Deliverable 5.2

"Key Performance Indicators of the regional electricity system"

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"Med-TSO—Mediterranean Project II"

Task 5.2 "Report on the Key Performance Indicators of the regional electricity system"

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1. Executive Summary

In the framework of the Mediterranean Project 2, the Task 5 is dedicated to Operation of Power system. Indeed, operation is a complex activity, where TSOs are fully engaged and perform their responsibility. Therefore, any coordination activity in this area requires a number of prerequisites to be put in place:

- A deep knowledge of the technical problems at the cross-border portions of the grid is required;
- Besides the technical capabilities, refined operational practices and optimal use of the network transfer capacity is essential for applying efficiently the reinforcement solution;
- TSOs belonging to interconnected power systems need mutual trust and coordination based on transparent and exhaustive information;
- Transparency and its relevant legislation are crucial, if the operational practices coordination is aimed also at developing the integration of markets.

All these conditions can be achieved through the practices of exchanging on a regular basis those data that are significant for the security of cross - border operation.

Setting up effective initiatives in this area is very time consuming if one considers, as an example, that the European TSOs started launching the first Regional Coordination Initiatives in 2008 and the process has not been concluded yet.

Before planning any complex initiative in the Operation area, preliminary activities are needed to consolidate the real cooperation among the TSOs, under the coordination of Med-TSO. The activities to be performed in this action try to address these mentioned issues, as a first step with reduced mobilization of resources.

Due to the very sensitive subject, dealing with confidentiality and security issues as well as companies' responsibility, a strong involvement of the institutions is expected (governments, regulators, eventually through initiatives and Associations).

In this fact a common Web-Platform for TSOs members to gather information on cross-border interconnections will be developed (Task 5.1);

The platform should evolve from a simple repository of basic data (e.g. on actual and forecast load, NTC availability, actual cross border exchanges etc.) to more sophisticated information on quality/security of operation (e.g., N-1 compliance, power frequency control, etc.) and linked with data bases to complement the planning process. The platform should have a public section and a Members-only section for confidentiality reasons.

Med-TSO considers the reporting of operational facts and figures concerning the interconnection as the most valuable part of the concrete knowledge sharing.

One application of the Platform is the statistics of power frequency control. The performance of the power frequency control should be regularly shared in a permanent ad hoc working group dedicated to the deep analysis of the causes of deviations for the sole scope of improving the interconnection in security and efficiency. Frequency quality is one of the main issues linked with RES accommodation.

A second application is the report of operational situations where criticalities hampered or risked hampering the security of the whole power system. Med-TSO will attempt to create consensus around investigation practices in case of major incidents.

So a part of this platform will be dedicated to publish several pieces of information regarding the key performance indicators of the regional electricity system (Task 5.2).

2. Introduction:

Systems and networks performance standards are important issues in modern power system as they ensure the efficient and secure functioning of the power system and appropriate quality of electricity supply. Therefore, there is a demand for common indicators that enable system operators and other qualified stakeholders to evaluate the power system performance. These indicators gives the reliability of electric power service and reflect operational issues.

This document is intended to identify the key performance indicators and their definitions that are currently used worldwide to assess the technical and economic (cost-effectiveness) performance of electrical systems.

The objective is to define the main pieces of information regarding key performance indicators of the regional electricity system in order to select a set of information that could be harmonized within the Mediterranean area and to be shared between Med-TSO members.

Otherwise, it should be noted that the document gives the standard formulas, if the TSOs use these indicators by means of other methods of calculation; it is up to them to specify these methods.

3. Transmission System Performance Indicators:

Electricity transmission companies normally measure their performance by using various types of qualitative and quantitative assessments. They measure achievements of their objectives through monitoring a number of performance indicators. Performance Indicators are the parameters that are related to transmission lines or transformers availability, service continuity or voltage profile. The indicators for the present technical performance of the transmission system are useful when planning the future developments to ensure a high degree of reliability of the transmission system

Otherwise, it is important to note that many detailed performance measures can be used internally in the company, but only those relevant for general interests are published.

It is important to distinguish between indicators of availability due to equipment outages, which pertain more to an asset management performance monitoring, and interruption of electric service to the grid users. Indeed, equipment outages do not automatically imply an interruption of service to the grid users; on the contrary, the reliability criteria at the basis of grid planning ensure that at least in N-1 contingencies the users are totally unaffected by the outage of one grid element.

From a grid user perspective, the indicators of service interruptions are those named “Interruption Indexes” and are typically calculated for the distribution grids, where most of the users are connected. Users connected to transmission level can suffer interruptions in case of multiple, concurrent outages, and/or cascading events. It is also customary to opt out interruptions at distribution level originating from disturbances at transmission level, although this parameter is mostly used by the regulator for determining the liability and the consequent economic penalty.

4. Transmission System Availability Indicators:

Availability of a transmission system is expressed as a function of the transmission circuit outages or Interruptions and it is evaluated using indicators that measure the number of outages and their

durations. Availability Indicators are measured in terms of the scheduled (planned) or forced outages separately. These outages also are typically classified according to their duration as transient outages, long outages and short outages. In addition, the transmission lines availability indicators could be measured categorized in terms of transmission voltage.

Transmission system availability can be assessed through Individual Performance Indicators and Overall Performance Indicators. Individual Performance Indicators are used to measure Transmission System availability of each individual Transmission Line and each individual Grid Substation Transformer.

The Individual Performance Indicators are defined below.

5. Transmission Lines Unavailability Duration per Year (in hours)

This measures the time duration per year where a single transmission line is out of service, averaged on all the lines of the system:

$$UD_L = \frac{\sum_{j=1}^{NL}\sum_{i=1}^{kt} H_{i,j}}{NL}$$

Where:

UD_L = Annual Unavailable Duration (in hours) of a Transmission Line
Hi,j = Duration of Outage "i", that affected Transmission Line "j" (in hours)
NL = Total number of Transmission Lines
kt = Total number of Outages of Transmission Line "j" during the reported year

This indicator can be expressed in percent as follow:

$$SU_L = \frac{\sum_{j=1}^{NL}\sum_{i=1}^{kt} H_{i,j}}{NL * 8760} \text{ x } 100$$

Where;

SUL = System Unavailability (Transmission Lines)
Hi,j = Duration of Outage "i", that affected Transmission Line "j" (in hours).
NL = Total number of Transmission Lines
kt = Total number of Outages of Transmission Line "j" during the reported year

NB: unavailability for long time duration should be excluded

a) Substation Transformers Unavailability Duration per Year (in hours)

This measures the time duration per year where a single substation transformer is out of service, averaged on all transformers of the system:

$$UD_T = \frac{\sum_{j=1}^{NT}\sum_{i=1}^{kt} H_{i,j}}{NT}$$

Where:

$UD\ T$ = Annual Unavailable Duration (in hours) of a Substation Transformer
Hi,j = Duration of Outage "i", that affected Substation Transformer "j" (in hours)
NL = Total number of Substation Transformers
kt = Total number of Outages of Substation Transformer "j" during the reported year

NB: unavailability for long time duration should be excluded.

b) System Average Frequency of Outages of Transmission Line per Year

This measures the number of interruptions per year per transmission line of the system:

$$SAFO_L = \frac{\sum_{j=1}^{NL} NO_j}{NL}$$

Where;

SAFOL = System Average Frequency of Outages of Transmission Line per Year
NO j = Number of Outages of Transmission Line "j" during the reported year
NL = Total number of Transmission Lines

Transmission Line outages can be further classified according to the duration of the outages as transient vs permanent, and the permanent outages classified in duration ranges (from minutes to months).

c) System Average Frequency of Outages of Substation Transformer per Year

This measures the number of interruptions per year per substation transformer of the system

$$SAFO_T = \frac{\sum_{j=1}^{NL} NO_j}{NT}$$

Where:

SAFOT = System Average Frequency of Outages of Substation Transformer per Year
NOj = Number of Outages of Transmission Transformer "j" during the reported year
NL = Total number of Transmission Transformers

Transformer outages also can be classified according to the duration of the outages (Eg: Ranging from less than ten minutes to greater than 4 weeks) and total number of outages in each time classification could be measured.

Overall System Performance Indicators which are used to measure overall Transmission System availability are defined below.

d) Transmission Line Availability:

$$SAL = (1 - SUL)\ \%$$

SAL = Transmission Line Availability
SUL = System Unavailability (Transmission Lines)

e) System Transmission Transformer Unavailability

This can be measured taking the fraction of time (expressed in percent) that Transmission Transformers are unavailable and disconnected from the Transmission System or by considering the extent of which the power transformer capacity remained unavailable.

$$SU_T = \frac{\sum_{j=1}^{NT}\sum_{i=1}^{kt} H_{i,j}}{NT*8760} \text{ x } 100 \quad \text{or} \quad SU_T = \frac{\sum_{j=1}^{NT}\sum_{i=1}^{kt} H_{i,j}*C_j}{TC*8760} \text{ x } 100$$

Where;

SUT = System Unavailability (Substation Transformer)
Hij = Duration of Outage "i", that affected Transmission Transformer "j" (in hours)
Cj = Capacity of Transmission Transformer "j" (in MVA)

NT = Total number of Transmission Transformers

kt = Total number of Outages of Transmission Transformer "j" during the reported year

TC = Total Installed Capacity of Substation Transformers (in MVA)

f) Transmission Transformer Availability

$$SAT = (1 - SUT)\ \%$$

Where;

SAT = Transmission Transformer Availability

SUL = System Unavailability (Substation Transformer)

g) System Average Frequency of Outages per km

This measures the average number of Outages per km of Transmission Lines (Expressed in number of outages per 100 km of lines)

$$SAFO\_L_{100} = \frac{\sum_{j=1}^{NL} NO_j}{\sum_{j=1}^{NL} LONG_j / 100}$$

Where;

SAFO_L100 = System Average Frequency of Outages per 100km

NO = Number of Outages of Transmission Line "j" during the reported year

NL = Total number of Transmission Lines

LONGj = Length of Transmission Line

h) System Average Interruption Frequency Index (SAIFI):

This indicator, which is recommended by the IEEE, measures the average number of interruptions experienced by each customer. All planned and unplanned interruptions are used in calculating the index. This indicator can be calculated as follows:

$$SAIFI = \frac{\text{Number of Interruptions During One Year}}{\text{Number of Customers}}$$

i) System Average Interruption Duration Index (SAIDI):

This indicator, also recommended by the IEEE, measures the yearly average interruptions duration per customer. The following formula is employed for calculating SAIDI:

$$SAIDI = \frac{\sum^{One\ Year} \text{Duration of Interruption (min.)}}{\text{Number of Customers}}$$

SAIFI and SAID is normally calculated over one year. If it is required for other periods, its name and equation should be modified accordingly. In addition, they can be calculated for each voltage level.

j) Customer Average Interruption Duration Index (CAIDI):

This index can be directly calculated as long as SAIFI and SAIDI are available:

$$CAIDI = \frac{\text{SAIDI}}{\text{SAIFI}}$$

III.2 Transmission System Power Quality Indicators:

To assess the performance of a transmission system not only the availability but also the quality of the power must be considered. Power quality indicators shows how the transmission line parameters comply with the defined standards.

The power quality measures and indicators are defined below.

a) Frequency Deviation Index (FDI):

Frequency variation is the deviation of frequency beyond a certain range from the nominal supply frequency. Any frequency excursions outside these limits for a defined duration or more (Eg: 60 Seconds) could be recorded as frequency limit violations.

Frequency deviation indicators can be defined to find the number of time or duration that the system frequency goes beyond the allowable range.

To figure out the extent of frequency excursions, frequency ranges can be also defined according the standard used by each TSO

- ✓ *Normal State* the Transmission System frequency is within the limit;
- ✓ *Alert State* the Transmission System frequency is beyond the normal operating limit;
- ✓ *Emergency State t*here is generation deficiency and frequency.

b) Voltage Deviation Index (VDI):

Voltage variation is the deviation of voltage in a certain range. Voltage deviations can be identified by monitoring the bus bar voltages of the grid substations.

Voltage deviation indicators can be defined to find the frequency or duration that the bus bar voltages violate the allowed voltage range.

- Number of voltage violations exceeding *n* minutes per year
- Percentage of time that the transmission voltage exceeds the permissible limits

c) Transmission Losses

Transmission losses can be calculated as the difference between the total electrical energy received from the generating plants and the total energy supplied to all bulk supply licensees. It is usual to express losses as a percentage value rather than absolute value. The losses are measured over a definite period, normally per year.

The definition of the transmission losses is defined as:

$$\%Transmission\ Losses = \frac{\sum E_G - \sum E_T}{\sum E_G} \text{X } 100\%$$

Where;

E_G = Total Energy injected into the grid perimeter (MWh) during reported year

E_T = Total Energy withdrawn from the grid perimeter (MWh) during reported year

III.3 Supply Security Indicators:

Power System security is the ability of the system to withstand sudden disturbances. To secure the supply the Transmission system must be able to deliver the power even under abnormal or

faulty conditions.

a) Energy Not Supplied (ENS)

This indicator gives an estimation of the Energy not supplied to the connected Load due to all possible causes over a year period. It can be calculated by using the following formula (MWh)

$$ENS = \sum_{i=1}^{kt} PD_i * H_i$$

Where

PDi = Power disconnected by transmission circuit Interruption""" (in MW).
Hi = Duration of Interruption 'I' (in hours)
kt = Total number of Interruptions during the reported year

Another indicator which is directly related to ENS could be expressed with ENS is "System Minutes Lost", this index measures the severity of each system disturbance relative to the size of the system, in terms of duration of total system wide blackout. It is determined by calculating the ratio of unsupplied energy during an outage to the energy that would be supplied during one minute, if the supplied energy was at its peak value. One system minute indicates an equivalent of total system interruption, with the magnitude of annual system peak, for one minute

The formula used for calculating the system minutes lost is;

$$System\ Minutes = \frac{Sum\ of\ Unsupplied\ Energy\ (MWmin)}{System\ Peak\ Load\ (MW)}$$

When this index for a specific incident is greater than one minute, that incident can be normally classified as a major interruption.

b) RES Curtailment:

Curtailment is the reduction of output of a **renewable generation** plant, below what it could have otherwise been produced given the available resources (e.g. available wind and solar irradiance). It is calculated by subtracting the **energy** that was actually produced, from the energy that theoretically could have been generated with the available resources if there were no limiting constrains (e.g. grid constrains, excess generation, etc).

The RES curtailment can be categorized according to the reasons for its occurrence and the rationale for voluntary and involuntary action. The table below summarizes the major reasons for RES curtailment:

Reason	Voluntary	Involuntary	Rationale
Network Constraints	Accepted in contracts (at time of connection)	Short term DSO controlled generation reduction	Avoid overinvestment in transmission and distribution capacity extension delays
Security	Specialized market	Max. generation limits for a number of consecutive hours, mainly enforced by TSO	Reduce reserve capacity costs/dynamic reserve dependent on variable generation
Excess generation relative to load levels	Low or negative power market prices induced	Generation limits enforced by TSO	Highest marginal costs generation should be curtailed if market fails

We can define the ratio for RES curtailment as the quantity of energy not delivered by RES

producers due to the curtailment process, divided by the total of RES energy produced in one year:

$$RES\ Curt = \frac{\sum_1^n ENLi}{\sum_1^n ERESj}$$

Where:

ENL_i: Energy not produced due to RES curtailment process for solar and wind energy in one year

E_{RES}: Total Energy produced from all Renewable energy sources in one year.

Note: this KPI is just for Wind and solar energy, hydro is considered as a dispatchabled source with no need for curtailment

RES Penetration Ratio

Year	Total Generation (GWh) A	Wind GWh) B	PV (GWh) C	Curtailed Energy (GWh) D	Penetration Ratio E = (B+C)/A	Curtailment Ratio F = D/(B+C)

*source: Curtailment of renewable generation: Economic optimality and incentives.

c) Overall Reliability of Transmission System:

The Overall Reliability of Supply for a transmission system is calculated using the formula;

$$\left(1 - \frac{ENS}{Total\ energy\ that\ would\ have\ been\ supplied\ by\ the\ transmission\ system}\right) X\ 100$$

Where;

ENS = Estimated Unsupplied Energy due to unavailability of transmission circuits

d) Average Interruption Time (AIT):

Which measures the total number of minutes that power supply, is interrupted during the year. This KPI is calculated from the ENS as follows:

$$AIT = \frac{8760 \times 60 \times ENS}{\text{Annual Electricity Demand (MWh)}}$$

III.4 Transmission System Assets Utilization

Assets which directly involve in Transmission Supply system are very critical for the secure operation are Transmission Lines and Grid Substation Transformers. Therefore, they must be utilized productively by keeping records of their loading capacities.

a) Grid Substation Overloading

Overloading of grid substations is defined based on the loading levels of grid substation power transformers. Overloading of transformers must be avoided to avoid overheating, leading to equipment damages and reducing the lifetime.

To assess the transformer overloading, the indicators can be defined to find the number of time or duration that the Grid Substations have overloaded over the reported year.

b) Transmission Transformer Utilization Factor

This measures the extent utilization of the transmission transformers with respect to their rated capacities. It is the ratio of the maximum load on a transformer to its rated capacity.

$$UF_{Pk} = \frac{\sum_{j=1}^{NT} P_j}{\sum_{j=1}^{NT} C_j} \text{X } 100\%$$

Where;

UFPk = Transmission Transformer Utiliztion Factor
Pj = Recorded Peak Load of Transformer "j" (in MVA) during reported period
NT = Total number of Substation Transformers
Cj = Rated capacity of Transformer "j" (in MVA)

c) Load Factor

Load Factor is an indicator of how steady an electrical load is over time. It is simply the average load divided by the peak load in a system over a period. But normally load factor is calculated subjected to the produced energy according to the following formula.

$$Load\ Factor = \frac{Total\ Generation\ During\ the\ Nominal\ Period}{Maximum\ Demand \text{ x No. of hours in the report period}}$$

Load factor of any system must be tried to keep in its maximum by pulling down the concentrated maximum demand and shifting the loads to periods of otherwise low usage. Load factor maximization is essential in maintaining the security of supply of the countries in which meeting the concentrated maximum demand is critical.

I. Maintenance Cost Indicators

The Maintenance Cost incurred to operate a bulk supply operation business is also an indicator of the financial performance of that operation. Maintenance cost includes the costs incurred that are directly related to the well-being, security, integrity, reliability and availability of equipment and installations. Technical labor/manpower costs, material cost, spares and vehicle costs associated with normal or day today operation and maintenance activities as well as preventive and corrective maintenance activities are also included.

a) Transmission Lines Maintenance Cost Index (TLMCI)

This indicates the annual maintenance cost per unit length of transmission lines.

$$TLMCI = \frac{Total\ Line\ Maintenance\ Cost}{\sum_{j=1}^{NL} LONG_j}$$

Where;

TLMCI = Transmission Lines Maintenance Cost Index
NL = Total number of Transmission Lines
LONGj = Length of Transmission Line "j" in km

The OHTLs maintenance works include mainly live line washing and line patrolling.

b) Substation Maintenance Cost Index (SMCI)

This indicates the annual maintenance cost per Substation.

$$SMCI = \frac{Total\ GSS\ Maintenance\ Cost}{NS}$$

Where;

SMCI = Substation Maintenance Cost Index
NS = Total number of Grid Substations

The substation maintenance activities include, but not limited to the followings: Daily, routine, monthly, quarterly, annual, preventive, predictive, break down and emergency maintenance work for grid stations (including maintenance of all equipment like transformers, circuit breakers, switchgear, measurement devices,…etc.

II. Interconnections Keys Indicators:

For the evaluation of electrical interconnection, several statistic pieces of information can be evaluated as:

a) Interconnection availability

b) Exploitation of interconnection capacities

The exploitation of interconnection capacities can be calculated by comparing the yearly-allocated NTC per border or by single line interconnector with the average yearly load flow on that same interconnection. (Ex. these data are available through ENTSO-E Data Portal for each European Interconnection. Actual load flow is measured conventionally every Wednesday at 03.00 am (proxy for off-peak load flow) and at 11.00 am (proxy for peak load flow). In order to calculate such Exploitation rate, the following formula can be used, where i stands for each interconnection and μ is the average of annual Load Flow values, measured as above:

$$ER_i = \frac{\mu_i(load\_flow)}{NTC_i} \times 100$$

Where ERi is the exploitation rate for the interconnector i.

c) Contribution to the security on system operating (to maintain frequency deviation)

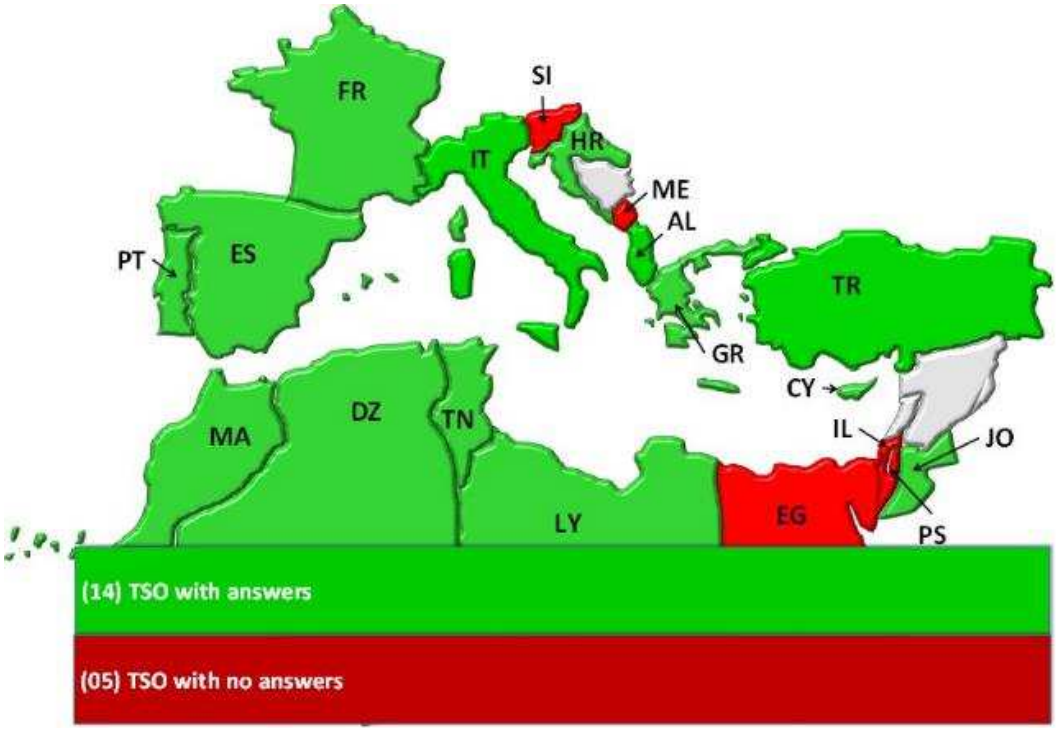
This indicator is not a quantitative one, but it can be evaluated by using an indication as “High”, “Medium” or “Low” impact.

d) Contribution to the development of RES and sharing system services

This indicator is not a quantitative one, but it can be evaluated by using an indication as “High”, “Medium” or “Low” impact.

III. Analysis:

The analysis is based on the answers of the TSOs on the questionnaire transmitted. This questionnaire gives the indicators presented above with two questions:
Q1: are these key indicators used by the national TSO? Possible answers: YES, NO, N/A
Q2: will these pieces of information from your power system be available to be published in Med-TSO website? Possible answers: YES, NO, N/A.
The responses received are from 14 TSOs on the 19 TSOs, so with a rate of 73%
The TSO that gives answers are presented on the map bellow:



Approach:

It should be recalled that the main objective is to identify the existing common indicators used by TSOs or to be harmonized in view of their publication on the Med-TSO platform.
Given that there is a disparity in the responses of the TSOs, an evaluation approach based on the average of the common responses between the TSOs for each indicator is adopted at first time for the use of the indicator by the TSO (Q1) and then for the possibility of its publication externally (Q2).

On the basis of the results obtained, the averages are identified as follows:

1. a first level of the averages equal to 50% and more;
2. a second level of averages between 30% and 50%;
3. a third level for the averages less than 30%.

Q1: are these key indicators used by the national TSO? Possible answers: YES, NO, N/A — **14/19 TSO answred the questionn** 14

Indicators that average 50% or more of the 14 responses received

Indicators that average between 30% and 50% of the 14 responses received

Indicators that average less than 30% of the 14 responses received

Q2: will these informations from your power system be available to be published in Med-TSO website ? Possible answers: YES, NO, N/A.

Indicators that average 50% or more of the 14 responses received

Indicators that average between 30% and 50% of the 14 responses received

Indicators that average less than 30% of the 14 responses received

	1		2		3		4		6		7		9		10		11		12		15		17		18		19		Avrage YES		Avrage NO		Avrage N/A		Avrage (YES)	
	AL		DZ		HR		CY		FR		GR		IT		JO		LY		MA		PT		ES		TN		TR									
Keys Indicators	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2
III.1 Transmission System Availability Indicators																																				
a) Transmission Line Interruption Duration per Year (in Hours and in percentage)	NO	NO	YES	NO	N/A	N/A	NO	NO	NO	NO	YES	YES	YES	NO*	YES	NO	NO		NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	5	1	8	11	1	1	36%	7%
b) Substation Transformer Interruption Duration per Year (in Hours)	NO	NO	YES	NO	N/A	N/A	NO	NO	NO	NO	YES	YES	YES	NO*	YES	NO	NO		NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	5	1	8	11	1	1	36%	7%
c) System Average Frequency of Outages of Transmission Line per Year	NO	NO	NO	NO	N/A	N/A	NO	NO	NO	NO	NO	NO	YES	NO*	YES	NO	NO		NO	NO	NO	NO	NO	NO	YES	NO	YES	YES	4	1	9	11	1	1	29%	7%
d) System Average Frequency of Outages of Substation Transformer per Year	NO	NO	NO	NO	N/A	N/A	NO	NO	NO	NO	NO	NO	YES	NO*	YES	NO	NO		NO	NO	NO	NO	NO	NO	YES	NO	YES	YES	4	1	9	11	1	1	29%	7%
e) Transmission Line Unavailability	NO	NO	NO	NO	N/A	N/A	NO	NO	YES	NO	YES	YES	YES	NO*	YES	NO	NO		NO	NO	YES	YES	YES	NO	YES	NO	YES	YES	8	3	5	9	1	1	57%	21%
f) System Transmission Transformer Unavailability	NO	NO	YES	NO	N/A	N/A	NO	NO	NO	NO	YES	YES	YES	NO*	YES	NO	NO		NO	NO	NO	NO	YES	NO	YES	NO	NO	NO	6	1	7	11	1	1	43%	7%
g) Transmission Transformer unavailability	NO	NO	NO	NO	N/A	N/A	NO	NO	YES	NO	YES	YES	YES	NO*	YES	NO	NO		NO	NO	YES	YES	YES	NO	YES	NO	NO	NO	7	2	6	9	1	1	50%	14%
h) System Average Frequency of Outages per km	NO	NO	YES	NO	N/A	N/A	NO	NO	YES	YES	NO	NO	NO	NO*	N/A	N/A	YES	YES	YES	YES	NO	NO	NO	NO	YES	NO	YES	YES	6	4	6	8	2	2	43%	29%
i) System Average Interruption Frequency Index (SAIFI)	NO	NO	YES	NO	N/A	N/A	YES	NO	YES	YES	YES	der app	YES	YES	YES	NO	NO		NO	NO	YES	YES	NO	NO	YES	NO	NO	NO	8	4	5	8	1	1	57%	29%
j) System Average Interruption Duration Index (SAIDI)	NO	NO	YES	NO	N/A	N/A	YES	NO	NO	NO	YES	der app	YES	YES	YES	NO	NO		NO	NO	YES	YES	NO	NO	YES	NO	NO	NO	7	3	6	9	1	1	50%	21%
k) Customer Average Interruption Duration Index(CAIDI):	NO	NO	NO	NO	N/A	N/A	YES	NO			YES	der app	YES	YES	YES	NO	NO		NO	NO	YES	YES	NO	NO	YES	NO	NO	NO	6	3	6	8	1	1	43%	21%
III.2 Transmission System Power Quality Indicators																																				
a) Frequency Deviation Index (FDI)	NO	NO	YES	NO	N/A	N/A	NO	NO	YES	YES	NO	YES	YES	YES	N/A	N/A	YES	YES	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	7	7	5	5	2	2	50%	50%
b) Voltage Deviation Index (VDI)	YES	YES	NO	NO	N/A	N/A	NO	NO	YES	NO	NO	YES	YES	YES	N/A	N/A	NO		NO	NO	NO	NO	YES	NO	YES	YES	NO	NO	5	4	7	7	2	2	36%	29%
c) Transmission Losses	YES	YES	YES	NO	YES	NO	YES	YES	YES	YES	YES	YES	NO	N/A	N/A	N/A	NO		YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	11	9	2	2	1	2	79%	64%
III.3 Supply Security Indicators:																																				
a) Energy Not Supplied (ENS)	YES	YES	YES	NO	YES	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES	NO	NO		YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	12	9	2	5	0	0	86%	57%
b) RES Curtailment			N/A	N/A			YES	NO			NO	YES	YES						NO	YES	NO	NO							2	2	3	2	1	1	14%	14%
c) Overall Reliability of Transmission System			NO	NO	N/A	NO	NO	NO	YES	YES	YES	YES	YES	YES	N/A	N/A	NO		NO	NO	NO	NO	NO	NO	YES	YES	NO	NO	4	4	7	6	2	1	29%	29%
d) Average Interruption Time (AIT)	YES	YES	YES	NO	N/A	NO	NO	NO	YES	YES	YES	YES	YES	YES	N/A	N/A	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	10	9	2	4	2	1	71%	64%
III.4 Transmission System Assets Utilization																																				
a) Grid Substation Overloading	NO	NO	YES	NO	N/A	NO	NO	NO	NO	NO	NO	NO	YES	NO	N/A	N/A	NO		NO	NO	NO	NO	NO	NO	YES	N/A	YES	NO	4	0	8	11	2	2	29%	0%
b) Transmission Transformer Utilization Factor	NO	NO	YES	NO	N/A	NO	NO	NO	NO	NO	NO	NO	YES	NO	N/A	N/A	NO		NO	NO	NO	NO	NO	NO	YES	N/A	YES	NO	4	0	8	11	2	2	29%	0%
c) Load Factor	NO	NO	NO	NO	N/A	NO	YES	YES	NO	NO	NO	NO	YES	NO	N/A	N/A	YES	YES	N/A	N/A	NO	NO	NO	NO	YES	N/A	YES	NO	5	2	6	9	3	3	36%	14%
IV. Maintenance Cost Indicators																																				
a) Transmission Lines Maintenance Cost Index (TLMCI)	NO	NO	NO	NO	N/A	NO	NO	NO	NO	NO	NO	under c	YES	NO	N/A	N/A	NO		N/A	N/A	YES	NO	NO	NO	YES	N/A	NO	NO	3	1	8	9	3	3	21%	7%
b) Substation Maintenance Cost Index (SMCI)	NO	NO	NO	NO	N/A	NO	NO	NO	NO	NO	NO	under c	YES	NO	N/A	N/A	NO		N/A	N/A	NO	NO	NO	NO	YES	N/A	NO	NO	2	1	9	9	3	3	14%	7%
V. Interconnections Keys Indicators:																																				
a) Interconnection availability;	NO	NO	NO	NO	YES	NO	N/A	N/A	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	NO	NO	YES	YES	YES	YES	YES	YES	8	9	5	5	1	1	57%	57%
b) Ratio between interconnection capacity and national electricity demand	NO	NO	NO	NO	N/A	NO	N/A	N/A	NO	NO	NO	YES	NO	YES	N/A	N/A	NO		NO	YES	NO	NO	YES	YES	N/A	N/A	YES	YES	2	5	8	5	4	3	14%	36%
c) Exploitation of interconnection capacities	NO	NO	NO	NO	YES	YES	N/A	N/A	NO	NO	NO	YES	NO	YES	N/A	N/A	NO		NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	5	8	7	3	2	2	36%	57%
d) Contribution to the security on system operating (to maintain frequency deviation)	NO	NO	NO	NO	?		N/A	N/A	NO	NO	NO	NO	YES	YES	N/A	N/A	YES	YES	NO	NO	NO	NO	?		YES	YES	NO	NO	3	3	7	7	2	2	21%	21%
e) Contribution to the development of RES and sharing system services	NO	NO	NO	NO	?		N/A	N/A	NO	NO	NO	NO	YES	YES	N/A	N/A	NO		NO	YES	NO	NO	?		YES	YES	NO	NO	2	3	8	6	2	2	14%	21%

1) The first category with the averages equal to 50% and more:

On this range (**09)** indicators are used by up of 50% of TSOs, but not all TSOs agree to publish these pieces of information. On the **(09)** indicators (05) indicators can be published by up of 50% of TSOs.

Average (Q1)	Keys Indicators	TSOs who use the indicator	Nbr	TSO who are willing to publish the informations	Nbr	Average (Q2)
	I. Transmission System Availability Indicators					
≥ 50%	e) Transmission Line Availability	FR, GR, IT, JO, PT, ES, TN, TR	8/14	GR, PT, TR	3/14	
	g) Transmission Transformer Availability	FR, GR, IT, JO, PT, ES, TN	7/17	GR, PT	2/14	
	i) System Average Interruption Frequency Index (SAIFI)	DZ, CY, FR, GR, IT, JO, PT, TN	8/14	FR, GR, IT, PT	4/14	
	j) System Average Interruption Duration Index (SAIDI)	DZ, CY, GR, IT, JO, PT, TN	7/14	GR, IT, PT	3/14	
	II. Transmission System Power Quality Indicators					
≥ 50%	a) Frequency Deviation Index (FDI)	DZ, FR, IT, LY, ES, TN, TR	7/14	FR, GR, IT, LY, ES, TN, TR	7/14	≥ 50%
	c) Transmission Losses	AL, DZ, HR, CY, FR, GR, MA, PT, ES, TN, TR	11/14	AL, CY, FR, GR, MA, PT, ES, TN, TR	9/14	≥ 50%
	III. Supply Security Indicators:					
≥ 50%	a) Energy Not Supplied (ENS)	AL, DZ, HR, CY, FR, GR, IT, JO, MA, PT, ES, TN	12/14	AL, FR, GR, IT, MA, PT, ES, TN	8/14	≥ 50%
	d) Average Interruption Time (AIT)	AL, DZ, FR, GR, IT, LY, MA, PT, ES, TN	10/14	AL, FR, GR, IT, LY, MA, PT, ES, TN	9/14	≥ 50%
	IV. Interconnections Keys Indicators:					
≥ 50%	a) Interconnection Availability ;	HR, GR, IT, JO, LY, ES, TN, TR	8/14	GR, IT, JO, LY, MA, ES, TN, TR	8/14	≥ 50%

2) The second category with the averages between 30% and 50%:

This category of indicators are used by 30% to 50% of TSO, those KPIs can be discussed and agreed among TSO to be used.

On this range **(08)** indicators are used by 30%-50% of TSOs, also not all TSOs agree to publish these pieces of information. On the **(08)** indicators only one indicator that is up to 50% of TSO agreed to published it. For the other **(07)** KPIs, less than 30% of TSO accept to publish them.

Average Q1	Keys Indicators	TSOs who use the indicator	Nbr	TSO who are willing to publish the informations	Nbr	Average Q1
	I. Transmission System Availability Indicators					
≤30%, >50%	a) Transmission Line Interruption Duration per Year (in Hours and in %)	DZ, GR, IT, JO, TN	5/14	GR	1/14	>30%
	b) Substation Transformer Interruption Duration per Year (in Hours)	DZ, GR, IT, JO, TN	5/14	GR	1/14	>30%
	f) System Transmission Transformer Unavailability	DZ, FR, LY, MA, TN, TR	6/14	GR	1/14	>30%
	h) System Average Frequency of Outages per km	DZ, FR, LY, MA, TN, TR	6/14	FR, LY, MA, TR	4/14	>30%
	k) Customer Average Interruption Duration Index(CAIDI):	CY, GR, IT, JO, PT, TN	6/14	GR, IT, PT	3/14	>30%
	II. Transmission System Power Quality Indicators					
≤30%, >50%	b) Voltage Deviation Index (VDI)	AL, FR, IT, ES, TN	5/14	AL, GR, IT, TN	4/14	>30%
	III.4 Transmission System Assets Utilization					
≤30%, >50%	c) Load Factor	CY, IT, LY, TN, TR	5/14	CY, LY	2/14	>30%
	IV. Interconnections Keys Indicators:					
≤30%, >50%	c) Exploitation of interconnection capacities	HR, PT, ES, TN, TR	5/14	HR, GR, IT, MA, PT, ES, TN, TR	8/14	**≥ 50%**

3) The second category with the averages less than 30%:

This category of indicators is used by less than 30% of TSO.

On this, range (**11)** indicators are used by less than 30% of TSOs, also less than 30% of TSO that agreed to publish those KPIs except one indicator.

Average Q1	Keys Indicators	TSOs who use the indicator	Nbr	TSO who are willing to publish the informations	Nbr	Average Q1
	I. Transmission System Availability Indicators					
>30%	c) System Average Frequency of Outages of Transmission Line per Year	IT, JO, TN, TR	4/14	TR	1/14	>30%
	d) System Average Frequency of Outages of Substation Transformer per Year	IT, JO, TN, TR	4/14	TR	1/14	
	III. Supply Security Indicators:					
>30%	b) RES Curtailment	CY, IT	2/14	GR, MA	2/14	>30%
	c) Overall Reliability of Transmission System	FR, GR, IT, TN	4/14	FR, GR, IT, TN	4/14	
	III.4 Transmission System Assets Utilization					
>30%	a) Grid Substation Overloading	DZ, IT, TN, TR	4/14	/	0/14	>30%
	b) Transmission Transformer Utilization Factor	DZ, IT, TN, TR	4/14	/	0/14	
	III. Maintenance Cost Indicators					
>30%	a) Transmission Lines Maintenance Cost Index (TLMCI)	IT, PT, TN	3/14	GR	1/14	>30%
	b) Substation Maintenance Cost Index (SMCI)	IT, TN	2/14	GR	1/14	
	IV. Interconnections Keys Indicators:					
>30%	b) Ratio between interconnection capacity and national electricity demand	ES, TR	2/4	GR, IT, MA, ES, TR	5/14	**≤30%, >50%**
	d) Contribution to the security on system operating	IT, LY, TN	3/14	IT, LY, TN	3/14	>30%
	e) Contribution to the development of RES and sharing system services	IT, TN	2/14	IT, TN	3/14	

IV. Conclusion:

On the basis of TSOs answers and at this stage, (**09)** indicators which are used by the most of TSOs, but only **(05)** KPIs could be shared among the members through web the web platform.

1. Frequency Deviation Index (FDI);
2. Transmission Losses;
3. Energy Not Supplied (ENS);
4. Average Interruption Time (AIT);
5. Interconnection Availability.

The rest of the four out of the nine can be agreed discussed by TSOs, about the opportunities to shared them, these are:

1. Transmission Line Availability
2. Transmission Transformer Availability
3. System Average Interruption Frequency Index (SAIFI)
4. System Average Interruption Duration Index (SAIDI)

A second category of **(08)** KPIs that are used by 30% to 50% of TSO, those KPIs can be discussed also in order to be shared within web platform.

1. Transmission Line Interruption Duration per Year (in Hours and in %)
2. Substation Transformer Interruption Duration per Year (in Hours)
3. System Transmission Transformer Unavailability
4. System Average Frequency of Outages per km
5. Customer Average Interruption Duration Index (CAIDI):
6. Voltage Deviation Index (VDI)
7. Load Factor
8. Exploitation of interconnection capacities

A last category of **(11)** KPIs, which are used only by less than 30% of TSO (only 3 or 4 TSO):

1. System Average Frequency of Outages of Transmission Line per Year
2. System Average Frequency of Outages of Substation Transformer per Year
3. RES Curtailment
4. Overall Reliability of Transmission System
5. Grid Substation Overloading
6. Transmission Transformer Utilization Factor
7. Transmission Lines Maintenance Cost Index (TLMCI)
8. Substation Maintenance Cost Index (SMCI)
9. Ratio between interconnection capacity and national electricity demand
10. Contribution to the security on system operating
11. Contribution to the development of RES and sharing system services.

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