



REPORT

CONFIDENTIAL

APPROVED

VERSION 1.0

INTERCONNECTION GRID CODE FOR THE PAN ARAB ELECTRICITY MARKET

PLANNING CODE

Arab Fund Grant Number 06/2018

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PC 1 OBJECT AND SCOPE OF THE PLANNING PROCESS

J.¹ The governmental objectives and the willingness of **Member States** are the driving forces of investments in strategic infrastructures like the **Electricity Systems**. To the purposes of this **Code**, the **General Agreement** is the binding document that summarize the goal of boosting the development of the **PAEM**. The compliance with the **General Agreement** and its goals are reminded in this Chapter.

PC 1.1.1 The object of the **Planning Code** is the **Long-Term Planning** of the **International Interconnections** of the **PAEM Electricity System**. Development of the **PAEM Electricity System** means the modification of the resources of the interconnected **PAEM Electricity System** made available to the **Operation**. The main scope of this code is the expansion of the **Relevant Grid**. The development of the generation is considered, and its **Adequacy** assessed, but it is not regulated in this code. Energy policies are assumed to be under full responsibility and autonomy of the **Member States**.

PC 1.2 Key Goals

PC 1.2.1 This **Code** assumes that the key goals of the planning of **International Interconnections** are to:

- a) increase the reliability of the **Electricity Systems** of the **Member States**;
- b) enhance the efficiency of the **PAEM**;
- c) design a sustainable **PAEM Electricity System**, also from the environmental point of view;
- d) contribute to the stability of the investments.

To these purposes, **TSOs** shall give high priority to the harmonization of the **National Development Plans** and their integration.

¹ J. : Justification

PC 1.3 Compliance Goals

PC 1.3.1 Each **TSO** must comply with the national transmission planning criteria and the **National Grid Codes** taking into consideration the main drivers of development in its country and the conditions of its **Grid**. The goal of harmonization in planning is that the **National Development Plans** will gradually acquire the more general objectives of a common **Master Plan** of the **International Interconnections** for the benefit of the whole **PAEM Electricity Systems**.

PC 1.3.2 As stated in Paragraph 3.4.1.1.4 of the **General Agreement**, this **Code**, is not intended to replace or merge the individual **National Grid Codes** on planning, but it aims at interfacing them and harmonizing the process of development of the **International Interconnections**.

PC 1.3.3 In order to give continuity to the process, the **TSOs** shall set up **National Development Plans** that take into account the last approved **Master Plan** and propose new or updated cross border **Projects** as input to the **Master Plan** in progress. This cyclic iteration between the **National Development Plans** and **Master Plan** shall be biannual.

PC 1.4 The Master Plan Outline

PC 1.4.1 The drivers of the **Master Plans** are the initiatives of the **Member States** in matter of **International Interconnection**. The initiatives are expressed in **Projects**. Such **Projects** can be proposed, changed or cancelled by the **Member States** at each iteration of the **Master Plan**.

PC 1.4.2 The **Master Plan** shall consist of:

- a) The summary of the **National Development Plans** of the **Member States** concerning the **Relevant Grid** over the time horizon of the **Master Plan**.
- b) The description of the **Projects** on **International Interconnections**, consisting of:
 - i. The **International Interconnections** between neighboring **TSOs**.
 - ii. The expected increase of **NTC** between the interconnected areas associated to each **Project**.
 - iii. The **Transmission System** reinforcements and/or the refurbishment needed to reach the targets and comply with the **Security of Operation**.
 - iv. The cost benefit analysis and the **Key Performance Indicator (KPI)** values.
- c) The recap of criteria and decisions adopted in the process.

d) **Projects** aiming at increasing the utilization of the existing infrastructures.

PC 1.4.3 The ranking of the **Projects**, in discharge of duties of Paragraph 3.3.1.7.3 of the **General Agreement**, shall be based on the cost benefit analysis and on the parameters that better reflect the policies of the Pan Arab **Region**.

PC 1.4.4 In no case shall the **Master Plan** be mandatory for the involved **TSOs**. **Projects** may be modified, presented in more than one **Mater Plan** with modifications or different evaluation of the benefits due to the changed general conditions or eventually cancelled.

PC 1.4.5 Seasonal reports or outlooks on **Adequacy**, considering the benefits from the **Energy Transfers**, are part of the **Operation Code**.



PC 2 THE PLANNING PROCESS IMPLEMENTATION

J. The complexity of the planning activities and the need to create the conditions of fruitful cooperation call for an active participation of the involved **TSOs** to the relevant committees and **Working Groups**. Moreover, the necessity to give continuity to the harmonization process and deliver a reference **Master Plan** of the interconnections require a clear schedule of activities.

PC 2.1.1 The proposed planning process is not a centralized process except for the **Adequacy** and market studies. In other terms the process collects the initiatives of the **Member States** but does not impose solutions to the **Member States**.

PC 2.2 Resources of TSOs to the Arab TSOs Committee

PC 2.2.1 The planning process starts with the preparation of the **Projects** that each **TSO** will include in its **National Development Plan**. This activity is performed autonomously by each **TSO** considering the conclusions and indications of the latest and current **Master Plan**. The part of the **National Development Plans** concerning the **Relevant Grid** and **International Interconnections** between **TSOs** is subject to coordination.

PC 2.2.2 The co-ordination of the **Projects** requires the collection of the initiatives, the analysis of the contents, the drafting activity of the **National Development Plan, Comitology** of the **Members States** and administrative issues. To this purpose, the **Arab TSOs Committee** will establish the **WG4-Plannning Working Group** and the **TSOs** agree to contribute with qualified resources. According to the **General Agreement** the **WG4**:

- a) may be permanent or temporary and reports to **Arab TSOs Committee**;
- b) shall work according to a term of reference, approved by **Arab TSOs Committee**;
- c) shall strive for unanimous decisions or decide according to rules accepted with the signature of the **General Agreement**;
- d) decides how to share the activities between internal **Working Groups**;
- e) can propose to hire external expertise for specific studies.

PC 2.2.3 **WG4** shall be chaired by an elected representative of one of the **Member States** staffed with a secretary and representatives of the **Member States**. The work shall be organized and shared among internal groups to be confirmed at any edition of the **Master Plan**:

- a) By **Expert Groups (EG)** assisting **WG4** in carrying out market, **Network** studies, and what else **WG4** will consider necessary.

- b) **Area Groups (AG)**, one per each **Synchronous Area** as defined in Article PC 4.2.4.

PC 2.2.4 **TSOs** shall contribute to the activities of **EGs** and **AGs** with qualified personnel and guarantee the needed time to accomplish the assigned tasks.

PC 2.2.5 The **WG4** shall support the **TSOs** in the assessments and in modelling their **Electricity System**, if required. **WG4** shall suggest modifications to the **Projects** as well. Despite such relationships the responsibility of the **Projects** still belongs to the **TSOs**. **TSOs** are free to accept or reject the suggested modifications.

PC 2.2.6 In discharging his duties, **WG4** may propose to **Arab TSOs Committee** for approval new ad-hoc groups.

PC 2.3 Timing for the Planning Process

PC 2.3.1 The main scope of the planning process is to deliver a long-term **Master Plan**.

PC 2.3.2 The planning horizon should be as the shortest **National Development Plan** but not less than five (5) years with 2-years rolling frequency.

PC 2.3.3 The target date for publishing shall be the 31st of December of Y-1. Hence the common planning process shall start the 1st of January of each year Y-2 (**Planning Process Starting Date**).

PC 2.3.4 During two (2) years of activity cooperation among the **TSOs**, it is required to harmonize the interconnection initiatives with the **Grid** expansion, generation and distribution plans and define **International Interconnections Projects**.

PC 2.3.5 The time schedule of the planning process is formulated in eleven steps, described in sequence. It is a **WG4** decision to shorten the schedule if possible and carry out some of these steps in parallel. The timeline is reported in Figure PC 1.

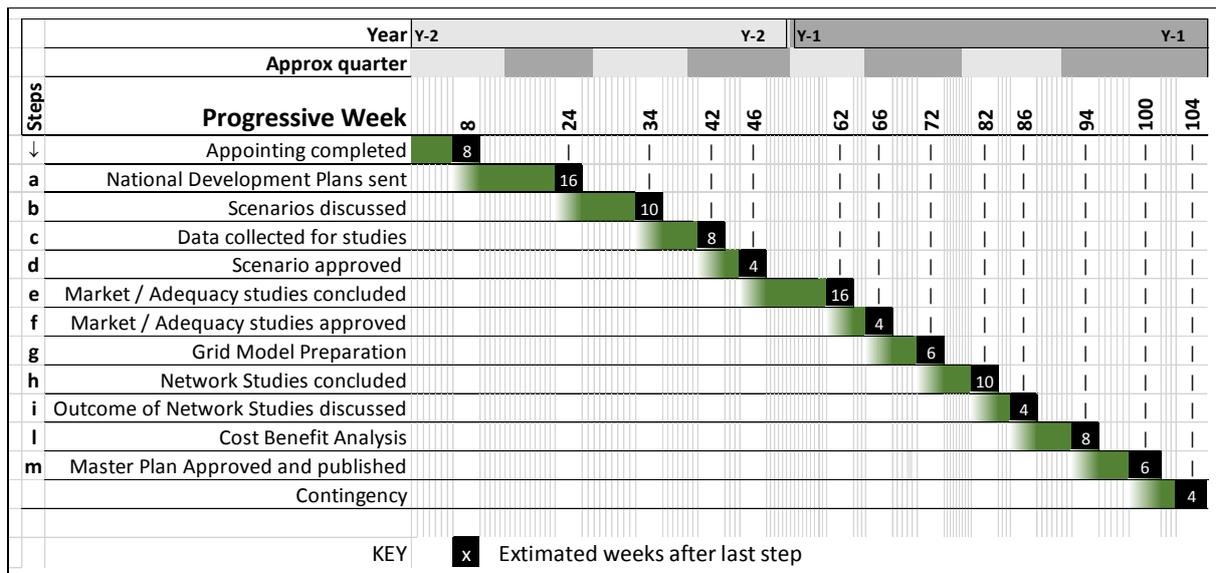


Figure PC 1. Timeline of the planning process.

PC 2.3.6 Preliminary Phase

PC 2.3.6.1 As a first step, before the 8th week of the Y-2, the Arab TSOs Committee should nominate the **WG4** and the TSOs members of it, staffing the **Area Groups** and the **Expert Groups**.

PC 2.3.6.2 The **Expert Group**, under proposal of **WG4** and approval of **Arab TSOs Committee**, can be supported by qualified external resources, recruited according the rules of the **General Agreement**

PC 2.3.6.3 **WG4** shall propose and the **TSOs** shall approve as soon as possible a binding detailed schedule in line with the requirements of Section PC 2.3 of this Code.

PC 2.3.7 STEP a). Collection of the National Development Plans Including the Interconnection Initiatives

PC 2.3.7.1 Almost three (3) months are granted to the **TSOs** to update their **National Development Plans** and align them to the priorities and targets of the **PAEM**.

PC 2.3.7.2 By *week a*² (24th week) (refer to Figure PC 1) each **TSO** involved in development **Projects** should forward to **WG4** its **National Development Plan** for the planning horizon prescribed by their applicable national regulations.

² Hereinafter, the term *week* followed by the relevant (*letter*) refers to the final progressive week at the end of the step identified with that *letter* in Figure PC 1.

PC 2.3.7.3 By the same date, **TSOs** should forward indications to extrapolate the **National Development Plans** till the final planning year as agreed in Article PC 2.3.2 ahead if their **National Development Plans** are shorter.

PC 2.3.7.4 The **National Development Plans** should at least highlight:

- a) The **Projects** of new cross border **International Interconnections**, the reinforcements needed and the expected increase of **NTC** for each of them and in total.
- b) The **Scenarios** and assumptions under which the **Projects** have been developed.
- c) Forecast data for the time horizon of the plan (**Demand** and **Generation** at the detail of kind of **Generation** source).
- d) Main goals associated to the **Projects**.

PC 2.3.7.5 **Projects** shall be presented in uniform editorial pattern to speed up analysis and presentations, without risk of misinterpretations.

PC 2.3.7.6 **Projects** can be single initiatives or **Clusters** of **Projects**. If aiming at the same objective, they complement each other.

PC 2.3.7.7 **Projects** are considered finalized only when techno-economic benefits are estimated and the costs of the cross-border **Project** plus the reinforcements are assessed through cost-benefit analysis. Therefore, **WG4** may recommend changes and **TSOs** may propose solutions during the process, to meet the recommendations received.

PC 2.3.8 ***STEP b). Definition of Scenarios and Drivers for the Interconnection***

PC 2.3.8.1 On the ground of the **PAEM** targets and considering the instances of the **TSOs** received, **WG4**:

- a) analyses the topics that drive the development of each **TSO**;
- b) performs an analysis of the drivers in each **Member State** and defines the reference **Scenarios** for the **Synchronous Areas** involved by the **Projects**. **TSOs** within **WG4**, decide the number of **Scenarios** to be developed. It is recommended to start with a minimum of two initial **Scenarios**. The initial **Scenarios** can evolve in more than two (2), but they never should exceed 4.
- c) classifies **Projects** received by the **TSOs** according to their maturity (proposals, bilateral agreements, government requests), goal (economic benefits, **VRE-units** accommodation, reliability, reduction of losses, **Adequacy**).

PC 2.3.8.2 **WG4** shall draw the conclusions on the way to approach the **Scenario** analysis, draft the investment list and – after approval – call for market and **Network** studies at **Synchronous Area** level by *week b*) (34th week) (refer to Figure PC 1).

PC 2.3.9 ***STEP c) and STEP d). Data Collection for Market and Network Studies***

PC 2.3.9.1 By *week c*) (42nd week) (refer to Figure PC 1), and based on the previous analysis, the **TSOs** complement the **Information** with the set of national data needed for the market analysis, as per Paragraph 3.4.1.2.1 of the **General Agreement**.

PC 2.3.9.2 The required **Information** for each of the **Scenarios** consists of forecast of the **Demand**, the power **Generation** mix, the conventional merit order in dispatching **Power-Generation Facilities** (based on standard costs of fuel and standard efficiency per type of unit) and the **NTC** between neighboring interconnected **Electricity Systems** in the format required by the adopted simulation tool and the **Grid Models** with and without the proposed **Projects**. According to the configuration of the internal **Grid**, **WG4** could require one or more **TSOs** to simulate the market at bidding zone level instead of a single nation level. This decision implies the obligation for the **TSO** to supply data split at **Bidding Zone** detail as well as intra **TSO Transfer Capacities** between **Bidding Zones**.

PC 2.3.9.3 **WG4** defines market **Scenarios**, driving parameters and **KPIs** (economics, reliability, adequacy) and by *week d*) (46th week) (refer to Figure PC 1) approval by **TSOs** is required.

PC 2.3.10 ***STEP e) and STEP f). Market Analysis***

PC 2.3.10.1 **WG4 / EG** performs the market studies. Hourly simulations are performed adopting a probabilistic approach. Market studies shall produce, for each **Scenario** and **Project**, the values of the **KPIs** taken as reference for **Adequacy** and **Socio Economic Welfare**.

PC 2.3.10.2 **WG4** shall also deliver gradually **Project** by **Project** results and complete the delivery of them not later than *week e*) (62nd week) (refer to Figure PC 1).

PC 2.3.10.3 **TSOs** have the faculty to discuss results and endorse final versions by the *week f*) (66th week) (refer to Figure PC 1).

PC 2.3.11 **STEP g). Network Set-up**

PC 2.3.11.1 Based on the results of market study, **Network** analysis must be performed in order to check the compliance with the security standard if the conditions of the market studies are applied. To this aim, the **Area Group** of each **Synchronous Area** of **WG4 / AG** agrees on several **Snapshots** per **Project** recognized as significant to the operation in peak and off-peak hours and in various seasonal situations. The market simulation variables of the **Snapshots** are taken from the 8760 hourly simulations of the market studies and mapped on the **Individual Grid Models** and merged in a **Common Grid Model** per **Synchronous Area** and per **Snapshot**.

PC 2.3.11.2 Each **Area Group** agrees on the portions of **Transmission Systems** that can be represented with equivalents to reduce the calculation burden, without appreciable loss of accuracy.

PC 2.3.11.3 The preparation of the **Common Grid Models** shall be concluded by *week g)* (72nd week) (refer to Figure PC 1).

PC 2.3.11.4 In case of connections between two **Asynchronous Areas** through an **HVDC System**, the **Grid Model** shall include the models of the two areas and the **HVDC System** for further thorough investigations. General prescriptions on the studies to be performed in such a case are also reminded in the **Operation Code**.

PC 2.3.12 **STEP h) and STEP i). Network Studies**

PC 2.3.12.1 Each **Area Group** of **WG4** coordinates the **Network** studies by running load flow studies on the **Common Grid Models** set up according to Article PC 2.3.11. Security standards are assessed with such studies and, if needed, reinforcements are considered.

PC 2.3.12.2 The applicable security standards are the same prescribed in the **Operation Code**. **AC** load flow simulations are recommended. Simplified models are allowed if consistent with the uncertainties of the **Long-Term Planning** processes.

PC 2.3.12.3 Short circuit studies should be carried out under the responsibility of the **TSOs** and include the needed provisions to improve the withstand capability in the reinforcements, according to the **National Grid Codes**, or applicable technical rules.

PC 2.3.12.4 In case the **WG4** considers the voltages and power flows adopted in the load flow studies less restrictive than the ones needed to comply with stability limits, **WG4** can decide to perform stability studies.

PC 2.3.12.5 Stability studies shall include, depending on the detected problems, transient and frequency stability, small signal stability and voltage collapse.

PC 2.3.12.6 **TSOs** coordinated by **WG4** shall deliver results by *week h*) (82nd week) (refer to Figure PC 1).

PC 2.3.12.7 Discussions, if any, shall be concluded by *week i*) (86th week) (refer to Figure PC 1).

PC 2.3.13 *STEP l). Cost Benefit Analysis*

PC 2.3.13.1 **TSOs** in the **Area Groups** shall implement the cost benefit analysis per **Project** and send results to **WG4** by *week l*) (94th week) (refer to Figure PC 1).

PC 2.3.14 *Step m). Approval and publication of a Master Plan*

PC 2.3.14.1 After approval of the **Master Plan** by the **TSOs**, **WG4** shall publish the **Master Plan** for public enquiry timely to publish it definitely in the **Regulation Report** by Pan-Arab ARC by *week m*) (100th week) (refer to Figure PC 1).

PC 2.4 Project Ranking Against Targets

PC 2.4.1.1 The **Master Plan** shall include quantitative elements for a transparent ranking process, if needed.

PC 2.4.1.2 **WG4** is entitled to draft merit order against given targets, at the end of the analysis and compile the list only if required.

PC 2.5 Disputes on the Results

PC 2.5.1.1 Disputes are regulated by Chapter 8 of the **General Agreement**. In the most complicated cases, the **Arab TSOs Committee** shall launch a committee with the specific task to support and advise **Pan-Arab ARC** and to instruct the debates.

PC 3 THE DATA INFRASTRUCTURE

J. The planning process of the interconnection is a continuous process based on a deep knowledge of the **Electricity Systems**. TSOs should contribute to create and sustain permanent infrastructures fit for the above-mentioned purposes.

PC 3.1 Central Database for Network and Market Studies

PC 3.1.1 The planning process – designed to guarantee the coordination among TSOs – requires efficient **Data Exchange** and a secure repository of data to be managed by the **Arab TSOs Committee**. To this purpose, TSOs shall cooperate to set up a relational **Central Database** to be gradually implemented no later than two (2) years from entering into force of this **Code**.

PC 3.1.2 The basic contents of the **Central Database** shall be organized in logical sections as follows:

- a) section dedicated to the market and **Adequacy**;
- b) section dedicated to **Network** analysis; and,
- c) section dedicated to statistics and reporting.

PC 3.1.3 Dedicated interfaces shall guarantee efficient exchanges of **Information** between the **Central Database** of the **Arab TSOs Committee** and the **Individual Database** of each TSO, primarily to avoid double work in uploading data in more than one **Individual Database**.

PC 3.1.4 The **WG3** shall coordinate the central activities in co-operation with **WG4**. **Arab TSOs Committee** will be responsible for the acquisition of the resources for design, deployment and maintenance of the **Central Database**.

PC 3.1.5 The location of the **Central Database** in physical servers or cloud solutions shall be agreed among the **Member States** according to costs and cyber security criteria.

PC 3.2 Interoperability of Evaluation Tools

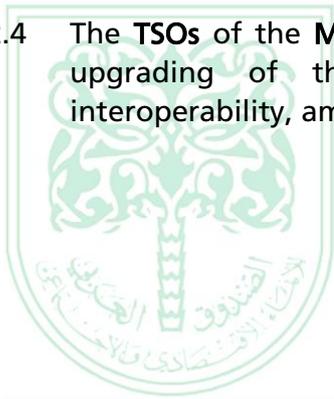
PC 3.2.1 **Evaluation Tools** are basically the package of models for market and **Adequacy** analysis and **Network** analysis. In principle, each TSO shall have the faculty to verify results of its interest.

PC 3.2.2 To the purposes of such evaluations, data uploaded or downloaded to the database must be easily converted in formats of software used by **TSOs**. The database shall guarantee the interoperability of such **Evaluation Tools** if the **TSOs** specify the needed interfaces.

PC 3.2.3 The **TSOs** shall actively contribute to the database implementation since the specification phase. They are required to provide the following:

- a) the declaration of the tools used in their respective companies;
- b) the declaration of any changes of packages used;
- c) the decision on common formats to be adopted;
- d) the availability to share costs;
- e) the availability to take part in the design;
- f) the availability to perform type and acceptance tests and database population.

PC 3.2.4 The **TSOs** of the **Member States** shall consider the continuous updating and upgrading of their **Network** analysis software packages, including interoperability, among their priorities.



PC 4 GUIDELINES & METHODOLOGY

J. The **Planning Methodology** is based on the evaluation of the costs and benefits of the interconnection **Projects** proposed by the **TSOs**. The benefits of the **Projects** are assessed simulating the market and the physical load flows. Such simulations are repeated in more than one **Scenario** to assess the improvements of the **KPIs** taken as a reference. Costs are evaluated at the end and they include the upfront investment and operation costs of the project.

PC 4.1.1 The development of the **International Interconnection** is primarily the expression of the willingness and the rights of the **Member States** to build and operate **Facilities**. This **Code** neither intends to limit such approach nor intend to propose to a **Member State** a **Project** that has not been generated by the involved **Member States** but pursues the objective to make available to the **Member States** guidelines, methodologies and cooperation models to the sole purpose of taking advantages from a synergic approach. The following is therefore not mandatory, but it has the value of guidelines to evaluate the advantages of the proposal **Projects** for the benefits of the **PAEM**.

PC 4.2 Synchronous Areas and Macro Regions Definition

PC 4.2.1 In the application of this **Code**, the **TSOs** shall consider the wide extension of the Pan Arab **Region** and the differences in development of the **TSOs** including the fact that not all of them are connected to any of the current **Synchronous Areas** and some of them have **Islands**.

PC 4.2.2 Even if the socio-economic growth can be more easily referred to a **Region**, the **Network** study approach in this **Code** shall refer mostly to the **Synchronous Areas** because the physical constraints must be correctly simulated.

PC 4.2.3 Nevertheless, the proposed **Planning Methodology** applies in general regardless to the physical distances and gives values to the differences (demographic, economic, time zone shifts, etc.) in the market simulations. Costs would automatically exclude much too long connections.

PC 4.2.4 **Synchronous Areas** are defined in Table PC 1.

Table PC 1. Synchronous Areas in the Pan-Arab Region.

Maghreb Synchronous Area (or Western Area);	Central Synchronous Area (or Central Area)	60 Hz Gulf Synchronous Area (or 60Hz Eastern Area)	50 Hz Gulf Synchronous Area (or 50Hz Eastern Area)	Islands (isolated systems or connected to other non-PAEM Electricity Systems)
Sub-Region Maghreb Interconnection (1)	Sub-Region EIJLLPST (1)	Sub-Region GCC (1)		- -
<ul style="list-style-type: none"> • Morocco • Algeria • Tunisia • Libya 	<ul style="list-style-type: none"> • Libya • Egypt • Jordan • Lebanon • Palestine • Syria • Iraq 	<ul style="list-style-type: none"> • KSA • GCCIA (2) 	<ul style="list-style-type: none"> • Kuwait • Bahrain • Qatar • U.A.E. • Oman • GCCIA (2) 	<ul style="list-style-type: none"> • Djibouti • Somalia • Comoros • Sudan • Mauritania

(1) As per 2.2.2 of GA

(2) As TSO of the backbone

(3) In brackets TSOs belonging to more than a Synchronous Area

PC 4.2.5 **Synchronous Areas** are revised as soon as **International Interconnection Projects** will connect the **Islands** to the **PAEM Electricity System**. Revisions could result in an enlargement of the **Synchronous Areas** when an **Island** is synchronously connected to a **Synchronous Area**, or a merger in case a new **International Interconnections** connects two of them.

PC 4.2.6 As far as market studies are concerned, the building blocks are the **Bidding Zones** which usually can be the same as the **TSO**. Each **Bidding Zone** is simulated with a node and connected with the others with a link whose capacity is the **NTC** existing or proposed in the projects.

PC 4.3 Objectives of a Long-Term Planning

PC 4.3.1 **TSOs** are committed to convene on a regular basis decided and agreed among the **TSOs** and issue long term **Master Plans** for the **PAEM Electricity System**. The main objective of **Transmission System** planning in the Pan Arab Region is to ensure, based on multilateral cooperation sponsored by **Member States**, the development of an adequate **Transmission System** to facilitate the development of the **PAEM** and:

- a) Provide a high level of **Security of Supply** in all the **Synchronous Areas** of the Pan Arab Region.
- b) Ensure the **SoO** of the whole Region.

- c) Contribute with the availability of electricity at reasonable costs to a sustainable development of the Pan Arab **Region**.
- d) Contribute to the economic efficiency of the entire **Region**.
- e) Promote and potentiate the integration of **RES** in the **Region**.
- f) Contribute to the internal market integration and the harmonization of the rules.
- g) Facilitate access to the **Transmission System** to all **Market Participants**.

PC 4.4 Assumptions

PC 4.4.1 To the purposes of PC 4.3, **WG4** shall verify the degree of relevance of the **TSO Projects** for the purpose of the objectives shared among **Member States** in the **General Agreement**, throughout a transparent assessment process based on the following assumptions:

- a) The data received by the **TSOs** are reliable and consistent with the ones adopted in their **National Development Plans**.
- b) The **Scenarios** are defined and shared among **TSOs**.
- c) The methodology and the algorithms for market and **Adequacy** studies and for **Network** studies are shared and agreed.

PC 4.4.2 **TSOs** shall be responsible for the input data and the assumptions made as a basis for further assessment.

PC 4.4.3 **Planning Methodology** and algorithms shall guarantee the traceability of the processes.

PC 4.5 Planning Data Requirements

PC 4.5.1 By eight (8) weeks – at most – after the definition of the **Scenarios**, each **TSO** shall provide the **WG4** with the following data about its **Electricity System**, in the format, definition and detail specified in the database or agreed within **WG4**:

- a) **Load** curves.
- b) Thermal **Generation** in terms of size, primary source, maintenance, base **Load**, must run, reliability, flexibility degree.
- c) **Generation** and CO₂ costs. The **Member States** should harmonize this information with fixed cost in relation to primary source and efficiency.
- d) Value of loss of **Load** associated to unsupplied electricity.

- e) Electricity production from hydro-based **Power-Generating Facilities** (run-of-river, natural inflow) and pump/storage capacity.
- f) Electricity production profiles or producibility from solar- and wind-based **VRE-units**.
- g) Electricity production profiles or producibility from all the other **VRE-units** and **Power-Generating Modules**.
- h) Power **Reserves** (shared or strategic **Reserve**).
- i) Number of nodes needed for the market modelling by each **Member State**.
- j) **NTC** and **TTC** at all its borders and intra **TSO**, between **Bidding Zones**.
- k) **Energy Transfer** towards neighboring **Electricity Systems** that do not belong to the Pan-Arab **Region**.
- l) Others (such as limitations in the use of water, exchanges planned and long terms **Bilateral** or **Multilateral Contracts** between **TSOs**).
- m) Load flows on reference **Networks** at the end of the planning horizon (i.e. **Individual Grid Models**).
- n) Single line diagrams of the **Grids**.
- o) Dynamic **Grid Model** for further simulations (when needed).

PC 4.6 Reference Scenarios

PC 4.6.1 **Scenarios** are possible situations that can happen in the future. **Scenarios** are quantitative descriptions of the future status or statuses of an **Electricity System**.

PC 4.6.2 **Scenarios** have a fixed number of parameters in common, but they differ from each other in the weighting factor that each of them assumes.

PC 4.6.3 Unless arranged otherwise by **WG4**, to represent the socioeconomic and the environmental policies of the Pan-Arab **Region**, **TSOs** shall weight and define no more than six (6) macro factors expressed by one or more significant parameters:

- a) Economy (**Gross Domestic Product (GDP)** growth, population growth, **Demand** forecast, primary resources price).
- b) Renewable energy penetration plans and boosting tendency.
- c) Technology development (storage, load management, smart grid).
- d) Expected new **Demand** (water desalination, electric cars, public transportation, energy efficiency).

- e) Market integration (internal market, **Regional** market, or global market);
- f) Thermal carbon free and neutral technologies.

PC 4.6.4 **WG4** and **TSOs** in **EG** shall agree on a set of **Scenarios** based on the parameters that were previously chosen.

PC 4.6.5 **WG4** and **TSOs** in **EG** shall define from (4) to six (6) **Scenarios** as a combination of the weights assigned to each of the selected parameters.

PC 4.6.6 Unless arranged otherwise by **WG4** and **TSOs**, or in case of lack of agreement, the following typical six (6) **Scenarios** could be considered by default:

- a) **S1. Security of Supply** improvement in a flat business trend.
- b) **S2.** Gas and local integration of renewable sources (main sources for the future).
- c) **S3.** Fast economic growth supporting the development of **International Interconnections** but low thermal plants development.
- d) **S4.** Sound environmental targets and market integration at Pan Arab level.
- e) **S5.** Environmental sustainability mutually approached. That is, the environmental challenges represent a common objective of more **Member States**.
- f) **S6.** Low economic development with **SoS** improvement.

PC 4.6.7 **WG4** may decide to modify the **Scenarios** on the basis of the preliminary results of the analysis.

PC 4.6.8 Unless arranged otherwise by **WG4**, the following indicators shall be calculated for each **Project** and for each **Scenario** by means of simulation of the coverage of the **Demand** performed according to the applicable market rules. Such indicators shall be included in the category of the benefits within the cost-benefit analysis of the new **Projects**, and defined as follows:

- a) *Improved Security of Supply (SoS)*, that is the ability of an **Electricity System** to provide an adequate and secure supply of electricity under ordinary conditions. To this purpose, the **Expected Energy Not Served (EENS)**, **Loss of Load Expectation (LOLE)**, and **Loss of Load Probability (LOLP)** are calculated.
- b) *Socio Economic Welfare (SEW) or market integration*, that is the ability of an **Electricity System** to reduce the power **Congestions**, and thus provide enough capacity of the **Transfer Capacity** for the electricity

markets and allow the development of a trading system in an economically efficient manner. The increase of **NTC** shall be calculated.

- c) *Integration of renewable energy*, that is the twofold ability of an **Electricity System** to accommodate new renewable energy-based **Power-Generating Facilities** and to minimize the curtailment of the renewable **Generation**.
- d) *Reduction in CO₂ emissions* that is the characterization of the reduction of CO₂ emissions in the **Electricity System**. Volume of reduced CO₂ shall be calculated.

PC 4.6.9 The evaluation of the impact of single **Projects** on the indicators can be performed by comparative analysis of the values with and without the **Project**:

- a) Method 1: to calculate the differences between the values assumed by simulating as if all the **Projects** have been implemented, and the same values assumed by excluding the **Project** to be assessed.
- b) Method 2: It is also possible to start from the situation where no **Project** has been implemented and calculate the differences in values assumed by the parameters adding the effects of the **Project** to be assessed.

PC 4.7 Adequacy and Market Studies Methodology

PC 4.7.1 Stochastic simulations of the coverage of 8760 values of hourly **Demand** in each **TSO's Control Area** are performed in the market studies.

PC 4.7.2 Simulations are driven by the applicable rules of the **PAEM**. They assess the **Adequacy** in the **Electricity System** of each **Member State**, with and without the **Project**.

PC 4.7.3 The results of the **Adequacy** simulations give quantitative **Information** about the **Adequacy** of the **Generation** in each **Member State** and its **Bidding Zone**.

PC 4.7.4 **Bidding Zones** are simulated as single nodes. The exchanges between bidding zones are characterized by the **TTC** between them.

PC 4.7.5 The benefits of each **Project** shall be evaluated in terms of the selected indicators.

PC 4.7.6 The market studies shall highlight the number of hours in which one or more borders are saturated by the resulting **Energy Transfer** and the cases where there is still room for beneficial development of **International Interconnections**. **WG4** shall make available such indications to the **TSOs** as a

signal to be taken into consideration for the **Master Plan** in progress and for the future. Indications can be used by **Pan-Arab ARC** to suggest and encourage investments in these borders.

PC 4.8 Network Study Standard Methodology

PC 4.8.1 **Network** studies shall verify the capability of the **Network** to sustain the load flows in the conditions simulated by the market studies and comply with the security standards for all the hours of the year.

PC 4.8.2 To simplify the process, it can be allowed to reduce the number of simulations, by relying on relevant **Snapshots**, performing calculations for the hours considered significant for the whole year, as prescribed hereto.

PC 4.8.3 *Snapshot Selection*

PC 4.8.4 A set of **Snapshots** in situations where the zone under study imports energy and a set where the same zone exports energy shall be selected. Each of such sets shall include one significant subset of peak hours and one of the off-peak hours.

PC 4.8.5 *Steady State Simulation Against Contingency Lists*

PC 4.8.6 Each **Snapshot** shall be merged with the reference **Network**, by assigning the in-feeds and out-feeds of the **Snapshots** to the nodes of the reference **Network**. Such generated **Networks** shall be processed until convergence in order to have as many consistent situations as the selected **Snapshots**.

PC 4.8.7 The security assessment is performed on each of the **Snapshots** according to the criteria adopted, assumed in the **Operation Code**, and to the requirements prescribed in the **Connection Code**.

PC 4.8.8 Simulations shall not include the already applied **Wide Area Protection Systems** if introduced by **TSOs** to overcome momentary insufficiency of the **Transmission System**.

PC 4.8.9 In case of violation of security limits, reinforcements can be suggested by **WG4**. **TSOs** take the responsibility to accept or refuse or proposing further solutions to be verified again.

- PC 4.8.10 After the **Network** studies, two further indexes shall be calculated:
- a) The variation of losses with and without the **Project** under assessment.
 - b) **Security of Operation** improvement with the **Project** under assessment.
- PC 4.8.11 Technical operation limits shall be the ones prescribed in the **Operation Codes** and the **Connection Codes**.
- PC 4.8.12 Security standards shall be the ones prescribed in the **Operation Codes** and the **Connection Codes**.
- PC 4.8.13 The criteria for identifying the contingencies and defining the **Contingency List** shall be the ones prescribed in the **Operation Codes** and the **Connection Codes**.

PC 4.9 Short Circuit Studies

- PC 4.9.1 Three phase faults and single phase to ground faults shall be calculated according to IEC 60 909 systematically in the simulations to verify the breaking and making capacities of the circuit breakers.
- PC 4.9.2 If the **Short-Circuit Current** exceeds 90% of the rated value of the breaking capacity of the circuit breakers, the replacement of circuit breakers shall be included in the reinforcements associated to the **Project** under assessment and this shall be added to the cost of the **Project** under assessment, for the purposes of the cost-benefit analysis. In the same case the replacement of the circuit breakers could not be the solution or the only solutions. E.g. splitting the substation in two substations or revising the earthing could be necessary to be considered.
- PC 4.9.3 Minimum **Short-Circuit Current** calculations shall be required at the terminals of the **HVDC Systems** to guarantee their correct functioning.
- PC 4.9.4 *Stability Studies (future)*
- PC 4.9.4.1 Stability studies should include: voltage collapse, frequency stability, transient stability and small disturbance angle stability.
- PC 4.9.4.2 In case of first **AC International Interconnection** between two **Synchronous Areas**, all these studies shall be performed by the proponent **TSOs**. In this case the stability studies go beyond the simple assessment of the **Project** because they could concern a general assessment of the compatibility of two

Synchronous Areas. **WG4** shall manage these cases with special commissions tasked to assess all aspects of such **International Interconnection** as per PC 4.10.

PC 4.9.4.3 In other cases, given the complexity of the studies, the amount of data and their quality, **WG4** may allow the performance of such studies or part of them with simplified models or postponement when the detailed design of the **International Interconnection** starts.

PC 4.10 Additional Studies

PC 4.10.1.1 In case a **Project** is the first **International Interconnection** between two **TSOs** belonging to different **Synchronous Areas**, or one of them is an **Island**, **WG4**, in cooperation with **WG2** and the involved **TSOs**, shall carry out and submit an overall feasibility study covering at least:

- a) **Short-Circuit Current** studies.
- b) Compatibility of practices adopted in operation.
- c) Compatibility of the **SCADA** systems.
- d) Time required to bridge the gaps, if any.

PC 4.10.1.2 In case the same first **International Interconnection** is in **HVAC** technology, the following is required:

- a) Stability studies with due attention to the **Power System Stabilizer** policy and settings.
- b) **Automatic Generation Control (AGC)** standard.

PC 4.10.1.3 If such studies show that modifications are necessary, ways and deadlines to carry out them must be scheduled before the time of implementation of the **Project** reported in the **Master Plan**.

PC 4.11 Cost Benefit Analysis

PC 4.11.1 Cost-benefit analysis shall be presented **Project** by **Project** in uniform editorial pattern, in order to facilitate its reading. For each **Project** the following sections are required:

- a) General settings: where at least the technical features of the **Project** are described, and the status of the **Project** is reported. It is required to specify if the **Project** is in one of the following stages: under

consideration; planned, but not yet in permitting; under construction; commissioned; cancelled.

- b) A section dedicated to the investment shall report:
 - i. The total costs of the **Project** and the ratio between the main work and the reinforcements.
 - ii. The associated OPEX.
 - iii. Costs for compensation works.
 - iv. A description of the investment costs per item. Items shall be described in number or engineering quantities at functional level (e.g. line, circuit breaker) and voltage level.
- c) A section dedicated to the benefits shall include the results of simulations per **Scenario**. For each **Scenario** at least:
 - i. The **TTCs** (in import and in export and for both interconnected **Electricity Systems**) with and without the **Project**.
 - ii. The ratio between the **TTC** and the sum of all the **Generation Capacity** installed to evaluate what could be a limit to the import / export of electricity.
 - iii. The **KPIs' Scenario** by **Scenario** mentioned in Article PC 4.7.5.
 - iv. Residual indicators like environmental impact, social Impact, and other impacts to be highlighted by the **WG4**.

PC 4.11.2 Standard unit costs shall be adopted in cost-benefit analysis. Unit costs shall be approved by **WG4** before starting the cost-benefit analysis process. **WG4** shall also approve the differences country by country where applicable (e.g. due to labor cost, special laws, compensations).

PC 4.12 Cross-border cost allocation

PC 4.12.1 Cross border cost allocation is subject to **Bilateral Contracts**. Fairness on the evaluations is recommended.

PC 4.13 Minimum Requirements of Individual Databases and Evaluation Tool

PC 4.13.1 **Individual Databases** should contain at least the same **Information** and set of data of the corresponding sections of the **Central Database**.

PC 4.13.2 Market simulations, based on probabilistic algorithms, should be run with software compatible with the one used at central level or the same, to facilitate the comparison of results.

PC 4.13.3 **Network** studies can be performed using tools whose only constraint is the easy interface with the software adopted at central level.

PC 4.13.4 To bridge the gap on modelling of **HVDC System** inverter-based **Power-Generating Facilities**, sharing the models, should be mandatory for the benefit of the quality of the simulations.

PC 4.14 Role of Regional TSOs/Market Facilitators

PC 4.14.1 As per 3.6.2.1.12 and 3.6.2.2 of **General Agreement**, a **Regional TSO / Market Facilitator**, without prejudice of the participation of TSOs, may:

- a) Represent in **WG4** the **Region** against the rest of the Pan Arab **Region**.
- b) Develop the **Region Electricity System** according to the **Planning Code** adopted in the **Region**.
- c) Contribute to the **Master Plan** with the conclusions on expansion **Projects** of the **Member States** of the **Region**. **Projects** shall be described with the same **Information** adopted for the entire Pan Arab **Region**.

PC 4.14.2 This implies that if the **Region** is isolated, and no **International Interconnections** with **Electricity Systems** outside the **Sub-Region** are proposed, the **Regional TSOs / Market Facilitator** is not obliged to take part in the simulations.

PC 4.14.3 In case of **Projects** of **International Interconnections** between a **TSO** of the **Sub-Region** and an external one, the **Project** will be developed according to the applicable bilateral agreement but evaluated with the criteria stated in this **Code**.

PC 4.15 Temporary Reductions of the Scope of Master Plan

PC 4.15.1 It is faculty of the **TSOs** to decide to limit the objectives of Section PC 4.3 in the first issue of the **Master Plan** strictly to the **GA** prescription. This requires:

- a) The presentation of **Projects** significant for the preset objectives.
- b) The selection of a reduced number of KPIs in the market and Adequacy studies.
- c) In alternative to b) simplified Network studies could be run, but in this case the comparison of **Projects** would risk being of scarce significance.

PC 4.15.2 This issue of the **Master Plan** could be identified as pre-**Master Plan**.



PC 5 GENERATION ADEQUACY FORECAST

J. This activity helps to share the structural problems of each **Member State**. It is also an important input to the planning process. **TSOs** shall contribute being aware of its importance and to fulfil the obligations of the **General Agreement**.

PC 5.1 Long-term Adequacy forecast

PC 5.1.1 Evaluations are required at single **TSO** level within the energy policy that each **Member State** shall perform by law. In the individual evaluations, the exchange with other **Member States** is simulated.

PC 5.1.2 Based on individual **Adequacy** forecast, the **KPIs** are derived by the market and **Adequacy** centralized studies, as described in Section PC 4.7.

PC 5.1.3 Seasonal **Adequacy** forecast is matter of the **Operation Code**.



PC 6 FORMAL OBLIGATIONS

- PC 6.1.1 The protection of sensitive **Information** is further stressed by the fact that both independent **TSOs** and **TSOs** belonging to vertically integrated utilities take part in the market studies.
- PC 6.1.2 Market studies require processing sensitive **Information**. This circumstance compels the use of conventional standard costs in the cost-benefit analysis.
- PC 6.1.3 **TSOs** are recommended to use as much as possible aggregated and anonymous **Information** to avoid the identification of the unit.
- PC 6.1.4 No **Party** may disclose data and **Information**.



PC 7 CENTRALIZATION OF PROCESS OR COLLECTION OF INITIATIVES

PC 7.1.1 The planning process, as prescribed in this **Code**, requires part of the activity to be performed by the **TSOs** in autonomy and part which needs to be performed in a centralized way.

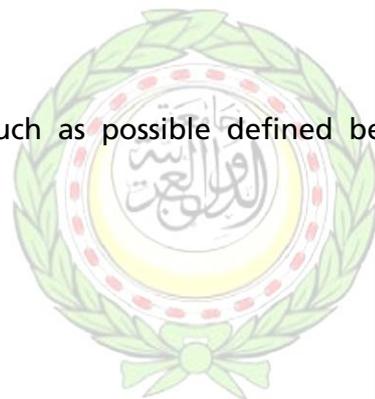
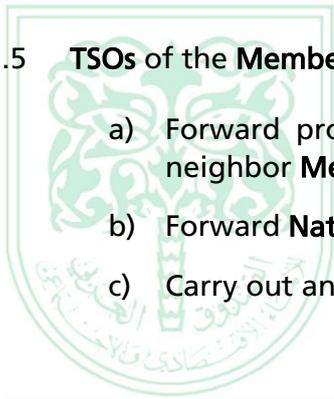
PC 7.1.2 The centralization is required by the assessment of the benefits of an **International Interconnection Project**, by the market simulations, the arrangement of **Common Grid Models**, the drafting, the presentation, and the publication of results.

PC 7.1.3 An efficient **Central Database** contributes to the efficiency of periodical centralized **Long-Term Planning** activities.

PC 7.1.4 Setting up a coordination body, in this **Code** indicated as **WG4**, is needed also to develop a transparency mindset.

PC 7.1.5 **TSOs** of the **Member States** shall:

- a) Forward proposals of **Projects** as much as possible defined between neighbor **Member States**.
- b) Forward **National Development Plans**.
- c) Carry out analysis of security.



PC 8 TRAINING

J. Training aims to acquire confidence, common understanding of the issues and autonomy in performing the **Master Plan**.

PC 8.1.1 **Pan-Arab ARC** shall be available to organize seminars on planning.

PC 8.1.2 First topic to be released concerns the results of the planning activity and the **Master Plan**.

PC 8.1.3 **TSO** personnel and members of the **WG4** shall receive training on:

- a) Basics on market principles.
- b) Probabilistic approach (theory and practice).
- c) Use of most common simulation tools for market and **Network** studies.

PC 8.1.4 **TSOs** shall receive training on the management of the database and data needed for planning.



PC 9 ANNEX A: DEFAULT SCENARIO SELECTION

This Annex describes an example of possible **Scenarios**. The example can be proposed as a basis for discussion and to trigger the planning process at the first time. Two macro areas are taken as part of generic **Region**. They are called Northern and Southern Area. Northern Area is characterized by mature level of development with signals of stagnation while the southern one is characterized by a fast growth in economy and population.

PC 9.1 Scenarios

PC 9.1.1 *S1. Security of Supply Improvement in a Flat Business Trend*

This is a conservative **Scenario**.

The **Load** consumption increases with the same trend in each **Member State**.

The economic development in most **Member States** is between 4 and 6% on average.

Energy policy is marked by the continuation of the current trend in each country. The policy of supporting renewable energies is pursued but their growth remains well below the level seen in other Northern countries.

The scope of **International Interconnection Projects** and internal **Grid Projects** are based on the improvement of the **SoS**.

PC 9.1.2 *S2. Gas and local integration of RESs (main sources for the future)*

This **Scenario** is a more environmentally sustainable **Scenario**, based on a bottom-up approach.

Each **Member State** decides a common policy to integrate **RESs** and maximize the effort to reduce climate changes.

The CO₂ price is high in Northern countries. The policy of the Southern countries is based on an attentive use of primary resources and the development of renewable energy funds with primary resources incomes.

Gas power plants are built in the South of the **Region** for the guaranty of supply and to minimize CO₂ emissions. These gas power plants also will have to be flexible to deal with a new energy mix based on renewable energy.

The **Load** consumption increases higher than the same S1 trend in each **Member State** because of the development of new electricity uses like public transportation in the Northern Countries and for the demographic increase.

The hypothesis on the economic environment is one of the partial cash-up phases of global **Demand** in the Northern **TSOs**. The development in the southern Area is between 4 and 6%.

Interconnection development in the South is based on the improvement of the **SoS** and exportation of **RES**.

PC 9.1.3 *S3. Fast economic Growth Supporting the Development of the International Interconnections but Low Thermal Plants Development*

This **Scenario** assumes that following the availability of new primary resources, the economy of the **Region** increases especially in the southern **Member States**. A 7% **GDP** growth could be expected in the southernmost **Member States** and 2% for the Northernmost **Member States**.

Southern **Member States** decide to develop free carbon thermal power plant to support the electricity **Demand** without consuming their primary resources.

New **International Interconnections** are built to share the low-cost electricity of this kind of power plants and to share production margins.

PC 9.1.4 *S4. Sound Environmental Targets and Market Integration at Regional level*

This **Scenario** is based on an approach with two issues:

- a) The CO₂ reduction for electricity production and for transportation (new electricity uses).
- b) High technology development for **Load** and **Generation** management especially in the Northernmost **Member States**.
- c) The investment in renewable energy and carbon-free thermal generation in the South to support electricity **Demand**, to limit the consumption of primary resources and to export the surplus of electricity.

This **Scenario** is based on many **International Interconnections** to support a global electricity market all around the **Region**.

PC 9.1.5 *S5. Environmental Sustainability Mutually Approached.*

This **Scenario** is an in-between **Scenario** regarding S3 and S4, where the **Member States** shall increase their cooperation to optimize their **Electricity System** and setting national environmentally sustainable energy policies.

PC 9.1.6 S6. Low progress with Security of Supply improvement

This Scenario is the worst-case Scenario for the Region. Due to a low economic development of the economy, each Member State limits the implementation of International Interconnections. Grid reinforcements are focused on the SoS.

PC 9.2 Weight of parameters vs. Scenarios

The simulations shall be performed using the following weights for each Scenario (in scale from 0 to 3).

Parameters	Scenarios					
	WEIGHTS					
	S1	S2	S3	S4	S5	S6
Economy (GDP growth, population growth, Demand Forecast, primary resources price);	2	2	3	2,5	2	1
Renewable energy penetration;	2	2	2	3	2	1
Technology development (storage, load management, smart grid);	2	3	2,5	3	2	1
New Load (water desalination, electric cars, public transportation, energy efficiency);	1	3	2	3	2	1
Market integration (internal market, Regional market, or global market);	1	1	3	3	2	1
Thermal carbon free technologies (i.e. nuclear development in the South of the Region area).	1	1	3	3	1	1