Norwegian National Rail Administration

Status of knowledge on high-speed rail lines in Norway

Report

July 2010

COWI

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Contents

Preface 5

Summary 6

1	**Introduction**	**13**
1.1	Why high-speed	13
1.2	The commission	14
1.3	The basic material	15
1.4	Description of method	18
1.5	Organisation of the report	20
2	**Experience internationally**	**21**
2.1	The Swedish report SOU 2009:74	21
2.2	Best Practice	22
2.3	Comparison	22
3	**Market analysis**	**25**
3.1	Method	25
3.2	Hypotheses - analysis - conclusions	26
3.3	Background and mandate for the market analyses	27
3.4	VWI	28
3.4.1	Relevant market	28
3.4.2	Model framework	29
3.4.3	Schedule and running times	32
3.4.4	Ticket prices	34
3.4.5	Results	34
3.5	Urbanet Analyse	35
3.5.1	Relevant market	36
3.5.2	Model framework	38
3.5.3	Model assumptions	39
3.5.4	Results	40
3.6	Norsk Bane	42

3.6.1 Relevant market 42
3.6.2 Model framework 43
3.6.3 Data basis 43
3.6.4 Results 43
3.7 Market shares and market delimitation 45
3.7.1 Delimitation of the market for high-speed rail lines in Norway 45
3.7.2 Market shares in VWI and UA1 do not tally with international experience 47
3.7.3 Good prevailing conditions for high-speed rail in Norway 48
3.8 Summary 49

4 Technical parameters 50
4.1 Assessment of scenarios and respective fare levels 50
4.2 Assessment of the required number of train units and capacity 51
4.2.1 Number of train units 51
4.2.2 Schedule and capacity 51
4.2.3 Single and double track routes 52
4.3 Technical regulations 53
4.4 Technical parameters - line routing 54
4.4.1 Vertical curvature 55
4.4.2 Mixed traffic 56
4.4.3 The proportion of tunnel 57
4.5 Summary 58

5 Technical challenges in construction 59
5.1 Assumptions for choice of route and adaptation to the landscape 59
5.2 Line routing 60
5.2.1 General aspects of line routing in the various corridors 61
5.3 Assessment of environmental effects 72
5.3.1 Cross section width of high-speed line 73
5.3.2 The VWI report on route and environmental effects 74
5.3.3 Proposal for simple analysis of the route to assess the consequences 75
5.4 Summary 75
5.4.1 Line routing 75
5.4.2 Environmental effects 76

6 Costs 77
6.1 Cost estimates 77

6.2	Assessment of costs in relation to national transport systems	82
6.3	Direct and indirect costs	83
6.4	Planning regulations and the route of the line	83
6.5	Summary	84
7	**Requirements for implementation and financing**	**85**
7.1	Models for organisation and financing	85
7.2	Summary	87
8	**Social effects**	**88**
8.1	Clarification of the purpose of and alternatives in the analyses	88
8.1.1	Reference alternative	88
8.2	Determining calculation assumptions	90
8.2.1	Discount rate	90
8.2.2	The analysis period	92
8.3	Mapping effects	93
8.3.1	Traffic effects	93
8.3.2	Monetised and non-monetised effects	93
8.3.3	Traveller benefit	95
8.3.4	Operator benefit	95
8.3.5	Effects for the public sector	96
8.3.6	Society in general	97
8.4	Valuation of effects	97
8.4.1	Calculation principles for traveller benefit and operator benefit	97
8.4.2	Time gains	98
8.4.3	Saved transport costs	103
8.4.4	Consequences for the public sector	106
8.4.5	Society in general (third party)	108
8.4.6	Tax costs	112
8.5	Assessment of sensitivity analyses and risk management	113
8.5.1	Description of risk and uncertainty	113
8.5.2	Sensitivity analyses	113
8.6	Summary and recommendations	114
9	**Recommendations**	**116**
9.1	Market, social economics and financing	116
9.2	Technical parameters and costs	117

10 Bibliography 118

Preface

The purpose of this report is to systematise the existing knowledge basis for high-speed rail lines in Norway and to evaluate previous reports and analyses at both national and international level.

The work has been carried out in collaboration by an interdisciplinary, international team consisting of COWI AS of Norway, COWI Denmark and the TRANSPORT RESEARCH INSTITUTE (TRI) of France as consultants.

The project manager at COWI was Selma Knudsen.

The contact at Jernbaneverket - the Norwegian National Rail Administration - was Lars Erik Nybø.

Summary

The Norwegian National Rail Administration has commissioned COWI AS to review the status of knowledge on high-speed trains in Norway up to 2009. The purpose of this assignment is to systematise the existing basis of knowledge on high-speed rail lines in Norway by evaluating previous reports and analyses at both national and international level.

In this report, we have attempted to reveal the weaknesses and deficiencies in what has been done so far and to provide input on what has been learned and what is worth transferring from the measures taken in other countries with regard to the planning and introduction of high-speed rail, while at the same time giving recommendations and a basis for further investigation.

The intention was to investigate and analyse several important topics: market analyses, technical parameters for high-speed trains that are relevant for Norway, technical construction issues (adapting to landscape and environmental effects), costs, implementation requirements, finance and socioeconomic effects. The most important findings in our report with regard to the stated topics are given below.

Market analyses

An assessment of the market basis is an essential part of the information on which a decision on developing high-speed rail lines in Norway can be taken. VWI, Urbanet Analyse and Norsk Bane have all investigated the market for high-speed rail lines in Norway. The reports of most relevance for the section on market analyses are:

- **VWI**: Feasibility Study Concerning High-Speed Railway Lines in Norway, Phase 1, Phase 2 and Phase 3

- **Urbanet Analyse**: *Markedet for høyhastighetstog*, (market for high-speed trains) report 9/2008 (UA1) and report 12/2009 (UA2)

- **Norsk Bane**: *Nytt jernbane og trafikkonsept for Sør- og Midt Norge* (new railway and traffic concept for South and Central Norway)

The reports contain so few similarities that it would be difficult to speak about a consensus regarding the traffic basis for high-speed rail. There are consequently great differences in the suggestions regarding the market basis for high-speed rail lines and the results are difficult to compare.

The most important differences between the reports is their assumptions about what the relevant market for high-speed rail lines should be.

- Norsk Bane uses a very broad market definition, first and foremost that the market for traffic in parts of the corridors is considered to be substantial.

- UA1 uses a narrow market definition in comparison, but this is later extended somewhat in UA2.

- VWI uses a market definition that is not unlike UA2.

Neither is there any consensus on what the foreseeable market shares are. It is difficult to compare the results of the different reports, since some of the differences in market share can doubtless be due to the differences in market definition. However it appears that

- Norsk Bane is the most optimistic with regard to possible market share, although the UA2 report also finds grounds for estimating a high market share.

- The market shares arrived at by VWI and UA1 are seemingly relatively low, not least when considered against international experience.

COWI's review of the status of knowledge on high-speed rail lines in Norway stresses the significance of defining the relevant market. When different reports are based on different market definitions, the results will necessarily be difficult to compare and it is difficult to consider whether some results may be more reasonable than others. None of the reports gives any fundamental grounds for its market definition or provides any documentary evidence of the assumptions that have actually been made.

Technical parameters

The most relevant reports on technical parameters are:

- **VWI**: Feasibility Study Concerning High-Speed Railway Lines in Norway, Phase 1, Phase 2 and Phase 3

- **Funkwerk and Railconsult**: High Speed Operations

The VWI report is not in accordance with the present technical rules for speeds over 250 kph. Most lines must be upgraded in a later feasibility study, so that they are in line with the prevailing rules. The stretches of line that lie in very meandering valleys will mainly have a higher proportion of tunnel sections than stretches in wider valleys that have the possibility of increasing curve radius, while at the same time having sufficient straight lines between the transitional curves.

The vertical aspect also presents a challenge, primarily due to stretches, such as Geilo - Bergen, with long ascents and descents, since long descents can put a severe load on the brakes. Stretches with long descents should therefore be specially considered with regard to the feasibility of such a vertical curvature.

In the existing material, the tunnel parts have not been studied at any detailed level. Proposing a tunnel length on the basis of a 1:250,000 map is hardly sensible. In critical stretches, more detailed map sections should have been used so that the tunnel could be placed in detail. An assessment of the tunnels could thus have been made more precisely. Against this background, the tunnel parts should be reviewed at a more detailed level.

Funkwelt & Railconsult and VWI both concluded that the proposed operation is feasible using single track. This raises problems, since there is not one single example of single track high-speed rail line anywhere else in the world. Other countries have chosen not to use single track because this would make it impossible to adapt services in line with demand (rush hours and low traffic periods). This can lead in turn to the loss of passengers and ticket income. The proposal for single track rail lines should therefore be reconsidered. The costs saved by building single track instead of double track must be balanced against the operational flexibility that is lost and the costs and possible loss of income that this rigid form of operation involves.

VWI assesses a form of operation taking into account the departure frequency and travel time for each corridor (a scenario for each corridor). VWI concludes with a speed of 250 kph and that Oslo-Trondheim should have a departure frequency of once an hour in the rush hours and every two hours otherwise. VWI gives no grounds for these conclusions, neither are they based on a specific traffic study. In order to be able to determine the optimum scenario, the effects of different fare levels, travelling times, stopping patterns and departure frequencies should be studied in a traffic model.

Technical challenges in construction

The most relevant report on technical challenges in construction is:

- **VWI**: Feasibility Study Concerning High-Speed Railway Lines in Norway, Phase 1, Phase 2 and Phase 3

Line routing

The purpose of VWI's study, as regards technical issues involved in construction, was among other things to find the most realistic corridor to be investigated in more detail in future. A feasibility study was chosen so as to illustrate the potential and the limitations of the various corridors. As we understand it, the screening of the various corridors in the VWI report was done in such a way as to arrive at a corridor and a route with the best potential for making positive use of high-speed trains. It does not appear that the other alternatives between towns have been considered and excluded. A later planning phase should therefore include a more thorough screening of the alternative routes in each corridor before the final choice of route is made.

As an overall study of alternative routes in the number of corridors that were investigated, the line routing shown in the VWI report provides a good enough answer to the type of challenges presented by the various routes. The report also gives some very rough estimates of quantities. The technical rules have also changed in recent years. This means that the routes need to be revised. New requirements mean that routes through narrow valleys with many ascents and descents may require an even higher proportion of tunnel and have less opportunity to follow the terrain.

There are further challenges relating to certain limited stretches that should be investigated further in later stages of planning. The greatest uncertainties relate to the routes in western Norway that have long tunnels beneath the fjords, long, high bridges with long spans and long tunnels and stretches with extreme ascents/descents. Greater consideration should be given to winter operations where the railways run high in the mountains, to see whether more comprehensive measures are required. This applies especially to the railway to Bergen.

The routes vary greatly in form and are very distinct from each other. Some of them go right into and beneath the town centre (Haugesund), others pass just outside (Sarpsborg/Kristiansand), while others are a good distance from the town centre (Hamar). The routes therefore have very different speed profiles, since the curvature is reduced within and nearing certain towns. In terms of costs, a route that goes through a town will involve a higher cost per metre. Placing a route through the outskirts of a town can reduce the level of conflict and the technical issues involved in construction.

Reducing the proportion of tunnel is and will remain a challenge for several of the routes. The routes with the lowest proportion of tunnel may provide the best opportunities for reducing costs, but this can also lead to greater environmental disadvantages.

Environmental effects

VWI's report provides very little information about consequences of environmental impact. The report only describes impact consequences under two cost elements: crossings and fences for wildlife. In this phase the cost should have been a percentage mark up in accordance with experience. As we see it these two items represent costs for mitigating measures for environmental impact consequences.

Several of the alternative routes that have been investigated go through areas where they will affect and change areas of undisturbed nature and open landscape and that are currently registered as national parks. It is equally important to clarify these conditions as planning criteria for the track itself so as to consider whether the route is feasible at all. In some of the routes a choice must be made between developing or conserving. VWI's report provides too little information about the routes' effect on the environment and landscape to be able to consider the extent of mitigating measures, other than costs per linear metre based on experience of similar projects.

Costs

The most relevant reports on costs are:

- **VWI**: Feasibility Study Concerning High-Speed Railway Lines in Norway, Phase 1, Phase 2 and Phase 3.

- **Metier**: Concept Evaluation, Cost Estimate and Uncertainty Analysis - Report 1: Basic assumptions and methodology, and calculations for the corridor Trondheim – Oslo

In general the studies provide a study of costs that is thorough, well adapted and relevant with regard to the different high-speed corridors in Norway.

We have however identified some issues and uncertainties, including that the studies generally underestimate the unit costs of building new high-speed rail lines, especially with regard to tunnel costs. Metier's uncertainty analysis of 2007 estimates an average tunnel cost of NOK 118,000 per linear metre for the Oslo-Trondheim stretch. Considered against other, comparable national tunnel projects, which have costs of around NOK 140,000 per linear metre of tunnel, this seems low. Building a high-speed rail line demands a high quality of execution and solutions. All tunnels should be built with good security and concrete vaulting. Bridges must have proper foundations and open lines will require a solid foundation and execution, taking into account the demanding winter conditions we have in this country and the speed of the train. Against this background, we believe that the costs in the Metier report are too low in comparison to what is realistic. We should also point out that the unit prices Metier is operating with are based on development being carried out as one contract to build the entire stretch, which will therefore have economies of scale that are reflected in the unit prices.

We also believe that VWI overestimates the total development costs somewhat. The estimates shown by VWI vary between NOK 200 and 450 million per kilometre of railway line. The figures are based on German cost rates from previous railway projects. To begin with this is a rather debatable procedure, since the costs must be somewhat different because of the different topography, environment, population and land-use planning systems between the two countries. Secondly, the figures have been estimated on the basis of single track with a relatively low speed. The low speed permits curves of greater radius so as to be able to avoid running the route through residential areas. This means that the need for expropriation is reduced and land costs are lower. It should also be possible to propose routes with fewer tunnels, which will in turn reduce costs.

Requirements for implementation and financing

The questions of finance and how construction is to be implemented are closely interrelated. The review of requirements for financing and implementation shows that splitting development and financing is inefficient, since this slows railway construction and creates unpredictability. The review also shows that a public-private partnership can be advantageous if it is appropriately arranged. Success depends on how the public-private partnership is organised, and especially the specification of the contract. Several of the studies recommend project financing that involves a total financing decision for the entire infrastructure construction. Various solutions for project management have been used in Scandinavia, such as taking out loans, annual grants with guarantees and grants for the entire project and infrastructure funding.

For implementation of the development, a model should be chosen that ensures certainty about financing of the entire project and that provides the optimum division of risk between the principals. The model must provide the best possible incentives for cost effectiveness and for keeping to the schedule (although not at any price if safety and quality are at risk). The model should also safeguard the quality requirements and ensure a total view of all phases, so that quality in the operational phase is taken into consideration during the construction phase.

Socioeconomic effects

Both VWI and ECON have carried out cost-benefit analyses of high-speed trains in Norway. VWI's cost-benefit analysis is based on German methodology, but includes Norwegian unit prices to some extent. ECON is based on Norwegian methodology. A comparison of the socioeconomic analyses of high-speed trains made by VWI and ECON has revealed three important differences.

Firstly, there is a difference between VWI and ECON regarding what effects of modal shift are included. In COWI's view, in this area ECON has ignored the potentially important elements in the socioeconomic use of high-speed trains. COWI believes that the German procedure is in agreement with the Norwegian National Rail Administration's guidelines for socioeconomic analyses, even though the technical calculation set up may be unusual from a Norwegian point of view. We also believe that VWI has not sufficiently investigated how the use of the modal shift is quantified and valued and we can only wonder about the level of cost savings from transfer of traffic.

Secondly, ECON has used a discount rate of 4.5 per cent, which corresponds to the recommended rate in Norwegian cost-benefit analyses. VWI has used an interest rate of 2 per cent, which corresponds to the German recommendation. About half the difference in calculated benefit between VWI and ECON is due to different interest rate estimates. COWI recommends that socioeconomic analyses of high-speed trains should follow ECON's procedure, that is with a discount rate of 4.5 per cent.

Thirdly, unlike ECON, VWI has not included a tax financing cost. COWI recommends using ECON's procedure, which is in line with Norwegian practice.

For future analyses, our recommendation is that new analyses should use a **gross method** that presents the effects for operators, travellers and the public sector in detail. Neither VWI nor ECON have used such a procedure. The result is that the analyses are not very transparent and are difficult to compare. It can also sometimes be difficult to fully understand the simplifications made in the reports as a result of the socioeconomic calculation not being completely detailed.

Also, the estimates of **market share** and **time values** are critical for calculating the benefit of building high-speed rail lines. There are no differences in principle between ECON and VWI's procedures. As shown in the market analysis however, there are other reports and experiences that question whether the area of competition between air and high-speed train is well enough represented in the VWI report. Questions may also be raised whether the time values that are used in the VWI and ECON calculations are representative for travellers by high-speed train. New socioeconomic analyses should go into these issues in more detail.

The ongoing development of methodology in socioeconomic analyses of transport investments may introduce new aspects that are not part of current practice: **added benefit**, **real price development** and **the reliability of travelling time**. It is worth considering whether these should be included in further investigation into high-speed rail lines in Norway. Added benefit is particularly relevant for large infrastructure investments.

1 Introduction

A process is under way, the purpose of which is to identify the need for and the benefits of developing high-speed rail lines in Norway. The process has been facilitated by the government, and the Norwegian National Rail Administration has full responsibility for leading the work of investigation.

A good deal of independent input has been obtained from several seminars and public enquiries. A number of studies and analyses have also been carried out that provide input on the market and the social and environmental effects of such a development.

The Norwegian National Rail Administration has commissioned COWI AS to review the status of knowledge on high-speed trains in Norway up to 2009. The purpose of this assignment is to systematise the existing basis of knowledge on high-speed rail lines in Norway by evaluating previous reports and analyses at both national and international level.

In this report, we have attempted to reveal the weaknesses and deficiencies in what has been done so far and to provide input on what has been learned and what is worth transferring from the measures taken in other countries with regard to the planning and introduction of high-speed rail, while at the same time giving recommendations and a basis for further investigation.

1.1 Why high-speed

High-speed rail lines have been evaluated in many parts of Europe and other parts of the world as a means of improving transport facilities. High-speed rail could be a competitive alternative to air travel. For example, there is no longer a Paris-Brussels air route, since it has been replaced by high-speed train.

The term high-speed train is used to cover all trains that run at over 250 kph on new track or 200 kph on upgraded track. This definition is not precise however and it varies from country to country. Regardless of the precise speed, it is evident that such trains demand very special infrastructure, operations and maintenance.

Conventional railways in Norway (normal trains) maintain a speed of under 100 kph, while trains in the rest of Europe run at 150-200 kph. Norway does not currently have a high-speed *network*, but one line, which is the Gardermoen line. This is constructed for speeds of 210 kph. Østfold-Sandbukta on the

Østfold line is designed for speeds of 200 kph, but with the current signal system the trains cannot run at more than 160 kph.

Experience shows that great time savings can often be made by choosing high-speed train instead of air, especially for destinations that are some distance from the airport. It is also often more comfortable to travel by train, since one avoids having to change means of transport along the way, as well as the waiting time and security checks at the airport.

The introduction of high-speed trains opens up completely new possibilities for the transport of both people and goods. Longer distances become practicable and commuting can cover a much wider geographical area than in the current situation. From a regional policy perspective, this can lead to significant changes in employment and residential patterns.

A natural consequences in the longer term is expected to be that a great deal of car traffic will go over to train, because it represents a more pleasant, comfortable and, not least, faster means of travel. In addition to taking the pressure off the road network, such measures also lead to considerable environmental gains. This is a natural consequence of transferring transport from road to rail and, in addition to the socioeconomic benefits, it is one of the most important, indeed decisive, factors in the choice of future transport solutions.

Even so, establishing high-speed rail lines is not without its problems, since the construction costs are great and there will necessarily be a not inconsiderable impact on the landscape. The question of development has given rise to much debate between proponents and opponents. It is therefore important to obtain information, which is something to which this summary of knowledge status is intended to contribute.

1.2 The commission

The purpose of the commission is to

- give a summarised, brief and technically focused presentation of the investigations that have been made in Norway
- discuss specifically the report recently presented in Sweden: SOU 2009:74 *Höghastighetsbanor – ett samhällsbygge för stärkt utveckling och konkurrenskraft* (High-speed rail lines - a social structure for strong development and competitiveness)
- give an overview of relevant international studies
- provide a good basis for seeing weaknesses and deficiencies in what has been done to date
- provide input on what has been learned and what is worth transferring from what has been done in other countries

- provide a basis for programming further investigations

Topics that the Norwegian National Rail Administration wanted covered included:

- the market analyses
- technical parameters for high-speed trains that are relevant for Norway
- technical construction issues - adapting to landscape and environmental effects
- implementation requirements
- costs
- financing
- social effects, including socioeconomic evaluations

1.3 The basic material

The Norwegian National Rail Administration provided COWI with the following studies:

Feasibility Study Concerning High-Speed Railway Lines in Norway Report Phase 1, 2006, VWI

In July 2006, the Norwegian National Rail Administration engaged VWI of Germany and its partners to perform consequence analyses for the following corridors:

- Oslo – Gøteborg
- Oslo – Stockholm
- Oslo – Trondheim
- Oslo – Bergen
- Oslo – Kristiansand/Stavanger
- Combinations of these corridors

The report includes market analysis, traffic prognoses and technical aspects.

Feasibility Study Concerning High-Speed Railway Lines in Norway WP 100: High-Speed-Basic-Analysis, 2006, VWI

The report describes technical aspects of conventional railways and high-speed rail in other countries.

Høyhastighets Jernbane i Norsk Terreng Noen karakteristiske trekk ved grunnforhold og topografi og tilpassende løsninger og kostnader **(High-speed rail in Norwegian terrain. Some characteristics of ground conditions and topography and suitable solutions and costs), 2007 , SINTEF and NGI**

The report includes unit costs for the construction of high-speed rail in Norway and a discussion of line routing. Technical requirements and physical conditions are of great significance for solutions and costs. The report explains some of the key connections on a general basis.

Feasibility Study Concerning High-Speed Railway Lines in Norway Report Phase 2, 2007, VWI

The report analyses the Oslo-Bergen and Oslo-Kristiansand/Stavanger corridors with a view to line routing, construction costs, operations, traffic and cost-benefit.

Feasibility Study Concerning High-Speed Railway Lines in Norway Report Phase 3, November 2007, VWI

The report analyses the Oslo-Trondheim and Oslo-Gøteborg corridors with a view to line routing, construction costs, operations, traffic and cost-benefit. This is less detailed than phase 2.

High-Speed Railway Lines in Norway Concept Evaluation, Cost Estimate and Uncertainty Analysis Report 1: Basic assumptions and methodology, and calculations for the corridor Trondheim – Oslo, 2007, METIER

The report presents assumptions, method and calculations for the Trondheim - Oslo corridor.

Statement on the VWI report, 2007, Norsk Bane AS

The document gives a critical assessment of the analyses carried out by VWI.

Høyhastighet og kapasitet High Speed Operations, 2008, Funkwerk and Railconsult

The purpose of this study is to ensure and improve the robustness of the infrastructure by answering the following questions:

- Is it advisable to integrate high-speed trains with other train traffic in Oslo's Intercity area?

- Is it advisable to run high-speed trains at a frequency of one or two hours on single track?

***Nyttekostnadsanalyse av høyhastighetstog i Norge* (Cost-benefit analysis of high-speed trains in Norway), 2008, ECON**

The purpose of the report was to give a professional, neutral and independent quality assurance of the cost-benefit analyses presented in the VWI group's report and compare this with the Norwegian methodological tools used by the Norwegian National Rail Administration. A further purpose was to determine the main principles for cost-benefit methodology for any further investigation and planning work regarding the construction of high-speed rail lines in Norway.

***Markedet for høyhastighetstog i Norge Supplerende markedsanalyse basert på anvendelse av den nasjonale persontransportmodellen NTM5* (The market for high-speed trains in Norway; Supplementary market analysis based on the application of the national passenger transport model NTM5), 2008, Urbanet Analyse**

This report is a supplementary market analysis and gives supplementary traffic prognoses to VWI's report. The analysis is based on the NTM5 model, which is the national passenger transport model developed for NTP Transportanalyser. This model has been used in many previous studies of long-distance travel in Norway.

***Samfunnsmessige virkninger av ulik organisering av jernbaneutbygging i Norge* (Social effects of various ways of organising railway development in Norway), 2008, Agenda Utredning & Utvikling AS**

The purpose of this report was to study social effects of typical rail development projects in Norway to calculate how much of the value creation in the project would come to Norwegian business, which industries would be most affected and what employment effects the development project would have on Norwegian society. Various organisational models are discussed.

***Samferdselskonsept for Sør- og Midt-Norge* (Transport concept for South and Central Norway), Part report 2008, Deutsche Bahn**

The report summarises the results presented in "*Jernbane- og trafikkonsept for Sør- og Midt-Norge, Sammendrag, Rapport mai 2009*" (Railway and traffic concept for South and Central Norway, Summary, Report May 2009) below.

***Markedet for høyhastighetstog i Norge Analyse av flypassasjerenes preferanser* (The market for high-speed trains in Norway; Analysis of air passengers' preferences), 2009, Urbanet Analyse**

The analysis discusses passengers' preferences for high-speed trains, in terms of both the value of shorter travelling time and preferences for trains of a higher standard. The analysis is based on a questionnaire survey of air passengers. This provides a basis for studying preferences and travel behaviour in more detail and assessing effects that are not generally covered in NTM5.

***Jernbane- og trafikkonsept for Sør- og Midt-Norge, Kapitel 1 og 2* (Railway and traffic concept for South and Central Norway, Chapters 1 and 2), 2009, Deutsche Bahn**

The report analyses results from VWI's report and includes various traffic data.

***Jernbane- og trafikkonsept for Sør- og Midt-Norge, sammendrag* (Railway and traffic concept for South and Central Norway, summary), May 2009, Deutsche Bahn**

The report presents line routing alternatives, construction costs and traffic prognoses.

***Höghastighetsjärnvägar – ett klimatpolitiskt stickspår* (High-speed railways - a climate policy siding), July 2009, Jan-Eric Nilsson, Roger Pyddoke**

The report investigates existing judgements of the socioeconomic benefits and discusses the role of rail investment in climate policy. The report is intended to contribute to a clarifying debate on the extent to which a major focus on high-speed rail is a climate policy necessity.

***Höghastighetsbanor – ett samhällsbygge för stärkt utveckling och konkurrenskraft,* (High-speed rail lines - a social structure for strong development and competitiveness), 2009, Statens Offentliga Utredningar (SOU 2009:74)**

The purpose of the report is to investigate the preconditions for high-speed rail development in Sweden. The report looks at whether the development of high-speed rail lines could help to achieve socioeconomically effective and tenable transport solutions for a developed transport system with improved capacity, navigability and accessibility.

***Høyhastighetstog i Norge* (High-speed trains in Norway), The Norwegian National Rail Administration**

This brochure is the Norwegian National Rail Administration's summary of the VWI group's assessments and results. The presentation of costs is similarly based on the reports of the Metier consultancy company.

Høyhastighetsringen and Norsk Bane

A meeting was also held with Høyhastighetsringen, whose general manager Jon Hamre presented their concept. COWI also attempted to hold a similar meeting with Norsk Bane, without success.

1.4 Description of method

The Norwegian National Rail Administration specified the topics that were to be investigated in the basis for tender. It was COWI's hypothesis that the various topics would to a certain extent require specially tailored methods of investigation. The strategy of methodology is however common and COWI therefore believed that it would be appropriate to outline this in a separate section on method.

Our original proposal for method sprang from the fact that the previous reports had come to different conclusions regarding whether high-speed trains are socioeconomically beneficial. The hypothesis was that these differences partly stemmed from the reports having drawn on different factors in their analyses and partly that the critical factors that are common to all the reports were differently valued.

In this project we therefore wished to systematically compare the assumptions and what factors the analyses include. Such a comparison would provide insight into why different analyses have arrived at different results and conclusions.

We also wished to compare the sensitivity analyses that had been made in the different reports. This would provide an overview of how uncertainty has thus far been revealed in the work of investigation, while also providing a basis for assessing which sensitivity analyses future studies should employ.

We also aimed to compare how risk is assessed and handled in the different reports, as regards both systematic and unsystematic risk. This comparison would reveal which factors have been assessed as subject to risk and in which ways this has been corrected in the analyses.

Table 3.1 illustrates how we wished to systemise the knowledge that already exists about high-speed trains. Analysis 1, 2 etc. are the publications/reports that are listed on page 6 of the specification of requirements from the Norwegian National Rail Administration. The factor rows illustrate assumptions, variables, parameters etc. that should be compared right across the different analyses. We would also organise the comparison and systemisation of results and conclusions in the same way.

Table 2.1: Model for systemising and comparing experiences

	Analysis 1	**Analysis 2**	**Analysis 3**	**Analysis *n***
Factor 1				
Factor 2				
Factor 3				
Factor *m*				

It is been shown in practice that the analyses in the reports we have assessed have not been sufficiently systematically documented to allow us to use the method we originally intended. Rather, it has been the case that the reports differ greatly in their choice of method and approach with regard to the individual assumptions, variables and parameters used in the analyses. It has not therefore been possible to establish a common analysis form to systemise the information in all the reports that have been reviewed, as illustrated in the figure.

Instead of using a common method of comparing the results of the various reports, we have therefore used different different approaches in the different sections of the report. Where relevant, the method used for the individual topics will be explained.

The somewhat diverse range of methodologies for the individual reports means that the existing reports can hardly be said to represent a collected basis of information. Only in a few areas is it possible to show where different reports arrive at comparable results and there is a consensus on important issues. The basis for future work on high-speed rail must therefore be characterised as somewhat fragmented.

1.5 Organisation of the report

In section 2 we look at international experience. Today many countries have high-speed trains and have therefore accumulated a great deal of experience. Much of this experience can usefully be included in any investigation into high-speed rail in Norway. For future work it will be especially useful to look at what aspects have been discussed and what conclusions have been reached in our neighbouring country Sweden. We discuss this in section 2, along with what is considered best practice internationally.

The subsequent sections will cover the various topics that the Norwegian National Rail Administration wished to have investigated. These sections provide a technically focused and independent presentation of the investigation work that has been done in Norway. Section 3 covers the market analyses. Section 4 discusses technical parameters, while section 5 looks at technical issues involved in construction. Costs will be evaluated in section 6. Sections 7 and 8 assess the requirements for implementation and financing, as well as the socioeconomic effects of high-speed rail.

Finally, section 9 gives recommendations for further work on high-speed rail in Norway.

2 Experience internationally

2.1 The Swedish report SOU 2009:74

SOU 2009:74 investigates the assumptions and preconditions for building high-speed rail lines in Sweden. Its main conclusion is positive, as regards developing high-speed rail lines rather than upgrading the existing rail network.

As far as Norwegian investigations are concerned, it is useful to look at what aspects have been discussed and what conclusions have been reached in Sweden regarding transport policy objectives, environmental consequences, socioeconomics, technical aspects and choice of route. We also note the proposed model for implementation and financing. It is also interesting to look at the possibilities of connecting to the European rail network, and here Norway is naturally dependent on Sweden.

With regard to Swedish transport policy objectives, high-speed rail gets a "positive" or "strongly positive" score in all the objectives assessed (briefly, these cover improvements for the population, business, regions etc.). As regards the environment, an impact on the landscape is unavoidable, but the negative effects can be reduced by locating the routes outside the most vulnerable areas. Moreover, high-speed rail will help lower emissions from transport.

Relevant routes for development are discussed, but more analysis is needed. The recommendation is to build a separate double track, and for passenger traffic only. Socioeconomic analyses have been carried out for the Stockholm - Malmø and Stockholm - Gøteborg routes that show a positive net benefit. It is pointed out that the results are uncertain and that there is a need for more thorough analysis of the socioeconomic aspect.

A model is proposed for implementation and financing. This would involve the government establishing a project company to coordinate planning, public procurement and future agreements regarding high-speed rail. The rolling stock is the operators' (rail traffic companies') responsibility. The project can be partly financed from non-government sources by means of charges to the operators for the use of the track and contributions from local authorities, regions and the EU. Income from traffic would also provide part of the financing. The need for government finance is assessed at almost half (47 per cent), or SEK 59 billion. It should be one, collective project.

2.2 Best Practice

Every country that has introduced high-speed rail travel has its own best practice for construction and operations and underlying reasons for the choice of its system. Line routings and the location of stations also provide specific grounds for system choice. Tracklaying and the pattern of stations are also specific, since they are based on sociodemographic and topographical conditions, and so is rail policy in each country.

A high-speed rail line is not really a specific system, but rather a set of construction criteria that permit high-speed rail travel.

EC Directive 96/58 defines high-speed rail as systems of rolling stock and infrastructure that regularly operate at or above 250 kph on new tracks or 200 kph on existing ones.

Compared with the world's other high-speed rail systems, Norway is a special case for the following reasons:

- A high level of domestic air travel and therefore strong market potential for high-speed rail
- A high gross domestic product (GDP) per head of population and strong growth within the market segment in question
- Low population density in the relevant high-speed corridors

It is generally considered that the nature of Norway's topography is particularly difficult for the development of high-speed rail lines, but this is not the case. Japan, France, Italy, Taiwan and South Korea have all either built or are building high-speed rail lines in similar or more difficult terrain to that found in Norway.[1]

2.3 Comparison

We cannot say that there is any clear best practice for high-speed rail lines, but rather leading categories of high-speed rail lines in each country. These categories correspond to the countries' specific needs and can be defined in the following way:

1. Very high speed with straight line routings and few stops

2. Regional high-speed rail lines with more stops and lower speed

3. Low costs and few cuttings with tilting trains and lower speeds

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[1]The construction of the high-speed line from Lyon to Turin is an obvious example. More examples are described in the section on building costs.

4. Maglev systems with very high speed, straight line routings and few stops

The table below gives a summary of the world's high-speed systems divided into the four categories above. We should note that the categorisation below is based on average speeds of rail lines for high-speed trains and no allowance is made for type of rolling stock (manufacturer). Neither are cases where high-speed trains operate on conventional lines at lower speed taken into account.

We can see that the regional type of high-speed rail is the most widespread practice, closely followed by type 1 based on very high speeds with straight line routings and few stops.

Table 2.1: The world's high-speed rail systems divided into different categories

Category	Country	Total length with high speed (km)	Scheduled trains	Record speed on test run	Average speed for scheduled trains
2	Austria	250	230 kph	275 kph	153 kph
1	Belgium	326	300, 250 kph	347 kph	237 kph
1, 2 and 4	China	6003	431 kph maglev 350, 330, 300, 250, 200 kph conventional	502 kph maglev 394 kph conventional	313 kph
3	Finland	60	220 kph	255 kph	152 kph
1	France	1700	320, 300, 280, 210 kph	574 kph	272 kph
2	Germany	1290	300, 280, 250, 230 kph (conventional)	550 kph maglev 406 kph conventional	226 kph
3	Italy	815	300, 260, 200 kph	368 kph	178 kph
1 and 4	Japan	2459	300, 275, 260 kph (conventional)	581 kph maglev 443 kph conventional	256 kph
2	Netherlands	100	300, 250, 140/160 kph	336.2 kph	<140 kph
2	Norway	60	210 kph	260 kph	151 kph
3	Portugal	314	220 kph	275 kph	<140 kph
2	Russia	600	250 kph	290 kph	172 kph
2	South Korea	240.4	300, 240 kph	355 kph	200 kph

Categor y	Country	Total length with high speed (km)	Scheduled trains	Record speed on test run	Average speed for scheduled trains
1	Spain	127.3	300, 250 kph	404 kph	236 kph
3	Sweden	0	200 kph	303 kph	173 kph
2	Switzerland	79	250, 200 kph	280 kph	<140 kph
1	Taiwan	335.5	300, 240 kph	315 kph	245 kph
2	Turkey	245	250 kph	303 kph	<140 kph
2	United Kingdom	109	300 kph, 201 kph	335 kph	219 kph
3	USA	0	241 kph, 201 kph	296 kph	161 kph

3 Market analysis

An assessment of the market basis is an essential part of the information on which a decision on developing high-speed rail lines in Norway can be taken. The result of such an analysis will contain several important components that can be used in an associated socioeconomic assessment of making such an investment, for example

- traffic basis for high-speed rail
- time values for passengers on high-speed trains
- the area of competition with other forms of transport

3.1 Method

It is possible to use many different approaches for analysing the market for high-speed rail travel in Norway. What they all have in common however is that there is considerable uncertainty attached to the conclusions. A particularly demanding challenge is that high-speed rail travel will be something completely new in the Norwegian market. Important characteristics affecting demand, such as price level, time values etc., cannot be estimated by observing actual behaviour. Instead we are forced to make assumptions on a more or less well-founded basis, on the basis of international experience for example. Another problem as regards method is that we cannot really say that any one procedure is the correct one to use on a completely general basis. Instead, specially adapted methods and tools are often used to analyse competitive conditions in a market. In some cases, game theory models for strategic behaviour will be relevant. In other cases, optimising models for estimating cost-minimising solutions will be preferable. A third alternative is to carry out surveys to identify consumer preferences for new options in relation to existing solutions. Different models complement each other rather than being pure alternatives. Since no one model or method is correct, it can often be an advantage to consider an issue from different angles.

Having to summarise the knowledge base for high-speed rail travel is methodically demanding in itself, not least being able to systemise the areas in which different reports have used different assumptions. We have therefore chosen to use a relatively general method that is used for cases of competition, that is to say in cases where the authorities assess the competitive conditions in a market (usually to decide whether a company has a so-called dominant market position or to assess whether a merger between two companies would give too strong a market position).

The assessment of an issue of competition is usually in two parts. In this context the two stages are useful, because in stage one a clear definition must be made of the alternatives high-speed rail travel is actually competing with.

- **Delimitation of the relevant market**: The specific basis for the market delimitation is an analysis of which products or services can actually be substituted with each other. Assessing the conditions for substitution should primarily be based on whether two or more products can satisfy the same need in the eyes of the consumer. There is normally no clear answer to what the correct market delimitation is. There will often be degrees of substitutability, and where you put the limit is often a question of judgement. Market delimitation is done by both product and geography.

- **Competition analysis**: Where possible monopolies are being judged, this part of the market analysis will normally consider whether conditions are in place for actual commercial competition. Assessment will often consider whether one party actually has a large market share, whether buyer power exists, degree of rivalry, start up possibilities, whether there is price or quantity competition etc.

In this report, our ambition is not to give a clear definition of market delimitation or to make an exhaustive competition analysis. In the summary of the status of knowledge, it is however important to emphasise that there are systematic differences between the various reports that are due to different, albeit sometimes implicit, assumptions about the relevant market. Also, all of the reports make a more or less explicit assessment of what a possible or foreseeable market share for high-speed rail might be. The different analyses have not however taken many competitive factors other than ticket price and travelling time into consideration and the conclusions largely depend on the results of comprehensive transport models.

3.2 Hypotheses - analysis - conclusions

Another methodological concept we will attempt to apply is to review the existing reports according to the following more general framework:

- **Hypotheses**: Ideally all economic analyses should be based on economic theory. One way of using theory is to formulate hypotheses for the analysis to be carried out. Generally speaking a hypothesis is a statement about an economic context, the correctness of which can be tested with the aid of empirical investigation.

- **Analysis**: Generally speaking what we mean by analysis is arriving at methods and models that are relevant for verifying a hypothesis.

- **Conclusions**: Given reasonable hypotheses and relevant methods/models, we are able to conclude an economic analysis, for example with an estimate of the traffic basis for high-speed rail travel.

We will look more closely at the extent to which the reports have formulated clear hypotheses, especially as regards what a reasonable market delimitation is or what the competitive situation could be expected to be between high-speed trains and other forms of transport. We will also look at whether the analysis models are relevant.

Before we comment on the results of the market analyses in the individual reports, it may be useful to put forward some alternative hypotheses regarding possible delimitations of the relevant market.

- **High-speed rail represents a separate relevant market.** This alternative would be reasonable if travellers by high-speed train could not substitute other journeys at all. In such a case, the market for high-speed rail would be entirely made up of newly created traffic.

- **End to end transport between larger Norwegian towns and cities.** This alternative would imply a high level of substitution between high-speed rail and other forms of transport for journeys that start and end in, or in the immediate vicinity of, the larger towns and cities. More specifically, such a market definition would imply a high level of competition between domestic flights and high-speed rail. High-speed rail could also be substituted with traditional Intercity trains.

- **All transport in a corridor between larger towns and cities.** This alternative represents a better delimitation than the one above. For example domestic flights for onward domestic or international transit would be considered as substitutable with high-speed rail. Also with this market definition, journeys by regional or Intercity train or by road in part of the corridor could be substituted with high-speed train.

- **All transport is included in the same relevant market.** This market delimitation would be relevant if all transport needs could be reasonably easily covered by all forms of transport.

3.3 Background and mandate for the market analyses

The reports that are most relevant for this section on market analyses are:

- **VWI**: Feasibility Study Concerning High-Speed Railway Lines in Norway, Phase 1 (VWI1), Phase 2 (VWI2) and Phase 3 (VWI3)

- **Urbanet Analyse**: *Markedet for høyhastighetstog* (market for high-speed trains), report 9/2008 (UA1) and report 12/2009 (UA2)

- **Norsk Bane**: *Nytt jernbane og trafikkonsept for Sør- og Midt Norge* (new railway and traffic concept for South and Central Norway)

During a meeting, the Norwegian National Rail Administration advised COWI that the VWI and Urbanet Analyse reports must be seen in relation to each other. Neither is in itself a complete market analysis that can be read independently of others; rather they represent a gradual development of the knowledge basis. As we understand the context, the VWI reports represent the first contributions, with the market analysis best developed in reports 2 and 3. Urbanet Analyse's study was carried out after the publication of the VWI analyses and thus builds on the experience of the VWI reports. Furthermore, the approach of the second Urbanet Analyse report is a result of insight obtained in the first study and the last report should be given the greatest weighting. Norsk Bane's analyses were carried out on an independent basis in relation to VWI and Urbanet Analyse.

The Norwegian National Rail Administration also impressed on COWI that the VWI and Urbanet Analyse reports had a limited level of ambition and must be seen as pre-feasibility studies.

In order to summarise the status of knowledge that the reports represent, one must thus understand both the context and the ambition of the existing analyses.

The mandate for the reports in question does not explain in any detail the background to the assignment, the extent to which the reports are based on earlier work or in what way differences in conclusions or results may be due to revision of the assumptions used.

3.4 VWI

The reports from VWI do not make any explicit division of the market analyses into hypotheses, analysis and conclusions. The expression relevant market is used in places, but there is no fundamental or qualitative discussion of the substitution possibilities between high-speed rail and other forms of transport. The analysis itself is based on the use of a well-established European traffic model that has been used for many years, including to develop the master plans for extending the German high-speed rail network.

3.4.1 Relevant market

Section 3.3.2 of VWI1 reads "*... all traffic segments could be of interest if High-Speed Services*". The model therefore includes basic data that describes the current traffic basis, by air, rail and road. VWI therefore apparently takes as its basis a very wide market definition and totally determines substitution possibilities from the model's parameters.

In VWI2 (section 5.2.1) however in the discussion of the traffic basis in the individual traffic corridors, there are formulae that indicate that a narrower definition of the relevant market has been used. The report argues that domestic flights for transit to other domestic destinations fall outside the relevant market. It is pointed out however that flights for international transit can in future be included in the same relevant market as high-speed rail. It is also assumed that Intercity traffic north of Oslo falls outside the relevant market. South of Oslo however both Intercity traffic and local trains to and from Østfold have been included. The present long-distance train traffic in the corridors is considered to belong to the same relevant market as high-speed rail.

The delimitation of the relevant markets in VWI2 has been done verbally. The assumptions have not been formulated as clear and distinct hypotheses or discussed on the basis of qualitative or fundamental assessments of the degree to which different transport solutions are substitutable. No tables are presented to show how large a proportion of the total traffic in the individual corridors falls outside the market delimitation. Neither are any tables presented to show traffic figures for air, car or bus in the basic, reference or action alternative.

VWI3 does not explain whether similar delimitations of the relevant markets have been made.

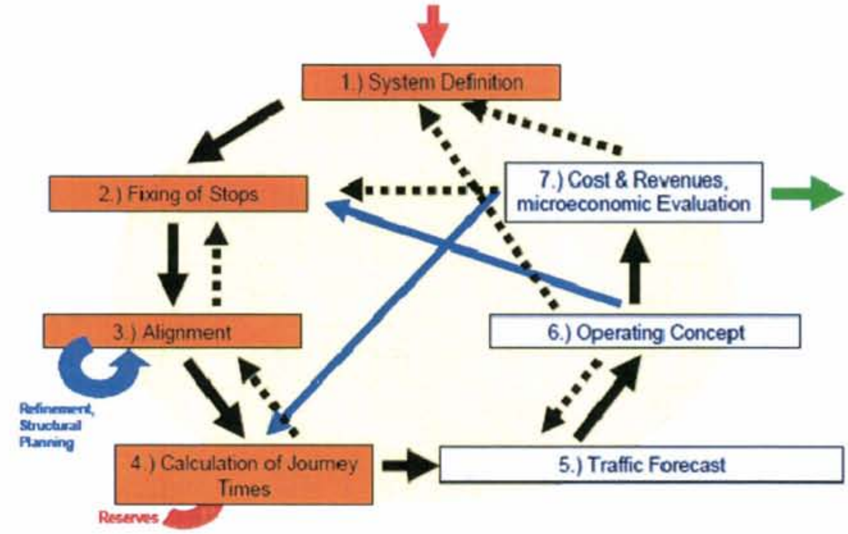
3.4.2 Model framework

VWI bases its market analyses on a very comprehensive transport model. The work VWI has done represents the most unified assessment of high-speed rail travel in Norway. By this we mean that technical and market assumptions are analysed within the framework of one single module. In general the study is based on technical specifications, operational studies, costs and demand models that are thorough, recognised and basically relevant for studying the market for high-speed rail transport. It would however have been beneficial for the report to include a discussion of the model's strengths and weaknesses as regards analysing a high-speed rail system in Norway.

The method used by VWI is illustrated in the figure below.

Figure 3.1: Illustration of VWI's method

Figure 3-1 Methodology of iterative planning and design of public transportation systems



Source: VWI (2006a), figure 3-1

Regarding method, VWI has however noted the following in its report "*Due to reasons of time and budget the planning, as pictured in figure 3.1, can only be run through once in this project, that means linear and without major feedbacks. It follows from this that the underlying system definition cannot be optimised iteratively*".

An implication of this limitation in method is that VWI is presenting conceptual solutions in every single corridor regarding routes, scheduling on single track and travelling times that are not based on iterative assessments of options or demand for high-speed rail. This creates uncertainty with regard to whether the operational scenarios are optimum or whether other alternatives could have been studied.

None of VWI's reports includes a clearly set-out presentation of the most important assumptions or exogenous input for the model analysis. Neither does the report present any documented connections or relationships between demand for high-speed rail and the following variables:

- Population growth by region
- Previous developments and future projections for GDP
- Time values for different types of journey
- Sociodemographic characteristics and travel purposes

- Distance between towns and cities for different means of transport (air, "normal" train, high-speed train, car and bus) for the basic, reference and project alternative

- Travel times by means of transport and origin-destination (OD pair)

- Previous developments and future projections for ticket prices and travel costs by car

- Significance of tourism

All these variables are of course included in VWI's models, but if the reader of the analysis is to be able to take an independent decision on the results, it would have been beneficial to present the assumptions in a clear and easily comprehended manner. It would for example have been very interesting to know which assumptions have a particular significance for the model results.

In VWI3, VWI has however included the following figure that basically shows how the model calculates the division of traffic between high-speed rail and air.

Figure 3.2: Market share as a function of travelling time

Source: VWI (2007b), figure 5-2

The figure shows that the market share for high-speed rail will be a declining function with travelling time. The relationship illustrated applies to corridors with a distance of 400 - 600 kilometres and a flying time of around 2 hours. The report does not explain the difference between the upper and lower limit, but we perceive this to be a relatively wide interval. Neither is any explanation given of whether the upper or lower limit is used in the calculations. The report points out that the relationship will be affected by a number of conditions, such as scheduling, accessibility of railway stations and airports etc. Furthermore this type of relationship only applies to specific OD pair relationships and not to composite journeys. How the composite journeys are modelled is not explained however.

It should be noted that the figure as drawn does not really make the leap to the calculated market share of high-speed rail lines. By this we mean that if travelling time is doubled from 2 to 4 hours and assuming that a flight will take 2 hours, high-speed rail will still achieve a market share as high as between 30 and 60 per cent.

3.4.3 Schedule and running times

The schedule proposed by VWI must be viewed as being conceptual and is not based on an analysis of traffic volume or traffic structure. Neither has the traffic potential of alternative scenarios been considered, so that it is difficult for the reader to decide whether the proposed schedule represents the optimum.

VWI presents the table below in its first report (phase 1), showing travelling times for the various routes.

Table 3.1: Running times for the different routes

Minimum Running Time on Main Markets (assuming direct lines and direct services)		
Line	Length of line	Minimum running time
Oslo - Trondheim	[illegible]	[illegible]
Oslo - Bergen	[illegible]	[illegible]
Oslo - Stavanger	[illegible]	[illegible]
Oslo - Kristiansand	[illegible]	[illegible]
Oslo - Göteborg	[illegible]	[illegible]
Oslo - Stockholm	[illegible]	[illegible]
Bergen - Trondheim	[illegible]	[illegible]
Bergen - Stavanger	[illegible]	[illegible]
Stavanger - Kristiansand	[illegible]	[illegible]

Source: VWI (2006a), table 3-7

The running times for high-speed rail are based on the assumption that the trains run at an average speed of between 130 and 180 kph. This range of speeds is not explicitly presented in VWI's report, so we have arrived at it ourselves on the basis of the running times and distances in the table above. VWI's report states that the operational speed of the trains is between 200 and 250 kph. These speeds are normally considered to be rather low to be able to define the train as a high-speed train.[2]

In an evaluation of high-speed rail, it is important to test the systems with the highest possible speed, so that the costs of building a high-speed rail line can be justified. Such an assumption means that the full potential of the new line is utilised. If the trains run at higher speed between the most important towns and cities, traffic will be higher and so the project will be more profitable. Higher speeds will also lead to lower operational costs.

With the speeds proposed by VWI, cheaper tilting train systems could be considered in some corridors instead of building a completely new line designed for 250 kph alone. This type of tilting train is in use in both Sweden and Finland.

The train concept and speeds chosen by VWI correspond to the conventional regional express trains in operation. These types of trains and lines are less profitable than high-speed rail lines. If VWI has arrived at these speeds because of technical track conditions or environmental, cost or political considerations, this is not explained in their report.

We recommend that high-speed scenarios with operational speeds of 300 kph or even 350 kph - which are now considered standard in the high-speed rail sector - are studied more closely.

VWI has not explained what assumptions are made for travelling times by air and car/bus. In order to understand VWI's results more clearly, it would have been interesting to compare travelling times for high-speed trains with competing means of transport. Such a comparison is quite essential to a

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[2] EC Directive 96/58 defines high-speed rail as systems of rolling stock and infrastructure that regularly operate at or above 250 kph on new tracks or 200 kph on existing ones.

competition analysis, and also an important part of the basis for defining the relevant market.

3.4.4 Ticket prices

VWI has not discussed the assumptions regarding ticket prices for HSR in its reports. Neither have the assumed fares for air travel or travel costs for car for each destination been explained. In the same way as for travelling times, being able to compare ticket costs for different means of transport is vital to a competition analysis. Consequently it would have been of great value if the assumptions in VWI's analyses had been better explained.

On a general basis, VWI assumes that ticket prices for air travel would be reduced by about 4 per cent a year up to 2020, ref. figure 3-17 in VWI1. They also assume that ticket prices for rail travel will rise by about 7 per cent a year up to 2020. The market share for rail falls considerably as a result of these assumptions. No grounds have been given for these assumptions and they have a negative effect on traffic projections for rail. The assumptions made regarding ticket prices would mean that there would be less traffic in the reference alternative in 2020 than there is today.

In order to verify the assumptions regarding developments in ticket prices, we should investigate how ticket prices for air and rail have developed over the last 10 years. We may use the historical trends to estimate a future trend for ticket prices for the two means of transport. Figure 3.5 in section 3.7.4 that shows relative prices for rail, road and air based on the consumer price index does not support the theory that rail fares will have a negative development as assumed in the VWI reports.

Our recommendation is to avoid assumptions that lead to significant changes to the present situation. *Best practice* in traffic projections is to keep to the situation as it is today. This means using the same ticket prices as today for the air and rail sectors in the future. In other words the relative prices will remain constant.

3.4.5 Results

A whole range of results is presented of simulations in the form of market shares and number of travellers by rail. The following summary table is drawn from the phase 2 and 3 reports, ref section 5-11 in VWI3 and section 5.2.2 in VWI2.

Table 3.2: Summary of number of high-speed rail passengers and market shares for different routes

		Mill Pass - km/day					
Lines/combinations of lines	Pass./day with instance	With instance	Without instance	Moved from		Newly created	Market share in 2020 with HSR
				Air	Car/bus		
Oslo-Bergen (Hallingdal/Numedal)	6,300	3	0.7	1	0.2	1.1	53%
Oslo-Kristiansand	4,050	1.4	0.45	0.2	0.35	0.4	27%
Oslo-Kristiansand-Stavanger	7,700	2.6	0.5	0.6	0.6	0.9	39%
Oslo-Kristiansand-Stavanger-Bergen	13,800	4.2	0.5	1.2	1	1.5	41%
Oslo-Bergen/Stavanger (Haukeli)	15,100	6	0.9	2.3	0.6	2.2	50%
Oslo Trondheim	5,350	2.28	0.52	0.86	0.3	0.6	45%

Source: VWI (2007a and 2007b), own comparison

It is worth noting from the table that the traffic basis for high-speed rail consists partly of traffic transferred from car, bus and air and partly of newly created traffic. In other words considerable substitution possibilities have been assumed, meaning that VWI appears to have used a relatively wide market delimitation which includes high-speed rail in the same market as air, car and bus.

Even so the market share is limited to about 30-50 per cent. VWI's reports do not indicate whether this is due to high-speed rail having its competitive ability limited by high generalised transport costs or whether traffic outside the relevant market has been included in the total market. As mentioned above, VWI2 for example assumes that air passengers transiting to destinations other than end points of the corridor are not in the same relevant market as high-speed rail. One could however consider that this traffic has been included when calculating market share. It might also be thought that VWI has used as a basis the lower limit for market share as it appears in figure 5-2 in VWI3 (repeated in table 3.2 above).

3.5 Urbanet Analyse

The other important source of market analysis on the potential for high-speed trains is the two reports from Urbanet Analyse, report number 09/2008 (hereinafter UA1) and 12/2009 (hereinafter UA2). The mandate for UA1 is to give a supplementary analysis based on the results of VWI. The analyses were to be based on a Norwegian transport model, NTM5, which has been used in many previous reports on long-distance travel in Norway.

The following tasks are specified for UA1

- Comparison with the results of VWI's analysis
- Investigate the market for intermediate stops
- Uncertainty and sensitivity analyses
- Suitability of the test model

The mandate for UA2 was to carry out a questionnaire-based survey among travellers by air in order to study preferences and travel behaviour in more detail, and to assess effects that are basically not handled in NTM5.

In its reports, Urbanet Analyse has not made any distinction between hypotheses, analysis model and results. Since part of the mandate was to test NTM5's "suitability", it would have been advantageous if more general hypotheses had been given for analysing the traffic basis for high-speed rail. This would give a clearer framework for justifying the relevance of using NTM to analyse the market for high-speed rail and the robustness of the results arrived at. The report underlines the uncertainty that has been raised about the analysis in relation to other studies that have used NTM.

3.5.1 Relevant market

What the UA1 analysis has in common with VWI is that it does not explicitly define what the relevant market for high-speed rail is. We understand that the procedure has been to include high-speed rail as a new transport possibility in NTM5 in certain corridors and where there are assumptions about ticket price and travelling time that are decisive in respect of which means of transport the traveller will choose. In other words it might appear that the market definition is thus determined through the choice of the model's parameters.

In UA1 the following table is presented that implicitly indicates the market delimitation.

Table 3.3: Modelled changes in travel volumes and market shares with the introduction of high-speed rail for travel between end points defined as Oslo and Bergen with hinterland. Journeys per day one way

Table 4-2 Modelled changes in travel volumes and market shares with the introduction of High-speed rail, for journeys between end point markets defined in Oslo and Bergen with hinterland. Journeys per day one way

Stopping pattern		OB1	OB2	OB3
Air	1,281	1,226	1,228	1,229
Bus	180	170	170	170
Car	956	924	925	926
Train	767	1,884	1,808	1,771
Total	3,184	4,204	4,131	4,096
Changes in journeys/day				
Air		-4%	-4%	-4%
Bus		-6%	-5%	-5%
Car		-3%	-3%	-3%
Train		146%	136%	131%
Total		32%	30%	29%
Market share/change in market share (% point)				
Air	40%	-11%	-11%	-10%
Bus	6%	-2%	-2%	-1%
Car	30%	-8%	-8%	-7%
Train	24%	+21%	+20%	+19%

Source: Urbanet Analyse (2008), table 4-2

The table shows traffic volumes between Oslo and Bergen (with hinterland) as end points, with and without high-speed rail. Alternative 1 (OB1) is a pure express connection between Lysaker and Bergen, while alternative 3 (OB3) includes a total of 6 stops between Oslo Central and Bergen. The figures in the first column show traffic without the high-speed alternative.

What is interesting about the table is that the number of journeys by air, bus and car are for all practical purposes the same in all four alternatives. In other words there appear to be very limited possibilities of substitution between high-speed rail and other forms of transport. In practice this means that rail represents an entirely separate relevant market. It would have strengthened the report considerably if this result had been explained.

UA2 studies the effect of changing one key assumption in the calculations, namely time values for travellers. UA1 assumes that time values are the same for high-speed rail passengers and travellers by ordinary train. In report 2, Urbanet Analyse has calculated the distribution between travellers by air and high-speed rail based on estimated time values for high-speed train from a survey of the preferences of air passengers. This new data basis is interesting because it gives a direct review of the area of competition between high-speed rail and air, based on a specific survey of the travellers in this market segment. Urbanet Analyse finds considerably higher time values for high-speed train compared with ordinary train. The re-estimated time values are about 10 - 20 per cent higher for high-speed rail than for air.

The updated report presents the following results for the percentages by **high-speed train/air**:

- **95 %/5 %** based on the assumptions for own time values for travellers by high-speed train.
- **75 %/25 %** based on the assumed time values for travellers by high-speed train, but corrected for a so-called rail factor, i.e. that the survey indicates that passengers have an independent preference for train beyond that indicated by differences in travelling time and ticket prices.

Figure 3.3: Prognoses for market share for high-speed train at different levels of what is offered by rail. Share of rail/air/market

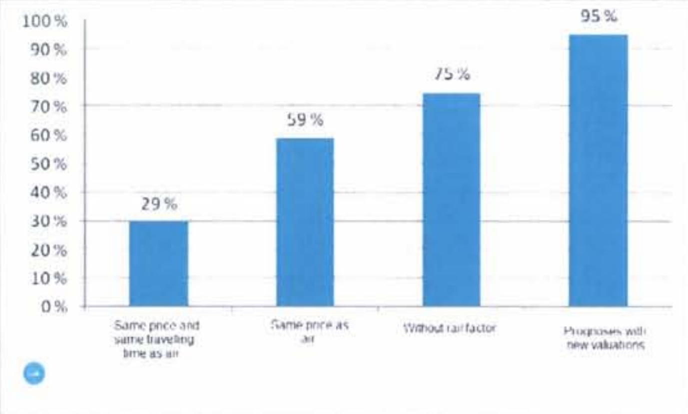


Figure S.2. Prognoses for market share for high-speed train with different levels of what train offers. Share of rail/air market. Source: Market Survey Gardermoen 2008

Source: Urbanet Analyse (2009), figure S.2

The results of UA2 indicate that when the newly estimate time values are used as a basis, then high-speed rail and air are clearly in the same relevant market. As we understand it however, UA2 has only looked at the end point market and not at all transport in the various corridors. Car and bus transport have also been ignored.

It would obviously have been of interest if Urbanet Analyse had qualitatively discussed whether using updated time values is more relevant than using time values for high-speed rail and traditional rail, as was done in UA1. Such a discussion could have been used based on an explicit delimitation of the relevant market, i.e. based on what consumers think about air and high-speed rail being substitutable.

3.5.2 Model framework

Urbanet Analyse's analyses are based on the NTM5 model, which is conceptually different from VWI's model. The model describes the demand for transport services for a given network of transport options. The demand functions are estimated on the basis of data from the travel behaviour survey Reisevaneundersøkelsen 97/98 and describe the relationship between the extent of journeys as a whole - divided into different relationships or different means of transport - and drivers such as travel time, ticket cost, frequency, the travellers' income, size of population and business in various zones etc.

In UA1, Urbanet Analyse states that the normal use of NTM5 involves extra uncertainty regarding the results, since they have introduced a type of train that did not exist when the model's parameters were estimated. This report takes as a basis equal ticket prices and time values for high-speed trains and other trains. New model calculations are made in UA2, based on estimating separate time values for travellers by high-speed train, on the basis of a questionnaire-based survey of air passengers.

3.5.3 Model assumptions

UA2 explains many of the key assumptions, so that it is possible for the reader to gain an impression of the area of competition between high-speed rail and air. Generally speaking, high-speed rail will cut travelling times by about a third compared with air. The exception is Oslo-Stavanger where the travelling times for high-speed rail and air would be the same.

The tables below give a summary of the assumptions made in UA2.

Table 3.4: Travelling times and prices, price relationship rail/air and travel relationship train/air - today

Table 4.1: Travelling times and prices, price relationship rail/air and travelling times relationship rail/air - today

	Oslo-Trondheim	Oslo-Bergen	Oslo-Kristiansand	Oslo-Stavanger
Travelling time by train today - door to door	8.14	8.52	6.11	8.56
Travelling time by air today - door to door	4.40	4.34	4.18	4.25
Difference in travelling time - door to door rail-air	04.18	04.54	03.38	06.52
Travelling time rail/air - today	1.9	2.1	1.6	2.3
Price rail today NOK	837	760	619	871
Price air today NOK	1.194	1.008	1.390	1.260
Price relationship rail/air today	0.7	0.75	0.45	0.69
Cost of travel to/from airport NOK	327	302	376	347

Source: Urbanet Analyse (2009), table 4.1

Table 3.5: Travelling times and prices, price relationship rail/air and travel relationship train/air - new and old

Table 4.2: Travelling times and prices, price relationship rail/air and travelling times relationship rail/air - new

	Oslo-Trondheim	Oslo-Bergen	Oslo-Kristiansand	Oslo-Stavanger
New travelling time high-speed train	150 min	135 min	130 min	200 min
Feeder time (from survey)	44 min	39 min	45 min	70 min
Total travelling time door to door with new train concept/high-speed train	194 min	174 min	175 min	270 min
Reduction in travelling time train	-240 min	-295 min	-150 min	-295 min
% change in travelling time by train	59	63	46	52
Travelling time rail/air - new train service/today's train service	0.69	0.64	0.68	1.02
Time between departures, train today, average	240 min	300 min	240 min	300 min
New time between departures, train	80 min	80 min	80 min	80 min
Improvement in per cent	67	73	67	73
Time between departures, air today	45 min	45 min	120 min	45 min
Difference time between departures rail and air today	195 min	255 min	120 min	255 min
Difference time between departures with new train concept	35	35	-40	35

Source: Urbanet Analyse (2009), table 4.2

The UA2 report makes different assumptions about ticket prices. Basically, the same ticket price is assumed for traditional rail and high-speed rail, but sensitivity calculations have been made to test the competitiveness of high-speed rail with ticket prices corresponding to those for air travel.

In UA1, travelling times and ticket prices have not been documented in the same way. On the other hand, this report shows assumptions regarding demographics, income trends, navigability of the road network and size of air option, but without explaining how the various assumptions affect demand for high-speed rail.

3.5.4 Results

An important part of the mandate for UA1 is to compare the results given by VWI with calculations from the NTM5 model.

Section 7 of UA1 concludes that "...without studying VWI's results in detail, we choose to conclude that the two analyses are on approximately similar lines...". The conclusion is based on the figure below.

Table 3.6: Comparison of the level of modelled number of passengers in the corridors in the prognosis year 2020 (boardings per day, without major road measures in NTM5)

Table 7-2 Comparison of level of modelled number of rail passengers in the corridors in prognosis year 2020 (boardings per day, without major road measures in NTM5)

Route	VWI	NTM5
Oslo-Bergen	6,150	6,200
Oslo-Kristiansand-Stavanger	7,700	6,450
Oslo-Trondheim	5,350	4,750

Source: Urbanet Analyse (2008), table 7-2

VWI and Urbanet Analyse (NTM5 in the table) have arrived at about the same traffic basis for high-speed rail, based on very different assumptions. We have seen above that in UA1 the traffic basis is overwhelmingly based on newly created traffic, while VWI's results show considerable transfer of travellers from air and car/bus. In our assessment the results are consequently much more diverse than the traffic figures in themselves indicate.

UA2 presents completely new estimates for market share for high-speed rail. The results are however only shown as the share of the rail/air market. In UA1, this share is at around 50-60 per cent. In UA2, with the exception of the time values for travellers by high-speed rail with otherwise similar assumptions, this increases to 75-90 per cent.

UA1 also presents the comparison table below.

Table 3.7: Modelled market share with and without high-speed train (2020 without major road measures in NTM5).

Table 7-3 Modelled market share with and without high-speed train (2020 without major road measures in NTM5)

VWI	Rail	Air	Car/Bus	Rail	Air	Car/Bus
	2005 (%) without high-speed			*2020 (%) with high-speed*		
Oslo-Bergen	16	61	23	54	37	9
Oslo-Stavanger	7	68	25	32	57	11
Oslo-Kristiansand	13	24	63	48	17	35
Oslo-Trondheim	16	45	39	51	28	21
NTM5	Rail	Air	Car/Bus	Rail	Air	Car/Bus
	2006 (%) without high-speed			*2020 (%) with high-speed*		
Oslo-Bergen	24	48	28	45	31	24
Oslo-Stavanger	14	50	36	31	37	32
Oslo-Kristiansand	22	28	50	32	21	47
Oslo-Trondheim	18	40	42	33	29	38

Source: Urbanet Analyse (2008), table 7-3

There are other interesting points to note from this table. Firstly the market shares in the basis year are very different. For train, the difference is up to 10 percentage points for all connections except Oslo-Trondheim. This may be due to two things. It may be a reflection of different market definitions. Since the shares in VWI are consistently higher for air, one might surmise that the total market in the VWI report is more weighted towards long journeys. Another explanation could simply be the differences in the data basis for passenger traffic. Whatever the reason, the differences in the basis year mean that it is difficult to compare VWI and UA1.

Another point is that VWI consistently reports a greater increase in market share for train if high-speed lines are built. While the market shares in the basis year are consistently low for trains in the VWI report, they are, with the exception of the Oslo-Stavanger route, 10 to 15 percentage points higher than the market shares in the UA1 project alternative. In other words VWI decides that high-speed rail increases the market share of rail by 20 to 25 percentage points more than UA1. Again, a possible explanation is that VWI has a narrower market definition than UA1.

It would have been very interesting if Urbanet Analyse had given a more detailed explanation of the large differences between the results in the UA1 and VWI reports. It would have been especially useful if statistics had been presented to show the traffic basis with various market definitions.

No corresponding comparisons have been made with the results from VWI and UA2.

3.6 Norsk Bane

DB International GmbH was commissioned by Norsk Bane AS to carry out a market analysis so as to prepare a new railway and traffic concept for South and Central Norway. In comparison with the reports from Urbanet Analyse and VWI, the analyses from Norsk Bane have been documented in a relatively limited way. For this reason our review of the results will be more summary than with the other two reports.

Norsk Bane has not formulated any explicit hypotheses for the area of competition between high-speed rail and other forms of transport.

Furthermore, Norsk Bane has used its own analysis model that is based on various sources of data, including Statistics Norway and the National Transport Plan, and has come up with conclusions in the form of prognoses of train traffic. The report from Norsk Bane also brings in goods transport in addition to passenger transport.

3.6.1 Relevant market

The expression relevant market is not used in the report from Norsk Bane, but since they conclude that new train lines or train offers take market share from all the other forms of transport, it indicates that their definition has high-speed rail included in the same relevant market as all other means of transport.

Norsk Bane also delimits the relevant market in terms of location of the stretches of track. They write in their report *"A new Norwegian railway and transport system must on the one hand orientate itself in accordance with the strong traffic flows between the largest towns and cities. On the other hand, it must serve as much of the rest of the country as possible"*. As they assess things, the most plausible corridors (for both passenger and goods transport) are:

- Oslo - Trondheim
- Oslo - Bergen/Haugesund/Stavanger
- Oslo - Kristiansand - Stavanger
- Oslo - Halden (- Gøteborg)

Norsk Bane appears to assume that all traffic in the corridors mentioned is included in the relevant market. Thus Norsk Bane has a much wider market delimitation than Urbanet Analyse or VWI. Perhaps the most important difference is that Norsk Bane includes relatively high traffic on the partial sections within each corridor. Since the report does not use the expression relevant market, and since it has not formulated hypotheses for competition in the transport market, Norsk Bane has not presented any argument why a broad market delimitation is plausible.

3.6.2 Model framework

DB International GmbH/Norsk Bane has developed its own model for estimating the effects of changes in rail options. The prognosis model for passenger transport has the following stages of calculation:

- Journey production
- Journey distribution by start and finish
- Calculation of distribution of means of transport
- Summing up of results for different sections of route

The model's relationships are estimated or quantified on the basis of relationship matrices for all travel purposes. The relationship matrices are compared with calculated generalised transport costs and together this gives the functions that describe the distribution of means of transport. With the aid of the generalised costs and projections of socioeconomic factors, the model calculates the effects of different development alternatives for the various forms of transport. Newly created traffic (induced traffic) is considered as an independent module in the model.

As we understand it, Norsk Bane's market model is no different in principle from the models used by Urbanet Analyse and VWI.

Norsk Bane also has projections for goods transport. Goods transport does not use the same model as passenger transport. This part of the report begins by deducing the existing rail transport and the rail transport that can be transferred to new lines. It also assumes that only transport that can be carried in combination traffic is relevant. The prognosis for goods transport is calculated by taking as a basis the amount of combined transport for the railways in 2007. This is multiplied by a factor of 1.58 and gives the estimate volume of goods for 2025. The factor comes from the assumed growth in GDP and average population growth.

3.6.3 Data basis

Norsk Bane makes a great deal of use of publicly available statistics as a data basis for its traffic prognoses. Population projections, employment trends and commuter flows are obtained from Statistics Norway. They have also used data from the national survey of travel behaviour. Some of the data for air traffic has been obtained from Avinor and the Norwegian National Rail Administration's strategic document has been used for goods transport.

3.6.4 Results

Table 3.8: Estimate for passenger transport in 2025

		Mill. Pass. km/day			
Lines/combinations of lines	Pass./day with instance	With instance	Moved from		Newly created
			Air	Car/bus	
Oslo-Bergen-Haugesund-Stavanger	46,300	13.3	3.2	6.2	3.0
Oslo-Trondheim	21,500	8.5	1.7	2.5	2.7
Oslo-Bergen-Haugesund-Stavanger (point to point)	19,500				
Oslo-Trondheim (point to point)	8,800				

Source: Deutsche Bahn (2009)

The table above shows Norsk Bane's estimate for passenger transport in 2025. Norsk Bane uses annual figures in its report, but to enable easier comparison with e.g. VWI's market analysis, we have chosen to present the figures in millions of passenger kilometres per day. For the Oslo-Trondheim route they have estimated 21,500 passengers, 8,800 of whom are point to point travellers. In comparison, VWI have estimated 5,350 point to point travellers on the same route, meaning that Norsk Bane's estimates are somewhat higher. As a consequence of this, the transport work (measured in passenger kilometres) per day used in Norsk Bane's analysis is much higher than VWI's. For Oslo - Bergen/Haugesund/Stavanger, the number of passengers a day is estimated as 46,300, with 19,500 of these being point to point travellers.

Norsk Bane's figures for transferred and newly created traffic are very high in comparison with those VWI and Urbanet Analyse have arrived at. For the line between Oslo and Trondheim, they estimate that 1.7 and 2.5 million passenger kilometres per day respectively will be transferred from air and from car/bus to rail in 2025. Newly created traffic is 3 million passenger kilometres per day. The figures are correspondingly high for the route between Oslo and Bergen/Haugesund/Stavanger.

Norsk Bane only presents the number of travellers for selected routes. Also, they give no overview of what the market shares for the different forms of transport will be in 2025.

Table 3.9: Quantity of goods in 2025

	Mill. tonne km/day		
Lines/combinations of lines	With instance	Moved from	
		Existing rail traffic	Road
Oslo-Bergen/Haugesund/Stavanger	11.5	5.5	6.0
Oslo-Trondheim	10.1	6.9	3.3

Source: Deutsche Bahn (2009)

For goods transport, Norsk Bane estimates that the transport work (measured in million tonne kilometres per day) that will be done on the line between Oslo and Trondheim will be 10.1 million tonne kilometres per day. The corresponding figure for Oslo - Bergen/Haugesund/Stavanger is 11.5 million tonne kilometres per day.

3.7 Market shares and market delimitation

In this section we have a brief assessment of some of the key factors in the market analysis.

3.7.1 Delimitation of the market for high-speed rail lines in Norway

In the introduction to this report we outlined four alternatives:

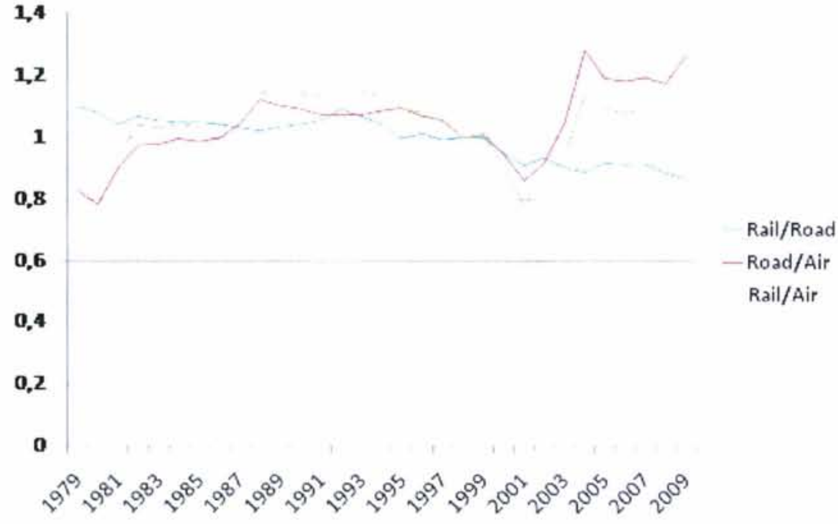
- **High-speed rail represents a separate relevant market.** UA1 appears to be based on a narrow market delimitation.
- **End to end transport between larger Norwegian towns and cities.** UA2 is based on this market definition.
- **All transport in a corridor between larger towns and cities.** VWI appears to use a definition that includes parts of the traffic in the whole corridor.
- **All transport is included in the same relevant market.** None of the reports uses such a wide market delimitation.

In our opinion neither of the two extremes is particularly plausible. An important reason for this is that transport is a derivative service and not directly useful in itself. As long as one transport alternative can produce the same service at a comparable price and quality to other transport alternatives, the various forms of transport must be included in the same relevant market. There are thus no a priori grounds for expecting high-speed rail to represent a completely separate relevant market. On the other hand, there is reasonable broad acceptance that there is a clear distribution of labour between different forms of transport. There are clear differences for example in the average length of journey by car, train and air. This draws us in the direction that the relevant market in which high-speed rail is included must be somewhere between the two extremes.

It may be interesting to make a quick assessment of whether car, rail and air currently represent a common relevant market or separate ones. A simple method is to look at whether the relative prices are stationary or not. If the relative prices of two products are stationary, that is to say that the price relationship remains constant over time, this is an indication that they represent a common relevant market. If prices are stationary in this way, this is often taken as an indication that the price trend for a product means a limitation on the price trend of the other product. Such a limitation may indicate that there are good substitution possibilities and competition between the two products.

In the figure below we have used data from the consumer price index in order to plot the price relationship between road, rail and air transport.

Figure 3.4: Price relationship between road, rail and air transport; data from the consumer price index 1979-2009



Source: Statistics Norway

The figure shows that the relative prices have varied a good deal over the course of time. There is however no clear sign that the prices converge or that they develop completely independently of each other. Over the course of the period, prices for rail have been reduced in comparison with road, while prices for road have risen in comparison with air. Both cases indicate that no stationarity exists. The price relationship between rail and air has changed less over the course of the period. A simple statistical test for stationarity (augmented Dickey-Fuller test) shows that it is rail/air that is the candidate that is closest to representing a common relevant market, while rail/road apparently represent separate markets.

This exercise indicates that a reasonable definition of the relevant market for high-speed rail should include limited segments of the transport market and that rail transport as such is closer to air than to road. This may indicate that travel over a certain distance in one corridor should be included in the same relevant market and that merely looking at the end point journeys between larger towns and cities in Norway is too narrow.

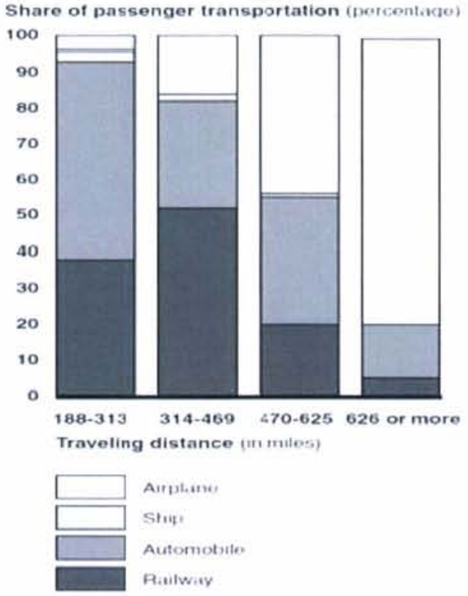
In practice perhaps the most important question is whether today's Intercity traffic and regional trains should be considered to be in the same market as high-speed trains. Today's Intercity traffic is characterised by having considerably more stops than is usual for high-speed rail. If high-speed rail is to be fully or partly substitutable with Intercity traffic, one must therefore imagine a feeder system to a limited number of regional hubs. It is also a prerequisite that high-speed rail will be competitive in terms of ticket price, combined travelling time and quality generally. In this case, market delimitation would become more a question of technical and operational factors than of travellers' preferences.

3.7.2 Market shares in VWI and UA1 do not tally with international experience

Both the VWI and the UA1 reports present market shares for air that are relatively high, which is not consistent with the observed and comparable competition situation between high-speed rail and air in other parts of the world. Here the ticket prices for high-speed rail have been set at a level that has ousted air travel to a great extent. In comparable cases, with regard to travelling time and market potential, it has been observed that the railway's market share tends to be at the upper level of VWI's figure 5-2 in VWI3.

An example of this is shown in the figure below. This is taken from GAO (2009) and shows market shares for various means of transport in Japan.

Figure 3.5: Market shares for various means of transport in Japan by transport length



Source: GAO presentation of Japanese Ministry of Land, Infrastructure, Transport and Tourism data

Source: GAO (2009), figure 3

The figure shows that for distances between 188 and 313 miles (300 to 500 km), which corresponds to a travelling time of between 1.5 and 3 hours at speeds around 200 kph, the market share for air will fall to below 5 per cent. As a rule of thumb, high-speed train is quicker than air for distances shorter than 500 km. In spite of this, VWI and UA1 find that the market share for air will be between 17 and 57 per cent.

There are many examples that show that high-speed rail can be implemented in such a way as to reduce the use of short flights:

- The high-speed rail line between Madrid and Seville radically changed the market share for air. The market share for air fell to 13 per cent in just 3 years. The distance between Madrid and Seville is 536 km, with a travelling time of about 2.5 hours, which makes it comparable with a high-speed rail line between Oslo and Bergen. Because of the almost identical travelling time and comparable market potential, Madrid-Seville is probably the most relevant example of market potential for high-speed rail in Norway.

- After 3 years, the high-speed rail line between Paris and Lyon (425 km and a travelling time of about 1.5 hours) had reduced the market share for air to 7 per cent. After ten years, the market share for air had been reduced to 3 per cent. Today, air has only a couple of per cent of the traffic between Lyon and Paris.

- After 6 years, the high-speed rail line between Paris and Brussels (264 km and a travelling time of 1 hour 22 minutes) has reduced the market share for air to 2 per cent.

We can also find exceptions to the above rule of thumb. For example the high-speed rail line between Paris and Marseilles (670 km and a travelling time of 3 hours 15 minutes), where the market share for air has only fallen to 30 per cent. This reduction in market share is still relatively large even though the reduction is on the wane. A significant proportion of the remaining air traffic comes from international transit flights from Paris to Marseilles, which is the port of entry to the Côte d'Azur and southern France generally. The relatively long travelling time, combined with a high percentage of international passengers, makes this example less comparable with the studies carried out in Norway.

We think there is reason to believe that high-speed rail travel in Norway could achieve a considerable market share in relation to air travel, as the examples from Japan, Spain, France and Belgium illustrate. We recommend that the cases above should be examined more closely in new analyses and that there should be benchmarking with regard to the effect of the introduction of high-speed rail on air traffic in comparable cases.

3.7.3 Good prevailing conditions for high-speed rail in Norway

There are other grounds to indicate that the market shares that appear in the VWI and UA reports may be too low. The prevailing conditions for introducing high-speed rail in the most important corridors in Norway could be very good for the following four reasons (which we feel have not be adequately considered in the existing studies):

1 The distances on the lines are in the area - less than 500 kilometres - where high-speed rail can compete with air. In this way high-speed rail can offer shorter door to door travelling times than air. It can also create a more effective journey from city centre to city centre, which are the principle places of origin and destination.

2 Domestic air traffic between the cities in question is exceptionally high and therefore gives great market potential if high-speed rail can compete on travelling times, price and comfort. This situation has been the case for all the examples mentioned above with distances of less than 500 km.

3 Time values in Norway are very high, especially within the market segment in question, so that the market will be strongly influenced by any reductions in travelling time offered by high-speed rail.

3.8 Summary

The reports from VWI, Urbanet Analyse and Norsk Bane contain so few similarities that it would be difficult to speak about a consensus regarding the traffic basis for high-speed rail. There are consequently great differences in the suggestions regarding the market basis for high-speed rail lines and the results are difficult to compare.

The most important differences between the reports is their assumptions about what the relevant market for high-speed rail lines should be.

- Norsk Bane uses a very broad market definition, first and foremost that the market for traffic in parts of the corridors is considered to be substantial.

- UA1 uses a narrow market definition in comparison, but this is later extended somewhat in UA2.

- VWI uses a market definition that is not unlike UA2.

Neither is there any consensus on what the foreseeable market shares are. It is difficult to compare the results of the different reports, since some of the differences in market share can doubtless be due to the differences in market definition. However it appears that

- Norsk Bane is the most optimistic with regard to possible market share, although the UA2 report also finds grounds for estimating a high market share.

- The market shares arrived at by VWI and UA1 are seemingly relatively low, not least when considered against international experience.

COWI's review of the status of knowledge on high-speed rail lines in Norway stresses the significance of defining the relevant market. When different reports are based on different market definitions, the results will necessarily be difficult to compare and it is difficult to consider whether some results may be more reasonable than others. None of the reports gives any fundamental grounds for its market definition or provides any documentary evidence of the assumptions that have actually been made.

4 Technical parameters

4.1 Assessment of scenarios and respective fare levels

VWI assesses a form of operation (departure frequency and travel time) for each corridor, in other words a scenario for each corridor. Urbanet Analyse investigates what effect various patterns of stops have on traffic. Urbanet Analyse mentions some fares for travel by high-speed rail, but they are neither documented nor compared with competing means of transport.

The scenario proposed by VWI, and also studied by Urbanet Analyse, is described like this:

- *The lines Oslo-Trondheim and Oslo-Gøteborg should be served with a connection every hour in peak times and every two hours out of peak times*
- *Maximum speed is set to 250 kph, parts of the lines will be served with 200 kph. This maximum speed allows competitive travel times to the plane in these relations and reduces energy consumption as well as investment and operation costs for the trains*
- *The lines will be built as double track lines in the greater Oslo area and as single track line outside this area*

(VWI (2006b), page 110)

VWI gives no grounds for the conclusions above. The conclusions are not based on a traffic study so it is therefore difficult to say anything about how VWI determines departure frequency or the speeds of the trains. To be able to decide on the optimum scenario, levels of speed, departure frequency and fares should be analysed in a traffic model.

VWI proposes a pattern of stops that is based on a study of the relevant geographical market area. We propose that the traffic generated by the various patterns of stops should also be analysed in the traffic model.

4.2 Assessment of the required number of train units and capacity

4.2.1 Number of train units

In planning high-speed trains for Norway, VWI proposes trains that correspond to ICE 3 six-carriage trains (one unit) produced by Deutsche Bahn AG. This train unit has a total capacity of 340 passengers.

If we use the traffic prognosis of 12,777 passengers a day for the Oslo-Bergen route (as VWI has estimated), we can determine that the number of trains required by the route would be 32 trains a day (one train an hour in each direction with an average operational day of 16 hours) of the ICE 3 type, each made up of two units and having a capacity of 680 passengers. This presupposes that 60 per cent of capacity would be utilised.[3] The number of train units required would thus be 6, taking into account a turnaround time of 6 hours for each train unit and a 1 hour departure frequency.

VWI proposes 10 trains (one unit) to serve 6,150 passengers a day. If we apply the same logic as above, this figure does not tally.

It is however normal for high-speed rail to offer a departure frequency of 30 minutes during rush hours so as to cover demand. If this should be the case in Norway, more train units would be required.

We assume that VWI is tied to a departure frequency of once per hour, since the schedule has little flexibility owing to the proposed single track high-speed rail line.

4.2.2 Schedule and capacity

The report prepared by Funkwerk and Railconsult provides good data with regard to operations, especially for the new infrastructure in Norway.

Even so, there should be a better correlation between operations, traffic prognoses and ticket income. This topic is not taken up in the report. We recommend that a better correlation between operations and optimising of income is achieved, so that actual operations correspond with what the market expects in terms of the number of trains and their capacity.

The customers' expectations should also be taken into account with regard to mixing passenger and goods transport on single track or with high speed, as well as for some corridors with a high proportion of tunnel.

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[3]The average utilisation of capacity for high-speed trains is 70 per cent in France and 50 per cent in Germany (European Environment Agency and SNCF).

4.2.3 Single and double track routes

Funkwelt & Railconsult conclude, as does VWI, that the proposed operation is feasible using single track. The location of crossing points is critical and closely linked with the chosen schedule. Funkwerk and Railconsult have the following comments:

One area we have concern about is Ringeriksbanen. We have been unable to identify a good service pattern on this route which can operate reliably as planned with the proposed crossing points.

It would be possible to arrange this if there were complete flexibility in timing Hønefoss trains between Oslo and Sandvika, but in practice there is not. We recommend that the whole route is considered for double track, with possible single track sections only where operationally acceptable and where the terrain makes double track prohibitively expensive.

(Funkwerk og Railconsult (2008), page 55)

Funkwerk and Railconsult state that for each high-speed corridor they have created a new schedule model that is based on the line speed and location of tunnels and gradients provided by the Norwegian National Rail Administration.

It is however unclear whether the schedule and conclusions in the report allow for all the tunnels (45-86 per cent of the routes) that VWI has proposed, or the bridges that VWI has not included in its assessments. If they do not, it is uncertain whether the proposed single track high-speed rail line is feasible given the intended departure frequency.

VWI proposes single track high-speed rail line. This raises problems, since there is not one single example of single track high-speed rail line anywhere else in the world. The main reason why other countries choose double track high-speed rail line is that with single track it is impossible to adapt services in line with demand (rush hours and low traffic periods), because operations on single track high-speed rail lines are so inflexible. This in turn leads to a loss of passengers and ticket income that is considerably higher than the approximately 15 per cent of construction costs that would be saved by choosing single rather than double track. In addition, single track leads to increased travelling times and higher energy consumption because of the uneven speeds along the track. We recommend that an assessment be made of double track high-speed rail lines in Norway.

4.3 Technical regulations

In phase 0 the VWI reports discuss which design parameters are used as a basis for line routings. This section looks at the requirements for "high-speed" lines that are set by the current technical regulations and what they mean for the routes that have been assessed.

The Storting has asked for rail tracks to be for 250+. This can be interpreted as meaning that design speeds between 200 and 250 kph are applied for Intercity traffic, while "+" is for high-speed. It is not yet certain what the "+" will stand for. With effect from 01.07.2010 the technical regulations also include a routing table for 300 kph. In Sweden, Svenske Banvärket, now Trafikvärket, has decided that their high-speed will be 320 kph.

When the regulations were changed to also include speeds up to 250 kph, the following was changed:

- Curve table extended to 250 kph with normal radius requirement = 4,000 m.
- Ballast thickness increased from 75 to 80 cm.
- Noise screening: distance from track centre to screen increased from 4.0 to 4.4 m.
- Railings on bridges: distance from track centre to railing increased from 3.3 to 3.5 m.
- Platform length for high-speed trains increased from 350 m to 400 m.
- The table for maximum speed in downward gradients was extended (see below).
- Greatest permitted speed in downward gradient: JD530, section 5, point 4.8, table 5.12:

Table 4.1: Maximum speed in downward gradient

Determining fall (maximum) (%)	Permitted speed (kph)
1.25[1)]	250
1.25	200
1.5	180
1.75	160
2	140
2.25	120
2.5	100

Source: Norwegian National Rail Administration (2006b), table 5.12

Higher speeds than those given in the table above may be applied if the signal system and rolling stock permit.

Otherwise, the Norwegian National Rail Administration has a great deal of technical equipment that is not authorised for 250 kph, including the contact conductor system. System 25 is only authorised for 250 kph with a current collector. These are conditions that can be resolved in other countries, so we believe they can also be resolved in Norway.

The difference between design speeds of 200 kph and 250 kph, as regards track geometry, according to the new technical regulations with effect from 01.01.2010, is shown in the table below.

Table 4.2: Differences for track geometry with design speeds of 200 and 250 kph

Limit values in accordance with technical regulations		**200 kph**	**250 kph**		**Comments**
Track separation in open sections	R > 5000	4.40 m	4.40 m	R > 5000	No difference in track geometry
	4000 < R < 5000	4.56 m	4.56 m	4000 < R < 5000	
	1000 < R < 4000	4.60 m	4.60 m	1000 < R < 4000	
Track separation in tunnels		4.50 m	4.70 m		Smallest track separation is increased. Air resistance issues must be considered by other technical areas.
Horizontal radius	Minimum. Normal requirement	2,400 m	4,000 m	Minimum. Normal requirement	Minimum permitted horizontal radius is increased.
Length of transition curve	Minimum. With normal requirements	208 m	262 m	Minimum. With normal requirements	Minimum permitted length of transition curve is increased.
Length of straight lines and circular curves	Minimum	100 m	125 m	Minimum	Minimum permitted element length is increased.
Camber	Maximum	105 mm	90 mm	Maximum	Maximum permitted camber is reduced
Vertical radius	Minimum	15,400 m	24,000 m	Minimum	Minimum permitted vertical radius is increased.
Ballast thickness		750 mm	800 mm		Ballast thickness is increased
Distance to noise screening		4.00 m	4.40 m		Minimum distance to noise screening is increased
Vertical rise/fall	Maximum	12.5 ‰	12.5 ‰	Maximum	Same values

Source: Norwegian National Rail Administration (2006b)

4.4 Technical parameters - line routing

The design parameters that are used as a basis for the VWI report would give a speed level of 200 to 300 kph on new stretches of track. It assumes that the developments currently planned would be built according to the regulations and speed profile prevailing when the report was written. The reports are primarily pre-feasibility studies in which the line routing is relatively undetailed, and thereby with a limited level of ambition. Technical parameters have and will be changed from this level up until implementation. The reports will therefore only give a rough assessment of the possibility of changing technical parameters. A more extensive job must be done in the next planning phase so as to raise the analyses and routings to a feasibility study level.

The VWI report has generally taken as a basis a horizontal radius of 2,600 metres for speeds of 250 kph and a camber of 100 millimetres. Maximum gradient is assessed as 1.25 per cent where geography permits a gentle rise or fall, but can be increased to a maximum of 3 per cent in difficult terrain. The vertical curve of the track is set at 25,000 metres. Tunnels of over 1.5 km are designed to have a parallel service tunnel with connections every 500 metres. Tunnel cross section of 75 m^2 with fixed track. Track is currently laid with ballast.

Norsk Bane's design parameters for its routes with a speed over 250 kph are a curve radius of over 3,000 metres and a gradient of maximum 1.25 per cent. The tunnel under Boknafjorden is an exception. Tunnel cross section is 60 m^2 or for double track tunnel 100 m^2.

Høyhastighetsringen described some design parameters in its report "Den nye Bergensbanen" (The new Bergen line, Høyhastighetsringen) (2009). The speed is 300 kph and the curve radius is 3,400 metres. A smaller curve radius is permitted where there is a pressing need to follow the terrain. The Numedal line is to be built as single track for passenger trains with a crossing point at 18 km.

Below we have attempted to summarise the figures and facts that it is possible to extract from the route maps that accompany the reports.

Table 4.3: Technical data from the route maps

Route	Horizontal curvature	Horizontal curvature Built-up areas	Vertical radius Rv	Route fall/rise ‰	Speed kph	Km new line	Km tot	Time
Hamar - Trondheim	3000 m	2000 m	25,000	12.5 ‰ - 25 ‰	250-300	366	464	2:45
Råde - Kornsjø	*	*	*	‰	200	70	70	2:20
Oslo-Bergen Numedal	2500 m	3500 m	25,000	15 ‰ - 30 ‰	250/300	364	405	2:40
Oslo-Bergen Hallingdal	2000 m	2000 m	*	30 ‰	200-250	338	378	2:25
Oslo-Bergen Haukeli	4000 m	2000 m	*	*	250	370	411	2:20
Porsgrunn - Kristiansand	2500 m	2000 m	*	*	200-300	162	333	2:10
Kristiansand - Stavanger	4000 m	4000 m	*	*	250	194	209	1:00
Stavanger - Bergen	3000 m	3000 m	*	20 ‰	*	221	221	
Technical regulations normal requirements	4000 m		24 000	12.5 ‰	250			
Minimum requirement		2900 m (250 kph)		20 ‰	-			

*No information on route found

4.4.1 Vertical curvature

Technical regulations have provisions for maximum rise/fall as shown below:

Table 4.4: Greatest permitted rise/fall on open line

Table 5.9 Greatest determining rise/fall on open line

	Greatest determining rise/fall (‰)		
	Lines with mixed traffic	Passenger traffic lines	Side tracks
Normal requirement	1.25	2	1.25
Minimum requirement	2[1]	2.5	3

1) Permitted in a length up to 3 km.

Source: Norwegian National Rail Administration (2006b), table 5.9

A simple consideration of the challenges that occur when design parameters limit gradient on the line can be seen from the following. If the line is run from Finse (1,222 metres above sea level) down to Bergen, which is approximately at sea level, the distance as the crow flies is about 120 km and the greatest determining descent will be a gradient of 10.16 per thousand. This means that the total and continuous drop from Finse down to Bergen will present a challenge for the train's brakes.

The nature of the gradient largely determines the choice of route and how much of the line needs to be in tunnels. The regulations state that there can only be 3 km with maximum gradient on tracks that have mixed traffic. The same requirement does not apply to passenger train lines, but section 4.8 of JD 530 gives guidelines for maximum permitted running speeds for trains on descending stretches of track. As well as the indicated speed limit, the running speed also depends on the train's braking system and the determining descent on the section of line the train is running over. The limitations in the technical regulations could lead to a greater proportion of tunnel and also longer tunnels when the routes are planned in more detail in the next phase.

4.4.2 Mixed traffic

VWI is based on mixed traffic from Oslo to Hønefoss/Stange/Porsgrunn/Råde, with new track, and primarily passenger track, onward from these points. There is no tradition of building dedicated passenger train lines in Norway and there will be a great deal of uncertainty regarding such a choice. A choice in which the technical parameters satisfy both goods and passenger traffic is better equipped for any future changes in wishes and requirements. Where dedicated passenger train lines are built, there is usually a separate goods line suitable for conveying goods and with good gradient conditions. Existing lines in Norway currently have poorer gradient conditions than is desirable. When new line is to be built on the Drammen-Bergen, Hamar-Trondheim and Halden-Kornsjø routes, it is reasonable to suppose that there will be consideration of a better route for goods traffic with better gradient conditions. It may be that some parts of the route (for example Kvikne-Støren) are laid as dedicated passenger train lines. Long tunnels are a disadvantage from a safety point of view for both goods and passenger traffic, but experience from other countries can be brought into use here. The VWI report should have had a somewhat better overview of which lines and what type of train traffic are to be allowed. As we read the report, dedicated passenger train traffic has been chosen for all high-speed lines.

4.4.3 The proportion of tunnel

VWI estimates a total length of tunnel for each of the alternatives, but proposing a length of tunnel on the basis of a 1:250,000 map is hardly appropriate, since a difference of just 1 millimetre on the map represents a distance of 250 metres in the actual terrain. The framework for VWI's work indicated an undetailed approach. In critical parts of the terrain a more detailed section of map should have been used, so that the tunnel could be located in more detail and a more precise estimate of tunnel length could have been made.

Given the considerable proportion of tunnel (48-86 per cent of the proposed lines - see VWI's table below), it will be very important to study alternative line routings with fewer tunnels. Tunnels have a negative effect on speed, the environment (during the construction phase), the length of the construction period, costs and passenger safety and comfort. The proposed new infrastructure should therefore be reasessed with a view to finding a line routing that demands fewer tunnels.

Table 4.5: Tunnel proportions of the corridors investigated

Line	Tunnel share [%]
Oslo – Bergen via Hallingdal	45
Oslo – Bergen via Numedal	45
Oslo – Haukeli – Bergen	66
Haukeli – Stavanger	79
Porsgrunn – Kristiansand	48
Kristiansand – Stavanger	55
Stavanger – Bergen	86

Source: VWI (2007b)

Table 4.6: Tunnel proportions of six other projects outside Norway

Line	**Tunnel and viaduct**
Hannover - Würzburg, (1991) 327 km	37 % tunnel Landrücken tunnel (10,779 metres) Mündener tunnel (10,525 metres)
Wuhan-Guangzhou	18% tunnel and 48% viaduct
Seoul-Busan	46% tunnel and 25% viaduct
Taipei-Kaohsiung	18% tunnel and 73% bridges

Taiwan High Speed Rail network	18% tunnel, (48 tunnels) including 7.4 km in Changhua County
Nuremberg–Erfurt high-speed railway	22% tunnel (22 tunnels totalling 41 km) Longest tunnels are the 8.3 km Blessberg and 7.3 km Silberberg tunnels

The length of many of the world's longest bridges is stated from end abutment to end abutment. No information is given about longest span, which will be important when crossing deep fjords in West Norway.

4.5 Summary

- The reports that have been prepared are not in accordance with the present technical rules for speeds over 250 kph. Most lines must be upgraded so that they are in line with the rules. The stretches of line that lie in very meandering valleys will mainly have a higher proportion of tunnel than stretches in wider valleys that have the possibility of increasing curve radius, while at the same time having sufficient straight lines between the transitional curves.

- The vertical aspect presents a challenge, primarily due to stretches, such as Geilo - Bergen, with long ascents and descents, since long descents can put a severe load on the brakes. Stretches with long descents should therefore be specially considered with regard to the feasibility of such a vertical curvature.

- In the existing material, the tunnel parts have not been studied at any detailed level and this should be done.

- The proposal for single track rail lines should also be reconsidered. The costs saved by building single track instead of double track must be balanced against the operational flexibility that is lost and the costs and possible loss of income that this rigid form of operation involves.

- In order to optimise fare levels, travelling times, stopping patterns and departure frequencies, the effects of the level of these variables should be studied in a traffic model.

5 Technical challenges in construction

This section assesses the routes themselves and how they are adapted to the landscape. We consider what challenges are presented by each route and whether there are any obvious possibilities for cost reducing measures or for reducing the consequences for the environment and society. To assess the routes we have used VWI's map material showing the routes, as well as maps that are generally available on the internet. As there is very little information beyond the route descriptions in the background reports themselves, we have mainly looked at the overall choice of route in the landscape with regard to the vertical curve.

It is worth pointing out, as mentioned earlier in the report, that there is a generally held belief that Norway has a particularly difficult topography for building high-speed rail lines. We do not believe this to be correct. Japan, France, Italy, Taiwan and South Korea have all either built or are building high-speed rail lines in similar or more difficult terrain to that found in Norway. This is further developed in our section on costs (section 6).

5.1 Assumptions for choice of route and adaptation to the landscape

One of the main purposes of the VWI study was to find the most realistic corridor to be investigated, so as to form the basis for further and more detailed planning of high-speed rail in Norway. A feasibility study was chosen so as to illustrate the possibilities and the limitations of the various corridors chosen. The studies conclude with a rough calculation of quantities and present fundamental differences between the corridors.

"..The study group sees their task for the study in finding a starting point for High-Speed-Rail in Norway and to show a way to start rather soon. Therefore corridors have to be found where the chance of realisation is the highest and the problems to be solved are the lowest. That does not mean that the corridors which are not chosen to take in the investigation are worse for instance by regarding travel demand, but they either are more expensive to build or there are different alternatives which have to be compared in detail to find the best of these."

(VWI (2006), page 5-1)

In phase 1, VWI considered which corridor was realistically the most feasible. Phase 2 then assessed which route in the corridor was best suited on the basis of a rough assessment of various data.

VWI writes as follows:

"As planning of High-Speed-Rail starts with a feasibility study in a rather big scale, not all non-monetised aspects can be considered. Detailed planning in a later phase has to deal with all aspects in an Environmental Impact Assessment according to the Norwegian Planning and Building Act.

In this study basis of the alignment planning are maps in a scale of 1:250.000, where smaller local environmental important areas can not recognised. The task is more to find the general alignment, choosing the right corridor and the optimal speed. This planning will be optimised – also in the point of view of environmental aspects – during the following phases of planning if there will be a decision to go on with the project. Therefore the actual alignment is not finally fixed and can be moved due to environmental issues."

(VWI (2007a), page 15)

In its report, VWI gives a very rough assessment of corridors and of routes within chosen corridors. For the chosen routes, it is possible to make a rough assessment of quantities and the distribution of tunnel/open stretches/construction. The object is to assess whether it is technically possible to build a high-speed line within the prevailing design criteria, as well as to present the differences between the corridors. Against this background, VWI has carried out a ranking and recommended in phase 2 of the report that Oslo - Trondheim and Oslo - Göteborg should be investigated in more detail.

VWI made its choice of which corridor had the greatest possibilities for positive use on the basis of several factors. Two of the factors are based on constructional feasibility and costs at a very general level. Different degrees of uncertainty are associated with the different corridors. Considerations other than the technical aspects of construction, which would arise during changes in assumptions in the course of more detailed planning, could give different results and priorities for the final location of the route within the corridor.

The assumptions given in the operational and market assessments give powerful guidelines as to where the line of the route is drawn. We would point out in this context assumptions such as the whole line being constructed as one development, no goods traffic on the line, single track, combined use with Intercity traffic etc.

5.2 Line routing

The VWI reports briefly discuss alternative routes. The routes have been assessed at a general level, which will necessitate detailing the routes in a wider perspective in later planning stages. By comparison, the operations and maintenance depot for train units has been described in great detail. As VWI says, the purpose is to give a recommendation of which corridor should be carried to the next stage. VWI presents sufficient information to estimate an overall cost level, reveal the most significant challenges and consequences and assess the technical feasibility of the different corridors. Even so, we believe that later planning stages should include a new assessment of which corridor and route should be chosen in the stretches that are being investigated, since the present route assessments have been at a very general level.

In phase 3 VWI describes in its conclusions that no ranking of the corridors has been made. The Oslo - Trondheim, Oslo - Bergen (Geilo) and Oslo - Stavanger corridors give relatively equal results. Oslo - Göteborg and Oslo - Trondheim have positive benefit. There is relatively great uncertainty about some of the corridors and more investigation is needed before one can be certain about the scope and feasibility. This applies especially to the line in West Norway and the proposed fjord crossings. Further investigations should focus on the areas of greatest uncertainty to see whether there are any negative or positive conditions and then assess the scope of these conditions and whether it is possible to build the route. This has been done to some extent in Metier's report, but some of the conditions must be gone into in more detail to show the extent of the uncertainty and costs more precisely.

5.2.1 General aspects of line routing in the various corridors

The maps shown in VWI's reports are of such a small scale that it is difficult to assess the need for constructions or the extent of filling and cutting. Such assessment requires a better presentation of map materials, perhaps even a separate volume of drawings. Some sections are shown with more detailed maps, but on the whole the difficult parts and areas are not described in the report.

It would appear that the routes mainly lie in the terrain of valley floors, with tunnels between the valleys. We cannot see that an assessment has been made of viaducts or bridges to cross valleys with the line located at high level. In one place there is consideration of keeping the route high in Numedalen, but it has been taken down to Geilo and then up to Ustaoset again. An assessment should be made of whether it is possible to locate the route high in the terrain and cross the valleys on high bridges or in the mountainside so as to maintain the height and thereby avoid great variations in the vertical curvature. A consequence of this could be that the route is more visible in the terrain.

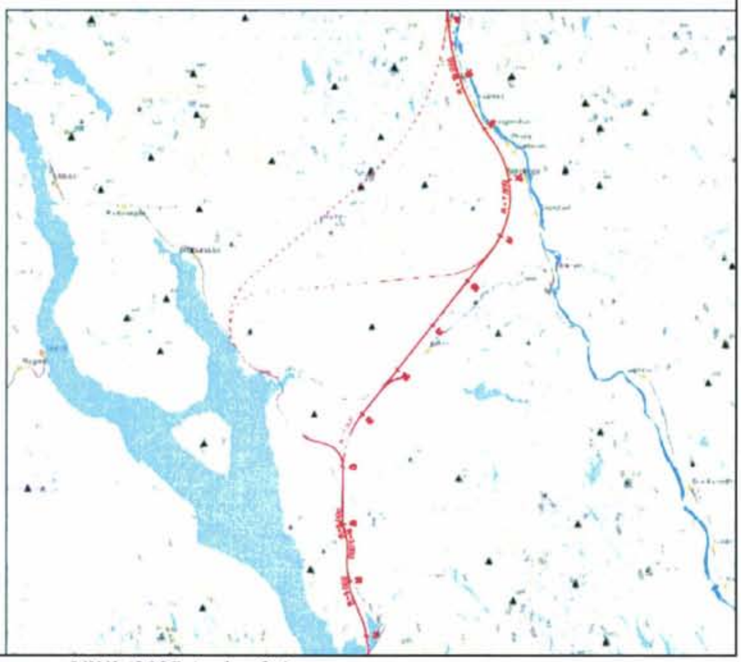
Geological challenges presented by the Moss-Halden and Minnesund-Heimdal stretches have been assessed in a report from NGI (Olsson and Morgan, 2007). NGI also contributed to the assessment of the costs of the proposed routes in the work done in Metier's report on costs. Geotechnical and constructional aspects are also discussed in the SINTEF/NGI report for the Oslo Trondheim/Halden routes. We cannot find any corresponding investigations of the other routes.

The text below gives a simple assessment of the various routes, to evaluate possible cost reductions, point out various areas of conflict and look at alternative routes that might provide input for later planning phases. All routes have been assessed on the basis of what is described and shown in the VWI phase 2 and 3 reports.

Sørli - Trondheim
The route branches off from the existing line at Sørli, descends into agricultural landscape and crosses under/over the E6 in cuttings across the agricultural areas at Stange in the direction of Løten. The route appears to keep to the elevation around Løten before entering the Østerdalen valley. A new station at Stange will be in the vicinity of the E6, thereby offering good accessibility to/from the motorway. The location of the new Stange station will be between the new Tangen station and Hamar station.

Figure 5.1: Routes between Tangen and Østerdalen with alternatives through central Hamar

Plan 3-1: Ground plan Oslo – Trondheim Part 1



Source: VWI (2007a), plan 3-1

VWI has not assessed the costs of developing new double track over Sørli - Lillehammer, since this is not proposed as a new route for high-speed rail. An assessment should be made of whether a new high-speed line should follow the new double track up to Lillehammer. New track could also be considered just east of Hamar where it goes beside the E6 and on up to Lillehammer. In the VWI report, other solutions are looked at that keep the present station. The development of new high-speed track Oslo - Trondheim should be viewed together with the Intercity strategy to Lillehammer. VWI has recommended not following Gudbrandsdalen with new high-speed track. To get over to

Gudbrandsdalen with high-speed track, a new tunnel must be built from Lillehammer to Koppang that would be around 55 km (across Åstdalen) before going on up to Østerdalen.

The route follows Østerdalen along the Glåma and the present line before climbing up the western side of Østerdalen and going over to Kvikne. It appears that the route VWI proposes is representative for the Koppang - Heimdal section. A couple of large bridges/embankments may be necessary where the line crosses the main valley or side valleys. An example is at Alvdal where the valley opens up and flattens out, while new track must maintain elevation in the terrain so as to climb up towards Kvikne. The VWI route appears to be the shortest and it has the least tunnel/constructions which means there is a strong possibility it is also the cheapest alternative. We must assume that there will be some more short and medium length culverts/tunnels in places, as well as by buildings. The most recent experience of this area is from the section beside lake Mjøsa. Here the County Governor has chosen to increase the proportion of tunnel so as to lessen the level of conflict. The route is only shown to Heimdal. The route onward to Trondheim should also be described in more detail.

An alternative to the route via Kvikne could be Rendalen-Hessdalen-Tolga-Selbu-Stjørdal-Trondheim. This route however be somewhat longer and probably more expensive. On the other hand this route may have minor conflicts with existing rail, road and building, and there could be more major conflicts with the natural surroundings in Tydal and Selbu.

VWI considers that it would be possible to establish a railway with a 1.25 per cent gradient between Oslo and Trondheim, with the exception of a stretch of about 70 km between Kvikne and Støren. Here the gradient would be 2.5 per cent. In this case consideration should be given to whether a route can be found that either alone or in combination with existing track can carry goods between Oslo and Trondheim with a maximum gradient of 1.25 per cent.

VWI follows the most obvious route for a new track between Oslo (Sørli) and Trondheim (Heimdal). The conflict level is judged to be highest at Løten (agriculture), in and near built-up areas (Koppang, Rena), the rail route via Kvikne where there is not currently any railway (wildlife/nature) and on the Støren - Heimdal stretch where the valley is narrow and has much other infrastructure.

Oslo - Göteborg

The chosen route mainly follows glacial deposits through Østfold that are described as moraine and which traditionally provide a good foundation for building, but the route also traverses agriculture and cultural heritage sites, of which there are many along the moraine in Østfold. The route goes via Solli, on to Sarpsborg and the station at Alvinjordet before crossing the river Glomma. Alternatives in later planning phases may be to run the route more to the north so that it will cross north of Solli, in a tunnel through Stikkaåsen, and north of the new Østfold central hospital. Thereafter the route would follow as shown in the VWI report via Kalnes to Tunejordet/Alvim, with a station here. The station is adjacent to the E6 and would allow a branch to the present Østfold line. It would thereby be possible to commute towards Fredrikstad and existing railway. The line is shown with a crossing of the Glomma to Årum and then follows the landscape to the existing line at Skjeberg. The line follows an otherwise open agricultural area beside the E6 and gives Sarpsborg station good access to the E6.

From Skjeberg the line follows the present railway to central Halden. This route is relatively easy to build as far as Berg crossing point. The route from Berg to central Halden runs beside Iddefjorden and may pose problems with regard to tunnels and crossing the Halden river at its estuary with a large bridge (with fairly poor building ground according to Halden operational area). Possible conflicts in this area are nature conservation and taking the fjord into account. The route as drawn shows a line across the present harbour where it uses the area of the present station as a station area. The costs of this are not known. They will probably be high, because the area has been shown to have very poor building ground. Conflicts with the town centre could be resolved but there would be a need to build two bridges, while the route would also impact on homes and businesses in Kirkegata. The speed through Halden must be low if major consequences are to be avoided. The routes between Haug and Halden must be assessed together with the development of the Intercity area.

The route from central Halden on to Kornsjø appears to go through a tunnel that rises to the fields by Idd church and then climbs to a new plateau at Aspedammen/Gullundmosen. The route continues to the north of Ørsjøen. In this section VWI has chosen not to run the route along the present railway. Why they have chosen to make it different is not made clear. The consequences will be greatest for nature and leisure activities, since the route runs north of Ørsjøen, which is an open space accessible from Halden.

No actual gradient is stated for the section from Halden up to Aspedammen. When working on a new route from Halden to Kornsjø, this should be seen in context with the problems faced by goods traffic in Tistedalsbakken. The tunnel between Halden and Aspedammen should be considered with regard to a 1.25 per cent gradient and the possibility of improving Tistedalsbakken and goods traffic to Europe. The route shown is suitable as a representative route for the corridor. But it raises questions regarding costs, which are around 11 million kroner. This appears rather low considering the bridge over the Glomma, passing the Solli area and a long, rising tunnel from Halden up to Aspedammen (compare with the cost of the Oslo-Ski double track). There is relatively easy building ground in most parts but the routes through Halden and major constructions will affect costs in this corridor.

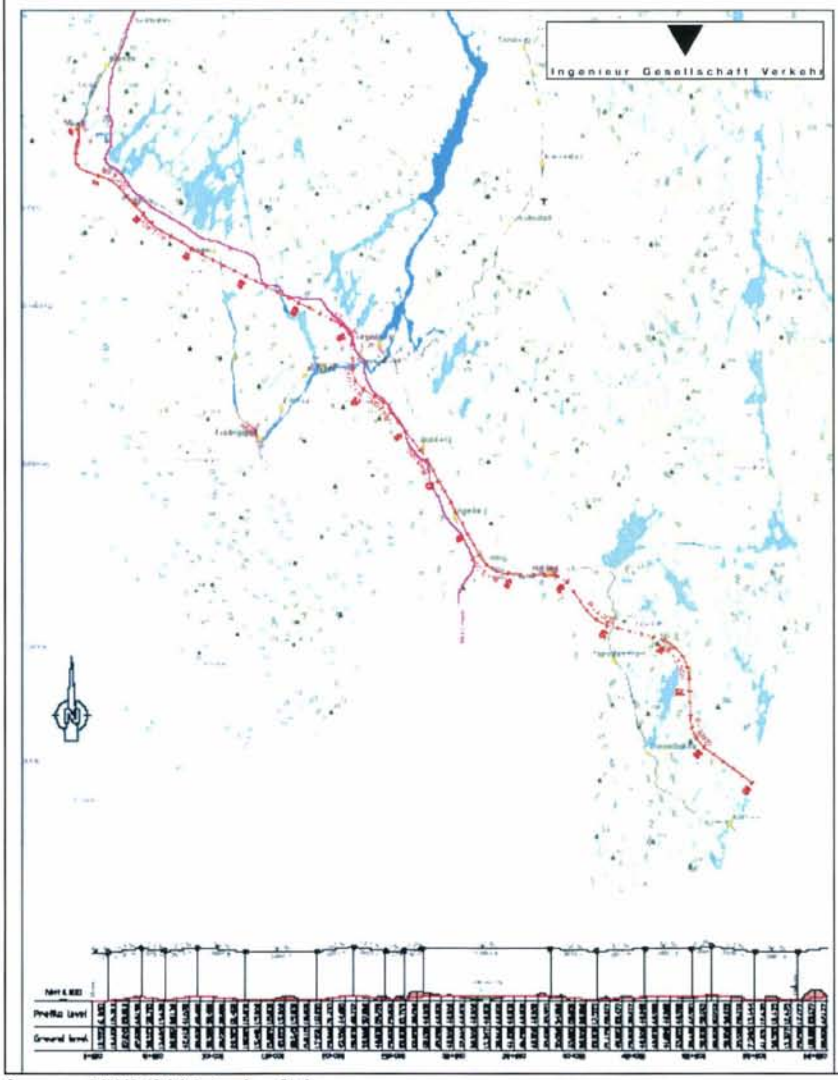
Alternative routes that might be considered are from Ingedal/Berg across Svinesund and east of Strømstad. A new station for Halden would be at Berg/Ingedal. The route will connect with Uddevalla and the Bohus line and will involve major investment on the Swedish side.

Another alternative is to run the line onward from Ingedal up towards Raet and Rokke before crossing past Tistedal. The new station for Halden would then be

Tistedal. This line would avoid the slope from Halden and upward, but would run through more virgin terrain, with the consequences that follow from impacting on an agricultural, natural and outdoor area with little building.

Figure 5.2: The route between Råde and Kornsjø

Plan 3-6: Ground plan Oslo – Gøteborg



Source: VWI (2007a), plan 3-6

The VWI report does not recommend going any further with Oslo - Stockholm unless this is done as a collaboration between Jernbaneverket and Trafikvärket. The reason for this is that most of the route lies on the Swedish side. The Swedish report on high-speed rail, which was presented on 14 September 2009, proposes building high-speed lines on the Stockholm - Göteborg and Stockholm - Malmö routes. Today the journey from Oslo to Göteborg takes 4 hours. With a new line, the travelling time is estimated at 2 hours 20 minutes.

The Oslo - Stockholm route currently takes 6 hours by train. With upgrades to two stretches, Lillestrøm to Åmotfors (80 km) and Hallsberg to Karlstad (119 km), travelling time can be reduced to around 3 hours. VWI has estimated the travelling time on a new line between Oslo and Stockholm as 4 hours, if it is only built on the Norwegian side, that is to say without a high-speed line on the Swedish side. With a new high-speed line between Göteborg and Stockholm, with an estimated travelling time of 2 hours 30 minutes, Oslo - Göteborg - Stockholm could be done in about 4 hours 50 minutes if the train passes through Göteborg without stopping.

Oslo - Kristiansand

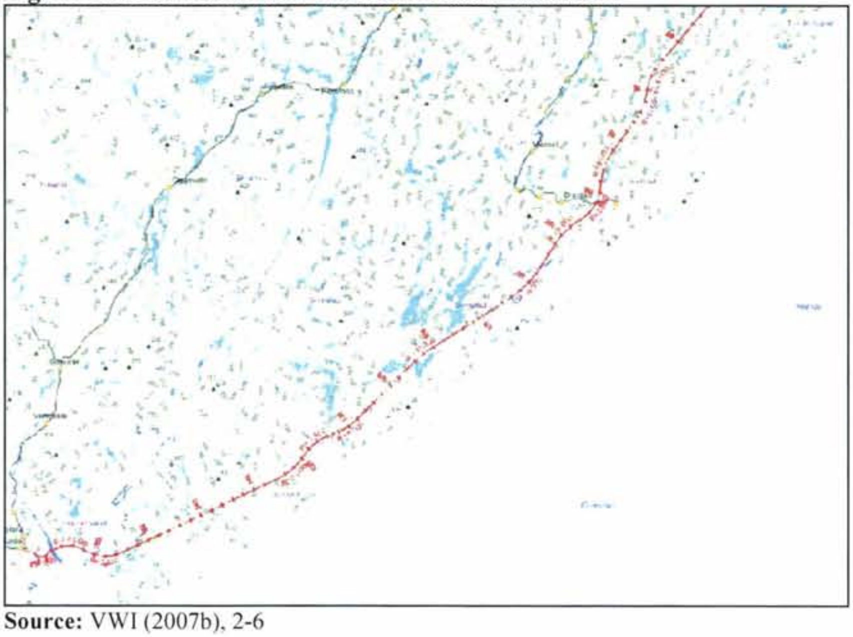
The route starts at Porsgrunn station and mainly follows the line described in the county plan of 1999, which recommends an outer corridor along the coast. This route can be built in two large sections, Porsgrunn - Skorstøl and Skorstøl - Kristiansand. The route will have many small, short tunnels (less than 5 km) and runs through slightly undulating terrain as far as Skorstøl.

An alternative route for Porsgrunn - Skorstøl could be to branch off of the present line before Porsgrunn station, follow the E18 and cross Frierfjorden together with the E18, so as to give a straighter line towards Skorstøl/Kristiansand. The advantage of this route would be that it is shorter, is more straightforward to build than going through the built-up area of Porsgrunn and would maintain speed for nonstop trains passing Porsgrunn.

Another alternative from Porsgrunn is to run the route through by going north of Frierfjorden so as to avoid having a large bridge and then beside Rv 356 to the Sørland line at Neslandsvatn. The new line would follow the direction of the present railway from Neslandsvatn and on to Gjerstad. The route straightens out to the present Sørland line outside Skorstøl and rejoins the Sørland line at Vegårdshei. This gives an inner line that uses areas that the Sørland line already goes through. This allows the possibility of building section by section and will not mean a completely new barrier in the areas where the line runs beside the Sørland line. The idea is to as closely as possible follow the present railway, which follows the line of the valley/terrain and mainly runs parallel with the coast down to Kristiansand.

South of Skorstøl the route shown in the outer corridor goes through several of the south coast towns. From the detail drawings showing the route it appears that speed will be reduced through these towns (R 2000 m). From the detail maps the route also appears to have many curves, while on the general maps it appears to have long straight lines. The opportunity for building section by section is limited, since the existing line runs further inland. The route as drawn goes through the towns. Consideration should be given however to running the route around the outskirts of the towns, so as to maintain the speed of passenger trains and reduce costs by avoiding built-up areas. For example one could consider building branch lines from the main line to the towns if there is a pressing need for a station in the town centre itself. The VWI only describes Arendal as a potential stopping place, which indicates that the line should be kept outside the other towns rather than running through them. Consideration could be given to including Kjevik airport in the section from Lillesand to Kristiansand. If the route had run further inland, there is a strong possibility of reducing the consequences for built-up areas, as well as giving lower development costs. Such a line would be less attractive if it became relevant in the future to run local trains between the centres of the south coast towns. The route runs through the centre of Kristiansand, which would lead to high unit prices and problems with difficult building ground.

Figure 5.3: Routes between Tvedestrand and Kristiansand



Source: VWI (2007b), 2-6

Kristiansand - Stavanger

The routes run close to Mandal, Lyngdal, Flekkefjord, Soknedal and Egersund. This is similar to the section east of Kristiansand that is run along the coast and brings the same consequences. The topography of this route mainly runs across valleys and hills, where to the east of Kristiansand it was more parallel with the line of the land. We can assume that the section between Kristiansand and Egersund would involve a great deal of construction, with bridges/viaducts and short tunnels. It could be advantageous to build the line section by section and place it in the same corridor as the E39 and existing railway. For example existing tunnels can be used for the new line or as escape routes if the new route runs parallel. Between Eigersund and Sandnes landscape conservation issues may dictate the choice of route. Costings should take this into consideration in this area.

Stavanger - Bergen
The route shows an almost straight line between Bergen and Stavanger with stops at Stord and Haugesund. There are two long undersea tunnels, of 43 and 55 kilometres, as well as a long bridge and two smaller ones. The route through Haugesund and Bergen/Nesttun is below ground level in a culvert. Both the tunnels under the fjords have two bores, one in each direction. The station in the culvert in Haugesund is associated with great uncertainty and high costs. Consideration should therefore be given to running the route outside the town centre.

An alternative development would be to run the line through Arna, which would make it possible to avoid having a tunnel through Bergen/Nesttun, while the bridge across Samnangerfjorden could be reduced in size or done away with. Costs may also be reduced, by running the route through less built-up areas. Even so, a great deal of the route would be through tunnel.

Oslo - Bergen via Hallingdal
The route follows the present railway through Hallingdal. As VWI points out this allows the possibility of having many connections between the two lines in case of line closure, as well as allowing for section by section development. The route appears to be very closely connected with the present railway, which may give unfortunate effects with existing rail and traffic. The route has many curves, some of which have a radius down to almost 2,000 metres. The current requirement for curve radius is 4,000 metres. This requirement would give a somewhat altered route in Hallingdal. This in turn could lead to a greater proportion of tunnel than is shown on the map.

This route assumes that the Ringerik line will be developed. The route and costs are therefore only shown west of Hønefoss. We are unsure if this is right, since the development of the Ringerik line is mainly to shorten the Oslo-Bergen route. If Oslo-Bergen runs through Numedal or Haukeli there is a possibility that the Ringerik line will not be developed. This issue should be described more closely in later planning.

The route from Geilo to Voss also follows the existing route to a great extent. Between Hallingskeid and Mjøllfjell a long tunnel has been chosen. It appears that the route could be upgraded to 4,000 metre radius without great changes to the route chosen. The route via Finse will present some challenges. The route here will rise to 1,222 metres above sea level. Building it close to existing track is both positive and negative.

It appears that the route between Voss and Bergen has been chosen to be as straight as possible so that high-speed trains can be run. Most of this part of the route runs through tunnels. If the curve radius is updated, the proportion of tunnel will probably increase.

Oslo - Bergen via Nummedalen (VWI)

The route VWI has indicated mainly follows the same corridor as Høyhastighetsringen between Flesberg and Geilo. Between Haugastøl and Voss on the other hand, VWI has followed the Bergen line. Høyhastighetsringen's route is described in more detail in the next section.

Figure 5.4: Routes through Numedalen

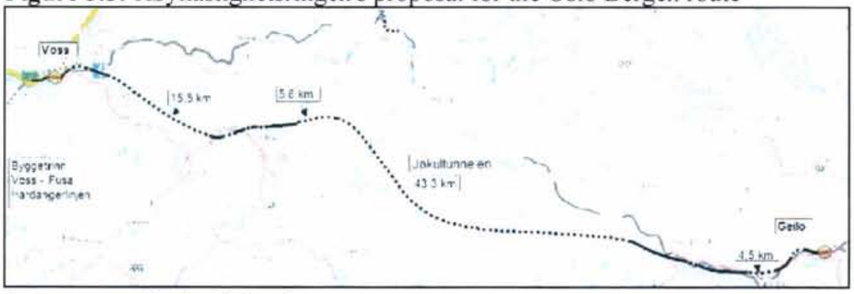
Source: VWI (2007b), plan 2-17

VWI's proposed route follows the existing line north from Drammen to Kongsberg, with a station in Kongsberg. The route runs though a relatively untouched area. This will therefore give some negative consequences for the area, but will also have the advantage of building away from built-up areas. Along Tunhovdsfjorden appears to be a good place to build, but is also possibly an area that is at present largely unaffected by other infrastructure. The route should be considered all the way from Drammen, so as to be able to consider routes that do not go through Kongsberg. This is mainly to see if the route could be made shorter by running straight on at Hokksund and up to

Numedalen. Satisfying the 4,000 metre radius requirement appears to be easier in Numedal than in Hallingdal.

Oslo - Bergen (Høyhastighetsringen)
Høyhastighetsringen has proposed a long tunnel from immediately to the north of Drammen station to Vestfossen. Unlike VWI's route via Numedalen, Høyhastighetsringen follows the mountainside up towards Holtefjell and runs in a tunnel up to Lyngdal, from where it runs in long curves until it meets VWI's route at Rollag. This route may appear to be shorter than the one chosen by VWI, but this route does not use Numedalslågen or Bingselva to climb but instead turns the route 90 degrees from the direction of travel. This gives a visible effect on the hillside at Hokksund. The choice of a long tunnel between Drammen and Vestfossen appears to be costly compared with using the present line. Between Haugastøl and Voss, Høyhastighetsringen has proposed a somewhat different route to that in VWI's report. In 2007, Høyhastighetsringen put forward a proposal for a tunnel from Haugastøl to Voss. VWI commented on this section in its report. The disadvantage of the Høyhastighetsringen route is a tunnel of almost 42 km and a gradient in the tunnel of 1.5 per cent. Its advantage on the other hand is that the highest point on the Bergen line is reduced to about 1,000 metres above sea level, just west of Haugastøl. The height differential from Voss of about 920 metres over about 80 km could give less of a descent down to Voss than the route via Finse.

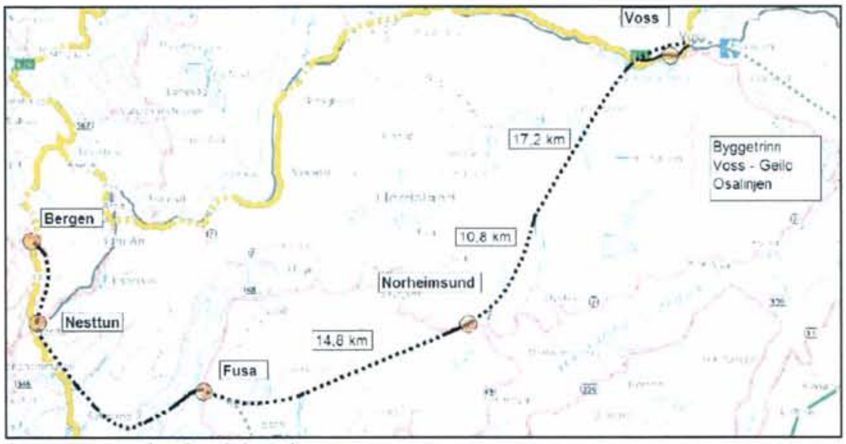
Figure 5.5: Høyhastighetsringen's proposal for the Oslo Bergen route



Source: www.høyhastighetsringen.no

Between Voss and Bergen, Høyhastighetsringen has proposed moving the Bergen line via Samnanger and Norheimsund. The route consists mainly of long tunnels, of 10.3 km, 13 km, 30 km and 5 km. Alternatively the route could run straight from Ulvik to Norheimsund, which would make the line shorter. Even so, it would still consist of long tunnels. In this case the route would run along Hardangerfjorden instead of Veafjorden where the Bergen line runs today.

Figure 5.6: Høyhastighetsringen's proposal for the Oslo Bergen route

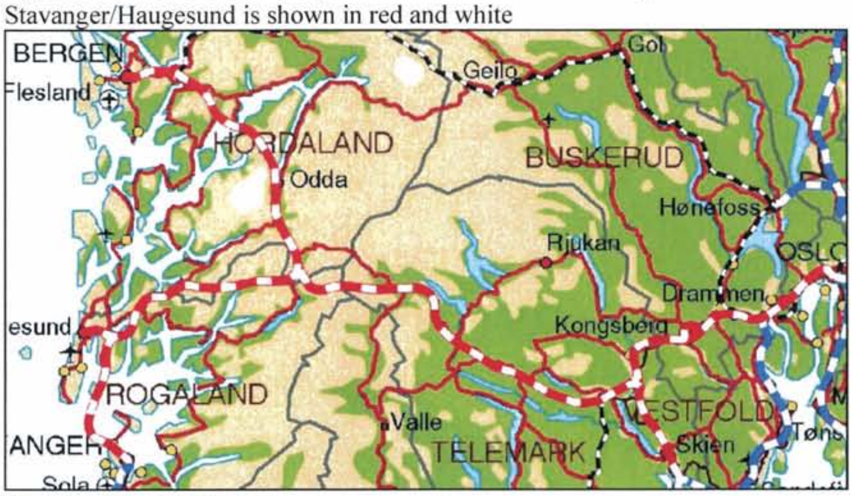


Source: www.høyhastighetsringen.no

Oslo Bergen via Haukelifjell

This route is shown in phase 3 of the VWI report. The route via Haukeli is mainly similar to the Norsk Bane route that was presented at a general level. VWI has not assessed a branch line to Haugesund. The route straightens and follows the Sørland line as far as Bø station, before following the valley up towards Haukeli. The line goes up to Tveitevannet (550 metres above sea level) before entering a 30 km tunnel under Haukeli to Suldalsvatnet. An alternative route is more of a straight line to Røldalsvatnet and on to Odda (80 metres above sea level). As with Hallingdal, the route is in typical V shaped valleys which present problems of rigid curvature and adapting to other infrastructure on the valley floor. Rockfalls and avalanches can also be a problem. One of the biggest challenges and uncertainties on this route is to cross Hardangerfjorden with a bridge span of almost 1,500 metres. This route has less of a height differential than via Geilo/Hallingdal, but it does present the problem of crossing Hardangerfjorden.

Figure 5.7: Norsk Bane's proposed route via Haukeli to Bergen and Stavanger/Haugesund is shown in red and white



Source: www.norskbane.no

Oslo Stavanger via Haukelifjell

The route shown in the VWI report goes outside Haugesund. Between Drammen and Haukeli it is the same as Oslo-Haukeli-Bergen. The route runs largely through tunnels as far as Ølen, apart from an open section near Sauda. From Ølen it follows the E134 and E39 on the surface, before the tunnel under the fjord to Stavanger.

An inner route that could be considered follows Rv 13 from Røldal down to Sandnes. This alternative has long traditional tunnels in the mountains and a long bridge across Høgsfjorden at Forsand, as well as a difficult crossing at Jøsenfjorden This is a somewhat different route to that shown in the VWI report that goes by Haugesund and the problems this involves in crossing Boknafjorden.

5.3 Assessment of environmental effects

The VWI report discusses environmental effects at a general level. The assessments described appear to be based on maps with a scale of 1:250,000, and the poor resolution they provide is a very bad basis for assessing the impact consequences on the terrain.

Noise is considered in phase 1. Noise is described as being a bigger problem in Gudbrandsdalen than in Østerdalen. Otherwise there is little assessment of environmental effects in phase 1.

High-Speed-Rail will create negative environmental impacts in Gudbrandsdalen probably more than in Østerdalen. E.g. less people will be polluted by noise in Østerdalen than in Gudbrandsdalen. There will be no benefits as regular stops and coverage of demand to compensate the negative impacts in the valleys. The higher demand in Gudbrandsdalen, however, allows a good feeder-traffic to High-Speed-Rail in Hamar."

(VWI (2006), page 5-4)

After the corridors, Oslo - Trondheim and Oslo - Halden respectively, were chosen, a deeper analysis was carried out in phases 2 and 3, in which the environmental effects of the various routes proposed for investigation were considered.

Phase 2 of the VWI report describes environmental effects in the chosen corridors. The assessment was made on the basis of routes drawn on a map with a scale of 1:250,000. The assessments only show the effect on *national parks and major conservation areas*. VWI was of the opinion that it was not possible to record smaller areas on this scale.

The topic of non-monetised effects is discussed as follows:

"Environmental aspects are an important issue in the planning of High-Speed-Rail. In the socioeconomic analysis, environmental aspects are included either

within a category where the elements are monetised or as non-monetised elements. Non-monetised aspects are:

- *landscape/cityscape,*
- *community and outdoor life,*
- *cultural heritage and*
- *natural resources."*

(VWI (2007a), page 14)

Noise and greenhouse gas emissions are discussed in phases 2 and 3. The environmental effects of reduced CO_2 emissions are considered in the report together with the proportion of tunnel for each section. The VWI report does not include a complete environmental audit for the transport sector with and without high-speed rail. Both the VWI and Banvärket reports state that developing high-speed routes will have a positive effect on the environment due to reduced emissions from the transport sector.

VWI further considers that planning work be followed up with analyses of the consequences of all monetised and non-monetised effects, including the natural environment, natural resources, landscape and cultural environment, in connection with more detailed assessments of the routes.

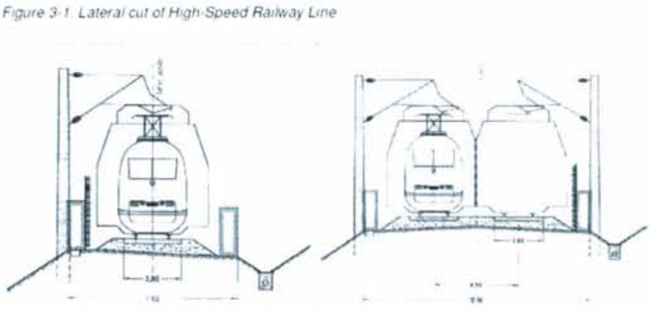
Wildlife fencing and crossings are the two elements that we can see have been included as regards impact consequences. It is planned to have a fence along the line to keep out wildlife, as well as crossings every 2 to 3 kilometres depending on the density of wildlife. For the Sørli - Trondheim stretch, 142 such crossings are planned at a cost of 2.5 million kroner each. 30 crossings are planned for Råde - Göteborg. The cost per crossing is possibly correct, but since no other costs for environmental disadvantages and mitigating measures have been included, the probability is that costs relating to impact consequences will increase.

5.3.1 Cross section width of high-speed line

VWI's phase 2 report shows an illustration of the width of a high-speed railway. This is reproduced below. No reference is made to other reports that could give more detailed information about the width that such a track could have.

Figure 5.8: Normal cross section of high-speed line

Figure 3-1 Lateral cut of High-Speed Railway Line



Source: VWI (2007a), figure 3-1

The width shown is the minimum area with which such a railway affects the surroundings it passes through. In addition to the railway itself there is a need for raised embankments and cuttings, safety zones, maintenance roads etc. The railway influences its surroundings with noise and light and also changes the traffic and movement patterns of the area it passes through. At this level of planning it may appear that it is sufficient to assess the actual railway itself, but the information in the VWI report raises expectations that they have made a more detailed assessment of the impact of the railway on the landscape than is actually the case. The next stage of planning should therefore include an assessment of the impact around the track itself, which can be used in turn to optimise the route and provide a better cost estimate of necessary measures.

5.3.2 The VWI report on route and environmental effects

VWI assessed the routes on the basis of 1:250,000 maps. The purpose of the feasibility study is to assess which corridors are best suited to high-speed rail lines and where costs and consequences are assessed as the lowest. This was largely done in phase 1. It is assumed that it is possible to adjust the route within the corridor so as to avoid the biggest consequences. The VWI report points out that there are better possibilities for changing the route in Østerdalen, since this is a U shaped valley that is wide enough to allow for adaptation, than in Gudbrandsdalen, which is a V shaped valley with a much narrower valley floor. Gudbrandsdalen also has more infrastructure and building, which again makes this corridor less suitable for adaptation.

It would have been useful to review the routes with a simple assessment with the aid of GIS tools that can give a more detailed description of the routes and the areas they pass through. Such an analysis could describe the route in relation to land use data and how many people it affects within a given distance (noise etc). Most of VWI's routes run through large built-up areas, which will give very high costs. As we understand it the route proposals are very general, but where a route goes through a town centre so as to have a central location this should be reflected in the costs. Some of the routes run close to towns where we cannot see that the trains will actually stop. We assume this has been done so as to make a stop possible if the market exists. If the trains will not stop at these places, the route should be moved further away from the built-up areas. In this context it would have been appropriate to assess where the route should lie instead and how location further away from the town centre affects the number of passengers. This has been done to some extent for Hamar but not for the other routes.

5.3.3 Proposal for simple analysis of the route to assess the consequences

N250 includes data at area level such as forest, enclosed fields, treeless areas, built-up areas, marsh and water. Sparser building is at point level and probably does not include all cabins and houses. N250 also has a good deal of generalisation in comparison with N50. Areas, lines and points are adapted to the scale and are therefore evened out and moved a good deal in some places, especially where space is tight. From a N250 base it is simple to analyse the proportion of the different types of area the route runs through, as a whole and at county and municipality level. One can work out the proportion of point and line information such as roads, rivers and houses within a given buffer distance from the proposed railway. It is also straightforward to connect to the database of the Directorate for Nature Management and carry out the same type of analysis on this material, as well as for example quaternary geology and bedrock from NGU.

The terrain model is used to define the route. We do not at present know the degree of accuracy of the terrain model that provides the basis. If it has the same accuracy as N250 indicates with 50 metres equidistance, a great deal of terrain will not be shown on this map and the proportion of tunnel will in reality probably be somewhat greater. A high-speed train requires rather gentle curves which means it is not so easy to bend around all the irregularities.

5.4 Summary

5.4.1 Line routing

As we understand it, the screening in the VWI report was done in such a way as to arrive at a corridor and a route with the best potential for making positive use of high-speed trains. It does not appear that the other alternatives between towns have been considered and excluded, but that there is the greatest possibility for finding benefit in the chosen alternatives and corridors, on the basis of the rough analysis that was carried out at this early stage. A later planning phase should therefore include a more thorough screening of the alternative routes in each corridor before the final choice of route is made.

As an overall study of alternative routes in the number of corridors that were investigated, the line routing shown in the VWI report provides a good enough answer to the type of challenges presented by the various routes, and the report also gives some rough estimates of quantities. The technical rules have also changed in recent years. This means that the routes need to be revised. New requirements mean that routes through narrow valleys with many ascents and descents may require an even higher proportion of tunnel and have less opportunity to follow the curvature of the terrain.

There are further challenges relating to certain limited stretches that should be investigated further in later stages of planning. The greatest uncertainties relate to the routes in western Norway that have long tunnels beneath the fjords, large bridges with long spans and long tunnels and stretches with extreme ascents/descents. More consideration should be given to winter operations where a line crosses high mountains to see if this involves substantial measures etc.

The routes vary greatly in form and are very distinct from each other. Some of them go right into and beneath the town centre (Haugesund), others pass just outside (Sarpsborg/Kristiansand), while others are a good distance from the town centre (Hamar). The routes therefore have very different speed profiles with tight curvature in and near town centres. In terms of costs, a route that goes through a town will involve a higher cost per metre. Placing a route through the outskirts of a town can reduce the level of conflict and the technical issues involved in construction.

Reducing the proportion of tunnel is and will remain a challenge for several of the routes. The routes with the lowest proportion of tunnel may provide the best opportunities for reducing costs, but this can also lead to greater environmental disadvantages.

5.4.2 Environmental effects

VWI's report provides very little information about consequences of environmental impact. The report only describes impact consequences under two cost elements: crossings and fences for wildlife. In this phase the cost should have been a percentage mark up in accordance with experience. As we see it these two items represent costs for mitigating measures for environmental impact consequences.

Several of the alternative routes that have been investigated go through areas where they will affect and change areas of undisturbed nature and open landscape and that are currently registered as national parks. It is equally important to clarify these conditions as planning criteria for the track itself so as to consider whether the route is feasible at all. In some of the routes a choice must be made between developing or conserving. VWI's report provides too little information about the routes' effect on the environment and landscape to be able to consider the extent of mitigating measures, other than costs per linear metre based on experience of similar projects.

6 Costs

6.1 Cost estimates

There are many different cost estimates for building high-speed rail lines in Norway. The estimates in VWI's report vary from 200 to 450 million kroner per kilometre for infrastructure and rolling stock, depending on track choice.

VWI writes in its report:

"For the following choice of corridors a rough calculation of investment costs based on German cost rates for railway projects was done. Due to cheaper Norwegian tunnel cost rates this special rate was reduced."

(VWI (2006), page 5-2)

This is a debatable procedure, since the costs of high-speed rail lines in Norway and Germany must be quite different. Among other things, topography, population and land-use planning systems are different in the two countries.

Norsk Bane and DB arrive at lower costs than VWI:

"The growth in goods and passenger traffic will demand building costs of an average 180-220 million kroner (at 2008 prices) per kilometre of new track. If at least one long distance route is to be realised by 2020, this will cost 80-130 billion kroner (at 2008 prices)."

(Norsk Bane and DB International (2009b), page 3)

"#The total length of the new Oslo-Trondheim line is 451 km (Gardermoen–Trondheim). Of this, 252 km is on embankments, in cuttings or at ground level, 177 km is in tunnels and 22 km is on bridges. Building and planning costs are estimated at NOK 73 billion. In addition there is NOK 6.2 billion for procurement of passenger trains and NOK 3.6 billion for goods trains. A reserve for unforeseen costs of 10% has also been added to all costs. This gives investment costs of NOK 81 billion for infrastructure and NOK 11 billion for rolling stock. The estimated construction time is seven years."

(Norsk Bane and DB International (2009b), page 6)

It is difficult to evaluate DB's cost estimate without having unit costs. DB proposes a cost of NOK 81 billion to upgrade 451 km of track. This is low in terms of international experience of cost per kilometre.

SINTEF arrives at lower costs than DB:

"Typical unit costs in million NOK per kilometre for different elements of groundwork (i.e. without track and other technical rail installations) for lines with the challenges we have mentioned above could be:

- *Open rail line in favourable terrain: 15 - 25*
- *Open rail line on soft ground: 40 - 60*
- *Open rail line with high cuttings and embankments: 45 – 70*
- *Single tunnel, depending on geology: 60 – 120*
- *Addition for parallel service tunnel: 30 – 50*
- *Bridge/viaduct for single track (normal span widths): 120 – 200*
- *Technical rail installations (all the way): approx. 25"*

(Beitnes and Olsson for SINTEF and NGI (2007))

The figures also tentatively include planning and administration costs.

"The variation between favourable terrain, such as in the lower part of Østerdalen, and undulating terrain such as Telemark (where it is possible at all) is very great. It is difficult to imagine total costs below NOK 60 million per kilometre, while average costs for line alternatives that include many bridges and tunnels can soon reach NOK 150 million per kilometre."

(Beitnes and Olsson for SINTEF and NGI (2007))

SINTEF and NGI's evaluation of the costs involved in building tunnels is very low. Cost levels observed in other parts of the world are NOK 300 to 400 million per kilometre.

Norsk Bane writes the following in its report:

"The VWI report stipulates building costs that are many times higher than figures experienced in relevant projects abroad. One is looking for example at costs for superstructure (rails, contact conductor, signals and tele) of 75 million kroner per kilometre for double track high-speed line. This is almost twice the costs of the complete high-speed lines opened in 2006 in Finland and Sweden, see section 4 of the report on the Haukeli line of 15.11.07."

We agree with Norsk Bane's assessment of the costs of superstructure. This cost should be NOK 25 million per kilometre maximum.

METIER presents substantial data on infrastructure costs for new high-speed rail lines in Norway. For the line between Trondheim and Oslo, with 366 km of new infrastructure, the total cost is estimated at NOK 162 million per kilometre.

The table below shows VWI's cost estimates for the line between Oslo and Trondheim. The total unit cost is NOK 168 million per kilometre.

Table 6.1: Investment costs Oslo-Trondheim, NOK million

Infrastructure	Investment MNOK
Tunnel (without superstructure)	8'454
Open line	14'398
Constructions	2'281
Superstructure	9'325
Stations	147
Power Supply	428
Special Infrastructure	289
Facilities	40
Contractor Costs	35'352
Management/Engineering	10'622
Land acquisition	468
Project Costs	46'442
Maintenance facilities	1'800
Total investment	48'242
Uncertainty	9'622
Total Estimate	**57'864**

Source: VWI (2007a), figure 6-1

VWI's cost distribution is not within the range we see for other high-speed rail projects around the world. VWI estimates that 19 per cent of the total costs will go to project management and engineer services and 17 per cent to uncertainty.

In our assessment, project management and engineer services should represent no more than 10 per cent of the costs of a rail project. We question whether uncertainty should be included in this way in a feasibility study. The uncertainty is typically linked to other investments the authorities may decide on, independently of the high-speed rail line.

In order to be able to evaluate the cost estimates, we have summarised the level of high-speed rail projects (observed and estimated) in various parts of the world in the table below.

Table 6.2: High-speed rail lines (observed and estimated) in various parts of the world

Project	Planned speed (kph)	Length (km)	Price/km (million €)	Price/km (million NOK)
Hannover - Würzburg	250	327	20.5	167
Cordoba-Malaga	300	155	16.8	137
Madrid-Barcelona-Figueras	300	753	17.7	144
Madrid-Valladolid	300	179	24.0	196
Paris-Strasbourg	350	300	19.0	155
Rhine-Rhône (eastern section) (project)	320	140	16.5	134
Le Mans-Rennes (project)	320	182	13.0	106
Tours-Bordeaux (project)	300	302	15.8	129
Bordeaux-Dax-Hendaye (project)	300	225	14.4	117
Bordeaux-Toulouse (project)	300	250	12.2	100
Poitiers-Limoges (project)	300	100	12.3	100
Marseilles-Toulon-Nice (project)	300	185	32.4	265*
Nîmes-Montpellier (project)	300	60	13.8	112
Lyon-Turin (project)	300	310	48,4	392*/**
Perpignan-Figueras	350	44	21.6	177
Copenhagen-Ringsted (project)	180	52	22.8	186
Wuhan-Guangzhou	350	968	12.7	103
Yatsushiro-Kagoshima	260	127	37.2	303***
Takasaki-Nagano	260	118	64.8	528***
Anaheim-Las Vegas (Maglev project)	500	433	21.8	177
Baltimore-Washington (Maglev project)	420	64	29.0	236*
Seoul-Busan	350	412	38.0	309**
Taipei-Kaohsiung	300	336	39.0	318**
Göteborg-Borås (project)	320	60	17.0	136

Project	Planned speed (kph)	Length (km)	Price/km (million €)	Price/km (million NOK)
Linköping-Södertälje (project)	320	160	15.3	123
Oslo-Trondheim	200/250	344	20.7	168
Oslo-Göteborg	200/250	65+170	22.5	183
Oslo-Bergen	200/250	395/405	28.8/27.5	234/224
Oslo-Røldal-Bergen	250	411	47.4	386
Oslo-Kristiansand-Stavanger - (Bergen)	200/250	554	36.1	294

Source: COWI, RFF and GOA (2009)

*These stretches have especially high area costs and environmental requirements, are disputed and require a large number of bridges and tunnels through the terrain.

**These lines require many bridges and tunnels since they go through mountains. The 53 km Alpine tunnel, which will be the world's longest rail tunnel and will be extremely difficult to build, represents half the cost of the Lyon-Turin project. Drilling the 53.1 km tunnel will take five and a half years, using 17 machines working from different points. It will be subject to high pressure on the tunnel walls, since this is one of the highest peaks in the Alps.

***Building costs are relatively high in Japan because of the need to secure against earthquake, the high cost of land and the need for many bridges and tunnels (up to 70 per cent for these lines).

120 km, or 37 per cent, of the 327 km Hannover - Würzburg route is in tunnels, the longest two of which are Landrücken Tunnel (10,779 m) south of Fulda and Mündener Tunnel (10,525 m) south of Hann.
Wuhan-Guangzhou, which recently opened, is 18 per cent tunnel and 48 per cent viaduct.
Seoul-Busan is 46 per cent tunnel and 25 per cent viaduct.
Taipei-Kaohsiung is 18 per cent tunnel and 73 per cent bridges.

The costs in the table do not include rolling stock.

For various reasons the costs of different projects are not directly comparable. This may be due to technical differences in accounting, expenses occurring at different times or the schedule for expenses not being available.

The costs that VWI has estimated for high-speed rail lines in Norway seem somewhat overestimated given that they are for single track and relatively low speeds. The low speed permits curves of greater radius so as to be able to avoid running the route through residential areas. This means that the need for expropriation is reduced and land costs are lower. It should also be possible to propose routes with fewer tunnels, which will also reduce costs.

6.2 Assessment of costs in relation to national transport systems

The methods used in Metier's report correspond with those used for major national investment projects. Norsk Bane and Høyhastighetsringen have not taken any assessment of uncertainty into account in their cost estimates.

Høyhastighetsringen has prepared cost estimates for the routes and has unit prices that differ greatly from Metier's report.

We have looked more closely at Metier's report on concept evaluation, cost estimates and uncertainty analyses for the Trondheim-Oslo route, prepared in October 2007.

Unit prices: (2007 price level) in Metier's report:

Tunnel: The unit prices used in the report:

- ID 1.1: NOK 75,000 per linear metre including entrances
- ID 1.2: NOK 20 million per rig
- ID 1.3: NOK 35,000 per linear metre service tunnel
- ID 1.4: NOK 40,000 per linear metre in addition for cross cuts between tunnels
- ID 1.5: NOK 60,000 per linear metre for tunnels through loose materials and long entrances

These unit prices appear to be low in comparison with similar major national tunnel projects in Norway. Altogether these IDs give an average tunnel cost of NOK 118,000 per linear metre of tunnel.

Comparable cost examples:

- **Skøyen - Sandvika:** The price level of this tunnel contract was about NOK 1,200 per m^3. Assuming a cross section of about 80 m^2 for the main bore, this gives a tunnel cost of about NOK 100,000 per linear metre of unfinished blasted tunnel. Concrete vaulting, lights, ventilation, emergency equipment and other electronics are in addition.
- **High standard road tunnel:** A high standard road tunnel with concrete vaulting, lighting and ventilation costs around NOK 140,000 per linear metre including entrances.

Bridges: The unit prices used in the report:

- ID 3.4: NOK 120,000 per linear metre of railway bridge

Given varying ground conditions, measures needed, height and width, this average unit price appears to be too low.

Railway line in the open: The unit prices used in the report:

- The total of all IDs gives a unit price of NOK 41,400 per linear metre.

The unit prices used appear to be of a similar level to those of comparable projects, although ground conditions will affect the linear metre price to a great extent.

When we met the Norwegian National Rail Administration, we were informed that the unit prices in the report are based on experience from rail projects in Norway, Germany and Sweden, and particularly the Åland and Botnia lines. In general the unit prices would not be below NOK 150,000 per linear metre for new railway line. It is important to point out that the unit prices in Metier's report are based on development being carried out as one contract to build the entire stretch, which will therefore have economies of scale that are reflected in the unit prices.

Against this background and our knowledge of the price levels of major national transport projects in recent years, building such a high-speed rail line would require a high quality of execution and solutions. All tunnels should be built with good security and concrete vaulting. Bridges must have proper foundations and open lines will require a solid foundation and execution, taking into account the demanding winter conditions we have in this country and the speed the train will maintain on such a track.

We therefore believe that the cost levels in the uncertainty analysis of 2007 are too low in relation to what would be realistic for a high-speed rail line between Oslo and Trondheim in Norway.

6.3 Direct and indirect costs

The costs presented in Metier's report are divided into eight main items, which are based on quantity. Two items have also been included that are percentage mark ups to the contractor costs. The costs that have been included for wildlife crossings should be entered as indirect costs, rather than direct costs as now. Experience-based costs representing a percentage mark up on the contract cost for groundwork should more correctly be entered as indirect costs for mitigating measures with regard to the route's consequences. Currently what is included as indirect cost is rather arbitrary and based on a rough assessment of the measures that are necessary. Direct costs should primarily cover groundworks, technical work for the railway itself, major constructions and road diversions, stations and major infrastructure for new line such as transformer stations and service depots.

6.4 Planning regulations and the route of the line

It is both demanding and irrational that the planning authority for such large-scale national transport projects rests with each individual local authority. This could lead to a problematical, time-consuming and not least costly planning process before building can start. This must be allowed for in the client's costs and planning costs.

Another condition that will greatly affect costs is the proportion of the route that will go through tunnels and over bridges. We believe that the proportion of line that is planned to be in tunnels and on bridges appears rather low.

6.5 Summary

In general the studies provide a study of costs that is thorough, well-adapted and relevant with regard to the different high-speed corridors in Norway.

We have however identified some issues and uncertainties, including that the studies generally underestimate the unit costs of building new high-speed rail lines, especially with regard to tunnel costs. Metier's uncertainty analysis of 2007 estimates an average tunnel cost of NOK 118,000 per linear metre for the Oslo-Trondheim stretch. Considered against other, comparable national tunnel projects, which have costs of around NOK 140,000 per linear metre of tunnel, this seems low. Building a high-speed rail line demands a high quality of execution and solutions. All tunnels should be built with good security and concrete vaulting. Bridges must have proper foundations and open lines will require a solid foundation and execution, taking into account the demanding winter conditions we have in this country and the speed of the train. Against this background, we believe that the costs in the Metier report are too low in comparison to what is realistic. We should also point out that the unit prices Metier is operating with are based on development being carried out as one contract to build the entire stretch, which will therefore have economies of scale that are reflected in the unit prices.

We also believe that VWI overestimates the total development costs somewhat. The estimates shown by VWI vary between NOK 200 and 450 million per kilometre of railway line. The figures are based on German cost rates from previous railway projects. To begin with this is a rather debatable procedure, since the costs must be somewhat different because of the different topography, environment, population and land-use planning systems between the two countries. Secondly, the figures have been estimated on the basis of single track with a relatively low speed. The low speed permits curves of greater radius so as to be able to avoid running the route through residential areas. This means that the need for expropriation is reduced and land costs are lower. It should also be possible to propose routes with fewer tunnels, which will in turn reduce costs.

7 Requirements for implementation and financing

The questions of finance and how construction is to be implemented hang closely together. We will therefore look at these two aspects as one. By implementation here, we mean organisational conditions.

Financing and organisation have been discussed by Agenda Utredning & Utvikling AS and in the Swedish public report SOU 2009:74. Agenda has used as a basis experience of major infrastructure projects, while the SOU report makes a presentation on a more fundamental level.

7.1 Models for organisation and financing

One problem with the present financing reform for rail development is that the projects are dependent on annual grants from the national budget, which leads to unpredictability and inefficient implementation. That this financing reform has not been done away with long ago is due to it also having some advantages: the government is not bound to expenses far into the future, but maintains the opportunity to control costs and cyclical policy. Because of the way it slows rail development however, many would prefer to see infrastructure development as a total finance decision for the entire project, so-called project financing. Both the Agenda and the SOU reports recommend this. In the case of high-speed rail, where the railway is expected to take market share from air traffic, the end point markets are important. Gains in the end point markets cannot be realised until the entire development has been completed, which would support the idea of treating the entire development as a whole rather than piecemeal projects.

Various solutions have been used with project financing (in Sweden and Denmark for example): taking out loans, annual grants with guarantees and grants for the entire project and infrastructure funding. Agenda mentions the possibility of creating a Norwegian infrastructure fund. This system is used in Denmark, where Trafikstyrelsen handles planning, Banedanmark carries out detail planning, development and operation of the infrastructure, while financing is by grants from an infrastructure fund (and partly as loans).

One potential source of financial contribution is user payment. In this context, users may mean the transport companies that use the infrastructure or the passengers on the new train service. For the transport company, user payment may be demanded via a charge for using the track, a charge that may then be passed on to the passengers. User payment can also be demanded directly from the passengers as a surcharge on tickets. On one hand, user payment can help to facilitate the realisation of the development. On the other hand it can have a deterrent effect on traffic. These are considerations that must be weighed up against financing from tax, which is not without costs itself (collection costs and distortion effects).

When it comes to the form of organisation, a public-private partnership (PPP) in some form or another may be appropriate. PPP is a contract between a public and a private party to carry out a development project and/or to provide a service. The government thus retains a certain amount of control, while the PPP can improve cost effectiveness. In terms of economic effects, a PPP is not in itself either a blessing or a curse. Success depends on how the public-private partnership is *organised*, and especially the specification of the contract. Different models may be chosen depending on what task - for example planning, development, operation or financing - is being outsourced to the private sector. In some projects it is appropriate for the same party to be responsible for both development and operation, so that the development phase will take into account what the best solutions for operation are. Also, the risk should be shared so that each party is responsible for the risk that party has influence over. Furthermore, the quality of the delivery depends on the extent to which it is possible to specify, monitor and measure quality.

The PPP model that Agenda looked at is that used in road sector projects in Norway. It is based on planning and development being transferred from the public sector to a private company. The private company is also responsible for financing the project. When the project is complete, the private company is also responsible for operating and maintaining the infrastructure. Involved parties that Agenda has interviewed believe that PPP brings an increased focus on progress and cost awareness, while ensuring that considerations of future operation and maintenance are safeguarded in the development phase. The contractor should bear the project's internal risks, while the government takes the risks associated with outside factors.

Examples of project financing and organisational models from the Gardermoen line and Botnia line projects (based on the Agenda report):

Botnia line: the development of the Botnia line is project financed and is fully financed with the aid of loans. The borrower is the Swedish government. The actual disposal of the funds is handled by a dedicated company, Botniabanan AB, which transfers the infrastructure to the authorities on completion. On completion the costs associated with the project will be paid back as rent over 40 years by Banvärket. Since the project is fully financed, it will not directly affect the national budget. Neither will the project depend on annual grants during the construction period. Experience with this form of financing shows that it provides more rapid development.

Gardermoen line: development of the Gardermoen line was project financed and a company, NSB Gardermobanen AS, was created to be responsible for the actual development and operation. NSB Gardermobanen AS financed the development with loans from the government and was to partly service these through user payment, i.e. a surcharge on ticket prices. When the development was completed, the project was handed over to the Norwegian National Rail Administration, which is responsible for operating the infrastructure, and the actual operations were transferred to a subsidiary company of NSB.

Alternative models for organisation are suggested in the Agenda report and the SOU:

- The Norwegian National Rail Administration is project manager and commissions a large contracting company for detail planning, development and possibly also operation.

- A project company is created that is owned by the Norwegian National Rail Administration. The project company is responsible for detail planning, development and possibly also operation.

- A project company is created that is responsible for planning and that outsources development and possibly also operation to a contractor.

This last point is the model recommended in the Swedish report.

7.2 Summary

The review shows that piecemeal development and financing is inefficient, that PPP can be an advantage if it is used appropriately and that project financing is recommended from many sides.

To implement the development, one should choose a model that

- ensures the certainty of financing for the whole project

- gives the optimum distribution of risk between the parties involved

- give the best possible incentive to cost effectiveness

- gives an incentive to keep to the schedule (although not at any price if it puts safety and quality at risk)

- safeguards quality requirements

- ensures a total overview at all stages, so that quality in the operational phase is taken into consideration during the development phase

8 Social effects

In this section we shall consider the treatment of social effects as they are presented in Norwegian and international studies of high-speed rail in Norway, as well as certain other sources. The studies we have particularly focused on in this section are ECON's cost-benefit analysis (ECON, 2008) and VWI's phase 2 report (VWI, 2007), although we have used other background reports and other sources where we have found it appropriate in this part of the assessment. We have also used the method manuals for cost-benefit analysis from Sweden, Denmark, England and Germany. VWI's cost-benefit analysis is based on German methods (Federal Ministry of Transport, Building and Housing, 2005), but has also partly made use of Norwegian unit prices. ECON's is based on Norwegian methods (Norwegian National Rail Administration, 2006).

Sections 8.1 and 8.2 cover calculation assumptions in the socioeconomic analyses. Section 8.3 gives an overview of the elements one would expect socioeconomic analyses of high-speed rail to cover, before section 8.4 reviews how VWI and ECON have handled these elements in their reports. Risk and sensitivity analyses are covered in section 8.5. Finally the findings regarding socioeconomic analysis are summarised in section 8.6, where we also give recommendations for further work on socioeconomic effects.

8.1 Clarification of the purpose of and alternatives in the analyses

8.1.1 Reference alternative

Before starting a cost-benefit analyses, the project's goals must be defined. The purpose of the VWI and ECON reports is to compare Oslo - Trondheim and Oslo - Gøteborg routes using high-speed rail with the present situation, within a given period. In order to achieve the project's goal it is therefore important to devise a precise and sufficient description of the situation with and without the measure.

The reference alternative describes the situation if the measure is not implemented. As VWI points out, this is not necessarily identical with the situation as it is today, rather the reference alternative should describe how the situation is expected to be during the analysis period if the measure is not implemented. The reference alternative should therefore include measures that have already been decided upon.

As mentioned, the aim of VWI's report is to compare two rail options in the year 2020. VWI's reference alternative includes all infrastructure projects that have been decided upon (or that have already started) for train, air and road. VWI has taken as its basis the National Transport Plan 2006-2015, and all investments up until 2015 (if high-speed rail is not realised) proposed in this plan have been included in the reference alternative. The extended capacity described in *Handlingsprogram for Jernbaneverket* (Action programme for the Norwegian National Rail Administration), which follows the National Transport Plan, has also been included in the reference alternative.

The development alternative describes the situation including the measure in question, which in this case is high-speed rail. VWI defines two development alternatives, one version with a high-speed rail line between Oslo and Trondheim and another version with a high-speed rail line between Oslo and Gøteborg. VWI has also analysed costs for a number of other corridors, but has not carried out any full cost-benefit analyses for these routes.

ECON mentions neither reference nor development alternatives in its report, but the purpose of the report is to provide independent quality assurance[4] of VWI's cost-benefit analysis. It is therefore natural to assume that the reference and development alternatives are the same as in VWI's report. ECON also mentions that the cost-benefit analysis is based on the same basic figures as VWI. ECON also specifically mentions that investments in goods transport in the reference alternative could be saved in the development alternative.

According to the Norwegian National Rail Administration's Method Manual JD 205, there are several factors that both the reference and development alternatives should describe.[5] Several of the factors named are described in the reference and development alternatives in the VWI report. Changes in infrastructure, traffic volume and distribution of means of transport in the relationships within the study area are described. In particular, traffic volume on the different routes is described in detail, for both the reference and development alternatives. In line with the method manual, the population around the main hubs for the Oslo-Trondheim alternative is shown. The macroeconomic development is not described any further however. Neither population and income developments nor price and cost trends are described. The report mentions that traffic demand will increase by 34 per cent because of demographic changes and economic growth, without specifying this any further. It is true to say that not all the factors mentioned in the method manual are relevant or important for this project. Population and income developments do however have a significant effect on the market shares of the different means of transport. This is something the report could certainly have studied in more detail. The market analyses are considered in more detail in section 4.

[4] Commissioned by the Ministry of Transport and Communications.

[5] Method manual JD 205 on socioeconomic analyses for rail, page 38.

We find no explicit description of the reference and development alternatives in the VWI report (the alternatives are described in several sections), but the most important points have been included in the description. The reference alternative described is based on the National Transport Plan, together with traffic volume in 2020. The development alternative includes a description of the measure itself, as well as assumptions for traffic volume, transport distribution and costs. It would still have been an advantage to collect together the two alternatives in a more systematic way, so that it would be easier to understand what the different alternatives actually contain.

Reference alternative 2020 Oslo-Trondheim
It is assumed that the Gardermoen line will be extended from Eidsvoll to Sørli, regardless of the implementation of high-speed rail. The extension of the E6 is also taken into consideration, as well as access to Trondheim between Heimdal and Trondheim central line. Even though the Gardermoen line is extended and travelling time will thus be cut by 20 minutes, market share is not expected to change, since the Oslo-Trondheim route is dominated by air traffic. Air passengers who transit in Oslo or Trondheim and continue to a domestic destination (about 1,000 passengers a day) are not included in the study, since this market is not within the railway's scope.

Reference alternative 2020 Oslo-Halden (-Gøteborg)
It is assumed that the Norwegian National Rail Administration will complete the new Intercity line from Oslo via Moss to Råde, regardless of the implementation of the high-speed rail project. It is planned to build double track between Oslo and Ski in the next few years as well as an extension of Moss station and a connection with the existing high-speed sections towards Ski and Råde. It is therefore necessary to design a route between Råde and the Swedish border. Development in Sweden has not been included in the analysis. An analysis has only been made of the high-speed line in the Norwegian part of the Oslo - Gøteborg route. VWI has included all these planned projects in the reference alternative.

8.2 Determining calculation assumptions

8.2.1 Discount rate

The discount rate is the required return on the measure. This means that the discount rate used should reflect how much society requires as compensation for investing in, for example, railway infrastructure. The required return will be affected by what kind of return is required by society, represented by the elected politicians. Uncertainty linked to the measure will also affect the size of society's required return. The uncertainty in a project is described through systematic and unsystematic risk. Systematic risk is, for example, the cyclical economic situation, while unsystematic risk is project-specific uncertainty such as geological conditions.

VWI and ECON use different discount rates for the analysis, 2 and 4.5 per cent respectively. The rate used by VWI corresponds to what in Norwegian cost-benefit analysis is called the risk-free discount rate. The risk-free discount rate indicates the cost to society of tying up capital in risk-free activities. This means that risk is not included when the various cost and benefit elements are discounted to the reference year in the analysis performed by VWI. On the other hand VWI adds a risk supplement of 20 per cent to its estimated infrastructure costs. ECON has used a discount rate of 4.5 per cent, which corresponds with that recommended in the Norwegian National Rail Administration's Method Manual JD 205. The rate of 4.5 per cent consists of the risk free rate of 2 per cent and a risk supplement of 2.5 per cent. This risk supplement is to handle the systematic risk in the project.

The risk supplement in the discount rate is not necessarily the most appropriate way of representing risk in all cases. In some cases the risk will be linked to specific conditions within the measure and it will be more appropriate to perform a qualitative risk assessment.

In the Department for Transport's guidelines in England, Transport Appraisal Guidance (TAG), and in The Green Book, the discount rate is set at 3.5 per cent and the analysis period at 30 years. TAG also recommends that a lower discount rate should be used to discount costs and benefits that come more than 30 years in the future. A gradual reduction of the discount rate is suggested.

According to the guidelines for Danish cost-benefit analyses (Ministry of Transport, 2003), by comparison, a discount rate of 5 per cent should be used for infrastructure projects in the transport sector. The Danes use a relatively long period for analysis: 50 years.

The reasons why different countries use different discount rates are due to both political decisions about the size of the required return and different ways of taking the risk into account.

In comparison with the Norwegian method, the effect of using the English method will be that a lower discount rate gives higher benefits in the future; one values future benefits relatively highly in relation to the benefit today. A longer period also gives a higher valuation of the benefit. These two effects both tend towards a higher valuation of benefit. The Danish method has a higher rate than in Norway, but also a longer analysis period. These two parameters have effects with opposite characteristics and the effect they have on the calculation of benefit will be specific to the particular case.

Our assessment of the various choices of discount rate is in agreement with ECON that a discount rate of 4.5 per cent should be used. This also agrees with the recommendations of the Norwegian National Rail Administration and the Ministry of Finance. VWI's uncertainty supplement on investment in infrastructure alone appears to be a procedure that does not take into account the possibility that other cost-benefit elements are uncertain. It should also be mentioned that high-speed rail is a project of a size that perhaps the existing methodology in Norway has not been dimensioned for. High-speed rail in

Norway will be a measure with a high proportion of fixed costs. This will tend to make the measure more risky since it is difficult to adapt it to changes in demand over time. Seen in isolation this would indicate that a higher discount rate should be used. This should lead to more attention being paid to sensitivity analyses when presenting results.

Using a discount rate of 4.5 per cent rather than 2 has major consequences for calculating the socioeconomic profitability in this case. The net benefit that VWI has calculated for the Oslo-Trondheim high-speed rail line would become negative, since the present value of the benefit will be approximately halved. This is because future benefit flows are given less weight with a higher discount rate.

8.2.2 The analysis period

The Norwegian National Rail Administration's Method Manual indicates that in the analysis of a project the following timings must be clarified: year of reference, year of implementation, year of effect, year of calculation and analysis period.

VWI takes care to present all benefits and costs in the form of annual amounts. The investment costs are therefore converted to annuities based on each component's lifetime. Annual benefit is calculated on the basis of traffic calculations for the year 2020, with and without high-speed rail. The report is clear about which date forms the basis for the analysis.

ECON has followed the Norwegian National Rail Administration's Method Manual in specifying the various timings in the analysis. The year of reference is 2015, the years of implementation are 2016-2019. The years of effect and time horizon extend to 2080. ECON has used the same lifetime for the infrastructure components, but has included reinvestment, which we believe is the right approach. The basis year for price level is 2006.

As is current practice, the basis is that the relationship between prices as it exists in the basis year remains constant throughout the analysis period. Different developments in real prices can change the relative relationship between prices (including time values), for example between means of transport, and also between benefit and costs. If all prices develop in line, the analysis will not be affected. If one cost develops at a different rate to prices generally, WebTAG (Department for Transport) recommends taking this into account. In order to make such a correction, we must have an advance opinion on future real price development for the relevant costs. Among the countries that perform cost-benefit analysis in a similar way to Norway, only the United Kingdom, as far as we can see, facilitates such corrections at present, but there are signals that Norwegian transport agencies will consider introducing this.

8.3 Mapping effects

8.3.1 Traffic effects

The basis for VWI's socioeconomic analysis is a relatively wide market analysis of the consequences of introducing high-speed rail in Norway. The analysis has been performed using a comprehensive simulation tool. As mentioned, VWI's market analyses has been supplemented by a report from Urbanet Analyse in which the effects of high-speed rail are simulated with the NTM5 model.

Both UA and VWI find that train will take considerable market share from both air and car/bus.

Table 8.1: Modelled market share with and without high-speed train (2020 without major road measures in NTM5).

Table 7-3 Modelled market share with and without high-speed train (2020 without major road measures in NTM5)

VWI	Rail	Air	Car/Bus	Rail	Air	Car/Bus
	2005 (%) without high-speed			*2020 (%) with high-speed*		
Oslo-Bergen	16	61	23	54	37	9
Oslo-Stavanger	7	68	25	32	57	11
Oslo-Kristiansand	13	24	63	48	17	35
Oslo-Trondheim	16	45	39	51	28	21

NTM5	Rail	Air	Car/Bus	Rail	Air	Car/Bus
	2006 (%) without high-speed			*2020 (%) with high-speed*		
Oslo-Bergen	24	48	28	45	31	24
Oslo-Stavanger	14	50	36	31	37	32
Oslo-Kristiansand	22	28	50	32	21	47
Oslo-Trondheim	18	40	42	33	29	38

Source: Urbanet Analyse (2008), table 7-3

ECON has not performed its own market analysis, but bases its own calculations on figures from VWI.

See otherwise section 3, which discusses the market analyses that have been put forward.

The most important driver behind high-speed rail being expected to take substantial market shares from air, car and bus is that high-speed rail involves reduced generalised travel costs in the eyes of the passengers. By this we mean that the total of ticket and time costs is lower for high-speed rail than for air, car or bus for a significant number of travellers.

8.3.2 Monetised and non-monetised effects

Neither VWI nor ECON take up non-monetised effects such as impact on nature and landscape and barrier effects. In a final assessment of development, the non-monetised effects must be taken into consideration together with the effects that have been quantified and monetised in the cost-benefit analysis.

The monetised effects that one should consider including in the cost-benefit analysis are:

- railway investment costs
- increased operation and maintenance costs with the rail infrastructure
- changes in operating costs for train companies (including investments in rolling stock)
- changes in ticket income for train companies
- changes in subsidy requirements for public transport companies charged to the public purse
- changes in operating costs for airlines
- changes in operating costs for bus companies
- changes in maintenance costs (wear and tear) for roads
- changes in road toll income
- changes in ticket income for airlines
- changes in ticket income for bus companies
- changes in ticket costs (driving costs for motorists) for travellers
- changes in the travellers time usage on travel
- changes in tax revenues to the government
- changes in noise costs
- changes in emissions costs, local environment
- changes in emissions costs, global environment (CO_2)
- changes in accident costs
- residual value of investment at end of analysis period
- tax cost of net effect on public budget
- investment savings on single projects within the reference alternative

There may also be costs relating to traffic handling in the construction phase. None of the reports presented describes special consequences for operators or travellers in the construction phase.

Changes to the transport system on this scale can cause changes in company and household location decisions, give the population better access to employment and give companies better access to a labour force of more relevant expertise. The extent to which cost-benefit analyses according to current practice cover such effects is a current professional debate. If the assumptions for perfect markets are fulfilled, the consumer and manufacturer surpluses calculated in the transport market will reflect the benefit to society (with the exception of external effects linked to the environment and accidents and tax costs, for which corrections are made). With market imperfections, *added benefits* of investments occur, that is to say socioeconomic effects that are not included in the present cost-benefit analyses. Empirical studies of the connection between transport investments and economic developments have shown that it is difficult to generalise when it comes to the extent and direction of effects (OECD 2008). No consensus has been established as to how such effects should be taken into account in socioeconomic analyses of transport investments, but there are examples of methods (Heldal et al. 2009; Department for Transport).

Below we review the extent to which ECON and VWI have taken the effects we have listed into account. We have structured the review to follow the same categories that are used in the Norwegian National Rail Administration's Method Manual, i.e. travellers, operators, the public sector and society in general.

8.3.3 Traveller benefit

Effects for travellers include changes in travelling time and costs (ticket costs for train, bus and air and driving costs for car). Travelling time is included by both VWI and ECON, although in somewhat different ways, as we shall see in section 4.10.6. There we will also go into more detail about the use of the net method, which means that changes in monetary travel costs for travellers are not a separate element in either VWI's or ECON's analysis.

8.3.4 Operator benefit

We assume that the operators affected are train and bus companies and airlines. It might also be relevant to include road toll companies because of reduced car traffic.

The operators will see changes to both costs and income. By costs, we are here thinking of operation of the transport, including maintenance and investment in rolling stock. Costs are connected to the form of operation, which in this case is defined in the case of high-speed rail. (This is discussed in detail in the VWI report.) For the other forms of transport affected, we do not how how what they offer will be adapted to the presumed changes in demand. ECON only considers the operating costs for high-speed rail and assumes that effects for other operators can be ignored, since they will adapt to the new basis for traffic and income. VWI concludes that society will save transport costs when traffic that would have gone by car, air and bus in the reference alternative travels instead by high-speed rail in the development alternative. The differences are included in the benefit of modal shift. This also applies to the transferred traffic. The total operating costs for high-speed rail are shown in a separate cost element however.

Changes in the operators' income are not considered in either ECON's or VWI's analysis, since they use the net method. This ignores transfers between parties, so that the travellers' ticket costs and the operators' ticket income - which cancel out the socioeconomic calculation - are not shown. Neither therefore is there any discussion of the extent to which the new train service will be financed from ticket income or public subsidy respectively. ECON does assume however that operation will be financed by ticket income and therefore does not calculate any tax cost in the operating costs.

8.3.5 Effects for the public sector

A review of the development alternative shows many effects on the public budget. The effects cover infrastructure costs, changes in tax revenues and transfers (subsidies/public purchases in public transport). According to the Norwegian method, a tax cost of 20 per cent of the total effect on the public budget should be reckoned on.

Changes to tax revenues are linked to fuel taxes and value added tax. This does not normally represent a significant amount and has been ignored here.

Transfers from the government to the operators are not considered in either the VWI or the ECON report. This is presumably outside their mandate for discussing how the new train system could be financed.

What remains as a basis for calculating tax costs is thus infrastructure costs. The largest cost element here is investment in new railway infrastructure. On top of this come operation and maintenance of the infrastructure. The investment, operating and maintenance costs in the VWI and ECON reports are based on the same cost estimate.

According to the recommended methodology, when investments are made in installations that have a longer lifetime than the analysis period, the residual value of the investment at the end of the analysis period should be taken into account. VWI operates with annuities that are based on the whole lifetime. Neither is residual value explicitly discussed in ECON's analysis.

In the development alternative it may be relevant to drop projects that will apparently be realised in the reference alternative. ECON considers that investments for goods traffic in the reference alternative can be saved in the development alternative, since track capacity from passenger traffic with normal trains will be released.

Depending on the amount of traffic that moves from road and air, operating and maintenance costs for infrastructure there may also be saved. ECON takes this into consideration with regard to wear and tear on roads.

The extent to which VWI has taken saved investment, operating and maintenance costs for infrastructure into account is not obvious.

As regards tax costs, ECON has included this in its figures, while VWI - in line with German methods - has not. If tax costs are not be calculated, as in the German method, taxes and other transfers between the government and other parties become irrelevant to the analysis. Such conditions are however relevant to the traffic analysis to the extent that they are reflected in the prices according to which the parties trade.

Identifying the effect on the public budget is moreover not only relevant to find the basis for the tax cost calculation. As we see it, it is the effect on the public budget that should be the denominator in the cost-benefit fraction if one intends to measure the net benefit achieved by society for each budget krone invested. If the operating costs of high-speed rail are to be covered by ticket income, it is wrong to include the operating costs in the denominator of the cost-benefit fraction as VWI has done. (ECON shows the net benefit, not the fraction.)

8.3.6 Society in general

External costs comprise monetised environmental and accident costs. Under monetised environmental costs, we would expect to find noise costs, local emissions costs and CO_2 costs. Both VWI and ECON cover all these. Accident costs are also covered by both analyses.

8.4 Valuation of effects

8.4.1 Calculation principles for traveller benefit and operator benefit

VWI's cost-benefit analysis is based on German methods (Federal Ministry of Transport, Building and Housing, 2005), but has also partly made use of Norwegian unit prices. ECON's cost-benefit analysis is based on Norwegian methods (Norwegian National Rail Administration, 2006).

In broad terms (apart from the employment effects, which are included in the German method) VWI and ECON take into account the same effects, but in different ways, at different levels of precision and to some extent with different weighting. In this section we shall concentrate on the main differences in the calculations, namely the valuation of benefits and costs for travellers and operators. Let us first outline a framework in relation to which the two analyses can be assessed.

We use the term existing traffic for journeys by train that exist in both the reference and development alternatives. By transferred traffic, we mean journeys by car, bus or air in the reference alternative where travellers choose train in the development alternative. Newly created traffic is journeys that do not take place in the reference alternative but are generated because what is offered in the development alternative has been improved. We could usefully consider ordinary trains and high-speed trains to be two different forms of transport, but neither VWI nor ECON has made this distinction in its presentation.

Benefit for the traveller consists firstly of changes in time costs (T^0 - T^1) and secondly of changes in ticket costs or driving costs (B^0 - B^1):

$$\textit{Traveller benefit} = T^0 - T^1 + B^0 - B^1$$

We are thinking here of passengers who originally travel by car, bus, air or train and who will make use of the new high-speed train. We ignore effects in the travel markets from which these travellers are transferred, that is to say that those who continue to travel by car or air after the new system is created are not considered to experience any changes in travelling time or costs.

Operators in most travel markets will be affected. Both airlines and bus companies will experience a loss of income and a cost reduction when traffic is transferred to the new trains, and there will be changes in income and costs for the train company or companies. By costs, we are thinking here of operation of transport, maintenance and investment (with the exception of publicly financed infrastructure). The sum of the income changes ($B^1 - B^0$) and cost changes ($D^0 - D^1$) for all operators gives the following change in operator benefit:

$$\textit{Operator benefit} = B^1 - B^0 + D^0 - D^1$$

The tickets represent a transfer from the travellers to the operators and are cancelled out in the socioeconomic calculation. What remains of the traveller and operator benefit is changes in time costs and changes in operator costs. If we use the so-called net method, these are the only elements we are concerned about from this part of the cost-benefit analysis. If on the other hand we choose to present the analysis by the gross method, in which the effects for the various parties are identified, we will show both the traveller benefit and the operator benefit explicitly. It is normal to express travel cost and time benefits jointly as generalised cost. The change in generalised cost is multiplied by the number of journeys (existing train traffic), while the newly created and transferred traffic is multiplied by half the change in generalised cost. Altogether, this represents the change in the consumer surplus in this travel market.

The gross method is especially useful if it is the case that the operators' shortfall generates a need for public subsidy, so that the subsidy is a cost on which tax cost will be calculated. If the purpose is to show the return on each invested public krone, such subsidies should also be included in the denominator when net benefit per budget krone is calculated. Operator costs that are *not* covered by the public budget should not be included in the denominator. The social effect of the changed transport cost that is *not* in the public budget should however be included in the net benefit and thereby in the numerator in the cost-benefit fraction.

The gross method is in line with the set up in the Norwegian National Rail Administration's Method Manual. However neither VWI nor ECON have used the gross method here, but have calculated time gains ($T^0 - T^1$) and changes in operator costs ($D^0 - D^1$).

8.4.2 Time gains

The travellers benefit from time gains with the introduction of high-speed rail. VWI calculates the benefit in the following way: the changes in the number of hours travelling time in total by train, bus and air respectively, multiplied by the time value for each means of transport. This corresponds to $T^0 - T^1$ from the framework above. Some new travellers also come in addition to those who were transferred from other means of transport. The newly created traffic is due to increased accessibility and is attributed a benefit equal to 10 per cent of the time gain that was calculated for the existing and transferred traffic. We can also consider this to be part of T^0 - T^1.

What is referred to in ECON's report as change in generalised cost appears only to apply to change in time cost. There is a change in generalised cost (or actual travelling time x time value) multiplied by the number of journeys. Newly created traffic is taken into account by multiplying the relevant number of journeys by half of the change in generalised cost, in line with the trapezoidal rule and with Norwegian practice.

Thus newly created traffic is treated differently in the two methods, while time saving for existing and transferred traffic is directly comparable. As regards the existing and transferred traffic, this does not in principle have anything to say about the calculation of saved time costs based on total change in travelling time, as VWI does, or on the change in time usage for the individual traveller multiplied by the number of travellers affected, as ECON does. The results should be the same if they are based on the same traffic figures, travelling times and time values. This is however not the case.

In order to illustrate this, we shall look more closely at the analyses of the Oslo-Trondheim corridor. The combined traffic figures from VWI's report also form the basis for ECON's calculation. The difference between the two calculations arises when we look at travelling time by the different means of transport. VWI is based on results from a transport model and also includes among other things an element of normal train in the case of high-speed rail. ECON makes a simplification and considers an average journey. In this simplification it would appear that all passenger journeys by train in the corridor are by high-speed train once this option has been created. This is the main reason why ECON's estimated time gain is higher than VWI's. Table 8.2 shows how this difference in assumptions affects the result of the benefit calculation.

The time values used are based on the Norwegian National Rail Administration's Method Manual and represent a weighted average of travel purposes. A small difference occurs because the rate for official journeys by air in VWI's calculation differs from that given in the Norwegian National Rail Administration's Method Manual - probably unintentionally.

Table 8.2: Comparison of saved time costs with different assumptions about travel time changes

VWI			**Assumption that all train travel is by high-speed train in the high-speed rail alternative (ECON)**		
Mill. hours reduction per year	*Time value (kr/hour)*	*Saved time cost per year (mill.kr)*	*Mill. hours reduction per year*	*Time value (kr/hour)*	*Saved time cost per year (mill.kr)*

Train	-3.50	145.20	-508.8	-0.94	145.20	-135.9
Car	0.88	213.20	186.8	0.60	213.20	128,8
Bus	0.99	88.20	86.9	0.63	88.20	55.9
Air	2.04	282.00	576.4	1.95	292.80	570.5
Total			**341.3**			**619.3**

Source: VWI (2007a) and ECON (2008), own comparison

VWI calculates that the time gains are worth NOK 341 million per year. With a 10 per cent addition for newly created traffic, VWI ends up with NOK 375 million.

ECON has calculated the average cost change for a journey in this corridor to be NOK 430. With the existing and transferred traffic of 1.44 million journeys per year, the time gain is worth NOK 619 million per year for this traffic. Including newly created traffic, the number of journeys rises to a total of 1.95 million and the result becomes 1/2 x (1.95 + 1.44) x 430 = NOK 729 million per year (trapezoidal formula).

ECON's simplification leads to an overestimate, while VWI has a small underestimate (given that the traffic figures are credible). With the time values from the Norwegian National Rail Administration's Method Manual and the travelling times from VWI, saved time costs for existing and transferred traffic would be NOK 363.4 million per year. The benefit for newly created traffic is in addition and according to the German method this will be 10 per cent of 363.4, so that the combined benefit of time and accessibility becomes NOK 399.7 million per year. According to the Norwegian method, the benefit for the newly created traffic is calculated as the number of journeys times half the change in generalised cost. If here we only consider the time costs in generalised costs, the change per journey will be about NOK 252 on average. The benefit of newly created traffic will thus be 0.5 x 252 x (1.95 - 1.44) = NOK 64.3 million per year, and the combined benefit of time gains becomes NOK 427.7 million per year.

The saved time costs we have described here are not the same as the traveller benefit as calculated in Norwegian practice. ECON points out that, to arrive at the traveller benefit, one must also take into account the change in ticket costs by means of public transport and driving costs by car that the traveller experiences. This would have been in line with the gross method. As mentioned, ECON does not consider ticket costs or income in this cost-benefit analysis, but only looks at time costs and operating costs (net method).

In the German method, the traveller benefit and operator benefit are not shown explicitly. Traveller benefit is covered partly by time and accessibility (newly created traffic) and partly by the benefit of change in the choice of means of transport. This last also partly covers the operator benefit.

Several questions arise in connection with the use of time values in cost-benefit analysis of high-speed rail. To begin with, it is a weakness that journeys by high-speed train and normal train are treated equally as regards the value of saved travelling time. What would the consequences have been for the analysis result if the time value of high-speed rail had been higher? Secondly, there are several ways of valuing time savings when journeys that are taken by a means of transport in the reference alternative are transferred to another means of transport in the development alternative. Which principle for choice of time value should be taken as a basis?

High-speed and normal trains are qualitatively different concepts and to some extent attract different market segments. It is therefore reasonable to suppose that the value of saved travelling time with high-speed trains is on average greater than with normal trains. The results of the Urbanet Analyse survey of air passengers' preferences indicates this. The time value for high-speed rail will probably be closer to that of air than that of normal trains.

We thus have two situations here:

I. The time value for high-speed trains is the same as that for normal trains, as in the analyses presented.

II. The time value for high-speed trains is higher than for normal trains and probably closer to that of air travel.

We recommend assessing II. This will have consequences for the results both in the transport model and in the cost-benefit analysis. We will consider here the consequences in the cost-benefit analysis. The result here is affected in various ways depending on how we proceed in valuing saved travelling time when traffic is transferred from one means of travel in the reference alternative to another in the development alternative.

Time values are based on willingness to pay for a shorter travelling time and include both traveller and means of transport specific components. For example a high level of income among travellers is a property that might help to raise the willingness to pay. High comfort is a property of the means of transport that might tend to reduce the willingness to pay, since (seen in isolation) it then becomes less important to spend less time on board. It is difficult to know anything about the composition of the traveller and means-of-transport-specific components for precisely the travellers who are transferred. There are at least three possible ways of calculating the time gain for the transferred traffic.

A) Time usage for the means of transport being transferred *from* (for example car) is valued with a time value for this means of transport (for example time value for car journeys). Time usage for the means of transport being transferred *to* (for example train) is valued with a time value for this means of transport (for example time value for train journeys). Saved time costs will be the difference between the two elements.

B) The basis is how many hours are saved (for example 2 hours on a journey that took 5 hours by car in the reference alternative and takes 3 hours by train in the development alternative). The time saved is valued with a time value for the means of transport the journey is being transferred *to* (train in this example).

C) Basis as in B, but saved travelling time is valued with a mix of the time values of the two means of transport involved.

VWI's calculation corresponds to A. Killi (1999) recommends B as a general rule and C if there is a large difference between the relevant time values. Caution is advised when using C. It is difficult to determine the conditions for mixing the two time values involved. Killi (1999) takes up this question in connection with transferring traffic to or from air, since up to now air has been the means of transport that distinguishes itself in terms of the level of time values. The recommendation there is to use 1/6 of the time value of the means of transport being transferred *from* and 5/6 of the time value of the means of transport being transferred *to*.

What might call for the use of a mix of the two time values in our case is that there may be a large difference in time value between car and high-speed train. The same applies to transfer between bus and high-speed train. Thus in these two cases the use of calculation method C may be sensible. For transfer between air and high-speed rail on the other hand, we believe that the time values are more equal. Here the value for the means of transport being transferred *to* should be used unadjusted (calculation method B).

It is probably the motorists with the highest time value who have the greatest inclination to choose train rather than car when travelling times by train are reduced. They could also have travelled more quickly before if they had chosen air, but there are preferences regarding means of transport that have caused them to prefer car. They may have a fear of flying for example or they may be unwilling to break the journey with waiting and security checks at the airport. These motorists may have stronger preferences for rail than for air, but as long as the travelling time by train was so long they continued to use the car. When the travelling time by train goes down, the potential in the benefit of saved travelling time is realised for them. Their time value is higher than the average for motorists. This indicates that it is appropriate to move in the direction of the time value by high-speed train, which we would assume to be higher than the average for either car or normal train.

We have now seen that the time value for travel by high-speed train can be as for normal train (I) or higher (II) and that there are different ways of valuing time savings in respect of traffic that is transferred between means of transport (A, B and C). We shall now see that the consequences of using I or II depend on whether we use A, B or C. Call the combinations AI, AII, BI and so on. Assume for the moment that traffic figures are the same regardless of which time value is used for high-speed train, so that we can study here the effect on the cost-benefit analysis alone.

Going from AI to AII means that high-speed rail will come out less well in the cost-benefit analysis. If we calculate saved time costs in the way VWI has done, and introduce a higher value for high-speed train, then higher time costs will arise from the development alternative.

On the other hand, if we go from BI to BII or from CI to CII it will be in high-speed rail's favour. The benefit of saved travelling time is valued more highly.

It is important to have these conditions clear in order to be able to assess claims such as that higher time value for high-speed rail will have a positive effect on the result of the cost-benefit analysis.

8.4.3 Saved transport costs

According to both the Norwegian and German methods, one should take into account that changes in usage of means of transport affect costs for travellers, operators and infrastructure holders. In general we can list the following effects of this project for travellers and operators (we ignore taxes here):

Table 8.3: Traveller and operator benefit with development

Traveller benefit	**Operator benefit**
ΔT Saved time costs	
ΔK Saved driving costs, car	
ΔB_{air} Saved ticket costs, air	ΔB_{air} Red. ticket income, air
ΔB_{bus} Saved ticket costs, bus	ΔB_{bus} Red. ticket income, bus
ΔB_{train} Increased ticket costs, train	ΔB_{train} Inc. ticket income, train
	ΔD_{air} Red. operating costs, air
	ΔD_{bus} Red. operating costs, bus
	ΔD_{train} Inc. operating costs, train

Some elements cancel each other out. This is handled in different ways in German and Norwegian practice.

German practice: Ignore tickets, which are pure transfers.

Table 8.4: Calculating benefit according to German practice

Traveller benefit	**Operator benefit**
ΔT Saved time costs	
ΔK Saved driving costs, car	
ΔB_{air} Saved ticket costs, air	ΔB_{air} Red. ticket income, air
ΔB_{bus} Saved ticket costs, bus	ΔB_{bus} Red. ticket income, bus
ΔB_{train} Increased ticket costs, train	ΔB_{train} Inc. ticket income, train
	ΔD_{air} Red. operating costs, air
	ΔD_{bus} Red. operating costs, bus
	ΔD_{train} Inc. operating costs, train

Consequently, VWI counts firstly the time gains ΔT, secondly the benefit of changed use of means of transport (brackets in the expression below), and thirdly the operating costs ΔD_{train} with the new trains.

$$\Delta T + (\Delta K - \Delta D_{train\ for\ those\ transferring\ from\ car}) + (\Delta D_{air} - \Delta D_{train\ for\ those\ transferring\ from\ air}) + (\Delta D_{bus} - \Delta D_{train\ for\ those\ transferring\ from\ bus}) - \Delta D_{train}$$

For us this appears to be a double count of the operating costs for train and for the part of the traffic transferred from other means of transport.

Norwegian practice: Assumes that operating costs and ticket income from means of transport other than the travel market we are considering offset each other.

Table 8.5: Calculating benefit according to Norwegian practice

Traveller benefit	**Operator benefit**
ΔT Saved time costs	
ΔK Saved driving costs, car	
ΔB_{air} Saved ticket costs, air	ΔB_{air} Red. ticket income, air
ΔB_{bus} Saved ticket costs, bus	ΔB_{bus} Red. ticket income, bus
ΔB_{train} Increased ticket costs, train	ΔB_{train} Inc. ticket income, train
	ΔD_{air} Red. operating costs, air
	ΔD_{bus} Red. operating costs, bus
	ΔD_{train} Inc. operating costs, train

Consequently according to Norwegian practice one should calculate traveller benefit consisting of elements in the left column and operator benefit consisting of elements to the right. If the assumptions hold that operation and income for air and bus are equivalent, Norwegian and German practice here should comprise exactly the same elements. There is thus nothing remarkable in calculating the benefit of changes in use of means of travel, but it is unusual, from a Norwegian point of view, that all the benefit associated with this should, according to the German method, be accumulated in one benefit element. Separate calculations for each party would have been more transparent.

What ECON does however, as far as we understand it, is to ignore everything other than time gains for travellers and operating costs for the new trains. There is a footnote comment that changes in ticket costs and driving costs should have been taken into consideration if traveller benefit were to be calculated completely.

The difference between VWI's and ECON's calculations in terms of *what elements are included* is therefore driving costs by car and operating costs (or ticket costs if you will) for air and bus.

What elements are included is one thing; how they are valued is another. We have seen that the time gains are handled somewhat differently in the two analyses. The operating costs for the new trains are the same, since the Norwegian analysis has adopted the German cost estimate. As regards the elements that in our view should have been included according to Norwegian practice, but which are not included here, namely the costs for car, air and bus for the travellers who want to travel by train in the development alternative, we assume that the standard German values used by VWI are higher than the corresponding Norwegian values. For time and budget reasons, VWI did not have the opportunity to estimate Norwegian rates. The basis they took was that it costs NOK 2.24 more per passenger kilometre for a traveller using car instead of train. The corresponding rate is NOK 1.52 for changing from bus to train and NOK 3.44 from air to train. In the Oslo-Trondheim corridor, this gives an annual total of NOK 1,288 million in benefit from modal shift.

This is the major difference in saved costs that is half the explanation of why VWI's analysis shows positive net benefit from high-speed rail, while ECON's analysis does not. (The other half of the explanation is the discount rate.) The reason is that VWI's calculation of cost savings with changes in choice of means of transport both includes effects that ECON has not taken into consideration and also values these effects highly. According to Norwegian practice, these effects should be taken into account, but they should be valued at different rates from those used in Germany.

In SOU 2009:74, a cost-benefit analysis has been carried out in which the benefit of changes in use of means of transport is calculated and included in the socioeconomic calculation. The Swedish calculation is in accordance with the gross method, which is to say that the analysis identifies effects for the operators' ticket income and operating costs. The result of the cost-benefit analysis is a benefit to cost ratio of 1.15, which is to say that the overall benefit is 15 per cent higher than the costs. We will not place any emphasis on the result here, since the calculation has been criticised for underestimating the costs and overestimating the income, but the method is of interest to us.

The Swedish analysis is an example that the assumption that reduced ticket income corresponds to reduced operating costs for air, as ECON implicitly assumes, is not commonplace. In the calculations, the income reduction for air is estimated to be 50 per cent higher than the reduction in costs. The Swedish calculations also show that an assumption that the reduction in ticket income for air is equivalent to increased ticket income for rail, as VWI has implicitly assumed, is not commonplace either. In the Swedish cost-benefit analysis, the ticket income for rail is estimated to increase by more than double the reduction in ticket income for air.

The recommended method in Norway, which is reflected in the Norwegian National Rail Administration's Method Manual, is to use the gross method where effects for the different parties emerge at the same time as only the net effects have an effect on the socioeconomic result. Neither of the analyses we have looked at uses the gross method. The net effects that we thereby expect to find in respect of effects for travellers and operators are changes in time costs for the travellers and changes in the operators' operating costs including investment in rolling stock.

We have found that:

- Saved time costs are overestimated in ECON's simplified calculation
- Saved time costs are slightly underestimated in VWI's calculation, because of the rate for time value for flights
- The benefit from changes in the choice of means of transport in VWI's analysis appears remarkably high. This element alone drives the benefit up considerably and the effect is further strengthened by the low discount rate that VWI uses (with a Norwegian level of discount rate, the amount of benefit from this element would have been roughly halved).
- Saved costs for air and bus have not been taken into account in ECON's analysis, and neither have driving costs for car.

We recommend that:

- The operating costs for the transport option and the investments in rolling stock should be included in the denominator in the cost-benefit fraction only to the extent that they are to be covered by the public budget.
- Traveller and operator benefit should be explicitly shown (even though it is not in principle wrong to show only net effects)

Different unit prices should be assessed for travel by high-speed train and by normal train. This applies to both time values and ticket prices and could have consequences for both traffic analyses and cost-benefit analyses.

8.4.4 Consequences for the public sector

The consequences that normally apply for the public sector with infrastructure projects, as we have mentioned before, are infrastructure costs (investment, operations and maintenance), any public purchases, changes to tax and duty revenues and tax costs. We shall ignore tax and duty revenues here. Tax costs will be discussed in a separate section below.

We shall not comment here on the level of the cost estimate, but on the procedure for the cost-benefit analysis. In the Norwegian method, investment costs are discounted to a year of reference and a residual value is calculated at the end of the analysis period that is discounted back to the year of reference. The residual value is based on linear depreciation. On the other hand VWI converts the various investment components into annuities based on the lifetime of each individual component, in spite of the fact that the German method manual also uses the residual value method. VWI confirms that it is normal practice to use annuities since this makes it possible to compare annual cost and benefit. What consequence does this difference in method have? The important thing here is the discount rate. With a low rate the difference in the results of the two methods will be small. A higher rate will mean that investment costs are higher with the annuity method than with linear depreciation and a calculation of residual value.

It is not necessarily correct to treat the operation of the trains as a public sector cost. Public purchases are not discussed in either the VWI or the ECON report, which is understandable since financing of high-speed rail has not been clarified. If we assume that an operator will operate the trains, then the operating costs, including investment in rolling stock, belong under operator benefit and not under consequences for the public sector. ECON explicitly states that they do not calculate tax costs on operating costs since they assume these will be financed from ticket income. That is to say, the operating costs for rail are not considered as a public sector cost. VWI on the other hand has not commented on how they view the operating costs for rail, but we observe that they are included in the costs in the denominator of the cost-benefit fraction. If the operating costs are *not* to be covered by the public budget, VWI's cost-benefit fraction then gives a false picture of the benefit per budget krone.

The wear and tear costs are part of the operations and maintenance costs of the infrastructure. For rail, these costs are included in the analyses in the calculated operations and maintenance costs for the infrastructure. It may also be relevant to allow for reduced wear and tear costs for the forms of transport that will lose traffic to rail, i.e. road and aviation. This wear and tear will naturally depend on the amount of traffic that is transferred.

In VWI's presentation, wear and tear is not a specific point. ECON includes reduced road wear and tear as a specific point. ECON says in its report that "In general terms we can estimate this [the benefit of reduced wear and tear] by multiplying the reduced traffic for the various forms of transport on the two routes by the length of an average journey and a set cost per vehicle kilometre for wear and tear". We agree with this viewpoint but note that there must be a difference between the costs per vehicle kilometre used by ECON and the rates in the Norwegian National Rail Administration's Method Manual. We can make the following calculation based on VWI's traffic figures and the Norwegian National Rail Administration's rates for reduced maintenance costs in other forms of transport with the transfer to train:

Table 8.6: Reduced maintenance costs

Traffic from	*Mill. vehicle km per year*	*NOK per vehicle km (JBV)*	*NOK mill. per year*
car	38.9	0.33	12.8
bus	3.4	3.09	10.5

air	4.5	3.51	15.7

Source: VWI (2007a) and Norwegian National Rail Administration (2007b), own calculations

From table 8.6 we can see that the reduction in maintenance costs will be about NOK 23 million a year as a result of the reduced road traffic. ECON has estimated the reduction in road wear and tear at NOK 1.4 million a year, which implies a much lower kilometre cost since the vehicle kilometres are the same. ECON also argues that the benefit is internalised for air traffic, since Avinor is paid by the airlines to cover wear and tear in the infrastructure. The Norwegian National Rail Administration's Method Manual indicates however that reduced maintenance costs can be included in respect of traffic transferred from both road and aviation.

8.4.5 Society in general (third party)

According to the Norwegian National Rail Administration's Method Manual, reductions in noise costs should be calculated on the basis of transferred traffic. As far as we can see, VWI has used the rates given in the manual, even though they do not state where the rate for the new rail line comes from (corresponds to NOK 1.43 per vehicle kilometre). It should also be pointed out that the figures have been miscalculated in VWI's report. The balance between with and without the instance should be NOK 1.41 million per year for the Oslo-Trondheim route and NOK 1.39 million per year for Oslo-Gøteborg. VWI calculates that only 10 per cent of the track is in areas where people will be exposed to noise pollution.

The two reports put a different value on the benefit of reduced local emissions. The method for valuing local emissions is to use values for transferred vehicle kilometres in different types of local environments. VWI's estimate is NOK 0.7 million for the Oslo-Trondheim route. VWI's basis is that 10 per cent of the length of track should be included and only the rates in the Norwegian National Rail Administration's guidelines for areas of low building density should be used. We would ask whether the rates for cities and other built-up areas should not be used as a basis here, because as we understand it the 10 per cent of track for which the Germans are valuing an effect is in built-up areas.

ECON argues that "VWI assesses that only 10 per cent of all local emissions should be included, while the Norwegian National Rail Administration's rates already take into account that part goes through built-up areas" (ECON, 2008, page 60), and therefore believes that the VWI estimate should be multiplied by a factor of 10. ECON's estimate is therefore NOK 10 million.

Our assessment is that VWI's estimate is too low. They have used the rates for areas of low building density for 10 per cent of the track. We believe that the 10 per cent VWI uses lies in built-up areas according to the argument used for calculating noise pollution. They have therefore not taken into account the effect on the other 90 per cent of track. We have made a recalculation of this value with the figures VWI uses (thus we use not 10 per cent of the estimated change in vehicle kilometres, but 100 per cent), allowing for 10 per cent of the track to be valued as an average of the values for cities and other built-up areas and the remaining 90 per cent at the value for areas of low building density. We thus arrive at an estimate of NOK 9 million a year in benefit. ECON's estimate is closer to ours.

Transferring traffic from road and air helps to save environmental costs in the form of reduced CO_2 emissions. According to the Norwegian method, costs in respect of global pollution should be based in principle on the costs of adapting emissions to Norway's obligations under the Kyoto Protocol for the period 2008-2012. Norway can meet the obligation through measures in other countries either through direct investment or by buying quotas in Europe. The price for buying quotas in Europe can therefore be used as a proxy for the cost of meeting the obligation and the price of the CO_2 quotas can therefore be used as an indicator for these costs. The Norwegian National Rail Administration's Method Manual JD 205 states that the most long term contracts listed on NordPool are the ones to be used. Both ECON and VWI have used the price of CO_2 quotas as an indicator, but VWI has used a much higher price than ECON.

VWI has followed the rate recommended in the German method. The German method is also based on the cost of meeting specific national targets, but follow's Germany's targets. CO_2 emissions are valued based on the cost of meeting the German target, which is an 80 per cent reduction in emissions by 2020 in relation to the 1987 level. Several studies have estimated that the cost of meeting the German target is between 163 € and 205 € per tonne. The method also recommends using the highest rate so as also to capture some of the other greenhouse gases.

ECON has followed the Norwegian method and has used as a basis the CO_2 quota price currently quoted by NordPool. When the report was written (2008), this price level was around 25-30 € per tonne. ECON chose to use a price of NOK 273.33 per tonne, which is considerably lower than a price of 205 € (205 € is equivalent to NOK 1,640 at an exchange rate of NOK 8 = 1 €). It should be mentioned that the present quota price is considerably lower, at 12-13 € per tonne. The price has dropped to this extent largely due to the financial crisis and the climate summit in Copenhagen not resulting in a global climate agreement.

The large difference in the CO_2 quota price is primarily due to the differences in the national targets. As mentioned the Norwegian method is based on the cost of adapting the emissions to Norway's obligations under the Kyoto agreement and it is appropriate to use this valuation for emissions reductions up until 2012. For emissions reductions after 2012, which is the case in both reports, the extent to which it is still appropriate to use the Kyoto agreement as a basis should be discussed. ECON discusses the issue in more detail and refers to the climate compromise, the aim of which is to exceed the Kyoto obligations. It is therefore expected that the cost of measures will rise. ECON refers to a report published by Statistics Norway that performs an assessment, commissioned by the Norwegian Pollution Control Authority (now the Climate and Pollution Agency), of future quota prices, given the EU's climate goals for 2020. The Statistics Norway report concludes with a price of NOK 800 per tonne. Even so, ECON decodes not to use this price on the basis that the EU's targets cannot be compared with the Norwegian ones. It is however pointed out that the Norwegian authorities should arrive at a new estimate for the valuation of emissions after 2012.

Klimakur 2020, an expert group made up of Norwegian government agencies, is carrying out an assessment of future quota prices based on the EU target. The report looks more closely at expected quota prices for 2012, 2015 and 2020 and on towards 2030. The report points out that there is a great deal of uncertainty connected with future quota price development, since future political decisions will have great significance for this. For the European quota system however, the future development of climate policy over the next few years is fairly predictable, since the EU's climate and energy package was presented in 2008 and included a target of a 20 per cent cut in greenhouse gas emissions. Klimakur 2020 concluded that quota prices of 18, 26 and 40 € in 2012, 2015 and 2020 respectively are realistic. An assessment of the prices in the quota markets in 2030 has been carried out by Point Carbon for Klimakur 2020, given the assumptions specified in the global model that formed the basis for the 2020 estimate. If the 2 degree target is to be achieved, this will give a quota price of about 100 € per ton in 2030. That would mean a substantial increase between 2020 and 2030. This is however highly uncertain, since many assumptions would have to be realised for this assessment to be correct.

As mentioned, the VWI report uses a rate of 205 € per tonne, which is more than 50 per cent higher than Point Carbon's estimate for 2030 and more than 80 per cent higher than ECON's price. Based on the Statistics Norway and Klimakur 2020 assessments, it is estimated that the future quota price will rise. Even so, none of the reports is anywhere near the German level of 205 € per tonne. ECON has used Norwegian standards and a quota price of NOK 273.33 per tonne is not far off the 2020 estimate of Klimakur 2020 (even though this analysis was made before the ECON report was written). It is however far from Statistics Norway's estimates. But ECON has used Norwegian methods and it therefore appears that ECON has used the correct rate. With a quota price of NOK 273.33 per tonne, in comparison with VWI's price of NOK 1,640 per tonne, the benefit will be NOK 106 million lower in ECON's calculation.

It would however still be sensible to carry out a review of how future quotas should be priced, especially for projects with an extended time horizon, as ECON also points out in its report.

VWI assesses the benefit of reduced accident costs by using the Norwegian National Rail Administration's rates for changed traffic volume for other competing means of transport. This is assessed at NOK 13.3 million per year. ECON points out that the German method does not distinguish between costs that are distributed between internalised and external costs. Apart from this, ECON does not have any great methodological objections to what VWI has done and uses the same value (NOK 13 million per year) in its calculations.

Our assessment of what has been done is that both ECON and VWI have allowed for changed traffic volume on other means of transport giving a gross reduction in accident costs for these means of transport. Neither VWI nor ECON has allowed for increased traffic leading to increased accident damage and injury for rail. This means that the benefit of reduced accident costs should be reduced by the number of vehicle kilometres by which train traffic is changed multiplied by the Norwegian National Rail Administration's rates (table 8.10 in the Norwegian National Rail Administration's Method Manual JD205). High-speed trains cannot be directly compared with the existing trains in Norway. The rates should also really be revised therefore.

A well-integrated labour market in Europe will be a benefit for Norway as a whole. In the analysis made by VWI, the effects of better international relations are included as a benefit. This benefit is calculated by using the proportion of journeys that are estimated to be international multiplied by 10 per cent of operating and train investment costs and 10 per cent of the benefit connected with modal shift and newly created traffic. We are critical of the way this item has been calculated. Neither does the Norwegian National Rail Administration include such considerations in its Method Manual. ECON believes that this effect is reflected through changes in ticket prices and the like, with which we agree. Time values, that is the benefit of reduced travelling time, reflect the benefit of the activity at the destination.

The benefit of international relations should not be included as a benefit element in a cost-benefit analysis since these are projects that are not particularly directed at improving collaboration between countries. We believe therefore that international relations should not be included in the cost-benefit analysis for this project.

VWI has included employment effects in its analysis, both during the construction period and as a result of operations. The Germans use rates for finding the benefit that comes from the number of new jobs per NOK 100 million invested. ECON's review of these calculations points out that the benefit has been calculated incorrectly in the German method, and also that the benefit of employment effects is not included in Norwegian cost-benefit analyses.

The Norwegian method for cost-benefit analyses does not include employment effects. The Norwegian labour market is not characterised by high structural unemployment, as is the German labour market. In the short term, and seen in isolation, development will lead to resources having to be moved from other parts of society if there is not available capacity where these resources are obtained. The development areas (the routes of the tracks) are relatively thinly populated, so that it will not be possible to obtain the entire labour force needed to develop the high-speed rail line from among unemployed living close to the development area. It is therefore reasonable to suppose that development will lead to no other effects than that resources must be moved from other parts of the country to the railway project under development. Seen as a whole, unemployment in Norway is low, and even though the financial crisis of 2009 has led to an increase in unemployment in the building industry, in our assessment there is not nearly enough available labour to permit this to be directly transferred to a rail project. It is therefore also reasonable to suppose that part of the labour force to be used for developing high-speed rail will come from abroad. There will also be a certain amount of new employment of staff along the line of the route and for operations, but this is also thought to be marginal in terms of employment.

AGENDA Utredning & Utvikling has carried out an analysis of social effects of various rail projects in Norway, in which they have looked at the employment effects of developing the railway between Sandvika and Asker. They found that the project employed almost 5,400 people, distributed over five years. They also write "The top year was 2003, when the project gave a combined employment effect equivalent to 1,700 full time jobs. It must be underlined that this does not necessarily refer to new jobs." They also write that foreign workers have been used to a small extent.

Our assessment is that employment effects, both during the construction phase and in operation, should not be included in a cost-benefit analysis. The situation in Norway indicates that a development of this size is more likely to lead to increased pressure on the competition for the available labour force, which will lead in turn to increased pay and higher prices. On this basis, employment effects are not something that should be included in the analysis as a benefit; they should either be omitted or included as a cost.

A distinction must be made between, on the one hand, employment effects relating to development and operation of the high-speed rail line and, on the other hand, effects on the labour market that the new line might lead to. Future investigations into high-speed rail in Norway should include an assessment of the additional benefit (refer to the discussion in the section "Monetised and non-monetised effects").

In the case of major infrastructure investments such as this, which affect several regions, it may be of interest to study regional effects. As regards indirect effects of the investment itself, the PANDA model can distribute these by industries in each region (at county level for example). In respect of distribution of the effects of the transport option, the results of the cost-benefit analysis can be presented by region.

8.4.6 Tax costs

Because of distortion effects and administrative costs relating to tax collection, according to the Ministry of Finance guidelines a cost of 20 per cent of publicly financed investment should be added.

The Danish method for cost-benefit analyses (Manual for socioeconomic analysis, 2004) says that "In Denmark distortion losses are reckoned at 20 per cent, according to the Ministry of Finance guidelines of November 1999. The distortion loss should be added to net public costs in the case of public sector finance, as well as the value of the time of those travelling on public service, ref below." This is the same rate as is recommended for Norwegian analyses, except that in Norway the costs of travel are not included in this context.

VWI has ignored such a tax financing cost entirely in its report. ECON on the other hand has included this cost for all infrastructure investments in the high-speed rail project.

The effects of increased tax costs will be especially important in this project, where the real investment is so high. This applies on the assumption that grants or subsidies to other areas of government responsibility are not reduced. The tax cost should thus be included in line with the Norwegian method.

8.5 Assessment of sensitivity analyses and risk management

8.5.1 Description of risk and uncertainty

Metier has carried out an uncertainty analysis of the high-speed rail project in Norway. They classify the uncertainty factors as social/political objectives, project organisation and competence, the contractor market, various interested parties, size of project, complexity and need for research and development. Metier uses a classification model that is similar to that described in the Norwegian National Rail Administration's Method Manual JD205. We have no methodological objections to what Metier has done.

VWI used data from Metier's uncertainty analysis in its own analysis.

The Metier and VWI approach has laid great emphasis on risk and uncertainty in the investment costs, but not in other elements that belong to a cost-benefit analysis, such as uncertainty in benefit components or traffic projections. Metier briefly mentions in its analysis that different interested parties will be affected by the project. ECON makes a good presentation of uncertainty factors in its summary, even though it has not dedicated a separate section to them.

8.5.2 Sensitivity analyses

VWI has not carried out any sensitivity analyses of key elements in its report. ECON has carried out a sensitivity analysis. The elements it has considered are shown in table 8.7.

Table 8.7: Elements in ECON's sensitivity analysis

Parameters that change	Description
CO_2 prices	In its analysis, ECON set a CO_2 price of NOK 273.33 per tonne. Here it is increased to NOK 1,649 per tonne, which is the same value as VWI uses

Economic growth	Assumption of a real growth of 2 per cent in annual benefit and operating costs
Uncertainty supplement to infrastructure investments	Reduce infrastructure investments from a total of NOK 57,864 million to NOK 48,242 million
High infrastructure costs	Costs are raised to the 90th percentile of NOK 80,800 million (from Metier's uncertainty analysis)
Low infrastructure costs	Costs are reduced to the 10th percentile of NOK 40,500 million (from Metier's uncertainty analysis)
Halving the number of travellers	Reduction of number of travellers from 1.95 million to 0.975 million
Doubling the number of travellers	Increasing the number of travellers to 3.9 million
Discount rate	Discount rate is reduced from 4.5 per cent to 2 per cent
Tax costs	Tax costs of 20 per cent are removed from the investment costs
Longer time horizon	Increase of time horizon to 94 years

Note: ECON has also combined some of these parameter changes
Source: ECON (2008)

It is important to perform sensitivity analyses so as to be able to see what drives the results of s cost-benefit analysis. For example, the total of the annuities of the infrastructure investments will be close to NOK 3 billion a year with a rate of 4.5 per cent, against about NOK 1.6 billion with a rate of 2 per cent, such as VWI uses. ECON has in our opinion performed a good sensitivity analysis and finds that none of the changes they have made can make the project profitable.

8.6 Summary and recommendations

A comparison of the socioeconomic analyses of high-speed trains made by VWI and ECON has revealed three important differences:

- There is a difference between VWI and ECON regarding what effects of modal shift are included. In COWI's view, in this area ECON has ignored the potentially important elements in the socioeconomic use of high-speed trains. COWI believes that the German procedure is in agreement with the Norwegian National Rail Administration's guidelines for socioeconomic analyses, even though the technical calculation set up may be unusual from a Norwegian point of view. We also believe that VWI has not sufficiently investigated how the use of the modal shift is quantified and valued and we can only wonder about the level of cost savings from transfer of traffic.

- ECON has used a discount rate of 4.5 per cent, which corresponds to the recommended rate in Norwegian cost-benefit analyses. VWI has used a rate of 2 per cent, which corresponds to the German recommendation. About half the difference in calculated benefit between VWI and ECON is due to different rate estimates. COWI recommends that socioeconomic analyses of high-speed rail should follow ECON's procedure.

- Unlike ECON, VWI has not included a tax financing cost. COWI recommends using ECON's procedure, which is in line with Norwegian practice.

Our recommendation for further analyses is:

- New analyses should use a **gross method** that sets out the effects for operators, travellers and the public sector in detail. Neither VWI nor ECON has used such a procedure. The result is that the analyses are not very transparent and are difficult to compare. It can also sometimes be difficult to fully understand the simplifications made in the reports as a result of the socioeconomic calculation not being completely detailed.

- Estimates of **market share** and **time values** are critical for calculating the benefit of building high-speed rail lines. There are no differences in principle between ECON and VWI's procedures. As shown in the market analysis in section 3 however, there are other reports and experiences that question whether the area of competition between air and high-speed train is well enough represented in the VWI report. Questions may also be raised whether the time values that are used in the VWI and ECON calculations are representative for travellers by high-speed train. New socioeconomic analyses should go into these issues in more detail.

- The ongoing development of methodology in socioeconomic analyses of transport investments may introduce new aspects that are not part of current practice: **added benefit**, **real price development** and **the reliability of travelling time**. It is worth considering whether these should be included in further investigation into high-speed rail lines in Norway. Added benefit is particularly relevant for large infrastructure investments.

9 Recommendations

In this section we shall make recommendations regarding the way forward in the investigation of high-speed rail in Norway.

9.1 Market, social economics and financing

For further work we recommend that a more thorough feasibility study is made of high-speed rail in Norway, considering in particular the following factors:

- A through investigation into and justification of the delimitation of the **relevant market**.
- Clearly documented assumptions with regard to **ticket prices and travelling times** for both high-speed rail and competing forms of transport.
- A clear definition of the **reference alternative**, which includes projects planned to be carried out by the Norwegian National Rail Administration and NSB, as well as road projects.
- Now socioeconomic analyses should consider the issues of **market share**, **time values** and **modal shift** in detail.
- We recommend an **examination of modal shift** between high-speed rail and other forms of transport, based on a more thorough study of the effect the introduction of high-speed rail on air traffic in comparable cases.
- New socioeconomic analyses should use a **gross method** that sets out the effects for operators, travellers and the public sector in detail.
- **Added benefit**, **real price development** and **the reliability of travelling time**. It is worth considering whether these should be included in further investigation into high-speed rail lines in Norway. Added benefit is particularly relevant for large infrastructure investments.

For implementation of the development, a model should be chosen that ensures certainty about financing of the entire project and that provides the optimum division of risk between the principals. The model should also give the best possible incentive to cost-effectiveness and to maintaining the schedule. The model must safeguard the quality requirements and ensure a total view of all phases, so that quality in the operational phase is taken into consideration during the construction phase.

9.2 Technical parameters and costs

For further work on technical parameters and costs, we recommend that a more thorough feasibility study is made of high-speed rail in Norway, considering the following factors:

- Developing and comparing **line routing** on a scale of 1/50 000 with a view to reducing the proportion of tunnel as much as possible

- Comparing and testing the **traffic models** of different operational plans (departure frequency, stops, fares and speed)

- Repeated **optimisation process** with a view to reducing construction costs and increasing ticket income

- Consideration of a **step by step upward adjustment to 300-350 kph** of the existing Oslo-Bergen and Oslo-Trondheim routes, beginning with a rectification of all sharp curves at the same time as avoiding tunnel construction. This would be to achieve the highest possible return on investment.

- Consideration should be given to introducing **tilting trains** on lines that will not be upgraded first. Both Sweden and Finland have decided on this approach.

- Because of the many stops on the Oslo-Kristiansand-Stavanger corridor, the feasibility of upgrading the existing line to **Intercity** instead of high-speed should be considered.

- We recommend that a better correlation between **operations and optimising of income** is achieved, so that actual operations correspond with what the market expects in terms of the number of trains and their capacity.

- We recommend that an assessment be made of **double track high-speed rail lines** in Norway.

10 Bibliography

AGENDA Utredning & Utvikling AS (2008) *Samfunnsmessige virkninger av ulik organisering av jernbaneutbygging i Norge.*

Beitnes A and R Olsson (2007) *Høyhastighets jernbane i norsk terreng. Noen karakteristiske trekk ved grunnforhold og topografi og tilpassede løsninger og kostnader*, memorandum of August 2009, SINTEF and NGI.

DB International (2008) *Samferdselskonsept for Sør- og Midt-Norge,* report of 13.11.2008.

Department for Transport: *Transport Analysis Guidance - WebTAG,* http://www.dft.gov.uk/webtag.

Deutsche Bahn (2009) *Jernbane- og trafikkonsept for Sør- og Midt-Norge,* summary

ECON (2008) *Nytte-kostnadsanalyse av høyhastighetstog i Norge.* Report 2008-154.

Federal Ministry of Transport, Building and Urban Development (2005) *Federal Transport Infrastructure Plan 2003: macroeconomic evaluation methodology*, as at June 2010 available at http://www.bmvbs.de/en/Service/Publications-,1932.13237/Federal-Transport-Infrastructu.htm

Funkwek and Railconsult (2008) *High Speed Operations.*

Norwegian Geotechnical Institute (NGI) (2007) *Geotechnical study of Moss-Halden and Minnesund-Heimdal,* technical note project number 250071171

Heldal N, I Rasmussen S Strøm and S Munawar (2009) *Mernytte av transportinvesteringer i storbyer.* Preproject, Vista Analyse.

Høyhastighetsringen (2009) *Den nye Bergensbanen.* Høyhastighetsringen AS, report, August 2009.

Jernbaneverket (2006a) *Samfunnsøkonomiske analyser for jernbanen.* Method Manual JD 205. Version 2.0 - June 2006.

Jernbaneverket (2006b) *Teknisk regelverk JD 530*

Jernbaneverket (undated) *Høyhastighetstog i Norge. En mulighetsstudie.*

Killi M (1999) *Anbefalte tidsverdier i persontransport.* Transportøkonomisk institutt, TØI report 459/1999.

Metier (2007) *Concept Evaluation, Cost Estimate and Uncertainty Analysis - Report 1: Basic assumptions and methodology, and calculations for the corridor Trondheim – Oslo.*

Nilsson J-E and R Pyddoke (2009) *Höghastighetsjärnvägar – ett klimatpolitiskt stickspår,* Rapport till Expertgruppen för miljöstudier 2009:3.

Norsk Bane and DB International (2009a) *Jernbane- og trafikkonsept for Sør- og Midt-Norge,* report May 2009.

Norsk Bane and DB International (2009b) *Jernbane- og trafikkonsept for Sør- og Midt-Norge, rapport mai 2009,* summary

OECD and International Transport Forum Joint Transport Research Centre (2008) *The Wider Economic Benefits of Transport: Macro, Meso and Micro Transport Planning and Investment Tools,* Round Table 25-26 October 2007, Boston, Discussion Paper No. 2008-6.

Olsson R and E K Morgan (2007) *Geotechnical study of Moss-Halden and Minnesund-Heimdal.* NGI, Technical Note 2007-03-22.

Statens Offentliga Utredningar (2009) *Höghastighetsbanor - ett samhällsbygge för stärkt utveckling och konkurrenskraft.* SOU 2009:74.

Transportministeriet (2003) *Manual for samfundsøkonomisk analyse - anvendt metode og praksis på transportområdet.*

Untied States Government Accountability Office (GOA) (2009), *High Speed Passenger Rail - Future Development Will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role,* GOA-09-317

Urbanet Analyse (2009) *Markedet for høyhastighetstog i Norge. Analyse av flypassasjerenes preferanser,* report 12/2009.

Urbanet Analyse (2008) *Markedet for høyhastighetstog i Norge. Supplerende markedsanalyse basert på anvendelse av den nasjonale persontransportmodellen NTM5,* report 9/2008.

Verkehrswissenschafliches Institut Stuttgart (VWI) (2007a) *Feasibility Study Concerning High-Speed Railway Lines in Norway, Report Phase 2, November 2007.*

Verkehrswissenschafliches Institut Stuttgart (VWI) (2007b) *Feasibility Study Concerning High-Speed Railway Lines in Norway, Report Phase 3, November 2007.*

Verkehrswissenschafliches Institut Stuttgart (VWI) (2006a) *Feasibility Study Concerning High-Speed Railway Lines in Norway, Report Phase 1, December 2006.*

Verkehrswissenschafliches Institut Stuttgart (VWI) (2006b) *Feasibility Study Concerning High-Speed Railway Lines in Norway,* code number 200 602 481, WP 300 High-Speed-Railway-Conditions

WSP Analys & Strategi (2009) *Samhällsekonomisk bedömning av höghastighetsbanor i Sverige,* report 2009:20.