

Towards a Common Target Regulatory Framework. Harmonising Technical Rules for the Mediterranean Power Systems from a TSO perspective

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SUMMARY

The progressive integration of the power systems within the Mediterranean region will benefit more than 500 million inhabitants, in more than 20 countries in 3 different continents. For this objective, the regulatory harmonisation constitutes a key pillar in order to preserve security of supply and improve the energy prices for the end users, while enabling the integration of the ambitious renewable energy targets in the region.

In this context, this paper summarizes the most relevant results of the cooperative work carried out by Med-TSO's *Technical Committee 2: Regulations and Institutions (TC2)* whose goal is to design a progressive harmonization of rules for the Mediterranean power systems. The work performed shows how from 4 main areas (Legal & Regulatory, Connection to the Grid, Operation of the interconnected systems and System Services Markets), from a number of potential issues subject to harmonisation, 135 technical issues were originally identified in the Starting Regulatory Framework (SRF) as more likely and then 66 of them have been selected for the final proposal included in the Common Target Regulatory Framework (CTRF).

For each of the 66 identified issues, it has been proposed the most suitable rule format (either internal or external, depending on the autonomy and competence of TSOs) and the estimation of implementation program (depending on estimated priority and period of application), which is compiled in the Common Tentative Roadmap (CTRM) including different time horizons.

KEYWORDS

Med-TSO – Technical Rules - Harmonization – TSO – Mediterranean region – Regulatory framework – Market integration – Coordination

¹ Med-TSO (association of 18 TSOs in the Mediterranean region – www.med-tso.com) Technical Committee 2 Regulations and Institutions is composed of the following 15 TSOs: REN (PT), ONEE (MA), SONLEGAZ/OS (DZ), STEG (TN), RTE (FR), GECOL (LY), TERNA (IT), CYP TSO (CY), OST (AL), NEPCO (JO), TEIAS (TR), PETL (PS), CGES (ME), IPTO (GR) and REE (ES).

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1. THE MEDITERRANEAN PROJECT. OVERVIEW ON RULES HARMONIZATION

The Mediterranean region comprises a wide area with more than 20 countries distributed in 3 different continents and more than 500 million inhabitants. In 2016, the total population of the countries bordering the Mediterranean was 525.6 million which represent 7.1% of the world population. The population growth in the Mediterranean region has a positive rate. In the future an increase in the social and economic development is expected so the global welfare must be improved in the coming years. One of the economic and social factors that could contribute to this development is energy and especially electricity. Total generation in 2016 was of 1,958 TWh; 25% of which came from renewable sources (483 TWh).

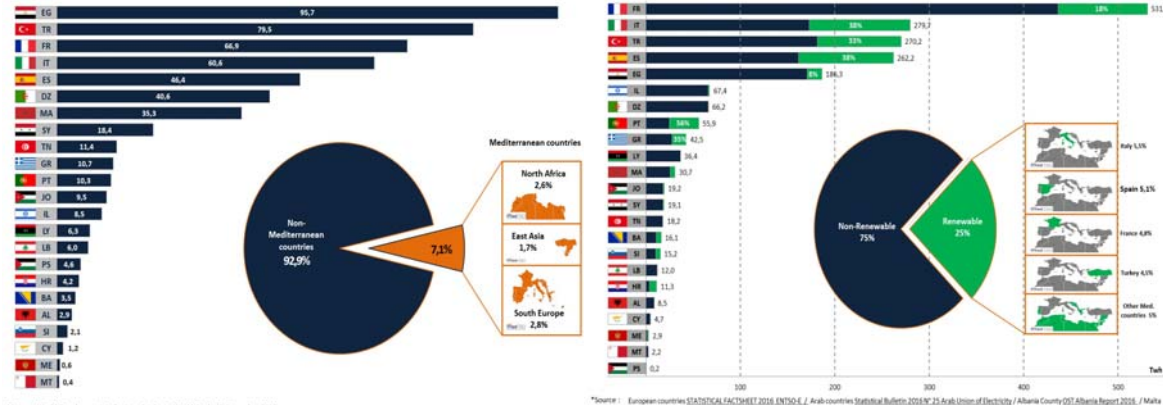


Figure 1: Mediterranean countries population 2016 (million inhabitants) and total generation 2016 (TWh)

Currently, the integration of the region is not only an opportunity but a necessity in order to comply with the ongoing development in the region and to increase the region stability (in terms of security, socio-economic development and sustainability). Energy is a key driver to obtain this objective of bringing closer the two shores of the Mediterranean. For this aim, the creation of a regional energy market is the milestone that will enable this integration.

Med-TSO (association of 18 TSOs in the Mediterranean region) has developed the Mediterranean Project (a 2015-2018 project funded by the European Commission) in order to contribute to reach this integrated regional energy market. Given the significance of infrastructures in achieving this goal, a coordinated planning of international interconnections and primary national transmission grids has been developed, providing the “hardware” to allow international exchanges, integration of new generation sources and market integration between both shores of the Mediterranean Sea. In addition, another key pillar is the “software” or the set of rules that should provide a common framework in the Mediterranean region by increasing the harmonization of significant regulation, in particular the technical rules necessary for developing and operating power systems as well as achieving a higher efficiency in terms of the management of system services. This harmonized regulation is of utmost interest in order to allow in terms of security the expected integration of renewables in the power system.

The relevance of providing a harmonized framework of rules has been identified and advanced in other areas. In the European Union, the 3rd Package included the need to develop a set of common rules for all those topics with multinational significance for the market integration and renewables deployment [1] and [2]. Although with a lower level of political integration, and therefore considering it in a longer term, this same driver has been assumed by Med-TSO within the Mediterranean Project. In this context this paper summarizes the main results of the cooperative work carried out by Med-TSO’s Technical Committee 2: Regulations and Institutions (TC2) whose goal is to develop and propose the progressive harmonization of rules for the Mediterranean power systems, from a TSO perspective. This goal was set to be achieved in three phases:

1. **Compilation of the Starting Regulatory Framework (SRF) -Technical Rules-**, including the analysis and summary of the current regulatory framework from a TSO perspective for the Mediterranean region.
2. **Common Target Regulatory Framework (CTRF) and Common Tentative Roadmap (CTRM)**. Based on the SRF a proposal of common rules in the Mediterranean region has been developed, identifying the concrete set of requirements that could be translated into rules for the whole region through a voluntary application by each country. This proposal has also included a proposed regulatory format for each identified topic and also a proposal of roadmap, in terms of horizon (short, medium or long term), to achieve the complete harmonization.
3. **Elaboration of draft set of Mediterranean network rules**. Considering the results of the previous activities, 3 rule models have been developed: a TSO-User Connection Contract, a TSO-TSO Operation Agreement and a Grid Code on Connection and Operation.

Having as a reference the European experience in the development of the electrical Network Codes (NCs) to facilitate the harmonization, integration and efficiency of the European electricity market, the whole process has been carried out focusing in 4 areas (Legal & Regulatory, Connection to the Grid, Operation of the interconnected systems and System Services Markets).

In order to guarantee that the resulting work is shared, assumed and applicable to the different Med-TSO power systems, specific task forces have been created distributing work and leadership between Med-TSO TC2 members thus maximizing involvement, allowing experiences and best practices sharing. In this context, the process has encompassed a number of surveys in order to collect the regulatory situation in each country.

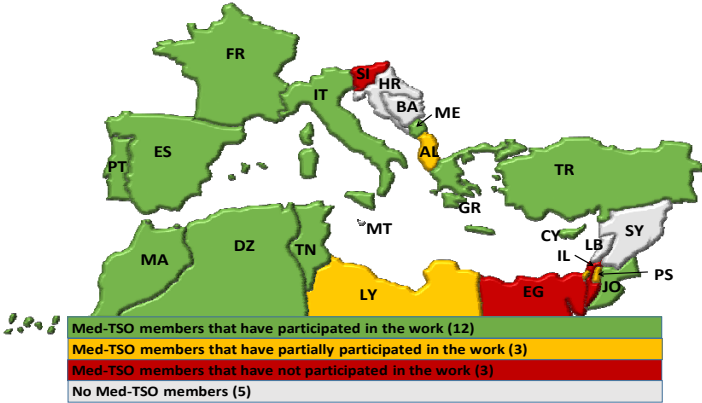


Figure 2: TSOs participating in the work

2. THE REGULATORY FRAMEWORK. FROM STARTING TO PROPOSAL OF COMMON TARGET

As a first stage, considering the 4 above mentioned areas, particular surveys and discussions among TSOs enabled the elaboration of a “List of topics potentially considered for a common regulatory framework”. The analysis performed enabled to identify 34 aspects and 135 issues² as those which **could be harmonized** for the Mediterranean region, constituting the **Starting Regulatory Framework in the Mediterranean Region** [3]. From this reference, an additional survey was launched in order to get the priority estimation by TSOs of the 135 technical issues already pre-selected and further discussions were carried out, what enabled to identify the 24 aspects and 66 issues that **should be harmonized** for the Mediterranean region, thus defining the **Proposal of Common Target Regulatory Framework** [4]. Figure 3 summarises the aspects and issues included in both Starting and Target Regulatory Frameworks.

² Issues refer to every particular topic which are currently regulated in the national context and are candidate for regional harmonization while aspects refer to a group of related issues (i.e., acceptable voltage ranges or low-voltage-though-capability are issues within the aspect called “Voltage Requirements”)

STARTING REGULATORY FRAMEWORK (SRF): 34 Aspects ⇨ 135 Issues		
1 Regulatory Aspect (11 Issues)		
13 Connection Aspects (41 Issues)	14 Operation Aspects (57 Issues)	6 System Services Markets Aspects (26 Issues)
<ul style="list-style-type: none"> • Connection procedure 2 • Frequency requirements 3 • Voltage requirements 2 • Reactive power requirements 1 • Short circuit requirements • Protection requirements 1 • Control requirements 4 • Power quality • Demand disconnection schemes 1 • System restoration capabilities • Demand side response services • HVDC requirements 1 • Compliance and monitoring 	<ul style="list-style-type: none"> • System states 1 • Technical requirements 5 • Information exchange 3 • Contingency analysis 5 • Dynamic stability • Management of international exchange programs 1 • HVDC technologies • Outage coordination 1 • Load frequency control 5 • Reserve management 1 • Defence plan 5 • Restoration plan 1 • Training 2 • Dispatch priority 	<ul style="list-style-type: none"> • Legal issues 5 • Capacity calculation 3 • Capacity allocation 5 • Dispatching and balancing 1 • Settlement and metering • Transparency 2
COMMON TARGET REGULATORY FRAMEWORK (CTRF): 24 Aspects ⇨ 66 Issues		
1 Regulatory Aspect (3 Issues)		
8 Connection Aspects (15 Issues)	11 Operation Aspects (32 Issues)	4 System Services Markets Aspects (16 Issues)

(In purple, aspects proposed with highest priority to be harmonised and included in the Target)

Figure 3: Starting and Common Target Regulatory Framework

Figure 4 shows for the different areas the selection ratios by which those issues present in the SRF have been included within the Target Proposal, resulting that 49% of the initial reference of 135 issues have been selected. The Figure also shows how the different areas are present in the Target Proposal, concentrating the operation area the majority of selected issues to be harmonised (32 operation issues represent 48% of the total selected).

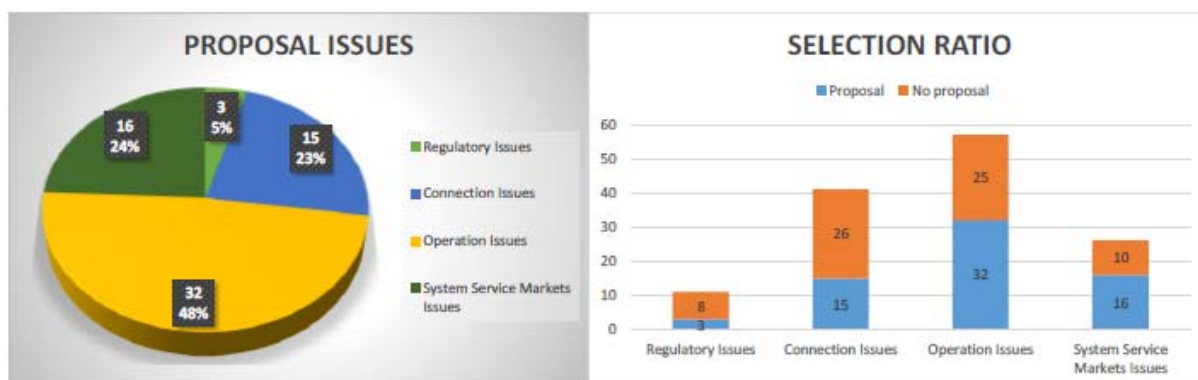


Figure 4: Relative proportion and selection ratios of issues included in CTRF for each area

The most important outcomes on the work performed are presented below separated in the 4 areas.

Legal and Regulatory Area. SRF analysis shows that, the TSOs are responsible for developing the technical rules while a competent authority exists responsible for the approval of such rules (NRA or competent Ministry). NRA or other competent authority is responsible for the settlement of disputes among stakeholders. In almost all Med-TSO countries the unbundling of activities is required in a similar way as within the EU legal framework. Anyway from the 11 issues included in the SRF only 3 have been prioritized and selected to be harmonized (CTRF), namely the need of having a coordinated

regulation for international interconnections, the need of unbundling between regulated and non-regulated activities and the need for a responsible authority (independent body) with transparent and neutral dispute settlement procedures between stakeholders.

Connection Area. In general, SRF analysis shows that the situation is quite homogeneous regarding the studies performed, the horizons and criteria considered in the studies, the obligations for users to send simulation models, the capacity connection priority or the limiting magnitudes required to connect to the transmission grid. Anyway only 2 issues from the connection procedure are proposed for harmonization: the implementation of load flow studies for access and connection and the N-1 security criterion for access capacity calculation, following internal agreements between TSOs.

With respect to frequency, voltage and reactive power behaviour, high level of harmonization should be introduced at least at synchronous area level, being the main driver the large penetration of renewables connected in the transmission system, both existing and expected in the near future, the impact of which in neighbouring systems can be significant, depending on their scale and the level of the power systems interconnection. SRF analysis show that operation in the range from 49.5Hz to 50.5Hz is required without time limitation in all Med-TSO countries, while differences exist in the duration of operation in lower and higher frequency ranges. In addition, requirements on the rate of frequency withstand capability are harmonised (or there is provision for future regulation) in all European countries including Turkey, while similar provisions exist in the Maghreb countries, where the services are applicable. Regarding voltage, the common time range limits without time limitation in the Med-TSO countries are presented in the following figure (between 0.95 and 1.05 pu in 400 kV and between 0.9 and 1.118 pu for voltages between 110 and 300 kV), while differences exist for voltages outside this ranges. In addition, most of the countries have defined fault ride through (FRT) capability profiles curves for different technologies. Based on the above a proposal on frequency and voltage ranges, rate of change of frequency withstand capability, over frequency and under frequency schemes and fault-ride-through capability has been proposed and is included in the CTRF. This proposal has also taken into consideration the provisions included in the “Regulation EU/2016/631, establishing a network code on requirements for grid connection of generators” [5]. As an example the following figures show the common requirements and proposals for frequency ranges, voltage ranges and fault ride through (FRT) capability.

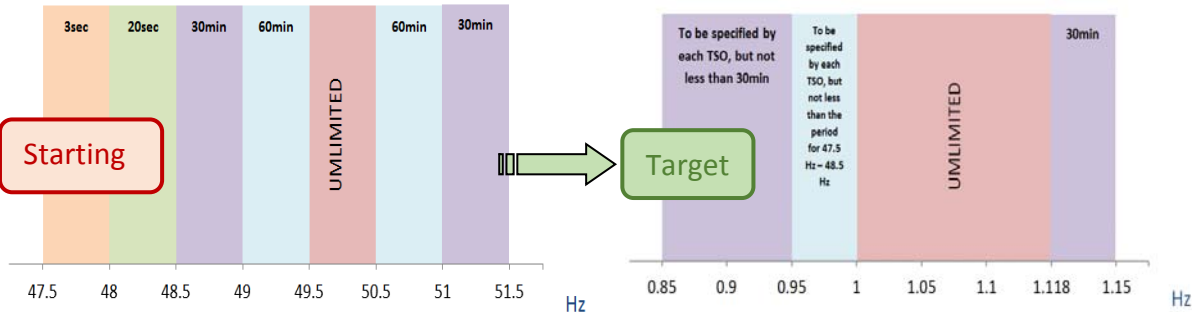


Figure 5: SRF (left) and CTRF (right) frequency/time range limits for users to withstand without damage

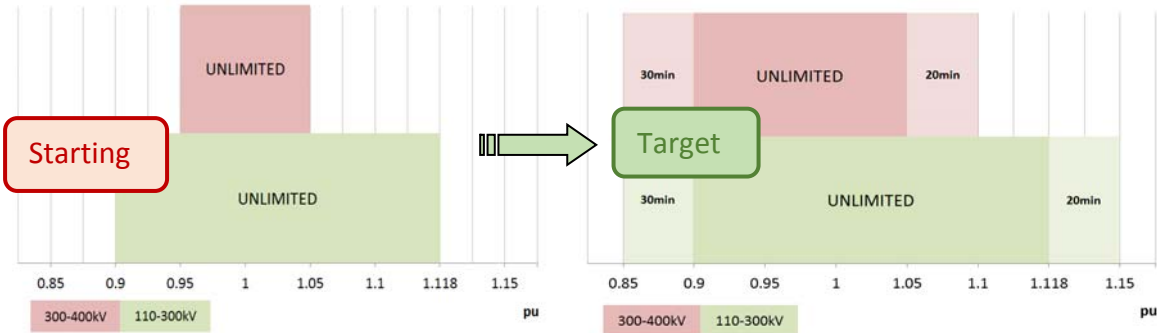


Figure 6: SRF (left) and CTRF (right) voltage/time range limits for users to withstand without damage

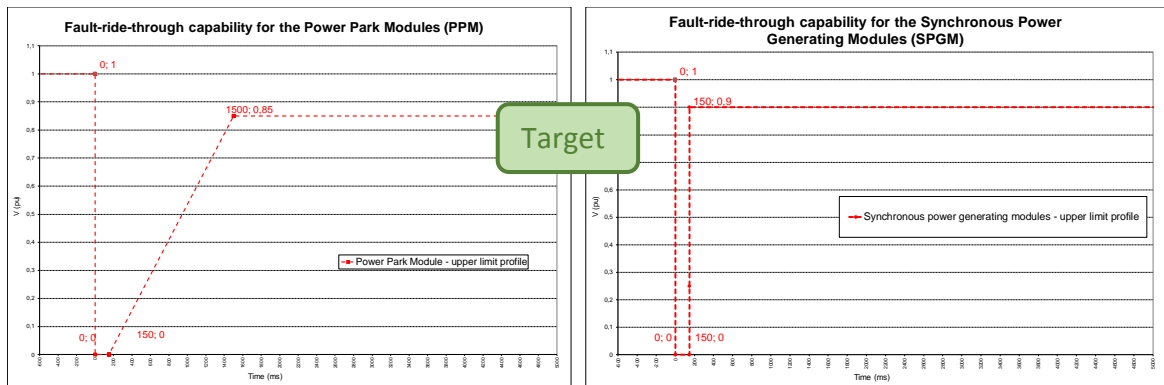


Figure 7: Proposal for harmonization for Requirements for compliance with FRT capability in the CTRF

SRF analysis also shows that in almost all countries, direct communication between user and TSO control centre is required, while observability and controllability requirements in general depend on the power limit. The communication system characteristics are similar in all Med-TSO countries: IEC standard protocol is always required while double communication channel, optic fiber and dedicated channels are widely required but not in all power systems.

Concerning protection and control, harmonized requirements on redundancy for telecommunication and protection schemes should be adopted, following internal agreements between TSOs and users, whereas observability and controllability of non-transmission facilities from the TSO control room should also be harmonized, with respect to their size and in compliance with the “*Regulation EU/2017/1485 establishing a guideline on transmission system operation*” [6]. Low frequency disconnection schemes should be agreed between neighbouring TSOs in the same synchronous area.

Concerning HVDC requirements, due to the anticipated increase of the number and the size of the HVDC links and in view of the harmonization process of HVDC requirements in European countries, the harmonization of HVDC requirements/criteria in Med-TSO region should also be foreseen, in particular where such interconnections may have a significant impact in the planning and operation of the grids.

Operation Area. In almost all countries, the same state classification is considered, with 5 different states: normal, alert, emergency, black-out and restoration. Anyway, deeper harmonization should be foreseen, including concrete and specific characteristics for each power system state regarding violation of operational security limits, frequency criteria, level of reserves, and activation of measures from the restoration plan.

Concerning technical requirements the SRF analysis shows that frequency and voltage ranges are quite similar, with small differences existing, while in most countries they may increase in extraordinary conditions. In some countries, specific voltage ranges apply for international interconnections. In general, the measures which apply for reactive power management are similar in most countries, including the switching of reactors and capacitors, power factor control by distribution companies, on-load tap changers transformers, opening lines and HVDC. Concerning reactive power management for international interconnections, in European countries reactive power is managed in a coordinated manner, while in the Maghreb countries and Jordan, reactive power is managed autonomously, avoiding reactive flow through the interconnections. System protection coordinated criteria not specified in the regulation are agreed with neighboring TSOs through common protocols or bilateral agreements/contracts. On this respect a minimum level of harmonization should be introduced concerning voltage ranges in normal and extraordinary conditions, reactive power management measures and system protection coordination criteria, while more exigent requirements could be established at national level. A minimum list of data should be exchanged between TSOs in the different time horizons, including more detailed data from the observability area.

Regarding exchange of information and data, the contingency list includes both grid (single or double lines, bus bars, transformers) and generation facilities considered as influential (with impact in the

neighboring system). Joint remedial actions are agreed and coordinated between TSOs, the most common being topology actions, countertrading, coordinated re-dispatching, lines tripping and PST tap changing. In all countries, contingency analysis considers the N-1 criterion, with specific restrictions considered on the security limits. The proposal of CTRF includes that the minimum list of major internal and external contingencies to be considered should be agreed between neighbouring TSOs, as well as the treatment of operational security limits and the minimum list of joint remedial actions to be activated in a coordinated manner between neighbouring TSOs.

HVDC technology exists in most countries, with the exception of Jordan, Morocco and Cyprus. Among them, only Spain and France have both LCC and VSC technologies installed, while in the rest of the countries only LCC technology exists. In all countries where HVDC technology applies, no special regulation for HVDC has been established yet with the exception of France and Italy that have already developed national HVDC regulation in this aspect. European Network Codes on HVDC were recently approved and are expected to apply in all European countries. Regarding HVDC technology selection, the different technical features between VSC and LCC are well-known. In this sense, positive experience has been reported from Greece for the operation of the LCC link with Italy and also from France, for the LCC link with the UK, identifying the need of management of inverse flows and voltage deviations. Short experience exists from the operation of the VSC link between France and Spain, however it has been already reported the impact of the commissioning of the VSC link for the enhancement of the voltage stability of the north-east Spanish region. Besides, the HVDC interconnector between France and Spain is the only HVDC link in the Mediterranean Region which operates in parallel with AC lines and until today no special operational problems or unexpected behaviour has been identified.

Harmonization of the international exchanges management and of outage coordination procedures are considered of high priority, especially if it affects interconnection capacity between neighbouring TSOs

Concerning load frequency control, the compliance schemes and the criteria to establish the quantity of the different types of reserves (FRR, FCR and RR) should be harmonized, together with the reserves management exchange procedures.

Coordination of the different mechanisms and procedures for the system defence plan is considered of high priority, in concrete, frequency deviation, voltage deviation, power flow, manual demand disconnection or inter-TSO assistance and coordination in emergency state. Restoration plans are also considered of extreme importance to be harmonized.

Regarding training and certification (qualification), the need of certification for real time operators and language requirements should be harmonized.

System Service Markets Area. SRF analysis shows that the structure of the electricity market in Med-TSO countries is based on two reference models: one market based, typical for European systems adhering to the ENTSO-E perimeter, with further classification of intermediate "hybrid" patterns and one non- market based, typical for North African and Middle Eastern systems.

The guarantee of security at domestic level and of coordinated management of exchanges at the borders is the principle that underlies the operation of all the electrical systems analyzed of the Mediterranean perimeter, the other distinctive feature being the respect of efficiency standards.

Harmonization of the contractual requirements for participation in the cross-border electricity trade should be foreseen, enabling in all Med-TSO countries other subjects (market participants) apart from TSOs to import and export electricity through international interconnections. A progressive degree of harmonization from "no market" to "market" based model should be introduced, including a development from bilateral internal agreements between countries to multilateral internal agreements between all TSOs (some general rules for all countries as the auction rules valid in ENTSO-E area); a scheme of technical and financial guarantees and the development of exchange programs (scheduling and management of international exchange programs).

Identification of the duties of the Market Operator should be performed, that in a preliminary model can be allocated under TSO's competences and successively allocated under an independent subject.

Harmonization of the basic technical requirements for participation on the cross-border trading activities and of the capacity calculation procedure is proposed, to include the implementation of N-1 security criterion for the calculation of the NTC. Such calculation should be done jointly by the neighbouring TSOs, following internal agreements between TSOs, using the same reference time horizons.

Regarding capacity allocation an external rule should include the procedure for allocating transmission capacity in all interconnections through a public auction and the type of capacity products to be allocated (duration and time profiling), while the internal agreements between TSOs should include specific details for each border. The subject responsible for the management of the allocation procedure should be the TSO, but in a further stage, for regional coordination issues, a supranational body (managed also by the different TSOs) should be in charge.

A multilateral procedure should be foreseen in order to guarantee the exchange programs, as well as the treatment of the unintentional deviations. Finally, a minimum level of transparency is proposed to be reached by all the TSOs both about general information from the electricity markets and specific information from the management of the international interconnections.

3. PROPOSAL OF COMMON TENTATIVE ROADMAP

For each of the 66 identified issues, an additional survey was launched oriented to capture the TSOs views on the temporal prioritization that should be applied for their regulatory harmonization (estimation of implementation program, depending on estimated priority and period of application). This, together with the proposal of the most suitable rule format (either internal or external rules³, depending on the autonomy and competence of TSOs) is compiled in the **Proposal of Common Tentative Roadmap (CTRM)** [7]. In this process, three time-horizons for regulatory harmonisation have been considered: short-term (2018-2020), medium-term (2021-2025), long-term (>2025).

Global results of the survey show a high level of temporal prioritization considered by most countries, while detailed analysis of the results, per country and area, show the expectations of each country on the quick development of the implementation process, and also which aspects or issues are considered as more urgent to work on. Thus, the block of the operation area includes the majority of topics that should have an important role in the first stages of the implementation process in the proposed harmonized regulation, while the block of system services markets area is also quite relevant to the short/medium horizon in the majority of the participating countries. The group of issues belonging to the connection area could have a relevant role in the short-medium horizon, while the block of the legal and regulatory is much diversified.

The final proposal of roadmap has been elaborated considering both dimensions previously used: the degree of importance for an issue to be harmonized and the temporal prioritization as explained above. As a result, next figure graphically represents the combined prioritization for the 66 selected issues in the 3 different time horizons (colors correspond to areas).

³ External Rules (where TSOs are not generally autonomous and need to be approved by competent authorities at national or regional level; this without prejudice that these rules might be proposed by TSOs –e.g. Grid Codes-, or higher regulation) or Internal Rules (where TSOs are generally autonomous in adopting agreements or contracts, either between TSOs or between TSOs and other stakeholders such as users or service providers; this without prejudice that these may need to be based on external rules as mentioned above).

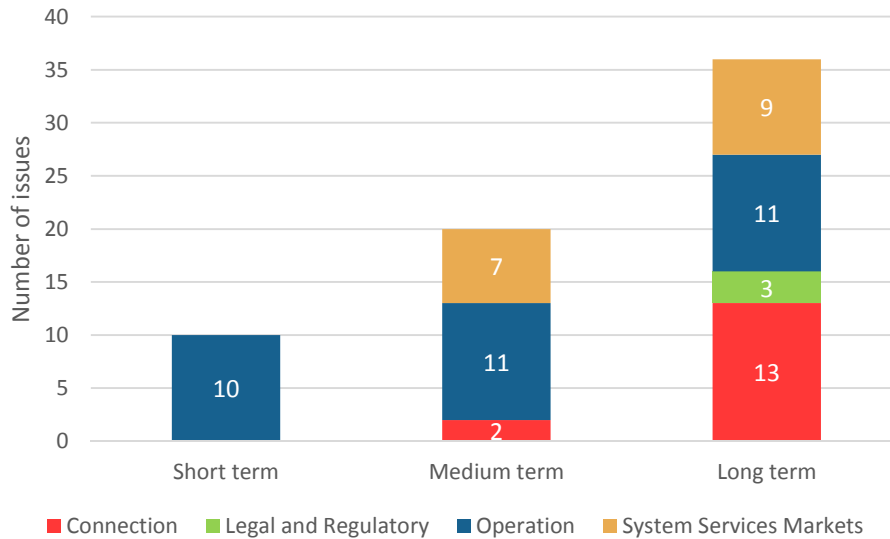


Figure 8: Time prioritization for the 66 issues included in the CTRF by technical area

Depending on the rule format for every issue (external, internal) an estimation of the practical implementation phases, with a specific duration, has been incorporated in order to schedule:

- Period for regulatory implementation phase, in which the regulation is imposed.
- Period for entry into force (practical enforcement which has been estimated) in which the actual compliance with above regulation is imposed.

As a result of the work, the concrete proposal of Common Tentative Roadmap is specified in detail for the 66 selected issues, characterizing priority and rule format, as well as specific estimated calendars for implementation and entry into force of the proposed rules. Based on the analysis performed, the correlation between the 66 technical issues, their level of degree of prioritisation and their temporal prioritisation, the technical issues have been finally grouped in 6 generic categories for the implementation process. A resulting general Chart is achieved with the appearance shown in the following figure.

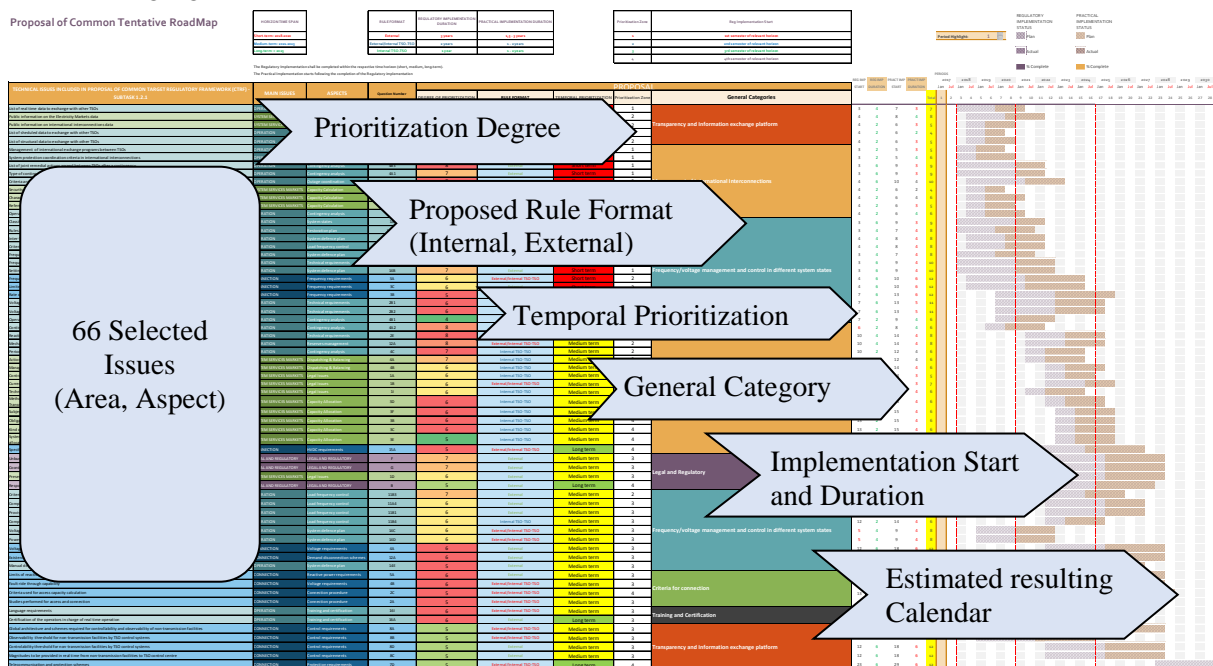


Figure 9: Proposal for Common Tentative Roadmap

4. CONCLUSION AND NEXT STEPS

The main conclusions of the work performed by TC2 is that in the current regulatory framework full harmonization is not yet achieved in any issue and all those analysed need to be further harmonized in some degree. A higher degree of harmonization has been identified for certain issues related to real time operation of interconnected systems, especially technical requirements, while others, such as reserves management and load frequency control, present many differences between power systems of the Mediterranean area. On the other hand, from the issues related to connection to the grid, some are subject to a more heterogeneous spectrum, while others are highly harmonized, such as the development of demand side response services or the control requirements between TSO and non-transmission facilities. Concerning system markets, two reference models are identified around the region in terms of structure: a market based model, typical for European systems adhering to the ENTSO-E perimeter; and a non-market based, typical for North African and Middle East systems.

Currently Med-TSO TC2 is working on the elaboration of a set of concrete rules to regulate both TSO-TSO and TSO-User relation implementing the proposals identified in the CTRF. In this phase 3, regulatory proposals have been identified as having a high level of priority to have a common model and are as follows:

- Connection Contract for users to connect to the grid.
- Operation Agreement between neighbouring TSOs.
- Grid Code with the chapters about requirements for connection and about system operation.

Other regulations will be developed in the future, as the chapters from the Grid Code about load frequency control, exchange of reserves and management of system service markets.

On a later stage, this proposal will be analysed from a zonal perspective taking into consideration the similarities and current degree of harmonization in neighbouring countries from the same geographical area. This new analysis will conclude in specific proposals of harmonized regulation with different roadmaps for implementation for concrete zones in the Mediterranean region before the full Mediterranean harmonization summarized in this paper is achieved.

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