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Deliverable 2.1:
Key needs, priorities and framework for the development of a common European pre-standard on DER interconnection

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1 Introduction: Framework and key needs for the development of a European DER Interconnection Standard

This first chapter provides an introduction on the issue, showing the current situation and the associated needs.
The current situation regarding interconnection requirements for Distributed Energy Resources (DER) in Europe is characterised by a wide diversity and even by the presence of some inadequacies which appear to represent barriers for the wide deployment of distributed energy resources.
In [1] (Draft for interconnection requirements in Europe), barriers for the interconnection of DER to the network have been classified into technical, business, regulatory and others barriers. Among the technical barriers, the lack of standardisation and the lack of testing procedures have been identified as particularly critical. Furthermore, a review of interconnection projects (connection process for different DER) showed that for about 25 % of the cases, the project developers encountered technical barriers. The difficulties associated with inadequate, unclear or non transparent interconnection requirements were mentioned in a large part of the cases. [2] presents a review of interconnection requirements focused on the so-called “New Member States”.
In another previous work, [3] (Report on “evaluation of the quality of supply requirements specified by existing standards, national legislation and relevant technical reports inside and outside EU”), provides a detailed analysis of the interconnection requirements related to power quality (PQ) for eight European countries and the USA. This report discusses the most addressed power quality issues and identifies the most critical where harmonisation is acutely needed. Again, the large discrepancies between the requirements in various countries are acknowledged as a barrier for the integration of DER.
[4] provides an interesting analysis of the areas of commonality and inconsistency in the elaboration of interconnection requirements. This preliminary assessment has underlined the urgent need for a novel, consistent and pan-European approach to DG interconnection issues.
Finally,[5] (“International standard situation concerning components of distributed power systems and recommendations of supplements”) shows the status and content of standards, legislative documents and Distributed Network Operators’ (DNO) requirements dealing with the interconnection of DER to the public distribution network. A detailed overview of the requirements and a comprehensive gap analysis has been performed for seven European countries and the USA. This report also provides some recommendations and introduces some useful concepts for harmonising the interconnection requirements like e.g. the segmentation concept.

Today, requirements may vary from utility to utility, are usually not transparent enough, and not uniformly applied, which results in additional costs for manufacturers and project developers to comply with the requirements. Under this framework, economies of scale are limited since manufacturers can not offer unique pieces of equipment for the European market but have to design, build, certify and sell different pieces of equipment for each national market. Various studies already pointed out the missing economies of scale. For example, the data for photovoltaic generation presented in [6] show that the learning rates calculated for inverters (not only playing the role of DC to AC converter but also interconnecting the generator to the grid) are about half those calculated for photovoltaic modules.

Although the above-mentioned inadequacies had been already clearly brought to the research community's attention more than three years ago, little has changed since then. This may be due to the fact that some technical issues are still not fully mature for harmonisation and that the harmonisation process is a very lengthy one. Moreover, the type of organisations involved in the development of such requirements very diverse:

- National parliaments
- Ministry covering energy issues (e.g. Energy Ministry of Industry Ministry)
- Regulators
- National standardisation bodies
- DNO associations
- DNOs

This diversity is also probably one of the major causes for the slowness of the harmonisation process.

As clear background, the absence of a harmonised interconnection standard has been identified as one of the most severe obstacles towards the deployment of distributed energy resources and as a result to the change toward active electricity networks. Addressing this diversity has been set a one of the most important objective of the research community and is thus also one of the key objectives of the European Network of Excellence of DER laboratories and Pre-Standardisation. As a first step for harmonisation, the work presented here intended to propose a structure for a European DER Interconnection Standard. The intention is to provide the results of this work to relevant working group(s) (i.e. CLC/TC8X) in order to favour progress toward harmonisation. In this sense, this report intends to be a first step driven by the research toward the adoption of such a European standard.

This technical report presents a structural analysis of interconnection standards in Europe (chapter 3) and proposes a structure for a European Standard for interconnection of Distributed Energy Resources (chapter 4). In the conclusion of chapter 3, the needs are clearly identified and some recommendations for the standard structure are made.

2 Scope

This document presents a draft structure for a European Standard for interconnection of Distributed Energy Resources (shortly *European DER Interconnection Standard EDIS*). The work presented in this document has been focused on developing a model for the structure for a European interconnection standard, leaving out the content and technical requirements for a following step.

The proposal for a structure has been developed on the basis of an analysis of current national and international standards, regulator or distribution network operators' guidelines, which is presented in chapter 3. Chapter 0 presents the proposed draft structure for the European DER Interconnection Standard.

It is not the intention of this report to repeat the results of previous work (e.g. to list in details the technical requirements). This report builds on the previous studies mentioned in chapter 1 ([1], [3], [4] and [5]), focuses on the structure of current interconnection standards and proposes a structure for a European Standard for interconnection of Distributed Energy Resources.

3 Structural Analysis of current Interconnection Standards

The analysis presented in this chapter is restricted to the very relevant documents such as national laws, royal or ministerial decrees or orders addressing explicitly the connection of DER to the public distribution network. This means that meaning that the following types of documents are usually not considered here:

- "generic" standards like standards from the EN 61000 series which are well-known and established.

Such standards may be referred to in some grid code for example, mentioning that some particular DER component shall comply with the requirements mentioned in the standard. This is often the case for example for single-phase inverters with an output current up to 16 A.

- general orders or decrees establishing the general rules of electricity systems and markets as well as grid codes specifying the rules between DNO and network users (consumers and producers). Even if they are very relevant, they do not go into the technical details important for the connection of DER.

If one particular document of this kind is however considered as very relevant, it may be referenced.

For the documents considered here, the general chapters such as definition, scope and references are not explicitly mentioned even if they are of course very important. It is assumed that such chapters are part of the interconnection document.

3.1 Analysis Method

Before going through all the relevant documents for interconnection of distributed generation to the public distribution network, a set of items helping to characterise and analyse the structure of the requirements has been identified. This list includes:

- Number of relevant documents

This item refers to the number of the "very relevant documents". This is of course very hard to define what a "very relevant document" is, but it should be understood as documents which must be consulted and understood by the different actors such as DNOs or manufacturers of DER components. Documents addressing the general framework of the electricity market are for example not considered here. The term document should be understood in a broad way: it can also designate a set of documents belonging to the same series.

- Nature of the documents

This item intends to classify the different types of documents which usually specify the interconnection requirements. The classification proposed here is kept very simple. One should always refer to the document in order to verify which type of document it is. The following categories are defined:

  - national laws, ministerial/royal decrees or orders (ORD)
  - national standards (NS)
  - grid codes or assimilated (disregarding if the grid code is approved by the regulator or proposed by DNOs…) (GC)
  - company regulations or guide (in some cases such as the absence of detailed and applicable requirements, company regulations may be considered) (CR)

In some countries, company regulations specify additional requirements. Due to the difficulty to access to these (internal) documents, they are not analysed here in details.

- Existence of dedicated documents for the interconnection of DER (DER specific documents)

This item is meant to determine if the requirements for connection of DER to the grid are specified (clearly) separately from the ones applying for example to consumers.

- Existence of requirements dedicated to a particular energy source (e.g. wind power or photovoltaics) or to a particular generating technology (e.g. inverter-connected generation)

A possible example would be the presence of a national standard for photovoltaic generators in addition to the grid code.

- Segmentation of the requirements

This item is meant to indicate whether the requirements clearly reflect in their structure the size of the DER. This means for example that a document or a chapter may be dedicated to small LV-connected DER, another to MV-connected DER…

- Separation between requirements and assessment methods or testing

This item intends to indicate whether the requirements, the assessment methods and the testing procedures are separated (through different documents, chapters, annexes…).

- Presence of assessment examples

This item simply informs if some assessment examples (e.g. case studies) are provided.

- Presence of issues not related to the integration into the grid

This item indicates if some issues which are not directly related to the interconnection of DER into the grid are addressed in the document. As example we may mention requirements related to buildings, to the storage components for biogas…

- Presence of organisational/administrative aspects

Finally, the presence of organisation aspects is also considered. These can include e.g. the description of the interconnection process (data flow between parties, deadlines …).

When reading this report, one should be aware that the classification of the interconnection requirements is not always unequivocal. For example some documents may be qualified as general and not be considered even if they contain to a limited extent requirements for RES. The figures are much simplified and reflect the understanding of the authors of the structure of the national documents (e.g. segmentation may be implemented for some issues only). They should be taken as such.

3.2 Analysis of the main characteristics of interconnection requirements in Europe

In this chapter, the nature and the structure of the interconnection requirements are described per country. The countries listed here are those belonging to DERlab for which data were available. The scope of this analysis may be expanded when information for additional countries is available.

3.2.1 Austria

Information provided by partner ARSENAL.

In Austria the basic technical framework is defined in the “Technical and organisational rules for operators and users of transmission and distribution networks (TOR)”. The TOR represent the national grid code and are also part of the so called “Market rules” for the liberalised electricity market, which have a special legal status, similar to a law. Besides the grid code, there is also a specific national standard that covers PV-installations including their connection to the grid, the ÖVE ÖNORM E2750, “Photovoltaic power-systems – Erection and safety requirements”.

The two major documents are therefore:

- TOR: Technical and organisational rules for operators and users of transmission and distribution networks
- ÖVE ÖNORM E2750: Photovoltaic power-systems – Erection and safety requirements

The section D4 of the TOR is the one addressing the connection of DER to the distribution network. However, it refers to the chapter 9 of section D2 “Recommendations for the assessment of network interferences”, which is not DER specific (it contains the recommendations for consumers and for generators).

The first document can be classified under grid code or assimilated; it is under the responsibility of the regulator and is developed with the help of the DNO association.

The second document is a national standard, under the responsibility of the Austrian standardisation institute (working group FNUA E 03: Photovoltaic energy conversion).

Both documents can be qualified as DER specific, except that the recommendations for the assessment of network interferences are specified for consumers and for generators in the same section (D2) in different chapters (chapter 9 for generators). As previously mentioned, some requirements are dedicated to a particular technology (PV) at document level (the national standard for PV generation), whereas others are dedicated to particular technologies (e.g. requirements for rotating machines vs. power converters) at the level of issues (e.g. synchronisation…). The segmentation concept is implicitly implemented through the use of different points at the level of issues (for example limits for voltage rise for LV and for MV are indicated within a same chapter with two sub-chapters). The requirements and the assessment methods are in the same way presented in two sub-chapters for each item. The national standard provides a testing procedure as normative annex. Moreover, explanations are also provided in the same way (sub-chapter), whereas assessment examples are provided in a separate chapter at the end of the document. In the national standard for PV systems, some non-interconnection related issues are dealt with (e.g. design of the DC installation).

Finally, organisation aspects are not dealt with in the TOR: they are covered by the market rules.

Figure 1 intends to illustrate the structure of the parts of the TOR relevant for the connection of DER to the public grid. Sections such as introduction, scope and definitions are not considered here.

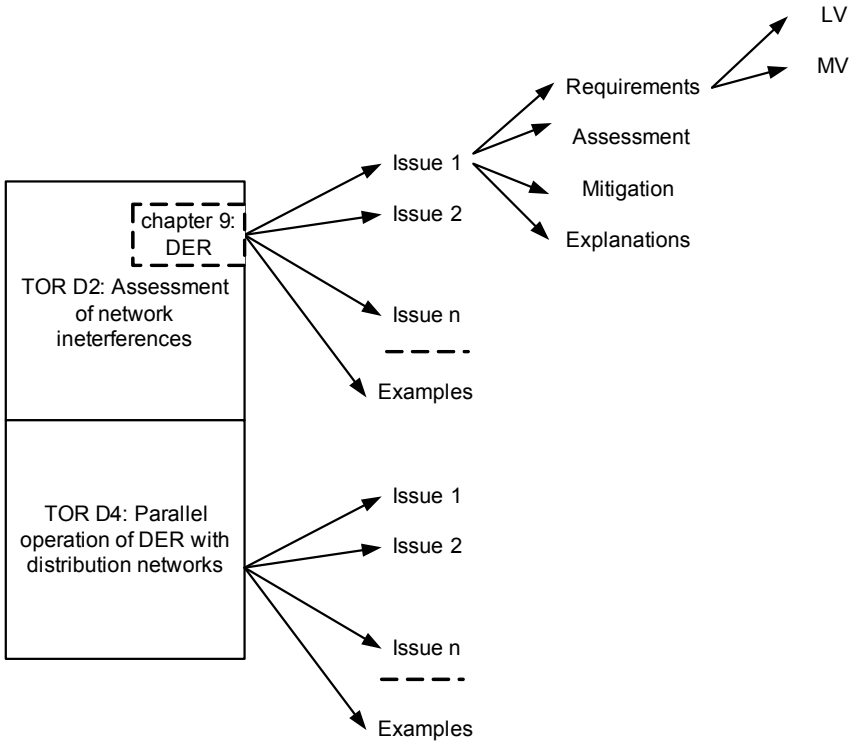


Figure 1: Simplified overview of the structure of the interconnection requirements expressed through the TOR (AT)

3.2.2 Germany

Information provided by partner ISET.

For Germany the technical framework defining the rules for interconnecting DER to the public distribution network is mainly set through three documents:

- VDEW Guideline for the connection of DG to the LV grid
- VDEW Guideline for the connection of DG to the MV grid
- VDE 0126-1-1, Automatic disconnection device between a generator and the public low-voltage grid

The first two documents are guideline issued by the association of DNOs while the third one is a national standard. All these three documents are therefore DER specific: they deal only with issues related to the connection of DER to the public distribution network. The two guidelines from the DNO association will be classified in this study as Grid-Code or assimilated. Some requirements are dedicated to particular technologies (converters vs. rotating machines) but usually apply to all types of energy resources. The segmentation concept is very clearly implemented since the requirements are expressed through two different documents: one for LV-connected DER and one for MV-connected DER. Requirements and assessment methods are specified for each issue (i.e. within each section). Examples of interconnection as well as assessment examples are provided in separate chapters at the end of the document. Explanations about the requirements are also included at the end of the document in a separate chapter. In the national standard about the disconnection device, the requirements that the disconnection device must comply with and the specifications for the type test are specified in two different parts. As informative annex, some explanations are provided. Finally, organisational aspects are only briefly addressed in the two guidelines (short description of the connection process).

Figure 2 intends to illustrate the structure of the VDEW guide.

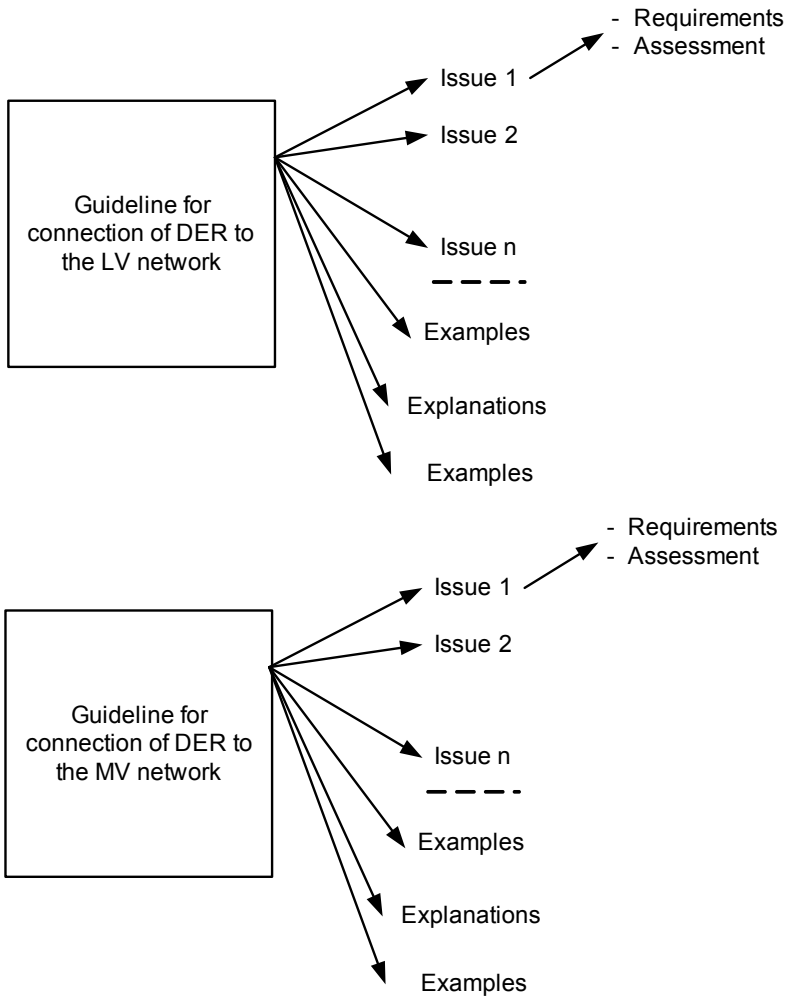


Figure 2: Simplified overview of the structure of the interconnection requirements expressed in the VDEW guidelines (DE)

3.2.3 Denmark

Information provided by partner RISOE 19.6.2008.

Grid connection of DG is regulated by the following documents (technical regulations):

- Teknisk forskrift 3.2.1 for elproducerende anlæg på 11kW eller derunder 2008-06-01 (only in Danish)
- Technical Regulations for thermal power station units larger than 11kW and smaller than 1.5MW 2007-07-20
- Technical Regulations for thermal power station units of 1.5MW and higher 2007-09-27
- Wind turbines connected to grid with voltages below 100kV 2004-05-19
- Wind turbines connected to grid with voltages above 100kV 2004-12-03

The legal foundation is in "Bekendtgørelse om systemansvarlig virksomhed og anvendelse af eltransmissionsnettet m.v., BEK. nr. 1463 af 19/12/2005. The technical regulations are developed by the TSO Energinet.dk after consulting the DNO's. The technical regulations can be complained about to the Danish Energy Regulatory Authority DERA.

Three types of technical regulations exist:

- small power producing units (below 11kW)
- Thermal power stations units above 11kW but divided for units smaller than or larger than 1.5MW
- Wind turbines

For small power producing units the technical requirements is a reference to EN50438 with Danish values for ranges for frequency and voltage. the Technical Requirement is organised as shown in Figure 3. The requirements assume that the unit is type tested and certified according to the standard (EN50438).

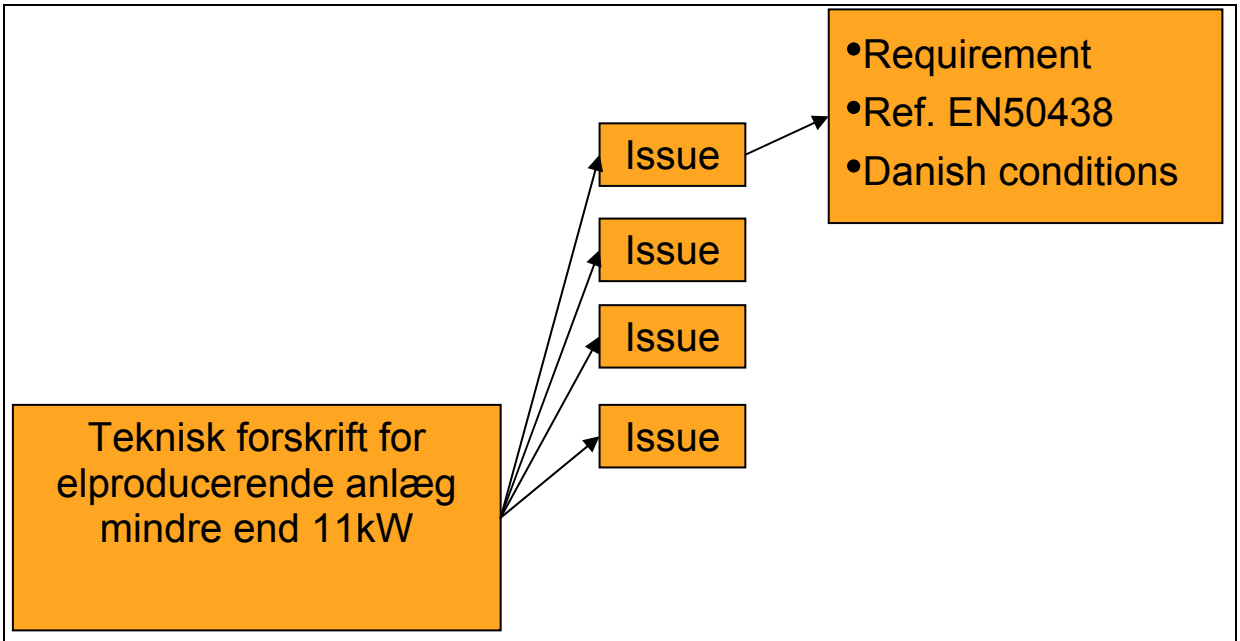


Figure 3 Simplified overview of "Teknisk forskrift for elproducerende anlæg mindre end 11kW"

For larger thermal units the technical requirements are organised as in Figure 4. The documents contain requirements for the grid connection and for the operation of the units. They

only contain very brief explanations for the issues and not for the values of the requirements. The documents include brief description of a unit commissioning procedure/documentation that is not based on any standards.

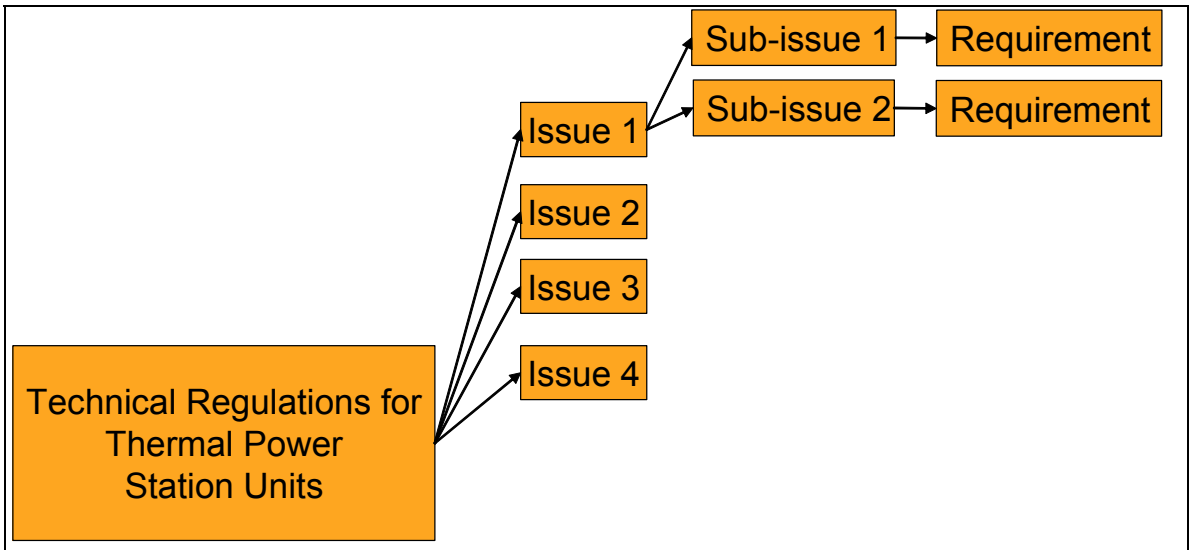


Figure 4 Simplified view of "Technical regulations for Thermal Power Station Units"

Wind turbines are handled separately. Two documents describe the requirements. They are separated by the level of the grid to which they are connected. The assumption is that wind turbines connected at the transmission level will be in the form of large wind farms and therefore the requirements are stricter. The Technical Requirements for wind turbines connected to grids with a voltage above 100kV does not include examples.

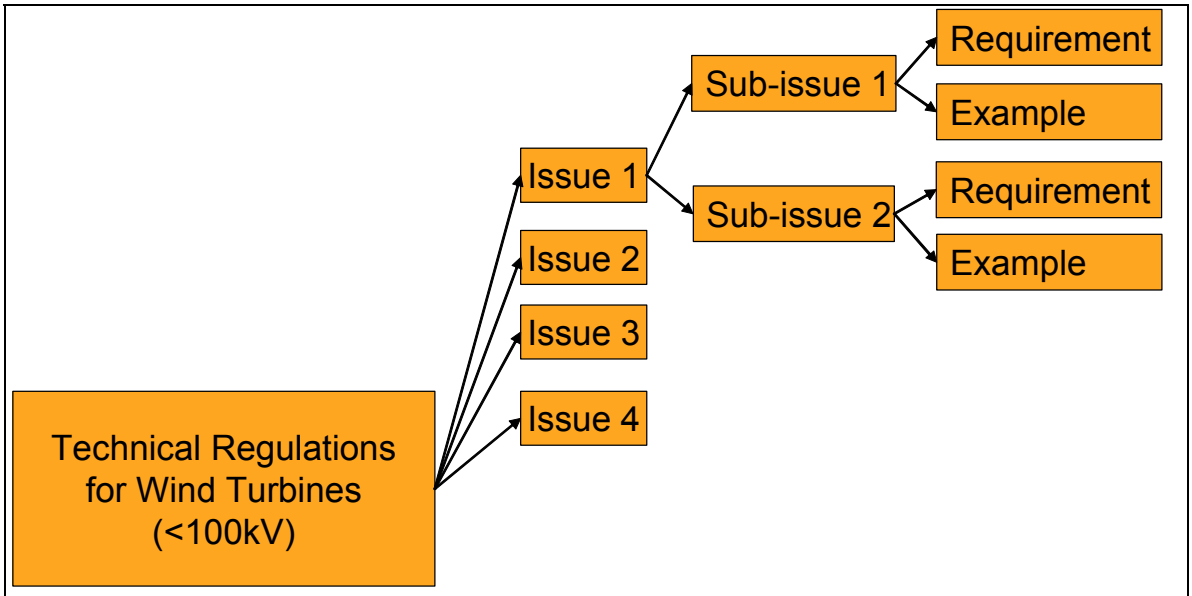


Figure 5 Simplified view of "Technical Regulations for Wind Turbines (<100kV)"

3.2.4 Spain

Information provided by partner LABEIN.

In Spain, the most important technical requirements for the connection of DER to the public distribution network are specified through a ministerial order and a royal decree (2 documents):

- Orden 5/9/1985: Administrative and technical rules for the operation and interconnection to the grid of hydroelectric power plants up to 5 MVA and "autogeneration plants"
- RD 1663/2000: interconnection of PV installations to the low voltage grid
- Decision of 4th of October 2006 of the General Secretary for Energy by which the operation procedure 12.3 "Response requirements for wind generators in case of voltage dips".

Both documents can be classified in the category ORD (ministerial order and royal decree). The first document (order) establishes the administrative rules for the connection and operation of DER connected to the distribution network, and the second one is dedicated to PV systems. This means that both are DER-specific. Requirements for some issues (e.g. protections) are addressed through different chapters depending on the technology (converters / synchronous generators / asynchronous generators). The segmentation concept is made (distinction between LV and MV) at the issue level (e.g. maximum power which can be connected to the LV network). Assessment methods as well as examples are not provided in the document. As mentioned in the title, this order contains organisational issues. Figure 6 illustrates the structure of the requirements in the ministerial order. The distinction between generators smaller or greater than 5 MVA is just an example (illustrating the use of a set of simplified requirements).

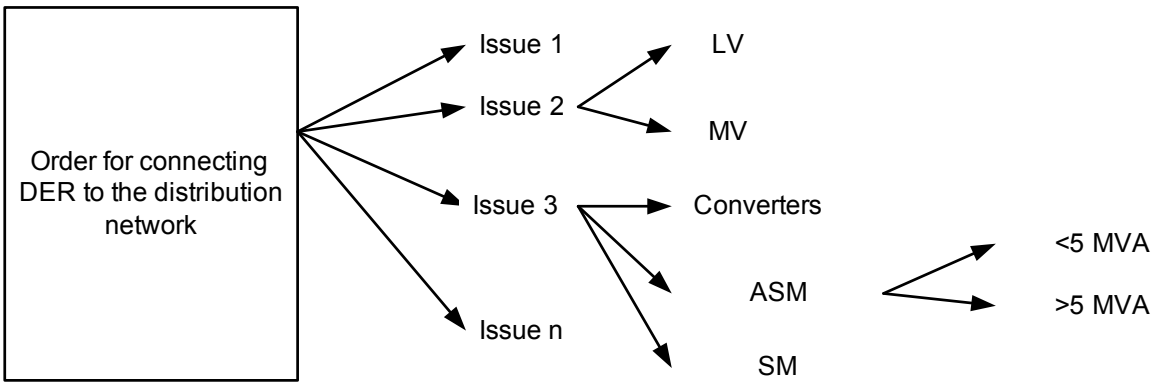


Figure 6: Simplified overview of the structure of the interconnection requirements expressed in the ministerial order (ES)

The second document (RD 1663/2000) is dedicated to the connection of PV systems up to 100 kW. Testing requirements are not included in this decree, and no examples are provided. This decree also contains procedural details.

The last document specifies the behaviour of wind generators in case of voltage dips. It is mainly structured according to the type of fault that may occur and makes reference to the royal decree 436/2004 which covers the general aspects.

3.2.5 France

Information provided by partner CEA.

In France, the most important technical requirements for the connection of DER to the public distribution network are specified through a ministerial order, a royal decree and a company guide (3 documents):

- Government decree n° 2003-229 of 13 march 2003 on the general technical requirements regarding design and operation which installations must fulfil for connection to the public distribution network
- Ministerial order of 17 March 2003 on the technical requirements regarding design and operation which production installations must fulfil for connection to the public distribution network (with one amendment from 22/04/2003 and another one from 27/10/2006)
- Distribution Technical Guide (published by EDF)

While the first decree covers consumers as well as generators, the ministerial order is dedicated to distributed generators: it is the most important. More over, the French Distribution Technical Guide edition follows the French Regulator deliberation published on April 7, 2004. The users of the public electricity distribution network operated by EDF can access to all documents constituting the Technical Guide on Internet. This technical Guide is still under completion but should be once finished very useful for all parties. The last two documents can therefore be qualified as DER specific documents. Some requirements of the order for the connection of DER to the public grid, some requirements are dedicated to particular technologies (e.g. synchronisation of synchronous generators…); the separation is made at the document level. The segmentation concept is explicitly and implicitly implemented. One section deals with requirements for LV-connected generators and another one with MV-connected generators. Furthermore, within one article, different paragraphs deal with e.g. different generators sizes (smaller than 1 MW, between 1 MW and 10 MW and greater than 10 MW). Some immunity requirements are set for (behaviour under disturbances), in particular for non interconnected grids. Assessment methods are not provided in the order; they may be integrated into the Distribution Technical Guide in the next future. Examples are not provided, but model contracts are provided. Organisational aspects are not included in the order, but represent an important part of the guide. Figure 7 intends to illustrate the structure of the ministerial order.

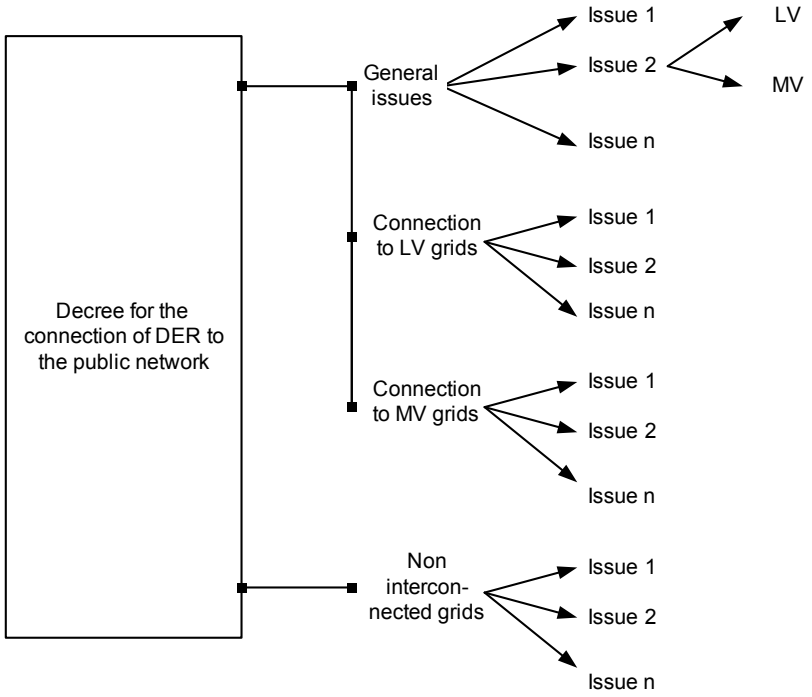


Figure 7: Simplified overview of the structure of the interconnection requirements expressed in the ministerial order (FR)

3.2.6 Italy

Information provided by partner CESI-R.

In Italy, the technical requirements for connecting DER to the public distribution network are mainly defined in the following two documents:

- CEI 11-20: Requirements for energy generation installations of power higher than 1 kW connected to the LV and MV grids
- DK 5940: Company requirement (ENEL Distribuzione): Connection requirements to the LV grid for PV installations (powers between 1 and 20 kW)

The first document is a national standard issued by CEI, the national standardisation institute, and the second one is a company regulation (ENEL). Both documents are DER-specific: they only address the connection of DER to the grid. While the national standard is energy resource neutral, the second document (the company regulation), is dedicated to the connection of photovoltaic generators to the grid. The national standard also specifies the requirements for different technologies through different sub-chapters (e.g. protection requirements for converters or rotating machines). The segmentation concept is done for some particular issues at the level of chapters (e.g. for protections). Otherwise it is done with less clearness within the chapters (e.g. limits for voltage distortion for rotating machines smaller or greater than 500 kVA). Explanations explicitly for the connection of DER are not provided, but some on the operation of distribution networks are given in a separate chapter, at the beginning of the document. Examples are not provided. Lastly, the organisational aspects are not addressed in the national standard.

The company regulation DK 5940 is organised into chapters addressing particular issues (e.g. reactive power, protections, etc.). The requirements for interfaces between DER and the distribution network are specified in an annex, where some testing aspects are also included. This regulation contains some procedural information (documents to provide to apply for interconnection).

Figure 8 provides a very simplified overview of the structure of the standard.

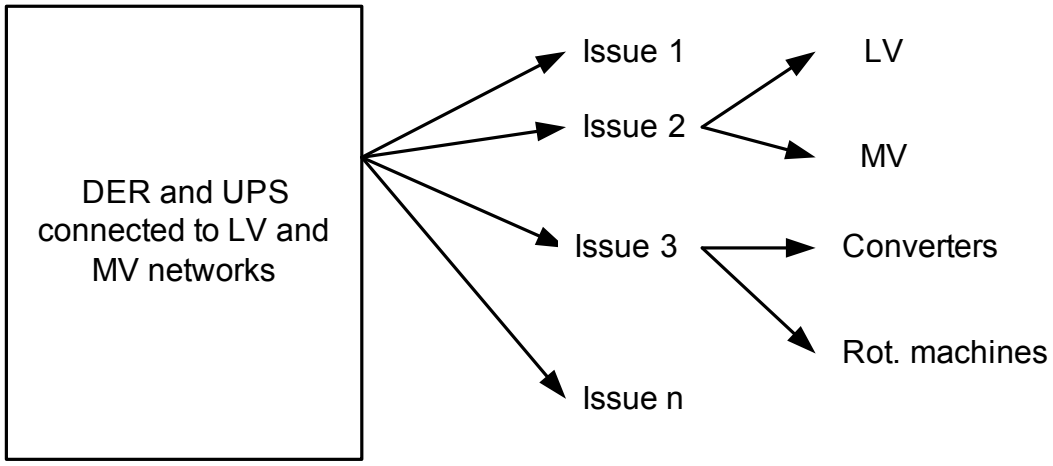


Figure 8: Simplified overview of the structure of the interconnection requirements expressed in the CEI standard (IT)

3.2.7 The Netherlands

Information provided by partner KEMA.

In The Netherlands the technical framework defining the rules for interconnecting DER to the public electricity grid is mainly set through these two documents:

- Netcode, April 1, 2006
- NVN 11400-0 "Windturbines - Part 0: Criteria for type certification - Technical requirements"

The first one is the Dutch Grid Code, the second one is a national pre-standard.
The Netcode establishes the rules between grid operators and users connected to the public electricity network and is not DER specific. The Mentioned standard is only applicable to wind turbines and (thus) DER specific.

The Netcode distinguishes first between (consumer) connections and production units, and subsequently between low and high voltage. Besides some general conditions that apply to all connections, the technical issues are addressed per mentioned category. The operating conditions are specified separately for producers and consumer/producers, where producers are divided between smaller and larger than 60MW. The netcode contains no explanations nor examples.
Figure 9 intends to illustrate the structure of the Netcode.

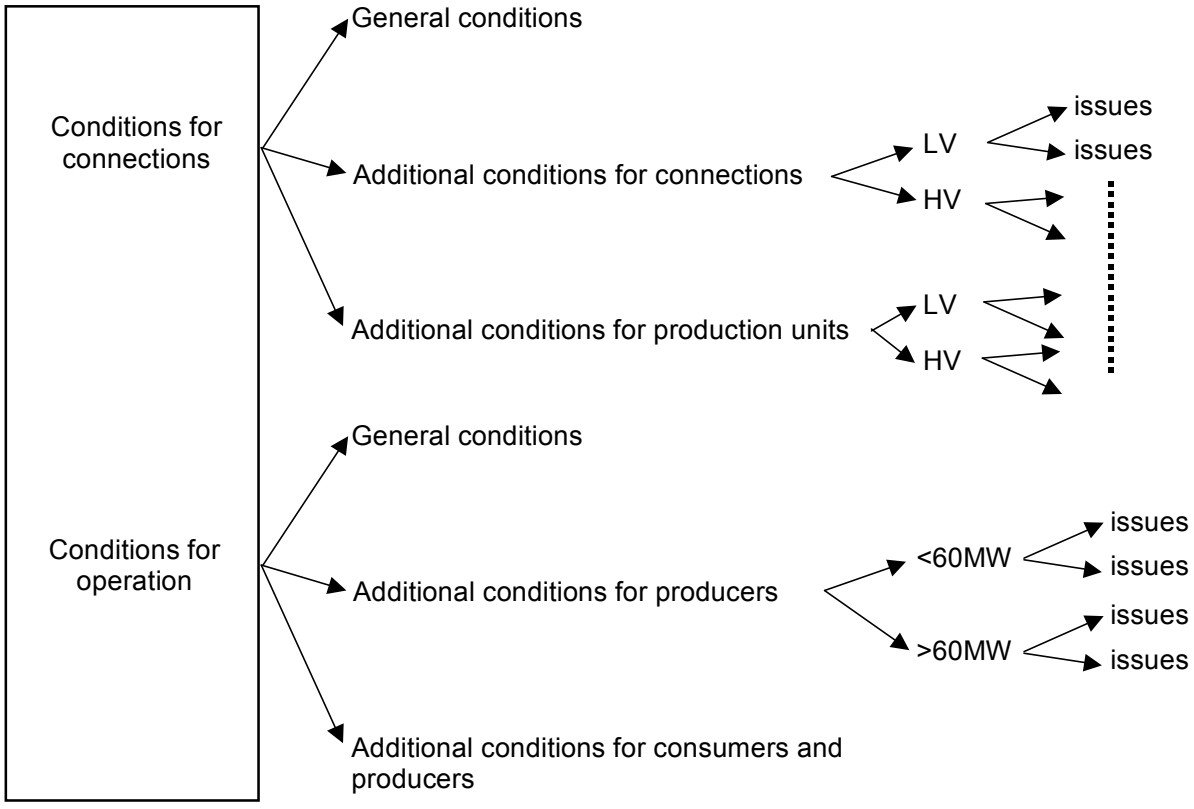


Figure 9: Simplified overview of the structure of the Netcode (NL)

3.2.8 United Kingdom

Information provided by partner UKDG.

In the UK, the Energy Networks Association has published the Engineering Recommendations (ER), ER G59/1, and ER G75/1, ER G83/1. All these documents are DG specific.

ER G59/1 was published in 1991. This document provides the requirements for connecting DG where the output does not exceed 5MW and the connection voltage is 20kV or below. In addition, an associated Engineering Technical Report, ETR 113/1 was published to provide guidance on meeting the protection requirements for G59/1.

ER G75/1 was published in 2002. This document provides the requirements for connecting DG where the output is above 5MW and the connection voltage is above 20kV.

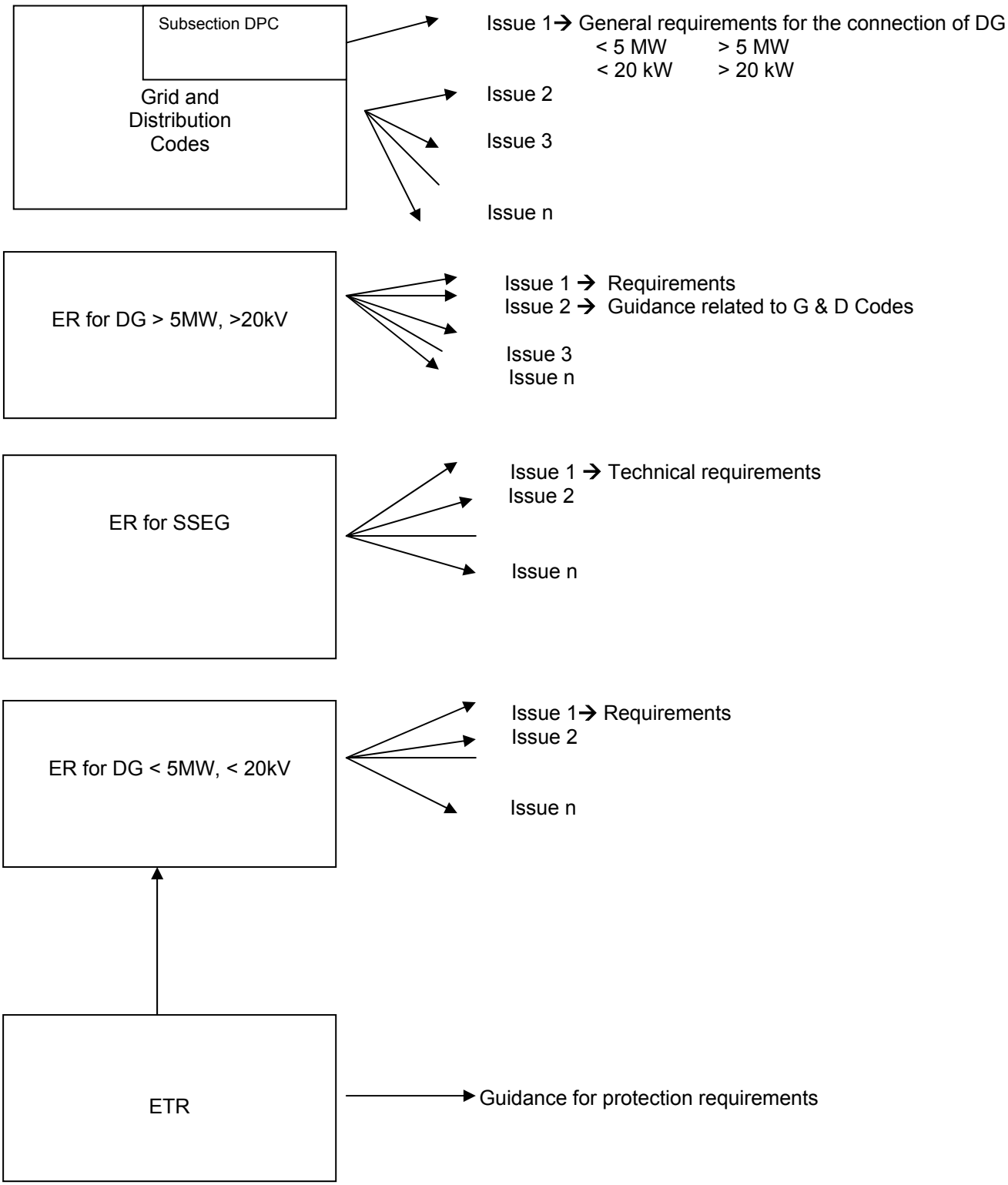
ER G83/1 was published in 2003. This document provides the technical requirements for the connection of Small Scale Embedded Generation (SSEG). In the context of ER G83/1, a SSEG is defined as generation whose output is less than 16A/phase and is connected to 230/400 ac single or multi phase.

In Great Britain, there are two codes that apply to the electricity supply system. These are the Grid Code which relates to the Transmission System and connections to it, and the Distribution Code which relates to the Distribution System and connection to it. The Distribution Planning and Connection Code (DPC) which is a subsection of the Distribution Code sets general requirements for the connection of distributed generation distinguishing the relative sizes of the plant to which G59/1 and G75/1 are applicable.

ER G59/1 sets out the requirements for the protective equipment of embedded generation. The protection generally include; inhibition of connection unless the supply is healthy and within limits, disconnection of generation during voltage and frequency deviations, disconnection of generation if one or more phases of network is lost. In order to meet the requirements set out in ER G59/1, full tests of the protective equipment must be agreed. These tests are the responsibility of the distribution generation developer and must be performed on site. For LV connection below 1kV, the tests results can be submitted to the distribution network operator (DNO) whereas connection above 1kV, the tests must be witnessed by the DNO.

ER G75/1 provides guidance to the embedded generation developer and the DNO on how the requirements set in Distribution and Grid Codes may be met when connecting embedded generation under ER G75/1. ER G75/1 identifies the relevant sections of the Distribution and Grid Code that is applicable to connection of generation under this recommendation. ER G75/1 discusses generating unit parameters, system parameters, load and generating plant connection security, islanded operation, system stability and black start capability. Under ER G75/1, generators wishing to connect to the distribution network must provide the DNO with parameters specified in the DPC. Additionally, the generation developer may also be required to inform the transmission network operator with the technical information according to the Grid code.

Figure 10: The interrelations between the national requirements in UK



3.2.9 Greece

Information provided by partner NTUA.

In Greece, the main document describing the technical requirements and assessment methodologies for the interconnection of DG to the distribution network is the following technical directives of the distribution utility PPC S.A.:

- "Technical requirements for the connection of independent generation to the grid"
- "Guide for the connection of PV installations to the LV network"

Additional provisions are included in the distribution network and transmission system Codes, as well as in the ministerial decree for the standardized grid connection agreement of DG stations.

The first directive comprises the technical evaluation framework and the limits set for DG installations to be connected to the public LV or MV distribution network. Therefore, they are DER specific documents. Both guidelines are classified in the "Grid-Code or assimilated" category. While the first one is applicable for any DG station, it still comprises specific provisions for wind power stations. The second document concerns specifically PV installations with installed capacities up to 100 kW. Hence, the documents are partly dedicated to particular energy sources.

With respect to the segmentation of the requirements, it does exist since the first document clearly differentiates between LV and MV-connected installations, in different chapters, while the second directive deals only with small PV plants. In both documents assessment methods are separated from testing procedures, although the latter part is relatively restricted. Several assessment examples are provided for a variety of installations. Issues which are not directly related to the interconnection of DER to the grid are not addressed in the two main directives. Some descriptions of organisational/administrative aspects are included in the documents (particularly in the second one). However such issues are covered more thoroughly by the relevant Codes and the Market Rules.

The main structure of the interconnection guidelines (as in the first directive) is outlined in Figure 11.

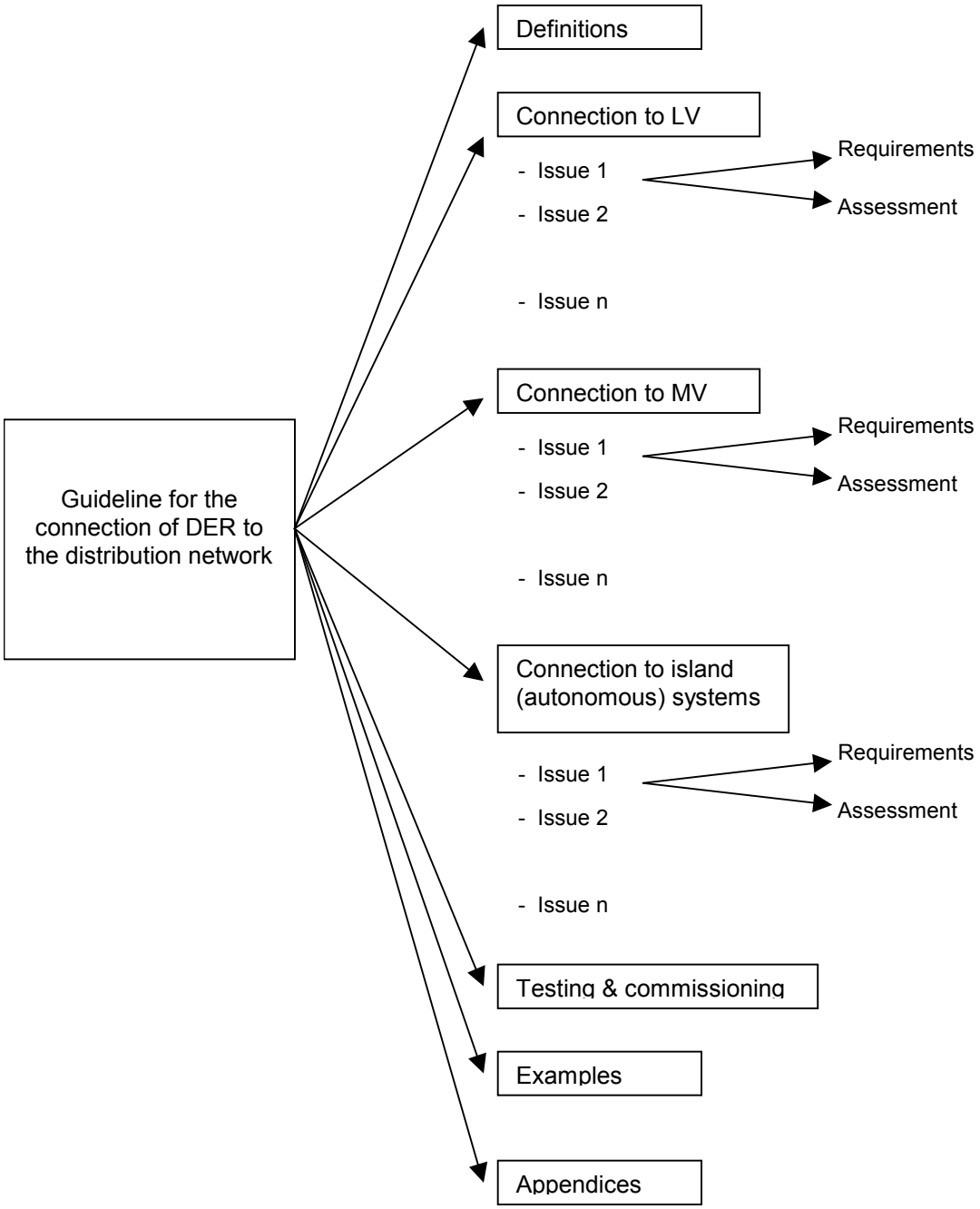


Figure 11 Outline of the structure of the interconnection guideline in Greece

3.2.10 Poland

Information provided by partner TULODZ.

In Poland the basics for interconnection rules are defined in Polish Energy Law, the Ordinance of the Ministry of Economy concerning detailed rules of the connection to the grid, operation and maintenance of transmission and distribution networks and each DNO regulations. It can be said that in Poland there is no dedicated regulation for DERs, mostly requirements and rules of interconnection are common for generators and loads. On the basis of ministry ordinance each DNO provides its own interconnection rules and requirements often they are different from case to case. The major document relevant to DER interconnection rules are therefore:

- Act of 10 April 1997: Polish Energy Law.
- The Ordinance of the Ministry of Economy dated 20 December 2004, concerning detailed rules of the connection to the grid, operation and maintenance of transmission and distribution networks.
- DNOs regulations based on Ordinance of the Ministry of Economy described above.

Interconnection of both the consumers and generators are executed on the basis of interconnection agreement and after fulfilling requirements described in each case by the DNO. Practically interconnection requirements are the same for consumers and DERs defined in the Ministry Ordinance as 'objects subjected to interconnection'.

According to the Ordinance objects are divided in following interconnection groups:

1) group I – objects interconnected directly to transmission network;
2) group II – objects interconnected directly to 110 kV distribution network;
3) group III – objects interconnected directly to MV distribution network;
4) group IV – objects interconnected directly to LV distribution network and of nominal power bigger than 40 kW or of nominal current of main protection bigger than 63 A;
5) group V – objects interconnected directly to LV distribution network and of nominal power not bigger than 40 kW and of nominal current of main protection not bigger than 63 A;
6) group VI – objects interconnected to the network temporarily;

Detailed requirement for each group are slightly different.

In the Ordinance RES are distinguished only in relation with certification of origin of energy introduced to the public network.

In Figure 12 rough structure of Ordinance regarding the interconnection requirements is presented.

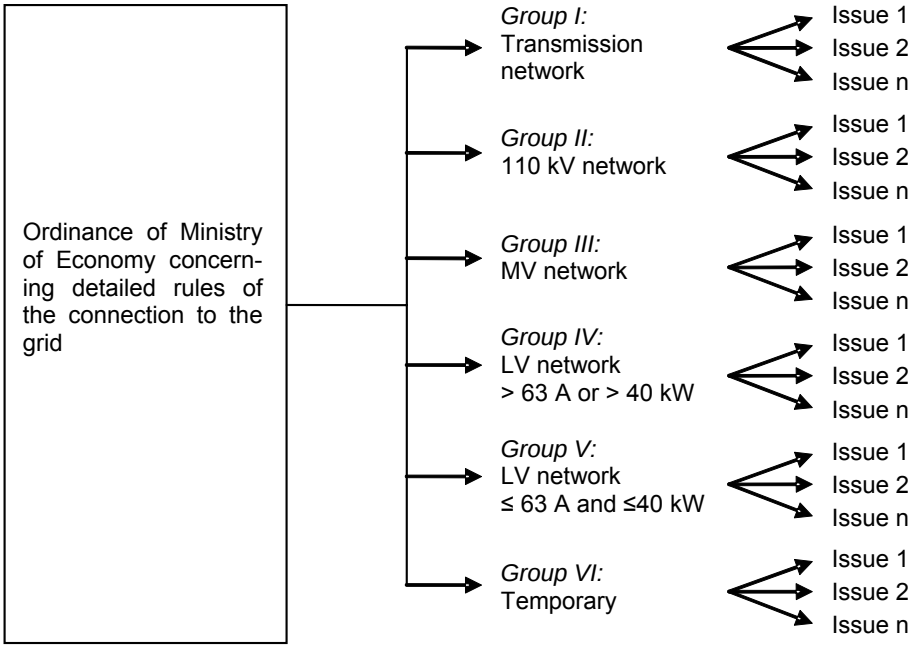


Figure 12: Simplified overview of the structure of the interconnection requirements expressed in the ministerial ordinance

3.2.11 Bulgaria

Information provided by partner TUSOFIA.

In Bulgaria, Energy Law (2003) - published by Ministry of Energy and Energy Resources (MEER) foresees increasing role of the RES&DER and define the general requirements for transmission and distribution network.

Most important technical requirements for the connection of DER to the public distribution network are specified through a ministerial order and decrees of State Energy Regulatory Commission (3 documents):

1. REGULATION No 6 on connection of electrical generators and consumers to the transmission and distribution electrical networks (2004) – published by Ministry of Energy and Energy Resources (at present Ministry of Energy and Economics)
2. BG Grid Code (2004)– published by State Energy Regulatory Commission (SERC)
3. Qualitative Indices (2004)– conforming Bulgarian State Standard BDS EN 50160 and BDS EN 61000-3-3 / published by State Energy Regulatory Commission (SERC)

The description of organizational/ administrative aspects is included in the first document. The basic steps are: 1. Preliminary investigations, preliminary contract between DSO and the investor, final contract between DSO and the person demanding the connection; 2. Issuance Licenses from SERC for construction project on DER; 3. Issuance Licenses from SERC for Energy production. However the issues are covered thoroughly by the relevant two documents - BG Grid Code and Qualitative Indices.

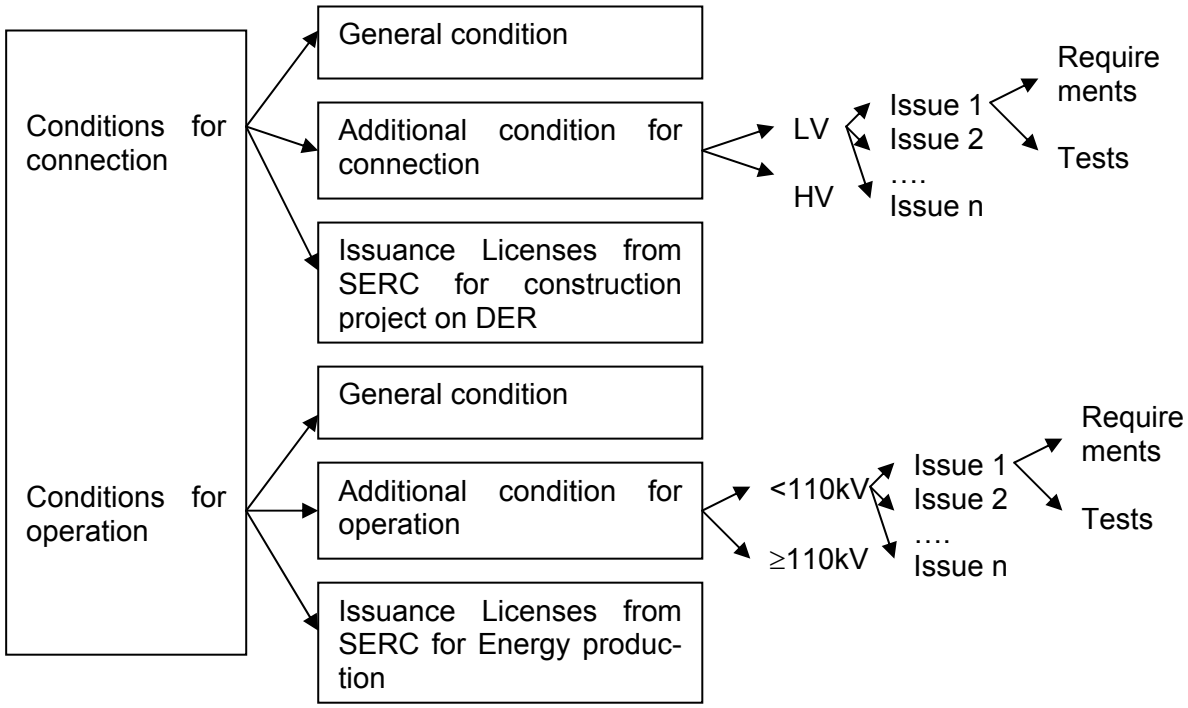


Figure 8: Outline of the sequence of steps of the interconnection guideline in Bulgaria

The frame of electrical devices and lines are defined in the Regulation No3/9.06.2004 for frame of electrical devices and lines - Issued by the Minister of Energy and Energy Resources. Monitoring on the network is held by National Energy Company (NEK).

Relevant to opening of energy market in Bulgaria from 01.07.2007 and the new European Energy policy (Conclusions of European council 8-9 march 2007) Ministry of Energy and Economics is in process of modification and addition of Regulation N6.

3.2.12 Summary of country characteristics

Table 1 summarises the information presented in the previous chapters (3.2.1 to 3.2.11). The information is very compressed; one should be careful when reading the table and interpreting the information and always refer to the detailed explanation in the corresponding chapters.

Table 1: Summary of the structural analysis in the 8 European countries considered.

Country		AT	BG	DE	DK	ES	FR	GR	IT	NL	PL	UK
No of documents		2	3	3		2	3	2	2	2	3	3
Nature of the documents		GC NS	– ORD – GC – NS	GC (2) NS	- GC	ORD (2)	ORD (2) CR (1)	- CR	NS (1) CR (1)	- GC (1) - NS (1)	– ORD(2) – GC(1)	- GC (3)
DER specific documents		Yes and No	Yes	Yes		Yes	Yes	Yes	Yes	Yes (NS) and NO (GC)	NO	Yes
Existence of dedicated requirements	At document level	Yes: PV (NS)	Yes: Wind (NS)	No	Yes. wind turbines, small generators	Yes: PV	No	Yes: PV	Yes: PV (CR)	Yes: PV (NS)	Yes : WT	No
	At issue level	Yes: Converters / SM / ASM	Yes: Converters /SM/ /ASM/	Yes: Converters / SM / ASM		Yes: Converters / SM / ASM	Yes: Converters / SM / ASM		Yes: Converters / SM / ASM			Yes: Converters / SM / ASM
Segmentation of the requirements		Yes: different points (LV/MV) within chapters	Yes: different points (LV/MV)	Yes: 2 different documents (LV/MV) and 1 additional document for protections of LV-connected generators	Yes: by size for non-wind turbine generators by grid voltage for wind turbines	Yes, but not clearly reflected in the structure	Yes: different chapters (LV,MV)	Yes: different chapters (LV,MV)	Yes, but not clearly reflected in the structure		Yes: different points (LV/MV/HV) within chapters	Yes: one document for small generator (<16 A):
Separation between requirements and assessment methods or testing		Separated: – 2 sub-items within chapters (GC) – Testing procedure as normative annex (NS)	Separated: – 2 sub-items within chapters (GC) - Testing procedure as normative (NS)	Separated: – 2 sub-items within chapters (GC) – own chapter for testing (NS)	Assessment methods or testing methods not described or only very briefly	Assessment methods or testing methods not described	Assessment methods or testing methods not described	Requirements separated. Testing methods not described or described very briefly	Assessment methods or testing methods not described		Assessment methods or testing methods not described	Testing arrangements specified in Annex
Presence of explanations (in addition to the requirements)		Yes: sub-item within chapters	No	Yes: separate chapter	no	No	No	No	No		No	Yes
Presence		Yes, in a	No	Yes: separate	only for wind	No	No	Yes	No		No	No

Country		AT	BG	DE	DK	ES	FR	GR	IT	NL	PL	UK
assessment examples		separated section		chapter	turbines connected below 100kV							
Presence of issues not related to the integration into the grid		Yes	No	No	no	No	No	No	No	Yes	No	No
Presence of organisational aspects		No	Yes	Yes	no	Yes	Yes/No	No	No (NS)/Yes(CR)	Yes	No	Yes

Legend (see chapter 3.1 for exact definitions of the terms):

- GC: grid code or assimilated
- NS: national standard
- ORD: order, decree or assimilated
- CR: company regulation

Interpretation of Table 1:

- **Number of relevant documents**

In all the considered countries, the most relevant technical requirements for connection DER to the public grid are specified through two or three documents. However, most of them make reference to other standards which shall also be considered when considering e.g. the requirements that a given DER component shall comply with.

- **Nature of the documents**

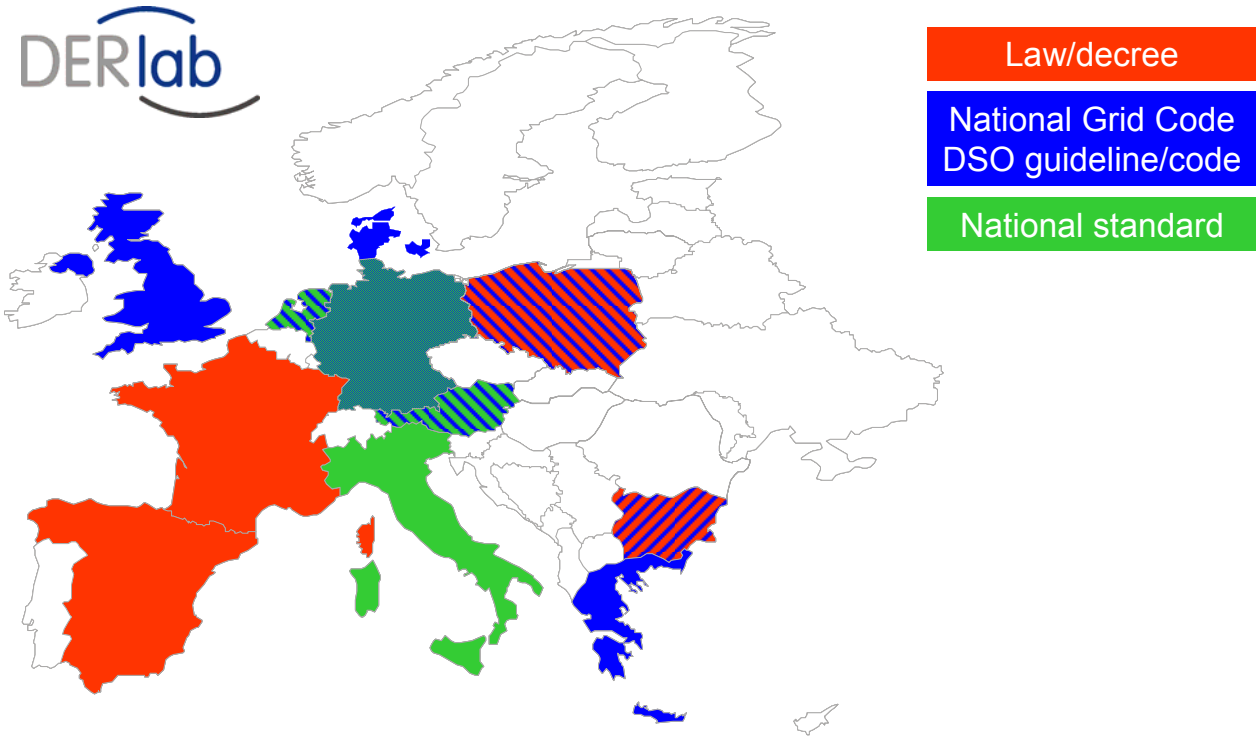


Figure 13: Nature of main technical documents governing the interconnection of DER in selected European Countries based on Table 1

The situation is in fact more complex that this figure suggests since the organisations involved in the elaboration of interconnection standards can have a drafting role or an enforcement/approval role (see e.g. [4]).

Table 1 shows that in most countries, the technical requirements for connection of DER are specified in grid codes or assimilated documents. Some countries have in addition to the requirements from the grid codes some dedicated standards (see following points). This disparity just reflects the difference in the organisation of European countries.

Order and decrees are usually “minimalist” and do not have examples or assessment methods. They therefore suppose the existence of additional documents such as guidelines (see the example of France with the Technical Distribution Guide).

When requirements are specified through decrees and orders, the situation may be complex since updates in the content of the decrees are usually made by publishing an additional decree, amending the previous one.

Regarding the process of establishing grid codes, network operators have historically been actively involved in the development of the codes even if the document is usually approved by the regulator. One should stress that in addition to these documents, distribution network operators may also have internal guidelines which are not publicly accessible. This is partly

due to the fact that some grid codes leave some latitude to the network operators which can therefore specify their own requirements.

– **Existence of dedicated documents for the interconnection of DER**

For almost all countries, the requirements for connecting DER to the distribution network are specified in one ore more document specific to DER. Only in a few cases these requirements are mixed with others (i.e. requirements for other network uses such as consumers).

– **Existence of requirements dedicated to a particular energy source or to a particular generating technology**

Half of the countries considered here have a document dedicated to a particular energy source (PV in most cases). This observation is not due to the fact that some particular technologies or energy sources deserve a special treatment but rather reflects a historical development. The rapid growing of photovoltaic plants for example created an acute need for an appropriate standard. The current trend is however to adopt energy source neutral requirements as far as the interconnection is concerned.

– **Segmentation of the requirements**

The segmentation concept is implemented at various levels, usually at rather low level: the differentiation according to the size of the generators is often made at the issue level. Only in a few cases, the requirements are clearly separated at the chapter level or even at the document level (e.g. Germany). Often, the segmentation level is mixed, meaning that some issues are gathered and addressed under one segment while others are not. The most widespread segmentation is the differentiation between LV- and MV-connected DER. A further segmentation within LV-connected DER is made in only a few cases (e.g. in UK).

– **Separation between requirements and assessment methods or testing**

A rather high portion of the documents do not contain any assessment or testing methods (usually decrees or orders). Those which contain such information either make a separation between requirements and assessment and testing at the issue level or gather all the testing issues in an own chapter or annex.

– **Presence of assessment examples**

Assessment examples are rarely provided (in only two documents). In these two documents, the assessment examples are gathered in a separate section.

– **Presence of issues not related to the integration into the grid**

One national standard also contains issues which are not related to the interconnection (Austrian standard for PV).

– **Presence of organisational/administrative aspects**

Finally, about half of the documents contain some organisation aspects such as the interconnection procedure (information flow, deadlines …). These aspects are usually gathered into a dedicated chapter at the beginning of the document.

The analysis whose main results are shortly summarised in Table 1 showed that even if some documents are very close in term of content (AT,DE contain similar requirements since there development is coordinated) they may have very a different structure. Furthermore, immunity requirements are in most cases not addressed.

3.3 Latest developments of DER relevant standardisation on the European level

In this chapter, three recent standardisation initiatives are worth mentioning at international level:

- the standardisation at European level: the draft European standard prEN 50438: [8]
- the setting up of CENELEC TC8X WG3 on "Requirements for the connection of generators above 16 A per phase to the LV distribution system or to the MV distribution system"
- the new project team PT 61000-3-15 at IEC level

3.3.1 Standardisation initiative for micro-generation: EN 50438

In 2003, a project to prepare a European standard for the connection of micro-generation (initially for micro-cogeneration) to the grid has been launched: EN 50438: *Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks*.

After two enquiries gathering numerous comments, the final draft has been submitted for vote. This standard was approved in April 2007, even if some countries have cast negative votes and/or repeated some critical comments. Substantial comments (e.g. on the setting of the frequency protection) such as requests to issue the document as Technical Specification have been formulated during the voting. When analysing the whole process which lead to the final draft, and in particular the fact that a very large number of critical comments had been received for both enquiries, the following should be stressed in order to learn from this standardisation initiative (based on the comments formulated during the enquiries):

- The scope of the standard was not clear enough from the beginning.
- The idea to include procedural aspects in a technical standard has been rejected by various experts (i.e. the idea to include the *inform and fit* approach, a notification sheet for the DNO). Finally, the *inform and fit* procedure is recommended, but a table of the (many) countries in which this procedure can not be implemented due to the regulatory framework is provided.
- The standard suffers from an obvious lack of consensus (the standard specifies for example default settings for protections and refers to a large number of national deviations where each country has its own requirements).
- The process did not succeed in successfully addressing technical issues critically needing harmonisation such as the injection of DC current.

The experience made with the development of this standard shows that the process of harmonising requirements even for a very narrow group of DER (micro-generators smaller than 16 A connected) is a long process for which the necessary prerequisite need to be present.

Without clear advancement in solving the technical concerns which are still not perfectly understood, the development of an interconnection standard is doomed to failure.

3.3.2 CENELEC TC8X WG3 on "Requirements for the connection of generators above 16 A per phase to the LV distribution system or to the MV distribution system"

During a CENELEC/TC8X meeting (17th of March 2005), it was decided "to set up an Ad hoc Group…to investigate, at European level, what is common about connection requirements of generators >16A per phase". Based on the work made by AHG5, TC8X decided to ask BT to approve the New Work Item. This request has been approved, resulting in the setting up of a working group WG3. The aim is to prepare a technical specification "Requirements for the connection of generators above 16 A per phase to the LV distribution system or to the MV

distribution system". The scope and purpose of this working group as stated in the call for experts are

Scope
The new work item will apply to generators, rated more than 16 A per phase and able to operate in parallel, directly or through static converter, with a Public Distribution Network, whether permanently or for a short time. The following main issues will be covered:

- *connection criteria to public distribution networks*
- *protection criteria (control, switching and protection equipment)*
- *safety criteria*
- *installation criteria*

Purpose
The purpose of the new work item is to define harmonised requirements to connect to the public network generators converting any primary source (wind, sun, hydro, etc.) in electrical energy avoiding specific product standards. This would help, in particular, to expand the market of renewable-driven generators by lowering connection costs. Manufacturers, producers and customers would benefit from the activity, as well as operational safety and environment. The new work item is also aimed at providing guidance to manufacturers and designers in implementing European directives on renewable energy sources and cogeneration, whose adoption date is quickly approaching. This makes the activity particularly urgent: should no specification be issued in a reasonable time, several manufacturer-specific products are expected to appear, with unnecessary differences among one another. Huge efforts and very long times would then be necessary to try to eliminate such differences.

An additional task has been assigned to this working group, namely the maintenance or EN 50438 (see chapter 3.3.1).

As important output of the DERlab work, the EDIS structure presented in this report has been adopted by the working group. The efforts are therefore currently devoted to the redaction of the standard content.

3.3.3 Standardisation activities for EMC issues related to DER: IEC PT 61000-3-15

At the beginning of 2006, a new work item proposal related to EMC for small distributed generators has been circulated. The scope of the propose work is to critically assess the existing and emerging national and international standards on EMC requirements for connection of generating systems to LV networks and to define proper common test conditions. The objective is to issue a Technical Specification, limited to EMC issues (immunity and emission) and not including other aspects of connection of generators to the grid. The content of the documents is currently the following:

- Scope
- Normative references
- Definitions
- Classification of the DG generators (rotating, inverter connected)
- Assessment of specific EMC requirements for DG
    - Emission
        - Harmonics
        - Unbalance
        - Flicker
        - DC Injection
        - ……
    - Immunity
        - Voltage dips
        - Voltage variations
        - Frequency variations
        - ……..
- Bibliography

This new work item proposal is now active: 11 countries are currently actively participating in the work. A draft standard is currently under discussion.

3.4 Conclusions of the Analysis and Recommendations

Due to the inherent organisation at country level (responsibilities for the development of the standards…), some constraints must be taken into account. Regarding the nature of the document specifying the interconnection requirements, the analysis showed that the existence of a European standard which could be referenced in national documents would ease the situation.

Following, a set of recommendation based on the analysis made is proposed:

- The standards should reflect a logical structure which serves the needs of the above-mentioned target groups (*user-oriented structure*). This structure should be explained at the beginning of the standard (overview diagram). This can prove to be very helpful considering the extent of the issues covered in the standard.
- It should be dedicated to the connection of DER to the public grid and should not cover the requirements for other user groups (e.g. consumers).
- The standard should be comprehensive: all the interconnection-relevant issues should be addressed in this standard. The different target groups (i.e. manufacturers, testing institutions, project developers, DNOs) should be able to find the most relevant information for them.
- The scope of the standard should be clearly limited to interconnection issues (for the requirements as well for the tests).
- The requirements and the conformance test procedure should be provided in separate chapters since they do not address the same target groups and do not serve the same objectives.
- The structure of the document or of the document series should reflect the segmentation structure. This should be ideally made at document level (meaning one standard per segment), or within the document.
- Harmonisation is only achievable by solving step by step the technical issues which are not fully mastered and the conflicting issues. Therefore, the interconnection standard should be adopted only once all the critical issues are properly dealt with. Issues requiring additional research work (e.g. contribution to active network operation) should be addressed in a separate (informative) part.
- Organisational aspects should be properly integrated into the standard. At the present stage of development, a harmonisation of procedural and organisational issues is not foreseeable in the very next future. Acknowledging the importance of these issues, but aiming at bringing soon a sound technical standard for interconnecting DER, these organisational issues should be dealt with in an informative annex in form of a recommendation. This way, the slowness to change and harmonise these issues will not slow down the harmonisation process for the technical standard.
- Requirements should intend to be technology/resource neutral and focused on interconnection issues rather than on aspects linked to the technology/resource. Such aspects should be covered by other standards (e.g. product standards).
- Information such as operation practises of explanations of the requirements can be very useful. They should be integrated into the standard in an appropriate way (e.g. informative annex).

The draft structure proposed in chapter 4 builds on these recommendations.

4 Proposed Draft Structure for a European Standard for interconnection of Distributed Energy Resources (EDIS)

4.1 Basic Framework

The basic proposed structure for the European Standard for interconnection of Distributed Energy Resources is made of 4 main parts:

- PART 0: Recommended procedure for interconnection of DER (informative)
- PART 1: Interconnection requirements (normative)
- PART 2: Conformance test procedure (normative)
- PART 3: Application Guide (informative)

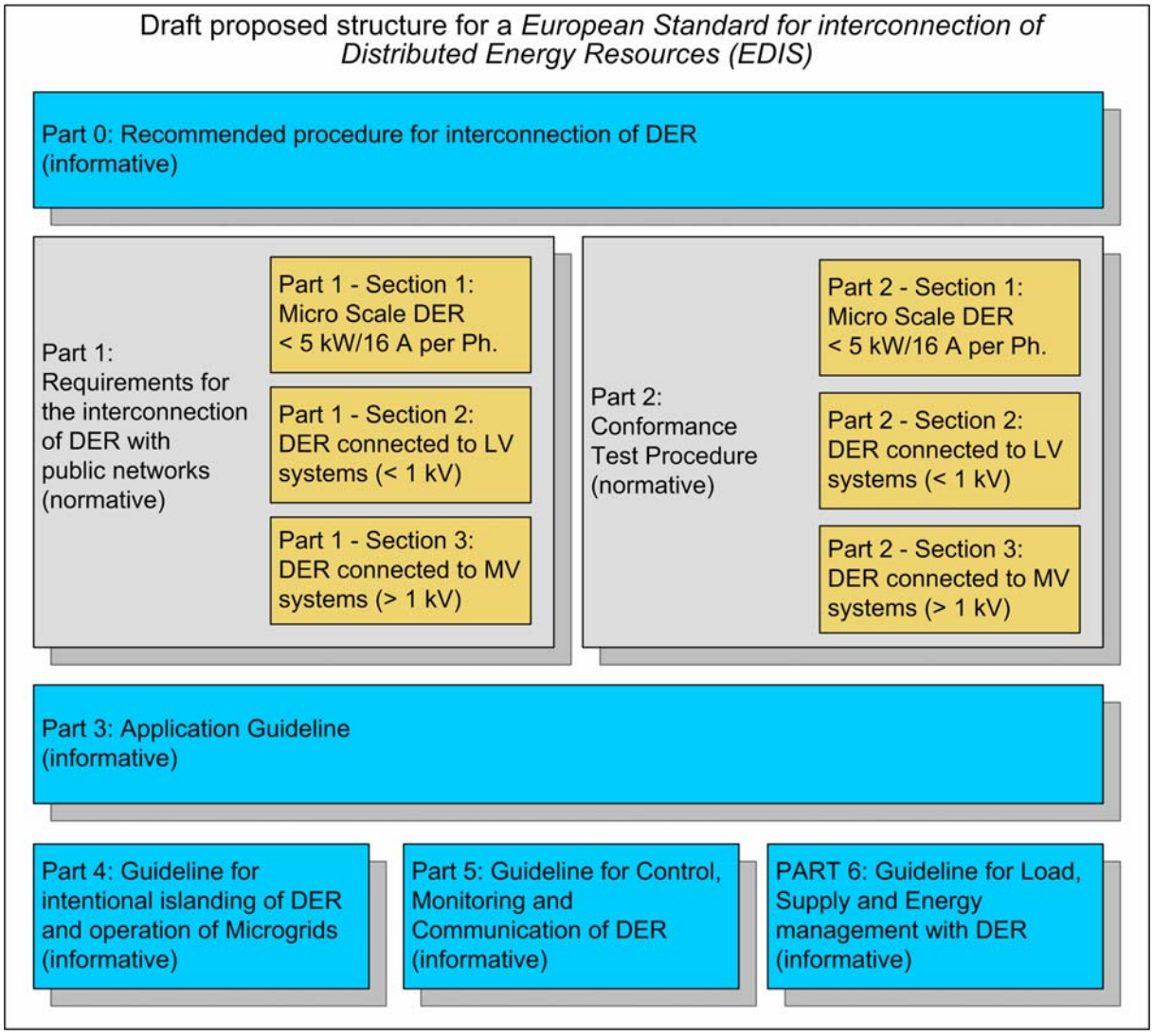


Figure 14: Proposed structure for the EDIS

In addition, the proposal is to have further guides on

- PART 4: “Guideline for intentional islanding of DER and operation of Microgrids” (informative)
- PART 5: “Guideline for Control, Monitoring and Communication of DER” (informative)
- PART 6: “Guideline for Load, Supply and Energy management with DER” (informative)

4.2 Description of the documents

4.2.1 PART 0: Interconnection Procedure

4.2.1.1 Purpose and scope of the document

The purpose is to specify a recommended procedure (organisational) for interconnection of DER. This part should cover the basic organisational steps.

As previously explained, the full harmonisation of procedural and organisational issues is not foreseeable in the very next future. Since this is a very important issue, it should be handled properly. A recommended procedure should be provided so that on the long-term national frameworks can be step by step adapted and the procedure used as standard interconnection procedure.

4.2.1.2 Proposed table of contents

To be expanded in further progress of the project.

4.2.1.3 Examples

The following figures show two examples for DER interconnection processes defined in DER interconnection documents. Both examples are from the U.S. where a lot of efforts have been made on the development and specification of appropriate processes.

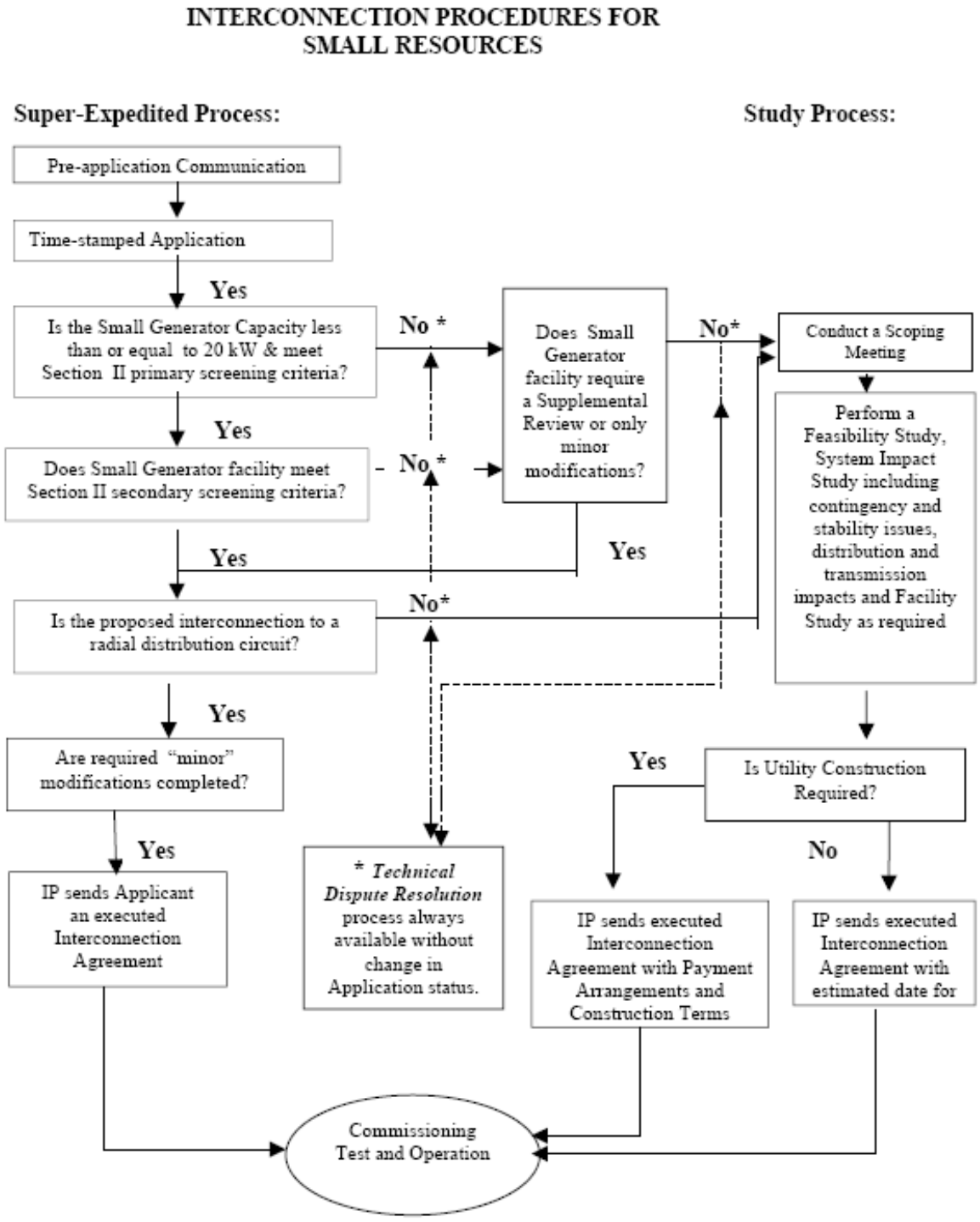


Figure 15 Flowchart: Interconnection Procedures for Small Resources (Source: NARUC Model Interconnection Procedures and Agreement for Small Distributed Generation Resources)

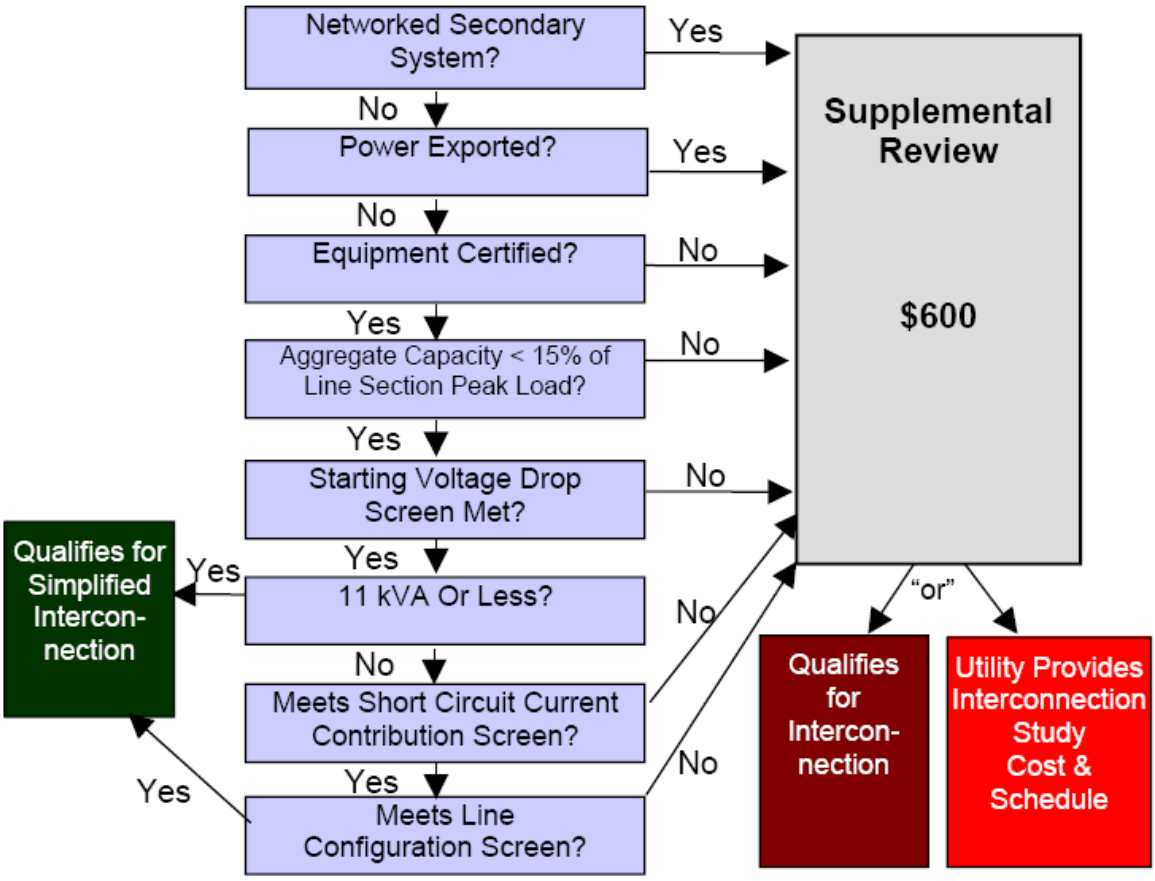


Figure 16 Example for interconnection assessment: California DG interconnection screening process

4.2.2 Part 1-X: Interconnection requirements

4.2.2.1 Purpose and Scope

Proposed Purpose and Scope:

This standard describes the criteria and technical requirements for interconnection of Distributed Energy Resources (DER) with electric networks. The requirements are defined irrespective of the primary source of energy.

The aim of the standard should be to provide requirements relevant to the characteristics, performance, operation and safety of the interconnection with the network in order to ensure in particular

- the safety of grid operation,
- the protection of the network,
- the electrical protection of the DER in case of network failures,
- the quality of supply.

The standard should be applicable to all DER (Generators and storage systems) to be connected to LV and MV networks, irrespective of their capacity and primary source of energy. There is no direct limit to the DER's capacity; however, the maximum individual and aggregate DER capacity which may be connected to a network is limited. A recommendation on adequate criteria and assessment procedures are to be provided in EDIS Part 0.

Proposed Limitations:

The following aspects are excluded from the scope:

- DER directly connected to (sub) transmission networks, such as large wind farms.
- Issues with respect to intended islanding operation of a DER; for this, a specific guideline might be necessary.
- Microgrid operation, i.e. the autonomous operation of parts of the network with DER separated from the main network. This operation should be covered within a specific "Guideline on intentional islanding of DER and operation of Microgrids".
- Contractual issues such as metering or other commercial matters;
- *Further aspects*

4.2.2.2 Proposed Segment related structure

In order to ease reading and application of the standard in practise, the technical criteria and requirements are specified on a network level and DER capacity based segments. This takes into account the structure of the DER market and enables to address each segment's specific issues.

A proposed vision for such segmentation is described in the following:

I. *Micro scale DER (LV connected, <5 kW / <16 A per phase)*:
These systems are mostly used in residential applications. For the development of a mass market e.g. for PV or micro CHP, the availability of dedicated common, generic technical requirements for components as well as clearly defined interconnection procedures are crucial to reduce the total project cost. The aim shall be to facilitate the connection of micro scale systems by addressing all technical aspects.

II. *Intermediate scale DG (LV connected, >5 kW / >16 A)*:
This segment consists of larger systems with a capacity which can be still connected to the LV networks. Typical examples are smaller commercial CHP units, biogas Plants or larger PV systems. This segment also includes multiple installations of micro generators within a planned installation project. For segment II, an individual assessment of the network impact and specific connection conditions might be required. For this purpose clear and transparent procedures (EDIS Part 0) need to be defined to allow smooth and streamlined project development.

III. *Large scale DG (MV connected):*
The third segment covers all installations with a capacity that requires a connection to MV networks, such as wind parks, larger CHP units. Individual, case by case solutions will be required to achieve an optimal integration into the network operation. Important issues such as voltage and reactive power control, production management as well as communication and controllability need to be taken into account. The purpose of the criteria defined for this sector should aim at making use of the advanced capabilities of modern DG to support network quality, reliability and security.

Regarding e.g. micro generators, the segmentation approach has already been adopted in different ways in various European countries' regulation, however, in most cases without a clear purpose oriented strategy.

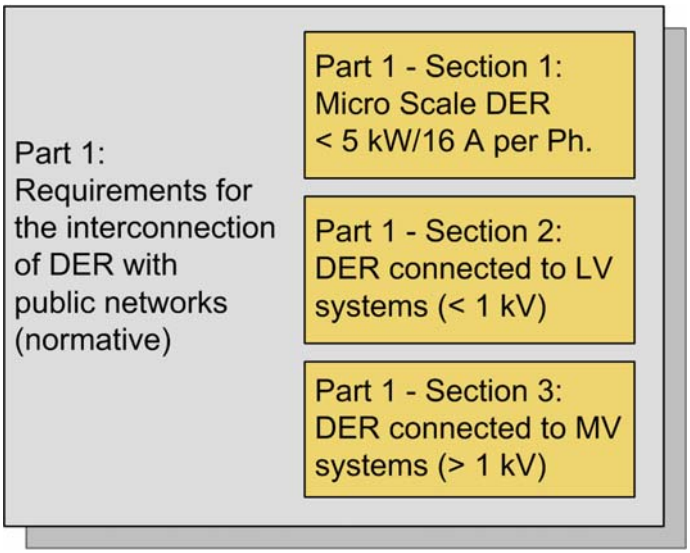


Figure 17 Proposed organisation of the Part 2 documents

Accordingly for each segment, the requirements should be defined in a separate document (Part 2-X where X represents the segment).

Technology specific issues should (only if necessary) preferably be covered within a technology annex to the Part 2 documents.

4.2.2.3 Proposed table of contents

Following, a structure is proposed for the European interconnection standard. It intends to be technology/resource neutral. However, some aspects may need to be dealt with separately such as Technology specific requirements (inverter/ rotating gen. based generation)

1. Scope, object
Scope, purpose, limitations (e.g. max size of DER)

2. Normative references
Ref to relevant standards (such as safety, EMC, etc)

3. General connection scheme
Provision of typical interconnection schemes

4. Definitions

5. Interconnection requirements
5.1 General requirements for the interconnection
5.1.1 Interconnection design issues
Functional design of the interconnection (relays to be used…)
Including e.g. functional safety issues

5.1.2 DER Control issues
E.g. Voltage regulation by DER

5.1.3 Starting, synchronisation and reconnection

5.2 Response to abnormal situations
Under this heading, requirements related to the response of the DER to abnormal grid conditions are covered. This includes in particular voltage and frequency, islanding as well as coordination and synchronisation issues.

5.2.1 Voltage
Protection requirements, including immunity (Ride-Through)

5.2.2 Frequency
Protection requirements, including immunity (Ride-Through)

5.2.3 Islanding
Protection requirements, including immunity (Ride-Through)

5.2.4 Reclosing and protection coordination

5.3 Power Quality

5.3.1 Limitation of steady-state voltage rise

Needs to be coordinated with interconnection assessment procedure

5.3.2 Limitation of voltage variations

Resulting from switching, load variations, etc.

5.3.3 Limitation of Harmonics and Interharmonics emission

5.3.4 Limitation of Flicker emission

5.3.5 Limitation of DC injection

5.3.6 Power factor

5.3.7 Limitation of Unbalance

5.3.8 Requirements for DER with PQ improvement functionality

Requirements for DER with the capability to improve the PQ at the connection point. This include e.g. Harmonics compensation, Mitigation of voltage dips and flicker, Voltage regulation features…

4.2.3 Part 2-X: Conformance test procedure

4.2.3.1 Purpose and Scope

The Part 2-X standards aim at specifying Type, Production and Commissioning tests that are necessary to validate that the DER equipment, particularly the interconnection functions and related equipment fulfil the requirements of the EDIS Part 1-X for the respective segment.

DER equipment that is interconnected to the public networks must meet the requirements specified in the Part 1-X standards. For this purpose, it is necessary to verify the compliance of the equipment with those requirements with the help of standardised test procedures. DER equipment qualified as conforming to the requirements can be readily accepted by the involved parties.

As this, the standard can also provide a guideline which can be applied in the process of certification of DER equipment although it should not describe the certification process itself. For this existing standards and processes (such as e.g. IECEE) are already available.

4.2.3.2 Proposed Segment related structure

The structure of the part dedicated to tests is shown below. The scheme is similar to the one of part 1.

Also here, the proposal is to have separate, segment specific documents

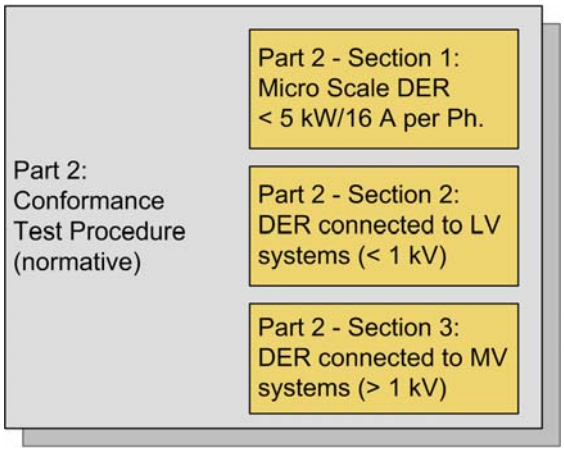


Figure 18: Proposed organisation of the Part 2 documents

4.2.3.3 Proposed table of contents

1. Scope, object

2. Normative references

3. Definitions

4. General requirements
- **4.1 Recommended test sequence**
- **4.2 Testing environment, accuracy requirements**
- **4.3 Requirements for the testing equipment**
- **4.4 Test Reports**

5. Type Tests
- **5.1 General tests**
  - **5.1.1 DER interconnection design verification**
  - **5.1.2 DER control tests**
  - **5.1.4 Starting, synchronisation and reconnection tests**
- **5.1 Tests for abnormal situations (verification of the behaviour and immunity)**
  - **5.1.1 Voltage**
  - **5.1.2 Frequency**
  - **5.1.3 Islanding**
- **5.2 Power Quality Tests**
  - **4.3.2 Voltage variations**
  - Resulting from switching, e.g.
  - **5.2.1 Harmonics and interharmonics**
  - **5.2.2 Flicker emission**
  - **5.2.3 DC injection**
  - **5.3.4 Unbalance**

5. Product Tests
- In-factory-tests

6. Commissioning Tests (if applicable)
- **6.1 Verifications**
- **6.2 Additional tests**
  (if some of the tests in 5.1 have not been conducted or must be performed again)

7. Repeated inspections (if applicable)

4.2.4 Part 3: Application Guide

This part should provide explanations on the requirements of the standard, examples of interconnection assessments.

1. Background

2. Explanation and application of the requirements in practise

2.1 DER control and interconnection design
- **2.1.1 Interconnection design issues**
- **2.1.2 DER Control issues**
- **2.1.3 Starting, synchronisation and reconnection**

2.2 Response to abnormal situations
- **2.2.1 Voltage**
- **2.2.2 Frequency**
- **2.2.3 Islanding**

2.3 Power Quality
- **2.3.1 Voltage rise**
- **2.3.2 Voltage variations**
- **2.3.3 Harmonics and interharmonics**
- **2.3.4 Flicker**
- **2.3.5 DC injection**
- **2.3.6 Unbalance**

Annexes: Discussions, explanations, Bibliography

4.2.5 PART 4: "Guideline for intentional islanding of DER and operation of Microgrids" (informative)

To be expanded in further progress of the project.

4.2.6 PART 5: "Guideline for Control, Monitoring and Communication of DER" (informative)

To be expanded in further progress of the project.

4.2.7 PART 6: "Guideline for Load, Supply and Energy management with DER" (informative)

To be expanded in further progress of the project.

5 References

[1] ENIRDGnet Project, Contract No. ENK5-CT-2001-20528, www.dgnet.org

[2] Report on Technical Constraints (Annex 1), SOLID-DER project, Contract No. 019938, www.solid-der.org

[3] Report on "evaluation of the quality of supply requirements specified by existing standards, national legislation and relevant technical reports inside and outside EU", DGFACTS Deliverable D1, Contract No. ENK5-CT-2002-00658, http://dgfacts.labein.es/dgfacts/index.jsp

[4] Interconnection of decentralised electricity generation. A review of standards, technical requirements and procedure in the EU-15. ELEP Deliverable 1.1+1.2, Contract No. EIE/04/175/S07.38664, www.elep.net

[5] International standard situation concerning components of distributed power systems and recommendations of supplements, DISPOWER Deliverable D2.1, Contract No. ENK5-CT-2001-00522, www.dispower.org

[6] A Review of PV Inverter Technology Costs and Performance Projections, NREL report, January 2006, www.nrel.gov

[7] NARUC Model Interconnection Procedures and Agreement for Small Distributed Generation Resources, www.naruc.org

[8] EN 50438: Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks, www.cenelec.org

6 Glossary

ASM	Asynchronous machine
CENELEC	European Committee for Electrotechnical Standardisation
CHP	Combined Heat and Power
DER	Distributed Energy Resources
DG	Distributed Generation
DNO	Distribution Network Operator
DSO	Distribution System Operator
EDIS	European Standard for interconnection of Distributed Energy Resources
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
LV	Low Voltage
MV	Medium Voltage
PF	Power Factor
PQ	Power Quality
PV	Photovoltaic
RES	Renewable Energy Sources
SM	Synchronous machine
SSEG	Small-scale embedded generators