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ELEP – EUROPEAN LOCAL ELECTRICITY PRODUCTION

DELIVERABLE 1.1 + 1.2

# INTERCONNECTION OF DECENTRALISED ELECTRICITY GENERATION

## A REVIEW OF STANDARDS, TECHNICAL REQUIREMENTS AND PROCEDURES IN THE EU-15

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# Introduction

Interconnection requirements for decentralised generators have been repeatedly singled-out as being major barriers to the deployment of micro-, small- and medium-sized renewable and cogeneration electricity production installations in the European Union.

Interconnection standards and requirements are the core issue addressed by the ELEP Project's Work Package 1. The intent behind the work carried out in WP1 is to map in sufficient detail the existing standards, requirements and procedures throughout the EU-15; highlight the areas of commonality and inconsistency and finally propose a set of recommendations. These tasks have in turn been the underlying basis for the WP's three deliverables: D1.1 on Interconnection Standards; D1.2 on Areas of Commonality and Inconsistency and D1.3 on Recommendations.

While all three deliverables form a whole, this report brings together Deliverables D1.1 and D1.2 as it was hard to envisage D1.2 as a standalone deliverable, independent from the analysis carried out in D1.1.

Deliverables D1.1 and D1.2 essentially paint a strikingly diverse picture for interconnection rules and procedures in the EU-15. In essence, there are as many sets of rules as there are Member States and one can only group countries along the lines of very generic approaches -at best. The overall sense of uncertainty and opaqueness is increased by the fact that in many instances there lacks a robust legal and regulatory framework for the interconnection of DG, resulting in bilateral negotiations between the project promoter and the local network operator.

The D1.3 interconnection recommendations propose a way to overcome the present regulatory haze engulfing the larger section of distributed generators in Europe.

# Chapter 1: European Standards

## 1.1 European and international standard setting bodies

A significant share of standards for electric, electronic, and electrotechnical devices is set by supra-national organisations. Due to the removal of barriers to trade in the 19th century, the manufacturers and users of such devices realised very early the need to harmonise the design criteria for goods and services. The most important standard setting body is the global IEC which has been established in 1908. Another key actor on the international stage is CENELEC, which comprises of the EU-25 and EFTA countries (without Liechtenstein). Finally, there are non-standard setting bodies, such as CIGRE which represents a worldwide forum for the exchange of information between experts and, thus, give important input to the discussions on the international level.

### 1.1.1 The European Committee for Electrotechnical Standardization (CENELEC)

CENELEC[1] is the key European standard setting body in the field of electrical and electronic goods and services. Currently, 28 European countries participate in the work of this organisation and develop via its manifold technical committees harmonized standards in order to remove barriers to trade and to cut compliance costs. CENELEC standards are voluntary but, due to their importance, represent in many cases semi-legal obligations. The co-ordination exercise undertaken by CENELEC is immense, which can be illustrated by the fact that not less than 15,000 technical experts from the participating countries are involved in its operation. The CENELEC central secretariat, located in Brussels, is in charge of the daily operations, co-ordination and promotion of CENELEC activities. With a staff of 31 people the central secretariat is rather small compared to the tasks it is assigned to.

CENELEC members are all EU-25 countries and the EFTA countries Iceland, Norway and Switzerland. In addition to this, the EU candidate countries Bulgaria, Croatia, Romania and Turkey (plus 4 more countries) enjoy an affiliate status. Technical experts can only participate at the work of CENELEC by being nominally chosen by a national member.

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[1] CENELEC – The European Committee for Electrotechnical Standardization (www.cenelec.org)

**Map 1 CENELEC member countries**

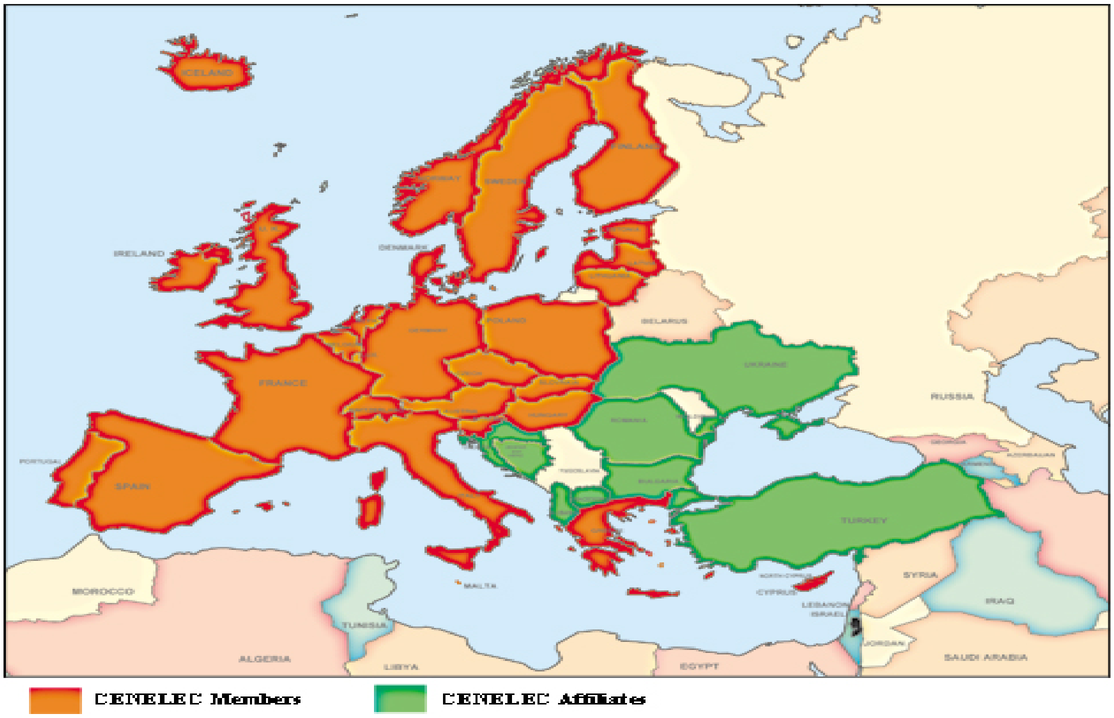


**Table 1  List of CENEC national members**

| | |
|---|---|
| Austria | Österreichischer Verband für Elektrotechnik |
| Belgium | Comité Electrotechnique Belge |
| Cyprus | Cyprus Organisation for Standardisation |
| Czech Republic | Czech Standards Institute |
| Denmark | Dansk Standard – Electrotechnical Sector |
| Estonia | Estonian Centre for Standardisation |
| Germany | Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE |
| Finland | Standardization in Finland |
| France | Union Technique de l’Electricité et de la Communication |
| Greece | Hellenic Organisation for Standardisation |
| Hungary | Hungarian Standards Institution |
| Iceland | Icelandic Standards |
| Ireland | Electro-Technical Council of Ireland Ltd |
| Italy | Comitato Elettrotechnico Italiano |
| Latvia | Latvian Standard |
| Lithuania | Lithuanian Standards Board |
| Luxembourg | Service de l’Energie de l’Etat |
| Malta | Malta Standards Authority |
| Netherlands | Netherlands Elektrotechnisch Comité |
| Norway | Norsk Elektroteknisk Komite |
| Poland | Polish Committee for Standardisation |
| Portugal | Instituto Português de la Qualidade |
| Spain | Asociación Espanola de Nomalizacion y Certificación |
| Slovakia | Slovak Electrotechnical Committee |
| Slovenia | Slovenian Insitute for Standardization |
| Sweden | Svenska Elektriska Kommissionen |
| Switzerland | Swiss Electrotechnical Committee |
| UK | British Electrotechnical Committee |

CENELEC standards are in most cases initiated in a top-down approach. In 80% of the cases, the initial document proposing to harmonise a standard comes from the IEC. The remaining 20% of initiatives either stem from the work done in a CENELEC technical committee or a tabled by national members of the organisation. When a suitable draft standard is available, it is submitted to the national members for enquiry, a procedure which lasts six months. The comments received are incorporated in the document, where possible, before a final draft is sent out for vote.

The voting on a standard usually takes three months. The votes are weighted according to the size of the country the CENELEC members represents. The range of the weighting is considerable: Germany as largest member has ten votes, whereas a small member, such as Malta has only one vote. The standard is approved if a majority of members is in favour, and if at least 71% of the weighted votes cast are positive.

### 1.1.2 The International Electrotechnical Commission (IEC)

The IEC[2] is one of the oldest international organisations and has been formed following an initiative of delegates at the International Electrical Congress of St. Louis in September 1904. IEC standards are voluntary but according to IEC President Renzo Tani (former CEO of Siemens Italy) there is a growing momentum for making them binding in the future. The mission statement of the Geneva-based organisation is summarized in Article 2 of the Statutes:

"The object of the Commission is to promote international co-operation on all questions of standardisation and related matters, such as the verification of conformity of standards in the fields of electricity, electronics and related technologies, and thus to promote international understanding. This object, *inter alia*, is achieved by issuing publications, including International Standards."

The IEC charter embraces all electrotechnologies including electronics, magnetics and electromagnetics, electroacoustics, multimedia, telecommunication, and energy production and distribution, as well as associated general disciplines such as terminology and symbols, electromagnetic compatibility, measurement and performance, dependability, design and development, safety and the environment.

Membership to the IEC is restricted to one member per country, which is officially recognized by the United Nations as a sovereign state. CENELEC is not a direct member at the IEC, but all of CENELEC members are directly organised with the IEC (the smaller ones as associate members). Other key players are the Standardisation Administration of China, the Bureau of Indian Standards, the Japanese Industrial Standards Committee, the Korean Agency for Technology and Standards, the Russian Scientific & Research Institute for Standardization and Certification, the Singapore standards, productivity and Innovation Board, and the American National Standards Institute, to name but a few. Representing 28 of 49 countries the "CENELEC-bloc" has considerable power in the IEC. The official languages of the organisation are English, French and Russian. The main task for the future will be to integrate the rapidly developing countries Asian nations.

[2] IEC – International Electrotechnical Commission (www.iec.ch)

The standards work of the IEC is carried out by several hundreds of technical committees and subcommittees, composed of representatives of member countries, each dealing with a particular subject. The primary duty of a technical committee or subcommittee is the development and systematic maintenance of international standards. Regarding the voting procedure, the IEC statutes foresee, in contrast to the weighted voting system of CENELEC, that each country has got one vote. Decisions are adopted at a meeting or by correspondence by a two-third majority of those members voting.

#### 1.1.3 International Council on Large Electric Systems (CIGRE)

The CIGRE[3] is not a standard setting body, but rather represents a forum that brings together researchers, academics, producers, manufacturers, system operators, traders, and regulatory bodies. CIGRE focuses on the fields of electricity, such as the developments and adaptation of grids, the optimisation of maintenance and life expectancy of electrical equipment, the organisation of utilities. Membership of the organisation comprises 4,000 individual members and 700 institutional members, coming from more than 80 countries around the world.

The central office of CIGRE is based in Paris and is in charge of running the daily operation. Main activities include the organisation of conferences and supervising 16 study committees. The CIGRE Study Committee C6 "Distribution Systems and Distributed Generation" has started work in the late 1990ies by analysing the impact of increased DG on electricity networks. While, in the short term questions, such as the status of DG technologies, energy management in the distribution network, and the contribution of DG to ancillary services are discussed, the Study Committee aims to, in the mid-term, analyse the possibilities of "active" distribution networks and the use of innovative storage devices.

## *1.2 Main standards*

By far most prominent European standard on electricity distribution systems is the CENELEC standard EN 50160, which has been lastly updated in the year 2000. Another important European-wide applicable document is the "Low Voltage Directive" which harmonises rules for all electrical equipment below a certain voltage threshold. Finally, CENELEC drives further the work for harmonising technical standards for micro power generation units that wish to connect to the distribution grid.

#### 1.2.1 EN 50160

The standard: **EN 50160:2000 Voltage characteristics of electricity supplied by public distribution systems** provides all the characteristics of the voltage, the acceptable limits and the criteria for their evaluation, with a special attention to the power quality.

**Slow Voltage changes**
Slow increase or decrease of the voltage generated by grid load variations or by exchange conditions of reactive energy.

[3] CIGRE – International Council on large electric systems (www.cigre.org)

**Fast Voltage changes**
Fast voltage changes, inside the values reported in the summary table showed below, due to insertion or disconnection of load and generators.

**Interruption**
The value of the voltage is less than 1% of nominal voltage (Vn=230/400V). The interruption could be:
- accidental, caused by transient or failure,
- programmed works with notice

**Temporary over-voltages**
Over-voltages (<10ms), due to failures, determine star center displacement (LV and MV)

**Transient over-voltages**
Over-voltages are due generally to fulmination or maneuvers.

**Harmonic Voltages**
Voltages can have a frequency multiple of the fundamental frequency, due to non-linear loads connected to the grid. It happens when the distorting loads are relevant with respect to total load of the grid.

**Voltage unbalance**
Voltage unbalance consists of the difference among phase voltages and phase angles, due to loads very unbalanced or phase interruptions.

Below is a summary of the criteria for the low voltage side of the supply network:

| Supply voltage phenomenon | Acceptable limits | Measurement Interval | Monitoring Period | Acceptance Percentage |
|---|---|---|---|---|
| Grid frequency | 49.5Hz to 50.5Hz<br>47Hz to 52Hz | 10 s | 1 Week | 95%<br>100% |
| Slow voltage changes | 230V ± 10% | 10 min | 1 Week | 100% |
| Voltage Sags or Dips (≤1min) | 10 to 1000 times per year (under 85% of nominal) | 10 ms | 1 Year | 95% |
| Short Interruptions (≤ 3min) | 10 to 100 times per year (under 1% of nominal) | 10 ms | 1 Year | 100% |
| Accidental, long interruptions (> 3min) | 10 to 50 times per year (under 1% of nominal) | 10 ms | 1 Year | 100% |
| Temporary over-voltages (line-to-ground) | Mostly < 1.5 kV | 10 ms | N/A | 100% |
| Transient over-voltages (line-to-ground) | Mostly < 6kV | N/A | N/A | 100% |
| Voltage unbalance | Mostly 2% but occasionally 3% | 10 min | 1 Week | 95% |
| Harmonic Voltages | 8% Total Harmonic Distortion (THD) | 10 min | 1 Week | 95% |

**Table 2 Voltage unbalance criteria in low voltage networks**

## 1.2.2 The Low Voltage Directive of 1973

On 19 February 1973, the Council of Ministers adopted European Commission Directive 73/23/EEC ("the Low Voltage Directive") on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits. The Low Voltage Directive is a so-called "old" approach Directive and as such did not provide for the use of CE marking. However, electrical equipment is also covered for certain purposes by other more recent new approach Directives which do require CE marking. Thus, to prevent possible confusion in the market place and to avoid problems of overlapping Directives, the Low Voltage Directive has been modified to introduce CE marking requirements.

Directive 93/68/EEC ("the CE Marking Directive") was adopted on 22 July 1993, its purpose, to introduce a harmonised set of rules relating to the affixing and use of CE marking. The rules brought about amendments to the Low Voltage Directive and these had to be implemented into national law. The

The modified Directive embodies a number of principles:

- only electrical equipment which does not jeopardise the safety of people, domestic animals and property shall be placed on the market;
- only electrical equipment which satisfies the CE marking requirements will be taken as complying with the requirements of the modified Low Voltage Directive and is thereby entitled to free circulation throughout the European Economic Area (EEA), unless there are reasonable grounds for suspecting that the product does not in fact meet the requirements;
- electrical equipment is not required to be tested or marked for approval by an independent third party;
- enforcement is the responsibility of each Member State within its national jurisdiction.

## 1.2.3 CENELEC TC 8X

CENELEC's Technical Committee TC 8X has been drafting standards both for micro-generators wishing to connect to the low-voltage distribution networks and for electricity production systems rated more than 16 A per phase and connected to the LV or MV networks.

<u>Electricity Production Systems Rated More Than 16 A per Phase and Connected to LV or MV Networks</u>

This standard will apply to rotating and static production systems converting any primary energy source into AC electrical energy, rated more than 16 A per phase and functioning in island or in parallel to MV or LV public networks, and aims at defining:

- Connection criteria to the public and non-public network;
- Protection criteria with reference to choice of the control, switching and protection equipment;
- Safety criteria with reference to the state of the neutral;
- Installation criteria and start-up;
- Production and consumption of reactive energy;
- Choice and dimensioning criteria of production plants.

Requirements for the Connection of Micro-generators in Parallel with Public Low-Voltage Distribution Networks

This standard will specify the technical requirements for the connection and operation of micro-generators, irrespective of the primary source of energy, in parallel with the public low-voltage distribution networks, where micro-generation refers to equipment rated up to and including 16 A per phase, single or multi phase 230/400 V (line voltage) or multiphase 230 V (phase-to-phase voltage). In some countries, this standard may be applied to generators with rating up to and including 25 A per phase. This standard prescribes an "Inform and fit" procedure.

The electrical interface is the principal focus and this includes the method of connection, the settings and protection requirements for connection, the operation of the electrical interface under normal conditions, emergency shutdown, distribution network-independent operation, start-up and distribution network synchronisation. The intention of the standard is to ensure that the micro-generator satisfies appropriate provisions for:

- The treatment of the DSO e.g. grid protection;
- Information to electricians working inside the house;
- Quality of supply;
- Electrical protection of the generation unit.

The standard, however, will exclude issues of rebalancing, metering and other commercial matters.

# Chapter 2: Standards and Technical Requirements in the EU-15 Member States

## 2.1 Austria

### 2.1.1 Institutional Issues

Based upon the legislations of the "Elektrizitätswirtschafts- und organisationsgesetz" (ElWOG), new authorities in the electricity sector have been set up for the regulation of the market. Among these authorities, the new regulatory body, E-Control[4] is not only responsible for monitoring the competition and supporting the Federal Ministry but has also taken over the development of the rules governing the function of the market.

In Austria this basic framework of rules is defined in the "Technical and organisational rules for operators and users of transmission and distribution networks (TOR)". These TOR are also part of the so called "Market rules" for the liberalised electricity market, which have de facto the status of a law, since they are the implementation of the ElWOG. On 1.10.2001, the Austrian utilities' association VEÖ[5] organised working groups which elaborated the basic framework for these rules. After discussions with the involved stakeholders, the first issue of the TOR was transferred to E-Control and published in 2001. The TORs define the basic framework for operators and users of electricity networks. At the moment working groups consisting of experts from E-Control and the utilities association VEÖ are working on a revision of the TOR, which is scheduled to be finalised in 2005.

ÖNORM[6] (Austrian Standards Institute) is the national standardisation body. Standards in the field of electrical engineering are elaborated by the ÖVE (Österreichischer Verband für Elektrotechnik, Austrian Electrotechnical Association). According to the Federal Law on safety measures and standardisation in the field of Electrical Engineering (ETG 1992), BGBl. 45/1993, the ÖVE is mentioned as the authority in charge of the elaboration and publication of the Austrian Regulations for electrical engineering. The standards are elaborated by Working Groups, which are organised in form of committees (FNA) and subcommittees (FNUA) within the ÖVE.

### 2.1.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

In general, Austrian DSOs observe the recommendations given by the TOR and set up their contracts on the basis of the TOR guidelines. Regarding protection, the same basic requirements are used. However, differences do exist regarding reactive power compensation. The power factor is set individually by the DNO for larger units, while smaller generators may or may not require compensation, depending on the DNOs own procedures. Also, there are no common requirements for voltage and power factor control capabilities of large distributed generators (in the MW range) defined in the TOR. Whether such systems have to be implemented or not is determined by the DNO. These points are problematic as Austria has no less than 133 distribution companies.

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[4] www.e-control.at
[5] www.veoe.at
[6] www.on-norm.at

Generally, the situation in Austria is far from being transparent when it comes to the treatment of interconnection applications. On the one hand, federal legislation has provided E-control with extensive monitoring tasks and powers. The Energie Regulierungsbehördengesetz of 2000 gives authority to e-control to "examine the files of all market participants" and to "inquire about all activities that fall under the scope of its competences". On the other hand, there is no specific requirement for e-control to carry out regular monitoring reports. As one consequence, it is at this stage not possible for e-control (or for any other agency) to assess whether grid companies discriminate against potential competitors in the power generation sector or not.

### 2.1.3 Interconnection Procedure

No detailed procedures are defined for commissioning of DG units. However, commissioning and initial start-up has to be coordinated with the grid operator. The grid operator reserves the right to be present for the inspection of the following points:

- Function and accessibility of the disconnection switchgear.
- Decoupling protection, including the verification of the settings and preparation of an inspection sheet, check of the power tripping of the contactors.
- Functional test of the compensation equipment.
- Compliance with the limits for permissible grid interferences.
- Compliance with the start-up conditions.
- Reactive power and voltage control.
- Measurement equipment.

The operator of the generator has to document the test of the decoupling protection equipment and prove the compliance with the requirements.

## *2.2 Belgium*

### 2.2.1 Institutional Issues

In Belgium, there exists a division of authority between federal and regional level with regards to DG. The federal authorities are the competent body for electricity tariffs, the high voltage electricity grid with a voltage of over 70 kV, the production of electricity (with the exception of the production of electricity from renewable energy sources and combined heat and power systems) and nuclear power. The regions (Flanders, Brussels-Capital and Wallonia) are the competent bodies for the distribution of electricity via networks with a voltage of less than or equal to 70 kV and the production of electricity from renewable energy sources and combined heat and power systems. This division of competencies is important to bear in mind when assessing the situation in Belgium since interconnection requirements are often based on federal or regional legislation and regulation rather than country-wide requirements.

The Belgian Institute of Standardization (BIN) and the Belgian Electrotechnical Committee (BEC) are the institutions which have the role of promoting the standardization and the establishment of the standards. The BIN is a semi-public, non-profit-making association depending on the Ministry for the Economic affairs, while the BEC is a private, non-profit-making association depending on private organizations. The BIN entrusts to the BEC the mission of organizing and to carry out work of standardization in the field of electricity (electrotechnical and electronic) as well on the national level as on the international level. The BIN is member of the International Organization for Standardization (ISO) and of the European Committee of Standardization (CEN). The BEC is Member of the International Electrotechnical Commission (IEC) and of the European Committee of Electrotechnical Standardization (CENELEC). Especially relevant to DG are working groups SC64 (electrical installations in buildings) and SC99 (system engineering and erection of electrical power installations in systems with nominal voltages above 1 kV ac and 1.5 kV dc).

BFE-FPE (Beroepsfederatie van de producenten en verdelers van elektriciteit in België – Fédération professionelle du secteur électrique en Belgique) is the federation of the electricity companies in Belgium. One of their tasks is to represent the electricity sector at certain institutions and committees, in regard to matters of common interest such as safety of installations, permissions, standardization and regulatory aspects. They also organize the offices of the Belgian committees of CIGRE and WEC (World Energy Council). Five technical commissions are active in BFE-FPE, the most important concerning DG being the technical commission C10 "Power Quality", as it is responsible for the creation of the document C10/11 on "the technical requirements for connection of dispersed generation systems operating in parallel on the distribution network", applicable to distribution networks of low and medium voltage for power up to around 15 MVA. This document does not include the general requirements under the RGIE ("Règlement general sur les installations électriques").

### 2.2.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

The requirements relevant to DG underwent redrafting in 2002 and 2003 and as a result the situation is rather straightforward with a general safety regulation which applies to all electrical installations and a technical requirement applicable for DG under 15 MVA. It should be noted that both the RGIE and the C10/11 are available free of charge. The division of competences between the Regions and the federal level adds complexity to the overall technical requirement framework but in each case, there is only a limited number of texts that apply, ensuring clarity for project developers.

Following the liberalisation of the electricity sector in Belgium, the regional governments of Wallonia, Flanders and Brussels-capital issued legislation clarifying the roles and the technical requirements for the interconnection of small generators to the public network. This clarification has ensured a better collaboration between the network operator(s) and the electricity producer. Up until then, the producer had to address any request for an interconnection directly to the historical utility, which was also his competitor. Now however, the network operator(s) have unbundled their generation and trading activities and are therefore sometimes helpful towards small generators that can help increase the reliability of their network. Besides this important change, the CREG also plays a vital role in ensuring fair interconnection pricing.

### 2.2.3 Interconnection Procedure

The decentralised generation facility may only be connected to the distribution network after obtaining a written authorisation from the DNO. This permission is also required if the decentralised generator wishes to make changes to its generation facility, in particular if the capacity is changed. The DNO reserves the right to verify correct operation at all times.

Prior to the commissioning of the plant, two studies have to be carried out. An initial orientation study ("*étude d'orientation*"), which costs €500 for installations between 250 kVA and 1,000kVA; €250 for installations between 56 and 250 kVA; €100 for installations under 56 kVA and is free for installations below 25kVA[7]. A detailed study ("*étude de detail*") which can cost between €100 and €11,000 depending on the company, the power range and the network the installation is to be connected to. Typical costs given by Cogensud[8] are €6,300 for a medium tension connection or €1,000 for a low tension connection. All the costs linked to grid connection are accessible on the CREG's website[9].

Before being connected to the network, the dispersed generator's facility must be inspected at the latter's own cost for compliance with AREI/RGIE regulations. During this control, the conformity with an automatic isolating system and the protection against direct current injection are verified. This inspection must be repeated once every 5 years, at the dispersed producer's own initiative and cost.

## *2.3 Denmark*

### <u>2.3.1 Institutional Issues</u>

The Danish electricity system is divided into two distinct regions covering the east and west of the country. Each of these regions has a system operator, Eltra in the west and Elkraft in the east. Through an act of the Danish parliament these two system operators will be merged along with Gastra (the Danish natural gas transmission company) in the autumn of 2005 to form Energinet[10]. Most of the electrical interconnection rules, recommendations and Standards that currently exist in Denmark are currently produced either by the network operators Eltra and Elkraft.

A more independent standard-stetting body is DEFU (Danish National Electricity Research Organisation) that is active in a number of international Standards development organisations. It also offers advice in planning, operating and maintaining electricity networks. In May 2005 DEFU merged with the Association of Danish Energy Companies. The DEFU publications generally relate to common requirements across Denmark whereas the Eltra and Elkraft documents cover specific requirements for their individual service areas. Once Energinet has been formally created, it will be responsible for the development of a single set of technical regulations covering the whole of the Danish electricity network, including requirements for the connection of small generators. These technical regulations are currently under development, and it expected that they will be in place sometime during 2006.

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[7] Prices from SIBELGA for 2005. These figures vary from Distribution system operator to another, e.g. WAVRE charges 3,172 EUR for the orientation study in the case of installations with a power rating above 56kVA and injecting power to the grid.

[8] Cogensud is the association for the promotion of cogeneration in the Walloon Region of Belgium.

[9] The legal basis for connection charging is the Royal Decree of 11 July 2002.

[10] http://www.energinet.dk/composite-18.htm

### 2.3.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

Until the creation of Energinet, the grid connections applicable to small generators in Denmark are regulated via two different sets of rules corresponding to the service areas of the two system operators Eltra and Elkraft. A (non-exhaustive) list of these interconnection regulations is included in Annex I, which also includes a selection of those common requirements published by DEFU. These documents will all be rationalised into a single set of regulations once Energinet is fully up and running. All of the DEFU documents are available for purchase via the DEFU website[11]. Some of the Eltra and Elkraft documents are available via the respective company websites[12].

In terms of the impact of these standards and regulations on DG, there is a relatively high level of visibility in terms of the connection requirements for small generation plant, and these have been in place for a number of years. Furthermore, the fact that Denmark is leading the way in Europe in terms of the penetration level of DG and RES within their energy market suggests that their interconnection rules, in conjunction with the other measures they have in place for the promotion of these technologies, have had a positive impact. The development of the common set of technical interconnection rules across Denmark that will result from the creation of Energinet is expected to be a further positive step. Another positive impact can be expected from with the Danish Energy Regulatory Authority (DERA)[13] which is responsible for market supervision.

### 2.3.3 Interconnection Procedure

In accordance with the Danish Electricity Supply Act[14], only generation facilities having a total capacity in excess of 25 MW require a licence. However, permits are required for land-based production plants, and the conditions and procedures relating to the issue of permits for these equipments are specified in Order 493 of 12 June 2003[15].

Example 1 – onshore wind turbines

Onshore wind farms are well established in Denmark, and as a consequence there are comprehensive baseline rules within Denmark for the planning and construction of wind turbine facilities. The Danish Wind Turbine Owners' Association (www.dkvind.dk) has published a description of the roles of the different authorities, relevant legislation and the procedures that need to be followed when establishing a wind energy plant[16]. Most onshore wind farms are in rural areas, and the local (regional) authorities are responsible for approving the location of the sites at which turbines will be located. These authorities also have the responsibility for issuing environmental (noise) approval. This permission is granted after period of time set aside for public objections and the consideration of these objections. If the project contains more than 3 wind turbines, or if the total height of a wind turbine exceeds 80m, the local authority is obliged to perform an Environmental Impact Assessment

[11] http://www.defu.dk/defu/defu_eng/e_default.asp

[12] http://www.eltra.dk/composite-11286.htm and
http://eng.elkraft-system.dk/elkraft/uk/News.nsf

[13] http://energitilsynet.dk/english/

[14] LBK 286 (20-04-2005) "bekendtgørelse af lov om elforsyning"

[15] BEK 493 "Bekendtgørelse om betingelser og procedurer for meddelelse af tilladelse til etablering af nye elproduktionsanlæg samt væsentlige ændringer i bestående anlæg"

[16] Leaflet P2: Planning of wind turbines

(EIA). Small turbines located at private residential dwellings do not require an EIA to be performed, nor do they require a new local area development plan.

Example 2 – Biogas plant
Biogas projects are required to go through a very time consuming process of planning and approvals. This includes the approval of the location at which the plant will be constructed, the approval of the construction itself, an environmental approval (as biogas is deemed "environmentally critical"), a separate Environmental Impact Assessment, and finally approval from the Danish food and veterinary authorities. Further information can be found on the website of the Danish Biogas Association (www.biogasbranchen.dk).

## *2.4 Finland*

### 2.4.1 Institutional Issues

The SESKO Standardization in Finland (former name until January 2003 was the Finnish Electrotechnical Standards Association) is an independent standards organization composed of 20 private and governmental bodies representing the main interest groups in the electrical and electronics field. SESKO was founded in 1943 under the auspices of the Association of Finnish Electrical Engineers, and was made an independent association in 1965. SESKO forms the Finnish National Committee of IEC and CENELEC.

At present, there exist more than 600 (about 17 000 pages) published electrotechnical SFS-standards in Finnish. Almost 90 % of them are based on international (IEC) and European (EN) standards. SESKO is a member of the Finnish Standards Association (SFS) which is responsible for the publication and sales of all national standards offered by various branch organizations.

Besides SESKO, the Energy Market Authority (EMV) plays a leading role. The Authority is responsible for executing the governmental acts and decrees and for giving specific instructions to DSOs. The draft bills and decrees dealing with energy and electricity are drafted by the Ministry of Trade and Industry with the basic rules governing the electricity market are given in the Electricity Market Act and in the Electricity Market Decree.

The Safety Technology Authority executes the safety acts and decrees and gives more detailed instructions about electrical equipment and installations.

Fingrid, the Finnish TSO has published the General Connection Terms and the Specifications for the Operational Performance of Power Plants, but these specifications apply only to units rated above 50 MWe, while the general connection terms focus primarily on units connecting to the high voltage network (110 kV and above).

### 2.4.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

The Finnish standards are a basis for technical requirements. The national/international standards for electrical equipment, electrical safety, networks and network operation are naturally applied to DG (no DG-specific national standards). It has been noticed that in practice some requirements should be higher than is set in standards (e.g. standard SFS-EN 50160 has too low requirements for the voltage quality when it comes to DG). The Finnish Electricity Association[17] (SENER) has in the past published technical recommendations about connecting small power plants to distribution networks; however, these aren't binding. The recommendations do not include any special limit for a small generation unit. The document covers: types of power plants and generators; network impacts (safety, power quality, voltage stability and reactive power, voltage transients, harmonics, losses, fault currents and interconnection calculations) and protection (different fault cases, basic protection and additional protection, islanding). The emphasis is put on guidelines and principles of protection. The recommendations do not include rules or procedures for interconnection and aren't very detailed.

The regulator doesn't set any particular levels for use of system (UoS) or connection charges, only some basic principles for tariff determination are given. According to the law all producers have to be connected non-discriminatively to distribution network and both the costs and benefits of DG should be taken into account when determining charges (e.g. DSO gets compensation for UoS charges from TSO if DSO has small (< 1 MVA) power plants connected to its network). On the other hand DSO has the right to collect all reasonable costs resulting from connection. In Finland DSOs have a large freedom to set their own connection and UoS charges. Only limitation is that UoS charges should be location independent. In practice, this freedom makes it possible to restrict a connection of certain type or size of DG. For small power plants relatively high connection and UoS charges might be barriers. This is the case especially when UoS charges include constant and power-dependent component or the location of DG-unit is far from the existing electricity network (e.g. wind power).

Because the technical recommendations published by the Finnish Electricity Association are not binding, DSOs can set these requirements quite freely and especially for small DG-units the complex protection, controlling or measuring requirements might be a barrier. Because the charges differ between DSOs, it restricts a free and profitable locating of DG. At the moment the Energy Market Authority is collecting and evaluating the UoS charges of generation. If there are signs of discrimination of some generation type or size, new regulations will be considered. A harmonised approach to the connection of DG would be welcome in Finland, given that the country has about 94 DSOs, many of which have little or no experience with DG.

In the meantime, Nordel has released a Nordic Grid Code (2004) with a section dedicated to "(laying) down certain basic rules for connection to the transmission system" ("Connection Code"). Because of the focus on transmission of electricity decentralised generators rated under 50 MWe are only briefly touched upon, in general terms.

### 2.4.3 Interconnection Procedure

The Finnish regulation model doesn't include any incentive for DSOs to connect DG to their networks. According to the law, the connection requirements shall be impartial and non-discriminatory. At the request of the project developer, the DSO shall give a comprehensive and sufficiently detailed estimate of the connection costs.

[17] Now an integral part of Energiateollisuus, the Association of Finish Energy Industries, created in 2004.

However, in practice, the connection procedure includes a lot of bilateral negotiations between the DSO and the DG owner, with no specific procedure covering these talks. The interconnection procedure is also rendered more complex to DG project developers due to the fact that most Finnish DNOs have no experience with the connection of DG and therefore have come up with their own company procedures on an ad hoc basis.

Fingrid's General Connection Terms document states that:

*"For the design of connection, Fingrid shall submit to the Connectee a proposal concerning the location of the connection point, information about short circuit and earth fault currents at the connection point and about the basic connection requirements. When the Connectee is dimensioning his electrical equipment, he shall take into account the basic design values and their forecast given by Fingrid.*

*The Connectee shall submit to Fingrid necessary information about the electrical equipment and systems included in or connected to the grid, such as cables transformers, generators and compensation equipment, and on the method of grid operation and ownership charges. Before commissioning the connection, the Connectee shall deliver to Fingrid the network chart and main circuit diagram (…)."*

## *2.5 France*

### 2.5.1 Institutional Issues

The French standardisation system is composed of AFNOR, Standardisation Offices (BN), Expert Groups and Government Representatives. AFNOR (French Standardisation Association) is the national standardisation body and acts as the French member body of the general European and international organisations, respectively CEN and ISO. AFNOR lists the needs for standardisation, works out the standardisation strategies, coordinates the Standardisation Offices, organises public inquiry and approves French standards. In each activity sector, Standardisation Offices lead standardisation committees and Expert Groups, formalize draft standards to be approved by AFNOR.

Each within their sector of activity, the Standardisation Offices are piloting the standards commissions and expert groups, are formalising the draft standards and their forwarding to AFNOR for public enquiry and approval, and are submitting French proposals for the relevant technical sector. In the majority of cases, the Standardisation Offices are attached to trade associations or technical centres and are financed by the enterprises and partners of the relevant sector. AFNOR is the standardisation bureau for the horizontal and multi-sectorial work and for those sectors without a Standardisation Office.

Belonging to all economic sectors, the experts constitute the very basis of the French standardisation system. For each subject, they provide their competence based on their origin: trade organisations and trade unions, producers, distributors, consumer associations, laboratories, labour unions and prevention bodies, environmental protection associations, public buyers, local and regional authorities, ministries… They express the needs for new standards, provide the technical content of the normative documents and update the latter and participate in the European and international standardisation work.

In addition to their expertise, the authorities play a specific role: all of the ministries are concerned by the standardisation policy, but it is the Inter-ministerial Delegate for Standards, appointed by the Minister for Industry, who sets out the general guidelines for the development of standards, checks their implementation and the requests for derogation, and monitors the work of the standardisation bodies. The Inter-ministerial Group for Standards assists the Minister for Industry in defining the orientations of the national and international policy of the authorities concerning standards and in evaluating this said policy.

The Strategic Committees manage jointly the major standardisation programmes (GPN) which group together the normative activities around a rallying topic, identifiable partners and a structure equivalent to that set up at European level. The Standardisation Bureau for Electric and Electronic systems and related to Distributed Generation is the UTE (Union Technique de l'Electricité)[18].

### 2.5.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

The long monopoly enjoyed by EDF on the French electricity system has meant that many of the interconnection requirements are ill-designed for the smaller generators and hinder their deployment. Many new regulations have been issued in the past few years and overall they have allowed for fairer interconnection requirements for DG. However, decentralised generators in France having to abide by the utility requirements of EDF are faced with very demanding technical requirements. More problematic still, however, is the insecurity surrounding the cost of interconnection to the network, especially for the smaller decentralised generators.

### 2.5.3 Interconnection Procedure

The procedure for the interconnection of a generator in France is rather complex and can be seen as an undue administrative burden by decentralised generators. Besides the several key steps detailed below, the main feature of the French interconnection procedure is the use of waiting lists relative to the medium and high voltage infrastructure (transformers and network) that have proven to have adverse effects on projects in the past.

Distributed generators in France who wish to connect to the public electricity distribution grid operated by EDF have to file a request for connection. The document named 'Procédure de traitement des demandes de raccordement des installations de production d'électricité aux réseaux publics de distribution'[19] (Identification NOP-RES_18E, Version V4 of 13 mai 2005) details the procedure[20]. In particular, it gives the rules relating to the management of the waiting list and the principles of the contractual relations between the project owner and the distributor (in this case EDF) from the connection request until the entry in operation of the electricity production installation.

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[18] www.ute-fr.com

[19] Identification NOP-RES_18E ; Version V4 of 13 May 2005.

[20] The connection of installations with a rated power equal to or under 36 kVA as well as those installations with a power between 36 kVA and 250 kVA are governed by different regulations, albeit very similar. The main difference is that they are not subject to the waiting lists, or only to some of them.

Projects with an installed capacity below 2.5 MWe can send EDF an information request ("*demande de renseignement*") to which EDF answers with a feasibility study ("*étude de faisabilité*"). This document gives an estimation only and is absolutely non-binding for EDF. Once the project is more advanced, the project owner has the option to request a detailed study (*"etude détaillée"*) from EDF. Once the project has been validated by the administration, the project owner has to request a detailed proposal ("*Proposition Technique et Financière*") for the connection of his installation. EDF will then carry out, within 3 months from the reception of the necessary documents, a detailed study. This step is mandatory and the technical and financial results are binding for both parties, if the project owner wishes to carry through his project. As soon as the project owner has accepted the detailed proposal and paid an initial payment, the distributor (EDF) carries out the final realisation studies. Based on these studies, EDF prepares the connection convention/contract. It contains the same elements as the PTF.

The interconnection and operation conventions, or the supply contract, specify the verifications that will be performed on the installation before its connection to the network and during the operation in order to verify that the installation complies with some requirements. In case of non-compliance that might affect the safety and quality of the network operation, the DNO (LV and MV up to 50kV) or the TSO (MV greater then 50kV and HV) may not allow the connection or disconnect the installation after notifying the user if the installation is already connected.

## *2.6 Germany*

### 2.6.1 Institutional Issues

The DKE "Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE" belongs both to the DIN (German Standardisation Institute) and the VDE (German Electronics Association). In general, this institution is responsible for electrotechnical standardisation. Two of its departments deal with issues touching the scope in question.

The VDN (German Association of Electricity Networks Operators) has among its members four operators of transmissions grids, 49 regional and 308 municipal operators of distribution grids, and five foreign grid operators. A working group of this organisation on grid coupling of DG resources composes the technical connection conditions (*"Technische Anschlussbedingungen"*) for the low and the medium voltage grid. These specifications are a recommendation to the members of the VDN concerning the connection of DG resources.

The BGFE ("Association for Mechanics and Electronics") belongs to the 35 commercial professional associations in Germany. This organisation runs the legal accident insurance and is responsible for 2.3 million insurants in approximately 99,000 companies. The BGFE is involved in all issues of electrical safety. This includes the safety of the personnel working on the grid and on domestic installations. Because of this responsibility the BGFE is involved in requirements on the safety of DG resources.

### 2.6.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

Due to the very large number of electricity network operators, the approaches to connecting distributed generation vary considerably across Germany. Under these circumstances, it is difficult to assess the transparency and impact of the interconnection procedure and to give a general statement on this question. An improvement of the current situation can be expected, however, as harmonizing the requirements for interconnection to the grid for the different energy sources is perceived as a necessity. So far, this has only been done for the lower power ranges, thanks to the work done by a photovoltaics committee. With the advent of domestic cogeneration, a joint and preferably European standardisation strategy should follow.

In July 2005, the *Energiewirtschaftsgesetz – EnWG* entered into force in summer 2005, and new rules on unbundling and grid access apply. In addition to that, the national regulator Bundesnetzagentur was officially created. The *EnWG* provides in §17 for "adequate, non-discriminatory and transparent" grid connection conditions. Moreover, the grid operators must offer conditions no less favourable than those that apply within their own or to associated companies. In §18 the federal government with the consent of the upper house is authorized to issue regulations on the "general terms and conditions for connecting to the medium- and low-voltage electricity net". Currently, such a regulation is in the legislative pipeline; adoption, however, is not expected before summer 2006.

### 2.6.3 Interconnection Procedure

For connecting to the low and medium voltage grids, the DG operator need to confirm that the design of his unit fulfils the relevant standards and complies with all guidelines. The first-time parallel operation is to be adjusted with the DNO and a certain procedure applies. During the inspection, the built system is compared with the design specifications, and the accessibility of the disconnection device is checked. Regarding metering, also the design of the metering device is to be compared with the contractual and technical instructions and (only for low voltage network connection) a start-up control of meters for supply and delivery has to be carried out.

In addition to this, an inspection of the operation of the disconnection unit has to be undertaken. It has to verify that the disconnection unit is activated by the required set points and that the disconnection times are met. If the disconnection unit is a type-tested device and a test report is available the inspection effort can be reduced.

## 2.7 Greece

### 2.7.1 Institutional Issues

The main player in the Greek energy market is the PPC, which was founded by the Greek state in 1950. The PPC owns and operates of the transmission network and the distribution network, on the mainland as well as on the islands (which are in many cases not interconnected). After enactment of Law 2244/94 that introduced a liberalisation limited to 50 MW installations (renewable and co-generation units) and Law 2773/22 for deregulation of energy market, PPC has become a corporation whose primary field of activity is the provision of energy to the commercial and industrial sectors in Greece, still supplying non eligible customers.

The regulator is the RAE (Regulatory Authority for Energy of Greece)[21], which was set up in 1999. The RAE is in charge of creating the most favourable conditions for market liberalisation and competition, and monitoring the implementation progress of renewable energy projects. Finally, the CRES (Centre for Renewable Energy Sources) shall not only promote renewable energy sources, but also rational use of energy and energy savings.

### 2.7.2 Visibility, Complexity and Impacts of the Standards on DG

The Distribution Directive 129 ("Interconnection of generating facilities to the distribution network") of December 2003 sets evaluation procedures, disturbance limits and interconnection technical requirements for connecting generating stations to the MV and LV network, up to a max capacity of 20 MW. It covers the power quality issues and the behaviour during fault conditions in the grid. The Distribution Network Operating Code (NOC) of August 2003 deals with the operation of the distribution network and the rights and obligation of the network operator and the various users (consumers and producers). Although it is a legal document, it also comprises fundamental technical requirements and constraints. The transaction principles and the obligations of all parties involved (DNO and producers) will be set forward.

One particular barrier to the development of DG in Greece is the establishment of sizing limits for non-interconnected islands. The allowable penetration of installed power capacity of some types of decentralised power stations, connected to the electricity grid of non interconnected islands, cannot exceed 30% of the peak power (MW) corresponding to their respective maximum hourly demand of the previous year.
It is also important to mention that, according to a recent Ministerial Decision[22], the connection of DG electricity stations on the mainland (up to 25 MW in power capacity) to PPC's power grid will always be done at mid-voltage, either directly to the mid-voltage grid, or through a mid-voltage/high-voltage substation, the cost of which will be borne entirely by the independent power producer. The applicable buy-back tariff for both energy and power will be based on PPC's mid-voltage, general use (B2) tariff, as set in Article 2, par. 3b of Law 2244/94. For RES power stations on the mainland, of more than 25 MW of capacity, the connection to PPC's grid will always be done at high-voltage, and the corresponding high-voltage buy-back tariff (which is lower in price than the mid-tension one) will be applied.

### 2.7.3 Interconnection Procedure

For the operator of DG units, the procedure of connecting his installation to the grid firstly includes a considerably financial contribution. The prospective producer is required to submit to the Minister of Development a letter of guarantee for about €30,000 MW installed (up to 2 MW) and about €51,500 for each additional MW. The installation license has a duration of 18 months.

Complex licensing procedures for DER-to-power projects, have been set by Ministerial Decree 2000/2002 (electricity-generation license, installation license, operation license). Moreover, MD 69269/90 (pre-sitting permit, approval of environmental terms and conditions) and Law 2941/2001 (approval of intervention on public land) constitute the single, most difficult obstacle today in the effective

[21] www.rae.gr
[22] MD 2190 of 8.2.1999

materialisation of DG investments in Greece. These procedures involve a multitude of central, regional and local authorities (departments, committees, councils, agencies, etc.), interwoven in a lengthy, bureaucratic and, at times, confusing licensing processes, that invariably take 18 to 24 months to complete. Any single DG installation license requires the official expression of (positive) opinion of more than 35 public-sector entities, at the central, regional and local level, and needs to be checked, in terms of conformity, with four national laws and seven ministerial decrees.

## *2.8 Ireland*

### 2.8.1 Institutional Issues

In Ireland, the Electricity Supply Board (ESB) currently dominates the electricity supply industry, it being a national vertically integrated utility 95% owned by the Irish government. Within ESB are a number of divisions, each of which is operated independently. One of these divisions, ESB Networks, is the authority to which all new generation plant must apply in order to obtain a connection to the Irish distribution network.

The National Standards Authority of Ireland (NSAI) is responsible for the establishment of Standards in Ireland. This work of the NSAI is carried out in the combined European standards system involving the Technical Committees of CEN and CENELEC. It is also a participant in ISO and the IEC. The Electro-Technical Council of Ireland, ETCI, is a voluntary body of organisations, sponsored by the NSAI, representing all aspects of electro-technology. The ETCI is recognised as the national electro-technical forum and the body in Ireland nominated to harmonise electrical standards under the EC "Low Voltage Directive". It is the Irish Member of the IEC and CENELEC.

For generation plants wishing to connect the distribution network, the responsibility for developing interconnection rules, technical guidance and Standards lies with ESB Networks, the Distribution Network Operator. ESB Networks is regulated by the Irish Commission for Energy Regulation (CEER).

### 2.8.2 Visibility, Complexity and Impacts of the Standards on DG

The general technical conditions for generation plant interconnection with the Irish distribution network are published free of charge in a series of documents on the ESB Networks website[23]. The Irish Distribution Code, which defines the high-level technical aspects of the relationship between the DNO and all Users of the Distribution System, is also available from the same source without charge. All of these documents have been developed to be complimentary, but the Distribution Code takes precedence in cases where there are overlaps or discrepancies.

The Distribution Code is prepared by ESB under the terms of the Electricity Regulation Act 1999[24]. The first version of the Code was approved by the Commission for Electricity Regulation (CER) in March 2000. All modifications and updates to the Code also need to be approved by CER in order to ensure that any changes are fair and comply with market regulations. The Distribution Code Review

[23] http://www.esb.ie/esbnetworks/standards_codes/downloads.jsp
[24] http://history.cer.ie/ELECTRICITY_REGULATION.pdf

Panel (DCRP), constituted to generally review and discuss the Distribution Code, is the body responsible for developing any suggested revisions and amendments to the Code. The DCRP itself was established by ESB under the terms of its Distribution System Operator licence.

The current system in Ireland gives responsibility for specifying technical requirements for interconnecting DG and RES schemes to the DNO (ESB), and these are defined in the Grid Code and associated documents referred to in that document. The CER (Regulatory body) provides independent approval for the Grid Code. The definition of technical connection requirements in Ireland is therefore considered to have a relatively high level of transparency.

### 2.8.3 Interconnection Procedure

The procedure for interconnection with the distribution system in Ireland is transparent and defined in the ESB Networks document "Guide to the Process for Connection to the Distribution System[25]", and comprises of several steps. The initial inquiry should ideally be made after having received planning permission from the local authority and should include payment for a network planning study, a site and location map, electrical single line diagrams of the proposed scheme, full details of the type of generator being connected and an approximate construction timescale. The cost of the network planning study is €500, this being refunded should the scheme be accepted.

Following the initial enquiry, ESB Networks submit a budget quotation letter to the applicant, which outlines connection options and associated estimated costs[26]. This quotation is based on the technical details of the applicant's facility provided in the application documentation, and includes a costing for the works to be undertaken by ESB Networks up to the connection point, and will be sent to the applicant within 18[27] weeks following application.

The acceptance of the budget costs by the applicant is normally required within three months of receipt of the budget quotation. This includes a signed Acceptance of Offer form, payment of a proportion of budget costs, and an agreement to transfer any substation site to ESB. All connection works being carried out by the applicant must comply with the Distribution Code (Annex 1 contains the relevant sections), and the associated guidance documentation detailed in the Appendix. These must be completed to specification prior to the commencement of ESB Connection Works on the applicant's site. The timescales for Connection Works and Final Energisation are typically 9 months and 1 month respectively.

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[25] www.esb.ie/esbnetworks/downloads/connection_process_doc_250602_ade.pdf

[26] See ELEP project report D2.1 "Distributed Generation connection charging within the European Union – review of current practices, future options and European policy recommendations" (2005)

[27] ESB "endeavour to issue the budget quotation within 8 weeks"

## 2.9 Italy

### 2.9.1 Institutional Issues

The Italian transmission networks are operated by the Independent System Operator GRTN (Gestore della Rete di Transmissione Nazionale[28]), while the distribution system is owned and operated by several local distributors. After the last changes introduced by the restructuring of the electricity sector in each area of the country only one DNO can be present operating the distribution network as an infrastructure free to be used by several different retail selling operators.

Connection rules for generators above 10 MVA define the participation of the plants to the frequency and voltage regulation. The main prescriptions are gathered in the Italian standard CEI 11-32: "Electrical energy production systems connected to III class network". Electricity can be sold through bilateral contracts between producers and free customers or through a reserved market to supply the distributors the energy they need to feed the other customers. Generators below 10MVA are subject to simplified rules. They do not have to participate in the system regulation.

The technical feasibility and the analysis of the issues related to the connection of a DG plant (voltage rise, voltage fluctuation, power quality) is practically left to the designers and to the distributors, who in some cases include general interconnection indications in their grid codes, except for the prescriptions given in some national and international standards. The Italian Electrotechnical Committee (CEI) is responsible to issue the technical standards in this field and has an active working group dedicated to the revision of this item.

The main Italian distributor, who is still the DNO in more than 80% of the Country, has then issued specifications that each plant must satisfy to be connected to its distribution grid and these internal rules became a reference to all the other smaller DNOs and for all the Operators. These specifications take into account the characteristics of the distributor own networks giving specifications for protections and their settings but leave undefined and subject to the Don's approval the possibility to connect generators bigger than 20 kWe and the total capacity which can be connected to a single branch of the distribution system.

### 2.9.2 Visibility, Complexity and Impacts of the Standards on DG

All these standards and information are not easily accessible to all the operators and are not fixed in general rules but left to a bilateral discussion between the local DNO and the small scale Producer which can be different site by site and subject to the DNO's representatives' discretionary actions. These unruled areas make the interconnection process felt as unclear and uncertain and are a real obstacle to the Distributed Generation diffusion.

The interconnection standards are issued by each local DNO but the reference is still ENEL Spa which was the past electricity monopolist. There are several different associations of power sector operators which are active in promoting discussions on the need of a clear national standard but none of them has the strength to force the issuing of a revision of the CEI standards taking into account the last technical developments in the DG technologies and fixing new interconnection rules based on

[28] www.grtn.it/grtnpubs/pubblicazioni/brochureENG.pdf

objective and clear distribution system characteristics and limits. A joint discussion table open to all the different stakeholders is not established yet even if it was announced several times by different authorities. Individual trials based on voluntary efforts seem to be inadequate to tackle this barrier.

### 2.9.3 Interconnection procedure

The operator asking for the interconnection of a new generator has to supply to the DNO all the information on the plant, on the interconnection schemes, on the protections and interconnection devices which will be used, and of the operating principles of the plant in normal and emergency operations. The DNO must check that the characteristics of the plant, jointly with the connection point and the operational procedures, are able to satisfy its own regulations and the technical and operational standards of the grid and then decide to allow or not the connection of the new generating capacity. If the preliminary checks show that, according to the DNO, the connection to an existing point does not satisfy the requirements or needs an upgrading of the network the connection is denied and the producer is asked to be charged for the investment needed for upgrading the grid.

In any case, the distributor owns and manages the connection equipments except if the line serves a single producer. In such a case the distributor may leave a portion of the interconnection under the property and responsibility of the producer. The delivery point is the point of frontier between the producer and the distributor equipments and the measuring devices must be installed in such location.

## *2.10 Luxembourg*

### 2.10.1 Institutional Issues

The Luxembourg Regulatory Authority ("*Organisme luxembourgeois de regulation"* - created on 22 March 2000) is placed under the responsibility of the Government's energy services ("*Service de l'énergie de l'Etat - SEE*"). It is involved in international and European standardisation activities. Until its creation in 2000, Luxembourg did not develop national standards, contrary to neighbouring countries and relied on the standards and technical prescriptions developed by the German VDE.

Since 2000, the ILR ("*Institut luxembourgeois de regulation*") is responsible for the regulation of the energy sector.
One of its three core missions with regards to Luxembourg's electricity market is to control the conditions for network access but it does not appear to be directly involved in the setting of technical interconnection requirements.

Neither the Law of 24 July 2000 relative to the organisation of the electricity market, nor the Grand-Ducal Regulation of 30 may 1994[29] concerning the production of electrical energy based on renewable energy sources and cogeneration deal with the issue of interconnection standards.

[29] For new renewable installations, the Grand Ducal Regulation of 1994 has been replaced with the Grand Ducal Regulation of 14 October 2005. As a result the 1994 regulation is applicable to new cogeneration plants only.

For small generation units (rated up to 1000 kVA), the distribution network operators active in the Grand-Duchy, together with the SEE, have developed specific technical prescriptions.

On August 2003, the dispositions of the "*Règlement ministeriel concernant les prescriptions de raccordement aux réseaux de distribution de l'énergie électrique B.T. au Luxembourg*" of 8 August 1989 were replaced by the "*Prescriptions de raccordement pour les installations à courant fort disposant d'une tension nominale inférieure ou égale à 1000V au Grand-Duché de Luxembourg*".

These prescriptions are to be followed together with the rules set in the Distribution Code and the requirements of the German VDEW[30].
Section 13 of the document states that:

"The developer, installer, owner of the connection and the (network) operator negotiate with the VNB (utility) the technical elements of the connection and the installation on a case-by-case basis for the following installations:

- Auto-producing installations operating in parallel to the VNB[31]'s low voltage network.
- Back-up emergency stand-alone generators for electricity supply during public network breakdowns."

For any aspect not covered by the prescriptions, Directives 89/336/CEE and 73/23/CEE apply, followed by European norms published by CENELEC, or, by default, the requirements of the German Verband der Elektrotechnik (VDE). This is especially true for installations not covered by the "*Prescriptions de raccordement (..)".*

### 2.10.2 Visibility, Complexity and Impacts of the Standards on DG

While the requirements for small generators are laid out in the prescriptions in some detail, larger decentralised units have to comply with the requirements set by the distribution network operator on a case-by-case basis. This is especially true for large wind projects.
While there is no document with the general rules for larger installations (typically connected to the 20 kV network), project developers are not without guidance as the DNOs in Luxembourg apply the German VDE norms.
Large cogeneration installations in Luxembourg are often not sized on the on-site heat load and are not connected to the grid in order to avoid having to comply with the technical connection requirements. However, cogenerators benefit from an extensive interpretation of the 1994 Regulation creating standard contracts: in order to get the premium electricity tariffs for exported CHP electricity, large cogeneration installations are composed of several small units each rated under 1.6 MWe.

### 2.10.3 Interconnection procedure

The interconnection procedure for small RES and CHP units are described in general terms in the standard contracts ("contrats-types") created by the Law of 30 may 1994.

[30] In particular the « Richtlinie für den Parallelbetrieb von Eigeberzeugungsanlangen mit dem Niederspannungsnetz des Elektrizitätsversorgungsunternehmens (EVU)".
[31] VNB : Luxembourg's distribution system operator.

There are two generic types of contracts, depending on the installed electrical capacity of the installation:

- Category I standard contracts for the connection of installations with an installed capacity of up to 500 kWe for electricity from RES and up to 150 kWe for cogeneration[32] units.

- Category II standard contracts for connection of installations with an installed capacity of 500 to 1500 kWe for electricity from RES and for cogeneration installations with an installed capacity of between 150 and 1500 kWe.

Article 3 of the standard contract deals with connection issues: the DSO is responsible for determining the technical requirements. All costs are borne by the generator (Article 3, paragraph 2), including those linked to metering (Article 6, paragraph 3).

The interconnection procedure for larger installations is not defined by any texts but follows a customary path. However, Cegedel does not give typical time lines. Upon reception of the official interconnection request, the DNO carries out a network study, usually completed within 2 months, which is followed by the work on the connection itself and finally the control and testing phase.

The new Grand Ducal Regulation adopted on 14 October 2005 states in its Article 4 that the contracts (including the contract on interconnection technical settings) between the RES plant owner and the DNO are subject to approval by the ILR.

## *2.11 Netherlands*

### 2.11.1 Institutional issues

In the Netherlands, the Hague-based DTe (Dutch Office of Energy Regulation)[33] is the main body responsible for energy supply. Its tasks are to remove barriers for an effective competition, to supervise the market liberalisation process, to ensure that customers will not experience unreasonable tariffs and conditions, to ensure the implementation of energy laws and rules, and to prepare regulations for the energy sector. The DTe is also involved in the process of licences for supplying into the public grid.

The NetCode deals with the conditions for connection, the rules for medium and long-term planning and lays down the conditions for operation.

TenneT is charged with the legal tasks for the management of the national grid as well as for maintaining the energy balance in the national electricity grid. The local energy companies are still responsible for the quality of the electricity in the distribution grid. They have the authority to impose additional quality requirements to local electricity generators.

NEN is the standardisation institute for The Netherlands. They produce standards, organise connected courses and supervise meetings. NEN has an annual turnover of

[32] Cogeneration units must operate for a minimum of 2500 hours per year and reach a minimum total efficiency of 80% to benefit from the terms of the standard contracts.
[33] http://www.nma-dte.nl/

€ 23 million and 285 employees. They are supervising the work of about 1,400 commissions with 7,000 members. For the electricity sector, NEN is issuing the standards for performance determination and safety aspects of electrical equipment, connections as well as for power quality.

### 2.11.2 Visibility, Complexity and Impacts of the Standards on DG

The starting point is that a new local electricity producer (LEP) has to learn which steps have to be taken with respect to the standards and procedures. There is no such thing as a primer that can be found on the internet or in a brochure. The best way to start is to contact an engineering bureau or an existing LEP about the steps to be taken. Finding a co-operative expert might be difficult, as has been experienced during this project. The availability of an official guide might help to remove this first barrier.

As soon as the steps are known, the project manager has to carry out a number of tasks in parallel. The municipality has to be contacted to see if the local development plan has foreseen the erection of a facility for electricity generation. If that is not the case, a procedure can be started to have the development plan changed but that might take more than a year. In addition, the municipality has to give a permit for the environmental impact. If the local air quality is at stake, special abatement measures can be prescribed or even any additional activity can be prohibited. This can also be the case for the noise limits, which might not allow the building of a wind turbine. Further, if no planning or environmental barriers exist, a building permit has to be acquired. The costs of such a permit can amount to 1% of the building costs, depending on the municipality. The duration of the procedure depends to a large extent on the nature of any objections from citizens. In case of serious objections, this might delay the procedure for at least half a year.

In parallel, the local grid operator has to be contacted for permission to feed into the grid. If the local grid can accommodate the power level, the grid operator is obliged to provide the permit. This procedure can consume up to half a year. The project manager might contact DTE in case of disagreement with the local grid operator, but normally the project manager will not notice the presence of DTE. In case of sufficient grid capacity, the LEP has to pay e.g. € 60000 to the grid operator for a 2 MW connection. The costs depend on the size of the connection. If the local grid has insufficient capacity, the LEP is responsible for the costs of any grid extensions. This might be the 400 V, the 10 kV, the 20 kV as well as the 50 kV systems including the transformers. There is no time limit for completing the procedures in this case. In practice, the LEP will not pursue his aims for connecting to the grid if the capacity is insufficient.

Another point is the contract for supplying electricity. The rules for this have also been set by DTE, but in general the LEP only has to contact a local energy service provider. Because of the open market, even a number of local energy service providers can be contacted. The energy service provider has to be the same company as the one that supplies the energy from the grid in case of failure of the LEP. Two providers for one connection would not work. In case of a natural-gas-fuelled installation, a contract has to be made with the gas supplier. If the gas supply capacity is insufficient, the costs for extending the gas grid will generally be for the LEP. The LEP can also apply for an energy savings investment bonus. SenterNovem, an agency of the Ministry of Economic Affairs, is carrying out the process.

### 2.11.3 Interconnection procedure

The physical connection between the grid and the LEP installation is the responsibility of the grid operator. The connection remains in possession of the grid operator even after the connection fee has been paid. There is a time span of 13 weeks between the moment that the agreement has been settled and the actual connection since the required components have to be bought. These components are by standard never in stock.

The part of the installation at the LEP side has to comply with the NEN rules. Normally, a certified company will install the necessary electrical equipment. An official inspector might only occasionally check the installation in case of smaller units. The installation company is fully responsible for compliance with the safety codes. The LEP owner does not notice the presence of the legislation, normally, since all the installation rules are covered in documents in possession of the official installer. The largest barriers for LEP:

- uncertainty about electricity and fuel prices,
- rapid policy changes with respect to financial support,
- no provisions for LEP in the local development plan,
- insufficient grid capacity.

## *2.12 Portugal*

### 2.12.1 Institutional Issues

Technical requirements for the connection to the electricity network of decentralised generation plants are mainly to be found in governmental decree-laws. The Instituto Portuges de Qualidade (IPQ) is Portugal's national standardisation organisation (ONN) and shares responsibility and oversight with the Portuguese electrotechnical institute (IEP), which is the sector standardisation organisation (ONS). The national electricity regulator is ERSE.

### 2.12.3 Visibility, Complexity and Impacts of the Standards and Requirements on DG

The interconnection procedure in Portugal is well mapped out and the technical standards applicable are also easily accessible to project developers. However, except for micro-sized units, the connection procedure requires many administrative steps involving the national central administration, creating an administrative burden. Furthermore, the connection capacity is only made available to DG promoters during specific and limited periods of time by the DGGE (Directorate General for Geology and Energy).[34]

The vast majority of decentralised generation plants connect to the low and medium voltage networks that are owned by EDP-Distribuiçao, the former monopoly. While the main technical requirements for the DG unit are set by decree-laws, there was much scope for negotiations between the project promoter and EDP in the past. These bilateral negotiations on network reinforcement costs did not offer many guarantees of transparent and fair treatment to the DG project developer.

[34] DGGE – Direcção Geral de Geologia e Energia (Directorate General for Geology and Energy, linked to the Ministry of Economy) www.dge.pt

### 2.12.3 Interconnection Procedure

The general administrative procedures applicable for RES and CHP power plants are defined in Decree-Law DL nº312/2001. In order to connect power plants to the grid, promoters must first introduce a Previous Information Request to the DGGE in order to determine which are the technical requirements for connection at the desired point of coupling. These requests must contain a summary of the technical specifications of the power plant and can only be sent by project promoters to the DGGE during specific periods of the year (first 2 weeks of each quarter). Furthermore, there is a limited amount of reception capacity that is globally considered for new plants in each of these periods. The Previous Information Request is then forwarded to network operators, which in turn must reply within 30 days so that the DGGE can give its answer to the promoters within 40 days after they filed their request. Whenever the Previous Information indicates technical unfeasibility due to unavailable network reception capacity, this must be technically justified in detail. Requests not met due to this reason are taken into consideration in later grid expansion planning.

After receiving the Previous Information from DGGE confirming the technical feasibility of the interconnection for the considered power plant, promoters may apply for the attribution of an interconnection point to the DGGE. This must be done within 70 days (or 12 months for the particular cases of hydroelectric and wind power plants). A bank guarantee deposit is also necessary. The DGGE has to decide whether or not to attribute the connection point to the promoter within 30 days after receiving the Interconnection Point Request. If there is no reason to refuse the request DGGE will attribute the connection point to the promoter and, if necessary, amend the predicted date for network capacity availability.

Whenever the network reception capacity is not sufficient to attend all interconnection point requests, DGGE may select part of these according to environmental, efficiency, economic and social criteria.

Electricity generators that deliver up to 150kWe to the electricity network may choose to be licensed and interconnected under the simplified legal framework created in 2002 by the Decree-Law DL nº68/2002.[35] One of the main differences between interconnection of micro-generation systems and interconnection of larger power plants is that all administrative procedures are managed by regional authorities, the DREs (Regional Directorates of the Ministry of Economy), rather than by the centralised DGGE. Another difference is that micro-generation operators deal directly with the distribution network operators whenever technical information on the interconnection point is necessary.

[35] Simplified licensing procedures have only been developed for micro-generation belonging to the commercial sector so far. For the residential sector, even more simplified rules are being drafted, but there is no confirmed deadline for their release.

## 2.13 Spain

### 2.13.1 Institutional Issues

In Spain the CNE (Comisión Nacional de la Energía – National Energy Commission) is the regulatory body for the energy systems. This organisation is in charge of drafting the electricity sector requirements, which become legislative documents after being enforced by the general courts and the regional legislative assemblies or by the government. The CNE has two consultative boards, one for electricity and other one for hydrocarbons. In the year 2001, the *permanent commission* of the electricity consultative board was created with the duties of issuing the reports asked by the consultative board, and of simplifying the work to be done by the consultative body by preparing the contents and the analysis of the issues to be studied.

While the consultative boards, where decisions are taken by a simple majority, appear to evenly balance representation of the market operators, end users and regional officials, the permanent commission is split evenly between regional representatives and market actors. The main problem of all requirements being issued as legislative documents is that the amendments must be done by means of new documents (not by new versions) so, at the end, the information is dispersed through documents with different numbers and dates. This makes difficult to find the necessary requirements, especially for persons usually not dealing with these issues.

AENOR is the national standardisation body[36]. A number of AENOR are devoted to issues affecting DG interconnection. This especially holds true of working groups AEN/CTN 207 (Electric Energy Transmission and Distribution) and AEN/CTN 217 (System Aspects for Electrical Energy Supply) which deal with power quality and grid connection issues.

### 2.13.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

It is for several reasons that interconnection requirements are perceived as preventing the deployment of distributed generation in Spain. The requirements for interconnection of DG are to be found in many different documents (most of which are legislative texts). As a result companies or individuals not accustomed to dealing with these issues are often at a loss. The requirements are often not very specific and as a result distribution network operators often apply different requirements. These can vary significantly from one DNO to another. Requirements are often perceived as going too far and as addressing worst case approaches rather than normal technical considerations.

### 2.13.3 Interconnection Procedure

The procedures regarding access and connection to the transmission and distribution grids are established in the Royal Decree 1955/2000, which regulates transport, distribution and generation activities, as well as the necessary administrative authorizations for electrical equipment. Additional dispositions for Renewable Energy Sources and CHP are laid out in the Royal Decree 2818/1998, and an entirely separate Decree (1663/2000) covers the specific case of PV connected to the low-tension grid.

[36] www.aenor.es

The detailed connection requirements are usually determined jointly between the DNO and the operator of the plant, based on the requirements and definitions of the grid code and national standards. For small generators, it is easier to find simplified practices for the assessment of the connection and standardised requirements for protection. The connection of larger units is usually assessed case by case, taking into account the network configuration at the envisaged point of coupling, capacity and technology of the plant and the operating conditions.

The producer must first send an access request to the distribution system operator (DNO) responsible for the area with all the technical information necessary for the DNO to determine whether there is sufficient available capacity for this new connection. The DNO has to give an answer within two weeks. If this connection might have an influence on the transmission network[37], the DNO forwards the access request to REE, who then must reach a decision within two months. The regulator, CNE, may settle any conflict on access rights.

Once a preliminary access point has been conceded, the producer may obtain the connection permit, which implies a more thorough examination by the DNO (and possibly the TSO) of the producer's Basic Project and Programme of Execution. Both the access and connection requests can be sent simultaneously, but the final connection permit will not be granted unless the access request has already received a favourable reply.

As soon as the connection permit is obtained, the connection contract may be signed immediately. The whole procedure is simplified in the case of PV installations connected to the low-voltage grid, and must be concluded within a month of the initial request, giving Spain one of the speediest connection processes in Europe. The law underlines the right of producers to non-discriminatory access to the grid, and draws out the general framework for connection procedures, but the connection process itself is purely a negotiation between the producer and the DNO.

## *2.14 Sweden*

### 2.13.1 Institutional Issues

The Swedish electrical grid is a part of the Nordel grid which covers the eastern part of Denmark, Sweden, Norway and Finland. The grid is divided into the Transmission grid (220 and 400 kV), the Regional grids (130, 70 and 40 kV) and the distribution grid (20, 10 and 0.4 kV). The transmission grid is owned by "Svenska Kraftnät", a state authority and also the system operator. The different regional networks are owned by several electricity companies and the distribution networks by about 170 different electricity companies, local distribution companies and municipalities. Today, the interconnection requirements are usually still determined via a joint discussion between the DNO and the operator of the plant, based on the requirements and definitions of the DNO's grid code and/or national standards.

[37] Rarely the case for DG, being generally only significant above 50 MW.

The Swedish Electrotechnical Commission (SEK)[38] handles the national and international standardization work and is member in IEC and CENELEC. However, there is today no separate technical committee for distributed generation.

The general protection is mainly controlled by Swedish law and standards, normally harmonized with EN and IEC standards. The most important one is "Starkströmsföreskrifterna", provided by the national authority "Elsäkerhetsverket". This controls how general electrical installations are to be made to ensure safety. Most of the rules are directly linked to EN and IEC standards. Another regulation to be used is the Swedish standard SS 436400 controlling electrical installations in buildings.

Svensk Energi ("Swedenergy")[39] is an industrial organization representing producers, distributors and traders in Sweden. It gives service and support to their members by distribution of information and know-how. Svensk Energi administers the AMP[40] document which contains most of the information needed for interconnection of DG up to 1.5 MW. Originally, it was written for interconnection of wind power plants, but is now to be used for all types of DG. This is the most important document for interconnection of DG units up to 1.5 MW.

### 2.14.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

For small generators, it is easier to find simplified requirements for protection. The connection of larger units is always assessed case by case, asking the DNO (TNO) to verify the network configuration and the operating conditions to allow the interconnection of new generation capacity. To simplify interconnection of DG, objective and clear regulations and standards are vital. This will also lead to accurate project cost estimations, short implementation time and safe operation for both the DG and grid owner/operator.

### 2.13.3 Interconnection Procedure

The AMP gives a detailed description of the administrative procedure including a standard form to be used for quotation inquiry. It contains as well the technical requirements and information about the underlying fundamental electrical design calculations. Also the interconnection procedure is defined in AMP. Shortly, the following procedure is to be followed when a new DG project is started

An informal dialogue with the grid owner is needed to make an initial check of the possibilities of interconnection. Then, a formal request of a quote from the grid owner is to be filed. The document to fill in is given in AMP. It is mandatory to attach documents such as test reports from the manufacturer of the DG, a full list of protections to be implemented, power quality information, reactive power compensation (if applicable), etc.

A quote is given by the grid owner. This defines the cost of the interconnection, technical requirements, proposal of a contract and the possible date of

[38] www.sekom.se
[39] www.svenskenergi.se
[40] „Anslutning av mindre produktionsanläggningar till elnätet" (Interconnection of smaller production units to the electrical network) of 2002

interconnection. A formal notification of the installation work is to be made by the installation engineer before any work can be started.

When the installation is ready for interconnection, the electrical grid owner is to be notified. Protocols showing the results of the required functional tests are to be attached together with updated schematics and descriptions. The grid owner must be invited to inspect and perform tests, for example relay protection tests, and participate in the first connection to the grid. When the grid owner has approved the connection to the grid, the generation can be started.

## *2.15 United Kingdom*

### 2.15.1 Institutional Issues

The development and maintenance of national standards in the UK is the responsibility of a number of different organisations, each having their own areas of interest. The UK Government provides a steer through the Department of Trade and Industry (DTI) and the regulator, OFGEM[41] (OFREG in Northern Ireland). Standards are produced and maintained by organisations including the British Standards Institution (BSI), the Health and Safety Executive (HSE) and, in relation to the electricity industry, the Energy Networks Association.

Licensed distribution businesses, or Distribution Network Operators (DNOs), are obliged under Condition 9 of their licences to maintain a Distribution Code detailing the technical parameters and considerations relating to connection to, and use of, their systems. All DNOs currently operate the same version of the code, and all modifications to the Code have to be approved by OFGEM.

The Distribution Code makes reference to a number of industry "Engineering Recommendations", issued and maintained by the Energy Networks Association (ENA), that provide specific guidelines for the connection of DG and RES equipment to distribution networks. ENA membership is restricted to owners and operators of energy networks in the UK[42]. The engineering recommendations therefore tend to reflect the technical requirements of the DNOs. It is the responsibility of the DCRP to determine whether these recommendations, or specific aspects of them, are incorporated into the distribution codes.

### 2.15.2 Visibility, Complexity and Impacts of the Standards and Requirements on DG

Significant progress has been made in recent years in the UK in terms of the development of interconnection standards (or more accurately, recommendations) for DG systems. As a result there are a number of reference documents now in existence within the electricity supply industry that contain detailed provisions with which DG projects are required to comply in different circumstances. The process of

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[41] The Office of Gas and Electricity Markets (OFGEM) is the regulator for Britain's gas and electricity industries. Its role is to protect and advance the interests of consumers by promoting competition where possible, and through regulation only where necessary (http://www.ofgem.gov.uk/ofgem/index.jsp)

[42] Other parties can become *Associates* of the ENA, benefiting from a number of ENA technical and engineering services

development of the Standards and Recommendations varies with the type of document being produced.

The Distribution Codes defines the technical parameters and considerations relating to connection to, and use of all of the DNOs' systems within the UK. It is maintained and revised by the Distribution Code Review Panel (DCRP). The membership of the DCRP includes DNOs, distribution network users and embedded (distributed) generators, and there are published rules and terms of reference[43] that define the remit and authority of the DCRP. Proposed revisions to the Distribution Codes are generally made available for stakeholder comment before publication, thus providing transparency within the process.

### 2.15.3 Interconnection Procedure

General guidance relating to the interconnection procedure in the UK are provided in the "Technical Guide to the Connection of Generation to the Distribution Network", issued by the UK Distributed Generation Co-ordinating Group, Technical Steering Group, February 2004.[44]

The detailed tasks involved in getting a connection vary with the size of the generator that is being developed, with larger plant generally having more complex the connection requirements. Small-scale DG schemes[45], for example, are not required to enter into detailed connection discussions with the DNO prior to commissioning their plants, although they must notify the DNO upon commissioning. This is not the case for larger installations[46], with the connection process comprising a number of key stages.[47]

The first phase is the project planning, where the developer puts together his plans for the scheme. This would normally involve the analysis of the DNOs' Long Term Development Statements[48] (LTDS). An information phase follows, where the developer submits details of the proposed generating plant to the DNO. In return the DNO is obliged to supply details of the network configuration local to the proposed connection site, along with a summary of the potential design issues and costs involved in connecting the generation at that point. Then the design phase starts: the developer submits a formal Connection Application to the DNO. From this information the DNO produces detailed connection designs and costs, and determines how much of the connection construction work could be undertaken by a Third Party, and how much the DNO must undertake itself.

During the construction phase the developer (or a contracted Third party) builds the new plant after entering into formal contracts with the DNO. Finally, there is a testing and commissioning phase, where the DNO and the developer complete the necessary Connection and Use of System Agreements, the developer tests and commissions the generator, and the DNO performs the necessary tests on the

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[43] http://www.energynetworks.org/dcode/pdfs/040801GBDCRPConstitution.pdf
[44] http://www.energynetworks.org/pdfs/FES_00318_v040211.pdf
[45] Units rated up to and including 16 A per phase at LV (400 V / 230 V)
[46] Units > 16 A per phase, and =< 50 MW
[47] Details of the steps involved can be found in sections 2.2.3 - 2.2.19 of "Technical Guide to the Connection of Generation to the Distribution Network".
[48] Annual statements from DNOs containing technical information about their distribution networks, particularly of interest to new generators and demand customers evaluating connection opportunities.

connection and energises it thereby connecting the generator to the distribution network.

For completion, the interconnection process for generation plant over 50 MW in size is the same as that described above for units > 16 A per phase, and =< 50 MW in terms of the interactions required between the developer and the DNO. However, the developer is also likely to be involved in a number of other processes that reflect the increased complexity of its involvement in the UK electricity market. In this case the main additional issues involved are the possible need for a Generation Licence, the possible need to become a party to the Balancing and Settlement Code[49] (BSC), and the need to become a party to the Connection and Use of System Code[38] (CUSC) if the generator is deemed to be using the National Grid transmission network.

[49] Details can be found via http://www.ofgem.gov.uk/

# Chapter 3: Areas of commonality and inconsistency

## *3.1 Standard setting in the EU-15*

The institutional issues surrounding interconnection procedures and requirements in the EU-15 Member States present a very diverse picture. There are only a limited number of types of organisation with the responsibility for preparing, drafting and creating technical standards and rules. These can either be national Parliaments, the ministry overseeing energy, national standardisation bodies, network associations, or finally network operator companies themselves.

European Member States do not share a common division of responsibilities between these different types of organisations, nor do they rely on all of these types of organisations to create the technical framework for interconnection. Rather, each Member State relies on a unique selection of actors to set the rules applicable to the connection of DG to the electricity grids. This in turn has influence on the set of technical requirements, as some institutional arrangements provide increased independence.

### 3.1.1 The role played by national standardisation organisations

It clearly emerges from the analysis of D1.1 that the role played by the national standardisation organisations varies significantly from country to country. In a majority of Member States, the national standardisation organisations do not play the leading role in developing the technical rules for DG and RES interconnection. This is especially true of **Austria**, the **United Kingdom**, **France**, and **Spain**.

It should be noted that in some of the countries reviewed, such as **France**, there are no specific national standards applicable to the interconnection of DG units to the electricity network differing from the international set of standards prepared by the IEC and CENELEC[50]. Direct reference to IEC and CENELEC standards is commonplace in Member States, as is the case in **Italy**.

### 3.1.2 Complexity of the standards and rules creation process

Given the limited role standardisation bodies have in setting the rules ultimately applicable to interconnection, Member States have in many cases opted for a system in which the rules are created by national electrotechnical or network associations. Thus in many cases the standards prepared by the national standardisation body –if any-, although applicable to the interconnection of DG, give way to the implementation of network or electrotechnical association requirements, as is the case in **Germany**, **Austria** and **Ireland** or DNO requirements as in **Italy**, while in **Belgium** the electricity producers' recommendations are applicable.

An alternative solution found in a number of Member States is for the technical requirements to be incorporated in direct or indirect legislation, as is the case in **Spain** (but are drafted by the regulator) and **Portugal**, but also to some degree in **France** (DNO requirements and ministerial decrees) and **Belgium** (electricity producers' recommendations and regional legislation).

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[50] Respectively the international electrotechnical standards organisation and the European electrotechnical standards organisation.

In many countries the system is made even more complex by the interrelations between the different organisations involved. Thus in **Austria** the technical regulations are prepared by the electricity network association but are then incorporated in the grid code which is the responsibility of the energy regulator. Exactly the same situation prevails in the **UK**. **Belgium**, due to its federal structure, offers three different legal frameworks for interconnection rules and procedures. However, the complexity of the system is tempered by the use throughout the country of the same electricity producers' recommendations.

### 3.1.3 Independence of drafting parties

The independence of the parties drafting the interconnection rules and requirements has proven extremely difficult to assess, with the exception of the Member States in which network associations lead the drafting process. In most of the countries where the responsibility lies outside the network associations, the composition of the technical committees drafting new rules is not publicly available. At best, a breakdown between representatives of utilities, electrotechnical research institutions, consumers and, in the case of **Spain**, regional authorities is given. In the case of **France**, the structure of the standardisation bodies is given in detail, but the sheer complexity of the institutional architecture makes it difficult to assess the independence of the experts from the dominant network operator.

Increases in the share of electricity production from decentralised generators have an impact on network management and accommodating DG requires DNOs to adopt novel approaches, something they overall are reluctant to do. While in a countries like the **Netherlands** and the **United Kingdom,** in which utilities were incentivised to operate and hence accommodate large shares of decentralised generation, the fact that the network associations or even the DNOs themselves are the organisations responsible for creating the technical rules generators must abide to in most countries is problematic. **Germany** is an example of this unfortunate situation, with the VDN, the network operators' association, drafting the generic technical regulations.

For a country such as **Ireland**, dominated by the vertically integrated utility ESB and with very little decentralised generation, the fact that the national energy regulator must approve any changes to the grid code is not necessarily a sufficient safeguard given that the revisions are suggested by DCRP, itself a direct emanation of the dominant utility. The **UK**, despite having a similar approach to that of **Ireland,** relies on a diversified group (the DCRP) to propose revisions of the grid code to the regulator.

The responsibility for drafting technical requirements most often still lies with the historical monopoly or dominant market players. This helps explain why in **Belgium** the electricity producers (including Electrabel) and not the myriad of network operators set the rules.

In **Italy**, our study has shown that the DNO has the last say in deciding on the connection of generators rated over 20 MWe and also determines the level of total capacity which can be connected to a single branch of the distribution system. In this case there clearly is a need for a transparent methodology that would dissipate any risk of abuse of dominant power.

### 3.1.4 Evolution of the interconnection rules

The technical rules applicable for the interconnection of RES and DG schemes have evolved since the mid-1990s throughout the EU Member States, perhaps with the exception of **Italy**, where RES and DG promoters have to comply with an old standard dating back several years. This evolution in the technical requirements is for a large part due to the increasing interest in RES and DG from policy makers but also from large electricity producers and network operators who since market liberalisation and activity unbundling now value DG's contribution to network stability. However, the evolution in the rules applicable also stems from the advances made in the field of network management and RES and DG unit technical specifications. This is the rationale behind the decision of authorities in **Ireland** to review the guide to interconnection procedure every three years.

**Table 3** Key organisations involved in the setting of rules[51]

| Type of organisation | Drafting role | Effective responsibility |
|---|---|---|
| National standardisation organisation | I (CEI) | I |
| Network operators association | UK; D; A | |
| Electrotechnical association or research organisation | DK | (DK) |
| Electricity producers association | B | B |
| Regulator | S | A; UK; IR (approval) |
| Ministry | F; P; (D soon) | P; B; S; P; F |
| DNO/company | I; IR; DK; GR; F | I; DK; GR; IR |

## *3.2 Administrative burden for decentralised electricity generators*

The activities carried out under ELEP Work Package 1 have been an opportunity to bring the administrative steps and procedures RES and DG project developers need to follow and comply with under scrutiny. Although administrative issues can be distinguished from the technical requirements themselves, an assessment of the rules (or indeed absence of rules) applying to the interconnection application and process itself was deemed to be of high significance, especially considering that RES and DG schemes also concern households and small businesses without prior experience in the field of interconnection. Also, long timelines and delays can be decisive factors in preventing the further investigation of on-site generation as an option.

Several key items are covered in this section namely, the availability and accessibility of standards and technical requirements; interconnection procedures; bilateral negotiations; licensing procedures and finally inspection and testing.

[51] This table acknowledges the possibility of two organisations enjoying responsibility for the technical rules.

### 3.2.1 Availability and accessibility of standards and technical requirements

The availability and accessibility of standards and technical requirements vary from country to country. Standards and technical requirements lie with a variety of organisations and in many cases project developers need to contact several organisations before they can have a clear overview of the technical rules their installation has to conform to.

In most countries the technical standards for interconnection can be downloaded from the standardisation organisation's website for a fee, as is the case in the **Netherlands**. More problematic is the situation where the complete set of standards and requirements applicable are dispersed and cannot be found and downloaded from a central or unique website. In **Ireland** however, the general technical conditions for connection to the network are available free of charge (as is the case in **Belgium**) on the DNO Website and all documents have been developed so as to be complementary. Another innovative practice from **Ireland** is the review of the interconnection procedure guide every three years. This contrasts sharply with the situation in **Italy** where rules are not easily accessible and DNOs rely on an outdated standard that does not fix specific parameter values to force DG promoters into bilateral negotiations, eventually imposing the set of specifications from the dominant DNO (ENEL Spa).

Technical requirements in **Spain**, where standards become legislation, are often problematic to clearly grasp, as any needed revision of the requirements results in the issuance of a new piece of legislation, thereby multiplying the number of sources of the technical regulations framework. In addition, it should be noted that non-specific requirements cause more uncertainty and difficulties in implementation than anything else. The issue of conflicting technical requirements is among those that need to be addressed urgently by national regulators, in cooperation with national standardisation bodies. Conflicting requirements create situations with high elements of uncertainty and usually are detrimental to DG project developers.

The administrative burden for the interconnection of DG plants to the electricity network can be partially relieved through the publication of standard interconnection contracts as in **France**, together with an interconnection guide document. This is especially welcome when the bulk of the rules are in hard to find governmental decrees and ministerial orders. It should be kept in mind that DG project developers are not legal experts and should not have to develop a special set of skills to simply get acquainted with the technical rules and regulations in force. Countries like **Germany**, **Ireland** and the **Netherlands** favour a multi-layer approach to the organisation of the set of standards and requirements, with the Network codes playing a central role.

### 3.2.2 Interconnection procedures

Interconnection procedures also present many differences according to the Member State. Interconnection procedures can be either detailed in legislation, in ministerial orders, in grid codes, set by the utilities association or simply be determined by the DNO itself. As with technical standards and requirements, an overview of EU Member States shows that all solutions are to be found with no single approach being predominantly accepted.

A few Member States have well defined interconnection procedures, as is the case in **Belgium, Spain** and **France**, but also **Portugal** and **Ireland**, where the procedure lays down typical timelines, something also found in **France** but made far less precise in the latter Member State due to the use of a waiting list system.

The need for streamlined procedures in each countries is particularly apparent in countries with a great number of DNOs since different interconnection procedures for each DNO can make this step very time and resource consuming for DG project developers, without necessarily bringing any additional benefits to the network operators themselves.

In some Member States, there are technology-specific and/or size-specific interconnection procedures. These simplified solutions typically concern photovoltaic units as is the case in **Spain** and **France**, but also micro and small-scale decentralised generation units, irrespective of the technology as in **Portugal** and the **United Kingdom**.

In a second group of Member States there are no defined interconnection procedures and hence RES and DG project developers have to follow the steps laid down by their DNO. **Austria** appears to be a Member State where the absence of a detailed interconnection procedure is causing problems. The absence of relevant information on this topic added to the lack of transparency of a procedure essentially left to the *bon-vouloir* of the 133 DNOs active in the country help create a sub-optimal situation, especially for the smaller generators. This is also true of **Germany**, where a similar situation prevails.

### 3.2.3 Interconnection guides

Interconnection guides offer many safeguards to the RES or DG project developer, especially for those with little or no prior experience in the field, and simplify this otherwise complex task.

The **United Kingdom** issued a 2004 interconnection guide that can be downloaded for free, while **Ireland** has adopted a similar approach and published a guide that will undergo revisions every three years to accommodate the most recent technical advances in the field of decentralised generation and network management.

In **Portugal**, the General Directorate for Energy has issued in 2003 a specific guide detailing the procedures applicable to microgenerators and also issued one for independent power producers dating back to 1994. In **France** the standardisation body, which is also the national electrotechnical organisation, issued a practical guide to interconnection in 2005.

### 3.2.4 Bilateral negotiations

Bilateral negotiations can cover a number of issues, ranging from technical requirements to the interconnection procedure itself onto the repartition of connection costs[52] between the RES and DG project developer and the DNO. In many Member States a project developer wishing to connect an RES or DG unit to the electricity network has to go into bilateral negotiations with the Distribution Network Operator. This is especially true in **Austria**, **Italy** and **Germany**, and to a varying degree in all other Member States, with the exceptions of **Belgium** (where the

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[52] This specific topic is addressed in Deliverable Report D2.1 Connection Charging.

comprehensive regulations leave virtually no room for negotiations), **France** (where the interconnection procedure is well mapped-out, despite being complex and uncertain) and of the **UK** in the case of microgenerators.

Bilateral negotiations can be provided for explicitly by the regulatory framework but in most cases arise from the silence of the texts detailing the technical and interconnection rules and procedures. Bilateral negotiations thus appear as a default solution and the trend in member States is to their gradual phasing out, as regulations are reviewed and new standards adopted.

The argument according to which direct negotiations offer optimal tailored solutions contradicts the aggregated results of the many case studies and examples collected in other European projects such as Sustelnet[53] and DG-GRID. The asymmetry in market power in favour of the DNO can be a great disincentive to the deployment of RES and DG in Europe. Even though national regulators have the powers to intervene in case of abuses, the uncertainty surrounding the outcome(s) of direct negotiations are powerful brakes to new RES and DG projects.

### 3.2.5 Licensing procedures

Complex licensing procedures as in **Greece** are a significant barrier to the greater deployment of DG, especially since the more authorities are involved the greater the chances that there are delays. Coupled with maximum penetration thresholds as in the case of non-interconnected Greek islands, this results in a stalemate, with no new DG schemes coming online.

### 3.2.6 Inspection and testing of installations

Of lesser importance, rules concerning the commissioning phase and the final inspection and testing of the installation by the DNO are also highly country-specific, if not network operator–specific. In **Germany**, this phase can be lengthy and costly, while in **Portugal** both the DNO and the licensing authority inspect the unit prior to entry into operation.

While in **Belgium** this phase is detailed in regional legislation, in **France** it is found in the interconnection convention or in the supply contract.
**Ireland** offers a nation-wide framework for the inspection and testing of installations, with the award of an 'Electrical Completion Certificate' opening the way to final commissioning tests.

**Table 4** Interconnection procedures

| **Item** | **Member States** |
|---|---|
| Detailed procedures | |
| Yes | B; S; F; P; IR; UK; GR; DK |
| No | A; D; I |
| Interconnection guide | |
| Yes | UK; IR; P; F |
| No | |
| Extensive bilateral negotiations | |
| Yes | I; A; D |
| No | B; F |

[53] Sustelnet project – Effective participation of distributed generation in liberalised electricity markets. http://www.electricitymarkets.info/sustelnet/index.html

## *3.3 The regulatory and technical framework for the connection*

Regulations and requirements can be either general, network specific, size specific, technology specific or a combination of any of the above. A cursory assessment of the practices in each Member State shows that all approaches are currently in use in the European Union and that each Member State has its own unique framework, with little or no consistency across the board. Although no feature appears to be found in every Member State, it is possible to divide those countries sharing some core framework elements into sub-groups.

### 3.3.1 The different approaches

The most common approach in the technical settings in Member States is the existence of distinctive sets of rules for synchronous and asynchronous generators.

Some Member States have technology-specific sets of technical rules. Intermittent sources of energy often have specific sets of technical rules, while this is nearly never the case for combustion technologies such as CHP, with the notable exception of **Denmark**.

Photovoltaic (PV) generators stand out as being the most often governed by specific sets of technical rules, with wind conversion technology coming second. PV generators have their own technical requirements in **France**, **Germany**, **Austria, Italy** and **Spain**.

Size specific sets of technical requirements can be found in **France**, **Spain**, **Italy**, **Greece**, the **Netherlands, Denmark** and the **UK**. A distinction is made in the **Netherlands**, the **UK** and **France** between microgeneration units in the kilowatt range and larger units that in most cases fall under the general set of requirements, while in **Italy**, **Spain, Denmark** and **Greece** the operational distinction is much higher, in the MW range.

Network specific sets of technical rules have in most cases been designed to cover the connection of plants to the low voltage networks, although some countries such as **Germany** have issued rules for each network level. Network-specific technical rules can also be found in **France, Germany, Ireland,** the **UK** and in **Denmark** (for LV and MV networks). In some cases, plant size is used to determine at which level of the network the DG unit is required to connect, which in turn carries specific technical rules. **Greece** provides an example in that all DG units rated under 25 MWe are required to connect to the medium voltage, while units rated above 25 MWe must connect to the high voltage network. In the **UK**, different rules apply if generators are connected at below or above 20 kV or have a rated output below or above 5MWe.

**Table 5** Approaches to technical requirements

| **Approach** | **Member States** |
|---|---|
| Generic | P |
| Technology-specific | DK; F; D; A; S |
| Size-specific | F; S; I; GR; NL; UK |
| Network-specific | F; GR; UK |

## 3.3.2 Power quality parameters

**Power Quality**
Power quality disturbances generally are classified into broad categories of voltage and frequency variations.

**Voltage Problems**
Voltage events are variations of voltage amplitude and occur at or near power line frequencies of 50 hertz. There are concerns and limitations about the amplitude of the variations from the nominal values and about their dynamics and frequency of occurrence. Among the types of voltage events are the following:

**Sags** are short-term cases of undervoltage in which the voltage fluctuation exceeds the allowable threshold for at least one cycle. Sags commonly are caused when heavy loads, such as motors, are switched onto the line, drawing heavy in rush currents that drop the voltage for short periods. Sags of sufficient magnitude can cause serious impacts to sensitive electronic equipment. When fluctuations of the nominal voltage $U_n$ occur over an appreciable time interval, they are known as undervoltage conditions.

**Surges (or swells)** are the opposite of sags, often resulting from the disconnection of heavy loads from the line. A surge is a transient wave of current, potential or power in an electric circuit. Also known as a swell, a surge of sufficient magnitude can have substantial effects on the power system, particularly electronic equipment. A variation of a surge is known as an overvoltage condition, which occurs when fluctuations of the nominal voltage $U_n$ occur over a long period of time.

**Voltage Variations (or Transients)** are faults which cause the voltage of the power supply to go outside normal limits for a period of time. Many transients are capable of causing immediate equipment failures. But, most of the time they cause minor damage to semiconductors, degrading their performance. This damage is cumulative and eventually reaches a point where sudden and complete failure of the component results. Particular attention is given to transient phenomena which are very fast and not detectable with normal protection devices and which can be very frequent and very dangerous for both the distribution network and the final power user.

**Parameter: Over Voltage**
Over Voltage can be defined as an abnormally high voltage condition lasting for some time which can be caused by circuit overloads, poor voltage regulation or intentional change in voltage by the utility. Over Voltage is a controlled setting combination of positive deviation from the Nominal Voltage Value and time duration. Sometimes these combinations are different according to generator size or to the technology used. To make a comparison among the data collected for the different Countries, a conservative method was adopted trying to highlight the worst possible combination which means the maximum deviation from the Nominal Voltage Value occurring for the maximum allowed time.

**Table 6** Technical requirements – over voltages

| | AT | BE | DK | FI | FR | GE | GR | IR | IT | LX | NL | PT | SP | SW | UK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max trip setting (%) | 30 | 6 | 6 | NA | 15 | 15 | NA | 10 | 20 | NA | 10 | 15 | 10 | 6 | 10 |
| Max clear. Time (s) | 5 | 0,12 | 60 | NA | 0,12 | 0,2 | NA | 0,5 | 0,1 | NA | 2 | 0,1 | NA | 60 | 0,5 |
| Worst combination | 1,5 | 0,0072 | 63,6 | NA | 0,018 | 0,03 | NA | 0,05 | 0,02 | NA | 0,2 | 0,015 | NA | 3,6 | 0,05 |
| Delta to mean value % | - 76 | - 99,9 | + 909 | - | - 99,7 | - 99,5 | - | - 99,2 | - 99,7 | - | - 96,8 | - 99,8 | - | 0 | - 99,2 |

The results show a very wide range of variability which can only in part be explained by the different possible grid conditions.

**Parameter: Under Voltage**

Under Voltage can be defined as an abnormally low voltage condition lasting for some time which can be caused by circuit overloads, poor voltage regulation or intentional change in voltage by the utility. Under Voltage is a controlled setting combination of negative deviation from the Nominal Voltage Value and time duration. Sometimes these combinations are different according to generator size or to the technology used. To make a comparison among the data collected for the different Countries, a conservative method was adopted trying to highlight the worst possible combination which means the maximum deviation from the Nominal Voltage Value occurring for the maximum allowed time.

**Table 7** Technical requirements – under voltages

| | AT | BE | DK | FI | FR | GE | GR | IR | IT | LX | NL | PT | SP | SW | UK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max trip setting (%) | 30 | 20 | 10 | NA | 15 | 20 | NA | 20 | 20 | NA | 10 | 15 | 15 | 10 | 10 |
| Max clear. Time (s) | 5 | 1,5 | 10 | NA | 0,12 | 0,2 | NA | 1 | 0,2 | NA | 2 | 0,1 | NA | 60 | 0,5 |
| Worst combination | 1,5 | 0,3 | 1 | NA | 0,018 | 0,04 | NA | 0,2 | 0,04 | NA | 0,2 | 0,015 | NA | 6 | 0,05 |
| Delta to mean value % | + 76,5 | - 64,7 | + 17,6 | - | - 97,9 | - 95,3 | - | - 76,5 | - 95,3 | | - 76,5 | - 95,3 | | + 605 | - 94,1 |

The results show a very wide range of variability which can only in part be explained by the different possible grid conditions.

**Parameter: Voltage Variations**

Like the previous ones, Voltage variations can be defined as an abnormally voltage conditions lasting for some time characterised by a very fast transient dynamic. They are monitored and controlled setting combinations of deviations from the Nominal Voltage Value and time duration including in some cases a frequency of occurrence limit. Sometimes these combinations are different according to generator size, to the grid characteristics or to the technology used. To make a comparison among the data collected for the different Countries was almost impossible since the indications collected are not homogeneous and can not be compared. This situation underlines a real need to define common limits and technical standards.

**Frequency Problems**

Frequency problems are connected to the deviation of the power system fundamental frequency from its specified nominal value. Frequency values significantly higher than the nominal frequency line of 50 hertz cause problems regarding maximum voltage level, energy content, rise time, phase angle and frequency of occurrence. Frequency events occur in several distinct varieties:

- A **unidirectional impulse** is a high frequency, transient wave of current, voltage or power of unidirectional polarity.
- An **oscillatory impulse** has both positive and negative polarity and poses two problems: first is the impulse with its associated rise time and peak voltage amplitude; second is the secondary frequency of the decaying waveform
- A **repetitive event** is a series of events that occur at regular intervals. These can be unidirectional, oscillatory or a combination.

**Parameter: Over Frequency**

Over Frequency can be defined as an abnormally high frequency condition lasting for some time. Over Frequency is a controlled setting combination of positive deviation from the Nominal Frequency Value and time duration. Sometimes these combinations are different according to generator size or to the technology used. To make a comparison among the data collected for the different Countries, a conservative method was adopted trying to highlight the worst possible combination which means the maximum deviation from the Nominal Frequency Value occurring for the maximum allowed time.

**Table 8** Technical requirements – over frequency

| | AT | BE | DK | FI | FR | GE | GR | IR | IT | LX | NL | PT | SP | SW | UK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max trip setting (%) | 6 | 1 | 6 | NA | 2 | 2 | NA | 1 | 2 | NA | 4 | 5 | 2 | 2 | 2 |
| Max clear. Time (s) | 0,1 | 0,1 | 0,3 | NA | 0,1 | 0,2 | NA | 0,5 | 0,1 | NA | 2 | 0,2 | 0,1 | 0,5 | 0,5 |
| Worst combination | 0,006 | 0,001 | 0,018 | NA | 0,002 | 0,004 | NA | 0,005 | 0,002 | NA | 0,08 | 0,01 | 0,002 | 0,01 | 0,01 |
| Delta to mean value % | - 52 | - 92 | + 44 | - | - 84 | - 68 | - | - 60 | - 84 | - | + 540 | - 20 | - 84 | - 20 | - 20 |

Like for voltage problems, the results show a range of variability which can only in part be explained by the different possible grid conditions

**Parameter: Under Frequency**

Under Frequency can be defined as an abnormally low frequency condition lasting for some time. Under Frequency is a controlled setting combination of negative deviation from the Nominal Frequency Value and time duration. Sometimes these combinations are different according to generator size or to the technology used. To make a comparison among the data collected for the different Countries, a conservative method was adopted trying to highlight the worst possible combination which means the maximum deviation from the Nominal Frequency Value occurring for the maximum allowed time.

**Table 9** Technical requirements – under frequency

| | AT | BE | DK | FI | FR | GE | GR | IR | IT | LX | NL | PT | SP | SW | UK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max trip setting (%) | 6 | 1 | 6 | NA | 5 | 6 | NA | 4 | 2 | NA | 4 | 5 | 2 | 4 | 6 |
| Max clear. Time (s) | 0,1 | 0,1 | 0,3 | NA | 0,1 | 0,2 | NA | 0,5 | 0,1 | NA | 2 | 0,2 | 0,1 | 0,5 | 0,5 |
| Worst combination | 0,006 | 0,001 | 0,018 | NA | 0,005 | 0,012 | NA | 0,02 | 0,002 | NA | 0,08 | 0,01 | 0,002 | 0,02 | 0,03 |
| Delta to mean value % | - 65,1 | - 94,2 | + 4,6 | - | - 70,9 | - 30 | - | + 16,3 | - 88,4 | - | + 365 | - 41,9 | - 88,4 | + 16,3 | + 74,4 |

Like for voltage problems, the results show a range of variability which can only in part be explained by the different possible grid conditions

**Conclusions**
The wide range of values founded in the Voltage and Frequency limitations existing in the analysed Countries clearly show the need of a common standard definition based mainly on technical parameters. Today what is a potential danger in a Country can be a normal operating condition in another Country. This create a big damage to the DG industry development since to be conservative and able to be installed in all the different EU Countries a DG generator must be compliant with the narrower limits becoming oversized, and over expensive, for most of its possible applications. This common standard should be based on reasonable technical parameter coming from the very wide field experience present in all the EU Countries and starting from the perspective that the common goal is a reliable and safe common power supply network which has to integrate also DG generators of different sizes and technologies giving their contribution in improving the entire system.

## 3.3.3 Safety issues

Safety is one of the main topics of the power network operators. Safety conditions have to be guaranteed to the final users, to the network operators' personnel always and in every condition taking care of all the possible implications of poor safety control system. The main concern is linked to islanding prevention which has the highest potential to become uncontrollable if not properly regulated and managed. Since safety schemes are in any case not perfect and their further improvement may impose financial or performance costs, it is necessary to understand the actual probability that a hazard will occur and what risks this event will present to human safety and to the electrical network. This allows the benefits of further risk reduction from better safety schemes to be balanced against the costs imposed by these schemes. If a simple and low cost safety scheme reduces risk to a level below other electrical risks that are currently considered acceptable, it is debatable whether another scheme with better detection performance, but higher costs (in financial or performance terms), is necessary.

**Outages and line interruptions**
They occur when the voltage drops to a level at which devices cannot perform their intended function. Short-term outages often are caused by events such as a utility breaker tripping to clear a fault and then re-closing automatically, while long-term outages typically result from accidents to power lines or utility transformer failure.

**Neutral-to-Ground voltage**
This concern is inherent in an electrical distribution system, and equipment manufacturers sometimes specify acceptable limits for neutral-to-ground voltage. A high neutral-to-ground voltage value represents a safety hazard and diverts part of the return current flow through the grounding conductor.

**LoM detection/islanding prevention**
Anti-islanding capability is an important requirement for distributed generators. It refers to the capability of a distributed generator to detect if it operates in an islanded system and to disconnect itself from the system in a timely manner. Islanding occurs when a portion of the distribution system becomes electrically isolated from the remainder of the power system, yet continues to be energized by distributed generators. Failure to trip islanded generators can lead to a number of problems for the generator and the connected loads. The current industry practice is to disconnect all distributed generators immediately after the occurrence of islands.

The island mode is an unregulated power system. Its behaviour is unpredictable due to the power mismatch between the load and generation and the lack of voltage and frequency control.  The main concerns associated with such islanded systems are:

- The voltage and frequency provided to the customers in the islanded system can vary significantly if the distributed generators do not provide regulation of voltage and frequency and do not have protective relaying to limit voltage and frequency excursions, since the supply utility is no longer controlling the voltage and frequency, creating the possibility of damage to customer equipment in a situation over which the utility has no control.
- Islanding may create a hazard for utility line-workers or the public by causing a line to remain energized that may be assumed to be disconnected from all energy sources.
- The distributed generators in the island could be damaged when the island is reconnected to the supply system. This is because the generators are likely not in synchronism with the system at the instant of reconnection. Such out-of-phase reclosing can inject a large current to the generators. It may also result in re-tripping in the supply system.
- Islanding may interfere with the manual or automatic restoration of normal service for the neighbouring customers.

The current industry practice is to disconnect all DGs immediately so that the entire feeder becomes de-energized. It prevents equipment damage and eliminates safety hazards. To achieve this goal, each DG must have the capability to detect islanding conditions and to automatically disconnect itself from the system. All anti-islanding schemes have some limitations, which may include:

- high implementation cost;
- need for coordination between the DG operator and the utility;
- susceptibility to false detection of islanding (nuisance tripping);
- possible non-detection of islanding under some conditions;
- possible reduction of utility power quality and voltage and frequency stability

All major islanding detection techniques can be broadly classified into two types according to their working principles. The first type consists of communication-based schemes and the second type consists of local detection schemes. The communication-based schemes use telecommunication means to alert and trip DGs when islands are formed. Their performance is independent of the type of distributed generators involved. The second type, which is the most common one, is local detection schemes that rely on the voltage and current signals available at the DG site. An islanding condition is detected if indices derived from the signals exceed certain thresholds (voltage, frequency, impedance).

It is almost impossible to try to compare limits existing in the different EU countries since they are normally imposed by each local DNO and may be different for applications and technology used.

Anti-islanding protection can be seen as the single largest technical barrier for DG interconnection in power distribution systems at present. The high cost associated with anti-islanding protection can have a deep impact on DG proposals making them unattractive.

**Conclusions**

There is a clear need to define a common strategy to deal with the interconnection barriers trying to identify low cost solutions for the DG industry. Coming to safety, there is a need to develop an "EU Guide for Safe Installation of Distributed Generators". The guide would focus on the subject of how to apply available anti-islanding technologies to existing systems and different technologies. The guide should include also rules for protection device suppliers for marking and verification of product performance and compliance to electrical codes. The guide should cover, among the others, the following points:

- Probability and risk associated with the formation of DG islands;
- Performance characteristics of commercially available anti-islanding devices;
- The characteristics of the distribution networks that have any impacts on the performance of anti-islanding protection schemes, their definitions and the allowed limits;
- Case studies, experiences and application examples;
- Methods and procedures to evaluate and select proper anti-islanding schemes
- Test methods for performance verification.

A second strategy could be to evaluate potential benefits to the existing networks linked to DG integration and to investigate if changes can be made to the existing distribution systems to reduce the existing barriers for anti-islanding protection. This proactive approach of making distribution systems work in harmony with distributed generators can be very effective also to lower the cost of anti-islanding protection. It is also visionary in the sense that this could be one of the first steps to create "DG-friendly" or “DG-improved” distribution systems. This strategy will promote a change on the perspectives of DG interconnection overcoming the current distribution system constraints to accept distributed generators. The various DG interconnection standards developed so far are focused on such constraints. Their goal is to make the DGs work in harmony with the existing systems but this is in facts a complete passive approach to the DG opportunity and it is time to deal with the constraints from an alternative and proactive perspective. This perspective is to create distribution systems that embrace distributed generators and work in harmony with them.

# Chapter 4: First conclusions

## *4.1 A mid-term assessment*

This document represents the outcome of the research activities carried out by a small team comprising of three manufacturers of decentralised power generators (Rolls-Royce, Turbec, Wärtsilä), a services provider (CESI) and a trade association (COGEN Europe) in the second half of the year 2005. The study is focussed on the EU-15 countries and explores the level of complexity, potential users of decentralised power solutions face when they clarify technical requirements with the local distribution network operator.

One key element of the study is to assess the level of diversity between EU Member States in terms of regulatory action, transparency and duration of the connection procedure. Another, highly technical, aspect concerns the differences between technical parameters that need to be fulfilled for the connection to the power grid. In order to display the information of each of the EU-15 Member States in a manner that allows for better comparison, the structure of each country analysis follows a rigid pattern. This analytical approach necessarily leads to the impression of uniformity. Reality, however, is even more complex than can be shown in a study of this size. Notwithstanding, the chosen approach serves its purpose. On the one hand it allows for the identification of barriers to the wider use of decentralised power supply. On the other hand, best practices among the EU-15 Member States become more visible.

## *4.2 Best practices identified in the EU-15 review*

### 4.2.1 Rules setting

Given the diverse picture offered by EU member States for standard and rules setting, it is difficult to give precedence to one institutional architecture over another. However, different Member States offer different elements of best practice that can then be collated to form a coherent corpus of best practices. While network operators have the required expertise to prepare technical rules, their legitimacy to do so without the participation of generators is questionable.

The responsibility for drafting the technical rules applicable should lie with the national electrotechnical association, under a clear mandate by the national standardisation authority and with guarantees as to the diversity of participants or should lie with the regulator itself.

The **UK** ensures the revisions to the distribution code are prepared by a diversified group: this is clearly a best practice. The clear interrelations between the different parties involved in the process and the ultimate responsibility of the regulator also appear to be best practices.

### 4.2.2 Administrative and procedure issues

The easy and free access to all relevant rules and requirements exists in only a handful of Member States. **Ireland** and **Belgium** both offer sound approaches, with all rules relevant free of charge. However, these cannot be found n a single centralised website.

Consistency of interconnection requirements is also a key issue but only **Ireland** appears to have developed a thorough and complementary approach to interconnection technical requirements and even for Ireland the case for conflicting requirements has been envisaged, with the distribution code superseding any other rule. The publication and regular revision of the interconnection guide in **Ireland** is also a best practice.

Several countries have developed detailed interconnection procedures that prevent DNOs from entering in direct bilateral negotiations with the RES or DG project developer. **Belgium** is a good example and **Ireland** offers typical timelines, while **Portugal** also offers a best practice in that it simplifies the procedure for the smaller units. The **UK**, however, is the Member States that offers the simplest interconnection procedure for microgenerators, as they only have to inform the DNO that they have connected a unit.

### 4.2.3 Approaches to the regulatory and technical framework for connection

No one approach appears to be better than another, with each one having its inherent benefits. Size-specific sets of technical requirements are the most commonplace and the distinction between requirements for microgenerators and those for larger units are the only approaches that stand out as best practices.

The **UK** approach to the connection of larger units is worthy of notice as the recommendations take into consideration both the network connection level and the rated output of the unit and do not assign a particular voltage level to a plant with a given output.

## *4.3 Next steps*

This preliminary assessment of interconnection standards, rules, and procedures in EU-15 Member States has underlined the urgent need for a novel, consistent and pan-European approach to DG interconnection issues.

The necessity and urgency of such a development derives from the recognition that the current situation in effect undermines the realisation of a truly functioning single European market for DG manufacturers; deters many potential investors from small-scale renewable and cogeneration projects and ultimately hinders the attainment of the Commission's objectives for penetration of renewables and cogeneration in the European Union.

The ELEP Project Consortium Partners, in a follow-up phase to Deliverables D1.1 and D1.2, are preparing a set of recommendations designed for energy policy makers keen to remedy the present state of affairs. These recommendations are to be found in Deliverable D1.3, due in February 2006.

Much has already been written on interconnection settings for decentralised generators, and European normalisation procedures are already underway to provide the European electricity community with common standards for the connection of decentralised generators. However, little attention has been paid to the administrative and procedural issues surrounding the interconnection of DG to the electricity networks, despite the fact that these have often been singled out as significant barriers to the deployment of decentralised generation. Taking this point fully into consideration, the recommendations currently under preparation are intended to address this lapse. Several driving principles underpin the recommendations: transparency; efficient administration and -whenever possible- streamlined procedures.

Recommendation drafting requires expert craftsmanship and has to be nurtured with debate and discussion. In preparing D1.3, great attention has been given to existing recommendation elements and best practice.

The objective of the ELEP Project Consortium, when embarking on this final leg of interconnection-related activities, has been to ensure the greatest stakeholder involvement possible -within the bounds of the project's limited timeframe and resources- and extensive dissemination. The final recommendations will be presented at a joint DG-GRID – ELEP workshop in March 2006.

# Annex I – List of standards

| **Austria** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| ElWOG – “Elektrizitätswirtschafts- und Organisationsgesetz” (Electricity economy and organisation law) | 2002<br>2004 | This law implements the EU electricity directive and regulates the liberalised Electricity market in Austria | Ministry of Economy and Labour, Section Energy |
| National grid code | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| TOR – “Technische und organisatorische Regeln für Betreiber und Benutzer von Übertragungs- und Verteilernetzen gemäß ElWOG” (“General technical and organisational rules for operators and users of transmission and distribution grids according to the Austrian electricity act (ELWOG)”) | various dates | The TOR series of documents represent the national grid-code. The series consists of 6 parts which cover almost all issues related to the technical and organisational operation of electricity grids. For DG, two parts are relevant, Part D2 (grid interferences and PQ) and D4 (grid-interconnection of DG) | Energie-Control GmbH (Austrian regulator) Working group TOR, experts from E-Control, DNOs and the Austrian Utility Association |
| TOR - Part D2 “Recommendations for the assessment of network interferences”<br>TOR D2:2004 | 1.6.2004 | General guidelines for the assessment of grid interference caused by equipment connected to power supply systems.<br>Section 9 provides special guidelines for the assessment of impacts caused by DG units. | Energie-Control GmbH (Austrian regulator) Working group TOR, experts from E-Control, DNOs and the Austrian Utility Association |
| TOR - Part D4 “Parallel operation of generation units connected to distribution networks”<br>TOR D4:2001 | 2001 | Technical rules for the grid-interconnection and operation of DG units in parallel with the distribution grid. | Energie-Control GmbH (Austrian regulator) Working group TOR, experts from E-Control, DNOs and the Austrian Utility Association |
| NOTE: The new edition of document TOR D4 on interconnection issues is currently under review and is expected to be published in December 2005. | | | |
| International standards | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| ÖVE/ÖNORM EN IEC 61000-3-2 Electromagnetic compatibility (EMC) - Part 3: Limits - Section 2: Limits for harmonic current emissions (equipment input current up to and including 16 A per phase) | 02/2002 | Contains requirements for harmonic currents caused by electrical and electronic equipment with an input current up to 16 A per Phase, which are intended for connection to a public LV distribution network | CENELEC TC210: Electromagnetic compatibility<br>IEC TC 77 / SC 77A: Electromagnetic Compatibility, Low-frequency phenomena |
| ÖVE/ÖNORM EN 61000-3-3 Electromagnetic compatibility (EMC) - Part 3: Limits - Section 3: Limitation of voltage fluctuations and flicker in LV supply systems for equipment with rated current up to and including 16 A per phase | 06/2002 | Contains requirements for voltage changes, voltage fluctuations and flicker caused by electrical and electronic equipment with an input current up to 16 A per phase, which are intended for connection to a public LV network and are not subject to conditional connection. | CENELEC TC210: Electromagnetic compatibility<br>IEC TC 77 / SC 77A: Electromagnetic Compatibility, Low-frequency phenomena |
| National standards | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| ÖVE/ÖNORM E2750 – “Photovoltaic power-systems – Erection and safety requirements”<br>ÖVE/ÖNORM E2750:2004 | 2004 | This is the national standard defining safety requirements for planning, installation and operation of Photovoltaic power systems. | ÖVE Austrian Electrotechnical Association/ ÖNORM Austrian Standards Institute<br>TC: ÖVE FNA-E03: Electrical low-voltage installations - photovoltaic energy conversion |

| **Belgium** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| MONITEUR BELGE – 2 Juillet 2003 – Arrêté royal modifiant les articles 68 et 235 du Règlement général sur les Installations électriques (RGIE) | 25/08/2003 | Modification of two articles of the Electric Installation Code, to consider the impact that DG may have on the grid. This Royal Decree deals mainly with security requirements. | Ministry of Economy, Federal Public Service |
| MONITEUR BELGE – 2 Juillet 2003 – Arrêté royal modifiant les articles 68 et 235 du Règlement général sur les Installations électriques (RGIE) | 25/08/2003 | Modification of two articles of the Electric Installation Code, to consider the impact that DG may have on the grid. This Royal Decree deals mainly with security requirements. | Ministry of Economy, Federal Public Service |
| MONITEUR BELGE – 2 Juillet 2003 – Arrêté royal modifiant les articles 68 et 235 du Règlement général sur les Installations électriques (RGIE) | 25/08/2003 | Modification of two articles of the Electric Installation Code, to consider the impact that DG may have on the grid. This Royal Decree deals mainly with security requirements. | Ministry of Economy, Federal Public Service |
| Moniteur belge – 28 décembre 2002 – Arrêté royal du 19 décembre 2002 établissant un règlement technique pour la gestion du réseau de transport de l'électricité et l'accès à celui-ci | 19/12/2002 | Royal decree on the technical requirements for operation of the electricity transmission network and access to this network | Ministry of Economy, Federal Public Service |
| Arrêté du Gouvernement wallon du 16 octobre 2003 relatif au règlement technique pour la gestion des réseaux de distribution d'électricité en Région wallonne et l'accès à ceux-ci | 16/10/2003 | Regional decree for Wallonia on technical requirements for distribution network operation and access to these networks | Walloon Government |
| Arrêté du Gouvernement wallon du 16 octobre 2003 relatif au règlement technique pour la gestion du réseau de transport local d'électricité en Région wallonne et l'accès à celui-ci | 16/10/2003 | Regional decree for Wallonia on technical requirements for local transmission network operation and access to these networks (30 to 70kV) | Walloon Government |
| VREG - Technisch Reglement - Distributie Elektriciteit- Vlaams Gewest, 14 octobre 2003 | 14/10/2003 | Regioanl technical requirements for electricity distribution network interconnection in Flanders | VREG |
| Company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Technical requirements for connection of dispersed generation systems operating in parallel on the distribution network (C10/11) | 07/08/2003 | It covers a range of capacities up to around 15 MVA. It does not cover the specific protection of Dispersed Generators, neither does it include the requirements of the general regulations for electrical equipment. | BFE-FPE |

| **Denmark** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Danish Electricity Supply Bill | 1999 | Defines the legal structure of the electricity supply industry in Denmark. Specifically lays down the rules governing consumer protection, environmental protection and security of supply in a liberalised market. | Danish Parliament (Folketing) |
| Company / industry recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Standardvilkår for nettilslutning af locale kraftvarmeanlæg | Draft | Requirements for local CHP systems between 0.1 and 25 MW rating | Elkraft |
| DEFU rekommandation 16: Spændingskvalitet i lavspændingsforsyningsnet | 2001 | Voltage quality specification in low voltage grid networks | DEFU |
| DEFU rekommandation 21: Spændingskvalitet i mellemspændingsforsyningsnet | 1995 | Voltage quality specification in medium voltage grid networks | DEFU |
| DEFU komiterapport KR 88: Nettilsutning af decentrale produktionsanlæg | 1991 | Grid connection of decentralised generation plants | DEFU |
| Rekommandation om drifttekniska specifikationer för värmekraftverk | 1995 | Recommendations for the operational specification of CHP systems | NORDEL |
| DEFU TR 293, 2' udgave: Relæbeskyttelse ved decentrale produktionsanlæg | 1995 | Protection requirements of decentralised generation plant | DEFU |
| Kraftværksspecifikationer for produktionsanlæg < 2 MW (N91/SP-515h) | 1995 | Power plant specification for generators below 2 MW | Eltra |
| Systemkrav til produktionsanlæg (N91/NP-134) | | System requirements for generation plant | Eltra |
| Kraftværksspecifikationer for produktionsanlæg mellem 2 og 50 MW (SP92-017a) | | Power plant specification for generation between 2-50 MW | Eltra |

| **Finland** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Electricity Market Act (386/1995) | 2004 | | Ministry of Trade and Industry |
| Electricity Market Decree (518/1995) | 1998 | | Ministry of Trade and Industry |
| | | | |
| Nordic Grid Code (includes Connection Code) | 2004 | Regional grid code lays down the basic rules for connection to the electricity transmission network. Focuses on plants above 50 MWe | Nordel |
| National standards /guidelines<br>There are no relevant National Standards different from the international ones for this issue. | | | |
| Company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| General Connection Terms of Fingrid Oyj's Grid | 2000 | General connection terms for plants connecting to the high voltage network (110 kV and above) | Fingrid (TSO) |
| Specifications for the Operational Performance of Power Plants | 2000 | Specifications applicable to units rated above 50 MWe | Fingrid (TSO) |
| Pienvoimaloiden liittäminen jakeluverkkoon (Connection of small power plants to distribution network) | 2001 | Generic recommendations for the connection of small power plants | Sähköenergialiitto ry SENER (former Finnsih Electricity Association, now Association of Finnish Energy Industries) |

| **France** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| 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<br>NOR: INDI0301060D | 13/03/2003 | Technical requirements for a new connection or extension of consumers and producers to distribution networks.<br>(Not applicable to interconnection to small networks which present less than 20 MW of generation neither to the interconnection of two public distribution networks) | Ministry of Industry |
| 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<br>NOR: INDI0301276A<br>Remark: there is also a ministerial order for consumption installations connected to the public distribution network. | 17/03/2003 | Technical requirements for a new connection or extension (by more than 10%) of producers to distribution networks<br>This order applies to generation installations feeding all or part of their production to the network so that they comply with the above ministerial decree | Ministry of Industry |
| Ministerial order of 22 April 2003, amendment to the 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<br>NOR: INDI0301379A | 22/04/2003 | Amendment to the previous order (regarding power factor). Concerns plants with a power range of 1 to 10 MWe. | Ministry of Industry |
| Government decree n° 2003-588 of 27 June 2003 on the **general** technical requirements regarding design and operation which **installations** must fulfil for connection to the public **transmission** network<br>NOR: INDI0301440D | 27/06/2003 | Technical requirements for a new connection of installations to the transmission network and to the HTB parts of the distribution networks, or in case of or important modifications (consumers, producers, public distribution networks, interconnections). Concerns plants with a power rating above 10 MWe. | Ministry of Industry |
| Ministerial order of 4 July 2003 on the technical requirements regarding design and operation which **production installations** must fulfil for connection to the public **transmission** network<br>NOR: INDI0301719A<br>Remark: there is also a ministerial order for consumption installations connected to the public transmission network. | 04/07/2003 | Technical requirements for a new connection or extension (by more than 10%) of consumers and producers (above 10 MWe) to the transmission network | Ministry of Industry |
| Old ministerial order of 3 June 1998 on the interconnection requirement | 03/06/1998 | The requirements given in this order will be in a near future contained in the grid code prepared by the DNO | |

| | | | |
|---|---|---|---|
| for autonomous **production** installations connected to the **HTA** network with a nominal power **greater than 1 MW** | | | |
| National standards /guidelines<br>There are no relevant National Standards different from the international ones for this issue. | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Guide pratique – Raccordement des générateurs d'énergie électrique dans les installations alimentées par un réseau public de distribution<br>[UTE C15-400] | 1/07/05 | Guide to the connection of electric generators in installations supplied by a public distribution network | UTE |
| Company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Contract for interconnection, access and operation of PV plants connected to the LV distribution network | | Contract to be signed between the DNO (EDF) and the producer. | EDF |
| Contract for production installations connected to the MV network (HTA) | | Contract to be signed between the DNO (EDF) and the producer. This contract is preliminary. | EDF |
| Connection of PV systems to the LV network: technical and contractual requirements | | Informative guideline issued by the EDF.<br>The content of this guideline is very similar to the contract: only the additional information will be indicated. | EDF |

| **Germany** | | | |
|---|---|---|---|
| Laws and decrees<br>National grid-code or similar documents | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Distribution Code – Regeln für den Zugang zu Verteilungnetzen | 08/2003 | Regulation for the access to the grid | Verband der Netzbetreiber –VDN- e.V. beim VDEW |
| Transmission Code – Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber | 2003 | Regulation for the access to the transmission grid | Verband der Netzbetreiber –VDN- e.V. beim VDEW |
| National standards | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| DIN VDE 0126, Selbsttätige Freischaltstelle für Photo-voltaikanlagen einer Nennleistung <= 4,6 kVA und einphasiger Paralleleinspeisung über Wechselrichter in das Netz der öffentlichen Versorgung | 1999 | Requirements on the disconnection unit between the DG system and the grid. According to (1) with this device an accessible disconnection-switch is not needed.<br>(0 to 30 KWe). | |
| DIN VDE 0100-551, Elektrische Anlagen von Gebäuden – Teil 5: Auswahl und Errichtung elektrischer Betriebsmittel; Kapitel 55: Andere Betriebsmittel; Hauptabschnitt 551: Niederspannungs-Stromversorgungsanlagen | 1997 | General rules for sizing and construction of power supply systems connected to the low voltage grid | |
| Technische Anschlussbedingungen für den Anschluss an das Niederspannungsnet „TAB 2000“, ISBN 3-8022-0627-4 | 2000 | General technical requirements for connecting loads and generators to the grid. | VDEW ( German Electricity Association, trade association of the electricity supply) |
| Company recommendations and guidelines | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Eigenerzeugungsanlagen am Niederspannungsnetz, Richtlinie für Anschluß und Parallelbetrieb von Eigenerzeugungsanlagen am Niederspannungsnetz, ISBN 3-8022-0646-0 | 2001 | Guideline for the connection of DG to the LV grid | VDEW ( German Electricity Association, trade association of the electricity supply) |
| Eigenerzeugungsanlagen am Mittelspannungsnetz, Richtlinie für Anschluß und Parallelbetrieb von Eigenerzeugungsanlagen am Mittelspannungsnetz, ISBN 3-8022-0584-7 | 1998 | Guideline for the connection of DG to the MV grid | VDEW ( German Electricity Association, trade association of the electricity supply) |
| VDN-Richtlinie: EEG Erzeugungsanlagen am Hoch- und Höchstspannungsnetz | 2004 | Guideline for the connection of plants eligible for promotion under the German Renewable Energy Sources Act to the high and extra-high voltage network | VDEW ( German Electricity Association, trade association of the electricity supply) |
| ER gänzende Hinweise zur VDEW-Richtlinie „Eigenerzeugungsanlagen am Niederspannungsnetz“ | 2005 | Amendment to the VDEW guideline on connection of DG to the LV grid | VDEW ( German Electricity Association, trade association of the electricity supply) |

| **Greece** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| The distribution directive 129 "Interconnection of generating facilities to the distribution network" | December 2003 | It sets evaluation procedures, disturbance limits and interconnection technical requirements for connecting generating stations to the MV and LV network, up to a max capacity of 20 MW. It covers the power quality issues and the behaviour during fault conditions in the grid and it is therefore completely relevant to DG. | |
| Distribution Network Operating Code (NOC) | August 2003 | It deals with the operation of the Distribution Network and ensures non-discriminatory access for authorised generators and authorised suppliers in the most economical, transparent and direct manner, – a Tariff Code for use of the Distribution System, including both use of System charges and principles for connection charges Maximum plant power is in the range of 20 MW | PPC |
| Law 2244/99 and associated Ministerial Decisions | October 1994 | The production of electricity by private power stations based on RES was liberalised to 50 MW. It aims to simplify bureaucratic procedures for issuing installation and operation licenses to all RES to power projects. | Minister of Development |
| Law 2773/99 | December 1999 | It respects EU directive 96/92EC and opens the Greece electricity market and regulates matters of energy policy.<br>Art 35 and 41 refer specifically to RES electricity and co generation | Minister of Development |

| **Ireland** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Electricity Regulation Act | 1999 | | Irish Parliament |
| Company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Distribution Code | Version V1.5 May 2005 | Defines the technical aspects of the working relationship between the DNO and all Users of the Distribution System | ESB Networks |
| Conditions Governing Connection to the Distribution System: Connections at MV and 38kV; Embedded Generators at LV, MV and 38kV (Document reference DTIS-250701-BDW) | September 2003 | Sets out the requirements for Customer equipment at the interface between the Distribution System and the Customer's installation | ESB Networks |
| General Conditions for Connection of Industrial and Commercial Customers and Generators to the Distribution System (Document reference DTIS-150200-AXY) | 28 November 2003 | Defines a series of standards terms and conditions for distribution system connection. Is a more "commercial" complement to the document DTIS-250701-BDW detailed above. | ESB Networks |

| **Italy** | | | |
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| National standards | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| CEI 11-20, Impianti di produzione di energia elettrica e gruppi di continuità collegati a la reti di I e II categoria | 1997 | Requirements for energy generation installations of power higher than 1 kW connected to the LV and MV grids | CEI (Comitato Elettrotecnico Italiano) |
| CEI 11-32, Impianti di produzione di energia elettrica connessi a sistemi di III categoria | 1999 | Requirements for energy generation installations connected to the HV grids | CEI (Comitato Elettrotecnico Italiano) |
| Company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Criteri di allacciamento di tetti fotovoltaici alla rete BT di distribuzione | | Connection requirements to the LV grid for PV installations (powers between 1 and 20 kW) | ENEL Distribuzione |

| **Luxembourg** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Law of 24 July 2000 relative to the organisation of the electricity market | 2000 | Law organising the electricity market in Luxembourg | Service de l'énergie de l'Etat (SEE) |
| Grand-Ducal Regulation of 30 May 1994 | 1994/2005 (see below) | Concerns the production of electrical energy based on renewable energy sources and cogeneration | Service de l'énergie de l'Etat (SEE) |
| Grand-Ducal Regulation of 14 October 2005 | 2005 | For renewable installations, the 1994 Regulation has been replaced by this Grand Ducal Regulation of 14 October 2005 | Service de l'énergie de l'Etat (SEE) |
| Prescriptions de raccordement pour les installations à courant fort disposant d'une tension nominale inférieure ou égale à 1000V au Grand-Duché de Luxembourg (August 2003) | 2003 | Replaces the previous ministerial regulation of 1989. Technical prescriptions for small generators rated under 1000 kVA | Service de l'énergie de l'Etat (SEE), drafted together with the DNOs |
| « Richtlinie für den Parallelbetrieb von Eigeberzeugungsanlangen mit dem Niederspannungsnetz des Elektrizitätsversorgungsunternehmens (EVU)". German VDEW | | German technical standard for parallel connection to the low voltage network | VDEW (Germany) |

| **Netherlands** | | | |
|---|---|---|---|
| The large number of amendments to existing standards and rules makes it quite complicated to find a complete overview in one document. The best way to work at the moment is to find an original version of a standard and then add all the amendments to it. | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Elektriciteitswet 1998 | July 1, 2005 | General law on electricity production | Ministry of Econ. Affairs and distribution |
| Netcode | May 18, 2005 | rules for the electricity network | DTe |
| Meetcode | May 18, 2005 | rules for measuring the network parameters | DTe |

| **Portugal** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Decreto-Lei No. 189/88 | 25 May 1988 | Decree-Law that defines the rules applicable to power production | |
| Decreto-Lei No. 168/99 | 18 May 1999 | Revises DL 189/88 and established new rules for RES and CHP plants | |
| Decreto-Lei No. 339-C/2001 | 10 December 2001 | Revises Decree-Law 168/99 | |
| Decreto-Lei No. 312/2001 | 10 December 2001 | Establishes rules regarding the management of grid capacity to receive power from IPPs. | |
| Portaria No. 1467-C/2001 | 31 December 2001 | Defines the payments related to the attribution of interconnection points, as defined in Decree-Law 312/2001. | |
| Decreto-Lei No. 186/95 | 27 July 1995 | Establishes rules applicable to power generation from RES and CHP | |
| Decreto-Lai No. 538/99 | 12 December 1999 | Establishes rules applicable to CHP | |
| Decreto-Lei No. 313/2001 | 10 December 2001 | Revises Decree-Law 538/99 | |
| Portaria No. 347/96 | 8 August 1996 | Establishes safety and technical requirements for the installation and operation of CHP plants | |
| Decreto-Lei No. 68/2002 | 25 March 2002 | Regulates the activity of micro-generation Group II | |
| Aviso No. 12936/2003 | 29 November 2003 | Licensing procedures for micro-generation plants of Group II, as defined in Decree-Law 68/2002 | |
| Company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Guia Técnico DGE de Junho de 1994 | June 1994 | Technical Guide for independent power producers | |

| **Spain** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| ORDEN 5/9/1985, Administrative technical rules for the operation and interconnection to the grid of hydroelectric power plants up to 5 MVA and "autogeneration plants" | 1985 | General rules for the interconnection of RES and cogeneration plants to the grid. Utilities are bound to buy the surplus of electricity generated by these installations and to pay for that energy higher price. | |
| RD 1955/2000, Gives rules for transmission, distribution, commercialisation, supply and permission procedures or electric energy plants | 2000 | It establishes the legal system that will be applicable to the activities of transmission, distribution, marketing and electricity supply. | |
| RD 1663/2000, interconnection of PV installations to the low voltage grid<br>Resolution 31/5/2001 - Annex | 2000<br>2001 | Interconnection of PV installations to the low voltage grid: application, technical conditions, contract, connection and first verification,… | |
| RD 2818/1998 production of electric energy by installations fed by RES, waste and cogeneration<br>RD 436/2004 substitutes the previous one | 1998<br>2004 | It defines the requirements and procedures to invoke the "Special System" (RES + Cogeneration), procedures for registration, energy supply conditions and economic rules. Incentives are set depending on technologies. | |
| National grid code | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| RD 842/2002. Royal Decree 842/2002, Spanish Low Voltage Code. ICT-BT 40: low voltage generating installations. | 2002 | Complementary instruction (ICT) applicable to generating installations, namely installations aimed at the transformation of any kind of non-electric energy into electric energy. | |
| International standards | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| UNE –EN 50160: Voltage characteristics of electricity supplied by public distribution systems. | 01/11/1994 | Power quality limits of the electricity supplied in the network | |
| UNE<br>Enforced by the RD 1955/2000 | | | |
| NOTE: other international standards are used, for example the IEC 61000 series, but not really enforced by law. | | | |
| IBERDROLA company recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Condiciones técnicas de la instalación de autoproductores | 12/1999 | The present document defines the general technical requirements asked by IBERDROLA for the interconnection to its network. Based on these criteria, particular requirements for each case will be defined. | |
| NOTE: A Royal Decree about interconnection of DG to the grid is under preparation. It was foreseen to be issued in year 2004 but it is delayed and has not been released yet. | | | |

| **Sweden** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Ellagen (1997:857) | 2/06/2005 | The law of electrical systems. | |
| Starkströmsföreskrifterna Elsäk-FS1999:5 | 12/1999 | Regulations regarding design and maintenance of high voltage electrical systems (in general above 50V) | |
| Elsäk-FS 2004:1 | 2004 | | |
| SS 436400 | 14/11/2003 | National standard regarding Electrical installations in buildings. | |
| National grid code | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| AMP ("Anslutning av mindre productionsanläggningar till elnätet") | 2002 | Interconnection of smaller production units to the electrical network. Created and administrated by Swedenergy, an industrial organization representing producers, distributors and traders in Sweden. It refers to several other national and international standards and regulations. | |
| International standards | | | |
| | Last revision | Abstract | Issued by/responsible TC |
| SS –EN 50160: Voltage characteristics of electricity supplied by public distribution systems. | 01/02/2002 | Power quality limits of the electricity supplied in the network | |
| NOTE: A lot of other international standards are used, for example the IEC 61000 series, but not really enforced by law. | | | |

| **United Kingdom** | | | |
|---|---|---|---|
| Laws and decrees | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| Electricity Act | 1989 | Provided the legislative framework for the initial setting up of the liberalised electricity market in the UK | UK Government |
| Utilities Act | 2000 | Defined new regulatory arrangements and amendments to the 1989 Electricity Act | UK Government |
| Energy Act | 2004 | Defines the creation of a single electricity market for Great Britain. Also includes provisions to support the development of renewable energy. | UK Government |
| Company / industry recommendations | | | |
| Document title | Last revision | Abstract | Issued by/responsible TC |
| The Distribution Code of Great Britain | Issue 5 August 2004 | Details the technical parameters and considerations relating to the connection to, and use of, DNO networks | Distribution Code Review Panel |
| The Distribution Code for Northern Ireland | | As above | |
| Engineering Recommendation G5/4 | Feb 2001 | Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission systems and distribution networks in the United Kingdom | Energy Networks Association |
| Engineering Recommendation G59/1 | 1991 | Recommendations for the connection of embedded generating plant to distribution systems (generation connected at 20 kV and below, and less than 5 MW) | Energy Networks Association |
| Engineering Recommendation G75/1 | Dec 2002 | Recommendations for the connection of embedded generating plant to distribution systems above 20 kV or with outputs over 5 MW | Energy Networks Association |
| Engineering Recommendation G83/1 | Oct 2002 | Recommendations for the connection of small-scale embedded generators (up to 16 A per phase) in parallel with public low voltage distribution networks | Energy Networks Association |
| Engineering Technical Report 113 | 1995 | Notes of guidance for the protection of embedded generating sets up to 5 MW for operation in parallel with distribution networks | Energy Networks Association |

# Annex II – Technical requirements

| Austria | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 1.0-1.3 Un<br>*1.06–1.2 Un*<br>For PV: 1.11 Un | 0.1-5 s, steps of 0.1s<br>*instantaneous to 5 s depending on the operating mode of the network*<br>For PV: 0.2 s |
| Under voltage | 0.7-1.0 Un<br>*0.7–0.9 Un*<br>For PV: 0.85 Un | 0.1-5 s, steps of 0.1 s<br>For PV: 0.2 s |
| Over frequency | 50-53 Hz<br>*50.5–52 Hz* | Adjustable to instantaneous, measurement periods under 0.14 s |
| Under frequency | 47-50 Hz<br>*48 – 49.5 Hz* | Adjustable to instantaneous, measurement periods under 0.14 s |
| LoM detection/islanding prevention | 0.85 Un and 1.13 Un, 1Ω, 0.3 Hz deviation | 0.2 s |
| Voltage variations | Increases<br>LV : Δ Umax = 3%<br>MV : ΔUmax = 2%<br>(operator may allow higher limits) | |
| Note: currently there are fixed limits for under-/over-voltage trip points defined in the standard (-15%/+10% Un), which refer to the present voltage band (-10%/+6% Un). | | |

In red: TOR D4:2000
*In Blue: DNO requirements*

| Belgium | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 1.06 Un<br>(and possibility of setting at 1.10 Un) | Instantly (max 0.12 s) |
| Under voltage | 0.80 Un | 1.5 s |
| Over frequency | *General case:* 50.5 Hz<br>*Synchronous generators connected to transmission network (operational range):*<br>Unlimited operation up to 51 Hz and operation for given period of time up to 52.5 Hz | Instantly |
| Under frequency | *General case:*<br>49.5 Hz<br>*Synchronous generators connected to transmission network (operational range):*<br>Unlimited operation to 48.5 Hz and operation for given period of time to 48 Hz | Instantly |
| LoM detection/islanding prevention | Current and time-out values specified by the DNO.<br>*General case:*<br>±0.5 Hz and 0.80–1.06 Un, with homopolar Uo delayed<br>*Synchronous generators connected to transmission network:*<br>48 Hz threshold for islanding (unless other specification in connection contract) | *General case:*<br>Instantaneous (except for upper minimum voltage: up to 1.5 s)<br><br>*PV:* 5s |
| Voltage variation | No voltage limits, but in parallel operation, voltage, frequency and phase difference must not cause Δ6% max in voltage. | |
| Disconnection is ensured within 0.2 s when voltage is out of range and when frequency deviation is higher than 0.2 Hz. | | |
| Note: for **asynchronous generators**, specific requirements are prepared by the network operator, and especially for generators using renewable energy sources and cogeneration. | | |

| Denmark | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | + 6% of nominal<br>+ 10% of nominal | 30-60 s<br>< 0.05 s |
| Under voltage | - 10% of nominal<br>- 30% of nominal | 2-10 s<br>≤ 0.05 s |
| Over frequency | f > 53 Hz | 0.3 s |
| Under frequency | f < 47 Hz<br>47 Hz ≤ f ≤ 47.5 Hz | 0.3 s<br>≥ 10 s |
| LoM detection / islanding prevention | df / dt ≤ - 2.5 Hz/s<br>df / dt ≥ + 2.5 Hz/s | 0.08-0.1 s<br>0.08-0.1 s |
| Voltage variation | Typically ≤ 4% voltage change is permissible upon connection/disconnection of a generator (DEFU recommendation 21) | |
| Note: These *typical* requirements are taken from the representative documents "Standardvilkår for nettilslutning af locale kraftvarmeanlæg" (Energi E2) and "Kraftværksspecifikationer for produktionsanlæg < 2 MW" (Eltra). | | |

| Finland | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | Stage 1: Un + 10%<br>Stage 2: Un + 15% | Stage 1: 1.5 s<br>Stage 2: 0.15 s |
| Under voltage | Stage 1: Un – 15%<br>Stage 2: Un – 50% | Stage 1: 5 s<br>Stage 2: 0.15 to 1 s depending on DNO network protection settings |
| Over frequency | 51 Hz | 0.2 s |
| Under frequency | 48 Hz | 0.5 s |
| LoM detection / islanding prevention | | 0.15 s |
| Voltage variation | | |

| France | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 1.15 Un | Instantly |
| Under voltage | 0.85 Un | Instantly |
| Over frequency | 51 Hz | Instantly |
| Under frequency | 47.5 Hz | Instantly |
| LoM detection / islanding prevention *(Old ministerial order, 3 June 1998, to be contained in upcoming grid code)* | *Type 1:* 0.85-1.15 Un; 47.5-51 Hz<br><br>*Type 2:* Same as Type 1 but time delay of 1-1.5 s for zero-sequence voltage relay<br><br>*Type 3:* 49.5–50.5 Hz (fast action relay) and instantaneous action relay trip if voltage falls below 25% of mean voltage at pcc.<br><br>*Type 4:* 49.5–50.5 Hz and time delay of 1 to 1.5s for zero-sequence voltage relay | *Type 1:* Instantaneous<br><br>*Type 2:*1-1.5 s<br><br>*Type 3:* Fast action and/or instantaneous<br><br>*Type 4:*1-1.5 s |
| Voltage variation (for connection and disconnection) | *Up to 50 kV:*Δ 5% max | 0.5 s |
| Note: Frequency (short term temporary operation): 46-48 Hz for 3 minutes | | |
| For PV:<br>German standard DIN VDE 0126 for decoupling protection integrated in inverter<br>Disconnection in less than 0.2 s when the voltage is out of the range [80%-115%]<br>Disconnection in less than 0.2 s when the frequency is out of the range ±0.2 Hz (for voltage between 70% and 120%).<br>External decoupling protection<br>Installations smaller than 10 kVA: 85%-110% of nominal voltage, instantaneous trip<br>Installations larger than 10 kVA: 85%-110% of nominal voltage, instantaneous trip and 49.5 Hz–50.5 Hz, instantaneous trip (44 Hz–52 Hz in overseas territory and Corsica). | | |

| Germany | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 264 V (0.80 Un) | 0.2 s |
| Under voltage | 184 V (1.15 Un) | 0.2 s |
| Over frequency | 51 Hz | 0.2 s |
| Under frequency | 47 Hz | 0.2 s |
| LoM detection / islanding prevention | 49.8-50.2 | 5 s |
| Voltage variation (for connection and disconnection) | EN 61000-3-3 or EN61000-3-11<br><br>*If not:*<br>LV: Δ3% Umax<br>MV: Δ2% Umax | LV: once in 5 min<br>MV: once in 1.5 min |
| In red: CLC/TC8X WG2<br><br>Frequency settings vary: Frequenzüberwachtung frequency levels are between 47.5 and 50.2 Hz with a maximum delay of 0.2s (DIN VDE 0126-1-1: 2005-05).<br>Voltage setting also vary: Fehlerstromüberwachtung voltage levels are required to be between 0.85 Un and 1.10 Un (DIN VDE 0126-1-1: 2005-05). | | |

| Greece | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 1.10 pu<br>(and possibility of setting at 1.15 pu) | 0.3 sec (until 1.2 sec) |
| Under voltage | 0.85 pu<br>(and possibility of setting at 0.80 pu) | 0.3 sec (until 1.2 sec) |
| Over frequency | 50.5 Hz (until 51.5 Hz) | 0.3 sec (until 1.2 sec) |
| Under frequency | 49.5 Hz (until 47.5 Hz) | 0.3 sec (until 1.2 sec) |
| LoM detection / islanding prevention | | |
| Voltage variation | | |

| Ireland | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | +10% of nominal | Typically < 0.5 s |
| Under voltage | -10% of nominal<br><br>-20% for wind farms | Typically < 0.5 s<br><br>1 s |
| Over frequency | +1% of nominal (50.5 Hz)<br><br>50.8 Hz for wind farms | < 0.5 s<br><br>< 0.5 s |
| Under frequency | -4% of nominal (48.0 Hz)<br><br>47.0 Hz for wind farms | < 0.5 s<br><br>< 0.5 s |
| LoM detection / islanding prevention | (a) ROCOF setting is typically – 0.4 Hz/s (0.55 Hz for wind farms)<br><br>(b) Vector shift setting is typically –6 degrees | < 0.5 s<br><br>< 0.5 s |
| Voltage variation | *No specific limits could be found relating to the voltage deviation caused by a DG scheme, other than compliance with the ± 10% voltage variation above.* | |
| Note: These parameters are found in "Conditions Governing Connection to the Distribution System: Connections at MV and 38 kV & Embedded Generators at LV, MV and 38 kV" issued by ESB Networks. | | |

| Italy | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 1.2 Un | 0.1s +/- 0.01 s |
| Under voltage | 0.8 Un | 0.2s +/- 0.02 s |
| Over frequency | 50.3 (default setting) or 51 Hz | Without intentional delay ≤0.1 s |
| Under frequency | 49 or 49.7 Hz (default setting) | Without intentional delay ≤0.1 s |
| LoM detection / islanding prevention | Under 400 kVA:<br>Voltage +/- 10% PCC<br>Frequency +/- 0.5% PCC<br>Phase ≤ π/18 rad<br><br>Over 400 kVA:<br>Voltage +/- 15% PCC<br>Frequency +/- 0.5% PCC<br>Phase ≤ π/18 rad | |
| Voltage variation | | |

| Luxembourg | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 115% Un | 0.2 |
| Under voltage | 80% Un | 0.2 |
| Over frequency | 50.2 | |
| Under frequency | 47.5 | |
| LoM detection / islanding prevention | | |
| Voltage variation | | |
| Note: Technical settings in Luxembourg are predominantly based on the requirements of CENELEC standards, or by default on those of the German Verband der Elektrotechnik (VDE) and of the VDEW. This is especially true for generators rated above 1000 kVA. | | |

| **Netherlands** | | |
|---|---|---|
| Quantity | Limits | Trip time |
| Power factor | 0.9 capacitive<br>0.9 inductive | |
| Over Frequency | 52 Hz | 2 s |
| Under Frequency | 48 Hz | 2 s |
| Upper voltage | 106% U nominal | 2 s |
| Under voltage | 80 % nominal | 2 s |
| Under voltage | 70% nominal | 0.2 s |
| Note: This applies for units with a power capacity over 5 kVA | | |

| Portugal | | |
| --- | --- | --- |
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 1.1-1.2 Un<br><br>For asynchronous microgeneration:<br>1.15 Un | 0.05-0.15 s<br><br>For asynchronous microgeneration:<br>0.07 s +/- 0.01 s |
| Under voltage | 0.7-1.8 Un<br><br>For asynchronous microgeneration:<br>0.8 Un | 0.05-0.15 s<br><br>For asynchronous microgeneration:<br>0.115 s +/- 0.01 s |
| Over frequency | 100/110 V: -100 to -500 mHz<br>230/400 V: -1 to 2.5 Hz<br><br>For asynchronous microgeneration:<br>50.5 Hz | 0.08-0.2 s<br><br>For asynchronous microgeneration:<br>0.08 s +/- 0.02 s |
| Under frequency | 100/110 V: -100 to -500 mHz<br>230/400 V: -1-2.5 Hz<br><br>For asynchronous microgeneration:<br>49.5 Hz | Acting time 80 to 200 ms<br><br>For asynchronous microgeneration:<br>0.08s +/- 0.02 s |
| LoM detection / islanding prevention | | |
| Voltage variation | 0.5-2 Un | |

| Spain | | |
| --- | --- | --- |
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | 110% | |
| Under voltage | 85% | |
| Over frequency | 51 Hz | |
| Under frequency | 49 Hz | |
| LoM detection / islanding prevention | | *Synchronous and self-excited asynchronous generators:*<br>Remote tripping under 0.3 s<br><br>*In LV for asynchronous generators:* <1 s |
| Voltage variations | Asynchronous:<br>5% drop max<br>Wind: 2% drop max),<br>3% drop max in low voltage<br><br>Synchronous under 1 MVA: 5% drop max | Synchronous and asynchronous: 1 s<br><br>(Synchronous under 1 MVA: 0.5 s) |

| Sweden | | |
|---|---|---|
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | Fast: 20 %<br>Slow: 6% | Fast: 0.2 s<br>Slow: 60 s |
| Under voltage | Fast: 20%<br>Slow: 10% | Fast: 0.2 s<br>Slow: 60 s |
| Over frequency | 51 Hz | 0.5 s |
| Under frequency | 48 Hz | 0.5 s |
| LoM detection / islanding prevention | *1)* | *1)* |
| Voltage variations | Slow: Wind: 2.5% *2)*<br>Fast: *3)* | |

1) In general, voltage amplitude and frequency protections are sufficient. If an important risk of cases when the production and the island grid consumption will be of the same size, phase shift or frequency shift (df/dt) protections are required. No settings of those are provided. In those cases, a ground fault detection system using a neutral point voltage measurement is required to prevent steady state operation towards a ground fault. This protection is to disconnect within 5 seconds.

2) The general limit is 2.5% at the connection point of the wind power plant. Wider limits can be accepted if detailed calculations show this.

3) The limits for fast voltage variations during operation of wind power plants are given by the flicker limits in the standard IEC 61000-3-7.

| United Kingdom | | |
| --- | --- | --- |
| Parameter | Maximum trip setting | Maximum clearance time (in seconds) |
| Over voltage | HV connected plant setting are agreed with DNO.<br>For small plant (<150 kVA), the setting is typically +10% of nominal | As agreed with the DNO<br><br>0.5 s |
| Under voltage | HV connected plant setting are agreed with DNO.<br>For small plant (<150 kVA), the setting is typically -10% of nominal | As agreed with the DNO<br><br>0.5 s |
| Over frequency | HV connected plant setting are agreed with DNO.<br>For small plant (<150 kVA), the setting is typically 50.5 Hz | As agreed with the DNO<br><br>0.5 s |
| Under frequency | HV connected plant setting are agreed with DNO.<br>For small plant (<150 kVA), the setting is typically 47.0 Hz | As agreed with the DNO<br><br>0.5 s |
| LoM detection / islanding prevention | Settings are agreed with the DNO. ETR 113 recommends a setting of 0.125 Hz/s based on known disturbances in the range 0.04-0.16 Hz/s. | For agreement with the DNO |
| Voltage variation | Typical limits for step voltage change caused by connecting / disconnecting a generator are ± 3% for planned events and ± 6% for unplanned events | For agreement with the DNO |