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CONNECTION OF GENERATORS AND OTHER CUSTOMERS - RULES AND PRACTICES -

Working Group
C6.02

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1. Introduction

Connecting to the grid system is a fundamental requirement in an electricity supply system, for customers (users of the grid) who want to feed in power (generators), take off power (consumers) or to transport power further (distributors). In a deregulated environment each entity will seek to optimise their own position and be hindered as little as possible by rules. The transmission and system operators, on the other hand, have to facilitate the market (as a monopoly activity or otherwise) and maintain the security and dependability of the transmission system. In order to achieve this, rules must be in place and these are most often laid down in so-called grid codes and/or system codes.

A Working Group of Cigré, named WG C6.02, was set up to study the rights and responsibilities of generators and other customers connected to networks, in different countries around the world.

The task was to:

- survey the main aspects in the grid codes of the countries taking part in the study, as regards generators and other customers;
- compare the specific rules and practices in the various countries;
- make a technical and (social) economical assessment of the different approaches; and
- review the opportunity for harmonisation of rules.

The first two subtasks are performed in depth; the third subtask is treated only technically, not economical. The last subtask has been worked out but this has not led to specific recommendations, although it is obvious that a clearer description and comparison of the practices as provided for in this study, will lead to further harmonization of the rules in the different systems.
Only medium and higher voltage level networks were considered in order to concentrate on the main aspects.

On the basis of an extensive questionnaire information was gathered from the following countries and states:

FR	France
IT	Italy
DE	Germany
BE	Belgium
NL	the Netherlands
NO	Norway
IE	Ireland
ES	Spain
E&W	England & Wales

JP	Japan
KR	Korea
QU	Queensland
NSW	New South Wales
SA	South Australia
VI	Victoria
WA	Western Australia
TA	Tasmania
NZ	New Zealand

In total 9 European systems, 2 Asian systems and 7 Oceanian systems (6 in Australia and 1 in New Zealand) are examined in this study, which means that the results give a broad overview of the practises in the world for treatment of the connection of customers to the grid. The countries involved have a combined load of approximately 650 000 MW and cover an area of more than 10 million km^2.

Split up in load and area the systems can be distinguished as follows:

- 5 power systems are smaller than 5000 MW, 7 systems between 5000 and 50 000 MW and 6 systems with load more than 50 000 MW;

- 6 systems cover areas smaller than 100 000 km^2, 7 systems are between 100 000 and 500 000 km^2 and 5 systems are larger than 500 000 km^2.

This report is structured in the same way as the questionnaire that was issued.

Chapter 2 covers the definition of connection, procedure for connection, ownership, tariffs and contractual agreements.

For two representative connection schemes, as given in the following figure, the limits for network system operation, ownership and investment cost, are discussed.

In the first case connection into an existing transmission system circuit via a new double circuit (in/out) line, a new substation and a radial circuit between the substation and the user's site, is assumed. In the second case an alternative connection is considered where the connection is made to an existing substation near the customer's site via a new bay.

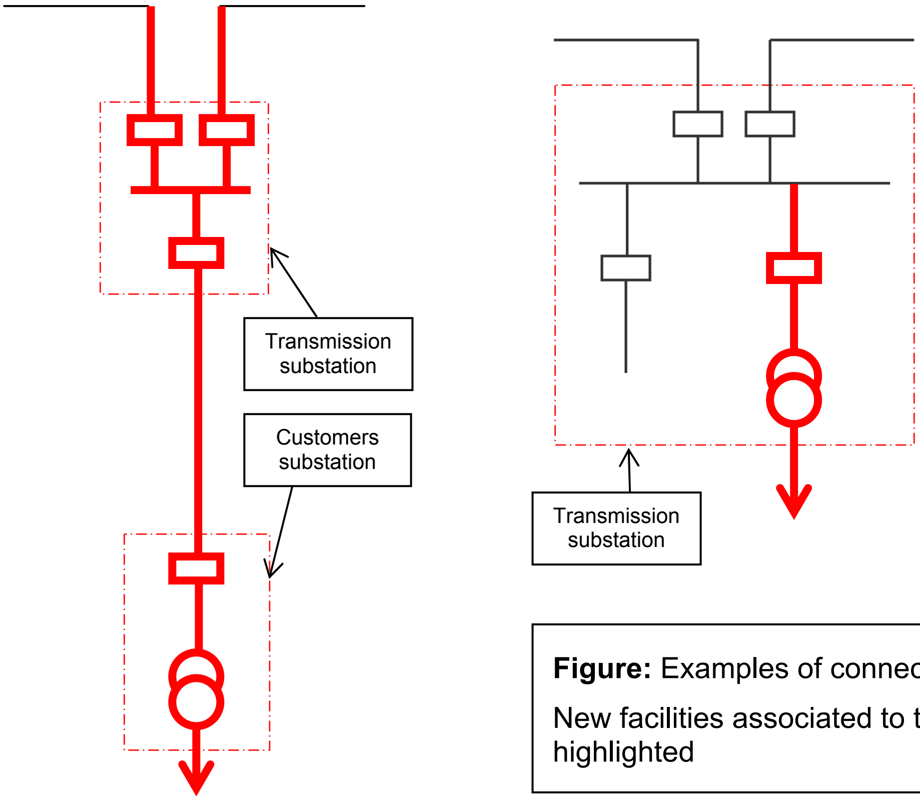


Figure: Examples of connection schemes

New facilities associated to the connection are highlighted

In chapter 3 the concept of the transmission service is discussed in more detail. Themes like firmness of access, maintenance planning, disturbance handling and service quality (power quality, availability, etc.), are considered.

In chapter 4 the impact of the connection on the transmission network, is discussed. This includes a discussion about monitoring, control and system capacity aspects.

In chapter 5 the connection of dispersed generation is considered. It is discussed whether there are special rules for dispersed generation and whether this depends on the method of coupling to the grid or the source of energy.

In chapter 6 the main conclusions and recommendations on the different subjects are brought together.

2. Connection to the Network

Power systems generally have connection and access procedures as regulated mechanisms for agents wishing to interact with the network, with the objective of injecting energy into or absorbing energy from the system.

The term connection is associated with the physical integration of an agent into the power system and has a similar meaning for the different power systems considered. Connection refers to the actions by which an existing or intending agent seeks to link and actually links a facility or set of facilities to the network.

The term access may be understood differently according to the power system considered. Although sometimes it may be understood as a part of the connection process, perhaps more often access designates the actual use of the system facilities, even if the agent is not physically linked to a particular system.

This chapter deals with the connection to the network and analyses aspects related to:

- The connection procedure
- Definition of the connection
- Connection tariffs
- Denial of connection and user constraints.

2.1. The Connection Procedure

In general, the connection procedure may be defined as the set of rules and requirements, which establish the way agents wishing to link their new facilities to the network, may do so. By extension, many systems also include within this procedure the mechanism by which a facility with an existing connection to the network may change their connection conditions.

Thus, the procedure involves agents as well as an entity (or maybe more than one), which is responsible for evaluating their application. The entity is entitled to approve or deny the agent's proposal, with a possible "counter-proposal" including another alternative for connection.

Facilities which require connection procedure

The connection procedure generally applies to the connection to the grid of new facilities.
By extension, many systems also include within this procedure the mechanism by which a facility with an existing connection to the network may change the connection conditions. These conditions may be power transfer changes in the facility or any other changes.
In all systems, a connection process –as a new connection- is required if power changes are considered substantial; however, the valuation of this does not always follow clear criteria. For instance, in Germany the TSO can object to the change until it is confirmed by a planning review.

Applications: responsible agents and bodies

In terms of the agents or entities involved, we may classify:

- The applicants:
  - generators, which may have different conditions or obligations for the different systems depending on size, type of energy source, …;
  - consumers, which may be eligible or not and have different treatment according to the regulations;

  - distributors, whose objective is to obtain the necessary support for their systems, when the distribution development may appear insufficient or less economically efficient. In many systems, this sort of connection is integrated within planning and not within connection procedure.
- The system agents or entities having some function or responsibility within the process for evaluation and approval of the applications for connection. In this group, we may find:
  - network service provider, NSP: the network companies, NC, owners of the grid assets, which may be distribution or transmission companies;
  - the independent system operator, ISO, especially when acting as grid manager (generally responsible for network planning);
  - the preceding functions may be carried out by the same entity when the grid and system management is accompanied by the ownership of the assets of the grids: transmission system operator, TSO, or distribution system operator, DSO.
- The regulatory body, which may exercise some supervising action or more generally deals with conflicts, which may arise during the connection process and prevents or corrects any regulatory malfunction of the process.

Resulting from the questionnaire, in most systems, applications are addressed to the network company, acting as the network service provider. In many of these cases, the network company can be the transmission (or distribution) system operator, since it also shares system operation functions.
In some countries with a formal separation between network and system operation (ISO), we may find that the ISO manages the connection together with the network company (for instance Italy, where presently the process of reunification of ownership and operation is ongoing) or schemes where both functions are involved (Victoria-Australia, where the use of system connection management is carried out by an Independent Planning Body with a final need of contracting also with the network company for connection). In Spain ISO and NC formally manage two consecutive sub-processes (SO for access and NC & SO for connection), although in practical terms REE (TSO) is playing both roles in the majority of the transmission grid.

Regarding the regulator, this is obviously a general factor for all systems (except Western Australia). Usually there is a specific body, independent or different from the Governmental Administration, which tends to be referred to as the regulator (term which is more or less adequate according to its functions and capability to "regulate").
The roles and duties of the regulatory body are different in each country, but in general it is in charge of ensuring the proper application of the rules. In particular, regarding the connection process, the regulatory body generally is responsible for supervising the process of connection and solving disputes when necessary. In France, Norway and Italy (in Italy the Regulator is the only body responsible for the tariffs) it also plays a role in the settlement of tariffs and in France and Norway its approval is needed for the network investments. In Australia, the regulator sets the allowable revenues and the NSP sets prices to recover the allowable revenue.

Another issue is the option for the connection applicant to apply to one or more companies. However, this is not always the applicant's choice but may instead be the legal requirement of the network service provider.
In fact, in most cases this "choice" does not reflect any degree of freedom for the applicant, but reflects the appropriate network service provider as the result of a combination of features of the facility to be connected to the grid.
The main features are geographical location, size (normally, rated power of the new plant) and voltage. In some cases, for a given location, size may impose voltage and therefore the network service provider: either the distribution or the transmission company/operator. In

some cases (Spain, the Netherlands), the applicant may choose voltage level and thus has a choice between distribution and transmission company/operator.

In terms of the process, Appendix 1 shows in a graphical representation how the connection procedure is established in the different power systems.

Rules and codes

This section focuses on how the different legal and technical requirements are established:

- From the point of view of the nature of regulation, this may be from laws to codes. The basic guidelines for connection philosophy may be included in laws (or decrees).
- On the other hand, codes are expected to provide greater detail both in the technical terms and the practicalities of the required processes. Within this issue, different approaches may be found and the grid code concept may be found in different practical ways.
- Another aspect is the authorship of these rules, whether it is the TSO or the NC, and what degree of autonomy they have, or if it is the regulatory body that is responsible for developing the rules.

In all countries technical requirements and the process for connection are described in laws and/or codes. Usually there are laws to give general rules, which are established by governments and codes to define the technical procedures, which are set by and enforced by regulators (or the government). In most cases, the codes are developed/proposed by the TSO or the NC. In Australia detailed implementation policy is set by the NSP.

In England and Wales, for instance, the grid code is made up of several discrete sections:

- a planning code, which provides generally for the supply of certain information by grid users in order for NGC to undertake the planning and development of the GB Transmission System;
- connection conditions, which specify the minimum technical, design and operational criteria which must be complied with by NGC at connection sites and by grid users connected to or seeking connection with the GB Transmission System;
- an operating code, which is split into a number of sections and deals with the day-to-day operation of the transmission system;
- a balancing code, which is split into three sections and deals with the submission of data and the balancing of the system in real time;
- a data registration code, which sets out a unified listing of all data required by NGC from grid users, and by users from NGC, under the grid code;
- general conditions, which are intended to ensure, so far as possible, that the various sections of the grid code work together.

Other “practical” aspects

Other aspects within the connection procedure refer to practicalities, and reflect the formal way of issuing the connection application, characteristics of the reply (obligation, time span, validity period) and the assignation of the costs of the process.

Formal applications are generally required in every system, normally written and must provide the required information to carry out the connection study. Sometimes, the exchange of information prior to the formal application can be made via e-mail or telephone. In Belgium the application is made via e-mail if it is addressed to the TSO and written if it concerns the DSO. In Ireland and France application forms are available via the Internet.

Network companies (or bodies to which applications must be addressed) always have the duty to respond to the applications that they receive.

The time span available to the NC or SO to reply to the applications is fixed in almost every system. The allowable time to reply reflects the content and required detail to be included by the NC in the response. The time span varies from 2 weeks to 5 months. A response time of two weeks only means coverage of the administrative process and excludes technical details and the formal offer to connect. In the Netherlands, Norway and New Zealand there are no specific rules about this subject; in Italy a provisional regulation is followed by GRTN, awaiting formal approval by the Regulator.

The time for which the connection reply is valid is established in most countries and varies roughly from 1 to 6 months (most around 2 months). In some systems the validity period is not fixed and in others it may be negotiated with the applicant. Mostly the validity affects the feasibility study but not the connection (this is normally agreed with the applicant).

Sometimes applications can interact with each other and may cause constraints on each other. In order to establish a priority, most of the countries use the “first in first out” system. When such interaction exists, offers may be revised. In the Netherlands, Italy, Japan, Korea, New South Wales and New Zealand there are no formal queuing systems. In Spain, a general ‘first in first out’ criterion is applied which has no consequence on preference in the connection or the possibility of production, but depending on the existence of studies in process concerning a particular area, all applications involved are replied after the results are obtained.

When the customer applies for connection to the network, a connection study needs to be completed. In most systems it is usually the customer who pays for the connection study. However in Spain, France and the Netherlands customers do not pay for the study; in France and the Netherlands their participation is envisaged.

Appendix 2 shows a comparative summary of the main aspects related to connection studies.

2.2. Definition of Connection

This section considers some physical issues concerning the connection assets and the limit of property ownership.

The way of connecting a facility to the transmission (or distribution) system requires the definition of a number of aspects of a different nature, legal, technical and economic:

- Legal aspects:
  Related to the limits of the assets, which are to be installed to enable the connection of the facility. The assets limits are to be defined in terms of:
    - property, whether it belongs to the user (the applicant) or to the network company
    - inclusion within transmission network, which will have consequences in terms of operation, and of asset remuneration.
- Technical aspects:
  Related to the equipment requirements in order to safeguard system security and general quality for the users, as well as the potential needs to reinforce the transmission system motivated by the connection.
  This section discusses:
    - the configuration requirements for new substations which are created as a consequence of the connection
    - acceptability criteria for connection to existing facilities, mainly the possibility of connecting to existing lines and how.

- Economic aspects:
  Related to the payments made by the applicant in order to cover the costs of the new connection assets or for other needs motivated by the connection. This is dealt with in section 2.3, particularly deciding who pays for the aforementioned costs (and how and to whom). Generally the division is between what the customer (the applicant) pays and what the network owner funds and recovers from all connected parties.

According to the questionnaire, systems have legal and technical definitions of the connection and the connection point. Generally, connection is defined as the physical attachment of the user system (new facility) to the network.
In most cases the connection point marks the ownership limit and the separation between user and network company (or system operator) responsibilities; then legal and technical operational boundaries coincide.
However, in some systems it is possible that radial connections may belong to the user and be part of the transmission system.

Usually the ownership limit is fixed at the breaker of the user substation and often the transmission grid company owns the breaker at the connection point. Some systems define the boundary between network and user installations in each contract; others have general rules but details are specified in contracts. In some cases, where there are connection facilities between the user and the network substations, there are some differences among different countries in the way of determining the transmission system boundary and the payment obligations for each part.

Moreover, for investment costs the boundary is not always located at the same point as the legal and technical boundary. In most cases, connection facilities which are only used by the customer, are funded by that customer, although they may belong to the network.

The schemes used for connection are usually defined in the connection agreement for each case. However, in some countries these schemes are established as general requirements and are not negotiable between the network company and the user.
Exceptionally, in some systems deviations from the schemes may be allowed and in that case they must always ensure the system's security and quality of service. In England & Wales the increased risks due to these deviations must be borne by the customer.

Appendix 3 illustrates the boundary of the transmission system, the ownership and investment cost for two representative connection schemes.

2.3. Tariffs and Costs for Connection

Following on from the physical aspects outlined in section 2.2, the tariffs to be paid by the applicant may cover the costs directly or indirectly caused by the connection as well as the use of the system resources.

Different power systems have different schemes of distributing these costs as well as different ways of pricing these resources.
In terms of pricing methods or tariff schemes, different methods are:

- The user does not pay specifically for the costs incurred for the particular connection but according to some general scheme, which may be related with more or less complication to quantities such as rated power, voltage of connection point. This method is more often applied to connection to distribution;
- The user pays for the costs incurred for the particular connection. This method is more often applied to connection to transmission.

For pricing related to costs, it is the investment in new facilities that is the most significant. Within the investments we must count not only the facilities and installation cost but also the associated expenses related to operation and maintenance of the equipment during the operational life.

In this respect, investments associated with the connection are frequently classified depending on the physical relationship, direct or indirect, with the actual connection:

- shallow Investments designate those directly related to establishing the connection and necessary to provide the physical link to the existing system (located “at the surface”);
- deep Investments designate those that are caused by the connection but which are not located at the connection point but further into the system (“deep from the surface”).
  In general, these investments provide a global benefit to the whole system, although their motivation may be conceptually simplified: they may be oriented to secure better operating conditions for the applicant (e.g. grid reinforcement to eliminate constraints in a heavily loaded part of the network) or to ensure the quality of supply to pre-existing system users (e.g. new reactive compensation to guarantee quality and security due to the connection of a new large consumer).

There are also other aspects that may differentiate tariffs in the different power systems in terms of:

- how the connection tariffs may be established or agreed upon, they may be considered regulated or commercial;
- the allocation of costs to generators and loads;
- incentives for customers whose connection defers network reinforcement.

Resulting from the questionnaire the following appeared:

- Deep costs are only paid by the customer in France and Germany; but only in case of generators. In Australia and New Zealand these are paid by both the user and the grid owner. In Norway if expenses exceed the NCs allowable revenues due to their connection there are extra charges for the customer.
- Shallow costs are paid by the user in every country. If the user is a generator, then mostly 100% of these costs are charged to them, but if it is a consumer there are countries where the fees are smaller (50% in Ireland).
- For shallow assets, operation and maintenance expenses mostly are included as part of connection charges. Sometimes the expenses are included as part of the use of system charges.
- Tariffs for the connection are regulated in most systems except in Germany, Japan and New Zealand where they are commercial. In Australia tariffs are commercial only for shallow costs.
- Usually in the case of radial connection, when the customer only uses it, they are required to pay for it even though the line may belong to the transmission system. When a second customer uses facilities initially paid for by one customer, some countries establish a “grand fathering” system that makes payments for part of the facilities to the first customer. This system exists in France, in Spain (applicable during five years since the starting of operation) and in Ireland (10 years for rebates).
- When applicants are deciding upon a connection point they may consider locations at which their connection would defer network augmentation. If they decide to do so, the system could consider rewarding them for avoiding the augmentation. Generally the systems considered do not have such pricing incentives for customers. In Australia there is a mechanism for making Network Support Service payments to connected parties that provide an alternative to network augmentation. In some countries (Ireland, Germany, England & Wales) customers pay for their impact on system losses in the network. In Ireland and England & Wales locational TUoS charges for

generators also rewards generators for locating in less congested parts of the system.

Appendix 4 gives a comparative summary of the main aspects related to costs and ownership.

2.4. Denial of Connection and User Constraints

Across the systems considered there is a mix of ways for dealing with new connections that introduce significant cost or technical issues on to the system. For some systems all applicants must be offered a connection agreement irrespective of any system related issues that they introduce whereas for others it is permissible, subject to certain criteria being met, to deny a connection agreement.

The criteria for denying applications are different in each system. Technical and economical reasons can be considered. Network operators often have the obligation to preserve the system security and quality and therefore if technical limits are exceeded they may not allow the new connection.

From the questionnaire it was found:

- Connection can never be denied in France, Italy, Germany, England & Wales, Australia and New Zealand even if a technical limit would be exceeded. A feasible connection solution should always be looked for, including all necessary reinforcements. In Ireland, in theory a connection can be denied, if it can be proven that it would pose a danger to system security or reliability, however a feasible connection including all necessary reinforcements must be sought, which means in practice connections are not denied.
- In Australia, connection can only be denied if a customer cannot meet minimum technical standards mandated in codes. Constraints on dispatch are managed through the energy market process; there are no rights to transmission capacity in Australia.
- In Norway and Queensland connection can never be denied for technical reasons but if it is not economic it may not be affordable.
- In Spain, the refusal concerns the connection solution proposed by the user in the application and it is mainly associated with system stability for generators and to power quality consequences for specific loads (high-speed trains, arc furnaces, …). The reply will include alternative solutions for access in other connection points or reinforcements to be made in the grid to solve the restrictions or congestions forecasts. Cost considerations are not included explicitly but are taken into account in the development criteria or dealt with in the planning process.
- In all other countries connection can be denied if a technical limit would be exceeded, especially if associated with system security, and solutions are too costly for either the network company and/or the customer.

Another aspect of the connection agreements deals with the possible constraints that a new connection can bring about to existing installations. The following was reported:

- Connection of a new generator/load may not result in constraints on existing ones in Japan, Western Australia and England & Wales.
- In Germany this should be avoided and in Norway this would be temporarily because they would augment the grid.
- In France and Italy, these constraints must not result in congesting the dispatch or a diminution of the quality of supply to other existing customers.
- In Spain, no constraints in level and quality of supply must appear on previous consumers motivated by new applicants (generators or loads). However, new

constraints may appear in previous generators by the connection of new users (generally other new generators) and these are solved via operation markets managed by the system operator (REE), either day-ahead or intra-daily seasons. Constrained-off generators are not compensated.

- In the case of Ireland loads cannot generate these constraints but generators can, and generators affected are compensated by the TSO. In the Netherlands the network operator bears the consequences of constraints if not agreed otherwise.
- In the other countries there might be constraints to existing generators caused by new connections, but this is usually never the case for existing loads.

3. Specification of Transmission Services

Once connected the user of transmission services may expect certain rights.
In this chapter the following issues are discussed:

- Ability to take load or generate
- Quality of supply
- Maintenance
- Consequences of disturbances.

3.1. Ability to take Load or Generate

A common conclusion is that there are some kinds of guarantees often regulated by a regulating body. There are however some countries lacking the regulator function and in those countries the guarantees are covered/regulated by bilateral contracts or standard contracts. Some countries distinguish guarantees between consumption (take load) and generation. Generation often has lesser degree of guarantees for firm access to grids.

Historically, access to the transmission system was described in engineering terms covering the ability of a generator to generate or a load to consume during the outage of a transmission element due to maintenance or a fault. The description generally related to security of supply using a deterministic description such as N-0, N-1 and N-2.

With the advent of markets the concept of access for loads has largely remained unchanged. Network owners continue to plan and develop their networks to meet the expectations of the demand side. Interruptions to loads due to normally occurring transmission constraints are not politically acceptable outcomes.

On the other hand, the diversity of available generation to meet load has meant historically a lesser level of access to the supply side, this continues today. Also, access to a generator can mean either physical access or financial compensation. Physical access means that a generator can generate to the level that the market dictates whenever the generator wishes to. Financial access means that a generator that is subject to power system constraints and consequently cannot generate to the level that the market would otherwise dictate is compensated for the constraint. Similarly, generators that are required to generate when the market would otherwise not require them to generate can be compensated.

Compensation mechanisms can be either part of the market rules as detailed in codes or provided for in connection agreements.

The degree of regulation varies a lot between the countries that have answered the questionnaire. More or less all countries say that there are regimes for providing firm access to the grid and that the condition for this is given by regulations or by standard contracts.

TSOs and DSOs normally propose a connection to the network user that fits best the wishes of the user and complies with the standards of the SO.

3.2. Quality of Supply (technical)

Quality of supply is mostly coupled to characteristics of the voltage delivered (voltage level, flicker, unbalance, harmonics, dips, etc.) and for this EMC is an important feature.

Electromagnetic compatibility (EMC) is concerned with the possible degradation of the performance of electrical and electronic equipment due to the disturbances present in the electromagnetic environment in which the equipment operates. For compatibility, there are two essential requirements:

- the emission of disturbances into the electromagnetic environment must be maintained below a level that would cause an unacceptable degradation of the performance of equipment operating in that environment;
- all equipment operating in the electromagnetic environment must have sufficient immunity for all disturbances at the levels at which they exist in the environment.

The *compatibility* level is intended to represent a measure for the cumulative disturbance level in a given environment, which is expected to be exceeded quite rarely (probability < 5 %). It is the specified electromagnetic disturbance level used as a reference level in a specified environment for coordination of the setting of emission and immunity limits.

For each disturbance phenomenon, the compatibility level must be recognised as the level of severity, which can exist in the relevant environment. All equipment intended for operation in that environment requires having immunity at least to that level of disturbance. Normally a margin will be provided between the *immunity* level and the compatibility level, appropriate to the equipment concerned.

Some disturbances have their sources in atmospheric phenomena, especially lightning, but also in the normal and unavoidable response of a supply system to electrical faults or to the switching of load or particular devices. Limits for *emission* cannot be assigned for these phenomena, since the sources are largely uncontrollable. Disturbances, which have their source in equipment, are highly diverse and, especially in the case of low frequency disturbances, any source to which a limit is to be applied is only one of many sources combining together. Still the objective of setting emission limits is to ensure that actual disturbance levels will only exceed the compatibility level with a very low probability.

The *planning* level is a level of a particular disturbance adopted as a reference value for the limits to be set for the emissions from large loads and installations, in order to coordinate those limits with all the limits adopted for equipment intended to be connected to the power supply system. The planning level is lower than the compatibility level by a margin, which depends on factors such as the structure and electrical characteristics of the supply network, possibility of resonance etc. The main objective is to ensure that the predicted level of disturbance does not exceed the compatibility level.

The *service* level is the highest disturbance level allowed for a certain phenomenon, which however still should be lower than the compatibility level.

Without taking notice of the stochastic characteristics of these phenomena the levels are in descending order: immunity level → compatibility level → service level → planning level → emission level.

In most countries there exist rules for planning levels. Often mentioned are Cigré and IEC standards, EN 50160 and some kind of national standard or code.

In almost every country there exist rules for service levels or they are being developed. Often mentioned are EN 50160, IEC-standards (IEC 38, IEC 61000-2-2, IEC 61000-2-12) and a national code or standard. The actual levels are taken directly from the existing standards or are adapted.

In most countries there is a differentiation depending on the voltage level. In France the differentiation is mainly for the number of interruptions.

3.3. Maintenance

TSOs and DSOs normally will propose a supply connection to the network user, which best fits to the wishes of the user and complies with the standards of the SO.
Maintenance and other reasons for planned outages of network components are most often coordinated with the system users. This is laid down in the grid code as an objective, or as an obligation or is part of the contractual arrangements between the SO and the system user. The procedure might be different in the different countries (for instance who takes the lead) but the purpose is the same, which means minimizing the effects for the system users.
The connection between TSOs and DSOs mostly is treated differently. Here the common aim is to minimize the consequences for both partners and to plan and to organize in the optimal way the maintenance keeping in mind the security rules.
Maintenance in the network normally is taken care of in the operational planning and management of the network of the respective TSO and DSO. The consequences for the system users in case of disturbed conditions are treated in the grid codes.
For instance in Italy, the maintenance of the lines and other facilities of the transmission network is coordinated by the TSO (GRTN) in conjunction with the various network owners; this is adjusted according to a rolling procedure.

3.4. Consequences of Disturbances

In one way or another all the countries report disturbances to their customers.

Some countries have given more explanation:

- In Italy the question is currently under consideration.
- In Germany it is depending on the dimension of the disturbance.
- In Belgium disturbances are subject of reporting to the customers directly connected to the transmission grid. The transmission network manager pays a limited fee to the customer for the energy not supplied.
- In the Netherlands disturbances are handled in consultancy if the customer can help in recovery. Disturbances are always reported.
- In Spain customers have the right of discount in their electricity bills by the distributor (even those connected to the transmission grid have their commercial contracts with distributors) for the energy not supplied. This discount has to be carried out during the first 3 months of the year following the supply interruption, and those discounts may be "passed-through" by the distributor to the transmission company when interruptions are due to transmission, within that mentioned period. The system operator must report the origin of disturbances –transmission or distribution- so that compensation is assigned. However, this only applies to energy not supplied and not to other aspects of power quality (waveform distortion), for which no compensation is established but the need to take the remedial actions through system development.
- In Australia, large disturbances are subject to reporting by the entity responsible for system security, not necessarily the network owner. Restoration is the responsibility of the TSO who coordinates with customers via transmission owners.

At least a few movable generators, transformers and lines are mostly available. Sometimes only lines or only transformers, or limited to certain voltage levels. In Spain some transformers, reactors and capacitors may be moved in a time span of months (spare transformation units are available) and there are emergency lines available mainly for natural disasters. In Belgium an emergency line 380 kV is available and normally there are always spare transformers available.

Penalty in case of a disturbance

Usually this is not automatically the case.

Special conditions must exist:

- In France and New-Zealand if guaranteed levels are exceeded.
- In Italy, the regulator is introducing penalties to the DSOs. Since the first regulatory period 2000-2003 a regulation of the "service continuity" of the distribution has been put in force. Results have been: improvements on service continuity; reduction of regional differences in such indexes, the implementation by the distributors of a common procedure of interruption recording. An automatic rebate mechanism, should the specific level not be complied, has shown its effectiveness. These and similar measures have been updated with the new ruling on the quality of service valid for second regulatory period 2004-2007.
- In Spain conditions for discount payable by the distributor are as follows: when the energy not supplied is associated to distribution nodes with an individual quality indicator lower than required (reference depending on type of nodes: rural, urban,...). Conditions for passing-through the discount payable by the transmission company: when the energy not supplied is associated to transmission nodes with an individual quality indicator lower than required (reference depending on whether the node is meshed or not) and the interruption has been caused by transmission as a conclusion of analysis by the system operator.
- In Belgium a financial compensation is foreseen in the ”connection contract”, as a function of the interruption time due to the TSO.
- In Victoria, the customer is penalised when causing a disturbance and proven to be negligent.

Incentives for better performance are rather rare:

- In Spain transmission companies receive their annual income partially depending on the performance of the facilities. The availability indices of the transmission companies compared with a required reference (this is applied to all the company assets, weighted by their rated power) allow an incentive or a penalty in the company income (reference is 97% at the moment).
- In Belgium some regulators ask for a reporting that prove that the level of power availability (interruption time) is maintained. For the moment no penalties are foreseen.
- In the Netherlands, the possibility exists to make this part of the connection agreement.
- In the Australian context the regulator has included a performance incentive scheme that can penalise or reward up to 1% of revenue for poor or good performance.

4. Consequences for the Network

This chapter discusses the mechanisms by which network owners manage their obligations to design and operate their networks and ensure facilities are in place for secure operation and control.

New generation typically triggers step changes in power flows across the network. But also changes in load and shut down of generation have consequences for the network. In order to ensure the secure operation of the transmission system the transmission system must possess adequate capacity to cope with the new patterns of power flow across all expected operating conditions.

Primary transmission capacity is not however the only determining factor in providing a secure network. The network owner must also ensure that all plant connected to the system meets minimum technical requirements so as to ensure that the system can be operated within operational standards.

The items listed below are discussed in the following sections:

- Minimum requirements for customers
- Short circuit level impact
- Remote monitoring and control
- Standard technical requirements/negotiable options
- Capacity need of the grid
- Obligations of dispersed generation
- Plant capabilities.

4.1. Minimum Requirements for Customers

In general the respondents to the questionnaire indicated that all minimum requirements to be met by loads and generators, are specified in grid codes or in other “equivalent” documents related to their Transmission and/or Distribution systems.

Typically the minimum requirements that Users will be required to accommodate relate to:

- voltage performance, in especially the maximum and minimum voltage on the system, the level of voltage step change, short and long term flicker levels;
- frequency deviation, i.e. the permitted frequency deviation across the system and for generators the allowable level of power output variation across the frequency range;
- maximum allowable fault clearance times at different voltage levels;
- voltage waveform quality, maximum levels of harmonic distortion on the system and maximum levels of unbalanced voltages.

4.2. Short Circuit Level impact

The issue of increased short circuit levels resulting from new connections is not treated consistently across all systems. In particular with reference to the potential cost of network reinforcement such as replacing circuit breakers or implementing different busbar layouts, should the new injections of power result in fault levels in excess of the existing short circuit capacity.

In particular:

- In the Netherlands and England & Wales no maximum short circuit levels are defined.

- In Italy and Spain standard levels are defined (for instance in Italy: 50 kA for 380 kV; 31,5-40-50 kA for 220 kV and 20-31,5 kA for the 120/150 kV voltage level).
- In France any reinforcement of the short circuit level is borne by the TSO.
- The Australian and England & Wales responses noted the generator short circuit ratio requirements as they relate to system transient stability. That is the ratio of field current at no load and rated volts to field current at rated generator current. In England & Wales a minimum ratio of 0.4 is specified.
- In Australia if the connection of a generator could lead fault levels being exceeded then generation will be constrained accordingly.

4.3. Remote Monitoring and Control

Normally there are standard requirements in terms of what operational data is to be provided and in terms of the means in which that data is provided.

In most cases it is the responsibility of the customer to provide data up to the interface point. From the interface point the transmission company takes responsibility for the transmission and monitoring of this data.

The Company responsible for market operations, not the network owner, has the responsibility to communicate the SCADA data to their control facility. The SCADA data includes status of equipment such as circuit breaker and disconnectors, and real and reactive power, voltages, and currents.

The SCADA data can also include dispatch instructions from the market operator.

In Italy, for instance, the producers transmit the signals related to system real time control to the ISO (GRTN). The data transmitted includes active and reactive power injected into the National Transmission Network (NTN), voltage at the point of injection and the status of the various circuit breakers and disconnectors connected to the NTN busbars. This data is collected by an Integrated Tele Management Operation System, which consists of a telecommunication Wide Area Network, data concentrators and local SCADA and Energy Management Systems (Remote Terminal Units - RTU, Man Machine Interface - MMI).

In Italy, the data exchange between producers and GRTN can de done in two ways. That is either direct connection between the RTUs of the producers and GRTN or indirect connection. Under the indirect system the plant data from the Producers is concentrated in the producers own Tele Operation Centre and from there transmitted to GRTN.
The costs associated with the installation and maintenance of the data-transmitting network from the producers to GRTN and the cost of providing software for making available the data to the GRTN are the responsibility of the producer.

4.4. Standard technical Requirements/Negotiable options

The framework under which a connection can be realised and standards can be met, so that a network owner or operator can meet their obligations to both newly connected parties and existing customers, can vary between strict adherence to standards by the new customers or through negotiation of performance with the network owner. Such arrangements may involve one customer meeting a higher standard so that another customer needs only to meet a lower standard. Examples being: reactive capability of generation where a synchronous generator could provide excess reactive to compensate for an asynchronous generator that may not be able to provide adequate reactive capability; or a disturbing load may not be able to meet emission levels but another load may be able to absorb the emissions.

In the Eastern states of Australia, for example, there is a codified framework for technical standards to be met by the network owner, generators and loads. The framework covers customer plant standards and includes:

- minimum access standards that must be met, if not met connection can be denied;
- automatic access standards which if met then connection cannot be denied;
- provision for negotiation of the actual standard met by the customer between the minimum and automatic access standards.

The plant standards cover protection schemes, reactive capability or power factor, load current balancing, voltage fluctuations, harmonics and voltage notching, load shedding and remote monitoring and control interfaces. Also, there is a set of system standards that must be met by the network owner (these include: voltage, harmonics, flicker, dips, swells, notching, voltage unbalance, system frequency, system damping and temporary power frequency overvoltages).

4.5. Capacity Need of the grid

The respondents identified that all transmission companies undertake system studies as part of their new connection offer process.

In most countries the capacity of the grid system is assessed against a series of deterministic standards, which specify a minimum level of security of supply to be met by the network. In some countries such as France, Ireland and England & Wales the requirement for associated deep reinforcements will be identified during the offer process and will be triggered by the customer signing the offer for connection. In this case the connectee is not eligible for full transmission access until all necessary reinforcements are in place and from that time they will be eligible for constraint payments if lack of transmission capacity restricts their operation. The transmission company will pay for these deep reinforcements, although the connectee will be required to guarantee the works during construction.

In some countries achieving a connection to the grid is not dependent on the completion of deep reinforcements and there is no guarantee of the availability of adequate capacity to ensure full dispatch. In these cases it is likely that the connectee will not be eligible for constraint payments should a lack of capacity impact upon their operation.

In the eastern states of Australia, for instance, the network owner has the responsibility to monitor the capability of the network and to produce annual planning reviews that highlight the prevailing and emerging issues associated with constraints on generation dispatch. The network owner will augment the network if the investment can be shown to meet a “regulatory test” which is a combination of meeting particular security and power supply quality technical standards or having net economic benefit. There is also a framework where private investment in network assets can occur.

4.6. Obligations of Dispersed Generation

Dispersed Generation, particularly from sources of wind energy, is an increasing reality in many systems.

In most networks the performance obligations that dispersed generation are required to meet are specified in the relevant grid code or distribution code. These performance requirements are typically based upon the maximum level of plant output. In some countries distributed generation may have a priority dispatch if it is based upon a renewable energy source like wind.

In Germany where there is a significant wind resource, special requirements for wind farms are under preparation. The same discussion is also taking place in Spain and some other countries. The next chapter mentions some of these new requirements.

In Belgium there are two different levels of reactive power output specified for dispersed generation.

In the Australian context generation units below 30 MW can self-dispatch, that is they are not under the direction of the market operator. The network owner can rely upon dispersed generation only if there is an agreement with the generator for what is known as network support services. The daily planning of generation in this environment, with a large quantity of self-dispatching intermittent generation, is becoming a key system security issue for the future.

4.7. Plant capabilities

Customers, especially generators, have to provide the network operator with detailed information about the capabilities of the installations. This is mainly outlined in the grid codes or in the application forms for connection.

In most cases the grid code defines the technical data that must be provided by the customers. This information must be sufficient for the network owner to undertake all types of system studies. The customer must also provide models of their plant; those models may, for example in Australia, or may not become public information accessible to all market participants. For generators the data may include capability diagrams, voltage regulation, governor features, boiler characteristics, loading rates, open and short circuit characteristics, generator transformer details, impedances and time constants.

5. Connection of Dispersed Generation

The development of dispersed generation is generally a consequence of attractive national incentives in order to reach some financial or environmental target like the Kyoto protocol for example. Until recently, dispersed generation meant small units and small total installed capacity and as such was considered as marginal.
Even if the unitary power of each installation can still be considered as small, the total amount of installed generation can represent or will represent a high percent of the national generating capacity, even exceeding 20%. From the connection point of view, the magnitude might be such that the possibilities of the distribution grid are far surpassed, and concentrations of hundreds of MW in connection points make that the term “dispersed” - although maintained in this document- not to be so precise.
As such, transmission or distribution system operators would appreciate it if these new installations behave like the conventional installations from a technical point of view. Providing inertia, frequency control, fault level control and fault ride-through ability are important issues.

In this chapter the following topics are treated:
- Special rules for dispersed generation
- Different rules depending on the source of energy
- Different rules depending on the type of coupling to the grid
- Possibility for dispersed generation to provide secure supply.

5.1. Special Rules for Dispersed Generation

Commercial incentives

Several mechanisms help the promotion of dispersed generation, including renewable energy sources (RES):
- subsidies, possibly combined with other mechanisms: the Netherlands and Spain (as one of the options, see below);
- obligation for the producers to provide a fixed percentage of green energy (e.g. 2%); consequently a green certificates market is developing: Australia, Italy, the Netherlands, United Kingdom;
- priority of dispatching (guideline in European regulation);
- obligation for the TSO or DSO to purchase green electricity at a fixed price: Germany, Ireland, Italy (old legislation), Korea and Spain (original option of a pre-established fixed price; besides there is another option of a price indexed to the pool price);
- obligation for the historical producer to purchase green electricity at a fixed price: France.

In some countries different schemes have been consecutively implemented, like in Spain where a recent regulation establishes currently, a fix remuneration indexed to the average pool price and an alternative option in which the reference to the pool price is lower, although a number of new complements/bonus are implemented: general incentives, long term supply guarantee, reactive resources, as well as new obligations as deviation management or compliance with ride-through capability requirements. The purpose of this is to encourage a major participation in the market mechanisms.

Network planning

The most general rule for network planning is to examine load flows on so-called “N-0” networks and for all “N-1” situations. “N-2” situations (double circuit failure or “N-1” during

maintenance) may also be examined (Spain, the Netherlands). Mostly both maximum and minimum power is examined as well as for the demand as for the generating units.
These rules apply both for conventional units and for dispersed generation connected to the network.
The case of wind power is slightly different (even if it is globally not treated differently from other types of generation) in the sense that the probability for a large wind farm to operate at maximum power is very low (a few hours per year). Some countries are studying the possibility to introduce a probabilistic approach, more suitable to this type of generation (Belgium).

Technical requirements
Dispersed generation, in the real sense of small installations or units, normally is connected to the distribution system. The design of medium voltage networks, however, is not always suitable to take significant amounts of generation. There is an impact on protection, loading of equipment and voltage margins to be kept.

In general, the performances required are less extensive for generation plants connected to distribution networks than for those connected to transmission systems, particularly for reactive and active power control.
However more stringent specifications for dispersed generation are in preparation in several countries: Belgium, France, Germany, Italy, Spain and Ireland. In presence of huge production from wind source, such production should remain connected in case of short interruptions. For instance having a fault ride-through capability for wind power plants (about 0.2 to 0.5 s for a voltage dip close to zero up to 20 %). And furthermore to support the voltage when a network is disturbed and the voltages do not recover sufficiently. This support must be provided within a short time after identification and must last several seconds.

Mostly up till now, islanding of parts of the public network is not permitted in order to avoid unexpected feeding into the network by dispersed generation (either in case of faults or during network maintenance). Over/under frequency and over/under voltage relays are required at the border (interface) between producers and public network.

Hardly any procedures or methodologies exist to express in money the advantages to the network by a dispersed generator connected to the MV or LV network.

5.2. Different Rules depending on the Source of energy

The technical rules defined in grid codes generally depend on the size and the voltage level of the installation and not on the primary source with the exception of wind generation and run of the river hydro generation that are exempt from frequency control. Complementary requirements may be applied like in Spain: the sum of wind farm nominal power must be lower than 5% of the expected short circuit level of the grid at the connection point.
Given the specificity of the commercial and contractual rules, intermittent generation participates rarely in the “balancing mechanism” between generation and demand. However in Spain, the participation in the Power Market gets an economical incentive. When generators do not contract their production, they are obliged to communicate the forecasted production programmes to the distribution company when the power capacity is over 10 MW (economical consequences for deviations).
More generally, in countries with a high penetration of wind power there is a requirement for generation forecasts the day ahead using weather forecasts and real time information of large parts of installed wind capacity (Spain and Germany). Information is generally exchanged between wind farms connected on HV and EHV networks and the TSO control centre (active and reactive power, status information…), but not between installations connected on MV networks and the TSO control centre. Such information may be available

in the DSO control centres, however there is rarely an automatic exchange of information between a TSO and DSOs (with the exception of Spain).

5.3. Different Rules depending on the Type of Coupling to the grid

In many countries, the rules are the same whatever the technology is. However adaptations are necessary in case of asynchronous generator for the control of reactive power: Australia, France, Ireland, Italy and Korea.
In some countries, there are specific rules for asynchronous machines with less severe requirements: Belgium, Germany, the Netherlands, Norway and proposed in Ireland.

5.4. Possibility for Dispersed Generation to provide Secure Supply

There are two aspects regarding this issue:

- from a technical point of view, it is considered that dispersed generation often trips during disturbed situation or voltage dip; thus SO cannot take it into account with the same availability as centralised generation;
- from a contractual point of view, due to the great variability in the output power of intermittent generation, it is considered that a customer including dispersed generation in its load must contract for the difference between internal load and actual generation. In addition, load reduction or contracts for supply shortfalls are required to cover generation tripping.

6. Conclusions and Recommendations

Power systems generally have connection and access procedures as regulated mechanisms for agents wishing to interact with the network, with the objective of injecting energy into or absorbing energy from the system.

In general, the connection procedure is defined as the set of rules and requirements, which establish the way agents wishing to link their new facilities to the network, may do so. By extension, many systems also include within this procedure the mechanism by which a facility with an existing connection to the network may change their connection conditions.

Resulting from the questionnaire, in most systems, applications are addressed to the network company, acting as the network service provider.
In some countries with a formal separation between network and system operation, the independent system operator manages the connection together with the network company or both functions are involved separately.

In all countries technical requirements and the process for connection are described in laws and/or codes. Usually there is a specific body, independent or different from the Governmental Administration, which tends to be referred to as the regulator. The roles and duties of the regulatory body are different in each country, but in general it is in charge of ensuring the proper application of the rules. In particular, regarding the connection process, the regulatory body generally is responsible for supervising the process of connection and solving disputes when necessary.

Network companies (or bodies to which applications must be addressed) always have the duty to respond to the applications that they receive.
When the customer applies for connection to the network, a connection study might be needed. In most systems it is usually the customer who pays for the connection study. However in some systems customers do not pay for the study, at least not when it is meant as a feasibility study.
Sometimes applications can interact with each other and may cause constraints on each other. In order to establish a priority, most of the countries use the "first in first out" system. When such interaction exists, offers may be revised.

All systems have legal and technical definitions of the connection and the connection point. Generally, connection is defined as the physical attachment of the user system (new facility) to the network.
In most cases the connection point marks the ownership limit and the separation between user and network company (or system operator) responsibilities; then legal and technical operational boundaries coincide. However, in some systems it is possible that radial connections may belong to the user and although be part of the transmission system.

For the cost splitting the boundary is not always located at the same point as the legal and technical boundary. In most cases, connection facilities which are only used by the customer, are funded by that customer, although they may belong to the network.
If the user is a generator, then mostly 100% of these shallow costs are charged to them, but if it is a consumer in some countries the fees are smaller.
Tariffs for the connection are regulated in most systems; sometimes they are commercial.

Deep costs that are caused by the connection but which are not made at the connection point but further into the system are only paid by the user in some countries and then mostly only in the case of generators. Sometimes both the user and the grid owner are paying, but mostly the network owner is obliged to bear the costs.

It is apparent that network reinforcement and constraint handling because of power changes in the facilities of the customers, are not at all uniformly dealt with in the countries surveyed in the enquiry. A real technical and economical assessment could perhaps clarify this issue.

The criteria for denying applications are also different in each system. Technical and economical reasons are considered everywhere. Network operators often have the obligation to preserve the system security and quality and therefore if technical limits are exceeded they may not allow the new connection.
For some systems all applicants must be offered a feasible connection solution irrespective of any system related issue that they might introduce.

Furthermore, the possible constraints that a new connection can bring about to existing installations are treated differently. Historically, access to the transmission system was described in engineering terms covering the ability of a generator to generate or a load to consume during the outage of a transmission element due to maintenance or a fault.
With the advent of markets the concept of access for loads has largely remained unchanged. Generation, however, often has lesser degree of guarantees for firm access to grids.
Compensation mechanisms can be either part of the market rules as detailed in codes or provided for in connection agreements.

In most countries, for the emissions of particular disturbances like harmonics, flicker, unbalance, etc. from large loads and installations, there is a differentiation depending on the voltage level in order to coordinate those limits with all the limits adopted for equipment intended to be connected to the power supply system.

In almost every country there exist rules, or they are being developed, for service levels which express the highest disturbance level allowed for a certain phenomenon. In some systems the number of interruptions is part of the defined service levels. And penalties are associated to these guaranteed standards. Incentives for better performance are also mentioned but these are mostly coupled to global network company regulation measures.

The minimum requirements to be met by loads and generators, are normally specified in grid codes or in other “equivalent” documents related to their transmission and/or distribution systems.

Quite often in the connection contract specific issues are covered, which are not standard like maintenance handling, providing extra services, etc.

In most cases it is the responsibility of the customer to provide data up to the interface point. From the interface point the transmission company takes responsibility for the transmission and monitoring of this data. Customers, especially generators, have to provide the network operator with detailed information about the capabilities of the installations.

In general, the technical requirements required for generation plants connected to distribution networks are less extensive than for those connected to transmission systems, particularly for reactive and active power control.

The technical rules depend generally on the size and the voltage level of the installation and not on the primary source with the exception of wind generation and run of the water hydro generation that are exempted from frequency control.

In some countries special requirements are being set up for wind farms in order to improve their ability to support the network during disturbances. It will be worthwhile to examine on a broader scale the problems encountered and the need for such requirements in the future.

Within the working group involved in making this report, the discussion has been very open and fruitful and has led to a deeper understanding of the approaches in different parts of the world. Via this report others can also take advantage of these deliberations.

Appendix 1. Connection Procedure Schemes

FRANCE

USER	RTE
⇐ Informal exchange of information ⇒	
Application Form ⇒	
	Connection Study Feasibility and Cost Connection Proposal — < 3 months
⇐	
< 3 months — Acceptance and payment of 10% of total price ⇒	
	Detailed studies Legal Authorisations
⇐ Connection Agreement ⇒	
	Realisation
⇐ Operation Agreement ⇒	
	Putting into commission the connection

ITALY

USER		GRTN or DC
Request Fee Payment (still under discussion)	⇒	
		Connection Study Request of additional information
	⇐	
Provide additional information		
	⇒	Connection Proposal
	⇐	
Acceptance or request for alternative solutions.		
	⇒	Approval of the project by TSO (GRTN) and/or DCs
	⇐	
Auction for the plants construction Bank Guarantee		
	⇒	Legal Authorisations Commissioning

Example from GERMANY

USER		DSO or TSO
Application	⇒	
		Feasibility study for grid connection
	⇐	
⇐	Memorandum of understanding	⇒
		Licensing procedure for grid connection and grid reinforcement. Project planning
⇐	Contract for grid connection	⇒
⇐	System Management Agreement Contract for grid usage System Services	⇒

BELGIUM

Grid code

USER		DSO or TSO	
Request	⇒	Request of additional information	10 days for TSO
Provide additional information	⇐ ⇒		
Technical Agreement between TSO and user			60 days
	⇐	Connection Proposal, with binding offer (cost)	40 days for TSO
Acceptance of proposal	⇒		30 days for user
Connection Agreement			

BELGIUM

TSO self-imposed

USER		DSO or TSO	
Request	⇒	Request of additional information	10 days for TSO
Provide additional information	⇐ ⇒	Connection Proposal	40 days for TSO
Acceptance of proposal	⇐ ⇒		40 days
⇐ Connection Agreement ⇒			

THE NETHERLANDS

USER		NC
	Inventory phase Study phase	
Application	⇒	
		Connection Proposal
	⇐	
Acceptance of proposal	⇒	
⇐	Project Agreement	⇒
		Building installation
⇐	Changing connection Agreement	⇒

NORWAY

USER		REGULATOR & GRID OWNER
Sends the project	⇒	
		Ask for necessary studies
	⇐	
Makes studies Application	⇒	
		Application on a public hearing
	⇐	
If project not accepted, complaints to government. Acceptance of proposal	⇒	
⇐	Project Agreement	⇒

IRELAND

USER				ESBNG	
Application (incl. fee)		⇒			
		⇐		Request of additional information	10 days
Provide additional information		⇒			
		⇐		Process application Connection Proposal	70 days
70 days	Acceptance of proposal (incl. relevant connection charges & bonds)	⇒		Connection Agreement	
⇐	Scheme construction			Scheme construction	⇒

SPAIN

ACCESS		
USER	**SO & TSM (REE)**	**TRANSCO (mostly REE)**
Access application ⇒		
	Information analysis Identification of connection point ⇒ Request of additional information	
⇐		
Provide additional information [< 1 month] ⇒		
⇐	Feasibility report < 2 months ⇒	

CONNECTION		
USER	**SO & TSM (REE)**	**TRANSCO (mostly REE)**
Project & Installation program ⇒	⇒ ⇒ ⇒ ⇒ ⇒	
		Analyses and determination of technical conditions Report on technical conditions for connection [< 1 month]
	Analyses ⇐	
⇐	Report [< 1 month] ⇒	
⇐	Contract between User and NC for access to the transmission grid ⇒	

ENGLAND & WALES

USER		NGC	
Application Form (Including all Data and Fee)	⇒		
		Data from customer checked Make studies Identify scheme options Scheme option selected Scheme developed Scheme Sanctioned	90 days
	⇐	Scheme Offer	
Offer signed			
⇐	Scheme construction	⇒	

JAPAN

USER		NC
Application of availability	⇒	
		Response
	⇐	
Application of construction		
	⇒	
⇐	Contract of Supply & Connection Contract of charges of construction	⇒
Deposit of charges		
	Construction Start of Supply & Connection	

KOREA

USER		KEPCO
Application Form	⇒	
		Receive application Connection proposal Approval of the regulator (KOREC) — <4 months
	⇐	
< 2 months — Agreement of connection	⇒	
⇐	Contract	⇒
Detail data offer	⇒	
		Connection guarantee
	Construction	

AUSTRALIA

USER		NETWORK SERVICE PROVIDER
Preliminary enquiry	⇒	Assess suitability of network Preliminary program showing 2 weeks contains milestones for connection
	⇐	
Application and fee payment	⇒	Studies (exchange of information with other networks) Request for additional information
Provide additional information	⇐	
Negotiate the connection proposal	⇐	Connection proposal (time required agreed between the parties)
	Connection Agreement	
	Advise the agency responsible for market operation and system security of the connection agreement	

Appendix 2. Summary of Studies for Connection

	EUROPE					
	FRANCE		ITALY		GERMANY	
Type of the study	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**
Responsible	TSO (RTE)	TSO (RTE)		TSO (GRTN) or DCs	TSO	
Time span to make it		3 months		90 days 60 days for plants utilising a new authorisation mechanism	2 weeks	
Contents				Mainly load flow and short circuit in case of need; stability studies only in particular cases	2-3 months	
Tariffs for the study		NC pays (customers participation envisaged)		Rules under discussion	Customer	
Binding				Orientative. No grid reserve		
Validity		3 months		60 days for the acceptance		
Bank Guarantee		10% of total cost		Only after the conclusion of auctioning		

	EUROPE					
	BELGIUM		NETHERLANDS		NORWAY	
Type of the study	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**
Responsible	TSO/DSO	TSO/DSO	TSO/DSO	TSO/DSO		Customer (the NC asks for the necessary studies)
Time span to make it	DSO: 30 days TSO: 40 days	DSO: 30 days TSO: 60 + 30 days (self-imposed: 40 days)	2-8 weeks	No formal time		Reasonable
Contents	Connection scheme & requirements & indicative cost of connection	Connection scheme & requirements & timing, engineering, binding cost of connection	Load flow, connection scheme, cost indication	Engineering of the connection, connection proposal, timing		
Tariffs for the study	Small-2250 €; medium-4500 €; large-9000 €; complicated-negotiated	% of connection cost	Generally no cost for customers but if it is necessary they must assist	By agreement		Customer
Binding	No	Yes, power reservation	No	Yes		
Validity	Not applicable	30 days for TSO and 40 for DSO		Stated in the offer (negotiated)		Time the offer is open
Bank Guarantee	No			Not for the studies		

	EUROPE					
	IRELAND		SPAIN		ENGLAND & WALES	
Type of the study	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**
Responsible	TSO	TN:TSO (ESBNG to become EirGrid)	SO (REE)	TC (mostly REE) + SO (must validate it)		NC (NGC)
Time span to make it	8 weeks + depending on scope	70 days after receipt of complete info (can be longer if complex offer)	2 months (from the moment that all the info is received)	1 month for TC + 1 month for the SO to validate it		90 days
Contents	Depends on scope, usually: connection method, deep reinforce-ments, budget costs and estimated lead times	Connection method, load flow, short circuit & dynamic stability studies, development of deep reinforce-ments	Load flow, short circuit, stability (Grid development aspects)	Engineering of the connection (transmission company)		Load flow, short circuit, stability
Tariffs for the study	Customer €10k+ depending on scope	Customer (see table)	No cost for customer	No cost for customer		Customer (see table)
Binding	No	Yes, if offer accepted	Orientative. No grid reserve	Guarantee for connection, not for operation		
Validity	No	70 days	6 months	1 month (to sign the contract of access to the grid)		90 days
Bank Guarantee	No	Yes, condition precedent for acceptance of offer	No	20% of the connection costs		

Tariffs E&W

Table A: Fixed Prices for New Bilateral Agreements

			MW	FEE (£'000)	AGREEMENT TYPE (as Table C)
1	Directly connected generation	North	< 300 =>300 < 1320 => 1320	35 + VAT 70 + VAT 100 + VAT	Bilateral Connection Agreement
		South	< 300 =>300 <1320 =>1320	25 + VAT 50 + VAT 70 + VAT	Bilateral Connection Agreement
2	Directly connected reactive only service provider		-	20 + VAT per site 10 + VAT for each additional / alternative site	Bilateral Connection Agreement
3	Embedded generation		=> 100	10 + VAT	Bilateral Embedded Generation Agreement
			=>50 <100	no application fee	Bilateral Embedded Generation Agreement
4	Embedded generation*		< 50	no application fee	refer to National Grid
5	New supply point		-	40 + VAT	Bilateral Connection Agreement
6	Second Tier Suppliers		-	no application fee	Contained in CUSC

Tariffs Ireland

Connection Offer Application Fees (plus VAT[13])

MIC & MEC Capacity Ranges	A Demand Capacity (MIC)	B Generation Capacity (MEC)	C Shallow Works (if Yes)
≤ 4 MW	€ 8,100	€ 9,300	€ 12,800
> 4 MW ≤ 20 MW	€ 14,100	€ 21,500	€ 22,500
> 20 MW ≤ 100 MW	€ 23,200	€ 31,000	€ 25,900
> 100 MW	€ 31,700	€ 33,200	€ 29,400
Demand only:	Fee = $A_{MIC} + C_{MIC} - D$		
Generation only:	Fee = $B_{MEC} + C_{MEC} - D$		
Demand & Generation:	Fee = $A_{MIC} + B_{MEC} + MAX\,[C_{MEC}, C_{MIC}] - D$		
Where D is the sum of the credits for pre-feasibility and advanced works studies still relevant. Determination of D will be in accordance with the Relevant Work Credit structure.			

	ASIA			
	JAPAN		KOREA	
Type of the study	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**
Responsible		NC		TN: KEPCO (Korean electric power corporation office) (responsible for transmission planning)
Time span to make it		3 months		4 months
Contents				Load flow, short circuit, stability (grid development aspects)
Tariffs for the study		Power producer and supplier		Customer
Binding				
Validity				6 months + coordination time
Bank Guarantee				

	AUSTRALIA AND NEW ZEALAND							
	QUEENSLAND		NEW SOUTH WALES		SOUTH AUSTRALIA		VICTORIA	
Type of the study	**Feasib. study**	**Connect. study**	**Feasib. study**	**Connect. study**	**Feasib. study**	**Connect. study**	**Feasib. study**	**Connect. study**
Responsible		NC, Network service providers		NC, Network service providers		NC, Network service providers		To an indepen-dent planning body
Time span to make it		10 working days for initial response. NC advises time to achieve connect-ion. Any changes agreed		10 working days for initial response. NC advises time to achieve connect-ion. Any changes agreed		10 working days for initial response. NC advises time. Any changes agreed		10 working days for initial enquiry and 20 for formal connect-ion appli-cation.
Contents						Load flow, short circuit, stability		
Tariffs for the study		Customer		Customer		Customer		Customer
Binding								
Validity		Time advised in offer		A reason-able period at discretion of the NC		Varies		Through agree-ment
Bank Guarantee								

	AUSTRALIA AND NEW ZEALAND					
	WESTERN AUSTRALIA		TASMANIA		NEW ZEALAND	
Type of the study	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**	**Feasibility study**	**Connection study**
Responsible	NC, Network service providers	NC, Network service providers		NC, Network service providers		NC, Network service providers
Time span to make it	Nothing mandated	20 working days for initial response up to 65 days for access offer		10 working days for initial response. NC advises time to achieve connection. Any changes agreed		Nothing mandated
Contents						
Tariffs for the study	Mixed	Customer		Mixed between customer and the NC		Mixed
Binding						
Validity	Varies	20 business days from issue of access offer		A reasonable period at discretion of the NC		Varies
Bank Guarantee						

Appendix 3. Boundary of the Transmission System, Ownership and Investment Costs for some Connection Schemes

In order to illustrate some of the issues of connection, two representative cases are considered:

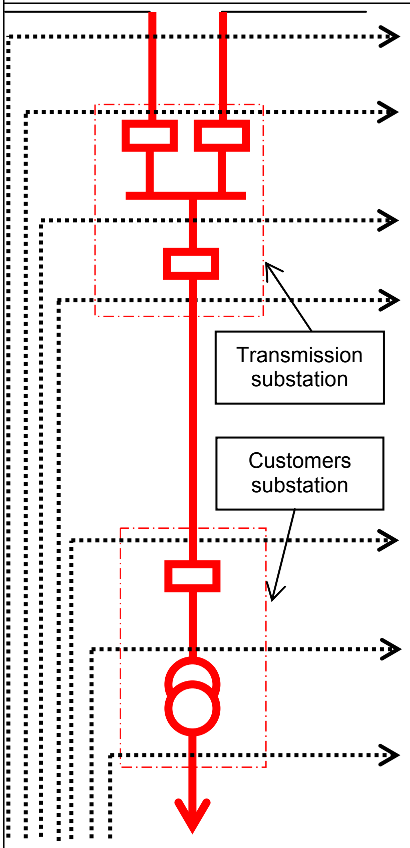
- Connection into an existing transmission system circuit via a new double circuit (in/out) line, a new substation and a radial circuit between the substation and the user's site.
- Connection to an existing substation near the customer's site via a new bay.

The figures diagrammatically summarise, for the representative cases, the responsibility limits for network system operation, ownership and investment cost.

To interpret the diagrams:

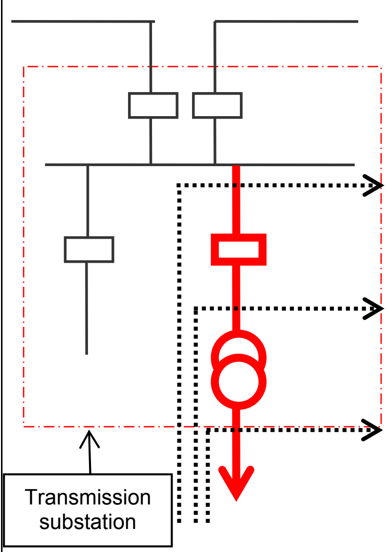
T = Transmission system operational limits	**G = Generators**
O = Ownership limit	**C = Consumers**
I = Investment Costs limit	**D = Distributors**

- Thin lines designate existing facilities.
- Thick lines designate new facilities associated with the connection.
- Operational responsibility relates to asset maintenance and performing switching operations, possibly under the direction of the network owner.
- All activities below the G, C or D entries are the responsibility of either the G, or C, or D.
- All activities above the G, C or D entries are the responsibility of the network owner.



Connection into an existing transmission circuit via a new double circuit (in/out) line, a new substation and a radial circuit	**FR**			**IT**			**BE**			**NL**			**IE**			**ES**			**E&W**			**KR**			**TA**		
	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I
			G C									G C -			G C D			G C									G C D
																								G C			
	*	*					G C	G C *	G C										G	G	G C D	G C	G C		G ^	G ^	
				G C D	G C D	G C D +				*	*					G C	G C										
	G C	G C								G C	G C		G C D #	G C D #											C ^	C ^	
	D	D	D													D	D	D									
							D	D	D	D	D	D							C D	C D					D	D	

* When connection facilities are used by only one customer these may belong to him.
\+ In Italy G, C, D pay and own connection facilities from its plant up to the busbar of the national transmission network. The cost of bay is borne by all transmission users and paid through the transmission tariff.
\- In the Netherlands distributor pays (part of) new installations if transmission capacity between TSO and DSO is already adequate.
^ In Tasmania the boundary is subject to negotiation for generators and consumers.
\# In Ireland consumers and distributors only pay 50% of investment costs shown.



Connection to an existing substation on the customers site via a new bay	**FR**			**IT**			**BE**			**NL**			**IE**			**ES**			**E&W**			**KR**			**TA**		
	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I	T	O	I
	G C D	G C D !	G C			G C D +			G C D			G C *	D G C	D G C	G C D			G C	G	G	G C D				G C ^	G C ^	G C D
				G C D	G C D		G C	G C								G C D	G C D	D				G C	G C	G C			
							D	D		G C D	G C D	D							C D	C D					D	D	

\+ In Italy usually distributors own the transformer in the primary distribution substations (EHV/MV). The cost of the bay could be sometimes borne by transmission/distribution tariffs.

! In France distributors do not own the transformer in the case of EHV/MV substation.

\- In the Netherlands distributor pays investment of transformer and bay if transmission capacity between TSO and DSO is already adequate.

^ In Tasmania the boundary is subject to negotiation for generators and consumers.

" In Korea generators were separated from KEPCO, but KEPCO has transmission and distribution asset until now.

Appendix 4. Summary of Cost Division and Ownership

	EUROPE		
	FRANCE	**ITALY**	**GERMANY**
Deep cost	Generators: 100% (they wait) Consumers: no	Not decided yet. At the moment general fees	Generators: 100%. Consumers: costs for upstream grid depending on voltage level and power
Shallow cost	Generators: 100%. Consumers: 100%. Main supply: 70% of additional supply and no further grand fathering contribution or 90% and grand fathering. *Grand fathering (= contribution paid by a second newcomer connected on assets financed by a first one)*	Not decided yet. At the moment general fees	Generators: bay (in general property of the SO) and connection facilities. Consumers: 100% of his installations and connections; facilities owned by SO
O&M	Generators: annual fee for everything (his connection facilities and the reinforcements brought about by him). Consumers: for their additional supply facilities. Fees: bays 7% of their value when new; lines and cables 3%		Generators: annual fee for bay system management; agreement between SO and system user (no use of system charges). Consumers: costs of managing the connection facilities owned by SO covered by use of the system charges. Both consumer and generator operate their own facilities
Ownership	Transmission system: RTE; connection facilities RTE or EDF. In specific cases generators are the owners of the connection link	Generator: generating unit breaker or measurement group if it is nearest the user (direct connections from the user plant included in the RTN are usually considered as customer plants). Load: general breaker	Generally TSO for the transmission system. Lines only used by a generator may be property of the generator. Some SO favour to own all bays in substations. For consumers the limit is in the transformer, which may belong to SO or to the consumer

	EUROPE		
	BELGIUM	NETHERLANDS	NORWAY
Deep cost	Discussed between regulator and TSO	The TSO/DSO pays the costs if reinforcements are needed according to the capacity plan	May be taken into account for the connection charge. In practice only for regional and local network
Shallow cost	Consumers and generators pay for shallow cost	Users	Connection charges if expenses exceed the NCs additional revenues due to the new connection. Consumer: shallow cost principles for transmission grid. Generators: generator only facilities paid by him
O&M	Customer pays annual fee for O&M, as percentage of new value. Percentage set by regulator	Customer pays annual fee for O&M or a fixed amount in advance	No rules, generally related to ownership. But local NC can operate customer's facilities. (Facilities of consumer included in use of network tariff; "Generators only" facilities not included in use of network tariffs)
Ownership	Not defined. TSO owns bays in transmission substation; connection link can be owned by TSO or customer	TSO/DSO owns all installations up to the substation on the grounds of the user (generator/consumer); between NCs the boundary is mostly on the lowest voltage level	No rules for connection facilities (in 80% of the cases they belong to the network). Only radial connections belong to users generally. Generators (not consumers) own the unit generator transformer and the related facilities. Regional networks: limit upstream the transformer (transformer not included in the Main Transmission Grid but many of them belong to Statnett)

	EUROPE		
	IRELAND	**SPAIN**	**ENGLAND & WALES**
Deep cost	TSO	System	Deep reinforcements are paid for by the transmission owner
Shallow cost	Generators: 100%. Consumers: 50%	Users	Transmission owner provides substation and customer connects into substation
O&M	All consumers pay (TUoS, Transmission Use of System) charges; distribution connected generators >10MW and all transmission connected generators pay TUoS. All transmission connected customers pay an ongoing service charge	Generators must pay an annual fee for O&M of their connection facilities (agreed in contract)	Customers pay for operations and maintenance directly based on the value of their connection assets and also through their capacity related Transmission Network Use of System charges
Ownership	The TAO (Transmission Asset Owner) ESB Networks owns all lines and substations that are part of the main transmission grid; it is proposed that customers may own tails from main transmission substations to their own site. The TSO is only responsible for operating and maintaining what the TAO owns	Transmission grid includes all breakers in transmission substations	All transmission system voltage assets for demand and generation customers are owned by National Grid Transco

	ASIA	
	JAPAN	**KOREA**
Deep cost	Mixed	No
Shallow cost	User	Users: connection facilities
O&M		Users: operating, removal and replacement
Ownership		Generally user owns connection facility, but if it is necessity on grid company, grid company can own it by agreement

	AUSTRALIA AND NEW ZEALAND			
	QUEENSLAND	**NEW SOUTH WALES**	**SOUTH AUSTRALIA**	**VICTORIA**
Deep cost	Mixed	Mixed	Mixed	Mixed
Shallow cost	User	User	User	User
O&M				
Ownership	The framework allows for multiple ownership of network infrastructure. By agreement for connection assets	The framework allows for multiple ownership of network infrastructure. By agreement for connection assets	The framework allows for multiple ownership of network infrastructure. By agreement for connection assets	The framework allows for multiple ownership of network infrastructure. By agreement for connection assets

	AUSTRALIA AND NEW ZEALAND		
	WESTERN AUSTRALIA	**TASMANIA**	**NEW ZEALAND**
Deep cost	Mixed	Mixed	Mixed
Shallow cost	User	User	User
O&M	Existing assets: cost reflective pricing. New assets: beneficiary pays		
Ownership	Network company. Network assets by agreement for connection assets	The framework allows for multiple ownership of network infrastructure. By agreement for connection assets	Network company

Appendix 5. List of websites

The websites where information on national codes and policies can be obtained are listed below:

Australia:	http://www.neca.com.au *in English*
Belgium:	http://www.elia.be *in Dutch/French/English*
France:	http://www.rte-france.com *in French/English*
Germany:	http://www.vdn-berlin.de *in German/English*
Ireland:	http://www.cer.ie *in English*
Italy:	http://www.grtn.it *in Italian/English*
Japan:	http://www.enecho.meti.go.jp *in Japanese/English*
Korea:	http://www.korec.go.kr *in Korean/English*
	http://www.kpx.or.kr *in English*
Netherlands:	http://www.nma-dte.nl *in Dutch/English*
Norway:	http://www.statnett.no *in Norwegian/English*
Spain:	http://www.cne.es *in Spanish/English*
	http://www.ree.es/index_ope.html *in Spanish*
United Kingdom:	http://www.nationalgrid.com *in English*