

**REVIEW OF STRUCTURES
FOR THE
SYSTEM DEVELOPMENT ACTIVITY**

**Working Group
C1.8**

April 2009



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Review of Structures for the System Development Activity

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ISBN: 978-2-85873-061-2

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Executive Summary

The main objective of the WG was to focus on the role and responsibility of the electricity industry actors with reference to **the system development** aspects taking into account the profound changes which have occurred during the last decade, as a consequence of the deregulation process in many regions of the world, this without giving any judgement on the industry structure chosen. In accordance with the TOR, the study aims to:

- 1 – Identify the responsible actors and the extent of their influence on the electric industry in relation to system development.
- 2 – Identify the effective physical boundaries between Generation, Transmission and Distribution and the impact that different choices of precise delimitation may have on system development.
- 3 – Identify the system development functions which are common (partially or fully) to the System Operator functions and to the Transmission Operator functions.
- 4 – Determine which actor has the full responsibility for each of these (defined) functions and how the involved parties work together on the development plans.
- 5 – Discuss the strengths and the weaknesses of the various structures according to possible scenarios of the economic and technical evolution of the electric industry.

Based on electric system characterizations, a survey was performed to assess points 1 to 4 of the TOR, focusing on functions related to system planning & development with regard to generation and transmission. It took into consideration the main aspects of system development including planning, technology, licensing, permits and, to some extent, operation and marketing related functions.

Among the CIGRÉ SC C1 members, 15 provided comprehensive answers to the survey questionnaire. It should be reminded that many of the participating members were still in the process of reforms or recently underwent reforms that involved changes of actors' activities. The 15 structures were analyzed as a whole or according to typical classifications differentiated by the extent of the system operator responsibilities:

- Vertical Industry Structure (**VIS** – most of the functions assigned to one Utility),
- Transmission System Operator structure (**TSO** – most of the system functions, transmission ownership and services functions are assigned to the "TSO". It excluded some functions related to Generation or Distribution sectors),
- Independent System Operator structure (**ISO** - like a TSO but without transmission ownership and, in some cases, without services functions responsibility).

1. Electrical system characterizations

A key issue of the analysis is the functional characterization in relation to the following questions:

- Q1: What should or may be called a "system" development function?
- Q2: In which way are these functions activated in different structures of the Electric Industry (EI)?

Historically, the "system" was mainly identified with the physical transmission network. Early EI reforms have conceptually defined sectors with respect to energy flow stages (generation, transmission, distribution and supply). A consequent issue is to delineate the physical boundaries of the system. For instance, should the power plant connection belong to the transmission sector or rather to the generation one? The connection has transmission system characteristics such as its possible impact on system dynamic stability or its potential for long term extension of the network. Alternatively, the connection may be considered dedicated to the power plant and be included in the generation sector. A second classification criterion sets up the "system" versus "asset facilities". Some aspects of this characterization were comprehensively addressed in Asset Management related works. Development activity such as planning is clearly a "system" function as the facility is treated as an element of the electric system. The equipment installation process is definitely an "asset facility" function as it does not impact the system.

System functions are generally connected with the national economy, associated with the public interest and regulation. "Assets functions" are usually associated with facility servicing, owner costs/benefits and may be also related to deregulation and competition.

The main challenge is to correctly map development functions which are connected to a specific asset but still impact the system. For instance, statutory and licensing activities are performed on a specific facility but they are also system related in many aspects: the project uncertainties associated with them require planning provisions and their environmental aspects are of public interest.

In order to track a function in different structures one has to be aware that similar activities may have different designations or even goals according to the economic structure. System planning activities which have led to a generation development plan in a Vertical Industry Structure (VIS) may be useful or even indispensable in other structures in order to ensure investment coherency together with future adequacy and security of the system. These activities may become even more critical in a deregulated industry as it is necessary to also verify congestion issues, market fairness, provide potential investors with production outlooks and, perhaps, evaluate generation tender proposals. Some of these activities are more complex since those responsible for network development cannot disregard the market mechanisms and their constraints (e.g., long-term contracts vs short-term biddings, balancing and settlement of the market), in addition to operating procedures, asset life time management and the uncertainty related to project deadlines. Even in a market oriented structure, system planning functions are still crucial for the continuity of market infrastructure and system operation in the long range.

2. Physical boundaries of the system

A further objective of the WG is aimed at assessing the **physical boundaries of the system** with respect to the different sectors of the EI (Generation, Transmission and Distribution). The connection has transmission system characteristics such as its possible impact on system dynamic stability or its potential for long term extension of

the network. Alternatively, the connection may be considered dedicated to the power plant and be included in the generation sector.

The outcome of our investigation shows that:

- As expected, almost all functions related to the production (generators and power station transformers) are performed by the **Generation** sector.
- In an ISO structure, the functions related to the connection between production and transmission, are performed by the **Generation** sector or by the **Transmission** sector or by both.
- In a TSO structure, all functions related to the transmission (lines and high voltage substations) are performed by the **Transmission** sector.
- In all the analyzed structures, the **Transmission** sector and the **Distribution** sector share the functions related to distribution (transmission-distribution substation transformers). **Distribution** is the main sector involved in medium voltage switchgear and substation physical barriers.

Actual variations between countries may be the result of the different system topologies. In countries where the gap between High Voltage and Medium Voltage is wide (single HV level to MV level) there are incentives for including transmission-distribution substations in the system; in countries where this gap is narrowed (more than one transmission HV level, the latest being close to MV level) the tendency may be to share the substation between Transmission and Distribution sectors. Possible physical boundaries may be also due to lack of experience on what might be "the best practice" pattern of boundaries (since unbundling reform is relatively new in most reporting countries).

3. Electric Industry Actors Characterization

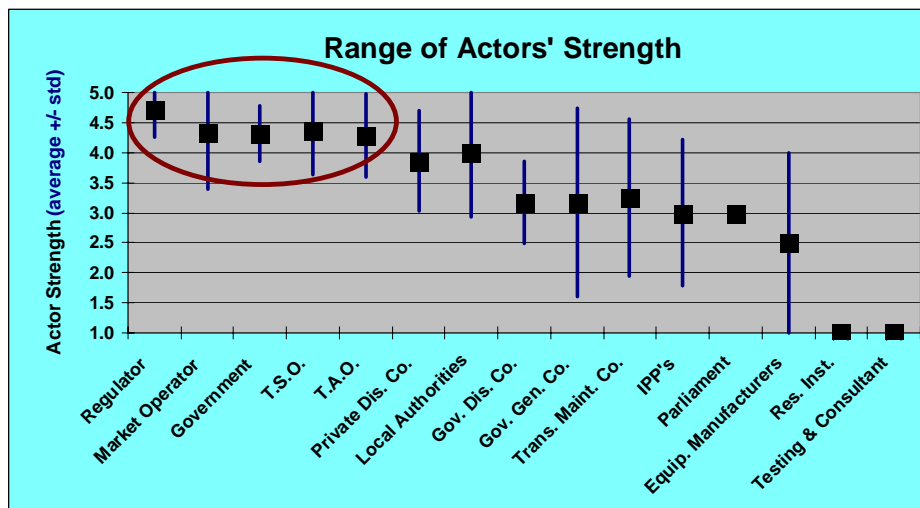


Figure E.1 Electric Industry Actors list and their respective "strength" in filling their activities (relative scale 0 (none) to five (high)) – survey results.

(TSO: Transmission System Operator; TAO: Transmission Asset Owner; Dis: Distribution; Co: Company; Gov: Governmental; Gen: Generation; Trans Maint: Transmission Maintenance; IPP's: Independent Private Producers; Res. Inst: Research Institutions)

Actors were characterized in the survey by their "strength" to fill the functions they are in charge of (Figure E.1). This characterization reflects the perceived level of authority of each actor with respect to his activities. The consequent impact power of the actor also depends on the relative importance of these activities in the specific industry structure.

4. Basic Electricity Industry Structures: mapping responsibilities

Numerous actors (figure E.1) are involved in the system and it is therefore of primary importance **to map the responsibilities of the companies to the various functions** in order to establish a basic industry structure.

Historically, the ISO was developed in countries where the transmission system was owned by many companies, with few exceptions, whilst the TSO was mainly implemented in countries where there was only one transmission company owner and it was relatively easy to unbundle Generation from Transmission. Of the participating members, 7 had an ISO structure at the time of answering the questionnaire, 4 were TSOs and 4 were Vertically Integrated Structures. Two of the ISO countries were in the process of transition to TSO structure. The results from the questionnaire showed:

- The ISO structure shows a rather sharp division between functions performed by transmission system operator versus those of transmission asset owners. While the primary functions of the operator are system operation and certain market-related functions, those of the asset owner are more directed to all stages of transmission planning, expansion and maintenance. Generation development functions are primarily fulfilled by IPPs and governments.
- The TSO structure shows high concentration of functions done by the single entity of TSO: transmission planning, statutory planning and licensing, equipment specification, system operation and network maintenance. Substation maintenance is also performed by distribution companies or private maintenance companies. Market functions are more spread out between the regulator and dedicated market operators.
- The Vertically Integrated industries show, as expected, high concentration of functions performed by the single utility, with certain tasks like market regulation, system licensing and determination of tariffs fulfilled by the regulator.
- As for the transmission planning functions, the dominant actors are the Transmission System Operator or the Independent System Operator: TSOs and ISOs are also in charge of System related functions. Involvement of Regulator and Government is also observed; indeed, in some cases, the Ministry of Energy or the Regulator are in charge of approving the development plans proposed by TSOs or ISOs.
- A significant dispersion of the responsibilities was observed for three categories of functions: Generation Development, Market and Transformation Asset Service Provider (Transformation substation design construction and maintenance) related functions.

5 Conclusions

This work is aligned with the efforts made by the professional community to better understand the System Development related functions and their interactions. It has presented a comprehensive mapping of the functions and, through the survey, assesses physical boundaries and actors appointment in various structures of the Electricity Industry.

5.1 Design and Planning

Even in Structures where the Development of the System is expected to be "automatically" fulfilled by the market, functions related to Design and Planning of the System remain strongly required to ensure solutions are technically feasible.

For example, the government and/or the regulator may forecast a healthy reference state¹ enabling the continuous comparison between the System as generated by the market and the reference state.

5.2 Development Implementation Functions

Development Implementation Functions for the Transmission System (includes all the functions needed to get mandatory permits and licenses) are mainly connected with System Functions so the uncertainty associated with sustainability and feasibility has been eliminated and the installation of the Asset may be managed without affecting System Development.

It should be noted that these functions are time consuming in most countries and deal with significant risks induced by the large financial investments often required for generation facilities. Therefore, for the generation sector, this family of functions might be more characteristic of "System" features than of "Asset" features if risk management is a main issue.

This remark is similar to the concept considered in some countries where peaking units may belong to the System Operator in order to prevent excessive price volatility and as part of a "self regulation control" of the electricity energy market. In the long term, this backup is meant to assure the System Development in case of unexpected (but possible) market failures.

5.3 Bundling

A review of survey responses indicates that the most common arrangement is for the system actors to be assigned responsibility for all the functions related to the planning, development and operation of the generation and transmission system, functions connected to the ownership of the transmission facilities, and the control of maintenance management resources of all the facilities within the physical boundaries of the System.

In appendix A, a methodology developed by the WG secretary is described by way of a case study. The methodology has not been tested by the CIGRE working group. It aims to analyze multiple criteria related to reorganization of the electricity industry with a view to identifying structures that will achieve pre-defined System Development goals according to each country's priorities.

¹ A reference planned system is one that meets "security of supply" criteria as well as other criteria such as environmental ones

1/ Introduction

The main objective of the WG was to continue and extend the work done by [2] WG37.32 'Review of the Industry Structure and Reform Status' published in 2002, and to focus on the system development aspects. A review was also conducted to determine which structures and processes were adopted in various countries in relation to the following parameters:

- Adequacy and security of the electric system
- Generation and transmission development plans
- Non-discriminatory access to the transmission network and management of the system
- Transparency to all the actors of the electric industry.

Although it is not the task of CIGRE to judge the industry structure chosen in different countries, interesting observations can be made on how the divisions of responsibilities regarding system development have developed over time in different parts of the world.

The analysis procedure was:

- 1 – Identify the responsible actors and the extent of their influence on the electric industry in relation to the system development.
- 2 – Identify the effective physical boundaries between Generation, Transmission and Distribution and the impact different choices for the precise delimitation may have on system development.
- 3 – Identify the system development functions which are common (partially or fully) to the System Operator functions and to the Transmission Operator functions.
- 4 – Determine which actor has the full responsibility for each of these (defined) functions and how all the involved parties are working together on the development plans.
- 5 – Discuss the strengths and the weaknesses of the various structures according to possible scenarios of the economic and technical evolution of the electric industry.

Despite the fact that the main objectives of the electrical system are similar in all countries (service reliability, affordability, accessibility and regard for environmental impact/sustainability), they have been implemented in rather different contexts since not only the structure of a specific economy varies but also there are different technical characteristics, environmental sensitivities, historical and cultural backgrounds and other local features.

The electrical system involves numerous and different technologies and has an impact on almost all the aspects of economic activities. Therefore, it is obvious that the way each part of it is conceived, managed and performs, will result in many possible effective industry structural configurations. Subject to constraints imposed at other levels, e.g. the European Union, each country prioritizes the above mentioned objectives according to its own history and culture, and furthermore, such priorities may change over time. This report aims to make observations from the system development perspective on consequences of this prioritization.

One can look at an electric industry structure as an ensemble of interactions of components and functions which are implemented and managed by active actors with certain impacts. The rules of the interactions between the actors seem to be country specific; however, the rules of physics and economics are still universal (and CO₂ output reduction is adding another global objective).

Chapter 2 of this report deals with the systematic identification and definition of the main characteristics of an electrical system used in this report: actors, functions, physical boundaries at various stages of the system life and development cycles. This was the basis of the questionnaire sent to the SC members. Chapter 3 presents the questionnaire responses of the different countries, and their analysis. Based on a brief discussion of the results, the last part of the work will present a reflection on impacts of typical electric system structures on possible goals of the system development. An innovative methodology to process and to analyze different industry structures is also reported in the appendix.

2/ Electrical system characterizations

This chapter deals with the systematic identification and definition of the main characteristics of an electrical system used in this report: actors, functions, physical boundaries at various stages of the system life and development cycles. This is the basis of the questionnaire whose results are presented and discussed in Chapter 3.

Electrical System Development is stated as adding, modifying or removing the assets and the links between them.

2.1 Actors

There are many **responsible actors** affected by system development. These actors have some responsibility for the implementation of the functions related to the electrical system. These actors are distinct from other stakeholders who have no direct responsibilities, even if the latter may have, sometimes, a strong influence on the system. For instance, environmental organizations or consumers are not considered as responsible actors here because their influence is indirect.

In addition to the functions for which the actor is in responsible, two fundamental aspects were found to be relevant in regard to the actor's impacts on the electricity industry structure.

The first one is the relative strength of the actor in filling the responsibilities he is appointed to. It is defined by the relative influence the actor has on the decision and implementation of the functions he is responsible for in the electricity industry.

The second one is the motivation (interest) of the actors in reaching the objectives of the industry. For instance, the generation system planning done by an actor that has no motivation for the security of supply will be quite different than if it was planned by an actor dedicated to the security of supply.

In the following table a list of the main actors is presented. This list was part of the questionnaire, and few additional actors are mentioned, such as parliament², manufacturers and research institutes. These additional actors have, generally, marginal influence.

Table 2.1 List of the main active actors in the electricity industry

| N° | Name | Explanation |
|----|--------------------------------------|---|
| 1 | Government | Directly involved in the electricity industry by owning the assets or approving at least important parts of system or asset planning – governments can be multi-national (e.g., EU), national or state/regional; local governments, see below |
| 2 | Regulator | Regulation of network fees, electricity prices or certain aspects of the electricity market. May be nominated by the government, often having nevertheless significant independence. There can be national and state/regional regulators |
| 3 | Government Production Company (GPC) | Part or all of the production assets can be owned or/and operated by a government company |
| 4 | Independent Private Producers (IPPs) | The same as actor 3 but owned or/and operated by private company; in unbundled systems, all generation companies are independent of the TSO, so that the term IPP is replaced by generation company |
| 5 | Transmission System Operator (TSO) | May be independent or part of another company. |
| 6 | Transmission Owner Company | Government or private company/ies. |
| 7 | Transmission Service Company | In some countries, there is a third type of company/ies in charge of maintenance |
| 8 | Distribution Companies | Private or governmental. Part of or independent from the transmission company/ies. |
| 9 | Local Authorities | In some countries they may have legal, statutory and environmental impact on system development. |

² Governments have executive powers which may more directly influence system planning and operations than Parliaments' legislative powers. Parliament was mentioned only once in the 15 answers and, in that case, was declared as "medium strength".

2.2 Life Cycle

The life cycle of the development of a power system is similar in each country; however, each stage of it may be of more or less importance to it. It may be said that the life cycle is a characteristic of assets only. The system assets include; power stations, lines, bus bars, switchgear, measuring equipment, transformers, communication, control and protection equipment, quality and stability related equipment at different levels of voltage, including lower voltage levels.

The development time scales from an asset or project viewpoint can be distinguished as follows:

(40-8 yrs before operation "b.o." horizon): Sustainability (strategic) indications study period - master planning asset need, localization, environmental and financial studies, asset technology options.

In these timescales, transmission system studies and strategic market analyses dominate and lead to the identification of promising individual projects to be implemented. System adequacy, security, quality and minimum cost as well as non-discriminatory system access and generation profitability are the important criteria. Environmental considerations form a mandatory framework for the options considered.

(10-2 yrs b.o. horizon): Feasibility study period - system needs and technical characterization of the asset (system planning step), statutory and environmental design licensing, technical specifications of the assets, construction permits.

In these timescales, the dominating question is how the individual asset or project fits into the system and into the market. System adequacy, security, quality and minimum cost as well as non-discriminatory system access and generation profitability remain leading criteria. Environmental studies become crucial. How the asset fits into system operation (steady state and transient) and market balancing is being studied, if that was not already done as part of the strategic studies.

(4-0 yrs b.o. horizon): Detailed design, procurement and acquisition, construction, commissioning, operation licensing, ownership.

In these timescales, the focus is on the individual asset or project.

(0-10/50 yrs after operation horizon): Operation, maintenance, upgrading, decommissioning (for economical, technical or regulation reasons).

In these timescales, the focus is both on the individual asset or project, and on how it fits into and interacts with the system, and especially with system operation and market balancing.

One should remember that significant modifications of the time scales may originate from technology upgrades induced by changes in the size of the system (e.g. voltage level, short circuit current) or by new technologies (e.g. cables vs. overhead lines, dispersed generation, etc.).

System developers should remember that there are many, parallel and different, interacting time scales in the development process. This factor has a direct influence on the economic optimization of the Electric Industry. By using only instantaneous equilibrium and marginal cost, only one or two of these time scales are actually well controlled. Neglecting these different timescales may be one of the major reasons of some of the evolution of electricity industry reform. On that point Crew et al [1] mentioned that

"Decisions on transmission infrastructure (and other assets in the electric power system) belong to the long-run time scale. The difference between the long-run perspective of potential investors and the short-run dictates of controlling the physical system has given rise to a

fundamental tension in regulation of the electric power system. On the one hand, there is a need to set up strong, centralized organizations, to ensure that operational authority and responsibility for short-term reliability is in the hands of competent technical professionals. On the other hand, the requirement that investors see opportunities to recover invested capital, plus a competitive return, requires attention to the level and certainty of cash flows that will accrue to specific assets should these be put in place. The key problem is that most of the debate on restructuring and market design has been focused on solving the real-time problems of transmission and system operation, but reliability is a function not just of these decisions, but also of medium-run and long run choices, including investment."

2.3 System Physical Boundaries

An asset may be defined as: a mandatory system component, an optional system component or an independent item connected to the system. The system physical boundaries are therefore varying according to the "mandatory" aspects and with the decision whether to include optional system components into the system. These boundaries may vary according to the stage of the life cycle when the asset is introduced. The physical boundaries of an electric system should be also examined in relation to two aspects: interconnection and unbundling of generation, transmission and distribution.

The main issues are;

- What assets should be included within the scope for system development?
- At which stage of its life cycle is an asset viewed as independent of the system and managed as such?
- Or should it be considered as a system component?

2.3.1 Interconnection

This issue was mentioned in the previous sections as a fundamental one in the definition of an electrical industry structure and "system development". There are still debates regarding interconnection in most common electricity markets. The rules and economic principles governing the development of interconnections, congestion management and access rights for generators can be the subject of intense policy debate for years. Henceforth, two possible approaches focused on system development issues are presented.

2.3.1.1 One possibility is to consider the "interconnection" element as a redundancy being a supplementary input/output to the system but not part of it (from the aspect of the development). Each country is developing its electrical system in an independent way, and therefore its physical boundaries are at the breaker of the interconnection line. For this development strategy, it is a must to verify (by simulation, for instance) the compatibility between the approach to the system development and the concept behind the rules that are regulating the opening of the interconnection, in various aspects such as:

- Electrical: how the flow of energy (direction and quantity) is controlled, what are the impacts on system security and supply quality, and what elements should be added to maintain the intended quality standards.
- Economic: how the economic profit of the different system actors will be affected by the interconnection operation rules.
- Market: The various possibilities of long and short term transactions through the interconnection.

2.3.1.2 Another possibility is to develop the "local" system as part of the whole interconnected system integrally. This approach could be adopted independently by each country/region/company that is interconnected. In such a case, system development will be planned and executed at a local level but with considerations to the interconnection.

Alternatively, this approach could be a common decision of all the interconnected partners. In this case the boundaries of the system will include all the "local" systems. The system development activities will be managed by the partners in a coordinated manner.

This issue is not the focus of this report and was not addressed in this Working Group's questionnaire. However, it can be observed that market dynamics, the development of renewable resources in locations with good availability of primary energy sources (e.g., wind) and further away from load centers, and also system reliability considerations all push national systems in the direction of increased cooperation with neighboring systems.

2.3.2 Unbundling

In a **completely generation market oriented system**, power generators are basically independent items during their whole life cycle, viewed from the transmission system perspective. This is essential for the system development activities (planning and implementation). The generation output feeders are then elements of the system as well as the corresponding bay in the switching station. Of course, all the analyses mentioned above for long- and short-term planning as well as operations must include the network elements as well as the loads/distribution systems as well as the power stations. However, the assets under the planning and operational control of the system development decision makers are limited to network assets in this scenario.

In a **vertically integrated utility**, the system boundaries will include the power stations, and they will be part of the planning and implementation up to the stage where all the mandatory authorizations of construction are obtained. A power station will be considered as an outsider (beyond the system) only during the stages of detailed design, construction and commissioning.

2.4 Functions

In this work, we extend the review, following the same approach, presented in Chapter 4 of the W37.32 report [2], emphasizing the functions of transmission and system operation.

Some important functions, dealing mainly with the national development planning of the system (production and transmission) were presented in the mentioned report but at a rather low resolution, which may suit countries with a low demand for an increase in power generation, but which is not sufficiently insightful for countries in which this issue is a major one. We therefore increased the level of the resolution for almost all the groups of functions and, as a major issue, added another group of functions, namely the "System Asset Planning Functions" which deals with early stages of assets planning (including the feasibility stage, see [3]).

The output of these functions is the formulation of well-defined projects (generation, transmission or substations) which are economically and technically proven, and for which all the necessary permits prior to construction are yet to be obtained. These asset projects are still in a conceptual stage, but they are strongly connected to the system planning process, and they may be in competition with other alternative projects. After this stage, these projects have their own life cycle, less influenced by system considerations, and with lower uncertainties. Therefore, they are less likely to be cancelled.

The list of the functions in the questionnaire was quite exhaustive and has been extended beyond system development related functions. There are two main reasons which justify this extension.

2.4.1 System or Asset functions

The first reason is related to the boundary between system functions and other functions which is not always clearly defined. For instance, when dealing with a project at the permitting stages, the way of managing it is similar to asset project management and one may decide that such a function is an asset related function. However, the project physical realization is still not assured: it may be banned by environmental reasons or by right of way problems, it may be put on hold as the actual increase in electricity demand is less than expected or as cost/benefit estimates change for market or other reasons, or it may be transferred to another geographical location with a different technology as, meanwhile, some other technical design has been evaluated as being more economic. So it also has to be managed within a system development management context and may be classified as a system related function, as illustrated in Figure 2.1. Both classifications are therefore legitimate

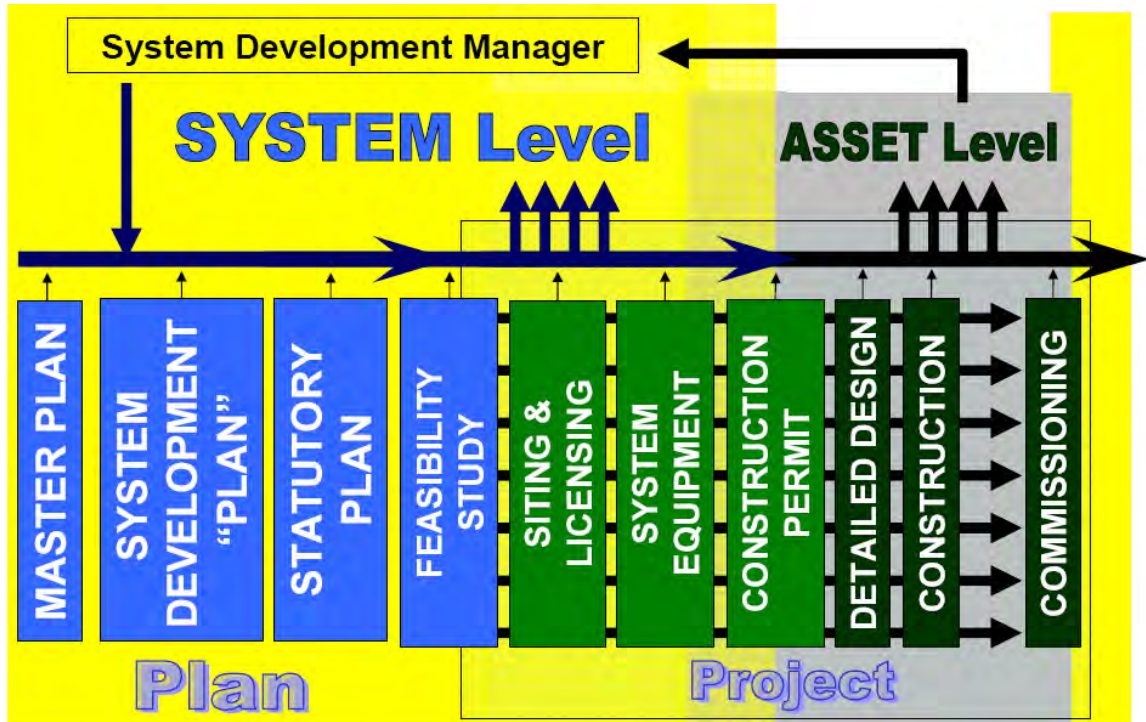


Figure 2.1 Distinction between system development functions classifications: planning/project stage versus system/asset level

Distinctions between functions associated with the assets and functions associated with the system are therefore often cause for uncertainties or repeated changes in the organization of transmission companies. The boundary between system and asset is thus also a key factor in analyzing the impact of the different electricity industry structures on system development, among other system issues. In [3], system functions were grouped as "Asset management" functions whilst asset functions were defined as "Service" ones. The nomenclature "system" pointed out the necessary "System View and Management" required in "Asset Management".

2.4.2 Complementary functions

The second reason is related to **conflicts of interest**. More traditionally, functions are classified as they appear in the life cycle (as done in paragraph 2.1). There exist well-known conflicts or shared objectives between those functions like between planning and detailed design, operation and maintenance and so on, depending on the characteristics of what is at stake. So, it is expected that, depending on whether such a group of functions is in the field of responsibilities of the same actor or belongs to different actors, it could have different impacts on the electricity industry and on system development.

An additional remark concerns the choice of a "function" notion rather than an "activity" notion. Indeed, in our mind, activity refers to a group of functions which are activated and therefore relates to the structure. A function is potentially a part of an activity which is dependent on the corresponding in-charge actor(s). For example, there are countries where there is no generation planning activity; however, the function itself still exists being implicitly fulfilled (with more or less efficacy) by market actors.

Table 2.2 lists the functions which were studied through the questionnaire. Some of the definitions/explanations are taken from the W37.32 Report [2].

Table 2.2 List of functions connected to electric system or assets life cycle

| | Functions | Explanation |
|------------|--|---|
| 1 | System Asset Planning Functions | |
| 1.1 | General | |
| 1.11 | Directives | Level of quality, reliability and other economical, technical or relevant directives and criteria which have to be fulfilled. |
| 1.12 | Long-term Demand Forecast | Including different scenarios for economic growth |
| 1.2 | Generation | |
| 1.21 | Generation Development Master Planning (from 5-10 up to 15-40 years) | Very long term production needs. It may be done at different strategic resolutions: Power, voltage, location, fuel repartition, size of the units, technology and so on. It has to be, frequently, coordinated with other national infrastructures. |
| 1.22 | Generation Technologies Studies | Process which leads to the assessment of the maturity of a technology. |
| 1.23 | Generation Development Planning (up to 5-10 years) | Long term production plan in which specific projects are technically defined. These projects were previously economically proven or requested by the directives. Business plan or equivalent is done for each project. |
| 1.24 | Generation Statutory Planning | Integration of the generation projects with other infrastructures and environmental constraints |
| 1.25 | Generation Projects Statutory and Environmental Licensing | Process which leads to the project statutory approval in its conceptual form (size, location, technology, main technical and environmental performances) |
| 1.26 | Generation Project Construction Permits | Functions which are necessary to the project construction permit. It includes generally advanced architectural and civil planning, mandatory construction and environmental specifications, legal and statutory liabilities to the relevant entities (bodies and persons). The permit issue generally reduces the risk and incertitude at a level that does not endanger the project realization. |
| 1.27 | Generation Statutory Feasibility Phase Management | Management of the project till the authorization or/and construction permit. |
| 1.3 | Transmission | |
| 1.31 | Transmission Development Master Planning (up to 15-20 years) | Very long term transmission needs. It may be done at different strategic resolutions: Capacity, location, technology and so on. It is generally also necessary to be coordinated with other national infrastructures. |
| 1.32 | Transmission Technologies Studies | Process which leads to the decision whether a certain transmission technology is mature or not. |
| 1.33 | Transmission Development Plan (up to 5-10 years) | Long term transmission plan in which specific projects which were proved (at the date of the planning) to be necessary in respect of the directives or economically valuable are technically defined. Business plan or equivalent is done for each project. |
| 1.34 | Transmission Statutory Planning | Integration of the transmission projects in coordination with other infrastructures and environmental constraints. |
| 1.35 | Transmission Equipment Specifications | Being part of the whole network, main equipment has to be coordinated to the system and is therefore a system issue. |
| 1.36 | Transmission Right of Way Statutory and Environmental Licensing | Process which leads to the project statutory approval in its conceptual form (size, location, technology, main technical and environmental performances) |

| | Functions | Explanation |
|------------|--|--|
| 1.37 | Transmission Projects Construction Permit | Functions which are necessary to the project construction permit. It includes generally advanced architectural and civil planning, mandatory construction and environmental specifications, legal and statutory liabilities to the relevant entities (bodies and persons). The permit obtainment generally reduces the risk and uncertainty at a level that does not endanger the project realization. |
| 1.38 | Transmission Statutory Feasibility Phase Management | Management of the project till the authorization or/and construction permit. |
| 1.4 | Transformation | |
| 1.41 | Substation (to distribution) Development Master Planning (up to 15-20 years) | Very long term transformation needs. It may be done by different strategic resolutions: Capacity, location, technology and so on. It is generally also necessary to be coordinated with other national infrastructures. |
| 1.42 | Substation Technologies Studies | Process which leads to the decision whether a certain substation technology is mature or not. |
| 1.43 | Substation Development Plan (up to 5-10 years) | Long term transformation plan in which specific projects which were proved (at the date of the planning) to be necessary in respect of the directives or economically valuable are technically defined. Business plan or equivalent is done for each project. |
| 1.44 | Substation Statutory Planning | Integration of the substation projects in coordination with other infrastructures and environmental constraints. |
| 1.45 | Substation Equipment Specifications | Being part of the whole network, main equipment has to be coordinated to the system and is therefore a system issue. |
| 1.46 | Substation Statutory and Environmental Licensing | Process which leads to the project statutory approval in its conceptual form (size, location, technology, main technical and environmental performances). |
| 1.47 | Substation Projects Construction Permit | Functions which are necessary to the project construction permit. It includes generally advanced architectural and civil planning, mandatory construction and environmental specifications, legal and statutory liabilities to the relevant entities (bodies and persons). The permit obtainment generally reduces the risk and uncertainty at a level that do not endanger the project realization. |
| 1.48 | Substation Statutory Feasibility Phase Management | Management of the project till the authorization or/and construction permit |
| 2. | Market Related System Functions | |
| 2.1 | Directives and Rules | Self-explaining |
| 2.2 | Information Spreading | Spread information so that the market will be transparent and as close as possible to a perfect market |
| 2.3 | Operation | System functions supporting electricity trading, such as administration of trading schedules submitted by traders, balancing group accounting, etc. Trading itself and power exchanges are outside the system scope. |
| 2.4 | Settlement | Of the difference between trading contracts at different time horizons and the actual electrical production and consumption. |
| 2.5 | Regulation & Audit | This function is also required to continuously improve the market rules and correct as well as possible any failure of the market. |
| 3. | System Operation Functions | |
| 3.1 | Operation Directives | Generally issued before each year or even season it indicates some operation constraints needed to prevent as much as possible risky condition taking into account the available production park and environmental based constraints. |
| 3.2 | Field Switching Operations | It may be done by the system operator or the transmission facilities operator. |
| 3.3 | Immediate Operation Planning | Next day or hours planning. |
| 3.4 | Dispatch & Control | Self-explaining |

| | Functions | Explanation |
|-----------------------------------|--|--|
| 3.5 | Information Gathering and Analysis | Information on the system facilities and lines operational states and on the short-term demand forecast |
| 3.6 | Procurement of Ancillary Services | Depends on the market development. It may include reactive power, capacity, reliability, quality services. |
| 4. System Access Functions | | |
| 4.1 | Access Directives | Procedures for new connection to the system |
| 4.2 | Connection Planning | Despite the fact that the connection may be accounted to the producer, the planning itself can be done by the system manager or any transmission actors |
| 4.3 | Set Connection Charges | How the connection charges (Investment, operation and maintenance) are calculated |
| 4.4 | Connection Licensing and Permit | As above (for instance 1.46 & 1.47) for the connection facilities |
| 4.5 | Connection Construction | Self-explaining |
| 4.6 | Connection Operation | Self-explaining |
| 4.7 | Connection Maintenance | Self-explaining |
| 5. | Asset related functions | Transmission or/and substation ownership, maintenance, detailed design, construction and commissioning. This is different of paragraphs 1.3 and 1.4 which are related to system/asset management functions. In this set of questions, there are some items which may be managed either as asset service issues or as system issues. |
| 5.1 | Transmission | |
| 5.11 | Network and Transmission Substations ownership | Such substations that are used for transmission purposes (different level of transmission voltage, power station connection to the network, switching connection between different transmission areas) |
| 5.12 | Network Maintenance Policies | System management or Transmission Actors? |
| 5.13 | Network Maintenance Planning | System management or Transmission Actors? |
| 5.14 | Network Maintenance Work | Self-explaining |
| 5.15 | Network Technical Upgrading | This may have system consequences. |
| 5.16 | Network expansion and/or upgrading – Detailed Design | Self-explaining |
| 5.17 | Network expansion and/or upgrading – Construction | Self-explaining |
| 5.18 | Network expansion and/or upgrading – Commissioning | Self-explaining |
| 5.2 | Transformation (to distribution) | For the relevant functions, It may also depend on the voltage level. |
| 5.21 | Substations Ownership | Self-explaining |
| 5.22 | Substations Maintenance policies | Self-explaining |
| 5.23 | Substations Maintenance Planning | Self-explaining |
| 5.24 | Substations Maintenance Work | Self-explaining |
| 5.25 | Substations Technical Upgrading | Self-explaining |
| 5.26 | Substations expansion and/or upgrading – Detailed Design | Self-explaining |
| 5.27 | Substations expansion and/or upgrading – Construction | Self-explaining |
| 5.28 | Substations expansion and/or upgrading – Commissioning | Self-explaining |
| 6. Transmission Charges | | |
| 6.1 | Revenue Requirements | |
| 6.2 | Set Tariff | |
| 6.3 | Collect Revenue | |

2.5 The System and the Electrical Economy/Industry

2.5.1 The dimensions of the Electric Industry (EI)

From the system analysis viewpoint, EI can be viewed as having three dimensions (Figure 2.2).

1. The “energy flow” dimension is based on the chain of electricity, e.g., generation, transmission and finally distribution to customers. This dimension has originally been the way the electricity industry was described. The customers associated with this axis are the traditional electricity energy producers and consumers. In this path the boundaries of the system are generally associated with those of the transmission system, and relationships between the different sectors are governed by grid codes.
2. The “asset dimension” refers to the physical power system facilities throughout their life cycle stages – (detailed) design, construction, operation and maintenance. One of the main issues in the functions connected to this dimension is to achieve safety norms and maintainability at the facility level.
3. The “system dimension” refers to integrated system planning and to management of the electricity infrastructure in an optimal way within a framework of short and long-term commitments to the technological, social, economic and legal norms and values. The system manager (operator) has the mission to coordinate the whole system in real-time including energy transmission, market balancing and settlement, as well as asset maintenance and upgrading extension. It services electricity chain customers under rules which should suit and fulfill the objectives of the whole electricity economy. The "system planner" has the mission to plan the infrastructure so that it enables the system operator to fulfill properly his functions (or monitor and alert the authorities if he has no responsibility in implementing an optimal or intended plan). As mentioned before, the main objectives are determined by the needs of the whole electricity industry and not by simple addition of all the needs of the customers of the electricity chain.

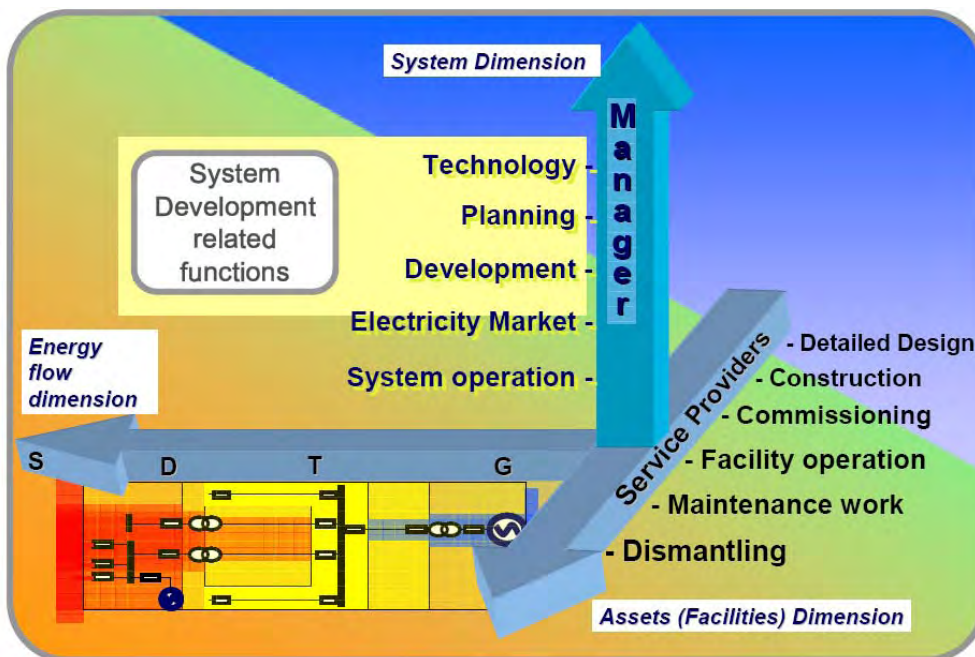


Figure 2.2 Classification of Functions families

Therefore, the “system dimension” connects between the EI needs and the two other dimensions (“energy flow” and “asset management”) by a range of means, from real-time power system management, to short-, medium- and long- term development planning and the technology selection processes as described in section 2.2.

Main families of functions may be related to the system and asset dimensions as described in figure 2.2 whilst their physical responsibility boundaries are defined on the energy-flow dimension. In any

case the transmission system will be in the scope of system development functions. In some cases other sectors (generation or distribution) may be or must be partly or fully included in the system dimension depending on the structure of the market and historical development of the system.

2.5.2 Structures of the Electric Industry

Apart from the classical Vertically Integrated Structure, two main basic EI structures are frequently mentioned - ISO (Independent System Operator) and TSO (Transmission System Operator). These two structures may be combined with different market structures. The following presentation is a generic one as there are many versions of these basic structures.

The ISO (Independent System Operator)

ISO is conceived as an entity that operates and controls the transmission assets on behalf of all the market participants. The basic idea is the separation of asset ownership from system operation. One key goal for the formation of an ISO is to ensure non-discriminatory treatment of all the market players. This competition enhanced by the ISO is sometimes considered an important option for vertically integrated utilities (VIU) where transmission owners own generation or where there are multiple owners of the interconnected transmission grid. In an ISO type structure there should not be any conflict of interest due to ownership of transmission assets. Figure 2.3 gives a schematic representation of the ISO structured industry.

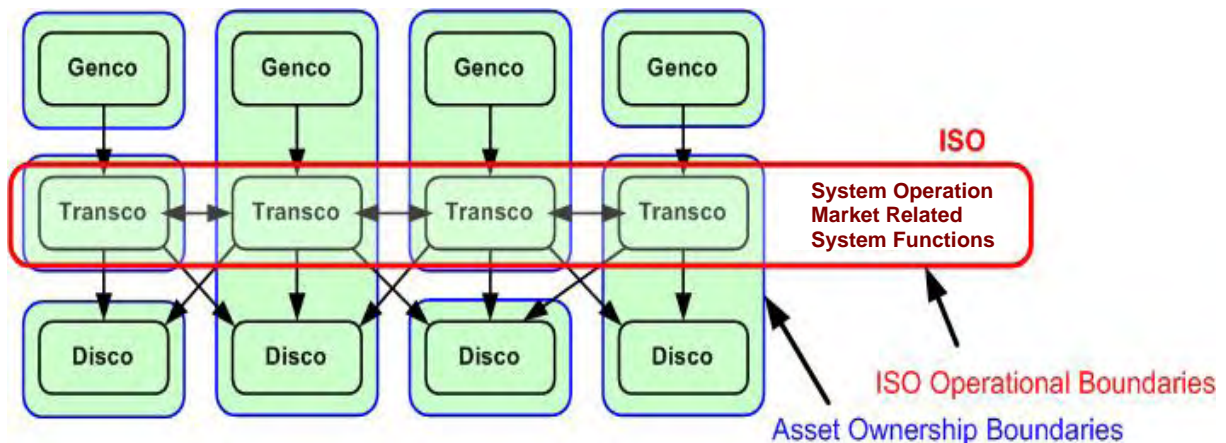


Figure 2.3 – Schematic Organizational Structure of ISO

According to Joskow and Tirole [4], historical and political rationales were a major factor in creating ISOs rather than independent TSOs in various countries (such as Australia, USA, Canada and, initially, in several European states). The main reason is that it may not be politically feasible to force the separation of transmission ownership from generation ownership and marketing activities. An ISO may be created to sit on top of the vertically integrated utilities to provide an independent network manager and administer network access and the market related system functions, i.e. to neutralize relationships between market participants and the vertically integrated owners of the transmission network's facilities (as was the case in Greece, Ireland, Croatia, Hungary, Poland and, initially, Italy). There may be geographically heterogeneous ownership of transmission assets and the horizontal integration of transmission assets is deemed to be politically unfeasible or undesirable (as was the case in USA, Canada and Australia). The ISO can then potentially manage a larger physical network with multiple transmission owners more efficiently than would be the case if each TSO operated its own control area.

Finally, it is sometimes argued that generation and transmission “compete” (that is they are horizontally as well as vertically related) with one another, that even a transmission owner with no generating assets cannot be truly independent and will have incentives to discriminate against generators on the network. In this case, an ISO that has no direct interest in the financial performance of the owners of any of the assets that comprise or utilize the transmission network may cause less mistrust.

The basic ISO model as described above may not have sufficiently considered transmission system planning and implementation of upgrades and expansion. To compensate this drawback, in the USA, FERC has launched the concept of **Regional Transmission Organizations (RTO)**. The RTO is to have primary responsibility for managing the planning and evaluation of required investments. Transmission Owners (TO) could be pushed to sell or lease transmission assets for a number of years for operation and expansion to the RTO. TO may still have owner rights, however reduced to minimum "passive ownership".

TSO (Transmission System Operator)

In the TSO model, Transmission Owner and System Operator are united. Figure 2.4 is a representation of a TSO structured industry. The main tasks of TSO are [5,6]:

- plan, budget, finance, and responsibility for the transmission network construction;
- accommodate new generators;
- facilitate robust long-term competition;
- maintain reliability;

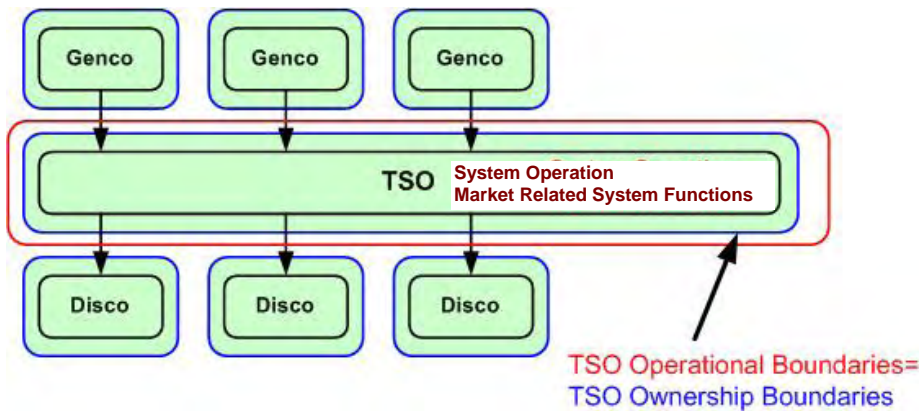


Figure 2.4 – Schematic Organizational Structure of TSO

This TSO model is characterized by the separation of transmission network functions (System Operator - SO and Transmission Owner - TO functions) from generation and power marketing functions. This can be achieved by different ownership or by effective regulation that ensures TSO decisions independent of generation and power marketing interests. System operation, network maintenance, and network planning and investment are integrated and can be managed in a coordinated manner by the TSO (examples are New Zealand and most of the European states). The TSO management is focused on the provision of all transmission services. Transmission planning is improved with the information gained from system operation. Defenders of the TSO scheme argue that it is difficult to implement strong performance incentives on an entity (the ISO) with no assets and little accountability and that the role of ISO regarding transmission planning has not been clearly established.

2.6 Conclusion

Consequences of electric industry structure reforms had pointed out the complexity of this industry and the advantage of characterizing this industry prior to structure modifications.

Different time scales are interacting, including planning time horizon, steady state system study at given hours of the day in different seasons and years, transient simulations down to microseconds, long term contracts and short term biddings, balancing and settlement of the market, asset life time management, deadlines and uncertainties of project management.

Functions of the system development may be classified in relation to the whole electric system or to the assets, in relation to the classical electric chain – generation, transmission, distribution and supply -, according to their strategic impact in the long and short term as sustainable related functions, feasibility studies functions, construction and operation phase. Close definitions and such classification were presented in asset management related work [3]. The "Owner" and Asset

Management" functions are system level related functions, "Service Providers" functions are asset level related functions.

Numerous actors are involved in the system and it is fundamental to map the responsibilities of the actors by functions in order to know which of the functions are not covered or over-covered.

Prior to any system structure assessment or modification the main objectives of the electric industry should be defined and sorted according to their respective priority.

2.7 References

- [1] Crew, Michael A., Kleindorfer Paul R. and Spiegel Menahem. "Reliability, Regulation and Transmission Investment", Working Paper, Wharton Risk Management and Decision Processes Center, University of Pennsylvania, Philadelphia, 2004
- [2] WG37.32 Final Report on: "Review of Industry Structure and Reform Status", October 2001
- [3] Ault, Graham W., van der Meijden, Mart A.M.M., Toneguzzo, Joe P., Welch, Ian, "Asset Management Investment Decision Processes", C1-106, CIGRE 2004
- [4] Joskow, Paul L. and Tirole, Jean, "Merchant Transmission Investment", The Journal of Industrial Economics 0022-1821, Volume LIII June 2005 No.2
- [5] Joskow, Paul L., "Patterns Of Transmission Investment", March 15, 2005, MIT
- [6] Rothwell, Geoffrey and Gómez, Tomás, "Electricity Economics: Regulation and Deregulation", 2003, Wiley-IEEE Press

3/ Survey of System Structures based on Questionnaire Responses

The questionnaire aimed to assess points 1 to 4 of the Terms of Reference (TOR) as follows:

- 1 – Identify **the responsible actors** and the extent of their influence on the electric industry in relation to system development.
- 2 – Identify the effective **physical boundaries** between Generation, Transmission and Distribution and the impact this delimitation may have on system development.
- 3 – Identify the **system development functions** which are common (partially or fully) to the System Operator functions and to the Transmission Operator functions.
- 4 – Determine which actor has the full **responsibility** for these (defined) functions and how all of the involved parties work together on the development plans.

This questionnaire drew on WG37.32's Final Report entitled "Review of Industry Structure and Reform Status (2002) and the CEER Report 2004 entitled "Security of Electricity Supply".

3.1 Industry Structures of Respondents

Fifteen CIGRÉ SC C1 members provided comprehensive answers to the questionnaire. It should be borne in mind that many of the participating members were still in the process of reform or had recently undergone reform that involved changes of actors' activities. The 15 structures were analyzed both together and by generally accepted classifications as described in section 2.5.2 (see Table 3.1) differentiated by the extent of the system manager responsibilities and by the type of unbundling as reported at the time the questionnaire was completed (see part 5 of the questionnaire and web-sites referenced):

- Four Vertical Industry Structures (**VIS** – most of the functions assigned to one Utility),
- Four Transmission System Operator structures (**TSO** – most of the system functions, transmission ownership and services (facilities related i.e. detailed design) functions are assigned to the TSO. It excluded some functions related to Generation or Distribution sectors),
- Seven Independent System Operator structures (**ISO** - like a TSO but without transmission ownership and, in some cases, without services functions responsibility).

Table 3.1 Country structure types

| Country | System management | Unbundling by | Market Management |
|------------------|-------------------|--------------------|-------------------------|
| Australia | ISO | Legal/ Ownership* | ISO |
| Belgium | TSO | Ownership | Separate BELPEX |
| Denmark | TSO | Ownership | Separate NORDPOOL, EEX |
| France | TSO | Ownership* | Separate POWERNEXT |
| Hungary | ISO* (TSO) | Legal* (Ownership) | ISO* |
| Ireland | ISO* (TSO) | Legal (Ownership) | ISO* (Separate SEMO) |
| Israel | VIS | NA | NA |
| Italy | ISO* (TSO) | Ownership* | Separate GME |
| Japan | VIS* | NA* | Separate JPEX |
| Northern Ireland | ISO | Management | ISO |
| Ontario-Canada | ISO | Ownership | ISO |
| Russia | VIS* (ISO) | NA* (legal) | NA* (separate – SO UES) |
| South Africa | VIS | NA | NA |
| Switzerland | ISO* | NA* | NA* |
| United Kingdom | TSO* | Ownership | Separate UK PX |

* NOTES (into bracket, nowadays situation when it is reported different from the state at questionnaire time)

AUSTRALIA Different States are characterized by different forms of unbundling. In the Australia National Electricity Market (NEM), National Electricity Market Management Company (NEMMCO) is both the system and market operator.

FRANCE RTE is unbundled from EDF by ownership within one holding company

- HUNGARY** Former ISO MAVIR was merged in at the end of 2005 with MVM as TSO. It is unbundled from MVM by ownership within one holding company. Separate market operator is planned. The change is not reflected in the analysis since the questionnaire was filled before the change.
- IRELAND** All Island Market was established in November 2007. This market is operated by the Single Electricity Market Operator (SEMO), which is a joint venture between EirGrid (Transmission System Operator in Ireland) and SONI (System Operator Northern Ireland). Irish Energy policy published in March 2007 is to transfer the transmission assets to EirGrid.
- ITALY** Former ISO GRTN was merged in 2005 with Transmission Asset Owner TERNA as a TSO. The change is not reflected in the analysis since the questionnaire was filled before the change.
- JAPAN** ESCJ was established in 2004 as a neutral organization which creates regulations for system development and operation while system dispatch is performed by 10 regional VIU in coordination
- RUSSIA** At the time of the questionnaire, reform was still in transitional stage. With effect from July 1, 2008, RAO "UES of Russia" will cease to exist as a legal entity. Hereby the restructuring of the Russian power sector is completed into a ISO type structure and a separate Market Operator.
- Switzerland** At the time of the questionnaire, the ISO had only functions of dispatch and coordination of domestic VIUs as well as central technical support of international electricity trade through Swiss borders
- UK** National Grid functions as TSO for England & Wales and ISO for Scotland

It is important to notice that there are no two identical structures and the classification was used only for the purpose of observing whether, despite this fact, some specific patterns may be observed.

3.2. Actor Strength

The first chapter of the questionnaire dealt with the different actors in the electricity system.

3.2.1 The questionnaire specification

*There are many **active actors** concerned by the system operation and by the transmission system, depending on the stage in the value chain and the life time of the system. Only the main ones were mentioned in the W37.32 report. We all understand that the industry organization also depends on the respective strength of the actors. In the following table, we give a list of possible actors that are aimed to be involved in the final organization (as foreseen today). Please comment and fill in if necessary. You may add some graphs to describe the interaction between the actors.*

References (if available)

Reports:

Internet Web Site:

Persons to contact:

For the actor's strength you may use two kinds of scales:

- An absolute scale from 0 to 5. (0 meaning non relevant; 1, very low; 2, low; 4, high; 5, very high.)*
- A relative scale, so that the total strength is equal to 100%, when 0% meaning non relevant, 1% officially relevant but with no real influence.*

Comments:

| <i>N°</i> | <i>Name</i> | <i>Explanation</i> | <i>Actual Name</i> | <i>Comment or Actual Definition</i> | <i>Strength</i> |
|-----------|-------------|--|--------------------|-------------------------------------|-----------------|
| 1 | Government | Directly involved in the electricity industry by owning the assets or approving the planning | | | |
| 2 | ... | | | | |

The members were reminded that the above questions were to be answered in relation to the first item of the TOR, and that the strength of actors was to be evaluated "in relation to system development".

3.2.2 Questionnaire Responses

The questionnaire proposed 9 main types of actors. The responses revealed an even wider range of actors: Government, Regulator, Parliament, Transmission System Operator (TSO), Transmission Asset Owner (TAO), Transmission Maintenance Companies, IPPs, Governmental GenCo, Governmental DisCo, Private DisCo, Market Operator, Local Authorities, Manufacturers/Construction Companies, R&D institutes and Universities, Testing and Consultant Companies.

Table 3.2 Actors' Strength

| | | | Reg. | Market Op. | Gov. | TSO | TAO | Private DisCo | Local Auth. | Gov. DisCo. | Gov. GenCo | Trans. Maint. Co. | IPP's | Parliament | Equip. Man. | Res. Inst. | Test.& Cons. |
|----------------|--------|------------------|-------|------------|-------|------|------|---------------|-------------|-------------|------------|-------------------|-------|------------|-------------|------------|--------------|
| ISO | Bundl. | Switzerland | | 5 | | 5 | 5 | 5 | 1 | | | | 5 | | | | |
| ISO | Un. | Australia | 4 | | 5 | 3 | 3 | 3 | 3 | 3 | 2 | | 2 | | | | |
| ISO | Un. | Hungary | 5 | 5 | 4 | 5 | 4 | 3 | 4 | | 1 | | 3 | 3 | | | |
| ISO | Un. | Ireland | 5 | | 5 | 5 | 5 | | 4 | 4 | 5 | | 2 | | | | |
| ISO | Un. | Italy | 4 | | 4 | 4 | 4 | | 5 | 2 | 2 | 4 | 2 | | 1 | 1 | 1 |
| ISO | Un. | Northern-Ireland | 5 | | 4 | 5 | 5 | 5 | | | | | 3 | | | | |
| ISO | Un. | Ontario-Canada | 5 | | 4 | 4 | 4 | 4 | 5 | | 4 | 4 | 4 | | | | |
| TSO | Un. | Belgium | 5 | | 4 | 4 | | 3 | 4 | 3 | | | 4 | | | | |
| TSO | Un. | Denmark | 4 | | 4 | 4 | | | 4 | 4 | | 4 | 5 | | | | |
| TSO | Un. | France | 5 | | 5 | 1 | | | 1 | | 5 | 1 | 1 | | | | |
| TSO | Un. | UK-England | 5 | | | 5 | | 4 | | | | | | | | | |
| VIS | Bundl. | Israel | 5 | | 4 | 4 | | | 4 | | | | | | | | |
| VIS | Bundl. | Japan | 5 | 3 | 5 | 3 | | | 5 | 3 | | | 3 | | 4 | | |
| VIS | Bundl. | Russian | 5 | | 4 | 5 | | | 5 | | | | | | | | |
| VIS | Bundl. | South Afrika | 4 | | 4 | 5 | | | | | | | 2 | | | | |
| Average | | | 4.714 | 4.3333 | 4.308 | 4.13 | 4.29 | 3.8571 | 3.7692 | 3.1667 | 3.1667 | 3.25 | 3 | 3 | 2.5 | 1 | 1 |
| Std. Deviation | | | 0.452 | 0.9428 | 0.462 | 1.09 | 0.7 | 0.833 | 1.31 | 0.6872 | 1.5723 | 1.299 | 1.225 | | | | |

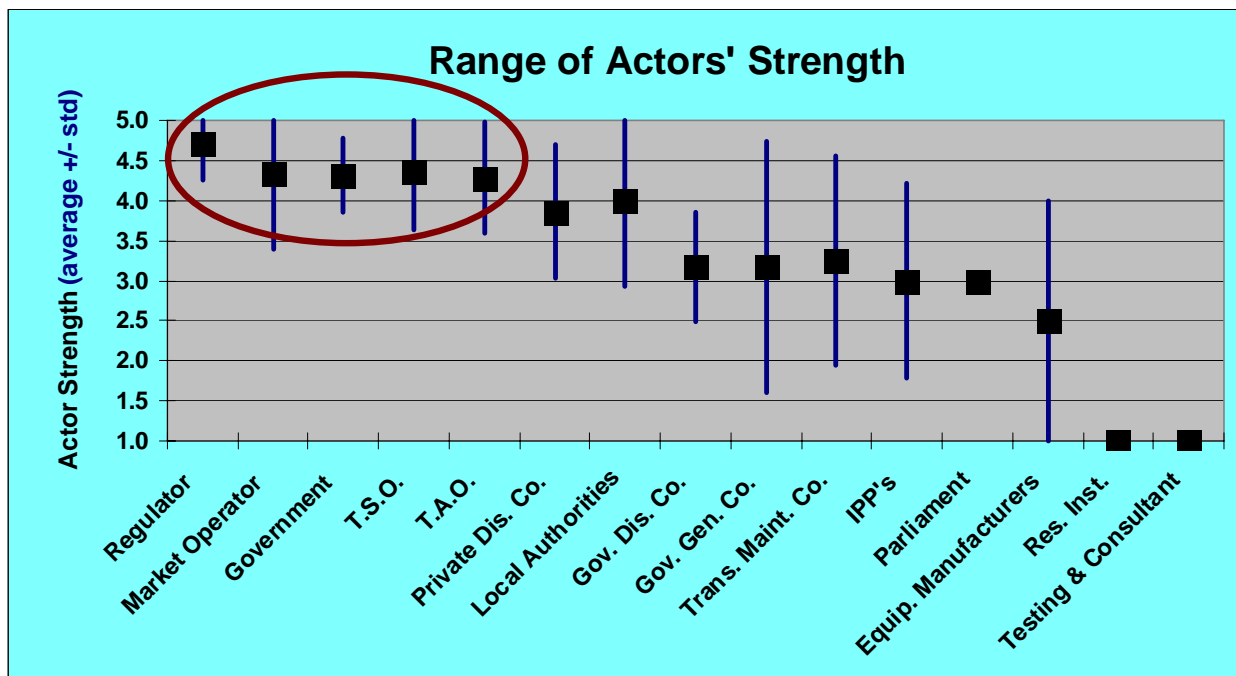


Figure 3.1 Distribution of Actor Strength (average value \pm 1 standard deviation)

Figure 3.1 presents the distribution of the strength of actors "in relation to the system development". The strength is expressed as the average value \pm 1 standard deviation of the data.

3.2.3 Comments on the responses

The regulator, governments, market operators, transmission asset owners and transmission system operators emerged in the survey as the principal strong actors in the structure where they are operating (Note: while the average strength for the market operator was high, only 3 of the 15 responders reported the market operator as being a principal actor).

The dispersion of the responses for these actors was quite small. Outlying results tend to reflect the particular characteristics of each structure.

There is no correlation between the actors' strength and the structure.

3.3. Physical boundaries between the different systems

One of the first steps in the restructuring process of the power industry is the separation of transmission activities (T) from generation (G) and distribution activities (D).

The following questions, which form the second part of the questionnaire, aim to identify the physical components of the entire electrical system on which the boundary between T, G and D was defined when considering each specific activity family (owning, planning etc..) as defined in the questionnaire.

3.3.1 The questionnaire specification

There are many legitimate possibilities to fix the boundaries between Generation, Transmission and Distribution as far as the physical electric system is concerned. These boundaries may also depend on the stage in the value chain of the electrical system. Please put the letters G, T, D according to your system.

Comments:

References (if available)

Reports:

Internet Web Site:

Persons to contact:

| | Generator | Power Station Transformer | Breaker at Power Station | Line | Breaker at Substation | High Voltage Switchgear (To Transmission) | Transformer Breaker | Transformer | Medium Voltage Switchgear (To Distribution) | Substation Physical Barrier |
|---------------------------------|-----------|---------------------------|--------------------------|------|-----------------------|---|---------------------|-------------|---|-----------------------------|
| <i>Owning</i> | | | | | | | | | | |
| <i>Planning</i> | | | | | | | | | | |
| <i>Conceptual Design</i> | | | | | | | | | | |
| <i>Equipment Specifications</i> | | | | | | | | | | |
| <i>Detailed Design</i> | | | | | | | | | | |
| <i>Buyer</i> | | | | | | | | | | |
| <i>Construction</i> | | | | | | | | | | |
| <i>Operation</i> | | | | | | | | | | |
| <i>Maintenance</i> | | | | | | | | | | |
| <i>Tariff</i> | | | | | | | | | | |

3.3.2 Questionnaire Responses

There follows a series of tables summarizing the responses. The responses have been grouped as follows:

- Table 3.3: All industry structures
- Table 3.4: Vertically integrated structures
- Table 3.5: ISO structures
- Table 3.6: TSO structures
- Table 3.7: Bundled industry structures
- Table 3.8: Unbundled industry structures

Table 3.3: All industry structures (14 out of 15 responded to this part of the survey)

| Physical Boundaries between different systems G, T, D - All Industry Structures - Absolute Numbers | | | | | | | | | | | |
|--|----|-----------|----------|------------|------|------------|---------------|---------------|--------|----|------------------|
| | | Generator | PS Trans | Breaker PS | Line | Breaker SS | HV Switchgear | Trans Breaker | Transf | MV | Physical Barrier |
| Owning | G | 14 | 14 | 12 | | | | | | | |
| | GT | | | 2 | 3 | | 1 | | | | |
| | T | | | | 11 | 14 | 13 | 13 | 8 | 5 | 3 |
| | TD | | | | | | | | 3 | 1 | 2 |
| | D | | | | | | | 1 | 3 | 8 | 7 |
| Planning | G | 14 | 13 | 8 | | | | | | | |
| | GT | | 1 | 5 | 3 | | 1 | | | | |
| | T | | | 1 | 11 | 14 | 13 | 14 | 8 | 6 | 4 |
| | TD | | | | | | | | 2 | 1 | 2 |
| | D | | | | | | | | 4 | 7 | 6 |
| Conceptual Design | G | 14 | 13 | 9 | | | | | | | |
| | GT | | 1 | 3 | 2 | | 1 | | | | |
| | T | | | 2 | 12 | 14 | 13 | 14 | 8 | 6 | 4 |
| | TD | | | | | | | | 2 | 1 | 2 |
| | D | | | | | | | | 4 | 7 | 6 |
| Equipm. Specific. | G | 14 | 11 | 7 | | | | | | | |
| | GT | | 3 | 5 | 2 | | 1 | | | | |
| | T | | | 2 | 12 | 14 | 13 | 14 | 8 | 6 | 4 |
| | TD | | | | | | | | 3 | 1 | 2 |
| | D | | | | | | | | 3 | 7 | 6 |
| Detailed Design | G | 14 | 13 | 1 | | | | | | | |
| | GT | | 1 | 3 | 3 | | 1 | | | | |
| | T | | | 1 | 11 | 14 | 13 | 14 | 8 | 6 | 4 |
| | TD | | | | | | | | 2 | 1 | 2 |
| | D | | | | | | | | 4 | 7 | 6 |
| Buyer | G | 14 | 13 | 1 | | | | | | | |
| | GT | | 1 | 3 | 4 | | 1 | | | | |
| | T | | | 1 | 1 | 14 | 13 | 14 | 8 | 6 | 4 |
| | TD | | | | | | | | 2 | 1 | 2 |
| | D | | | | | | | | 4 | 7 | 6 |
| Construction | G | 14 | 13 | 1 | | | | | | | |
| | GT | | 1 | 3 | 3 | | 1 | | | | |
| | T | | | 1 | 11 | 14 | 13 | 13 | 8 | 6 | 4 |
| | TD | | | | | | | 1 | 2 | 1 | 2 |
| | D | | | | | | | | 4 | 7 | 6 |
| Operation | G | 14 | 13 | 7 | | | | | | | |
| | GT | | 1 | 6 | 3 | | 1 | | | | |
| | T | | | 1 | 11 | 14 | 13 | 14 | 7 | 5 | 3 |
| | TD | | | | | | | | 3 | 1 | 2 |
| | D | | | | | | | | 4 | 8 | 7 |
| Maintenance | G | 14 | 13 | 9 | | | | | | | |
| | GT | | 1 | 4 | 2 | | 1 | | | | |
| | T | | | 1 | 12 | 14 | 13 | 14 | 9 | 6 | 4 |
| | TD | | | | | | | | 2 | 1 | 2 |
| | D | | | | | | | | 3 | 7 | 6 |

G=Generation, GT=Generation/Transmission, T=Transmission, TD=Transmission/Distribution, D=Distribution

Table 3.4: Vertically integrated structures (all 4 VIS responded)

| Physical Boundaries between different systems G, T, D - Vertically Integrated Utilities - Absolute Numbers | | Generator | PS Transf | Breaker PS | Line | Breaker SS | HV Switchgear | Transf Breaker | Transf | MV | Physical Barrier |
|--|----|-----------|-----------|------------|------|------------|---------------|----------------|--------|----|------------------|
| Owning | G | 4 | 4 | 3 | | | | | | | |
| | GT | | | 1 | | | 1 | | | | |
| | T | | | | 4 | 4 | 3 | 4 | 3 | 2 | 2 |
| | TD | | | | | | | | 1 | 2 | 2 |
| Planning | G | 4 | 3 | 2 | | | | | | | |
| | GT | | 1 | 2 | | | 1 | | | | |
| | T | | | | 4 | 4 | 3 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |
| Conceptual Design | G | 4 | 3 | 1 | | | | | | | |
| | GT | | 1 | 3 | | | | | | | |
| | T | | | | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |
| Equipm. Specific. | G | 4 | 3 | 2 | | | | | | | |
| | GT | | 1 | 2 | | | 1 | | | | |
| | T | | | | 4 | 4 | 3 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |
| Detailed Design | G | 4 | 3 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | 1 | | | | |
| | T | | | | 3 | 3 | 3 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |
| Buyer | G | 4 | 3 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | 1 | | | | |
| | T | | | | 4 | 4 | 3 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |
| Construction | G | 4 | 3 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | | | | | |
| | T | | | | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |
| Operation | G | 4 | 3 | 1 | | | | | | | |
| | GT | | 1 | 3 | | | 1 | | | | |
| | T | | | | 4 | 4 | 3 | 4 | 3 | 2 | 2 |
| | TD | | | | | | | | 1 | 2 | 2 |
| Maintenance | G | 4 | 3 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | 1 | | | | |
| | T | | | | 4 | 4 | 3 | 4 | 4 | 3 | 3 |
| | TD | | | | | | | | | 1 | 1 |

G=Generation, GT=Generation/Transmission, T=Transmission, TD=Transmission/Distribution, D=Distribution

Table 3.5: ISO structures (6 out of 7 ISO responded)

| Physical Boundaries between different systems G, T, D - ISO Structured Industries - Absolute Numbers | | Generator | PS Trans | Breaker PS | Line | Breaker SS | HV Switchgear | Trans Breaker | Transf | MV | Physical Barrier |
|--|----|-----------|----------|------------|------|------------|---------------|---------------|--------|----|------------------|
| Owning | G | 6 | 6 | 5 | | | | | | | |
| | GT | | | 1 | 2 | | | | | | |
| | T | | | | 4 | 6 | 6 | 5 | 2 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | 1 | 2 | 4 | 5 |
| Planning | G | 6 | 6 | 3 | | | | | | | |
| | GT | | | 2 | 2 | | | | | | |
| | T | | | 1 | 4 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | | 3 | 4 | 5 |
| Conceptual Design | G | 6 | 6 | 4 | | | | | | | |
| | GT | | | 1 | 1 | | | | | | |
| | T | | | 2 | 6 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | | 3 | 4 | 5 |
| Equipm. Specific. | G | 6 | 6 | 4 | | | | | | | |
| | GT | | 1 | 1 | 1 | | | | | | |
| | T | | | 1 | 6 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | | 3 | 1 | 1 |
| | D | | | | | | | | 2 | 4 | 5 |
| Detailed Design | G | 6 | 6 | 4 | | | | | | | |
| | GT | | | 1 | 2 | | | | | | |
| | T | | | 1 | 4 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | | 3 | 4 | 5 |
| Buyer | G | 6 | 6 | 4 | | | | | | | |
| | GT | | | 1 | 2 | | | | | | |
| | T | | | 1 | 4 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | | 3 | 4 | 5 |
| Construction | G | 6 | 6 | 4 | | | | | | | |
| | GT | | | 1 | 2 | | | | | | |
| | T | | | 1 | 4 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | 1 | 2 | 1 | 1 |
| | D | | | | | | | | 3 | 4 | 5 |
| Operation | G | 6 | 6 | 3 | | | | | | | |
| | GT | | | 2 | 2 | | | | | | |
| | T | | | 1 | 4 | 6 | 6 | 6 | 1 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | | 3 | 4 | 5 |
| Maintenance | G | 6 | 6 | 4 | | | | | | | |
| | GT | | | 1 | 2 | | | | | | |
| | T | | | 1 | 4 | 6 | 6 | 6 | 2 | 1 | |
| | TD | | | | | | | | 2 | 1 | 1 |
| | D | | | | | | | | 2 | 4 | 5 |

G=Generation, GT=Generation/Transmission, T=Transmission, TD=Transmission/Distribution, D=Distribution

Table 3.6: TSO structures (all 4 TSO responded)

| Physical Boundaries between different systems G, T, D - TSO Structured Industries - Absolute Numbers | | Generator | PS Trans | Breaker PS | Line | Breaker SS | HV Switchgear | Trans Breaker | Transf | MV | Physical Barrier |
|--|----|-----------|----------|------------|------|------------|---------------|---------------|--------|----|------------------|
| Owning | G | 4 | 4 | 4 | | | | | | | |
| | GT | | | | 1 | | | | | | |
| | T | | | | 3 | 4 | 4 | 4 | 3 | 2 | 1 |
| | TD | | | | | | | | 1 | 2 | 1 |
| Planning | D | | | | | | | | | | 2 |
| | G | 4 | 4 | 4 | | | | | | | |
| | GT | | | | 1 | | | | | | |
| | T | | | | 3 | 4 | 4 | 4 | 3 | 2 | 1 |
| Conceptual Design | TD | | | | | | | | 1 | 2 | 1 |
| | D | | | | | | | | | | 2 |
| | G | 4 | 4 | 4 | | | | | | | |
| | GT | | | | 1 | | | | | | |
| Equipm. Specific. | T | | | | 3 | 4 | 4 | 4 | 3 | 2 | 1 |
| | TD | | | | | | | | 1 | 2 | 1 |
| | D | | | | | | | | | | 2 |
| | G | 4 | 3 | 2 | | | | | | | |
| Detailed Design | GT | | 1 | 2 | 1 | | | | | | |
| | T | | | | 3 | 4 | 4 | 4 | 3 | 2 | 1 |
| | TD | | | | | | | | 1 | 2 | 1 |
| | D | | | | | | | | | | 2 |
| Buyer | G | 4 | 4 | 4 | | | | | | | |
| | GT | | | | 2 | | | | | | |
| | T | | | | 2 | 4 | 4 | 4 | 3 | 2 | 1 |
| | TD | | | | | | | | 1 | 2 | 1 |
| Construction | D | | | | | | | | | | 2 |
| | G | 4 | 4 | 4 | | | | | | | |
| | GT | | | | 1 | | | | | | |
| | T | | | | 3 | 4 | 4 | 4 | 3 | 2 | 1 |
| Operation | TD | | | | | | | | 1 | 2 | 1 |
| | D | | | | | | | | | | 2 |
| | G | 4 | 4 | 3 | | | | | | | |
| | GT | | | 1 | 1 | | | | | | |
| Maintenance | T | | | | 3 | 4 | 4 | 4 | 3 | 2 | 1 |
| | TD | | | | | | | | 1 | 2 | 1 |
| | D | | | | | | | | | | 2 |
| | G | 4 | 4 | 3 | | | | | | | |
| | GT | | | 1 | 4 | 4 | 4 | 4 | 3 | 2 | 1 |
| | T | | | | | | | | | | 1 |
| | TD | | | | | | | | 1 | 2 | 1 |
| | D | | | | | | | | | | 2 |

G=Generation, GT=Generation/Transmission, T=Transmission, TD=Transmission/Distribution, D=Distribution

Table 3.7: Bundled industry structures (all 5 bundled industries responded)

| Physical Boundaries between different systems G, T, D - Bundled Industry Structures - Absolute Numbers | | | | | | | | | | | |
|--|----|-----------|----------|------------|------|------------|---------------|---------------|--------|----|------------------|
| | | Generator | PS Trans | Breaker PS | Line | Breaker SS | HV Switchgear | Trans Breaker | Transf | MV | Physical Barrier |
| Owning | G | 5 | 5 | 4 | | | | | | | |
| | GT | | | 1 | | | 1 | | | | |
| | T | | | | 5 | 5 | 4 | 4 | 3 | 2 | 2 |
| | TD | | | | | | | | 1 | 1 | 3 |
| Planning | D | | | | | | | 1 | 1 | 3 | 3 |
| | G | 5 | 4 | 1 | | | | | | | |
| | GT | | 1 | 3 | | | 1 | | | | |
| | T | | | 1 | 5 | 5 | 4 | 5 | 4 | 3 | 3 |
| Conceptual D | TD | | | | | | | | 1 | 2 | 2 |
| | D | | | | | | | | | | |
| | G | 5 | 4 | 2 | | | | | | | |
| | GT | | 1 | 2 | | | 1 | | | | |
| Equipm. Spec | T | | | 1 | 5 | 5 | 4 | 5 | 4 | 3 | 3 |
| | TD | | | | | | | | 1 | 2 | 2 |
| | D | | | | | | | | | | |
| | G | 5 | 4 | 2 | | | | | | | |
| Detailed Desi | GT | | 1 | 2 | | | 1 | | | | |
| | T | | | 1 | 5 | 5 | 4 | 5 | 4 | 3 | 3 |
| | TD | | | | | | | | 1 | 2 | 2 |
| | D | | | | | | | | | | |
| Buyer | G | 5 | 4 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | 1 | | | | |
| | T | | | 1 | 5 | 5 | 4 | 5 | 4 | 3 | 3 |
| | TD | | | | | | | | 1 | 2 | 2 |
| Construction | D | | | | | | | | | | |
| | G | 5 | 4 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | 1 | | | | |
| | T | | | 1 | 5 | 5 | 4 | 5 | 4 | 3 | 3 |
| Operation | TD | | | | | | | | 1 | 2 | 2 |
| | D | | | | | | | | | | |
| | G | 5 | 4 | 1 | | | | | | | |
| | GT | | 1 | 3 | | | 1 | | | | |
| Maintenance | T | | | 1 | 5 | 5 | 4 | 5 | 3 | 2 | 2 |
| | TD | | | | | | | | 1 | 3 | 3 |
| | D | | | | | | | | | | |
| | G | 5 | 4 | 3 | | | | | | | |
| | GT | | 1 | 1 | | | 1 | | | | |
| | T | | | 1 | 5 | 5 | 4 | 5 | 4 | 3 | 3 |
| | TD | | | | | | | | 1 | 2 | 2 |
| | D | | | | | | | | | | |

G=Generation, GT=Generation/Transmission, T=Transmission, TD=Transmission/Distribution, D=Distribution

Table 3.8: Unbundled industry structures (9 out of 10 unbundled industries responded)

| Physical Boundaries between different systems G, T, D - Unbundled Industry Structures - Absolute Numbers | | Generator | PS Trans | Breaker PS | Line | Breaker SS | HV Switchgear | Trans Breaker | Transf | MV | Physical Barrier |
|--|----|-----------|----------|------------|------|------------|---------------|---------------|--------|----|------------------|
| Owning | G | 9 | 9 | 8 | | | | | | | |
| | GT | | | 1 | 3 | | | | | | |
| | T | | | | 6 | 9 | 9 | 9 | 5 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| Planning | G | 9 | 9 | 7 | | | | | | | |
| | GT | | | 2 | 3 | | | | | | |
| | T | | | | 6 | 9 | 9 | 9 | 4 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| Conceptual Design | G | 9 | 9 | 7 | | | | | | | |
| | GT | | | 1 | 2 | | | | | | |
| | T | | | 1 | 7 | 9 | 9 | 9 | 4 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| Equipm. Specific. | G | 9 | 7 | 5 | | | | | | | |
| | GT | | 2 | 3 | 2 | | | | | | |
| | T | | | 1 | 7 | 9 | 9 | 9 | 4 | 3 | 1 |
| | TD | | | | | | | | 3 | 1 | 2 |
| Detailed Design | G | 9 | 9 | 7 | | | | | | | |
| | GT | | | 2 | 3 | | | | | | |
| | T | | | | 6 | 9 | 9 | 9 | 4 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| Buyer | G | 9 | 9 | 7 | | | | | | | |
| | GT | | | 2 | 4 | | | | | | |
| | T | | | | 5 | 9 | 9 | 9 | 4 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| Construction | G | 9 | 9 | 7 | | | | | | | |
| | GT | | | 2 | 3 | | | | | | |
| | T | | | | 6 | 9 | 9 | 8 | 4 | 3 | 1 |
| | TD | | | | | | | 1 | 2 | 1 | 2 |
| Operation | G | 9 | 9 | 6 | | | | | | | |
| | GT | | | 3 | 3 | | | | | | |
| | T | | | | 6 | 9 | 9 | 9 | 4 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| Maintenance | G | 9 | 9 | 6 | | | | | | | |
| | GT | | | 3 | 2 | | | | | | |
| | T | | | | 7 | 9 | 9 | 9 | 5 | 3 | 1 |
| | TD | | | | | | | | 2 | 1 | 2 |
| D | G | | | | | | | | | | |
| | GT | | | | | | | | | | |
| | T | | | | | | | | | | |
| | TD | | | | | | | | 2 | 5 | 4 |

G=Generation, GT=Generation/Transmission, T=Transmission, TD=Transmission/Distribution, D=Distribution

The responses to the questionnaire were illustrated with the help of a color scheme, which indicates the range of components that are considered to belong to **Generation**, **Transmission** and **Distribution**. For instance, the generator is coloured blue for all activities (owning, maintaining etc), which means that 100% of the responses allocate it to the generation sector irrespective of the activity. When considering the line from the generator to the substation for the TSO structured industry (in Figure 3.3), the yellow color for maintenance indicates that all responding countries allocate it to transmission.

| Color | % Generation | % Transmission | % Distribution |
|--------------|--------------|----------------|----------------|
| Dark Blue | 100 | - | - |
| Blue | 90 | 10 | - |
| Light Blue | 80 | 20 | - |
| Light Green | 70 | 30 | - |
| Green | 50 | 50 | - |
| Yellow | 10 | 90 | - |
| Orange | - | 100 | - |
| Light Orange | - | 90 | 10 |
| Dark Orange | - | 80 | 20 |
| Red-Orange | - | 40-60 | 40-60 |
| Red | - | 20-30 | 70-80 |
| Dark Red | - | - | 100 |

The green color for the other activities, however, indicates that some respondents allocate it to generation, rather than to transmission. The questionnaire responses are grouped by two classifications: firstly (Figures 3.2 to 3.4) by system operation structure (ISO, TSO and VIS) and, secondly (Figures 3.5 and 3.6), by the state of bundling.

Figure 3.2 Boundaries between the different systems for an ISO structured industry

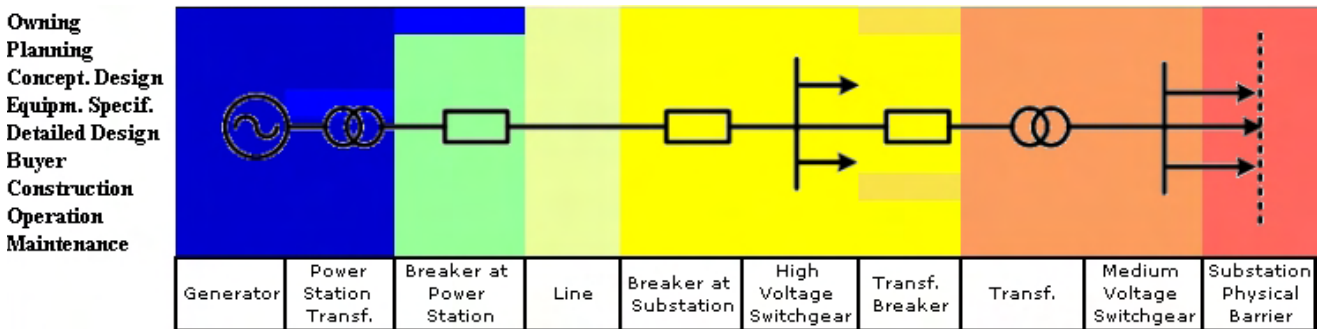


Figure 3.3 Boundaries between the different systems for a TSO structured industry

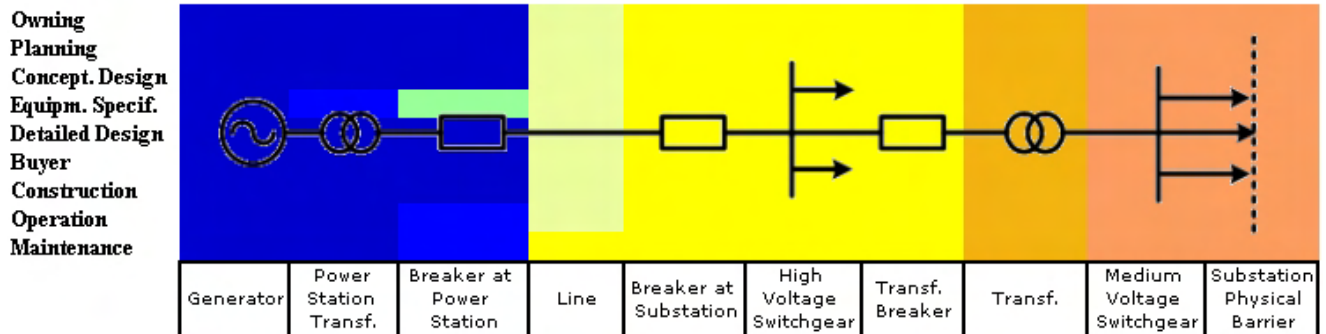


Figure 3.4 Boundaries between the different systems for a VIS structured industry

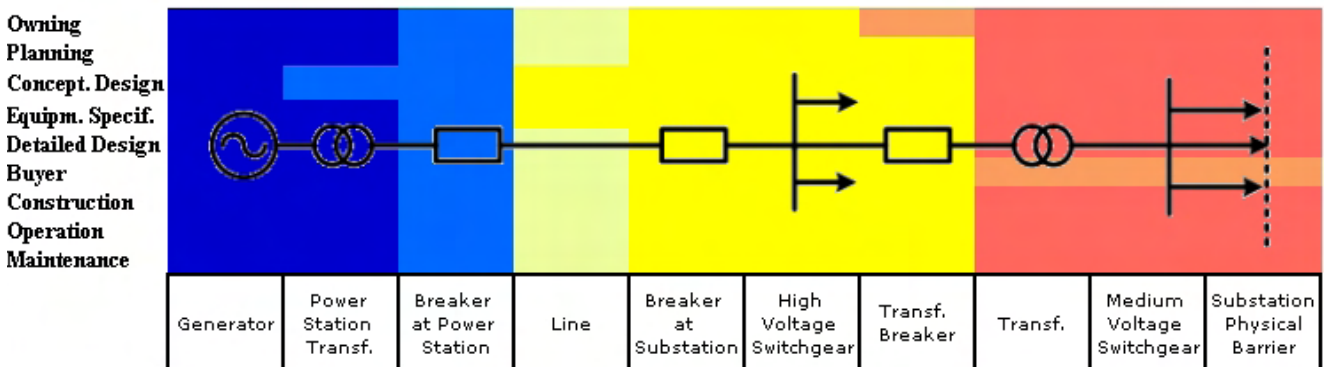


Figure 3.5 Boundaries between the different systems for a unbundled industry

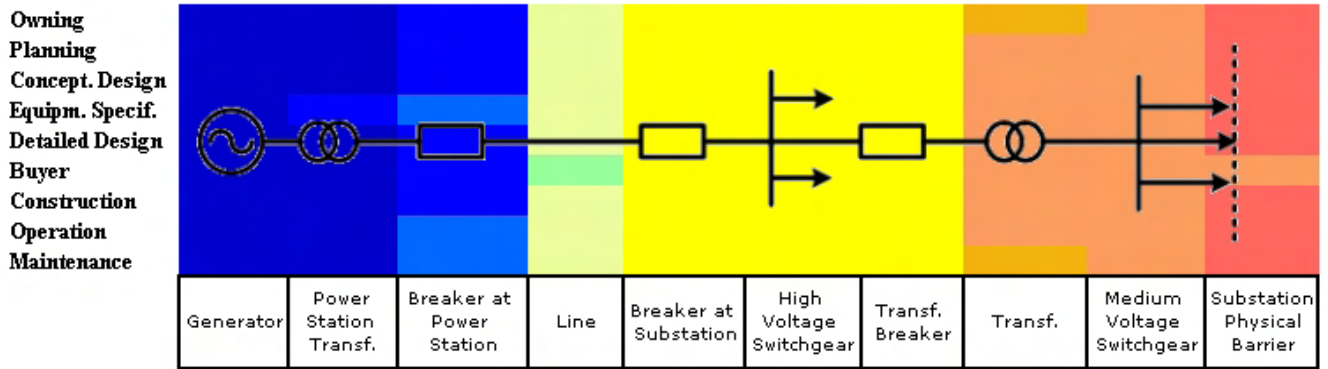
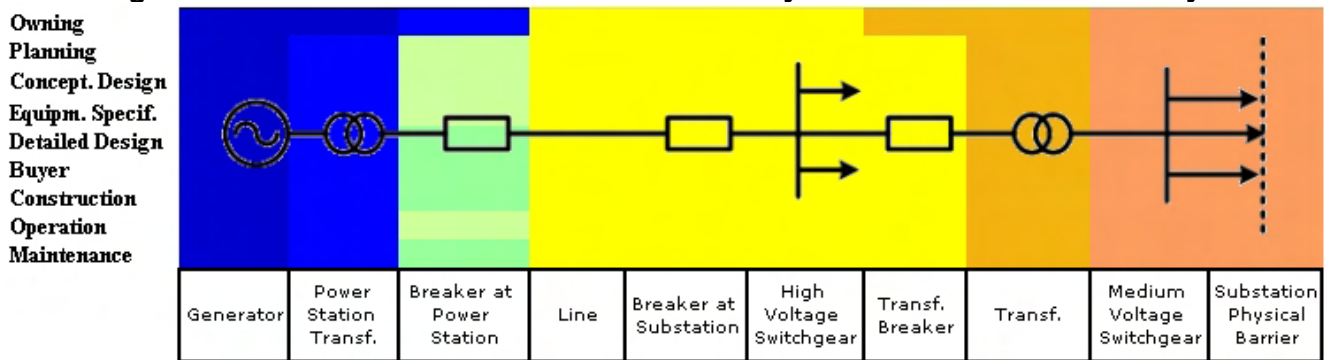


Figure 3.6 Boundaries between the different systems for a bundled industry



3.3.3 Comments on the responses

The first observation is that there are some components which are universally classified as belonging to a specific sector (i.e., generator to generation, HV busbar to transmission). The boundary between sectors is not universal, however, and depends both on the country and the activity. Different economic and market views of the system have given many possible alternatives to set these boundaries. The fact that, even for a given component (i.e., the generator), some plant specifications are dictated by economic drivers (i.e., demand for energy) and others by electrical constraints (i.e., dynamic characteristics) may explain the different decisions reached in each country. Evolution of structures and feedback from the field may also be contributory factors to the fuzzy pattern of the boundary locations.

From an electrical viewpoint, all three sectors form one bundled system. For instance, generator connections, part of which may be owned by the generation sector, may affect the development of the transmission system and the security of the electrical system as a whole. Furthermore, the amount of generation connected to the distribution sector may affect the dynamic behavior of the whole system under disturbance conditions. As far as technology is concerned, all of the main parameters of the equipment, including generation, should be commensurate with the operational requirements of the entire electrical system.

Accordingly, system development and system operation activities cross physical boundaries as defined by unbundling in order to ensure the long term adequacy and security level of the electrical system. Based on the defined boundaries of the sectors, different actors are involved and each has its own set of responsibilities. In order to maintain system integrity and development efficiency, not to mention the safety of the facilities, it is essential to coordinate the activities of the actors involved and to define their exact responsibilities. This has been done at different levels of precision in legislation and in grid codes subsequent to industry reform.

Decisions on the location of boundaries also affect the ownership of assets and tariffs as they can influence investments decisions: development of renewable energy in a region which is far removed from load centers will be influenced by whether the ownership of the connection line is allocated to the generation or transmission sector.

3.4 Actors and Functions

Chapter 3 of the questionnaire dealt with the link between the main and associated actors and the functions for which those actors are responsible.

3.4.1 Questionnaire specifications

As far as Transmission and System Operation Functions are concerned we extend the review presented in Chapter 4 of the W37.32 report, generally keeping the spirit of this review. Some important functions, mainly dealing with the national development planning of the system (production and transmission) were presented in this review at a resolution which may suit countries in which the increase in Power Generation need is relatively low, but which is not enough for a country to which this item is significant.

We therefore increased the resolution of the details of almost all the groups and, as a major issue, added another group of functions, namely the "System Asset Planning Functions" which is dealing with the early stages of asset planning (including the feasibility stage as presented at last CIGRE Meeting in the paper C1-106 (2004) "Asset management investment decision processes"). The outcome of these functions is composed of well-defined projects (generation, transmission or transformation) which are economically and technically demonstrated, and for which all the necessary permits prior construction have to be obtained. Up to this stage, the asset project is still at a conceptual stage, strongly connected to the system planning and may be in competition with alternative project solutions. After this stage, it has its own life cycle much less influenced by system considerations, with much less incertitude, and is seldom stopped.

Comments:

In the following table, you are asked to comment the definition of the function if necessary, and to link the different functions to the actors we defined in the first paragraph, mentioning their number in the relevant column (main actor or associated actors). When a function is not relevant put a 0 or a -.

References (if available)

Reports:

Internet Web Site:

Persons to contact:

| | | Explanation | Main Actor | Associated Actors | Comments |
|------------|--|--------------------|-------------------|--------------------------|-----------------|
| 1 | System Asset Planning Functions | | | | |
| 1.1 | General | | | | |
| | | | | | |

3.4.2 Questionnaire responses

In the subsequent tables, the results were visualized according to the following legend. The color of the cell represents the % of responses giving responsibility to the actor for that function.

The aggregate results for all the countries are presented in Table 3.9.

| Value % | Color |
|-------------------|--------------|
| x<20 | |
| 20≤x<40 | |
| 40≤x<65 | |
| 65≤x | |

As mentioned above, the reporting countries are

- 7 Independent System Operator structures (**ISO**) – See Table 3.10
- 4 Transmission System Operator structures (**TSO**) – See Table 3.11
- 4 Vertical Industry Structures (**VIS**) – See Table 3.12

Some functions were aggregated as there always were appointed to the same actor.

Table 3.9 Functions performed by main actors – All structures

| Function | # | TSO | TAO | MO | Reg | Gov | IPP | Dis | Loc | No | Oth |
|--------------------------------------|---------|-----|-----|----|-----|-----|-----|-----|-----|----|-----|
| Directives | 1.11 | 5 | 3 | | 2 | 2 | | | | 1 | 1 |
| Long-term Demand Forecast | 1.12 | 7 | 3 | | | 3 | | 2 | | | |
| G. (Generation) Dev. Master Plan. | 1.21 | 3 | | | 1 | 4 | 3 | | | 3 | 1 |
| G. Technologies Studies | 1.22 | 4 | | | | 2 | 5 | | | 1 | 3 |
| G. Dev. Plan. (Planning) | 1.23 | 4 | | | 1 | | 6 | | | 2 | 2 |
| G. Stat. (Statutory) Plan. | 1.24 | 4 | 1 | | | 2 | 6 | | 1 | 1 | |
| G. Stat and Env. Licensing | 1.25 | 5 | | | 1 | 4 | 3 | | 2 | | |
| G. Construction Permits | 1.26 | 2 | | | 1 | 2 | 5 | | 3 | | 1 |
| G. Stat. Phase Manag. | 1.27 | 4 | | | | 1 | 8 | 1 | | | 1 |
| T. (Transmission) Dev. Master Plan. | 1.31 | 6 | 6 | | | 1 | | | | 2 | |
| T. Technologies Studies | 1.32 | 5 | 8 | | | 1 | | | | | 1 |
| T. Development Plan | 1.33 | 6 | 9 | | | | | | | | |
| T. Statutory Planning | 1.34 | 4 | 7 | | | 3 | | | 1 | | |
| T. Equipment Specifications | 1.35 | 4 | 11 | | | | | | | | |
| T. Right of Way Licensing & Permit | 1.36&37 | 3 | 8 | | | 2 | | | 3 | | |
| T. Stat. Phase Management | 1.38 | 4 | 11 | | | | | | | | |
| Sb. (Substation) Dev. Master Plan. | 1.41 | 3 | 7 | | | | | 3 | | 2 | |
| Sb. Technologies Studies | 1.42 | 3 | 10 | | | 1 | | 1 | | | |
| Sb. Development Plan | 1.43 | 4 | 10 | | | | | 1 | | | |
| Sb. Statutory Planning | 1.44 | 4 | 8 | | | 1 | | 1 | 1 | | |
| Sb. Equipment Specifications | 1.45 | 3 | 11 | | | | | 1 | | | |
| Sb. Licensing & Permit | 1.46 | 4 | 7 | | | 1 | | 1 | 2 | | |
| Sb. Stat. Phase Management | 1.48 | 4 | 9 | | | | | 2 | | | |
| Market Directives and Rules | 2.1 | 5 | | 1 | 5 | 1 | | | | 1 | |
| Market Information Spreading | 2.2 | 5 | 1 | 3 | 2 | | | 1 | | 1 | |
| Market Op. & Settlement | 2.3&4 | 7 | 2 | 3 | | | | | | 1 | |
| Market Regulation & Audit | 2.5 | 1 | | 1 | 9 | | | | | 2 | |
| Syst. (System) Operation Directives | 3.1 | 12 | 3 | | | | | | | | |
| Syst. Field Switching Operations | 3.2 | 11 | 4 | | | | | | | | |
| Syst. Immediate Operation Planning | 3.3 | 12 | 3 | | | | | | | | |
| Syst. Dispatch & Control | 3.4 | 13 | 1 | | | | 1 | | | | |
| Syst. Information Gath. and Analysis | 3.5 | 11 | 3 | | 1 | | | | | | |
| Syst. Proc. of Ancillary Services | 3.6 | 13 | 2 | | | | | | | | |
| Syst. Access Directives | 4.1 | 3 | 3 | | 7 | 1 | | | | 1 | |
| Syst. Connection Planning | 4.2 | 5 | 8 | | 1 | | | 1 | | | |
| Syst. Set Connect. Charges | 4.3 | 2 | 8 | | 5 | | | | | | |
| Syst. Connect. Licensing and Permit | 4.4 | 3 | 8 | | 1 | 1 | 1 | 1 | | | |
| Syst. Connect. Construction | 4.5 | 3 | 10 | | | | 1 | 1 | | | |
| Syst. Connect. Operation | 4.6 | 6 | 6 | | | | 1 | 2 | | | |
| Syst. Connect. Maintenance | 4.7 | 2 | 10 | | | | 1 | 2 | | | |
| Net. (Network) and T. ownership | 5.11 | 3 | 12 | | | | | | | | |
| Net. Maintenance policies | 5.12 | 5 | 10 | | | | | | | | |
| Net. Maintenance Plan. & Work | 5.13&14 | 3 | 12 | | | | | | | | |
| Net. Upgrading | 5.15-18 | 3 | 11 | | | | | 1 | | | 1 |
| Sb. ownership | 5.21 | 1 | 7 | | | | | 6 | | | 1 |
| Sb. Maintenance policies | 5.22 | 2 | 6 | | | | | 6 | | | 1 |
| Sb. Maintenance Planning | 5.23 | 1 | 8 | | | | | 5 | | | 1 |
| Sb. Maintenance Work | 5.24 | 2 | 5 | | | | | 6 | | | 1 |
| Sb. Upgrading | 5.25-28 | 1 | 7 | | | | | 6 | | | 1 |
| T. Revenue Requirements | 6.21 | 3 | 7 | | 3 | 1 | | | | | |
| T. Set Tariff | 6.22 | 2 | 5 | | 6 | 1 | | | | | |
| T. Collect Revenue | 6.23 | 6 | 7 | | 1 | | | | | | |

TSO: Transmission System Operator; TAO: Transmission Asset Owner; MO: Market Operator; Reg: Regulator; Gov: Government; IPP: Independent Power Producers; Dis: Distribution (public or private); Loc: Local Authorities; No: Nobody; Oth: Others (Transmission Other Co's, Genco, Parliament, R&D institutes)

Table 3.10 Functions performed by main actors – ISO structures

| Function | # | TSO | TAO | MO | Reg | Gov | IPP | Dis | Loc | No | Oth |
|--------------------------------------|---------|-----|-----|----|-----|-----|-----|-----|-----|----|-----|
| Directives | 1.11 | 3 | 1 | | 1 | | | | | 1 | 1 |
| Long-term Demand Forecast | 1.12 | 4 | 2 | | | 1 | | | | | |
| G. (Generation) Dev. Master Plan. | 1.21 | | | | | 2 | 2 | | | 3 | |
| G. Technologies Studies | 1.22 | 1 | | | | 1 | 3 | | | 1 | 1 |
| G. Dev. Plan. (Planning) | 1.23 | | | | 1 | | 5 | | | 1 | |
| G. Stat. (Statutory) Plan. | 1.24 | 2 | | | | 1 | 4 | | | | |
| G. Stat.and Env.Licensing | 1.25 | 3 | | | | 2 | 2 | | | | |
| G. Construction Permits | 1.26 | | | | 1 | 1 | 3 | | 2 | | |
| G. Stat. Phase Manag. | 1.27 | 1 | | | | | 6 | | | | |
| T. (Transmission) Dev. Master Plan. | 1.31 | 3 | 3 | | | | | | | 1 | |
| T. Technologies Studies | 1.32 | 3 | 4 | | | | | | | | |
| T. Development Plan | 1.33 | 3 | 4 | | | | | | | | |
| T. Statutory Planning | 1.34 | 2 | 4 | | | 1 | | | | | |
| T. Equipment Specifications | 1.35 | 1 | 6 | | | | | | | | |
| T. Right of Way Licensing & Permit | 1.36&37 | 1 | 4 | | | 1 | | | 1 | | |
| T. Stat. Phase Management | 1.38 | 1 | 6 | | | | | | | | |
| Sb. (Substation) Dev. Master Plan. | 1.41 | 1 | 4 | | | | | | | 1 | 1 |
| Sb. Technologies Studies | 1.42 | 1 | 6 | | | | | | | | |
| Sb. Development Plan | 1.43 | 1 | 5 | | | | | | | | 1 |
| Sb. Statutory Planning | 1.44 | 1 | 4 | | | 1 | | | | | 1 |
| Sb. Equipment Specifications | 1.45 | | 6 | | | | | | | | 1 |
| Sb. Licensing & Permit | 1.46 | 1 | 3 | | | 1 | | | 1 | | 1 |
| Sb. Projects Construction Permit | 1.47 | 1 | 3 | | | 1 | | | 1 | | 1 |
| Sb. Stat. Phase Management | 1.48 | 1 | 4 | | | | | | | | 2 |
| Market Directives and Rules | 2.1 | 4 | | | 2 | | | | | 1 | |
| Market Information Spreading | 2.2 | 4 | | 1 | | | | 1 | | 1 | |
| Market Op. & Settlement | 2.3&4 | 5 | 1 | 1 | | | | | | | |
| Market Regulation & Audit | 2.5 | 1 | | | 5 | | | | | 1 | |
| Syst. (System) Operation Directives | 3.1 | 6 | 1 | | | | | | | | |
| Syst. Field Switching Operations | 3.2 | 5 | 2 | | | | | | | | |
| Syst. Immediate Operation Planning | 3.3 | 6 | 1 | | | | | | | | |
| Syst. Dispatch & Control | 3.4 | 7 | | | | | | | | | |
| Syst. Information Gath. and Analysis | 3.5 | 6 | 1 | | | | | | | | |
| Syst. Proc. of Ancillary Services | 3.6 | 7 | | | | | | | | | |
| Syst. Access Directives | 4.1 | 2 | 1 | | 3 | | | | | 1 | |
| Syst. Connection Planning | 4.2 | 2 | 4 | | | | | 1 | | | |
| Syst. Set Connect. Charges | 4.3 | 1 | 5 | | 1 | | | | | | |
| Syst. Connect. Licensing and Permit | 4.4 | 1 | 4 | | 1 | | 1 | | | | |
| Syst. Connect. Construction | 4.5 | | 5 | | | | 1 | 1 | | | |
| Syst. Connect. Operation | 4.6 | 2 | 3 | | | | 1 | | | | 1 |
| Syst. Connect. Maintenance | 4.7 | | 4 | | | | 1 | 1 | | | 1 |
| Net. (Network) and T. ownership | 5.11 | | 7 | | | | | | | | |
| Net. Maintenance policies | 5.12 | 2 | 5 | | | | | | | | |
| Net. Maintenance Plan. & Work | 5.13&14 | | 7 | | | | | | | | |
| Net. Upgrading | 5.15-18 | 0-1 | 7-6 | | | | | | | | 0-1 |
| Sb. ownership | 5.21 | | 3 | | | | | 2 | | | 2 |
| Sb. Maintenance policies | 5.22 | 1 | 2 | | | | | 2 | | | 2 |
| Sb. Maintenance Planning | 5.23 | | 4 | | | | | 2 | | | 1 |
| Sb. Maintenance Work | 5.24 | 1 | 1 | | | | | 3 | | | 2 |
| Sb. Upgrading | 5.25-28 | | 3 | | | | | 2 | | | 2 |
| T. Revenue Requirements | 6.21 | 1 | 4 | | 2 | | | | | | |
| T. Set Tariff | 6.22 | 1 | 3 | | 2 | 1 | | | | | |
| T. Collect Revenue | 6.23 | 3 | 4 | | | | | | | | |

TSO: Transmission System Operator; TAO: Transmission Asset Owner; MO: Market Operator; Reg: Regulator; Gov: Government; IPP: Independent Power Producers; Dis: Distribution (public or private); Loc: Local Authorities; No: Nobody; Oth: Others (Transmission Other Co's, Genco, Parliament, R&D institutes)

Table 3.11 Functions performed by main actors – TSO structures

| Function | # | TSO | MO | Reg | Gov | IPP | Dis | Loc | No | Oth |
|--------------------------------------|---------|-----|----|-----|-----|-----|-----|-----|----|-----|
| Directives | 1.11 | 3 | | | | | | | 1 | |
| Long-term Demand Forecast | 1.12 | 2 | | | 1 | | 1 | | | |
| G. (Generation) Dev. Master Plan. | 1.21 | 1 | | 1 | | 1 | | | | |
| G. Technologies Studies | 1.22 | 1 | | | | 2 | | | | 1 |
| G. Dev. Plan. (Planning) | 1.23 | 1 | | | | 1 | | | 1 | |
| G. Stat. (Statutory) Plan. | 1.24 | 1 | | | | 2 | | | 1 | |
| G. Stat. and Env. Licensing | 1.1 | | | 1 | 1 | 1 | | 1 | | |
| G. Construction Permits | 1.26 | | | | 1 | 2 | | | 1 | |
| G. Stat. Phase Manag. | 1.27 | | | | 1 | 2 | 1 | | | |
| T. (Transmission) Dev. Master Plan. | 1.31 | 3 | | | | | | | 1 | |
| T. Technologies Studies | 1.32 | 3 | | | | | | | | 1 |
| T. Development Plan | 1.33 | 4 | | | | | | | | |
| T. Statutory Planning | 1.34 | 3 | | | 1 | | | | | |
| T. Equipment Specifications | 1.35 | 4 | | | | | | | | |
| T. Right of Way Licensing & Permit | 1.36&37 | 4 | | | | | | 1 | | |
| T. Stat. Phase Management | 1.38 | 4 | | | | | | | | |
| Sb. (Substation) Dev. Master Plan. | 1.41 | 1 | | | | | 2 | | 1 | |
| Sb. Technologies Studies | 1.42 | 3 | | | | | 1 | | | |
| Sb. Development Plan | 1.43 | 4 | | | | | | | | |
| Sb. Statutory Planning | 1.44 | 4 | | | | | | | | |
| Sb. Equipment Specifications | 1.45 | 4 | | | | | | | | |
| Sb. Licensing & Permit | 1.46 | 3 | | | | | | 1 | | |
| Sb. Projects Construction Permit | 1.47 | 4 | | | | | | | | |
| Sb. Stat. Phase Management | 1.48 | 4 | | | | | | | | |
| Market Directives and Rules | 2.1 | | | 2 | | | | | 2 | |
| Market Information Spreading | 2.2 | 1 | 1 | | | | | | 2 | |
| Market Op. & Settlement | 2.3&4 | 1 | 1 | | | | | | 2 | |
| Market Settlement | 2.4 | 2 | 1 | | | | | | 1 | |
| Market Regulation & Audit | 2.5 | | | 2 | | | | | | |
| Syst. (System) Operation Directives | 3.1 | 4 | | | | | | | | |
| Syst. Field Switching Operations | 3.2 | 4 | | | | | | | | |
| Syst. Immediate Operation Planning | 3.3 | 4 | | | | | | | | |
| Syst. Dispatch & Control | 3.4 | 3 | | | | 1 | | | | |
| Syst. Information Gath. and Analysis | 3.5 | 3 | | 1 | | | | | | |
| Syst. Proc. of Ancillary Services | 3.6 | 4 | | | | | | | | |
| Syst. Access Directives | 4.1 | 2 | | 2 | | | | | | |
| Syst. Connection Planning | 4.2 | 4 | | | | | | | | |
| Syst. Set Connect. Charges | 4.3 | 2 | | 2 | | | | | | |
| Syst. Connect. Licensing and Permit | 4.4 | 3 | | | | | 1 | | | |
| Syst. Connect. Construction | 4.5 | 4 | | | | | | | | |
| Syst. Connect. Operation | 4.6 | 3 | | | | | 1 | | | |
| Syst. Connect. Maintenance | 4.7 | 4 | | | | | | | | |
| Net. (Network) and T. ownership | 5.11 | 4 | | | | | | | | |
| Net. Maintenance policies | 5.12 | 4 | | | | | | | | |
| Net. Maintenance Plan. & Work | 5.13&14 | 4 | | | | | | | | |
| Net. Upgrading | 5.15-18 | 4 | | | | | | | | |
| Sb. ownership | 5.21 | 1 | | | | | 2 | | | |
| Sb. Maintenance policies | 5.22 | 1 | | | | | 2 | | | |
| Sb. Maintenance Planning | 5.23 | 1 | | | | | 2 | | | |
| Sb. Maintenance Work | 5.24 | 1 | | | | | 1 | | | |
| Sb. Upgrading | 5.1-28 | 1 | | | | | 2 | | | |
| T. Revenue Requirements | 6.21 | 2 | | | 1 | | | | | |
| T. Set Tariff | 6.22 | 1 | | 2 | | | | | | |
| T. Collect Revenue | 6.23 | 3 | | | | | | | | |

TSO: Transmission System Operator; MO: Market Operator; Reg: Regulator; Gov: Government; IPP: Independent Power Producers; Dis: Distribution (public or private); Loc: Local Authorities; No: Nobody or Non Available; Oth: Others (Transmission Other Co's, Genco, Parliament, R&D institutes)

Table 3.12 Functions performed by main actors – VIS structures

| Function | # | VU | MO | Reg | Gov | IPP | Dis | No | Oth |
|--------------------------------------|---------|-----|-----|-----|-----|-----|-----|----|-----|
| Directives | 1.11 | 1 | | 1 | 2 | | | | |
| Long-term Demand Forecast | 1.12 | 2 | | | 1 | | 1 | | |
| G. (Generation) Dev. Master Plan. | 1.21 | 2 | | | 2 | | | | |
| G. Technologies Studies | 1.22 | 2 | | | 1 | | | | 1 |
| G. Dev. Plan. (Planning) | 1.23 | 3 | | | | | | | 1 |
| G. Stat. (Statutory) Plan. | 1.24 | 2 | | | 1 | | | | 1 |
| G. Stat. and Env. Licensing | 1.25 | 2 | | | 1 | | | | 1 |
| G. Construction Permits | 1.26 | 2 | | | | | | | 2 |
| G. Stat. Phase Manag. | 1.27 | 3 | | | | | | | 1 |
| T. (Transmission) Dev. Master Plan. | 1.31 | 3 | | | 1 | | | | |
| T. Technologies Studies | 1.32 | 3 | | | 1 | | | | |
| T. Development Plan | 1.33 | 4 | | | | | | | |
| T. Statutory Planning | 1.34 | 2 | | | 1 | | | | 1 |
| T. Equipment Specifications | 1.35 | 4 | | | | | | | |
| T. Right of Way Licensing & Permit | 1.36&37 | 3-2 | | | 1 | | | | -1 |
| T. Stat. Phase Management | 1.38 | 4 | | | | | | | |
| Sb. (Substation) Dev. Master Plan. | 1.41 | 4 | | | | | | | |
| Sb. Technologies Studies | 1.42 | 3 | | | 1 | | | | |
| Sb. Development Plan | 1.43 | 4 | | | | | | | |
| Sb. Statutory Planning | 1.44 | 3 | | | | | | | 1 |
| Sb. Equipment Specifications | 1.45 | 4 | | | | | | | |
| Sb. Licensing & Permit | 1.46 | 4 | | | | | | | |
| Sb. Projects Construction Permit | 1.47 | 3 | | | | | | | 1 |
| Sb. Stat. Phase Management | 1.48 | 4 | | | | | | | |
| Market Directives and Rules | 2.1 | 1 | 1 | 1 | 1 | | | | |
| Market Information Spreading | 2.2 | 1 | 1 | 2 | | | | | |
| Market Op. & Settlement | 2.3&4 | 2-1 | 1-2 | | | | | 1 | |
| Market Regulation & Audit | 2.5 | | 1 | 2 | | | | 1 | |
| Syst. (System) Operation Directives | 3.1 | 4 | | | | | | | |
| Syst. Field Switching Operations | 3.2 | 4 | | | | | | | |
| Syst. Immediate Operation Planning | 3.3 | 4 | | | | | | | |
| Syst. Dispatch & Control | 3.4 | 4 | | | | | | | |
| Syst. Information Gath. and Analysis | 3.5 | 4 | | | | | | | |
| Syst. Proc. of Ancillary Services | 3.6 | 4 | | | | | | | |
| Syst. Access Directives | 4.1 | 1 | | 2 | 1 | | | | |
| Syst. Connection Planning | 4.2 | 3 | | 1 | | | | | |
| Syst. Set Connect. Charges | 4.3 | 2 | | 2 | | | | | |
| Syst. Connect. Licensing and Permit | 4.4 | 3 | | | 1 | | | | |
| Syst. Connect. Construction | 4.5 | 4 | | | | | | | |
| Syst. Connect. Operation | 4.6 | 4 | | | | | | | |
| Syst. Connect. Maintenance | 4.7 | 4 | | | | | | | |
| Net. (Network) and T. ownership | 5.11 | 4 | | | | | | | |
| Net. Maintenance policies | 5.12 | 4 | | | | | | | |
| Net. Maintenance Plan. & Work | 5.13&14 | 4 | | | | | | | |
| Net. Upgrading | 5.15-18 | 4 | | | | | | | |
| Sb. ownership | 5.21 | 4 | | | | | | | |
| Sb. Maintenance policies | 5.22 | 4 | | | | | | | |
| Sb. Maintenance Planning | 5.23 | 4 | | | | | | | |
| Sb. Maintenance Work | 5.24 | 4 | | | | | | | |
| Sb. Upgrading | 5.25-28 | 4 | | | | | | | |
| T. Revenue Requirements | 6.21 | 3 | | 1 | | | | | |
| T. Set Tariff | 6.22 | 2 | | 2 | | | | | |
| T. Collect Revenue | 6.23 | 3 | | 1 | | | | | |

VU: Vertical Unit; MO: Market Operator; Reg: Regulator; Gov: Government; IPP: Independent Power Producers; Dis: Distribution (private); No: Nobody; Oth: Others (Genco)

3.4.3 Comments on the responses

Unsurprisingly, of the functions analyzed, **most are primarily the responsibility of the System Operator/ Transmission Owner.**

Responsibility seems to have been allocated to a wide range of actors for three specific categories of functions:

- Generation Development functions (from 1.21 to 1.27 – see tables 3.9-3.12)
- Market functions (from 2.1 to 2.5)
- Substation functions (from 5.21 to 5.26)

Two reasons may support these observations:

- Generation Development and transmission to distribution Substation functions appointment are all affected by the fuzzy physical boundaries of the system. Accordingly, the range of legitimate responsible actors is spread
- The structure of the electricity industry and market is still under development in most of the responding countries and the relatively short time since the start of restructuring suggests that the most efficient structures may not yet have emerged.

ISO, TSO and VIS structures

Tables 3.10 to 3.12 present the same information grouped by the dominant structures: ISO, TSO and VIS. Note that, for TSO and VIS structures, since the Transmission System Asset Owner (TAO) is also the Transmission System Operator, the respective columns were merged into one column. It should be emphasized that the present observations are relevant for the countries that responded and should be used with caution in any extrapolation.

Comparing the results yields the following predictable observations:

- **The ISO structure** shows some divergence between functions performed by transmission system operator and those performed by transmission asset owners. While the primary functions of the operator are system operation and market related system functions, those of the asset owner are more focused on transmission expansion and maintenance stages. No pronounced trend is observed for the transmission planning function. The latter is frequently subject to mandatory agreement between the TSO, who are best placed to describe the system characteristics, and the TAO. Generation development functions are primarily fulfilled by TSO, IPPs and governments.
- **The TSO structure** shows a high concentration of functions done by the single entity of TSO: transmission planning, statutory planning and licensing, equipment specifications and also system operation and network maintenance. Substation maintenance is also performed by distribution companies or private maintenance companies. Market functions were spread between the regulator and dedicated market operators.
- **The VIS industries** show, as expected, a high concentration of functions performed by the single utility, with certain tasks like market regulation, system licensing and the determination of tariffs done by the regulator.

3.5 Summary

Analysis of the questionnaire responses provides insights into several aspects of the electricity supply industry:

- The **physical boundaries** of the system change throughout the life cycle. Accordingly, this needs to be accounted for explicitly in any structural change which could affect System Development functions.
- Regarding the **strength of Actors**, the results show that the strongest actors are the Regulator, Government, Market Operator, Transmission System Operator and Transmission Asset Owner. The spread of views among the responding countries is quite small for those actors but still emphasizes the particular characteristics of each country's structure.
- The strength of actors is only one of the parameters that defines the actors' influence on the Electricity Industry. This influence also depends on the functions for which the Actors are in charge and on the motivation of the Actors with respect to the goals of System Development.
- Significant dispersion of responsibilities is evident mainly for three categories of Functions: Generation Development, Market and transmission to distribution Substation related functions.

4/ Conclusions

The main objective of the work was to review structures chosen in different countries in relation to the system development activities. The review was conducted in 2005 through a comprehensive questionnaire to which there were 15 respondents:

- Four Vertical Industry Structures (**VIS** – most of the functions assigned to one Utility),
- Four Transmission System Operator structures (**TSO** – most of the system functions, transmission ownership and services (facilities related i.e., detailed design) functions are assigned to the TSO. It excluded some functions related to Generation or Distribution sectors),
- Seven Independent System Operator structures (**ISO** - like a TSO but without transmission ownership and, in some cases, without services functions responsibility).

The questionnaire aimed to assess points 1 to 4 of the Terms of Reference (TOR), namely:

- 1 – Identify **the responsible actors** and the extent of their influence on the electric industry in relation to system development.
- 2 – Identify the effective **physical boundaries** between Generation, Transmission and Distribution and the impact this delimitation may have on system development.
- 3 – Identify the **system development functions** which are common (partially or fully) to the System Operator functions and to the Transmission Operator functions.
- 4 – Determine which actor has the full **responsibility** for these (defined) functions and how all of the involved parties work together on the development plans.

4.1 Actors

The regulator, governments, market operators, transmission asset owners and transmission system operators emerged in the survey as the principal strong actors in the structure where they are operating (Note: while the average strength for the market operator was high, only 3 of the 15 respondents reported the market operator as being a principal actor). The dispersion of the responses for these actors was quite small. Outlying results tend to reflect the particular characteristics of each structure. One may remark that these actors have to deal with the system as a whole and not only as a conglomeration of facilities and so, may be defined as "system actors". No correlation between the actors' strength and the structure was found.

4.2 Boundaries

There are some components which are universally classified as belonging to a specific sector (i.e., generator to generation, HV busbar to transmission). The boundary between sectors is not universal, however, and depends both on the country and the activity. Different economic and market views of the system have given many possible alternatives to set these boundaries. The fact that, even for a given component (i.e., the generator), some plant specifications are dictated by economic drivers (i.e., demand for energy) and others by electrical constraints (i.e., dynamic characteristics, voltage levels) may explain the different decisions reached in each country. Evolution of structures and feedback from the field may also be contributory factors to the fuzzy pattern of the boundary locations.

From an electrical viewpoint, all three sectors (generation, transmission and distribution) form one bundled system and may affect the development and the security of the electrical system as a whole. As far as technology is concerned, all of the main parameters of the equipment, including generation, should be commensurate with the operational requirements of the entire electrical system.

Accordingly, system development and system operation activities cross physical boundaries as defined by unbundling in order to ensure the long term adequacy and security level of the electrical system. Based on the defined boundaries of the sectors, different actors are involved and each has its own set of responsibilities. In order to maintain system integrity and development efficiency, not to mention the safety of the facilities, it is essential to coordinate the activities of the actors involved

and to define their exact responsibilities. This has been done at different levels of precision in legislation and in grid codes subsequent to industry reform.

Decisions on the location of boundaries also affect the ownership of assets and tariffs as they can influence investments decisions: development of renewable energy in a region which is far removed from load centers will be influenced by whether the ownership of the connection line is allocated to the generation or transmission sector.

It should be interesting to study the evolution of these boundaries together with the convergence of the structures towards a stable one. The reform process is still too dynamic and too young to reach clear conclusions and make firm recommendations.

4.3 Functions allocations

Unsurprisingly, of the functions analyzed, most are primarily the responsibility of the System Operator/ Transmission Owner.

Responsibility seems to have been allocated to a wide range of actors for three specific categories of functions:

- Generation Development functions
- Market functions
- Substation functions (from transmission to distribution)

Two reasons may support these observations:

- Generation Development and Substation functions appointment are all affected by the fuzzy physical boundaries of the system. Accordingly, the range of legitimate responsible actors is spread
- The structure of the electricity industry and market is still under development in most of the responding countries and the relatively short time since the start of restructuring suggests that the most efficient structures may not yet have emerged.

ISO and TSO structures

It should be emphasized that the present observations are relevant for the countries that responded and should be used with caution in any extrapolation. Comparing the results yields the following predictable observations:

- **The ISO structure** shows some divergence between functions performed by transmission system operator and those performed by transmission asset owners. While the primary functions of the operator are system operation and market related system functions, those of the asset owner are more focused on transmission expansion and maintenance stages. No pronounced trend is observed for the transmission planning function. The latter is frequently subject to mandatory agreement between the TSO, who is placed to describe the system characteristics, and the TAO. Generation development functions are primarily fulfilled by TSO, IPPs and governments.
- **The TSO structure** shows a high concentration of functions done by the single entity of TSO: transmission planning, statutory planning and licensing, equipment specifications and also system operation and network maintenance. Substation maintenance is also performed by distribution companies or private maintenance companies. Market functions were spread between the regulator and dedicated market operators.

4.3.1 Design and Planning

Even in Structures where the Development of the System is expected to be "automatically" fulfilled by the market, functions related to Design and Planning of the System remain strongly required to ensure solutions are technically feasible. For example, the government and/or the

regulator may forecast a healthy reference state³, enabling the continuous comparison between the System as generated by the market and the reference state.

4.3.2 Development implementation Functions

Development Implementation Functions for the Transmission System (includes all the functions needed to get mandatory permits and licenses) are rather connected to System Functions so the uncertainty associated with sustainability and feasibility has been eliminated and the installation of the Asset may be managed without affecting System Development.

It should be noticed that these functions are in most countries time consuming and deal with significant risk induced by heavy investment in production facilities. Therefore, even for the generation sector, this family of functions might be more characteristic of "System" features than of "Asset" features if risk management is a main issue.

This remark is similar to the concept that peak units may belong to the System Operator in order to prevent excessive price volatility and as part of a "self regulation control" of the electricity energy market. In the long range, this backup would assure the System Development in case of unexpected (but possible) market failures.

4.3.3 Bundling

A review of survey responses indicates that the most common arrangement is for the system actors to be assigned responsibility for all the functions related to the planning, development and operation of the generation and transmission system, functions connected to the ownership of the transmission facilities, and the control of maintenance management resources of all the facilities within the physical boundaries of the System.

4.4 Strength and Weakness

This work is aligned with the efforts made by the professional community to better understand the System Development related functions and their interactions. It has presented a comprehensive mapping of the functions, and through the survey, it assesses physical boundaries and the roles of different actors in various structures of the Electricity Industry.

However, the study needed to stop short of clearly presenting pros and cons, as originally planned, since most of the reported structures are still being modified and it is not easy to relate such strengths or weaknesses to a specific feature of a dynamic structure. Impacts are generally long term ones and more reliable reviews may be processed when structures are stable.

In appendix A, a methodology developed by the WG secretary is described by way of a case study. It aims to analyze multiple criteria related to reorganization of the electricity industry, hopefully as structures that will achieve pre-defined System Development goals according to country priorities.

³ A reference planned system is one that meets "security of supply" criteria or any other goal criteria such as environmental ones

Appendix A Impact Analysis – Numerical Example

A.1 System Structure Impact Review

It is nowadays still premature to proceed to a comprehensive review of the System Structure Impact.

a - Most of the Structures are still being modified and only few have reached some kind of steady state. The observed effect may therefore be consequent to a previous version of the Structure, while the involved actors may not give objective conclusions.

b - As shown in chapter 2, such analysis should lead to a comparison between the intended goals and the resulting effects which were obtained. Precise objectives have not been always available for all the countries.

In most states that went into the reform process and are in various intermediate stages, there is no way back. Although there are almost as many variants of ESI modifications as there are countries, there are three major basic structures: TSO, ISO and RTO as defined in chapter 2.

This appendix presents a methodology developed by the WG secretary that analyses multiple criteria related to the EI reorganization and was applied to a test case for its own country. It has not been tested yet in other countries.

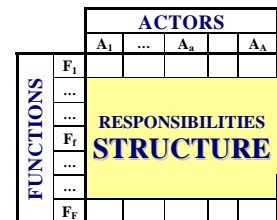
A.2 Basis of the Methodology

The methodology is aimed to be a universally (Structure Independent) applicable tool to "predict" qualitative Structure effects on different targeted Goals G_g .

The effect of a Structure S on Goal G is evaluated through an index called Impact(S,G). The vector Impact(S, G_g) might be compared to the chosen priorities of the Electricity Industry which the Structure should have reflected.

A.2.1 Structures

A Structure S is defined as the assignment of Functions to Actors (or appointment of Actors for Functions) as having either Main Responsibility or Associate Responsibility.



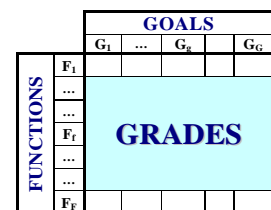
The analyzed structures for the Case Study are presented in section A.3.

A.2.2 Grade (Relevance of Function F to Goal G)

Each Function F may be more or less relevant for achieving goal G or preventing it. This relevance will be defined as the "Grade" (Gr) of the Function F relatively to a specific Goal G. Grade range was defined using the scale from -2 to +2. The scaling rationale is summarized in Table A.1 The Grade table is Structure Independent ("Universal")

Table A.1 Grade Scale (Relevance of a Function F to Goal G)

| Grade (Gr) | Relevance |
|------------|----------------------------|
| +2 | The function is a "MUST" |
| +1 | "Nice to have" |
| 0 | Irrelevant |
| -1 | Minor Obstacle to the Goal |
| -2 | Major Obstacle to the Goal |



A.2.3 Motivation (of Actor A in pursuing Goal G)

Each Actor A inherits, by definition and by his title, interests to meet his Goals. In this approach, the motivation is a structure-independent parameter vector. Table A.2 presents the definition of the Motivation Scale

Table A.2 Motivation Scale (of an Actor A in achieving a Goal G)

| | Motivation (Mo) |
|---|--------------------|
| 5 | Active Support |
| 4 | Passive Support |
| 3 | Indifference |
| 2 | Passive Resistance |
| 1 | Active Resistance |

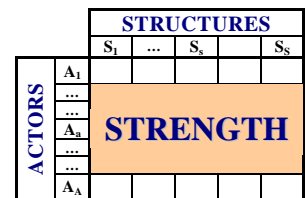


A.2.4 Strength (of an Actor A in fulfilling his role)

The strength of an Actor is measured by his influence on the decision taking and implementation process in the electricity industry. This factor was analysed in chapter 3. The Strength was assumed to be Structure dependent.

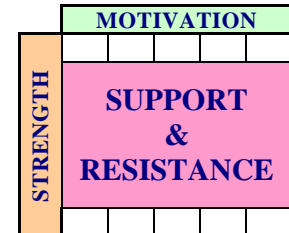
Table A.3 Strength scale (of an Actor A in Structure S)

| | Strength (St) |
|---|---------------|
| 5 | Very Strong |
| 4 | Strong |
| 3 | Some Strength |
| 2 | Weak |
| 1 | Very weak |



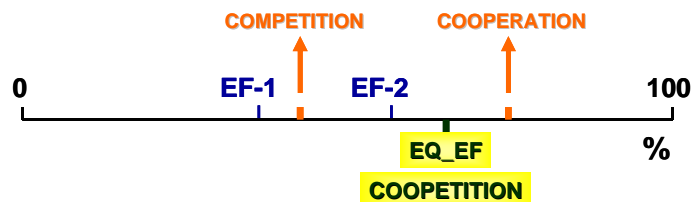
A.2.5 Support and Resistance Efficacy

Support Efficacy of an Actor A towards a Goal G will be applied in connection with Functions which are relevant to the Goal G (grades +1 and +2). Resistance Efficacy of the Actor A will be applied on Functions which provide obstacles to the Goal G (grades -1 and -2). An Actor in charge of Functions that are relevant to meet some goal, will fulfil them to some extent, even if his interest is to resist achieving the goal. This assumption is based on the fact that they are responsible Actors. A resistant Actor will therefore have some Support Efficacy which is expected to increase with an increase in strength. On the opposite, a supporting Actor to a specific Goal G, but in charge of a Function defined as an obstacle to Goal G, will exercise its Resistance Efficacy. This occurs, of course, at a sensibly low level, compared to a resistant Actor.



A.2.6 Equivalent Actor: coopetition

In the last paragraph, the Support and the Resistance Efficacy have been defined for a single Actor A. When more than one Actor are in charge, one may, a priori, consider two possible opposite effects which are generally mixed: pure cooperation which is supposed to improve achievement, or pure competition which might generally degrade achievement.



Key words of the analysis in these observations are "in charge" and "responsible". The situation may be very different when the same people are acting under one responsible authority.

The Equivalent Support and Resistance of a group of Actors \tilde{A} aimed to fulfil a function as an "equivalent actor" is defined as "coopetition", a combination of pure cooperation and pure competition.

A.2.7 Structure Impact

The Impact of a Structure on a Goal is calculated from the previous defined data (Grade, Motivation and Strength) using the Models of Efficacy and Competition taking into account two structural effects:

Standard Impact, which is the sum of all Function impacts as fulfilled by their "Equivalent Actor", and

Bonus Impact, which is a measure of the effect of Actor Leadership on a Goal.

The Structure Impact methodology is summarized in the following illustration. The results may be presented in a "radar scheme" format, where each axis stands for a goal and each curve for a Structure.

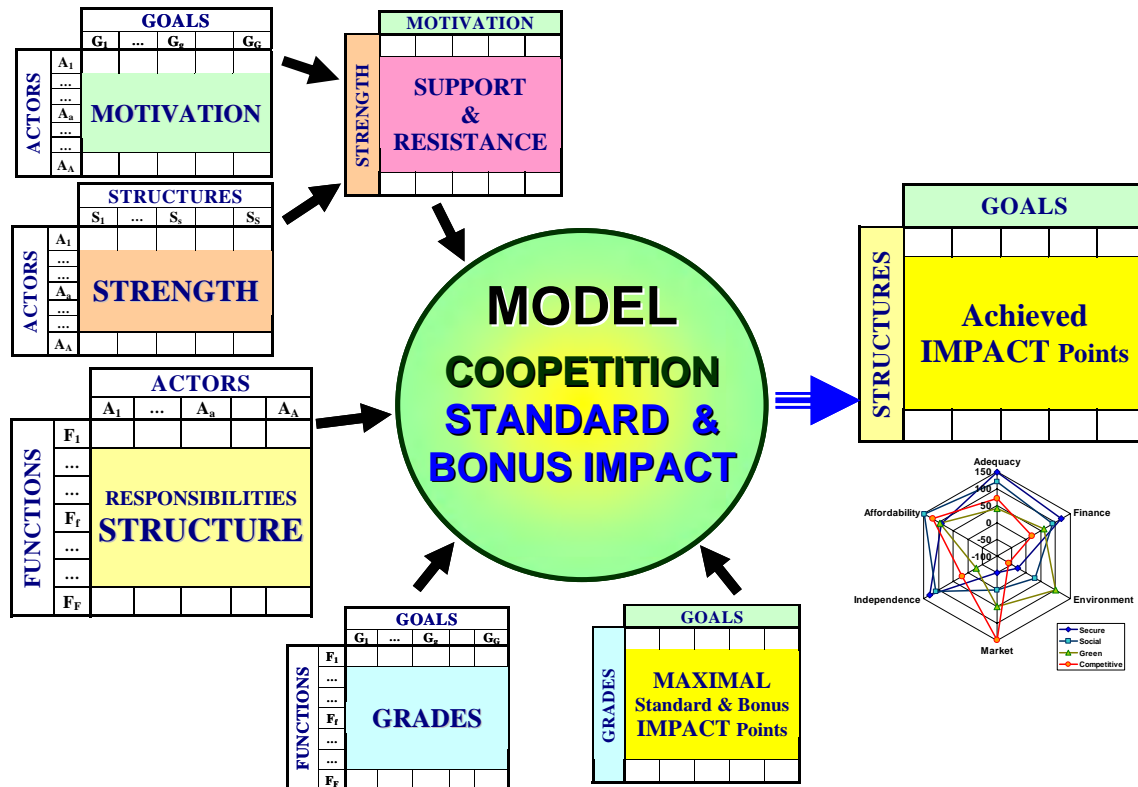


Figure A.1 Illustration of the Structure Impact Methodology

A.3 Case Study Presentation

The methodology has been applied for a specific country in order to compare four types of structures, so-called VIS, TSO, ISO and RTO, as described in chapter 2.

A.3.1 The studied goals family

Six objectives groups were defined in order to focus the analysis. The objectives are defined for the electricity industry as a whole and not for specific actors.

- | | | |
|-------|------------------------------|--|
| AV | Service Availability | (including reliability and security of supply) |
| AF | Service Affordability | (including price and accessibility) |
| En_In | Energy Independence | (including fuel diversification, energy efficiency and conservation measures – this point is essential for interconnected countries for which the level of dependence on neighbors should be provided) |
| M_D | Market Development | (including fair competition and third party open access) |
| EN | Environmental goals | (including CO2 minimization and renewables) |
| FI | Financial goals | (including investment risk and ROI) |

A.3.2 Country Case Study Background

Historically the Electricity Industry was based on a state-owned (as mostly in Europe) VIU (Vertically Integrated Utility). Prior to reform, the VIU has been directed to provide high service availability and energy independence.

A first step, in the reform process, was to open the electric economy to some competition, by IPPs introduction, aiming to increase both affordability and concern to environment issues (through renewables and gas rather than coal). Heavy regulation and fear from privatization and unbundling caused the VIU to increase the focus on the stated goals. Benchmarking of the electricity parameters had shown good achievements.

Presently, the next step should lead to some degree of unbundling of the Electricity Industry. The extent of this unbundling is still under discussion. One interesting open issue is connected with the Transmission Sector. Should the System Operator be also the Asset Owner (TSO)? If not, what should be the degree of System Operator control on Assets (similar to pure ISO or RTO extended authority)?

A.3.3 Strength and Motivation of the Actors

The list of the actors and their strength were derived from the questionnaire answers but are not representative of any specific country. In the Case Study, Market Operator is included in the TSO as it is in many countries. It is important to emphasize that the methodology has to be tailor-made for each country.

Particular assumptions were made regarding a possible RTO structure, which was introduced in the test case despite the fact that no reporting country has adopted such a structure. The assumptions for this specific country may also differ substantially from RTO definitions in other parts of the world. Here, these assumptions reflect a decrease in the strength of independent actors relative to the TSO, (as, for instance, the aim of the recent regulations is to leave to transmission asset owners only the passive ownership properties).

Table A.4 Example Assumptions on Actors Strength in Different Structures

| | ↓Actor Name | Structure Name→ | VIS | TSO | ISO | RTO |
|---|--|-----------------|------------|------------|------------|------------|
| 1 | Government (Gov) | | 5 | 4 | 3 | 3 |
| 2 | Regulator (Reg) | | 5 | 5 | 4 | 4 |
| 3 | Vertical Utility (VIU) | | 5 | | | |
| 4 | Government Production Company (GPC) | | | 3 | 4 | 4 |
| 5 | Independent Private Producers (IPP) | | 2 | 3 | 4 | 3 |
| 6 | Transmission System Operator (TSO) | | 5 | 5 | 4 | 4 |
| 7 | Transmission Owner Company (TOC) | | | | 4 | 2 |
| 8 | Distribution Companies (Dis) | | | 3 | 4 | 3 |
| 9 | Local Authorities (Loc) | | 4 | 3 | 3 | 3 |

Table A.5 Example Assumptions on Actors Motivations for the Different Goals (Structure Independent)

| | ↓Actor Name | Goals→ | Av | Af | En_In | M_D | ENV | FI |
|---|--|--------|-----------|-----------|--------------|------------|------------|-----------|
| 1 | Government (Gov) | | 4 | 4 | 5 | 5 | 5 | 5 |
| 2 | Regulator (Reg) | | 4 | 5 | 3 | 4 | 3 | 2 |
| 3 | Vertical Utility (VIU) | | 5 | 4 | 5 | 3 | 4 | 3 |
| 3 | Government Production Company (GPC) | | 3 | 3 | 4 | 3 | 2 | 3 |
| 4 | Independent Private Producers (IPP) | | 1 | 1 | 3 | 5 | 1 | 5 |
| 5 | Transmission System Operator (TSO) | | 5 | 4 | 5 | 4 | 4 | 4 |
| 6 | Transmission Owner Company (TOC) | | 3 | 1 | 3 | 3 | 2 | 5 |
| 7 | Distribution Companies (Dis) | | 4 | 3 | 3 | 3 | 2 | 4 |
| 8 | Local Authorities (Loc) | | 3 | 4 | 3 | 3 | 5 | 2 |

A.3.4 Grades

Table A.6 presents the relevance of the functions towards the major six objectives groups for the Case Study. This relevance is Structure Independent as discussed in chapter 2.

Table A.6 Example Assumptions on Relevance of Functions to Goals (Grade)

| | Function Name | Av | Af | En_In | M_D | ENV | FI |
|---------|--|----|----|-------|-----|-----|----|
| 1.11 | Directives | 2 | 2 | 2 | 2 | 2 | 2 |
| 1.12 | Long-term Demand Forecast | 2 | 1 | 1 | 1 | 1 | 1 |
| 1.21 | Gen. Development Master Planning (up to 15-40 years) | 2 | 1 | 2 | 1 | 2 | 1 |
| 1.22 | Gen. Technologies Studies | 2 | 1 | 2 | 0 | 2 | 2 |
| 1.23 | Gen. Development Planning (up to 5-10 years) | 2 | 1 | 1 | 1 | 2 | 2 |
| 1.24 | Gen. Statutory Planning | 0 | 0 | 0 | 2 | 2 | 0 |
| 1.25 | Gen. Projects statutory and environmental licensing | -2 | 0 | 0 | -1 | 2 | -2 |
| 1.26 | Gen. Project Construction Permits | -2 | 0 | 0 | -2 | 1 | -1 |
| 1.27 | Gen. Statutory Feasibility Phase Management | -2 | 0 | 0 | -1 | 2 | -1 |
| 1.31 | Trans. Development Master Planning (up to 15-20 years) | 2 | 1 | 2 | 1 | 2 | 1 |
| 1.32 | Trans. Technologies Studies | 2 | 1 | 1 | 1 | 1 | 1 |
| 1.33 | Trans. Development Plan (up to 5-10 years) | 2 | 2 | 1 | 2 | 1 | 2 |
| 1.34 | Trans. Statutory Planning | -2 | 0 | 0 | -2 | 2 | 0 |
| 1.35 | Trans. Equipment Specifications | 2 | 0 | 0 | 0 | 1 | 0 |
| 1.36 | Trans. Right of Way and environment licensing | -2 | 0 | 0 | -1 | 2 | -2 |
| 1.37 | Trans. Projects Construction Permit | -2 | 0 | 0 | -2 | 1 | -1 |
| 1.38 | Trans.n Statutory Feasibility Phase Management | -2 | 0 | 0 | -1 | 2 | -1 |
| 1.41 | Subs. Development Master Planning (up to 15-20 years) | 2 | 1 | 1 | 1 | 1 | 1 |
| 1.42 | Subs. Technologies Studies | 2 | 0 | 1 | 0 | 1 | 1 |
| 1.43 | Subs. Development Plan (up to 5-10 years) | 2 | 2 | 0 | 1 | 1 | 1 |
| 1.44 | Subs. Statutory Planning | 0 | 0 | 0 | 0 | 2 | -1 |
| 1.45 | Subs. Equipment Specifications | 2 | 0 | 0 | 0 | 1 | 0 |
| 1.46 | Subs. statutory and environment licensing | -2 | 0 | 0 | 0 | 2 | -1 |
| 1.47 | Subs. Projects Construction Permit | -2 | 0 | 0 | 0 | 1 | -1 |
| 1.48 | Subs. Statutory Feasibility Phase Management | -2 | 0 | 0 | 0 | 2 | -1 |
| 2.1 | Directives and Rules | 1 | 1 | 1 | 2 | 1 | 2 |
| 2.2 | Information Spreading | 1 | 1 | 0 | 2 | 0 | 2 |
| 2.3 | Operation | -2 | -2 | -2 | 2 | -2 | 2 |
| 2.4 | Settlement | 0 | 0 | 0 | 2 | 0 | 0 |
| 2.5 | Regulation & Audit | 1 | 1 | 0 | -2 | 0 | 1 |
| 3.1 | Operation Directives | 2 | 1 | 1 | 2 | 2 | 1 |
| 3.2 | Field Switching Operations | 2 | 0 | 0 | 0 | 0 | 0 |
| 3.3 | Immediate Operation Planning | 2 | 1 | 0 | 1 | 1 | 0 |
| 3.4 | Dispatch & Control | 2 | 1 | 0 | -2 | 0 | 0 |
| 3.5 | Information Gathering and Analysis | 2 | 0 | 0 | 2 | 0 | 1 |
| 3.6 | Procurement of Ancillary Services | 2 | 0 | 0 | 2 | 0 | 1 |
| 4.1 | Access Directives | 2 | 1 | 0 | 2 | 0 | 2 |
| 4.2 | Connection Planning | 2 | 0 | 0 | 1 | 0 | 2 |
| 4.3 | Set Connection Charges | 0 | 1 | 0 | 1 | 0 | 1 |
| 4.4 | Connection Licensing and Permit | -2 | 0 | 0 | -1 | 2 | -1 |
| 4.5 | Connection Construction | -1 | 0 | 0 | 1 | -1 | 0 |
| 4.6 | Connection Operation | 1 | 1 | 0 | 1 | -1 | 1 |
| 4.7 | Connection Maintenance | 1 | 0 | 0 | 0 | 0 | 0 |
| 5.11 | Net. and Transmission Substations ownership | 2 | 2 | 1 | 0 | 0 | 2 |
| 5.12/13 | Net. Maintenance policies and Planning | 2 | 0 | 0 | 2 | 0 | 0 |
| 5.14 | Net. Maintenance Work | 2 | 0 | 0 | 1 | 0 | 0 |
| 5.15 | Net. Technical Upgrading | 2 | 0 | 0 | 1 | 1 | 1 |
| 5.16 | Net. expansion (and/or upgrading) – Detailed Design | 2 | 0 | 0 | 0 | 0 | 0 |
| 5.17/18 | Net. expansion – Construction & Commissioning | 2 | 0 | 0 | 0 | -1 | 0 |
| 5.21 | Subs. Ownership | 2 | 2 | 0 | 0 | 0 | 2 |
| 5.22/23 | Subs. Maintenance policies and Planning | 2 | 0 | 0 | 1 | 0 | 0 |
| 5.24 | Subs. Maintenance Work | 2 | 0 | 0 | 0 | 0 | 0 |
| 5.25 | Subs. Technical Upgrading | 2 | 0 | 0 | 0 | 0 | 1 |
| 5.26 | Subs. expansion (and/or upgrading) – Detailed Design | 2 | 0 | 0 | 0 | 0 | 0 |
| 5.27/28 | Subs. expansion – Construction & Commissioning | 2 | 0 | 0 | 0 | -1 | 0 |
| 6.1 | Revenue Requirements | 2 | 2 | 0 | -2 | 0 | 2 |
| 6.2 | Set Tariff | 0 | 2 | 0 | -2 | 0 | 2 |

A.3.5 The different structures responsibility assignment.

Table A.7 Example Assumptions on VIS Responsibility (Main (M) or Associate (A) Actors)

| | Actor | Gov | Reg | IPP | VIU | Loc |
|---------|--|-----|-----|-----|-----|-----|
| 1.11 | Directives | M | M | | | |
| 1.12 | Long-term Demand Forecast | A | | | M | |
| 1.21 | Gen. Development Master Planning (up to 15-40 years) | | | | M | |
| 1.22 | Gen. Technologies Studies | | | | M | |
| 1.23 | Gen. Development Planning (up to 5-10 years) | M | M | | M | |
| 1.24 | Gen. Statutory Planning | M | | | M | A |
| 1.25 | Gen. Projects statutory and environmental licensing | M | | | M | M |
| 1.26 | Gen. Project Construction Permits | A | | | M | M |
| 1.27 | Gen. Statutory Feasibility Phase Management | | | | M | |
| 1.31 | Trans. Development Master Planning (up to 15-20 years) | | | | M | |
| 1.32 | Trans. Technologies Studies | | | | M | |
| 1.33 | Trans. Development Plan (up to 5-10 years) | M | M | | M | |
| 1.34 | Trans. Statutory Planning | M | | | M | M |
| 1.35 | Trans. Equipment Specifications | | | | M | |
| 1.36 | Trans. Right of Way and environment licensing | M | | | M | M |
| 1.37 | Trans. Projects Construction Permit | | | | M | M |
| 1.38 | Trans.n Statutory Feasibility Phase Management | | | | M | |
| 1.41 | Subs. Development Master Planning (up to 15-20 years) | | | | M | |
| 1.42 | Subs. Technologies Studies | | | | M | |
| 1.43 | Subs. Development Plan (up to 5-10 years) | M | | | M | |
| 1.44 | Subs. Statutory Planning | M | | | M | M |
| 1.45 | Subs. Equipment Specifications | | | | M | |
| 1.46 | Subs. statutory and environment licensing | M | | | M | M |
| 1.47 | Subs. Projects Construction Permit | | | | M | M |
| 1.48 | Subs. Statutory Feasibility Phase Management | | | | M | |
| 2.1 | Directives and Rules | | M | | | |
| 2.2 | Information Spreading | | A | | M | |
| 2.3 | Operation | | | | M | |
| 2.4 | Settlement | | | | M | |
| 2.5 | Regulation & Audit | | M | | | |
| 3.1 | Operation Directives | | | | M | |
| 3.2 | Field Switching Operations | | | | M | |
| 3.3 | Immediate Operation Planning | | | | M | |
| 3.4 | Dispatch & Control | | | | M | |
| 3.5 | Information Gathering and Analysis | | A | A | M | |
| 3.6 | Procurement of Ancillary Services | | | A | M | |
| 4.1 | Access Directives | | M | | M | |
| 4.2 | Connection Planning | | | A | M | |
| 4.3 | Set Connection Charges | | M | | M | |
| 4.4 | Connection Licensing and Permit | M | | M | | M |
| 4.5 | Connection Construction | | | A | M | |
| 4.6 | Connection Operation | | | A | M | |
| 4.7 | Connection Maintenance | | | M | M | |
| 5.11 | Net. and Transmission Substations ownership | | | | M | |
| 5.12/13 | Net. Maintenance policies and Planning | | | | M | |
| 5.14 | Net. Maintenance Work | | | | M | |
| 5.15 | Net. Technical Upgrading | | | | M | |
| 5.16 | Net. expansion (and/or upgrading) – Detailed Design | | | | M | |
| 5.17/18 | Net. expansion – Construction & Commissioning | | | | M | |
| 5.21 | Subs. Ownership | | | | M | |
| 5.22/23 | Subs. Maintenance policies and Planning | | | | M | |
| 5.24 | Subs. Maintenance Work | | | | M | |
| 5.25 | Subs. Technical Upgrading | | | | M | |
| 5.26 | Subs. expansion (and/or upgrading) – Detailed Design | | | | M | |
| 5.27/28 | Subs. expansion – Construction & Commissioning | | | | M | |
| 6.1 | Revenue Requirements | | M | | A | |
| 6.2 | Set Tariff | | M | | A | |

Table A.8 Example Assumptions on TSO Responsibility (Main (M) or Associate (A) Actors)

| | Actor | Gov | Reg | GPC | IPP | TSO | Dis | Loc |
|---------|--|-----|-----|-----|-----|-----|-----|-----|
| 1.11 | Directives | M | M | | | | | |
| 1.12 | Long-term Demand Forecast | M | | | | M | M | |
| 1.21 | Gen. Development Master Planning (up to 15-40 years) | M | | | | M | | |
| 1.22 | Gen. Technologies Studies | | | A | | M | | |
| 1.23 | Gen. Development Planning (up to 5-10 years) | M | | | | M | | |
| 1.24 | Gen. Statutory Planning | M | | A | A | M | | |
| 1.25 | Gen. Projects statutory and environmental licensing | M | | M | M* | | | M |
| 1.26 | Gen. Project Construction Permits | A | | M | M* | | | M |
| 1.27 | Gen. Statutory Feasibility Phase Management | | | M | M* | M | | |
| 1.31 | Trans. Development Master Planning (up to 15-20 years) | M | | | | M | | |
| 1.32 | Trans. Technologies Studies | | | | | M | | |
| 1.33 | Trans. Development Plan (up to 5-10 years) | M | | | | M | A | |
| 1.34 | Trans. Statutory Planning | M | | | | M | M | M |
| 1.35 | Trans. Equipment Specifications | | | | | M | A | |
| 1.36 | Trans. Right of Way and environment licensing | M | | | | M | M | M |
| 1.37 | Trans. Projects Construction Permit | | | | | M | M | M |
| 1.38 | Trans.n Statutory Feasibility Phase Management | | | | | M | | |
| 1.41 | Subs. Development Master Planning (up to 15-20 years) | | | | | M | A | |
| 1.42 | Subs. Technologies Studies | | | | | M | | |
| 1.43 | Subs. Development Plan (up to 5-10 years) | | | | | M | A | |
| 1.44 | Subs. Statutory Planning | M | | | | M | A | |
| 1.45 | Subs. Equipment Specifications | | | | | M | A | |
| 1.46 | Subs. statutory and environment licensing | | | | | M | A | M |
| 1.47 | Subs. Projects Construction Permit | | | | | M | A | M |
| 1.48 | Subs. Statutory Feasibility Phase Management | | | | | M | | |
| 2.1 | Directives and Rules | M | A | | | A | | |
| 2.2 | Information Spreading | | A | | | M | | |
| 2.3 | Operation | | | A | A* | M | | |
| 2.4 | Settlement | | | | | M | | |
| 2.5 | Regulation & Audit | | M | | | | | |
| 3.1 | Operation Directives | | | | | M | | |
| 3.2 | Field Switching Operations | | | | | M | | |
| 3.3 | Immediate Operation Planning | | | | | M | | |
| 3.4 | Dispatch & Control | | | | | M | A | |
| 3.5 | Information Gathering and Analysis | | A | A | A | M | A | |
| 3.6 | Procurement of Ancillary Services | | | A | A | M | | |
| 4.1 | Access Directives | | M | | | M | | |
| 4.2 | Connection Planning | | | A | A | M | | |
| 4.3 | Set Connection Charges | | M | | | M | | |
| 4.4 | Connection Licensing and Permit | M | | M* | M | | | M |
| 4.5 | Connection Construction | | | A* | A | M | | |
| 4.6 | Connection Operation | | | M* | M | M | | |
| 4.7 | Connection Maintenance | | | M* | M | M | | |
| 5.11 | Net. and Transmission Substations ownership | | | | | M | | |
| 5.12/13 | Net. Maintenance policies and Planning | | | | | M | A | |
| 5.14 | Net. Maintenance Work | | | | | M | M | |
| 5.15 | Net. Technical Upgrading | | | | | M | | |
| 5.16 | Net. expansion (and/or upgrading) – Detailed Design | | | | | M | M | |
| 5.17/18 | Net. expansion – Construction & Commissioning | | | | | M | M | |
| 5.21 | Subs. Ownership | | | | | M | A | |
| 5.22/23 | Subs. Maintenance policies and Planning | | | | | M | M | |
| 5.24 | Subs. Maintenance Work | | | | | M | M | |
| 5.25 | Subs. Technical Upgrading | | | | | M | | |
| 5.26 | Subs. expansion (and/or upgrading) – Detailed Design | | | | | M | | |
| 5.27/28 | Subs. expansion – Construction & Commissioning | | | | | M | | |
| 6.1 | Revenue Requirements | | M | | | A | | |
| 6.2 | Set Tariff | | M | | | A | | |

Table A.9 Example Assumptions on ISO Responsibility (Main (M) or Associate (A) Actors)

| | Actor | Gov | Reg | GPC | IPP | TSO | TOC | Dis | Loc |
|---------|--|-----|-----|-----|-----|-----|-----|-----|-----|
| 1.11 | Directives | M | M | | | | | | |
| 1.12 | Long-term Demand Forecast | M | | | | M | | M | |
| 1.21 | Gen. Development Master Planning (up to 15-40 years) | M | | | | M | | | |
| 1.22 | Gen. Technologies Studies | A | | A | | M | | | |
| 1.23 | Gen. Development Planning (up to 5-10 years) | M | | M | A | | M | | |
| 1.24 | Gen. Statutory Planning | M | | A | A | M | | | |
| 1.25 | Gen. Projects statutory and environmental licensing | M | | M | M* | | | | M |
| 1.26 | Gen. Project Construction Permits | A | | M | M* | | | | M |
| 1.27 | Gen. Statutory Feasibility Phase Management | | | M | M* | | | | |
| 1.31 | Trans. Development Master Planning (up to 15-20 years) | M | | | | M | M | | |
| 1.32 | Trans. Technologies Studies | | | | | M | M | | |
| 1.33 | Trans. Development Plan (up to 5-10 years) | M | | | | M | M | M | |
| 1.34 | Trans. Statutory Planning | M | | | | | M | M | M |
| 1.35 | Trans. Equipment Specifications | | | | | M | M | M | |
| 1.36 | Trans. Right of Way and environment licensing | M | | | | | M | M | M |
| 1.37 | Trans. Projects Construction Permit | | | | | | M | M | M |
| 1.38 | Trans.n Statutory Feasibility Phase Management | | | | | | M | M | |
| 1.41 | Subs. Development Master Planning (up to 15-20 years) | | | | | M | M | M | |
| 1.42 | Subs. Technologies Studies | | | | | M | M | M | |
| 1.43 | Subs. Development Plan (up to 5-10 years) | M | | | | M | M | M | |
| 1.44 | Subs. Statutory Planning | M | | | | | M | M | M |
| 1.45 | Subs. Equipment Specifications | | | | | M | M | M | |
| 1.46 | Subs. statutory and environment licensing | M | | | | | M | M | M |
| 1.47 | Subs. Projects Construction Permit | | | | | | M | M | M |
| 1.48 | Subs. Statutory Feasibility Phase Management | | | | | | M | | |
| 2.1 | Directives and Rules | M | A | | | A | | | |
| 2.2 | Information Spreading | | A | | | M | | | |
| 2.3 | Operation | | | A | A* | M | | | |
| 2.4 | Settlement | | | | | M | | | |
| 2.5 | Regulation & Audit | | M | | | | | | |
| 3.1 | Operation Directives | | | | | M | | | |
| 3.2 | Field Switching Operations | | | | | M | A | | |
| 3.3 | Immediate Operation Planning | | | | | M | | | |
| 3.4 | Dispatch & Control | | | | | M | | A | |
| 3.5 | Information Gathering and Analysis | | A | M | M | M | M | A | |
| 3.6 | Procurement of Ancillary Services | | | A | A | M | | | |
| 4.1 | Access Directives | | M | | | M | M | | |
| 4.2 | Connection Planning | | | A | A | M | M | | |
| 4.3 | Set Connection Charges | | M | | | A | M | | |
| 4.4 | Connection Licensing and Permit | M | | M* | M | | M | | M |
| 4.5 | Connection Construction | | | A* | A | | M | | |
| 4.6 | Connection Operation | | | M* | M | M | | | |
| 4.7 | Connection Maintenance | | | M* | M | | M | | |
| 5.11 | Net. And Transmission Substations ownership | | | | | | M | | |
| 5.12/13 | Net. Maintenance policies and Planning | | | | | M | M | A | |
| 5.14 | Net. Maintenance Work | | | | | A | M | M | |
| 5.15 | Net. Technical Upgrading | | | | | M | M | | |
| 5.16 | Net. expansion (and/or upgrading) – Detailed Design | | | | | A | M | M | |
| 5.17/18 | Net. expansion – Construction & Commissioning | | | | | | M | M | |
| 5.21 | Subs. Ownership | | | | | | M | A | |
| 5.22/23 | Subs. Maintenance policies and Planning | | | | | M | M | M | |
| 5.24 | Subs. Maintenance Work | | | | | | M | M | |
| 5.25 | Subs. Technical Upgrading | | | | | A | M | | |
| 5.26 | Subs. expansion (and/or upgrading) – Detailed Design | | | | | | M | | |
| 5.27/28 | Subs. expansion – Construction & Commissioning | | | | | | M | | |
| 6.1 | Revenue Requirements | | M | | | | A | | |
| 6.2 | Set Tariff | | M | | | A | A | | |

Table A.10 Example Assumptions on RTO Responsibility (Main (M) or Associate (A) Actors)

| | Actor | Gov | Reg | GPC | IPP | TSO | TOC | Dis | Loc |
|---------|--|-----|-----|-----|-----|-----|-----|-----|-----|
| 1.11 | Directives | M | M | | | | | | |
| 1.12 | Long-term Demand Forecast | M | | | | M | | M | |
| 1.21 | Gen. Development Master Planning (up to 15-40 years) | M | | | | M | | | |
| 1.22 | Gen. Technologies Studies | A | | A | | M | | | |
| 1.23 | Gen. Development Planning (up to 5-10 years) | M | | A | A | | M | | |
| 1.24 | Gen. Statutory Planning | M | | A | A | | | | |
| 1.25 | Gen. Projects statutory and environmental licensing | M | | M | M* | | | | M |
| 1.26 | Gen. Project Construction Permits | A | | M | M* | | | | M |
| 1.27 | Gen. Statutory Feasibility Phase Management | | | M | M* | | | | |
| 1.31 | Trans. Development Master Planning (up to 15-20 years) | M | | | | M | M | | |
| 1.32 | Trans. Technologies Studies | | | | | M | M | | |
| 1.33 | Trans. Development Plan (up to 5-10 years) | M | | | | M | A | A | |
| 1.34 | Trans. Statutory Planning | M | | | | M | A | M | M |
| 1.35 | Trans. Equipment Specifications | | | | | M | A | A | |
| 1.36 | Trans. Right of Way and environment licensing | M | | | | | M | M | M |
| 1.37 | Trans. Projects Construction Permit | | | | | | M | M | M |
| 1.38 | Trans.n Statutory Feasibility Phase Management | | | | | M | M | M | |
| 1.41 | Subs. Development Master Planning (up to 15-20 years) | | | | | M | A | A | |
| 1.42 | Subs. Technologies Studies | | | | | M | A | A | |
| 1.43 | Subs. Development Plan (up to 5-10 years) | M | | | | M | A | A | |
| 1.44 | Subs. Statutory Planning | M | | | | M | A | A | M |
| 1.45 | Subs. Equipment Specifications | | | | | M | A | A | |
| 1.46 | Subs. statutory and environment licensing | M | | | | M | A | A | M |
| 1.47 | Subs. Projects Construction Permit | | | | | M | M | A | M |
| 1.48 | Subs. Statutory Feasibility Phase Management | | | | | M | M | | |
| 2.1 | Directives and Rules | M | A | | | A | | | |
| 2.2 | Information Spreading | | A | | | M | | | |
| 2.3 | Operation | | | A | A* | M | | | |
| 2.4 | Settlement | | | | | M | | | |
| 2.5 | Regulation & Audit | | M | | | | | | |
| 3.1 | Operation Directives | | | | | M | | | |
| 3.2 | Field Switching Operations | | | | | M | A | | |
| 3.3 | Immediate Operation Planning | | | | | M | | | |
| 3.4 | Dispatch & Control | | | | | M | | A | |
| 3.5 | Information Gathering and Analysis | | A | A | A | M | A | A | |
| 3.6 | Procurement of Ancillary Services | | | A | A | M | | | |
| 4.1 | Access Directives | | M | | | M | A | | |
| 4.2 | Connection Planning | | | A | A | M | A | | |
| 4.3 | Set Connection Charges | | M | | | M | A | | |
| 4.4 | Connection Licensing and Permit | M | | M* | M | | M | | M |
| 4.5 | Connection Construction | | | A* | A | | M | | |
| 4.6 | Connection Operation | | | M* | M | M | | | |
| 4.7 | Connection Maintenance | | | M* | M | | M | | |
| 5.11 | Net. And Transmission Substations ownership | | | | | M | M | | |
| 5.12/13 | Net. Maintenance policies and Planning | | | | | M | A | A | |
| 5.14 | Net. Maintenance Work | | | | | A | M | M | |
| 5.15 | Net. Technical Upgrading | | | | | M | M | | |
| 5.16 | Net. expansion (and/or upgrading) – Detailed Design | | | | | A | M | M | |
| 5.17/18 | Net. expansion – Construction & Commissioning | | | | | M | M | M | |
| 5.21 | Subs. Ownership | | | | | A | M | A | |
| 5.22/23 | Subs. Maintenance policies and Planning | | | | | M | M | M | |
| 5.24 | Subs. Maintenance Work | | | | | | M | M | |
| 5.25 | Subs. Technical Upgrading | | | | | A | M | | |
| 5.26 | Subs. expansion (and/or upgrading) – Detailed Design | | | | | | M | | |
| 5.27/28 | Subs. expansion – Construction & Commissioning | | | | | M | M | | |
| 6.1 | Revenue Requirements | | M | | | | A | | |
| 6.2 | Set Tariff | | M | | | A | A | | |

A.3.6 Maximal Impacts

Maximal Impact was stated to be the same for all goals. Deciding that the Impact on the Goal is 100 points for all hold together "MUST" functions, the group of "NICE to have" functions was assumed to have maximal impact of 20 points, and so, the groups "Minor Obstacle" and "Major Obstacle" may prevent achieving the Goal respectively, at -15 and -75 points.

Maximal Bonus (actor strong leadership gain) was evaluated in the case in which one Actor is responsible for all the group of functions of a specific Grade. It was attributed only for "MUST" and "Major Obstacle" functions, respectively with 50 and -30 points. Therefore the range of possible performance is between -105 to 150 points. A score of 120 and more for a Goal may indicate that too many resources are invested in it.

Table A.11 Maximal Impacts (Standard and Bonus)

| Function Group Grade | +2 | +1 | 0 | -1 | -2 |
|-----------------------|-----|----|---|-----|-----|
| Standard Group Points | 100 | 20 | 0 | -15 | -75 |
| Bonus Group Points | 50 | 0 | 0 | 0 | -30 |

A.4 Example Case Study Results Given the Assumptions

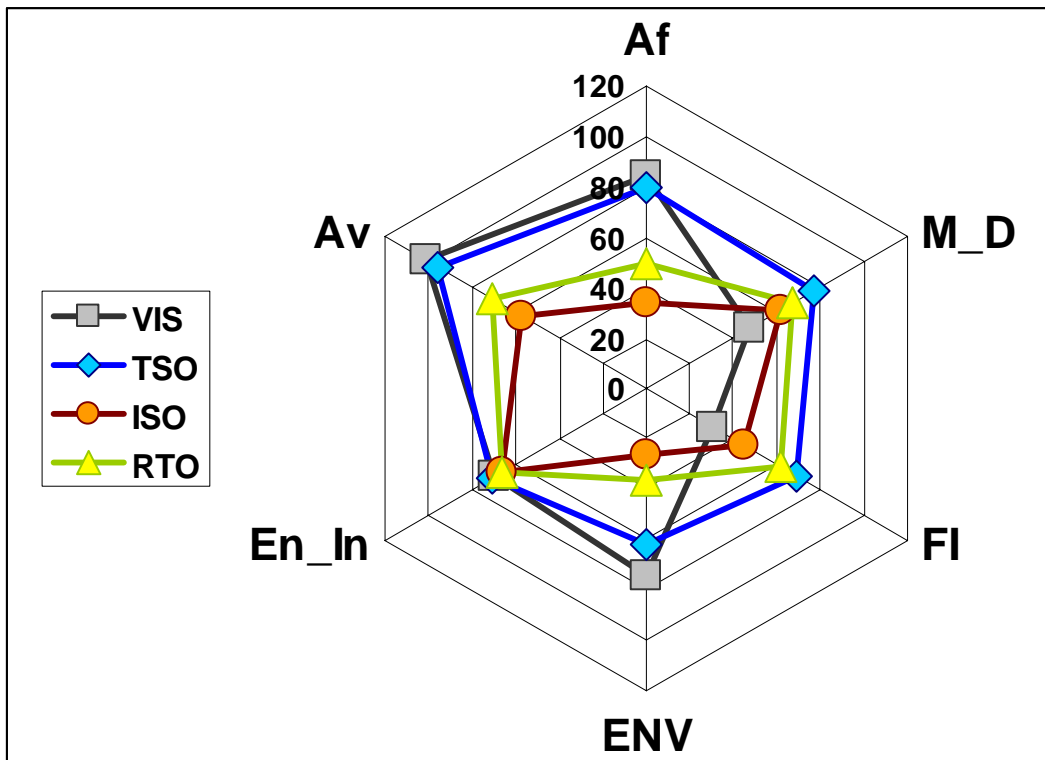


Figure A.2 Structures Impact for the Case Study

Table A.12 Structures Impact for the Case Study

| | Af | Av | En_In | ENV | FI | M_D |
|------------|-----------|------------|-------|-----------|-----------|-----------|
| VIS | 84 | 101 | 70 | 75 | 30 | 47 |
| TSO | 80 | 96 | 70 | 62 | 69 | 77 |
| ISO | 34 | 57 | 66 | 27 | 45 | 62 |
| RTO | 50 | 71 | 66 | 37 | 62 | 67 |

In this Case and given the assumptions noted above, VIS has given the better performances for almost all "collectivity" goals.

TSO leads to sensible improvements of the finance and market.

RTO improves ISO performances but is still far from TSO and VIS achievements.

A.5 Structure Impacts on System Development Goals

The model enables structured discussion and an active mediation among the involved actors and builds a common reference base. It provides sufficient flexibility to be adapted to different principles and cultures.

One conclusion from this Case Study serves to illustrate the potential insight that can be gained from applying the model based on a structured discussion of stakeholders: Given the particular assumptions made, the Case Study indicates that spreading the authority for different system and asset functions among several actors can induce fuzzy responsibility assignments which can decrease the efficiency of the EI Structure toward the Development Goals. One main reason for this can be lower motivation of some market actors towards system development. This corresponds to recent trends in legislation which are modified in order to reinforce the authority and extend the responsibility of the TSO (European directives) and of the RTO (Bill 500).