SUMICSID

Integrated, Parallel Energy Regulation

PREPROJECT 5 – FINAL REPORT

Per Agrell
Peter Bogetoft

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Disclaimer

This is the final report on a pre-project on regulation of alternative technologies in energy distribution, commissioned by the Norwegian Water Resources and Energy Directorate (*NVE*), delivered 2003-02-04 by the authors, professors Per AGRELL and Peter BOGETOFT for SUMICSID AB.

The contents has been subject only to a brief review from the Commissionee and expresses only the viewpoint of the authors, who exclusively bear the responsibility for any possible errors.

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Summary

There are numerous positive and negative interactions between alternative sources of energies and ways to distribute these. This makes a coordinated regulation of the energies very important. At the same time, this is a complicated task that has only recently received much practical and theoretical attention. We therefore suggest starting with more general investigations of the structural aspects.

A descriptive structural analysis (or systems analysis) starts by asking questions like: Who are the stakeholders? What are their motives? What are their tasks, rights and obligations? What are the information distribution and flow? What are the synergies? Next, a normative structural analysis investigates how to design or adjust the industrial and regulatory structures to ensure that the energies are developed in a coordinated manner, that the parties are properly motivated and that transaction costs are limited.

1. Introduction

Background

1.01 The Norwegian Water Resources and Energy Directorate (NVE) is appointed regulator for the electricity distribution and transmission sectors in Norway. Currently, NVE operates an individualized revenue-cap system for electricity distribution concessionaires with five-year regulation periods. The regulatory regime will be unconditionally revised effective from 2007, which means that the regulator NVE on behalf of the Oil- and Energy Department (OED) of the Government will investigate alternative regimes until 2004, when they have to be settled. To anchor the potential reforms, the investigations are to be intensified during 2003. The Oil- and Energy Department has commissioned a study by SNF on the principles of network regulation (von der Fehr *et al.*, 2002), which will guide the further work where applicable.

1.02 Based on individual reflection and the SNF report, NVE has defined five pre-projects to be concluded in 2002 and early 2003:

1) Degrees of freedom in the NVE choice of regime? ECON
2) Ex-post vs. ex-ante regulation. SUMICSID
3) Survey of existing evaluations of the current regime. PWCoopers
4) Efficiency analysis and benchmarking in regulation. SUMICSID
5) Incentives for non-grid technological innovation in regulation. ECON, Sefas, SUMICSID.

1.03 The project committees of pre-projects 1 thru 4 consist of NVE, OED and representatives for industry and consumer organizations, for pre-project 5 the responsibility is shared by NVE and ENOVA. After the reporting of all pre-projects, the project committees may decide to launch full-scale projects in one or more areas as in 1.02.

1.04 This report is the draft report on pre-project 5, commissioned by NVE and ENOVA. The Norwegian title of the pre-project is "Incentiver til alternative tiltak til nettutbygging". The report is authored by senior associates, professors Per Agrell and Peter Bogetoft from SUMICSID AB.

1.05 Preliminary speculations on these issues were presented at the NVE-ENOVA meeting in Trondheim, Nov.7, 2002, and the subsequent work has been guided by the task outline from NVE as of Nov.20, 2002.

Objectives

1.06 The purpose of this pre-project is to expand on some of the proposals presented at the Trondheim meeting and to use this to develop at more specific proposal for a subsequent main project.

1.07 In designing the proposal, we have been guided by in particular two objectives.

1.08 First of all, combined energy regulation is an obviously complex task that takes practitioners and theorists alike into largely unexplored territory. An important objective is therefore to keep a proper perspective and avoid spending endless hours on the details of one particular road while ignoring a series of alternative both entirely different avenues.

1.09 Secondly, we suggest that the interactions among the energies (the substitutability, complementarity, economies of scope, economies of scale etc) are very important and one of the key differences between single energy and multiple energy regulation. An objective has therefore been to choose an approach that will highlight these interactions.

Outline

1.10 Based on the above, we have chosen to start in chapter 2 by the overall regulatory objectives and tradeoffs, viz. independence, externality, efficiency and control. Next, we briefly discuss some main advantages and disadvantages of multi-utilities in chapter 3. This introduces in a very direct way the fundamental new questions in combined energy regulation, namely the pros and cons of horizontal integration. A more thorough analysis of the pros and cons of different industrial and regulatory structures is given in the next chapter 4. We suggest that structural or systems analysis should play a significant role in a subsequent main study on combined energy regulation. We continue in chapter 5 by briefly commenting on the interaction with some more detailed characteristics of the regulatory mechanisms. The final chapter presents a proposal for subsequent analysis.

2. Regulatory Objectives and Trade-Offs

2.01 In this part, we discuss the overall objectives of a regulation covering parallel energies and we emphasize the necessary trade-offs. In so doing, we emphasize four fundamental concerns, wiz independence, externalities, efficiency and control. Any energy planner must strike a balance among these concerns. An alternative approach, which can lead to a more complete list of objectives, can be developed along the lines we used in our pre-projects on Ex post Regulation (FP2). We close this chapter by briefly recalling this approach.

2.02 The *regional energy planner* here refers to the unit that is responsible for the overall development of all energies. In practice, it may be a regulator or a regulators' forum coordinating the activities of individual energy regulators. The task may also be outsourced to a company, perhaps as it is temporarily done in Norway, a company like the electricity distribution company, that already have a good knowledge of the areas (and, less attractively, private interests in one energy type).

Independence

2.03 A good regional energy planner must be independent of the market actors and look for economically sound tradeoffs between the different energies. Independence does here go further than an unbundling requirement, since co-ownership or board capture would jeopardize the decision autonomy and integrity. Potential entrants in the generation, distribution and retail levels would be discouraged by the mere suspicion of preferential treatment of incumbents in the construction and operation of the energy markets. Sensitive market information could also be exploited by affiliated enterprises to the detriment of market functioning.

2.04 The independence requirement would favor a state controlled planner or non-profit governance, and it would disfavor vesting the overall responsibility for energy planning in a (major) player like a distribution company. Independence could also favor a system where not only the planning, but also the implementation is outsourced to the same private company. The "energy company" should than be responsible for all energy services and be evaluated on the basis hereof. The clear and focused responsibility of course does not necessarily lead to a single firm structure as the primary energy provider may outsource the provision of some services to secondary providers.

Externalities

2.05 The joint operation of alternative energies is associated with externalities or synergies. By this we mean that the benefits and costs generated in one type of energy may affect and be affected by those generated in other types of energy. Positive synergies are those leading to cost savings while negative synergies make it less attractive to operate a multi-energy system.

2.06 Synergies, positive and negative, between electricity and other utilities may be present in the *horizontal* dimension, i.e. in the production, distribution or consumption levels. They usually derive from economies of scale and scope involving rights of way, physical assets, customer service functions, project development expertise, and administrative costs. A recent review of the British gas and electricity industries found, for example, that utilities dealing in both forms of energy could achieve cost savings of up to 10 percent compared to the cost of individually operated energies.

2.07 Synergies are also possible in the *vertical* dimension i.e. across the production, distribution and consumption levels. Introducing demand management at the consumption level, for example, may reduce the generation and distribution capacity needed. Rather than focusing exclusively at more investments in net assets, or exclusively focusing at market instruments to circumvent a congestion problem, an integrated, multi-energy structure can ensure socially optimal decisions.

2.08 Emphasizing the synergies and externalities would highlight the benefits of an integrated organization, an energy multi-utility provider. At the same time, the horizontal cooperation of alternative utilities may come at the cost of missing to exploit energy-non-energy synergies like when telecommunication services are distributed using the electrical net. A joint consideration of the system-wide externalities would speak in favor of a fully integrated production-transmission-distribution system with amble allowance for supplementary network activities.

Efficiency

2.09 The productive efficiency of the energy system is a measure of the amount of resources allocated in relation to the achieved benefits for the society. Technical efficiency is a question of doing whatever is done in the best possible way while allocative efficiency is a question of doing the right things at the right time using the right combination of resources. At the system level, the utilization of synergies is a source of both technical and allocative efficiency.

2.10 Large structures and in particular public and non-profit organizations with multidimensional tasks have complicated internal motivation problems that lower their 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 to avoid slack in the operations would therefore favor privatized organizations with clearly specified goals, which may be achieved by unbundling the functions. On the other hand, the system wide efficiency, as fuelled by the synergies, may favor larger organizations.

Control

2.11 The regulators are in charge of regulating, or at least monitoring, the activities of the energy agents, in particular those where a competitive pressure cannot guarantee efficient operations.

2.12 External control of integrated, large enterprises with multiple objectives is a complex task. 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. This favors firms operating at one level (production, distribution, retail) of one energy line (electricity or gas, for example).

Regulatory tradeoffs

2.13 As indicated above, trade-offs are necessary. The desire to create a regional energy coordination that is independent of individual energies and firms, that exploits synergies, that leads to efficient operations of the individual firms and that allows reasonable control by regulators, creates a tension between having simple, small firms covering a *narrow* part of the energy spectrum and having large, complex firms covering a *broad* spectrum of energy and energy levels.

2.14 The structural trade-offs are summarized in table 2.1 below. A plus (+) indicates that the objective is favored by (or important for) the associated organization while a minus (-) indicates a negative impact of the organization on the objective.

Table 2.1 Pros and cons of integrated utilities

Objectives	Narrow Utilities	Broad Utilities
Independence	+	0
Synergies	-	+
Efficiency	+	0
Control	+	0

Dynamic integration-disintegration

2.15 Economic research in regulation has pinpointed the need for dynamism in the regulation of market interfacing natural monopolies, cf. e.g. Estache and Martimort(2001). 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.

Finer Multiple Criteria Evaluations

2.16 Above, we have sketched four important concerns in the design of regulatory and industrial structures. They are based on sound economic principles. In a more elaborate design and / or evaluation effort, one can proceed as discussed in our report on FP2, cf. Agrell and Bogetoft (2002b), by systematical identifying the goal and means hierarchies. The above concerns will correspond to relatively aggregated descriptions in an end-means hierarchy.

2.17 In the FP2 report, we stressed the importance of coordination, motivation and transaction costs:

Coordination: ensure that the right services are produced at the right time and place.

Motivation: ensure that the parties have individual incentives to make coordinated decisions.

Transaction costs: ensure that coordination and motivation are provided at the lowest possible cost.

2.18 A regulation must therefore coordinate the action of independent individuals, ensure that individuals have private motives to implement their part of a coordinated plan, and ensure that coordination and motivation is accomplished at least possible transaction costs.

2.19 The emphasis on synergies corresponds to a focus on coordination. Although much or modern advancements in micro-economic theory have stressed motivational issues and how they impede coordination, we think that the coordination objective deserves considerable attention as well. The emphasis on control corresponds to the motivation perspective while efficiency and independence corresponds to ensuring reasonable coordination despite of motivation problems.

3. On Multi-Utilities

3.01 Multi-utility companies that provide a number of different utility services and are regulated by more than one utility regulator are starting to emerge in many countries. They constitute – as already explained - a natural and likely firm structure in relation to the parallel energies setting, and it is therefore useful to comment briefly on the likely pros and cons of such firms. There is a recent but growing applied and academic literature on multi-utilities, cf. for example the bibliography by Regulateonline (2003), and a detailed examination of this literature seems useful as part of the main project. Here, we only give some extracts to supplement and extent the pros and cons derived in chapter 2.

3.02 Multi-utilities have the potential to provide benefits in terms of economies of scale, scope, and convenience, but it also raises a series of market and regulatory problems. Thus for example, the competitive discipline from substitutes may be eliminated, costs may be shifted from competitive industry lines to monopoly lines, and separate regulators may find it more difficult to maintain an effective regulatory grip over specific utility services for which they exercise responsibility. The question facing policymakers is whether the emergence of multi-utilities should be encouraged as a means of improving synergies, or subjected to closer regulation to guard against the potential dangers from less control from the market.

Benefits

3.03 Multi-utilities may lead to *lower costs*. Utilities that bundle two or more services may cut costs through economies of scale and scope involving rights of way, physical assets, customer service functions, project development expertise, and administrative costs. A recent review of the British gas and electricity industries found, for example, that utilities dealing in both forms of energy could achieve cost savings of up to 10 percent compared to those that supplied gas alone, cf. Sommer (2001)

3.04 Multi-utilities may also improve the *convenience* for the consumers that only have to make transactions with one rather than a series of service providers.

3.05 Allowing multi-utilities could also *increase ex ante competition* for the concession rights. New entrants may be discouraged if large investments are required to build out network infrastructure – or if the geographical area is small and the cost of presence therefore relatively high. By allowing the company to be simultaneously involved in several lines of services, the costs may be shared and more competition (for the monopoly rights?) may be encouraged.

Likely Disadvantages

3.06 Multi-utilities may *reduce competition between substitute services*. Some utility services, notably power and gas, compete for the same customers in many countries. The inter-energy competition can reduce market power and thus facilitate regulators' tasks. The integration of electricity and gas distribution in one firm may increase the need for supervision and regulation.

3.07 Multi-utilities may also *adversely affect competitio*n in other ways. For example, a multi-utility heat and power provider may use its position in a monopolized heat market to improve its position in the power market and hereby deter competitive entry herein. The increased market power may flow from the multi-utility's knowledge of existing customers, or its ability to bundle services, but it may also stem from its ability to allocate common costs within the firm in a way that gives it an unfair competitive advantage in the contestable business.

3.08 Multi-utilities may *complicate cost evaluations in regulatory reviews* and may hereby make tariff regulation and relative performance evaluation more difficult. The difficulties may not (only) be the result of strategic manipulations of accounts. They may also reflect the fact that the allocation of common costs is a difficult task to begin with. The primary benefit of multi-utilities, namely the synergies among the provision of different services, is also what makes it difficult to un-bundled the cost contributions. The literature on cost allocation (relying on cooperative game theory) may give useful principles. A series of methods – with examples from the food industry - are provided in Bogetoft and Olesen (2002)

3.09 Multi-utilities may also *challenge regulatory coordination*. To avoid that the utility gets opportunities to manipulate the regulation process involving multiple regulators – and to avoid that the regulators impose to harsh conditions on the companies by each taking a single regulator perspective – coordinated regulation is needed. The regulators may merge – to match the industry structure, or – if they stick to energy or fuel lines - they may at least coordinate by regular exchange of information and meetings in regulatory forums etc. The analysis is the next chapter illustrates the need for coordinated actions. The discussion of bundling in the next chapter also suggests the somewhat counterintuitive result, that it may in some cases be easier to regulate a large, multi-utility monopolist than a series of single utility, partially competing utilities.

Important decisions

3.10 Based on the above, we can summarize some important decision to be made in the regulatory design process.

3.11 One decision concerns the *extent to which multi-utilities should be allowed* – or what cross-ownership restrictions to impose. This will be important when privatizing new areas, when allocating concession rights, when evaluating proposed mergers and acquisitions, and when evaluating requests to extend the services in an incumbent utility.

3.12 Another – but related – decision concerns what to require in terms of *accounting separation*, i.e. the requirement that the costs of each regulated business must be accounted for separately, sometimes called "ring-fencing." For example, detailed rules may be designed to govern the allocation of joint costs, and restrictions may be imposed on transfer pricing between business lines. Rules of this kind have been developed in most western countries.

3.13 A third decision concerns the *future organization of regulatory bodies* – and the extent to which the organization should match the industry development. The use of joint working groups among individual regulators may be a useful compromise. We discuss the interaction between the regulatory and industrial structures in more details in the next chapter.

4. Structural Analysis and Design

4.01 When analyzing a new system, it is in general useful to start with a relative aggregate structural analysis. A structural analysis – or a systems analysis – looks at questions like:

1) *Who are the stake-holders: Consumers, net-companies, producers, regulators*
2) *What are their motives: Consumer surplus, profit maximization, staying in office, minimize effort etc?*
3) *What are their tasks, rights and obligations: Who shall do what and when?*
4) *What are the information distribution and flow: Who knows and signals what to whom?*

Relevance

4.02 The advantage of a structural analysis is that it protects against an unbalanced focus on an arbitrary set of more or less important details. A structural analysis supports a systems perspective in the sense that all or at least most of the *system wide impacts* of a change are accounted for. By highlighting the interactions, we reduce the risk of sub-optimization, i.e. the improvement of performance in a sub-system at the costs of deteriorated performance in other, linked sub-systems.

4.03 A further advantage of a structural analysis is that it supports getting the essentials right, the *economic infra structure*. With a nice structural configuration, the reliance on simple motivation mechanisms, competitive pressures etc often suffice to generate a reasonable well functioning system. In case of messy structural characteristics, it is intuitive more likely that we need elaborate and complicated incentive mechanisms to avoid unwanted side effects.

Descriptive, normative or predictive analysis

4.04 Observe also, that a system analysis in the above sense can be both *descriptive*, trying primarily to describe (and understand) the existing structure, and *normative*, trying to support and prescribe the design of new structural characteristics.

4.05 In applied analyses, an intermediate form may also be useful when the time and other resources are limited. It extends descriptive analyses by trying to predict the impact of given economic conditions and perhaps a set of pre-decisions about the structure of regulation etc. But it falls short of comprehensive normative analysis by not discussing the optimal design of a regulatory structure, e.g. We may call this intermediate type of structural analyses predictive.

Four simple configurations

4.06 In the following we investigate in a few more details the combination of industrial and regulatory structures. The purpose is two-fold. First, the questions we address are important in the choice of a regulation. Secondly, and most importantly, we undertake some simple evaluations to exemplify what a structural analysis may be all about.

4.07 We distinguish between separate and integrated configurations on the industry and regulatory sides. A *separate* configuration means that two or more, rather autonomous, companies (or regulators) are operating at the same time, while an *integrated* structure assumes that the companies (or regulators) are merged or at least closely coordinated. Figure 4.1 below illustrates the resulting four configurations.

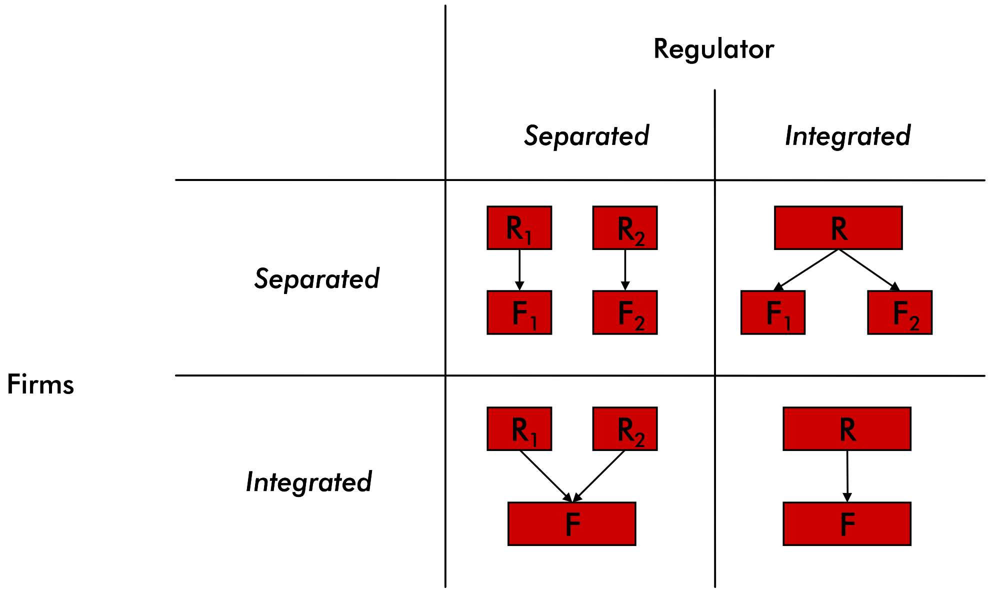


Figure 4.1 Four alternative structures

Regulator = regulation

4.08 Before proceeding, it is very important to understand that the *regulators here represent regulations rather than organizations*. A regulatory organization is often responsible for the regulation of several areas, all of which are governed by separate laws and principles. In his case, we talk of multiple regulators although the roles may be delegated to the same organization.

4.09 In a Norwegian context, it may be considered entirely unrealistic to let anyone but NVE be responsible for energy regulation at large. However, NVE will represent several regulations and therefore be considered as representing separate regulators. Electricity, gas, wind etc energies are regulated by the same laws and principles and subject to the same aspirations. Only if this were the case would be talk about NVE as a single regulator.

4.10 I some case, however, it is not only the law and regulatory methods that distinguish one regulator from another There may also be physically different regulators influencing the energy sector simultaneously. Indeed, this is the case in many countries including Norway. Observe that *a wide variety of economic policies* - like antitrust laws, competitive principles, environmental restrictions, labor protection, and national support to less developed regions – have implications for an energy sector just like a traditional regulatory scheme like CPI-X has it. The multiple regulators may therefore represent different resort ministries trying to influence the operations in one or more energy sectors.

4.11 In summary, the structures in Figure 4.1 have multiple, very relevant and realistic interpretations and can be used to distinguish between alternative settings and characteristics of the industry-regulator structure in Norway and elsewhere. The regulator represents a regulation and several regulators may therefore be the responsibility of a single regulatory organization.

Horizontal integration

4.12 In the worked-through analysis of four structures below, we will think of firms and regulators in different energy lines, i.e. the separation-integration dimension is *horizontal*, like when one firm handles gas and the other electricity. We use a general formulation of the model. The possible interpretations of the structures are many but are left somewhat open. We shall give examples as we go along.

4.13 At this point it suffices to mention that the horizontally competing energies may be on *equal footing*, like when wind versus heat-pumps are used to supplement the general use of electrical heating. This is the primary case modeled below.

4.14 The competing energies may however also be on *unequal footing* as when gas and electricity is competing for house heating. There are many other and flexible uses of electricity, such the heating supply from electricity is like a residual supply. The heating supplied by gas on the other hand may represent the primary uses of gas and the gas based heating supply cannot be thought of as a residual supply.

4.15 We note, that a similar discussion and analysis is possible if we think of vertical separation-integration issues. We shall return briefly to this after the analysis.

Substitution

4.16 In this illustrative analysis, we stick to the general idea that the two energies are *substitutes*. Thus, for example, the consumer may chose between water distributed, central heating and electrical heating. Also, we think of the firms as being able to produce more or less of the good. The amount produced is the decision variable of the firms.

(One can also think of the products as representing variations in qualities or variations in the installed capacities.

4.17 To keep things very simple, we will assume that the two energies – in relation to the consumers - are *Cournot duopolists*. Hence, the companies offer quantities, say q_1 and q_2, to the consumers, the markets clears and the resulting prices are settled. It is well known that a context where the firms select capacities in a first stage and they compete on prices in a second stage, leads to similar results, cf. Tirole (1990). We emphasize, that alternative models of competition and product differentiation are available in the literature, e.g. Cournot, Bertrand, Stackelberg, spatial, vertical (quality) and horizontal (spatial) differentiation, and that the relative usefulness of the alternative models should be explored in a main project.

Consumer values

4.18 An important input to a structural analysis is the general structure of the consumer values. In particular, the switching costs and the extent to which the energies can substitute each other must be described since it affects the appropriate industrial structure, including the degree of competition we can allow.

4.19 In the more specific analysis of structure below, we assume that the *demand* conditions are defined by the consumers having values

$$V(q_1,q_2)=a + a_0(q_1+q_2)-\tfrac{1}{2}a_1q_1^2-\tfrac{1}{2}a_1q_2^2-a_2q_1q_2$$

where $a_1 > a_2$. Hence, the products are substitutes – but not perfect substitutes. Note that to keep things simple, we assume that the demands for the two products are symmetric. The prices clearing a market with supply q_1 and q_2 are therefore given by the marginal values of the two products

$$p_1=a_0-a_1q_1-a_2q_2$$

$$p_2=a_0-a_1q_2-a_2q_1$$

In the following, we will sometimes solve a specific numerical example. Here we assume that $a_0=10, a_1=2$ and $a_2=1$.

4.20 In the context of alternative energies, it is often unrealistic to assume that individual consumers demand a wide spectrum of different energies. To heat a house, a consumer needs electrical heating panels, water radiators, a heat pump re-circulation system or some other fixed investments and it will typically be cost efficient to stick to one type of installation. In such cases, we may think of the demand relations as representing *regional demand*, i.e. the demand relations are at an aggregate rather than individual level.

Production costs

4.21 Just like the interactions among the energies are important on the value side, they are important on the costs side. An important input to a structural analysis is therefore some general information about production and distribution costs, and in particular how these costs depends on the simultaneous generation and distribution of two parallel energies (positive and negative synergies).

4.22 In the specific analysis below, we assume that *costs* to the firms when they produce q_1 and q_2 respectively, are

$$C_1(q_1)=c_0+c_1q_1+ \tfrac{1}{2}c_2q_1^2$$

$$C_2(q_2)=c_0+c_1q_2+\tfrac{1}{2}c_2q_2^2$$

once again symmetric for simplicity. We assume that the fixed costs are sufficiently small to make production attractive in all cases.

4.23 Observe that we assume positive economies of scale for small value of the productions and, if c_2 is strictly positive, dis-economies of scale for large values of the average costs are decreasing, at least for small value of the production, as in a usual natural monopoly setting. In the numerical examples, we use $c_0=2, c_1=2$ and $c_2=1$. This means that average costs are decreasing until the production level is 2.

4.24 In case of a joint production of the two products, we assume that there are *synergies* halving the fixed costs, such that the cost function of a multi-utility is

$$C\ (q_1,q_2)=c_0+c_1q_1+ \tfrac{1}{2}c_2q_1^2+c_1q_2+\tfrac{1}{2}c_2q_2^2$$

Multi- or single use energies.

4.25 Although one energy form technically can be transformed to another, it may not be economically attractive to do so. In particular, it may not be attractive to do so at a small scale. The areas in which the energies compete and substitute each other will therefore differ. If we consider electricity, gas and water born heat as three examples, it is obvious that electricity can serve the full spectrum of energy needs in households while gas and water born heat primarily are useful for heating. If we study the competition between gas and water born heat, the demand relations above may therefore be thought of as residual demand given the exiting access to electricity. In a similar way, it we compare electrical and gas heating, we may think of the electrical costs function as the costs in excess of what it costs to supply the other services. This means that the framework we have defined can cover cases where more or less comparable energies are used for competing purposes.

Socially optimal outcome

4.26 In a structural analysis - as in more detailed analyses of operations - it is useful to have sight on the socially optimal outcome. This ideal benchmark might be hard to identify in details, but partial knowledge will usually provide relevant guidance and provide an understanding of the losses from imperfect information, regulation etc.

4.27 In our stylized setting, the *socially optimal* production with two firms would maximize the social surplus S equal to consumer benefits minus production costs

$$S(q_1,q_2)=V(q_1,q_2)-C_1(q_1)-C_2(q_2)$$

Using the first order conditions, $dS/dq_i=0$, $i=1,2$, and symmetry, the socially optimal production levels is found as

$$q_1=q_2=(a_0-c_1)/(a_1+a_2+c_2)$$

with resulting prices

$$p_1=p_2=a_0-(a_1+a_2)(a_0-c_1)/(a_1+a_2+c_2)$$

In the numerical example, we get

$$q_1=q_2=2 \text{ with resulting prices } p_1=p_2= 4$$

4.28 Note that the firms' profits in the numerical example equal 0. This is coincidental. With marginal cost pricing, the right cost information is shared with the consumers. However, total revenue may exceed (for large quantities) or fall short of (for small quantities) total costs by the cost function being convex with a positive fixed costs. Any surplus or deficit can be covered using fixed fees, e.g. connection fees.

4.29 With a single, multi-utility firm, the socially optimal production levels and prices are the same since the marginal costs and values are unaffected. The only difference is that the social benefits increases since the synergy effect saves us c_0.

4.30 We now study the four industry-regulation structures in figure 4.1 in more details.

STRUCTURE A: SEPARATED-SEPARATED

4.31 Consider first the case A of two separate firms (F_1 and F_2), say distribution companies, more or less tightly controlled by two regulators (R_1 and R_2).

No regulation

4.32 If the regulators do not interfere but rely solely on the competition between the energies, the outcome is found as a Nash Equilibrium in the duopoly game between the two firms. Given the production of firm 2, q_2, firm 1 maximizes profit

$$\Pi_1(q_1,q_2)=p_1q_1-C_1(q_1)=(a_0-a_1q_1-a_2q_2)q_1-c_0-c_1q_1-\tfrac{1}{2}c_2q_1^2$$

with respect to q_1. This gives the response function

$$q_1=(a_0-a_2q_2-c_1)/(2a_1+c_2)$$

The profit and response functions for firm 2 are similar

$$\Pi_2(q_1,q_2)=p_2q_2-C_2(q_2)=(a_0-a_1q_2-a_2q_1)q_2-c_0-c_1q_2-\tfrac{1}{2}c_2q_2^2$$

$$q_2=(a_0-a_2q_1-c_1)/(2a_1+c_2)$$

4.33 The resulting symmetric *equilibrium with no regulation* is therefore

$$q_1=q_2=(a_0- c_1)/(2a_1+a_2+c_2)$$

In the numerical example we get

$$q_1=q_2=4/3 \text{ with prices } p_1=p_2=6$$

Compared to the socially optimal production levels, we see that the firms supply less than optimal levels. The competitive pressure is not sufficient to motivate a lack of regulatory interference. The outcome with weak regulators, captured by the industry, would be similar.

4.34 The outcome is even worse if the firms collude and form a tacit collusion or energy cartel. In this case, and provided they have sufficiently high value of future profits, they would act like a monopolist with two production plants (i.e. who do not exploit synergies). In each period, the cartel maximize joint profits

$$\Pi_1(q_1,q_2)+ \Pi_2(q_1,q_2)$$

leading to the *cartel equilibrium with no regulation*

$$q_1=q_2=(a_0- c_1)/(2a_1+2a_2+c_2)$$

In the numerical example we get

$$q_1=q_2=8/7 \text{ with prices } p_1=p_2=46/7$$

Revenue cap regulation

4.35 With price elastic demand and no universal service obligations, the regulators cannot ensure the optimal outcome using revenue caps. If revenue caps were set above the present levels, it would not affect behavior. If revenue caps were set below the non-regulated levels, the firms would lower production to save costs. Revenue caps would therefore tend to support the cartel behavior!

4.36 It is relevant - and possible but beyond the scope of this note – to explore the revenue cap regulations with different types of *service* *obligations*. One possibility would be to have a joint service obligation, another to impose service obligations on one firm, the primary provider, and let this firm outsource some of its obligations to the other firm.

Price cap regulation

4.37 We here determine the outcome if the regulators both interfere by a price cap regulation. Using price caps, the firms will not benefits from reduced production levels. To the contrary, to keep up revenue with a lower price, they would tend to increase production.

4.38 The regulatory outcome depends on the coordination among the regulators, the costs of regulatory effort, the informational asymmetries etc. In an extended study, it is therefore relevant to analyze *a series of regulators-industries equilibria*.

4.39 To take the simplest possible case here, we assume that regulator 1 interferes while regulator 2 free rides and does not try to affect prices. We also assume, that this is common knowledge to the firms and regulators. If firm 2 produces q_2, the marginal value to consumers of energy 1 is $p_1=a_0-a_1q_1-a_2q_2$ and the regulator would like to ensure that marginal value equals marginal costs $c_1+c_2q_1$. The regulator's preferred output from firm 1 is therefore

$$q_1=(a_0-a_2q_2-c_1)/(a_1+c_2)$$

when firm 2 produces q_2. This is effectively the social planner's reaction curve to the behavior of firm 2. We assume that the un-regulated firm 2 is aware of the regulation imposed on firm 1. It therefore reacts according to its reaction curve from above, i.e.

$$q_2=(a_0-a_2q_1-c_1)/(2a_1+c_2)$$

taking into account the regulatory impact on q_1.

4.40 Solving for an equilibrium in the regulator 1 – firm 1 – firm 2 game, we get the (equilibrium) production levels

$$q_1=(-2a_1a_0-c_2a_0+2a_1c_1+c_1c_2+a_2a_0-a_2c_1)/a_2^2-2a_1^2-3a_1c_2-c_2^2)$$

$$q_2=(a_2a_0-a_1a_0-a_2c_1-c_2a_0+c_1c_2+a_1c_1)/a_2^2-2a_1^2-3a_1c_2-c_2^2)$$

The price cap is found by inserting into the demand equations.

In the numerical example, we get

$$q_1=16/7,\ q_2=8/7,\ p_1^{cap}=30/7,\ p_2=38/7$$

4.41 Compared to the socially optimal outcome, we see that the lack of regulatory effort in regulator 2 forces regulator 1 to increase prices beyond first best level. The reason is that the marginal value of energy 1 is relatively higher by the less than optimal supply of energy 2.

4.42 Compared to the non-regulated outcome, we see that the active regulator 1 makes firm 1 increase its production by lowering its price. Part of the social gain is up-set by the response of firm 2, however. In the usual Cournot way, an increase in any firm's production is partly up-set by a decrease in the other firms production. In fact, in the numerical example, firm 2 is back on the cartel quantity.

4.43 In summary, we see that an unbalanced regulatory effort makes the regulated outcome fall short of the first best – even in the case of perfect information.

4.44 It would be relevant to analyze *other regulatory behavior*, including cases with more coordination, with asymmetric information etc. The ex ante ex post dichotomy is relevant here as well. If one energy, say energy 2, is regulated according to ex ante expectations like in a CPI-X model, while the other energy line, say 1, is regulated with a yardstick scheme, the outcome may well be as above, where the regulation of firm 2 was fixed at a sub-optimal level – represented here by the extreme of no regulation.

STRUCTURE B: SEPARATED-INTEGRATED

4.45 Consider next the case of two separate firms (F_1 and F_2) controlled by a single regulator (R).

No regulation

4.46 The non-regulated outcome in this case is as previously. In this case, however, the single regulator can coordinate his regulation of the two firms.

Regulation

4.47 Using his perfect information, the integrated regulator sets price caps equal to the prices in the social optimum

$$p_1^{cap}=p_2^{cap}=a_0-(a_1+a_2)(a_0-c_1)/(a_1+a_2+c_2)$$

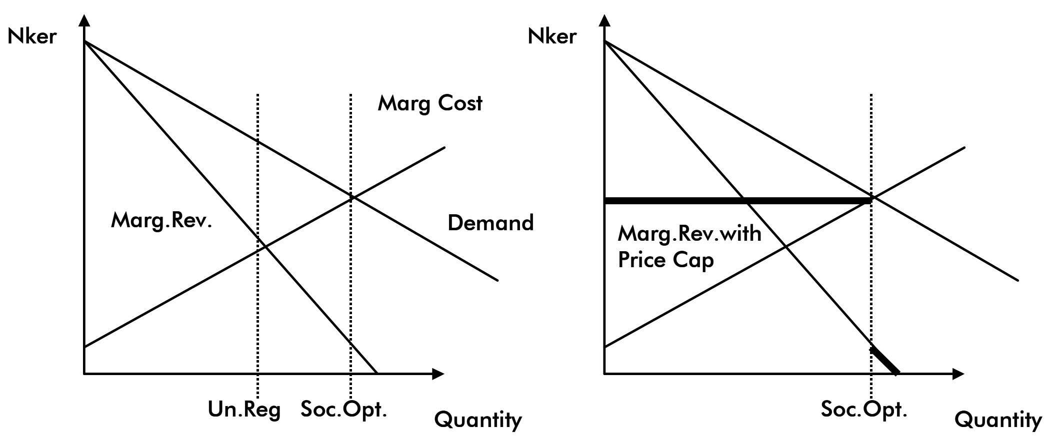
and the firms will implement the resulting first best production plans

$$q_1=q_2=(a_0-c_1)/(a_1+a_2+c_2)$$

since for all production levels below, the marginal revenue exceeds marginal costs as illustrated in figure 4.2. In the numerical example, we get

$$p_1^{cap}=p_2^{cap}=4 \text{ and } q_1=q_2=2$$

Figure 4.2 Price cap regulation



STRUCTURE C: INTEGRATED- SEPARATE

4.48 As a third structure, consider the case of a single, multi-utility firm (F) being controlled by a two separate regulators (R_1 and R_2).

No regulation

4.49 The non-regulated outcome in this case is similar to the cartel outcome in the Separate-Separate structure, i.e. the production levels are

$$q_1=q_2=(a_0- c_1)/(2a_1+2a_2+c_2)$$

and in the numerical example

$$q_1=q_2=8/7$$

4.50 The integrated firm effectively acts like a monopolist, and the need for regulation is more obvious than ever. The disciplining power of Cournot competition is lost due to the integration of the firms.

4.51 The only advantage from a social point of view is that the integrated multi-utility contrary to a tacit collusion (cartel) realizes the synergies and saves c_0 (=2 in the numerical example) on the fixed costs.

Regulation

4.52 The regulated outcome depends again on the degree of regulatory coordination and effort. We assume like in structure A that only regulator 1 limits prices while regulator 2 free-rides. Letting p_1^{cap} be the price cap on the first product, the integrated firm maximizes profit subject to the price condition

$$\text{Max}_{q_1,q_2}\ p_1q_1+p_2q_2-C(q_1,q_2)$$

$$\text{s.t. } p_1=\min\{p_1^{cap},\ a_0-a_1q_1-a_2q_2\}$$

$$p_2=a_0-a_1q_2-a_2q_1$$

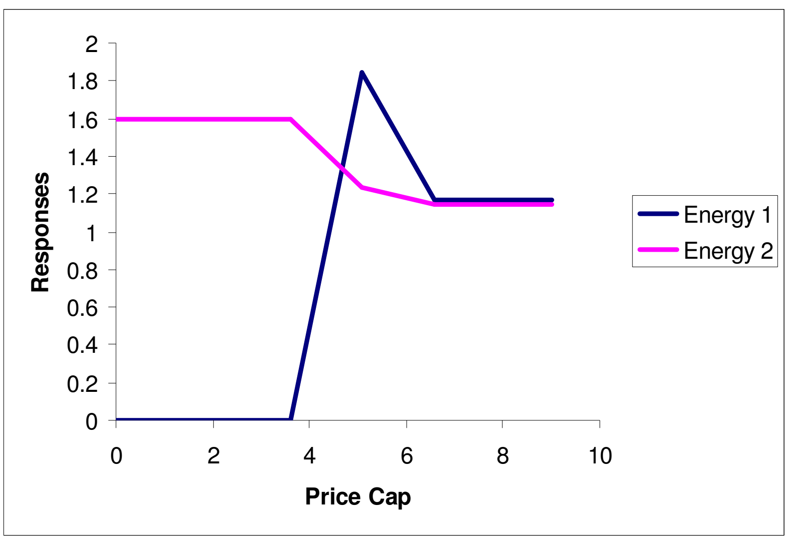
4.53 The result is quite messy but in the numerical example, the quantities (response functions) are summarized in Table 4.1 below.

Table 4.1 Responses to single energy price cap regulation

p_1^{cap}	q_1	q_2
0 – 18/5	0	8/5
18/5 – 66/13	$-9/2+(5/4)\,p_1^{cap}$	$5/2-(1/4)\,p_1^{cap}$
66/13 – 46/7	$72/17-(8/17)\,p_1^{cap}$	$26/17-(1/17)\,p_1^{cap}$
46/7 – …	8/7	8/7

In the first interval, the price cap is very hard and the best the multi-utility can do is to substitute entirely into producing the non-regulated second energy. In the last interval, the price cap is not binding at all – the prices that follow from unconstrained monopoly behavior are less than the price cap anyway. The response functions are illustrated in figure 4.3 below.

Figure 4.3 Multi-utility responses to single utility price cap



4.54 The active regulator R_1 uses the predicted responses (on both markets) to determine the price cap on the first good as

$$\text{Max}_{p_1^{cap}}\; V(q_1,q_2)-C(q_1,q_2)$$

s.t. q_1 and q_2 given by the response functions.

4.55 In our numerical example we get

$$p_1^{cap} = 66/13,\ p_2 = 74/13,\ q_1 = 24/13,\ q_2 = 16/13$$

4.56 We observe that the prices on energy 1 will be set too high compared to first best. This is done because the firm uses its market power in the second energy and limits the supply hereof. In turn, this makes the marginal value of the first product higher. Compared to the case of two single utilities, we see that the regulator now puts less price pressure on the first energy. The reason is that the integrated utility will respond to a too low energy 1 price by cutting the production hereof – and simple producing more energy 2. We see this behavior – and lack of monotonicity – in the response functions as well. This is different from a case of individual utilities where the energy 1 producer cannot switch and go for a relatively higher earning on energy 2.

STRUCTURE D: INTEGRATED- INTEGRATED

4.57 Imagine finally that there is full coordination at both the regulation and industry sides. We have a single regulator (R) controlling the behavior of a single firm (F).

No regulation

4.58 In this case, the unregulated outcome is as in structure C, i.e. the firm act like a monopolist. The consumers suffers from having lost the disciplining effects of (imperfect) competition in structure A. Again, however, there is a social gain from the realized synergies.

Regulation

4.59 Since we now have a single regulator, we expect that it regulates both energies in a balanced way. Using price caps, it can implement the full information, socially optimal outcome by choosing prices

$$p_1^{cap} = p_2^{cap} = 4$$

as in the social optimum.

Comparison of the four structure

4.60 The outcome in the four structures is summarized in Table 4.2 below. Here, we have also calculated the generated social surplus S (minus the fixed, parameter a).

Table 4.2 Numerical comparisons of four structures

	Social Opt.	Struture A (S-S)			Structure B (S-I)		Structure C (I-S)		Structure D (I-I)	
		Unreg. Cournot	Cartel	Single Price Reg.	Unreg. Cournot	Integrated Price Reg.	Unreg. Monopolist	Single Pric Reg	Unreg. Monopolist	Integrated Price Reg.
q_1	2.00	1.33	1.14	2.29	1.33	2.00	1.14	1.85	1.14	2.00
q_2	2.00	1.33	1.14	1.14	1.33	2.00	1.14	1.23	1.14	2.00
p_1	4.00	6.00	6.57	4.29	6.00	4.00	6.57	5.08	6.57	4.00
p_2	5.00	6.00	6.57	5.43	6.00	4.00	6.57	5.69	6.57	4.00
$S-a$	14.00	10.22	9.06	11.02	10.22	12.00	11.06	12.96	11.06	14.00

4.61 From the discussion above and the numerical evaluations in Table 4.2, we can make a series of conclusions.

4.62 First of all, an integration of the regulators, i.e. a high coordination and uniform effort to control both prices, is preferred to a separation of regulators that do not coordinate and where some regulators may free-ride on he effort of others.

4.63 Secondly, the integration of firms is attractive from the point of view of synergies, e.g. the sharing of planning, costumer, juridical departments and the sharing of costs of access etc. We have modeled this by a fixed cost in the integrated firm that is less than the sum of fixed costs in the individual firms.

4.64 Thirdly, the integration of firms is unattractive from the point of view of incentive provision since it limits the use of competition as an incentive device.

4.65 The gains and losses from an integrated company are illustrated by the numerical social value in the examples above. Single price regulation with an integrated company saves an addition costs of 2 by the integration but losses a (small) amount of 0.06 by the loss of competition making the difference in social value between structure A and C equal to 1.94.

4.66 A fourth – more ambiguous effect – relates to the regulatory burden of bargaining with one big as compared to two smaller companies. The bargaining may be more burdensome with a larger company with presumable more expertise. On the other hand, it may be advantageous to only interact with one rather than two companies.

4.67 The pros and cons of the four structures are summarized in a simple multi-criteria evaluation in Table 4.3 below.

Table 4.3 Summary of pros and cons of structures

Criteria	Structure A: S-S	Structure B: S-I	Structure C: I-S	Structure D: I-I
Motivation costs (incentives)	0	+	-	0
Coordination costs	-	0	0	+
Transaction costs	0	+	-	0

Further structural issues

4.68 Through our analysis of four industry-regulator configurations we have illustrate how structural questions can be addressed using the tools of micro economics in general and industrial economics in particular. The analysis has only been illustrative and scratched the surface of such normative and descriptive structural analysis.

4.69 In a full-scale project, it would be relevant to extend the analysis above using more details about the value and cost synergies among the energies. Also, a series of additional issues should be addressed. We now mention some of them without illustrating in any details the kind of analysis it would take to investigate them.

Other structures

4.70 We have sketched four possible regulator-industry relations above, but there are of course many others and the study of some of these should be included in the main project. The choice of exactly which structures to analyze in a main project shall be determined by combining a literature search and theoretical analyses with the ideas and traditions of the Norwegian regulators and industry

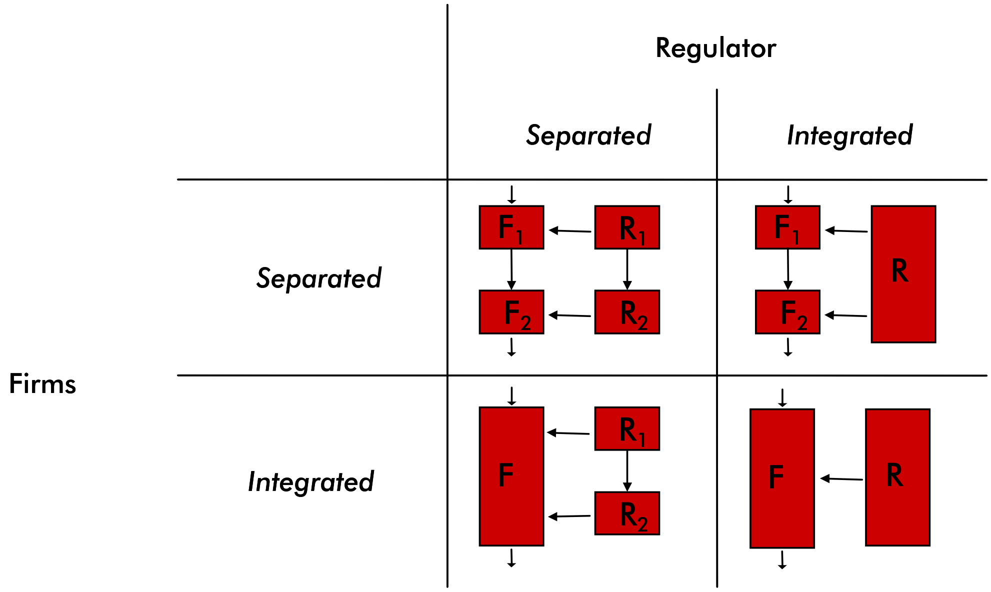
4.71 One possibility – not unlike the present *Norwegian approach* – is to let the presumably well-informed electrical distribution company have particular obligations to be involved in multi-energy coordination and planning. It seems clear that the *out-sourcing of coordination* to one of the players can be analyzed using similar tools as above.

4.72 In particular, the otherwise unregulated setting could lead to an imperfect competitive setting like the so-called Stackelberg oligopoly models. It is well known that a Stackelberg equilibrium may be socially preferable to a Cournot outcome. This means – somewhat counterintuitive - that *consumers my actually benefit from the attempt by the privileged company to exploit market behavior*. When the energies are complementary rather than substitutes, e.g. when gas is used for base level heating and electricity is used to cover excess demand - another line of literature one could rely on is that of vertical coordination and the theory of undersupply because of double marginalization. A third line of literature of relevance for the outsourcing scenario is that of primary-secondary providers and concession auctions.

4.73 In the bulk of this chapter, we have taken a horizontal focus and analyzed the coordination of two substituting energies – like the use of electricity or gas for heating. A similar analysis of vertical substitutions and complements are – as indicated - possible as well and may also be very relevant. Again, there are many vertical structures to consider.

4.74 To illustrate, we have sketched four structures in Figure 4.4 below. Clearly, the four vertical structures mimic the horizontal structures analyzed above. The only difference is that the production is now floating trough a supply chain with F1 followed by F2 rather than via two separate supply chains F1 and F2. The two levels may for example be generation (F1) and distribution (F2) or generation-distribution (F1) and consumption (F2).

Figure 4.4 Four vertical structures



4.75 In the vertical structures there are again a series of interactions and synergies to consider in the regulation. In the first (generation-distribution) example, the location and nature of generation affects the appropriate design of the distribution network (to ensure sufficient capacity, to avoid creating market power for niece producers etc) and vice versa (the lack of distribution net may for example be compensated for by an appropriate location of generation, including the introduction of decentralized, small scale generation). In the second (distribution-consumption) example, the lack of network investments may for example, be compensated for by an appropriate (node) pricing that will affect demand, and the development of new demand management technologies, like intelligent house-ware, may reduce the need for network investments.

4.76 We have expanded in quite a few details on the synergies in the vertical structure of electricity in the TSO-charter project, cf. Agrell and Bogetoft (2002a). At this point, it suffices to stress that a lack of regulation – or an inappropriate regulation - of one level will tend to affect the optimal choice of an active regulator engaged in another level. Analysis of such more or less coordinated regulation can be undertaken using industrial economics like in our analysis of horizontal structures above.

Other regulations and behavior

4.77 The analysis of how the different structures would operate could also be modified. In the examples above, we have made a series of assumptions about regulatory coordination, fully rational behavior, regulatory information etc that could be varied in a full-scale project. At least a full-scale project should investigate the sensitivity of the results to the behavioral assumptions.

4.78 In particular, we note that regulatory coordination could in practice take many forms. The stylized possibilities of perfect coordination on the one hand and single regulator free riding on the other hand are simply extremes on a continuum of scenarios. Also not only price cap regulation could be considered. Approaches like revenue cap regulation, light handed regulation and charter-based regulation may be included as well, cf. below. Again, the spectrum of alternatives to consider should be delineated in close interaction with the regulators and the industry and taking into account the regulatory heritage.

Other objectives

4.79 In the evaluation of the four alternative structures above, we relied on the objectives of maximizing social surplus, defined as the difference between consumer values and production costs. We also discussed how the objectives of providing motivation, ensuring coordination and minimizing transaction costs contributed to this overall objective.

4.80 In a further study, it is relevant to consider a wider spectrum of objectives. Introducing a broader systems perspective may extend the objectives. We may distinguish between extensions in the temporal, horizontal and vertical dimensions.

4.81 In the *temporal dimension*, it may be relevant to distinguish between short run objectives related to operations and long run perspectives related to investments. The long run perspective should also take into account the added uncertainty about technology, demand etc in the long run, cf. our discussion of imperfect information and incomplete contracts below.

4.82 In the *vertical dimension*, it may be relevant to evaluate the optimality of decisions all along the supply chain. In particular, we believe it is relevant to think more carefully about the behavior of consumers. Above, the consumer decisions are partially modeled via the value and demand relations. By requiring these to hold, we ensure that prices reflect marginal values. On the other hand, prices in some of the configurations may not reflect marginal costs. In effect, the social welfare may not be maximized. Moreover, in the presence of synergies that affect marginal costs, the cost allocation on different energies is far from simple. The use of cooperative cost allocation mechanism like in Bogetoft and Olesen (2000) may be necessary and still the interaction with consumption will have to be carefully analyzed.

4.83 A more thorough analysis of the demand decisions would be relevant in a full-scale project. It should discuss what cost information is transmitted through prices in the different configurations and schemes, and the extent to which this provides the relevant information for consumers to make, for example, the right investments in alternative energy appliances.

4.84 In the *horizontal dimension*, *environmental concerns* should also be taken into account. Production costs and consumers values do not – by definition – account for the environmental externalities. This may call for modifications of consumer prices and producer remunerations. The interaction with the private incentives, however, is complicated, and it requires considerable skills to set prices and subsidies right in a system with integrated energies. Our analysis of the combined Danish central heating and electricity generation system clearly shows the inefficiencies that may result from historical ad hoc decisions motivated by environmental concerns – and the mistakes one can make if this history is ignored in subsequent efficiency analyses, cf. Agrell and Bogetoft (2001).

Other informational conditions

4.85 In the analysis of our four structures, we have assume perfect information about costs and value at all firms and consumers, as well as the ability to make complete contracts specifying the reimbursements in all circumstances. In reality, of course, we have imperfect information and incomplete regulation (contracts).

4.86 *Imperfect information* about the costs of the firms lies on the heart of modern regulation theory. It affects the regulatory practices and approaches that can be used, as it has been discussed in numerous studies, including FP2 and FP4, cf. Agrell and Bogetoft (2002b, 2003). In relation to the structural perspective introduced here, it is useful to point to at least two effects.

4.87 First, the degree of integration among energies affects the ability to overcome asymmetric information via *relative performance evaluations*. Part of the reason for unbundling is to facilitate control by having simpler firms that can be compared across regions using for example efficiency analysis like DEA. With integrated companies, the issue of allocating costs on the different energies is complicated and comparability in general decreases.

4.88 Secondly, the integration of energies may limit the informational rents that can be extracted by the firms if the regulator takes advantage of *bundling*. Loosely speaking, the information asymmetry about the costs of a bundle of energies may be less than the sum of uncertainties. The advantages of bundling exist even when the underlying costs of producing the energies are independent and there are no synergy effects. This can be demonstrated and analyzed along the lines suggested in Antle, Bogetoft and Stark (1999).

4.89 *Incomplete regulation* refers to the fact that not all circumstances can be foreseen when setting price caps, revenue caps etc. New technologies may develop, new environmental concerns may arise, new demand management tools may develop etc. Incomplete contracts in general call for a renegotiation of the payment plans etc, cf. also our discussion in FP2.

4.90 The allocation of decision rights and obligations and the general structure of the industry are very important in such situations. We can talk about the structure of efficient rights. This has been emphasized in the recent literature on institutional design, cf. for example the survey in Martimort, Donder and Villemeur (2002). The idea is actually quite simple. With perfect information, the allocation of property rights is not important since rational agents will negotiate the proper use and allocation of all possibilities. This is an instance of the famous "Coase Theorem". With asymmetric information and incomplete contracts, however, the allocation of decision rights and obligations, property rights etc is very important since it affects the threat points and status quo in the subsequent renegotiations.

5. Regulatory Mechanisms and Elements

5.01 It is difficult to develop good regulatory schemes even in the partial context of a single energy line. It is therefore very ambitious to look for optimal schemes in a multi-energy setting. Moreover, given the novelty of the – practical and theoretical – interest in multi-energy regulation, we suggest that a detailed study of specific schemes is pre-mature. This explains our emphasis on structural aspects above.

5.02 On the other hand, the effect of one or the other industry and regulatory structure also depends – at least somewhat – on the incentives mechanisms used. In this chapter, we illustrate this by a series of simple observations. We take a brief look at a number of regulatory mechanisms and elements and discuss how they can help us solve the basic coordination, motivation and transaction costs problems in an integrated energy system. The discussion hereby provides numerous links with the other pre-projects.

Delegation

5.03 A response to the complexity of the problem, the importance of synergies and system wide effects, and the presumably large amounts of asymmetric information, is to rely more on delegation and less on intrusive regulation. There are several versions of this. We remind the reader of four types of extended delegation, which has been, discussed in other NVE projects recently, viz light-handed regulation, ex post regulation, charter of accountability and menu of contracts.

Light-handed regimes

5.04 One way to introduce more delegation and less intrusive regulation is using a so-called light-handed approach. In this, the regulator simply monitors the development of the system and interferes ex post in case of misuse of the trust vested in the industry. We have expanded on this in FP2 on Ex post regulation, cf. Agrell and Bogetoft (2002b)

5.05 The light-handed regulator can with a low cost perhaps collect some data ex post to indicate abuse or to measure the effectiveness of the *self-regulation* that may be present in the market. Combined with harsh penalties for abuse, the light-handed approach can be high-powered and very efficient. So far, the principle has only been used in New Zeeland and Sweden for regulation of electricity distribution, but it is common in, e.g., anti-trust regulation.

5.06 Extending the scope to other sectors, the light-handed regulation is analogous to the *regulation by rights* concept that is extensively used in, e.g., environmental regulation. Here, the regulator designs a mechanism under considerable uncertainty regarding the future technology in addition to the information asymmetry. Mechanisms with ex-ante rules, usually certifications and detailed instructions on the production, distribution, use and disposal of hazardous materials or processes, are extensively used in European contexts. The regulator takes a considerable risk from the firms in a trade-off between the moral hazard of asymmetric information and the risk of hit-and-run on behalf of the firms. Generally, the regulation is extensively process-oriented and suffers from problems of technology lock-in with time.

5.07 A related approach to regulation uses *liabilities*. Rather than micro-managing the firms, the regulator is now challenged with the task of monitoring the final outcomes of production and assuring that liability claims are enforced. In the American common law system, this has lead to substantial punitive damages being paid by ex-post negligent firms. However, if firms can avoid paying liabilities or pay them through taxes etc. the system cannot guarantee the optimal investment and service level. An illustration to this phenomenon is found in telecom regulation of fixed nets. If concessions are awarded based on lowest price subject to an ex-post level of service (coverage, failure rate, etc.), a hit-and-run firm can win the contract by neglecting investments and then cease to exist when the damage is observed. To limit this risk, regulators demand frequently the posting of a bond to offset the consumers' risk. In economic theory, this bond is called the *hostage* and could sometimes be substituted for shares of stock, assets or other (profitable) concessions.

Ex post regulation

5.08 Also, the idea of ex post regulation is related to this movement towards more delegation. Given the complexity of the multi-energy problems and given the uncertainties involved, it is not optimal to fix the operating conditions ex ante like in a CPI-X scheme. It has advantages to commit ex ante to a certain ex post adjustment, including the use of new information, renegotiations of the contractual conditions etc. We have discussed a spectrum of ex ante ex post regimes in FP2, cf. Agrell and Bogetoft (2002b).

Charter of Accountability

5.09 Another version of the delegation alternative is to regulate via a Charter of Accountability. We developed this idea in the in 2002 TSO project that NVE was involved in, cf. Agrell and Bogetoft (2002a).

5.10 A charter is a written document that defines the franchises, rights and obligations of an organization. Extended delegation is motivated by the existence of asymmetric information and considerable system wide effects, i.e. positive ad negative synergies. The charter clarifies the society's expectations on the organization, but the regulator may desire to do more. The relative autonomy and financial position of the energy companies 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 Charter of Accountability is therefore an act of clarifying the functions of the actors 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.

Menu of contracts

5.11 A fourth way to introduce more delegation and adaptation to local conditions is to use a menu of regulatory schemes that the multiple or the integrated companies can choose from. We discussed these possibilities in the FP2 project as well, cf. Agrell and Bogetoft (2002b). Compared to the light-handed and charter alternatives, the use of a menu of contracts controls the delegation more firmly by defining a set of operating conditions ex ante. This has the advantage of avoiding endless and uncertain re-negotiations and the disadvantage of allowing for some but not entirely flexible usages of new local information.

Value focus

5.12 Whatever the overall regulatory regime, there will be some performance evaluation involved. The performance measure is one of the details that can have a non-trivial impact on the balanced use and development of alternative energies. We discuss more details of performance evaluations and how they interact with regulation and incentives in the FP4 pre-project, cf. Agrell and Bogetoft (2003).

5.13 Traditional performance evaluation models have several variables that essentially are process oriented and concern the inputs or means rather than ends. They use for example km lines, number of transformers etc. in addition to some output-based measures like costumer characteristics or peak capacity offered. Also, and most significantly, performance evaluation models tend to focus on one type of energy, say electricity, as opposed to the services like heating, light etc.

5.14 In general it will improve the incentives of the companies to make proper trade-offs if the performance measures focus on the outputs and values created rather than on the resources spend. This means that the regulation should stress product attributes and final values and neither processes nor ex ante boundaries among the energies. The philosophy of the Swedish so-called net-utility model is precisely that companies should be rewarded for the utilities they generate, not the ways they generate them.

Internalizing system wide effects

5.15 We emphasize that although a multi-utility may ensure a better trade-off between the energies it include, it may also misuse the possibilities by charging high prices on relatively price-inelastic services.

5.16 Moreover, a possibly better trade-off among the included energies is no guaranty of appropriate trade-offs towards non-included energies. A company covering electricity and gas, for example, may not make appropriate trade-offs towards central heating. Similarly, an energy company may not make appropriate trade-offs towards demand management and market facilitation but focus instead on (excessive) network investments.

5.17 It is the role of the regulators – and in particular the role of the integrated regulator - to ensure that the system wide effects influence the operations of separate or integrated companies.

5.18 One way to do so is that a well-informed regulator tries to derive optimal quantities and to control these via for example price-caps. This is the approach we have illustrated in chapter 4 above.

5.19 Another way is that a well-informed company tries to demonstrate the impact its operations have on the system at large, both in horizontal and vertical dimensions. This is the approach emphasized by the charter of accountability. In Agrell and Bogetoft (2002a), we derived a full set of metrics that a (transmission) company can invoke to demonstrate its system wide (vertical) effects. A similar approach could be relevant in a multi-energy context.

5.20 The general way to voluntary implement appropriate decisions is that the same firm faces all the costs and benefits created system wide from its operations. In this way, it internalizes its effects and will tend to make the right trade-offs. This is similar to the way externalities are dealt with in the micro-economic literature. A system wide set of metrics like Agrell and Bogetoft (2002a) may help ensuring such incentives.

Concessions

5.21 A related issue concerns the way concession rights are defined and assigned.

5.22 It we outsource the balancing of alternative energies, we must give energy concessions rather than say electricity concessions, gas concessions etc. By using energy concessions and by measuring energy performance, we internalize the trade-offs between the different sources of energies.

5.23 Of course, the disadvantage of this – as discussed also in previous chapters - is that combined energy companies with general energy concessions will be less disciplined by the competitive pressure of substitutes. Relative performance evaluations and yardstick competition etc are of course still possible across regions, but intra regional energy competition is less. To avoid that the information rents gets excessive, one can try to introduce harsh competition for the concession rights ex ante – and repeated testing of who is the appropriate concession holder. A system of primary and secondary providers may contribute to such incentives without discouraging the proper investments out of fear from loosing the concession. We are presently doing research on such issues.

Further issues

5.24 In this chapter, we have commented on several ways in which the project of combined energy regulation interacts with the other NVE pre-projects. We close by noting that a careful reading of the emerging multi-utility and multi-regulator literature most likely will point to further interactions between the structural aspects that we have emphasized here and the regulatory approaches and elements.

6. Further Work

6.01 In this section, we identify subjects for further investigations in a subsequent main project.

6.02 It is difficult to develop good regulatory schemes even in the partial context of a single energy line. It would therefore seem overly ambitious to derive and calibrate optimal schemes in a multi-energy setting. Moreover, given the novelty of the – practical and theoretical – interest in multi-energy regulation, we suggest that a detailed study of specific schemes is premature.

Structural aspects

6.03 Rather, we propose to start with a study stressing the structural aspects and only towards the end of this project, to start speculating about more specific mechanisms and regulatory elements.

6.04 The *structural or systems aspects* concerns the basics of any economic system, viz. who are the agents and what are their interests, who are given the rights to do what and when, how are the multiple activities balanced and coordinated, what information is flowing, and in broad terms, how are the agents rewarded etc.

6.05 We propose also that in particular the *interaction of energies and measures to improve energy utilization* should be a primary focus. By definition it is the parallelism that distinguishing combined energy regulation from single energy regulation. Moreover, the balancing is hard and – if not properly coped with – can lead to substantial social losses. We suggest therefore that intra- and inter-company coordination and intra and inter-regulation coordination should play a prominent role in a subsequent main project.

6.06 The different energies – or the different levels in the energy supply chains – are typically under the influence of several firms that are more or less competitive and enjoys more or less natural monopoly rights. Some of the energies are multi-purpose and can compete in a wide spectrum of application while others are more specific and useful only for specific purposes, say heating, at a more local scale.

The *technological characteristics* together with the *industrial structures* obviously affect the coordination of the energies.

6.07 Similarly, the different energies – or the different levels in the energy supply chains – are typically affected by a series of rules, price support schemes, incentive mechanisms, environmental constraints etc and it is the balancing of these influences that determines the outcome. By *intra and inter regulator coordination* we think of the degree to which these different influences are balanced to ensure a desirable outcome.

A three phase approach

6.08 There are a large number of relevant issues to investigate even in a study stressing structural aspect. For the purpose of project planning, we therefore suggest a three-phase approach that gradually can be adjusted to focus on the issues that seems particularly important. The important issues will depend on the actual magnitude of the theoretically possible effects. The important issues will also depend on what the regulators etc consider to be politically acceptable changes.

6.09 A further advantage of the three-phase approach is that the results from the initial phases will be useful even if subsequent phases are abandoned. Hereby, decisions as to the initialization of the different phases can be taken sequentially.

Phase 1 Descriptive

6.10 The first phase is largely empirical. Its aim is to identify the systems under study, the interactions among firms and the main regulatory influences.

6.11 More specifically, the first phase must

SYNERGIES AND INDUSTRIAL STRUCTURE

> Delineate and investigate in more details the possible synergies and substitution effects among different energy sources and transportation modes. This involves interaction with energy specialists, engineers etc and could be supported using a workshop with representatives from the different energies. The aim is to establish a description that is sufficiently detailed to be representative and yet sufficiently

focused and aggregated to allow for subsequent industrial economics analysis in phase 2 and 3.

Describe the present industry structure, and its dynamics, in Norway.

REGULATORY STRUCTURE

Describe the incumbent regulatory structure and degree to which the regulations are coordinated. Again, this involve interaction with industrial representatives and regulators, e.g. in a workshop, to identify what they consider to be the main regulations influencing firm behavior.

6.12 Establishing a good description of the systems under study will require the active participation of industrial players and regulatory representatives, e.g. in small workshops. This affects the intensity of the project phase in order to be finished in 4 months.

Phase 2 Predictive

6.13 The second phase starts from the description of the industrial and regulatory set-up and seeks to derive the likely performance of the existing system, including the incumbent regulations. The primary aim is to identify if changes are needed to pursue specified goal and to identify changes and approaches that are particularly critical.

6.14 More specifically, the second phase must

COMBINE INDUSTRIAL AND REGULATORY CHARACTERISTICS

Derive from the described synergies and substitution effects and the existing industrial structure the likely development of the industrial structure under the incumbent regulations.

Evaluate the degree of coordination and balanced energy development and the likely rents and efficiency under i) the incumbent regulations, ii) a socially optimal industry structure (with perfect information), and perhaps iii) socially optimal industry <u>and</u> regulation structures. Derive from this the possible maximal impact of an improved coordination of the regulations.

These predictions involve the use of industrial economics tools of analysis as illustrated in the simple examples in chapter 4. Naturally, the predictions will be indicative rather than firm and precise.

Perhaps test the theoretical predictions using (international) experience. This involves describing the industrial structure and dynamics in some key countries, and linking the structure with the regulatory setting.

6.15 This part is more analytical and hence less demanding in terms of calendar time. Still, to allow fro the clarification of some assumptions via interactions with industry and regulators, a time window of approximately 3 months much be planned with.

Phase 3 Normative

6.16 The aim of the last phase is to discuss in a more normative study the necessary changes in terms of the structural aspects and to some degree the regulatory nuts and bolt. This is the design phase, where the preferred industrial and regulatory structures are on the agenda. The phase will analyze the desirable compromise between competition and coordination and ways to ensure both by appropriately defined mechanisms like revenue caps etc. It extends the analysis in the previous phases by allowing more givens to be varied. Again, however, the degrees of freedom to allow can be guided by the descriptive study and the necessity to get political acceptance.

6.17 More specifically the third phase must

INDUSTRIAL AND REGULATORY STRUCTURES

Outline a spectrum of alternative regulatory structures. The spectrum should vary from a single, comprehensive coordinated regulator to a multiplicity of parallel regulators covering each energy supply chain. The spectrum should also vary from fully centralized to vertically decentralized structures where the regulation is outsourced to lower levels.

Predict the equilibrium between regulation structures and industry structures by taking into account also the industrial responses to a new regulation. This involves the use of industrial and regulatory economics (including multi-utility regulation). Also, to cope with the more intricate aspects of imperfect information, it requires the use of recent advances in information economics and incentive theory.

Compare the social attractiveness of the resulting industrial structures and behavior under the incumbent and alternative regimes.

OPTIMAL SYSTEMS STRUCTURE

Conclude as to the characteristics of the best industry and regulatory structures for the energy sector. This involves a system description that outlines the players, their individual decision areas, and the informational flows between them. In particular, it allocates responsibilities to individual players and penalty/reward codes to give them proper incentives.

TOWARDS IMPLEMENTATION

Delineate the steps that will lead to an implementation of the optimal structure.

Have initial discussions as to the role of alternative regulation mechanisms and tools, e.g. charter of accountability, primary-secondary concessions rights that are granted for a limited period of time, energy based revenue cap models, menus of contracts etc.

6.18 The time needed for this phase is very dependent on the extent to which the choice sets can be restricted, but at least 4 calendar months must be set aside for such analysis as well.

Project plan

6.19 The overall project plan under the intensive option is depicted in Figure 6.1 below. Phases 1 and 2 are overlapping in that the last part of the descriptive phase of the regulatory structure can be made simultaneously with the first predictive studies under complete deregulation. The milestones represent when important progress reports and presentation on the direction of the project will be presented. Milestone 1 gives a summary of the industrial structure, milestone 2 a complete description, milestone 3 presents the final analysis of the current system and milestone 4 corresponds to the final normative analysis.

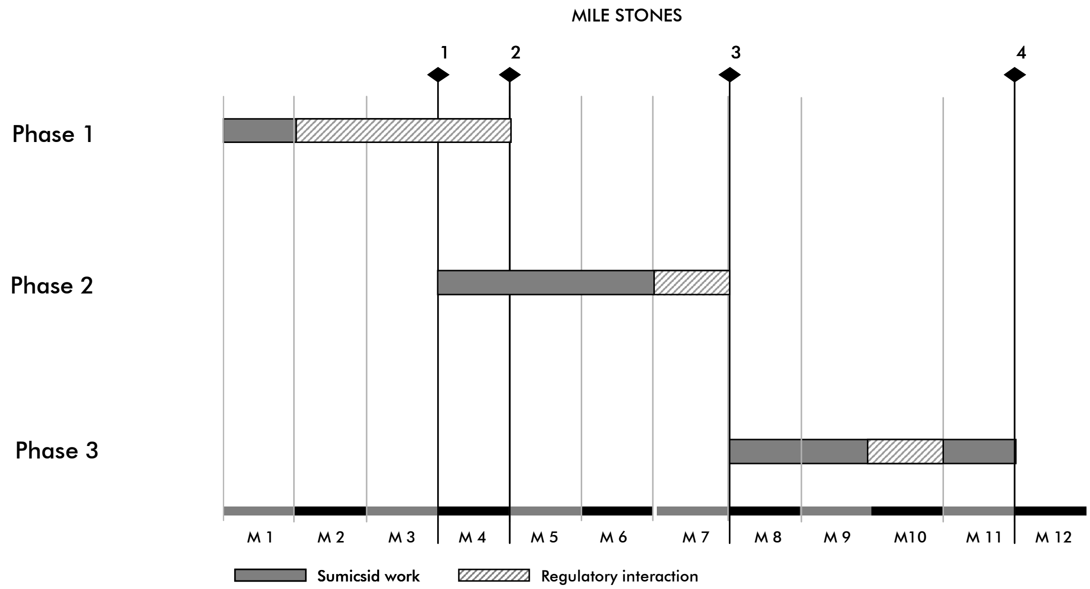


Figure 6.1 Project timeline with milestones.

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SUMICSID

SUMICSID AB
Tunbyn 502 Tel: +46 60 56 51 41
S-855 90 Sundsvall, SWEDEN Fax: +46 60 56 51 41
sweden @ sumicsid.com

SUMICSID (BELGIUM)
Rue de la piété 11 Tel: +32 10 47 83 65
B-1160 Bruxelles, BELGIUM Fax: +32 10 47 83 24
belgium @ sumicsid.com

SUMICSID (DENMARK)
Fru Ingesvej 19 Tel +45 57 83 15 18
DK-4180 Sorø, DENMARK Fax: +45 57 83 15 18
denmark @ sumicsid.com

http://www.sumicsid.com