Sustainability of Alpine railway tunnel projects – an analysis of the Brenner Base Tunnel

Thomas Stoiber

Abstract

Discussing perspectives and trends for the future, the concept of sustainability has emerged as a commonly used term in almost all fields of science, just as in the transport planning sector. For instance, at public presentations the Brenner Base Tunnel is characterised as sustainable although the item has neither been defined nor evaluated for railway tunnel projects in the Alps. This evaluation analyses corresponding indicators for ecologic, social and economic considerations and draws a differentiated conclusion about the sustainability of the Brenner Base Tunnel and other comparable projects.

Keywords: sustainable development, railway tunnel infrastructure

1 Introduction

The growing demand for transport on Alpine corridor-tracks poses the risk of undesirable ecological and social impacts. This has led to a public desire to upgrade the transalpine transport system. Whereas road traffic has grown continually on Alpine corridors during the past decades (see figure 1), the railways have increasingly lost their market shares. As a result, a radical modernisation of the Alpine railway lines has been called for by politicians and transport planners. At the Brenner, the most heavily-travalled transit corridor in the Alps, a decision is expected in 2007 on wether to build a new high-speed railway project: the Brenner Base Tunnel. With a

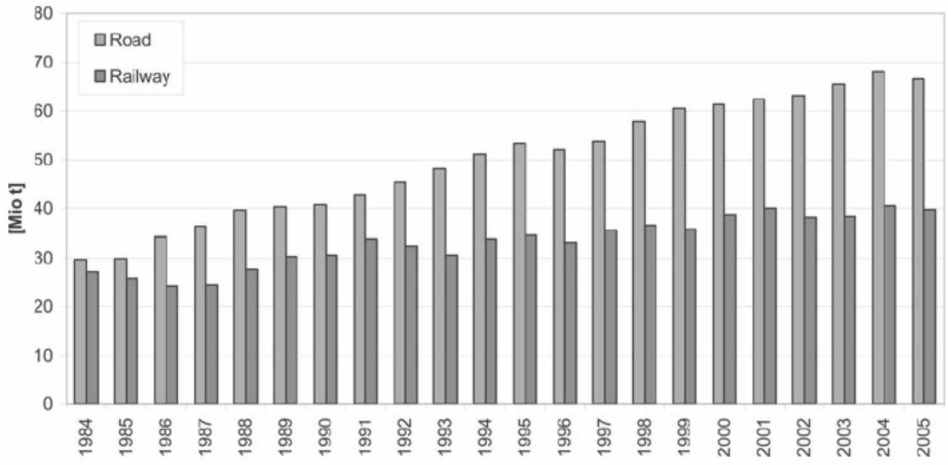

Figure 1: Transalpine goods traffic in the inner Alps mountain range (adapted from ARE 2006)

length of 55 kilometres, this tunnel will connect Innsbruck, Austria, with Franzensfeste, South Tirol, reducing travel distance by some 28 km, travel time by 68 minutes (Kummer 2006, 20) and the ruling grade from 2.3% to 0.8% in comparison with the existing alignment. Similar projects are currently planned or under construction on different other Alpine transit routes.

The analysis is based on the diploma thesis of Stoiber (2007), which aims at pointing out the sustainability of these infrastructure projects. In a first step, corresponding indicators for ecological, social and economic considerations are derived according to international conventions. In a second step, the Brenner Base Tunnel is taken as an example for quantifying, describing and discussing the expected effects in order to draw a general conclusion about the sustainability of the tunnel projects in question.

2 The concept of sustainability for Alpine railway tunnel projects

The original and commonly used definition of sustainability goes back to the report 'Our common future' delivered by the World Commission of Environment and Development (WCED). This report defined the vision of sustainable development – "*to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED 1987, 8). According to this perception, sustainable development clearly refers to the satisfaction of needs, or more basically that of the basic need of mobility, which inevitably relates to the original motivation of translocation: the spatial linkage of different activities. This need finally causes traffic with its expenses regarding infrastructure, transportation means as well as environmental and social pressures. Depending on individual trip distances covered, the choice of transport mode and the time effort, equal mobility needs can thus be satisfied with completely different amounts of traffic volume. On the other hand, according to the WCED definition, sustainable development requires risk mitigation for future generations, such as a reduction of resource consumption or greenhouse gas emissions. In summary, a more sustainable traffic development is associated with needs-driven mobility with reduced transportation demand (Becker 2003, 15).

In this regard, a hierarchic structure of objectives consisting of avoidance of traffic, modal shift and compatible operation is applied to evaluate the Brenner Base Tunnel.

Avoidance of traffic: Alpine railway tunnel projects do not contribute to avoiding traffic because of newly created capacities and significant reductions of running times. These effects probably produce induced traffic which cannot be dealt with in the current analysis.

Modal shift from road to rail can be seen as the main objective of the infrastructure projects in question. The potential of shifted persons and goods can be quantified according to traffic forecasts for 2015 taken from different scenarios which have been calculated by BBT-SE (BBT 2003). The trend-scenario, which assumes the current political trends without systematic support of public transport and fur-

thermore the construction of all Alpine tunnel projects, is not able to increase the market share of rail transport neither in goods nor in passenger traffic on the Brenner transit route. Instead, the consensus-scenario contains a set of measures that foster the competitiveness of Alpine railways and produces a modal shift to the railway routes of about 4.9 million tons per year in goods and 2.2 million persons per year in passenger traffic (Stoiber 2007, 126). A specially calculated capacity-scenario factors out all influences of other Alpine transit corridors and assumes a political framework which loads both the existing railway route and the tunnel track up to capacity restraints. Under these conditions the amount of modal shift is stated to 22.7 million tons of transported goods and 5.3 million travellers per year. Whereas the sustainability of modal shift to conventional railway infrastructure has been verified scientifically, this question is not clarified for Alpine railway tunnel projects.

Compatible operation: In order to examine if a tunnel project guarantees a more compatible operation of transalpine transport, the following questions have been answered using balances and elite interviews:

Ecologic aspects:

- Is the stated modal shift able to balance the effort of constructing the Brenner Base Tunnel regarding primary energy consumption, greenhouse gases and air pollution?
- How is the qualitative relationship between the ecologic disturbances of the construction and the advantages of modal shift?

Social aspects:

- How will the conditions of accessibility, public health and transport safety develop after the construction of the Brenner Base Tunnel?

Economic aspects:

- What economic advantages and what charges are expected?

The operation time of Brenner Base Tunnel was assumed to 100 years. To evaluate the overall project as sustainable, at least one of the three aspects has to be improved without worsening one of the other aspects of sustainability. The associated indicator system for sustainability of Alpine tunnel projects is visualised in figure 2.

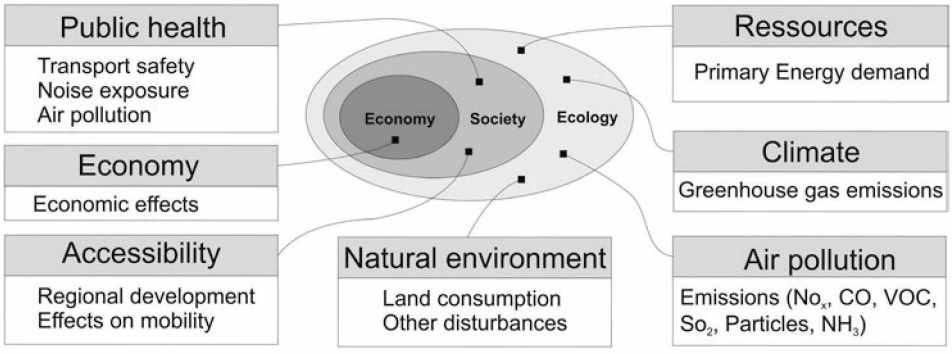

Figure 2: Evaluation of sustainability for railway tunnel projects

3 The sustainability of the Brenner Base Tunnel

3.1 Ecological indicators

3.1.1 Land consumption

The effects of an Alpine railway tunnel project on natural environment predominantly concern the construction period. Limited to areas between 6,000 and 40,000 m² (BBT 2003) for each construction site and to disposal sites for low-quality rock material, the amount of land consumption compared to other transport infrastructures can be seen as marginal. Despite all required areas foreseen for an unlimited secondary utilisation, the construction sites especially in Riggertal, Pfitschtal and Padastertal are situated in widely naturally preserved areas and are therefore in danger of partial destruction.

3.1.2 Other disturbances

Further environmental pressures result from endangering different founts, particularly the thermal spring Brennerbad, and from pressures on receiving water courses. Because of deduction to hydropower plants, the rivers along the Brenner corridor often carry residual flows that are very sensitive to wastewaters discharged even according to prescriptive limits of nitrate and nitrite from the construction sites. If the Brenner Base Tunnel is going to fulfil the requirements for ecological sustainability despite the high intensity of environmental pressures, it is necessary to demonstrate measurable advantages such as quantifiable balances between input period during construction phase and output period during infrastructure use.

3.1.3 Primary energy demand

The result of roughly estimated energy balances is shown in table 1. On input side all relevant positions during the construction period of the Brenner Base Tunnel have been considered. About two thirds of this amount is caused by the production of reinforced concrete and about one fourth is utilised for the tunnel driving process. The output side describes the effects of modal shift, dislocation of trains from the current railway line to the tunnel track and additional expenses for illumination and ventilation assuming that the modal shift effects calculated in chapter 2 would last during the whole operating period of 100 years. The result shows a negative trend for trend-scenario and positive trends for the consensus- and the capacity scenario.

3.1.4 Greenhouse gas emissions

The different energy sources such as fossile fuel combustion for road traffic and the average mix of electric power generation for rail traffic and different construction methods produce greenhouse gas emissions (INFRAS 2004, FFE 1999) that have been balanced in table 2 according to the global warming potential of carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4) and nitrous oxide (N_2O). The result in general shows the proportional relationship between energy demand and greenhouse gas production.

Table 1: Energy balance of the Brenner Base Tunnel (Stoiber 2007, 81).

	Cumulated Energy Demand (CED) [GWh]		
	Trend	**Consensus**	**Capacity**
Input	7,800	7,800	7,800
Output	−3,100	−12,600	−31,400
Balance	4,700	−4,800	−23,600

Table 2: Balance of greenhouse gas emissions (Stoiber 2007, 83).

	CO_2 equivalents [1000 t]		
	Trend	**Consensus**	**Capacity**
Input	2,800	2,800	2,800
Output	−300	−3,500	−11,600
Balance	2,500	−700	−8,800

3.1.5 Air pollutants

In analogy to the calculation of greenhouse gases the emissions of the different substances hydrocarbon (HC), carbon monoxide (CO), nitrogen oxides (NOx), particles and sulphur dioxide (SO_2) to be caused by input and output effects of the Brenner Base Tunnel have been identified (see table 3). For the different air pollutants, even for consensus scenario a definite conclusion cannot be drawn, since substances that are predominantly produced during electric power generation (HC, SO_2) are not compensated sufficiently by modal shift from road to rail.

In conclusion, trend scenario with intensely negative balances regarding all ecological fields of evaluation is not able to countervail the different ecologic disturbances of the infrastructure. Considering the calculations for air pollutants, a definite result can't be achieved for the consensus scenario, too. Only the capacity-scenario is undoubtedly able to foster sustainable development under the ecological criteria derived above.

3.2 Social indicators

3.2.1 Transport safety

High speed rail traffic has the lowest risk of causing accidents, injuries and mortalities compared to all other transportation modes (Vieregg-Rössler 2006). A risk analysis accomplished by BBT-SE (BBT 2003) especially for the Brenner Base Tunnel provides evidence that the concept of two separate tunnels connected to each other every 300 metres and the existence of intermediate stations with the possibility of evacuation to the surface fulfils all current safety standards of railway transport. As a consequence, an improvement of transport safety standards is assured when assuming a systematic modal shift from road to rail (consensus and capacity-scenario).

Table 3: Balance of different air pollutants (Stoiber 2007, 84).

		HC [t]	CO [t]	NOx [t]	Particles [t]	SO_2 [t]
Trend	Input	7,200	1,400	4,600	500	6,600
	Output	−300	−1,100	−700	−100	−200
	Balance	6,900	300	3,900	400	6,400
Consensus	Input	7,200	1,400	4,600	500	6,600
	Output	−2,800	−9,000	−11,400	−500	−1,300
	Balance	4,400	−7,600	−6,800	0	5,300
Capacity	Input	7,200	1,400	4,600	500	6,600
	Output	−9,000	−25,800	−41,300	−1,500	−4,300
	Balance	−1,800	−24,400	−36,700	−1,000	2,300

3.2.2 Noise exposure and air pollution

Several households in the surroundings of the Brenner Base Tunnel construction areas will be affected by delivery traffic and rock material treatment processes. In order to alleviate these effects, extraordinarily burdening facilities will be located far from settlement areas or will be protected by different accompanying measures.

The average noice level on an exemplarily chosen cross section on Brenner motorway for the different scenarios compared to a minimum-scenario (BBT 2003), which is politically equivalent to trend-scenario but does not include the Brenner Base Tunnel, is shown in table 4. Neither for trend nor for consensus-scenario a significant decrease of noise emissions can be verified. Only the capacity-scenario shows a reduction of 2 decibel, which is correspondent to an improvement of individual perception of about 20%. However, under these conditions the current railway track over the Brenner axis is loaded up to capacity restraints which produces additional noise immissions in neighboured settlement areas. Hence, noise exposure is not a relevant criterion to evaluate the social sustainability of the Brenner Base Tunnel. As far as air pollution on the Brenner corridor is concerned, table 3 shows that the traffic relevant substances NOx and particles are significantly reduced assuming the capacity-scenario.

3.2.3 Effects on mobility

All experts from transport policy, spatial planning and transport companies to be interviewed attested a positive development of mobility aspects with implementing the new railway axis on the Brenner corridor. They expect better train connections between Italy and Central Europe, an attractive additional transport offer particularly for Innsbruck and Bolzano, and the opportunity for new commuter relationships. However, there is the danger of long distance transport offers being removed from areas isolated from the attractive high speed rail. There might be the possibility of compensating this lack of service with a systematic extension of regional transport on the current axis, as currently planned in South Tyrol.

Table 4: Balance of noise emissions (Stoiber 2007, 86).

	dB(A)
Minimum	75.9
Trend	76.0
Consensus	75.4
Capacity	73.5

3.2.4 Effects on regional development

On the one hand, the accessibility of extra-alpine regions can be megliorated significantly; on the other hand inner-alpine regions suffer from increasing pressure of competition. Especially the accessibility situation of Alpine regions goes also along with advantages such as fortification of local structures. Hence, the infrastructure projects in question change the perceived geography on the Brenner corridor and produce positive as well as negative effects which are hardly evaluable in total.

3.3 Economic indicators

Older case studies of Hoffmann (1985) show, that during the construction period of high speed railway lines, publically placed orders are able to generate multiplier effects of factor 2 up to 2.5 of the overall infrastructure costs particularly for major enterprises of the construction industry, electrotechnology, suppliers of construction material, iron and steel industry and engine construction. However, the construction of the Brenner Base Tunnel ties up capital that otherwise could be invested in alternative infrastructure projects with similar effects.

Assuming that freight trains will be dislocated to the tunnel track whenever possible, an utilisation ratio of 70% is reached for the trend-scenario, 75% for the concensus-scenario and by definition 100% for the capacity-scenario. These numbers indicate that the future operator will have got good chances to break even the current expenses and to contribute partially but not completely to the construction costs (BBT 2003, 12). In common economic analyses criteria such as accessibility, environmental conditions, potentials of regional development and transport safety are to be considered additionally. Especially the environmental costs caused by the transportation system currently are paid by society. According to standard values of external costs (INFRAS 2000) these savings are almost as large as the estimated infrastructure costs for consensus scenario, whereas capacity scenario is able to exceed the construction costs by far. As a consequence, assuming a systematic modal shift to the railway Brenner Base Tunnel can contribute to an economically sustainable development.

4 Conclusions

The results of the various balances and discussions show that the Brenner Base Tunnel is generally able to foster sustainable development assuming scenarios that enable a systematic shift of traffic from road according to politically- and also operationally determined factors. However, such a general framework of encouraging public transport and rail freight services is currently not guaranteed and has to be formulated on European level. As a result, it is not possible to draw a final conclusion about the success of the Brenner Base Tunnel in terms of sustainable development.

The design of the Brenner Base Tunnel is largely standard for Alpine railway tunnel projects. Its construction will thus be quite similar to other projects in the Alps that have already been completed or are under construction. Due to this similarity the results of this study are quite transferable to other projects. Since Switzerland in its transport policy explicitly promotes a shift of traffic onto the railway system and accordingly incorporates its tunnel projects into an integrated planning approach, the projects at Gotthard and Lötschberg are likely to show advantages compared with other EU projects in terms of sustainability.

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