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Summary:

Walking- and cycling track networks in Norwegian cities

Cost- benefit analyses including health effects and external costs of road traffic

Cost- benefit analyses of walking- and cycling track networks in three Norwegian cities are presented in this study. A project group working with a National Cycling Strategy in Norway initialised the study. Motivation for starting the study is the Parliament's request to the Government (St.meld.nr 24 (2000-2001)) where the Government are asked to: *"prepare a National Cycling Strategy where the main goal is to make it safer and more attractive to choose bicycle as means of transport. This Strategy must form a part of the National Transport Plan."* The Norwegian Agency for Health and Social Welfare, and the Norvegian Public Roads Administration financed the study.

Walking- and cycling track networks are not sufficient – Other measures, like safe crossing- and parking facilities, should also be implemented

Development of continuous walking- and cycling track networks has potential for increasing the amount of walking and cycling in Norwegian cities. However, since there is large uncertainty regarding substitution from car to walking and cycling, the analyses are presented as scenarios. In the scenarios it is assumed that also other measures (e.g. safer crossing facilities and safer parking facilities for bicycles) must be implemented to achieve high future shares of pedestrians and cyclists. That means that other measures are implicitly included in the scenarios, but not directly included in the cost- benefit analyses of the cycle track networks. The Norwegian cities Hokksund, Hamar and Trondheim are used as cases.

Cost- benefit analyses at a strategic level

The cost- benefit analyses of cycle track networks are at a superior strategic level. That means that the designs for different sections of the networks are *not* part of the analyses. (I.e. the analyses is not suited for making decisions about how large sections of the networks that should be designed as separate tracks for walking and cycling, cycle-lanes in the road and sections of mixed traffic). Designs of the networks *could* have been included in the analyses, but that would have required detailed data about pedestrian and cycle traffic on the different sections of the networks. Such detailed data is not available yet. Therefore, the analyses are based on average amounts of pedestrian and cycle traffic on the cycle track networks in the three cities.

Cycle track networks in Hokksund, Hamar og Trondheim – Length and costs

An average cost of 7500 NOK per meter walking- and cycling track is used in the analyses. Different designs of the network can result in higher or lower costs per meter. However, in the cost estimate used, the Public Roads Administration has taken height for the fact that this is a measure that *may* have a high cost per meter. By implementing high, but realistic, cost estimates in the analyses we keep open the opportunity set in the next task; which is to choose the designs that gives the best overall solution for different sections of the network. Table 1 shows lengths and costs for construction of walking- and cycle track networks in Hokksund, Hamar og Trondheim. In addition, maintenance costs of 35 NOK per meter per year (Kolbenstvedt m fl 2000) and a tax-cost factor of 20% of budget costs, are included in the analyses.

Table 1: Length and costs for construction of walking- and cycle track networks in Hokksund, Hamar og Trondheim.

Length and cost of walking- cycle track networks	Hokksund	Hamar	Trondheim
Planned main network for cycling (length in km)	15,1	32,9	220,0
Remaining parts of the network (length in km)	3,2	2,1	80,0
Cost estimates for completing the main network (mill. NOK)	23,6	15,8	600,0

Source: TOI-report 567/2002

Estimates of today's- and future amounts of walking and cycling

In order to make meaningful cost- benefit analyses of measures for pedestrians and cyclists without too large uncertainties, we need the best possible description of today's and future distribution of travel between different means of transport.

Today's distribution between different means of transport is estimated from the Norwegian nationwide travel survey from 1997/98. This survey shows that Norwegians travel on average 3,2 journeys per day and it gives a distribution of these daily journeys between different means of transport. However, we have to make assumptions based on travel lengths and length of the cycle track networks in order to estimate the average annual daily traffic (ADT) of pedestrians and cyclists on the walking- and cycling track networks. The following assumptions are done in order to do this estimation:

- Journeys less than 5 km by bicycle or as pedestrian have an average length of 3 and 1 km, respectively.
- Journeys longer than 5 km by bicycle or as pedestrian have an average length of 6 km.
- Of the total amount of kilometres cycling and walking in the cities 70 and 20 %, respectively, takes place on the walking- and cycle track networks.

Future distribution between different means of transport is estimated from today's distribution and assumptions about percentage changes from today's distribution. Our "best estimate" of future distribution between different means of transport is based on Lodden (2002) and the following assumptions:

- Walking- and cycle track networks gives 20 % (5-40% in sensitivity analyses) **induced** walking and cycle journeys. (By induced walking and cycle journeys is meant journeys that not would have taken place without the new networks and not journeys that today is done by other modes of transport.)
- 15 % (0-35 % in sensitivity analyses) of today's journeys less than 5 km done by car and public transport, are **substituted** by walking or cycling.
- Among today's journeys by car or public transport that in the future are substituted by walking or cycling, about 1/3 is replaced by walking and 2/3 by cycling.

Table 2 shows the estimated total number of km walked and cycled in the different cities and the average daily traffic (ADT pr km) of pedestrians and cyclists at the walking- and cycling track networks in Hokksund, Hamar og Trondheim.

Table 2: Estimated total number of km walked and cycled in the different cities and the average daily traffic (ADT pr km) of pedestrians and cyclists at the walking- and cycling track networks in Hokksund, Hamar og Trondheim.

	Today's traffic		Future traffic ("best estimate")	
City/ Mode of transport	Number of km in city area	ADT at the w/c-track network	Number of km in city area	ADT at the w/c-track network
Hokksund				
Walking	9777	129	12306	163
Cycle	6308	292	11012	510
Hamar				
Walking	20671	126	26019	158
Cycle	13336	283	23282	495
Trondheim				
Walking	143851	131	180369	164
Cycle	152058	484	228955	728

Source: TOI-report 567/2002

Benefit components in a "complete" cost- benefit analysis

The cost- benefit analyses include estimates of the following benefit components:

- *Traffic accidents.* It is not known whether substitution from car and public transport to walking and cycling will result in more or less people injured in traffic accidents (Elvik et al 1997 and Elvik 1998). A walk- and cycle track network with safe crossing facilities will probably reduce the number of traffic accidents involving pedestrians and cyclists. However, in order to avoid overestimation of the benefit, we have assumed that the number of traffic accident resulting in personal injury will not be changed because of the new walking- and cycling tracks.
- *Travel time.* Cycling on a walking- and cycle track could probably reduce travel time compared to cycling on a sidewalk. Compared to cycling in the road, the travel time will probably be the same or a bit longer on a walking- and cycle track. In the cost- benefit analysis we have assumed that travel time for pedestrians and cyclist are not changed because of the walking- and cycle tracks (Sælensminde and Elvik 2000). We assume that travel time for car drivers that not substitute to walking or cycling is reduced in cities with road congestion. This is included in the analysis for Trondheim as reduced congestion costs (Eriksen m fl 1999).
- *Insecurity.* Insecurity felt by pedestrians and cyclists moving along a road is included in the analyses with a cost of 2 NOK per km (Stangeby 1997, Elvik 1998). Assuming an average speed of 20 km/h the cost of insecurity is about 40 NOK/h for cyclists. Compared to the values of travel time included in cost- benefit analyses for crossing facilities, the estimated cost of insecurity seems to be of reasonable magnitude (Elvik 1998, Elvik and Sælensminde 2000).
- *School bus transport.* School children are offered transport to and from school if the road is appreciated to be too dangerous to walk or cycle along. We have assumed that 50 percent of these children will not need transport if the walking- and cycle track networks (with safe crossing facilities) are constructed. Information from the municipalities indicates that the reduction in the number of school children offered school transport could be about 78 in Hokksund, 34 in Hamar and 120 in Trondheim. Based on an estimated cost of 3,90 NOK pr child-km (price adjusted from Engebretsen and Hagen 1996) the cost per child with school transport is calculated to 4680 NOK per year.
- *Less severe diseases and short time absence.* As a benefit of physical activity (walking and cycling) we have assumed that short time absence is reduced by 1 percentage point (from 5% to 4%) (Elvik 1998). Average wage cost is estimated to 250.000 NOK per year. I.e. an economic saving of 2500 NOK per year per person employed that becomes more physical active. Twenty five percent of all journeys is assumed to be work-trips. In order to not overestimate this benefit we have assumed that 50 percent of new pedestrians and cyclist will gain better health due to the additional walking and cycling.
- *Severe diseases and long time absence/disability.* Physical activity (walking and cycling) reduces the occurrence of severe diseases. In order to not overestimate this benefit we have only included four types of severe diseases in the cost- benefit analyses. The four types of diseases included, is the diseases that SEF (2000) estimates what these cost the society in the form of medical costs, treatment costs and possible production loss. The four types of diseases are cancer (five different types), high blood pressure, diabetes type 2 and muscle-/skeleton diseases. In addition we have estimated costs due to welfare loss for people hit by these diseases. The welfare loss is estimated to 60 percent of the total costs. This is the same magnitude as for welfare loss for people injured in traffic accidents (Statens vegvesen 1995). In order to not overestimate the benefit of reduction in severe diseases we have assumed that 50 percent of new pedestrians and cyclist will gain better health due to the additional walking and cycling. In the cost- benefit analysis an economic saving of 7300 NOK per year per person that becomes "moderate more physical active" is included.
- *External costs of road transport.* In order to not overestimate the accident costs these are excluded from external costs of road transport. The reason is that we have assumed that the number of injury accidents is not affected by a substitution from car and public transport to walking and bicycling. Included in the external costs are CO2-emissions, local emissions to air, noise, congestion and infrastructure costs. These are from Eriksen et al (1999) and are price adjusted to 1,36 and 9,03 NOK per km for cars and buses, respectively, in major cities (Trondheim). For minor cities (Hokksund and

Hamar) the external costs are 0,40 and 4,57 NOK per km for cars and buses, respectively.

- *Parking costs.* Parking costs are estimated based on rental prices companies pay for parking places in the different cities. Although most companies probably have lower parking cost than Europark's rental prices, these prices are actually paid by the companies for parking place rental for their employees (and customers?). These parking costs are therefore judged as a realistic estimate of the marginal parking costs for companies. In the analysis we have not included a potential less need of parking places for customers. Work-trips by car substituted by walking or cycling is in the analyses assumed to reduce parking costs for business companies in Trondheim, Hamar and Hokksund by 1165, 560 and 325 NOK per month, respectively.

The point of including the four latter components is to do cost- benefit analyses that are as "complete" as possible. By complete we mean that the most important components are included. However, because of uncertainties in the valuation of the different components, it is not claimed that the components are included with accurate estimates. These complete cost- benefit analyses will nevertheless gain insight into the magnitude and scale of the most important components that ought to be included in analyses of the economic consequences to society of measures for pedestrians and cyclists.

Reduced insecurity is the only change in the generalised travel costs

Analyses of the demand for travel usually assume that this demand is a function of generalised travel costs. The concept of generalised travel costs traditionally includes the sum of actual travel costs and costs of travel time. However, a journey often involves other costs than pure cash outlays and time consumption. Such costs may for example be related to distaste and inconvenience related to travelling.

In our analyses we assume that some travellers will begin travelling as pedestrians and cyclists as a result of a new built walking- and cycling track. However, this new walking and cycling activity is not based on assumptions about reductions in objective accident risk, but on the travellers' subjective experience that is has become safer and less inconvenient to travel by walking and bicycle. People's subjective comprehension about insecurity is of course influenced of their information of objective accident risk, but it is their subjective comprehension of insecurity that influences their choice of transport mode. I.e. it is reduced insecurity that inter into the generalised travel costs and not the objective accident risk.

Compared to today's situation, we assume that travel costs and travel time for different modes of transport do not change because of a new walking- and cycle track. These costs are therefore not changed in the generalised travel cost in the cost- benefit analyses.

Cost- benefit analyses based on "best estimate" of future walking- and cycling traffic

An investment project's calculated profitability to the society is denoted as *net benefit*. If net benefit is positive, the project is assumed to be profitable to the society (given the premises the calculations are based on). Net benefit is the present value of the benefit minus the cost components. The *net benefit- cost ratio* indicates benefit per cost unit. If net benefit is larger than zero, the net benefit- cost ratio will also be larger than zero. If this is the case, the investment project is judged to be profitable to the society. The net benefit- cost ratio indicates therefore which projects that may be the most profitable per unit money invested.

In addition to the specific assumptions presented above, the results from the cost- benefit analyses presented in Table 3 are based on a discount rate of 5 percent and a 25-year lifetime of the projects. As seen, the investment in walking- and cycle track networks in these three Norwegian cities seems to be highly profitable to society.

In the cost- benefit analyses presented in Table 3 reduced costs related to severe diseases constitute approximately two-third of the total benefit in Hokksund and Hamar and approximately half of the total benefit in Trondheim. Among the other benefit components considerable contributions comes from reduced parking costs, reduced costs due to less short time absence and reduced external costs of transport. Reduced costs because of less need for school children transport constitutes only about 1 percent of the total benefit.

Reduced insecurity, the only component that changes in the generalised travel costs, constitutes about 11 percent of total benefit in Hokksund, 4 percent in Hamar and 20 percent in Trondheim. These differences reflect the facts that Hamar lack least walking- and cycling tracks in order to complete the network, and Trondheim lack most (conf. Table 1). In

Table 3: Benefits and costs (based on best estimates of future walking and cycle traffic) of investments in walking- and cycling track networks in Hokksund, Hamar and Trondheim. Unit: NOK.

Benefit- and cost components	Hokksund	Hamar	Trondheim
Benefits of walking- and cycle tracks (present value)			
Accidents (assumed no change)	0	0	0
Travel time (assumed no change)	0	0	0
Reduced insecurity for today's pedestrians	4 191 324	2 711 764	107 638 228
Reduced insecurity for today's cyclists	9 464 281	6 123 338	398 225 323
Reduced insecurity for new future pedestrians	542 116	350 746	13 662 470
Reduced insecurity for new future cyclists	3 529 085	2 283 299	100 694 117
Reduced costs for school children transport	2 572 427	1 104 824	3 611 291
Reduced costs related to less severe diseases and short time absence	16 730 962	35 374 034	269 247 101
Reduced costs related to severe diseases	97 708 819	206 584 360	1 572 403 071
Reduced external costs of motorised road transport	9 445 569	19 970 631	124 449 172
Reduced parking costs for employers	9 484 654	34 553 324	433 356 016
TOTAL BENEFIT	153 669 236	309 056 320	3 023 286 790
Costs of walking- and cycle tracks (present value)			
Capital costs	23 625 000	15 750 000	600 000 000
Maintenance costs	1 553 857	1 035 905	39 463 045
Tax-cost factor, 20% of budget costs	5 035 771	3 357 181	127 892 609
TOTAL COSTS	30 214 629	20 143 086	767 355 654
Net benefit- cost ratio	**4,09**	**14,34**	**2,94**

Source: TOI-report 567/2002

addition, Trondheim has a relatively larger amount of cycle traffic today which benefit from reduced insecurity, than the other cities.

Appraisal of the applicability of the analyses and conclusions regarding net benefit to society

Conclusions regarding the applicability of the analyses, profitability to society and perspectives with respect to prioritisation of transport investments:

- The cost- benefit analyses are based on high, but realistic cost estimates, and "low" benefit estimates in order to prevent overestimates. The analyses are therefore judged to produce "down-to-earth" and conservative estimates of the profitability to society of building walking- and cycling track networks in Norwegian cities.
- Best estimate of future walking and cycling traffic leave no doubt that building walking- and cycling track networks in Hokksund, Hamar and Trondheim is profitable to the society. Net benefit- cost ratios in these cities are approximately 4, 14 and 3, respectively.
- Compared to the relatively low net benefit- cost ratios for other transport investments (conf. e.g. "The National Transport Plan 2002-2011"), investment in walking- and cycle tracks in Norwegian cities is a chance for the transport sector to make investments with considerably higher profitability to society than seen for a long time.

In spite of the fact that the single components in the cost- benefit analyses partly are subject to large uncertainties, the minimum estimate of future walking and cycle traffic in the sensitivity analyses shows that:

- Uncertainties in the cost estimates and the discount rate do not influence the conclusion about profitability to society.
- Uncertainties in the estimates of future walking and cycle traffic influence the magnitude of the net benefit- cost ratio, but it is probably in any case higher than zero. Irrespective of this uncertainty, investment in walking- and cycle track networks seem therefore profitable to society.

Barrier costs related to motorised road traffic

The cost- benefit analyses of walking- and cycling tracks include estimates of the most important benefit components. The results from such "complete" CBAs gives the possibility to calculate the benefit to society that is not realised because road traffic in Norwegian cities today obstruct people from choosing bicycle and walking as much as they otherwise would have preferred. This non-realised benefit to the society is an estimate of the *barrier costs* caused by road traffic.

Road traffic obstructs a realization of a “natural” amount of walking and cycling in the city areas. By “natural” amount of walking and cycling we mean that amount of walking and cycling that would have taken place if people could choose transport mode according to their preferences in a situation where road traffic did not cause insecurity and other inconveniences.

Table 4 presents the calculated average barrier costs for Hokksund, Hamar og Trondheim. The barrier costs (benefit losses) are calculated by taking the total benefit from the “best estimate” of future walking and cycle traffic in Table 3 and subtract the total benefit from the “minimum estimate” of future walking and cycle traffic from the sensitivity analyses. In order to estimate the external barrier cost and avoid double counting, the benefit of reduced insecurity for pedestrians and cyclists are excluded from this calculation.

Including the barrier costs calculated in Table 4 in total external costs from road traffic (Eriksen et al. 1999, also including accident costs), will increase the external cost for buses by approximately 33 percent. For cars (using petrol as fuel) inclusion of the barrier cost will increase the external cost by about 43% for Hokksund and Hamar, and by about 31% for Trondheim.

Our “best estimate” of future walking- and cycle traffic corresponds to an increase in the share of cycle journeys from 5 percent to day to 9 percent in the future in Hokksund and Hamar. In Trondheim the increase in cycle traffic will be from 9 percent to day to 13 percent in the future. If the “natural” amount of walking- and cycle traffic is larger than we have assumed in our “best estimate”, the barrier cost presented in Table 4 are under-estimates. If for example the “natural” amount of walking- and cycle traffic corresponds to a future share of cycle traffic at about 13 percent in Hokksund and Hamar, and 18 percent in Trondheim, the barrier cost will be more than doubled compared to the estimates in Table 4. Regardless of this uncertainty, the conclusion is that:

- Barrier cost is a large external cost related to motorised traffic. It is therefore important to take the barrier cost into account, in the same way as other external cost, when for example the issue is to determine the “right” level of car taxes or to evaluate different kind of restrictions on car use.

Table 4: Calculated average barrier costs related to motorised road traffic in Hokksund, Hamar and Trondheim. Calculations based on “best estimate” of future walking and cycle traffic.

Barrier costs calculated as benefit loss (different units)	**Hokksund**	**Hamar**	**Trondheim**
Benefit loss due to non-realised benefit of a “natural” amount of walking and cycle traffic (NOK, present value)	123 773 667	276 192 952	2 195 788 978
Benefit loss, NOK per year (annuity)	8 782 046	19 596 569	155 796 624
Benefit loss, NOK per day	24 060	53 689	426 840
Benefit loss, NOK per journey non-realised walking- and cycle traffic	7,98	8,42	9,60
Benefit loss, NOK per km non-realised walking- and cycle traffic	**3,74**	**3,95**	**4,33**
Benefit loss, NOK per motorised journey (all passenger transport journeys added 20 % freight transport journeys)	0,73	0,77	1,33
Benefit loss, NOK per motorised ”person”-km (assumed an average of 5 km per motorised journey)	0,15	0,15	0,27
Benefit loss, cars (NOK pr vehicle-km when assumed an occupation of 1,77 persons per car)	**0,26**	**0,27**	**0,47**
Benefit loss, buses (NOK pr vehicle-km when assumed an occupation of 10-12 passengers per bus)	**1,46**	**1,54**	**3,20**

Source: TOI-report 567/2002