Maria Sandsmark

A regional energy paradox - the case of Central Norway

2008:12

Maria Sandsmark

A regional energy paradox -
the case of Central Norway

Arbeidsnotat / Working Paper 2008:12
Høgskolen i Molde / Molde University College

Molde, november / November 2008

ISSN 1501-4592

ISBN-13 978-82-7962-107-2

A regional energy paradox – the case of Central Norway*

Maria Sandsmark

Molde Research Institute,
Britveien 4, N-6411 Molde, Norway

Tel: +47 71 21 42 84, Fax: +47 71 21 42 99
E-mail: maria.sandsmark@himolde.no

Abstract

Central Norway is expected to have a gap of 8 TWh in 2010 because of heavy investments in electricity intensive industry. The region has two landing sites for natural gas and a considerable potential for wind power to cover the gap. Small-scale hydropower and upgrading of existing hydropower plants also constitute a regional energy potential. Paradoxically, the most realistic investment prospect seems to be extensive investments in new transmission lines to cover the electricity deficit. The aim of this paper is to present a problem of regional supply security and public intervention and discuss possible directions for improving regulators' practical authorisation tools.

Key words: Regional electricity market; Supply security; Investment; Regulatory risk

JEL Classification: L11; L51; L94

---

* Financial support from the Business and Management Research Fund in Mid-Norway is gratefully acknowledged.

1. Introduction

In theory, deregulated electricity markets should provide appropriate investment incentives to market participants. However, in practice the expected gains from restructuring processes are often restrained by market imperfections and the vagaries of nature and politics, c.f. the discussion in Joskow (2007). A case in the point is Central Norway. The aim of this paper is to present the development of the current energy paradox in this part of Norway and discuss the challenges that deregulated electricity markets face when demand increases sharply whereas the realisation of new generation capacity or transmission lines is hampered by environmental regulation, lumpy investments and lack of appropriate policy measures. Any lessons learned from the undesirable development of this sub-market in the overall well-functioning Nordic exchange area, may be relevant in the process of integrating EU member states to make a robust single European electricity market.

Central Norway consists of the three counties: North-Trøndelag, South-Trøndelag, and Møre and Romsdal. The geographical area covers 17 percent of the Norwegian mainland and it is inhabited by 14 percent of the Norwegian population. The fourth largest Norwegian town, Trondheim, is part of the region. The most important industries in Central Norway are fisheries, maritime industry, furniture industry and petroleum industry. Northern Europe's largest aluminium work is located in the region. Moreover, since 2007 natural gas from Europe’s third largest gas field, Ormen Lange, has been processed onshore at Nyhamna in Møre and Romsdal, where gas is dried and compressed before it is exported 1 200 km to Easington, UK, in an offshore pipeline. At peak production, close to 20 percent of the UK gas demand will be delivered from these gas wells. The processing plant has increased the annual energy demand in the region by 1.2 TWh and the maximum load by 120 MW, and there are plans for further expansions in the near future.

By the time the investment plans for the Ormen Lange processing plant was approved by the government in 2004, other energy-intensive companies in the region, particularly the large aluminium plant, had increased energy demand considerably. As a result, Møre and Romsdal county experienced an increase in energy demand of 86 percent from 2002 to 2007 and the current energy deficit is 4.3 TWh under normal inflow conditions. The total energy deficit in Central Norway is 6.3 TWh, expecting to grow to 8 TWh by 2010. In a normal situation, the import capacity to the region is sufficient to cover this deficit. However, due the large share of hydro power generation in the region – amounting to approximately 90 percent – and the associated stochastic inflow variability, supply security is a great concern. The Nordic system operators have the responsibility for both the security of supply and the high-voltage grid. In Norway, the system operator is the state-owned grid company Statnett SF.

The substantial increase in the electricity demand in Central Norway did not come as a surprise. The investment plans for expanding the activities at the aluminium plant, for example, was initiated as early as 2000. Also, Statnett have planned and carried out large central-grid reinforcements in the region since 2002. However, these investments are not sufficient to secure energy supply in a dry year and the need for local investments in new generation capacity was duly communicated. It was warned that without developments in new electricity generation capacity, extensive investments in new transmission lines to cover the deficit were inevitable. Moreover, Statnett's own analyses, e.g. Statnett (2005), concluded that investments in new electricity generation close to the large electricity consumers in the region would be more economically efficient than covering the electricity gap via investments in new transmission lines. Specifically, the line alternative in question is a 250-300 km 420 kV line passing trough 19 municipals on the ragged west coast of Norway, crossing several fjords and affecting areas important for tourism industries, recreation areas, biological diversity and a world heritage site – the Geiranger Fjord. Consequently, the suggested transmission investment have created a substantial resistance within the involved communities, but also environmental organisations, such as the Norwegian branch of Friends of the Earth, have opposed the investment and demanded investigations in alternative measures. Moreover, the total cost of the transmission investment is substantial, estimated to Euro 227 million (NOK 2 billion). Anyway, in late 2005 the list of reported investment plans in new generation capacity in Central Norway with indicated completion by 2010 amounted to 16.5 TWh, i.e. a total of 12.4 TWh gas-fired electricity generation, 2.8 TWh wind power and 1.3 TWh small-scale hydropower, with plans for an additional 11.5 TWh by 2015 (c.f. Sandsmark and Hervik, 2006).

The investment plans are founded on the basis that the region has two landing sites for natural gas and a considerable potential for wind power and some hydropower. However, low project profitability, hazy environmental measures or local opposition have so far prevented the realisation of most plans for new generation capacity in Central Norway. Therefore, rising electricity prices and an impending danger of a voltage collapse raise the question of how a region with abundant energy recourses could experience a situation that threatens the reliability of electricity supply. Before I discuss possible answers to this question, I present some further characteristics of the regional electricity market of Central Norway and any regulatory attempts to mitigate the unfavourable development and associated consequences.

2. Central Norway electricity market characteristics – 2008

The Nordic electricity market is a highly integrated system with a common power exchange, Nord Pool. Historically, since the deregulation of the Norwegian market in the early 1990s, the market has been subsequently expanded with Sweden, Finland, and Denmark joining in turn, c.f. Johnsen (2003), von der Fehr et al. (2005) and Amundsen and Bergman (2006) for elaborations. The Nordic Power Exchange includes an implicit day-ahead capacity auction on the interconnectors between geographical bidding areas (Elspot). The electricity spot price that balances sale and purchase within the exchange area disregarding any transmission constraints between the bidding areas, is denoted the system price. Hydropower generation is concentrated in Norway and Sweden, whereas Denmark and Finland are dominated by thermal generation and to a lesser extent wind power. Due to the characteristics of electric power as a commodity, the market situation may in practice change every hour and, consequently, also capacity utilisation and flows on the transmission lines and interconnectors, crating grid congestions. Therefore, having a joint market place does not imply that a common Nordic price always prevails; the bidding areas may become separate price areas.

The Norwegian market is under normal conditions divided into two bidding areas, a Southern Norway Elspot area NO1 and a Northern Norway Elspot area NO2. However, in periods with major and long-termed bottlenecks in the regional and central grid system, Statnett may define more appropriate bidding areas. Therefore, when the hydrological situation in Central Norway gave rise to concern during the autumn of 2006, Statnett announced that NO2 was to be divided into two price areas, Central Norway Elspot area NO2 and Northern Norway

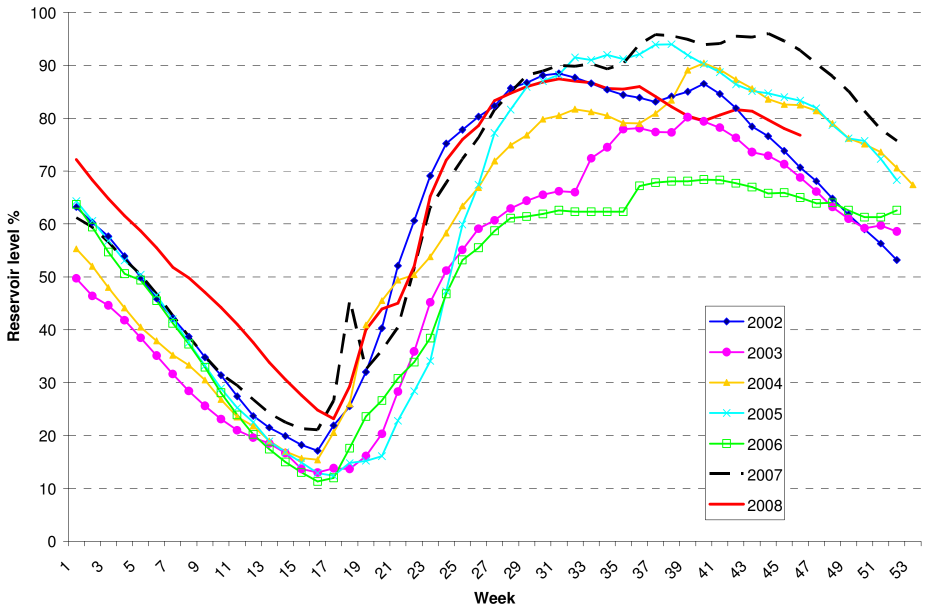
Elspot area NO3, respectively. Figure 1 depicts the seven Elspot areas prevailing at the Nordic Power Exchange NordPool from November 20 2006 to November 17 2008.

Figure 1 Elspot areas in the Nordic Power Market from 20.11.06 to 17.11.08

Source: Statnett SF

To get an idea of the annual variable abundance of water in Central Norway, Figure 2 is included to show the weekly reservoir content of the area corresponding to Elspot area NO2 from 20.11.06 to 17.11.08, since 2002.

Figure 2 Reservoir content for "Elspot area NO2", from 2002 to week 46 2008



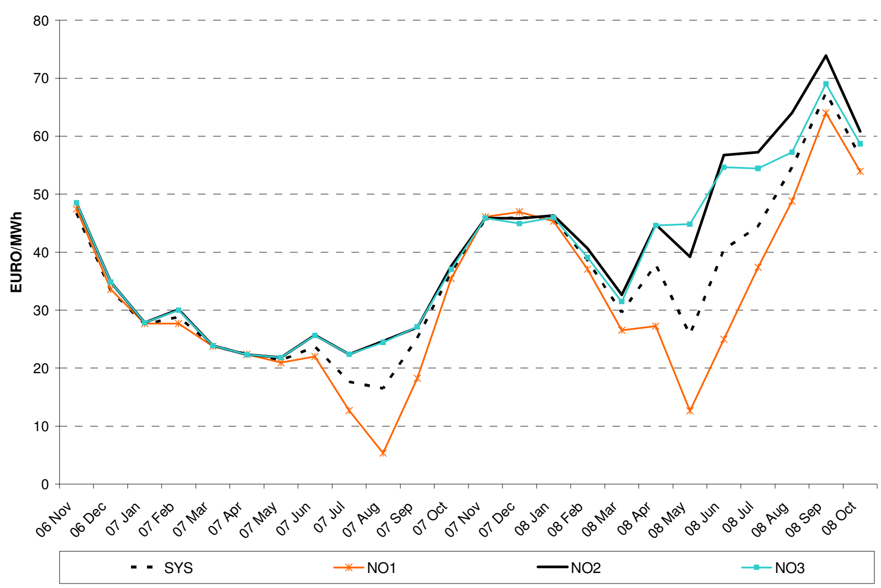
Source: The Norwegian Water Resources and Energy Department (NVE)

We observe from the illustration the relatively low reservoir level during the autumn of 2006. Note also the low levels four years earlier – during the autumn of 2002 – when the Nordic Exchange area experienced the most severe precipitation shortfall in more that 50 years. Establishing Central Norway as a bidding area is the first measure of twelve on Statnett's "SAKS-list" – a list of measures in case of severely stressed power situations that also includes procurement of energy options to large consumers, also implemented in 2006, and reserve power plants.

The purpose of establishing a new bidding area is to convey to the market agents more correct price signals – prices that reflect the physical scarcity of energy – and thereby strengthen the reliability of electricity supply in the corresponding region. In a deregulated market when the demand for a scarce resource increases, its price will rise making it more profitable to invest in new production facilities. Also, it gives the consumers an incentive to reduce their demand – and in the case of electricity supply security – to increase energy efficiency. Furthermore, establishing a Central Norway bidding area changes the flows on the transmission lines, bringing relatively more electricity into the region than out.

This measure also has a direct negative welfare effect on the citizens of Central Norway. Even though the gain is a reduced probability of experiencing rationing or blackouts, lasting price differences between regions, affecting both household budgets and the competitiveness of the local industry, are difficult to sustain politically. The average monthly spot prices for Central Norway and Northern Norway, i.e. NO2 and NO3 respectively, did not differ much the first year (from November 2006 to November 2007), but the subsequent year the price differences have been more evident. Figure 3 presents the development in price levels for Elspot areas NO1, NO2, NO3 and the System price for the period from the separation of the Norwegian electricity market into three bidding areas, November 2006, and up to October 2008.

Figure 3 Average monthly prices for Elspot areas NO1, NO2, NO3 and the System price, November 2006-October 2008, Euro/MWh



Source: NordPool

From the figure we also observe that the price differences between Southern Norway and Central and Northern Norway have been substantial, corresponding to periods with extraordinary bottleneck problems in the transmission system, particularly during the summer of 2008 when hydro inflow was peaking and the export capacity out of Southern Norway to Sweden and Denmark was limited. Without the newly established Nord-Ned cable – the interconnector between Southern Norway and the Netherlands – the price differences would most likely have been even larger during these months.

In order to study more closely the impact the different Elspot prices have had on households and industry and commerce in Central Norway, Table 1 presents the average annual spot prices for the different Norwegian Elspot areas from November 2006 to October 2008. Based on this information some simple numerical examples are presented to illustrate the different wholesale energy costs between the Norwegian price areas.

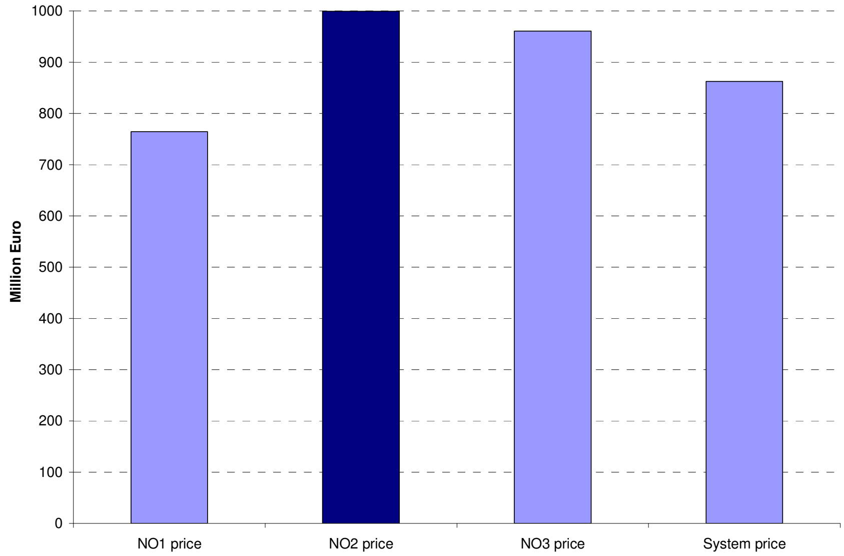
Table 1 Average annual prices for Elspot areas NO1, NO2, NO3 and the System price from November 06 to October 08

	NO1	**NO2**	**NO3**	**System price**
Average Euro-cent/kWh Nov 06 – Oct 07	0,025	0,029	0,029	0,027
Average Euro-cent/kWh Nov 07 – Oct 08	0,039	0,051	0,049	0,044

Source: NordPool

However, actual individual prices will vary depending on the retail company and the contracts (spot/variable/fixed price) the consumers have. Nevertheless, as an illustration consider the electricity consumption in Central Norway during 2007, amounting to a total of 19.6 TWh, multiplied with the average annual Norwegian Elspot prices (NO1, NO2 and NO3) and the average NordPool System price corresponding to the period from November 2007 to October 2008, c.f. the bottom row of Table 1. The resultant energy wholesale costs are depicted in Figure 4.

Figure 4 Energy consumption of 19.6 TWh priced with the average spot price for NO1, NO2, NO3 and the System price for the period Nov 07-Oct 08



Source: NordPool, NTE (2008), TrønderEnergi (2008), Istad (2008)

As previously illustrated, we see that the largest cost difference is between customers in the NO1 area and those in the rest of the country. More specifically, based on wholesale prics electricity consumers in Central Norway had 31 percent higher energy costs compared to consumers in Southern Norway and 4 percent higher energy costs compared to consumers in Northern Norway. Moreover, the NO2 price in the above example is 16 percent higher than the NordPool System price. It is worth noting again that the limited export capacity out of Southern Norway to a large extent is accountable for the relatively large spot price difference between consumers in NO1 and the rest of the country. On the other hand, this point is muffled in the public debate.

Anyway, in October 2008, the hydrological situation in Central Norway was such that Statnett decided that for the time being, NO2 and NO3 will re-emerge to one single bidding area on November 17 2008. Still, the electricity consumers in Central Norway should not expect a noticeable reduction in spot prices. Moreover, due to the completion of the last of the measures on Statnett's SAKS-list – establishing reserve power plants – Statnett has temporarily overcome the most serious threat to the electricity reliability in Central Norway.

In 2007 Statnett received consent to build two natural gas-fired mobile power plants in Central Norway (Møre and Romsdal county), each with an installed capacity of 150 MW. The mobile power plants shall be available for Statnett in situations with severe lack of energy, and Statnett must receive permission from the Norwegian Water Resource and Energy Directorate every time a plant is going to produce. At the outset, the total investment costs amounted to approximately Euro 170 million (NOK 1.5 billion) and the mobile power plants were scheduled to finish early 2008. By the end of 2008, one power plant is ready to operate and the total investment costs have risen by 53 percent.

The consent to build mobile power plants was given without requirements for CO_2 management, and the decision has been opposed by environmental groups. Also a potential investor of a permanent natural-gas fired generation plant with localisation close to where one of Statnett's mobile power plants now stands, have argued against the investment decision, claiming that it would have been more economically efficient to spend the investment cost on regional permanent production capacity. To make the arrangement compatible with the state aid rules of the European Economic Area (EEA) agreement, the potential investor suggested a public tender for new electricity generation capacity for security of supply similar to the CADA (Capacity and Differences Agreements) arrangement in Ireland, c.f. the European Commission (2003). A question that emerges is: What is the appropriate level of public interference when deregulated electricity markets experience problems with reliability of supply?

3. Electricity supply security and public intervention

Recurring situations of supply security problems in deregulated electricity markets call for improved public measures or more efficient incentives to market participants, or both. Well-known electricity crisis include Chile (1998/1999), California (2000/2001) and Brazil (2001), see e.g. Watts and Ariztía (2002), Joskow (2001) and Lock (2005) for overviews and comparisons. The case of Central Norway – a region rich on energy resources but still threatened by an electricity supply deficit – illustrates the scope of the problem. However, the Norwegian authorities did not introduce price caps on end-user prices, as was the case in California, but "released" the regional electricity price to allow it to rise in accordance with low reservoir levels and limited import capacity. On the other hand, one can ask if the interventions of state owned Statnett, induced by the measures on the SAKS-list – and particularly the procurement of energy options and the purchase of mobile power plants – could have dampened the market participants' propensity to invest in permanent generation capacity.

Statnett has assured that the energy options and mobile power plants will not be brought into action before the likelihood of rationing rises above 50 percent. But estimating this probability is neither straight forward nor transparent, see the discussion in ECON (2007), and the effects on market prices are also uncertain. Furthermore, now that the installations of the mobile power plants are soon finished, some market participants argue that the plants ought to produce already when the regional spot prices are high, to reduce regional price differences. Although the regulation authorities dismiss the idea at the present, potential investors in new generation capacity in the region may fear that price spikes originating from supply deficits will be inhibited, and their investment incentives may be hampered. Investors depend on relatively high prices in some hours to be able to cover both the operating costs and the investment costs of new capacity, c.f. Joskow (2007). Moreover, the resources that Statnett uses to change the supply-demand balance by buying energy options from large consumers should also be offered to incremental supply and transmission expansions – "levelling the playing ground", c.f. Ruff (2002) who criticise campaigns to increase demand response by subsidies in the US.

EU's Electricity Directive requires that measures adopted by the transmission system operators (TSOs) are market based. Thus, the TSO in EU Member States can not be involved in generation activities, as owing mobile power plants for reserve purposes. However, as noted above, the Electricity Directive permits a tendering procedure for building new generation capacity when the authorisation procedure is insufficient to ensure security of supply, as implemented in Ireland. But the question of when investment decisions should be left to market participants and when regulatory authorities should intervene to promote investments does not have a clear answer, c.f. the discussion in Bjørnebye (2007). It may, for example, be the case that the under-investment in new generation capacity is the result of regulatory uncertainty or is sustained by strict authorisation requirements.

In Norway, a prerequisite for granting a concession to build a generation facility is economic efficiency. The reason is the assumed difference between private costs and social costs with regard to building and operating energy facilities. The regulatory authorities have provided the industry with a cost-benefit guide (NVE, 2003) to facilitate the task of documenting economic efficiency, but positive and negative external effects are not duly accounted for. Lack of empirical basis for assessing external effects, positive or negative, is said to be the cause. More specifically, environmental costs – other than CO_2 costs – are difficult to measure and, therefore, excluded from the calculation. Positive external effects are only sought included in energy economising projects, in a qualitative manner.

The guide fixes the discount rate based on different categories of energy projects, except for large projects for which individual estimates must be carried out. There exists no unified methodology for analysing the economic costs and benefits of an investment compared to its environment, for example projects that include positively or negatively correlated events (related to natural or economic factors, climate etc.) associated with the different investment alternatives. Different projects may have different impacts on the vulnerability of the energy system and security of supply: An earth cable has a different risk of failure given variations in temperature compared to a line, and a thermal power plant has a more stable capacity in dry years than a hydropower plant. Similarly, the value of a wind power plant can be higher if it is located in the same area as a hydropower plant with reservoir capacity. There are alternative approaches for handling uncertainty and the insurance aspect in a theoretical regulatory perspective. An example is Joskow and Tirole (2005), who point to the distribution of a diversification gain from a transmission investment by alluding to the CAPM principle: An investment that gives benefits when other investments work less well, should be rewarded, for instance through the discount rate in a cost-benefit analysis. Further, Sandsmark and Vennemo (2007) argue that investments that reduce risk should have a rate of return requirement lower than the risk free rate.

Methods for including or discussing real option values (other than the option to postpone an investment decision) are not included in the cost-benefit guide. Some projects may facilitate (or obstruct) subsequent investments in the energy system – and such real option values (or losses) should be evaluated. Real option values in academic energy analyses include Keppo and Lu (2003) and Kjærland (2007). The latter find an empirical correlation between real option theory, c.f. Dixit and Pindyck (1994), and aggregate investment behaviour in Norwegian hydropower.

4. Concluding remarks

The large investments in electricity intensive industry and petroleum industry in Central Norway, starting at the turn of the century, were known to cause a severe regional electricity supply deficit unless new local electricity generation capacity or extensive transmission capacity were built. In the deregulated Norwegian electricity market, investments in generation capacity shall be carried out by market agents based on spot price signals and decisions regarding investments in the central grid shall be taken by the system operator, Statnett. Central Norway is a region rich on energy resources – natural gas, wind and hydro – but irreversibility, lumpiness and the effect sequencing of projects may have on the regional spot price level create a complex investment environment. Combined with stochastic hydro inflow, fuel price variability, environmental conflicts and regulatory risk, the value of waiting for more information to be revealed may be substantial. Now, in 2008, building expensive and disputed import capacity seems the only realistic alternative to meet regional supply security.

It is a paradox that a system operator should spend more than EUR 455 million (NOK 4 billion) on transmission investments and mobile power plants in a region with plenty of energy resources. One can ask if this is the most economically efficient allocation of resources. Was public intervention – here through Statnett – necessary for supply security or could the investment decision of Statnett have contributed to regulatory risk and the postponing of market agents' investments?

Anyhow, economic theory and its basis in perfect market contexts offer little practical advice on how to manoeuvre between laissez-faire and public intervention in face of regional electricity supply security. However, observing the development of the regional electricity market of Central Norway indicates that the regulatory authorities could improve the cost-benefit analysis that underlie the concession processes by increasing its scope to include qualitative assessments of real option values, correlated projects and strategic firm behaviour. Although more demanding, it would enhance the regulators' understanding of a complex market and increase the flexibility of authorisations. Furthermore, the supply security measures available to the system operator should be market based only, and any effort to shift the supply-demand balance should include all alternative means (demand/supply/transmission).

References

Amundsen, E. S. and L. Bergman (2006) Why has the Nordic electricity market worked so well? *Utilities Policy*, 14, 135-147

Bjørnebye, H. (2007) Electricity generation capacity tenders in the security of supply interest: It's all wrong, but it's all right, EUI Working Papers, RSCAS 2007/06, Florence School of Regulation, European University Institute

Dixit, A. and R. S. Pindyck (1994) *Investment Under Uncertainty*, Princeton University Press, Princeton, New Jersey

ECON (2007) Decision criteria for the use of SAKS-measures, ECON-Report 2007-113, Oslo

European Commission (2003) State aid N 475/2003 – Ireland, Public Service Obligation in respect of new electricity generation capacity of security of supply, http://ec.europa.eu/community_law/state_aids/comp-2003/n475-03.pdf

Istad (2008) Power system analysis Møre and Romsdal, Main Report 2008, Istad Nett, May 2008 (in Norwegian)

Johnsen, T. A. (2003) Residential customers and competitive electricity markets: The case of Norway, *The Electricity Journal* 16(1), 74-79

Joskow, P. L. (2001) California's electricity crisis. *Oxford Review of Economic Policy*, 17, 365-388

Joskow, P. L. (2007) Competitive electricity markets and investment in new generating capacity, in *The New Energy Paradigm* (ed. Dieter Helm) Oxford University Press, Oxford

Joskow, P. L. and J.-J. Tirole (2005) Merchant transmission investments, *Journal of Industrial Economics*, 53(2), 233-264

Keppo, J. and H. Lu (2003) Real options and a large producer: the case of electricity markets, *Energy Economics*, 25, 459-472

Kjærland, F. (2007) A real option analysis of investments in hydropower – The case of Norway, *Energy Policy*, 35, 5901-5908

Lock (2005) The new electricity model in Brazil: and institutional framework in transition, *The Electricity Journal*, 18, 52-61

NTE (2008) Power system analysis for North-Trøndelag 2008-2023, Main Report, Nord-Trøndelag Elektrisitetsverk, May 2008 (in Norwegian)

NVE 2003 Economic analysis of energy projects – a guide (in Norwegian), the Norwegian Water Resource and Energy Directorate, Oslo

Ruff L. E. (2002) Demand response: Reality versus "resource", *The Electricity Journal*, 15, 10-23

Sandsmark, M. and A. Hervik (2006) Problems in the regional electricity market – power intensive industries against the current in Central Norway (in Norwegian) Report 0612, Molde University College/Molde Research Institute, Molde

Sandsmark, M. and H. Vennemo (2007) A portfolio approach to climate investments: CAPM and endogenous risk, *Environmental and Resource Economics*, 37(4), 681-695

Statnett (2005) Synergies between natural gas and electricity in Central Norway (in Norwegian), Report Statnett SF December 2005, Oslo

TrønderEnergi (2008) Regional power system analysis for South-Trøndelag 2008 – 2023 Main Report June 2008 (in Norwegian)

von der Fehr, H.-N. M., E. S. Amundsen and L. Bergman (2005) The Nordic Market: Signs of stress? *The Energy Journal Special Issue: EUROPEAN ELECTRICITY LIBERALISATION,* 71-98

Watts D. and R. Ariztía (2002) The electricity crisis of California, Brazil and Chile: lessons to the Chilean market. Proceedings of the 2002 Large Engineering Systems Conference on Power Engineering, 7-12