The Integration of Scandinavia with the European Natural Gas Market

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Scandinavia is an outlier in the European gas market, with very low gas consumption levels. Given the favorable prospects for longer term European gas supply, the paper considers how the Scandinavian region could be more closely knit with the European gas market. The costs and logistics of a pipeline from the Norwegian gas fields through mid-Sweden and southern Finland, to link up with existing pipes carrying Russian gas, are reviewed in detail. Norwegian gas appears to be competitive with alternative fuels in satisfying growing energy needs along the pipe. But given the erratic energy policies in the two countries, private agents are unlikely to undertake the necessary long term investments. Political guarantees are necessary to bring such investments about.

La Scandinavie, avec un niveau de consommation de gaz très bas, constitue un cas aberrant sur le marché du gaz européen. En raison des perspectives favorables d'un approvisionnement en gaz européen à plus long terme, l'étude envisage la manière dont la Scandinavie pourrait être liée plus étroitement au marché du gaz européen. Elle analyse en détail les coûts et la logistique qu'impliqueraient la contruction d'un gazoduc qui, à partir des champs de gaz norvégiens, traverseraient le centre de la Suède et le Sud de la Finlande pour rejoindre les gazoducs existantes qui transportent le gaz russe. Le gaz norvégien semble être compétitif par rapport aux fuels de substitution pour satisfaire les besoins croissants en énergie tout au long du gazoduc. Toutefois, en raison des aberrances que présentent les politiques énergétiques dans ces deux pays, les agents privés n'entreprendront probablement pas les investissements à long terme qui s'imposent. Des garanties politiques sont nécessaires pour entraîner de tels investissements.

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1. Introduction

Scandinavia, defined for the present purpose to comprise Denmark, Finland, Norway and Sweden, represents a semi-virgin market for natural gas. Significant gas consumption in the area started relatively late, and, though growing over time, continues to be small, both in absolute terms, and relative to the rest of Europe.

The purpose of the present paper is to explore the issues that arise in the implementation of a large-scale expansion of gas usage in Scandinavia. The plausibility of such an expansion has been strongly increased by several developments that occurred over the past 1-2 decades, and that have significantly improved the attractiveness of natural gas as an energy source, in Europe and elsewhere. These developments have been dealt with at length in other contributions to the conference. They comprise: (a) impressive reductions in the cost of gas production, and a decline in its price; (b) an emerging perception that the potential gas resources from which European needs could be served, are ample; (c) the likelihood that the European gas market will become more competitive, in consequence both of political efforts, and of the proliferation of agents involved with production and transmission; (d) the impressive improvements in gas use technology, strengthening the competitiveness of gas versus other fuels; and (e) the increasing importance attached to the environmental advantages of gas.

The paper proceeds as follows. In section 2, I provide a perspective to the unimportance of Scandinavian gas consumption in a European context, and make an attempt to explain why this is so. Section 3 quantifies the future demand for energy in the Scandinavian countries, that might plausibly be covered by gas. In section 4, consideration is given to the cost of delivered gas in Scandinavia, and in particular to the cost of the sizable infrastructure that must be established, if gas consumption in Sweden and Finland is to expand. The implications for supply security of alternative infrastructural arrangements are also briefly considered. The cost of gas supply is juxtaposed in section 5 against the costs of alternative sources of energy, to clarify the competitiveness of gas in satisfying the emerging energy needs. Section 6 enquires whether there is a role that the governments ought to assume to prompt a wider introduction of gas in Sweden and Finland. Section 7, finally, presents a brief summary of findings and conclusions.

Throughout the paper, quantities are measured in million tons of oil equivalent (MTOE). One MTOE corresponds to 1.11 billion m^3 (BCM) of gas, and to 11 TWh (gross terms). The assumed Swedish exchange rate is SEK 7.30/$, which implies that a unit cost of SEK 0.1/kWh (the unit most commonly used in Sweden) equals $4.03/mmBTU.

2. Why is the Scandinavian Gas Market Semi-Virgin?

Before answering this question, it is necessary, first, to demonstrate that Scandinavian gas consumption is relatively undeveloped, and that gas plays a limited role in the region's energy systems. This readily appears from Table 1, where the significance of gas in the Scandinavian region is compared with that in Western and Eastern Europe, using three different measures. All three indicate the relative unimportance of gas in Scandinavia as a whole, compared to other parts of Europe.

Column 4 provides an absolute measure of gas use. It reveals that Scandinavian consumption, less than 6 MTOE in 1994, was only 2.3% of the West European total, and corresponded, roughly, to consumption in Austria alone. One conclusion from this observation is that whatever may plausibly happen to Scandinavian consumption levels, the repercussions on the European market as a whole will be quite small.

Column 5 shows the importance of gas in total primary energy supply (TPES), the broadest measure of primary energy usage, in European countries and regions. With a gas share of 6% in TPES, the Scandinavian region is a clear outlier (along with Greece, Portugal and Spain), in comparison with both West and East European averages of around 20%.

Column 6, finally, depicts the Economic importance of gas consumption among Europe's nations and regions. In Scandinavia, the intensity of gas use (measured as gas consumption per unit of GDP) was less than one third of the West European average, and an even smaller fraction of the East European figure (the abnormal East European intensity is due to the persevering communist legacy of energy waste, and to the sharp macroeconomic implosion since 1990). It should be mentioned that the greater gas intensity in Finland, as compared to Denmark, despite the same share of gas in TPES in both countries, is a reflection of the higher overall energy intensity in the former country.

There are, of course, sharp differences between the Scandinavian countries. Norway consumes no marketed gas at all (internal use of gas in the oil and gas industry itself does occur), while Swedish consumption is exceedingly small by all the above measures. Finland and Denmark, in contrast, are more significant gas users, but even for these two, the importance of gas in the energy system and in the national economy falls substantially below the West and East European averages.

The gas market in Scandinavia is not only marginal in a European context, it is also of very recent origin. In 1984, gas was already a firmly established fuel in Europe, with a 15.5%

Table 1: Economic density and gas usage in Europe in 1994

	GDP ($bil.)	Surface (10^3 km^2)	Economic density ($mil./km^2)	Gas consumption (MTOE)	Share of gas (in TPES)	Gas intensity (TOE/ $mil. GDP)
	(1)	(2)	(3)	(4)	(5)	(6)
Finland	96	338	0.28	2.7	0.12	28.1
Denmark	147	43	3.42	2.5	0.12	17.0
Sweden	195	450	0.43	0.7	0.02	3.6
Norway	108	324	0.33	0.0	0.00	0.0
	546	1155	0.47	5.9	0.06	10.8
Netherlands	329	37	8.89	34.2	0.43	103.6
UK	1014	245	4.14	60.9	0.28	60.1
Italy	1020	301	3.39	40.9	0.27	40.1
Austria	196	84	2.33	5.8	0.25	29.6
Ireland	52	70	0.74	2.2	0.23	42.3
Belgium/ Luxembourg	240	34	7.06	10.1	0.18	42.1
Germany	2042	357	5.72	61.1	0.18	29.9
France	1319	552	2.39	27.7	0.12	21.0
Switzerland	260	41	6.34	2.0	0.08	7.7
Spain	480	505	0.95	6.5	0.07	13.5
Greece	78	132	0.59	0.0	0.00	0.0
Portugal	88	92	0.96	0.0	0.00	0.0
	7644	3605	2.13	257.3	0.20	33.6
Eastern Europe[1]	250	1168	0.21	51.0	0.19	204.0
Total Europe	7894	4774	1.65	308.3	0.20	39.1

1/ Albania, Bulgaria, Czech Rep, Hungary, Poland, Romania, Slovakia, and former Yugoslavia. The GDPs for Albania and former Yugoslavia are qualified guesses by the author. The GDPs for the other countries are for 1993, and are based on the average commercial exchange rates of that year.

Note: Columns 4 and 5 are from BP (1995). The numbers reflect "commercial" energy only, and disregard "own use," e.g., by the oil and gas industry.

Sources: BP (1995); World Bank (1995); OECD (1995a), (1995b).

share of TPES in Western Europe, and 19.0% in Eastern Europe, but Scandinavian consumption at the time amounted to less than one MTOE, virtually all of it in Finland, where it accounted for a mere 4% share of total Finnish energy usage.

There is no one single factor that can fully account for the relative importance of gas in individual European nation's energy systems. At least three plausible partial explanations come to mind, with the individual country position likely to be shaped by them all.

The **first** factor helping to explain the importance of gas, is an ample availability of domestic resources. This would account for the heavy gas use in the Netherlands and the UK. Explanations to the absence of gas consumption in Norway, a large producer and exporter, would then have to be sought elsewhere.

The **second** plausible reason for heavy gas use is the natural or policy-induced absence of alternative sources of energy. Austria, and Italy, intensive gas consumers, have not been naturally endowed with other sources of energy, and the governments of both have decided against the nuclear option. France and Sweden, in contrast, rely heavily on nuclear power, with a much smaller dependence on gas in consequence. Germany's nurture of its domestic coal sector, likewise, has been a clear constraint to its gas use. Norway's hydro and oil resource wealth has obviously contributed to its indifference towards gas consumption so far. The UK is an exception in this regard. The gas sector has been developed in a large way despite the country's sizable oil and coal production.

The **third** factor has to do with the specific characteristics of gas. The transport costs for this fuel are high, and subject to sizable economies of scale. Hence, the economics of its use depend heavily on the volume and geographic concentration of consumption. High economic density, defined as GDP/km^2, should improve the advantage of gas. Obversely, gas should become a less economic fuel, relative to other sources of energy, where economic density is low, and consumption geographically dispersed. Column 3 in Table 1 provides the economic densities of European countries and regions. This column suggests that gas is particularly unimportant in Sweden, Norway, Spain, Greece and Portugal, and Finland in some measure, on account of the very low economic densities characterizing these countries. Ireland is an aberration in this regard, while Eastern Europe is entirely unrepresentative, given this region's economic implosion in the 1990s, and the fact that economic considerations played a subordinate role in the communist buildup of energy infrastructures.

In a scrutiny of the low gas consumption in Scandinavia, the second and third factors appear to have the highest relevance: Norway and Sweden have not so far developed large-scale gas consumption, because ample availabilities of alternative fuels (hydro and oil in Norway; nuclear in Sweden) have provided for the needs. In addition, the low economic density of Finland, Norway and Sweden has been a constraint to gas market developments. The relatively limited gas use in Denmark defies these explanations and stands out as a surprise. The country's own gas production, the absence of alternative domestic fuels, and its relatively high economic density all suggest that gas consumption should have been substantially higher.

3. The Potential for Expanded Gas Use in Scandinavia

The potential for increased gas consumption in the Scandinavian countries from the mid-1990s and until 2010 is briefly reviewed in the following paragraphs. Such potential can arise either from net growth of energy usage, or from inter-fuel substitution.

No one knows what the future consumption of gas in Scandinavia will be. But some definite numbers are needed as starting points for the economic assessments of the cost of gas supply, which follow in the next section. In Table 2, I present a set of plausible numbers for this purpose. The projections contained in the table have been inspired by recent works by others, as quoted in the table's sources. The projections separate out gas consumption for pure power generation and other uses. The latter contain a very important component of combined heat and power, a very common installation in the Scandinavian energy sector, but less usual in the rest of Europe.

Interestingly, the predominant current thinking suggests very slow growth of overall energy consumption in Scandinavia. For Denmark, a slow decline in overall TPES is foreseen, while for the other countries, the growth of primary energy use works out at substantially below 1%/year, less than half the expected rate of economic growth. Total energy usage in the four Scandinavian countries is seen to rise by no more than 7.5 MTOE between 1994 and 2010, with Sweden and Finland alone accounting for 8.4 MTOE. Given the low growth of TPES, the envisaged increases in gas consumption all imply an expanded role for gas in total energy usage.

As is argued below, the foreseen gas consumption developments in Norway and Denmark are somewhat limited, and do not involve any dramatic change in gas infrastructure, or in the relationship with the European gas market as a whole. That is why I deal with these two countries first, and somewhat briefly. In contrast, the plausible changes in Sweden and Finland offer the main potential for integrating Scandinavia with the European gas market, primarily through the new large-scale infrastructural installations that will be needed to permit expanded gas usage. These developments are in focus in the rest of the present paper.

Norway is the country easiest to deal with

Table 2: Current and projected TPES and gas consumption in Scandinavia (MTOE)

	1994				2010				Gas consumption increase 1994-2010		
	TPES	Gas consumption			TPES	Gas consumption					
		Total	Power	Other		Total	Power	Other	Total	Power	Other
Norway	20.3	0	0	0	22.0	1.0	0	1.0	1.0	0	1.0
Denmark	20.6	2.5	0	2.5	18.0	5.0	2.5	2.5	2.5	2.5	0
Sweden	43.7	0.7	0	0.7	49.0						
SW Sweden						1.2	0	1.2	0.5	0	0.5
Mid Sweden[1]						3.0	1.2	1.8	3.0	1.2	1.8
Mid Sweden[2]						6.0	4.2	1.8	6.0	4.2	1.8
Finland	22.9	2.7	0	2.7	26.0	6.7	2.0	4.7	4.0	2.0	2.0

1/ Nuclear intact.
2/ Partial nuclear decommissioning.

Source: Current, BP (1995). Projected, own assessments inspired by CERA (1995); IEA (1995a); NC (1994); and ÅF (1995).

in terms of future gas demand. As noted, there is significant own use of gas by the oil and gas industry itself (3.8 MTOE in 1995), and this is anticipated to grow over time. In contrast, the domestic market for traded gas is non-existent in the mid-1990s, and is not expected to attain any importance over the projection period. My assessment, based on the NC study, envisages domestic marketed consumption at about 1 MTOE at the end of the projection period, predominantly in the manufacturing of petrochemicals.

The consumption developments in **Denmark** are also relatively straightforward. Oil and coal have so far dominated the country's energy usage, with coal by far the most important fuel for power and heat generation. Gas in the mid-1990s was almost entirely used in the residential/commercial sector, and by industry. Analyses of future expansions in gas usage, all point at the replacement of coal in power and heat generation, to help the country comply with its environmental ambitions.

As in the case of Norway, the envisaged Danish gas consumption growth will have no significant impact on the wider Scandinavian and European gas market. With rising gas production, Denmark will be able to satisfy its own needs and simultaneously expand its exports, primarily to Germany. Its pipeline network is already well-developed, and does not require any fundamental change to accommodate the growing consumption trend. Given Denmark's economic density and its easy topography, the costs of required pipeline expansion will be moderate.

The following two country cases are more complex, and have much wider international ramifications. They are also inter-related in that a combined effort to satisfy expanded gas consumption in Sweden and Finland yields considerable economies of scale. Most of the envisaged expansion of gas use in the two countries is seen to take place in limited geographical areas where the density of economic activity is relatively high. The detriment to gas from low economic density, discussed above, therefore, will be limited.

In analyzing the circumstances of **Sweden,** it is instructive to separate out the consumption developments along the existing pipeline in the South-Western part of the country, and those that may emerge along a new pipeline in "mid-Sweden," stretching from a landing point at Göteborg, past Jönköping, Linköping, Stockholm and Uppsala, to an exit point around Gävle.

Swedish consumption in the mid-1990s, 0.7 MTOE, all imported from Denmark, occurs in the south-west of the country. This market is anticipated to expand to 1.2 MTOE by 2010, and to continue its reliance on Danish supplies. As hitherto, the future market in south-west Sweden will continue, by and large, as an appendage to the Danish gas market.

Projections for 2010 of potential gas consumption along a possible new pipeline in mid-Sweden can usefully be divided into three separate components. The first, dominated by combined heat-power generation, but also comprising the needs of industry and commerce, has been assessed at 1.8 MTOE. The second, absorbing 1.2 MTOE of gas, is seen to satisfy the growing needs of electricity. The third and crucial component, 3 MTOE or more, is to replace nuclear power capacity that might have been closed down by that time. The three components together, add up to 3 MTOE if the nuclear industry stays intact and to 6 MTOE in the event of partial nuclear decommissioning.

Given the economies of scale in gas transport, the Swedish nuclear policies are of great significance for the decisions to expand the geographical coverage of the gas market to mid-Sweden.

Gas is supplied to **Finland** through a pipe stretching from the Russian border through a large part of the country's densely populated South. About half of total gas demand in the mid-1990s, 2.7 MTOE, was by combined heat-power stations, most of the rest by industry.

Finnish energy policy considerations are of critical importance for future gas consumption. The government is unwilling to expand gas use in pure power production, unless the supplies from Russia can be supplemented by gas from another source (NC 1994). At the same time, Finland's Parliament has decided against further expansion of nuclear power.

The potential gas demand expansion until 2010 assumes that the existing pipeline system will be extended to the West coast, and connected with a Swedish pipe that can supply Norwegian gas. Such a connection presupposes coordination with Sweden, for the supply of Norwegian gas could definitely not be motivated by the additional Finnish needs alone. On these provisos, total gas demand is projected to grow by 4 MTOE, of which 2 MTOE for pure power generation. Without access to Norwegian gas, demand in Finland would be politically constrained, and the power generation needs would, presumably, have to be satisfied by imported coal.

In the following considerations of an expanded pipeline system to supply Norwegian gas to Sweden and Finland, it is assumed that the entire Finnish market expansion would be satisfied, at least contractually, by Norwegian gas. This prompts an economic assessment of the following cases for the supply of Norwegian gas through a new pipeline system:

	Potential gas volume (MTOE)
• Sweden 6 (nuclear decommissioned), and Finland 4	10
• Sweden 3 (nuclear intact), and Finland 4	7
• Sweden alone (nuclear decommissioned)	6
• Sweden alone (nuclear intact)	3

4. How Much Will It Cost?

The basic structure of Norwegian gas supply to Sweden, and the onward connection to Finland is depicted in Figure 1. There are, obviously, common elements to all the four cases listed above. Studies in the mid-1990s invariably envisage supply from Kårstö, close to Stavanger, where offshore gas is landed and treated before onward shipment to the European continent. A new offshore pipeline would have to be laid from Kårstö, across the Northern tip of Denmark, and onwards, to land around Göteborg on the Swedish West coast. This pipeline, about 650 km in all, could have the same carrying capacity all through, adjusted to the Swedish and Finnish needs. Alternatively, the economics might be improved by giving the Kårstö-Denmark section a higher capacity, with the surplus gas transported south through the Danish pipeline system, to markets in central Europe. Consideration of the latter alternative is outside the scope of the present paper.

A trunk pipeline would have to be laid across mid-Sweden, beginning at the landing point close to Göteborg, and ending at Gävle, or possibly further south, if gas is not to move onwards to Finland. The full distance to Gävle is around 600 km.

Branch lines through Sweden, to regional distribution centers, would have to be established. The total distance of these has been assessed at about 700 km.

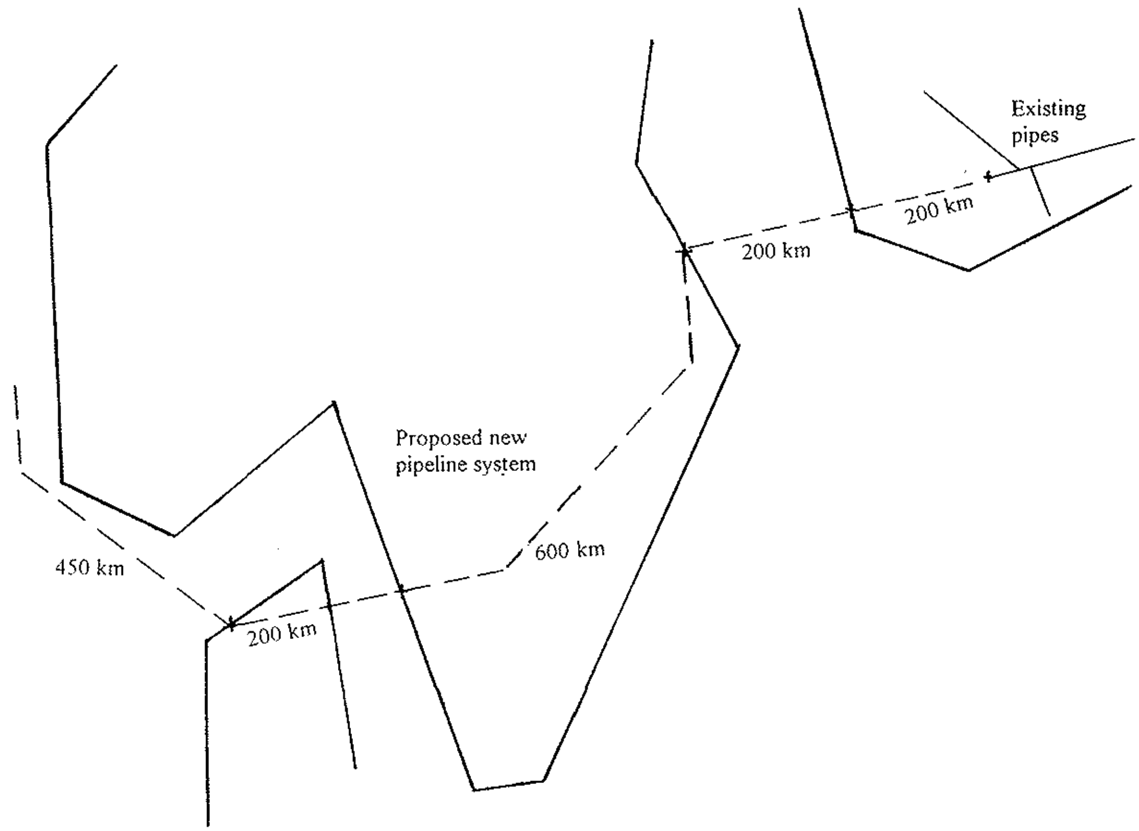

Figure 1: Proposed Gas Pipeline System through "Mid-Sweden" to Finland

For smooth functioning, the non-power market in Sweden would require storage facilities to even out temporary fluctuations. The new Finnish market, in contrast, is assumed to operate without additional storage. The branch lines and storage installations are not shown in Figure 1.

In order to serve Finnish needs, the trunk pipe would have to continue for some 200 km under the Gulf of Bothnia, and then a further 200 km, to connect with the existing pipeline system which carries Russian gas.

As in Sweden, branch lines would be needed from the new Finnish trunkline portion to regional distribution centers. These extensions might total about 300 km.

A multitude of assessments of the investment requirements to establish such a pipeline system and of the ensuing unit costs of gas, have been undertaken over the years. The following computations massage the results of such assessments and integrate them with the findings obtained in interviews with some of the directly involved parties, e.g., Gasum in Finland, and Stockholm Energi and Vattenfall Naturgas in Sweden. My computations also draw upon both generic and specific gas supply cost estimates published by IEA (IEA 1995b), and on similar but unpublished material compiled by the World Bank. Standard longevities of the installations are assumed, as is a 10% real return on capital invested.

Though the cost figures represent no more than broad orders of magnitude, they provide a clear feel for the economics of gas in the alternative cases under consideration. Since the costs are split up into major components, it should be easy for other analysts with better access to data, to substitute their numbers for mine, in the instances where my figures are deemed to be flawed.

I start by considering the transportation elements detailed above. In the next step, I add the estimated cost of gas and the distribution cost, to establish the total cost of supply at the customer's gate.

Table 3 provides the pertinent numbers for the analysis of transport costs. Each of the four cases is considered in turn.

Case 1 involves total gas flows in the trunk line from Norway and through Sweden of 10 MTOE. The onward trunkline to Finland is taken to carry only 4 MTOE. However, it is assumed to be built so that its capacity be easily expanded to 10 MTOE, to permit maximum flexibility, e.g., by Russian gas replacing Norwegian gas in Finland and Sweden through swap arrangements, and with the additional facility for transporting some Russian gas further south through Scandinavia. In cases 2-4, no provisions have been made for corresponding facilities for easy capacity expansion.

Two items need to be added to the above transport cost computations, in order to obtain the cost of gas supply at the customer's gate. These are the cost of the gas itself, and the cost of distribution from the regional centers.

There are two measuring rods for determining the price at which the Norwegian producers might make gas available FTP (free to pipe) at Kårstö on a long term basis. The first is the assertion by IEA (IEA 1995b) that representative production and treatment costs in relevant North Sea fields amount to $1.00-1.50/mmBTU. The production cost at Troll, for example, is set at $1.20. IEA also asserts that concurrent cost levels may be lowered in the next 1-2 decades by 30-50%, in consequence of wider use of new technologies and management approaches. The second measuring rod is the price of Norwegian gas landed at Zeebrugge or Emden. This price has averaged somewhat below $2.50/mmBTU in recent years (WGI, several issues) or just above $1.50, if the 1000 km subsea transport cost from the Norwegian offshore region is deducted. These two measuring rods in combination lead me to the plausible conclusion that gas could be purchased FTP at a price no higher than $1.50.

Will the Norwegians in fact be willing to make gas available at such a price? This obviously depends on the price that their gas will command 10 years hence in central European markets. My belief, supported by some of the other contributions to this conference, is that the first decade of the next century will see a buyers' market in Europe, with gas sellers struggling to find outlets for their increasing gas volumes. With such an outlook, the Norwegian suppliers should be eager to sell at the indicated price, both for profit reasons, and to preempt further Russian encroaches into the Scandinavian market.

In comparison with most other European countries, the distribution costs in the new markets in Sweden and Finland will be quite low. This is because these markets almost exclusively attend to large scale customers, comprising power and district heating stations, and industrial and commercial premises. The cost of distribution to power stations is virtually nil, while the cost to serve the other customer categories is only a fraction of the cost of distributing to individual households. To simplify, I assume an average distribution cost of $0.4/mmBTU in all cases, and disregard the distinction between power stations and other customers, as well as the distinction between the two Swedish supply cases, in which the higher volume involves a larger proportion of cheaply distributed gas for power generation.

The above provides the missing elements needed to determine the cost of gas at the customer's gate in mid-Sweden and Finland. The results for the different cases are summarized in Table 4.

The transport cost analyses contained in Table 3 yield some pretty common sense results. The most important is to point to the very strong economies of scale. The economics of gas transport improve very strongly with rising volumes.

There is little saving in the total investment cost on account of volume alone. Case 1, involving a total throughput to Sweden and Finland of 10 MTOE, requires total investments of

Table 3: Investment requirements and unit costs of transporting Norwegian gas to Sweden and Finland

	Dist (km)	Flow (MTOE)	Investment (SEK bil.)	Investment ($ mil.)	Costs ($/mmBTU)
Case 1. Total volume 10 MTOE to Sweden and Finland					
Joint					
Scanpipe Kårstö-Göteborg	650	10	8.5	1160	0.40
Göteborg-Gävle trunk	600	10	7.5	1030	0.40
Total	1250	10	16.0	2190	0.80
Sweden					
Joint, as above					0.80
Branch lines	700	6	3.5	480	0.30
Storage			2.2	300	0.20
Total cost to Sweden					1.30
Finland					
Joint, as above					0.80
Gävle-Turku	200	4	2.0	270	0.30
Turku-connect exist pipe	200	4	1.8	250	0.20
Branch lines	300	4	1.2	160	0.20
Total cost to Finland					1.50
Aggregate investments, case 1			26.7	3650	
Case 2. Total volume 7 MTOE to Sweden and Finland					
Joint					
Scanpipe Kårstö-Göteborg	650	7	7.5	1030	0.50
Göteborg-Gävle trunk	600	7	7.0	960	0.50
Total	1250	7	14.5	1990	1.00
Sweden					
Joint, as above					1.00
Branch lines	700	3	3.0	400	0.50
Storage			2.2	300	0.40
Total cost to Sweden					1.90
Finland					
Joint, as above					1.00
Gävle-Turku	200	4	2.0	270	0.30
Turku-connect exist pipe	200	4	1.8	250	0.20
Branch lines	300	4	1.2	160	0.20
Total cost to Finland					1.70
Aggregate investments, case 2			24.7	3370	
Case 3. Total volume 6 MTOE to Sweden only					
Scanpipe Kårstö-Göteborg	650	6	7.0	960	0.60
Göteborg-Gävle Trunk	600	6	6.5	890	0.50
Branch lines	700	6	3.5	480	0.30
Storage			2.2	300	0.20
Total			19.2	2630	1.60
Case 4. Total volume 3 MTOE to Sweden only					
Scanpipe Kårstö-Göteborg	650	3	7.0	960	1.20
Göteborg-Gävle Trunk	600	3	5.5	750	0.90
Branch lines	700	3	3.0	400	0.50
Storage			2.2	300	0.80
Total			17.7	2410	3.40

Table 4: The cost of Norwegian gas supply at the customer's gate in Mid-Sweden and Finland ($/mmBTU)

	Case 1	Case 2	Case 3	Case 4
Sweden				
Gas price Kårstö	1.50	1.50	1.50	1.50
Transmission (table 3)	1.30	1.90	1.60	3.40
Distribution	0.40	0.40	0.40	0.40
Total	3.20	3.80	3.50	5.30
Finland				
Gas price Kårstö	1.50	1.50		
Transmission (table 3)	1.50	1.70		
Distribution	0.40	0.40		
Total	3.40	3.60		

some $3.7 billion. In case 2, with a 30% lesser throughput, the investment requirements decline by less than 8%. The Sweden only network considered in cases 3 and 4, obviously involves much lesser investment needs.

The economies of scale emerge starkly in the unit cost figures, as the little altered capital costs are divided by falling gas volumes. In case 1, the cost of delivering gas to Sweden is lower than for transporting it onwards to Finland, both on account of the higher Swedish volume and the shorter distance. In case 2, the Swedish cost turns out to be the higher one, as the cost of branch lines and storage is divided by the lower throughput. With high Swedish volumes (cases 1 and 3), a combined Swedish-Finnish network yields considerable unit cost savings to Sweden, compared with the cost levels in an isolated Swedish venture. The savings become quite dramatic when Swedish import volumes are low (cases 2 and 4).

As just demonstrated, a combined venture to serve both Sweden and Finland with Norwegian gas brings clear cost advantages to Sweden. For Finland, the two-country venture is a virtual necessity for procuring Norwegian gas, for a sole Finnish endeavor would involve an insurmountable economic deterrent, on account of both volumes and distances. But other important, commercial, logistical and political advantages of the inter-connection of Norwegian and Russian gas supply through the proposed Swedish-Finnish project should also be spelled out:

(a) The availability of two gas sources provides a far greater political and commercial security of supply than one source in isolation. This has been clearly recognized in the Finnish government's decision not to expand gas use in power generation unless a new supply source can be opened up.

(b) In terms of transport logistics, and considering Europe as a whole, it should be cheaper to supply Finland and Sweden from Russia, and to ship Norwegian gas south to Central Europe. The transport advantage may well be realized through swap arrangements, even if there is a long-term contract for eastward shipments of Norwegian gas. The potential for economic swaps, in turn, might induce the Norwegian contractual suppliers to accept a somewhat lower price, than they would if the pipe to Sweden represents a dead end.

(c) Access to two alternative gas sources offers the buyers a more competitive supply, and the opportunity to bargain for lower prices in future negotiations to renew the initial contract, or to procure additional supplies.

The cost assessments of cases 1, 2 and 3 yield quite encouraging results, when compared with the prices paid in Western Europe. Most of the gas supply to Sweden and Finland in the proposed venture would be absorbed by large customers, with annual consumption ranging between 5 and 100 MCM. Delivered costs work out at between $3.20 and $3.80/mmBTU. For comparison, in mid-1995, gas users with an annual consumption of 10 MCM in seven leading West European countries had to pay more. The following prices for firm supplies to such customers were reported by *World Gas Intelligence* (WGI, June 16, 1995):

- France $ 3.70 (+10 % tax)
- Spain $ 4.50
- UK $ 3.75
- Belgium $ 4.67
- Netherlands $ 4.16 (+8 % tax)
- Germany $ 5.50 (+12 % tax)
- Italy $ 4.18 (+11 % tax)

From these figures it would appear that if gas can be sold in Scandinavia at the cost figures indicated for cases 1 through 3, then the large consumers in the two countries would in most cases reap a significant advantage over consumers in Western Europe. For Finland, this conclusion might need some modification, given the absence of storage in the plans, and the ensuing constraint on firm supplies.

Case 4 contrasts with the remaining cases, by recording substantially higher costs. In fact, the costs of this case turn out to lie above the prices in all the seven countries just quoted. On account of the unfavorable costs of this case, there is little purpose in considering it further, until the prospects for establishing gas ventures as described in cases 1, 2 and 3 have been exhausted.

5. Will Gas Be Able to Compete in Satisfying the Potential Demand?

In what follows, I make the very simple but not implausible assumption that the prices of fossil fuels will remain at their 1994-95 real levels until 2010, when the proposed Scandinavian gas venture should have been firmly established. I claim that this price projection is not less likely than alternatives in which fossil fuel prices rise. In fact, my assumption closely resembles the projections of one of the two major scenarios for global energy market developments, prepared by the IEA in 1995 (IEA, 1995b).

Given unchanged fossil fuel prices, how well will the gas supplies to Sweden and Finland, proposed in cases 1 through 3 be able to compete with other energy sources, in the potential markets quantified in Table 2 above? It may be useful to separate out the role of gas in pure power generation, and in other uses, respectively.

Pure Power

The discussion about the competitiveness of alternative fuels to satisfy the needs of pure power stations concerns **new** power generation, and not the competitiveness of new gas power with **existing** non-gas installations. As is apparent from Table 2, the potential needs for gas in pure power generation would dominate the total potential needs for gas in cases 1 and 3, where Swedish nuclear installations are partly decommissioned (6.2 and 4.2 MTOE respectively), and would account for some 45% of the total even in case 2 (3.2 MTOE), where the Swedish nuclear industry is assumed to remain intact.

The prospects for gas taking over these pure power markets appear to be very favorable, primarily because there are few alternatives that are acceptable and economically superior to gas. New nuclear facilities are politically excluded in both countries, as are any significant additions to hydropower capacity. With gas at the supply costs indicated above, the combined cycle power generation offers a clearly more economical alternative in Scandinavian circumstances than new power stations using oil and coal (IEA 1991; Nordhaus 1995). Furthermore, in the case of coal, there are the additional problems of popular non-acceptance to the siting of power plants, and the increasing political objections in both countries to expanding coal usage on environmental grounds.

Importation of gas-generated Norwegian power to Sweden does not offer a more attractive economic alternative than power generation in Sweden and Finland using Norwegian gas. The volumes of potential gas needs for pure power generation are so high that the transportation of gas to Sweden is clearly more economical than the transportation of power derived from the same gas (Wiklund, 1995). Because of longer transport distances, this argument applies with even greater force to the gas destined for Finland.

The indicated gas market for pure power generation appears to be a safe bet. Indeed, in the circumstances described in the preceding paragraphs, the supply of gas emerges not only as a potentially useful source to satisfy the needs of pure power stations, but as a necessity for which there are no obvious alternatives.

Other Gas Uses

The case for gas is à priori not as clear in the combined heat-power, industrial and commercial markets, assessed in Table 2 at 3.8 MTOE, of which some 1.8 in Sweden. Substantial parts of these markets are already satisfied with other fuels, e.g., fuel oil, coal, peat, and, importantly, forest-based biomass. Where new installations or the rebuilding of existing ones are needed to accommodate gas, the gas option would have to be sufficiently superior, to motivate not only the cost of gas, but also the accompanying cost of investment capital.

The findings of a recent study (Energidata 1995) suggest that the Swedish potential demand figure is not unrealistic, and that, in fact, it may be an underestimate.

The study focuses on the energy needs and the possible market for gas in space heating and industry in 2005, within a wide corridor along the proposed Swedish trunk line from Göteborg to Gävle. The total actual and projected purchased energy consumption for these purposes is detailed in Table 5. The study uses a bottoms up approach, exploring the most economic way to satisfy the energy requirements in individual plants, taking existing capital installations and their remaining life time into account. The projections assume unchanged Swedish energy taxes. Different price assumptions distinguish the two alternative projections presented in the table. The following price developments at the large customers' gates, in constant 1995 dollars/mm BTU (original numbers in SEK/MWh converted on the basis of SEK 0.1/kWh = $4.03/mmBTU) were employed:

	1995 price mid-Sweden (excl. tax)	Projected price in 2005	
		Base case	"Cheap gas"
• Light fuel oil	4.63	5.48	5.48
• Natural gas	2.82*	5.26	4.06
• Forest-based biomass	4.43	4.43	4.90

*Border price

Table 5 prompts several observations. First, in addition to the indicated figures, there is a very sizable own use of biomass by the forest industry, 8.3 TWh in 1993, and assessed to grow to 9.0 TWh by 2005. Second, the table suggests that overall demand will remain virtually stagnant, and reveals inter-fuel substitution to be the dynamic force of change. Third, the figures demonstrate the effects of a queer anomaly in Swedish energy taxation. Biomass

Table 5: Purchased Energy Use in Space Heating and Industry in "Mid-Sweden" (TWh)

	1993	2005	
	Actual	Base case	"Cheap " gas
Space heating			
Electricity	5.0	5.0	5.0
Oil and coal	31.0	15.0	16.0
Biomass	6.5	19.0	9.0
Gas	0.7	6.0	15.0
Total	43.2	45.0	45.0
Industry			
Electricity	0.9	0.9	0.9
Oil, coal & heat	6.1	7.4	6.2
Biomass	0.2	0.0	0.0
Gas	0.5	1.6	2.8
Total	7.7	9.9	9.9
Space heating and Industry combined			
Electricity	5.9	5.9	5.9
Oil and coal	36.1	19.6	19.9
Biomass	6.7	19.0	9.0
Gas	1.2	7.6	17.8
Total	49.9	52.1	52.6
Total, MTOE			

Notes:
a) 11.7 TWH = 1 MTOE
b) Space heating sold to industry has been eliminated from the combined numbers.
Source: Energidata 1995

constitutes a fiscally favored energy raw material, hardly burdened at all by special energy taxes. Fossil fuels, in contrast, are heavily taxed in most uses. The total normal impositions (excluding VAT) on coal and oil amount to more than $6/mmBTU, and to $3.40 on gas. Producers of space heat, therefore, have very strong incentives to use biomass. Constrained domestic supplies in fact have to be supplemented by imports, sometimes from as far away as the Mediterranean, to satisfy demand. The manufacturing industry, however, is partly exempt from energy taxes. Its fiscal dues amount to only $1.9/mmBTU for coal, and less for oil and gas. At these lower fossil fuel tax rates, biomass cannot compete. This explains the insignificant consumption of purchased biomass by industry.

The "Cheap gas" case of the study projects gas consumption in mid-Sweden in 2005 (excluding pure power) of 1.5 MTOE. For several reasons, the indicated volume may prove to be an underestimate. (a) In the cost computations of cases 1 through 3 above, the cost of gas in mid-Sweden will work out lower than in the Energidata study. (b) The fiscal anomaly, favoring imported biomass is irrational. A large part of the fossil tax relates to emissions of CO_2. *Ceteris paribus*, however, imports of biomass imply a greater use of fossil fuels in the exporting country, and additional fossil fuel use in the transport of biomass, with little or no net reduction in global CO_2 emissions. Rationality suggests that since it does not serve the purported purpose, the tax exemption on imported biomass will not persevere. The biomass price will then rise by more than the study indicates, given the domestic capacity constraints, increasing the usage of gas in consequence. (c) Electricity prices in Sweden have been below full replacement costs over the past decade. They are expected to rise substantially in the first decade of next century, to induce the investments in new capacity that will be needed, irrespective whether nuclear power is decommissioned. This, in turn, will induce the heat producers to replace part of the electricity they use by other fuels, including gas.

These adjustments to the price assumptions employed by the Energidata study would raise gas consumption in mid-Sweden in the non-power sectors to more than 1.5 MTOE in 2005, and, with some further growth in total energy demand, to an even higher level by 2010.

The findings of the Energidata study, along with the above elaborations lead me to the assertion that the indicated Swedish potential non-power gas consumption volumes can be realized, and possibly exceeded. Even though I have no similar evidence from Finland, I infer that the corresponding Finnish non-power consumption potential of 2 MTOE, is equally realistic.

In conclusion, then, the overall potential gas market sizes in mid-Sweden and southern Finland, identified earlier in this paper, appear to be sober and achievable. Accepting the assessed cost of delivered gas when volumes are sizable, this fuel will clearly provide a competitive addition to the energy raw materials supply in the event of nuclear decommissioning in Sweden, but the competitiveness appears to remain in a venture catering to both countries, even if the Swedish nuclear industry remains intact.

6. Is There a Role for Governments?

Suppose that the above economic assessments fairly reflect the potential long run competitiveness of the proposed gas expansion venture. Private agents might nevertheless hesitate to bring it about, because of its size, the very long period over which the investment returns would be reaped, and because of the plethora of uncertainties on the way. Is there then a case for the governments to provide support through active intervention of some sort?

In the mid-1990s, when privatization and deregulation are in vogue, and public intervention is often looked upon with suspicion, while freely operating markets are regarded as the best tools to assure efficiency and social benefit, this is not an opportune question to ask.

Yet, it must be recalled that the vogue is of recent origin, and that, over long periods, informed opinion has seen it wise and appropriate to pursue profound public involvements in the energy sector, to assure the establishment of indispensable infrastructure, or to correct market failures.

It is significant that past public intervention has shaped the energy sectors of Sweden and Finland in different ways, and has locked them into particular positions which are difficult to change. An example from some time ago is the forceful public initiative to launch nuclear power. A more recent one is the favored fiscal treatment of biomass, tying significant shares of heat production in the two countries to this fuel. These measures have obviously reduced the potential market for gas, and are retarding its development, an important consideration, given the strong economies of scale, characterizing the supply of this fuel.

At the same time, the evolving policy environment has led to a situation where gas appears to be an indispensable component in the satisfaction of growing energy needs. As noted, the concurrent policy stance in the two countries precludes new nuclear installations, and makes it very hard to expand hydropower and coal usage. Forest based biomass in Finland and Sweden does not offer a true alternative to gas in a longer term perspective, for its resource base in the two countries is restricted, and its domestic supply curve becomes exceedingly steep as volumes rise (Lunnan and Moen 1991). Under these conditions, the introduction and/or expansion of gas on a large scale in the densely populated parts of Sweden and Finland appears to be a virtual necessity for satisfying the emerging energy needs.

Past energy policies in the two countries have been erratic, promoting one fuel at a given point in time, and restraining its use at another time, according to prevailing fashion. This was less of a problem when most energy investments were in public hands, so that the risks inherent in policy instability remained with the policy maker himself. More recently, as decision-making in the energy sector has been transferred to private agents, or to public corporations mandated to generate acceptable capital returns, the unpredictability of how coming policies will be shaped tends to paralyze long run decisions. For example, on account of the perceived policy risks, some municipal energy companies in Sweden refuse to invest in projects with payoff periods beyond 3 years. Such behavior, while rational to the companies, is not conducive to maximizing national benefit.

Ironically, the investment impasse caused by the combination of policy unpredictability and the shift towards private and/or profit-oriented decision makers, could lead to the choice of coal instead of gas in satisfying the additional energy needs that are bound to emerge over time, despite the clear economic and environmental advantages of the latter fuel. On account of its indivisibilities and economies of scale, gas requires investment decisions of huge magnitude. Coal, in contrast, can be introduced piece-meal, and the lesser investments at each time make it easier for the investors to absorb the risks of policy instability.

It would appear that the governments of Sweden and Finland have an unavoidable role to play in the large-scale introduction of gas, considered in the present paper. Even if they abstain from direct participation in the proposed gas venture, through equity or by the provision of financial subsidies, it is essential that they reduce the policy risks faced by the investors. This can be done in different ways. First, the governments ought to clarify their views on the energy policy environment in which the gas venture will evolve. The most important clarification concerns the future fate of Sweden's nuclear power, for it will determine both the size and the likely timing of the gas venture. Second, they should provide assurances to indemnify the losses caused to investors by sharp changes in future energy policy directions. And third, they might consider a temporary lightening of the fiscal regime to which this fuel is subjected, to assure a speedy market growth, and early advantage of scale economies.

I have so far given consideration only to Norwegian gas and to the roles of the governments in the two consuming countries. But additional supplies of gas could conceivably also be provided by Russia, despite the frequently expressed political and supply security hesitation. And active roles to bring additional gas to Sweden and Finland could conceivably also be played by the governments of Norway and Russia, the potential suppliers.

An earlier section of this paper noted that pure transport logistics involving Europe as a whole, suggested the use of Russian gas in mid-Sweden and Finland, permitting larger shipments of Norwegian gas to Central Europe. The preference given to Norwegian supplies in current Scandinavian gas debates appears to rest upon two grounds: (a) lingering feelings about political insecurities of Russian gas deliveries; and (b) the prospects offered by employing the Western source, for linking the markets in mid-Sweden and Finland to two alternative suppliers. The relevance of the first ground is in some doubt. The Soviet Union established a record of high reliability as gas supplier, and Russia has a lot of credibility to lose by destabilizing its gas sales to Scandinavia for political ends. The second ground, however, carries considerable commercial significance, as noted in the earlier discussions.

There are no obvious reasons why the government of Norway, or its state owned gas suppliers should be willing to take direct financial involvements in the mid-Swedish and Finnish gas infrastructure, to reduce the policy-related risks and uncertainties faced by the major gas actors in the receiving countries. If these actors hesitate to undertake the long term engagements on commercial grounds, the hesitations are bound to be shared by the Norwegians. The Norwegian parties have no superior leeway for influencing energy policy in Sweden and Finland, and so reducing the risks. And besides, the Norwegian supplies have an established and virtually limitless market in central Europe.

The motivations for such involvements by Russia or state owned Gazprom, are distinctly stronger. After decades of relative isolation within the FSU during the Soviet era, Gazprom has burst into downstream foreign investments in the 1990s, to secure markets for the potentially huge increases in its exported gas supply. This comprises joint ventures of a variety of kinds, including the expansion and diversification of export pipeline networks in such varied locations as Turkey, Greece, Bulgaria, Poland, Germany and Finland. During the "stable" Soviet times, virtually all gas exports to Europe were transported via a bundle of pipes through Ukraine and Czechoslovakia. To expand capacity and enhance the security of supply, Gazprom has taken the initiative to establish a new pipeline system through Belarus and Poland to Western Europe. The next natural step in this policy of expansion may be a pipeline through Finland and Sweden and into the European heartland. Even though the low economic density of Sweden and Finland along this route is a disadvantage, such a pipeline makes perfect geographic sense, because it shortens the distances from the Siberian sources to the ultimate markets in and around Germany.

Given Gazprom's strong desires to establish and protect foreign markets for its gas, and its wishes to expand and diversify its supply routes, the company might have an interest in expanding the capacity of existing pipes in Finland, and extending the system through the rest of southern Finland, mid-Sweden and Denmark, with a primary purpose of adding to its supply lines for delivery on the European continent. The markets en route might then be regarded as an additional bonus, so that the risk of losing these markets in consequence of some unforeseen energy policy developments in Scandinavia would not by itself put the investment venture in jeopardy.

There is no scope in the present paper for exploring the political, geographic and economic details of such an initiative by Gazprom. The Swedish and Finnish gas actors would have to tag on, to establish the link with Norwegian gas, for such a link is of no interest to the Russians. From a Scandinavian perspective, perhaps the most important aspect of this potential Russian initiative is that it puts some competitive pressure on the Norwegian suppliers. Russian gas is potentially there to satisfy the Swedish and Finnish needs, if it proves hard to strike a favorable supply deal with Norway.

7. A Summary of Findings and Conclusions

European gas consumption has tended to develop concentrically. Gas is most intensively used in the economically dense heart of the continent, and least intensively, or not at all, in the economically sparse periphery. Scandinavia is one such peripheral region, with gas consumption geographically limited and quite small. In 1994, marketed gas in the four Scandinavian countries amounted to no more than 5.9 MTOE, 2.3% of the West European total.

Several developments over the past 1-2 decades have significantly improved the competitiveness of gas among fuels, both on the supply and demand side of the market. Analyses of the gas market, undertaken ten or more years ago have little validity in the mid-1990s, and there is reason to take a new look at the improved conditions for further geographic expansion of gas usage in Europe. This paper investigates the prospects for increased gas use in Scandinavia, focusing on mid-Sweden and Southwest Finland, where gas is not yet used, but where a substantial potential demand has been established. The time perspective is limited to 2010.

The investment and delivered cost levels, along with more general commercial and political considerations suggest that a joint Swedish-Finnish venture to bring Norwegian gas to both countries is more likely than conceivable alternatives. Expanded use of gas in Finland, with Russia as the only source, is seen to carry unacceptable political and commercial risks. The cost of supply of Norwegian gas to Finland will be outrageously high, unless Sweden shares in the cost and absorbs part of the flow. The cost of Norwegian supply to Sweden will be significantly lowered by the extension of the pipelines to Finland. Sweden will also gain in terms of supply security from such an extension by obtaining access to Russian supply.

The potential markets for Norwegian gas in 2010 in the three main cases considered in the paper amount to between 10 and 6 MTOE, the variation depending on whether Swedish nuclear power is partly decommissioned and whether supply to Finland forms an integral part of the project. In a fourth case, with an exclusively Swedish project, and the Swedish nuclear industry remaining intact, the potential market shrinks to 3 MTOE, but the cost of gas becomes uncompetitive, so this case is abandoned at an early stage in the ensuing analysis.

Large infrastructural installations will be required to introduce gas in the new regions. The investment costs of the viable cases are in a range between $3.7 and $2.6 billion. The unit cost of supply works out at between $3.20 and $3.80/mmBTU at the large customers' gates. This comprises a cost of $1.50/mmBTU for the gas in Norway, delivered to pipe in the proximity of the producing fields. The delivered cost figures are quite low in comparison with what gas users have to pay in the heart of Europe.

An analysis of the competitiveness of gas in the power, heat and industry markets in mid-Sweden and Southern Finland reveals that the indicated potential volumes provide a realistic assessment of usage, if gas becomes available. Gas will not only be competitive; its introduction appears to be a virtual necessity for satisfying growing energy needs, given the policy decisions against nuclear and hydropower expansion, and the environmental reluctance to increase coal use. This is true even if the Swedish nuclear industry remains intact. The possibility of nuclear decommissioning raises the urgency to plan for more gas.

With the political ideologies that dominate in Scandinavia in the 1990s, it is unlikely that the Swedish and Finnish governments would take direct participation in the proposed gas venture, or provide financial subsidies to facilitate the necessary gas investments. At the same time, the predominantly profit oriented agents in charge of the gas markets in Sweden and Finland are deterred from taking the long run investment decisions, because they fear the unpredictable consequences of continued erratic energy policies by the governments in the two countries.

It is essential that the authorities in Sweden and Finland spell out their longer term energy policy objectives, for this will reduce the uncertainties about the environment in which an expanded gas market will operate. A clarification of what will happen to Sweden's nuclear power is particularly important. To facilitate investments in the gas venture under consideration, and to speed up the introduction of this fuel in mid-Sweden and South-West Finland, the governments might also provide assurances that they would indemnify the investor losses caused by sharp and unforeseen changes in future energy policy directions. For the same purpose, the governments might also temporarily sweeten the fiscal treatment of gas.

In 1994, overall gas consumption in Sweden and Finland was 3.4 MTOE. Even if Swedish nuclear power stays intact, the proposed gas market expansion would raise the usage of this fuel to between 9 and 10 MTOE by 2010. If nuclear decommissioning is pursued, the total market might expand to 14-15

MTOE in that year. In both cases, the share and intensity of Swedish and Finnish gas use would remain relatively low in a European context. Nevertheless, the proposed venture would extend the northward integration of the European pipeline system, thereby providing additional supply security, and further opportunities for useful swaps to optimize the physical gas flows in Europe.

References

ÅF (1995) *Granskning av Nordiska Ministerrådets Rapport* (*Review of the Nordic Council Report*), (Stockholm: ÅF-Energikonsult).

BP (1995) *Statistical Review of World Energy* (London).

CERA (1995) *Outlook for the Northern European Gas Market*, a study for Stockholm Energi, (Cambridge, Mass).

Energidata (1995) *Konkurrensen mellan biobränslen och naturgas* (*Competition between biofuels and natural gas*), (Göteborg).

IEA (1991) *Natural Gas Prospects and Policies* (Paris).

—(1995a) *Coal Information 1994* (Paris).

—(1995b) *Oil, Gas and Coal Supply Outlook* (Paris).

—(1995c) *World Energy Outlook* (Paris).

Lunnan, A. and K.J. Moen (1991) *The Future of Energy From Biomass - A Case Study From Norway*, SLU Research Note No 219 (Uppsala).

NC (1994), *Naturgasens Roll i Norden och Baltkum Fram till Ar 2010, (The Role of Natural Gas in the Nordic and Baltic Regions until 2010)*,, Nordic Council, TemaNord 1994:638, Copenhagen.

Nordhaus W (1995) *The Swedish Dilemma: Energy Versus the Environment*, (Stockholm: SNS).

OECD (1995a) *Main Economic Indicators*, (Paris).

—(1995b) *Short-term Economic Indicators, Transition Economies*, No. 2 (Paris).

WGI (bimonthly), *World Gas Intelligence*.

Wiklund S.E. (1995) *Transiteringskostnader för naturgas och elenergi* (*The Costs of Natural Gas and Power Transmission*) (Stockholm: Svenska Gasföreningen).

World Bank (1994) *World Development Report 1994* (Washington).