Climate OptiOns for the Long term
COOL

1st COOL Europe Workshop
Centre for European Policy Studies (CEPS)
Brussels, 29th of November 1999

Briefing Document

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1. Introduction

On the following pages you find some starting material for the First European COOL(Climate OptiOns for the Long term)-workshop on November 29th 1999. This workshop is the first in a series of four in which long term strategies for Climate Change Policy in Europe will be connected to long term sector strategies (Transport and Energy/Industry).

The material in this paper is not meant to be complete or comprehensive. After all the participants themselves are the ones who bring in the main input to the workshops. The material in this paper is meant to inspire you and to trigger you to come up with your own ideas. We aim for a creative and inspiring working-atmosphere during the workshops. Thinking seriously about the long term needs a creative and open mind. Other thinking patterns have to be followed than we are normally used to. As part of the Backcasting concept followed by the COOL-project, this first workshop focusses on "Images of the Future". The particpants will construct a picture about how the European society might look like when the criterium of a -80% greenhouse gas emission reduction is satisfied.

The document contains the following information:

Section 2: An introduction on the "Backcasting" concept. Long term thinking should be more than day-dreaming or a kind of science-fiction. The backcasting concept provides a meaningful structure for thinking about the future when at the same time focussing on choices in the present which will have implications for the future. The four COOL workshops will follow the different steps of the backcasting concept. In this way each work-shop has its own focus. At the same time each workshop also presents a step forward in the process towards an overall vision on long term strategies and short term choices.

Section 3: An introduction on the challenges regarding Transport in the 21st century. Several studies are presented shortly. Criteria are given for a transport system that is compatible with an 80% reduction of CO_2 emissions.

Section 4: An introduction on the challenges regarding Energy supply in the 21st Century. Examples are given of elements of possible futures.

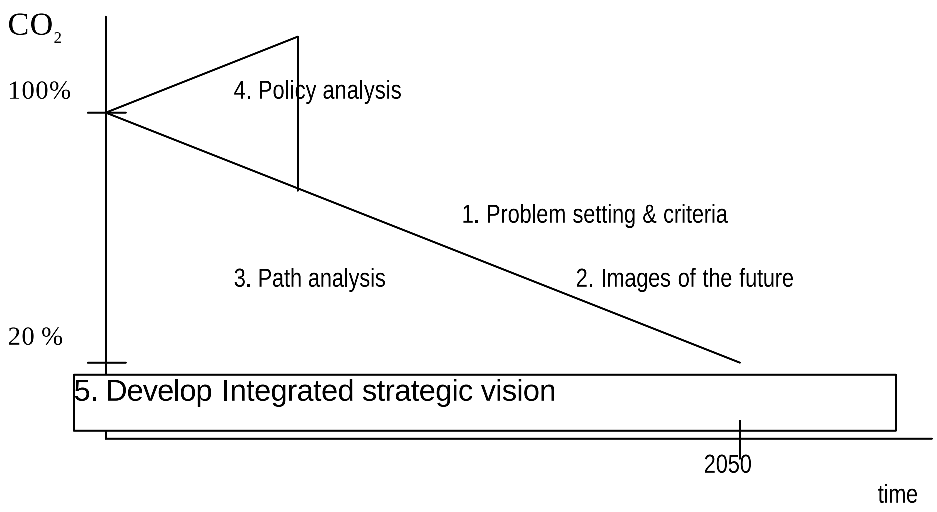
Appendix I:
In Appendix I as an example two possible future pictures of the Netherlands are presented. It gives an idea how a future picture of a country in 2050 might look like. The pictures are being used in the Dutch National Dialogue sub-project of COOL. Though for the European situation those kind of pictures are far more difficult to draw, we present them for you to inspire you in your thinking about Europe in 2050. The pictures might trigger discussion on elements for a future picture for Europe.

Appendix II:
For your reference information on current trends in Energy and Transport is provided.

2. Backcasting

"The major distinguishing characteristic of backcasting analysis is a concern, not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backwards from a particular desirable end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point." (Robinson, 1990)[1]
The backcasting methodology to be used in the COOL Europe dialogue can be described in a few principal steps (see figure 1 below). Please refer for more detail also to the workplan of the COOL-Europe-workshops which was sent out before.

Figure 1: Main steps of backcasting



Step 1: Define the problem (the greenhouse effect) and set criteria for a solution (reduce emissions of carbon dioxide from human activities by 80 % by 2050).

Step 2: Work out images of the future, e.g. an energy and transport system in Europe in 2050 that meets the requirements. At workshop I participants will generate ideas of key features of such systems and start clustering these ideas into outline images. These outlines will then be elaborated back-office by the project-team.

Step 3. Analyse the path from today up to the image of 2050. Identify change processes that are necessary in order for society to meet the criteria by 2050. Analyse lead-times for such processes - e.g. rate of diffusion of fuel cell technology - and when they will have to start. As this step includes some technical analysis it will be started by the project-team before workshop II. The results will serve as an input to that workshop. The participants in workshop II will finalise the path analysis.

Step 4. Compare the path with present trends - not just regarding carbon dioxide, but also regarding consumption patterns, transport volumes, etc.- and analyse the gap (see figure). Specify where the trends are particularly unfavourable from the point of view of the images of the future. Generate ideas on how to close the gap. Synthesise these ideas into policy recommendations. The focus should be on what can be done today but with a view to long- term targets. Step 4 will be started at the 2nd COOL Workshop and will be finalised at the 3rd COOL Workshop

[1] Robinson, 1990, 'Futures under glass: a recipe for people who hate to predict', Futures, October 1990.

Step 5: Formulation of an Integrated Strategic Vision. The Images of the future (step 2), the path analysis (step 3) and the actions needed today to close the gap between present trends (step 4) will be integrated into one strategic vision. This will happen in the 4rth COOL Workshop.

In al steps it is important to include technical, behavioural, institutional and political aspects.

In the First workshop different techniques for freely brainstorming about the future will be used. It is often useful to distinguish between diverging and converging phases of creative intellectual work. In the *diverging* phase of a workshop the aim is to generate as many ideas as possible in a limited time. The aim is to generate a lot of ideas of “elements in a solution”, where ‘solution’ means a transport or energy system that meets the required CO_2 reductions. Elements could be e.g. fuel cell vehicles or IT-shopping.

In this phase it is important to stimulate an associative thinking and to relax the critical judgement. When a set of ideas has emerged, a *converging* phase starts, where one tries to find ways of structuring the material and to prioritise among the ideas. In practical terms, *clustering* and *voting* are useful techniques to start a convergence process.

3. Transport in the 21st Century

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3.1 Criteria to be fulfilled by a transport system that is compatible with an 80 % reduction of CO2 emissions

There is a general requirement of an 80 % reduction of CO2 emissions for all future images of the COOL project. However, there is substantial uncertainty as regards what restraints on the transport sector could be inferred from this principle. Will it be necessary to restrict energy use in the transport sector? That depends on the supply of renewable energy sources and the possibilities of storing CO2 from the use of fossil fuels. Furthermore, a widespread use of solar cells to produce hydrogen would change the scene completely. Is such a development realistic? These are matters to be dealt with by the Energy group. In the meantime (during workshop 1), the Transport group needs some provisional assumptions in order to outline a transport system that would meet the CO2 requirements. These assumptions should be quite demanding in order to be a real test of the potential for change of the transport system.[2]

Provisional targets to be met by the transport sector by 2050

1. The total amount of energy available for the European (EU 15) Transport sector in 2050 is 50 % of the 1992 level.
2. The share of biofuels in total fuel supply in 2050 is 50 % - at a global level.

Comments: Criterion 1 is based on the following assumptions:[3]

a) each country is entitled to a share of total world supply of energy that corresponds to its share of the world population (the equity dimension of sustainability);
b) there is no widely spread technology for collection and storage of carbon dioxide from fossil fuels;
c) c) hence, the CO2 target puts an upper bound on the use of fossil fuels;
d) d) also, the sustainable use of bio-mass will be limited.

3.2 List of important issues and ideas on possible solutions

Based on a few backcasting studies on sustainable mobility we have compiled a set of key issues and ideas on possible elements in a solution to the environmental problems caused by transport. The studies differ in e.g. time horizon, targets to be met, geographical area etc. Therefore, it cannot be taken for granted that all ideas are relevant to COOL or that they cover all of interest. Instead the material provided here is just meant as an input that may stimulate innovative thinking.

* Is there a technological fix or will travel behaviour have to change as well?

* Land-use: Decentralised concentration means that residential areas become more concentrated to urban centres and sub-centres and to a few big cities in each region. Such a spatial pattern will minimise travel according to some researchers.

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[2] If the Energy group arrives at the conclusion that energy is no serious restriction by 2050, then these criteria can be relaxed. The reverse is more difficult, i. e, to first outline a transport system that uses a lot of energy and then find that energy supply will be a bottleneck.

[3] See Energy and Climate Criteria for Sustainable Transportation in S. Hunhammar, 1999, Exploring Sustainable Development with Backcasting, Doctoral thesis at Stockholm university.

* Reduce structurally forced travel (mostly short-range daily trips). These trips are dependant on the spatial structure of society - where we live and where we work etc.

* Tele-commuting and IT-cottages in sub-centres of urban areas. For a growing number of people working from home or a suburban tele-office becomes feasible, making daily trips to the job unnecessary.

* Tele-conferences might be a substitute for business travel

* Tele-shopping has a potential to reduce transport

* Tourism is a fast growing energy-intensive activity (often long trips by air)

* Environmental zones may promote cleaner technologies and niche vehicles

* Car-pooling

* Lighter vehicles means less use of energy per person-kilometre

* Higher energy efficiency in vehicles

* Modal shift - a shift to cleaner modes of transport (e.g. from lorry to train and from car to bus or train)

* De-materialisation and factor 10 - a reduction of resource use in production would reduce freight transport volumes (other things being equal)

* Just-in-time delivery

* Tradable mobility rights: an overall restriction on travel with tradable mobility rights to individuals and enterprises.

Sources:

1) OECD 1998, Environmentally Sustainable Transport - Report on Phase II of the OECD EST Project, Volume 1.

Comment: This report summarises backcasting studies of sustainable transport carried out in several OECD countries. The studies have been co-ordinated by the OECD. Three scenarios are presented, one with an emphasis on technological solutions (EST1), one with an emphasis on capacity constraint (EST2) and one that is a combination (EST3). There is also a Business as Usual scenario for reference purposes.

2) Peter Steen et al. 1998, A Sustainable Transport System for Sweden. WCTR, Antwerp, Elsevier Science Ltd.

Comment: This is a conference paper summarising a Swedish backcasting study. The Images of the future developed meet tough sustainability targets for the year 2040. The strategy relies on improved technology and measures that will curb the growth of transport volumes, especially as regards daily short-range trips (commuting to work, for shopping etc.). This is achieved through a combination of IT communication (tele-commuting, tele-shopping, tele-conferencing) and spatial planning.

3) POSSUM 1998, Final Report, from a project funded by the European Commission under the Transport RTD Programme of the 4th Framework Programme;

Comment: This is a backcasting study of sustainable mobility in Europe with a time horizon of 2020. Two main strategies are combined, viz. technological improvements and decoupling of economic growth from transport growth. The relative importance of these two strategies vary between scenarios (there are three scenarios), depending on differences in such external factors as the climate for co-operation, life-styles and dominant values.

4) Naturvårdsverket 1996, Att miljöanpassa Sveriges transportsystem - en scenariostudie (in Swedish), Report 4633. This is a report from the Swedish Environmental Protection Agency: Adapting the Swedish Transport System to Environmental Requirements - a Scenario Study.

Comment: This study was carried out by the Swedish Environmental Protection Agency but with participation of stakeholders such as the car industry, the Railway administration etc. The report presents one scenario up to the year 2020.

5) Stephen Peake & Chris Hope, 1994. Sustainable mobility in context - Three transport scenarios for the UK, Transport Policy 1 (3) 195 - 207.

Comment: This article presents a Sustainable Mobility scenario for UK based on (policies for) decoupling of economic growth from transport growth. Two reference scenarios are used, one Business as Usual scenario (continuation of observed trends) and one scenario based on National Road Traffic Forecasts.

6) M.C. de Soet & R.A.M. Stevers, 1994. Possible Scenarios for Mobility in a Sustainable Society - A conceptual experiment, in Environmental issues: proceedings of Seminar C held at the PTRC European Transport Forum, University of Warwick, England, 1994.

Comment: The authors both come from the Ministry of Transport and Public Works, the Netherlands. The paper outlines three rather extreme scenarios of sustainable mobility, Yuppieland with very expensive passenger transport and advanced systems for freight transport, Underland with an emphasis on underground transport (collective) and Landland where each individual is assigned a mobility quota, which is very limited and tradable.

4. Energy Supply, Industrial Energy use in the 21st century

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4.1 Energy for the 21st century

What will be the characteristics of the energy supply and demand system in the second half of the next century, given the starting point for COOL-Europe: an 80 per cent carbon dioxide reduction by 2050 and an increase in the use of renewable energy sources? Many sectors will have to implement adaptations to the existing energy infrastructure.

With regard to ***electricity production***, the use of waste and biomass, wind energy, import of renewable electricity (e.g. hydro) and in the long term, solar energy, will become increasingly important options. But also fossil fuels like natural gas and coal, will or might (still) be important energy carriers, provided that the emitted GHGs can be removed and stored, e.g. in aquifers or in empty oil- and gas fields.

An overview of the current inputs in electricity generation is given in Figure 1.

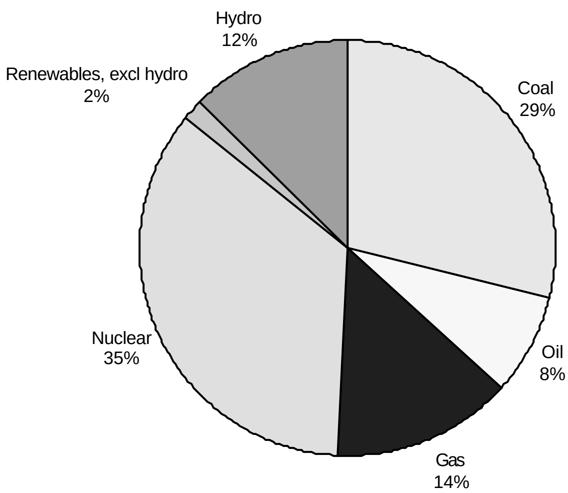


Figure 1. Electricity generation in the EU by source. Source: [CEC, 1999]

Concerning ***industrial energy use***, energy efficiency improvement will still be a very important route to achieve this sustainable energy system. But also material efficiency and other processes can contribute significantly to GHG emission reduction.

It is probably necessary to design tomorrow's energy policy in such a way that a sustainable energy system can be reached in the next decades. It may be necessary to make strategic decisions on the short term. These decisions will probably have far-reaching consequences for possibilities to reach a sustainable energy system on the long term.

Options to reduce CO_2- emissions in inustry

Several options to reduce CO_2-emissions by manufacturing industry exist. Energy efficiency improvement can be considered as the major option. A wide range of technologies is available to improve energy efficiency in the manufacturing industry.

Apart from these existing technologies, a range of new technologies is under development. An overview is given in e.g. [Blok et al., 1995].

According to De Beer (1998), who carried out an in-depth analysis for three sectors, the new industrial processes hold the promise of further reducing the specific energy consumption of industrial processes by 50% compared to the presently most efficient (excluding the minimum energy use that is required for the process anyway). This means that it will be possible to sustain substantial rates of energy efficiency improvement also on the longer term.

An another option frequently mentioned is material efficiency improvement. Some integral approaches give an overview of the total possible impact of changes in the material system. For example Gielen (1999) has modelled the total Western European materials and energy system, using a linear optimisation model (Markal). The implementation of material efficiency improvement options, reduces the GHG emissions with 20% in 2030 at costs up to 800 $/tC compared to the business-as-usual scenario. Apart from 'end-of-pipe' options, especially material substitution is important, e.g. replacement of petrochemical feedstocks by biomass feedstocks. At higher costs, also waste management options (energy recovery, plastics recycling) are selected by the model. Gielen notes that in his analysis the effect of material efficiency of product design is underestimated.

Carbon dioxide recovery from flue gases is feasible from industrial processes that operate on a sufficiently large scale. This is comparable to CO_2-recovery in the national energy supply system.

Another option is fuel switch. This may be illustrated by the fact that - per sector - the average carbon intensity of fuels used in industry is compared to the country with the lowest carbon intensity [IEA, 1997b]. This indicates that fuel switching within the fossil fuels can reduce CO_2 emissions by 10 – 20%. It is however not clear whether the switch is feasible in practical situations, or what the associated costs are.

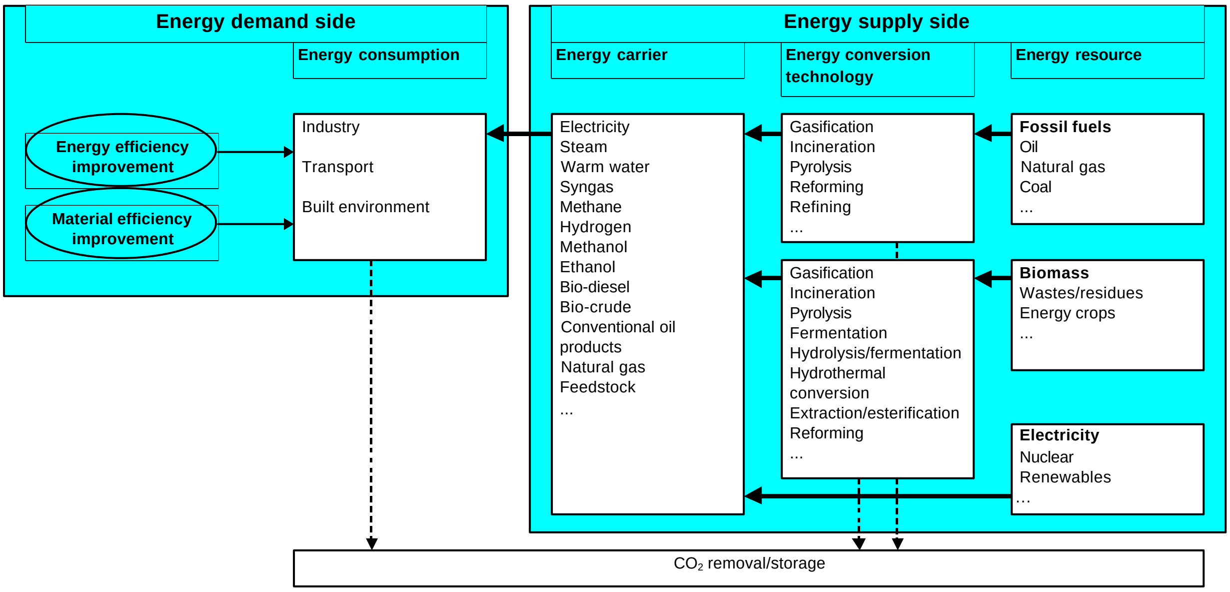
Renewable energy (notably biomass) can also be applied in the manufacturing industry, but is treated in the next section.

Options to reduce CO_2 in the energy supply system

Also on the supply side CO_2- emission reduction is possible. Many options exist (see also the scheme below). CO_2-neutral resources (or almost CO_2- neutral) are all the renewable sources (biomass, solar PV, wind, etc) and nuclear electricity. But in combination with CO_2-removal, also the fossil fuels can be used as carbon dioxide neutral sources, provided that the required additional energy for removing and storing CO_2 is available. The accompanying energy carriers are dependent on the energy conversion technology chosen.

So the resources and technologies are available to reduce CO_2-emissions significantly on the supply side, leading to the key question:

Which aspects will play an essential role in the long-term energy supply system, i.e. (see also the scheme below):



- Which energy sources and primary energy carriers (renewable, fossil, nuclear,...)?
- Which secondary energy carriers (hydrogen, methanol, electricity, heat, biofuels, "new gases"...)? Will we have a system with many carriers, or a system with only a limited amount of carriers (eg all-electric-society)?
- What are the conversion techniques (gasification, pyrolysis, solar-PV, wind, ...)
- Which end-use of energy (fuel cell, heat pump, heat distribution grids, electric appliances,...)
- Centralised or decentralised? In the last couple of years, a trend towards a decentralised energy supply system is observed. In a sustainable system, will small-scale decentralised conversion units be preferable to large-scale, centralised units? Will household and industries do their own conversion (e.g. bio-gas production, micro CHP) or will the more centralised conversion units prevail?
- Energy infrastructure: what are the necessary changes? Can we use the existing infrastructure with an electricity grid, a natural gas grid, local heat distribution grids and fluid transport fuels in a sustainable energy supply system? Or do we need a radical different infrastructure, to meet future demands? The transition to new energy carriers has consequences for the accompanying infrastructure. Depending on the energy carrier, minimal or substantial changes are necessary. For example hydrogen has a low energy-volume ratio compared to other possible energy carriers. Distributing a comparable amount of energy thus requires a larger transport volume and existing natural gas grids cannot be used without adaptations. Methanol is a corrosive fluid, thus having consequences for materials used. In case of a significant increase in the use of electricity, transport capacity has to be extended.

Energy carriers of the future
Important elements of the energy supply system are the energy carriers. The current carriers are mainly fossil fuels, its derivatives, and electricity. In a sustainable energy system, the energy carrier will mainly be derived from renewable sources. Other than the currently used energy carriers can become important. In this context, hydrogen and (bio-) methanol are frequently mentioned as promising alternatives, but other renewable and/or CO_2-neutral energy carriers can also be considered.
In the transition phase between entirely fossil and renewable energy supply concepts, CO_2-neutral energy carriers can make an important contribution.

4.2 Development trajectory towards a sustainable energy supply system

Changing the energy supply system is a complex activity, because generation and end-use of energy are coupled in a chain of interdependent activities. For example domestic natural gas equipment cannot use hydrogen as such, and the production of substantial amounts of biomass will bring economic, social and logistic consequences.
Directing this process is even more complex. A strategy could be to start by changing the energy conversion and wait until a later stage before looking at the end-user. A transition phase can be created in which CO_2-neutral energy carriers are produced by a combination of renewable energy sources and fossil fuels in combination with CO_2-removal. The latter can then be phased out in a later stage. In the long term, a shift to synthetic fuels replacing gaseous and fluid fossil fuels can occur.

4.3 Some criteria for developing visions

The following sections are only examples. Please do not let these criteria and visions hamper your creativity.

Several criteria are important while developing visions and trajectories. These criteria can be in the area of social-economic feasibility (is the proposed vision socially acceptable?), economic feasibility (is it financially affordable?), technical feasibility (can we expect that the proposed vision is technically available in 2050?), politically feasible (import/export dependency, suitable within national, international policies and laws), etc.
Next to this, a situation that is flexible can be desirable, e.g. to be able to incorporate technological development, or to avoid being dependent on one type of energy source (e.g. hydrogen and methanol can be produced from several feedstocks: fossil fuels and biomass; hydrogen can also be produced by electrolysis of water).
Numerous other criteria can be taken into account while developing visions.

Examples of visions

Example 1. Centralised vs decentralised

- Assumption: Natural gas will be an important energy source in the next century
- In **central units**, natural gas will be converted to hydrogen. Accompanying CO_2 emissions will be removed and stored (in the ocean, empty gas fields or aquifers).
- Hydrogen is transported and **locally** converted to the desired energy carrier: electricity or heat (on a district level including heat distribution, or near the end-user).
- Final conversion technologies: CHP (gas turbine, fuel cell), heat pumps, etc.

Example 2. Fertiliser industry

- The fertiliser industry currently uses natural gas to produce syngas, as a hydrogen supplier for ammonia production.
- Assumption: Natural gas (with CO_2-storage) and biomass (with or without CO_2-storage) will be important energy sources.
- In **central units,** natural gas or biomass will be converted to hydrogen.
- Hydrogen is transported and **locally** converted to ammonia.

Example 3. Transport

- Assumption: Natural gas (with CO_2-storage) and biomass (with or without CO_2-storage) will be important energy sources.
- CO_2-neutral transport fuels are produced.
- Using an adapted infrastructure, these fuels are delivered at the end-user.
- Final conversion technology: (improved) combustion engine.

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APPENDIX I: Sustainable energy systems on the long term- two visions on the Dutch Energy system

Sustainable energy systems on the long term

- two visions on the Dutch energy system -

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Vision A - Free Market

Economy and social environment

In vision A, the world is characterised by rapid economic development. International co-operation stimulates economic expansion and enables world-wide diffusion of technology. The national income and consumption per capita are five times the 1990 figures, indicating a high growth rate compared to the past 50 years. The most important driving force for this highly dynamic development is a strong commitment to market-based solutions. The level of education is high. People are focused on personal gain and want the liberty to guide their self-development. Individualism characterises this picture. In the year 2050 the Netherlands have 16.1 million inhabitants. This population is old and the average number of people per household is far below the 1990 level.

Land use

People value comfort and space; they live in large houses in green suburbs. People work a lot at home; the space used for offices therefore equals about that in 1990. The surface industrial complex need has increased by 30% compared to 1990. Car-ownership has greatly increased compared to 1990. Transportation of persons and freight is done mainly by road. Therefore the infrastructure has strongly expanded compared to 1990. The number of flight movements has increased by a factor of 10 since 1990. There are several large airports in the Netherlands. Agriculture is even more intensive than in 1990. The area used for the agriculture has decreased one-third compared to 1990; the production, however, is 50% above the 1990 level.

Energy and the environment: attitude

In vision A, the supply and resources of fossil energy and materials have not met constraints. Strong competition and rapid technological developments keep energy (and raw material) prices stable and low. In this context, solar and wind energy cannot compete with fossil energy. Energy consumption levels are high. Society encounters problems and decision-making by means of a Cost-Benefit Analysis, in which relevant elements are capitalised on. In general, people are not willing to change their behaviours. With respect to the climate-issue (which is reduced to the CO_2 issue by the year 2050) this attitude implies that supply-oriented technological solutions are favoured. Due to the significant use of fossil fuels, CO_2 emission reduction will mainly be achieved by underground storage and import of sustainable energy carriers (such as biofuels).

Energy demand

The industrial efficiency (energy and materials) has considerably improved. This development is driven by strong competition in the liberalised world market. In heavy industry energy savings of about 25-50%, compared to current levels, are assumed. In light industries savings reach about 40%. Material savings of paper, plastics and base metals due to lean packaging designs and enhanced recycling schemes are about 20% compared to 1990. A large part of the value added in the 2050 economy is generated by the (commercial) service sector, whose energy demand is below the 1990 level due to minimum-energy offices, efficient office equipment and solar heating. Specific energy consumption in greenhouse horticulture is 70-80% below the 1990 level.

Freight transport demand is limited by more efficient planning of logistic systems. Bulk goods are transported through pipelines to a high extent. Road transport however, remains favourable, also for passengers. In 2050, the share of public transportation in the modal split is significantly lower than in 1990. Energy consumption by cars is limited due to the propulsion by highly efficient fuel cells instead of the internal combustion engine. These fuel cells use hydrogen. Holidays abroad, international business travel and highly increased air freight have increased air movements by a factor of ten compared to 1990 levels. CO_2 emissions from aviation are, however, minimal due to efficiency improvements in planes and the use of biomass-derived synthetic fuels.

Energy supply

The energy system and infrastructure have undergone a complete modernisation. A hydrogen grid-network takes care of the supply of H_2 for the transportation fleet and for CHP installations. Infrastructure to collect CO_2 from large-scale power plants, heavy industries and H_2 factories is also installed. Because of the low, stable energy prices, natural gas and especially hard-coal are the favourable primary energy sources. Large-scale power plants with 50-70% efficiency are more economical than small, decentral units. The combination of coal-bed methane winning and CO_2 storage plays a significant role in the production of hydrogen and electricity. Also nuclear power plants could contribute to a CO_2-free energy supply system. The assumption is made here that people accept nuclear energy after the introduction of inherently safe reactor designs and the availability of new safe methods to cope with nuclear waste.

Imports of electricity and bio-energy are significant. Bio-energy is competitive with the combination of coal + CO_2 storage and is therefore used as a fuel in power plants and especially for the production of transportation fuels. Together with bio-energy, oil remains an important feedstock for the petrochemical industry. The role of wind and PV is limited; PV is too expensive, while wind energy contributes to no more than 10% of the national power supply. Electrical-driven heat pumps and solar collectors cover the major part of the demand for space heating.

Vision B - Awareness

Economy and social environment

Vision B is characterised by limited trade and transfer of technology. The focus is on the particular identity and the self-supply of the region. People highly value their natural surroundings and a healthy environment and want to contribute to a better society. They strive for sustainability. Family values are important. Along with a social policy towards immigration, these values result in a population number of almost 19 million people in 2050. The level of education is high and the income per capita is 2.5 times the 1990 level.

Land use

The average number of people per dwelling is slightly below the 1990-level. The size of the average dwelling has not changed, but the number of dwellings has increased with more than 30%. In general, houses are situated in compact cities. The share of public transport in the overall mobility has increased. Furthermore, people use bicycles for short distances. Despite the modest growth of the individual need for transportation, the use of cars has increased by 70% compared to 1990 due to the population increase. Road transport dominates freight traffic, but the share of trains and boats has increased significantly. More space is needed for railways and roads, but this is taken care of by careful spatial planning. The Netherlands has acquired a second national airport since the activity level of aviation has increased by a factor of 6 compared to 1990. Total land use in the agricultural sector has decreased by 10%. Consumption of meat has decreased, while people eat more ecologically produced food. Functions of land use in the Netherlands are less scattered and diffuse than in 1990. The Netherlands has more protected large-scale ecological areas. About 10-15% of the land is used for bio-energy production, particularly in areas where biomass production can be combined with other functions.

Energy and the environment: attitude

Savings on materials and energy are largely driven by concern for the environment and awareness that supplies within one's own region are limited.

In vision B too energy prices are relatively high due to more limited competition on a less open world market. However, the main incentive for energy conservation is the fundamental choice to meet the demand as much as possible with renewables, reject nuclear energy and to limit the use of fossil energy to a minimal level. People are willing to adapt their behaviours so as to limit the CO_2 emissions and to pay the extra costs of renewables and a more decentralized energy supply.

Energy demand

The energy demand in 2050 is *below* the 1990 level. This is a result of structural effects (large share of the service sectors in the GDP shifts from heavy basic industries towards more valuable specialised manufacture, reductions in fertilizer production, etc.) and of drastic energy efficiency meaures; integrated industrial complexes use highly efficient CHP and heat cascading. Material efficiency of society is increased considerably due to far reaching recycling schemes and material-efficient product designs. Buildings and greenhouses have excellent insulation levels that minimize the energy consumption in the built-up environment.

The growth of passenger transport is kept within limits, partly because of relatively short distances from home to work. Bicycle and public transport are favoured in the compact cities. The use of cars has increased, but the total energy demand of cars is below the 1990 level due to the use of highly efficient, bio-ethanol-driven fuel cells. Aviation has grown sharply compared to 1990 levels, but this does not result in GHG emissions due to strong efficiency improvements of planes and the use of synfuels on the basis of bio-energy. The train is a main alternative for flying for the short and medium ranges.

Energy supply

Energy infrastructure does not significantly differ from the situation in 1990. On the production side however, wind turbines (mainly offshore) and PV (mainly on buildings) cover 40% and 15%, respectively, of the national electricity demand. PV is expensive but people are willing to pay for it. Due to the intermittant character of wind and PV, storage-power and flexible-peak power generation capacity (Fuel cells on the basis of natural gas) are needed. Part of the electricity production comes from coal-fired power plants in combination with CO_2 storage. CO_2 is also injected into coal beds to produce methane. This methane is net CO_2 free. Winning of coal-bed methane thus requires CO_2 to be removed in large-scale industries and power plants and to be transported to the coal fields. The demand for space heating is met by the large-scale application of solar collectors and by CHP-coupled district heating.

Bio-ethanol for the fuel cells in cars is produced in ‘bio-refineries’. Feedstock for the chemical industry and synfuels for aviation are also products from the conversion of bio-energy in these refineries. The transport sector dominates the final energy consumption. Therefore bio-energy has a 2/3 share of the total energy mix. The total demand for bio-energy in the Netherlands requires 4 million acres of land, far more than available within our borders. As a result, 85% of the bio-energy is imported, while 15% is produced within the Netherlands itself.

Appendix II Current trends in Transport, Energy use & supply

Energy: current situation and existing scenarios

Primary energy demand in the EU in 1995 was around 58 EJ. This is around 17% of the world's total [IEA, 1997]. In 1995, the most important energy carrier were oil and oil products (liquid fuels), with a contribution of 40%, of which more than half is meant for transport purposes. Natural gas is also an important energy carrier (both for electricity production and for consumption in households), as well as solids (coal, etc.), which are mainly used for electricity production and, in the form of cokes, in the iron and steel industry.

With regard to forecasting, many scenario studies have been carried out about the share of all the fuels up to 2010 or 2020. One example is given in Figure 2. The scenario pictured is the so-called Shared Analysis scenario, the result of a study financed by the Energy Directorate General of the European Commission, and is intended for illustrational purposes only.

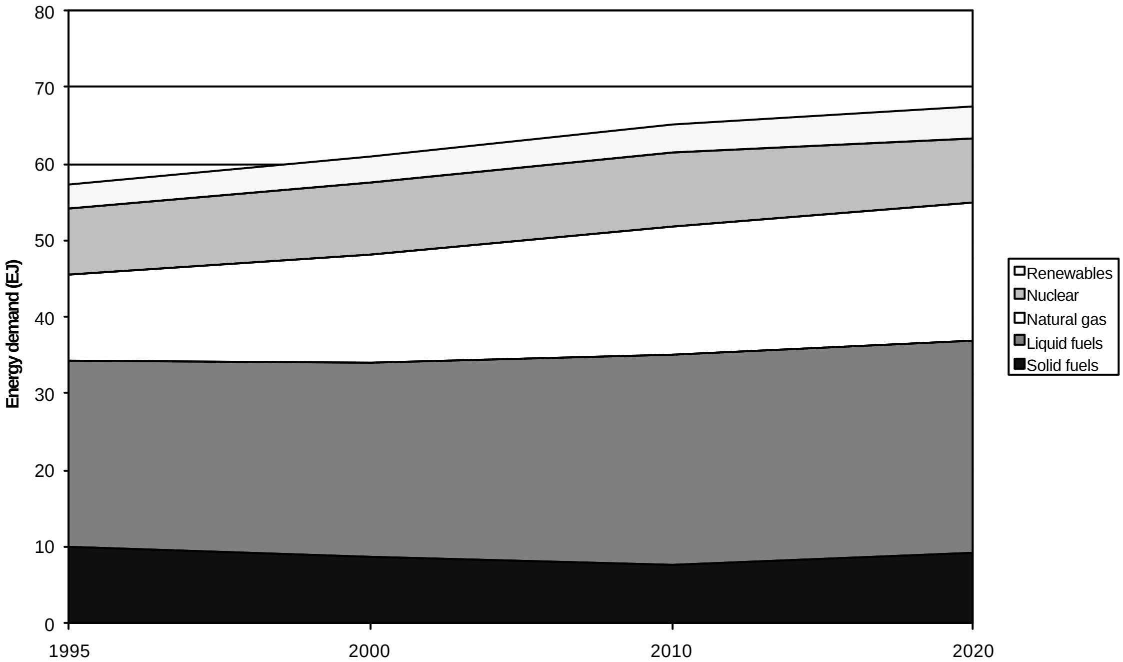

Figure 2. Primary energy demand as forecasted within the Shared Analysis scenario. Source: [CEC, 1999]

Transport: current situation in the EU

Total energy use in the EU-15 for passenger transport is estimated at 8 EJ. The distribution over the various modes of transport is given in
Figure 3.

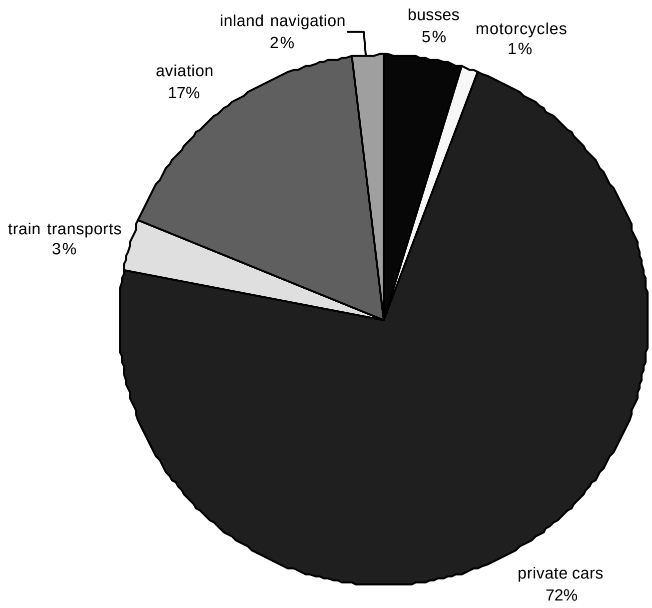

Figure 3. Energy use in the EU-15 for passenger transport, by mode of transport in 1995. Source: [Capros, 1999]

With regard to goods transport, total energy use in the EU-15 is around 3.5 EJ, of which around 95% is used by trucks.

An overview of the expected developments with regard to the total amount of person kilometres in the EU is given in the following figure.

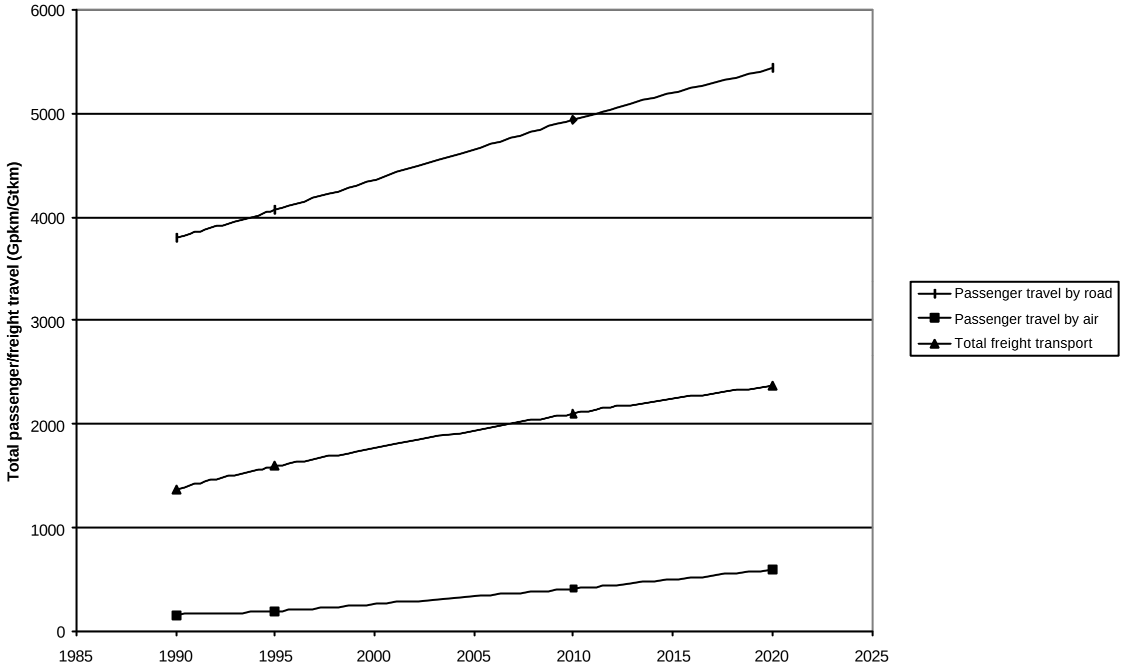

Figure 4. Total amount of person/ton kilometres for person travel and freight transport.

The industrial sector: current situation

Emissions of carbon dioxide are still the most dominant contribution of manufacturing industry to total GHG emissions. These emissions are mainly connected to the use of energy, although some process emissions occur (e.g. the cement industry).

The current situation with regard to final energy consumption in the industrial sector is given in . Total final energy consumption in the EU is around 11 EJ. Please note that around half of this final energy consumption is electricity and steam, which are generated from primary fuels with an average efficiency of 54%.

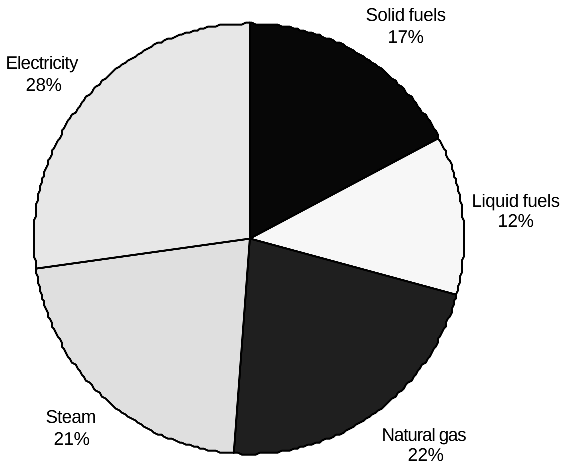

Figure 2. Final energy demand in the EU manufacturing industry. Source: [CEC, 1999]

A useful breakdown of the manufacturing industry is into energy-intensive and less energy-intensive industries. The first category (often indicated as heavy industry) includes the production of metals, refineries, pulp and paper, basic chemical and non-metallic minerals (especially cement). The energy intensity is typically more than 20 MJ per $ value added [Schipper and Meyers, 1992].
The remainder of the industrial sectors is called light industry.

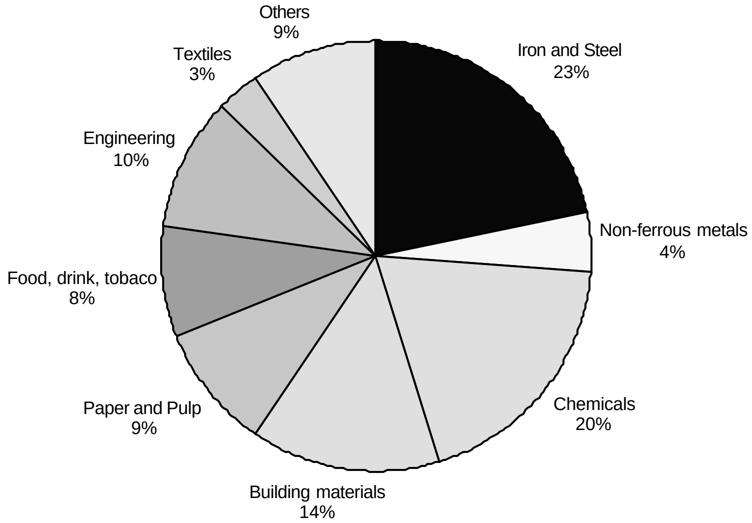

Figure 3. Overview of the relative share of energy consumption by EU-15 industry. Source: [CEC, 1999]

The development of energy use within the manufacturing industry is analysed by Unander et al. (1999). Generally, the development of energy use can be broken down into three factors: volume, structure and energy efficiency. A quite remarkable result is that in nearly all countries structural change within manufacturing industry had a positive effect on energy use in the period 1994-1998, i.e. there is a shift towards more energy-intensive industries. It was also found - with some exceptions – that energy intensity declined continuously [Unander et al, 1999; Worrell et al, 1997].