DECENTRALISED GENERATION PUBLICATION OF FRENCH CONNECTION RULES

Olivier GONBEAU EDF ERD–France olivier.gonbeau@edf.fr
Jean-Luc FRAISSE EDF ERD–France jean-luc.fraisse@edf.fr
Jean-Luc RAIMON EDF ERD–France jean-luc.raimon@edf.fr
Frédéric BALTES EDF ERD–France frederic.baltes@edf.fr
Coralie NASLIN EDF ERD–France coralie.naslin@edf.fr
Pierre BOUSSEAU EDF R&D–France pierre.bousseau@edf.fr

ABSTRACT

The French Distribution Technical Guide called "Référentiel technique" aims at presenting regulatory aspects and technical connection rules. The "Référentiel technique" indexes study methods, presents contract models and describes information to be exchanged between the Distribution System Operator (DSO) and the network users (especially for Decentralised Generation).
The publication of the French Distribution Technical Guide answers to the transparency obligation introduced by connection rules decree (published on March 13, 2003) which stipulates in its article 5 that: "the connection study is undertaken within transparency and non-discriminatory framework. The general methods and the assumptions used must be published by Distribution System Operator ".
More over, The French Distribution Technical Guide edition follows the French Regulator deliberation published on April 7, 2004. The users of the public electricity distribution network operated by EDF can access to all documents constituting the Technical Guide on Internet website http://www.edfdistribution.fr. Furthermore, the French Distribution Technical Guide existence is brought to all network user attention before the conclusion of any contract. All these publications make it possible to check results obtained for the DSO connection offers. Since June 2005, the French Distribution Technical Guide components are published or updated at the rhythm of the dialogue with the users representatives.

INTRODUCTION

The electricity distribution network has been specified and developed to distribute energy from the transmission grid downstream to MV and LV loads. Hence, the arrival of embedded generation implies additional constraints on the planning and the operation of the distribution networks. Power quality can be altered: over-voltage, flicker, voltage/current harmonics, attenuation ripple control of signals while the distribution network operator is responsible for the quality of the supplied energy. Thus, since 1994, the development of Decentralised Generation has forced technical rules to evolve. In April 1995, a first technical order was published in France followed by others orders (in 1997, 1998 and 1999).The transposition of European directive, opening up the network market in February 2000, has defined new technical connection rules divided in a decree and a technical order specific for producer (respectively published on March 13th and 17th, 2003). The requirements (replacing the technical orders published between 1995 and 1999) list general principles but do not specify any generation power processes and do not deal with the grid connection studies implementation.
As a consequence, the Distribution System Operator developed design methods and tools to take into account the embedded generation and its specificities. These features are implemented into French Distribution Technical Guide. Figure 1 describes the actual regulation related to connection rules and all publication associated.

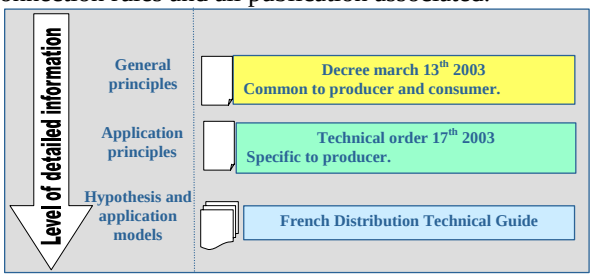

Figure 1 French regulation and publication related to Decentralised Generation connection

The network requirements and technical rules apply to types of generation plants i.e. whatever the energy source and the generation process used. The "Référentiel technique" is divided into chapters in order to explain and describe connection rules and procedure.

CONSTRUCTION OF FRENCH DISTRIBUTION TECHNICAL GUIDE

Further more, each of the guide's document has to be discussed with grid users. To this effect, the regulator has asked Distribution System Operator to create a consulting committee. This committee is made up of sub-committer, one of which relates to generation units and requirements they had to comply with for the connection to the grid. In order to allow for the largest possible consultation, the Distribution System Operator has created an internet web site for the technical guide consultation and collecting of feedbacks. For each document, a consultation report is established and communicated to the French regulator.

CONNECTION PROCEDURE

Procedure for a waiting list

In order to deal with the largest number of connection requests submitted to them, the French System Operators have defined a procedure relying on waiting lists. This procedure concerns all types of power plants with a construction authorization. Since the grid capacity limitations involve both the transmission and the distribution networks, the procedure implies a coordination between the transmission system operator and the distribution system operator for the management of the waiting lists. Thus, this procedure aims at clarifying the connection waiting list, keeping in the list only "serious" projects with a good probability to be build up and as a consequence to propose realistic studies. The following figure presents grid connection offer (mostly for wind farms) on French continental distribution network on January 2007.

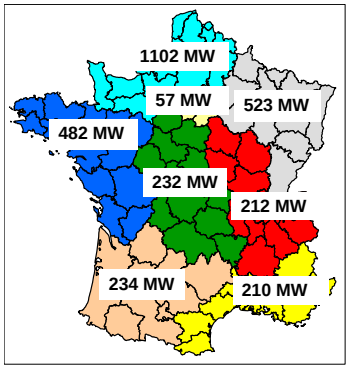

Figure 2 Waiting lists for Decentralised Generation connections on distribution network January 2007

Information exchange for connection offer

In addition of setting up a procedure allowing the management of connection request, the "Référentiel technique » describes information to be exchanged between the Distribution System Operator and the network users in order to justify connection offers. Figure 3 describes the relations between the Distribution System Operator and the representative of the future generation unit. Three major stages are identified :

① Connection information, the representative of the future generation unit gives information about the generation unit. There are administrative (construction authorization, localization) and technical information (power injected to the network, number on wind turbines, IEC 61400-21 report…).

② Technical studies and rules described hereafter.

③ Connection Offer with a publication of study data.

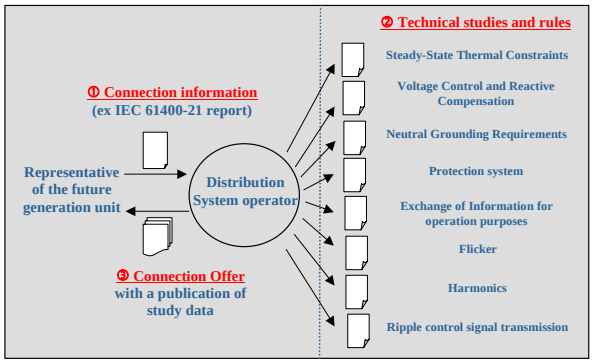

Figure 3 – Principle of Information exchange for connection offer

All these documents are a part of the "Référentiel technique" and published on Distribution System Operator web site http://www.edfdistribution.fr.

TECHNICAL STUDIES AND RULES

The connection of a DG on a distribution network affects the physical phenomena in steady state (currents, voltages), and in transients (flicker, short-circuit currents, etc). So the network operator has to perform a grid connection study for each new connection in order to determine the optimal solution that enable to fulfill the technical, regulatory and contractual constraints towards the network users. Today, connection studies can be distinguished out into three levels:

The **first** level consists in identifying issues common to all generation power unit. Indeed, issues such as grid capacity and steady-state configuration can be handled with the same methods as for classical generation units. Thus, The producer submits the grid connection request along with general data about the project to the system operator. All input values and study methods are described for :

- Steady-State Thermal Constraints
- Voltage Control and Reactive Compensation
- Neutral Grounding Requirements
- Protection system
- Exchange of Information for operation purposes

The **second** level deals with the determination of specific disturbances induced. The most significant example is wind energy, for which a segmentation is made in six various families (depending on the technology used), to determine the studies to perform. This distinction is necessary in particular for the power quality aspects such as flicker, harmonics and ripple control signal attenuation.

The **third** level applies to a detailed integration study of the wind farm impact following the identified disturbances. This detailed study is based on the power quality assessment standard of wind turbines connected to the grid (IEC 61400-21). This study is composed of several items:

- Inrush transients when switching on transformers that can entail some voltage control problems
- Flicker (based on IEC 61400-21) :

- continuous operation
- switching operations

– Harmonics (based on IEC 61400-21)
– Ripple control signal transmission.

The aim of all these studies is to forecast the expected disturbances levels and to determine the point of common coupling that will avoid the power quality deterioration. As a general rule, this methodology aims at keeping a grip on the distribution operator technical objectives, that is to say optimal network performances for all.

Steady-State Thermal Constraints

In France, the voltage level for the grid connection of a generating plant depends on its size. Table below gives the requirements concerning the voltage level at the connection point as a function of the size of the generating plant.

Voltage limits	Effective levels	Power limit
U ≤ 1 kV (single phase connection)	230V	P ≤ 18 kVA
U ≤ 1 kV (three-phase connection)	400 V	P ≤ 250 kVA
1 kV < U ≤ 50 kV	15kV, 20 kV	P ≤ 12 MW

Voltage control and reactive compensation

The value of the reactive power produced and the control mode (voltage, power factor or reactive power control) are determined by the Distribution System Operator in accordance with steady state voltage requirements.

When the grid connection study shows a voltage constraint in steady state (corresponding to an over-voltage for DG connection), different solutions are possible. In order to avoid a network reinforcement paid by the DG an adjustment of the reactive power is defined. This adjustment create a modification of the voltage regulation for the DG with a new reactive power consign (consumed or produced). The next presents required reactive power capacities for connections to the French distribution grid.

Connection Level	Installed power	Connection conditions regarding voltage control and reactive power
LV	P ≤ 250 kVA	No reactive power must be consumed Q ≥ 0
MV	P ≤ 1 MW	0 ≤ Q ≤ 0.4 Sn equivalent to 0 ≤ tg φ ≤ 0,43
	1 MW < P ≤ 10 MW	-0.1 ≤ Q ≤ 0.5 Sn equivalent to -0.1 ≤ tg φ ≤ 0,577
	10 MW <P ≤ 12 MW	-0.2 ≤ Q ≤ 0.6 Sn equivalent to -0.2 ≤ tg φ ≤ 0,75

A specific rule applies for classical induction generators: their reactive power needs and the possibly required additional reactive power generation are provided by capacitor banks connected either to the producer's installation or to the HV/MV substation. The reactive power produced by the capacitor banks at the DSO's request shall not exceed 0.4 Sn.

Neutral Grounding Requirements

On MV grids, the neutral must not be grounded at the generating plant location while the plant is connected to the network. Any underground cables leading to the generating plant must have their shields connected together and connected to the plant ground.

Protection system

The connection of DG units can affect the proper operation of the protection system. The behaviour of DG units may be rather different depending on the type of generators (synchronous or induction) and on their coupling systems to the grid (direct coupling or through power electronics interface).

More specifically, generating plants connected to distribution networks are equipped with decoupling protection systems in order to :

– ensure that the protection and automatic control systems fitted by the DSO on the network are able to operate properly,
– prevent operation of isolated networks under no-fault conditions, thus preventing the DG units to supply power to other users under abnormal voltage and frequency values and avoiding false couplings when these networks are reconnected to the main distribution network,
– instantly disconnect the DG plants in the event of a fault occurring during the special operating conditions which apply when live work is being carried out on the MV overhead network.

The DSO specifies to the producer the performances which are expected from the decoupling protection. The decoupling protections are mainly based on over- and under- voltage (MV : [85% - 115%] for V), over- and under-frequency ([47.5 – 51] Hz or [49.5 – 50.5] Hz) criteria and in some cases on an automatic control link with the protections implemented at the substation level (such as the feeder protection or other protections which may lead to the islanded operation of DG units on parts of the distribution grid).

For photovoltaic installations connected to LV grid, most of them are installed with power electronics witch comply with DIN VDE 0126 that ensure protection function.

Exchange of Information for operation purposes

The requirements of Exchange of Information for operation depend of the DG impact :

- Its nominal apparent power is larger than 25% of the rating of the HV/MV transformer when the DG plant is connected to a dedicated feeder (feeder with no other users connected),
- Its maximum nominal active power is larger than

25% of the maximum load on the feeder, when the DG unit is not connected to a dedicated feeder.

The contents of the production program, the time period, as well as how much ahead of time it should be sent, are defined in an agreement between the producer and the DSO These information's have to be exchanged particularly when there is an impact on the transmission grid (Steady-State Thermal Constraints).

Flicker

The flicker produced by a generating plant shall be limited in such a way that the DSO can respect the requirement Plt $\leq$ 1 (Probability Long Term). The base levels on the MV grid are 0.35 for Pst (Probability Short Term) and 0.25 for Plt.

Harmonics emission

The harmonic currents injected on the grid shall be limited to the following values :

Odd harmonics	k_n (%)	Even harmonics	k_n (%)
3	4	2	2
5 and 7	5	4	4
9	2	>4	0.5
11 and 13	3		
>13	2		

$$I_{n\lim} = k_n \frac{P_{ref}}{\sqrt{3} \cdot U_c}$$

where $I_{n\,lim}$ is the limit current value for harmonics number n, P_{ref} is the maximum apparent power of the generating plant, U_c is the contractual voltage, and k_n is a coefficient depending on the harmonics number and given in the previous Table.

Transmission of the remote control signals

The influence of the Decentralised Generation plants on the transmission of the remote control signal has to be assessed and if it is affected, appropriate measures have to be taken in order to maintain the signal level to an acceptable value for the network users.

CONCLUSIONS AND NEW REGULATORY REQUIREMENTS

A new ministerial order has been issued the 27th of October 2006 concerning DG grid connection. It modifies the ministerial order of the 17th of March 2003 related to the design and operation technical requirements of production units connected to French distribution networks. It stipulates new requirements for above 5 MW DG in case of disturbed grid operation. They concern :

① Operation in case of exceptional frequency. Without disconnection, the production units should be able to withstand frequencies in the range of [47.5 Hz; 52 Hz] temporarily[1], and [49.5; 50.5 Hz] permanently (normal operating range). For frequencies lower than 49.5 Hz, the production unit shall not reduce its active power of more than 10% of the active power at 49.5 Hz.

② Operation in case of exceptional voltage. The production units shall be able to withstand without disconnection exceptional voltages temporarily. The magnitudes and corresponding durations are specified in the new ministerial order.

③ Stability in case of short-circuit. A short-circuit on the transmission network creates a voltage dip that can be seen on a large area and affects both the transmission network and the related distribution networks. With the ever increasing dispersed generation penetration level, the resulting DG units disconnection can lead to a significant power decrease and can so endanger the network operation in a situation already weakened by the fault. Hence, new requirements have been defined concerning DG operation in case of short-circuit.

"The production units connected to a distribution network shall be designed to be able to withstand without disconnection short-circuits on the HV transmission network to which the considered distribution network is connected." To ensure the fulfilment of this requirement, the producer checks the dynamic stability of its production unit in case of a voltage dip such as the one presented in the informative annex of the ministerial order.

The Distribution System Operator provides the producer with the network data required to perform the studies, accordingly to the state of the art, that enable to assess this requirement. The Technical Guide of the DSO specifies the generic models to perform these studies, the stability criteria and stability margin which must be respected.

Hence these requirements will lead to a modification of the distribution Technical Guide. These modifications might concern the voltage dip the production units have to withstand without disconnection. Indeed, the voltage dip mentioned in the ministerial order is informative. If relevant, modifications might be included.

Furthermore, accordingly to the new requirements, the threshold of the decoupling protections will be changed to fit with the specified voltage dip. Then, connection studies methods concerning the risk of islanding (than enable to define the type of decoupling protection), and the short-circuit currents methods might be modified.

1 Exceptional operating ranges : [47.5 ;49.5 Hz], [50.5, 52 Hz] divided in different sub ranges with specified duration from 3 min to 15min.