Deliverable 2.1.B

“Connection Procedure Proposal”

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“Med-TSO—Mediterranean Project II”

Task 2.1: “Mediterranean common target regulatory framework (phase II)”

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1 Executive Summary

One of the main result expected by the Mediterranean Project 2 (MP2) is the establishment of a complete set of Rules for progressing in the harmonization of regulation in the Mediterranean region for power system rules (activity 2.1 "Technical rules") and a proposal for a fast track implementation project (Pilot Project) through a "zonal approach" considering a subset of rules in selected zones of the Mediterranean (activity 2.2 "Elaboration of zonal target regulatory framework and tentative roadmap").

The activity 2.1 completes and complements the work already accomplished in Mediterranean Project 1, progressing with further identification and proposal for technical rules necessary for developing and operating the power systems, in the perimeter of the network codes, efficient management of the system services and common process for the connection procedure (Deliverables 2.1A Med Grid Code Chapter on System Services and 2.1B Connection Procedures).

The Objective of the present deliverable 2.1. B is to develop a potential common proposal for the connection procedure of generation facilities to the transmission grid. This is a key step that would pave the way to an opening of the Electricity markets, by providing generators with clear rules and procedures for connecting to the grid operated by the TSOs.

This report does not intend to become a binding procedure but serve as guidelines that the TSOs could use through the entire Mediterranean region.

The work has been developed by Med-TSO Technical Committee "Regulation and Institutions" with the direct involvement of participating TSOs.

2 Background and methodology

Between 2015 and 2018 Med-TSO developed Mediterranean Project 1, a 3-year project supported also by the European Commission. One of the tasks included in this project was the development of a proposal of Common Target Regulatory Framework in the Mediterranean region.

One of the issues included in the proposal was the need to harmonize the technical criteria used for access and connection of non-transmission facilities to the grid. This report complements that proposal including a common procedure for application.

Four main issues are detailed in the following chapters regarding different aspects to be considered within the connection procedure.

In chapter 3 the two basic approaches for generation expansion are explained: top-down and bottom-up, including also a “mix” approach that could be used in the region.

The procedure itself it´s detailed in chapter 4 including the potential links with the administrative procedure.

Chapter 5 deals with the studies to be performed by TSO and the criteria used to evaluate spare capacity in the transmission grid.

In chapter 6 the economic aspect is included with considerations on how to deal with the cost of the transmission grid needed for the connection of generation facilities.

3 General approach for generation expansion

From the power system perspective, generation is needed in order to comply with the prescribed levels of supply reliability and efficiency as well as social-environmental requirements and objectives.

General approach for generation expansion and grid development management should be to determine the procedures and principles for the standards to be applied in planning and operating the electricity transmission system in a reliable and low-cost manner and ensuring the system stability and to determine the conditions for the supply reliability and quality to be applied in order to supply quality.

However, the massive development of renewable energies, which often constitutes the main part of the new generation connection, highlights a double evolution of the production mix, in terms of the geographical distribution of production on the one hand, and of variability of production on the other hand:

1) the distribution of production on the national territory will evolve by being less concentrated (slowdown in the development of thermal units of greater power, or even their closure) and differently localized (increase in production in areas that are currently lacking, reduction of potential in historic areas of thermal generation and reinforcement concentrating on certain areas that are very windy or have extensive open areas);

2) The daily and seasonal production will become more variable in volume but also in spatial distribution: alternation can be observed between episodes of high production in one part of the country (for example on sunny days in summer) or in another distant region (for example during windy nights in winter) in larger proportions than today.

The development of renewable energies, however, brings another challenge for the network operators in charge of planning and connection activities, that of assembling a reliable set of assumptions to carry out these activities in an efficient manner. Indeed, both the localization and the scale and dynamics of development of new renewable energies result both from a national energy policy led by a centralized entity, and from local economic actors who will make their choices based on local parameter specific to a given location.

In this context, different approaches may be used in order to incorporate the generation or to assess the acceptability of applications. To this respect, we could think of the following general approaches:

i. “Top-Down” in which a global strategy is established, or an global optimisation is carried out, and as a consequence a number of general guidelines are drawn or detailed decisions are made in terms of what sort of generation, in which area (even in which bus or substation), in which horizon…, should be installed. This would constitute the reference for the TSO assessment of the access to the grid applications.

ii. “Bottom-Up” in which the general strategy –if any- is translated into regulatory incentives or mechanisms by which generation promoters develop or try to develop their projects taking into account regulatory signals concerning technology, connection point (location, voltage, …), commissioning year, etc.

The advantages of **the "Top-Down" approach** seem obvious, with the ambition to achieve a technico-economic optimum both in terms of setting the structure of grid developments, and on programming over time. This highly centralized approach gives planners the opportunity to take into account national objectives and to define them at the local level by seeking the best solutions in the sense of the national community. In particular, this global approach, which can be termed "expansion planning", makes it possible to compare all costs and benefits, regardless of the identity of those who support them.
For the location of renewable energies, the stakes in terms of producible (wind, sunshine), availability of land, acceptability or environmental impacts will however remain the first

determinants of producers' choices (even if mitigated in the case of Tender mechanism), and will logically lead to adaptations of infrastructure including on the major transmission network. The Top-down approach theoretically allows all of these elements to be combined, including network development needs and potential threshold effects.
The success of this approach will also lie in the planner's ability to take into account long-term objectives of energy policy, typically between 10 and 15 years, in order to back network investment decisions with assumptions compatible with depreciation periods.
But the strength of this approach is also its weakness, namely the difficulty of implementation in real situations because of the impossibility of gathering accurate and sufficiently detailed assumptions, and ultimately, to make planning decisions that would not meet the connection needs of producers at the local level. Two consequences then, that of having an insufficient network development and lagging behind the reality of the needs, or else in the opposite case, to engage in network development which will prove useless.

The "Bottom-Up" approach can provide a structural solution to this lack of detailed information since it generally involves feeding the process of collecting hypotheses directly from producers' connection requests. Thus, each actor locally analyses the best economic optimum, the cost of the network development being (at least partially) integrated through the connection fee.
To work properly, the network managers in charge of planning and connection must set up, often complex, processes for managing the connection request queue, with the establishment of generally first-come-first served rules.
To avoid blocking the process, it can be completed by cleaning mechanism of the queue, for example with the imposition of a maximum duration between the connection request and the commissioning of the installation. The process may also take into account the effects of artificial saturation of the connection capacity and the complexity of the analysis of connection requests having a mutual influence.
Experience shows that, although the transmission grid can generally accommodate the first wind and photovoltaic energy installation projects without any particular problem, its connection capacity can quickly be saturated in many areas, which are nevertheless favourable to the development of these forms of energy.
However, the connection of new facilities is often conditioned by the prior development of the network, otherwise the limitations of production over longer and longer periods are expected. Without a global vision, it is difficult for TSOs to develop connection capacities wisely.
Although the Bottom-Up approach does not prevent network development, it nevertheless encounters difficulties of its own. The first weakness stems from the lack of long-term vision of the connection and evacuation needs because of the inclination of the project promoters to pay full attention to the projects to develop in the next few years, horizon too short to base network development decisions on sufficiently strong assumptions. Another difficulty often put forward is related to the grid development financing mechanism, linked to the principles of queue

management, and which can lead to focus on a single project a financing need for grid development. This problem of threshold effect may generates a blockage of projects in the areas concerned by these constraints.

In many cases, a **mixed approach** is used. For example, in Portugal there is a national global energy strategy established by the government with ambitious objectives for the development of power generation from RES. This strategy is aligned with broader EU-level objectives and is materialized in a National Plan for Energy and Climate – PNEC 2030 (Plano Nacional de Energia e Clima 2021-2030), which sets objectives in terms of promoting RES development, in particular wind, solar and hydro power. On the other hand, on a yearly basis, the generation promoters have access to updated information about generation reception capacity in the transmission grid. This reception capacity is managed by the General Directorate for Energy and Geology (DGEG), the TSO and the DSO. Up until recently, these capacities were allocated on a "first come, first served" basis. However, in July 2019 the Portuguese government conducted a competitive auction to allocate capacities for the grid connection of solar generation projects. These auction allowed interested promoters to bid, either through a discount on a reference feed-in tariff value or, alternatively, through a contribution to the power system[1]. Independently from other organized capacity auction procedures that may follow in the future, promoters are free to apply for a grid connection outside the framework of these auctions. Such applications will be analysed on a case-by-case basis by the TSO (and the DSO), and in case there is no reception capacity available, promoters will subject themselves either to waiting for reception capacity to became available or to support the associated grid reinforcements that may be necessary to enable the connection of their project in an acceptable timeframe. The conjunction of the described approaches, which comprise: 1) a top-down approach through the definition of global strategic targets (and associated policy instruments); and 2) a bottom-up approach by allowing private initiative to develop projects that prove viable, results in an overall mixed approach in what concerns generation expansion in Portugal.

The mixed approach is also used in France as follows:

- Top-Down: French Ministry is competent to publish a Decree that gives indicatives figures for the objectives in different types of production. This is the Programmation Pluriannuelle des Energies (PPE) (Pluriannual Program for Energies) mentioned in the Energy code. RTE indeed publishes every year a "Generation Adequacy Report" (last one published in September 2016) but it does not drive PPE objectives.
- Bottom Up: Regional Development Plans for Renewables have been set locally since 2012 that aim at promoting RES generator connection and anticipating grid development needs. RES development targets over 2020, defined by local State services, are translated into size and location of future renewable energy sources to design network investments. Grid development

[1] Under the second option promoters subject themselves to market conditions and commit to pay a fixed fee to the power system (bidding fee). The NPV of the cashflows associated to each bid is calculated in order to ensure comparability among different bidding options used by the bidders (feed-in vs. contribution to the system).

costs are shared among RES generators to reserve the required network capacity for them and prevent windfall effect. RTE also gives signals for the location of new generation by publishing on its web site information on the free capacity of every substation. This is an important and useful economic signal: if the capacity is not available that means that it will be necessary to reinforce the grid. Excepted for specific call for tenders, generators have to request for connection.

In the e **Errore. L'origine riferimento non è stata trovata.** a summary of the approach used in each country is presented:

	Top-Down (national)	Top-Down (regional)	Mixed approach	Bottom-Up with TSO commitment to grid expansion	Bottom-Up without TSO commitment to grid expansion
TEIAS		X (in general)			X (distributed RES)
SONELGAZ/OS	X				
ONEE	X (conventional)		X (renewables)		X (renewables)
HOPS					
OST	X				X(distributed RES)
TERNA			X		
STEG	**X** (in general)		**X (RES)** (authorization & concession)		**X (RES)** (self-consumption)
RTE	X [1]		X [2]		
CYP TSO			X		
REN			X		
REE			X		
IPTO			X		
CGES			X		

Table 1- Generation expansion approach by country

Explanatory notes:

1 for the development of off-shore wind power, the French government is issuing tenders. Implementation areas and connection schemes are determined by the Administration in consultation and with the contribution of RTE for the connection to the transmission grid
2 RTE draws up a regional renewable energy connection scheme (S3REnR) to achieve the objectives set at regional level by local Authorities in consultation with project promoters

In the Portuguese case there is a mixed approach. For instance hydro projects are subject to a centralized top-down planning approach and the recent (July/2019) solar connection capacity auction is also an example of a top-down approach. However, promoters are also free to develop their own initiatives in a liberalized way, both for RES and thermal projects.

4 Access and Connection Technical Procedure. Link with admisitrative procedures and with transmission planning

The Access and Connection Procedure is the first step that any non-transmission facility has to make to incorporate to the power system. This is a very continuous process, that could take at least 6 months (but is very variable), and can be summarisied in the following steps:

1. Procedure for access. During this procedure, the System Operator evaluates the capacity of the grid to integrate a new facility, from the point of view of the system behaviour. The main aspect it value is that there is enough capacity in the bus, for the plant to be connected. At the end of this procedure, if there is spare capacity after the studies performed with the criteria detailed in chapter 4, the facility will receive the Access Permission for a specific capacity.
   Specific requirements could be established at national level in order to be able to apply for an access permission.
   - Bank guarantee.
   - Need to apply with a coordinated application of all the facilities connected in the same connection node.
   - Transmission facility already included in the National Development Plan (existing or planned).

   In addition, specific conditions could also be established in order to maintain the "obtained capacity", i.e. the project should be commissioned in a period of time after the Access Permission.

2. Procedure for connection, oriented to evaluate the technical feasibility of the new elements and their connection to the grid (engineering requirements) as well as the feasibility of the installation project and programme (physical feasibility of the connection itself in the existing or planned substations) to be proposed by the applicant agent. At the end of this procedure, if everything is right, the facility will receive the Connection Permission.
   Acces and Connection Permissions could be provided together in a single step.

3. Signature of a Connection Contract and a Construction Contract with the TSO. In many cases, both contracts could be unified in a single one. In the Connection Contract some general rules on maintenance conditions periods of validity, as well as the formalization of the Access and Connection Permissions are included.
   In case new transmission facilities are needed, a specific contract (Contract for Project) could be signed, where the applicant is committed to the tramitting and building of the needed transmission facility (new bay or substation). In fact could be considered as a Pre-Contract for Construction, but in some cases is needed so that TSO proceeds to apply for the Administrative Authorization of the needed transmission facility (new bay or substation).

In principle some type of queue system is used to give the access and conection permissions: "first come, first served". In addition, some kind of financial guarantee at some point of this process, like a payment or a bank guarantee, is usually needed.

Access and connection permissions are required conditions so that the applicant may get the Administrative Authorization of its non-transmission facilities (the generation plant itself but also the non-transmission facilities to physically connect to the transmission grid), which is a required condition for the following contracts with the TSO.

When new transmission facilities are needed a prerequisite related with the need of being included in the transmission national development plan could be considered. This prerequisite could be established for analyzing an access and connection application or for the construction of the new transmission facility.

Anyway, as it is presented in the **Errore. L'origine riferimento non è stata trovata.**, the link between the administrative authorization and the connection procedure is rather heterogeneous in the region.

	YES, Connection Procedure needed for AA	YES, AA needed for Connection Procedure	YES, AA not needed for the application but a at a later stage	YES, but only for the physical connection (commissioning)	NO
TEIAS		X			
SONELGAZ/OS	X			X	
ONEE		X			
HOPS		X			
OST		X			
TERNA	X				
STEG		X			
RTE			X		
CYP TSO			X		
REN	X				
REE	X				
IPTO		X			
CGES		X			

Table 2. Link between the administrative authorization and the connection procedure by country

Explanatory note: Promoters are required to firstly address the TSO to obtain the Capacity Reserve Title (connection procedure) and only then initiating the administrative authorizations before the Directorate General for Energy and Geology (DGEG). After obtaining a production license, issued by the Directorate General, promoters return to the TSO to formalize the connection procedure.

For information figures about connection procedure alive applications in the transmission grid and the average response time are shown in the **Errore. L'origine riferimento non è stata trovata.**.

	Alive connection applications		Alive connection application with binding agreements		Average TSO time Connection Procedure process (days)	
	RES (Nr of installations / MW)	Conventional (Nr of installations / MW)	RES (Nr of installations / MW)	Conventional (Nr of installations / MW)	RES	Conventional
TEIAS	> 4000 > 30 GW	> 30 > 20 GW	> 200 > 10 GW (Transmission level)	> 10 > 8 GW (Transsmission level)	15 days<t<45 days	15 days<t<45 days
SONELGAZ/OS	13/266	59/19050	NA	Must-run PPT	3-4 months	3-4 months
ONEE	NA	> 15 >3.7 GW	NA	> 30 7 GW	1 month	N.A.
HOPS	1020	240	493	160	Min 1800	Min 1800
OST					3months<t<24 months	3months<t<24months
TERNA	1388 / 61700 MW	40 / 12100	N/A	N/A	Publication expected in 1Q 2020	Publication expected in 1Q 2020
STEG					2 or 3 years Details link	
RTE	180 inst.[1] / 12600 MW	13 inst.[2] / 1250 MW	68 inst.[3] / 7200 MW	18 inst.[3] / 5100 MW	9-54 Months[4]	9-54 Months[4]
CYP TSO	3 / 80 MW	1 / 260 MW	N/A	N/A	*500 days (from application to Connection Contract*	*500 days (from application to Connection Contract*
REN	> 2000 / > 100 GW (from June until end of Oct./2019)	N.A.	> 20 / > 2GW	N.A.	45 working days + 90 working days + line bay construction (on avg 2 years). See note 2) for details	N.A.
REE	1530 / 82.653	44 / 5.463	1.985 / 100.129	62 / 9.107	10 months (including 6 months for the applicant)	
IPTO	1011 / 21483MW	7 / 2790 MW	79 / 1571 MW	9 / 2481 MW	A+B+C (4+1+6) months	A+B+C (4+1+6) months
CGES	100,6	0	46	0	4 months	4 months

Table 3. Alive applications in the transmission grid and the average response time by country

Explanatory notes:

1 Cumulative number/capacity over January-October 2019 period
2 Incl. conventional generation, storage facilities and interconnections
3 Situation on the 1st November 2019
4 The connection process duration is strongly depending on the nature of new transmission assets needed (9 months in the case of no additional HV equipments needed)

1) These are estimated figures (not accurate). These figures refer only to transmission grid connection requests.
2) The TSO has 45 working days for answering to the initial application concerning the available grid reception capacity. Subsequently, upon a request for proposal by the applicant for the line bay development/construction, the TSO has 90 working days to present a proposal. The proposal for the line bay development will set a timeline for the construction of the bay, which on average is close to 24 months.

In Greece, average TSO time refers to the following steps of the Procedure process:

Connection Application ←A→ Non Binding Connection Offer ←B→ Binding Connection Offer ←C→ Connection Contract

5 Studies and criteria for access and connection assessment

Studies for access and connection assessment which must be applied by the TSOs represent an important step in the procedure for access and connection to the System. Such studies may be implemented in parallel with or sequentially with the administrative procedures and may be processed by the TSOs on an individual basis at specific milestones of the general procedure for access and connection for each application, but also globally at any time when the TSOs receive and manage a large number of applications.

For each application for access and connection to the power system, the most economically feasible and technically acceptable scheme is selected. In particular the general principles followed for selecting the type and dimensioning of connection projects are:

- **a)** meeting the security criteria analysed below and
- **b)** minimizing the costs of connection projects by choosing the most cost-effective way of connecting the User
- **c)** Defining the needed reinforcements for connecting to the grid.
- **d)** Ensure the system stability and the impact in the electrical system.
- **e)** Ensure the respect of the quality and the respect of the standards of the power quality.

5.1.1 Studies

The studies implemented by the TSOs for access and connection assessment, the specific milestones and the relevant criteria applied are determined below. It should be noted that the milestones on which each particular study shall be processed may differ depending on the specific procedure followed by each TSO.

A. Studies for Access Application

During the initial phase of the application for access to the Grid, a number of preliminary studies shall be performed by the TSO, in order to evaluate the power system behavior and capability considering the integration of the facilities of the Applicant (User) within the System. Such studies aim to examine whether the conditions (available power at the points of delivery, short-circuit power, reliability, etc.) prevailing in the possible connection point of the User's facilities to the System are sufficient to operate without risk to the operation (failures, harmonics, flicker and sudden voltage fluctuations, violation of short-circuit limit values), both in the system itself and in the transfer of power and energy from the system to the User's facilities without causing unacceptable disturbances and also to determine the optimal scheme for the connection of the User to the system.

Such studies shall include:

- **steady state analysis (load flow)** in which the behavior of the power system is analyzed in the event of minor changes, such as load and topology changes, to detect any low frequency oscillations
- **short-circuit analysis** in which maximum short circuit current values at the system nodes are calculated in accordance to international standards
- **dynamic analysis,** in particular transient stability, which analyses the ability of the System to return to normal operation following major and critical disturbances and the ability of the System units to remain synchronized
- **power quality analysis**
- **preliminary engineering assessment of the project**

In the case of some TSOs, during this initial phase only load flow studies are performed and more specialized studies are implemented at a second stage. Also at this stage, in the case of most TSOs the results of above mentioned studies are indicative and non-binding (not translated to connectable capacity) but informative of potential constraints.

B. Studies for Connection Application

During the phase of application for connection to the Grid, further analysis shall be performed by the TSO associated to the engineering and feasibility aspects of the construction project, with the aim to guarantee the development and commissioning of the facilities enabling the connection. In this advanced stage and depending on the size and complexity of the necessary expansion or reinforcement of the System, the TSO on a case-by-case basis, may also perform additional specialised studies to assess the impact of the proposed connection to the system, such as overvoltage studies, in particular with regard to cable connections.

In the case of most TSOs, the results of the studies performed at this advanced stage are more binding and translated to connectable transmission capacity, in the sense that the additional capacity of each Applicant should be taken into consideration as an injection in the point of connection and access should be denied to new applicants over a certain limit.

The studies performed at both milestones described above take into account the planning of the transmission system, in different operating conditions, seasonal/hourly relevant situations and time horizons (for example peak and off-peak conditions of summer and winter demand for a mid-term planning horizon).

C. Reactive power optimization study

In some cases of applicants, a reactive power compensation study is needed to improve the voltage profile and optimize the reactive power production and reduce active power losses.

Simulations must be performed to optimize the reactive energy compensation during peak periods to maintain a good voltage profile. The results of the simulations may identify, in some cases, not only a need for reactive power compensation but also new needs for network reinforcement. Under these conditions, additional reinforcement proposals will then be considered.

D. Power quality analysis

For connecting renewable energy resourses to the network, power quality analysis should be performed in order to ensure that there is no imact related to the connection of the new project in terms of harmoniques, unbalance voltage, flicker etc. Such analysis could be performed by the TSO or provided by the applicant with the validation of the TSO.

5.1.2 Criteria

In general, the criteria used in the Studies for Access and Connection are similar to the ones used for planning, not the ones used for operation.

A. Preliminary validity criterion

In general, this is criterion is related to the Applicant's installation minimum magnitude required depending on the voltage level to which it can be connected in the System.

Requirements used in France are listed in the Table **4**:

Table 4. List of requirements used in France.

Generation Unit Max Power	Connection Voltage Level
< 12 MW	1kV<Un<50kV
< 50 MW	50kV<Un<130kV
< 250 MW	130kV<Un<350kV
> 250 MW	350kV<Un<500kV

Relevant minimum threshold for Greece for access permission to the transmission system is 8MW.

In some systems, the criterion of preliminary validity is a combination of the magnitude of the installation and the connection distance. Values listed in the Table **5**refer to the System of SONELGAZ/OS, in which the users (customers) are connected to the voltage levels of 10, 30, 60, 220 and 400 kV.

For the powers P ≤ 15 MW, the connection voltage level is 1kV <Un≤30kV independently of connection distance.
For the powers P 15MW, the electric dipole moment "S" is calculated with S = P × D (D = connection distance) and the voltage level is determined according to the following table:

Table 5. Criterion of preliminary validity applied in Algeria.

S (MW × km)	Connection Voltage Level
60 ≤ S < 300 (MW × km)	60 kV
300 ≤ S < 1 000 (MW × km)	220 kV
1 000 ≤ S < 2 500 (MW ×km)	400 kV

In Spain generation facilities connected to the transmission grid have a minimum threshold in order to be able to apply for the access permission.

- 250 MW in 400 kV.
- 100 MW in 220 kV.

B. Static security criteria

The steady state analysis (load flow) assesses the behaviour of the power system, taking into account the static security criteria implemented by each TSO, which in general are as follows:

- **N criterion** (normal operation): voltage levels of all system buses and line loading should be maintained within the limits foreseen for each system for normal operation.
- **N-1 criterion** (emergency state): voltage levels of all system buses and line loading should be maintained within the limits foreseen for each system for emergency state

  In particular, criterion N-1 refers to the loss of the following elements of the System:

  - Production unit
  - Transmission Line (overhead or cable)
  - EHV/HV autotransformer
  - Reactive compensation device (capacitor, reactor, SVC)
  - DC link (one pole)

In the case of some TSOs, N-2 criterion is also implemented. This refers to cases of loss of more than one System elements following a single failure event, selected based on the probability of occurrence of the event and/or the severity of its impact on the System (for example simultaneous loss of two 400kV circuits on common carrier).

C. Short circuit criteria

Short-circuit calculations are performed taking into account the connection of the Applicant's installation to the System, based on which short-circuit levels of all system buses should be maintained within the limits foreseen for each System. Such criterion aims to:

- prevent violations of the rated capacity of the substation equipment (breakers) to which the Applicant shall be connected
- provide an assessment of the minimum short-circuit levels in the System due to the massive integration of RES and the ongoing shut down of synchronous generation
- design a rule-of-thumb to be applied as limiting criterion, particularly for the non-dispatchable generation (solar or wind), and therefore to be translated into connectable transmission capacity

In general, maximum short-circuit levels are calculated for peak load conditions (Peak Scenario), taking into account all system elements and available generation units (based on specific standards, such as IEC60909), while minimum short-circuit levels are calculated for Off-peak load conditions (Minimum Scenario), taking into account the relevant operating conditions (lines out of operation).

Although in most systems no minimum short-circuit current values are imposed, both maximum and minimum short-circuit current values without the contribution of the concerned User are also calculated at the point of connection, in order to properly select the settings of the protection system of the User installations, particularly in case of RES.

Some indicative values used by REE for the maximum power for non-dispatchable generation (solar or wind) to be installed and connected to a substation are:
Pins,max (Wind Generation) ≤ 6,25%Scc
Pins,max (Solar PV Generation) ≤ 5%Scc

In the case of IPTO, the maximum short-circuit current at any point of the System should not exceed the values imposed by the Greek Grid Code, namely 31 kA for the 150kV System and 40 kA for the 400 kV system. Moreover, it must be ensured that the contribution of new installed RES generation does not result to short-circuit current values larger than 90% of the above threshold.

D. Dynamic security criteria

In certain cases of Applicants, dynamic behaviour analysis is performed (particularly when control interactions are expected with HVDC installations), aiming to asses the ability of the power system to return to normal operation following major and critical disturbances and the ability of the power system units to remain synchronized. In the case of most TSOs results of dynamic studies are non-limiting (not translated to connectable capacity) but informative of potential constraints, requiring further exchanges with the User and possible alteration/reinforcement of the connection scheme.

More specifically, in accordance with HVDC NC Article 25 (HVDC systems Fault Ride Through capability), TSOs shall specify the magnitude and time profile of active power recovery that the HVDC system shall be capable of providing.

According to RTE after fault clearing, the converter should provide post fault active power recovery. The active power transmission will resume to 90% of pre-fault level within 150ms and final value within 200ms. According to TERNA, maximum time for recovery is set to 200ms with an accuracy is 10% of pre-fault power

5.1.3 Survey

In the **Errore. L'origine riferimento non è stata trovata.** the studies performed during the connection procedure in the different Mediterranean power systems are shown:

	Load Flow	Short circuit	Dynamic	Power quality	Feasibility & Engineering assessment	RES curtailment	Special schemes + smart grid solutions	Studies provided by applicant (specify)
TEIAS	X	X	X	X				
SONELGAZ/OS	X	X	X		X			
ONEE	X	X	X	X	X	X	X	X
HOPS	X	X	X	X	X	X		x
OST	X	X	X	X	X		X	Simulation models on the behavior in both steady state and dynamic simulations or in electromagnetic transient simulations.
TERNA	X				X			
STEG	X	X	X	X	X			X
RTE	X	X	X	X	X	X	X	
CYP TSO	X	X	X					X (Complete Model of Electrical Equipment in Digsilent Software)
REN	X[1]	X[1]	X[1 & 2]	X[2]				
REE	X	X[1]	X		X			
IPTO	X	X	X*	X**	X			X *** (submarine cables)
CGES	X	X	X	X	X			

Table 6. Studies performed during the connection procedure in the different Mediterranean power systems

Explanatory notes:

[1]REN publishes the grid connection capacities per grid node on a yearly basis. These grid connection capacities result from grid studies performed at grid planning level (for planning horizons up to: five / ten-years). As so, upon a new connection request, if the request lies within the available grid connection capacities, no further studies are needed. Conversely, should the applicant request a grid connection beyond the available grid connection capacities, the indicated grid studies should be performed in order to assess the grid connection viability and the corresponding grid reinforcement needs. The cost of these additional studies is borne by the applicant.

[2]Studies by applicants to prove network compatibility and dedicated regulations (in certain cases compliance declarations were accepted).

In Spain, the only reason for denying an application is the short circuit limits.

In Greece, during the connection procedure specialized studies can be performed for specific projects:
* Ad-Hoc (cable energization studies, transient stability for HVDC interconnections)
** Ad-Hoc (Harmonics for cable interconnections)
*** Under approval by IPTO

6 Cost of transmission grid needed for connection

The TSO examines the connection applications to the National Transmission Grid (NTG) to define, case by case, the connection solution on the basis of criteria that, taking into consideration the technical and economic aspects of the connection works, can guarantee continuity and security in operating the NTG to which the new plant is to be connected.

In elaborating the connection solution, the TSO defines the reinforcements needed to create, locally, a grid configuration adequate for insertion of the plant into the grid identifying any work on existing electricity grids which becomes strictly necessary for the purpose of meeting the connection application. Referring to the connection solution, grid connection plant is the portion of the connection plant pertaining to the TSO, included between the input point of the pre-existing grid and the connection point and is divided in:

- NTG connection plant: a plant pertaining to the NTG which, therefore, constitutes NTG grid development work;
- user plant for connection: a portion of a connection plant whose creation, management, operation and maintenance shall be the responsibility of the applicant.

The connection estimate (a general minimal technical solution), which is elaborated by the TSO after the analysis of the connection application, is accompanied by:

- the average costs for the construction of the grid plant for connection;
- the connection fee which is determined taking into consideration:
  - the type of plant to be connected (considering principally the type of source);
  - the construction costs related to the grid plants for connection and the work on the existing electricity grids except for work related to the NTG;
  - the value of the operational conventional maximum power under normal definitive operating conditions, on the basis of the voltage level Grid Code of the conventional technical connection solutions.

Upon submitting the connection application, the applicant must pay the TSO a specific fee for obtaining the connection estimate. Connection steps are characterized by some specific fees resumed in the following Table 7.

Table 7. Specific fees applied to the connection steps in Italy

Types of fee	When it must be paid
Fee for obtaining the connection estimate	At the moment of the connection application
Fee for changing the connection estimate	At the moment of the request for changes to the connection estimate, if this request is made by the applicant
Fee for verification and evaluation activities for the purpose of issuance of the opinion on compliance of the project with the technical requirements pursuant to the Grid Code	At the moment of presentation to the Operator of the project for the grid plants for connection and for any work on existing electricity grids
Fee for processing the detailed minimal technical solution and elaborating the pre-contract	At the moment of closing the authorization phase and requesting the pre-contract
Connection fee	Payed at the moment of accepting the connection estimate (X% for example 30% amount) and, at a later time at the moment of accepting the detailed minimal technical solution (X% for example 70% amount) and finalizing the Connection contract

For production plants powered by sources that are not renewable nor high-performance co-generation, the connection fee is equal to costs for the construction of the grid plant for connection and any work on existing electricity grids, excluding any work related to the NTG.

For plants powered by renewable sources the connection fee is calculated on the base of an incentive ratio, which is function of the power for connection purposes.

The following Table 8 **compares the connection fees between RES and no-RES plants in the Italian case.**Table 8. Comparison of the connection fees between RES and no-RES plants in the Italian case.

Grid plant for connection	Connection fee for RES	Connection fee for NO RES
Bay in existing/new substation	$\frac{Power\ of\ RES\ plant\ [MW]}{Bay\ conventional\ maximum\ power\ [MW]} \cdot Construction\ cost\ [€]$	$Construction\ cost\ [€]$

A summary of who should pay the different assets of the transmission grid is showed in**Errore. L'origine riferimento non è stata trovata.** and **Errore. L'origine riferimento non è stata trovata.**.

Who pays? Generators (G) or System (S)	New bay in existing substation	New substation	Only new bay in new substation	Deep reinforcement	Other
TEIAS	S	G or S	G or S	S	
SONELGAZ/OS	G (renewables) S (conventional)	S	G (renewables) S (conventional)	G or S	For conventional: S up to 50 km
ONEE	G	G		G	
HOPS	G	G		G	
OST	G	G		G	
TERNA	G (conventional) G +S (renewables G pay with an incentive ratio)	G (conventional) G +S (renewables G pay with an incentive ratio)	G (conventional) G +S (renewables G pay with an incentive ratio)	G (conventional) G +S (renewables G pay with an incentive ratio)	
STEG	G	G		G	
RTE	X [1]	X [1]		X [1]	
CYP TSO	G	G	G	G	
REN	G	S – currently G and/or S – in the near future can be possible	G	S and/or G	
REE	G	S	G	S	
IPTO	G	G		S	
CGES	S	G or S		G	

Table 9.- Summary of who should pay the different assets of the transmission grid

Explanatory notes:

1) TEIAS is owner of all the transmission facilities and responsible for their operation.
2) the applicants preference is determined by connection agreement that new substation and only new bay in new substation will be installed by G or S.

1 Under the S3REnR framework, the producer pays the direct connection works plus a share of the works to be created in the frame of the connection scheme (proportional to the power of the installation) whatever the place where it is located in the Region.

1) General case: the applicant will pay the bay and line to connect the power plant to the grid
2) Future: the applicant will pay the bay and line to connect the power plant to the grid, as well as the network reinforcements in order to create reception capacity for new generation.

In Spain, for G: Investment costs (not O&M costs).

	Bank Guarantee	Application	Pre-agreement	Binding Agreement	Construction
TEIAS	X			X	
SONELGAZ/OS	NA	NA	NA	NA	NA
ONEE		X		X	X
HOPS	X				
OST	X			X	X
TERNA		X	X	X	
STEG				X	X
RTE				X	X
CYP TSO	X		X (connection estimate)	X (installment payments)	
REN	X[1]	X[2]		X	X
REE	X	X[1]		X	X
IPTO	X*			X** (A)	X** (B)
CGES			X	X	

Table 10. Calendar of payments made by applicant during the connection procedure

Explanatory notes:

[1] A Bank Guarantee is requested by the TSO upon issuing the Capacity Reserve Title after the initial application (i.e. in order to secure that Capacity Reserve Title). Furthermore, another Bank Guarantee is also requested prior to the beginning of the operation of the transmission connection line. Since this line is developed by the applicant but then transferred to the TSO, a bank guarantee is requested in order to secure any defects detected during the initial period of operation (2 years).

[2] This is just a symbolic payment which is due with the initial application. All costs with development of line bay are due with the binding agreement signature (initial payment) and during and upon conclusion of the development of the line bay (interim and final payments).

Regulation to develop connection studies costs is expected, but still not developed.

In Greece:

* A Bank Guarantee is requested at the beginning of the procedure in the case of Special Projects

** An advance payment (A) ≤ 250k€ is requested with the binding agreement and the remaining (B) of the Total Payment (A+B) is requested with construction

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