Large Scale Integration of Micro-Generation to Low Voltage Grids

Contract No: ENK5-CT-2002-00610

WORK PACKAGE G

DG2

Regulatory Regimes for Supporting Development of MicroGrids

June 2005

Large Scale Integration of Micro-Generation to Low Voltage Grids

Contract No: ENK5-CT-2002-00610

WORK PACKAGE G

Technical Report for Deliverable DG2

Evaluation of DG Regulatory Practices in Europe

Final

December 2005

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Introduction

Over the last few years, a number of European Governments have set demanding targets to provide a considerable percentage of their electricity consumption from renewable sources. This policy is driven by the need to reduce the level of carbon dioxide and other greenhouse gases emissions as committed in the Kyoto protocol. In order to achieve the objectives, a number of policies have been exercised by different authorities across the Europe to support the development and connection of renewables and highly efficient thermal plants (CHP) into electricity networks especially to distribution networks.

Generally, the present regulatory practices have addressed sensibly the technical requirement for connecting DGs to distribution systems in order to maintain safety and power quality. This includes the development of new standards associated with DG technologies, connection practices, protection schemes, ancillary services and metering. A number of policies have also been implemented to attract connections of small scale embedded generators (SSEGs) by providing financial incentives to small generators such as the exemption of transmission use of system charges and transmission losses charges, climate change levy exemption, and Renewables Obligation as in the UK.

However, it is evident that SSEGs still face complex commercial challenges. Due to the lack of economies of scale, a relatively high capital cost for renewables technology, and the intermittent nature of renewable sources, small scale DGs will not be able to compete with central generators in the competitive electricity market environment with the current market arrangement. As competition leads to low electricity prices in the wholesale energy market, DG projects will become less attractive if DGs' revenue can only come from selling energy in the wholesale market without opportunities to earn additional revenues from the benefits they provide to the systems.

Therefore, commercial questions such as creation of a level playing field, development of market for aggregators, and cost reflective network pricing to acknowledge the costs and benefits of distributed generation to the networks in addition to the key technical questions such as active management of distribution networks, coordination of the operation between microgrids and public electricity systems, and islanding mode operation are still required to be addressed and solved. More radical changes may be necessary to facilitate efficient integration of the operation and development of microgrids in the systems, in order to extract the additional value of micro grids in terms reducing of the overall system operating costs, network investment deferral, service quality and reliability improvements and provision of a variety of services to support network operation during various disturbances.

Within Work Package G (WPG) of the MICROGRIDS project, the current regulatory policies in the UK, Holland, Spain and Greece particularly in the context of connecting micro generation and the development of microgrids have been reviewed and are presented in this report. The report consists of four sub reports contributed from various partners during the course of the project. The report aims to provide adequate information regarding the current regulatory practices, and to provoke constructive discussions on how regulation should move forward to facilitate the development of DGs including microgrids.

Large Scale Integration of Micro-Generation to Low Voltage Grids

Contract No: ENK5-CT-2002-00610

WORK PACKAGE G

Report

Overview of the UK Regulation for Connection of Small Scale Embedded Generation

Final Draft

December 2004

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1. Introduction

Regulation is always used as one of the main drivers to lead the evolution of electricity supply industry to achieve better economic and technical performance. In more than a decade, electricity industry in the UK has been continuously reformed to provide cheaper electricity prices with better services to electricity customers by optimising the management of the electricity supply industry. The policies have shown promising results in term of the low electricity price, secured supply and the ability to select electricity suppliers that can be currently enjoyed by the customers.

Over the last few years, the demand for using renewable energy sources and energy efficient generation technologies has increased significantly to meet the objectives for reducing carbon and other greenhouse gases emissions as set in the Kyoto protocol. The UK and other European government have set a demanding target to provide a considerable percentage of their electricity consumption from renewable sources. It is then expected to see the rapid development of generation technology based on the renewable sources such as wind, solar, PV, fuel cells, hydro. The development also include highly efficient micro CHP which can produce electricity within the range of 80 – 90% efficiency as a major improvement compared with the typical 30%- 60% efficiency of conventional combustion plants. Most of the renewables energy production sources are connected and distributed across a wide area in the distribution systems.

This raises complex technical challenges on the operation of power systems with large number of small scale generators connected to relatively weaker networks compared with the strong transmission systems. The challenges include the intermittency and uncertainty nature of the resources, and the ability of small generators to provide system support services. Other important issues relate to the economics and future designs of electricity markets with the large number of plants with various sizes.

These challenges will, in turn, impose serious questions as to what market and commercial arrangements are needed to manage the balance between demand and supply in a system composed of millions of small generators? What market arrangements would facilitate efficient energy and ancillary services trading? What regulatory approaches would facilitate evolution of the system from its present to its future form?

This report presents an overview of the UK electricity industry and the policies taken by the government to stimulate rapid growth in the number of Distributed Generation connected to distribution networks. Several issues have been highlighted in the context of whether the policies can stimulate and facilitate rapid development of DG connections in the UK systems.

The report is organised as follows.

Chapter 1 introduces a number of challenges regarding the development of future technical and market architectures to facilitate and stimulate the development of and the connection of Small Scale Embedded Generation and microgrids.

Chapter 2 describes the commercial structure of the UK electricity industry. It contains a brief summary about the primary wholesale electricity market mechanisms, the ancillary services markets and the required licensing for generation, transmission, distribution and suppliers.

Chapter 3 presents a non-exhaustive list of main challenges for DG including microgrids in the present market structures. Due to size, distributed generators especially micro sources will not have the same economies of scale ability to compete with the large generators in the wholesale market. Due to intermittency, the generators based on the renewable sources face imbalance charges as the UK trading arrangement penalises, the imbalance rendered by the inability of generators to meet their schedules. Other challenges in the context of profiling and metering small generators and the islanding operation of microgrids are also discussed.

Chapter 4 describes the policies that have been taken by the British government over the last few years to provide financial incentive to stimulate new investment and development in the generating plants based renewable energy sources and CHP. This includes the exemption from transmission use of system charges, exemption from transmission losses charges, climate change levy exemption, the implementation of renewables obligation and the initiative to implement shallower and cost reflective distribution network use of system charges that can acknowledge and appropriately reward the benefits of DG onto network costs.

In Chapter 5, the statutory framework for connection of small scale embedded generation to public electricity systems is presented. This includes the connection procedures for single and multiple installation of the small generators and the procedures for the connection of larger generators up to 5 MW at 20 kV or below. The issues about islanding operation, the need for providing ancillary services and the complexity in the control systems are also discussed.

At the end of the report, a summary is given.

2. Overview of the UK electricity industry

2.1. Commercial structure of the industry

The current Great Britain (GB) electricity system is divided into two inter dependent systems covering two different geographical areas: (i) England and Wales (E&W) and (ii) Scotland. Different commercial architectures had been developed for the two systems to stimulate competitive electricity market environment and to achieve high efficient management of electricity industries.

In E&W, the ownerships of generation, transmission and distribution businesses were unbundled and privatised to facilitate competition in electricity supply. Private investment in generation is encouraged and purely driven by the opportunity and demand in the electricity market. But transmission and distribution systems are still regulated monopoly businesses. Transmission system is owned and operated by National Grid Transco. There are twelve Distribution Network Operators (DNOs) own distribution network in E&W. These wire business recover the capital and operation including maintenance costs of their assets by charging the network customers using the approved methodologies.

The commercial structure enables industrial, commercial and domestic electricity users to do transactions with any one of a number of competing electricity suppliers who buy electricity in bulk from competing generators in a whole sale electricity market. At present, the central feature of the wholesale market is the New Energy Trading Arrangements (NETA).

In Scotland, the Scottish electricity market is split into two mutually exclusive trading areas of two electricity companies, ScottishPower and Scottish and Southern Energy. As the structure does not unbundled wire and supply businesses, these companies are responsible for the whole operation of the transmission and distribution systems and active in electricity generation, trading and supply in their area. The Scottish market, however, is also open to other suppliers, traders and independent generators.

At present, there is undergoing project called British Electricity Trading and Transmission Arrangement (BETTA) to construct a single wholesale electricity market in E&W and Scotland. NGT will be granted to be a single GB Transmission System Operator (TSO) although the ownership of the transmission systems in Scotland is kept by ScottishPower and Scottish and Southern Energy. The wholesale electricity market structure adopted in BETTA will be similar with NETA.

2.2. Wholesale Trading

In E&W, electricity is traded in decentralised and centralised forward and spot markets. In the decentralised forward market, bilateral trading of electricity between suppliers and self-dispatched large generators is done ahead of time. Electricity is also traded in forward and future markets through a centralised power exchange. Generation and demand schedule are submitted to NGT at a certain period of time in advance of real time operations to enable NGT to prepare a secure transmission system operation. NGT then operates a balancing mechanism (BM) market as a spot market to ensure the balance between supply and demand and also security in the system. All participants in the BM market are called BM units. All BM units who cause imbalance for example by contracting less or more than required or failing to fulfil the schedule will be penalised and need to pay balancing charges.

Only large generators (more than 100 MW) are involved in the wholesale market. More than 90% of electricity generated by small (the renewables and CHP) generators is sold directly to suppliers who sell it as part of their energy portfolio. At present, smaller generators do not have to participate directly in the market and generally have limited impact on their suppliers' overall imbalance risk.

2.3. Ancillary service markets

In addition to the primary wholesale electricity market, various ancillary markets such as reserve and reactive power markets were also developed in England and Wales to provide competition in the provision of ancillary services. These services are critically required to support the operation of transmission system and to deliver an acceptable power quality to the customers.

Reactive market, for example, is held periodically every 6 months. NGT opens a tender to invite independent VAr providers (generators) to submit the price for utilising their reactive power resources. The selected providers are then contracted by NGT to provide reactive power support. Similarly, NGT invites generating companies to submit bids for the utilisation of their plant to provide various services such as fast and standing reserve in the reserve market. It is important to note that the ancillary services purchased from the ancillary service market are supplements to the obligatory ancillary services that need to be provided by generators as part of the conditions to obtain generation license.

2.4. Licensing and regulations

2.4.1. Regulators

The Office of Gas and Electricity Markets (Ofgem) is the UK government firm who is responsible for regulating prices and performance in the monopoly elements of the UK electricity supply industry, and also for making determinations to resolve disputes between different parties in the industry. Ofgem has regulatory jurisdiction over England, Wales and Scotland although its statutory duties with respect to the Scottish electricity supply industry are shared with the Secretary of State for Scotland.

The Secretary of State has the power, after consultation with Ofgem, to grant licences for the generation, transmission or supply of electricity and to authorise exemptions from the requirement to hold a generation or supply licence. Licences granted under the Electricity Act have a number of regulatory functions such as:

- to regulate, where appropriate, the economic behaviour of licence holders;
- to set up a framework for competition in generation and the progressive introduction of competition in supply;
- to underpin the arrangements relating to security of supply;

- to protect the technical integrity of power systems;
- to make provision for certain types of customer services.

As a rule, companies involved in the generation, transmission, distribution or supply of electricity are required to hold licences. There are some exemptions to this requirement. The issue will be described in more details in the following sections.

2.4.2. Generation License

Owners of large electricity generating plants are required to hold generation licences. This requirement applies to large distributed generators, as well as to major power stations. Owners of smaller generation schemes are exempted from the requirement to hold generation licences. This exemption covers most distributed generators.

The criteria for exemption are normally based on the declared net capacity (DNC) of the scheme. If the DNC of the scheme is above 100MW a licence is required: for a DNC of less than 50MW the plant is fully licensed by “exemption” (Class A exemption), and between 50MW and 100MW the decision on licensing is that of the DTI on a case by case basis.

2.4.3. Transmission License

NGT is the only holder of a transmission licence in England and Wales. This details the regulatory provisions governing the company’s duties to maintain an efficient, co-ordinated and economical electricity transmission system, not to discriminate between users or classes of users and to facilitate competition in the generation and supply of electricity. NGT’s transmission licence prohibits it from purchasing or otherwise acquiring electricity on its own account for the purpose of sale to third parties.

2.4.4. Distribution License

The twelve DNOs of England and Wales hold distribution licences. Under the terms of these licenses, each DNO is allowed to distribute electricity within its own geographical area. To facilitate competition in supply, each DNO is required under the terms of its licence to allow any licensed supplier to use its distribution network for the purpose of transferring electricity from the transmission system (and from distributed generators) to customers.

The monopoly nature of distribution network businesses may need to be reviewed in future to attract new private investors and developers of microgrids. Unless this market is open, the development of microgrids will depend only to the investment strategic decisions of the DNOs. Unless there is a strong financial incentive for DNOs to develop microgrids, it will be difficult to see microgrids in the UK distribution networks.

2.4.5. Supply License

Unless covered by an exemption, any person who supplies electricity to any premises is required to hold a supply licence. A company can be exempted from the need to hold a Supply Licence if it fulfils one of the criteria for exemption specified in The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001 – Statutory Instrument No. 3270. These include exemption for small suppliers who do not supply any electricity other than that which they generate themselves, and who do not supply more than 5MW at any time, of which not more than 2.5MW is supplied to domestic consumers.

2.4.6. Scottish Licences

Scottish DNOs and transmission system operators now hold separate distribution and transmission licences which are materially identical in their content to those in England and Wales.

2.4.7. Others

In addition to the main electricity supply industry activities of generation, transmission, distribution and supply, there are also a range of other activities for which a form of licensing is required. These other activities concern the management of data relating to transfers of electricity. They include the provision of electricity meters, meter operation, data collection and data aggregation.

3. Market challenges for microgrids

3.1. Economies of scale: the need of aggregation

During the initial state of NETA, there were concern that small generators participating in NETA could not take part in trading directly because of the costs and financial risks involved in setting up their own systems for administering trading and forecasting output. These issues can be split into two. The first issue refers to the lack of economies of scale for small generators. The second issue is related to the financial cost incurred by the balancing charges in NETA because of the uncertainty in the renewable energy resources used by small generating plants.

A review conducted by Ofgem summarised that prices and outputs for small generators had fallen by 17% and 44% respectively. In April and May 2001, the profit per unit output fell by 72% compared with the same period prior to the introduction of NETA. As any shortfall from BM units including the small generators was charged according to the balancing mechanism, Ofgem found that such generators had to pay on average £60/MWh for any shortfall due to the nature of intermittency in their energy resources that consequently had a direct impact on their electricity output.

One of the possible solutions to increase the ability of the generators to forecast their output is to reduce the time scale (gate closure) when the final notification of the schedule (FPN) needs to be submitted to NGT. In July 2002, the one-hour gate closure was introduced replacing the previous 3.5 hours gate closure. It is evident that the policy reduces the financial risk due to less uncertainty in their output estimation.

Another alternative solution is to consolidate a number of small generators by aggregating their outputs to reduce the variability of the total outputs. In order to be effective, the consolidation process should include a relatively large number of units to produce diversity, which reduces the variability of the outputs. However, a consolidation market has not been effectively developed in UK. Some in the industry remain sceptical over the development and effectiveness of consolidation.

For microgrids, the role of aggregator is important to represent a cluster of micro sources, storages, and controllable loads to a larger electricity market outside the microgrids. As it is impractical (even impossible) to handle the complexity of trading electricity from millions of various sizes of electricity sources in a single market, the market need to be decentralised (Figure 3-1). Because of economies of scale, active sources in microgrids (micro sources, storages and controllable loads) would be beneficial to have simplified arrangement that can be provided by the aggregators for participating in the electricity market.

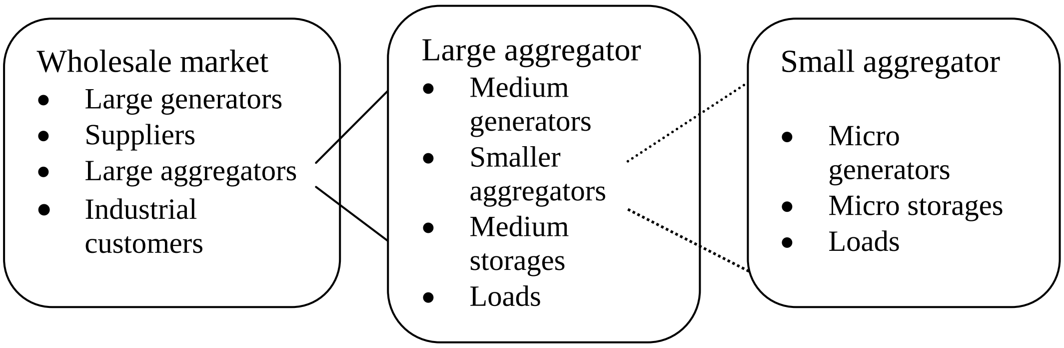

Figure 3-1 Hierarchy of consolidation for smaller electricity units

3.2. Profiling and metering

As prices for electricity in the wholesale market float freely and always change dynamically, time series of electricity production and consumption for generation and customers need to be recorded at each half an hour to settle the required correct payment and charges. However, typically only continuous meters are provided for small (typically domestic) customers. The economic appraisal was conducted by an authoritative study at the time of introducing full supply competition at the retail level in 1998/1999 to determine the feasibility of using half hourly meters for all customers. It was evident that the costs of installing such meter equipments were not justified for the small (typically domestic) customers.

In the absence of half-hourly metering, the demand and generation from small customers are estimated using profiling techniques. In the UK, this practice has been successfully implemented to the small demand customers. A number of profiles have been developed such as unrestricted and restricted domestic and non-domestic profiles for the demand customers based on their electricity utilisation characteristics. On the other hand, profiles for micro generation have not been developed yet. The process for developing new profiles for micro generation is still under consultation.

Another important issue is regarding the type of technology used for metering micro generation. There are various options suggested by Embedded Generation Working Group (EGWG) involving the use of either single or bidirectional meter or import and export meter and half hourly meter. Each option will have different impact on the settlement process.

3.3. Fair level of playing field

Electricity tariffs consist of various cost elements incurred in the generation, transmission, distribution and retail of electricity. The costs consist of the capital, operation (fuel, losses) including overhead and maintenance costs. These costs are recovered by levying the use of electricity to the customers. In order to prevent (or minimise) cross subsidy, customers' charges should be derived such that they reflect the temporal and spatial contribution of each customer to the costs.

As bulk of electricity is still produced by central generators, the power flows from the central generators through transmission and distribution wires to the end-customers. Consequently, the further the location of the customers, the higher electricity tariffs they need to pay because the costs incurred to transmit the power to the remote users are higher than the one for the local users (Figure 3-2).

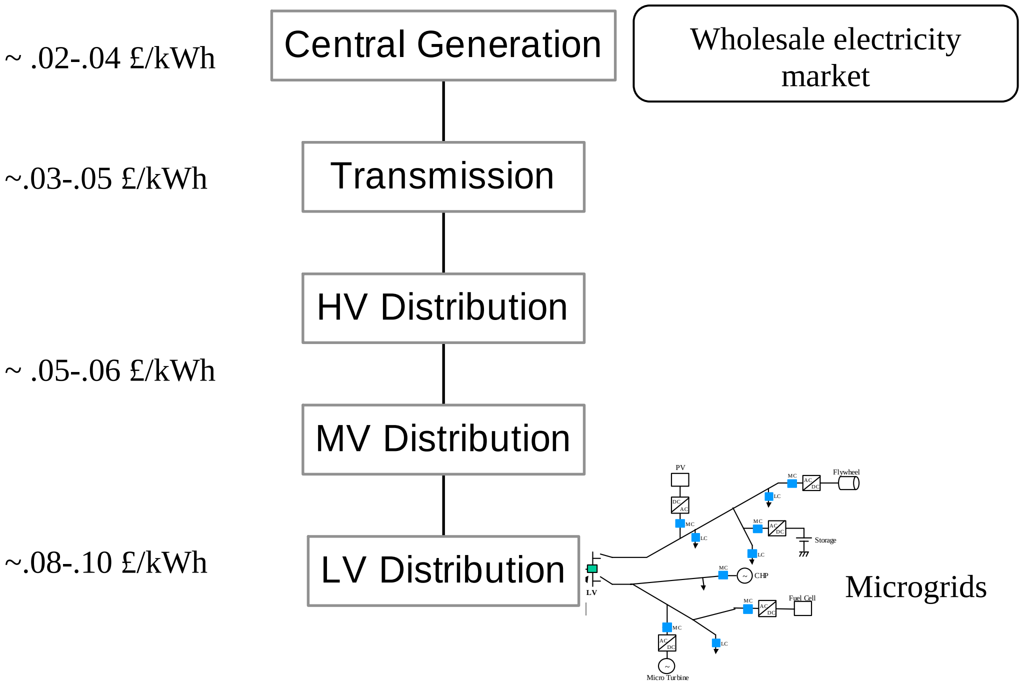

Figure 3-2 Prices of electricity

One of the important characteristics of micro generators is the location of the generators, which is very close to loads. Therefore, the value of supply from the local micro generators should be at least equal to the cost of importing power from higher voltage networks (central generation) at the same node. In this case, the micro generators should compete with the electricity suppliers at around 8 – 10 p/kWh and not with the central generators at 2 – 4 p/kWh in the wholesale market. Bearing in mind that the distribution network charges and retail charges are not reflected in the overhead cost of the central generators. However, at present the output of small distributed generators is purchased by the suppliers at the level of 2 – 4 p/kWh. In this perspective, the present condition is unfair and not attractive for the local micro generators.

Because of the economies of scale and technology used, a unit cost of generating power from the micro generators is likely to be higher than the central generating plants' unit cost. This means that the micro generators are unlikely to be able to compete with the central generators if they are competing at the same market. Unless this issue is resolved, the development and investment of micro generation will only be focused on the requirement to supply their own demand without sharing their resources to the larger system.

3.4. Autonomy of microgrids

Microgrids are designed to operate in islanding mode in events of failure in public electricity systems. With the ability to continuously supply their own loads while disconnected from the main public systems, the reliability performance in the microgrids significantly increases and interruptions can be reduced. But in the UK, this kind of operation mode is still prohibited due to safety and other various reasons.

Allowing two operation modes (i) grid connected and (ii) islanding modes actually raises difficult challenges in the trading structure of electricity and market operation in the UK. This is because of the implicit assumption taken in the electricity market that power bought from any generators can reach any customers in the system. This norm is valid as long as the system is not split into several islanding systems.

In the UK, the end- customers can select and switch their electricity suppliers to obtain better electricity prices and services. In order to supply the customers, the suppliers purchase in bulk electricity from the central generators in the wholesale market. As long as the system remains intact, it does not really matters which generators actually supply which loads. However, when the system is split, it is obvious that generators located at the different system will not be able to supply the loads in the other systems. It is unlikely that the suppliers can predict accurately the amount of electricity need to be purchased from local generators since the occurrence of fault is accidental. This problem needs to be solved before the occasional islanding operation in the UK can be allowed. However, it is important to note that this problem does not occur in electricity structures which use only a single supplier (e.g. in a monopsony market) since the output of all generators is purchased only by the same supplier.

4. Policies to encourage renewable energy

Over the last few years, the British government has implemented consistently a number of energy policies that provide financial incentive to stimulate new investment and development in the generating plants based renewable energy sources to achieve the 2010 target. The target specifies that 10 percent of energy consumption will be supplied by the renewables and CHP. This target was set to meet the level of reduction of green house gases agreed by the government in Kyoto. The policies include the exemption for small generators to pay transmission charges, losses charges, climate change levy and also requirement for the electricity suppliers to buy "green" energy from the renewables and the initiative to apply shallower and cost reflective network pricing methodologies to reward distributed generation on the benefits that they bring to the distribution network.

4.1. Exemption from transmission and losses charges

Under the assumption that the impact of small generators on losses and demand of transmission capacity is relatively small, generators that have capacity less than 50 MW are exempt from transmission charges, losses charges and other operation costs. These are known as embedded benefits, which can be seen as a kind of subsidy to stimulate Distributed Generation expansion in the distribution networks. This exemption is applied only to the small generating plants that do not need to hold a generation licence.

Under the Electricity Act, the generating plants having declared net capacity (DNC) less than 50 MW are not required to hold generation licenses. Consequently, the micro sources which typically have installed generating capacity less than 100 kW will not need generation licenses and will be exempt from transmission charges, losses charges and other operation costs.

4.2. Climate Change Levy exemption for the renewables

The Climate Change Levy (CCL) was introduced on 1 April 2001. Non-domestic electricity customers pay the levy at a rate of 0.43p/kWh. The renewables and "good quality" CHP source electricity are exempt from the CCL. These generators can earn Levy Exemption Certificates (LECs) to demonstrate this exemption.

Hence, the suppliers may be willing to pay a premium for electricity sourced from eligible renewables and good quality CHP, up to the rate of CCL. However, LECs cannot be traded separately from any export power, so must be sold to the supplier responsible for the export.

4.3. Renewables Obligation

The Renewables Obligation is an obligation on licensed electricity suppliers to provide a specified proportion of electricity from renewable sources. It was introduced on 1 April 2003 and requires all suppliers to source initially 3% of their power, rising to over 10% by 2010, from eligible renewable resources. Suppliers can meet their obligation through producing Renewables Obligation Certificates (ROCs) and/or by paying buy-out. The ROC holds details of exactly how a unit of electricity was made, by whom and finally who bought and used it. If they have not managed to produce the required amount of green energy themselves they must buy ROCs on the open market to make up the shortfall. Any shortfall between the amount of their obligation and the number of ROCs is charged according to the regulated buy-out price (around 3.14 p/kWh). Monies raised from the buy-out payments will be recycled to suppliers in proportion to the number of ROCs redeemed.

ROCs are traded separately to the actual electricity itself. It can be seen as additional revenue on top of the price paid for the unit of electricity. Eligible generators can sell ROCs independently of their generation to traders or suppliers. Suppliers should be willing to pay for ROCs an amount equal to their avoided buy-out price plus the value attributable to the recycling of ROCs. The value of ROCs will vary each year depending on the level of the obligation and the volume of eligible generation. Early indications, from the auctions, suggest a value of ROCs in 2002/03 was around £45/MWh.

Micro generation based renewable sources such as PV and wind will be eligible for selling ROCs which could increase substantially their revenue. However, there are two issues. Firstly, power must be supplied by a licensed supplier to be eligible. This might therefore only relate to the export from micro-generation and not that consumed on-site. Buy back arrangements have been proposed for larger on-site generatiors to get around this problem, by selling all generation to a supplier and buying back in the on-site demand. However, such arrangements might not be practical for micro generators. Total generation would also have to be metered under these arrangements and this may required either that meter registers within the equipment be certified for this purpose, or that a separate generation meter be installed.

Secondly, due to size, annual generation will be typically very low in the order of 1 MWh to 2 MWh. Most generators submit monthly ROC reconciliations, on which basis micro generators would never generate over 1 MWh. This is likely to be extended to an annual reconciliation for micro generators. Even so, rounding could have a significant impact on value. The banking rules for ROCs require that generation in each year be tagged with a vintage, thereby ruling out reconciliations over a period of more than one year.

CHP generation is not eligible for ROCs unless fuelled by renewable sources. A number of parties have lobbied for a CHP obligation to ensure that the Government meets its 10GW target by 2010. If introduced, there may be additional value for micro CHP generators, though this is unlikely to be of the same magnitude as the ROC value.

4.4. Cost reflective charging methodology for pricing of distribution networks

In England and Wales, a generation customer currently pays typically deep connection charges while a demand customer pays connection charges for the costs incurred by the connection up to one voltage level beyond the voltage of connection and pay DUoS charges for rest of the costs. Since deep connection charges may be significant, it has been suggested that this may be preventing DG from entering into the market.

In the light of stimulating DG connection in the long term, generation customers should face shallower or shallow charges for connection to the distribution system. This requires new methodologies to cost reflectively price the use of distribution networks since the present methodology (Distribution Reinforcement Model) was not designed specifically to take into account the contribution of DG into network reinforcement requirement. The methodology should also give economic indicators such as rewards to demand and generation customers for benefits that they may create in terms of providing system security, deferring the need for system investment, and etc. This can stimulate the investment of distributed generation in the right place in the network that reduces losses and network investment requirement. The reward can also provide additional revenue or at least reduce the charges of using distribution networks.

In general, the use of shallow connection charges is desirable for users who request new connection because the network charges are paid in a long-term basis and spread across all customers who use the network. This eases the burden of customers to pay a relatively large amount of money up front. In addition, since network charges are distributed accordingly to all network users and not only to the users who trigger the need of reinforcement, the issues of “ride through” or dispute between DG developers and DSO over the allocation of network reinforcement costs can be avoided.

At present, DSOs and Ofgem have intensive discussions and works for preparing shallower cost reflective charging methodologies for DG that will be included in the next distribution pricing control scheme in April 2005 as an interim arrangement before the fully cost reflective pricing methodology can be implemented in the next distribution pricing control scheme in 2007.

5. Statutory framework for connection of small scale distributed generation

5.1. Connection procedure

A two-stage procedure is recommended to facilitate the connection and operation of Small Scale Embedded Generation (SSEG) in parallel with public low voltage distribution networks and to ensure that DNOs are made aware of these connections. Each stage can be considered to be mutually exclusive. SSEG is defined as a generating unit rated up to and including 16A per phase at LV – 400/230 V. This procedure can be found in the Engineering Recommendation G83/1.

5.1.1. Stage 1: Single installation of SSEG

The installer only needs to give notification to the DNO with the necessary information within 30 days of the SSEG unit being commissioned. There is no need to ask planning permission neither or the DNO to assess the impact of connection because it is unlikely that the single installation of SSEG will affect significantly the performance of the public distribution network. However, if the work of the installation is not carried out by the DNO, there is a possibility that DNO will not be aware in advance that there are more than single SSEG installed at almost the same time and may influence network performance.

5.1.2. Stage 2: Multiple installation of SSEG

In the case of a project to install multiple SSEG units in a close geographic region it is recommended strongly that the installer discusses the installation project with the local DNO. The DNO will need to assess the impact of the new connection and specifies the condition required for the connection.

5.1.3. Larger generator rated up to 5 MW at 20 kV below

For larger generators, the connection process comprises a number of key stages as shown in Figure 5-1.

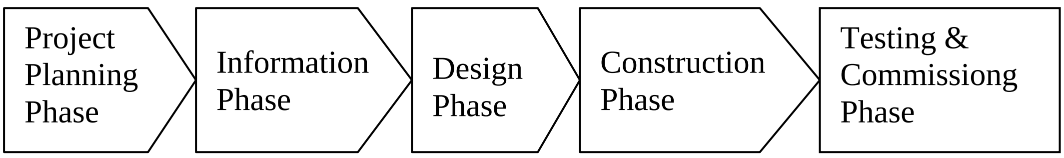

Figure 5-1 Overview of the connection process for DG rated up to 5 MW at 20 kV below

In order to identify the opportunities for the connection of generation to a DNO's network, the developer should consult published information such as DNO's Long Term Development Statement (LTDSs) in the project planning phase. The proposed generating plant then needs to be submitted to the DNO; then the DNO will describe the configuration of the network in the vicinity of the proposed connection site and the potential design issues and costs involved in connecting generation at that point. This phase is called information phase.

After discussion with the DNO, the developer then submits a formal connection application to the DNO. The DNO will respond by producing detailed connection designs, costings and identifies part of the connection construction work that could be undertaken by a third party and the part that need to be done by the DNO itself. After this design phase, the developer enters into contracts with the DNO and, if so desired, the third party contractors to carry out the necessary construction works. This phase is called the construction phase. Finally, the developer tests and commissions the generating plant in the presence of the DNO, if required, and the DNO carries out the necessary tests on the connection and energises it, thereby, connecting the developer's plant to the distribution network.

5.2. Islanding operation

There are two methods of operating DG allowed in the UK at present. The first method is a continuous or occasional parallel operation with the PES. This means that DG operates in parallel with the supply from the PES for the purpose of maintaining the continuity of supply when changing over from one source of supply to the other. The second method is an operation with alternative connection to the PES system. This means that the operation of DG cannot be paralleled with the PES.

In the UK, islanding operation mode is still prohibited at present. This means that if there is a fault at PES that trips the supply connection to the DG, the operation of DG must be terminated immediately. ER G59/1 in section 6.4 specifies that protective equipment must be provided by Embedded Generation to achieve the following objectives:

- to inhibit connection of the generating equipment to the PES supply unless all phases of the PES supply are energised;

- the generating unit must be disconnected from the system when a system abnormality occurs that results in an unacceptable deviation of the voltage or frequency at the point of supply, and when there is a loss of one or more phases of the PES to the installation;

- to ensure the operation of automatic disconnection of the generating plant and the operation of an alarm with audible and visual indication in the event of a failure of any supplies to the protective equipment that would inhibit its correct operation.

As the concept of microgrids is new, the ER G59/1 does not take into consideration the possibility of operating distributed generation in the islanding grid system. With the inability to continuously connect to the grids in the event of loss of supply from PES, the ability to operate the "healthy" grids in the islanding mode is ruled out.

This barrier limits the value of microgrids since the reliability of supply will not be improved substantially as the local micro sources are required to be switched off during the fault in the PES and cannot be used to supply continuously part or all of the local demand. Unless this issue is resolved, the attractiveness of microgrids in the context of enhancing the security of supply decreases. Micro generation does not have the opportunity to earn additional revenue by selling a service to improve the security of supply.

There are also several technical challenges in area of protection and safety, synchronization procedure and network performance in the islanding mode, which need to be resolved before the islanding operation can be allowed. New Engineering Recommendation is definitely required to standardise the isolated operation of some parts of PES or private grids system.

5.3. Provision of ancillary services

Ancillary services are the services required from generators and other sources to support the secure operation of transmission and distribution system and to maintain power quality (voltage and frequency) to be within the approved limits according to the standards. Ancillary services include the provision of reactive power, voltage control, spinning and standing reserve, frequency control, and black-start. In order to obtain these services, generators are obliged to provide part of these services as conditions for their generation licenses. Other services are obtained commercially from ancillary service markets as discussed in section 2.3. Most of these services are obtained from large generators. Contribution from small generators is still relatively small or negligible.

In future, it is unclear whether millions of small distributed generators will physically replace a number of large generating plants. If it is, then there will be a necessity for the small generators to provide the same services as the large generators. This will raise technical and economical challenges. The challenges include the complexity of contracting and controlling the ancillary services obtained from a large number of distributed resources. However, it is also unclear whether all distributed generators need to provide these services as an obligation or the provision of the services can be efficiently driven by market.

Currently, SSEG are required to be capable of operating within 0.95 lagging to 0.95 leading power factor when it operates at rated power unless otherwise agreed with the DNO, e.g. for power factor improvement. This means that adequate active or passive reactive devices such as Static VAr compensators, capacitors, and/or reactors need to be installed. Currently there is no requirement for SSEG or DG to provide voltage regulation services as required for large central generating plants. Initiative has been taken by NGT to enforce regulation that requires DG to provide similar voltage control regulation as the central generators. Consequently, this requirement will impact the financial cost of DG projects as more infrastructures are required. Due to the size, the cost imposed from the requirement may reduce substantially the feasibility of the project if the service is not rewarded appropriately to recover the cost.

At present, there is no requirement for SSEG to provide reserve and frequency control services. Due to size, these services from SSEG are still insignificant at this moment. These services from SSEG become increasingly important when the installed capacity of SSEG increases. Moreover, SSEG may be able to provide better performance of these services in the context of reliability and fast response characteristics depending on SSEG technology.

5.4. Control architecture

5.4.1. Active management

Large penetration of DG (including SSEG and microgrids) in the PES will increase the complexity of power flowing through distribution wires. With the altered power flows, various aspects in the system such as losses, capacity requirement, and control requirement will be different. This raises challenges in the design and operation of distribution systems. Various technical issues include voltage rise effect, increase of fault level and network congestion among others.

In order to resolve the issues, significant additional investment is required especially if DNOs still operate the system using “fit and forget” approach (passive management). Alternatively, the system can be operated in more active manner (active management) that may reduce substantially the demand of additional investment at the expense of more complex control system architecture.

At present, the Government provides incentive and grants to DNOs to encourage innovative management including technology in the distribution networks to achieve better performance in term of designing and controlling the system. It is still unclear whether the incentive is attractive enough for DNOs however it seems that many network companies are still reluctant to change the way of their operation.

5.4.2. Decentralised control architecture

Controlling millions of SSEG is definitely a major challenge for the present Distribution System Management control system architecture. At present, SSEG is self-dispatch and not controlled centrally. As the impact of SSEG on the distribution systems is still relatively small, hence, there is no need to control actively the generating unit When the total installed capacity of SSEG becomes larger, active management is required in order to minimise the required additional investment. It is difficult or even impossible to control efficiently and effectively a system with large number of active resources such as generating units, VAr compensators, storages and controllable loads in various sizes. Hence, there is a need to decentralise control activities to provide more efficient control architecture and also to provide autonomy as required by microgrids. However, technology that allows decentralisation of control activities in the network has not been fully developed, neither tested on large scale power systems yet. Unless these technical issues are resolved, problems of controlling large number of small DG will remain.

6. Summary

This report has presented an overview of the structure of the UK electricity industries. The market mechanisms based NETA and the ancillary services markets in the UK have not yet accommodated fully the distinct characteristics of the small and distributed generators based on the intermittent energy sources. Various policies have been implemented to resolve these issues. Although the results are promising, there are still a lot of works need to be done in various areas such as the development of markets for aggregators and the fair level of playing field for the small distributed generators. Issues about the metering and profiling for micro generation and the islanding operation of microgrids also need to be resolved.

Various policies taken by the British government to stimulate renewables and high thermal efficient plants such as CHP have also been described. The policies aim to create more conducive and attractive environment for the distributed generation by exempting those generators from paying various charges such as transmission use of system charges, transmission losses charges, and climate change levy. In addition, the electricity suppliers also need to meet an obligation to provide a certain percentage of their total energy production from renewables. This policy provides additional revenue for renewables. The monies obtained from selling the Renewables Obligation Certificates are recycled back by the government to help the growth of renewables. Furthermore, an important initiative has been taken by the government to apply shallower and cost reflective Distribution Use of System Charges (DUoS) charges to Distributed Generation. This policy will significantly ease the financial burden of the DG and improve the feasibility of the DG projects.

Procedures for connecting small scale embedded generation (SSEG) have also been developed over the last few years. Various technical recommendations can be used as standards approved by the government to ensure the public safety and the compatibility operation of the generators with the public electricity systems. Various technical issues still need to be resolved before large penetrations of SSEG and microgrids can be seen in the UK systems. Standards may need to be modified to enable islanding operation of microgrids and to control large number of SSEG.

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Review of the regulatory situation in the Netherlands with respect to Microgrids

Contribution to Work Package G, task TG3 of the EU Project "MICROGRIDS"

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1 Introduction

This report was prepared as a contribution to the EU 5th Framework Project called MIGROGRIDS. A microgrid is a new type of power system, created by the interconnection of small, modular generation sources to low voltage distribution systems. A microgrid can be connected to the main power network or be operated autonomously, if it is isolated from the power grid, in a similar manner to the power system of a physical island.

1.1 Objectives of the MICROGRIDS project

The objectives of the MICROGRIDS project are:

- To increase the penetration of Renewable Energy Sources (RES) and other micro-sources in order to contribute for the reduction of greenhouse gas (GHG) emissions.
- To study the main issues regarding the operation of microgrids in parallel with the mains and in islanding conditions that may follow faults;
- To define, develop and demonstrate control strategies that will ensure the most efficient, reliable and economic operation and management of microgrids;
- To define appropriate protection and grounding policies that will assure safety of operation and capability of fault detection, isolation and islanded operation;
- To identify the needs and develop the telecommunication infrastructures and communication protocols required
- To determine the economic benefits of the microgrid operation and to propose systematic methods and tools to quantify these benefits and to propose appropriate regulatory measures.

1.2 Context of this report

Work package G (WPG) of the Microgrids project is entitled " Regulatory, commercial, economic and environmental issues" and focuses on market issues, both from a regulatory and from an economical perspective.

This report, which was submitted to WPG by EMforce B.V. in its position as an assistant contractor, provides an overview and assessment of the regulatory and business environment for microgrids in the Netherlands.

2 History of distributed power in the Netherlands

A relevant overview of the development of distributed power in the Netherlands is provided by an IEA report issued in 2002[1]. It concludes that the development of the electricity industry up to 1995 was influenced strongly by the Government's policies to reduce CO2 emissions and to improve energy efficiency.

2.1 The rise and fall of CHP

A variety of incentives resulted in a particularly favourable investment climate for Combined Heat and Power generation (CHP). By 1995 CHP accounted for approx. 30% of the installed electricity generation capacity in the Netherlands.

The Electricity Act of 1989 created a separation between electricity generation and transmission on one hand, and electricity distribution on the other hand. Generation was concentrated in four generating companies. The generating companies together owned and operated the national transmission network. Distribution companies at that time were regional or municipal companies. The electricity produced by the four generating companies plus all imported electricity was sold to the distribution companies following a standardized tariff system.

The generating companies owned and controlled most of the large CHP units. By the year 2000 this segment totalled 107 gas-turbine based units providing 4500 MW, most of them used in district heating schemes.[2]

The distribution companies invested or participated mostly in smaller, gas-engine based units, installed in greenhouses, small industries and hospitals. The incentive for distribution companies to control such units was provided by the tariff system for electricity, which incorporated a considerable financial reward for peak shaving.

The deregulation of the electricity market initiated by the Electricity Act of 1998 (to be discussed in more detail in Chapter 3) meant an end to all incentives mentioned above. Owners of CHP units, who did not consume all generated electricity within their own facility, had to sell the excess power on the market in competition with large generating stations. The market price was so low, in combination with rising prices for natural gas, that many of them could not cover their marginal cost and had to shut down. For many greenhouse owners heating their greenhouse with a conventional boiler proved to be more cost-effective than using a CHP unit and selling the electricity on the market.

Generating companies owning CHP plants for district heating were contractually forced to keep their units in operation but sought to increase their income from the heat they provided. Unofficial analysis shows that these units cover their marginal cost because the efficiency and O&M costs of their units are more attractive than for the smaller gas-engine based units. Profits however were too low to justify any new investements.

In order to prevent a sharp decline in CHP-produced electricity, the Government has now created additional schemes to provide financial support, both on the investment side and on a kWh basis to improve the marginal cost figures.

2.2 Interconnection of CHP

The interconnection situation for CHP in the Netherlands has always been comparatively favourable. This is due to a large extent to the fact that most of the CHP units were built by the utilities themselves or by large industries having strong electricity connections already. Network problems caused by large amounts of CHP have occurred but were mostly resolved by the utilities who had an interest in operating the units. But also private investors most of the time had little problems in gaining access to the network. Distribution networks in the Netherlands are relatively strong and can accommodate considerable amounts of distributed generation without causing much problems for the network operator.

2.3 Wind power

Despite favourable wind conditions, the development of wind power has not kept pace with European countries like Germany, Denmark and Spain. This is caused mainly by complicated permission procedures. For wind power, network connection is frequently an issue because most wind farms are located in rural areas. The local distribution network is not rated for the amounts of power generated by the wind turbines and the regulatory structure (discussed in the next chapter) does not provide ways of socialising the high costs involved with interconnection.

3 Present electricity regulation in the Netherlands

The electricity Act of 1998 implemented market reforms in order to comply with EU regulations. The transmission system was transferred to a newly formed state-owned company called TenneT. TenneT owns and operates the transmission system and manages the import/export interconnectors.

The generating companies, having transferred their share in the transmission system to TenneT, were privatised. Three of them were sold to foreign utilities, one of which recently sold on its Dutch generating assets to one of the larger Dutch distribution companies. The fourth generating company was owned by regional distribution companies already and is now a full subsidiary of one large Dutch distribution company.

Distribution companies have been forced to implement an administrative separation between the ownership and operation of networks on one hand and the generation and supply of electricity on the other hand. In steps, the market for supply has been opened to full competition; starting with the largest customers (> 1 MW) from 1999, medium-sized customers (> 100 kW) from 2002; and the remaining customers now planned for July 2004. There is already a fully open market for green power. All customers opting for green power can choose their own supplier.

The Electricity Act of 1998 defines the electricity network as a regulated monopoly. In the definition of the Electricity Act, the network operator is the party that has the unique concession to operate the public electricity network within a specified geographic area. Operation of the network means making all strategic decisions with regard to the network; it comprises long-term and medium-term planning, providing new connections, setting standards for utilization of assets, setting maintenance standards and setting the network tariffs. The network operator is permitted to outsource the day-to-day operational activities to commercial parties.

In order to create a level playing field for all parties wishing to use the network for transporting their electricity, the network operator has to be fully independent. A network operator is not permitted to be directly or indirectly involved in electricity generation or trading activities, except when it comes to purchasing his own network losses from the market. If a network operator is owned by a company involved in such activities, which is normally the case in the Netherlands, the governance structure of the network operator has to be such that the parent company cannot influence or control the network operator's decisions. The Dutch Office for Energy Regulation *Dienst toezicht en uitvoering energie* (DTe) is very strict in enforcing the independence of network operators.

The income of a network operator consists mainly of the network charges paid by the customers connected to his network. Such charges consist of:

- A non-recurring charge for establishing a connection; dependent upon the voltage level, the kVA rating of the connection and the distance from the nearest suitable interconnection point to the existing network of that voltage level. This applies for load customers as well as for generation;
- a monthly kW (for bigger customers a kVA) charge paid for the import rating of the connection;
- a kWh (and for bigger customers a kVarh) charge paid for the amount of electricity imported. For smaller customers there is no charge for exported electricity; net metering is not applied; a time-dependent tariff is possible.

- For bigger generators (10 MVA and up), a MWh charge paid for electricity supplied into the network.
- A system charge per kWh consumed. This is levied by the distribution companies and transferred to TenneT to pay for its activities as a system operator.

Balancing responsibility is applicable to every connection rated 100 kVA and up. These customers must be metered in 15 minutes intervals. Data have to be collected daily in order to calculate their contribution to the balance. Smaller customers may choose to have an interval meter installed, but can also choose to be metered on the basis of a profile.

Every customer can choose to be balance-responsible for himself or to transfer his responsibility to his energy supplier. A balance-responsible party has to declare his total of generation, his total of consumption and his total of import/export in fifteen minute intervals to TenneT one day ahead. An ex post calculation is used to verify whether that party has fulfilled its declaration. Every deviation outside a defined margin is penalized based on the cost incurred by TenneT to contract and invoke balancing power.

The economy of this system is based very much upon the assumption that power is produced in central generating stations and supplied into the transmission system or high-voltage grid; and subsequently distributed by a distribution system, characterized by a power direction which is always top-down. It can be shown that the kW and the kWh charges are based on the assumption that the power involved has passed all the higher voltage levels in order to arrive at the customer's meter.

Network operators have freedom in setting their tariffs, but the tariffs require approval from DTe. For each network operator, DTe calculates a weighted average of all tariffs to produce a number which represents the average tariff of that network operator. During the present regulatory period, this average is subjected to price cap regulation following the CPI-x system. In order to enforce increased efficiency, the x factor applied during the present period has a uniform value of 3.2% per year, requiring network operators to cut costs by approx. 9% over the period 2001-2003. For the period 2004-2006, particular x values have been assigned to each network operator, varying from 1.3% to 6.3% per year.

As a consequence, network operators have stopped making any investments unless they have an obligation to do so. They have also become hesitant in connecting new generation, unless it is obvious that the generation in question is so small compared to the local network capacity that on the network side of the meter nothing special has to be done. In other cases a network operator will attempt to transfer any cost involved, including the technical interconnection analysis, to the generator.

4 Regulatory issues relevant to microgrids

Of the regulatory situation described in the previous chapter, the following are particularly relevant for the creation of microgrids.

4.1 Commercial position of the network operator

The present regulatory context does not permit a network operator to treat similar customers differently. That means that, if a part of his network were to be operated as a microgrid, the network operator would not be in a position to offer the customers in that microgrid different connection attributes. This applies to the tariff system used, but also to technical conditions which may be applicable like improved local reliability or forms of demand side management required to operate the system in an islanded mode.

These restrictions are so severe that the creation of a microgrid is economically feasible only if it is not operated by a network operator as defined by the Electricity Act.

4.2 The alternative way to operate a network

The Electricity Act provides an escape for the operation of networks which have special technical characteristics or which have been optimised in particular for reasons of energy efficiency. Such networks may be exempted from the requirement of being operated by a network operator as defined by the Electricity Act.

This exemption, which is generally referenced as "Article 15" because it is described in Article 15 of the Electricity Act, is granted by the Minister of Economic Affairs upon an advice from DTe. Several dozens of applications are filed each year, mainly by operators of networks on industrial sites where a considerable part of the electricity is generated locally by one large CHP owner who trades his electricity directly to other companies on the same site. There is a considerable economic benefit by having only a single connection to the public electricity network and sharing the cost of the local network between the companies on that site. Pure economic benefit is not accepted by DTe as a valid argument for receiving an Article 15 exemption. However if this economic benefit is necessary to support the feasibility of the CHP unit, the energy conservation provided by the CHP is accepted as an argument.

DTe publishes every application and every decision on an application on the Web. Details for which the applicant requests confidentiality are not published.

4.3 Applying for an exemption ex Article 15

The operation of an Article 15 network is not subject to price regulation. For that reason it would be very attractive for owners of public networks as well, to invest in networks with an Article 15 status. DTe has a very strict policy in not accepting an Article 15 application for a network of which the owner is linked in any form to an existing network operator. There are several examples of technically qualifying industrial networks, where the Article 15 exemption was not granted only because the network was owned by a joint venture in which one of the parties was an existing utility.

The decision to grant an Article 15 exemption is accompanied by additional conditions. These conditions are mainly a subset of the requirements applicable to conventional public networks and are intended to protect the interests of individual customers. For example if the network is used to supply residential customers, the voltage and frequency of the network must comply with the same standards as applicable in conventional distribution networks. Generally the owner of the network is required to submit a yearly report to DTe providing basic figures like number of customers, amount of electricity generated and consumed. In contrast to public network operators, the operator of an Article 15 network has no obligation to connect, for a standard price, every customer who requests a connection within his geographical area. One of the most common conditions to an Article 15 exemption is however that to every customer requesting a connection, a reasonable proposal has to be made.

Exemptions ex Article 15 are granted only for networks serving less than (the equivalent of) 500 residential customers. This rule is based on an interpretation of the Electricity Act by DTe and is not a law by itself. The interpretation of the word "equivalent" is up to the discretion of DTe as well.

The background for this policy is the following. The development of new networks exceeding the size of 500 customers is governed by a specific extension to the Electricity Act called the "Government Decision on the Installation of Electrical Infrastructures" (Bestuursbesluit aanleg elektrische infrastructuren, "Baei"). This decision requires that the design and development of new infrastructures exceeding the size of 500 residential customers or equivalent must be publicly tendered by the local municipality. Once in an operational stage, such a network will be operated again by a network operator in accordance with the terms of the Electricity Act, but this could be someone else than the regional network operator who traditionally would have had the concession in that area.

4.4 Transparency to the market

One of the interesting questions concerning a microgrid with an Article 15 exemption is: Do customers within that network have to purchase electricity as a cooperative, or is the microgrid just a legal alternative to a public network and can they still buy electricity on the market ? This issue has been discussed informally with DTe. Although DTe tends to prefer the latter option, they would not reject the cooperative approach if it can be shown:

- that this approach benefits the customers
- that there is a price control structure in place that also in the future, customers will not be worse off than if they had been able to buy electricity on the market.

EMforce has recently, together with KEMA, developed a governance structure for a microgrid for a consortium of housing developers[3]. As this is proprietary material it is not possible to quote details from this work. It was shown however that it is possible to manage the network in such a way that customers still buy their electricity on the market and that they derive an economic benefit from being connected to a microgrid instead of to the traditional distribution network. In order to achieve this, there has to be a considerable amount of local electricity generation (30-50% of the consumption as a minimum) and a considerable amount of load that can be easily managed (in this case, all dwellings were heated and cooled by collective systems based on heat pumps). Apart from that, the network could offer additional reliability services at a premium price.

4.5 Ownership and governance of a microgrid

Many of the conditions accompanying an Article 15 exemption relate to the protection of the interests of individual customers. As the network is not subject to a price regulation regime, another system has to be in place to ensure that customers will pay reasonable prices, now and in the future.

The best way to achieve this is to create a form of collective ownership of the network. The network is then the property of the owners of the houses. Technical activities related to the operation of the network can be subcontracted to qualified companies and as these contracts can be tendered, a fair cost level is ensured. For tax reasons this is a rather attractive option, but not all house owners like the idea of being connected to a network of which the quality and the price level are determined by majority votes of his fellow house owners. This is also a marketing issue and new insights are anticipated to develop over the next few years.

5 Assessment and outlook

The regulatory system in the Netherlands has caused a network tariff regime under which distributed electricity generation is much more attractive if the electricity is consumed "behind the meter" than if the electricity has to be exported to the public network. In order to share a DG unit between multiple users, the option of a private network is therefore in terms of economy an attractive and sometimes even the only feasible option. This creates a considerable business opportunity for microgrids.

The Dutch regulatory authority DTe has only unofficially expressed itself about the microgrid concept described in the preceding chapters. Off the record however there is great enthusiasm, in particular because it is believed that an innovative structure like a microgrid could be a platform for the development of new and market-responsive services. Protection of the interest of the individual customers remains a key parameter and proposals will be primarily checked against that parameter.

The legal position of the existing utilities as network operators is such that they are not the most obvious parties to participate in the establishment of microgrids. It should be noted that most of the operational experience available today in an existing utility is not embodied in the network operator (as a company), but has been placed in a services organisation which sells its services on a more or less competitive basis to the network operator. Such network management organisations are also in the market as subcontractors for the day-to-day management of a microgrid. In such a structure, although the utility does not own or govern the network, the expertise and economy of scale of the old utility can benefit microgrids as well.

The volume of new dwellings being built in the Netherlands is between 50,000 and 100,000 a year. Apart from that, between now and 2015 many 30-50 year old city precincts will be rigorously renovated involving the refurbishment or even replacement of tens of thousands of dwellings each year. Many of these projects can be categorised in the range of 50-500 units per project and would qualify for the microgrid approach described here. Property developers are very keen on developing concepts which are enablers for the integration of more renewable energy and improved customer services. Leading project developers in the Netherlands are now raising Government funds to develop a pilot involving a private network. As this solution seems to be the most promising in achieving virtually zero energy housing at a manageable cost level, active support form the Government, both in finance and in the field of building regulations, is expected.

Other segments like industrial sites and horticultural clusters may benefit from the microgrid concept as well, but require much more tailoring to achieve an attractive solution for each specific case. It is anticipated that by its size in the Netherlands, the housing segment in cities and suburbs will be the leader in the development and acceptance of microgrid solutions.

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MICROGRIDS

Large Scale Integration of Micro-Generation to Low Voltage Grids

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Report for Work Package G, Task G3

Practices for connecting microsources in Spain

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Abstract

1 Introduction

The Law 54/1997 of the Electric Sector established the principles of a new operating model based on the free market, and it also pushed the development of electricity generators subject to special regulations, such as renewable energy sources, waste and cogeneration.

The RD2818/1998 about geration of electric energy by renewable energy sources, waste and cogeneration, developed the Law 54/1997 for this kind of energy sources and established a new operating model for them. It established the procedures to be considered a generator subject to special regulations, its economics and the conditions of energy supply to the network.

In terms of interconnection of microsources to the electricity distribution network, the RD2818/1998 did not specify any specific regulations, and so, further regulations were needed.

This document will focus on the two main regulations in effect in Spain regarding the interconnection of microsources to the electricity distribution network.

Chronologically the first specific regulation to be published was the RD1663/2000 about interconnection of PV plants to the low voltage network. The most important aspects of this regulation will be described.

The second regulations to be described in this document is the RD843/2002 that is the revised Electrotechnical Regulation for Low Voltage, and it includes a specific Technical Complementary Instruction, ITC-BT-40 about low voltage generating plants. The most important aspects of this Technical Complementary Instruction will be described.

2 RD1663/2000: Interconnection of PV Plants to the Low Voltage Network

These regulations are applicable to photovoltaic plants with a maximum rated power of 100 kVA and if their interconnection to the distribution network is done in low voltage, being low voltage a maximum ac voltage of 1 kV.

2.1 Administrative Process

2.1.1 Request

The plant owner must request to the distribution company the connection point and the necessary technical conditions to make the project or the technical documentation of the plant, in function of the installed power. The request must contain the following information:

-Name, address and phone number of the owner

-Location of the plant

-Single-line diagram of the plant

-Suggested point of connection

-Technical characteristics of the plant that must include the peak power of the panels and the rated power of the plant, description of connecting modes and characteristics of the inverter or inverters, and description of the protection devices and connection elements

If further documentation is needed, the distribution company has to request it within 10 days after the reception of the request and justifying the cause of that request.

2.1.2 Determination of the Technical Conditions of the Connection

1. Within a time limit of one month after the reception of the request, the distribution company must notify to the requester its proposal about connection conditions including, at least, the following information:

A) Proposed point of connection and metering.

B) Rated maximum and minimum voltage of the network in the connection point.

C) Short-circuit power expected during normal operation in the connection point.

D) Maximum available rated power of connection in that point, according to the capacity of transport of the line or, if it is the case, the capacity of transformation of the transformation centre.

E) If the point of connection and metering for the supply of energy is different from the point of feeding, a justifying report of this circumstance.

2. If the maximum available rated power of connection is lower than the rated power of the photovoltaic plant, the distribution company must determine which network elements must be changed to match both powers. The cost of the modifications must be paid by the owner of the plant if he is the unique owner of the whole installation, or by mutual agreement if there are more owners. If there is a disagreement, the Competent Administration must solve it within three months since its intervention is requested.

3. If the distribution company does not notify within the time limit, the concerned person can request the intervention of the Competent Administration which will proceed to request the delivery of the mentioned data. The Competent Administration will notify this information to the plant owner.

If the requested data is not delivered within fifteen days since its request by the Competent Administration, the company will incur in an administrative infringement as stated in articles 60.11 and 61.1 of the Law 54/1997, of November the 27th, of the Electric Sector.

4. The proposal of the distribution company about the connection point and connection conditions will be in effect for a year since the data of notification to the plant owner.

5. In case of disagreement with the proposal of the distribution company, the requester can, in accordance to article 20.2 of the RD 2818/1998, apply to the Competent Administration to solve the disagreement by establishing the conditions that the involved parts must obey. The decision must be taken within three months since it was requested.

The criteria to solve the conflict will be based in causing the least possible cost to the plant owner, attaining the established technical conditions.

2.1.3 Contract

1. The plant owner and the distribution company will subscribe a contract by which the technical and economical relationships between them will be managed. The contract sample model will be established by the General Energy Directorate, in accordance to article 17 of the RD 2818/1998.

2. Once the connection point and technical conditions have been agreed, the distribution company must subscribe this contract within a month since the owner's requirement.

3. Any disagreement about the contract that is going to be subscribed will be solved by the Competent Administration within a month counting since its intervention was requested by one of the parts.

2.1.4 Connection to the Network and First Verification

1. Once all the tests performed by the authorised installer have been passed, he will issue a report with the main characteristics of the plant and stating that the tests have been passed. If for the tests connection of the photovoltaic plant to the network were necessary, this connection will have a temporary status and it will have to be notified to the distribution company.

2. After completing the installation, subscribing the contract and negotiating the report of passing the tests, the plant owner can request to the distribution company the connection to the network, for which it will be necessary to submit the report.

3. The distribution company can perform at any time a first verification of the elements that affect the reliability and safety of electricity supply, and must receive from the owner the fee established in the regulations in effect.

4. If a month passes counting since the request of connection to the network without objections from the distribution company, the plant owner can proceed to the connection to the distribution network.

5. The distribution company will send to the Competent Administration, with a copy to the National Energy Committee, during the first month every year, a list of commissioned plants during the last year in his territorial ambit, specifying for each of them the owner, location, peak power and rated power.

6. If as a consequence of the verification the distribution company finds any incidence in interconnection equipment or in the plant, it will inform if it proceeds, to plant owner and will grant him a sufficient deadline to fix it.

7. In case of disagreement, the plant owner or the distribution company can request more detailed inspections and the intervention of the Competent Administration, which in case that the connection to the distribution network has not been performed, must solve within a month since its intervention was requested.

2.1.5 Obligations of the Plant Owner

1. The photovoltaic plant owner is responsible of maintaining the plant and the equipment of interconnection and protection in perfect operating conditions.

Distribution companies can propose to the Competent Administration for their approval, verification programs of the equipment of reliability and safety of electrical supply to be performed by the companies apart from other verification programs that can be established by the Competent Administrations.

These verifications will be paid by the companies themselves.

2. In case of a network failure or an important perturbation related with the plant, and justifying it previously, the distribution company can verify the plant without authorisation from the Competent Authority. An important perturbation is defined as a perturbation that affects the distribution network and causes the electricity supply not to reach the quality levels established by the regulations in effect.

3. If a photovoltaic plant perturbs the operation of the distribution network not complying with the electromagnetic compatibility limits, quality of service or any other aspect of the regulations in effect, the distribution company will notify it to the Competent Administration and to the plant owner, for him to proceed to repair the deficiencies within 72 hours.

If after the deadline the problems persist, the distribution company could proceed to disconnect the plant, notifying it immediately to the Competent Administration. In this case, after the causes of perturbations have been solved, to proceed to the connection of the plant, the plan owner must submit to the distribution company and the Competent Administration the justification signed by a competent technician or authorised installator, which describes the fixing operations done.

If there is a disagreement about the existence and causes of perturbations, it can be requested the intervention of the Competent Administration that has a deadline of a month to solve the disagreement.

4. The plant owner must have a communication media to put immediately into contact the control centres of the distribution network with the people that operates the photovoltaic plant.

2.2 Technical Conditions of PV Plants Connected to the Low Voltage Network

2.2.1 General Technical Conditions

1. The operation of the photovoltaic plants that are referred in this RD must not cause damage, to the network, decrease of safety conditions, nor variations above the regulations that are applicable to these plants.

Besides, the operation of these plants cannot create dangerous working conditions for the maintenance personnel of the distribution network.

2. If the distribution line is de-energised, due to maintenance or due to the actuation of a protection device, the photovoltaic plant must cease to energise the distribution line.

3. The conditions of network connection will be determined in function of the rated power of the photovoltaic plant, to avoid harmful effects to the users with sensitive loads.

4. To establish the connection point to the distribution network, the following characteristics will be considered: capacity of transport of the line, installed power in the transformation centres and distribution in different phases of generators subject to special regulations that contain single-phase inverters.

5. In the generating circuit to the metering device, it cannot be placed any other means of generation, accumulation or loads apart from the photovoltaic generator.

6. If a photovoltaic plant is affected by perturbations of the distribution network, the regulations in effect about quality of service will be applied.

2.2.2 Specific Interconnection Conditions

1. Photovoltaic plants can be interconnected in low voltage, provided that the sum of their rated power is not above 100 kVA. The sum of the rated powers of the plants subject to special regulations connected to a low voltage line cannot exceed half of the capacity of transport of the line in the point of connection, defined as the design technical capacity of the line in that point. If it is necessary to make the connection in a transformation centre, the sum of the rated powers of the plants subject to special regulation connected to that centre cannot exceed the capacity of transformation for that level of voltage.

2. If the rated power of the photovoltaic plant to be connected to the distribution network is above 5 kW, the connection of the photovoltaic plant to the network will be done in three phases. That connection can be done with one or more single-phase inverters of up to 5 kW, to the different phases, or directly with a three-phase inverter.

3. In the connection of a photovoltaic plant, the voltage variation caused by the connection and disconnection of the photovoltaic plant cannot be above 5% and cannot cause in any user connected to the network, an excess of the limits indicated in the Electrotechnical Regulation for Low Voltage

4. The power factor of the energy supplied to the distribution network must be as near as possible to the unity. Photovoltaic plants connected in parallel with the network must take the necessary measures to comply with it, or come to an agreement about this issue with the distribution company.

2.2.3 Metering and Billing

1. When there are electric consumptions in the same place of the photovoltaic plant, the consumptions must be placed in independent electric circuits and of their metering devices. The metering of those consumptions must be done with their own and independent devices that will serve for its billing purposes.

The output meter must have capacity to meter in both ways and if not, between the output meter and the circuit-breaker, an input meter will be placed. The electric energy that the owner will bill to the distribution company will be the difference between the output and input of the photovoltaic plant. In a plant with two metering devices, it will not be necessary to have a supply contract for the photovoltaic plant.

All the elements of the metering device, input and output, will be sealed by the distribution company.

The authorised installer will only be able to open the seals with written permission from the distribution company. But in case of danger, the seals can be removed without permission of the distribution company, informing immediately to the distribution company.

2. The placement of the metering devices and if necessary, of the hourly switching devices must comply with MIE BT 015.

Metering sites must be signalled in an indelible way so that the each plant owner is clearly identified. Besides, it must specify if it is an input or output energy metering device.

Metering devices must comply with the regulations in effect and their precision must be at least of class 2, as regulated in RD 875/1984 of March the 28th.

3. The characteristics of the output metering device must be such that the current corresponding to the rated power of the photovoltaic plant must be within 50% of the rated current and the maximum current of the precision of the device.

4. When the plant owner chooses the billing type that is subject to the electricity production market final mean hourly price, as defined in RD 2818/1998 of December the 23th, it must comply with the Regulation of Metering Points, Consumptions and Transits of Energy.

2.2.4 Protections

The protection system must comply with the regulations in effect, must be certified in the documentation of the plant and must include:

1. Manual circuit-breaker, it must be magnetothermal with a short circuit current above the one stated by the distribution company in the point of connection. This circuit-breaker must be accessible to the distribution utility at any time to allow manual disconnection.

2. Automatic differential circuit-breaker to protect people in case of a derivation of some elements of the direct current part of the plant.

3. Automatic circuit-breaker of the interconnection for the automatic connection-disconnection of the photovoltaic plant in case of loss of voltage or frequency of the network, together with an interlock relay.

4. Protection for the interconnection of maximum and minimum frequency (51 and 49 Hz) and maximum and minimum voltage (110% and 85%).

5. These protections can be sealed by the distribution company after verifying them.

6. The re-closing of the switching device and so, of the connection with the low voltage network will be automatic once the network voltage has been restored by the distribution company.

7. The inverter can have the maximum and minimum voltage and maximum and minimum frequency protections embedded and if so, the automatic opening-closing operations will be done by the inverter. In this case, it will only be necessary to have a manual circuit-breaker and an automatic differential circuit-breaker if the following conditions are met:

a) The functions will be done using a contactor which re-closing will be automatic once the rated network supply conditions are restored.

b) The contactor, controlled usually by the inverter, can be activated manually.

c) The contactor status (ON/OFF) must be clearly signalled in the front of the equipment and in a highlighted place.

d) If sealable protections are not used for the interconnection of maximum and minimum frequency and maximum and minimum voltage, the inverter manufacturer must certify:

d.1) Calibration values of voltage.

d.2) Calibration values of frequency.

d.3) Type and characteristics of the equipment used internally for fault detections (model, brand, calibration, etc.).

d.4) Passing of the corresponding tests of voltage and frequency limits.

While no technical instructions are regulated, the testing procedures and certifications done by the equipment manufacturers will be accepted.

e) If protection functions are done using a software for control operation, the physical seals will be substituted by certificates of the inverter manufacturer that mention explicitly that the program is not accessible by the plant user.

2.2.5 Earthing Conditions of PV Plants

Earthing of interconnected photovoltaic plants will always be done in a way that does not alter the earthing of the distribution company, ensuring that no transfer or defects to the distribution network is produced.

The plant must have a galvanic separation between the low voltage distribution network and the photovoltaic plant, either using an isolation transformer or any other means that performs the same functions.

The photovoltaic plant masses must be connected to a earth independent of the neutral earth of the distribution company and of the rest of the masses of the supply, in accordance to the Electrotechnical Regulation for Low Voltage.

2.2.6 Harmonics and Electromagnetic Compatibility

Emission and immunity levels must comply with the regulations in effect, and the certificates that assure it must be included in the documentation.

3 RD842/2002 Low Voltage Regulation: ITC-BT-40 Low Voltage Generating Plants

3.1 Conditions for Connection

3.1.1 Isolated Generating Plants

They are defined as generating plants that cannot be connected to the Public Distribution Network by any means.

The connection to the receivers, in plants where coupling with the Public Distribution Network or with another generator is not possible, must contain a device that allows the connection and disconnection of the load in the output circuit of the generator.

When there is more than one generator and their connection needs synchronising, a manual or automatic equipment must be available to perform that operation.

Portable generators must contain over-current and direct and indirect contact protections suitable to the load they are feeding.

3.1.2 Support Generating Plants

They are defined as generating plants that are connected to the Public Distribution Network but cannot work in parallel with the network. A switching device must be installed to avoid these plants working in parallel with the network. Load transfer operations are allowed.

The alternative feeding (network or support) can be done in some points that must have a switching device for all active conductors and the neutral conductor, to avoid the coupling of both power sources.

When load transfer operations are forecast, the connection of the generating plant to the Public Distribution Network must be done in a single point and the following requirements must be fulfilled:

- Load transfer operations are allowed only for generating units with a power rating higher than 100 kVA.
- In the instant of interconnection between the generator and the Public Distribution Network, the neutral of the generator must be disconnected from earth.
- The switching device must be installed next to the metering instruments of the Public Distribution Network, with accessibility for the Distribution Company.

- A protection must be installed to avoid the generator supplying power to the network.
- Maximum and minimum voltage, maximum and minimum frequency, over- current and short-circuit, interlock to avoid energising the line when it is de-energised and loss of synchronism protections must be included.
- It must have a synchronisation device and the interconnection cannot be maintained during more than 5 seconds.

The switchgear must include an auxiliary contact to allow connecting to a separate earth the neutral conductor of the generator, when load transfer operations are forecast.

The protection elements and their connections to the switchgear must be sealed or it must be assured by alternative methods that the initial triggering parameters cannot be modified and the electricity distribution company must have permanent access to that element, when load transfer operations are expected. The switchgear operation device must be accessible to the self-generator.

3.1.3 Interconnected Generating Plants

They are defined as generating plants that are normally working in parallel with the Public Distribution Network.

The maximum power of generating plants interconnected to the Public Distribution Network, will be conditioned by the characteristics of the network: service voltage, short-circuit power, load capacity of the line, power consumed in the low voltage network, etc.

a) Maximum power of generating plants interconnected in low voltage

In general terms, the interconnection of generating plants to 3x400/230 V low voltage networks will be allowed when the sum of the rated powers of the generators is not neither above 100 kVA nor above half the output capacity of the centre of transformation to which the line of the Public Distribution Network to which the generating plant is connected.

In 3x220/127 V three-phase networks, generating plants of up to 60 kVA or half the output capacity of the centre of transformation to which the line of the Public Distribution Network to which it is connected are allowed. In this cases the whole plant must be ready to operate in the future with 3x400/230 V.

For wind generators, to avoid network fluctuations, the rated power of the generators cannot be above 5% of the short-circuit power in the point of connection to the Public Distribution Network.

b) Specific conditions for starting and coupling of the generating power plant to the Public Distribution Network

Asynchronous Generators

The voltage drop must be below 3% of the rated voltage of the network.

For wind generators, the maximum frequency of the connections must be of 3 per minute, with a voltage drop limit of 2% of the rated voltage during 1 second.

To limit the current and voltage drop in the instant of interconnection to the values indicated above, suitable devices must be used.

The interconnection of an asynchronous generator to the network will not be done until, driven by the turbine or the motor, the generator has reached an speed between 90% and 100% of the synchronous speed.

Synchronous Generators

The use of synchronous generators in generating plants that are going to be interconnected to Public Distribution Networks must be agreed with the electricity distribution company, according to the necessity of independent operation of the network and the exploitation conditions of the network.

The plant must have an automatic or manual synchronisation device.

This device is dispensable if the interconnection can be done as an asynchronous generator. If so, the starting characteristics must comply with the conditions of the asynchronous generators.

The interconnection of the plant to the Public Distribution Network must be done when in the synchronisation operation the differences between the electric magnitudes of the generator and the network are not above the following values:

- Voltage difference ± 8 %
- Frequency difference ± 0,1Hz
- Phase difference ± 10º

The points where no synchronisation device exists and the parallel interconnection is possible, an electric interlock must be placed between the generating plant and the Public Distribution Network to avoid parallel operation.

c) Switching and metering devices to be placed in the interconnection point

In the source of the generating plant and in a unique and permanently accessible point to the electricity distribution company, a circuit-breaker with associated protections must be placed. These protections must assure that the internal faults of the plant do not perturb the normal operation of the networks to which it is interconnected and if a fault occurs, the protections must open the circuit-breaker and it cannot be re-closed until the Public Distribution Network has a stable voltage.

The protections and the wiring of the circuit-breaker must be sealable and the switching device must be accessible to the self-generator.

The gang switch must have an auxiliary contact to allow disconnecting the neutral from the Public Distribution Network and to connect it to earth when the generating plant works isolated from the network.

When it is forecast to supply energy from the generating plant to the Public Distribution Network, in the end of the coupling installation, a metering device that meters the energy supplied by the self-generator must be installed. This metering device can share elements with the device that meters the energy supplied by the Public Distribution Network, provided the energy metering in both ways is logged in an independent way.

The metering device must have elements suitable for the type of hourly discrimination that is determined.

In generating plants with asynchronous generators, it must be placed a metering device to log the reactive energy absorbed by them.

When the compliance of energy supply programs must be verified, suitable metering and logging devices must be placed.

d) Control of reactive energy

In plants with asynchronous generators, the power factor of the plant must not be below 0.86 of the power rating and suitable capacitor banks must be installed when necessary.

These plants must have suitable protection devices to assure the disconnection in less than 1 second when there is an interruption in the Public Distribution Network.

The electricity distribution company can exempt the power factor compensation if reactive power can be generated.

Synchronous generators must have enough reactive power generating capacity to keep the power factor between 0.8 and 1 in lead or lag. To keep the supplied reactive power stable, it must be installed an excitation control to permit the regulation of reactive power.

3.2 Wiring Cables

Wiring cables must be dimensioned for a current of at least 125% of the maximum current of the generator and the voltage drop between the generator and the point of interconnection to the Public Distribution Network, cannot be of more than 1,5%, for the rated current.

3.3 Waveform

The generated voltage must be almost sinusoidal, with a maximum harmonic rate, for any working condition of:

Harmonics of even order:	4/n
Harmonics of third order:	5
Harmonics of odd order (≥ 5):	5/n

The rate of harmonics is the relation, in %, between the root mean square value of the harmonic of order n and the root mean square of the first harmonic.

3.4 Protections

The prime mover and the generators must have the specific protections recommended by the manufacturer to reduce damage caused by internal or external faults.

The output circuits of the generators must have the protections set in the corresponding CTI (Complementary Technical Instructions) that are applicable to them.

In generating plants that can be interconnected to the Public Distribution Network, a group of protections to trigger the interconnection circuit-breaker must be placed in the source of the plant. These protections must be homologated and properly verified and sealed by a recognised laboratory.

The minimum protections that must be placed are the following:

- Over current, using magneto-thermal direct relays or equivalent devices.
- Instantaneous minimum voltage, connected between the three phases and the neutral and with an triggering time of less than 0.5 seconds when the voltage reaches 85% of its rated value.
- Maximum voltage, connected between a phase and the neutral, and with a triggering time of less than 0.5 seconds when the voltage reaches 110% of its rated value.
- Maximum and minimum frequency, connected between phases and which has to trigger when the frequency is below 49 Hz or above 51 Hz during more than 5 periods.

3.5 Earthing Installations

3.5.1 Introduction

Generating plants must have earth systems to ensure that the voltages that can arise in the metallic masses of the plant do not surpass the values set in the MIE-RAT 13 of the Regulations about Technical Conditions and Security of Electric Power Stations, Substations and Centres of Transformation.

The earth systems of generating plants must have adequate technical conditions to avoid fault transfers to the Public Distribution Network and to private installations.

3.5.2 Characteristics of the Earth Connection According to the Type of Operating Scheme of the Generating Plant towards the Public Distribution Network

a) Isolated generating plants connected to installations that are fed exclusively by those plants

The earth network of the installation connected to the generating plant must be independent from any other earth network. Earth networks are considered independent when the circulation of the maximum fault current in one of them does not cause voltage differences above 50 V, with respect to the earth of reference, in the other.

In this type of installations the neutral of the generator and the masses of the plant must be earthed following one of the systems explained in the ITC-BT08.

When the generator does not have the neutral accessible, the system can be earthed using a wye three-phase transformer that can also be used for other auxiliary functions.

If some generators are working in parallel, the junction of the neutrals of the generator must be earthed in a unique point.

b) Support generating plants, connected to installations that can be fed, independently, by those groups or by the Public Distribution Network

When the Public Distribution Network has the neutral earthed, the earth connection diagram must be of type TT and the masses and feeders of the installation must be connected to an independent earth.

If it is technically impossible to make an independent earth connection for the neutral of the generator, and with previous specific authorisation from the Competent Administration, the same earth can be used for the neutral and the masses.

When feeding the installation from the generating plant and load transfer is forecast, an auxiliary pole must be placed in the interconnecting switchgear to connect the neutral of the generator to earth.

c) Interconnected generating plants, connected to installations that can be fed simultaneously or independently by those groups or by the Public Distribution Network

When the installation is coupled to a Public Distribution Network that has the neutral earthed, the earth connection diagram must be of type TT and the masses and feeders of the installation must be connected to an independent earth from the neutral of the Public Distribution Network.

When the installation is not coupled to the Public Distribution Network and is fed exclusively from the generating plant, there must be an auxiliary pole in the self-acting switch that disconnects the neutral of the Public Distribution Network and connects to earth the neutral of the generator.

For the protection of the generating plant there must be placed a device that detects the current that circulates through the connection of the neutrals of the generators to the neutral of the Public Distribution Network and disconnects the installation if it is above 50% of the rated current.

3.5.3 Wind Generators

The earth connection of the protection of the tower and the surge arresting equipment that is mounted in it must be independent from the rest of the earths of the installations.

3.6 Commissioning

For the commissioning of support or interconnected generating plants, besides the procedures that must be done accordingly to the legislation in effect in the Competent Administrations, the project about the parts that affect to the coupling conditions and reliability of the electricity supply, must be submitted to the electricity distribution company. The company, before commissioning the plant, can verify that the interconnection installations and other elements that affect to the reliability of supply are done accordingly to the regulations in effect. If disagrees, it must be communicated to the Competent Administrations to solve the problem.

This procedure is not necessary for isolated generating plants.

3.7 Other Regulations

All the procedures related to the determination of the interconnection point, the project, the commissioning and maintenance of the generating plants must follow the criteria that is established in the legislation in effect.

The electricity distribution company can, when it detects an immediate risk to people, animals and goods, disconnect interconnected generating plants, communicating it subsequently to the Competent Administration Organ.

4 References

[1] RD2818/98 Producción de Energía Eléctrica por Instalaciones Abastecidas por Recursos o Fuentes de Energías Renovables, Residuos y Cogeneración

[2] RD1663/2000 Conexión de Instalaciones Fotovoltaicas a la Red de Baja Tensión

[3] RD842/2002 Reglamento Electrotécnico de Baja Tensión

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Micro-Generation to Low Voltage Grids

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Contents

1. Abstract

The present report aim is to evaluate from a critical point of view the current regulatory framework in Spain, regarding DG and the application of Microgrids.

The first chapter gives some brief information about the Distributed Generation situation in Spain. It deals with the beginning of DG, the present situation and the future objectives for renewables.

The second chapter gives a general overview of the most relevant legislation that governs DG from different points of view: the network, the market, the support schemes… The documents are analysed taking into account how Microgrids are affected by them. The main result is that Microgrids have not been considered up to now in the Spanish legislation.

The conclusions chapter is based on the previous mentioned analysis and it is stressed the need of including the Microgrid concept in the Spanish legislation.

In the annex, two relevant legislative documents dealing with DG connection to the low voltage grid are studied.

2. DG at the national electricity market

Although small hydro plants have been used since a long time in the rural areas of Spain, it can be considered that the Distributed Generation (after the “centralised generation era”) started in the eighties with the development of cogeneration plants, installed mainly in the industrial sector (paper mills, tile industries, etc.). These plants were generally connected to the Medium Voltage network.

The European Union Electricity Directive, 96/92/CE made the electricity sector change in the whole Europe through the establishment of the rules for a common internal market of electricity. This development of the electricity system was also pushed by the increasing environmental concern in the society and in the countries of the whole world. Its better known consequence was the Kyoto protocol (1997), pursuant to the United Nations framework convention of climate change (1992), whose objectives were translated in the European Union by means of, amongst others, a Green book on the security of energy supply, a White book for RES and in different directives as the 2004/8/EC for cogeneration promotion or the 2001/77/EC for the promotion of electricity generated by RES.

In Spain, the introduction of schemes to support the deployment of renewable and energy efficient technologies pushed significantly the use of Distributed Generation, specially in some of the generation energy sources (wind, bio-fuels and bio-gas). These are the main highlights of these support schemes at national and regional level:

- Feed-in tariffs
- Fiscal incentives
- Investment and R&D support schemes

The installed power of renewable energies, cogeneration and waste plants under 10 MW, at the end of year 2003, is indicated in the Table 2-1:

Table 2-1: DG situation at 2003

DG generation plants[1]	Installed power (MW)	%[2]	Sold energy (GWh)	%

[1] Source CNE, Year 2003

[2] Percentages are with respect to the total electricity generation

DG generation plants[1]	Installed power (MW)	%[2]	Sold energy (GWh)	%
Solar	10	0,02	10	0,004
Hydro	1.196	2,0	3.905	1,7
Wind	374	0,6	729	0,3
Biomass & Wastes	229	0,4	756	0,3
Wastes treatment & reduction	108	0,2	404	0,2
Cogeneration	2.230	3,8	5.491	2,3
Total DG	*4.247*	*6,9*	*11.295*	*4,8*
Total	*61.223*	*100,0*	*237.330*	*100,0*

The Renewable Energy Promotion Plan (REPP) established the objectives for the renewable energy deployment in year 2010 and the financial means offered by the administration to achieve them. Two versions have been issued 2000-2010 and its revision, 2005-2010. The overall targets for year 2010 are to achieve:

- Renewable energies should provide at least 12% of the total energy demand
- 29.4% of electricity is generated by renewable energies
- 5.75% of bio-fuels in transport.

Plans for 2010 and situation in 2004 for electricity generation, independent of installation size, for renewable energies according to the REPP:

Table 2-2: Renewable Energy Promotion Plan state and objectives

Technology	2004		2010	
	Power (MW)	Energy (GWh)	Power (MW)	Energy (GWh)
Hydro (>50 MW)	13.251	25.014	13.251	25.014
Hydro (>10 <50 MW)	2.897	5.794	3.257	6.480
Hydro (< 10 MW)	1.749	5.421	2.199	6.692
Biomass	344	2.193	2.039	14.015
- Biomass plants	344	2.193	1.317	8.980
- Co-combustion	0	0	722	5.036
Urban solid wastes	189	1.223	189	1.223

Wind	8.155	19.571	20.155	45.511
Solar Photovoltaic	37	56	400	609
Biogas	141	825	235	1.417
Solar Thermal			500	1.298
TOTAL	27.032	60.096	42.494	102.259

3. Regulatory Regime in Spain

The European Union Electricity Directive, 96/92/CE, was implemented in Spain by the **law 54/1997**, which governs the activities of the electricity sector. This law defined the "Special Regime" concept (Régimen Especial), which includes the electricity generation units up to 50 MW using renewable energy sources and cogeneration. This law has been modified and developed by several Royal Decrees, resolutions, plans… dealing with different aspects of it. Find below a list of some of the most relevant legislative documents dealing with the Distributed Generation in Spain, either directly or indirectly.

- RD 2818/1998 substituted by the **R.D. 436/2004**: it defines the economic and legal regime of the Special Regime.
- **RD 1955/2000**: it governs the transport, distribution and supply activities of electric energy.
- **Resolution of 2001/04/05**: Operation rules of the electric energy production market (based on RD 2019/1997)
- **Renewable Energy Promotion Plan**: it establishes objectives for the renewable energy deployment in year 2010.

Other legislative documents affect the interconnection of DG to the grid:

- The **ministerial order from the 5th of September of 1985** established the administrative technical rules for the operation and interconnection to the grid of the hydroelectric power plants up to 5 MVA and the so-called "autogeneration" plants. This order is today still in force for the interconnection of DG to the grid.
- **RD 1663/2000** for the interconnection of PV plants to the Low Voltage Network.
- **RD 842/2002** (Low Voltage Code), in its part **ICT-BT 40**, low voltage generation installations are treated.

In Spain most of the official documents dealing with DG are legislative. This has a main disadvantage: the requirements are dispersed through many different documents because every amendment requires a new document. The consequences are that, on one hand, they are difficult to find and, on the other, it is difficult to be aware of every modification and new document.

As positive aspect, the documents are free and easily accessible through internet, by contrast to standards that normally must be purchased.

There is a great need of a new document dealing with the interconnection of DG to the grid. In fact, most of the requirements still in force come from the Ministerial Order issued in 1985, when DG was only starting. Only small photovoltaic installations have some new requirements (R.D. 1663/2000) but the part related to the connection to the grid is based mainly on the Order 5/9/1985. Currently, a Royal Decree on this issue is under preparation.

The Microgrid concept does not appear in any of the documents currently in force in the Spanish legislation. We will use the above mentioned list to analyse the possibilities of installing a Microgrid in the Spanish electricity system.

3.1.1. Electricity Production

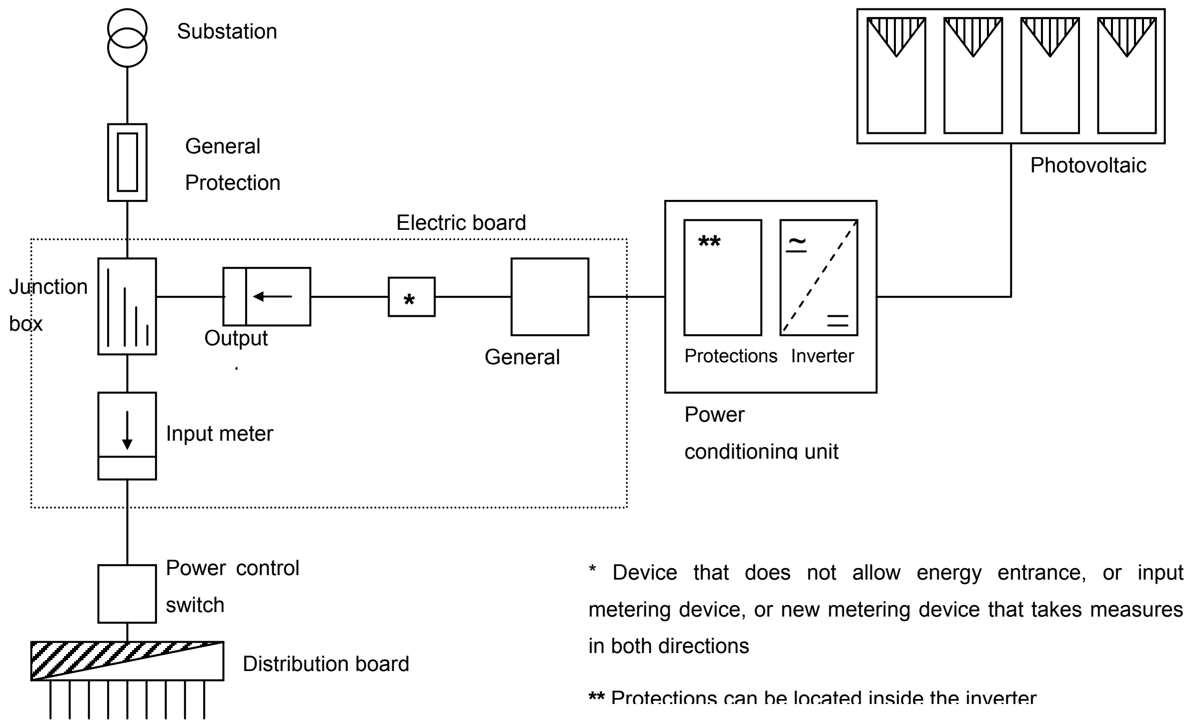
The electricity production activity is liberalised in Spain.

The owner of an installation included in the Special Regime can sell its production (if renewable) or surplus (if cogeneration or wastes treatment) either to the distributor (regulated tariff) or at the electricity market (pool, bilateral contract or specified period). In this last case, the installation can participate in the market through a selling agent (aggregator). The energy cannot be sold to final consumers directly, if not at the market.

Units from 1 MW are allowed to participate at the pool and from 50MW must participate at it. Smaller units have the possibility of aggregate through a selling agent, which can bid for a group of generation units.

The bids must be presented for each production unit on hourly basis at the pool. The Microgrid should be considered as different production units and one bid should be presented for each of the units willing to sell energy at the pool.

Regarding interconnection, as mentioned before, the RD 1663/2000 is the only document which provides some interconnection detail for DG units. According to its contents, low voltage photovoltaic installations must follow the scheme below.



Due to the fact that in Spain renewables can sell all the energy that they produce, their connection point is located outside the consumption installation and between the PV modules and the metering device no other generation or storage equipment can be connected. This configuration requires also that the production units of the Microgrid are considered separately. Besides this, all the storage facilities could only be connected to the individual consumption installations.

In all cases, the Spanish legislation does not permit unintentional islanding. When there is a fault in the line, the generation units must disconnect and are not allowed to reconnect until the reclosing is firm.

3.1.2. Electricity Distribution

If connected to the distribution grid, the following points might be interesting for Microgrids:

- Transport and distribution activities are regulated.
- The Distribution grid operators can only deny the grid access for capacity reasons when the safety, continuity or the power quality of the network are endangered.
- The supply of the electric energy to consumers will be carried out by distributors (to tariff consumers) or by supply companies (to qualified consumers).
- The producers which have their units connected to the grid will only be connected at one point in normal circumstances.

- Installations bigger than 10 MW must communicate to the distributor their electricity generation previsions in hourly basis, in case that they do not participate in the market.
- Distributors are responsible for the power quality of their consumers and of the consumers represented by their suppliers (unless it is demonstrated that a third party is responsible for some event or disturbance).
- Cooperative societies of consumers are allowed to develop distribution activities.

3.1.3. Direct lines

They are those lines that link the production centre with the consumption centre of the same owner or of a qualified consumer. Their construction permission must be requested and both producers and qualified consumers can apply for it.

Its use is excluded from the payment established for transport and distribution activities. The applicants of the permission of the construction of direct lines must prove their legal, technical and economical capacity.

They can only be used by the owners of the administrative permission and by their installations or subsidiaries (at least they should be proprietary of 25%). The access to third parties is denied. The opening to third parties of the use of the grid will require its sale, transfer or contribution to a transport or distribution company so this grid is part of the general system.

This would allow the installation of Microgrids isolated from the grid. According to the previous requirements, the installations should belong to the owners of the administrative permission; a solution could probably be setting up a cooperative of the people taking part on the Microgrid.

3.1.4. Economic Regime – Feed in Tariffs

The *Renewable Energy Promotion Plan* fixes objectives for the installed power or generated energy of the renewable installations, no matter if connected to the grid or not, or inside a Microgrid or not. However, according to the current legislation is difficult that Microgrids can get any economic support.

Any electricity producers using renewable energies, cogeneration or energy obtained from the treatment of wastes can be part of the "Special Regime". However, the RD 436/2004, which describes the feed-in tariff system, does not consider the possibility of different technologies connected to the same point of the grid. Installations must be included in one specific category, group and subgroup, in order to receive the premium and incentives and the classification is done with regard to the different technologies according to the following table.

Category	Technologies
a) Auto-producers	a.1.1 Natural Gas Cogeneration a.1.2. Rest of cogenerations a.2 Plant using waste energies from devices not devoted to energy generation (incl. P ≤ 1 MW)
b) Renewables	b.1.1 Solar Photovoltaic (P ≤ 100 MW) b.1.1 Solar Photovoltaic (Rest)
	b.1.2 Solar Thermal
	b.2.1 Wind on-shore (P ≤ 5 MW) b.2.1 Wind on-shore (Rest) b.2.2 Wind off-shore (P ≤ 5 MW) b.2.2 Wind off-shore (Rest)
	b.3 Geothermal, waves, tides, ocean-thermal, sea-currents
	b.4 Hydro < 10 MW
	b.5. Hydro > 10 MW (10 <P≤ 25 MW) b.5. Hydro > 10 MW (25 <P≤ 50 MW)
	b.6 Biomass from energetic crops, forest activities or agricultural activity b.7 Biomass from livestock manure, bio-fuels or biogas b.8 Biomass from industrial activities of forest or agricultural sector.
c) Valorized wastes	c.1 Urban Solid Waste
	c.2 Other wastes
	c.3 Plants using wastes in more than 50% of their primary energy
d) Cogeneration for the treatment and reduction of wastes	d.1 Pig slurry
	d.2 Sludge
	d.3 Other wastes

According to this, all the production units of the Microgrid should be considered separately and included into the distribution grid in order to have each of them a different connection point to the grid. Each of them should have meters to record their generated energy.

4. Conclusions

Considering the existing legislation in Spain, the deployment of Microgrids isolated from the grid does not seem to be a big problem, though deeper legal analysis might be required to establish firmly this respect. The use of direct lines may allow the construction of Microgrids separated from the distribution grid.

The difficulties start when considering a Microgrid connected to the grid. Up to now, the Microgrid concept has not been taken into account in the legislative documents that govern the electricity sector in Spain. According to the analysis performed on the legislation, feed-in tariffs, electricity market and distribution network mechanisms require that Microgrids are taken as individual production units and not as a whole.

When connected to the distribution grid, the Microgrid becomes part of it and is subjected to the same requirements:

- Distributors are responsible for power quality issues
- Production of energy and distribution must be separated activities
- Units bigger than 10 MW must inform about their generation previsions
- In case of fault in the network, the plant connected to that line is not allowed to maintain voltage in the grid
- Etc.

It is necessary to create the Microgrid concept in the electricity sector legislation in Spain. Specific obligations and rights for Micrograms should be defined between all actors, so their benefits can improve the quality of the electricity in the network.

5. References

[1] "Ley del sector eléctrico", CNE, 4th edition, 2005. (Spanish electricity sector law)

[2] "Real Decreto 436/2004, de 12 de marzo, por el que se establece la metodología para la actualización y sistematización del régimen jurídico y económico de la actividad de producción de energía eléctrica en régimen especial", Ministerio de Economía, BOE 2004/03/27

[3] "Real Decreto 1955/2000, de 1 de diciembre, por el que se regulan las actividades de transporte, distribución, comercialización, suministro y procedimientos de autorización de instalaciones de energía eléctrica", Ministerio de Economía, BOE 2000/12/27

[4] Resolución de 5 de abril de 2001 "Reglas de funcionamiento del mercado de producción de energía eléctrica", BOE, 2001/04/20

[5] "Plan de fomento de energías renovables en España 2005-2010, Resumen" Ministerio de industria y comercio e IDAE, August 2005

[6] "Present status of DG in Spain: National codes, standards, requirements and rules for grid-interconnection and operation", IBERDROLA and LABEIN, DISPOWER project (ENK5-ct-2001-00522)

[7] "RD1663/2000, de 29 de septiembre, sobre conexión de instalaciones fotovoltaicas a la red de baja tensión", Ministerio de Economía, BOE 2000/09/30

[8] "RD842/2002, Reglamento electrotécnico de baja tensión", Ministerio de Ciencia y Tecnología, BOE 2002/09/18

6. ANNEX: Requirements for LV grids in Spain

RD 1663/2000: Interconnection of PV plants to the Low Voltage Network

RD 842/2002 Low voltage Code: ICT_BT-40 Low Voltage Generation Plants

6.1. RD1663/2000: Interconnection of PV Plants to the Low Voltage Network

These regulations are applicable to photovoltaic plants with a maximum rated power of 100 kVA and if their interconnection to the distribution network is done in low voltage, being low voltage a maximum ac voltage of 1 kV.

6.1.1. Administrative Process

6.1.1.1. Request

The plant owner must request to the distribution company the connection point and the necessary technical conditions to make the project or the technical documentation of the plant, in function of the installed power. The request must contain the following information:

- Name, address and phone number of the owner
- Location of the plant
- Single-line diagram of the plant
- Suggested point of connection
- Technical characteristics of the plant that must include the peak power of the panels and the rated power of the plant, description of connecting modes and characteristics of the inverter or inverters, and description of the protection devices and connection elements

If further documentation is needed, the distribution company has to request it within 10 days after the reception of the request and justifying the cause of that request.

6.1.1.2. Determination of the Technical Conditions of the Connection

1. Within a time limit of one month after the reception of the request, the distribution company must notify to the requester its proposal about connection conditions including, at least, the following information:

   a) Proposed point of connection and metering.

b) Rated maximum and minimum voltage of the network in the connection point.

c) Short-circuit power expected during normal operation in the connection point.

d) Maximum available rated power of connection in that point, according to the capacity of transport of the line or, if it is the case, the capacity of transformation of the transformation centre.

e) If the point of connection and metering for the supply of energy is different from the point of feeding, a justifying report of this circumstance.

2. If the maximum available rated power of connection is lower than the rated power of the photovoltaic plant, the distribution company must determine which network elements must be changed to match both powers. The cost of the modifications must be paid by the owner of the plant if he is the unique owner of the whole installation or by mutual agreement if there are more owners. If there is a disagreement, the Competent Administration must solve it within three months since its intervention is requested.

   If the distribution company does not notify within the time limit, the concerned person can request the intervention of the Competent Administration which will proceed to request the delivery of the mentioned data. The Competent Administration will notify this information to the plant owner.

3. If the requested data is not delivered within fifteen days since its request by the Competent Administration, the company will incur in an administrative infringement as stated in articles 60.11 and 61.1 of the Law 54/1997, of November the 27th, of the Electric Sector.

4. The proposal of the distribution company about the connection point and connection conditions will be in effect for a year since the data of notification to the plant owner.

5. In case of disagreement with the proposal of the distribution company, the requester can, in accordance to article 20.2 of the RD 2818/1998, apply to the Competent Administration to solve the disagreement by establishing the conditions that the involved parts must obey. The decision must be taken within three months since it was requested.

The criteria to solve the conflict will be based in causing the least possible cost to the plant owner, attaining the established technical conditions.

6.1.1.3. Contract

1. The plant owner and the distribution company will subscribe a contract by which the technical and economical relationships between them will be managed. The contract sample model will be established by the General Energy Directorate, in accordance to article 17 of the RD 2818/1998.
2. Once the connection point and technical conditions have been agreed, the distribution company must subscribe this contract within a month since the owner's requirement.
3. Any disagreement about the contract that is going to be subscribed will be solved by the Competent Administration within a month counting since its intervention was requested by one of the parts.

6.1.1.4. Connection to the Network and First Verification

1. Once all the tests performed by the authorised installer have been passed, he will issue a report with the main characteristics of the plant and stating that the tests have been passed. If for the tests connection of the photovoltaic plant to the network were necessary, this connection will have a temporary status and it will have to be notified to the distribution company.
2. After completing the installation, subscribing the contract and negotiating the report of passing the tests, the plant owner can request to the distribution company the connection to the network, for which it will be necessary to submit the report.
3. The distribution company can perform at any time a first verification of the elements that affect the reliability and safety of electricity supply, and must receive from the owner the fee established in the regulations in effect.
4. If a month passes counting since the request of connection to the network without objections from the distribution company, the plant owner can proceed to the connection to the distribution network.
5. The distribution company will send to the Competent Administration, with a copy to the National Energy Committee, during the first month every year, a list of commissioned plants during the last year in his territorial ambit, specifying for each of them the owner, location, peak power and rated power.
6. If as a consequence of the verification the distribution company finds any incidence in interconnection equipment or in the plant, it will inform if it proceeds, to plant owner and will grant him a sufficient deadline to fix it.

7. In case of disagreement, the plant owner or the distribution company can request more detailed inspections and the intervention of the Competent Administration, which in case that the connection to the distribution network has not been performed, must solve within a month since its intervention was requested.

6.1.1.5. Obligations of the Plant Owner

1. The photovoltaic plant owner is responsible of maintaining the plant and the equipment of interconnection and protection in perfect operating conditions.

   Distribution companies can propose to the Competent Administration for their approval, verification programs of the equipment of reliability and safety of electrical supply to be performed by the companies apart from other verification programs that can be established by the Competent Administrations.

   These verifications will be paid by the companies themselves.

2. In case of a network failure or an important perturbation related with the plant, and justifying it previously, the distribution company can verify the plant without authorisation from the Competent Authority. An important perturbation is defined as a perturbation that affects the distribution network and causes the electricity supply not to reach the quality levels established by the regulations in effect.

3. If a photovoltaic plant perturbs the operation of the distribution network not complying with the electromagnetic compatibility limits, quality of service or any other aspect of the regulations in effect, the distribution company will notify it to the Competent Administration and to the plant owner, for him to proceed to repair the deficiencies within 72 hours.

   a) If after the deadline the problems persist, the distribution company could proceed to disconnect the plant, notifying it immediately to the Competent Administration. In this case, after the causes of perturbations have been solved, to proceed to the connection of the plant, the plan owner must submit to the distribution company and the Competent Administration the justification signed by a competent technician or authorised installator, which describes the fixing operations done.

   b) If there is a disagreement about the existence and causes of perturbations, it can be requested the intervention of the Competent Administration that has a deadline of a month to solve the disagreement.

4. The plant owner must have a communication media to put immediately into contact the control centres of the distribution network with the people that operates the photovoltaic plant.

6.1.2. Technical Conditions of PV Plants Connected to the Low Voltage Network

6.1.2.1. General Technical Conditions

1. The operation of the photovoltaic plants that are referred in this RD must not cause damage, to the network, decrease of safety conditions, nor variations above the regulations that are applicable to these plants.

   Besides, the operation of these plants cannot create dangerous working conditions for the maintenance personnel of the distribution network.

2. If the distribution line is de-energised, due to maintenance or due to the actuation of a protection device, the photovoltaic plant must cease to energise the distribution line.

3. The conditions of network connection will be determined in function of the rated power of the photovoltaic plant, to avoid harmful effects to the users with sensitive loads.

4. To establish the connection point to the distribution network, the following characteristics will be considered: capacity of transport of the line, installed power in the transformation centres and distribution in different phases of generators subject to special regulations that contain single-phase inverters.

5. In the generating circuit to the metering device, it cannot be placed any other means of generation, accumulation or loads apart from the photovoltaic generator.

6. If a photovoltaic plant is affected by perturbations of the distribution network, the regulations in effect about quality of service will be applied.

6.1.2.2. Specific Interconnection Conditions

1. Photovoltaic plants can be interconnected in low voltage, provided that the sum of their rated power is not above 100 kVA. The sum of the rated powers of the plants subject to special regulations connected to a low voltage line cannot exceed half of the capacity of transport of the line in the point of connection, defined as the design technical capacity of the line in that point. If it is necessary to make the connection in a transformation centre, the sum of the rated powers of the plants subject to special regulation connected to that centre cannot exceed the capacity of transformation for that level of voltage.

2. If the rated power of the photovoltaic plant to be connected to the distribution network is above 5 kW, the connection of the photovoltaic plant to the network will be done in three phases. That connection can be done with one or more single-phase inverters of up to 5 kW, to the different phases, or directly with a three-phase inverter.
3. In the connection of a photovoltaic plant, the voltage variation caused by the connection and disconnection of the photovoltaic plant cannot be above 5% and cannot cause in any user connected to the network, an excess of the limits indicated in the Electrotechnical Regulation for Low Voltage
4. The power factor of the energy supplied to the distribution network must be as near as possible to the unity. Photovoltaic plants connected in parallel with the network must take the necessary measures to comply with it, or come to an agreement about this issue with the distribution company.

6.1.2.3. Metering and Billing

1. When there are electric consumptions in the same place of the photovoltaic plant, the consumptions must be placed in independent electric circuits and of their metering devices. The metering of those consumptions must be done with their own and independent devices that will serve for its billing purposes.

   The output meter must have capacity to meter in both ways and if not, between the output meter and the circuit-breaker, an input meter will be placed. The electric energy that the owner will bill to the distribution company will be the difference between the output and input of the photovoltaic plant. In a plant with two metering devices, it will not be necessary to have a supply contract for the photovoltaic plant.

   All the elements of the metering device, input and output, will be sealed by the distribution company.

   The authorised installer will only be able to open the seals with written permission from the distribution company. But in case of danger, the seals can be removed without permission of the distribution company, informing immediately to the distribution company.
2. The placement of the metering devices and if necessary, of the hourly switching devices must comply with MIE BT 015.

Metering sites must be signalled in an indelible way so that the each plant owner is clearly identified. Besides, it must specify if it is an input or output energy metering device.

Metering devices must comply with the regulations in effect and their precision must be at least of class 2, as regulated in RD 875/1984 of March the 28th.

3. The characteristics of the output metering device must be such that the current corresponding to the rated power of the photovoltaic plant must be within 50% of the rated current and the maximum current of the precision of the device.
4. When the plant owner chooses the billing type that is subject to the electricity production market final mean hourly price, as defined in RD 2818/1998 of December the 23rd, it must comply with the Regulation of Metering Points, Consumptions and Transits of Energy.

6.1.2.4. Protections

The protection system must comply with the regulations in effect, must be certified in the documentation of the plant and must include:

1. Manual circuit-breaker, it must be magneto-thermal with a short circuit current above the one stated by the distribution company in the point of connection. This circuit-breaker must be accessible to the distribution utility at any time to allow manual disconnection.
2. Automatic differential circuit-breaker to protect people in case of a derivation of some elements of the direct current part of the plant.
3. Automatic circuit-breaker of the interconnection for the automatic connection-disconnection of the photovoltaic plant in case of loss of voltage or frequency of the network, together with an interlock relay.
4. Protection for the interconnection of maximum and minimum frequency (51 and 49 Hz) and maximum and minimum voltage (110% and 85%).
5. These protections can be sealed by the distribution company after verifying them.
6. The re-closing of the switching device and so, of the connection with the low voltage network will be automatic once the network voltage has been restored by the distribution company.
7. The inverter can have the maximum and minimum voltage and maximum and minimum frequency protections embedded and if so, the automatic opening-closing operations will

be done by the inverter. In this case, it will only be necessary to have a manual circuit-breaker and an automatic differential circuit-breaker if the following conditions are met:

a) The functions will be done using a contactor which re-closing will be automatic once the rated network supply conditions are restored.

b) The contactor, controlled usually by the inverter, can be activated manually.

c) The contactor status (ON/OFF) must be clearly signalled in the front of the equipment and in a highlighted place.

d) If sealable protections are not used for the interconnection of maximum and minimum frequency and maximum and minimum voltage, the inverter manufacturer must certify:

d.1) Calibration values of voltage.

d.2) Calibration values of frequency.

d.3) Type and characteristics of the equipment used internally for fault detections (model, brand, calibration, etc.).

d.4) Passing of the corresponding tests of voltage and frequency limits.

While no technical instructions are regulated, the testing procedures and certifications done by the equipment manufacturers will be accepted.

e) If protection functions are done using software for control operation, the physical seals will be substituted by certificates of the inverter manufacturer that mention explicitly that the program is not accessible by the plant user.

6.1.2.5. Earthing Conditions of PV Plants

Earthing of interconnected photovoltaic plants will always be done in a way that does not alter the earthing of the distribution company, ensuring that no transfer or defects to the distribution network is produced.

The plant must have a galvanic separation between the low voltage distribution network and the photovoltaic plant, either using an isolation transformer or any other means that performs the same functions.

The photovoltaic plant masses must be connected to a earth independent of the neutral earth of the distribution company and of the rest of the masses of the supply, in accordance to the Electrotechnical Regulation for Low Voltage.

6.1.2.6. Harmonics and Electromagnetic Compatibility

Emission and immunity levels must comply with the regulations in effect, and the certificates that assure it must be included in the documentation.

6.2. RD842/2002 Low Voltage Regulation: ITC-BT-40 Low Voltage Generating Plants

6.2.1. Conditions for Connection

6.2.1.1. Isolated Generating Plants

They are defined as generating plants that cannot be connected to the Public Distribution Network by any means.

The connection to the receivers, in plants where coupling with the Public Distribution Network or with another generator is not possible, must contain a device that allows the connection and disconnection of the load in the output circuit of the generator.

When there is more than one generator and their connection needs synchronising, manual or automatic equipment must be available to perform that operation.

Portable generators must contain over-current and direct and indirect contact protections suitable to the load they are feeding.

6.2.1.2. Support Generating Plants

They are defined as generating plants that are connected to the Public Distribution Network but cannot work in parallel with the network. A switching device must be installed to avoid these plants working in parallel with the network. Load transfer operations are allowed.

The alternative feeding (network or support) can be done in some points that must have a switching device for all active conductors and the neutral conductor, to avoid the coupling of both power sources.

When load transfer operations are forecast, the connection of the generating plant to the Public Distribution Network must be done in a single point and the following requirements must be fulfilled:

- Load transfer operations are allowed only for generating units with a power rating higher than 100 kVA.

- In the instant of interconnection between the generator and the Public Distribution Network, the neutral of the generator must be disconnected from earth.
- The switching device must be installed next to the metering instruments of the Public Distribution Network, with accessibility for the Distribution Company.
- A protection must be installed to avoid the generator supplying power to the network.
- Maximum and minimum voltage, maximum and minimum frequency, over- current and short-circuit, interlock to avoid energising the line when it is de-energised and loss of synchronism protections must be included.
- It must have a synchronisation device and the interconnection cannot be maintained during more than 5 seconds.

The switchgear must include an auxiliary contact to allow connecting to a separate earth the neutral conductor of the generator, when load transfer operations are forecast.

The protection elements and their connections to the switchgear must be sealed or it must be assured by alternative methods that the initial triggering parameters cannot be modified and the electricity distribution company must have permanent access to that element, when load transfer operations are expected. The switchgear operation device must be accessible to the self-generator.

6.2.1.3. Interconnected Generating Plants

They are defined as generating plants that are normally working in parallel with the Public Distribution Network.

The maximum power of generating plants interconnected to the Public Distribution Network, will be conditioned by the characteristics of the network: service voltage, short-circuit power, load capacity of the line, power consumed in the low voltage network, etc.

6.2.1.3.1. Maximum power of generating plants interconnected in low voltage

In general terms, the interconnection of generating plants to 3x400/230 V low voltage networks will be allowed when the sum of the rated powers of the generators is not neither above 100 kVA nor above half the output capacity of the centre of transformation to which the line of the Public Distribution Network to which the generating plant is connected.

In 3x220/127 V three-phase networks, generating plants of up to 60 kVA or half the output capacity of the centre of transformation to which the line of the Public Distribution Network to which it is connected are allowed. In this cases the whole plant must be ready to operate in the future with 3x400/230 V.

For wind generators, to avoid network fluctuations, the rated power of the generators cannot be above 5% of the short-circuit power in the point of connection to the Public Distribution Network.

6.2.1.3.2. Specific conditions for starting and coupling of the generating power plant to the Public Distribution Network

Asynchronous Generators

The voltage drop must be below 3% of the rated voltage of the network.

For wind generators, the maximum frequency of the connections must be of 3 per minute, with a voltage drop limit of 2% of the rated voltage during 1 second.

To limit the current and voltage drop in the instant of interconnection to the values indicated above, suitable devices must be used.

The interconnection of an asynchronous generator to the network will not be done until, driven by the turbine or the motor, the generator has reached an speed between 90% and 100% of the synchronous speed.

Synchronous Generators

The use of synchronous generators in generating plants that are going to be interconnected to Public Distribution Networks must be agreed with the electricity distribution company, according to the necessity of independent operation of the network and the exploitation conditions of the network.

The plant must have an automatic or manual synchronisation device.

This device is dispensable if the interconnection can be done as an asynchronous generator. If so, the starting characteristics must comply with the conditions of the asynchronous generators.

The interconnection of the plant to the Public Distribution Network must be done when in the synchronisation operation the differences between the electric magnitudes of the generator and the network are not above the following values:

- Voltage difference: ± 8 %
- Frequency difference: ± 0,1Hz

- Phase difference: ± 10º

The points where no synchronisation device exists and the parallel interconnection is possible, an electric interlock must be placed between the generating plant and the Public Distribution Network to avoid parallel operation.

6.2.1.3.3. Switching and metering devices to be placed in the interconnection point

In the source of the generating plant and in a unique and permanently accessible point to the electricity distribution company, a circuit-breaker with associated protections must be placed. These protections must assure that the internal faults of the plant do not perturb the normal operation of the networks to which it is interconnected and if a fault occurs, the protections must open the circuit-breaker and it cannot be re-closed until the Public Distribution Network has a stable voltage.

The protections and the wiring of the circuit-breaker must be sealable and the switching device must be accessible to the self-generator.

The gang switch must have an auxiliary contact to allow disconnecting the neutral from the Public Distribution Network and to connect it to earth when the generating plant works isolated from the network.

When it is forecast to supply energy from the generating plant to the Public Distribution Network, in the end of the coupling installation, a metering device that meters the energy supplied by the self-generator must be installed. This metering device can share elements with the device that meters the energy supplied by the Public Distribution Network, provided the energy metering in both ways is logged in an independent way.

The metering device must have elements suitable for the type of hourly discrimination that is determined.

In generating plants with asynchronous generators, it must be placed a metering device to log the reactive energy absorbed by them.

When the compliance of energy supply programs must be verified, suitable metering and logging devices must be placed.

6.2.1.3.4. Control of reactive energy

In plants with asynchronous generators, the power factor of the plant must not be below 0.86 of the power rating and suitable capacitor banks must be installed when necessary.

These plants must have suitable protection devices to assure the disconnection in less than 1 second when there is an interruption in the Public Distribution Network.

The electricity distribution company can exempt the power factor compensation if reactive power can be generated.

Synchronous generators must have enough reactive power generating capacity to keep the power factor between 0.8 and 1 in lead or lag. To keep the supplied reactive power stable, it must be installed an excitation control to permit the regulation of reactive power.

6.2.2. Wiring Cables

Wiring cables must be dimensioned for a current of at least 125% of the maximum current of the generator and the voltage drop between the generator and the point of interconnection to the Public Distribution Network, cannot be of more than 1,5%, for the rated current.

6.2.3. Waveform

The generated voltage must be almost sinusoidal, with a maximum harmonic rate, for any working condition of:

- Harmonics of even order: 4/n
- Harmonics of third order: 5
- Harmonics of odd order (≥ 5): 5/n

The rate of harmonics is the relation, in %, between the root mean square value of the harmonic of order n and the root mean square of the first harmonic.

6.2.4. Protections

The prime mover and the generators must have the specific protections recommended by the manufacturer to reduce damage caused by internal or external faults.

The output circuits of the generators must have the protections set in the corresponding CTI (Complementary Technical Instructions) that are applicable to them.

In generating plants that can be interconnected to the Public Distribution Network, a group of protections to trigger the interconnection circuit-breaker must be placed in the source of the plant. These protections must be homologated and properly verified and sealed by a recognised laboratory.

The minimum protections that must be placed are the following: Over current, using magneto-thermal direct relays or equivalent devices.

Instantaneous minimum voltage, connected between the three phases and the neutral and with a triggering time of less than 0.5 seconds when the voltage reaches 85% of its rated value.

Maximum voltage, connected between a phase and the neutral, and with a triggering time of less than 0.5 seconds when the voltage reaches 110% of its rated value.

Maximum and minimum frequency, connected between phases and which has to trigger when the frequency is below 49 Hz or above 51 Hz during more than 5 periods.

6.2.5. Earthing Installations

6.2.5.1. Introduction

Generating plants must have earth systems to ensure that the voltages that can arise in the metallic masses of the plant do not surpass the values set in the MIE-RAT 13 of the Regulations about Technical Conditions and Security of Electric Power Stations, Substations and Centres of Transformation.

The earth systems of generating plants must have adequate technical conditions to avoid fault transfers to the Public Distribution Network and to private installations.

6.2.5.2. Characteristics of the Earth Connection According to the Type of Operating Scheme of the Generating Plant towards the Public Distribution Network

6.2.5.2.1. Isolated generating plants connected to installations that are fed exclusively by those plants

The earth network of the installation connected to the generating plant must be independent from any other earth network. Earth networks are considered independent when the circulation of the maximum fault current in one of them does not cause voltage differences above 50 V, with respect to the earth of reference, in the other.

In this type of installations the neutral of the generator and the masses of the plant must be earthed following one of the systems explained in the ITC-BT08.

When the generator does not have the neutral accessible, the system can be earthed using a wye three-phase transformer that can also be used for other auxiliary functions.

If some generators are working in parallel, the junction of the neutrals of the generator must be earthed in a unique point.

6.2.5.2.2. Support generating plants, connected to installations that can be fed, independently, by those groups or by the Public Distribution Network

When the Public Distribution Network has the neutral earthed, the earth connection diagram must be of type TT and the masses and feeders of the installation must be connected to an independent earth.

If it is technically impossible to make an independent earth connection for the neutral of the generator and with previous specific authorisation from the Competent Administration, the same earth can be used for the neutral and the masses.

When feeding the installation from the generating plant and load transfer is forecast, an auxiliary pole must be placed in the interconnecting switchgear to connect the neutral of the generator to earth.

6.2.5.2.3. Interconnected generating plants, connected to installations that can be fed simultaneously or independently by those groups or by the Public Distribution Network

When the installation is coupled to a Public Distribution Network that has the neutral earthed, the earth connection diagram must be of type TT and the masses and feeders of the installation must be connected to an independent earth from the neutral of the Public Distribution Network.

When the installation is not coupled to the Public Distribution Network and is fed exclusively from the generating plant, there must be an auxiliary pole in the self-acting switch that disconnects the neutral of the Public Distribution Network and connects to earth the neutral of the generator.

For the protection of the generating plant there must be placed a device that detects the current that circulates through the connection of the neutrals of the generators to the neutral of the Public Distribution Network and disconnects the installation if it is above 50% of the rated current.

6.2.5.3. Wind Generators

The earth connection of the protection of the tower and the surge arresting equipment that is mounted in it must be independent from the rest of the earths of the installations.

6.2.6. Commissioning

For the commissioning of support or interconnected generating plants, besides the procedures that must be done accordingly to the legislation in effect in the Competent Administrations, the project about the parts that affect to the coupling conditions and reliability of the electricity supply, must be submitted to the electricity distribution company. The company, before commissioning the plant, can verify that the interconnection installations and other elements that affect to the reliability of supply are done accordingly to the regulations in effect. If disagrees, it must be communicated to the Competent Administrations to solve the problem.

This procedure is not necessary for isolated generating plants.

6.2.7. Other Regulations

All the procedures related to the determination of the interconnection point, the project, the commissioning and maintenance of the generating plants must follow the criteria that is established in the legislation in effect.

The electricity distribution company can, when it detects an immediate risk to people, animals and goods, disconnect interconnected generating plants, communicating it subsequently to the Competent Administration Organ.

THE REGULATORY FRAMEWORK FOR THE GREEK ELECTRICITY INDUSTRY

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(version 2.0)

Introduction

The regulatory framework for the Greek electricity industry has changed significantly over the past years as a result of European Union and Greek government measures designed to increase competition in the electricity market. This new regulatory framework has been implemented by the Liberalization Law while a Ministerial decision has established that the market for all high or medium voltage electricity users (currently representing 35% of the electricity supply market in terms of power consumption) has been opened to competition.

The regulatory framework implemented distinguishes between the activities of generation, transmission, distribution and supply. The framework also distinguishes between the interconnected transmission system and the distribution network and between the interconnected system and the autonomous islands.

1. The Liberalization Law

Prior to the Liberalization Law the regulatory framework for the Greek electricity industry gave Power Public Corporation (PPC) an almost exclusive right to generate, transmit and distribute electricity. The only exceptions were certain industrial entities allowed to produce electricity primarily for their own consumption, as well as other private commercial companies producing energy from renewable resources and co-generation. The Greek government regulated the tariffs that were charged to the customers and any tariff increase required the approval of the Minister of National Economy and Finance. PPC was the only responsible for the daily and yearly program of the generating units on the basis of its internal operational procedures. PPC was also the only responsible for the transmission system and distribution network.

On 22nd December 1999 the Liberalization Law came into force to comply with the Electricity Directive. The Liberalization Law initiated the transformation of the Greek electricity sector from a monopoly to an industry open to competition. The principal regulatory provisions of the Liberalization Law may be summarised as follows:

- the electricity sector is supervised by the Minister of Development;

- RAE (“Regulatory Authority for Energy”) is established as the independent authority whose principal responsibility is to control and monitor the liberalising energy sector;

- both the Minister of Development and RAE must act in such a way as to protect the environment, satisfy Greece's electricity requirements, verify the ability of licensed generators and suppliers to finance their activities, promote competition in generation and supply, protect the interests of consumers, promote efficiency, take into account the cost of research and development and protect the public against health and safety dangers;

- the operation of any electricity business, defined as the activities of generation, transmission, distribution or supply of electricity, requires a licence. Licences are granted by the Minister of Development, on the basis of a recommendation from the RAE. Entities operating electricity business must treat all users equally and, subject to delivering their public service obligations, must aim to achieve a competitive electricity market;

- PPC retains the ownership of the interconnected transmission system while the right to operate and plan its development is granted to another company named HTSO (Hellenic Transmission System Operator S.A.). PPC also retains the right to use the interconnected transmission system for non-electricity purposes provided this does not compromise the safe, secure and economic operation of the interconnected transmission system and provided that there is no cross-subsidisation of non-electricity activities by electricity customers;

- PPC retains the ownership of, and the right to operate, the distribution network;

- the operation of the electricity market is principally governed by four codes, each as approved by a Ministerial Decision: the Grid Code, regulating the physical operation of the interconnected transmission system; the Power Exchange Code, regulating financial transactions in respect of the interconnected transmission system; the Network Code, regulating the distribution network; and the Supply Code, regulating supply to all customers;

- PPC, as an integrated electricity business, is required to keep separate accounts for its generation, transmission and distribution businesses;

- HTSO must despatch generation on the basis of the lowest cost of generation, subject to transmission and technical constraints and the requirement to prioritise the despatch of electricity generated from renewable resources, cogeneration and, in respect of up to 15% of annual consumption, indigenous fuel sources; and

- tariffs for all electricity businesses other than supply to Eligible Customers are recommended by the RAE and are subject to the approval of the Minister of Development. There are also special interim provisions regulating the price PPC can charge to Eligible Customers for electricity while it supplies 70% or more of the Eligible Customer market.

1. Recent amendments to the Liberalization Law

On 29th August 2003 the law 3175/2003 came into force. This law modifies in many issues the Liberalization Law. The main amendments are the following:

- The current dispatch mechanism has been modified and a compulsory energy market is developed, that is going to operate on the basis of hourly bids to HTSO, provided that each bid will reflect, at least, the variable cost of the relevant generator unit.

- Imbalances are designated as the differences between the scheduled energy injections and/or consumptions to or from the system and the respective energy quantities that were injected or consumed in real time, within the daily energy market operation. HTSO may enter into agreements with generators in order to maintain auxiliary services and reserve supply to the daily market participants, based on non-discriminatory procedures for cost minimization.

- HTSO may enter into agreements for power capacity after bid procedure, in order to reserve the system supply provision. During a first period, HTSO may issue an invitation for bids of up to 900 MW generation capacity that will be produced by new generation plants entering into the system up to 1st July 2007. HTSO may also introduce other mechanisms for the sufficient generating capacity reserve, under RAE's supervision.

- The suppliers' designation has been extended in order to include trading companies in addition to supply and distribution companies. Moreover those that may guarantee the availability of the necessary generation capacity installed in the E.U. (i.e. based on contracts) may apply for supply licence.

- Issue of supply licence to PPC for 1600 MW generation capacity – cold reserve setting: PPC is granted a generation licence for the construction of new generation capacity or for the renewal of existing generation capacity up to 1600 MW, provided that the respective old plants generation capacity will be set into cold reserve. The management of old plants will be performed exclusively by the HTSO, according to the Grid Code and under HTSO instructions, in order to provide both auxiliary services and generating reserve.

2. Generation Licensing

Under the Liberalization Law, any entity or person wishing to generate electricity must obtain either a generation licence or an exemption. The procedure for obtaining a licence or an exemption and the terms of a licence are set out in the Authorizations Regulation for Generation and Supply, which was issued pursuant to the Liberalization Law and came into force on 8th December, 2000. Licences and exemptions are only available to European Union entities and citizens.

In respect of the interconnected system, a prospective generator must submit an application to RAE. RAE makes a recommendation taking into account certain factors, which include: system security, protection of the environment, efficient generation, the proposed primary fuel source and generation technology, the technical and financial capabilities of the applicant, the long-term energy planning for Greece, consumer protection and national security. The application procedure should generally take no more than six months from the submission of an application to the issue of a decision by the Minister of Development.

Generating plants with a capacity of no more than 20 kW, reserve plants with a capacity of no more than 150 kW (or, in the case of industrial plants, 900 kW), research plants with a capacity of no more than 2 MW and plants established by the Centre for Renewable Sources of Energy (Greece) are entitled to apply for an exemption from the requirement for a generation licence.

3. Distribution

The Liberalization Law gives PPC the exclusive right to own and operate the distribution network. This role is carried out by PPC's Distribution business unit. Third party access to the distribution network is regulated by RAE and PPC must provide access to the distribution network in an efficient, transparent, timely and non-discriminatory manner.

PPC imposes an once only connection fee, defined according to a methodology approved be the Minister of Development, to all suppliers, customers and generators that have access to the distribution network. All users who connect to the distribution network will be required to enter into an agreement with PPC for their connection and use of network. PPC is entitled to charge a tariff for use of the medium and low voltage systems to all end-users, which is subject to approval by the Minister of Development.

4. Supply

One of the principal means by which competition is to be introduced to the Greek electricity market is by allowing new suppliers to enter the market. The Liberalization Law provides that, while PPC remains the sole supplier in relation to Non-Eligible Customers, new suppliers can be licensed to supply electricity to Eligible Customers. Under the Liberalization Law, any entity wishing to supply electricity requires either a supply licence or an exemption. The procedure for obtaining a licence and the terms of a licence are set out in the Liberalization Law and the Authorisations Regulation for Generation and Supply. Licences and exemptions are only available to European Union entities.

A supply licence specifies the maximum demand to be supplied by the licensee. The most important condition for the issue of a supply licence is that the licensee must either own sufficient generating capacity installed in the European Union, or can guarantee the availability of generation capacity installed in the European Union, to meet this demand. The licensee must also prove its financial robustness and solvency. In the case of any capacity that is not installed in Greece, the prospective licence must also demonstrate that it can guarantee the availability of the necessary capacity of the transmission systems and of the interconnections required for the transmission of the electricity in Greece.

5. Eligible and Non-Eligible Customers

The Liberalization Law, in accordance with the Electricity Directive, distinguishes between Eligible and Non-Eligible Customers. The Liberalization Law provides that the percentage of Eligible Customers must represent a percentage of power consumption equal to the percentage of the electricity market Liberalization determined each time by the European Commission. In accordance with the above, defines that Eligible Customers are all customers consuming more than 100 GWh per year and per point of consumption, and others defined in Decisions of the Minister of Development, on the RAE's recommendation. A Decision of the Minister of Development dated 9th January, 2001 defines Eligible Customers, with effect from 19th February, 2001, as all high- or medium-voltage electricity users together currently representing 35% of the electricity market by consumption, which exceeds the current requirements of the European Commission. However, according to the Electricity Directive 2003/54 this percentage of Eligible Customers shall increase from 1st July, 2004 to include all non-household consumers, with the exception of non interconnected islands.

Non-Eligible Customers are principally residential consumers and (till 1st July, 2004) small and medium-sized businesses connected to the low voltage network. All consumers on the autonomous islands are also Non-Eligible Customers. PPC has the exclusive right and obligation to supply electricity to Non-Eligible Customers. The terms, including tariffs, on which PPC provides this supply are regulated by the Supply Code.

6. Public Service Obligations

As the incumbent electricity provider in Greece, PPC must carry out certain public service obligations, including:

- charging customers on the autonomous islands electricity tariffs that are the same as the electricity tariffs PPC are entitled to charge to Non-Eligible Customers on the interconnected system, *although these tariffs do not cover the average cost of generation on the autonomous islands*;

- providing electricity to certain customers at a discount, including agricultural customers, municipalities, large families, earthquake victims and small newspaper publishers. Consequently, the price charged to these customers does not allow PPC to recover its costs of generation; and

- irrigation obligations, which require PPC to release water from its hydroelectric station, thereby generating electricity at times of the day that may not be the most economical for PPC.

Under the Liberalization Law. a special account administered by the HTSO provides limited compensation for the provision of public service obligations, from which the HTSO makes payments to all entities within the Greek electricity industry responsible for meeting public service obligations.

7. Renewable Generators and co-generators in the interconnected system

The Liberalization Law requires the HTSO to purchase the energy generated by Renewable Generators and co-generators producing from renewable resources that are connected to the interconnected system under 10-year renewable power purchase contracts.

8. Autonomous Islands

On the autonomous islands, all of which fall within the Distribution business unit, Power Public Corporation remains the monopoly supplier and is the exclusive owner and operator of the distribution network, which, in the case of Crete, Rhodes and Lesvos, includes a limited high voltage network. The autonomous islands are the subject of a separate regulatory regime, which is described in this section.

8.1 Generation

As operator of the distribution network PPC prepares, subject to approval from the RAE, a forecast of the demand for generating capacity. If this forecast indicates a need for new capacity the Minister of Development may issue an invitation for bids to construct such capacity. In the event that this process still results in insufficient generating capacity on these islands, or is unsuccessful, the Minister of Development is entitled to grant a generation licence to PPC to ensure continuous electricity supply. PPC may be obliged to ensure a continuous uninterrupted supply of electricity on the autonomous islands and, accordingly, to construct additional generating capacity. The Minister of Development intends to apply to European Commission for an exception from the bid procedure obligation for new generation plant construction in the autonomous islands.

As operator of the distribution network PPC manages the dispatch of generation on each autonomous island on the terms to be set out in the Network Code once it is published.

There are similar provisions in relation to Renewable Generators as for the interconnected system. On the autonomous islands PPC, as operator of the distribution network, takes on the HTSO's role in entering into 10-year contracts with all Renewable Generators. A capped electricity tariff, pursuant to the Liberalization Law, applies and PPC is compensated for any shortfall between PPC's payments under these contracts and the price it receives for the generation by a payment from the HTSO. The HTSO charges this payment to the Special sub-account of the Uplift Account. In addition PPC, as operator of the distribution network, must buy all energy generated by Renewable Generators in the autonomous islands and as a result must pay for whatever level of generation a Renewable Generator produces.

8.2 Distribution

All the lines on the autonomous islands, notwithstanding that some lines on Crete, Rhodes and Lesvos are high voltage, form part of the distribution network. Consequently PPC has the exclusive right to own, operate and exploit this network and will do so in accordance with the Network Code.

8.3 Supply

Pursuant to the Liberalization Law, the Minister of Development is required to grant PPC an exclusive supply licence for the Non-Eligible Customers, which comprise all PPC's customers on the autonomous islands. Accordingly, PPC supplies these customers on the basis described above.

APPENDIX 1

A new law has been recently voted in the Greek Parliament concerning the regulatory framework for the Greek electricity industry. The new law adapts the Greek legislation to the Electricity Directive 2003/54 considering all remaining issues of the Directive not included in the provisions of the previous laws.

The main points of the new law are:

- All non-household consumers, with the exception of non interconnected islands, shall be Eligible Customers while this percentage will be 100% from 1st July, 2007.
- The Hellenic Transmission System Operator S.A. takes over the role of the Distribution Operator, as well.
- A new Operator is established for the non interconnected islands including the small islands that are excluded by the provisions of the Directive.

Another law is also under preparation for the Renewable Energy Sources giving strong motivation to the small size RES production mainly by PVs. It is considered that that both laws will lead to the development of microgrids in Greece, even though specific provisions may be necessary for their application. The results of the Microgrids Project should valuable and the whole Project may contribute to this direction.