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SCENARIOS FOR TRAFFIC CO_2 POLICY IN FINLAND FOR 2025

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ABSTRACT

Traffic is a sector that has growing problems facing the challenges that the Kyoto protocol suggests for global climate protection. The problems seem to be worsening as well in less developed as in the more developed countries. Europe is no exception in this manner, since the CO_2 emissions have increased at the same rate as traffic volumes in the late 1980's and in the 1990's, despite of technical development. Finland has followed this pattern, too.

The specific focus of the study is the fairly close correlation of three variables in 1970-1996 in Finland: GDP, road traffic volume and CO_2 emissions from road traffic. There are several strategies for stopping the growth of the CO_2 emissions. In this study, future scenarios of traffic are presented and they are operationalised into the development options of GDP, road traffic volume and CO_2 emissions from road traffic for 1997-2025.

On the basis of a review on social scientific literature of different environmental policy strategies, a total of five scenarios are constructed: Business as Usual, Economic and Technological Optimism, Ecological Modernisation, Structural Change and Deep Ecology. The scenarios are then applied more specifically into the future of GDP, road traffic volume and the CO_2 emissions from road traffic in Finland.

The study concludes that there are several strategies available in meeting the challenges of climate change in general and Kyoto protocol in particular. No single strategy can be recommended on the basis of scientific literature on environmental policy, because the choice is essentially a matter of values, politics and theory of the nature of climate change. Social scientific environmental research can, however, produce a set of alternative strategic scenarios for decision-makers.

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"At present the integration of environmental and transport policy does not seem to be functioning anywhere."
Martin Jänicke and Helmut Weidner (1997, 308)

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Key words: traffic, road traffic, gross domestic product, carbon dioxide emissions, carbon dioxide policy, scenario.

1. CLIMATE AND TRAFFIC

1.1 Global Climate Change

The natural green house effect has probably been increased by human emissions of green house gases. On the basis of radiative forcing, most important of the human induced greenhouse gas emissions is carbon dioxide (CO_2), other important being halogenated hydrocarbons, methane (CH_4) and nitrous oxide (N_2O) (IPCC 1990, xx; see also IPCC 1992, 47-67). In 1990, the Intergovernmental Panel on Climate Change (IPCC) still regarded anthropogenic climate change as one possibility (IPCC 1990, xi-xii). After substantial climatological research, the IPCC contributed a Second Assessment in 1995, which concluded that the balance of evidence suggests that a human induced climate change has already begun and can be discerned from natural variation (IPCC 1996a, 4-5; Bach 1998).

Despite the growing consensus that climate has already changed and changes all the time, there are still disagreements. The Kyoto protocol to the United Nations Framework Convention on Climate Change (UNFCCC) has agreed on emission targets to stabilise the total emissions of greenhouse gases to the year 1990 level on a timescale of 2008-2012. But according to the IPCC reports, an approximately 60% reduction of CO_2 emissions from the 1990 level will be needed to stabilise the CO_2 concentration of the atmosphere (IPCC 1990, xi, xviii; IPCC 1996a, 85; IPCC 1996c, 387-388). Even though a consensus on the emission targets has been formulated, there are still different views concerning the best means to achieve the targets (Kyoto Protocol…1997).

One additional problem is that although there would be general agreement on the level of emissions for a country, there still remains a lot to speculate about the emission targets within a societal sector. Climate policy has implications in every societal sector: energy production, health care, traffic, agriculture, metal industry, education etc. Main sectors in the climate policy debate in Finland are energy production and traffic.

This study focuses on traffic, which was responsible for 20-25% of the carbon dioxide emissions both worldwide, in the European Union (EU15) and in Finland in the 1990's (IPCC 1996b, 683, EU Transport in… 1999, 81; Ministry of Transport… 1999a, 3).[1] In the EU15, CO_2 emissions from traffic increased more rapidly in 1985-1995 than CO_2 emissions from other sources (EU Transport in… 1999, 81). Thus, the importance of traffic in climate policy seems to be increasing (see also Jänicke and Weidner 1997).

Another characteristic of traffic is that it is hard to manage because of the magnitude of actors involved. There are no major point sources of emission, but the aggregated effect of traffic on climate is substantial. Access to mobility and especially the private car are also symbols of individual freedom, although this seems more apparent than real when considering congestion. According to some attitude surveys, European as well as the Finnish majority do support policies aiming at reduction of car use in priciple but do not support concrete restrictive measures (Socialdata 1992; Lankinen 1995; Sairinen 1996, 81-84; Steg et al 1997).

1 The estimate of the share of CO2 emissions of traffic, was 22% for world in 1990 (IPCC 1996b, 683), 26% for EU15 in 1995 (Eurostat 1999, 81) and 20% for Finland in 1997 (Ministry of Transport… 1999a, 3). The CO2 share of traffic is relatively low in Finland because of energy intesive forest and metal industry and relatively high proportion of fossil fuels in energy production (Wahlström et al 1996, 194).

1.2 GDP, Traffic Volumes and CO_2 Emissions of Traffic in the EU

To be of operational relevance, climate policy studies seem to need to focus on concrete social action that forms a link between economy and environment. Traffic provides an example of this kind of link.

Due to technical development, the fuel efficiency of vehicles improves and this should be seen as stagnating or decreasing CO2 emissions. However, this effect has been overruled by at least three factors in the EU15 countries. Firstly, the passenger traffic volume has increased even faster than the GDP[2] between 1970-1995. At the same time, the freight transport volume has increased approximately at the same rate as GDP. Secondly, the volume growth has been most rapid in motorised road transport and air transport, which produce more CO2 emissions per passenger kilometre and tonne kilometre than rail transport and soft modes.

Thirdly, people have been buying bigger cars with more powerful engines, which consume more fuel. The total effect has been that the CO2 emissions from transport in general and road transport specifically increased even faster than passenger kilometres and tonne kilometres between 1985-1990 and at the same rate between 1990-1995. (Figure 1.2; EU Transport in… 1999, 10, 38, 56, 81.) According to a study conducted for the European Conference of Ministers of Transport, even the CO2 emissions per vehicle kilometre did not seem to decrease in Western Europe between 1985-1995 (Figure 1.1; ECMT ref. Lampinen 1998, 9).

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Figure 1.1 The Weighted Average Fuel Consumption of New Passenger Cars in Seven Countries: Germany, Austria, Belgium, France, Italy, Great Britain and Sweden in 1980-1995 (70% of the European markets) (ECMT, ref. Lampinen 1998, 9).

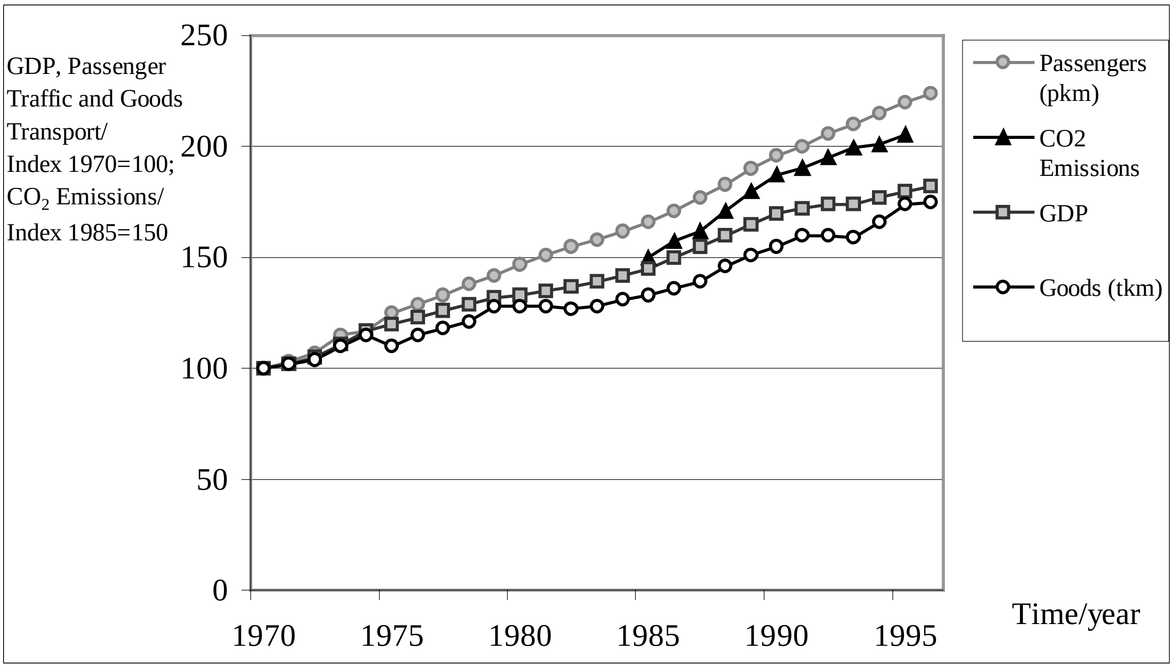

Figure 1.2 GDP, Passenger Traffic and Goods Transport in EU15 1970-1996 and CO_2 Emissions from Traffic in EU15 1985-1995 (EU Transport in… 1999, 10, 81).

[2] The GDP values in this study are presented in real terms and market exchange rates.

Road traffic emitted approximately 85% of the CO_2 emissions from traffic in the EU15 countries in 1985, 1990 and 1995 (EU Transport in… 1999, 81). The figure does not take into account the fossil fuel burned to electricity for rail transport, but even if it did, the figure would still be approximately 80% (*ibid*, 80). It seems adequate to concentrate on road traffic as the main source of traffic related CO_2 emissions.

1.3 GDP, Road Traffic Volume and CO_2 Emissions from Road Traffic in Finland

Finland has followed approximately the same pattern as the EU15 average. Some special features compared to other EU15 countries should be mentioned. Traffic volumes have been increasing a little slowlier, almost according to GDP values. The average fuel consumption of private cars did not decrease in Finland even in the early 1980'ies, which makes the relation between GDP and CO_2 emissions from traffic same as in the EU average. There was a strong correlation between GDP, road traffic volume and the CO_2 emissions of road traffic in 1970-1996 in Finland (Figure 1.3).[3]

Another special feature of Finland is the recession in the early nineties, that was deeper in Finland than in the EU15 countries on average (Figures 1.2 and 1.3). It was partly a followup of overheating of the economy in the late eighties. Another factor was the collapse of Soviet Union, which also collapsed the Finnish export to Soviet Union.

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Figure 1.3 The volume and CO_2 emissions of road traffic, and the GDP of Finland in 1970-1996 (Mäkelä 1997; FinnRA 1997; Statistics Finland 1997).

[3] A more comprehensive analysis of the features of Finnish traffic is conducted in chapter 3.2 in connection with the Business as Usual Scenario.

2. RESEARCH PROBLEM

The purpose of this study is to formulate scenarios of possible futures of the GDP, road traffic volume and the CO_2 emissions from road traffic in Finland. The main focus is on policy strategies but also changes in human values, lifestyles and technology are examined. The scenarios are formulated on the basis of theoretical literature of environmental policy. This paper has been written in order to operationalise the theoretical literature with regard to the specific object of climate policy of the transport sector in Finland. The argument is qualitative in nature, but the scenarios are illustrated by numerical key factors.

The time frame concerns years 1970-1996[4] on the background data and approximately the same timescale to the future 1997-2025. The time frame is long enough for known prototype technologies to gain a significant market share and it is also compatible with the time that building new infrastructure has impacts on society and environment. The time frame adopted here is a tryout for balancing between the underestimation and overestimation of possibilities for social change.

[4] This was the last year available in Winter 1998, when the background data was collected.

3. FIVE SCENARIOS ON CO_2 POLICY OF TRAFFIC

3.1 Choise of the Scenarios

In this chapter, five scenarios of environmental policy applied to traffic are presented. The source of the scenarios and the qualities included in them are condensed to this very brief summary in chapter 3.1. The scenarios are as follows:

- Business as Usual
- Economic and Technological Optimism
- Ecological Modernisation
- Structural Change
- Deep Ecology

The distinction is adopted from the works of Naess (1981, 22-27, 122-139), Jänicke (1988, 14-16), Sairinen (1996, 28-38) and Kaivo-oja (1999), and is supposed to describe the possible strategies in environmental policy. Business as Usual describes the reference scenario, where little or no adjustment of the past policies is made. It is close to a combination of remediation and end-of-pipe policies treated by Jänicke[5] and Sairinen[6].

Economic and Technological Optimism here describes similar qualities as Naess's shallow ecology[7], the boomsday scenario by Kaivo-oja[8] and the preventive environmental policy by Sairinen[9]. Also the narrow technology oriented interpretation of ecological modernisation is close to this scenario (see Spaargaren & Mol 1992).

Ecological Modernisation has similar qualities as Jänicke's view. From Sairinen, I have adopted the feature that not only technology is changed but also some human behaviour.[10] Kaivo-oja's concept of

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[5] Jänicke's (1988, 14-16) original concepts here are *"Reparatur und Kompensation"*, which could be translated remediation and compensation of environmental problems. With the concept *"Entsorgung"* he clearly meant applying end-of-pipe technology. Part of Jänicke's categories come from Gerau (1978).

[6] Sairinen (1996, 30, 32-34) used the concept *"päästöjen alueellinen ohjaus"* which could be translated as dilution of emissions and means that emissions are led as far away from the environmental type protected as possible. He also uses a concept *"puhdistus- ja suodatinpolitiikka"* which means applying end-of-pipe technology. Sairinen's distinction is based on a wide review on literature of environmental policy (ibid, 29).

[7] Naess's original concept is *"grunda ekologiska rörelsen"* which can be translated as shallow ecological movement as contrast to the deep ecological movement. A difference of these is that shallow ecology includes hard technology and centralised ways of production and administration, whereas deep ecology includes soft technology with decentralised ways of production and administration (Naess 1981, 22-27, 122-139).

[8] The Boomsday scenario of Kaivo-oja originates from Stiglitz.

[9] Sairinen's concept preventive environmental policy, *"ennakoiva ympäristöpolitiikka"* differs a bit from the same concept, *"Vorsorge"* of Jänicke (1988, 14-16).

[10] Sairinen merges Jänicke's ideas of technology-oriented ecological modernisation and sosially oriented structural change strategies to the concept ecological modernisation. For example Jokinen (1995) argues that these should be kept separate and gives empirical examples of differences. (See also Massa 1995.)

strong sustainable development is also similar as ecological modernisation here. This concept has little to do with the sustainable development strategy presented by the Brundtland Commission.[11]

Structural Change scenario is similar to Jänicke's idea of structural change. Deep Ecology is adopted more in the spirit of Naess and Kaivo-oja[12], less in Sairinen's view of ecological fundamentalism.[13]

Some parts of the distinctions presented in the references are left over from the scenarios here. From Sairinen, the strategy of nature conservation seems to have little importance in terms of traffic volumes and CO_2 emissions. From Kaivo-oja, weak sustainable development and doomsday are merely descriptions of policy failures instead of environmental policy strategies, which are dealt with in this study.

All the scenarios except the Business as Usual are expected to meet the goals of the Kyoto protocol, where EU15 countries committed themselves to reduce CO_2 emissions by 8% from the base year 1990 to the time frame between 2008-2012. Finland has a target to maintain the 1990 level of CO_2 emissions to 2010 and the same target was set for traffic sector as well (Ministry of Transport... 1999a, 1).

Although the basis of this study is qualitative and heuristic in nature, the theoretical scenarios are operationalised into a quantitatively measurable state. The figures presented are not directly based on model calculations but are merely illustrative examples of what the qualitative theories might mean in practise. Some key factors, such as the private car density, average annual car kilometres and traffic volume are tested to maintain internal consistency of the scenarios.

All scenarios have the assumption of ageing population and stagnating curve with practically no net increase in population[14] which is the same as the demographic forecast by Statistics Finland that was used in the Finnish Road Administration national Road traffic forecast for 1995-2020 (FinnRA 1995, 65). The Business as Usual scenario is more thoroughly presented and argued than the other theoretical scenarios, because it represents a reference for all the others.

As Schwarz et al (1982) have written, the choice of the parameters that are varied between different scenarios is crucial to the relevance of the scenarios. When making policy scenarios, at least part of the parameters varied should be different kinds of policy measures. Major explanatory factors that are altered between the scenarios in this study are as follows:

- the relation of material versus non-material production
- regional structure and urban structure
- people's values
- technological development of vehicles
- fuel taxation
- vehicle taxation
- transportation infrastructure

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[11] According to Kaivo-oja, Stiglitz sees that sustainable development includes a fairly slow economic growth, which differes from the sustainable development defined by the Brundtland Commission, including annual 3% growth in GDP per capita (Our Common... 1987). This is way faster than business as usual. Between 1970-1994 the total gross world product (GWP) grew 2,8% annually and the world population increased from 3,8 billion to 5,7 billion, which makes the average annual GWP per capita growth only 1,1% (Brown et al 1994, 99; UNEP 1998).

[12] Kaivo-oja refers to Karshenas (1994) who argues against the deep ecology thinking on the basis of the situation in the third world. In this study however, the focus is on Finland, which is a Western industrialised economy with a high output rate (eg. Bach 1998, 499).

[13] Calling view fundamentalist labels it politically unfeasible. An evaluation of the different scenarios is not the point of this paper, so a more respectful concept was adopted. Sairinen also refers to the Finnish author and fisherman, Pentti Linkola (eg. 1986), whose views differ clearly from those of Naess.

[14] The figures used are 5,15 million in 1996, 5,3 million in 2015 and 5,2 million in 2025 (FinnRA 1995, 65).

3.2 Business as Usual

In the theoretical Business as Usual (BAU) scenario, the future will continue the same way as in the past development of 1970-1996. The Finnish economy will be based fairly strongly on material growth, especially the metal and forest industry. As the economy will grow, people's income will increase and they will spend the extra money by, among other things, buying and driving more private cars. No significant new policies to restrict this trend will be used and no change in the prevailing individualist human values is expected. Only little technical improvement concerning the CO_2 emissions of traffic will occur.

Instead of pure mathematical extrapolation, a slight stagnation of the three curves would occur in the business as usual scenario.[15] The CO2 emissions trend would stagnate earlier and more clearly than the road traffic volume, which in turn would stagnate earlier and more clearly than the GDP (Figure 4.1). Concerning traffic, the Business as Usual scenario is formed on the basis of baseline forecasts of the Finnish Road Administration (FinnRA 1990; 1995).[16]

The stagnation needs explanation. The pit in the GDP curve of Finland in early 1990'ies is regarded as a sign of a slight drop of the long term growth speed. Substantial explanation can be found in the collapse of Russian and some other Eastern European economies in the 90'ies. Also, it is assumed here, that the economic boom of Finland in the late 1980'ies was a sign of overheating. These assumptions are, of course, questionable and differ e.g. from the views presented by FinnRA (1995, 75). Adopting FinnRA forecasts for 1996-2020 and extrapolating it for 2020-2025 would give the total growth of GDP approximately 100%,[17] but here a more moderate growth is expected, namely 80%, which equals an average 2% annual growth in real terms.

One important factor for stagnation of road traffic volume is that the theoretical maximum private car density is estimated to be 550…600 cars per 1000 inhabitants, because only 60% of population will be capable of driving a car (Roos & Altshuler ref. FinnRA 1990, 73; FinnRA 1995, 131). According to the baseline forecast of FinnRA (1995), the private car density would increase from the 380 in 1996 to 510 cars per 1000 inhabitants in 2020 as more and more people can afford it due to economic growth (FinnRA 1995, 128-131; Ministry of Transport… 1999b, 85).

Even with a fairly steady growth of income and with an even distribution of the additional income, the poorest quintile of households would have a high threshold of buying a car (FinnRA 1990, 54; FinnRA 1995, 131). The FinnRA (1995, 128) forecast suggested also, that there is a fraction of people, who do not want to run a car. The price of a car is relatively high in Finland compared to other EU states, of which only Portugal and Denmark had higher prices in 1993 (FinnRA 1995, 83). This will probably limit the growth of car density, too.

Here it is assumed that the private car density of Finland would be approximately 540…560 cars per 1000 inhabitants in 2025 in the Business as Usual scenario. Another stagnation driving force has been suggested to be the possible drop of average annual car kilometres from the 19 thousand kilometres of the mid-nineties to the level of 18 thousand of the more automobilised countries (FinnRA 1995, 110-115). This development is questionable, because the declining rate of average annual car kilometres may have turned

[15] In this business as usual scenario, only the policy and the values of society are extrapolated, not the variables. There are outer almost independent variables that affect also traffic, mainly demographic factors, that are kept constant here.

[16] There are differences between FinnRA (1990, made in 1989) and FinnRA (1995) forecasts. The 1989 forecast was more growth oriented and suggested higher car density, 550 private cars per 1000 inhabitants for 2010 whereas the 1995 forecast suggested 510 for 2020. The theory behind the forecast is more clearly explained in FinnRA (1990). The FinnRA (1995) forecast also contributed two alternative scenarios for the baseline scenario, namely a Market oriented scenario and a Sustainable growth scenario. The former is close to the Economic and technological optimism scenario presented in this paper and the latter seems to locate between the Ecological modernisation and Structural change scenarios.

[17] This figure consists of 3,5% annual growth for 1995-2000, 3% for 2000-2005 and 2% for 2005-2020 and is applied from the forecasts produced by Ministry of Treasury, VATT and ETLA (FinnRA 1995, 75).

to a steady state 1985-1996 in Finland and even to growth in countries like Denmark and USA (Figure 3.1). Thus, here it is assumed that according to business as usual policy and values the average annual car km would not decrease anymore. It might even rise a little, when the car density would come closer to the saturation level. A figure of 20 thousand average annual private car km is used in the Business as Usual scenario.

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Figure 3.1 Average Annual Passenger Car Kilometres per Vehicle in Selected Industrial Countries in 1960-1996 (TRRL, IRF and VDA ref. Ministry of Transport... 1999b, appendix p. 22-23).

The CO_2 emissions per vehicle kilometre would decrease in the Business as Usual scenario because the efficiency of the engines would get better and the growth of car weight would stagnate. The impact of the technological development would be only slight because in the business as usual scenario people would keep on buying cars with more engine power. On the goods transport side, smaller units would be transported just in time, which would somewhat prevent emissions per tonnekm to decrease (FinnRA 1990, 69-70; FinnRA 1995, 75; Lampinen 1980).

The economic values and the values of freedom to move individually dominate in the Business as Usual scenario. Environmental values do not represent significant role since the *laissez faire* approach to climate change is adopted. The future development of the GDP, road traffic volume and the CO_2 emissions from road traffic in the hypothetical Business as Usual scenario is illustrated in Figure 3.2.

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Figure 3.2 The Volume and CO_2 Emissions of Road Traffic and the GDP in Finland between 1970-1996 and in the Hypothetical Business as Usual scenario in 1997-2025.

3.3 Economic and Technological Optimism

The theoretical Economic and Technological Optimism scenario is based on the idea that a high growth rate of the economy will accelerate the development and applications of more environmentally sound technologies. GDP and road traffic volume would continue increasing as they have been doing in the past without any stagnation. The CO_2 emission curve would stay on the level of the 90's and slightly drop in the end of the period.

Substantial arguments presented for the BAU scenario (chapter 3.2) supposed stagnation especially for road traffic volume. Furthermore, technology has been developed in the past already, but there has been no significant improvement in fuel efficiency. Why would it change in the future? There is, of course, room for other arguments as well which claim that no stagnation of road traffic volume would occur and still the CO_2 emissions from road traffic could be reduced.

One point criticises the expected saturation level of private car density. There could be demand for several cars per person for different purposes, eg. a little car for commuting to work and a bigger car for longer holiday trips. Also, the senior citizens of the future might be more fit and healthy to drive a car than is expected in the BAU scenario. Also, with the use of information technology the safety of ageing drivers could be better guaranteed. In the Economic and Technological Optimism the private car density of Finland would grow up to approximately 590...610 private cars per 1000 inhabitants and the fraction of people not wanting a car would be more marginal than in the BAU scenario.

The computerised transport managing systems (telematics) would prevent traffic jams and improve the efficient use of the road capacity, especially in goods transport but also in passenger traffic (eg. Rillings 1997; Svidén 1999). Also, new lanes for motorways and major streets would be constructed more than in the business as usual scenario. This would probably increase travel speed and access to further places and therefore more average annual km per car. A figure of 22 000 km per car per year is assumed to describe the ETO scenario.

Technological development would produce better fuel efficiency in the ETO scenario. This is also encouraged politically by decreasing the taxes for buying a new car. A success from the 8 l/100 km in 1996 to 5 l/100 km can be seen in traditional combustion engines. Also, new technologies are an important part of the ETO scenario and the market share of hybrid electric vehicles, electric cars and later on hydrogen cars would increase to approximately 20…30% to 2025 from the few tens of vehicles in 1996. Similar ideas are presented by Svidén (1999) [18] and Wouk (1997).

The urban structure would be more dispersed in the ETO scenario than in the BAU scenario. This is due to the mechanism that more people would want to live in single family houses than blocks of flats, which is difficult in densely populated areas. This in turn would be unfavourable for public transport that would loose its market share.

The economic values and the values of freedom to move individually dominate in the ETO scenario, too. But there is a different, more respective attitude towards the environment than in the BAU scenario, although the risk of climate change would not be taken very seriously.

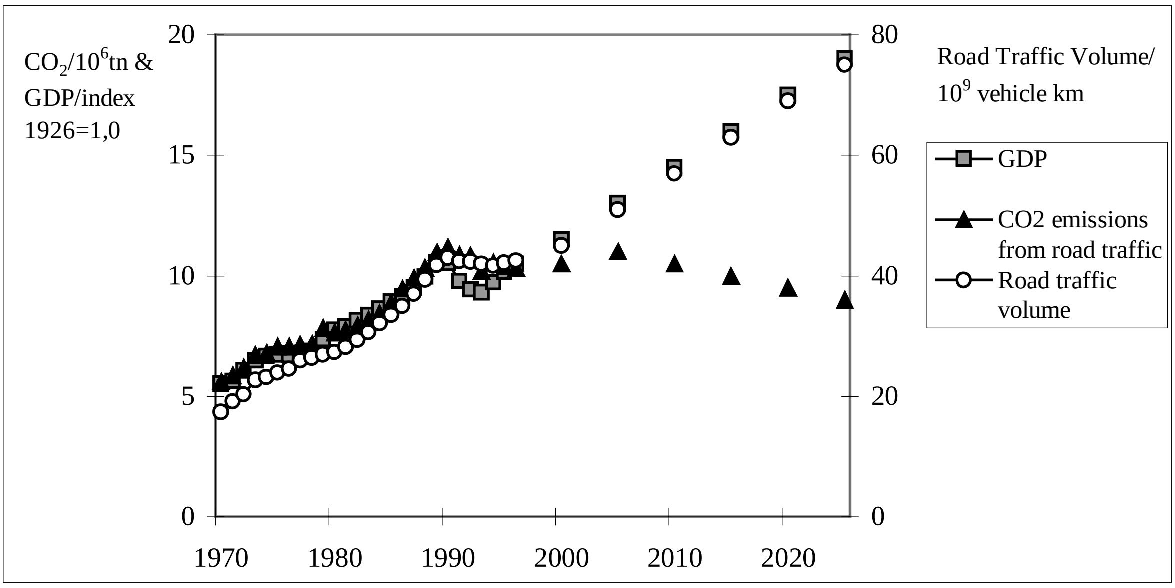

Figure 3.3 The volume and CO_2 emissions of Road Traffic and the GDP in Finland in the Economic and Technological Optimism Scenario.

[18] Svidén (1999) expected further that natural gas will largely substitute oil and carbon fibres will substitute steel by 2020.

3.4 Ecological Modernisation

Ecological modernisation (EMO) is the most difficult scenario to formulate in a concrete manner (see also Sairinen 1996, 18). Some features of it are more clear than others. Main point is that people's values would become more respective towards the environment and the evironmental impacts of certain actions would be more carefully assessed by societal institutions and by individuals, as well. Technology would be more environmentally oriented in the EMO scenario than in the ETO scenario (eg. Sagar 1995) and less for maximising short term profit, whereas in the ETO scenario, the environmentally favourable qualities of new technology would be a by-product of the general developing process.

The growth of the GDP would be at the same level as in the BAU scenario. Because of the more long term profit horizon, the GDP would grow slowlier than in the ETO scenario. This would probably slow down the rate how fast new technology would spread to the markets because the income rate would increase slowlier.

Also, the growth of the traffic volume would continue in the Ecological Modernisation scenario, but less steeply as the GDP and less steeply as the volume in the BAU scenario. This would be a consequence of more people planning their trips and more people using public transport. The effect cannot be seen very dramatically in the road traffic volume because the modern individual life style would still produce a lot of mobility. The private car density would grow to the level of the BAU scenario, 540...560 private cars per 1000 inhabitants, but the average annual car km would be little less, approximately 18 000 km.

On freight transport, a change in production structure to less material oriented production would affect a stagnation of the growth of tonne km but it would also effect some extra vehicle km because the units for transport would be smaller. Some of the freight would be transfered from road to rail because of environmental reasons, but the technical feasibility of rail to transport smaller units in a decentralised regional structure would be poor. Thus, the net substitution effect would be only limiting the growth of road transport instead of stopping the growth.

The CO_2 emissions would decrease slightly from the level of the 90'ies in the EMO scenario. Although the average fuel consumption would be little more than in the ETO scenario due to longer vehicle life-cycles, the lower road traffic volume would produce less carbon dioxide. The net effect of these contradictory factors, compared to the ETO scenario, would be zero.

Telematics would play a major role in the EMO scenario, too – both in passenger traffic and goods transport. Additionally to the ETO scenario, some actual physical traffic would be substituted by telecommunications. Especially, this would happen concerning international flights but a little could be seen in domestic road traffic as well.

In the Ecological Modernisation scenario, there is a clear statement that economical, social and environmental values can be fulfilled at the same time.

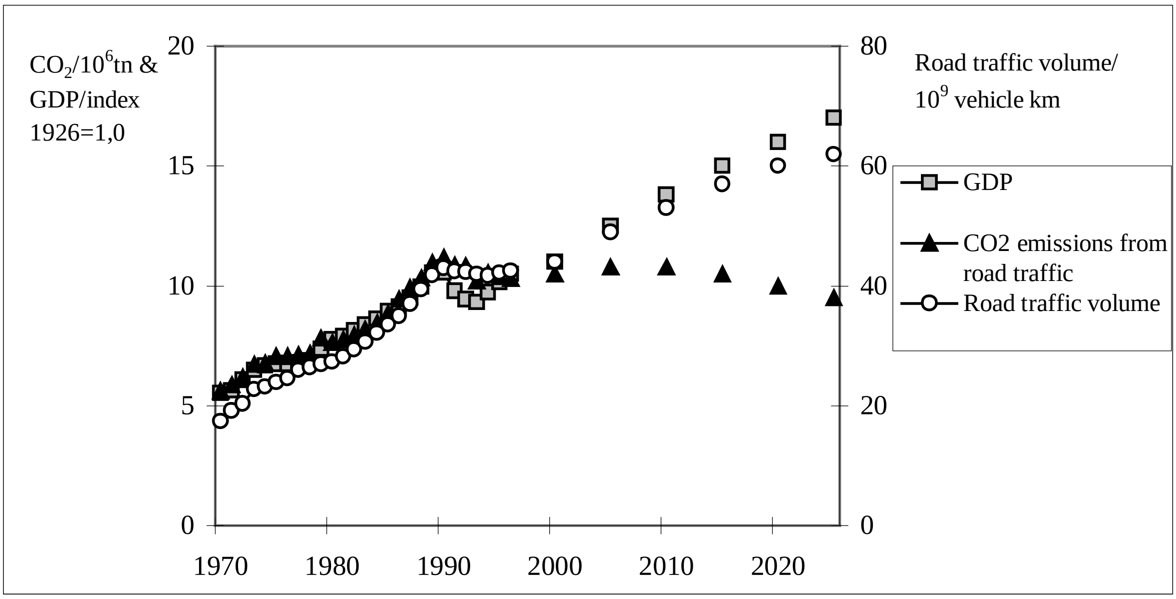

Figure 3.4 The Volume and CO_2 Emissions of Road Traffic and the GDP of Finland in the Ecological Modernisation Scenario.

3.5 Structural Change

The Structural Change (SC) scenario starts from the idea that the material intensive production and consumption structures should be changed in order to achieve environmental sustainability (Jänicke (1988, 14-16). In passenger traffic, that would clearly mean modal shift from private cars and flights to bicycle, walking and surface public transport. As for freight transport, a change from road to rail and waterborne modes is expected. These starting points have a clear implication for urban infill, because a dense urban sturcture is more suitable for public transport than a sprawl area. That kind of structure would also generate less traffic volume.

As only the structure of the economy is changed, a somewhat questionable assumption is made, that the growth of the GDP will be as in the EMO and BAU scenarios.

Although the total passenger and freight transport volumes would still increase a little in the Structural Change scenario, the road traffic volume would stay in the same level as in the 90's. This would happen as a consequence of the modal split required. As for freight, the shift from road to rail would be a difficult one, because of the small units that would stem from the qualitative change in production. There would be less bulk to transport and more high-tech products. The dense urban structure would still probably offer some potential for trade-off.

As a consequence of environmental emphasis on the development of technology, transport policy and individuals' choice of traffic mode, the CO_2 emissions of road traffic would drop significantly from the level of 1990's.

In the Structural Change scenario, telematics play a minor role in passenger traffic, because the prevention of traffic jams by increasing the road capacity is seen to increase traffic volume. In goods transport it will be adopted. Several policy instruments would be adopted more effectively in order to affect real change in travel behaviour: taxes for fuel, monetary and regulatory subsidies for surface public transport, parking restrictions for private cars, speed limits etc.

In more concrete terms, these factors are here assumed to produce approximately 17 000 annual average private car km per year. The drop is not very great from the other scenarios described above, because the restrictive private car policy would raise the threshold of buying a car and less low-use cars would be bought. The private car density in Finland would thus be 440...460 private cars per 1000 inhabitants in the Structural Change scenario.

In the structural change scenario, there is seen to be contradiction between increasing mobility and the environmental values, but there is a clear trust in the compatibility between economical and environmental values.

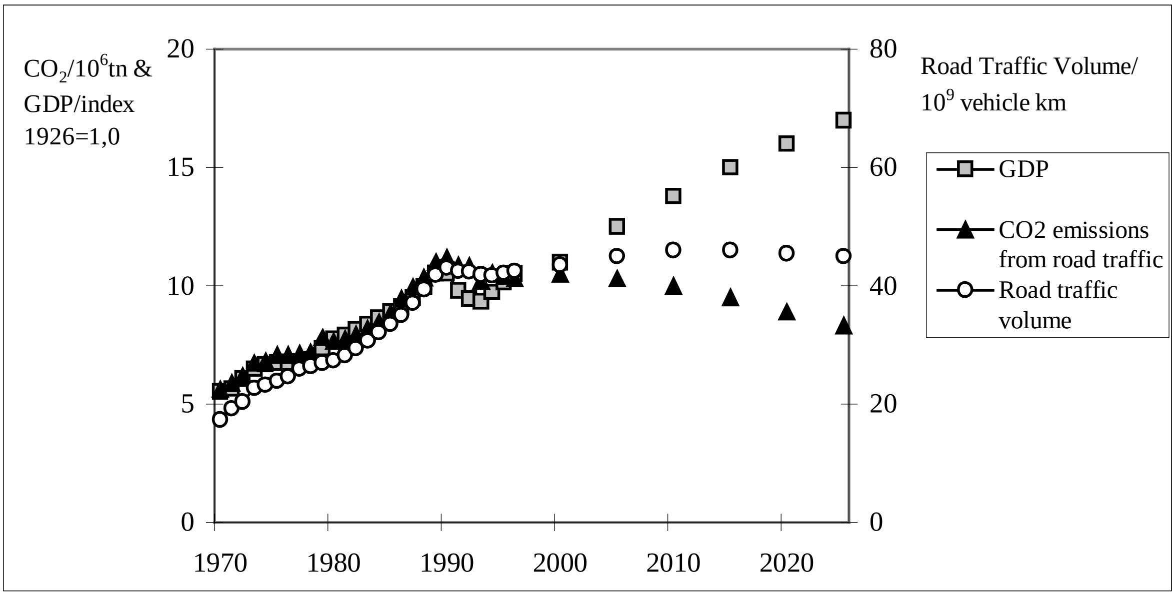

Figure 3.5 The volume and CO_2 emissions of road traffic and the GDP in Finland in the Structural Change Scenario.

3.6 Deep Ecology

The background idea of the Deep Ecology (DE) scenario is, that the growth of environmentally harmful ways of production and consumption should not only be stopped but even turned to decrease in industrialised countries (Naess 1981, 22-27). As for passenger traffic, this would mean a drop of private car driving and flights. In freight transport this would mean some decrease of total tonne km and clear decrease in road transport volume.

A scenario like this would probably stop the growth of GDP as well. If people would value a simple life and social relations more than shopping goods, it is assumed here, that it would have a clear effect on GDP. There would be only minor GDP growth if any.

The road traffic volume would also decrease clearly. The background of this goal is, that there is little evidence of the success of the technical development in the past, concerning GDP, road traffic volume and the CO_2 emissions from road traffic (Figure 3.6).

As the income rate would not grow and might even decrease a little, people would buy less new cars. As a consequence, the car industry would have less profit to invest in improving technology and the car stock would get older. These factors would lead to a slowlier reduction rate of CO_2 emissions per vehicle km than in the previous scenarios. A clear change to smaller cars would occur, though. Thus, the total CO_2 emissions of road traffic would decrease faster than the road traffic volume.

In the Deep Ecology scenario, the risk of climate change would be taken very seriously and it would include the idea that western countries have already exceeded the limits to growth. The reduction of road traffic volume would be achieved partly by increasing fuel taxes, but the main measures would be norms and physical changes – more streets would be blocked from private cars. More emphasis would be stated to public transport and on the infrastructure of bicycling. The passenger kilometres would drop slightly, too.

As the Deep Ecology scenario sees centralised systems as an important reason for environmental problems, a more decentralised form of living would be adopted. From the community criterion it can be derived that an emphasis of little towns and villages is important. Little towns are more consistent with the goal of reducing car traffic than little villages and sprawl areas.

A figure of 370...390 private cars per 1000 inhabitants is assumed in the Deep Ecology scenario, which equals the car density of the mid-nineties in Finland. The average annual car km would decrease because of the more calm life-style and the high fuel prices to circa 15000 km.

In the deep ecology scenario, some anti-modern features can be seen. Living a simple life is valued and economical growth is seen to be the principal cause for environmental problems. The distinction between material and non-material growth is not accepted because there is not enough evidence of it. Increasing mobility is not seen as increasing freedom but merely increasing obligation to move.

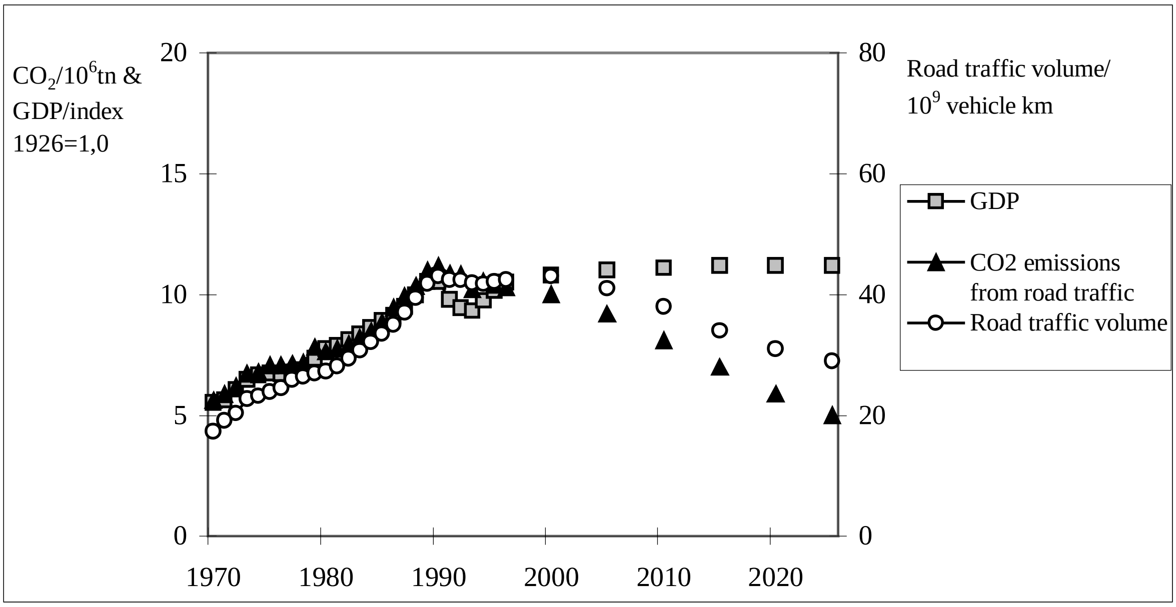

Figure 3.6 The volume and CO_2 emissions of road traffic and the GDP in Finland in the Deep Ecology Scenario.

3.7 Summary of the Scenarios

The characteristics of the theoretical scenarios can be summarised in a set of continuums illustrated in Figure 3.7.

GDP

Rapid growth	Moderate growth	Zero growth	Moderate decrease	Rapid decrease
ETO	EMO, BAU, SC	DE		

Road traffic volume (vehicle km)

Rapid growth	Moderate growth	Zero growth	Moderate decrease	Rapid decrease
ETO	BAU EMO	SC	DE	

Passenger traffic volume (passenger km)

Rapid growth	Moderate growth	Zero growth	Moderate decrease	Rapid decrease
ETO	BAU, EMO	SC DE		

Freight transport volume (tonne km)

Rapid growth	Moderate growth	Zero growth	Moderate decrease	Rapid decrease
ETO	BAU EMO	SC	DE	

CO_2 emissions from road traffic

Rapid growth	Moderate growth	Zero growth	Moderate decrease	Rapid decrease
	BAU	ETO, EMO	SC	DE

Values

Individualism				Communalism
	ETO EMO BAU		DE SC	

Utilism towards nature				Respect for nature
BAU	ETO	EMO SC	DE	

Urban structure

Sprawl				Dense
ETO	BAU	EMO DE	SC	

Regional Structure

Centralised				Decentralised
ETO	SC BAU	EMO	DE	

Symbolic transport mode

Aeroplane	Private car	Fast train	Bicycle	Computer
ETO	BAU	SC	DE	EMO

Relation between society and economy

Economy rules policy				Policy rules economy
ETO	BAU	EMO	SC DE	

Figure 3.7 Summary of the position of the theoretical scenarios in relation to some key factors (BAU=Business as Usual; ETO=Economic and Technological Optimism; EMO= Ecological Modernisation; SC=Structural Change; DE=Deep Ecology).

4. DISCUSSION

The previous chapters have demonstrated that there are several strategies to meet the challenges of climate change in general and Kyoto protocol in particular. No single strategy can be recommended on the basis of research on environmental policy, because the choice is essentially a matter of values, politics and the theory of the nature of climate change. Social scientific environmental research can, however, produce a set of alternative strategies and scenarios for decision-makers. (See eg. de Jouvenel 1967; Amara 1981; Godet 1986; Mannermaa 1986; Inayatullah 1990; Tapio 1996; Kuusi 1999)

When alternative future scenarios are formulated, a critical point is, which factors are varied between scenarios (Schwarz et al 1982; Steg et al 1997). A distinction can be made on the basis of what decision-makers can affect and what they have very little influence on (de Jouvenel 1967; Hirschhorn 1980). If only those factors that cannot be influenced by decision-makers are varied, there is nothing to make decisions on. On the other hand, if only those factors, that decision-makers have strong influence on, are varied, there is a risk of being hit by a surprising external factor. A balance between the factors external and internal to decision-making should be searched when making scenarios (Meristö 1991; Kuusi 1999). This general idea should also be addressed when considering the CO_2 policy of traffic.

In the light of wider strategies for change, the discussion on which climate policy instruments are the best seems somewhat unimportant. As Jänicke (1997, 6) states on the basis of empirical case studies, the way an environmental policy instrument is used seems more important than the question of what particular instrument is used. Thus, the factors that are altered between different scenarios should be the force and focus of certain instruments rather than the instruments themselves.

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