DOMINOES – DELIVERABLE

D6.9 Standardization Proposals Year 1

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Executive Summary

Year one of the DOMINOES project focused on the development of a DOMINOES local market concept. Related to this work, for example, use cases and business models have been developed. The key themes in these are utilization of demand response and flexibility for the benefit of DSOs and other stakeholders in the power system, peer to peer (P2P) trading and sharing of energy, and aggregation services.

This document reviews the current and potential future regulatory framework related to the above mentioned themes and reviews and discusses standards related key to technological issues such as cyber security and energy storage systems. Furthermore, partners' activities related to standardization and regulation are summarized.

List of Acronyms

BM	Business model
BRP	Balance responsible party
DC	Direct current
DR	Demand response
DSO	Distribution system operator
ECSP	Energy community service provider
ED	Proposed Directive on common rules for the internal market in electricity
EMC	Electromagnetic compatibility
EPS	Electric power system
ER	Proposed Regulation on the internal market for electricity
ESCO	Energy service company
ESS	Energy storage system
FCR	Frequency containment reserve
mFRR	Frequency restoration reserve, manual
NRA	National regulatory authority
P2P	Peer to peer
RD	Directive on the promotion of the use of energy from renewable sources
RMS	Root mean square
SCADA	Supervisory control and data acquisition
SGAM	Smart Grid Architecture Model
STATCOM	Static synchronous compensator
SVC	Static VAR compensator
TOGAF	The Open Group Architecture Framework
TSO	Transmission system operator
UC	Use case

1 Introduction

1.1 Purpose and scope of the deliverable

This deliverable, D6.9, is a part of the WP6 Dissemination, standardization, regulation and exploitation and the Task 6.2 Standardization and regulatory issues (T6.2). The aim of T6.2 is to produce recommendations for changes in existing local market related standards and regulatory rules. The deliverables of T6.2 also list standardization activities of all project partners with updates every 13 months.

This deliverable reviews issues in the current regulatory framework (section 2) and potential changes in regulation (with focus on the 'Clean energy for all Europeans' legislative package) (section 3) that have an impact on the development and utilization of the DOMINOES concept. Furthermore, standardization related to cyber security (section 4) and energy storage systems and inverter driven technologies (section 5) are reviewed and discussed as these are key technical issues for local energy markets and the DOMINOES concept. Partners' activities with standardization organizations or regulatory/legislative bodies are summarized in section 6. Finally, section 7 concludes the report.

First, however, the subsection 1.2 briefly summarizes the development of the DOMINOES concept during the first year of the project.

1.2 DOMINOES concept

During the first year of the DOMINOES project use cases and business models related to utilization of local energy markets were developed. Table 1.1 summarizes the use cases developed in T1.2. Table 1.2. presents the business models developed in T5.1 and the relationships between the use cases (UCs) and business models (BMs).

Table 1.1 DOMINOES UCs developed in T1.2 [1]

ID	Use case name	Target
1	Local market flexibility and energy asset management for grid value	Usage of local community distributed flexibility for grid management, including available storage systems and energy/power services to enable a more efficient renewable integration at Low Voltage level, with reserved capacity to serve grid needs and mitigate technical constraints.
2	Local Market Data Hub Manager and technical validation and flexibility tool	The Local Energy Market Data Hub Manager and Technical Validation of market transactions focus on the behaviour of the Data Manager role that will provide information to local trading market platform (LEMH) as well as the role of Technical Validator (TV) that should assess technically all transactions intentions provided to the LEMH in a defined timeframe.
3	Local community market with flexibility and energy asset management for energy community value	Use of flexibility and management of resources for the benefit of the local market
4	Local community flexibility and energy asset management for retailer value	Use of flexibility and energy asset to provide value to the retailer
5	Local community flexibility and energy asset management for wholesale and energy system market value	The usage of flexibility and management of energy assets of the local community for the wholesale and energy system market value.

Table 1.2 DOMINOES BMs developed in T5.1 and UC/BM-relations [2]

ID	Provider	Service	Client	Related UCs
1	Flexibility service provider (aggregator/ community manager)	Aggregated flexibility as a service. The flexibility service provider will provide the aggregated flexibility as a solution to grid operators and balance responsible parties.	DSO/ BRP/ TSO	1, 2, 3
2	Aggregator	Aggregators offer a new flexibility service to help the DSO solving congestion problems.	DSO	1, 2
3	DSO	A transactive platform where end-users can make local energy transactions. End-customers receive signals from the DSO to promote local energy transactions. DSO provides incentives to end-users when local transactions contribute to the reduction of penalties caused by congestion situations.	Energy customers	1, 3, 5
4	Community Manager	The Community Manager (CM) acts as an aggregator. Optimal scheduling and sharing of PV generation among the community are provided aiming at the reduction of bills and green self-consumption.	End-users (i.e., public buildings equipped with PV generation and community members)	3
5	Local market operator (Flexibility comes from actors in the local market).	Use of the local market flexibility to be valued in the wholesale market or to optimize the retailers' portfolio	Retailer	4, 5
6	Energy service provider (role can be taken by multiple parties)	ICT infrastructure to manage local market that can be used a. For energy community benefits in and energy community service provider (ECSP) role b. As an ICT tool by other stakeholders for multiple purposes	Energy communities	2, 3, 4, 5

		In addition, the service provider may provide communities with assistance in choosing/sizing generation/storage/control systems in cooperation with technology providers.		

The key themes in the use cases and business models and thus in the DOMINOES concept include:

- Utilization of demand response and flexibility for the benefit of DSOs and other stakeholders in the power system
- Peer to peer (P2P) trading and sharing of energy
- Aggregation

Therefore, the review of current and potential future regulatory framework focuses on these themes.

1.3 References

[1] D1.3 Use cases and application scenarios requirements. Dominoes deliverable. http://dominoesproject.eu/wp-content/uploads/2017/12/D1.3-Use-Cases-and-application-scenarios-requirements-v1.1_public.pdf. Accessed 23 November 2018.

[2] D5.1 Formulation of alternative local market place enabled business models. Dominoes deliverable. http://dominoesproject.eu/wp-content/uploads/2017/12/D5.1_DOMINOES_Final_28Sept2018.pdf. Accessed 23 November 2018.

2 Issues in the current regulatory environment (LUT)

The current regulatory framework with regard to the key elements of the DOMINOES project varies widely between different countries and also within the European Union. Next, some problems regarding providing demand response services, aggregators' role, peer to peer trading or sharing, and DSOs' opportunities to utilise demand response are discussed.

2.1 Demand response

At the moment, the opportunities of demand response resources to participate in electricity market vary widely in Europe. The smart Energy Demand Coalition (SEDC, renamed later as smartEn) published in 2017 a review [1] on regulatory framework for explicit demand response[2] in 18 European countries. In many of the reviewed countries, participation of demand response resources is allowed only in small number of programs (e.g. in Portugal, only interruptible contracts and in Spain, tertiary control and interruptible contracts) and furthermore, some programs allowing load participation do not allow aggregated loads (this applies to the interruptible contracts in Portugal and Spain) which means that only large industrial end-users are eligible to provide demand response [1]. Thus, in addition to the resource eligibility, the requirements for minimum bid size may prevent participation in some markets. On the other hand, in some of the European markets, loads (including aggregated loads) are eligible to provide several types of balancing and ancillary services [1]. For example in Finland, demand response resources are eligible to provide frequency containment reserves (FCR) and manual frequency restoration reserve (mFRR, balancing energy and capacity) for the TSO and strategic reserves for the Finnish Energy Authority [1]. In Great Britain, almost all ancillary services programs are open to demand response (in most cases this applies also to aggregated DR) and furthermore, demand response can take part in the capacity mechanism [1].

In addition to the issues related to access to markets where demand response could be traded, some barriers for implicit demand response, or end-users' reactions to incentives built into energy or network tariffs, also remain. Especially delays in deciding about large-scale rollout of smart meters affect the ability to offer such incentives. Furthermore, in

[2] The report uses the following definition for explicit demand response: "In Explicit Demand Response schemes (sometimes called "incentive-based") the aggregated demand-side resources are traded in the wholesale, balancing, and, where applicable, Capacity Mechanisms. Consumers receive direct payments to change their consumption (or generation) patterns upon request, triggered by, for example, activation of balancing energy, differences in electricity prices or a constraint on the network. Consumers can earn from their consumption flexibility individually or by contracting with an aggregator: either a third-party aggregator or the customer's retailer."

some countries, the current formulation of retail or network tariffs regulation (see e.g. [2]) may act as a barrier for new types of tariffs.

2.2 Aggregators

The EU legislation in effect in 2018 does not set detailed guidelines for the role of aggregators. For example, Directive 2009/72 concerning common rules for the internal market in electricity [3] mentions aggregators only in the recital stating, "Transmission system operators should facilitate participation of final customers and final customers' aggregators in reserve and balancing markets." Also, in many national markets, the role and market access of aggregators (especially independent or third party aggregators) remains unclear.

One key issue related to the independent aggregators' market access is how their activities (trades, controls etc.) are taken into account in the balance settlement. If a demand response aggregator that does not supply energy to the end-users controls their consumption, it may cause imbalance to retailers if this is not taken into account in the balance settlement.

2.3 Peer to peer trading and sharing

European electricity end-users have significantly contributed to the investments in renewable power generation. However, the opportunities of end-users to invest in own generation vary dramatically according to the types of housing. For example, in Finland, residents of housing companies (i.e. apartment houses, terraced houses) wanting to invest in e.g. solar panels are in a worse position than residents living in detached houses [4]. The current regulatory framework does not support sharing of PV generation between the residents of the housing company. According to the Finnish legislation, each household has to be billed according to their individual meter and thus, even though the generation of a housing company's PV plant would in practice be consumed within the building by its residents, the electricity tax and grid tariffs would be billed as if the PV generation came via the distribution grid [4].

Furthermore, in some cases the regulatory framework may altogether prohibit peer to peer supply. For example, in the Netherlands only electricity suppliers with a licence granted by the Dutch National Regulatory Authority are allowed to serve domestic customers which means that prosumers are able to sell their surplus electricity only to their contracted supplier[3] [5].

[3] Some exceptions for renewable electricity generation experiments and trading within participants of the same project.

2.4 DSOs' opportunities to utilise flexible resources

DSOs recover their costs and are remunerated through regulated revenues, and therefore the remuneration mechanism for DSOs guides the network operation and planning decisions [6]. Thus, economic regulation that focuses solely on capital expenditure may discourage the use of flexibility by DSOs [7]. In some cases, the regulatory framework does not incentivize the use of flexibility mechanisms by DSOs (such as DR, dynamic tariffs or storage) even when they would be cost-effective compared to standard grid solutions. Furthermore, regulation of the structure of network tariffs may in some countries limit DSOs' opportunities to design demand response incentives built into tariffs.

In the Portuguese regulation, the existence of flexibility mechanisms, like for example demand response, is foreseen. However, frameworks and market rules that allow their use in a market environment have not yet been developed. Currently the Regulator has on-going proposals of pilots in order to test these mechanisms and define the best rules to the Portuguese context.

In Finland, the economic regulation of DSOs treats investments and bought services differently which means that if a network component is occasionally overloaded, it is more profitable for the DSO to replace it than use smart solutions (such as demand response) [8].

To promote the efficient use of flexibility, changes in economic regulation are being planned an implemented in some countries. In Australia, for example, DSOs are incentivized to utilize the demand side resources by the Demand management incentive scheme published by the Australian Energy Regulator (AER) in December 2017 and by the Demand management innovation allowance mechanism (updated in 2017). The incentive scheme [9] encourages the DSOs to "undertake efficient expenditure on relevant non-network options relating to demand management". This is done through a financial incentive which will be included in the DSO's allowed total annual revenue for a regulatory year. The Demand management innovation allowance mechanism [10] provides DSOs research and development funding for demand management projects that have potential to reduce long term network costs. The allowance is provided in the form of a fixed amount of additional revenue.

2.5 References

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[2] Weck, M. H. J., van Hooff, J., van Sark, W. G. J. H. M., 2017. Review of barriers to the introduction of residential demand response: a case study in the Netherlands. International Journal of Energy Research, Vol. 41, pp. 790–816.

[3] DIRECTIVE 2009/72/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC

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[5] Lammers, I., Diestelmeier, L., 2017. Experimenting with law and governance for decentralized electricity systems: adjusting regulation to reality? Sustainability, Vol. 9, No. 2.

[6] Vallés, M., Reneses, J., Cossent, R., Frías, P., 2016. Regulatory and market barriers to the realization of demand response in electricity distribution networks: a European perspective. Electric Power Systems Research, Vol. 140, pp. 689–698.

[7] CEER: Flexibility use at distribution level – A CEER conclusions paper. Ref: C18-DS-42-04. 17-July-2018. https://www.ceer.eu/documents/104400/-/-/e5186abe-67eb-4bb5-1eb2-2237e1997bbc. Accessed on 29 October 2018.

[8] Ministry of Economic Affairs and Employment: Älyverkkotyöryhmän ehdotukset ja niiden tarkemmat perustelut – Älyverkkotyöryhmän loppuraportin liite [Smart Grid Working Group's proposals and their reasoning – Appendix to the final report of the Smart Grid Working Group]. http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161119/Liite_TEM_33_2018.pdf. Accessed 16 November 2018.

[9] AER: Demand management incentive scheme – Electricity distribution network service providers. December 2017. https://www.aer.gov.au/system/files/AER%20-%20Demand%20management%20incentive%20scheme%20-%2014%20December%202017.pdf. Accessed on 20 November 2018.

[10] AER: Demand management innovation allowance mechanism – Electricity distribution network service providers. December 2017. https://www.aer.gov.au/system/files/AER%20-%20Demand%20management%20allowance%20mechanism%20-%2014%20December%202017.pdf. Accessed 21 November 2018.

3 Potential changes in regulation (LUT)

3.1 Clean Energy for all Europeans

The European Commission published in November 2016 a package of legislative proposals under the title 'Clean Energy for all Europeans' [1]. The package proposed directives / amendments to directives on

- Energy performance of buildings [2]
- Promotion of the use of energy from renewable sources [3]
- Energy efficiency [4]
- Common rules for the internal market in electricity [5]

And regulations on

- Governance of the Energy Union [6]
- Internal market for electricity [7]
- Risk-preparedness in the electricity sector [8]
- Establishing a European Union Agency for the Cooperation of Energy Regulators [9]

The revised Energy Performance of Buildings Directive (2018/844) [10] was the first adopted measure from the package, entering into force in July 2018. The directives on renewables and energy efficiency, and the regulation on governance came into force on December 2018 [11].

The legislative proposals included in the package address several themes relevant for the DOMINOES project and would thus have impact on the utilization of the DOMINOES concept if they were adopted. The proposals with the largest impact are the Directive on common rules for the internal market in electricity (abbreviated as ED in the following tables) and the Regulation on the internal market for electricity (ER). In addition, the adopted Directive on the promotion of the use of energy from renewable sources (RD) [12] addresses for example renewable energy communities.

Next subsections present the most relevant parts of the proposals (or the adopted directive on renewables) concerning energy communities, demand response, aggregators, DSOs, TSOs, and market rules in the balancing market and in day-ahead and intraday markets. The column titled Content includes the proposed articles without any modifications and the column Relevance the interpretation of the key issues for the DOMINOES concept.

3.1.1 Energy communities

Energy communities are at the core of the DOMINOES project. The package includes definitions for a 'local energy community' and a 'renewable energy community' and the rights of such communities and their members.

Table 3.1 Content on energy communities

Art.		Content	Relevance
ED	7	7. 'local energy community' means: an association, a cooperative, a partnership, a non-profit organisation or other legal entity which is effectively controlled by local shareholders or members, generally value rather than profit-driven, involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at local level, including across borders;	Definition of local energy community
ED	16	1. Member States shall ensure that local energy communities: (a) are entitled to own, establish, or lease community networks and to autonomously manage them; (b) can access all organised markets either directly or through aggregators or suppliers in a non-discriminatory manner; (c) benefit from a non-discriminatory treatment with regard to their activities, rights and obligations as final customers, generators, distribution system operators or aggregators; (d) are subject to fair, proportionate and transparent procedures and cost reflective charges. 2. Member States shall provide an enabling regulatory framework that ensures that: (a) participation in a local energy community is voluntary; (b) shareholders or members of a local energy community shall not lose their rights as household customers or active customers; (c) shareholders or members are allowed to leave a local energy community; in such cases Article 12 shall apply; (d) Article 8 (3) applies to generating capacity installed by local energy communities as long as such capacity can be considered small decentralised or distributed generation; (e) provisions of Chapter IV apply to local energy communities that perform activities of a distribution system operator; (f) where relevant, a local energy community may conclude an agreement with a distribution system operator to which their network is connected on the operation of the local energy community's network;	Rights of local energy communities and their members Right to leave a local energy community

		(g) where relevant system users that are not shareholders or members of the local energy community connected to the distribution network operated by a local energy community shall be subject to fair and cost-reflective network charges. If such system users and local energy communities cannot reach an agreement on network charges, both parties may request the regulatory authority to determine the level of network charges in a relevant decision; (h) where relevant local energy communities are subject to appropriate network charges at the connection points between the community network and the distribution network outside the energy community. Such network charges shall account separately for the electricity fed into distribution network and the electricity consumed from the distribution network outside the local energy community in line with Article 59 (8).	
RD	2	(16) 'renewable energy community' means a legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity; (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities; (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits;	Definition of renewable energy communities
RD	22	1. Member States shall ensure that final customers, in particular household customers, are entitled to participate in a renewable energy community while maintaining their rights or obligations as final customers, and without being subject to unjustified or discriminatory conditions or procedures that would prevent their participation in a renewable energy community, provided that for private undertakings, their participation does not constitute their primary commercial or professional activity. 2. Member States shall ensure that renewable energy communities are entitled to: (a) produce, consume, store and sell renewable energy, including through renewables power purchase agreements; (b) share, within the renewable energy community, renewable energy that is produced by the production units owned by that renewable energy community, subject to the other requirements laid down in this Article and to maintaining the rights and obligations of the renewable energy community members as customers;	Rights of renewable energy communities and their members

		(c) access all suitable energy markets both directly or through aggregation in a non-discriminatory manner. 3. Member States shall carry out an assessment of the existing barriers and potential of development of renewable energy communities in their territories. 4. Member States shall provide an enabling framework to promote and facilitate the development of renewable energy communities. That framework shall ensure, inter alia, that: (a) unjustified regulatory and administrative barriers to renewable energy communities are removed; (b) renewable energy communities that supply energy or provide aggregation or other commercial energy services are subject to the provisions relevant for such activities; (c) the relevant distribution system operator cooperates with renewable energy communities to facilitate energy transfers within renewable energy communities; (d) renewable energy communities are subject to fair, proportionate and transparent procedures, including registration and licensing procedures, and cost-reflective network charges, as well as relevant charges, levies and taxes, ensuring that they contribute, in an adequate, fair and balanced way, to the overall cost sharing of the system in line with a transparent cost-benefit analysis of distributed energy sources developed by the national competent authorities; (e) renewable energy communities are not subject to discriminatory treatment with regard to their activities, rights and obligations as final customers, producers, suppliers, distribution system operators, or as other market participants; (f) the participation in the renewable energy communities is accessible to all consumers, including those in low-income or vulnerable households; (g) tools to facilitate access to finance and information are available; (h) regulatory and capacity-building support is provided to public authorities in enabling and setting up renewable energy communities, and in helping authorities to participate directly; (i) rules to secure the equal and non-discriminatory treatment of consumers that participate in the renewable energy community are in place. 5. The main elements of the enabling framework referred to in paragraph 4, and of its implementation, shall be part of the updates of the Member States' integrated national energy and climate plans and progress reports pursuant to Regulation (EU) 2018/1999	

		6. Member States may provide for renewable energy communities to be open to cross-border participation. 7. Without prejudice to Articles 107 and 108 TFEU, Member States shall take into account specificities of renewable energy communities when designing support schemes in order to allow them to compete for support on an equal footing with other market participants.	

3.1.2 Demand response and aggregators

The proposal contains the first definition for 'demand response' in the EU legislation. In addition, 'aggregator' and 'independent aggregator' are defined. Rights to provide demand response services (also by aggregators) are defined.

Table 3.2 Content on demand response and aggregators

Art.		Content	Relevance
ED	2	16. 'demand response' means the change of electricity load by final customers from their normal or current consumption patterns in response to market signals, including time-variable electricity prices or incentive payments, or in response to acceptance of the final customer's bid, alone or through aggregation, to sell demand reduction or increase at a price in organised markets as defined in Commission Implementing Regulation (EU) No 1348/2014[47];	Definition of demand response (DR)
ED	2	14. 'aggregator' means a market participant that combines multiple customer loads or generated electricity for sale, for purchase or auction in any organised energy market; 15. 'independent aggregator' means an aggregator that is not affiliated to a supplier or any other market participant;	Definition of aggregator and independent aggregator
ED	13	1. Member States shall ensure that, where a final customer wishes to conclude a contract with an aggregator, such engagement shall not require the consent of the final customer's supplier. 2. Member States shall ensure that a final customer wishing to terminate the contract with an aggregator, while respecting contractual conditions, is entitled to such termination within three weeks. 3. Member States shall ensure that final customers terminating a fixed term contract with an aggregator before its maturity are not charged any termination fee that exceeds	End-user's right to conclude/end a contract with an aggregator End-user's access to their DR data

		the direct economic loss to the aggregator, including the cost of any bundled investments or services already provided to the final customer as part of the contract. 4. Member States shall ensure that final customers are entitled to receive all relevant demand response data or data on supplied and sold electricity at least once per year. 5. Member States shall ensure that the rights referred to in paragraphs 1, 2, 3 and 4 are granted to final customers in a non-discriminatory manner as regards cost, effort or time.	
ED	17	1. Member States shall ensure that national regulatory authorities encourage final customers, including those offering demand response through aggregators, to participate alongside generators in a non-discriminatory manner in all organised markets. 2. Member States shall ensure that transmission system operators and distribution system operators when procuring ancillary services, treat demand response providers, including independent aggregators, in a non-discriminatory manner, on the basis of their technical capabilities. 3. Member States shall ensure that their regulatory framework encourages the participation of aggregators in the retail market and that it contains at least the following elements: (a) the right for each aggregator to enter the market without consent from other market participants; (b) transparent rules clearly assigning roles and responsibilities to all market participants; (c) transparent rules and procedures for data exchange between market participants that ensure easy access to data on equal and non-discriminatory terms while fully protecting commercial data; (d) aggregators shall not be required to pay compensation to suppliers or generators; (e) a conflict resolution mechanism between market participants. 4. In order to ensure that balancing costs and benefits induced by aggregators are fairly assigned to market participants, Member States may exceptionally allow compensation payments between aggregators and balance responsible parties. Such compensation payments must be limited	Requirements for access and non-discriminatory treatment of (aggregated) DR in organised markets and in ancillary services provision Regulatory framework to allow aggregators to enter markets without consent from other market participants, no obligations to pay compensations to suppliers or generators Compensation payments between aggregators and balance responsible parties may be allowed

		to situations where one market participant induces imbalances to another market participant resulting in a financial cost. Such exceptional compensation payments shall be subject to approval by the national regulatory authorities and monitored by the Agency.5. Member States shall ensure access to and foster participation of demand response, including through independent aggregators in all organised markets. Member States shall ensure that national regulatory authorities or, where their national legal system so requires, transmission system operators and distribution system operators in close cooperation with demand service providers and final customers define technical modalities for participation of demand response in these markets on the basis of the technical requirements of these markets and the capabilities of demand response. Such specifications shall include the participation of aggregators.	
ER	11	1. Dispatching of power generation facilities and demand response shall be non-discriminatory and market based unless otherwise provided under paragraphs 2 to 4.	Non-discriminatory dispatching of generation and DR

3.1.3 DSO

DSOs opportunities to utilise flexibility are defined especially in a dedicated article 32 in the proposed internal market directive titled "Tasks of distribution system operators in the use of flexibility."

Table 3.3 Content concerning DSOs

Art.		Content	Relevance
ED	32	1. Member States shall provide the necessary regulatory framework to allow and incentivise distribution system operators to procure services in order to improve efficiencies in the operation and development of the distribution system, including local congestion management. In particular, regulatory frameworks shall enable distribution system operators to procure services from resources such as distributed generation, demand response or storage and consider energy efficiency measures, which may supplant the need	Regulatory framework to enable and incentivise DSOs to procure services such as DR Requirement for DSOs to define standardised market products for the services

		to upgrade or replace electricity capacity and which support the efficient and secure operation of the distribution system. Distribution system operators shall procure these services according to transparent, non-discriminatory and market-based procedures. Distribution system operators shall define standardised market products for the services procured ensuring effective participation of all market participants including renewable energy sources, demand response, and aggregators. Distribution system operators shall exchange all necessary information and coordinate with transmission system operators in order to ensure the optimal utilisation of resources, ensure the secure and efficient operation of the system and facilitate market development. Distribution system operators shall be adequately remunerated for the procurement of such services in order to recover at least the corresponding expenses, including the necessary information and communication technologies expenses, including expenses which correspond to the necessary information and communication infrastructure. 2. The development of a distribution system shall be based on a transparent network development plan that distribution system operators shall submit every two years to the regulatory authority. The network development plan shall contain the planned investments for the next five to ten years, with particular emphasis on the main distribution infrastructure which is required in order to connect new generation capacity and new loads including re-charging points for electric vehicles. The network development plan shall also demonstrate the use of demand response, energy efficiency, energy storage facilities or other resources that distribution system operator is using as an alternative to system expansion. The regulatory authority shall consult all current or potential system users on the network development plan. The regulatory authority shall publish the result of the consultation process on the proposed investments. Member States may decide not to apply this obligation to integrated undertakings serving less than 100 000 connected consumers or serving isolated systems.	Adequate remuneration for DSOs for the procured services Network development plans that demonstrate use of DR and other alternatives to system expansion

ED	36	1. Distribution system operators shall not be allowed to own, develop, manage or operate energy storage facilities. 2. By way of derogation from paragraph 1, Member States may allow distribution system operators to own, develop, manage or operate storage facilities only if the following conditions are fulfilled: (a) other parties, following an open and transparent tendering procedure, have not expressed their interest to own, develop, manage or operate storage facilities; (b) such facilities are necessary for the distribution system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the distribution system; and (c) the regulatory authority has assessed the necessity of such derogation taking into account the conditions under points (a) and (b) and has granted its approval. 3. Articles 35 and 56 shall apply to distribution system operators engaged in ownership, development, operation or management of energy storage facilities. 4. Regulatory authorities shall perform at regular intervals or at least every five years a public consultation in order to re-assess the potential interest of market parties to invest, develop, operate or manage energy storage facilities. In case the public consultation indicates that third parties are able to own, develop, operate or manage such facilities, Member States shall ensure that distribution system operators' activities in this regard are phased-out.	DSOs allowed to own, develop, manage or operate energy storages only if other parties have not expressed interest in it
ER	16	1. Charges applied by network operators for access to networks, including charges for connection to the networks, charges for use of networks, and, where applicable, charges for related network reinforcements, shall be transparent, take into account the need for network security and flexibility and reflect actual costs incurred insofar as they correspond to those of an efficient and structurally comparable network operator and are applied in a non-discriminatory manner. In particular, they shall be applied in a way which does not discriminate between production connected at the distribution level and production connected at the transmission level, either positively or negatively. They shall not discriminate against energy storage and shall not create disincentives for participation in demand response.	Updates and additions in requirements for network tariffs, charges must take need for flexibility into account, no discrimination of storages or disincentives for DR participation Time differentiated tariffs may be introduced

		Without prejudice to paragraph 3, those charges shall not be distance-related. 2. Tariffs shall grant appropriate incentives to transmission and distribution system operators, over both the short and long term, to increase efficiencies, including energy efficiency, foster market integration and security of supply, and support investments and the related research activities. … 7. Distribution tariffs shall reflect the cost of use of the distribution network by system users including active customers and may be differentiated based on system users' consumption or generation profiles. Where Member States have implemented the deployment of smart metering systems, regulatory authorities may introduce time differentiated network tariffs, reflecting the use of the network, in a transparent and foreseeable way for the consumer. 8. Regulatory authorities shall provide incentives to distribution system operators to procure services for the operation and development of their networks and integrate innovative solutions in the distribution systems. For that purpose, regulatory authorities shall recognise as eligible and include all relevant costs in distribution tariffs and introduce performance targets in order to incentivise distribution system operators to raise efficiencies, including energy efficiency, in their networks.	
RD	24	8. Member States shall require electricity distribution system operators to assess at least every four years, in cooperation with the operators of district heating or cooling systems in their respective area, the potential for district heating or cooling systems to provide balancing and other system services, including demand response and storing of excess electricity from renewable sources, and whether the use of the identified potential would be more resource- and cost-efficient than alternative solutions.	Requirement for DSOs to assess the potential of district heating or cooling systems to provide system services

3.1.4 TSO

The requirements concerning TSOs are also of importance to the DOMINOES concept because local communities and markets could provide e.g. balancing services for the TSOs.

Table 3.4 Content concerning TSOs

Art.		Content	Relevance
ED	40	The transmission system operator shall ensure that the procurement of balancing services and, unless justified by a cost-benefit analysis, non-frequency ancillary services, is: (a) transparent, non-discriminatory and market-based; (b) ensures effective participation of all market participants including renewable energy sources, demand response, energy storage facilities and aggregators, in particular by requiring regulatory authorities or transmission system operators in close cooperation with all market participants, to define technical modalities for participation in these markets on the basis of the technical requirements of these markets and the capabilities of all market participants.	Provision of balancing services and non-frequency ancillary services open for DR, storages, aggregators
ED	54	1. Transmission system operators shall not be allowed to own, manage or operate energy storage facilities and shall not own directly or indirectly control assets that provide ancillary services. 2. By way of derogation from paragraph 1, Member States may allow transmission system operators to own, manage or operate storage facilities or assets providing non-frequency ancillary services if the following conditions are fulfilled: (a) other parties, following an open and transparent tendering procedure, have not expressed their interest to own, control, manage or operate such facilities offering storage and/or non-frequency ancillary services to the transmission system operator; (b) such facilities or non-frequency ancillary services are necessary for the transmission system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the transmission system and they are not used to sell electricity to the market; and (c) the regulatory authority has assessed the necessity of such derogation taking into account the conditions under points (a) and (b) of this paragraph and has granted its approval.	TSOs not allowed to own, manage or operate storages unless other parties are not interested in it

		3. The decision to grant derogation shall be notified to the Agency and the Commission along with relevant information about the request and the reasons for granting the derogation. 4. The transmission system operator shall perform at regular intervals or at least every five years a public consultation for the required storage services in order to assess the potential interest of market parties to invest in such facilities and terminate its own storage activities in case third parties can provide the service in a cost-effective manner.	

3.1.5 Market rules

Market rules in the balancing market and in day ahead and intraday markets also impact the opportunities of services to and by local communities.

Table 3.5 Balancing market rules

Art.		Content	Relevance
ER	5	1. All market participants shall have access to the balancing market, be it individually or through aggregation. Balancing market rules and products shall respect the need to accommodate increasing shares of variable generation as well as increased demand responsiveness and the advent of new technologies. 2. Balancing markets shall be organised in such a way as to ensure effective non-discrimination between market participants taking account of the different technical capability of generation from variable renewable sources and demand side response and storage. 3. Balancing energy shall be procured separately from balancing capacity. Procurement processes shall be transparent while at the same time respecting confidentiality. 4. Balancing markets shall ensure operational security whilst allowing for maximum use and efficient allocation of cross-zonal capacity across timeframes in accordance with Article 15. 5. Marginal pricing shall be used for the settlement of balancing energy. Market participants shall be allowed to bid as close to real time as possible, and at least after the intraday cross-zonal gate closure time determined in accordance with Article 59 of Commission Regulation (EU) 2015/122238. 6. The imbalances shall be settled at a price that reflects the real time value of energy.	Aggregator access to balancing market, non-discrimination of DR

		7. The sizing of reserve capacity shall be performed at regional level in accordance with point 7 of Annex I. Regional operational centres shall support transmission system operators in determining the amount of balancing capacity that needs to be procured in accordance with point 8 of Annex I. 8. The procurement of balancing capacity shall be facilitated on a regional level in accordance with point 8 of Annex I. The procurement shall be based on a primary market and organised in such a way as to be non-discriminatory between market participants in the prequalification process individually or through aggregation. 9. The procurement of upward balancing capacity and downward balancing capacity shall be carried out separately. The contracting shall be performed for not longer than one day before the provision of the balancing capacity and the contracting period shall have a maximum of one day. 10. Transmission system operators shall publish close to real-time information on the current balancing state of their control areas, the imbalance price and the balancing energy price.	

Table 3.6 Day-ahead and intraday market rules

Art.		Content	Relevance
ER	7	1. Market operators shall allow market participants to trade energy as close to real time as possible and at least up to the intraday cross-zonal gate closure time determined in accordance with Article 59 of Regulation (EU) 2015/1222. 2. Market operators shall provide market participants with the opportunity to trade in energy in time intervals at least as short as the imbalance settlement period in both day-ahead and intraday markets. 3. Market operators shall provide products for trading in day-ahead and intraday markets which are sufficiently small in size, with minimum bid sizes of 1 Megawatt or less, to allow for the effective participation of demand-side response, energy storage and small-scale renewables. 4. By 1 January 2025, the imbalance settlement period shall be 15 minutes in all control areas.	Minimum bid size 1 MW or less 15 minute imbalance settlement period

3.1.6 Active customers and renewables self-consumers

'Active customer' and 'renewables self-consumer' defined in the package are potential members in the local market.

Table 3.7 Content on active customers and renewables self-consumers

Art.		Content	Relevance
ED	2	8. 'active customer' means a customer or a group of jointly acting customers who consume, store or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes provided that these activities do not constitute their primary commercial or professional activity;	Definition of active customer
ED	15	1. Member States shall ensure that final customers: (a) are entitled to generate, store, consume and sell self-generated electricity in all organised markets either individually or through aggregators without being subject to disproportionately burdensome procedures and charges that are not cost reflective; (b) are subject to cost reflective, transparent and non-discriminatory network charges, accounting separately for the electricity fed into the grid and the electricity consumed from the grid, in line with Article 59(8). 2. The energy installation required for the activities of the active customer may be managed by a third party for installation, operation, including metering and maintenance.	Right to generate, store, consume and sell self-generated electricity
RD	2	(14) 'renewables self-consumer' means a final customer operating within its premises located within confined boundaries or, where permitted by a Member State, within other premises, who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity;	Definition of renewables self-consumer
RD	21	1. Member States shall ensure that consumers are entitled to become renewables self-consumers, subject to this Article. 2. Member States shall ensure that renewables self-consumers, individually or through aggregators, are entitled: (a) to generate renewable energy, including for their own consumption, store and sell their excess production of renewable electricity, including through renewables power purchase agreements, electricity suppliers and peer-to-peer trading arrangements, without being subject: (i) in relation to the electricity that they consume from or feed into the grid, to discriminatory or disproportionate procedures and charges, and to network charges that are not cost-reflective;	Rights of renewables self-consumers, e.g. right to sell excess renewable production

		(ii) in relation to their self-generated electricity from renewable sources remaining within their premises, to discriminatory or disproportionate procedures, and to any charges or fees; (b) to install and operate electricity storage systems combined with installations generating renewable electricity for self-consumption without liability for any double charge, including network charges, for stored electricity remaining within their premises; (c) to maintain their rights and obligations as final consumers; (d) to receive remuneration, including, where applicable, through support schemes, for the self-generated renewable electricity that they feed into the grid, which reflects the market value of that electricity and which may take into account its long-term value to the grid, the environment and society. 3. Member States may apply non-discriminatory and proportionate charges and fees to renewables self-consumers, in relation to their self-generated renewable electricity remaining within their premises in one or more of the following cases: (a) if the self-generated renewable electricity is effectively supported via support schemes, only to the extent that the economic viability of the project and the incentive effect of such support are not undermined; (b) from 1 December 2026, if the overall share of self-consumption installations exceeds 8 % of the total installed electricity capacity of a Member State, and if it is demonstrated, by means of a cost-benefit analysis performed by the national regulatory authority of that Member State, which is conducted by way of an open, transparent and participatory process, that the provision laid down in point (a)(ii) of paragraph 2 either results in a significant disproportionate burden on the long-term financial sustainability of the electric system, or creates an incentive exceeding what is objectively needed to achieve cost-effective deployment of renewable energy, and that such burden or incentive cannot be minimised by taking other reasonable actions; or (c) if the self-generated renewable electricity is produced in installations with a total installed electrical capacity of more than 30 kW. 4. Member States shall ensure that renewables self-consumers located in the same building, including multi-apartment blocks, are entitled to engage jointly in activities referred to in paragraph 2 and that they are permitted to arrange sharing of renewable energy that is produced on their site or sites between themselves, without prejudice to the network charges and other relevant charges, fees, levies and taxes applicable to each renewables self-consumer. Member States	

		may differentiate between individual renewables self-consumers and jointly acting renewables self-consumers. Any such differentiation shall be proportionate and duly justified. 5. The renewables self-consumer's installation may be owned by a third party or managed by a third party for installation, operation, including metering and maintenance, provided that the third party remains subject to the renewables self-consumer's instructions. The third party itself shall not be considered to be a renewables self-consumer. 6. Member States shall put in place an enabling framework to promote and facilitate the development of renewables self-consumption based on an assessment of the existing unjustified barriers to, and of the potential of, renewables self-consumption in their territories and energy networks. That enabling framework shall, inter alia: (a) address accessibility of renewables self-consumption to all final customers, including those in low-income or vulnerable households; (b) address unjustified barriers to the financing of projects in the market and measures to facilitate access to finance; (c) address other unjustified regulatory barriers to renewables self-consumption, including for tenants; (d) address incentives to building owners to create opportunities for renewables self-consumption, including for tenants; (e) grant renewables self-consumers, for self-generated renewable electricity that they feed into the grid, non-discriminatory access to relevant existing support schemes as well as to all electricity market segments; (f) ensure that renewables self-consumers contribute in an adequate and balanced way to the overall cost sharing of the system when electricity is fed into the grid. Member States shall include a summary of the policies and measures under the enabling framework and an assessment of their implementation respectively in their integrated national energy and climate plans and progress reports pursuant to Regulation (EU) 2018/1999. 7. This Article shall apply without prejudice to Articles 107 and 108 TFEU.	

3.1.7 Smart meters

The proposal includes some updated requirements for smart meters.

Table 3.8 Requirements for smart meters

	Art.	Content	Relevance
ED	20	Where smart metering is positively assessed as a result of cost-benefit assessment referred to in Article 19(2), or systematically rolled out, Member States shall implement smart metering systems in accordance with European standards, the provisions in Annex III, and in line with the following principles: (a) the metering systems accurately measure actual electricity consumption and provide to final customers information on actual time of use. That information shall be made easily available and visualised to final customers at no additional cost and at near-real time in order to support automated energy efficiency programmes, demand response and other services; (b) the security of the smart metering systems and data communication is ensured in compliance with relevant Union security legislation having due regard of the best available techniques for ensuring the highest level of cybersecurity protection; (c) the privacy and data protection of final customers is ensured in compliance with relevant Union data protection and privacy legislation; (d) meter operators shall ensure that the meter or meters of active customers who self-generate electricity can account for electricity put into the grid from the active customers' premises; (e) if final customers request it, metering data on their electricity input and off-take shall be made available to them, via a local standardised communication interface and/or remote access, or to a third party acting on their behalf, in an easily understandable format as provided for in Article 24, allowing them to compare deals on a like-for-like basis; (f) appropriate advice and information shall be given to final customers at the time of installation of smart meters, in particular about their full potential with regard to meter reading management and the monitoring of energy consumption, and on the collection and processing of personal data in accordance with the applicable Union data protection legislation;	Updated requirements for smart meters, e.g.: Measurement of electricity injected to the grid, Metering data must be made available to end-users via a local standardised interface and/or remote access or to a third party representing the user Metering and settlement at same time resolution as the imbalance period in the national market

		(g) smart metering systems shall enable final customers to be metered and settled at the same time resolution as the imbalance period in the national market.	

3.1.8 Data management

The proposal also includes guidelines for data management. This would guarantee data access to at least customers, suppliers, TSOs, DSOs, aggregators and ESCOs.

Table 3.9 Guidelines for data management

Art.		Content	Relevance
ED	23	1. When setting up the rules regarding the management and exchange of data, Member States or, where a Member State has so provided, the designated competent authorities shall specify the eligible parties which may have access to data of the final customer with their explicit consent in accordance with Regulation (EU) 2016/679 of the European Parliament and of the Council 52 . For the purpose of this Directive, data shall include metering and consumption data as well as data required for consumer switching. Eligible parties shall include at least customers, suppliers, transmission and distribution system operators, aggregators, energy service companies, and other parties which provide energy or other services to customers. 2. Member States shall organise the management of data in order to ensure efficient data access and exchange. Independently of the data management model applied in each Member State, the party or parties responsible for data management shall provide to any eligible party with the explicit consent of the final customer, access to the data of the final customer. Eligible parties should have at their disposal in a non-discriminatory manner and simultaneously the requested data. Access to data shall be easy, while relevant procedures shall be made publicly available. 3. Member States or, where a Member State has so provided, the designated competent authorities shall authorise and certify the parties which are managing data in order to ensure that these parties comply with the requirements of this Directive. Without prejudice to the tasks of the data protection officers under Regulation (EU) 2016/679, Member States may decide to require from parties managing data the appointment of compliance officers who shall be respon-	Data access at least for customers, suppliers, TSOs, DSOs, aggregators, ESCOs

		sible for monitoring the implementation of measures taken by the relevant parties for ensuring non-discriminatory access to data and compliance with the requirements of this Directive. Compliance officers or bodies designated pursuant to Article 35(2)(d) may be required to fulfil the obligations of this paragraph. 4. No additional costs shall be charged to final customers for access to their data. Member States shall be responsible for setting the relevant costs for access to data by eligible parties. Regulated entities which provide data services shall not profit from that activity.	

3.1.9 Summary of the most relevant issues

The Clean energy for all Europeans package includes several points relevant for the DOMINOES project. Firstly, the package defines the concepts of “local energy community” and “renewable energy community” which are both closely related to the local energy market developed in DOMINOES. At least the following requirements would thus have impact also on the development of the local energy market concept:

- Local energy communities must be able to access all organised markets directly or through aggregators or suppliers
- Members of local energy communities do not lose their rights as household customers
- Members must be able to leave the local energy community

The package also takes stand on the role of aggregators and independent aggregators and acknowledges the right of end-users to enter into contracts with aggregators (also without the consent of their supplier). This would thus give multiple stakeholders the ability to act as the aggregator (or energy community service provider or community manager) discussed in the DOMINOES use cases and business models. Furthermore, the package promotes the access of aggregators in all organised markets and ancillary service provision which is not currently possible in all European markets.

The proposals also impact DSOs abilities to utilise flexibility. For instance, the national regulatory frameworks should enable and incentivise DSOs to procure services such as demand response and DSOs should also be adequately remunerated for the procured services. This together with access to TSO markets would thus promote the ability of the local communities to provide the services for other stakeholders’ needs.

As a detail regarding market rules, the proposal requires that the imbalance settlement period will from 2025 onwards be 15 minutes in all control areas. Furthermore, smart metering systems must enable metering and settlement at the same time resolution as the imbalance period in the national market. This thus sets a framework for defining the settlement process in the local energy markets also. On the other hand, this would also make higher resolution consumption data available than today.

3.2 Other changes

3.2.1 CEER recommendations

During spring 2017, the Council of European Energy Regulators (CEER) conducted a public consultation on good practice for flexibility use at distribution level. Participants of the consultation and a workshop organised by CEER (in March 2018) were asked to comment DSOs' role in accessing flexibility services and enabling an environment for the provision of flexibility, and the regulatory framework to enable flexibility us at the distribution level [13]. Based on the consultation and other CEER work, CEER agreed the following principles for flexibility use at distribution level [13]:

- "The regulatory framework for DSOs should be non-discriminatory and not hinder or unduly disincentivise DSOs from facilitating the development of flexibility.
- The regulatory framework should enable the development of a full range of possible flexibility services, while also ensuring that it is robust enough to deliver the best outcomes for consumers and the system as a whole (to the extent that this is within the scope of NRA's responsibilities in each country). NRAs should ensure that no options are prematurely ruled out.
- All sources of flexibility that benefit the grid, including generators, storage, and demand side response, should be treated in a non-discriminatory manner when procured by network operators. Regulatory incentives should avoid any bias towards specific technologies that deliver flexibility.
- DSOs should be able, under the relevant regulatory frameworks, to access and use flexibility services provided by grid users for managing the distribution network, where the use of this flexibility is considered to be the most economical solution and avoids undue distortion to markets and competition.
- Within the framework set by the relevant European legislation, the details on the roles and responsibilities of DSOs should be determined at national level, given the diversity of situations, legislation and needs across EU Member States and the varying nature of DSOs (e.g. size and location).
- It is vital to differentiate between the use of flexibility by market actors and the use of flexibility that benefits the grid by the DSO. This distinction is due to their different competitive, technical and regulatory conditions. The source of flexibility may be the same, the purpose is different.
- Intensify the discussion on principles and roles and responsibilities regarding DSO-TSO coordination in the field of flexibility."

These principles are not binding rules. Instead, they are supposed to guide the national regulatory authorities (NRAs) in developing national frameworks.

3.2.2 New metering services and meter requirements

Virtual metering services would facilitate the utilization of solar PV (or other generation forms) in buildings with multiple end-users with individual meters (the problem addressed in section 2.3). This kind of service was supported in the final report [14] of the Smart Grid Working Group established by the Finnish Ministry of Economic Affairs and Employment to create a shared view of the smart electricity system of the future. The group members represented the energy industry, energy users, authorities and universities. To support energy communities within housing companies the group stated: "no network service charge should be paid to the distribution network company for energy generated and consumed within the property if it does not cross the access point to the distribution network and consequently does not pass through the distribution network. It must be possible to computationally separate the electricity transmitted to the energy community via the distribution network company from the electricity generated by the energy community itself [14].

The Smart Grid Working Group also proposed requirements for the next generation of smart meters [15]. Especially the following proposals are relevant for the DOMINOES concept:

- Load control functionality for actors who have considerable controllable loads (e.g. electric heating)
- Energy information should be registered at least at the same time resolution as the imbalance settlement period. Ability to update time resolution remotely.
- Measurement of withdrawal from and injection to grid separately for each phase (no netting at the meter)
- Ability to remotely update the software defining the functionalities of the metering device

In addition to the European level recommendations/requirements for smart meter functionalities, also national recommendations like these can have an impact on the local market development and ease of developing services for prosumers.

3.2.3 Building regulation

The need to automate demand response of end-users is discussed in several sources (e.g. [16]). Suggested measures to help facilitate demand peaks and otherwise enable automated demand response include for example [16]:

- Electricity plan of building and documentation of installations prepared for demand response
- Guidelines for electricity planning and installation in buildings to prevent demand peaks caused by large simultaneous loads
- Smart electric vehicle charging systems

Such approach is supported also in the Smart Grid Working Group [15] that is "in favour of cost-effective building regulation that supports demand-side management and smart charging of electric cars." Furthermore, to facilitate the further installations enabling demand-side management, the group states that "once the building has been completed, customers should be given up-to-date planning documents for the building technology systems, including the final drawings of the electrical wiring, HVAC and plumbing automation systems."

3.3 References

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4 Cyber security standards (UoL)

4.1 Introduction

It is well recognised that critical infrastructures play a key role in maintaining a modern society and provide critical support for the economic activities. These critical infrastructures consist of energy, finance, health and transport sectors. Among them, the energy infrastructure may be one of the most complex and critical infrastructures as the other sectors largely rely on it to deliver essential services to the society [1]. Therefore, a lasting disruption may significantly affect the society, industry and business trade with a strong impact on the Gross Domestic Product (GDP).

The energy sector and its contribution to economy and society may be disturbed by potential cyber incidents and attacks. The energy sector consists of both legacy and next generation technologies that gradually introduce new intelligent components to the energy infrastructure communicating with other sectors or systems. In spite of their stability and cost-effectiveness, legacy systems have demonstrated evident weaknesses and unpreparedness against cyber attacks. For example, the Ukraine power grid attack in 2015 demonstrated the potential impact of cyber attacks to the electricity subsector. Therefore, the state of art systems such as Supervisory Control and Data Acquisition (SCADA) and Distributed Control Systems (DCS) require substantial improvements with regards to their immunity to cyber threats.

As one of the most effective solutions against cyber attacks, the adoption of security standards can define the scope of security functions and specifications needed, policies for managing information and human assets, criteria for evaluating the effectiveness of security measures, techniques for ongoing assessment of security and for the monitoring of security breaches and procedures for dealing with security failures.

4.2 Cyber security standardisation

Many standard and guidelines documents have been formulated and published in recent years to support information management in energy sector. In this section, we will survey a number of EU standards whilst examining other important international standards and guidelines.

EU cyber security standards and regulations

In the EU, the first comprehensive policy document on cyber security is “the Cyber Security Strategy of the European Union” [2], adopted in February 2013. In this document, the overall framework for EU initiatives of cyber security and cybercrime is provided.

In July 2016, the EU Parliament adopted the NIS Directive [3], which constructs a set of unified network and information security rules that require regulatory obligations in coordinating national cyber security policies and incident response. This Directive provides legal measures to improve the level of cyber security and targets at identifying good practices for the entire organisation to follow.

The EU General Data Protection Regulation (GDPR) was applied in April 2016 and will be formally adopted in 2018. This regulation hopefully strengthens data protection rights of individuals and supply business with clear, up-to-date operational rules.

A number of organisations and groups have been established, for example, activities on network and information security are supported by the European Network and Information Security Agency (ENISA, the Computer Emergency Response Team for the EU institutions (CERT-EU), the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI). These organisations have continuously making progress in developing and updating standards of the Critical Infrastructure Protection (CIP) and Critical Information Infrastructure Protection (CIIP) [4].

In September 2015, DG Energy established the Energy Expert Cyber Security Platform (EECSP) with a mandate to provide guidance to the European Commission (EC) on policy and regulatory directions at the EU level, in particular addressing the energy sector. The European Energy Information Sharing and Analysis Centre (EEISAC) was launched in 2015 to build a bridge between four EU energy utilities and other sector stakeholders with the financial support of DG Home Affairs.

Following EECSP report and the European Commission proposal "Clean Energy for all Europeans" of 30th November 2016 – which acknowledges the importance of cybersecurity for the energy sector; the EC relaunched in the spring of 2017 the Expert Group 2 (EG2) to prepare the ground for a potential Network Code on energy-specific cybersecurity. In the future, this Network Code might establish the rules, with guidance from the Agency for the Cooperation of Energy Regulators (ACER), to facilitate a harmonised approach to face cybersecurity challenges and gaps of the electricity subsector, such as:

- Implementation of baseline requirements and advanced Cybersecurity for all operators of essential services (OES);
- Adoption of risk management methodologies;
- Implementation of an early warning system for all energy stakeholders.

After December 2018, the EC shall evaluate the adequacy of the final report, and, if confirmed, invite ENTSO and an EU DSO association to develop the Network Code, that shall be later submitted to ACER for evaluation. If ACER provides a positive opinion and recommendation to the EC, the Network Codes will finally be ready for adoption, building up to what is already deemed compulsory under the NIS Directive and scoped by an energy specific secondary legislation.

International Cyber Security Strategies

Similar cyber security initiatives and regulations have been created outside the EU, especially in the USA. The Framework for Improving Critical Infrastructure Cybersecurity was developed and issued by the US National Institute of Standards and Technology (NIST) in February 2014. This framework aims to apply effective practices of risk management to improve the security and resilience of critical infrastructure. In January 2015, the Energy Sector Cybersecurity Framework Implementation Guidance was produced by the US Department of Energy and the electricity oil and gas industries. One of the important tools shown in this guideline is the Electricity Subsector Cyber Security Capability Maturity Model (ES-C2M2). Other important tools include: the CIP Standards that raise regulatory cyber security requirements, and Guidelines for Smart Grid Cyber Security by NIST that tailored cyber security strategies to specific smart grid-related characteristics, risks and vulnerabilities. Two pieces of legislation were also passed in the USA in 2015: the Protecting Cyber Networks Act and the National Cyber Security Protection Advancement ACT, e.g. [5].

In 2009, Australia published their Cyber Security Strategy to improve the detection and mitigation to cyber threats. Australia set up two agencies to monitor and respond to cyber attacks: The Australiana Cybercrime Online Reporting Network and Australian Securities and Investments Commission, using the NIST Cyber Security Framework [6].

In July 2015, China released a consultation draft of a new Cyber Security Law, which became effective in June 2017 [7]. This Law imposes obligation on the providers of information network, products and services. Key IT hardware and equipment have to meet mandatory security qualifications and hold government certification before the purchase occurs.

Singapore set up the Cyber Security Agency (CSA) in April 2015, and delivered a five-year National Cyber Security Masterplan that leads to secure and trusted hub in terms of critical infocomm infrastructure [8].

In September 2015, the Japanese Government approved the second Japanese Cybersecurity Strategy in order to handle the continuous threats to the national critical security infrastructure. Japan also published The Cybersecurity Policy for Critical Infrastructure Protection (4th Edition) in April 2017, and the Common Standards for Information Security Measures for Government Agencies in 2016 [9].

4.3 Comparisons of standards

There are a number of security standards for energy sector to support the business and regular workloads. Some examples are:

- IEC 61850: A set of standards of describing the design of electrical substation automation and distributed energy resources.
- IEC 623511: Security measures for TC 57 series of protocols, including authenticated access & data transfer, prevention of eavesdropping, prevention of playback and spoofing and intrusion detection.
- IEC 60870-5: Standards used for SCADA system to Remote Terminal Unit (RTU) data communications in EU.
- IEC 62443: Network and system security in industrial communication networks.
- NIST IR 7628: Overview of the cyber security strategies used to develop the high-level cyber security Smart Grid requirements.
- ENISA: Security measures for energy sector, and cooperation and information sharing among energy sector stakeholders - including ISACs (Information Sharing and Analysis Centres) and CSIRTs (Computer Security and Incident Response Teams) active in the energy sector.
- ETSI TC-Cyber: This develops standards to increase privacy and security for organisations and citizens across Europe. It provides security of infrastructure, devices, services and protocols, in addition to security advice, guidance operational security requirements to users and infrastructure operators.

To determine what standards should be used in a cyber security system, we need to evaluate all the existing standards, regulations and guidelines published in the society. The following table shows the bodies involved in global cyber security standards, whilst a more comprehensive list of bodies is kept by ETSI in ETSI TR 103 306 [10].

Table 4.1 Bodies involved in global cyber security standards

3GPP	CCRA	ETSI ISI	IIC	OAA	Platform Industrie 4.0
3GPP SA2	CEN	ETSI LI	InfluxDB	OASIS	RIOT
3GPP SA3	CENELEC	ETSI MTS-SIG	IO-Link	OASIS CTI	ROS
3GPP SA5	CEPOL	ETSI NFV	IoT Security Foundation	ODVA	SAE International
3GPP CT	CERT-EU	ETSI NTECH	IoTivity	OGC	SensiNact
ACDC	CIA	ETSI SAGE	IPEN	OIC-CERT	SGIP
ACEA:	CIIAII	FIDO Alliance	IPSO	OM2M	Sofia2
AEF	CIS	FIRST	ISA	OMA	TCG
AIOTI	CLEPA	Fi-ware	ISF	OMG	The KNX Association
AllJoyn	Contiki	GlobalPlatform	ISO	OneM2M	The Open Group
Allseen Alliance	Continua: Health Alliance	GSMA	ISO JTC1/SC27	ONOS	The ULE Alliance
Apache Spark	CSA	GSMA FASG	ISO JTC1/SC6	OPC Foundation	The ZigBee Alliance
APCERT	CSC	H2020	ISO JTC1/SC7	Open Connectivity Forum	ThingSpeak
Arduino:	CSCG	HGI	ITU ITU-D	OpenDaylight	Thread group
ASHRAE	DICOM	HL7 International	ITU ITU-R	openHAB	TMForum
Automation ML	easyway	HYPER/CAT	ITU ITU-T	OpenIoT	UDG Alliance
AVNU	eCl@ss	ICANN	ITU	OpenRemote	UniverSaal
BEREC	EclipseIoT	IEC	LinuxIoTDM	OpenStack	UPnP
Bluetooth	ECRG	IEEE	LoRa Alliance	OpenWSN	W3C
Broadband Forum	ENISA	IEEE 802 LAN/MAN Standards Committee	MITRE	OPFNV	Weightless
C2C-CC	Enocean Alliance	IEEE P2413	Mosquitto	OSCE	Wi-Fi Alliance
CA/B Forum	ERTICO - ITS Europe	IETF	NATO	OSGi Alliance	WWRF
Cable Labs	ETSI	IETF IRTF	NATO CCDCOE	OWASP	
Calypso	ETSI CYBER	IETF MILE	NATO LIBGUIDE	Paho	
CCC	ETSI E2NA	IETF SACM	NIST	Particle	
CC-Link	ETSI ESI	IHE	Node-RED	PI International	

One of the criteria is to look at the following major questions [11] and ‘measure’ the maturity of the standards before they are defined:

- Which standards are the most update to date?
- Which standards are relevant to our operations, related to marketing, compliance, defending and auditing?
- Are the chosen standard reference architectures relevant to our operations, e.g. SGAM or TOGAF?

Other criteria include: applicability; Security and Privacy; Security Scope; Related Smart Grid Standards; Adequacy; Benefits; Problems and Gaps; Usability; Interoperability. For demonstrating the use of these criteria, we take a look at the following example [12].

Table 4.2 Example of measuring standard maturity

NIST 7628: Guidelines for smart grid cybersecurity		
Description	This standard has three guidelines for smart grid cybersecurity. Volume 1: Smart grid cybersecurity strategy, architecture and high-level requirements. Also, it provides a framework to implement cybersecurity strategies for smart grids. It helps assessing risks and identifying security requirements. Volume 2: Privacy and smart grid. This is related to information sharing and fours levels of privacy (i.e. personal information, personal privacy, behavioural privacy and personal communication privacy). Volume 3: Supportive analysis and references. This provides classes of potential vulnerabilities for the smart grid, identifies specific protocols, interface, applications and practices that should be used to solve smart grid problems.	
Applicability	Requirements, guidelines and implementation	
Security and privacy	The standard is related to seven domains within the smart grid: transmission, distribution, operations, generation, markets, customer and service provider. It proposed logical interfaces ad allocates them to a logical interface category.	
Security scope	The guideline has the full life-cycle for securing a smart grid system, from risk analysis, through cybersecurity requirement elicitation to the implementation of a secure smart grid.	
Related smart grid standards	The NIST framework and roadmap for smart grid interoperability standards, release 2.0 (NIST Special Publication 1108) which adds 22 standards, specifications and guidelines to the 75 standards NIST recommended.	
Adequacy	Use Case 1	High
	Use Case 2	Medium
	Use Case 3	Medium
Benefits	This addresses cybersecurity for smart grid systems and provides architecture diagrams for each logical interface category. It also specifies high-level security requirements for the smart grid.	
Problems and gaps	No.	

Usability	Sets definition, interfaces and security objectives. It also provides use cases where cybersecurity requirements, stakeholders and data privacy recommendations are specified.
Interoperability	This standard comes from the Smart Grid interoperability Panel (SGIP).

4.4 Recommendations for the standards

After having examined the progress made in the field, we here present the recommended standards and solutions from the security point of view in order to address security requirements. Below the table describes the standards that are recommended for implementation in this project.

Table 4.3 Recommendations

Standard & Technology names	Recommendations	Requirements
TLS (IETF FRC 5246)	This standard can be used to ensure confidentiality and integrity in centralised architecture. The use of PKI makes this standard difficult to deploy in a decentralised architecture with client authentication.	R-Sec-19
IEC 62351	Security in energy management systems: provides security recommendations for important protocols, most of them used mainly in the energy sector (includes IEC 60870-5, DNP3, IEC 60870-5-101 and IEC 60870-5-104).	n/a
NIST SP 800-82	Guide to Industrial Control Systems which defines the typical topology of SCADA systems, identifying threats and vulnerabilities	n/a

	and providing recommendations and countermeasures to mitigate these risks.	

In addition to the above recommendations, we make further suggestions as follows:

- Each standard and technology shall implement a log capability so that abnormal events can be recorded at any time.
- Each standard and technology is advised to follow ENISA recommendations with respect to cryptographic algorithms and key sizes. This helps avoid privacy issues. For example, for RSA algorithms, the key size is at least 2048 bits.

4.5 References

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5 Energy storage systems and inverter driven technologies (USE)

In this early stage of the project, there are several concepts that are still being defined and the scope is still slightly shifting as the proposals for implementation and validation are being accepted. The University of Seville has focus its efforts regarding standardization and regulation in the study of the current regulatory frame with the focus set on ESS and inverter driven technologies.

The results will allow to identify possible standards and regulations that should be addressed, analysed and taken into account for the development of future tasks, such as the validation activities. This study will also provide some insight on potential problems that should be addressed in the future, consulting regulatory bodies to ensure that the implementation of the DOMINOES concept is achievable.

Test procedures and system specifications, besides conventional standards and regulations may also be subjected to special requirements by the grid operators, reflecting local grid connection specificities, internal rules for distributed energy resources integration and national regulatory requirements (besides European regulation and standards).

5.1 Energy storage systems (ESS)

As renewable energies are taking an increasingly important role nowadays, there is a generation percentage the electrical system cannot take advantage of. The generated energy surplus could be stored for a subsequent use, and consequently be leveraged. Increased deployment of ESS in the distribution grid could also make it easier to cover the energy demands of the users [1]. Therefore, the existence of Energy Storage Systems is intended to be a key asset and provide services and improvements to our power grid systems. Its versatility to mediate between variable sources and variable loads make ESS adequate to be considered an essential part of the grid equipment.

This section includes a list of tests and requirements that should be addressed according to different standards which will provide the means to facilitate the deployment of ESS within an infrastructure of safety-related regulations, specifications and standards. There are several aspects such as performance, environmental durability, the quality of assurance and assessment criteria, interoperability, communication requirements, system integration and installation, etc., which need to be taken care of. There are many organizations and important research groups such as the European Committee for Electrotechnical Standardization (CENELEC), the Institute of Electrical and Electronics Engineers (IEEE) or the International Electrotechnical Commission (IEC) that intend to establish and unify these requirements and regulations. These are aimed to protect the public health, safety and welfare.

According to [2], standardization topics for ESS include: Terminology, basic characteristics of ES components and systems, communication between components, interconnection requirements, safety, testing, and guides for implementation. Those aspects should be addressed in the development of the project, and, to ensure that, an analysis of references regarding ESS is exposed in the following sections of the document.

5.1.1 Normative References

Several standards and guidance material have been formulated and issued to support the correct fully functioning of every device and component within the EPS. The following referenced documents help to achieve the correct identification, use, verification and installation to provide the optimal reliability and performance of the ESS. Hence, it is highly recommended to use these documents as a guideline for the use, installation, design and evaluation of ESS:

- IEEE Std. 2030.2-2015, IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS). End-Use Applications, and Loads.
- IEEE Std. 2030.3-2016, IEEE Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications.
- IEEE Std. 1547-2018, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.
- IEC 62933-5-2 Electrical energy storage (EES) systems Part 5-2: Safety requirements for grid integrated EES systems - electrochemical based systems

5.1.2 Test procedures

As stated in the IEEE Std. 2030.3-2016 [3], all the equipment that is connected to the grid has considerable safety requirements that have to be met to properly protect electric power systems. ESS need protection from potential damaging effects such as short circuits, voltage and frequency deviations, overloads and anti-islanding. ESS are also demanded to meet the technical requirements of the electric power system, even if applied ESS in an EPS are acting whether as a power source or as load.

There are different test procedures which need to be accomplished, classified as: type tests, production tests, installation evaluations, commissioning tests and periodic tests.

Table 5.1 - ESS test items as stated in IEEE Std. 2030.3-2016 [3]

Nº	Test Item	Type tests	Production tests	Commission-ing tests	Periodic tests
1	Temperature stability	X			
2	State of charge (SOC)	X			X
3	Conversion efficiency	X			
4	Response time	X			X
5	Ramp-rate	X			X
6	Synchronization	X	X	X	
7	Reconnection after abnormal condition	X	X		
8	Harmonics	X			X
9	Flicker	X			
10	Voltage unbalance	X			
11	Open phase	X	X		
12	Overcurrent	X			
13	DC injection	X	X		
14	Response to abnormal voltage condition	X	X		X
15	Response to abnormal frequency condition	X	X		X
16	Unintentional islanding	X	X	X	
17	Low-voltage ride through (LVRT)	X	X		
18	Interconnection	X			

19	Continuous operation	x	x		
20	Stop charging/discharging	x		x	

As it is shown in the table above, there are 4 events where testing should be conducted:

- Type tests: Prior to the many production tests, some standards require to verify the ESS design specifications and rating. If there is any critical change in the design, manufacturing processes, components, material or firmware, the type test shall be re-performed.
- Production tests: Following to the type tests, it is needed that ESS go through many production tests before delivery. These tests shall follow the regulations detailed in IEEE Std. 1547.1-2015 [4].
- Commissioning tests: The commissioning test shall be performed after the ESS is installed and ready to operate. A technical report shall be produced with the detailed results of all tests, together with the list of settings and parameters the test was performed. This report shall follow a written procedure indicated by the manufacturer and approved by the ESS owner and EPS operator. Once it is revised and accepted, there is no need to repeat it.
- Periodic tests: The aim of these tests is to periodically verify the ESS is fully functioning after a certain continuous time of operation. The ESS protective functions and associated batteries shall remain working properly. The interval between these periodic tests shall be specified by the manufacturer. If there is any change of ESS functional software/firmware or any modification in ESS configuration there shall be reperformed corresponding new type tests.

5.2 Inverter driven technologies

This section includes some information to set the basis of a unified approach to the specification, design and use of the inverters used in transformers. The unification of this information is aimed to help avoid potential problems caused by improperly defined, missed or misinterpreted points of consideration. It also sets constraints that are important in terms of specification, efficient design and reliable application of transformers.

Distributed Photovoltaics (DPV) power generation systems require to follow certain technical specifications to be detailed in this document. The inverter and transformer manufacturer shall review the possible system design and installation options, although many of those conditions are not easy to be verified in a laboratory. Thus, it might be needed to perform actual field experimentation.

5.2.1 UNE 206007 IN

This UNE inform contains a list of requirements to be fulfilled in generation plants that inject energy to a distribution grid through inverters based in electronics in Spain [5] [6]. The contents of this document are relevant for the development of the project due to the fact that the energy harvester to be developed is going to be installed in the facilities of the University of Seville (USE), Spain.

The next table contains a list of the different sections and requirements from the document that contains relatable information:

Table 5.2 Requirements from UNE 206007 IN

Requirements	Description	Comments
DC injection to the grid	For inverters with low frequency transformers it is not required to perform any test, since low frequency guarantees the lack of DC injection to the grid. For inverters with high frequency transformers it is required that the DC current injected to the grid by the inverter is not superior to the 0.5% of the RMS of the inverter output nominal current.	
Performance against insulation failures	The inverter is required to measure the impedance between the photovoltaic generator and the ground. The measurement circuit shall detect an insulation resistance between the active parts of the photovoltaic generator and ground, below the required values stated in the UNE-EN 62109-2. Below these values, the inverter shall proceed as follows:	

	- Inverters with no transformers shall indicate an insulation failure and disconnection from the grid. - Inverters with low or high frequency transformers shall indicate an insulation failure but it is not needed to proceed with a disconnection from the grid.	
Defective current detection in the photovoltaic generator	It is not required to perform any test on inverters with low or high frequency transformers. In the case of inverters with no transformers, a surveillance unit shall be placed between the grid and the photovoltaic generator to monitor the defective current to the ground.	
Abnormal voltage or frequency disconnection	Inverters shall disconnect from the grid whether the voltage or frequency at the connection point is not within the established permissible range. To verify this condition the inverter should be connected to a grid simulator to check its response to these variations. The test shall verify the security protection levels and disconnection times detailed in UNE-EN 61400-21 or UNE-EN 50438. For three phase inverters the disconnection shall occur within the established time	

	range when there is a voltage or frequency surpass in any of the three phases.	
Abnormal voltage or frequency reconnection	The abnormal conditions protection shall keep the inverter disconnected until the grid voltage and frequency values remains stable within the specified permissible range after three minutes of normal functioning.	
Unintentional islanding detection	Inverters in installations provided with anti-islanding protection systems in the connection point to the grid do not require to include anti-islanding systems. Inverters connected to the low voltage grid shall follow the requirements stated in UNE 206006 IN. Inverter anti-islanding systems shall not prevent the fulfilment of the requirements at the installation level.	
Overvoltage generation	Inverters shall not generate overvoltage in its alternating connection. Tests shall be performed to verify this characteristic. These tests shall be validated once the generated voltage by the inverter at the measurement point is not superior than the values stated in UNE 206007-1:2013 IN.	
Grid quality	Depending on the nominal current values of the inverter, there are other requirements that shall be fulfilled.	

	Steps for the fulfilment of the requirements for harmonics for different values of nominal currents are detailed in UNE-EN 61000-3-2, UNE-EN 61000-3-12 and UNE 21000-3-4. The proceeding steps for different values of the nominal current for the voltage fluctuations (flickering) fulfilment requirements are detailed in UNE-EN 61000-3-3 and UNE-EN 61000-3-11.	
Desynchronization	The photovoltaic inverter must tolerate a reconnection out from synchronism, preventing abnormal reconnection times inferior than the anti-islanding system reconnection time.	
Frequency range to bear without disconnection	The amount of time that the installation must be kept connected to the grid before disconnecting while deviation from the nominal frequency (50Hz) appears.	Includes a different set of requirements for systems out of the Iberian Peninsula. The values seem achievable in most situations.
Capability of standing variation of frequency over time	Specifies the maximum hertz per second that a system must be capable of handling without disconnecting from the grid. A list of tests to check this is also proposed.	Possible issues with reactive power if the system does not adapt to the phase-shifting.
Power reduction to increasing frequency	Inverters should be able to ensure that the reduction of the injection of active power when a rising on the frequency of the system appears.	

Withstanding temporary voltage reductions	Stablishes the maximum values of deviation from the nominal voltage over time that the system must be able to withstand before disconnecting from the grid	Once again, there is a distinction between the territories in the Iberian Peninsula and those elsewhere.
Reactive power generation/consumption in nominal conditions	The manager of the grid usually stablishes the reactive power reference. The system should aim for a power factor close to 1 unless this contradicts the references sent by the grid operator.	

There are some specifications for generation plants with an active power rating between 100kW to 1MW, which are not that interesting for the scope of this project.

5.2.2 EN 50438

This European standard specifies the technical requirements for protection, safety and exploitation possibilities for small generation units (maximum current per phase: 16A, 230/400V), designed to work side by side with public distribution grids in low voltage [7].

The list of requirements set in the document is considerably long and covers the whole scope of generation devices that could be integrated in local markets at a low voltage level, which encompasses conventional installations from prosumers and generation assets in LV. The two addressed areas are technical requirements and generation operation security. It includes an annex where the procedure to be followed by the DSO which belong to the different Members of the EU is specified.

DOMINOES' proposal specifies that the requirements present in the regulation will be followed, for this reason, it is really important to keep them in mind in the different developments to be performed in the project and in validation activities as well.

However, further test procedures and specifications may be included by the grid operators, reflecting local grid connection specific requirements, internal rules for distributed energy resources integration and national regulatory requirements.

5.2.3 IEC 61400-27

This document specifies standard dynamic electrical simulation models for wind power generation. As it is stablished in DOMINOES' proposal, this standard will be followed in the development of the project, paying special attention to the models for wind generation that are included in IEC 61400-27-1 [8].

The purpose of this standard is clear: to provide quality dynamic models that can be used for truly test the effect of wind generation in power system. The models obtained while following this standard, however, will present a list of limitations that should be taken into account [8]:

- The models are not intended for long term stability analysis.
- The models are not intended for investigation of sub-synchronous interaction phenomena.
- The models are not intended for investigation of the fluctuations originating from windspeed variability in time and space. This implies that the models do not include phenomena such as turbulence, tower shadow, wind shear and wakes.
- The models do not cover phenomena such as harmonics, flicker or any other EMC emissions included in the IEC 61000 series.
- The models have not been developed explicitly with eigenvalue calculation (for small signal stability) in mind.
- The models specified here apply only to wind turbines, and therefore do not include wind power plant level controls and additional equipment such as SVCs, STATCOMs and other devices.
- This standard does not address the specifics of short-circuit calculations.
- The models are not applicable to studies of extremely weak systems including situations where wind turbines are islanded without other synchronous generation.
- Some other technical limitations.

The standard includes a set of requirements and specifications focusing in the following areas:

- Parameters and initialisation.
- Modular structure: A generic modular structure and 4 types.
- Module library: A list including aerodynamic, mechanical, generator, electrical, control and grid protection models.

It includes a validation procedure that focuses on three main items, namely:

- Voltage dips.
- Reference point changes.
- Grid protection.

The use of this recommendations as a guideline will allow the design of relevant models for wind turbines that could increase the value of the demonstration and validation activities to be carried in the context of the project.

5.2.4 EN 61724:1998

This EN standard sets the guidelines for the measurement, data exchange and analysis of photovoltaic generation systems that inject energy to a distribution grid through inverters based in electronics. Monitoring photovoltaic system performance is relevant for the development of the project in activities such as the validation in demonstrators, design of energy harvesting systems and evaluate the efficiency of the control algorithms used in power inverters [9].

The following table contains a description of the different sections of the monitorization method:

Table 5.3 Monitorization method in EN 61724:1998

Measurement	Description	Comments
Irradiance measurement	Irradiance measurement shall be performed by calibrated reference devices called pyranometers. Irradiance values shall be measured in the PV field plane. This information shall be used in the analysis of the photovoltaic systems performance. Irradiance could also be measured in the horizontal plane to establish comparisons of standard meteorologic data between different locations.	
Ambient temperature measurement	Temperature measurements shall be performed in a representative location of the PV field conditions, by using different temperature sensors placed in the shade.	
Wind speed measurement	Wind speed measurements shall be performed in a representative location of the PV field conditions at an appropriate height.	

Module temperature measurement	Measurement sensors shall be placed at the top of the modules, ensuring they do not affect the module temperature.	
Voltage and current measurement	Both AC and DC parameters shall be measured.	
Electrical power measurement	The electrical power parameters can be DC, AC or both. The DC power can be calculated in real time as a product of voltage by current, or measured directly with a power sensor. The DC voltage and the input power to the inverter in isolated systems can have an important component of AC overlapped. It may be required to use a DC wattmeter to measure DC power with precision. The AC power could be measured using a power sensor that takes into account the power factor and the harmonic distortion.	
Data acquisition system	An automatic data acquisition system is required to gather all the previous measurements. This system shall be commercially available including properly documented user manuals and technical support.	
Sampling interval	The sampling interval for parameters that vary directly with the irradiance shall be 1 min or less. Parameters with greater time constant could be specified an arbitrary interval between 1 min and 10	

	min. Special considerations shall be taken into consideration to increase the sampling frequency for any parameter that may change rapidly depending on the load of the system. All parameters shall be continuously measured during the specified monitoring period.	
Data process operation	Sampled data of each measured parameter shall be processed in time-weighted means. Maximum and minimum values including the transients of special interest shall be determined when required.	
Register interval	Each hour all the processed data shall be gathered and registered. Every interval shall be asigned the time and final date of the measurement period.	
Monitorization period	Monitorization period shall be long enough to gather all the representative operational data of the load and environment conditions. Hence, the minimum continuous monitorization period shall be selected according to the final use of the acquired data.	

5.3 Final comments

The study of the standards listed above has provide relevant knowledge regarding the implementation and development of systems based on renewable generation and ESS.

The requirements and specifications identified will be helpful to design, build and implement the energy harvester that will be tested in the laboratories of the University of Seville. If any new equipment was needed in any demonstrator, most of the requirements set on this deliverable could also be used.

The standards focused on ESS that have been analysed provide a set of requirements for the secure installation and operation of these devices in different levels, which will allow the design of a scalable energy harvester which is safe. Regarding Inverter driven technologies, the standards that have been analysed provide important requirements to be fulfilled by generations plants and small generation units in Spain, allowing the test of the harvester in a real environment. In addition to that, EN 61724:1998 focuses on the measurement and data exchange and analysis while IEC 61400-27 provides relevant information for the implementation of wind power generation models, which will allow the implementation of these models in simulation and validation activities.

For the time being, no mayor issues that could present problems for the DOMINOES concept have been identified, nevertheless, it is recommended to keep these standards in mind in the future when any modification that involves the installation or modification of inverters and/or ESS is required. In the future, these and new relevant standards will be studied in more depth to make sure that every development proposed in the project is implementable, and to assure a future where a real implementation of the concepts and results obtained in DOMINOES is possible.

5.4 References

[1] IEEE Std. 2030.2-2015, IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS). End-Use Applications, and Loads. https://standards.ieee.org/standard/2030_2-2015.html

[2] IEC Electrical Energy Storage White Paper. https://www.iec.ch/whitepaper/pdf/iecWP-energystorage-LR-en.pdf

[3] IEEE Std. 2030.3-2016, IEEE Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications. https://standards.ieee.org/standard/2030_3-2016.html

[4] IEEE Std. 1547.1a-2015, IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems - Amendment 1. https://standards.ieee.org/standard/1547_1a-2015.html

[5] UNE 206007-1:2013 IN Requisitos de conexión a la red eléctrica. Parte1: Inversores para conexión a la red de distribución.

[6] UNE 206007-2:2014 IN Requisitos de conexión a la red eléctrica. Parte 2: Requisitos relativos a la seguridad del sistema para instalaciones constituidas por inversores.

[7] UNE-EN 50438 Requisitos para la conexión de microgeneradores en paralelo con redes generales de distribución en baja tensión

[8] IEC 61400-27-1:2015 Wind turbines - Part 27-1: Electrical simulation models - Wind turbines

[9] UNE-EN 61724:2000 Monitorización de sistemas fotovoltaicos. Guías para la medida, el intercambio de datos y el análisis.

6 Activities related to standardization organizations and regulatory bodies

DOMINOES partners' activities related to standardization, regulation and legislation were mapped with a web-based survey conducted in November 2018. The activities reported in this survey are summarized in this section.

LUT has a representative in the national standardisation committee SK69 Electrical road vehicles and industrial trucks managed by SESKO, the National Electrotechnical Standardization Organization in Finland. The national committee participates standardisation work of the committees IEC/TC 69 (Electric road vehicles and electric industrial trucks) and CENELEC/TC 69X (Electrical systems for electric road vehicles) and also observes committees IEC/TC 21(Secondary cells and batteries), IEC/SC 23H (Plugs, Socket-outlets and Couplers for industrial and similar applications, and for Electric Vehicles), IEC/SC 121B (Low-voltage switchgear and control gear assemblies) and ISO/TC22/SC21 (Electric Road Vehicles).

The national committee SK69 prepares national standardisation in the field of EV charging for Finland and provides national guidelines to follow.

Furthermore, Empower has a representative in SESKO's committee SK8 Systems aspects for electrical energy supply and is involved in discussions on flexibility management technology implementation.

Empower has been active in the IEEE Power and Energy Society and DG CONNECT discussions on facilitation of flexibility information exchange (e.g. implementation of datahubs). Empower has also done background work on flexibility as part of balance settlement and network ancillary service value for the Finnish Energy Authority.

Finally, to facilitate solar PV production in housing companies (problem described in section 2.3), LUT has been involved in writing a policy brief[4], published in August 2018, that promotes allowing the use of virtual metering services for dividing building's PV generation between the residents.

In the following years of the DOMINOES project, Empower will keep contributing to the ongoing standardization and regulatory work through SESKO in Finland while EDPD's experience at EU level on various fora, such as EDSO4SG, Bridge2020 WG Regulation

[4] http://smartenergytransition.fi/wp-content/uploads/2018/08/Taloyhti%C3%B6n-asukkaiden-aurinkos%C3%A4hk%C3%B6n-tuotantoa-tulisi-edist%C3%A4%C3%A4-lains%C3%A4%C3%A4d%C3%A4nt%C3%B6muutoksella-politiikkasuositus-30082018.pdf

and ETIP SNET, will set-out the vision for the smart networks, storage and integrated systems.

7 Conclusions

Year one of the DOMINOES project focused on the development of the DOMINOES local market concept including, for example, use cases and business models. Due to the early phase of the project, partners' involvement in standardization work arising from the DOMINOES project has been limited. Activities will be reported again January 2020 and March 2021.

This deliverable has reviewed the regulatory framework concerning key issues in the DOMINOES concept: utilization of demand response and flexibility, peer to peer trading and sharing of energy, and aggregation services. Furthermore, the standardization regarding key technologies has been reviewed and discussed.

If the legislative proposals included in the 'Clean energy for all Europeans' package will come into effect, they will clarify some of the gaps raised in section 2. This involves, for example, the role and rights of independent aggregators. However, the potential arrangements for handling imbalances caused by third party aggregators to other market participants are not elaborated in the proposal. This issue will be considered in the further development of the DOMINOES local market concept.

The proposed electricity market directive states that regulatory framework shall enable DSOs to procure services from distributed generation, demand response or storages. DOMINOES project supports this view.

The review of standardization in focused on the following key issues: cyber security, energy storage systems and inverter driven technologies. Other themes can be addressed in future releases of T6.2 as the DOMINOES concept becomes more elaborate.

Overall, the development of the DOMINOES concept is in line with the European climate and energy targets and the goal of consumer empowerment. At the European level, current regulation and standards do not set major restriction for the DOMINOES concept. However, the situation varies between individual countries in Europe especially when it comes to access of demand response resources in the ancillary services markets. Furthermore, DSOs' opportunities to utilize flexible resources may vary significantly as the regulatory frameworks are set on a national level. These key issues will affect the implementation of the DOMINOES concept in some countries if market rules and regulatory frameworks are not updated.