Charter of Accountability for Transmission Operators

TSO PROJECT

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2002-06-12

Disclaimer

This is the final report on the TSO Charter of Accountability from the first phase in the TSO benchmarking project. The project is undertaken jointly by the energy-regulators in Denmark, Finland, the Netherlands, Norway and Sweden. The report is presented at the TSO workshop June 12-13, 2002.

The contents has not been subject to any formal review, nor endorsement from the Commissionee and expresses only the viewpoint of the authors, who exclusively bear the responsibility for any possible errors.

Summary

This report on the Charter of Accountability elaborates on the methodological, economical and informational challenges involved in the definition of benchmarking metrics for transmission systems.

The transmission operators are few, large and deal with a particularly complex system task. On the one hand, they plan, build and maintain grids in compliance with technical norms of supply reliability. On the other hand, they monitor, price and enforce the real-time electricity market, with a considerable impact upon price formation, market power and market entry. To the complexity adds the fact that they are internally heterogeneous, with differing autonomy and objectives in terms of their main task.

Hence, a fair and constructive assessment of the transmission systems has to be founded in an framework that takes their means and ends into account.

A charter is a written document that defines the franchises, rights and obligations of an organization, in this case a transmission system operator. We discuss six different functions that transmission operators have adopted, and we identify four different regulatory aims, viz coping with independence, externality synergies, efficiency, and the control problem.

A charter clarifies the society's expectations on the transmission operator, but the regulator may desire to do more. The relative autonomy and financial position of the operators rightly require them to be accountable for their operations. Accountability is the obligation or willingness to accept responsibility or to account for one's actions.

The TSO Charter of Accountability is an act of clarifying the functions of the transmission operator and a system of metrics on how to assess these functions. In the spirit of delegation and accountability, the operators and the regulators have a common interest in the definition and implementation of such performance metrics.

The Charter provides a common framework for a series of performance assessment models that are under implementation, along with indications for further development.

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1. Introduction

Background

1.01 The regulatory authorities in Denmark (Danish Energy Regulatory Authority), Finland (Energy Market Authority), the Netherlands (Dte, Dutch Energy Regulator), Norway (NVE, Norwegian Energy Directorate), and Sweden (STEM, Swedish Energy Agency) have jointly conducted a project on international benchmarking of central grids, cf. policy document NVE (2002). The objectives of the project were to (i) conduct an operational benchmarking of construction and maintenance costs and (ii) develop service oriented measures.

1.02 SUMICSID has initiated the work towards comprehensive service measures since the conception of the project (cf. SUMICSID reports *Towards a TSO Service Model,* 2001-11-29). The work has been supported by the regulators and consultants from ECON and Frontier Economics. The results are summarized in this report as the Charter of Accountability, including integration of other models, uncertainty and quality regulation.

Outline

1.03 The report is divided into a descriptive part (chapter 2), an analytical part (chapters 3 and 4), a synthetic part (chapters 5, 6, 7) pointing towards the conclusions (chapters 8 and 9). The first chapter sets the transmission system activities into a wider economic context, relating it to the long-term viability of the open electricity market. The methodological chapter 3 addresses some critical information properties of the evaluation problem, for which solutions of delegation and accountability are formulated in the succeeding chapter 4. The analysis is concretized in the fifth and sixth chapter, where partial and comprehensive measures are defined, contrasted and illustrated. The chapter on comprehensive measures also shows how to achieve a consistent aggregation of partial measures, using among others the ECOM model score as part. Modeling of uncertainty and supply reliability is done in chapter 7, where a range of decision analytical models are presented towards the Energy at Risk and Power at Risk metrics. The synthesis of the evaluation problem and the proposed set of metrics is presented as the Charter of Accountability in chapter 8. The report is closed with conclusions and some suggestions for further work.

Limitation

1.04 The analysis in this report does not explicitly treat issues, albeit potentially relevant, that concern the design, implementation or coordination of national regulations of transmission systems. The analysis is intentionally taking a fairly general and aggregated social welfare objective on the transmission system that may or may not be fully realized at an individual market. Thus, the analysis is freed from given institutional constraints.

1.05 The different countries in the TSO project have different regulatory approaches, different ownerships of the TSO etc. To be useful in the different countries, we shall not embark in any details in policy analysis. Instead we shall focus on the benchmarking aspects that can be useful in a variety of set-ups. On the other hand, to make the project and benchmarking relevant, it is necessary to at least sketch the possible applications in regulatory settings. In particular, it is important to understand the role and tasks of TSO and to do so in centralized as well as decentralized systems. By looking at the spectrum of possible regimes, we get a better picture of good performance measures.

2. Transmission Systems and the Market

2.01 The fundamental objective of a transmission system operator is to ensure the electrical stability of the interconnected system so that electrical energy can be transported from generators to distribution networks. The operator provides open access to the transmission system, monitors and controls system operations to ensure a moment-to-moment energy balance, manages congestion, schedules generation (or reviews the technical feasibility of schedules submitted by others), acquires ancillary services such as disturbance reserves and voltage support, and plans or approves requests for maintenance of transmission and generation facilities. Many system operators also administer spot and real-time balancing energy markets. These operators generally perform metering, accounting, settlement, and billing for the markets, but may also initiate, enforce or administer market instruments related to congestion, supply safety and load control.

2.02 By distinguishing six important functions or roles, the autonomy and independency of an operator may be put in a correct context to enable, among other things, performance assessments. The functions are:

1) Market facilitator
2) System operator
3) Grid builder: planner
4) Grid builder: constructor
5) Grid maintainer
6) Grid owner/leaser

2.03 The first three functions are *strategic functions* with long-term impact on system performance. The fourth and fifth functions are *operational functions* with comparatively less long-term system-wide impacts. The ownership is normally tightly connected to regulatory and institutional practices.

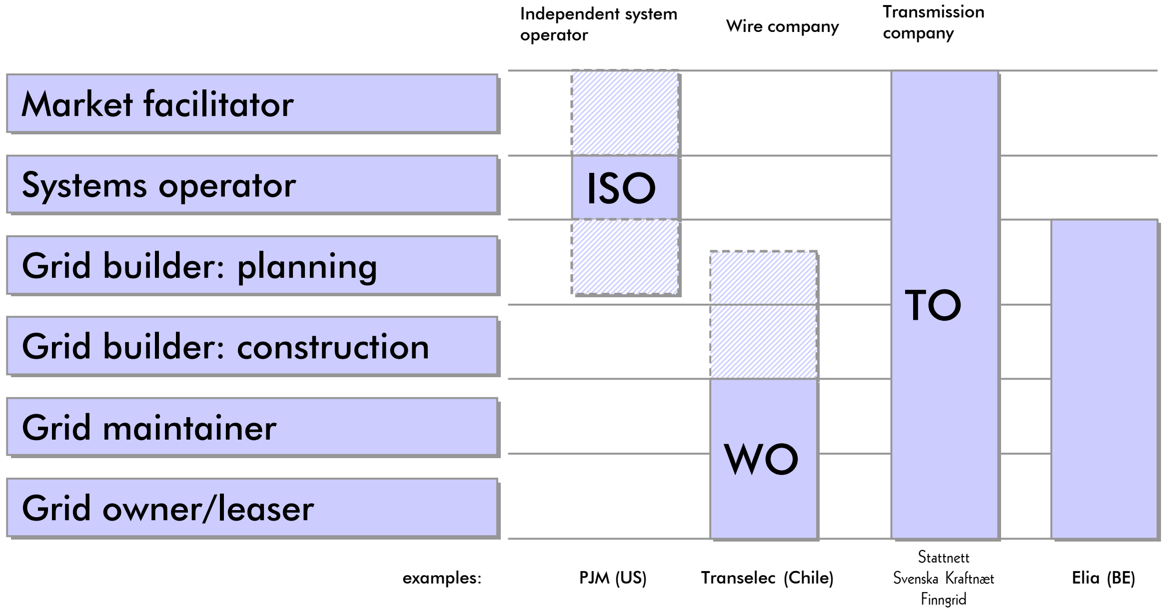

Figure 2.1 TSO Functions and Organizational Type.

Market Facilitator

2.04 The establishment, monitoring and enforcement of an advance electricity exchange require to some extent the informational support of the transmission system operator. The TSO will necessarily be involved in the final settlement of the delivery of the good and may also pose additional fees for its transmission. Independent market operators normally handle the clearing, trading and management of financial instruments for the electricity market. The closest integration of these market operators is information exchange with independent system operators (ISO), such as in UK. However, notably in Scandinavia the integrated TSO have gone further in their support of the market and actively promote trading, develop instruments and guarantee deliveries. To execute this role, they enjoy legal rights to impose fees and contractual conditions, e.g. on cross boundary trade. The rationale for a TSO to take on market facilitation is the strong informational externalities between system operations and market operations. As long as the market is relatively thin and linked to the physical delivery of energy, subject to transmission constraints, a regular financial market maker continues to be dependent on the TSO. From a financial short-term perspective, the execution of this role is relatively inexpensive and may be self-financed through trading fees. From a long-term perspective, the successful design and implementation of trading markets will have a profound impact on the overall effectiveness of the energy market liberalization.

System Operator

2.05 The purpose of system operations is to ensure the real-time energy balance, to manage congestion, to schedule and dispatch generation (or to review the technical feasibility of schedules submitted by others), and to acquire ancillary services such as disturbance reserves and voltage support. System operations are subject to the limitations of the existing grid, but information arrangements and tariff structure may either aggravate or alleviate congestion management problems. Given its central position in terms of market and technical information, the competence and independence of the system operator will have short- as well as long-term effects on social welfare. The Swedish TSO has challenged the notion of the integrality of the task, delegating operational balance services to regional transmission coordinators with limited decision rights. The initiative prompts for a further analysis of the strategic vs. operational contents of the role, with an eye for how best practice operation can be identified, evaluated and documented in an international setting. From a partial benchmarking sense, it is noted that the system operations function provides TSO with tools to both identify and to some extent moderate congestion problems. Thus, partial measures on line utilization should be supplemented with information on the TSOs authority to deal with balancing services.

Grid Builder: Planning

2.06 The analysis, planning and drafting of grid expansion and network installations involve the careful consideration of supply and demand factors over a long-term horizon. In absence of bilateral agreements between the actors themselves, the grid builder assumes the responsibility for the backbone of the market place: the grid. Investments, albeit sequential and incremental, involve substantial amounts of money and have an expected service life of 30 years or more. Observed performance is only an imperfect indication of future performance in this respect, as the complexity has increased considerably following the liberalization of the market. Integrated producer-distributors had possibilities to internalize the benefits of grid investments using information that is no longer available, such as long-term generation capacity planning. Hence, the strategic grid-planning role has to be assessed from a more comprehensive and forward-looking perspective, explicitly addressing future system-wide impacts of current actions.

Grid Builder: Construction

2.07 The physical construction of a grid and the installation of network assets in an existing grid is an example of a large, complex infrastructure project.

Superior information on construction costs may give advantages in grid planning. However, there may also be synergies, positive as well as negative, with other construction projects (pipelines, tunnels, bridges...) that could be used as outsourcing arguments. In either case, the realization of a planned grid extension on time and within a give budget is not a controversial issue for evaluation. Once the grid has been planned, the margin for cost reductions (or slack) is limited in any adequate project management framework.

Grid Maintainer

2.08 The maintenance of a given grid involves the preventive and reactive service of assets, the staffing of facilities and the incremental replacement of degraded or faulty equipment. Although limited in terms of scope, the relative costs are bounded below by the need to maintain adequate supply reliability and rapid disturbance relief. The absence of complete contracts and comprehensive quality measures also limit the ability to pursue drastic cost reductions in this operational activity. Partial benchmarks may also promote suboptimal investment levels at the TSO or at the supply side.

Grid Owner/Leaser

2.09 The collected value of a national transmission grid constitutes a large sunk investment, the dynamic financing of which is the focus of the grid owner. Historically a political role for nationalized grids, it is gradually becoming more professionalized in line with other infrastructure investments (bridges, tunnels, highways). Given a low financial risk and stable revenue streams, the financing of the grid is ideally such that it permits costefficient and timely investments. Arrangements with state ownership under private leasing is another solution to obtain stable operation, each of which is associated with its pros and cons. Integration of grid ownership and operation complicates social welfare analysis, as financing using tariffs endogenously also determines the capital structure. The current trends in TSO point at separation of grid ownership and operation for cross-boundary transmission lines and transit lines.

An example

2.10 An independent system operator (ISO) performs function 2 and potentially influences functions 1 and 3. A grid franchisee without system operations or investment rights is called a wire company (WO), responsible for functions 4 and 5 only. The integrated Northern European transmission operators (TO) are addressing all six tasks, although the devotion and modes of operation vary across countries. E.g., the Swedish TSO has since its conception de-emphasized the non-strategic parts of system operations (decentralized balance services) and grid construction and proactively managed the market facilitation function in cooperation with the Norwegian Statnett (enforcement of open transit trading at NordPool). The importance weights of the functions may be deducted from letters of instruction, electricity acts, internal mission statements, annual reports and accounting statements. An example is given in Figure 2-2, where the some figures for the Swedish TSO SVENSKA KRAFTNÄT are given. The cost allocation to the five functions is for illustration only, but the relative importance between grid owner-builder and maintenance in terms of expenditure is clear.

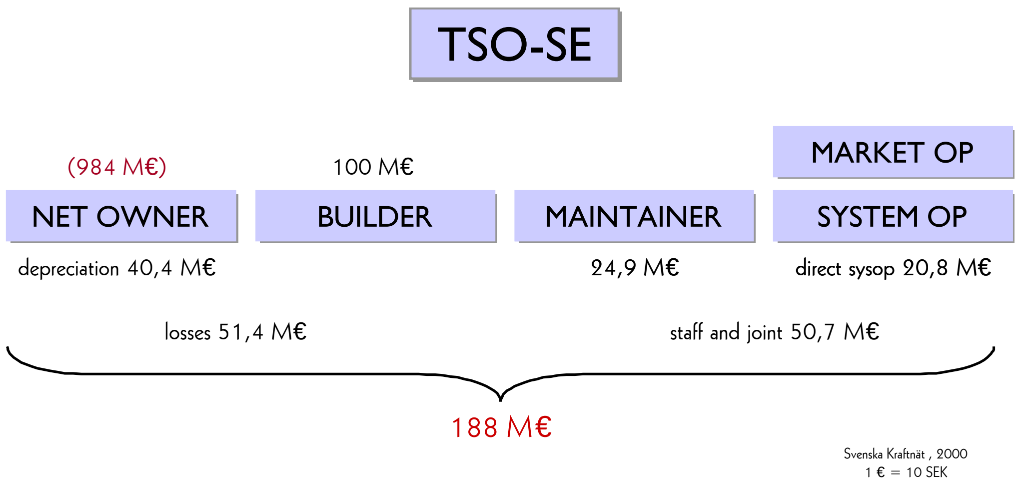

Figure 2.2. A full-service TSO with annual costs figures.

2.11 The legislative or voluntary attribution of functions to a TSO is a matter of compromise between the *independence requirement*, the *externality synergies,* the *efficiency requirement*, and the *control problem*.

Independence

2.12 A transmission operator that handles the strategic market facilitation and system operations functions must be completely independent from the market actors. Independence goes further than just unbundling, since co-ownership or board capture (in non-profit TSOs) by actors would jeopardize the decision autonomy and integrity. Potential entrants in the generation market would be discouraged by the mere suspicion of preferential treatment of incumbents in the construction and operation of the market grid. Sensitive market information could also be exploited by affiliated enterprises to the detriment of market functioning. The independence requirement would favor a state controlled or non-profit governance of the strategic functions.

Externalities

2.13 The joint execution of construction, maintenance and operation on a common grid is associated with positive externalities or synergies. Investments may be made with a comprehensive assessment of lifecycle costs and benefits in comparison also to non-transmission interventions such as system and market operations. Rather than focusing exclusively at more investments in net assets (like a WO or a TO without system operations), or exclusively focusing at market instruments to circumvent a congestion problem (like an ISO), an integrated TO can make socially optimal decisions. Initiatives such as load control using negative power contract, differentiated nodal pricing and other non-transmission solutions are evidence of such optimization. Emphasizing the externalities would highlight the benefits of an integrated organization (TO). However, a joint consideration of the system-wide externalities would speak in favor of a fully integrated production-transmission-distribution system.

Efficiency

2.14 The productive efficiency of the transmission company is a measure of the amount of resources allocated in relation to the achieved benefits for the society. Large structures and in particular public and non-profit organizations with multidimensional tasks have complicated internal incentive problems that lower their productive efficiency. From a pure efficiency viewpoint, a profit maximizing enterprise has a superior motivation in that it can clearly communicate, measure and incentivize its objectives internally. The efficiency requirement in the operations would favor privatized organizations with clearly specified goals, which may be achieved by unbundling the functions.

Control

2.15 The regulator is charged with the task to regulate, or at least monitor, the activities of the TSO. External control of integrated, large enterprises with multiple objectives is a complex task. We will discuss this issue at length in the next section. However, it suffices to conclude that an institutional solution to this problem is found in unbundling the functions. By diminishing the scope and scale of the operations of a regulated entity, external control is facilitated.

Regulatory tradeoffs

2.16 Depending on political, social, technical and economic factors that are beyond the scope of this project, the legislators and regulators have put different weight on the four requirements above, cf. IEA (1998) and Figure 2.3. This fact is not more controversial than the various institutional solutions that countries have formulated for other activities with network externalities, such as railways, higher education, public services and law enforcement. However, the given tradeoff will also affect the mode and scope of an external evaluation of the TSO, as in the current benchmarking project. Returning to Figure 2-1, since the ISO and the WO have no activities in common, a comprehensive measure for their performance cannot be based on direct benchmarking. Analogously, a direct comparison between the grid utilization for a WO and a TO would not yield interesting results, since the WO is limited in its decision authority.

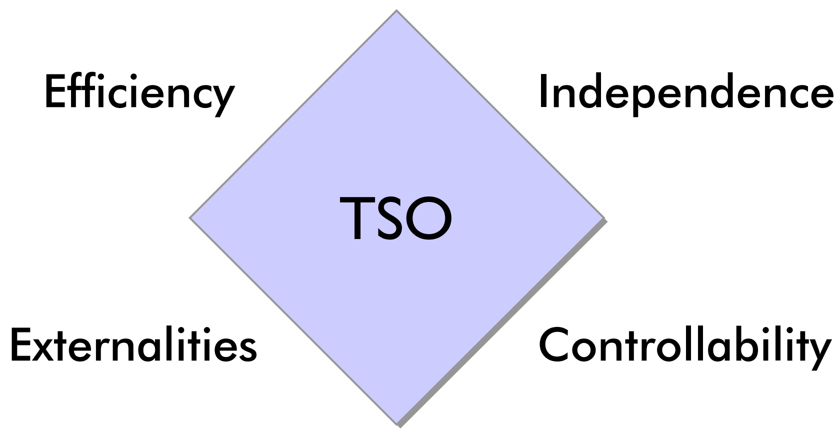

Figure 2.3 The organization of the TSO is a result of a compromise.

Dynamic integration-disintegration

2.17 Economic research in regulation (Estache and Martimort, 2001) has pinpointed the need for dynamism in the regulation of market interfacing natural monopolies, such as the TSO. At the establishment of the market, entry and independence may be more important for the institutional compromise than for an already well functioning market, which focuses more at the efficiency argument. This gradual shift of preferences is then reflected in the regulator's use of instruments and incentives, as well as in the legislative allocation of tasks. Analogously, the fact that the European market has a considerable diversity in the institutional solution is then neither a sign of dysfunction, nor an eternal necessity

Multifaceted evaluation

2.18 Recognizing the multiple functions of the TSO, their importance and interdependence, on the one hand and the institutional design interests that lie behind a certain organizational structure, on the other hand, it is important that the benchmarking reflects the societal interests. To be effective in our quest to coordinate the transmission industry and to motivate optimal efforts, we must find benchmarks that do not only measure the measurable today, but that also warrant for continued and reliable performance in the future.

2.19 As we will show below, there exists a coherent and effective strategy to benchmark the transmission operations. By carefully analyzing the impediments and obstacles for a straightforward relative performance evaluation, we find the key to a mutually interesting challenge for the regulators and the industry. It involves the active participation in defining the procedures and forms for performance assessment, a comprehensive Charter of Accountability including best practice procedures to assess, document and verify system-wide effects.

3. Methodological Challenges

3.01 From a methodological point of view, the evaluation of a TSO is particularly complicated. The asymmetry of information is extreme and the possible consequences of a misleading evaluation are dramatic by the system wide effects.

The asymmetric information

3.02 A typical TSO has – or should have - superior information about the costs and benefits of its operations. This is not a new phenomena in regulation and can to some extent be overcome by moving from absolute effectiveness analysis to relative efficiency evaluations, i.e. by comparing the performance with others and avoiding the weighing together of the multiple dimensions of efficiency. There are reasons to believe however that the informational rents will be particularly large in the case of a TSO.

3.03 The first difficulty concerns the cost side. The difficulty lies in the very limited number of TSOs working under similar conditions. Indeed, the different functions and organizational forms described above as well as the complicating factors we have identified in the TSO benchmarking project suggest that considerable effort is needed to ensure comparability.

3.04 The second complication, concerning the asymmetry of information about benefits, is even more troublesome. The traditional approach is to use several measures to proxy for the different benefit dimensions and to focus on efficiency rather than effectiveness. The difficulty in the case of the TSOs however is that even the delineation of the possible output dimensions is difficult and that the measuring of a TSOs outputs requires the active participation of the TSO. The relevant benefits concerns the creation of social value in the short and long run by reducing the transmission constraints between supply and demand points. To evaluate this in full detail requires very precise information about the structure of the grid, the supply and demand as well as elaborate engineering models of the operation of the electrical system. Also, relevant benefits concerns reliability and safety which most be calculated by coupling the elaborate engineering models with the stochastic nature of the supply and demand. All in all, we believe that it is difficult to make a comprehensive measurement of the benefits of a TSO, even narrowly defined as an intermediate transporter, without collecting vast information about the full chain and indulging in elaborate modeling parallel to what the TSO have – or should have.

3.05 The third difficulty is associated with high social costs of a misleading evaluation. It is well known from the theory of multiple task incentives, cf. Holmström and Milgrom (1991) that if a principal cannot adequately measure the whole range of effects, he may be better off refraining from using high-powered compensation schemes based on partial measures.

The system wide effects

3.06 In the case of a TSO the possible consequences of mis-specified incentives are potentially dramatic as it can have cascading costs in the whole electricity supply chain. The TSO is not a simple production unit transforming inputs to outputs, largely independent of other agents. A TSO is an intermediary in a supply chain and as we know from recent advances in supply chain management, the operation of one stage can have huge chain wide impacts.

3.07 In fact, the special role and position of a TSO has long been acknowledged by lawmakers and TSOs alike and is reflected in the social planner role and the independence that is part of the objective of a TSO. The TSO is a special agent to regulate. It is like a police force or an institution that shall help discipline the production and distribution agents and that shall assist making socially attractive arrangements when private, bilateral arrangements may fail by strategic behavior and the existence of so called public goods and free riding possibilities.

3.08 All of this does not mean that a TSO should not be regulated or benchmarked. In spite of its divine role, it does not mean that it has only noble objectives. It just means that the regulation and benchmarking should be focused more on the role and competence of the TSO as a social planner and less on the possible extraction of rents. It is in most cases likely better to have a slightly fat, but impartial police force or social planner, than a lean and mean police force or planner.

Ways ahead

3.09 Now, given the extreme information asymmetry and the particular role of a TSO as an intermediary with social obligations in a supply chain, how can we proceed to benchmark the TSO in relevant ways? How should a benchmarking exercise of a TSO deviate from a more traditional benchmarking of distribution companies? We suggest that at least two new – but interrelated - perspectives should be introduced. One concerns delegation and accountability and the other the utilization of a spectrum of internally consistent performance measures.

4. Delegation and Accountability

Types of information

4.01 The design of economic mechanisms in general and regulatory schemes in particular depend on the asymmetry of information and the possibility to verify the information that may become available, cf. e.g. Kreps (1990) or Bogetoft (1994).

4.02 If the information that becomes available in the future is *common and verifiable*, it can be contracted upon directly. It simple requires the use of conditional incentive schemes. A CPI-X scheme where the price-cap is adjusted for developments in the CPI exemplifies this.

4.03 Information that is *private but verifiable* can be used in much the same way. One possibility is to undermine the privacy of the information, i.e. to transform the setting into one of common and verifiable information, via relative performance evaluations like in the classical benchmarking of distribution companies. Another is to require privately informed party to provide the necessary documentation and to use this in a pre-announced way, say via a menu of contracts. Compared to the case of private and non-verifiable information considered next, the verifiability of possible signals makes the strategic aspects much less severe. Not all types of cheap talk will work.

4.04 If the information that becomes available is *public but non-verifiable* to a third party, it can be used via renegotiations. By establishing long-term relations and reputation, this can be an effective arrangement. Alternatively, it can be used by agreeing on a menu of contracts a priori and by allowing one of the parties to chooses from this based on new, non-verifiable information.

4.05 Information that is both *private and non-verifiable* is the most difficult to handle. Using a menu of contracts and allowing the well-informed to choose from this using his private information is the obvious possibility. It will allow the parties to take some advantage of the new information but it will also tend to give the well-informed a strategic advantage. Of course, the contractual arrangements can in some cases make the well-informed pay a priori for the right to make decisions a posteriori.

Problem	Verifiable	Non-verifiable
Public	Contractible	Commitment
Private	Secrets, signals	Cheap talk

Solution	Verifiable	Non-verifiable
Public	Complete contract	Renegotiable contracts
Private	Contingent contracts	Menus of contracts

Figure 4.1. The problems and solutions associated with asymmetric information.

Delegation

4.06 The use of a menu of contracts that the well informed can choose from is similar to the *delegation of decision rights* to the best informed. Via the so-called *revelation principle*[1], it can be shown to be the optimal arrangements in many instances of extreme asymmetric information.

4.07 To illustrate, consider the case where the activities of the TSO creates social benefits B and generates costs C. Assume also that the TSO gets private information about B and C. The social benefits and costs may be generated in many ways and places, ranging from improved ability to operate at the optimal scale in generation companies, reduced costs of monitoring in the TSO, improved quality at the consumers or improvement in the environmental impacts on society at large.

4.08 Now, inspired by the general *industrial economics* literature, cf. e.g. Tirole (1989), if the TSO is risk-neutral and not restricted by short term liquidity constraints, an optimal arrangement is that the TSO pays the expected net benefit, E(B-C), for the right to decide on the implementation of possible changes and that it is allowed to extract the actual rents that is hereby realized. This represents a truly decentralized and deregulated regime. Of course, to determine the price of the TSO role, one needs information about the a priori distribution of benefits and costs. Also, in practice, since some of the benefits and costs may be located outside the TSO, the TSO will have to document its impact and to sell the benefits or compensate for the costs it generates.

[1] Cf Myerson(1979)

4.09 A less radical regime inspired by the *capital budgeting* literature, cf. e.g. Antle et al. (1999), that is optimal under limited liability is that the regulator defines cost threshold or compensation levels to the TSO depending on the benefits that it can document. By rationing the investments the regulator reduces the informational rents that the TSO can extract. Again, this arrangement requires that the TSO can document the values it generates – and that the regulator has some a priori information about the distribution of costs.

4.10 The aim of the present TSO project is not to develop regulatory policies and we shall therefore not discuss the delegated arrangements in details here. The aim of the above discussion of menu of contracts and delegated decision making is simply to point to an alternative to traditional benchmarking that may be particularly relevant in view of the extreme asymmetry of information and the potential impact of mis-specified incentive plans.

Accountability

4.11 Under menu based schemes and conditionally delegated decision making, the *burden of proof* as to the costs and benefits of different TSO activities is at least *partly reversed*. It now rests on the TSO. This is natural given their superior information and access to models etc.

4.12 Reversing the burden of proof does however not solve all problems. The regulator may find it difficult to evaluate the documentation forwarded by the TSO. In theory, this can lead to a situation, where the TSO enjoys excessive rents and pursues private objectives, as the regulator cannot evaluate the documentation of cost reduction and goal alignment forwarded by the TSO. This raises the need for the regulator to discipline or at least challenge the TSOs documentation activities.

4.13 The regulator can discipline the TSO claim of net social welfare effects in at least two ways in the setting under reversed burden of proof.

4.14 First, he can make partial if not comprehensive performance evaluation whenever possible. Especially on the costs side, i.e. in the evaluation of C, traditional benchmarking tools as exemplified by the *Maintenance* and the *Intermediate Service models*, respectively, can be useful. Hence, we believe that there are still important uses of the *partial cost benchmarking exercises*.

4.15 Secondly, the regulator can develop *Charter of Accountability*. By defining which aspects to document and which aspects are important and by using best practice methods to provide such documentation, the regulator can at the same time contribute to goal alignment and challenge the TSO. The Charter of Accountability is particularly relevant in the documentation of the benefit side B.

Partial measures

4.16 We believe therefore that by comparing ways to document social welfare effects and the system wide impacts of TSO decisions, and by making *best practice benchmarking of these documentation procedures*, the individual regulator can discipline the TSO use of the (conditionally) delegated decision power.

4.17 At a principal level, we can distinguish at least two types of documentation with associated regulatory responses.

4.18 First, a TSO can negotiate direct *bi- or trilateral agreements* with the producers and distributors. Changes that – possibly after a redistribution of gains – are win-win solutions (Pareto improving) can be implemented by the TSO directly. No documentation is required – except possibly for statements from the parties that the independence requirement is not violated. Cf. Bushnell and Stoft (1995), Wu and Varaiya (1995).

4.19 In other cases the TSO can identify decisions with positive net social welfare effects, but without being able to finance these because of collective goods aspects and *free riding*. In such cases the TSO must document the net gains by information about benefit and cost impact throughout the chain. Such decisions, if sufficiently documented, can be implemented by the regulator granting general tariff changes.

4.20 An example of such elements of a charter of accountability is the Norwegian quality imbursement scheme. Here, the documentation of impacts is standardized via outage costs for different groups etc and the distribution companies are allowed to extract all the rents from adaptations of the quality level.

5. Partial Measures

5.01 Incentive theory suggests that any information source that can improve the regulator's inference about the TSO's activities are useful, cf. the seminal studies by Holmström (1979,82). In this chapter, we discuss different *partial measures* that may be employed in the performance assessment. The chapter ends with examples of partial measures

5.02 By the focus of the information source, one can distinguish between input based, output based or process based evaluations.

Input-based measures

5.03 The traditional difficulties in incentive theory are related to the so-called effort and ability of the agent. If the effort and ability inputs can be observed directly, one can make *input based incentive schemes* that effectively eliminates the TSO's information rent. If the effort and ability cannot be observed, one must live with second-best arrangement leaving some information rents to the agent.

5.04 In a second best world, an input based analysis, like a cost model, can still be useful. The intuition is that the aim will now be to minimize the observable inputs that can substitute for the non-observable ones. Such a partial input based approach is particularly relevant in cases, where the agent has no direct control over the outputs.

Output-based measures

5.05 As a substitute or supplement to a partial input based approach one can use an *output-based scheme*. The intuition is that for fixed values of the observable inputs, higher levels of effort and abilities will be associated with a higher output. An output-based approach is the obvious choice when the inputs are fixed or sunk.

5.06 As we have explained above, the complexity of a TSO's activities and their organizational forms, make it difficult to define a comprehensive set of inputs and outputs. Moreover, should a list of relevant outputs be delineated, it is still very difficult for an outside observer like the regulator to measure the amount of outputs produced. In fact, the outputs are more or less private information to the TSO, if at all observable. The regulation may also have such emphasis on externalities and independence that the scope of delegated operations prompts for measurement only of final output, i.e. social welfare effects in the chain. As will be discussed, the estimation/determination of these effects depend to some extent on the capabilities of the operator to assess them. Indications of operator capabilities thus increases the value of non-verifiable information on performance.

5.07 In such cases, it is natural to seek other sources of information. Interesting information may be extracted from the internal procedures of the TSO. This leads to so-called *process benchmarking*. In a process benchmarking the processes of a TSO may be evaluated, often by comparison with other TSOs.

Process benchmarking

5.08 A process oriented benchmarking approach may serve several purposes in the TSO evaluation. First, using the information theoretic arguments above, it is one way to gauge the general effort level and ability of a TSO. Second, it gives a good starting point for investigating the implemented TSO objectives. It may hereby contribute to goal-alignment. Thirdly, it is provides useful information about the likely performance of the TSO in the future – information that is difficult to extract solely from observations of performance today.

5.09 An analogy with university evaluations is relevant here. The outputs of university departments are difficult to characterize using readily measurable indicators. The essential output of a university department is the social benefits it generates in the long run from the information it produces today. Instead, evaluations use a serious of proxies like number of PhDs. students, number of publications etc even though they are only indicators with some uncertain correlation with the social value 10-20 years down the road. In addition, university evaluations often involve peer reviews. A group of professors from similar departments visits the department and delineate the working relationships, the working relationships between PhDs. students and tenured faculty, (informal PhD. training), the support facilities, the incentive structures, the carrier opportunities etc. None of the procedures and structures are outputs in any absolute sense but the general idea is that they makes it more likely that the relevant outputs will be delivered in reasonable amounts also 10 years from now.

5.10 In a TSO, some of the relevant processes for potential process benchmark are

- The delegation of overall objectives internally in the organization

- The measurement of progress towards objectives
- The internal incentive system
- The competence improvement procedures
- The cost accounting systems
- The procedures for investment review
- The participation in regional/European coordination
- Etc.

5.11 To develop a comprehensive list of processes to benchmark, one can use a hierarchical breakdown of the overall objective, maximization of social welfare for example, into the coordination, motivation and transaction costs dimensions in the short and the long run.

TSO Reorientation

5.12 The complexity of the TSO operation may in broad terms be classified from the perspectives of *technological* and *market* dynamics. In pre-liberalization periods where the rate of technological change has been high, the operators have been forced to adjust their assets and procedures to new materials and technologies. However, largely the pre-liberalization was characterized by large stability in the technology and market. Naturally, such conditions of great predictability lead to a focus of planned optimality and cost efficiency, goals that could be pursued in the integrated utilities. In the deregulated era, the rate of market change has rapidly increased by the introduction of new markets and more strategic generator behavior. This situation requires new skills from the TSO, not only to plan, construct and maintain a grid for a given demand, but to really focus at the market intervention role matching supply and demand. The change towards market facilitation can also be interpreted as a urge for higher system flexibility, where the processes and services of the TSO must undergo the same scrutiny as in competitive firms. From a regulation and evaluation viewpoint, proofs of such adaptive capability are non-existing in the past, but vital for the future level of social welfare. Process benchmarking may here contribute to document the ability of the TSO to adjust and proactively shape the market dynamics.

Micro-management?

5.13 A regulator may micromanage a firm by requiring detailed information about its operations to (i) directly intervene or (ii) allocate or dimension reimbursements. Micro-management is likely to be socially costly under asymmetric information. The principles of the Charter are such that the better informed firm has an interest to disclose information to pre-empt intrusive or distorted intervention by the regulator. We suggest that the regulators encourage rather than compel the TSO to such disclosure.

Example 1: Grid planning

5.14 The grid-planning role is one of the most important and complex of the TSO functions. Without any claim of exhaustiveness, we will illustrate the Charter concept with a partial analysis of the role.

5.15 The objective of the grid planner can be to address future capacity expansion demands in a cost-efficient and reliable way. Thus, it involves a stochastic analysis of future supply, demand and transmission technology.

5.16 The means of a grid planner are tools and staff in combination with information about the existing grid and forecasts of supply and demand.

5.17 The information can be obtained as *input-, output-* or *process-based* indicators. Below we give some examples on such measures. *Note immediately that it is not the intention to assess all these measures, but to illustrate how a complex planning problem can be attacked using partial information.* It is the purpose of the ongoing project to generate and critically evaluate such indicators.

5.18 The inputs to the planning functions are gross measures that may be compared to other means to dealing with supply reliability management, e.g. negative power contracts and generation capacity contracts.

- Annual investments in grid expansion
- Fixed budget (staff, equipment) for investment planning

5.19 Output based measures center on the value of the new expansion.

- Expected average energy cost incl. transmission
- Expected total congestion costs
- Expected cost of interruption (different scenarios)
- Expected frequency of interruption (total and in segments)
- Expected duration of interruption (total and in segments)
- Expected change in share of losses per transmitted energy unit

5.20 The process-based measures focus at the way the planning is undertaken, with particular focus at the *staff, tools* and the *procedures.*

Staff

- Average educational level per employee (in planning)
- Training days per year and employee (in planning)
- Staff turnover (%)
- In-house research department (y/n)
- Trainee program (y/n)
- Average salary level, controlled for age, education and seniority
- ...

Planning tools

- Type of planning model (deterministic, stoch.)
- Scope of model (supply, demand, transmission losses)
- Demand elasticity model
- Generation behavior model (monolithic, decentralized)
- Climate model
- Pricing model (data, function, assumptions)
- Output documentation (intervals, NPV)
- ...

Procedures

- Investment reviews (scope, documentation)
- Turn-around time for investment analysis (average)
- Follow-up of past investments (projects, losses, congestion)
- Model revision system (in-house, consultants)
- ...

5.21 As the planning activity is inherently addressing a future market that is functionally different from the regulated system, the process dimension is initially more important than the input and output measures. Gradually, as data become available, one may use incremental difference measures for output, comparing incremental improvements of social welfare rather than absolute levels.

Example 2: Grid ownership

5.22 Owning the grid is not much of an effort on behalf of the operator, but financing its expansions involves the same financial skills as for any infrastructure investment. It goes without saying that public ownership has advantages in terms of risk premium, but not necessarily in terms of timing and flexibility.

5.23 The objective is to find a minimum cost financing with adequate risk exposure and flexibility for expected future growth.

5.24 The means are the standard financial operations (equity, loans, bonds, leasing etc.), extended with possible ways to directly finance investments through augmented tariffs in some legislations. The function may be outsourced to the government or handled by the operator.

5.25 The information obtained is quantitative and simple to analyze. Since the underlying risk is small, the financial operations should reasonable have the same standards as any corporate financing of the same scale.

5.26 Some output-based measures are

- Weighted cost of debt (proportion of different duration)
- Exposure to foreign currency
- Average yield on liquid assets and short liabilities
- Value-at-risk (95% and 99%) to interest rate and currency.
- Distribution of duration of long loans

5.27 The obtained measures may be readily compared to other financing, which could give input to international discussions on WACC for regulators with rate of return regimes.

6. Comprehensive Measures

6.01 It lies beyond the scope of this project, and probably beyond what is theoretically possible at present, to derive a comprehensive measure that gives a global performance assessment of a TSO. This explains why we suggest to use of a series of partial measures involving both input, process and output evaluation elements.

6.02 Still, adequately defined numerical performance measures of a larger share of the TSO activities have obvious advantages in regulation. Simply compiling a list of (relevant) partial measures leaves much of the discretion (and burden) on the regulator. The regulator must decide how to use the different measures. We will illustrate how the partial measures can be used elsewhere. What is obvious, however, is that although guidance can be given, the trade-offs and relative importance of the partial measures is largely left at the regulator's discretion. A comprehensive approach is superior in this respect. We will therefore discuss how to move towards such evaluations in this section.

6.03 Our discussion will put the ECOM (Efficiency of Construction, Operations and Maintenance, cf. Munthe, 2002) and the proposed NMT (Network Modeling Tool) measures in perspective by showing how they fit together and what they include and exclude. Our discussion will also indicate how the sequence of model based measures started with the ECOM and the proposed NMT measures can be extended in future developments of the TSO project.

Principle

6.04 The regulator is ultimately vested with the task to assure that the electricity market *chain value*, i.e. the consumers' benefits less producers' cost, is maximized (or at least improved). The monitoring of the TSO cost is one step that should be accompanied with an estimate of the chain effects. The difference between the two effects is particularly evident for the strategic activities related to grid planning, congestion management and market facilitation, that involve fairly limited direct TSO costs but large welfare impact. Hence, we offer a parallel analysis in the following where the TSO costs and the chain value are analyzed.

The ECOM and NMT measures

6.05 In the construction and maintenance model, ECOM, the actual (standardized) building and maintenance costs are gauged against the costs of building and maintaining the equipment using efficient construction and maintenance procedures. The latter is a measure of grid size or standardized replacement value – or simply grid equipment costs. This leads to the unit costs

$$\frac{\text{actualcosts}}{\text{equipmentcost}}$$

A high value indicates a problem in the maintenance and construction activities of the TSO, or a deviation from the normalized quality standard that the equipment costs are defined for.

6.06 The ECOM model does not evaluate whether the existing components are the relevant ones. Freezing the routing and evaluating only the installed assets along existing corridors, we can measure the corridor capacity (in) efficiency by the unit capacity costs

$$\frac{\text{equipmentcosts}}{\text{corridor capacitycosts}}$$

where the corridor capacity costs are the necessary costs if the supply and demand points are connected along the existing corridors as measured by the network modeling tool (NMT).

6.07 In total, the two models give a decomposition of some of the inefficiency of a TSO:

$$\frac{\text{actualcosts}}{\text{equipmentcosts}} \bullet \frac{\text{equipmentcosts}}{\text{corridor capacity cost}}$$

6.08 If the first ratio is high, it suggests that the TSO has a particular problem in the construction and maintenance activities and that alternative procedures, e.g. outsourcing of the maintenance or purchasing via a tender procedure, may be useful. If the latter factor is large, it indicates that the planning activities could be improved. In particular, the sequential updating of the equipment along the different corridors may be inadequate.

6.09 From a methodological perspective, in both models the calculated costs, i.e. the model costs viz. the equipment costs and the corridor capacity costs

– may not correspond to real costs in an absolute sense. The general expectation however is that there is a *homothetic* relationship between models and reality in the sense that model captures a certain percentage of the real costs – and that this percentage is the same for all TSOs. To make the individual partial measures meaningful on their own, we may then measure against another TSO, most obviously the best TSO in the dimension we consider, using

$$\frac{\text{actual costs}}{\text{equipment costs}} / \min_{TSO} \frac{\text{actual costs}}{\text{equipment costs}}$$

$$\frac{\text{equipment costs}}{\text{corridor capacity cost}} / \min_{TSO} \frac{\text{equipment costs}}{\text{corridor capacity cost}}$$

This would also correspond to the actual usage of the partial measures in the regulation of annual revenue caps. The second measure would then provide one (of several) correctional factors for the continued usage of partial measures of the ECOM type. A firm that continuously lowers its grid planning efficiency while increasing its ECOM score could then be challenged on its investment policy.

Further costs and benefit decompositions

6.10 The ECOM and NMT approaches only cover part of the construction and planning activities. In principle, however, we can continue the identification of inefficiency components in other parts of the TSO activity portfolio.

6.11 We can for example include financing efficiency by decomposing the first factor into on addressing financing and one capturing the construction aspect

$$\frac{\text{actual costs}}{\text{financial costs}} \bullet \frac{\text{financial costs}}{\text{equipment costs}} \bullet \frac{\text{equipment costs}}{\text{corridor capacity cost}}$$

where the financial costs here are the capital costs for the actual asset base using optimal financing. A high value of the first score would indicate a comparatively higher financing cost, perhaps an issue of regulatory choice (prescribed WACC, limited financing options). A high value of the second score would challenge the officers responsible for construction and maintaining – or for organizing the tenders in case the activities are outsourced.

6.12 We will now illustrate how the full sequence of costs and benefits associated with all the TSO's activities could be decomposed along similar lines. The crucial question in any such decomposed benchmarking procedure is to decide what is *variable* or controllable, i.e. what the benchmarking model can optimize over, and what is *fixed*, i.e. what the benchmarking model at the given step takes for given. The evaluation at any level is then the possible gains from improving the controllable factors, the variable, and leaving the non-controllable, the fixed, at the realized value.

6.13 The choice of relevant controllables will be a compromise between the desirable and the possible. It is desirable to make the controllables be variables that the TSO directly or indirectly can affect. Hereby, the measurement can be used to make the TSO accountable for its activity. On the other hand, administrative costs, complexity, modeling and data limitations limit the range of feasible analyses. A pragmatic solution in this case will be to freeze some variables at their actual values.

A comprehensive decomposition

6.14 A possible comprehensive decomposition could involve the five essential TSO activities. Here we have grouped two of them, construction and maintenance and decomposed one of them, planning, to make the decomposition consistent with the ECOM and NMT measures. The decomposition is illustrated in the table below.

Table 6.1 Decomposition of TSO costs and chain value.

TSO Activity	Variable Optimize over all below	Fixed Constrained by all above	TSO Costs	Chain Value
Future (Long term ideal)	S&D Costs and Benefits and their location	Demography Topology Weather	Long run transmission costs	Long run Unconstrained Chain Value
Market Facilitation	Matching S&D bids	S&D Costs and Benefits	Cost and Benefit matching costs	Unconstrained dispatch Chain Value
Sys.Ope.	Matching S&D profiles	S &D bids	Bid matching costs	Chain value given strat.behav.
Planning	Routing	S&D profiles	Capacity Costs	Present Chain value
	Equipment	Routing	Corridor Costs	Present Chain value
Construction and Maintenance	Prices, hours etc	Equipment	Equipment costs	Present Chain value
Financing	Loans	Capital need	Financial costs	Present Chain value
Present			Act. Constr. & Maint. Costs	Present Chain value

6.15 In the Table 6.1 above, we have distinguished between the following profiles

Generation and load profiles / S and D profiles:
The realized generation time series and consumption time series in the different, possibly aggregated, nodes under present operations

Generation and load bids / S and D bids:
The generation and consumption bids over time in the different, possibly aggregated, nodes under present operation. The bids combined with the dispatching procedures determines the profiles.

S&D costs and benefits / Marginal Costs and Benefits:
The underlying marginal production costs and marginal consumption values. Combined with strategic behavior, they generate the S and D bids.

6.16 Also, the TSO costs concepts we use are defined as follows

Financial Costs
Minimal cost of financing the capital needs of the TSO.

Equipment Costs
Minimal cost necessary to buy, install, maintain and operate the kits the TSO presently have.

Corridor Costs
Minimal costs necessary to install, maintain and operate sufficient capacity along the existing corridors to match present generation and load profiles.

Capacity Costs
Minimal costs necessary to install and operate on a green field the capacities necessary to match present generation and load profiles.

Bid Matching Costs
Minimal costs necessary to install and operate on a green field the capacities necessary to match present supply and demand bids and to operate the Systems Operations that clears the bidding games.

Cost and Benefit Matching Costs
Minimal costs necessary to install and operate on a green field the capacities and system operations costs necessary to match present cost and benefit curves.

6.17 The Chain values are defined as follows:

Present Chain Values
This is the net chain values, i.e. the difference between the consumer benefits and producer costs in the presently realized generation and load profiles.

Chain Values given strategic behavior
This is the difference between consumer benefits and producer costs that will be realized with improved systems operations when the strategic bidding is taken into account.

Unconstrained dispatch Chain Value
This is the difference between the consumer benefits and producer costs that can be realized if strategic behavior is eliminated through market making activities.

Long run unconstrained Chain Value
This is the difference between the consumer benefits and producer costs that can be realized when the location and composition of generation and demand is improved.

6.18 Observe that to evaluate the chain net benefits, the TSO must predict the behavior of producers and consumers. The connection between their (marginal) costs and benefits and the observed load and generation profiles depend on their strategic behavior and the market clearing mechanisms. In tern, this depend on all TSO activities, most notably the planning, systems operations and market facilitation activities. Figure 7.1 illustrates this.

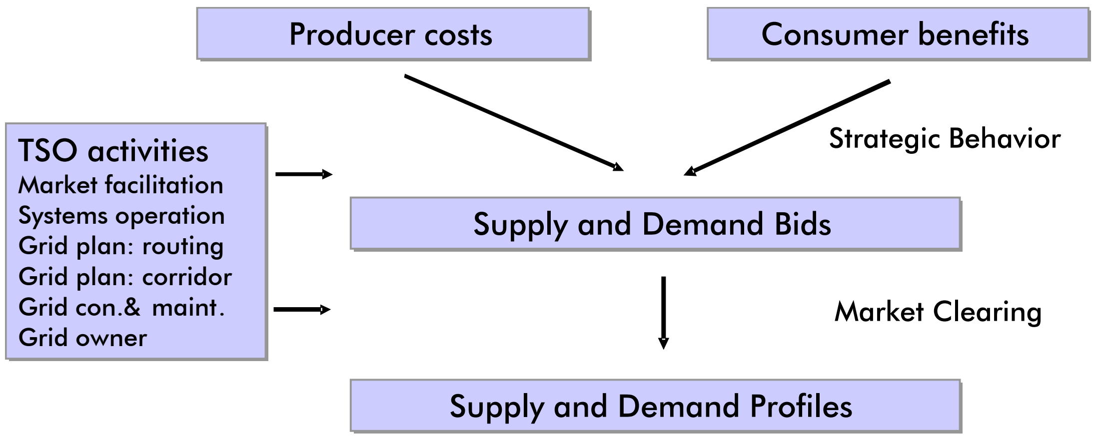

Figure 6.1 - Chain responses to TSO actions.

Examples

6.19 To illustrate the subsequent efficiency measures and efficiency decompositions, it is useful to think of a more specific example. A hypothetical illustration is given in Table 6.2 and Figures 6.2 and 6.3 below.

Table 7.2 Decomposition of TSO costs and chain value.

TSO Activity	CapEx	OpEx	Chain Value	Marg. CapEx	Marg. OpEx	Marg. Chain Value
Future (Long term ideal)	70	22	140	0	0	10
Market Facilitation	70	22	130	-10	-2	10
Systems Operations	60	20	120	0	-4	10
Planning Route	60	16	110	5	-1	0
Planning Equipment	65	15	110	5	-2	0
Construction and Maintenance	70	13	110	20	-2	0
Financing	90	11	110	10	-1	0
Present	100	10	110	0	0	0

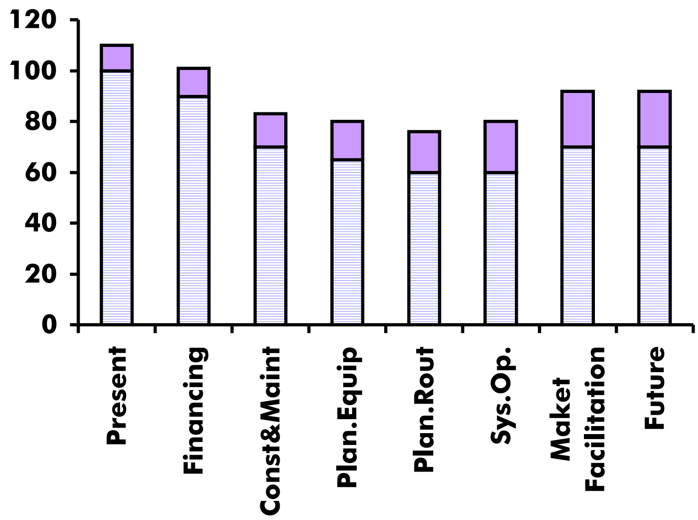

Figure 6.2 TSO costs (capex + opex).

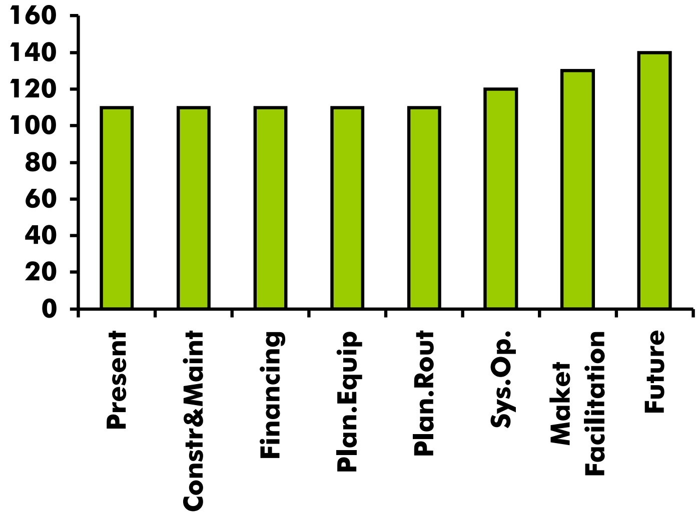

Figure 6.3 Chain values.

Efficiency measures

6.20 With a series of costs and benefit measures as illustrated in the table above, one can make decomposed efficiency analysis using either ratios or differences.

6.21 The use of *ratios* has already been illustrated above. In principle, one can continue the sequence of ratios to give a full decomposition of TSO costs

Table 6.3 Ratio decomposition of TSO costs.

TSO Activity	TSO Costs	Efficiency Indices	Scores
Future (Long term ideal)	Long run transmission costs	C & B Matching Costs / LR Transmission Costs	92/92 = 1.00
Market Facilitation	Cost and Benefit matching costs	Bid Matching Costs / C & B Matching Costs	80/92 = 0.87
Systems Operation	Bid matching costs	Capacity Costs / Bid Matching Costs	76/80 = 0.95
Planning	Capacity Costs	Corridor Costs / Capacity Costs	80/76 = 1.05
	Corridor Costs	Equipment Costs / Corridor Costs	83/80 = 1.04

Construction and Maintenance	Equipment costs	Financial Costs / Equipment Costs	101/83 = 1.22
Financing	Financial costs	Actual Costs / Financial costs	110/101 = 1.09
Present	Act.Constr. & Maint. Costs	PRODUCT= Actual Costs / LR Transmission Costs	PRODUCT = 110/92 = 1.19

6.22 In the specific example, we see that the TSO seems to be doing particular poorly on financing, construction and maintenance while the planning and system operations costs savings are less significant. The market facilitation score is somewhat smaller than unity indicating a non-trivial increase in TSO costs. This may still be rational as the gains chain gains may more than exceed the cost increases.

6.23 Similarly one can decompose the Chain Values (Consumers' Benefits minus Producers' Costs) to become as in table 6.4

6.24 We see how large scores in this case is an indication of the attractiveness from a chain perspective of the TSO activity in question. With the specific numbers, we see that the particular operator has 27% overall potential that is distributed almost equally over the more strategic functions relating to congestion, market facilitation and systems operations.

6.25 These decompositions contain information that is very useful for the industry and regulator alike to improve upon the services of transmission sector. Further comments and advice on how to use this will be the subject of a separate note. For now, it suffices to mention that to make trade-offs between TSO costs and Chain values, it may be more convenient to work with an additive decomposition of costs and values as indicated in tables 6.5 and 6.6 below.

Table 6.4 Ratio decomposition of chain value.

TSO Activity	Chain Value	Efficiency Indices	Scores
Future (Long term ideal)	Long run Unconstrained Chain Value	LR Unconstrained Chain Value / Unconstrained Dispath Chain Value	140/130 = 1.08
Market Facilitation	Unconstrained dispatch Chain Value	Unconstrained Dispatch Chain Value / Chain Value given Strat.Behavior	130/120 = 1.08
Sys.Ope.	Chain value given strat.behav.	Chain Value given Strat.Behavior / Present Chain Value	120/110 = 1.09
Planning	Present Chain value	Present Chain Value / Present Chain Value	110/110 = 1.00
	Present Chain value	Present Chain Value / Present Chain Value	110/110 = 1.00
Construction and Maintenance	Present Chain value	Present Chain Value / Present Chain Value	110/110 = 1.00
Financing	Present Chain value	Present Chain Value / Present Chain Value	110/110 = 1.00
Present	Present Chain value	PRODUCT= LR Unconstrained Chain Value / Present Chain Value	140/110 = 1.27

Table 6.5 Additive decomposition of TSO costs.

TSO Activity	TSO Costs	Efficiency Indices	Scores (savings pot.)
Future (Long term ideal)	Long run transmission costs	C & B Matching Costs - LR Transmission Costs	92 - 92 = 0
Market Facilitation	Cost and Benefit matching costs	Bid Matching Costs - C & B Matching Costs	80 - 92 = -12
Sys.Ope.	Bid matching costs	Capacity Costs - Bid Matching Costs	76 – 80 = -4
Planning	Capacity Costs	Corridor Costs - Capacity Costs	80 - 76 = 4
	Corridor Costs	Equipment Costs - Corridor Costs	83 – 80 = 3
Construction and Maintenance	Equipment costs	Financial Costs - Equipment Costs	101 - 83 = 18
Financing	Financial costs	Actual Costs - Financial Costs	110 – 101 = 9
Present	Act.Constr. & Maint. Costs	SUM= Actual Costs - LR Transmission Costs	SUM = 110 - 92 = 18

Table 6.6 Additive decomposition of chain value.

TSO Activity	Chain Value	Efficiency Indices	Scores (Chain Gains)
Future (Long term ideal)	Long run Unconstrained Chain Value	LR Unconstrained Chain Value - Unconstrained Dispath Chain Value	140 -130 = 10
Market Facilitation	Unconstrained dispatch Chain Value	Unconstrained Dispatch Chain Valu Chain Value given Strat.Behavior	130 - 120 = 10
Sys.Ope.	Chain value given strat.behav.	Chain Value given Strat.Behavior - Present Chain Value	120 - 110 = 10
Planning	Present Chain value	Present Chain Value - Present Chain Value	110 - 110 = 10
	Present Chain value	Present Chain Value - Present Chain Value	110 - 110 = 0
Construction and Maintenance	Present Chain value	Present Chain Value - Present Chain Value	110 - 110 = 0
Financing	Present Chain value	Present Chain Value - Present Chain Value	110 - 110 = 0
Present	Present Chain value	SUM= LR Unconstrained Chain Value - Present Chain Value	140 - 110 = 30

6.26 In this case, we can see immediately that even though it is costly for the TSO to be involved in market facilitation, it pays off from a social point of view since the chain value increases more than the TSO costs.

Further decompositions

6.27 Of course, one can split the tasks further to get more detailed decompositions and / or to measure some parts of a task but not all.

6.28 For example, we could spilt the market facilitation role in installation of new capacity (strategic lines) and development of new trading mechanisms (auctions, contracts etc). This would lead to a two-way splitting of the market facilitation activity like we already have a two-way splitting of the planning task.

6.29 In similar ways, the planning task can be split in further sub-tasks by innovative uses of a formalized network modeling tool, such as the proposed NMT. One can for example consider in the kit costs under deterministic conditions (perfect foresight) by using a few states representing today's conditions. Also, one can consider the kit costs under realized variations in supply and demand by using states that reflect variations over, say, the last 10 years. Finally, the proper analysis of higher level planning should be made using the concepts developed below for decision making under uncertainty.

The ideal TSO

6.30 It is tempting to define the ideal, or best practice TSO, as the one that use best practice financing procedures, best practice construction and maintenance procedures, best practice planning procedures etc. That is, one can construct an ideal TSO by picking the best performance in all activity dimensions.

6.31 An advantage of this is that all TSOs will have something to learn. It is unlikely that one TSO should outperform the others on all tasks.

6.32 A possible complication with this approach is that the externalities (dependencies) among activities may render the ideal unit infeasible. What a TSO can accomplish in one dimension may depend one its activities in other dimensions. If it has been given a sparse network to save on capital costs it may be more difficult to make systems operations improvements.

The order of efficiency measurements

6.33 In the examples above, we have assumed that the regulatory improvements starts at the button and continues towards the top of the activities hierarchy. This reflects the general development of the TSO project. Assuming financing is fixed by regulatory discretion, for example, we first seek to save on construction and maintenance, Next, we seek to improve route capacity, then routing, systems operations and finally market facilitation.

6.34 We note that other improvement sequences could be pursued. If we used a different improvement sequence, we would however have to adjust the cost and benefit measures as they – on all levels – assume that the previous steps have been optimized. In fact, it is necessary to go back and re-optimize previous decisions in view of subsequent activity choices. This also means that any decomposition of efficiency, cf. above, will to some extent depend on the sequence in which we plan improvements to be introduced.

6.35 The difficulties of finding activity specific improvements potentials is a consequence of the synergies or externalities between the activities. Thus for example, the gains from improved systems operations depends on the equipment we have installed during the construction phases as well as the equipment we introduce in the market facilitation phase.

6.36 Formally, the existence of synergies or externalities means that the TSO's costs are not decomposable, i.e.

$$C(a_1, a_2, \ldots, a_n) \neq \sum_{i=1}^{n} C(a_i)$$

where a_i is the i'te activity (say sys.operations). The existence of (allegedly positive) synergies between activities makes it important to remember what values we have fixed in the other dimensions when we seek to improve a particular dimension. The sequential cost decomposition suggested by the marginal costs columns in the table above is just one way to allocate costs to activities.

6.37 Similarly, the chain values involves interactions between the different activities and the chain values are therefore not uniquely decomposable in activity related value contributions

$$V(a_1, a_2, \ldots, a_n) \neq \sum_{i=1}^{n} V(a_i)$$

Again, this means that the marginal value decomposition we have made in the table above presumes a specific improvement strategy (staring at the bottom of the activities hierarchy).

Multidimensional costs and benefits

6.38 A further complication in the development of comprehensive performance measures is the intrinsically multidimensional character of the costs and benefits accruing to the TSO and the chain. The benefits and costs relating to different regions, consumer groups, periods, etc may not be equally important and moreover, the tradeoffs between them may differ between different countries. This naturally complicates performance evaluations.

6.39 To the extent possible, one should of course aggregate the different cost and benefit dimensions. Under certain – unfortunately non-trivial – conditions costs in different periods can be aggregated in net present values by discounting, benefits to different groups can be aggregated by weighing with income etc.

6.40 When one cannot aggregate the dimensions (further), the only theoretically sound approach is to move from effectiveness to efficiency evaluation. This means that instead of looking for best benefits - cost practices one must look for practices that give as much of all benefit types and uses as little as possible of all costs types. To summarize the performance of a unit in this framework, one can then use a series of indices as they have been proposed in the efficiency analysis literature, cf. eg Cooper e.a.(2000) or Coelli e.a. (1998).

6.41 To illustrate this, let us assume the four TSOs, A,B, C and D have used the same cost to give benefits (e.g. transmitted energy at the same load profile) in two different periods or regions 1 and 2 as indicated in Figure 6.1 below. Assuming that it is always easier to produce less benefits than more, one would then say that both A, B and C are efficient while D is inefficient. A possible measure of the inefficiency of D is the so-called Farrell(1957) based radial output efficiency score F=|OD*|/|OD|. The interpretation is that F is the largest factor by which TSO D would be able to expand its output by simply imitating the best practice of the other units. In the Figure, D is compared B and receives a score of approximately 1.5. Hence, TSO D has a non-used improvement potential of at least 50%.

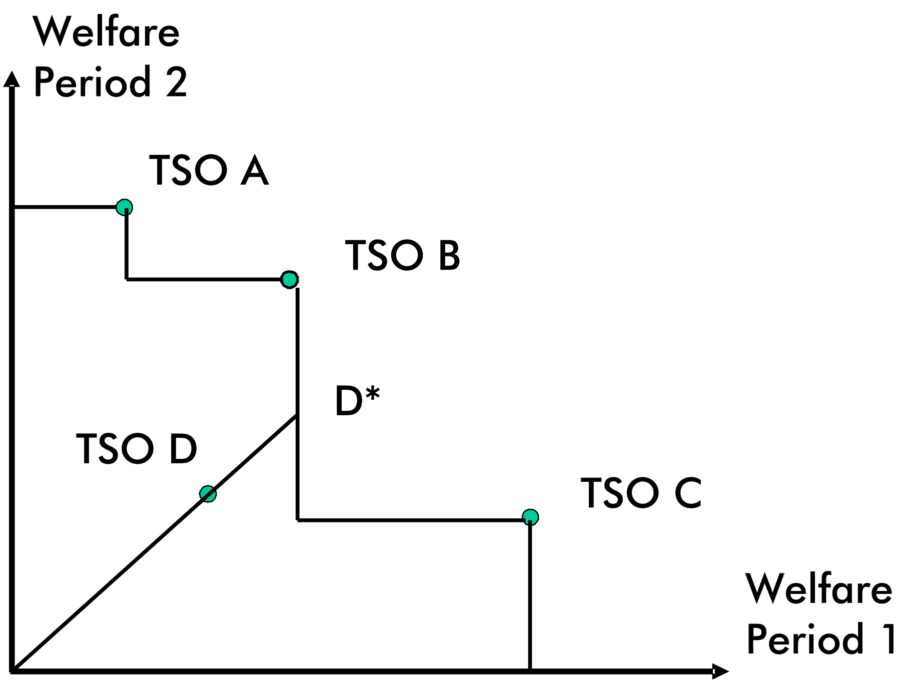

Figure 6.4 - Performance evaluation with non-commensurable outputs.

7. Uncertainty and Quality

7.01 Uncertainty, i.e. the inability to foresee the near and distant future with full precision, plays an important role in the TSO operations and planning. Since the scale and nature of uncertainty vary between different TSOs and the national trade-offs between cost and the management of uncertainty may be different, it is important to consider uncertainty when evaluating TSOs.

7.02 In this Chapter, we offer a conceptual framework, that can clarify the role of uncertainty in the context of performance evaluation and accountability.

Uncertain Factors

7.03 Several uncertain factors influence the TSO. At the operational level, the hourly and daily variations in supply and demand must be coped with via systems operations, power contracts etc. At the tactical level, the expected developments in supply and demand, nationally as well as internationally, affect the upgrading and maintenance of equipment, the borders of pricing zones etc. The tactical decisions also depend on a series of other factors, e.g. changes in environmental regulation, changes in labor and capital markets, etc. At the strategic level, the choice of routings, interconnectedness, market design etc are influenced by the same factors as well as new ones like the development of regulatory regimes, the uncertainty about long run locations of supply and demand nodes, changes in generator technology etc.

States

7.04 To clarify the notion and impacts of uncertainty, one can take the classical state contingent approach and define

s = a state /contingency / scenario
S = the set of possible states

The idea is that we can estimate or imagine the set of possible outcomes S but that we cannot know exactly which state s in S is going to be realized before "after the fact". A specific state will then amount to a specification (amount, time and location) of actual supply and demand, external conditions (reservoir levels, temperature, ...), and operating constraints (environmental restrictions imposed on line design, etc).

Uncertain consequences

7.05 The presence of uncertainty makes it impossible to foresee the consequences of alternative TSO actions. To formalize this, we may think of the outcome from having used actions *a* in state *s* as specified by

$$x(a,s) = \text{consequences of actions } a \text{ in state } s$$

7.06 The consequences can – depending on the focus of the decision and evaluation – range from very specific technical implications like net-losses on a given line segment given the allocated power transfer (*a*) and the weather conditions (*s*), to very general system wide effects like the state contingent overall TSO costs and chain net-benefits

$$C_{TSO}(a,s) = \text{TSO's costs from choosing actions } a \text{ in state } s$$
$$B_{CON}(a,s) = \text{consumers' benefits from TSO actions } a \text{ in state } s$$
$$C_{PRO}(a,s) = \text{producers' costs under TSO actions } a \text{ in state } s$$

In this case we can think of the social welfare as the consequences

$$X(a,s) = B_{CON}(a,s) - C_{PRO}(a,s) - C_{TSO}(a,s)$$

Here the first two elements $B_{CON}(a,s) - C_{PRO}(a,s)$ define what we have referred to as chain net benefits above.

The impact of uncertainty on evaluation

7.07 From the point of view of performance assessment, the presence of uncertainty makes snap-shot evaluations or evaluations in hindsight inappropriate. The same behavior will by chance get different evaluations depending on the realized values of the state variables.

7.08 To illustrate this, look at Figure 7.1 below. Two possible actions, a_1 and a_2, are considered along with the social values they generate in different states.

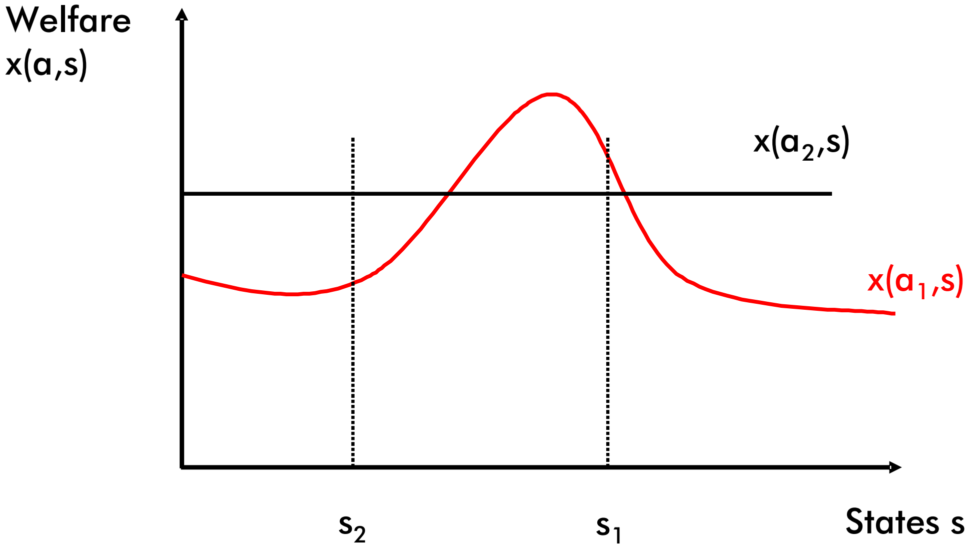

Figure 7.1 State contingent performance.

7.09 We see that in the intermediate states, the first action is superior, while in the more extreme states, the second action is superior. Therefore, if we only make a snap-shot evaluation we will favor the first action a_1 if for example s_1 is realized and the second action a_2 if for example s_2 is realized. Both conclusions are of course grossly misleading – the truth is that both actions have pros and cons and that the choice between them requires further ideas about how to aggregate performance in different states.

7.10 We will discuss more specific aggregations below. At the principal level, however, it is worthwhile to note that the state-contingent evaluation problem is basically a multiple criteria problem similar to the one cause by having multiple dimensional costs and benefits as discussed in the previous chapter. Indeed, we want to have as many benefits and as few costs in not only a given state but in every possible state. There is a large literature on Multiple Criteria Decision Making (MCDM), cf. eg. Bogetoft and Pruzan(1991,97), Steuer(1986), and Vincke(1992). This literature propose different ways to aggregate different performance dimensions.

Types of uncertainty and aggregation of state contingent performance

7.11 The multiple criteria aggregation problems under uncertainty has special characteristics that have motivated several more specific and more or less well-founded aggregations procedures. In the scientific literature it is now common to distinguish between four cases, viz. *ignorance, uncertainty, risk* and *certainty*. We will now define these and discuss the associated aggregations.

Ignorance

7.12 Under ignorance, the decision maker or evaluator are not even able to delineate the set of possible states *S*. The difficulty of foreseeing technological innovations and research outcomes are prime examples. The ignorance leads to incomplete contracts and regulation that must be renegotiated over time. There is of course an element of ignorance in any decision making and evaluation context. On the other hand, ignorance may be less significant in some contexts – in particular in short and medium term evaluations – and we therefore approximate the situation using uncertainty instead.

7.13 The literature on ignorance is limited and there is no generally accepted aggregation approaches for this case. In this context, we refer to the strategic adaptive capacity that is sought for in situations where the technology and the market changes, cf. 5.12.

Uncertainty

7.14 Uncertainty is the case where *S* can be delineated, i.e. the (most important) future states can be identified. Several aggregation procedures have been proposed for this case.

7.15 One is the pessimistic *Wald's maximin* approach that evaluates a decision by its worst possible outcome, i.e. the aggregated outcome $V(a)$ in case of (attractive) outcomes $x(a,s)$ is:

$$V(a) = \min_s x(a,s)$$

7.16 Another is the hindsight oriented *Savage's minimax regret criterion* that evaluates a decision by the worst that may possible be foregone (the *regret*) by taking this action instead of another one:

$$V(a) = \min_s (\max_a x(a',s) - x(a,s))$$

7.17 A third criterion is the *Laplace's principle of insufficient reason* which assigns all possible outcomes equal weight:

$$V(a) = \frac{1}{\text{Number of States}} \sum_{s \in S} x(a,s)$$

7.18 It is easy to demonstrate that the choice between these aggregations can have significant impact on the resulting evaluations.

Risk

7.19 Risk involves additional information. It requires that not only the possible states but also their odds, relative likelihood or subjective probabilities can be specified, i.e.,

$p(s)$ = probability that state s is going to be realized

7.20 The access to probability information enables the decision maker or evaluator to put more weights on performance in states that are more likely. This can be done simply by evaluating according to *expected outcome* as a generalization of the Laplace's criterion:

$$V(a) = \sum_{s \in S} x(a,s)\, p(s)$$

7.21 More generally, however, risk attitudes should be taken into account. In most cases, risk makes a fixed consequence preferable to a random consequence with the same expected value (risk aversion). This can be dealt with using the so-called hypothesis of expected utility maximization. Let $U(.)$ transform consequences into utilities, this *expected utility criterion* is then

$$V(a) = \sum_{s \in S} U(x(a,s))\, p(s)$$

7.22 There is a large body of literature – dating back to von Neuman-Morgenstern(1944) - on when evaluations can be done using this criterion - and how to find the transformation $U(.)$ to begin with.

7.23 In many cases, the expected utility criterion can be approximated by using a *risk-adjusted mean consequences measure*. Let where E(x(a,*s*)) be the expected consequences like in the generalized Laplace criterion, and let VAR(x(a,*s*)) be the variance of the consequences and R a measure of the degree of risk aversion.

$$V(a) = E(x(a,s)) - R \cdot VAR(x(a,s))$$

7.24 In addition to the general approaches above, more ad hoc approaches are often used in specific evaluations. One such is the *Roy's safety first principle* that evaluates a decision in relation to the probably of ending in an acceptable outcome X_A, e.g. an outcome without outages

$$V(a) = \Pr\{s \mid x(a,s) \in X_A\}$$

Certainty

7.25 To complete our listing of alternative cases, we have that the extreme opposite of ignorance is *certainty*. This is the case where there is only one possible state $S = \{s\}$, i.e. we can predict the near and distant future with full precision. This is of course equivalent to having a one-point degenerated probability distribution $p(.)$. Under certainty, the aggregation problem disappears.

Reliability and Quality

7.26 Energy reliability means the capability of the electricity system to deliver to consumers the desired amount of energy, of a defined quality. Power reliability means the capability of the electricity system to deliver to consumers the desired amount of power, of a defined quality. Supply reliability is a joint term covering both energy and power reliability.

7.27 Reliability is tightly connected to uncertainty. It concerns the ability of the system to absorb or at least adjust to uncertainty events without running into outages, brown-outs or undesirable variations in power quality. The minimax and safety first criteria are typical example of reliability measures.

7.28 Consider the example in Figure 7.2 below, where we assume decision making under uncertainty (S is estimated). Let the action a be e.g. the dimensioning of the transmission system to accommodate anticipated states. For "easy" states below a level s_A the physical grid absorbs the state without need for further action by the TSO. This can be interpreted as the true "copperplate" situation where the grid configuration allows for relatively straight-forward dispatching. Above the level s_A, the grid has some limitations that must be managed with other interventions, system operations, ancillary services, demand side management, zonal pricing etc. However, these measures are only sufficient until a certain level s_R, above which the transmission service is insufficient (e.g. outages or rationing).

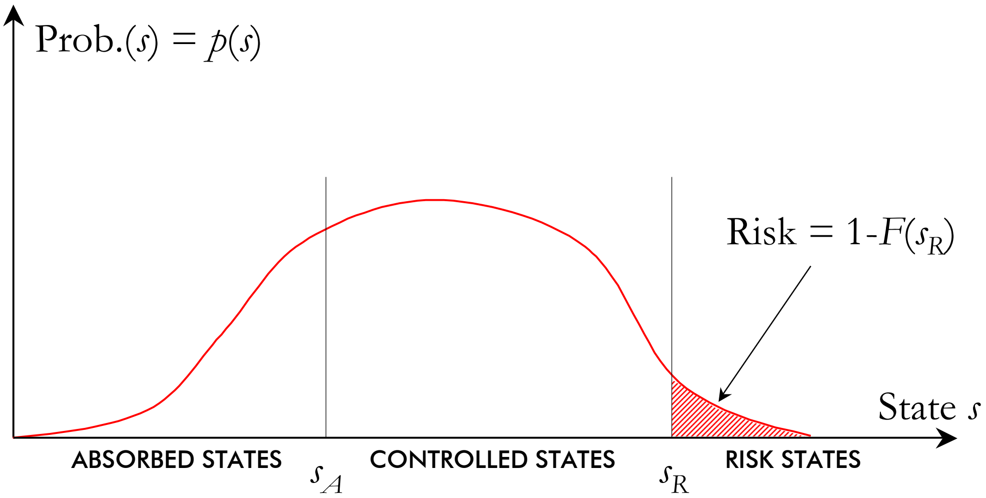

Figure 7.2 - State space *S* with probability of occurrence *p*(*s*) and degree of control.

7.29 One particular aggregation (a special case of Roy's criterion) is now the grid service level, F (s_R), that could be used as a policy variable. However, this neglects the information two grids at the same service level could have different consequences, *given that there was a failure*. To further these reasoning, we introduce the power and energy profiles for the states.

7.30 In Figure 7.3, the demand for power transferred (in a specific cut of the grid) is graphed over the states. The shape of the graph is arbitrary and in itself cannot be used for decision making, since the likelihood of the event need to be taken into account.

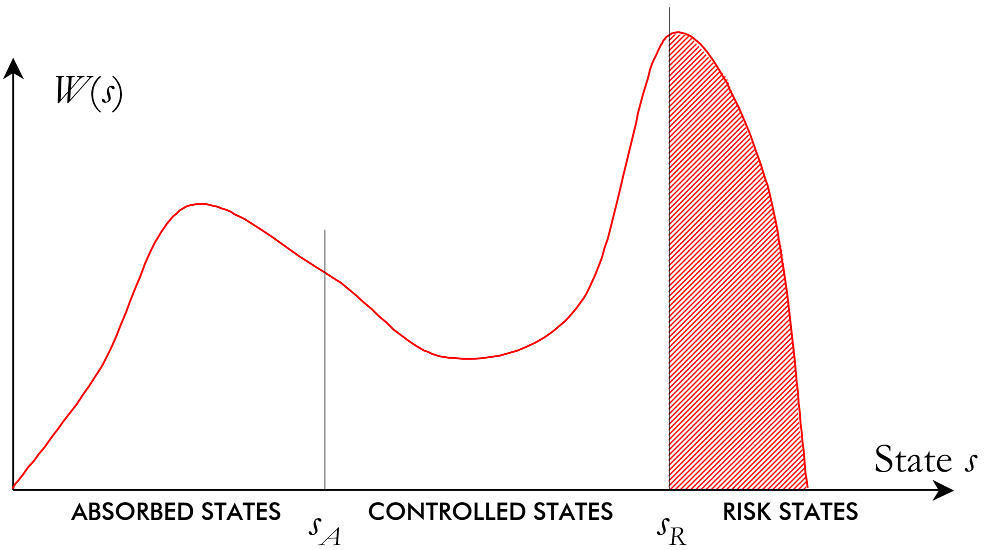

Figure 7.3 - State space *S* with power demand W(s).

Power at Risk (PaR)

7.31 We may now use the aggregation function to combine Figure 7.2 and Figure 7.3 into one measure, Power at Risk (PaR). This can – like the expected utility criterion above - be interpreted as the expected power deficit when the grid operations are out of control. We call this an operationalization of the *power reliability* criterion under uncertainty,

$$PaR(a) = \sum_{s \geq s_R} W(a,s)p(s)$$

Energy at Risk (EaR)

7.32 Similarily, we may consider *energy reliability* using the Energy at Risk (EaR) criterion, based on the energy demand in each state, Q(*s*) in Figure 7.4 to calculate the expected amount of energy non-delivered in the case of failure,

$$EaR(a) = \sum_{s \geq s_R} Q(a,s)p(s)$$

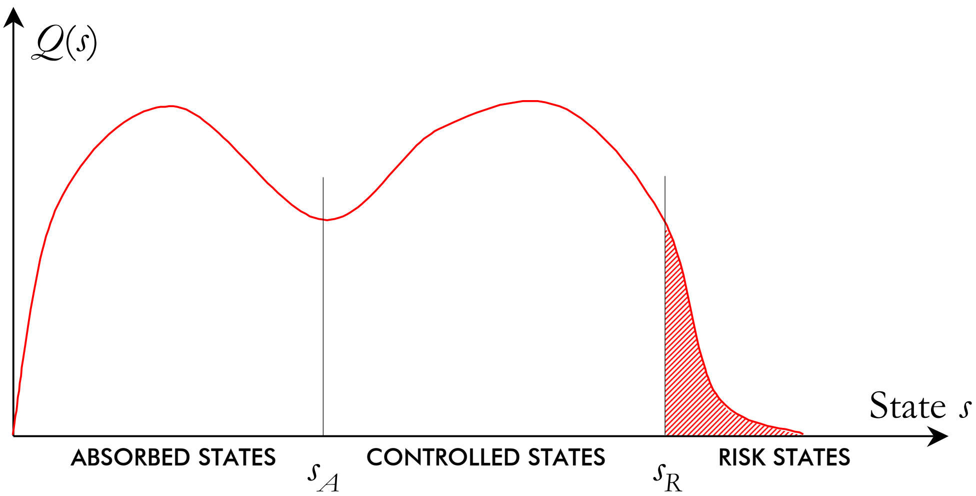

Figure 7.4 - State space *S* with energy demanded Q(s).

7.33 Using the PaR and EaR measures, systems that allegedly operate at the samke level of supply reliability may now be analyzed from the viewpoint of e.g. social welfare (marginal cost of outages etc).

Towards adequate evaluations

7.34 The purpose of the above discussion is to emphasize that uncertainty must explicitly be dealt with in the evaluation of TSOs. The change of market structure and the need to coordinate or cope with independent actors in a disintegrated, unbundled system makes this more important than ever.

7.35 Desirable TSO behavior considers the uncertain nature of future supply and demand etc. Likewise, the appropriate TSO evaluation and regulation must allow for uncertainty and long run evaluations and avoid misleading conclusions based on snap-shot performance or naive hindsight observations. The different notions of uncertainty and the alternative aggregations of performance across states show that this is a challenging aspect of TSO decision making and evaluation. At the same time, however, it is not unexplored territory and there are several theoretical results to draw on.

7.36 First of all, *ignorance* about the future can motivate keeping options open, working with less coupled systems with buffers and some amount of over-capacity.

7.37 The mere delineation of possible states will make the evaluations more precise although a choice most still be made as to the importance attached to performance in different states. For some states and cases, insufficient information can suggest using the equal weights, even in our Energy at Risk and Power at Risk measures. For other problems where for example quality standards or outages are at stake, a more pessimistic evaluation is more relevant and the performance of a system in this case my use the worst case scenario like in the maximin approach. In cases of future competition for funds and limited commitment, it may also be tempting to use a minimax regret criteria although we generally believe that this is a response to a sub-optimal behavior, hindsight evaluations.

7.38 If it is also possible to assign probabilities to the different possible states, the evaluations can be refined. Different state probabilities motivates different trade-offs. There is for example no reason to take costly flexibility investments in a situation with predictable demand. Also, different risk attitudes motivates different trade-off. In tern, different risk aversions may be the result of different income level, difference industry-structure, different capital and insurance markets etc.

8. Charter of Accountability

8.01 In the chapter, we define the concept of the Charter of Accountability based on the previous analysis. Before proceeding to the full decomposition of measures under certainty and uncertainty, we provide two examples of the information that could be compiled under such performance assessment with mixed instruments.

Charter

8.02 A *charter* is a grant, definition and guarantee of rights, franchises, or privileges from the sovereign power to a city, educational institution, or corporation. It differs in generality from a *mission* that is confined to a specific period and in structure from a *regulation* or *legislative act* that focuses at the governance and authority of decision making. The Charter serves here to communicate the integrality of the coordination task, whatever institutions, operators and regulation that are involved. Since transmission is the supporting pillar of the integrated energy market, it is natural that the Charter defines the expectations and decision rights that are assigned to each of the agents, as a consequence of regulation and/or business practice. The agreement in itself is a sign of collaborative rather than antagonistic relations between the regulator and the operator.

Accountability

8.03 As discussed above, a situation with delegated decision rights and system responsibility does not translate into an arbitrary transfer of rents and information to an appointed agent. Although intervention by uninformed actors may hurt system performance, lack of supervision and external service expectations may inflict equally degrading effects. Hence, the specific situation of a regulated system coordinator necessitates an explicit recognition of accountability towards the regulator. As well as the Charter may list tasks not uniquely legally assigned by regulation (such as transmission rights and obligations) but also common responsibilities (such as market facilitation), the accountability should in principle cover all areas of activity.

Charter of Accountability

8.04 Combining the two needs, we arrive at (i) a statement of the coordination activities that the common market requires and (ii) a set of internally coherent measures that support the act of accountability towards goal achievement by the operators. The Charter of Accountability transcends the national regulation and business practice (by not limiting the expectation to regulatory delegation) in the same way as it complies with it (by not infringing upon the regulators' discretionary application of it). In this sense, it is an intemporal act that survives the *ad hoc* partial performance assessments whose justification are merely instrumental to a given regulation policy. Furthermore, the Charter defines the performance dimensions all the way to the social welfare under uncertainty, which clearly is a daunting tasks to implement, but nevertheless must be the ultimate objective of the activity.

Building blocks

8.05 The starting points for the charter are the six *functions* of transmission services: market facilitation, system operations, grid planning, grid construction, grid maintenance and grid financing. For each of the functions, there exists some institutional attribution of *means* and *ends* to agencies, private or public operators. Based on these components, partial measures may be outlined under the Charter to assess the level of goal achievement in each function.

8.06 Since integration between functions is highly desirable, we also propose some models that simultaneously address multiple related functions, such as system operations and grid planning. Such models can then be applied to all TSOs that have common responsibilities for the assessed functions. Table 6.1 gives a quick overview of the scope of such analysis, the objectives and constraints that can be defined and the information that could be used to document the impact.

Function	Ends (ex.)	Means (ex.)	Information (ex.)
Market facilitator	High volume, efficient, competitive market	Volume contracts Enforcement	Share of trade, volatility, prices
System operator	Cost-effectiveness	Scheduling, instr. penalties, tariffs,	Congestion costs, distortions
Grid planner	Cost-efficient, reliable system expansion	Models, Invest lines, stations, contracts,	Competence, costs, system reliability,
Grid constructor	Meeting budget Timely completion	Staff, contracts, resources,	Proj performance, monitoring
Grid maintainer	Cost-effectiveness Supply reliability	Staff, installations, outsourcing,	ECOM, cost shares, correction times
Grid owner	Flexible, cost-efficient financing	Financial ops, equity, loans, bonds.	Interest rates Risk exposure

Table 6.1 Schematic means-ends decomposition for TSOs.

9. Further Work

9.01 The TSO Benchmarking project stands before its first test, delivering the results from the first phase: the TSO Charter of Accountability and the ECOM model. Already, the joint efforts of the pioneer group of regulators have shown the commitment to system coordination and comprehensive evaluation, the dedication to rigorous and sound modeling, and the constructive guidance into a rewarding dialogue with the grid operators. The next phase may extend the project in two senses.

9.02 First, the addition of new members will necessitate the adaptation and possible adjustment of tools and communication to fit the new needs. The Charter needs to be concretized to the regulatory level, bringing the principles into hard work by clarifying regulatory discretion, data collection, roles and tradeoffs in the TSO relation. Further applied work can give (i) explicit reference to the individual conditions of each country with respect to the Charter, (ii) analyses of which aspects of the Charter cocktail of instruments that could be relevant in a specific system, (iii) analyses of how and when given instruments could be practically applied in the regulation, monitoring and interaction with a grid operator and (iv) suggestions for anticipation of possible national challenges with respect to the implementation of the Charter.

9.03 Second, the project must follow through in its promise to go for the true chain values, rewarding sound congestion management and discouraging opportunistic actions. To this effect, we highlight the need to model and implement the market facilitation, congestion management and system operation activities of high chain impact and limited variable cost. This project will also bring life and synergy to the proposed NMT. Careful modeling along the deterministic and probabilistic lines outlined in this report would stress the importance of the market facilitation role. Moreover, it would give a robust and convincing base to address the heavy questions in grid operations, internally as well as externally. It is also an indispensable part of the long-term work to align incentives for joint capacity management.

9.04 Third, depending on the decisions pending the further development of the NMT, there are promising possibilities to implement and assess numerical estimates of selected comprehensive measures under certainty and uncertainty. These extensions would further the implementation of the Charter in countries where regulatory data is sparse or incompatible with the current market.

9.05 Extensions along these lines will provide the participating regulators with a strong portfolio of instruments in 2003, consistently addressing the multiple complex activities of grid planning and operation without resorting to micro-management. A bright prospect not only for the TSO-regulatory relation, but indeed for the integrated electricity market.

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