Transparency of the solution is determined by how well documented the technology is. The business model transparency itself depends on the concrete use case.
Knowledge Gain	Not applicable.

4.3.2 Technologies for Flexibility in Prosumer's Environment (WP4)

The aim of WP 4 is the development of technologies that can calculate flexibility and provide these calculations to the energy market. The information can be used for both manual decisions and for triggering automated action in buildings and energy assets (in the form of dispatching flexibility if there is a request from the market). Here, the development of NILM Algorithms will be also included. The interview partners were two project managers of Hypertech, one working in the domain of DR and smart grid technologies for five years, and one working in the domain of reliable power systems and demand-response for more than five years.

Table 25 Prosumer Technologies related Expert Interview Insights on High-Priority Topics

Topic	Key statements (condensed and/or paraphrased)
Comfort in Setup and Usage	Comfort constraints are incorporated into the optimization problem. User is allowed to override actions. Easy setup and no need to install additional devices by just scanning a QR-code (QR code to be developed within WP3).
Economic Benefits	No direct compensation for end users in the project, but economic benefits are usually a part of providing DR.
Environmental Benefits	Benefits usually achieved as a consequence of demand-response technology, as it seeks to limit use of non-renewable electricity use.
Privacy Concerns	Solution itself does only collect anonymized data. Pilot partners might collect other data during the project (e.g. on UX)
Trust in Providers/Operators	In the project, trust building will happen before the actual user involvement. The software itself is not open source, but the functionality and how the end user can be affected will be explained in general terms.
Time Savings	Meaningful demand-response cannot be done manually; so the use of such technology is not an alternative to a conventional procedure. Thus, the technology is not considered "time saving".
Interoperability	Followed as one of the most generic requirements of the project. The interoperability for end-users will be fostered by easier integration of devices by just scanning a QR-code (QR code to be developed within WP3).
Safety during Setup/Usage	Setup will have to be made during a visit from a technician or project representative in the course of OPENTUNITY. No actual safety problems are expected for the users of the system.
Business Model Transparency	The WP itself is not doing business models. However, there are many opportunities for business models in the context of the OPENTUNITY technologies. The business models of the service provider is considered relevant for end users, not the business model of the software provider.
Knowledge Gain	Users can theoretically gain a lot of knowledge during usage. However, end users need to be motivated and training workshops might be required.

4.3.3 Technologies for Grid Operators (WP5)

The aim of the WP is the provision of the required technology to grid operators for mainstreaming local flexibility provision. This Work Package will in general provide a powerful grid monitoring and control that will facilitate to know the grid status in real-time and analyze the flexibility necessities of the grid and kicking-off DR campaigns. Although the operation of the solutions is generally not noticeable to the end users, they provide them benefits like higher quality of supply and facilitates the integration of DER. The interview partners were a computer engineer who has been working with ETRA for 20 years, and an industrial engineer with a master's degree in energy management and 6 years of experience as project coordinator at ETRA.

Table 26 Grid Operator Technology related Expert Interview Insights on High-Priority Topics

Topic	Key statements (condensed and/or paraphrased)
Comfort in Setup and Usage	Front ends designed to support grid operators in their business; no actual "comfort" focus.
Economic Benefits	Flexibility expected to be associated with economic benefits for both grid operators and end users (when they participate in DR campaigns).
Environmental Benefits	The tool will facilitate the installation of more distributed (renewable) energy sources.
Privacy Concerns	Data about energy consumption is already available in the facilities of the system operators and they will be only used for a different purpose.
Trust in Providers/Operators	Use of certified smart meters for the state estimation algorithms ensures that the main piece of hardware including its firmware is safe.
Time Savings	Time savings are not a key aspect of the solution developed within WP5 in OPENTUNITY.
Interoperability	For system operators, interoperability is fostered by using an open data format.
Safety during Setup/Usage	Every aspect of setup and usage is considered safe.
Business Model Transparency	Business Models from DSOs/TSOs will change thanks to the new roles that EU regulation wants to take and the technology to be developed.
Knowledge Gain	Insights derived during the app usage can potentially foster knowledge and improve understanding for the DSO employees.

4.4 Outlook on User Acceptance and User Experience related Work in OPENTUNITY

As it became clear in the course of the literature research and the multi-stage expert procedure, the focus with regard to User Acceptance and User Experience will be on aspects closely linked to the concrete use of the technologies on a micro- and meso-level. The consideration of the broader socioeconomic context and impacts (macro level) will improve the understanding of how User Acceptance and User Experience are systematically embedded. This selection reflects the technological focus of OPENTUNITY and can be understood as a least common denominator that enables the user-related monitoring of the OPENTUNITY developments across different regions, use cases and user groups.

Despite the broadly supported consolidation, we expect that the relevance of the selected topics to vary across the different use cases and demos. To account for such differences in the empirical work, we will use both a core set of variables that will be monitored equally across all demos, and a set of activities that focus on the special features of the respective technologies and cases with reasonable detail. In order to adequately weight the topics for the respective use cases and demos, we will estimate their empirical relevance for the respective user groups (e.g. by a Conjoint analysis or a discrete choice experiment).

As set out in the proposal, the User Acceptance and User Experience related work in the project aims at understanding the most important push- and pull-factors for the acceptance and adoption of solutions under development. Besides the general measurement and analysis of relevant variables that might foster or hinder the acceptance and adoption, a thorough look at the subgroup level will be decisive for understanding the most critical factors for a just, successful and broad rollout of OPENTUNITY technologies.

5 Discussion and Conclusion

This report sets the boundary conditions and defines key research areas for the OPENTUNITY project. It is based on a literature review analyzing the state of the art in the area of standardization, business models, and user acceptance regarding theories, methods, and topics most relevant for OPENTUNITY. These first results were refined with the insights and knowledge of the project partners (survey, interviews with demo sites, and tool developers).

The current status in these areas is described, pointing out areas where a special focus should be laid upon as part of OPENTUNITY. This refers to the following topics:

- Overcoming technical barriers (e.g. lack of smart metering data)
- Identification of standardization needs and active contributions toward this goal
- Analysis of regulatory barriers (e.g. lack of regulation)
- Financial settlement between aggregators and end-consumers
- Quantification of economic benefits
- Delivering a comprehensive understanding of the role and relevance of high-priority topics in different use cases and user groups
- Develop an actionable and replicable strategy that supports user acceptance and user experience in the development and rollout of smart energy solutions.

Regarding user engagement, a strong focus will be laid on aspects closely linked to the concrete use of the technologies rather than examining the broader socioeconomic context (e.g. society-wide social impacts). User Acceptance and UX research approach in OPENTUNITY will be designed to cover both a holistic view across the demos, as well as a reasonable degree of detail regarding specific features of solutions and use cases.

Quite similarly, the economic assessment will focus on the actual OPENTUNITY demo set-up and tools and benefits for the involved actors (DSO/TSO and aggregators). In general, the different role of actors in the proposed business models is an area of interest that will be further analyzed as part of this project. Preliminary business models canvases are already presented in this report and set the basis for further economic analysis.

Regarding standardization, a comprehensive list of relevant standards was collected, and standards that need improvement were identified. No standards were found regarding the topics “flexibility market and market design” as well as “Remuneration schemes for local energy and flexibility markets”, which could be identified as a possible gap and will be in detail considered in the next steps. Moreover, IEC 62746 “Systems interface between customer energy management system and the power management system” (Energy Management Systems) contains several published and under development parts, where OPENTUNITY contribution might be valuable. OPENTUNITY results might also be useful to contribute to a future review of the TR or new Standards on the topic of the technical report ISO/IEC TR 30176:2021 ED1 “Internet of Things (IoT) - Integration of IoT and DLT/blockchain.

This report presents an observation of the current status of the three topics. Any development in the area will be thoroughly followed throughout OPENTUNITY.

6 References

6.1 Norms and Regulations

CEN Website (www.cen.eu)

CENELEC Website (www.cenelec.eu)

ISO Website (www.iso.org)

IEC Website (www.iec.ch)

EUR-Lex (eur-lex.europa.eu)

European Commission website (<https://energy.ec.europa.eu/>)

European Commission Mandate database
(ec.europa.eu/enterprise/standards_policy/mandates/database)

European Commission Energy website (ec.europa.eu/energy/en/topics/energy-efficiency)

6.2 Business Models and User Experience related References

[1] BestRES, „Existing business models for renewable energy,“ http://bestres.eu/wp-content/uploads/2016/08/BestRES_Existing-business-models-for-RE-aggregators.pdf, 2016.

[2] SmartSPIN, „D2.1 - REVIEW OF EXISTING BUSINESS MODELS FOR SMART ENERGY SERVICES,“ <https://www.smartspin.eu/wp-content/uploads/2022/07/SmartSPIN-D2.1-Review-of-existing-business-models-for-SES.pdf>, 2020.

[3] M. Hamwi, I. Lizarralde und J. Legardeur, „Demand response business model canvas: A tool for flexibility creation in the electricity markets,“ <https://www.sciencedirect.com/science/article/pii/S0959652620345832>, 2021.

[4] V2MARKET, „D2.3 Value Proposition Canvas,“ <https://v2market-project.eu/wp-content/uploads/2022/07/D2.3-Value-Proposition-Canvas.pdf>, 2022.

[5] D. Fioriti und Frangioni, A., „Optimal sizing of energy communities with fair revenue sharing and exit clauses: Value, role and business model of aggregators and users,“ <https://www.sciencedirect.com/science/article/pii/S0306261921007376>, 2021.

[6] F. Farrukh und B. Pellerin, „Business ecosystem of local flexibility platforms with corresponding business models in a digital energy system,“ <https://ieeexplore.ieee.org/document/9830297>, 2022.

[7] BRIDGE, „General Assembly - CONCLUSION AND NEXT STEPS,“ https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu/sites/default/files/download/BRIDGE%202023%20GA%20-%20Conclusions_FINAL%20VERSION.pdf, 2023.

[8] ETSI, „Smart Applications REFerence (SAREF) ontology“, <https://saref.etsi.org/>, [Accessed 2023]

-
- [9] oneM2M, „oneM2M – The IOT standard”, <https://www.onem2m.org/>, [Accessed 2023]
- [10] DRIMPAC project, „D5.3 - Policy and market reform recommendations v.1,“ <https://www.drimpac-h2020.eu/wp-content/uploads/2020/10/D5.3-Policy-market-reform-recommendations-report.pdf>, 2020.
- [11] S. Chondrogiannis, J. Vasiljevskaja, A. Marinopoulos, I. Papaioannou und G. Flego, „Local Electricity Flexibility Markets in Europe,“ https://publications.jrc.ec.europa.eu/repository/bitstream/JRC130070/JRC130070_01.pdf, 2022.
- [12] smartEN, „Recommendations for Electricity Market,“ https://smarten.eu/wp-content/uploads/2022/12/FINAL-smartEn_EMD_PositionPaper-1.pdf, 2022.
- [13] G. Küpper, S. Hadush, A. Jakeman und K. Staschus, „ASSET Study on Regulatory priorities for enabling Demand Side Flexibility,“ <https://op.europa.eu/en/publication-detail/-/publication/38fbccf2-35de-11eb-b27b-01aa75ed71a1/language-en>, 2020.
- [14] F. Bovera, M. Delfanti und E. Fumagalli, „TOTEX approach for regulating electricity distribution networks: a comparison of UK and Italy initiatives,“ 2020.
- [15] BRIDGE, „General Assembly 2023 - Conclusions and next steps,“ https://bridge-smart-grid-storage-systems-digital-projects.ec.europa.eu/sites/default/files/download/BRIDGE%202023%20GA%20-%20Conclusions_FINAL%20VERSION.pdf, 2023.
- [16] Mordor Intelligence, „ADVANCED DISTRIBUTION MANAGEMENT SYSTEM MARKET SIZE & SHARE ANALYSIS - GROWTH TRENDS & FORECASTS (2023 - 2028),“ <https://www.mordorintelligence.com/industry-reports/advanced-distribution-management-system-market>.
- [17] Internationales Energy Agency, „Digitalization & Energy,“ <https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf>, 2017.
- [18] ENTEC, „Digitalisation of Energy Flexibility,“ <https://op.europa.eu/en/publication-detail/-/publication/c230dd32-a5a2-11ec-83e1-01aa75ed71a1/language-en>, 2022.
- [19] E. M. Rogers, Diffusion of innovations, 4th ed. New York: Free Press, 1995.
- [20] N. El Malouf, 'Diffusion of Innovations', in Theoryhub Book, 1st ed., S. Papagiannidis, Ed., Newcastle upon Tyne, 2022. [Online]. Available: <https://open.ncl.ac.uk/theory-library/TheoryHubBook.pdf>
- [21] P. Lai, 'The literature review of technology adoption models and theories for the novelty technology', JISTEM, vol. 14, no. 1, pp. 21–38, Jun. 2017, doi: 10.4301/S1807-17752017000100002.
- [22] I. Sahin, 'Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers' Theory', TOJET, vol. 5, no. 2, pp. 14–23, 2006.
-

-
- [23] F. Davis D., 'A Technology Acceptance Model for empirical testing new end-user information systems: theory and results'. Massachusetts Institute of Technology, 1985.
- [24] D. Marikyan and S. Papagiannidis, 'Technology Acceptance Model', in Theoryhub Book, 1st ed., S. Papagiannidi, Ed., <https://open.ncl.ac.uk/theory-library/TheoryHubBook.pdf>, 2022.
- [25] D. L. Goodhue and R. L. Thompson, 'Task-Technology Fit and Individual Performance', *MIS Quarterly*, vol. 19, no. 2, p. 213, Jun. 1995, doi: 10.2307/249689.
- [26] D. Marikyan and S. Papagiannidis, 'Task-Technology Fit', in Theoryhub Book, 1st ed., S. Papagiannidis, Ed., Newcastle upon Tyne, 2022. [Online]. Available: <https://open.ncl.ac.uk/theory-library/TheoryHubBook.pdf>
- [27] Venkatesh, Morris, Davis, and Davis, 'User Acceptance of Information Technology: Toward a Unified View', *MIS Quarterly*, vol. 27, no. 3, p. 425, 2003, doi: 10.2307/30036540.
- [28] D. Marikyan and S. Papagiannidis, 'Unified Theory of Acceptance and Use of Technology', in Theoryhub Book, 1st ed., S. Papagiannidis, Ed., Newcastle upon Tyne, 2022. [Online]. Available: <https://open.ncl.ac.uk/theory-library/TheoryHubBook.pdf>
- [29] A. Lowe, A. C. Norris, A. J. Farris, and D. R. Babbage, 'Quantifying Thematic Saturation in Qualitative Data Analysis', *Field Methods*, vol. 30, no. 3, pp. 191–207, Aug. 2018, doi: 10.1177/1525822X17749386.
- [30] G. Alkaws, N. Ali, and Y. Baashar, 'The Moderating Role of Personal Innovativeness and Users Experience in Accepting the Smart Meter Technology', *Applied Sciences*, vol. 11, no. 8, p. 3297, Apr. 2021, doi: 10.3390/app11083297.
- [31] R. Bertoldo, M. Poumadère, and L. C. Rodrigues Jr., 'When meters start to talk: The public's encounter with smart meters in France', *Energy Research & Social Science*, vol. 9, pp. 146–156, Sep. 2015, doi: 10.1016/j.erss.2015.08.014.
- [32] M. Goulden, B. Bedwell, S. Rennick-Egglestone, T. Rodden, and A. Spence, 'Smart grids, smart users? The role of the user in demand side management', *Energy Research & Social Science*, vol. 2, pp. 21–29, Jun. 2014, doi: 10.1016/j.erss.2014.04.008.
- [33] W. Li, T. Yigitcanlar, I. Erol, and A. Liu, 'Motivations, barriers and risks of smart home adoption: From systematic literature review to conceptual framework', *Energy Research & Social Science*, vol. 80, p. 102211, Oct. 2021, doi: 10.1016/j.erss.2021.102211.
- [34] E. O'Dwyer, I. Pan, S. Acha, and N. Shah, 'Smart energy systems for sustainable smart cities: Current developments, trends and future directions', *Applied Energy*, vol. 237, pp. 581–597, Mar. 2019, doi: 10.1016/j.apenergy.2019.01.024.
- [35] B. K. Sovacool and D. D. Furszyfer Del Rio, 'Smart home technologies in Europe: A critical review of concepts, benefits, risks and policies', *Renewable and Sustainable Energy Reviews*, vol. 120, p. 109663, Mar. 2020, doi: 10.1016/j.rser.2019.109663.
- [36] C. Wilson, T. Hargreaves, and R. Hauxwell-Baldwin, 'Benefits and risks of smart home technologies', *Energy Policy*, vol. 103, pp. 72–83, Apr. 2017, doi: 10.1016/j.enpol.2016.12.047.
-

- [37] J. Gomez-Vilardebo and D. Gündüz, 'Smart Meter Privacy for Multiple Users in the Presence of an Alternative Energy Source', 2014, doi: 10.48550/ARXIV.1408.0213.
- [38] E. McKenna, I. Richardson, and M. Thomson, 'Smart meter data: Balancing consumer privacy concerns with legitimate applications', *Energy Policy*, vol. 41, pp. 807–814, Feb. 2012, doi: 10.1016/j.enpol.2011.11.049.
- [39] C. Rottondi, G. Verticale, and A. Capone, 'Privacy-preserving smart metering with multiple data Consumers', *Computer Networks*, vol. 57, no. 7, pp. 1699–1713, May 2013, doi: 10.1016/j.comnet.2013.02.018.
- [40] G. P. J. Verbong, S. Beemsterboer, and F. Sengers, 'Smart grids or smart users? Involving users in developing a low carbon electricity economy', *Energy Policy*, vol. 52, pp. 117–125, Jan. 2013, doi: 10.1016/j.enpol.2012.05.003.
- [41] K. T. Raimi and A. R. Carrico, 'Understanding and beliefs about smart energy technology', *Energy Research & Social Science*, vol. 12, pp. 68–74, Feb. 2016, doi: 10.1016/j.erss.2015.12.018.

7 Annex 1 List of identified Standards (CEN-CLC-ETSI-ISO-IEC-ITU)

7.1 Smart Grids

7.1.1 List of Standards

Document reference	Title	Subtopic
ISO 50006:2014	Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI) — General principles and guidance	Baseline Calculation
HD 60364-8-2:2018 + A11:2019 + A12:2021	Low-voltage electrical installations - Part 8-2: Prosumer's low-voltage electrical installations	Prosumers electrical installations
IEC 60364-8-82:2022	Low-voltage electrical installations - Part 8-82: Functional aspects - Prosumer's low-voltage electrical installations	Prosumers electrical installations
EN 60447:2004	Basic and safety principles for man-machine interface, marking and identification - Actuating principles	Prosumers electrical installations
EN 60529:1991	Degrees of protection provided by enclosures (IP Code)	Prosumers electrical installations
EN 60670-21:2007	Boxes and enclosures for electrical accessories for household and similar fixed electrical installations -- Part 21: Particular requirements for boxes and enclosures with provision for suspension means	Prosumers electrical installations
EN 60715:2017	Dimensions of low-voltage switchgear and controlgear - Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories	Prosumers electrical installations
EN 60898-1:2019	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation	Prosumers electrical installations
EN 60898-2:2021	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 2: Circuit-breakers for a.c. and d.c. operation	Prosumers electrical installations
EN 50090-1:2011	Home and Building Electronic Systems (HBES) - Part 1: Standardization structure	Home and Building Electronic Systems (HBES)

EN 50090-3-1:1994	HOME AND BUILDING ELECTRONIC SYSTEMS (HBES). PART 3-1: ASPECTS OF APPLICATION. INTRODUCTION TO THE APPLICATION STRUCTURE.	Home and Building Electronic Systems (HBES)
EN 50090-3-2:2004	Home and Building Electronic Systems (HBES) -- Part 3-2: Aspects of application - User process for HBES Class 1	Home and Building Electronic Systems (HBES)
EN 50090-3-3:2009	Home and Building Electronic Systems (HBES) -- Part 3-3: Aspects of application - HBES Interworking model and common HBES data types	Home and Building Electronic Systems (HBES)
EN 50090-3-4:2017 + AC:2018-05	Home and Building Electronic Systems (HBES) - Part 3-4: Secure Application Layer, Secure Service, Secure configuration and security Resources	Home and Building Electronic Systems (HBES)
EN 50090-4-1:2004	Home and Building Electronic Systems (HBES) -- Part 4-1: Media independent layers - Application layer for HBES Class 1	Home and Building Electronic Systems (HBES)
EN 50090-4-2:2004	Home and Building Electronic Systems (HBES) -- Part 4-2: Media independent layers - Transport layer, network layer and general parts of data link layer for HBES Class 1	Home and Building Electronic Systems (HBES)
EN 50090-4-3:2015	Home and Building Electronic Systems (HBES) - Part 4-3: Media independent layers - Communication over IP (EN 13321-2)	Home and Building Electronic Systems (HBES)
EN 50090-5-1:2020	Home and Building Electronic Systems (HBES) - Part 5-1: Media and media dependent layers - Power line for HBES Class 1	Home and Building Electronic Systems (HBES)
EN 50090-5-2:2020	Home and Building Electronic Systems (HBES) Part 5-2: Media and media dependent layers - Network based on HBES Class 1, Twisted Pair	Home and Building Electronic Systems (HBES)
EN 50090-5-3:2016	Home and Building Electronic Systems (HBES) - Part 5-3: Media and media dependent layers - Radio Frequency for HBES Class 1	Home and Building Electronic Systems (HBES)
EN 50090-6-1:2017	Home and Building Electronic Systems (HBES) - Part 6-1: Interfaces - Webservice interface	Home and Building Electronic Systems (HBES)
EN 50090-6-2:2021	Home and Building Electronic Systems (HBES)- Part 6-2 IoT Semantic Ontology model description	Home and Building Electronic Systems (HBES)
EN 50090-6-3:2023	Home and Building Electronic Systems (HBES) - Part 6-3: 3rd Party HBES IoT API	Home and Building Electronic Systems (HBES)

D2.2 Standardization landscape and socioeconomic context

EN 50090-7-1:2004	Home and Building Electronic Systems (HBES) -- Part 7-1: System management - Management procedures	Home and Building Electronic Systems (HBES)
EN 50631-1:2023	Household appliances network and grid connectivity - Part 1: General Requirements, Generic Data Modelling and Neutral Messages	Household appliances network and grid connectivity
EN 50631-2:2023	Household appliances network and grid connectivity - Part 2: Product Specific Mappings, Details, Requirements and Deviations	Household appliances network and grid connectivity
EN 50631-3-1:2023	Household appliances network and grid connectivity - Part 3-1: Specific Data Model Mapping: SPINE and SPINE-IoT	Household appliances network and grid connectivity
EN 50631-4-1:2023	Household appliances network and grid connectivity - Part 4-1: Communication Protocol Specific Aspects: SPINE, SPINE-IoT and SHIP	Household appliances network and grid connectivity
EN ISO 16484-5:2022	Building automation and control systems (BACS) - Part 5: Data communication protocol	Home and Building Electronic Systems (HBES)
ISO/IEC TR 15067-3-2:2016	Information technology — Home Electronic System (HES) application model — Part 3-2: GridWise interoperability context-setting framework	Home and Building Electronic Systems (HBES)
ISO/IEC TR 15067-3-7:2020	Information technology — Home Electronic System (HES) application model — Part 3-7: GridWise transactive energy systems research, development and deployment roadmap	Home and Building Electronic Systems (HBES)
ISO/IEC TR 15067-3-8:2020	Information technology — Home Electronic System (HES) application model — Part 3-8: GridWise transactive energy framework	Home and Building Electronic Systems (HBES)
IEC TS 60364-8-3:2020	Low-voltage electrical installations - Part 8-3 : Functional aspects - Operation of prosumer's electrical installations	Prosumers electrical installations
IEC TR 63097:2017	Smart grid standardization roadmap	Smart Grids (General)
IEC SRD 63200:2021	Definition of extended SGAM smart energy grid reference architecture model	SGAM

7.1.2 Standards under development

Document reference	Title	Subtopic
ISO 50006	Energy management systems — Evaluating energy performance using energy performance indicators and energy baselines	Baseline Calculation
prEN 50090-4-4	Home and Building Electronic Systems (HBES)- Part -4-4 HBES IoT Point API	Home and Building Electronic Systems (HBES)
EN 50491-12-1:2018	General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Smart grid - Application specification - Interface and framework for customer - Part 12-1: Interface between the CEM and Home/Building Resource manager - General Requirements and Architecture	Home and Building Electronic Systems (HBES)
EN 50491-12-2:2022	General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 12-2: Smart grid - Application specification - Interface and framework for customer - Interface between the Home / Building CEM and Resource manager(s) - Data model and messaging	Home and Building Electronic Systems (HBES)

7.2 Smart Meters

7.2.1 List of Standards

Document reference	Title	Subtopic
EN 62056-1-0:2015	Electricity metering data exchange - The DLMS/COSEM suite - Part 1-0: Smart metering standardization framework	Meter management data
EN IEC 62056-3-1:2021	Electricity metering data exchange - The DLMS/COSEM suite - Part 3-1: Use of local area networks on twisted pair with carrier signalling	Meter management data
EN 62056-4-7:2016	Electricity metering data exchange - The DLMS/COSEM suite - Part 4-7: DLMS/COSEM transport layer for IP networks	Meter management data
EN 62056-5-3:2017	Electricity metering data exchange - The DLMS/COSEM suite - Part 5-3: DLMS/COSEM application layer	Meter management data

D2.2 Standardization landscape and socioeconomic context

EN 62056-6-1:2017	Electricity metering data exchange - The DLMS/COSEM suite - Part 6-1: Object Identification System (OBIS)	Meter management	data
EN IEC 62056-6-2:2018	Electricity metering data exchange - The DLMS/COSEM suite - Part 6-2: COSEM interface classes	Meter management	data
EN 62056-7-3:2017	Electricity metering data exchange - The DLMS/COSEM suite - Part 7-3: Wired and wireless M-Bus communication profiles for local and neighbourhood networks	Meter management	data
EN 62056-7-5:2016	Electricity metering data exchange - The dlms/cosem suite - Part 7-5: Local data transmission profiles for Local Networks (LN)	Meter management	data
EN 62056-7-6:2013	Electricity metering data exchange - The DLMS/COSEM suite - Part 7-6: The 3-layer, connection-oriented HDLC based communication profile	Meter management	data
EN 62056-8-3:2013	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-3: Communication profile for PLC S-FSK neighbourhood networks	Meter management	data
EN IEC 62056-8-4:2019	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-4: Communication profiles for narrow-band OFDM PLC PRIME neighbourhood networks	Meter management	data
EN 62056-8-5:2017 + AC:2018-01	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-5: Narrow-band OFDM G3-PLC communication profile for neighbourhood networks	Meter management	data
EN 62056-8-6:2017	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-6: High speed PLC ISO/IEC 12139-1 profile for neighbourhood networks	Meter management	data
EN IEC 62056-8-8:2020	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-8: Communication profile for ISO/IEC 14908 series networks	Meter management	data
EN 62056-9-7:2013	Electricity metering data exchange - The DLMS/COSEM suite - Part 9-7: Communication profile for TCP-UDP/IP networks	Meter management	data
EN 62056-21:2002	Electricity metering - Data exchange for meter reading, tariff and load control -- Part 21: Direct local data exchange	Meter management	data
EN 62056-42:2002	Electricity metering - Data exchange for meter reading, tariff and load control -- Part 42: Physical layer services and procedures for connection-oriented asynchronous data exchange	Meter management	data
EN 62056-46:2002 + A1:2007	Electricity metering - Data exchange for meter reading, tariff and load control -- Part 46: Data link layer using HDLC protocol	Meter management	data

D2.2 Standardization landscape and socioeconomic context

EN 13757-1:2021	Communication systems for meters - Part 1: Data exchange	Sensing devices for NILM systems
EN 13757-2:2018	Communication systems for meters - Part 2: Wired M-Bus communication	Sensing devices for NILM systems
EN 13757-3:2018	Communication systems for meters - Part 3: Application protocols	Sensing devices for NILM systems
EN 13757-4:2019	Communication systems for meters - Part 4: Wireless M-Bus communication	Sensing devices for NILM systems
EN 13757-5:2015	Communication systems for meters - Part 5: Wireless M-Bus relaying	Sensing devices for NILM systems
EN 13757-7:2018	Communication systems for meters - Part 7: Transport and security services	Sensing devices for NILM systems
IEC TS 62056-1-1:2016	Electricity metering data exchange - The DLMS/COSEM suite - Part 1-1: Template for DLMS/COSEM communication profile standards	Meter management data
IEC TS 62056-6-9:2016	Electricity metering data exchange - The DLMS/COSEM suite - Part 6-9: Mapping between the Common Information Model message profiles (IEC 61968-9) and DLMS/COSEM (IEC 62056) data models and protocols	Meter management data
IEC TS 62056-8-20:2016	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-20: Mesh communication profile for neighbourhood networks	Meter management data
IEC TS 62056-9-1:2016	Electricity metering data exchange - The DLMS/COSEM suite - Part 9-1: Communication profile using web-services to access a DLMS/COSEM server via a COSEM Access Service (CAS)	Meter management data
IEC TS 62056-41:1998	Electricity metering - Data exchange for meter reading, tariff and load control - Part 41: Data exchange using wide area networks: Public switched telephone network (PSTN) with LINK+ protocol	Meter management data
IEC TS 62056-51:1998	Electricity metering - Data exchange for meter reading, tariff and load control - Part 51: Application layer protocols	Meter management data
IEC TS 62056-52:1998	Electricity metering - Data exchange for meter reading, tariff and load control - Part 52: Communication protocols management distribution line message specification (DLMS) server	Meter management data
IEC TS 62786:2017	Distributed energy resources connection with the grid	Prosumers electrical installations

IEC TS 63297	Sensing devices for NILM systems	Sensing devices for NILM systems
ETSI TS 103 264 V3.1.1 (2020-02)	SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping	Meter management data
TR 50572:2011	Functional reference architecture for communications in smart metering systems	Meter management data

7.2.2 Standards under development

Document reference	Title	Subtopic
prEN IEC 62056-5-3:2021	Electricity metering data exchange - The DLMS®/COSEM suite - Part 5-3: DLMS®/COSEM application layer	Meter management data
prEN IEC 62056-6-1:2021	Electricity metering data exchange - The DLMS/COSEM suite - Part 6-1: Object Identification System (OBIS)	Meter management data
prEN IEC 62056-6-2:2021	Electricity metering data exchange - The DLMS®/COSEM suite - Part 6-2: COSEM interface classes	Meter management data
prEN IEC 62056-8-11	Electricity metering data exchange – The DLMS/COSEM suite – Part 8-11: Communication profile for Wi-SUN field area mesh networks	Meter management data
prEN IEC 62056-8-12:2022	Electricity metering data exchange – The DLMS/COSEM suite - Part 8-12: Communication profile for Low Power Wide Area Networks (LPWAN)	Meter management data
EN 13757-2:2018/prA1	Communication systems for meters - Part 2: Wired M-Bus communication	Sensing devices for NILM systems
prEN 13757-3	Communication systems for meters - Part 3: Application protocols	Sensing devices for NILM systems
prEN 13757-7	Communication systems for meters - Part 7: Transport and security services	Sensing devices for NILM systems
FprEN 13757-8	Communication systems for meters - Part 8: Adaptation layer	Sensing devices for NILM systems

7.3 Power systems management and associated information exchange.

7.3.1 List of Standards

Document reference	Title	Subtopic
ISO/IEC 15067-3:2012	Information technology — Home Electronic System (HES) application model — Part 3: Model of a demand-response energy management system for HES	Energy Management systems
ISO/IEC 15067-3-3:2019	Information technology — Home Electronic System (HES) application model — Part 3-3: Model of a system of interacting Energy Management Agents (EMAs) for demand response energy management	Energy Management systems
EN ISO 50001:2018	Energy management systems - Requirements with guidance for use	Energy Management systems
EN 61850-3:2014	Communication networks and systems for power utility automation - Part 3: General requirements	Communication networks and systems for power utility automation
EN 61850-4:2011 + A1:2020	Communication networks and systems for power utility automation - Part 4: System and project management	Communication networks and systems for power utility automation
EN 61850-5:2013 + A1:2022	Communication networks and systems for power utility automation - Part 5: Communication requirements for functions and device models	Communication networks and systems for power utility automation
EN 61850-6:2010 + A1:2018	Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in electrical substations related to IEDs	Communication networks and systems for power utility automation
EN 61850-7-1:2011 + A1:2020	Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

EN 61850-7-2:2010 + A1:2020	Communication networks and systems for power utility automation -- Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)	Communication networks and systems for power utility automation
EN 61850-7-3:2011 + A1:2020	Communication networks and systems for power utility automation -- Part 7-3: Basic communication structure - Common data classes	Communication networks and systems for power utility automation
EN 61850-7-4:2010 + A1:2020	Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data classes	Communication networks and systems for power utility automation
EN IEC 61850-7-420:2021	Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources and distribution automation logical nodes	Communication networks and systems for power utility automation
EN 61850-8-1:2011 + A1:2020	Communication networks and systems for power utility automation -- Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3	Communication networks and systems for power utility automation
EN IEC 61850-8-2:2019	Communication networks and systems for power utility automation - Part 8-2: Specific communication service mapping (SCSM) - Mapping to Extensible Messaging Presence Protocol (XMPP)	Communication networks and systems for power utility automation
EN 61850-9-2:2011 + A1:2020	Communication networks and systems for power utility automation - Part 9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3	Communication networks and systems for power utility automation
IEC/IEEE 61850-9-3:2016	Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation	Communication networks and systems for power utility automation
EN 61850-10:2013	Communication networks and systems for power utility automation - Part 10: Conformance testing	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

EN IEC 61968-3:2021	Application integration at electric utilities - System interfaces for distribution management - Part 3: Interface for network operations	Energy Management systems
EN IEC 61968-4:2019	Application integration at electric utilities - System interfaces for distribution management - Part 4: Interfaces for records and asset management	Energy Management systems
EN IEC 61970-301:2020 + A1:2022	Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base	Energy Management systems
EN IEC 61970-302:2018	Energy management system application program interface (EMS-API) - Part 302: Common information model (CIM) dynamics	Energy Management systems
EN IEC 61970-452:2021	Energy management system application program interface (EMS-API) - Part 452: CIM static transmission network model profiles	Energy Management systems
EN 61970-453:2014 + A1:2019	Energy management system application program interface (EMS-API) - Part 453: Diagram layout profile	Energy Management systems
EN IEC 61970-456:2022	Energy management system application program interface (EMS-API) - Part 456: Solved power system state profiles	Energy Management systems
EN IEC 61970-457:2021	Energy management system application program interface (EMS-API) - Part 457: Dynamics profile	Energy Management systems
EN 61970-552:2016	Energy management system application program interface (EMS-API) - Part 552: CIMXML Model exchange format	Energy Management systems

D2.2 Standardization landscape and socioeconomic context

EN IEC 62325-301:2018	Framework for energy market communications - Part 301: Common information model (CIM) extensions for markets	Framework for energy market communications
EN 62325-351:2016	Framework for energy market communications - Part 351: CIM European market model exchange profile	Framework for energy market communications
EN 62325-450:2013	Framework for energy market communications - Part 450: Profile and context modelling rules	Framework for energy market communications
EN 62325-451-1:2017	Framework for energy market communications - Part 451-1: Acknowledgement business process and contextual model for CIM European market	Framework for energy market communications
EN 62325-451-2:2014 + AC:2016-08	Framework for energy market communications - Part 451-2: Scheduling business process and contextual model for CIM European market	Framework for energy market communications
EN 62325-451-3:2014 + A1:2017	Framework for energy market communications - Part 451-3: Transmission capacity allocation business process (explicit or implicit auction) and contextual models for European market	Framework for energy market communications
EN 62325-451-4:2017	Framework for energy market communications - Part 451-4: Settlement and reconciliation business process, contextual and assembly models for European market	Framework for energy market communications
EN 62325-451-5:2015	Framework for energy market communications - Part 451-5: Problem statement and status request business processes, contextual and assembly models for European market	Framework for energy market communications
EN IEC 62325-451-6:2018	Framework for energy market communications - Part 451-6: Publication of information on market, contextual and assembly models for European-style markets	Framework for energy market communications

D2.2 Standardization landscape and socioeconomic context

EN IEC 62325-451-7:2021	Framework for energy market communications - Part 451-7: Balancing processes, contextual and assembly models for European style market	Framework for energy market communications
EN IEC 62325-451-8:2022	Framework for energy market communications - Part 451-8: HVDC Scheduling process, contextual and assembly models for European style market	Framework for energy market communications
EN IEC 62325-451-10:2021	Framework for energy market communications - Part 451-10: Profiles for Energy Consumption Data ("My Energy Data")	Framework for energy market communications
EN IEC 62325-503:2018	Framework for energy market communications - Part 503: Market data exchanges guidelines for the IEC 62325-351 profile	Framework for energy market communications
EN 62351-3:2014 + A1:2018 + A2:2020	Power systems management and associated information exchange - Data and communications security - Part 3: Communication network and system security - Profiles including TCP/IP	Framework for energy market communications
EN IEC 62351-4:2018 + A1:2020	Power systems management and associated information exchange - Data and communications security - Part 4: Profiles including MMS and derivatives	Framework for energy market communications
EN IEC 62351-5:2023	Power systems management and associated information exchange - Data and communications security - Part 5: Security for IEC 60870-5 and derivatives	Framework for energy market communications
EN IEC 62351-6:2020	Power systems management and associated information exchange - Data and communications security - Part 6: Security for IEC 61850	Framework for energy market communications
EN 62351-7:2017	Power systems management and associated information exchange - Data and communications security - Part 7: Network and System Management (NSM) data object models	Framework for energy market communications

D2.2 Standardization landscape and socioeconomic context

EN IEC 62351-8:2020	Power systems management and associated information exchange - Data and communications security - Part 8: Role-based access control for power system management	Framework for energy market communications
EN 62351-9:2017	Power systems management and associated information exchange - Data and communications security - Part 9: Cyber security key management for power system equipment	Framework for energy market communications
EN 62351-11:2017	Power systems management and associated information exchange - Data and communications security - Part 11: Security for XML documents	Framework for energy market communications
IEC 62746-10-1:2018	Systems interface between customer energy management system and the power management system - Part 10-1: Open automated demand response	Energy Management systems
IEC 62746-10-3:2018	Systems interface between customer energy management system and the power management system - Part 10-3: Open automated demand response - Adapting smart grid user interfaces to the IEC common information model	Energy Management systems
IEC TR 62746-2:2015	Systems interface between customer energy management system and the power management system - Part 2: Use cases and requirements	Energy Management systems
IEC TS 62746-3:2015	Systems interface between customer energy management system and the power management system - Part 3: Architecture	Energy Management systems
IEC TR 61850-1:2013	Communication networks and systems for power utility automation - Part 1: Introduction and overview	Communication networks and systems for power utility automation
IEC TS 61850-1-2:2020	Communication networks and systems for power utility automation - Part 1-2: Guideline on extending IEC 61850	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

IEC TS 61850-1-2:2020/AMD1:2022	Amendment 1 - Communication networks and systems for power utility automation - Part 1-2: Guideline on extending IEC 61850	Communication networks and systems for power utility automation
IEC TS 61850-2:2019	Communication networks and systems for power utility automation - Part 2: Glossary	Communication networks and systems for power utility automation
IEC TR 61850-7-5:2021	Communication networks and systems for power utility automation - Part 7-5: IEC 61850 modelling concepts	Communication networks and systems for power utility automation
IEC TR 61850-7-6:2019	Communication networks and systems for power utility automation - Part 7-6: Guideline for definition of Basic Application Profiles (BAPs) using IEC 61850	Communication networks and systems for power utility automation
IEC TS 61850-7-7:2018 + AMD1:2023	Communication networks and systems for power utility automation - Part 7-7: Machine-processable format of IEC 61850-related data models for tools	Communication networks and systems for power utility automation
IEC TR 61850-7-500:2017	Communication networks and systems for power utility automation - Part 7-500: Basic information and communication structure - Use of logical nodes for modeling application functions and related concepts and guidelines for substations	Communication networks and systems for power utility automation
IEC TR 61850-10-3:2022	Communication networks and systems for power utility automation - Part 10-3: Functional testing of IEC 61850 systems	Communication networks and systems for power utility automation
IEC TS 61850-80-1:2016	Communication networks and systems for power utility automation - Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104	Communication networks and systems for power utility automation
IEC TR 61850-80-3:2015	Communication networks and systems for power utility automation - Part 80-3: Mapping to web protocols - Requirements and technical choices	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

IEC TS 61850-80-4:2016	Communication networks and systems for power utility automation - Part 80-4: Translation from the COSEM object model (IEC 62056) to the IEC 61850 data model	Communication networks and systems for power utility automation
IEC TR 61850-90-1:2010	Communication networks and systems for power utility automation - Part 90-1: Use of IEC 61850 for the communication between substations	Communication networks and systems for power utility automation
IEC TR 61850-90-2:2016	Communication networks and systems for power utility automation - Part 90-2: Using IEC 61850 for communication between substations and control centres	Communication networks and systems for power utility automation
IEC TR 61850-90-3:2016 + COR1:2020	Communication networks and systems for power utility automation - Part 90-3: Using IEC 61850 for condition monitoring diagnosis and analysis	Communication networks and systems for power utility automation
IEC TR 61850-90-4:2020	Communication networks and systems for power utility automation - Part 90-4: Network engineering guidelines	Communication networks and systems for power utility automation
IEC TR 61850-90-5:2012	Communication networks and systems for power utility automation - Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118	Communication networks and systems for power utility automation
IEC TR 61850-90-6:2018 + COR1:2020	Communication networks and systems for power utility automation - Part 90-6: Use of IEC 61850 for Distribution Automation Systems	Communication networks and systems for power utility automation
IEC TR 61850-90-7:2013	Communication networks and systems for power utility automation - Part 90-7: Object models for power converters in distributed energy resources (DER) systems	Communication networks and systems for power utility automation
IEC TR 61850-90-8:2016	Communication networks and systems for power utility automation - Part 90-8: Object model for E-mobility	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

IEC TR 61850-90-9:2020	Communication networks and systems for power utility automation - Part 90-9: Use of IEC 61850 for Electrical Energy Storage Systems	Communication networks and systems for power utility automation
IEC TR 61850-90-10:2017	Communication networks and systems for power utility automation - Part 90-10: Models for scheduling	Communication networks and systems for power utility automation
IEC TR 61850-90-11:2020	Communication networks and systems for power utility automation - Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications	Communication networks and systems for power utility automation
IEC TR 61850-90-12:2020	Communication networks and systems for power utility automation - Part 90-12: Wide area network engineering guidelines	Communication networks and systems for power utility automation
IEC TR 61850-90-13:2021	Communication networks and systems for power utility automation - Part 90-13: Deterministic networking technologies	Communication networks and systems for power utility automation
IEC TR 61850-90-14:2021	Communication networks and systems for power utility automation - Part 90-14: Using IEC 61850 for FACTS (flexible alternate current transmission systems), HVDC (high voltage direct current) transmission and power conversion data modelling	Communication networks and systems for power utility automation
IEC TR 61850-90-16:2021	Communication networks and systems in power utility automations - Part 90-16: Requirements of system management for Smart Energy Automation	Communication networks and systems for power utility automation
IEC TR 61850-90-17:2017	Communication networks and systems for power utility automation - Part 90-17: Using IEC 61850 to transmit power quality data	Communication networks and systems for power utility automation
CLC/TS 61970-2:2005	Energy management system application program interface (EMS-API) - Part 2: Glossary	Energy Management systems

D2.2 Standardization landscape and socioeconomic context

IEC TS 61970-555:2016	Energy management system application program interface (EMS-API) - Part 555: CIM based efficient model exchange format (CIM/E)	Energy Management systems
IEC TS 61970-556:2016	Energy management system application program interface (EMS-API) - Part 556: CIM based graphic exchange format (CIM/G)	Energy Management systems
IEC TR 62325-103:2017	Framework for energy market communications - Part 103: Review of information exchanges within the deregulated European style retail energy market from a CIM perspective	Communication networks and systems for power utility automation
IEC TS 62325-502:2005	Framework for energy market communications - Part 502: Profile of ebXML	Communication networks and systems for power utility automation
IEC TS 62351-1:2007	Power systems management and associated information exchange - Data and communications security - Part 1: Communication network and system security - Introduction to security issues	Communication networks and systems for power utility automation
IEC TS 62351-2:2008	Power systems management and associated information exchange - Data and communications security - Part 2: Glossary of terms	Communication networks and systems for power utility automation
IEC TS 62351-100-1:2018	Power systems management and associated information exchange - Data and communications security - Part 100-1: Conformance test cases for IEC TS 62351-5 and IEC TS 60870-5-7	Communication networks and systems for power utility automation
IEC TS 62351-100-3:2020	Power systems management and associated information exchange - Data and communications security - Part 100-3: Conformance test cases for the IEC 62351-3, the secure communication extension for profiles including TCP/IP	Communication networks and systems for power utility automation
IEC TS 62351-100-6:2022	Power systems management and associated information exchange - Data and communication security - Part 100-6: Cybersecurity conformance testing for IEC 61850-8-1 and IEC 61850-9-2	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

IEC TR 62351-10:2012	Power systems management and associated information exchange - Data and communications security - Part 10: Security architecture guidelines	Communication networks and systems for power utility automation
IEC TR 62351-12:2016	Power systems management and associated information exchange - Data and communications security - Part 12: Resilience and security recommendations for power systems with distributed energy resources (DER) cyber-physical systems	Communication networks and systems for power utility automation
IEC TR 62351-13:2016	Power systems management and associated information exchange - Data and communications security - Part 13: Guidelines on security topics to be covered in standards and specifications	Communication networks and systems for power utility automation
IEC TR 62351-90-1:2018	Power systems management and associated information exchange - Data and communications security - Part 90-1: Guidelines for handling role-based access control in power systems	Communication networks and systems for power utility automation
IEC TR 62351-90-2:2018	Power systems management and associated information exchange - Data and communications security - Part 90-2: Deep packet inspection of encrypted communications	Communication networks and systems for power utility automation
IEC TR 62351-90-3:2021	Power systems management and associated information exchange - Data and communications security - Part 90-3: Guidelines for network and system management	Communication networks and systems for power utility automation

7.3.2 Standards under development

Document reference	Title	Subtopic
prEN IEC 62746-4	Systems interface between customer energy management system and the power management system - Part 4: Demand Side Resource Interface	Energy Management Systems

D2.2 Standardization landscape and socioeconomic context

IEC TR 62746-2 ED2	Systems interface between customer energy management system and the power management system - Part 2: Use cases and requirements	Energy Management Systems
ISO/IEC 15067-3-30 ED1	Information technology - Home Electronic System (HES) application model - Part 3-30: EMA functional requirements and interfaces	Energy Management Systems
ISO/IEC 15067-3-31 ED1	Information technology - Home Electronic System (HES) application model - Part 3-31: Protocol of Energy Management Agents for demand response energy management and interactions among these agents	Energy Management Systems
ISO/IEC 15067-3-51 ED1	Information technology - Home Electronic System (HES) application model - Part 3-51: Framework of an On-Premises Narrow AI Engine for an Energy Management System using Energy Management Agents	Energy Management Systems
FprEN IEC 61970-302:2022	Energy management system application program interface (EMS-API) - Part 302: Common information model (CIM) dynamics	Energy Management systems
prEN IEC 61970-303	Energy Management System Application Program Interface (EMS-API) - Part 303: Common information model (CIM), Network Model Management	Energy Management systems
FprEN IEC 61970-457:2022	Energy management system application program interface (EMS-API) - Part 457: Dynamics profile	Energy Management systems
prEN IEC 61970-459	Energy Management System Application Program Interface (EMS-API) - Part 459: Framework for managing shared network model information	Energy Management systems
prEN IEC 61970-501	Energy management system application program interface (EMS-API) - Part 501: Common Information Model Resource Description Framework (CIM RDF) schema	Energy Management systems

D2.2 Standardization landscape and socioeconomic context

IEC 61850-6 ED3	Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in electrical substations related to IEDs	Communication networks and systems for power utility automation
prEN 61850-6-2	Communication networks and systems for power utility automation - Part 6-2: Configuration description language for extensions for human machine interfaces	Communication networks and systems for power utility automation
EN 61850-7-3:2011/prA2	Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes	Communication networks and systems for power utility automation
IEC TR 61850-7-6 ED2	Communication networks and systems for power utility automation - Part 7-6: Guideline for definition of Basic Application Profiles (BAPs) using IEC 61850	Communication networks and systems for power utility automation
IEC TR 61850-80-5 ED1	Communication networks and systems for power utility automation - Part 80-5: Guideline for mapping information between IEC 61850 and IEC 61158-6 (Modbus)	Communication networks and systems for power utility automation
IEC TS 61850-80-6 ED1	Communication networks and systems for power utility automation – Part 80-6: Using IEC 61850 for communication between substations and control centres	Communication networks and systems for power utility automation
IEC TS 61850-80-7 ED1	Communication networks and systems for power utility automation - Part 80-7: Communication services and data model to support IEC 61850 system management	Communication networks and systems for power utility automation
IEC TR 61850-90-7 ED2	Communication networks and systems for power utility automation - Part 90-7: Object models for power converters in distributed energy resources (DER) systems	Communication networks and systems for power utility automation
IEC TR 61850-90-19 ED1	Communication networks and systems for power utility automation - Part 90-19: Using Role Based Access Control (RBAC) and IEC 61850	Communication networks and systems for power utility automation

D2.2 Standardization landscape and socioeconomic context

PWI TR 61850-90-20 ED1	Communication networks and systems for power utility automation - Part 90-20: Guideline to redundancy systems	Communication networks and systems for power utility automation
IEC TR 61850-90-21 ED1	Communication networks and systems for power utility automation - Part 90-21: Travelling wave fault location	Communication networks and systems for power utility automation
IEC TR 61850-90-22 ED1	Communication networks and systems for power utility automation - Part 90-22: SCD based substation network auto-routing with visualization and supervision support	Communication networks and systems for power utility automation
IEC TR 61850-90-23 ED1	Communication networks and systems for power utility automation - Part 90-23: Use of IEC 61850 for microgrid systems	Communication networks and systems for power utility automation
IEC TR 61850-90-27 ED1	Communication networks and systems for power utility automation - Part 90-27: Use of IEC 61850 for thermal energy systems connected to electric power grid	Communication networks and systems for power utility automation
PWI 62325-452-1 ED1	Day Ahead Market	Framework for energy market communications
PWI 62325-452-4 ED1	Weather data to support market operations	Framework for energy market communications
PWI 62325-452-5 ED1	Communications with Demand Response Systems	Framework for energy market communications
PWI 62325-550-2 ED1	Common Dynamic Data Structures for DAM, RT, FTR	Framework for energy market communications

PWI 62325-552-1 ED1	Dynamic Data Structures for DAM	Framework for energy market communications
FprEN IEC 62351-3:2023	Power systems management and associated information exchange - Data and communications security - Part 3: Communication network and system security - Profiles including TCP/IP	Framework for energy market communications
prEN IEC 62351-7	Power systems management and associated information exchange - Data and communications security - Part 7: Network and System Management (NSM) data object models	Framework for energy market communications
FprEN IEC 62351-9:2023	Power systems management and associated information exchange - Data and communications security - Part 9: Cyber security key management for power system equipment	Framework for energy market communications
prEN IEC 62351-14	Power systems management and associated information exchange - Data and communications security - Part 14: Cyber security event logging	Framework for energy market communications
IEC TS 62351-100-4 ED1	Power systems management and associated information exchange - Data and communication security - Part 100-4: Cybersecurity conformance testing for IEC 62351-4	Framework for energy market communications

7.4 Information security, cybersecurity and privacy protection.

7.4.1 List of Standards

Document reference	Title	Subtopic
ISO 8000-117:2023	Data quality — Part 117: Application of ISO 8000-115 to identifiers in distributed ledgers including blockchains	Blockchain and distributed ledger technologies
EN ISO/IEC 15408-1:2020	Information technology - Security techniques - Evaluation criteria for IT security - Part 1: Introduction and general model (ISO/IEC 15408-1:2009)	Data anonymisation and data security

D2.2 Standardization landscape and socioeconomic context

EN ISO/IEC 15408-2:2020	Information technology - Security techniques - Evaluation criteria for IT security - Part 2: Security functional components (ISO/IEC 15408-2:2008)	Data anonymisation and data security
EN ISO/IEC 15408-3:2020	Information technology - Security techniques - Evaluation criteria for IT security - Part 3: Security assurance components (ISO/IEC 15408-3:2008, Corrected version 2011-05)	Data anonymisation and data security
EN ISO 22739:2022	Blockchain and distributed ledger technologies — Vocabulary	Blockchain and distributed ledger technologies
ISO 23257:2022	Blockchain and distributed ledger technologies — Reference architecture	Blockchain and distributed ledger technologies
EN ISO/IEC 27000:2020	Information technology - Security techniques - Information security management systems - Overview and vocabulary (ISO/IEC 27000:2018)	Data anonymisation and data security
EN ISO/IEC 27001:2017	Information technology - Security techniques - Information security management systems - Requirements (ISO/IEC 27001:2013 including Cor 1:2014 and Cor 2:2015)	Data anonymisation and data security
ISO/IEC 9834-8:2014	Information technology — Procedures for the operation of object identifier registration authorities — Part 8: Generation of universally unique identifiers (UUIs) and their use in object identifiers	Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs)
ISO/TR 3242:2022	Blockchain and distributed ledger technologies – Use cases	Blockchain and distributed ledger technologies
ISO/TR 23244:2020	Blockchain and distributed ledger technologies — Privacy and personally identifiable information protection considerations	Blockchain and distributed ledger technologies
ISO/TR 23249:2022	Blockchain and distributed ledger technologies – Overview of existing DLT systems for identity management	Blockchain and distributed ledger technologies
ISO/TR 23455:2019	Blockchain and distributed ledger technologies — Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems	Blockchain and distributed ledger technologies
ISO/TR 23576:2020	Blockchain and distributed ledger technologies — Security management of digital asset custodians	Blockchain and distributed ledger technologies

ISO/TS 23258:2021	Blockchain and distributed ledger technologies — Taxonomy and Ontology	Blockchain and distributed ledger technologies
ISO/TS 23635:2022	Blockchain and distributed ledger technologies — Guidelines for governance	Blockchain and distributed ledger technologies

7.4.2 Standards under development

Document reference	Title	Subtopic
ISO/DIS 22739	Blockchain and distributed ledger technologies — Vocabulary	Blockchain and distributed ledger technologies
prEN ISO/IEC 15408-1 rev	Information security, cybersecurity and privacy protection - Evaluation criteria for IT security - Part 1: Introduction and general model	Data anonymisation and data security
prEN ISO/IEC 15408-2 rev	Information security, cybersecurity and privacy protection - Evaluation criteria for IT security - Part 2: Security functional components	Data anonymisation and data security
prEN ISO/IEC 15408-3 rev	Information security, cybersecurity and privacy protection - Evaluation criteria for IT security - Part 3: Security assurance components	Data anonymisation and data security
prEN ISO/IEC 15408-4	Information security, cybersecurity and privacy protection - Evaluation criteria for IT security - Part 4: Framework for the specification of evaluation methods and activities	Data anonymisation and data security
prEN ISO/IEC 15408-5	Information security, cybersecurity and privacy protection - Evaluation criteria for IT security - Part 5: Pre-defined packages of security requirements	Data anonymisation and data security

7.5 Internet of Things (IoT)

7.5.1 List of Standards

Document reference	Title	Subtopic
ISO/IEC TR 30176:2021 ED1	Internet of Things (IoT) - Integration of IoT and DLT/blockchain: Use cases	Integration of IoT and DLT/blockchain

7.6 Artificial Intelligence and machine learning

7.6.1 List of Standards

Document reference	Title	Subtopic
EN ISO/IEC 22989:2023	Information technology — Artificial intelligence — Artificial intelligence concepts and terminology	Deep learning/Deep Neural Networks
EN ISO/IEC 23053:2023	Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)	Deep learning/Deep Neural Networks
ISO/IEC TR 24029-1:2021	Artificial Intelligence (AI) — Assessment of the robustness of neural networks — Part 1: Overview	Deep learning/Deep Neural Networks

7.6.2 Standards under development

Document reference	Title	Subtopic
prEN ISO/IEC 23053	Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML) (ISO/IEC 23053:2022)	Deep learning/Deep Neural Networks
prEN ISO/IEC 22989	Information technology - Artificial intelligence - Artificial intelligence concepts and terminology (ISO/IEC 22989:2022)	Deep learning/Deep Neural Networks
ISO/IEC TR 24368:2022	Information technology — Artificial intelligence — Overview of ethical and societal concerns	Deep learning/Deep Neural Networks

7.7 Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks

7.7.1 List of Standards

Document reference	Title	Subtopic
EN IEC 63110-1:2022	Protocol for management of electric vehicles charging and discharging infrastructures - Part 1: Basic definitions, use cases and architectures	Protocol for management of EV charging and discharging infrastructures

7.8 Automatic identification and data capture techniques

7.8.1 List of Standards

Document reference	Title	Subtopic
ISO/IEC 18000-2:2009	Information technology — Radio frequency identification for item management — Part 2: Parameters for air interface communications below 135 kHz	RFID
ISO/IEC 18004:2015	Information technology — Automatic identification and data capture techniques — QR Code bar code symbology specification	QR

7.8.2 Standards under development

Document reference	Title	Subtopic
ISO/IEC DIS 18004	Information technology — Automatic identification and data capture techniques — QR Code bar code symbology specification	QR

7.9 Power quality

7.9.1 List of Standards

Document reference	Title	Subtopic
EN 50160:2022	Voltage characteristics of electricity supplied by public electricity networks	Power Quality
EN 60059:1999 + A1:2009	IEC STANDARD CURRENT RATINGS	Power Quality
IEC TS 63222-1:2021	Power quality management - Part 1: General guidelines	Power Quality

7.10 GIS

7.10.1 List of Standards

Document reference	Title	Subtopic
EN ISO 19115-1:2014 + A1:2018	Geographic information — Metadata — Part 1: Fundamentals	GIS
EN ISO 19115-2:2019 + A1:2022	Geographic information — Metadata — Part 2: Extensions for acquisition and processing	GIS
EN ISO 19119:2016	Geographic information — Services	GIS
ISO 19147:2015	Geographic information — Transfer Nodes	GIS
EN ISO 19148:2021	Geographic information — Linear referencing	GIS
EN ISO 19125-1:2006	Geographic information — Simple feature access — Part 1: Common architecture	GIS
EN ISO 19126:2021	Geographic information — Feature concept dictionaries and registers	GIS
ISO 19170-1:2021	Geographic information — Discrete Global Grid Systems Specifications — Part 1: Core Reference System and Operations, and Equal Area Earth Reference System	GIS
ISO/TS 19115-3:2016	Geographic information — Metadata — Part 3: XML schema implementation for fundamental concepts	GIS
CEN ISO/TS 19139-1:2019	Geographic information - XML schema implementation - Part 1: Encoding rules (ISO/TS 19139-1:2019)	GIS
ISO/TS 19157-2:2016	Geographic information — Data quality — Part 2: XML schema implementation	GIS

7.10.2 Standards under development

Document reference	Title	Subtopic
EN ISO 19111:2020/prA2	Geographic information — Referencing by coordinates — Amendment 2	GIS

prEN ISO 19115-3	Geographic information — Metadata — Part 3: XML schema implementation for fundamental concepts	GIS
ISO/AWI TR 19174	Geographic Information – Securing interoperability among heterogeneous city domain information models	GIS

8 Annex 2 Standards from other organizations

8.1 W3C

Document reference	Title	Subtopic
Decentralized Identifiers (DIDs) v1.0	Decentralized Identifiers (DIDs) v1.0	Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs)
Verifiable Credentials Data Model v1.1	Verifiable Credentials Data Model v1.1	Decentralized Identifiers (DIDs) and Verifiable Credentials (VCs)

8.2 IEEE

Document reference	Title	Subtopic
IEEE 1815-2012	IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3)	Communication networks and systems for power utility automation
IEEE 1547-2018	IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces	Communication networks and systems for power utility automation

8.3 Connectivity Standards Alliance

Document reference	Title	Subtopic
Matter 1.1 Core Specification (Matter 1.2 is expected to be published soon)	Matter 1.1 Core Specification	Plug and play recognition of devices
Matter 1.1 Device Library Specification (Matter 1.2 is expected to be published soon)	Matter 1.1 Device Library Specification	Plug and play recognition of devices
Matter 1.1 Application Cluster Specification (Matter 1.2 is expected to be published soon)	Matter 1.1 Application Cluster Specification	Plug and play recognition of devices

9 Annex 3 Other documents/protocols of interest

OTHER DOCUMENTS/PROTOCOLS	RELATED TO
MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3	Modbus TCP/IP
MODBUS/TCP Security Protocol Specification	Modbus TCP/IP
Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. J	Modbus TCP/IP
MODBUS over Serial Line Specification and Implementation Guide V1.02	Modbus TCP/IP
MODBUS MESSAGING ON TCP/IP IMPLEMENTATION GUIDE V1.0b	Modbus TCP/IP
Object Messaging Specification for the MODBUS/TCP Protocol Version 1.1	Modbus TCP/IP
OPC Data Access (OPC DA)	OPC-DA
OPC XML-Data Access	OPC XML-DA
OPC 10000 Series [1...79]. OPC Unified Architecture Core	OPC UA
OPC 10000 series [80...99]. OPC Unified Architecture Field eXchange (UAFX)	OPC UA
OPC 10001 Series [1...99]. UA Core - Amendments for Version 1.04	OPC UA
OPC 10009-1. UA - 1.04 Profile Snapshots	OPC UA
OPC 10009-2. UA - 1.05 Profile Snapshots	OPC UA
OPC 10040. IEC 61850 - Electrical Substation Automation	OPC UA

PRIME Specification v1.4	PRIME
OCPP1.6 and OCPP2.0	OCPP
OSCP 2.0	OSCP
Sunspec Modbus	Sunspec
Sunspec Modbus for 1547	Sunspec
Sunspec Blockchain	Sunspec
USEF: THE FRAMEWORK EXPLAINED	USEF
SAREF core	The Smart Applications REFerence (SAREF)
MQTT 5 Specification	MQTT
Application Work Group Z-Wave Specifications, Release 2023A	Z-Wave
NGSI-v2 Specification	Fiware

10 Annex 4 Related Standardization Committees/Groups

10.1 CEN/CENELEC/ETSI (European level)

Technical Committee	1.1.1 CEN-CENELEC-ETSI Coordination Group on Smart Grids (CG-SG)
Scope-Focus-Description of activities	<p>The CG-SG advises on European standardization requirements relating to smart electrical grid and multi-commodity smart metering standardization, including interactions between commodity systems (e.g., electricity, gas, heat, water), and assesses ways to address them. This includes interactions with end-users, including consumers/prosumers. Its aim is to promote the deployment of open and interoperable data architectures, based on European and international standards. The scope also includes any standards needed to design, operate, and maintain electrical grids securely and efficiently. In the specific area of metering, its scope includes electricity, water, gas and heat/cooling metering devices and systems, and associated architectures. Within its scope the Group will address the European requirements resulting from the Clean Energy Package, including secondary legislation, and any other relevant Commission initiatives. The CG-SG shall also receive inputs from and provide input to the European Commission's activities related to standardization in the field of smart grids and meters. With respect to international standardization activities on smart grids and meters, the Group shall monitor the progress of the relevant standardization activities in ISO, IEC and ITU, and promote coordination between the European activities and those at the international level and promote when needed the consideration of European requirements within international standardization.</p> <p>The Group shall not develop standardization deliverables (e.g. European Standards, Technical Specifications, Technical Reports), but may develop informative material intended for the public domain after approval by the CEN and CENELEC Technical Boards (BTs) and ETSI Board.</p>
Relevant SC/WG	<ul style="list-style-type: none"> • CEN/CLC/ETSI/CG-SG/WG EUPOL EU Policy • CEN/CLC/ETSI/CG-SG/WG Privacy and Security • CEN/CLC/ETSI/CG-SG/WG STD (Set of Standards) • CEN/CLC/ETSI/CG-SG/WG SmartMeters
Background	<p>In 2009, the European Commission and EFTA mandated CEN, CENELEC and ETSI the development of an open architecture for utility meters involving communication protocols enabling interoperability (smart metering). In response to this request (M/441), CEN, CENELEC and ETSI decided to combine their expertise and resources by establishing the Coordination Group on Smart Meters (CG-SM).</p> <p>In March 2011, the European Commission and EFTA issued the Smart Grid Mandate (M/490) requesting CEN, CENELEC and ETSI to develop a framework to enable ESOs to perform continuous standard enhancement and development in the smart grid field. In order to perform the requested work, the ESOs combined their strategic approach and established the Coordination Group on Smart Energy Grids (CG-SEG).</p> <p>In January 2021, taking into consideration the close contact between both Groups since the beginning of its creation when the European Commission issued the mandates M/441 (utility meters) and M/490 (smart grid), CEN and CENELEC BTs and ETSI Board decided to merge both groups.</p>
Documents (Other than Standards)	<ul style="list-style-type: none"> • Sustainable Processes • First Set of Consistent Standards • Reference Architecture

	<ul style="list-style-type: none"> • Information security and data privacy • Framework Document • Extended Set of Standards support Smart Grids deployment (PDF) • Overview Methodology and its annexes (all PDF): <ul style="list-style-type: none"> ○ General Market Model Development ○ Smart Grid Architecture Model User Manual ○ Flexibility Management • Smart Grid Interoperability (PDF) and its tool (Excel) • Smart Grid Information Security (PDF) • Smart Grid Set of Standards: Report 1 (PDF) • Final Report of the Working Group Clean Energy Package • SM-CG report • Smart Meters Co-ordination Group - Privacy and Security approach – part I to IV <p>All these documents are available at:</p> <p>https://www.cenelec.eu/areas-of-work/cen-cenelec-topics/smart-grids-and-meters/smart-grids/</p> <p>and:</p> <p>https://www.cenelec.eu/areas-of-work/cen-cenelec-topics/smart-grids-and-meters/smart-meters/</p>
--	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.2 CEN/CLC/JTC 13 Cybersecurity and Data Protection
Scope-Focus-Description of activities	<p>Development of standards for cybersecurity and data protection covering all aspects of the evolving information society including but not limited to:</p> <ul style="list-style-type: none"> - Management systems, frameworks, methodologies - Data protection and privacy - Services and products evaluation standards suitable for security assessment for large companies and small and medium enterprises (SMEs) - Competence requirements for cybersecurity and data protection - Security requirements, services, techniques and guidelines for ICT systems, services, networks and devices, including smart objects and distributed computing devices <p>Included in the scope is the identification and possible adoption of documents already published or under development by ISO/IEC JTC 1 and other SDOs and international bodies such as ISO, IEC, ITU-T, and industrial fora. Where not being developed by other SDO's, the development of cybersecurity and data protection CEN/CENELEC publications for safeguarding information such as organizational frameworks, management systems, techniques, guidelines, and products and services, including those in support of the EU Digital Single Market.</p>

Technical Committee	1.1.3 CEN/CLC/JTC 14 Energy management and energy efficiency in the framework of energy transition
Scope-Focus-Description of activities	<p>Standardization in the field of energy management within the energy transition framework in close coordination with CEN/CENELEC sectorial strategy including, but not limited to, subjects such as: Energy management systems, energy audits, energy efficiency and energy performance improvement, energy and savings calculation methodologies, energy efficiency improvement financing (For example: Valuation of Energy Related Investments,</p>

	Energy Performance Contracting minimum requirements, etc.), energy services providers, energy measurement and monitoring, role of enabling technologies and RES within the energy management and energy efficiency framework, taking into account the horizontal role of JTC 14 and in order to avoid overlap with scopes of other TCs, the following fields are excluded from the scope: Specific technologies or systems activities within the scope of other CEN, CENELEC or Joint CEN-CENELEC TCs, environmental issues.
--	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.4 CEN/CLC/JTC 19 Blockchain and Distributed Ledger Technologies
Scope-Focus-Description of activities	To prepare, develop and/or adopt standards for Blockchain and Distributed Ledger technologies covering the following aspects: <ul style="list-style-type: none"> - Organizational frameworks and methodologies, including IT management systems; - Processes and products evaluation schemes; - Blockchain and distributed ledger guidelines. <p>The JTC will focus on European requirements, especially in the legislative and policy context, and will proceed with the identification and possible adoption of standards or other relevant documentation already available or under development in other SDOs or regulatory bodies, which could support the EU Digital Single Market and/or EC Directives/Regulations. Special attention will be paid to ISO/TC 307 standards. If required these standards will be augmented by CEN TRs and TSs.</p>

Technical Committee	1.1.5 CEN/CLC/JTC 21 Artificial Intelligence
Scope-Focus-Description of activities	The JTC shall produce standardization deliverables in the field of Artificial Intelligence (AI) and related use of data, as well as provide guidance to other technical committees concerned with Artificial Intelligence. The JTC shall also consider the adoption of relevant international standards and standards from other relevant organisations, like ISO/IEC JTC 1 and its subcommittees, such as SC 42 Artificial intelligence. The JTC shall produce standardization deliverables to address European market and societal needs and to underpin primarily EU legislation, policies, principles, and values.

Technical Committee	1.1.6 CEN/TC 287 Geographic Information
Scope-Focus-Description of activities	Standardization in the field of digital geographic information for Europe: The committee will produce a structured framework of standards and guidelines, which specify a methodology to define, describe and transfer geographic data and services. This work will be carried out in close co-operation with ISO/TC 211 in order to avoid duplication of work. The standards will support the consistent use of geographic information throughout Europe in a manner that is compatible with international usage. They will support a spatial data infrastructure at all levels in Europe.

Technical Committee	1.1.7 CEN/TC 294 Communication systems for meters
Scope-Focus-Description of activities	Standardization of communications interfaces for metering and submetering systems for Water, Fuel Gases, Heat and similar energies and fluids where the protocols are applied to the meters, sensors and actuators and systems used to provide metering services. Security

	<p>features like Confidentiality, Authenticity and Integrity are provided at the application and lower layers. Cooperation with CENELEC and ETSI, in relation to consistent protocol and use of spectrum, is an essential condition for achieving interoperability between entities in systems. Excluded from this scope are areas, which are under the responsibility of CLC/TC 205 and CEN/TC 247.</p>
Relevant SC/WG	<ul style="list-style-type: none"> • CEN/TC 294/WG 2 Data exchange for meters on DLMS/COSEM systems Scope: Define ISO/OSI layers for all DLMS/COSEM metering systems within the scope of CEN/TC 294 in a generic way. Maintain the object identification system (OBIS) for meters. • CEN/TC 294/WG 4 Data exchange for meters on M-Bus systems Scope: Prepare, maintain and evolve standards for the lower layers for bidirectional wired data exchange and for the upper layers for uni- and bidirectional data exchange of metering systems, taking into account the scope of CEN/TC 294, and the nominal service life of the devices in the market. Maintain part 3 of the EN 1434 series hosted at CEN/TC 176. • CEN/TC 294/WG 5 Data exchange for meters on wireless M-Bus systems Scope: Prepare, maintain and evolve standards for the lower layers for uni and bi-directional data exchange of metering systems over radio communication, taking into account the scope of CEN/TC 294 and the nominal service life of the devices in the market. Provide a management protocol for controlling the radio link. • CEN/TC 294/WG 7 Adaptation layer Scope: CEN/TC 294/WG 7 aims at developing and maintaining a standard that specifies an "Adaptation Layer" to transport M-Bus upper layers over wireless communication protocols other than Wireless M-Bus. These alternative radio technologies (known as LPWAN or Low Power Wide Area Network technologies), developed outside CEN/TC 294, could be based on Internet Protocol or not and operate either in licensed or unlicensed frequency bands

Technical Committee	1.1.8 CLC/TC 8X System aspects of electrical energy supply
Scope-Focus-Description of activities	To prepare the necessary standards framework and coordinate the development, in cooperation with other TC/SCs, of CENELEC standards needed to facilitate the functioning of electricity supply systems in open markets. TC8X also covers High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV.

Technical Committee	1.1.9 CLC/TC 13 Electrical energy measurement and control
Scope-Focus-Description of activities	Standardization in the field for metering equipment and systems (using whenever possible IEC standards), including smart metering systems, for electrical energy measurement, tariff- and load control, customer information and payment, for use in power stations, along the network and at energy end users, as well as to prepare international standards for meter test equipment and methods. Excluded: Standardization for the interface of metering equipment for interconnection lines and industrial consumers and producers requiring energy management type interfaces to the control system, covered by IEC/TC 57

Technical Committee	1.1.10 CLC/TC 16 (DISSOLVED) Basic and safety principles for man-machine interface, marking and identification
Scope-Focus-Description of activities	Basic and safety principles for man-machine interface, marking and identification

Technical Committee	1.1.11 CLC/TC 23BX Switches, boxes and enclosures for household and similar purposes, plugs and socket outlet for D.C.
Scope-Focus-Description of activities	<p>a) To prepare standards for general purpose switches including electronic switches, time-delay switches, remote control switches and isolating switches, Fireman's switches, for a.c. only, with rated voltage not exceeding 440 V, and with a maximum rated current not exceeding 125 A, intended for household and similar purposes, either indoors or outdoors.</p> <p>b) To prepare standards for switches and related accessories for use in Home and Building Electronic Systems (HBES), with a working voltage not exceeding 250 V a.c. and a rated current up to and including 16 A, intended for household and similar purposes, either indoors or outdoors and to associate electronic extension units. c) To prepare standards for general purpose plugs and fixed and portable socketoutlets,</p> <p>with a rated voltage not exceeding 440 V d.c. and a rated current not exceeding 10A, intended to be used in restricted access areas where only skilled or instructed people have access. d) To prepare standards for general purpose boxes and enclosures for household devices, boxes and enclosures with provision for suspension means, connecting boxes and enclosures, floor boxes and enclosures, enclosures for housing protective devices and similar power consuming devices with a rated voltage not exceeding 440 V, intended for household and similar purposes, either indoors or outdoors. e) To prepare standards for ancillary products which relate to/incorporate products covered by a), b), c), e.g. luminaire couplers, adaptors/cable reels, indicator light units, etc.</p>

Technical Committee	1.1.12 CLC/TC 23E Circuit breakers and similar devices for household and similar applications
Scope-Focus-Description of activities	To prepare harmonized standards for electrical circuit breakers for overcurrent protection, devices protecting against electric shock and all related accessories. These devices are used for household and similar purposes. The word "similar" includes locations such as offices, commercial and industrial premises, hospitals, public buildings etc. This equipment is intended for fixed installations or for use in or with appliances or other equipment. This equipment may include electronic components.

Technical Committee	1.1.13 CLC/TC 57 Power systems management and associated information exchange
Scope-Focus-Description of activities	To prepare international standards for power systems control equipment and systems including EMS (Energy Management Systems), SCADA (Supervisory Control And Data Acquisition), distribution automation, teleprotection, and associated information exchange for real-time and non-real-time information, used in the planning, operation and

	<p>maintenance of power systems. Power systems management comprises control within control centres, substations and individual pieces of primary equipment including telecontrol and interfaces to equipment, systems and databases, which may be outside the scope of TC 57. The special conditions in a high voltage environment have to be taken into consideration. NOTE 1: Standards prepared by other technical committees of the IEC and organizations such as ITU and ISO shall be used where applicable. NOTE 2: Although the work of TC 57 is chiefly concerned with standards for electric power systems, these standards may also be useful for application by the relevant bodies to other geographical widespread processes. NOTE3: Whereas standards related to measuring and protection relays and to the control and monitoring equipment used with these systems are treated by TC 95, TC 57 deals with the interface to the control systems and the transmission aspects for teleprotection systems. Whereas standards related to equipment for electrical measurement and load control are treated by TC 13, TC 57 deals with the interface of equipment for interconnection lines and industrial consumers and producers requiring energy management type interfaces to the control system</p>
--	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.14 CLC/TC 64 Electrical installations and protection against electric shock
Scope-Focus-Description of activities	To prepare International standards - concerning protection against electric shock arising from equipment, from installations and from systems without limit of voltage, - for the design, erection foreseeable correct use and verification of all kind of electrical installations at supply voltage up to 1 kV a.c or 1,5 kV d.c., except those installations covered by the following IEC committees: TC 9X, TC 18X, TC 44X, TC 97, TC 99X, - in co-ordination with TC 99X, concerning requirements additional to those of TC 99X for the design, erection and verification of electrical installations of buildings above 1 kV up to 35 kV. The object of the standards shall be: - to lay down requirements for installation and co-ordination of electrical equipment, - to lay down basic safety requirements for protection against electric shock for use by technical committees, - to lay down safety requirements for protection against other hazards arising from the use of electricity, - to give general guidance to IEC member countries that may have need of such requirements, and - to facilitate international exchanges that may be hampered by differences in national regulations. The standards will not cover individual items of electrical equipment other than their selection for use.
Relevant SC/WG	<ul style="list-style-type: none"> CLC/TC 64/WG 30 Low-voltage electrical installations - Part 8-2: Smart Low-Voltage Electrical Installations <p>Scope: Future HD 60364-8-2</p>

Technical Committee	1.1.15 CLC/TC 69X Electrical systems for electric road vehicles
Scope-Focus-Description of activities	To prepare European standards related to electrical systems for road vehicles, totally or partly propelled from self-contained power sources

Technical Committee	1.1.16 CLC/SR 70 Degrees of protection provided by enclosures
Scope-Focus-Description of activities	Degrees of protection provided by enclosures

Technical Committee	1.1.17 CLC/TC 121A Low-voltage switchgear and controlgear
Scope-Focus-Description of activities	To prepare harmonized standards for low-voltage apparatus, based on concluded international standards (normally prepared by IEC SC 121A).

Technical Committee	1.1.18 CLC/TC 210 Electromagnetic Compatibility (EMC)
Scope-Focus-Description of activities	To prepare EMC standards and guidelines with particular emphasis on the application of the EMC Directive and other EC Directives that contain EMC references and to coordinate all EMC activities in CENELEC.

Technical Committee	1.1.19 CLC/TC 247 Building Automation, Controls and Building Management
Scope-Focus-Description of activities	Standardisation of building automation, controls and building management systems and services for residential and non-residential buildings. These standards include the definitions, requirements, functionality and test methods of building automation products and systems for automatic control of building services installations. The primary integration measures include application interfaces, systems and services to ensure an efficient technical building management in cooperation with commercial and infrastructural building management. Excluded from this scope are areas of building automation which are under the responsibility of other CEN/CENELEC TC's.

10.2 ISO/IEC/ITU (International level)

Technical Committee	1.1.20 ISO/IEC JTC 1 Information technology
Scope-Focus-Description of activities	Standardization in the field of Information Technology
Relevant SC/WG	<ul style="list-style-type: none"> • ISO/IEC JTC 1/SC 6 Telecommunications and information exchange between systems Scope: Since SC6 was established in 1964, SC6 has worked on standardization in the field of telecommunications dealing with the exchange of information between open systems, including system functions, procedures, parameters as well as the conditions for their use. This standardization encompasses protocols and services of lower layers including physical, data link, network, and transport as well as those of upper layers including but not limited to Directory and ASN.1: MFAN, NFC, PLC, Future Networks and OID. • ISO/IEC JTC 1/SC 25 Interconnection of information technology equipment Scope: Standardization of microprocessor systems, interfaces, protocols, architectures and associated interconnecting media for information technology equipment and networks to support embedded and distributed computing environments, storage systems and other input/output components. Standards for home and building electronic systems in residential and commercial environments to support interworking devices (IoT-related) and applications such as energy management, environmental control, lighting, and security. Cabling system standards for information and communication technology (ICT), in all types of residential, commercial and industrial environments for the design, planning and

	<p>installation, test procedures, automated infrastructure management systems and remote powering. NOTE: JTC 1/SC 25 standards reference IEC standards for cables, waveguides and connectors.</p> <ul style="list-style-type: none"> ISO/IEC JTC 1/SC 27 Information security, cybersecurity and privacy protection Scope: The development of standards for the protection of information and ICT. This includes generic methods, techniques and guidelines to address both security and privacy aspects, such as: Security requirements capture methodology; Management of information and ICT security; in particular information security management systems, security processes, security controls and services; Cryptographic and other security mechanisms, including but not limited to mechanisms for protecting the accountability, availability, integrity and confidentiality of information; Security management support documentation including terminology, guidelines as well as procedures for the registration of security components; Security aspects of identity management, biometrics and privacy; Conformance assessment, accreditation and auditing requirements in the area of information security management systems; Security evaluation criteria and methodology. SC 27 engages in active liaison and collaboration with appropriate bodies to ensure the proper development and application of SC 27 standards and technical reports in relevant areas. ISO/IEC JTC 1/SC 31 Automatic identification and data capture techniques Scope: Standardization of data formats, data syntax, data structures, data encoding, and technologies for the process of automatic identification and data capture and of associated devices utilized in inter-industry applications and international business interchanges and for mobile applications. ISO/IEC JTC 1/SC 41 Internet of Things and Digital Twin Scope: Standardization in the area of Internet of Things and Digital Twin, including their related technologies. Serve as the focus and proponent for JTC 1's standardization programme on the Internet of Things and Digital Twin, including their related technologies. Provide guidance to JTC 1, IEC, ISO and other entities developing Internet of Things and Digital Twin related applications. ISO/IEC JTC 1/SC 42 Artificial Intelligence Scope: Standardization in the area of Artificial Intelligence. Serve as the focus and proponent for JTC 1's standardization program on Artificial Intelligence. Provide guidance to JTC 1, IEC, and ISO committees developing Artificial Intelligence applications
--	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.21 ISO/TC 184 Automation systems and integration
Scope-Focus-Description of activities	Standardization in the field of automation systems and their integration for design, sourcing, manufacturing, production and delivery, support, maintenance and disposal of products and their associated services. Areas of standardization include information systems, automation and control systems and integration technologies. Note: There will be active collaboration with the relevant technical committees responsible for areas such as machines, manufacturing resources and facilities, robotics, electrical and electronic equipment, PLC for general application, quality management, industrial safety, information technologies, multi-media capabilities, and multi-modal communication networks.
Relevant SC/WG	<ul style="list-style-type: none"> ISO/TC 184/SC 4 Industrial data

	<p>Scope: Standardization of the content, meaning, structure, representation and quality management of the information required to define an engineered product and its characteristics at any required level of detail at any part of its life-cycle from conception through disposal, together with the interfaces required to deliver and collect the information necessary to support any business or technical process or service related to that engineered product during its life-cycle.</p>
--	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.22 ISO/TC 205 Geographic information/Geomatics
Scope-Focus-Description of activities	<p>Standardization in the design of new buildings and retrofit of existing buildings for acceptable indoor environment and practicable energy conservation and efficiency. Building environment design addresses the technical building systems and related architectural aspects, and includes the related design processes, design methods, design outcomes, and design-phase building commissioning. Indoor environment includes air quality, and thermal, acoustic, and visual factors. Covering and including: aspects of sustainability related to indoor environmental quality and energy that can be addressed in the design of buildings and the design of retrofits of existing buildings; general principles of building environment design; design of energy-efficient buildings; building automation and control systems in building and retrofit design; indoor air quality in building and retrofit design; indoor thermal environment in building and retrofit design; indoor acoustical environment in building and retrofit design; indoor visual environment in building and retrofit design; design of heating and cooling systems including radiant; and application of methods of testing and rating the performance of building environmental equipment in the design of new buildings and retrofits. Excluded: other ergonomic factors; methods of measurement of air pollutants and of thermal, acoustic and lighting properties; thermal performance and energy use in the built environment (ISO TC 163); methods of testing for performance and rating of building environmental equipment in existing buildings; inspecting or rating existing buildings; and, construction. Covering also: Standardization of the holistic assessment of the energy performance of new and existing buildings as well as building retrofits, in close collaboration with ISO/TC 163 by means of the ISO/TC163/WG4 Joint working group TC 163 & TC 205 Energy performance using holistic approach, including: terms and definitions; system boundaries for buildings and technical systems; assessment of the overall energy performance of buildings, taking into account the energy performance of building elements; building related systems (heating, cooling, domestic hot water, ventilation, lighting, system controls, transport, and other energy related systems); indoor and outdoor conditions; local energy production (on site and at district level); (use of) energy sources (including renewable); building commissioning; assessment of overall energy efficiency; and means of expressing the energy performance and energy performance certification of buildings.</p>

Technical Committee	1.1.23 ISO/TC 211 Geographic information/Geomatics
Scope-Focus-Description of activities	<p>Standardization in the field of digital geographic information. This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. Within the scope of geographic information, these standards may specify methods, tools, and services for data management. Data management is understood to include acquiring, processing, analyzing, accessing, presenting, and publishing data for users and systems. The work shall link to</p>

	appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.
--	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.24 ISO/TC 301 Energy management and energy savings
Scope-Focus-Description of activities	Standardization in the field of energy management and energy savings

Technical Committee	1.1.25 ISO/TC 307 Blockchain and distributed ledger technologies
Scope-Focus-Description of activities	Standardization of blockchain technologies and distributed ledger technologies.

Technical Committee	1.1.26 IEC/SyC Smart Energy
Scope-Focus-Description of activities	Standardization in the field of Smart Energy in order to provide systems level standardization, coordination and guidance in the areas of Smart Grid and Smart Energy, including interaction in the areas of Heat and Gas. To widely consult within the IEC community and the broader stakeholder community to provide overall systems level value, support and guidance to the TCs and other standard development groups, both inside and outside the IEC. To liaise and cooperate with the SEG Smart Cities and future SEGs, as well as the future Systems Resource Group.

Technical Committee	1.1.27 IEC/TC 3 Documentation, graphical symbols and representations of technical information
Scope-Focus-Description of activities	Standardization in the field of documentation, graphical symbols and representations of technical information, covering: 1) Rules, principles and methods focusing on machine sensible representation of information. This includes but is not limited to: Definition and identification of classes and properties (e.g. sematic data), ontologies and data dictionaries (e.g. CDD), information models for structuring of technical data and document management, information exchange based on existing communication means. It includes definition, co-ordination and management of the information required during the whole life cycle of a device, system, or plant, also covering aspects of documentation. 2) Rules, principles and methods focusing on human sensible representation of the information. This includes but is not limited to: Presentation of information in documentation, graphical symbols for use in documentation, graphical symbols for the human interaction with equipment. The standards deal with the presentations and graphical symbols as shown in documents or on equipment, independently of their forms of representation, analogue or digital, but may also include requirements for the development of documentation. 3) Rules, principles and methods for general and safety related marking, identification and arrangement of information in electrical installations, equipment and man-machine interfaces. This includes but is not limited to: The meanings of colours and alternative means, when used for marking and identification, the arrangement of indicating devices and actuators, coding principles for indicating and actuating devices, terminal designation of electrical and electronic components, apparatus and equipment, designation of certain designated conductors,

	marking of electrical and electronic equipment with ratings related to supply and to its properties, marking of bare and insulated conductors.
--	------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.28 IEC/TC 8 System aspects of electrical energy supply
Scope-Focus-Description of activities	<p>To prepare and coordinate, in co-operation with other TC/SCs, the development of international standards and other deliverables with emphasis on overall system aspects of electricity supply systems and acceptable balance between cost and quality for the users of electrical energy. Electricity supply system encompasses transmission and distribution networks, generators and loads with their network interfaces. This scope includes, but is not limited to, standardization in the field of:</p> <ul style="list-style-type: none"> • Terminology for the electricity supply sector; • Characteristics of electricity supplied by public networks; • Network management from a system perspective; • Connection of network users (generators and loads) and grid integration; • Design and management of de-centralized electricity supply systems (e.g. microgrids, systems for rural electrification). <p>While relying on efficient and secure data communication and exchange, TC 8's scope does not include standards for communication with appliances and equipment connected to the electric grid or for communication infrastructure serving the electric grid. TC 8 is responsible for basic publications (horizontal standards) on standard voltages, currents and frequencies ensuring the consistency of the IEC publications in these fields. TC 8 cooperates also with several organizations active in the field of electricity supply such as CIGRE, CIRED, IEEE, AFSEC, IEA.</p>

Technical Committee	1.1.29 IEC/TC 13 Electrical energy measurement and control
Scope-Focus-Description of activities	Standardization in the field of AC and DC electrical energy measurement and control, for smart metering equipment and systems forming part of smart grids, used in power stations, along the network, and at energy users and producers, as well as to prepare international standards for meter test equipment and methods. Excluded: Standardization for the interface of metering equipment for interconnection lines and industrial consumers and producers (covered by TC 57).

Technical Committee	1.1.30 IEC/TC 23 Electrical accessories
Scope-Focus-Description of activities	<p>To coordinate between the different subcommittees of TC 23 and with other technical bodies within and outside IEC, aspects concerning safety, EMC, coordination, performance, compatibility interoperability, interchangeability, energy efficiency and terminology for electrical accessories contributing to the global management of the electrical energy. To prepare standards for electrical accessories and related systems, for AC and DC, for household and similar purposes, the word "similar" including locations such as offices, commercial and industrial premises, hospitals, public buildings, etc. These accessories and related systems are: Intended for fixed installations or for use in or with appliances and other electrical or electronic equipment, and may include electronic components, and related software and digital interfaces. Normally installed by instructed or skilled persons and are normally used by ordinary persons. It includes in particular the following products, systems and aspects, handled by the Technical Committee or Subcommittees depending on their</p>

nature: Adaptors, appliance couplers, automatic reclosing devices, cable reels, cable trunking systems, cable ducting systems, cable support systems, circuit breakers for overcurrent protection, conduit systems, connecting devices, contactors, cord extension sets and cord sets, devices for the Connection of Luminaires (DCLs), devices mitigating the risk of fire due to the effect of arc fault currents, devices protecting against electric shock, electrical Energy Efficiency products, enclosures for accessories, guidance for additional functions for protection devices, HBES switches and related accessories for use in Home and Building Electronic Systems (HBES), Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS), plugs and socket-outlets, Power frequency overvoltage protection devices, switches (mechanical and electronic). Note 1: For the terms "skilled persons", "instructed persons" and "ordinary persons", see Publication IEC 61140; 3.30, 3.31 and 3.32. A lot of standards for the above-mentioned products are handled by the subcommittees of TC 23. But some products are under the direct responsibility of TC 23 due to their nature, such as:

a) Standards for single phase and multiphase installation couplers intended for permanent connection in fixed installations with a rated voltage up to and including 500 V a.c. and a rated connecting capacity up to and including 10 mm² in indoor electrical installations.

b) Standards for sound signalling devices with integral enclosures or sound signalling devices intended to be fitted into or supplied with enclosures according to IEC 60670 intended for household and similar purposes with rated voltages greater than 50 V a.c. or 75 V d.c. and not exceeding 250 V a.c. or 250 V d.c., and with rated power inputs not exceeding 100 VA.

c) Standards for clamping units for connecting devices for the connection of electrical conductors having a cross-sectional area of 0,2 mm² up to and including 35 mm² copper conductors and up to and including 50 mm² aluminium conductors with a rated voltage not exceeding 1000 V a.c. and 1500 V d.c. intended for household and similar purposes.

d) Standards for connecting devices as separate entities for the connection of two or more electrical conductors having a cross-sectional area of 0,2 mm² up to and including 35 mm² copper conductors and up to and including 50 mm² aluminium conductors with a rated voltage not exceeding 1000 V a.c. and 1500 V d.c. intended for household and similar purposes.

e) Standards for male and mating female flat quick-connect terminations for use as either an incorporated or an integrated part of an equipment or of a component, or as a separate entity, for connecting electrical copper conductors up to and including 6 mm² with a rated voltage not exceeding 1000 V a.c. and 1500 V d.c. intended for household and similar purposes.

f) Standards for Safety, EMC and installation aspects of Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS), in relation to TC23 electrical accessories.

- Electrical safety of HBES/BACS.

- Environmental Conditions and Requirements for HBES/BACS,

- Functional safety of HBES/BACS.

- EMC requirements and tests of HBES/BACS.

	<p>- Installation of HBES/BACS</p> <p>- Use of HBES/BACS to manage electrical energy and to relate to external systems enabling smart grids, Active Assisted Living (AAL), security, entertainment and other applications</p> <p>g) Guidelines for safety requirements and standards for electrical accessories for household and similar purposes intended for use in d.c. circuits, the word “similar” includes locations such as offices, commercial and industrial premises, hospitals, public buildings. Note: This work is of interest for information technology applications, renewable energy applications etc.</p> <p>h) Standards for Energy Efficiency Management systems, functions or solutions to be integrated or implemented in equipment products or devices of TC23 and its SCs either used in existing or new electrical installation - for optimizing the overall efficiency of a.c. or d.c. electrical energy for household and similar use. The work on these publications also include considerations on system electrical energy performance, energy supply, procurement practices for energy using equipment and systems, and energy use as well as measurement of current electrical energy usage. The work covers the general principles, requirements and testing procedures for Energy Efficiency Management systems resulting from stand-alone products or from any type of combination of devices and accessories aiming to manage, to monitor and to optimise the use of electrical energy within an electrical installation supplying energy to loads, either from the grid or from local energy production and/or storage (ILP&S). It will take into account all technical and economic inputs and the overall interconnection and communication influencing the design and algorithms leading to managing, reducing, measuring, optimizing and monitoring the efficiency of electrical energy usage. The work does not cover the drafting of product standards in hands of SC23K. Note: The work covers combination of sensors, detectors, effectors, loads, control units, etc. aiming to optimize the efficiency of an electrical service from an energy point of view. For example a combination of sensors, control unit and heating/cooling devices for temperature control.</p> <p>i) A technical report in view of the harmonisation of the general rules applied by TC 23 and its subcommittees.</p> <p>New standards for new products, systems or aspects as mentioned under section C of the TC 23. SBP are already included in the present scope. Due to the need for these new standards and as electrical accessories and related systems are fundamental parts of the building infrastructure, this will definitely require coordination/cooperation with TCs, such as TC 21, TC 22, TC 34, TC 57, TC 61, TC 64, TC 72, TC 82 and TC 108. For Lighting Systems within Building premises, TC23 is responsible for Electrical Accessories, such as control devices and certain aspects of dedicated networks. Details of work on control devices and Lighting Systems are currently under consideration in IEC SEG9/WG5 “Advisory Group on Lighting Systems”. New trends in technology and in the market as mentioned in the TC 23 SBP under section E are not yet covered by the present scope. TC 23 has Group Safety Function for: Connecting devices, either as separate entities or as integral parts of an end product, primarily for connecting external electrical supply conductors, for use with conductor cross-sectional area of 0,2 mm² up to and including 35 mm² copper conductors and up to and including 50 mm² aluminium conductors, but excluding connecting devices intended for data and signal circuits.</p>
Relevant SC/WG	<ul style="list-style-type: none"> • IEC/TC 23/SC 23B Plugs, socket-outlets and switches <p>Scope: a) To prepare safety and performance standards for general purpose switches including electronic switches, for example, time-delay switches, remote control switches and isolating switches, with rated voltage not exceeding 440 V, and with a maximum rated current not exceeding 125 A, intended for household and similar purposes, either indoors</p>

or outdoors. In particular performance includes the energy consumption of 23B accessories. The operation and control of the electronic switches can be achieved: - intentionally by a person via an actuating member, a key, a card, etc., via a sensing surface or a sensing unit, by means of touch, proximity, turn, optical, acoustic, thermal etc. - by physical means, e.g. light, temperature, humidity, time, wind velocity, presence and movement etc. - by any other influence;

b) To prepare safety and performance standards for switches and related accessories for use in Home and Building Electronic Systems (HBES), with a working voltage not exceeding 250 V a.c. and a rated current up to and including 16 A, intended for household and similar purposes, either indoors or outdoors and to associated electronic extension units. An HBES switch is a device using two way communication designed to make or break and/or to control, directly (e.g. actuator) or indirectly (e.g. sensor), the current in one or more electric circuits. The communication can use different media e.g. Twisted Pair (TP), Power Line (PL), Infra Red (IR) and Radio Frequency (RF). In particular performance includes the energy consumption of 23B accessories In particular:

- HBES switches can be used for the operation of lamp circuits and the control of the brightness of lamps (dimmers) as well as the control of the speed of motors (e.g. those used in ventilating fans) and for other purposes (e.g. heating installations),
- HBES switch are all kind of HBES devices e.g. switches, sensors, actuators, switched-socket-outlets, associated electronic extension units, etc.
- The operation and control of the HBES switches are performed: - intentionally by a person via an actuating member, a key, a card, etc., via a sensing surface or a sensing unit, by means of touch, proximity, turn, optical, acoustic, thermal, etc. - by physical means, e.g. light, temperature, humidity, time, wind velocity, presence and movement, etc, - by any other influence; etc,
- And transmitted - by an electronic signal via several media, e.g. powerline (mains), twisted pair, optical fibre, radio frequency, infra-red, etc...

c) To prepare standards for plugs, fixed and portable socket-outlets, fused plugs, socket-outlets for appliances, switched socket-outlets with and without interlock, plugs and socket-outlets for SELV, with a rated voltage not exceeding 440 V and a rated current not exceeding 32 A, intended for household and similar purposes, either indoors or outdoors.

d) To prepare standards for boxes and enclosures for household devices, boxes and enclosures with provision for suspension means, connecting boxes and enclosures, floor boxes and enclosures, enclosures for housing protective devices and similar power consuming devices with a rated voltage not exceeding 1 000 V a.c. and 1 500 V d.c., intended for household and similar purposes, either indoors or outdoors. These standards are applicable to boxes, enclosures intended to house accessories which are in the field of other TC 23 Subcommittees and are produced in conjunction with other Subcommittees.

e) To prepare standards for ancillary products which are related to/incorporate in products covered by a), b), c), d) e.g. Devices for the Connection of Luminaires (DCLs), adaptors, cable reels, indicator light units, cord extension sets etc.

- **IEC/TC 23/SC 23E Circuit-breakers and similar equipment for household use**

Scope: To prepare and to update standards for:

- circuit-breakers and residual current devices of rated currents not exceeding 125 A and rated voltages not exceeding 440 V for protection against overcurrent and/or against electric shock in domestic and similar installations,

- residual current devices for monitoring the conditions of insulation of domestic and similar installations,

- circuit-breakers for equipment of rated currents not exceeding 125 A and rated voltages not exceeding 440 V designed to protect equipment for use in domestic and similar installations,

- electromechanical contactors for household and similar purposes,

- control and protection devices for battery-powered vehicle supplies,

- arc fault detection devices (AFDD) of rated currents not exceeding 63 A and rated voltages not exceeding 240 V a.c. for household and similar uses.

The standards concern devices intended to be used by ordinary persons in installations or equipment not subject to maintenance and contain all specifications necessary for certification purposes: sets of samples to be submitted, test sequences to be applied and conditions for approval.

They shall also include all specifications necessary for certification purposes concerning the groups of samples, the tests sequences each group shall be submitted and the number of failures admitted.

In working out such standards and according to the guidelines given by the SMB, close coordination is being kept continuously with SC 121A, dealing with the standards for low voltage switchgear and controlgear mainly intended to be used by instructed persons in installations subject to supervision and maintenance (In particular SC 121A is the leader for the preparation of standards for circuit breaker, whilst SC 23E is the leader for the preparation of standards for RCDs).

The work of the subcommittees takes into account the specifications prepared by TC 109, SC 77A and by TC 64. An official liaison with CTL has been established by nominating a liaison member who is also member of the parallel WG in the CTL organization SC 23E has Group Safety Function for: Residual Current Devices (RCDs) Definition of Residual Current Devices taken from IEC 60755 a residual current device is a mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

- **IEC/TC 23/SC 23H Plugs, Socket-outlets and Couplers for industrial and similar applications, and for Electric Vehicles**

Scope: To prepare standards for industrial plugs, socket-outlets and couplers suitable for use in industrial, commercial, private or public locations, either indoors or outdoors. To prepare standards for other accessories, such as industrial cable reels among others, intended for use with industrial plugs, socket-outlets and couplers. To prepare standards for connection products intended for the connection of electric vehicles to the supply network and/or to dedicated supply equipment. The rated voltages of products covered by these standards lie within IEC 60038.

Technical Committee	1.1.31 IEC/TC 57 Power systems management and associated information exchange
Scope-Focus-Description of activities	To prepare international standards for power systems control equipment and systems including EMS (Energy Management Systems), SCADA (Supervisory Control And Data Acquisition), distribution automation, teleprotection, and associated information exchange for real-time and non-real-time information, used in the planning, operation and maintenance of power systems. Power systems management comprises control within control centres, substations and individual pieces of primary equipment including telecontrol and interfaces to equipment, systems and databases, which may be outside the scope of TC 57. The special conditions in a high voltage environment have to be taken into consideration. Note 1: Standards prepared by other technical committees of the IEC and organizations such as ITU and ISO shall be used where applicable. Note 2: Although the work of TC 57 is chiefly concerned with standards for electric power systems, these standards may also be useful for application by the relevant bodies to other geographical widespread processes. Note 3: Whereas standards related to measuring and protection relays and to the control and monitoring equipment used with these systems are treated by TC 95, TC 57 deals with the interface to the control systems and the transmission aspects for teleprotection systems. Whereas standards related to equipment for electrical measurement and load control are treated by TC 13, TC 57 deals with the interface of equipment for interconnection lines and industrial consumers and producers requiring energy management type interfaces to the control system.

Technical Committee	1.1.32 IEC/TC 64 Electrical installations and protection against electric shock
Scope-Focus-Description of activities	To prepare international Standards: Concerning protection against electric shock arising from equipment, from installations and from systems without limit of voltage; for the design, erection foreseeable correct use, proper functioning and verification of all kind of electrical installations at supply voltage up to 1 kV AC. or 1,5 kV DC., except those installations covered by the following IEC committees: TC 9, TC 18, TC 44, TC 97, TC 99; in co-ordination with TC 99, concerning requirements additional to those of TC 99 for the design, erection and verification of electrical installations of buildings above 1 kV up to 35 kV. The object of the standards shall be: to lay down requirements for installation and co-ordination of electrical equipment to lay down basic safety requirements for protection against electric shock for use by technical committees to lay down safety requirements for protection against other hazards arising from the use of electricity (e.g. thermal effects, overcurrent, fault currents, voltage disturbances) to specify the operational characteristics and performance criteria necessary for selection of equipment for installation applications to give general guidance to IEC member countries that may have need of such requirements and to facilitate international exchanges that may be hampered by differences in national regulations. The standards will not cover individual items of electrical equipment other than their selection for use. Note the following identifies the horizontal functions that have been assigned to TC 64:

Technical Committee	1.1.33 IEC/TC 69 Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks
Scope-Focus-Description of activities	To prepare publications on electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks (hereafter EV) drawing current from a rechargeable energy storage system (RESS). Possibilities to transfer power/energy include

	<p>conductive power/energy transfer, wireless power/energy transfer and battery swap. The different publications can cover, but are not limited to: general requirements (e.g. safety, EMC, construction, testing); functional requirements (e.g. charging modes); communication between the EV and the EV supply equipment; electrical power/energy transfer between EV and supply network (G2V and V2G); management of the corresponding infrastructures in view of offering the associated value added services. EV include but are not limited to passenger cars and buses, two and three-wheel and light four-wheel vehicles, trucks and goods vehicles, trailers and special and industrial trucks. Trains, trams and trolleybuses are out of scope of TC69.</p>
--	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.34 IEC/TC 70 Degrees of protection provided by enclosures
Scope-Focus-Description of activities	<p>To prepare international standards including appropriate test methods for degrees of protection provided by enclosures against ingress of solid foreign objects and water and against access to dangerous parts. Such degrees should be expressed by the IP Code. Standardization of access probes for use in IEC Publications. NOTE: There is no intention on the part of TC 70 to establish test methods if they are already available in IEC Publications, e.g. Publication 68. Horizontal Safety Function: Degrees of protection provided by the enclosures against ingress of foreign solid bodies, water and access to live or moving parts and standardization of accessibility probes. Such degrees should be expressed by the IP classification system.</p>

Technical Committee	1.1.35 IEC/TC 77 Electromagnetic compatibility
Scope-Focus-Description of activities	<p>To prepare standards and technical reports in the field of electromagnetic compatibility (EMC), with particular emphasis on general application and use by product committees. (Horizontal function). The scope covers the following aspects of EMC: Immunity and related items, over the whole frequency range: basic and generic standards; emission in the low frequency range ($f \leq 9$ kHz, e.g. harmonics and voltage fluctuations): basic, generic and product (family) standards; emission in the high frequency range ($f > 9$ kHz): disturbances not covered by CISPR 10 (1992), in co-ordination with CISPR (e.g. mains signalling). Product immunity standards are not included. However, at the request of product committees, TC 77 may also prepare such standards under the co-ordination of ACEC. Horizontal Safety Function: Electromagnetic compatibility in so far as safety aspects are involved.</p>
Relevant SC/WG	<ul style="list-style-type: none"> • IEC/TC 77/SC 77A EMC - Low frequency phenomena <p>Scope: Standardization in the field of electromagnetic compatibility with regard to low frequency phenomena ($ca \leq 9$ kHz, see note). Note: This limit frequency can be adapted to a higher frequency according to the phenomena or equipment</p>

Technical Committee	1.1.36 IEC/TC 85 Measuring equipment for electrical and electromagnetic quantities
---------------------	------------------------------------------------------------------------------------

Scope-Focus-Description of activities	To prepare international standards for equipment, systems, and methods used in the fields of measurement, test, recurrent test, monitoring, evaluation, generation and analysis of steady state and dynamic (including temporary and transients) electrical and electromagnetic quantities, as well as their calibrators. Such equipment includes devices for testing the safety of power distribution systems and connected equipment, devices for monitoring the power distribution systems, electrical measuring transducers, signal generators, recorders together with their accessories. NOTE: Product safety aspects are covered by TC 66.
---------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical Committee	1.1.37 IEC/PC 118 Smart grid user interface (DISBANDED)
Scope-Focus-Description of activities	The Project Committee PC118 was disbanded 31/12/2018. All publications are currently under the responsibility of the Chinese National Committee.

Technical Committee	1.1.38 IEC/TC 121 Low-voltage switchgear and control Switchgear and controlgear and their assemblies for low voltage
Scope-Focus-Description of activities	To prepare international standards for low-voltage switchgear and controlgear equipment for industrial, commercial and similar use rated below or equal to 1 kV a.c. and 1,5 kV d.c, electromechanical as well as semiconductor (solid state) equipment. The scope includes open and enclosed separate items of equipment as well as assemblies which are the combinations of items of equipment into complete functional units.
Relevant SC/WG	<ul style="list-style-type: none"> • IEC/TC 121/SC 121A Low-voltage switchgear and controlgear <p>Scope: To prepare international standards for low-voltage switchgear and controlgear equipment for industrial, commercial and similar use rated below or equal to 1 kV a.c. and 1,5 kV d.c.. The scope includes open and enclosed separate items of equipment as well as combinations of items of equipment into complete functional units, electromechanical as well as semiconductor (solid state) equipment. Group Safety Function: Connecting devices, either as separate entities or as integral parts of an end product for connecting external electrical supply conductors, for use with conductor cross-sections above 35 mm² up to and including 300 mm².</p>