Views on the future

Two visions on the Dutch energy supply

for use by the National Dialogue

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Preface

Two visions have been constructed for the Netherlands of 2050 to be used in the sector groups' dialogue, which forms part of the Cool National subproject. These visions have been constructed assuming an 80% reduction in the Dutch 1990 level of greenhouse gas emissions in the year 2050, in other words, long term.

The visions sketch two different pictures of the Netherlands in 2050. They differ on the following essential points: the international context, demography, behaviour, size and structure of the economy, and the energy and material supplies. In offering these visions to the dialogue groups we try to facilitate and stimulate the discussion on future energy and material supplies in the Netherlands.

Contents

1. Introduction

COOL National

The international climate policy is aimed at stabilising the concentration of greenhouse gases in the atmosphere. In the long term, this means a reduction in emissions of roughly 80% by about 2050 when compared to the 1990 level. The emissions of the five non-CO_2 greenhouse gases (CH_4, N_2O, HFC-PFC-SF_6) can be drastically reduced in the short term using relatively simple technical measures. We can therefore expect them to play no substantial role in the emission total in 2050. The problem for CO_2 is quite different. CO_2 emissions are closely related to the supply and demand of energy. Achieving an 80% reduction of CO_2 by 2050 will require a fundamentally different supply of energy and materials, especially when we take into account a much larger economy. In the COOL National project, the government wants to actively involve the actors (sector groups) in the discussion of those alternative energy and material supplies.

Dutch greenhouse gas emissions

In the Kyoto Protocol (1997) agreements were made on reducing the emissions of six greenhouse gases. Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) account together for 95% of the total Dutch greenhouse gas emissions. CO_2 emissions are almost totally the result of combustion of coal, crude oil and natural gas. Mainly the cattle breeding sector, waste disposal and the extraction and distribution of oil and gas release methane. Nitrous oxide is emitted mainly during nitric acid production and through the nitric cycle in the agriculture.

The three "new" greenhouse gases are HFCs and PFCs (a set of gases mainly used in substition for CFCs) and SF_6 . SF_6 is mainly used in high-voltage switches.

The total greenhouse gas emission is calculated with help of the relative greenhouse effect of greenhouse gases with respect to CO_2. By calculating the emission of all greenhouse gases and multiplying them by their relative greenhouse value the total greenhouse gas emission in CO_2-equivalents is determined. The Dutch emission of greenhouse gases in 1998 was 240 million metric tons in CO_2 equivalents. The table below gives an overview.

Greenhouse gas	***Main source***	***Emission Mton CO_2 eq.***
CO_2	combustion fossil fuels	186
CH_4	agriculture, waste disposal, natural gas system	22
N_2O	agriculture, nitric acid industry	22
HFCs	CFC substitution	7
PFCs	CFC substitution, aluminium production	2
SF_6	high-voltage switches	2
Total		**241**

The function of the visions

The COOL approach makes use of two possible future visions of the Netherlands in 2050, in which the “–80%” climate goal is achieved. These visions are very different to one another, but both sketch a conceivable view of the Netherlands in 2050 for the participants in the discussion. To do this, information about the society, the economy and use of space have been put together to make a plausible and coherent story. Visions of the distant future, such as 2050, are obviously very uncertain and are largely random in character. Developments in the various fields (economy, culture, technology etc.) can occur in numerous combinations. The number of variations is practically infinite. For this reason, the visions presented here should only be regarded as possible, conceivable situations and definitely not as “best-guesses” of future developments.

The visions have two functions within the COOL dialogue. On the one hand, they are aids for the discussion, in that they provide a context which can assist us when thinking about a “different” Netherlands of the future. On the other hand, the necessary assumptions have been made in the visions to stimulate the discussion and dialogue on the changes needed in the supply of energy and materials.

A and B

The chosen visions differ considerably in their assumptions with regard to the situation in the Netherlands in 2050 (behaviour, population, economic and spatial structure, etc.) without actually being “extreme”. The views sketch a conceivable image of the Netherlands in 2050. All ingredients which may come up in the discussions are included as much as possible in the visions. From an efficiency point of view, and to allow international comparisons, it has been decided to let these visions fit with visions being developed in the IPCC framework. The emphasis in vision A is on dynamics, free market and consumption, while vision B is characterised by moderate growth and the willingness to adapt/consideration. Both visions are described in more detail in the following sections.

2. GENERAL DESCRIPTION OF THE VISIONS

2.1 Vision A

International relations

In this vision, the differences in prosperity between rich and poor countries worldwide have disappeared, partly due to fast developments in the transport and communication technology areas. International co-operation promotes productivity growth and enables the faster diffusion of technology. This has led to significant mobility of people and ideas.

The world is characterised by a fast and successful economic development. The most important motivation behind the high dynamics is the trust placed in market-oriented solutions. The level of investment is high, both in technology and in education. The emphasis in this vision is on the market mechanism and increasing productivity, partly due to the faster introduction of new and more efficient technology.

Social environment and demographics

People are focused on personal progress and want the freedom to control their own development. Ambitions are important: people want to make financial progress and achieve something in their lives. The average level of education is high. It is important to enjoy life, and the consumption level is high. Attention for nature, the environment, and the wellbeing of your fellow man do not have priority. Individualism is the characteristic for this vision. Women as well as men are included in employment and work over forty hours a week.

Daycare centres are commercial like the social service sector. Education is taken care of mainly by private schools. Society is characterised by technological market-oriented solutions and approaches. Decision-making processes are fast and there are limited opportunities for participation.

The family does not have a prominent role in society. The proceeds of the economic growth are mainly used mainly for more growth, and for a small part for social affairs, and the environment and nature. In a world where the differences in prosperity between countries have disappeared, there are still groups within the regions which profit less from the prosperity. Differences in incomes increase and certain groups fall behind socially. In the multicultural society polarisation has therefore taken place. Crime is dealt with in a repressive way.

The world population has grown to 9 billion people in 2050. The average age is higher than in 1990. In the Netherlands, the ageing of the population is quite advanced. The Dutch population, at 16.1 million inhabitants, is a little higher than in 1990. The high prosperity results in a long life expectancy and a low birth and death rate. In combination with a high appreciation of self-development, this has lead to a large proportion of one and two-person households. The thinning out of the family is evident: the Netherlands has 10% more inhabitants than in 1990 and there are 50% more homes.

Economy and consumption

Due to the dynamics of the free market and the high mobility of people, goods and technology, the size of the world economy (added value) is almost 9 times as large in 2050 as it was in 1990. The OECD countries have not grown as quickly; despite this, the total GDP in the Netherlands is over 5 times that of 1990. This implies the same growth as in the last 50 years (including the huge growth during the post war reconstruction).

The income per head of the population in the Netherlands in 2050 is 5 times as high as in 1990. The consumption of meat and dairy products per head is a little higher than in 1990. Compared to 1990, the most significant changes in spending patterns are in foreign tourism and the buying of services. People go on foreign holidays several times a year. The aeroplane is by far the most popular form of transport for holidays; there are 15 times as many flight movements as in 1990. Many day trips and recreational activities are enjoyed within the Netherlands.

There is a high degree of car ownership, extensive suburbanisation and dense transport networks, both national and international. Most of the passenger and freight transport in the Netherlands takes place by car and truck. The number of private kilometres clocked-up is 80% as high as in 1990, and road freight transport is a factor of 12 higher. Freight transport by rail grows, but passenger transport by rail is down compared to 1990. The size of inland shipping is roughly one and a half times what it was in 1990.

Energy and the environment

When there are problems in this world, they are solved, where possible, using a cost-benefit analysis. Giving the parts in question a value (to capitalise) does this. In this exercise issues concerning nature, environment and durability are valued low.

Energy and materials are abundantly available worldwide. This is mainly due to the fast technical improvements in energy extraction. The energy prices are relatively stable and low; incentives to save energy in this free market are low. Due to the fast technological modernisation, the prices of solar and wind energy are significantly lower than in 1990, but can not compete with fossil fuel energy on a large scale. Energy use is high and there is little willingness to pay higher costs for sustainable energy or energy saving technology.

People are not prepared to adapt their behaviour in order to reduce CO_2 emissions; necessary measures must have as little as possible an effect on material prosperity and the consumption pattern. People are prepared to pay for measures by which they can keep their consumption pattern. This means that technological or buy-off solutions are quickly turned to in this view, stimulated by the market-forces and powerful R&D. Due to the heavy use of fossil fuels, greenhouse gas emissions are mainly reduced by CO_2-storage and imported (sustainable) energy carriers. Alternatives, which fit into this vision, are the use of nuclear energy and the use of hydrogen technology. The most important motivation behind dematerialization is the costs involved in the waste problem.

Space

People like comfort and space. Cities are therefore made up of large suburbs, where the people live in spacious park cities. The use of space for living is one third higher than in 1990, while the population is only 10% larger. Many people in the strongly growing service sector work at home, so that the space required for offices is equal to that in 1990. The large industrial complexes use some 30% more space than in 1990. The Netherlands has several large airports due to the demand for air travel, which is 15 times higher than in 1990. There is a high degree of car ownership and the largest proportion of freight transport is via the roads. The capacity of the road system is calculated to meet this demand. Broad motorways connect the city suburbs, industrial areas, ports and airports.

Due to the high price of land in the Netherlands the competitive position of the land-dependent agriculture has got worse. Agricultural acreage is one third less in 2050 than in 1990. Nature areas are exploited to fulfil the huge demand for recreation. The landscape is characterised by a park-like layout.

2.2 Vision B

International relations

In vision B, different regions in the world have developed in different directions. There is less international trade and interaction. There are also fewer powerful international institutes. In vision B, the emphasis is on an own identity and self-sufficiency. These important values are developed within the individual cultural and/or economic regions.

Social environment and demographics

Nature is highly valued. The wellbeing of people and animals and a good environment is thought to be just as important as prosperity. Social aspects play a prominent role in decision making; we pay a great deal of attention to our fellow man. Distribution of wealth and equality in society is being worked on. The classical family is just as important as in 1990. There are as many men as women involved in employment and they work 32 hours a week. Men and women have equal responsibilities in raising their children. Day care centres and social services are part of the public sector.

The level of education is high. The government runs education. People are doing well financially and want to contribute to the progress of society as a whole. Self-development is not of primary importance but goes hand in hand with the development of a sustainable and sociable society. People attach importance to quality and sustainability, quantity is less important. Society has been set up so that as many people as possible can be involved in decision-making. The proceeds of the economic growth are mainly invested in a sustainable economy, social affairs and the environment and nature. The society in the Netherlands is multicultural. A large part of the working population is immigrant and is well integrated in all levels of society. Teaching standards and values at local level prevents crime.

In vision B, the world population in 2050 consists of 9.4 billion inhabitants. The OECD shows hardly any growth at 13%. The Netherlands is an exception: in 2050 we have 18.9 million inhabitants. This is both due to the family-oriented society and the results of a social immigration policy. The Netherlands in 2050 does have more older inhabitants than in 1990. The number of homes per inhabitant in the Netherlands rises by some 15%. The thinning out of families increases slightly in this vision.

Economy and consumption

In vision B, the world economy in 2050 is more than 5 times as large as in 1990. Despite an increased involvement and the social attitude of the citizens, the relative income differences between the OECD and the rest of the world still exist. The GDP of the Netherlands is 4 times that of 1990. The income per head of the population in the Netherlands in 2050 is more than 3 times as high as in 1990. People go on holiday several times a year. Holiday destinations close to home are particularly popular, but long distance travel is still in demand. Passenger air transport is much increased compared to 1990, by a factor of 8.

The use of cars has risen by 40% per person. Due to the large increase in the population, the total number of kilometres clocked-up in cars is 80% higher. With respect to 1990, the use of public transport increases by 40% per inhabitant. In total, public transport is used 80% more as in 1990. The bicycle is used for shorter distances. The largest proportion of passenger and freight transport takes place by car and truck, but, compared to 1990, 9 times as much is transported via rail and one and half as much via inland shipping. Agriculture is considerably less intensive than in 1990. More than 10% less space is used for agricultural purposes in 2050 than in 1990, and production in the cattle breeding industry, in particular, is lower. Mainly ecological products are consumed and the consumption of meat is lower than in 1990.

Energy and environment

Due to the intensive focus on nature and the environment, environmental problems are seen in the broader context of sustainable development and society. Solutions are first sought at a local or regional level. Solutions aim at combining the gradual adaptation of behaviour and technology improvements. A great deal of energy is put into gaining the necessary broad public support. Dematerialization is an important factor in the Netherlands, since this decreases pressure on the environmental system.

The energy systems differ worldwide depending on the availability of natural resources in the region. In our region, the development of cleaner and more efficient technologies is driven by the notion that we must be economical with energy and material supplies. As a result of the moderate technological advancements with regards to energy recovery, the energy prices are relatively high. This is also a motivation for energy savings.

In order to push back the CO_2 emissions, people are prepared to accept measures that can significantly affect their every day behaviour. People are willing to use public transport and there is a general willingness to pay higher costs for small-scale sustainable energy supplies and ecological products. At the same time, there is a fast diffusion of energy technology with lower emissions (fuel cells, clean energy carriers, combined heat and power), so that local pollution does not occur as readily.

Space

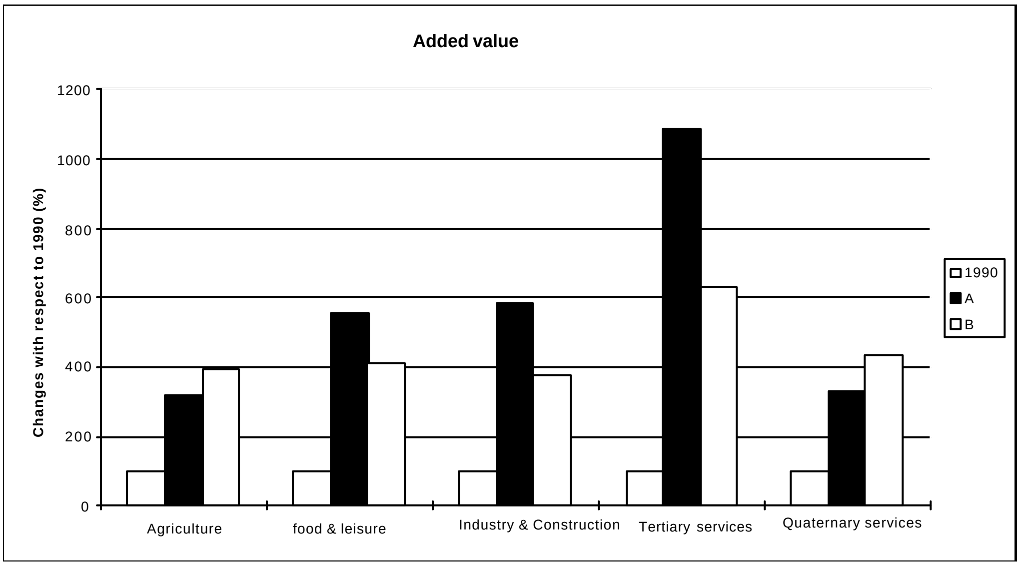
In this vision, people live in compact busy cities. Within the cities, the concentrated built-up areas are linked up to public transport. Living and working are strongly integrated in this vision. The car remains the favourite, but public transport plays an important role in passenger transport. Both the number of motorways and the number of railways have increased since 1990. For shorter distances, air traffic has lost ground to the train. The Netherlands has two national airports in this vision to meet the demand for air travel. Due to the large service sector, there are many offices when compared to 1990. The space for living and working is more efficiently dealt with, but the large population lays claim to the available space. The space used for agriculture in 2050 is more than 10% less than in 1990. In addition to production, agriculture has an important ecological and recreational function. New characteristics in the landscape are large fields with crops which are used for biomass production (poplar, willow, miscanthus). Despite the growth in the built-up environment, there are more large nature areas than in 1990.

2.3 The visions compared: differences of emphasis

In vision A of the world, the emphasis is on international co-operation, whereas in B the emphasis is on the regional identity and self-sufficiency. People, ideas and capital are less mobile in vision B than in vision A. There are more technical innovations in A than in B. The world economy in A is nine times as large as in 1990, compared to a fivefold increase in B. In A, the world population is somewhat smaller than in B. The difference is much larger in the Netherlands. We have almost 3 million inhabitants more in vision B than in vision A.

Vision A has an individualistic, competitive society, where you put your own interests above those of others. B, on the other hand, is a sociable and family-oriented vision, where your fellow man and public interests are central. In the individualistic vision of A, the thinning out of the family will take place much quicker than in the socially minded B. The ageing of the population also takes hold quicker in A.

Nature and the environment are used by people for progress in A, and it is mainly for these reasons that they are important. In B, nature and the environment come first. The aim is a sustainable society which does not strain the environment. It is the market mechanisms which mainly rule in A, while in B there is strict regulation and distribution of wealth. In B, the Dutch “poldermodel” is favoured for various social issues. Vision A, on the other hand, gives few opportunities for participation and has a very reserved government.



The Dutch economy in A is more than 5 times as large as in 1990, compared to a growth of more than a factor of 4 in B. However the population in B is 15% larger than in A. The people in A are thus one and a half times as rich. Due to the larger population size in B, the absolute consumption is only a quarter lower than in A.

In B, recreation is largely carried out close to home and holidays in the Netherlands are also popular. In A, a great part of the population flies off to foreign destinations. The people from A fly two and a half times as often as those in B. In B, public transport is available on a much wider scale than in A, and a B resident travels at least one and a half times more often by public transport. In A, people use mainly their cars, some 15% more often than in B, but because there are some 15% more people living in B, just as many kilometres are clocked up as in A. Rail transport and inland shipping is gaining ground faster in B than in A. Due to the high appreciation of nature, cattle breeding in vision B is animal friendly and extensive. In vision A, agriculture is highly intensive and the wellbeing of the livestock is not of prime importance.

Table 2.1 Some figures for the Netherlands in both visions with respect to 1990. The 1990 value is adjusted to 100.

1990=100	Vision A	Vision B
Population	110	130
GDP	570	440
Consumption	680	510
Private cars (pers.km)	180	180
Public transport (passenger	100	180
Airtraffic (flight movements)	1560	780
Road transport (ton.km)	1200	760
Land use for agriculture	65	78

Environmental problems in A are solved in a cost-benefit analysis, while in B the environment is most important. In B, people are prepared to spend more and to change their behaviour to arrive at a sustainable solution. The people in A choose the cheapest solution and are not prepared to change their behaviour. Measures must have as little effect as possible on their prosperity and consumption patterns.

The people in A live in large houses in spacious suburbs, while in B the people live in compact cities and in smaller houses. There are many motorways in A, and in B there is more of a railway infrastructure. In addition to a production role, the extensive agriculture in B also plays an ecological and recreational role. In B there are large nature areas. The nature areas in A are fragmented by roads, agriculture and built-up areas.

Table 2.2 Differences of emphasis (qualitative)

	Vision A	**Vision B**
World view	Internationally oriented "Global Village"	Regionally oriented, world trade blocks
	Worldwide convergence	
Social environment	Individualistic	Sociable, Family-oriented
	Low appreciation of environment and nature	Environmentally minded
	Own interest first	Distribution of wealth, social equity
	Wellbeing of fellow man subordinate to own interests	Wellbeing of fellow man important
Economy & consumption	High economic growth and dynamics	Less dynamics and economic growth
	Part of world economy	Part of EU trade block
	Motivated by market mechanisms, little government	Regulation, strong government
	Recreation abroad	More nature areas / recreation within the Netherlands
	Quantity above endurability	Durable goods, quality
Use of Space	Subarbanisation	Careful use of space
	Nature areas fragmented	Large continuous nature areas
Traffic and transport	High demand for mobility passenger and freight transport	High demand for mobility passenger transport, moderate demand for freight transport
	Much private traffic	Public transport
	Road transport dominant	More freight trains and inland shipping
Energy & environment	Quick diffusion of technology	Technology develops less quickly
	New infrastructures quick to implement	Possible solutions on demand side important

	No change in behaviour	Willingness to adapt behaviour
	Cost-benefit analysis	Environment and sustainability given priority

3 ENERGY SYSTEMS IN 2050

3.1 Introduction

The following 3 steps were followed in composing quantitative visions on the energy system of the Netherlands in 2050.

1. An inventory of the most important options and technologies that could play a role in the future energy system was carried out. This inventory includes energy efficiency options in industry, residential and commercial buildings and transport, a wide variety of energy conversion technologies (renewables, nuclear and fossil-fuel-based options) as well as options that will result in a reduction of non-CO_2 Greenhouse Gases. A large and broad information base was used to prepare this inventory: scenario studies for the energy system, databases and evaluations and outlooks on specific technologies. A background document that contains more detailed information on the options investigated will become available during the dialogue. Fact sheets on the options contain information on the expected performance of the technologies (e.g. efficiencies), outlooks on costs and R&D requirements, as well as uncertainties and (technological) barriers that may apply when those options are commercialised and applied.

2. A consistent group of options was selected for each vision. These options have plausible relationships with the socio-economic contexts described in the previous chapter. There are also many arbitrary aspects that played a role in making this selection. Arguments behind the choices for applying certain options and technologies in the different visions are given throughout the text. Choices and argumentation are open for debate.
   For each vision the main criterion for selecting a group of options is that the overall result is group of options have to result in an 80% reduction in GHG emissions compared to 1990 levels. In vision A, the design of the energy system is largely directed by cost arguments. People prefer luxury, comfort and material wealth. This makes it unlikely that lifestyles are adapted solely for environmental arguments. Thus, expensive (energy) options are not favoured. In vision B, options to reduce CO_2 emission reductions are based on gradual adaptation of the people's behaviour and on technological improvements. Compared to A, cost arguments are less important in the design of the energy system and principal choices are made in favour of renewables to minimise the need of fossil fuels and against nuclear energy.

3. A quantitative analysis of the energy balance for the visions was carried out. In order to determine the total energy demand and the contribution of the energy supply mix, a simple and transparent methodology is followed: on the basis of the sectoral economic growth indices for the period 1990-2050 and current (1990) energy indicators, the energy demand without any efficiency improvement is calculated. Next, in order to decrease the energy demand, material efficiency improvement is first taken into account. This results in a reduced demand for raw materials and transport movements. Secondly, energy-efficiency improvements per sector are included. This step results in a further reduction of the final energy demand. Thirdly, the energy supply mix is chosen. Applying renewables (solar energy, biomass) or carbon storage for fossil fuels then reduce greenhouse gas emissions (GHG) to the desired 20% of 1990 levels.

The most important characteristics for technology development and the selection of options will be discussed first. The descriptions are divided into the following sections: industry, residential and commercial buildings the transport sector, agriculture, food production and land-use aspects, the energy system, non-CO_2 greenhouse gases and international aspects.

3.2 Energy system vision A

Characteristics of technology development and the selection of options

World trade increases drastically in this vision. The dynamic economic development ensures that technological development in many areas progresses rapidly. People prefer luxury and comfort and earn more than sufficient money to pay for this. The high incomes of people and the importance of material wealth make it unlikely that lifestyles are adapted solely for environmental arguments. The design of the energy system is largely determined by cost-benefit analyses without taking the environmental costs into account. Relative expensive (energy) options (both for enhancing energy efficiency and energy supply options) are therefore not favoured.

Industry

The main industrial production sectors (such as the chemical industry and metallurgical industry) have to compete on a liberalised world market. Far-reaching energy efficiency measures that result in additional costs for manufacturers are therefore not accepted. On the other hand, the need for low production costs and unremitting improvement in the quality of products require continuous innovation and process improvements. Strong improvements in energy efficiency are therefore still considered realistic. However, the main driving force is not a strong policy aiming at energy efficiency improvement but the need to reduce production costs and improve product quality. This is in fact a strong impetus for the introduction of new processes. Production technology is updated according to the latest standards.

Examples of new processes in industry can be found in the steel industry where cokes production is no longer needed due to the introduction of a new steel-making process in which coal (or charcoal) can be used directly. Improved catalysts, membrane separation technologies (e.g. for separation of gases at high temperatures) and far-reaching process energy integration schemes are major measures in the petrochemical industrial sectors. Large-scale production facilities are taken up in strongly interlinked industrial complexes. Pulp & paper production takes place in integrated complexes as well, making use of recycled paper, optimal use of organic residues for power generation and strongly reduced energy consumption through advanced paper-drying techniques.

Overall, in heavy industry, energy savings of about 20-50% per unit of output are observed when compared to current levels. In some light industrial sectors (e.g. the food and beverage industry), energy savings sometimes move up to 80%, in particular through the use of process heat. On average, primary energy savings reach about 40% in the light industry.

Increased materials efficiency

Energy savings through increased material efficiency have been attained. Specific measures include reduction in the use of paper through greater use of digital information storage and transfer, lean packaging designs and recycling schemes. Raw materials that can be recycled are largely produced in highly advanced waste-treatment separation schemes in advanced waste treatment facilities. Overall, material savings for plastics and paper amount to about 20% compared to baseline levels. For base metals (steel, aluminium), similar savings are observed. Specifically for steel production this means that the role of electric arc furnace based steel production has increased.

Guide numbers for energy and material savings in industry, compared to 1990 levels

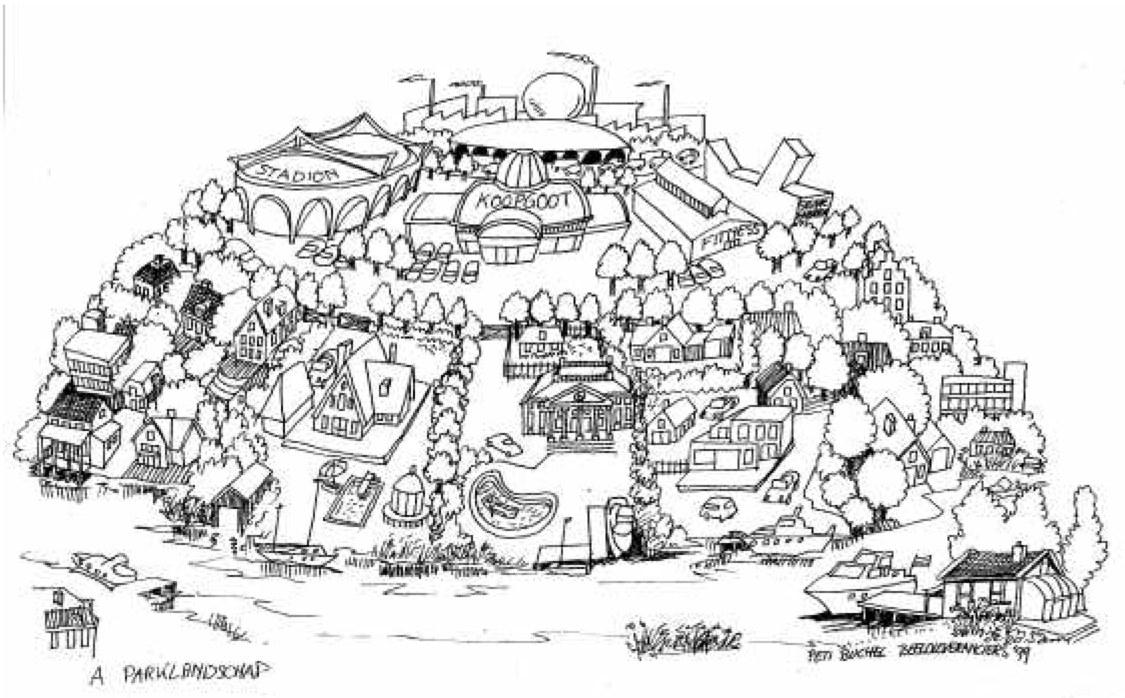
Industrial sector	Material savings (% change with respect to 1990)	Primary energy savings (% change with respect to 1990)
Steel	20	35
Non-ferro	20	35
Ammonia/fertiliser	50	31
Petrochemical	20	13
Paper & pulp	20	25
Cement	--	43
Light industry	N/A.	44

Living

A comfortable life-style has a high priority in this vision. People prefer detached homes on larger parcels of land in a park-like suburban environment with ample possibilities for recreation and relaxation. Land use for urbanisation, roads (and industry/offices) increases considerably. On average, people live in dwellings that are about 50% larger than in 1990 if expressed on a per person basis. The electricity consumption increases due to increased utilisation of luxury items such as waterbeds, freezers, dryers, etc. New electrical appliances (such as household robots) are also introduced. However, more efficient appliances partly compensate for the increasing number of energy services in households. In existing dwellings, wall, loft, floor and glass insulation can be applied. Average designs for newly built homes include a highly insulated shell equipped with a heat pump for the bulk of the heat demand, seasonal storage of heat and a hot-water system based on solar heating. Solar heating as a whole plays an important role in covering the heat demand of both existing and newly built houses but the additional energy demand for space heating is still substantial due to the large residential areas. For older city centres, district heating is still applied. However, the majority of the built-up areas are equipped with heat pumps. Heat pumps are not likely to be very cheap but have to be applied if an 80% reduction of CO_2 emission is to be realised.

Work

The service sector is important. The growth of the service sector has considerably surpassed the average economic growth figures. Trade and services linked to trading activities make a large contribution to this part of the economy. The total energy demand of the service sector is, however, controlled by minimum energy offices, efficient office equipment and solar heating.



Living in vision A

Transport

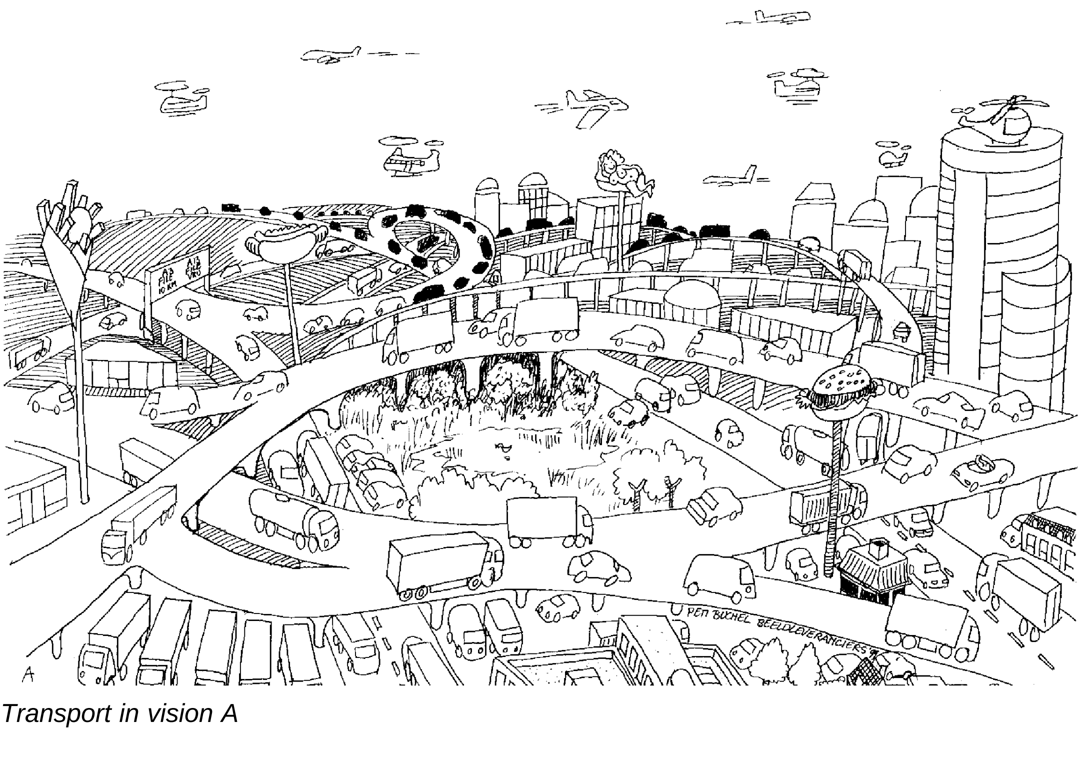
High standards of living and high incomes combined with a more individualistic society have resulted in a strong increase in the total number of passenger kilometres compared to 1990 levels. A strong preference for the car, prevails with obvious consequences for the infrastructure, which has been highly expanded. Public transport does not grow at the same pace and is concentrated in the major urban areas with high population densities.

Freight transport also increases significantly. Some reductions in the demand for transport are obtained by more efficient planning of logistic systems, with savings in the number of kilometres up to 25% for freight transport compared to a baseline development.

The fleet of cars, i.e. passenger cars and trucks, is equipped with fuel cells for on-board power generation. Fuelled with hydrogen, vehicles are more efficient than the Internal

Combustion Engine Vehicles (see Table 3.2), that dominate the current transportation fleet. However, the production of hydrogen accounts for a larger energy use than diesel or petrol does. Nevertheless, the overall energy (and CO_2) balance is positive. A major advantage of fuel cell traction is that zero emission vehicles are obtained. This technology has a very positive influence on the reduction of NO_x, dust particles, CO, hydrocarbons and SOx, leading to strongly reduced urban air pollution levels.

Air transport increases drastically (a factor 12) because of a high demand both for passenger and freight transport. Recreation & holidays abroad, as well as business travel, are the main driving forces of increases in passenger transport. Additional airport capacity is realised in various parts of the country. Air transport is a difficult category in technical terms for reducing greenhouse gas emissions. Efficiency improvements in aeroplanes up to 50% are observed but in terms of fuel demand these improvements are insufficient to compensate for the high growth figures. A solution to avoiding greenhouse gas emissions is provided by the production of synfuels (hydrocarbons that can be produced with well-defined combustion properties) by using biomass as feedstock. Overall, this results in a carbon-neutral fuel. Hydrocarbons are preferred for planes since these fuels have a high energy density.



Transport in vision A

Although the impacts with respect to emission to air from (road) transport are strongly reduced and despite the use of carbon-neutral fuels such as hydrogen and biomass derived hydrocarbons, the energy use by the transport sector is still substantial due to the strong growth of passenger and commercial transport. Roughly half of the national energy end-use in 2050 is accounted for by transport.

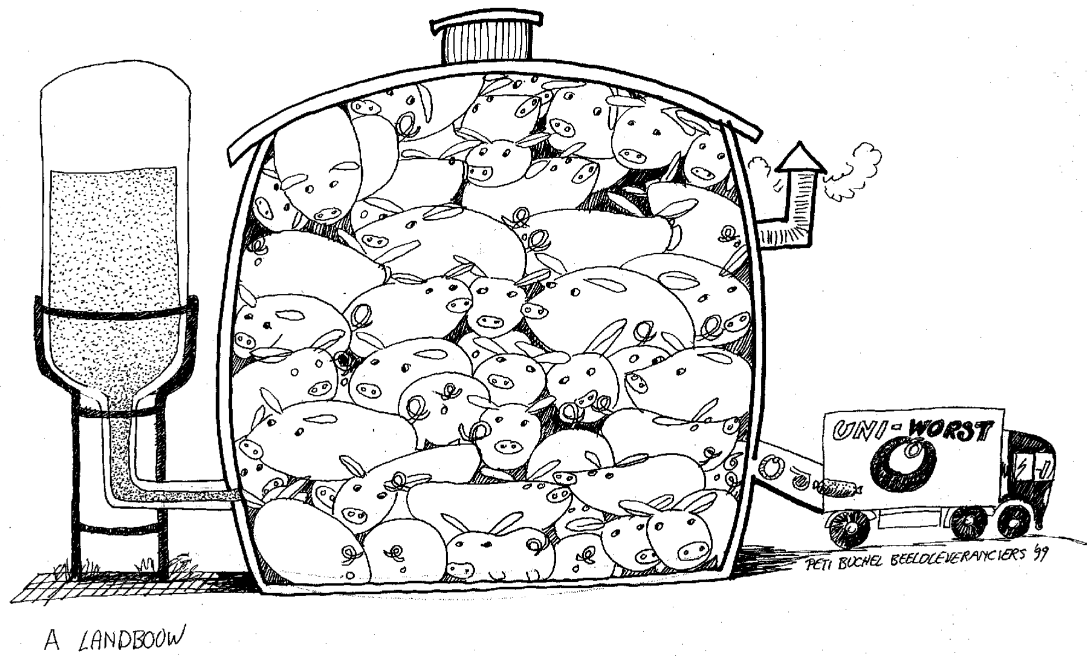
It should be noted that almost all the transportation fuels required are derived either from carbon-neutral fuels, biomass, or by producing hydrogen from fossil fuels (in particular coal), combined with CO_2 removal and storage. Therefore the throughput of the traditional oil refineries has been strongly reduced.

Table 3.2 dominant transport modes and their characteristics

	Transport performance			
	Performance Unit (PU)	Total 2050	Transport performance indicator (1990=100)	
Individual passenger transport (pass. Car)	Vehicle km	150 billion	167	
Freight transport	Ton.km	357 billion	870	
Air transport	Number of flight movements	3,6 million	1200	
	Energy Use			
	Unit	Energy use 2050	Energy efficiency indicator (1990=100)	Energy use total fleet 2050
Individual passenger transport	MJ/vehicle km	0.88	40	108 PJ
Freight transport	MJ/ton.km	1.06	60	409 PJ
Air transport	GJ/flight movement	12.75	50	46 PJ

Agriculture, food production and land-use

The agricultural sector operates in an open and competitive world market and therefore has to comply with stringent economic conditions (low market prices). This is achieved by highly intensive production systems: glasshouse culture and intensive non-soil bound livestock (chicken, pigs). Together with the products from high value-added horticulture (bulb, flowers), these are the most important export products. These industrial and controlled production facilities lead to reductions of non-CO_2 greenhouse gases in the agricultural sector. However, the emissions from CH_4 and N_2O particularly linked to cattle raising remain to some extent.



Agriculture in vision A

Glasshouse culture takes place in a high-tech environment with fully closed production systems so as to minimise the environmental impact. The energy use, in particular for heating, is reduced by 70-80% when compared to current levels.

Indigenous biomass production (energy farming) plays a negligible role. Available land is used preferably for nature with a recreational function. Available residues, and especially combustible waste residues, make a relatively modest contribution to the energy supply mix.

The energy system

Due to rapid economic growth and dynamic technological development, the energy system and energy infrastructure have undergone a complete modernisation. The entire new energy infrastructure meets new efficiency, environmental and safety standards. One of the demands is a highly reduced carbon intensity. A hydrogen grid network is assumed; this relates especially to the distribution of hydrogen for the vehicle fleet, and partly to industrial sectors and larger Combined Heat and Power facilities (consisting of highly efficient and clean fuel cells). Smaller-scale electricity production capacity can take place in the residential and commercial buildings and industrial plants where there is a need for smaller amounts of (lower temperature) heat. Fuel cells are again the conversion systems of choice for this type of Combined Heat and Power production.

Infrastructure to collect CO_2 (trunk lines) from various sources and subsequent storage is also created. Because CO_2 storage is widely applied to reduce CO_2 emissions (54 Mton), the economies of scale for CO_2 storage make this option relatively cheap.

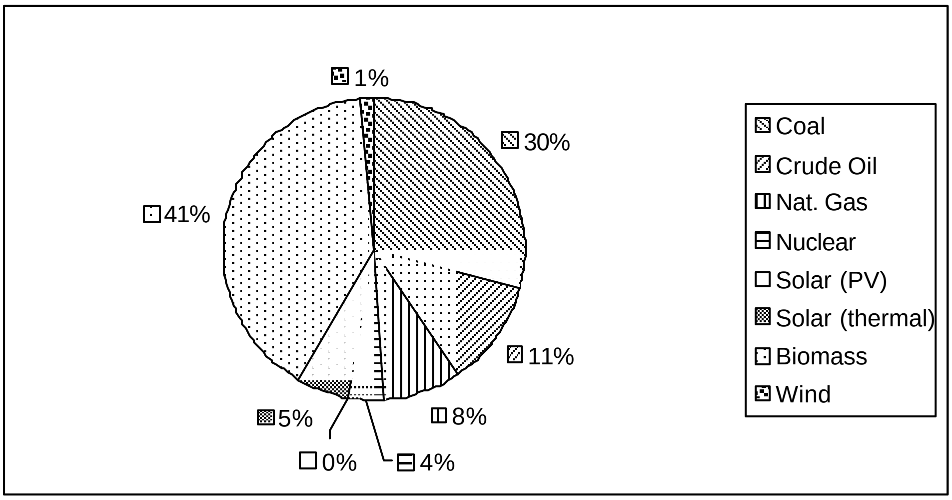


Figure 3.1 Primary energy carriers used for the energy supply in vision A

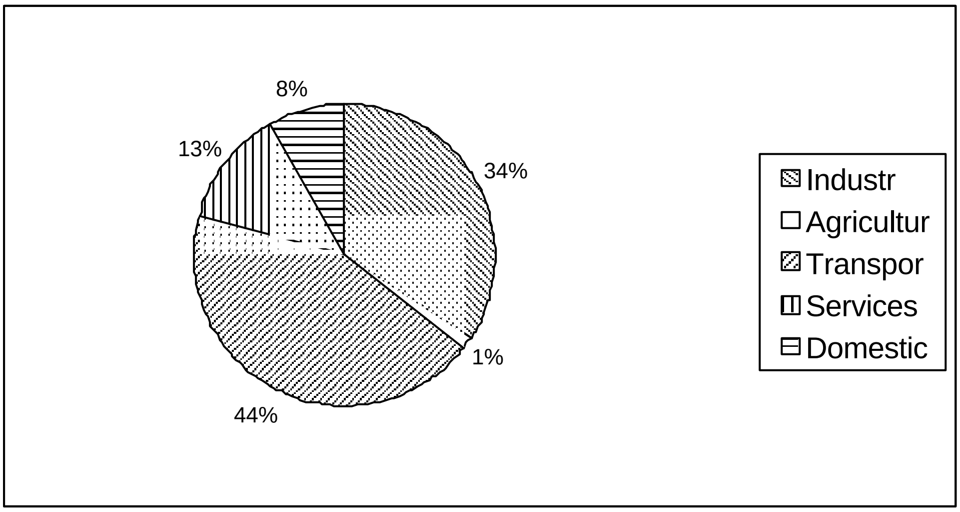


Figure 3.2: The most important demand categories, expressed as a share of primary energy consumption in vision A

CO_2 is collected mostly at large, centralised power generation plants and hydrogen production facilities. Furthermore, various heavy industries, such as producers of ammonia and a number of chemical processes allow for cheap and efficient removal of CO_2.

There is a preference for cheap energy carriers. Strong competition on the world energy market make large quantities of cheap fossil fuels available, particularly coal and natural gas (the latter partly from unconventional sources such as Coal Bed Methane and methane stored in clathrates, particularly in deeper sea and ocean waters). Coal, with cost levels around 1 U$/GJ is a preferred fuel. It can be used both for the production of electricity and hydrogen.

Market forces largely determine the way the energy system is designed and cost minimisation is an important driver. This implies a tendency towards larger-scale production capacity instead of a decentralised energy (electricity) supply system. This production capacity is built closely to industrial centres for optimal heat utilisation.

Advanced power plants with efficiencies in the range of 50-70% can easily be equipped with CO_2 recovery steps with only moderate economic and efficiency penalties. Very important is the production of hydrogen from coal, used for transportation purposes. Carried out on a large scale and combined with CO_2 removal, the hydrogen is carbon neutral and can be produced with high-energy conversion efficiencies of about 60%.
A significant part of "coal based" power generation and hydrogen production comes from Coal Bed Methane. Injecting CO2 in deep coal layers produces coal Bed Methane. The methane (CH_4) present in those coal layers is displaced by the CO_2, resulting in a CO_2-neutral gaseous energy carrier.

Nuclear energy also plays a role in the future energy mix, in particular for power generation (30%). Waste heat from nuclear power plants is also used for industrial heat and district heating. Thanks to the development of inherently safe reactor designs and new methods for treating nuclear wastes (rapid breakdown of long-life isotopes), the societal resistance against this energy option will have diminished by the year 2050. Low power generation costs forms another argument for the introduction of nuclear reactors. Furthermore, these reactors do not solely depend on uranium for fuel requirements, but can also be fuelled by thorium.

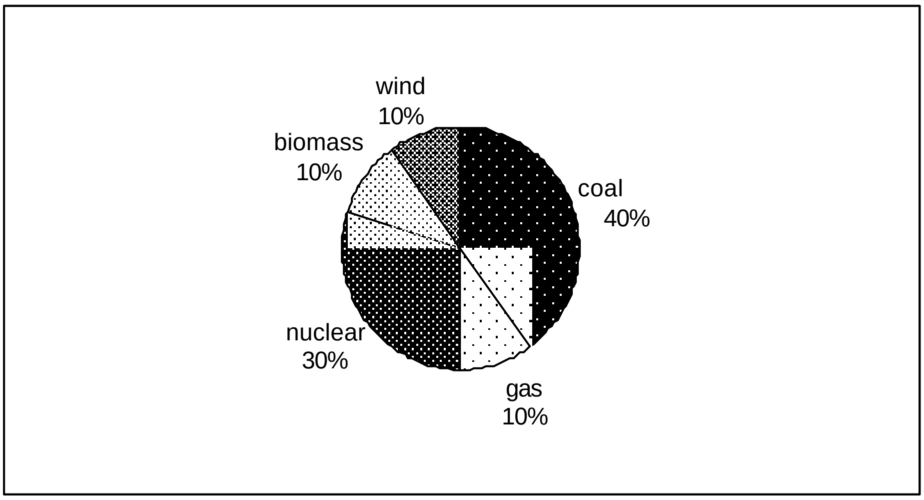


Figure 3.3: Primary sources for electricity production in vision A

The energy balances for the Netherlands for 2050 is enclosed in the appendix.

The energy mix

Import of electricity is anticipated, especially since by the year 2050, a liberalised open energy market has led to a fully functional European grid and free trade in electric power and gaseous energy carriers. Nuclear-based electricity from France but potentially also surplus wind power from the UK can contribute to the Dutch demand.

Another major energy supply option is the import of bio-energy. Produced cheaply in large areas of Eastern Europe, Latin America and Sub-Saharan Africa, both raw biomass and energy carriers from biomass (hydrogen in particular) finds their way to the Dutch energy system. Biomass production costs could be in the same range as the costs of coal utilisation. Because there is no need for CO_2 removal and subsequent storage, bio-energy competes with fossil fuels. Biomass is used especially for the production of synfuels, the production of hydrogen for transportation, and partially for the production of electricity and some feedstock for the chemical industry. Mineral oil remains an important feedstock for the petrochemical industry but not for transportation fuels.

Renewables such as wind and PV only play a moderate role. Wind energy is particularly applied offshore in large parks and thus makes a relatively modest contribution of 10% to the electricity supply. The application of PV is limited to niche markets since it generally supplies more expensive electricity than the large centralised capacity. Solar heating makes a very significant contribution by taking care of a substantial part of the demand for low temperature heat in dwellings and offices (about 100 PJ). The contribution of other renewables is negligible.

Some key technologies in vision A

Although a large number of options and technologies play a role in the "A - energy system" of 2050, a few key options can be highlighted:

Transport

Energy for transport has come to form a major part of the energy demand. Fuelled with hydrogen, fuel cell vehicles are more efficient than the Internal Combustion Engine Vehicles, that dominate the current transportation fleet. However, the production of hydrogen accounts for a significant larger energy use than diesel or petrol does. Nevertheless, the overall energy (and CO_2) balance is positive. Very important other characteristics of FCVs are the contribution to reducing other emissions such as NO_x and dust, which result in strongly improved (urban) air quality.

Energy system

Production of hydrogen and power from coal with CO_2 removal and storage; fossil fuels, in particular, coal and methane derived from coal beds still play a key role in covering the energy demand. Sustainable and competitive use of fossil fuels is possible with advanced technologies such as gasification, high temperature gas separation and advanced power cycles. Such systems allow for cheap and efficient removal of CO_2, resulting in carbon neutral power and hydrogen. Energy efficiencies of these systems are high (50-70%) when applied on a large scale (e.g. 1000 MWth input).

Industry

Overall efficiency improvement in heavy industry combined with material savings; since industrial production grows considerably in this view, increasing energy efficiency and (raw) material efficiency are important aspects of keeping the energy demand within limits.

Built-up environment

Energy-efficient dwellings: if no measures are taken, energy use in the built-up environment will increase drastically due to more luxurious standards of living and larger dwellings. Furthermore, these houses are built in suburban environments making application of district heating (CHP) very difficult; this increased energy efficiency of dwellings (in particular heat demand) is therefore very important. High levels of thermal insulation, heat recovery equipment and widespread application of solar heating keep the final energy demand of the built-up environment within acceptable limits. The remaining heat demand is covered by efficient heat pumps.

Non-CO_2 greenhouse gases

A number of important contributions to non-CO_2 greenhouse gas emissions (when expressed in greenhouse gas equivalents) is reduced to almost zero. Fluorinated gases (HFCs, PFCs and SF_6) are still used in a number of applications where no competitive alternatives have been developed. However, the total contribution of fluorinated gases to global warming is small. Industrial emissions of N_2O are reduced significantly by improved combustion equipment and are brought back to negligible levels.
Emissions of non-CO_2 GHG by traffic (largely N_2O in 1990) are reduced to zero due to a hydrogen-fired Fuel Cell Vehicle fleet that does not have these emissions. Fluorinate gases in airco applications in cars are replaced by suitable alternative technologies.

In agriculture, the emissions of CH_4, as a result from fermentation, and N_2O, which results from the use of fertiliser, remain present to some extent. A mix of technical measures such as closed stables, optimal feeds and central treatment of manure keeps emissions levels low. Altogether, the emissions of non-CO_2 greenhouse gases are considerably reduced compared to 1990.

International aspects

Trade is a crucial aspect of the economy of Europe and the Netherlands in 2050. Export of various products which are produced in the Netherlands have a serious impact on the energy demand of the Dutch economy. Prominent examples are the chemical industry, the throughput of energy carriers (refineries, partly fed by biomass feedstock's) and the export of agricultural products (meat, flowers). The future allocation of the related energy consumption is very uncertain and will surely be subject to debate.

Trade of emission rights is an option that would fit well in the context described here, since there is a preference for cost minimisation to obtain emission reduction. Starting position is the absence of international emission trading in the full knowledge that this will be subject for debate.

3.3 ENERGY SYSTEM VISION B

Important characteristics regarding technology development and the selection of options

In this vision, society acknowledges the importance of a clean environment and social responsibilities, both on a local and on a global scale. In various sectors of the economy and areas of society specific (local or regional) policies steer developments instead of market forces. Options to reduce CO_2 emission reductions are based on the gradual adaptation of the people's behaviour and on technological improvements. Principal choices are made to reduce GHG emissions as far as possible in the Netherlands itself. In vision B cost-benefit analyses take environmental cost into account in the design of the energy system and principal choices are made in favour of renewables, for minimising the need of fossil fuels and against nuclear energy.

Industry

The energy use of industrial production increases, although less pronounced than in the A vision. Partially, structural effects cause this because the need for raw materials is reduced. Examples are ammonia production, since the demand for artificial fertilisers is limited due to ecological agriculture. Furthermore, the energy intensity of some heavy industry (the chemical industry in particular) is considerably reduced by shifts from base chemicals towards more valuable special products.

Industry is supported in increasing its energy efficiency, which leads to considerable improvements of the energy performance of the various production sectors. A wide variety of energy efficiency measures are applied. Major examples are: strongly increased electro steel production at the expense of primary steel, which is caused by increased recycling rates, and highly efficient and integrated paper & pulp production that make maximum use of recycled resources. Besides, advanced drying techniques are implemented in paper production and many light industries, with very low specific energy requirements. Clean processes minimise other emissions and the amounts of waste produced.

As a whole, industrial complexes are strongly integrated and supplied with power and heat by highly efficient combined heat and power generation capacity. Far reaching integration allows for heat cascading, which limits the industrial energy use considerably. In light industry, which is an important factor in the total industrial energy use, average energy savings amount around 60%.

Materials efficiency

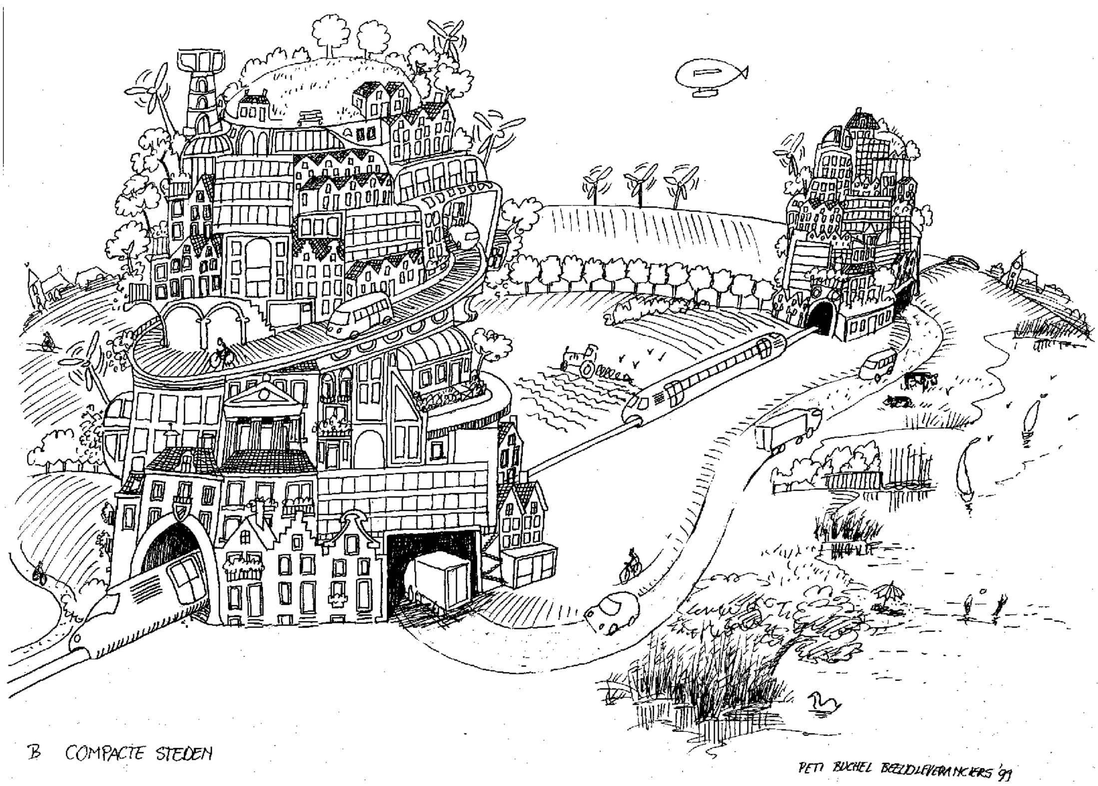
The use of recycled raw materials by the heavy industries (base metals, chemical, paper and building materials) is maximised. Consumers give support to recycle goods (electronic equipment, cars) and packaging as well as adapted product designs that minimise material inputs. Building materials are recycled or used for energy production after use (such as wood). This leads considerable energy savings; compared to baseline levels paper and plastic consumption for example, are reduced by 40%.

Living

The average size of dwellings does not change compared to 1990 if expressed on a per person basis. Dwellings are so-called zero-emission dwellings; they are are supposed to generate as much energy as is consumed for the energy functions addressed within the EPN (which means that the energy consumption of domestic appliances is not counterbalanced). The dwellings consist of a highly insulated shell equipped with a high efficiency boiler, seasonal storage of heat and renewable options such as photovoltaic solar energy and a thermal hot water system. The preference for renewable energy sources such as solar heating is applied on a large scale to cover the demand for space heating and hot water for both dwellings and offices. Compact cities make the application of heat distribution (from Combined Heat and Power plants) feasible in many areas, although the need for space heating is strongly reduced due to excellent insulation levels of dwellings and offices.

Work

The service sector is a very important part of the economy. The growth of the service sector surpasses the economic growth rate figures considerably. Particularly the non-commercial services contribute largely to overall employment, and also to the gross domestic product. Energy use in the service sector is reduced to modest levels due to the large-scale application of highly energy efficient offices. Large office complexes are supplied with district heating and make maximum use of solar heating. Working areas are integrated with living areas, and tele-working and flexible working times are well accepted and widely applied.



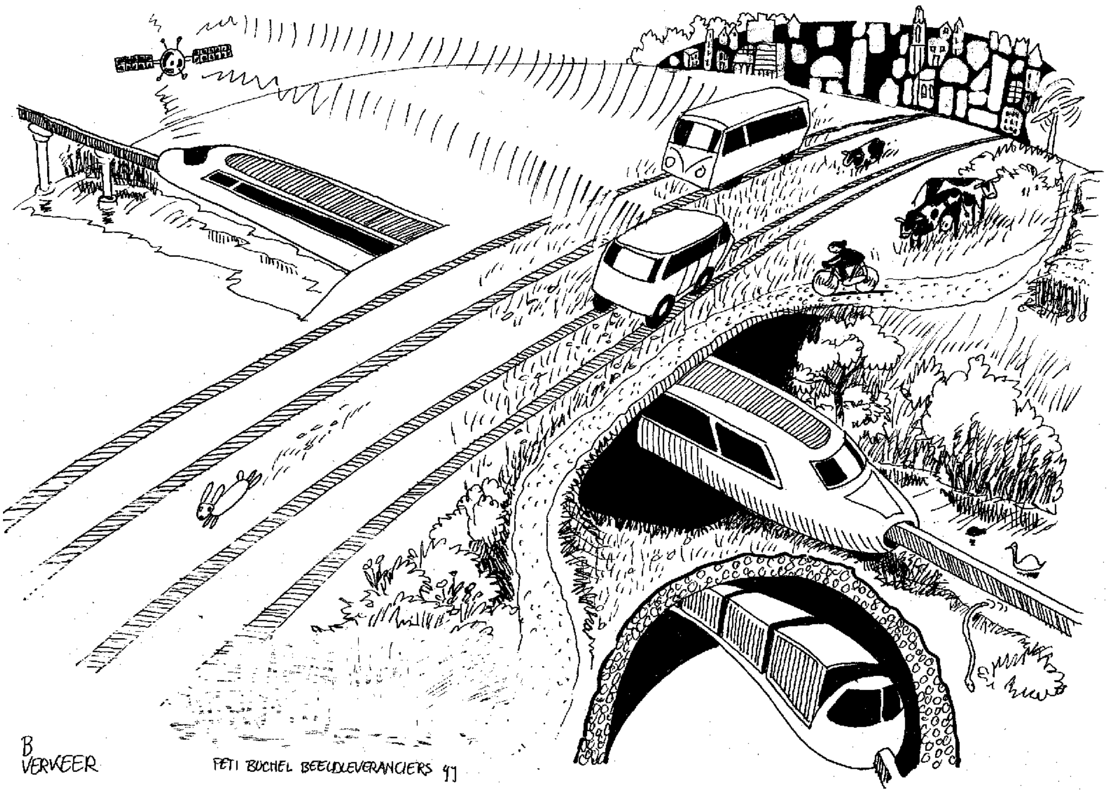
Living in vision B

Transport

The demand for transportation services (surface passenger and freight transport as well as air traffic) increases substantially, but more modest than in the A vision. Due to the spatial planning of the urban areas which result in compact cities in which living and working functions are brought close together, the demand for transport is reduced.

The role of cycling is important thanks to a cyclist-friendly design of the urban infrastructure. Furthermore, public transport plays a key role. Due to advanced and comfortable means of public transport, the pressure on the road network is kept within limits. Improved public transportation services, with high frequency, and modern subways have brought the public transport systems to high levels of comfort and quality. Clean fuel cell vehicles are used for individual transport (mostly cars), as well as for trucks and buses. Fuels are biofuels, mostly alcohols. FCVs are more efficient than Internal Combustion Engine vehicles. However, the production of bioalcohols is less energy efficient than that of diesel and gasoline. The total energy consumption of the transport sector is a major factor in the national energy demand, but the application of biofuels ensures that this energy demand does not result in CO_2 emissions. A small part of the biofuels is produced in the Netherlands and imported from bio-energy exporting countries in e.g. Latin America and Eastern Europe. Electricity is the energy carrier used for most public transport systems

Air transport grows by a factor of 6 compared to 1990, which is a very large increase, but on the other hand, much lower than in the A vision. Energy efficiency of aircrafts increase by 60%. Despite the energy efficiency improvements, the high growth in air traffic leads to



Transport in vision B

a higher use of energy than is the case in 1990, although the energy consumption it is much lower than in vision A.

Shorter distance air traffic is to a large extent replaced by rail transport. Remaining shorter distance aircraft is largely equipped with advanced turboprop design engines that combine a high efficiency with very low emission levels. Since aircraft are powered by biomass-derived hydrocarbons (synfuels), air transport does not contribute to the net CO_2 emissions.

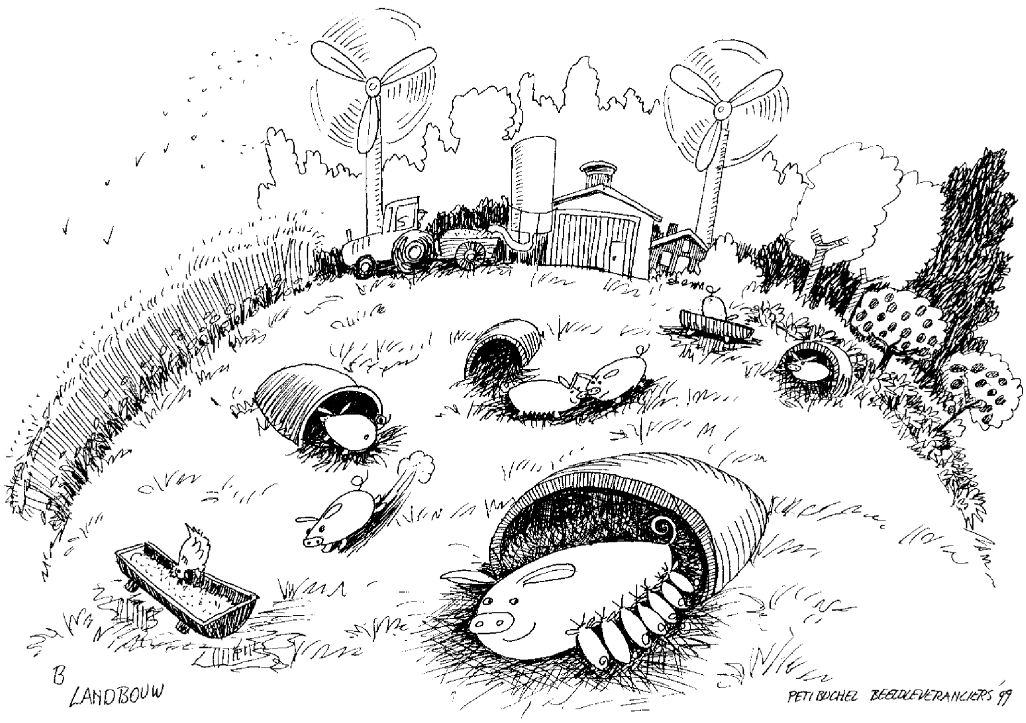
Agriculture, food production and land use

The development of urban structure is towards dense cities in which work and living are integrated. Such a structure limits the demand for transportation and decreases the pressure on the agricultural and nature areas. Nature areas in the Netherlands are therefore expanded. However, agriculture remains the key land-use function. In agriculture emphasis lies more on ecological methods of farming, characterised by low input levels and minimal environmental impacts. In order to meet the demands for food products, more land is needed for the same quantity of food products. Consumers appreciate the “ecological” agricultural products; there is a strong preference for “natural foods”. The added value of agricultural products is, however, increased and society is willing to pay for more expensive produce.

There is also a strong tendency to combine nature functions (as well as recreation) with extensive forms of agriculture meeting stringent environmental standards.

The energy-intensive agricultural subsectors, especially the glasshouse culture, become less important. Intensive cattle breeding (chicken, pigs) is phased out for environmental and ethical reasons, although cattle (e.g. diary and part beef) is still raised in considerable numbers. Cattle raising remain one of the main sources of GHG emissions (largely methane).

Part of the land is used for biomass production (largely in combination with other functions, such as buffer zones for nature areas and recreation). Although significant in terms of land surface, this indigenous biomass production makes only a modest contribution to the energy supply mix of the Netherlands. Combined with residues from agriculture and organic wastes, this contribution amounts to about 15% of the primary energy demand.



Agriculture in vision B

The energy system

Two aspects are very important for the energy system in the B vision. First, the total energy demand in terms of primary energy carriers has not increased due to developments in the economic structure (reduced energy intensity) and far-reaching energy-efficiency measures throughout the entire economy. The more modest growth in energy consumption and growth of economic activity compared to vision A has put less strain on the energy infrastructure (distribution of power, heat, gas and fuels). Consequently, the capacity of the energy infrastructure in place at the beginning of the 21st century remains sufficient. This results in a preference for adapting the existing energy infrastructure instead of designing and installing a completely new system. Second, there is a targeted societal preference for renewable energy sources (wind, solar energy and bio-energy). Since renewables (solar and wind, in particular) play an important role in the energy supply and specifically power generation, the energy system must be able to deal with the intermittent character of these supply options. This is realised by installing storage capacity and in particular by investing in flexible power generation capacity fired with natural gas (without CO_2 storage, since this would be uneconomical for gas-fired capacity with low load factors).

An advantage of a large share of renewables (linked to a European grid) is that the fluctuations are less severe than for smaller shares linked to a local grid.

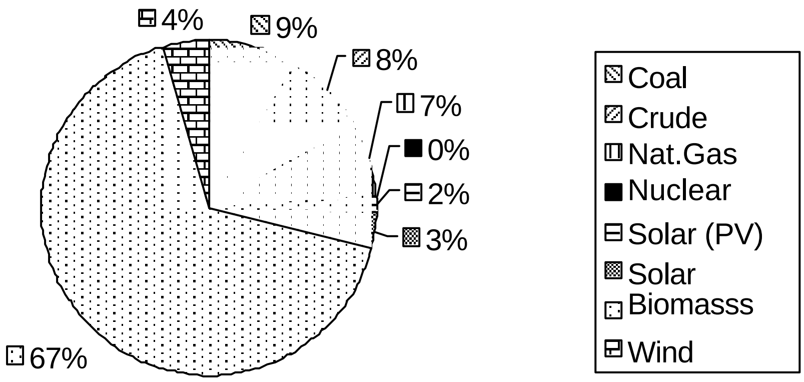


Figure 3.4 Primary energy carriers used for the energy supply in vision B

The main characteristic of this B vision is that renewables are strongly supported. Nuclear energy is mainly left out of the (Dutch) energy supply mix and the use of fossil fuels minimised as far as possible. This leads to impressive development of the wind-power capacity; both on-shore and particularly offshore. The technical potential of wind-power generation is about 15,000MWe installed capacity. This results in a net contribution to the power generation of about 40%, making wind the single most important electricity generating energy source.

Another highlight of the power generation in this vision is the structural, large-scale, application of solar energy, which is largely concentrated and integrated in the built-up environment (industry, urban areas and agriculture). Photovoltaic energy is fully integrated in the built-up environment. PV is still a relatively expensive option for power generation in 2050, but the higher power generation costs are accepted by society, and become, partially, part of the prices of houses and offices. The contribution of PV to the total power needs is around 15%. Solar heating contributes considerably to meeting low temperature heat demands (around 150 PJ primary energy).

The bulk of the remaining energy needs is supplied by bio-energy; two thirds of the national energy demand is covered by bio-energy. “Bio-energy refineries” are the main consumers of biomass. Bio-energy refineries produce bio-alcohols for transportation as well as hydrocarbons in order to partially cover the feedstock needs of the chemical industry (the remaining demand is still covered by mineral oil). Part of the energy outputs of those integrated complexes are heat and power. Such complexes are typical of a large-scale and built-in seaport areas where biomass can easily be supplied from all over the world. This reduces supply risks caused by fluctuations in biomass production in various regions. Part of the biomass-fired capacity can also be fed with fossil fuels when needed.

A small part of the biomass (about 15% of the total primary energy demand) originates from local sources, such as (the organic fraction of) waste and agricultural residues. Also, it is partly cultivated, in particular in areas where the cultivation of biomass can be combined with other land-use functions, such as buffer zones for nature areas and sound insulation barriers. In the case of forestry, the supply of timber, pulpwood and biomass fuels are combined. In total, about 200 PJ can be produced from indigenous biomass. The bulk of the biomass, however, is imported. Imported bio-energy consists of raw biomass (for large-scale biomass conversion capacity in sea harbours) and the import of biofuels. Regions providing biomass are found worldwide: Eastern Europe, Latin America, Canada and Sub-Saharan Africa are the most important suppliers. The Netherlands needs roughly about 4 million hectares abroad to produce the biomass and biofuels needed to meet the national energy demand.

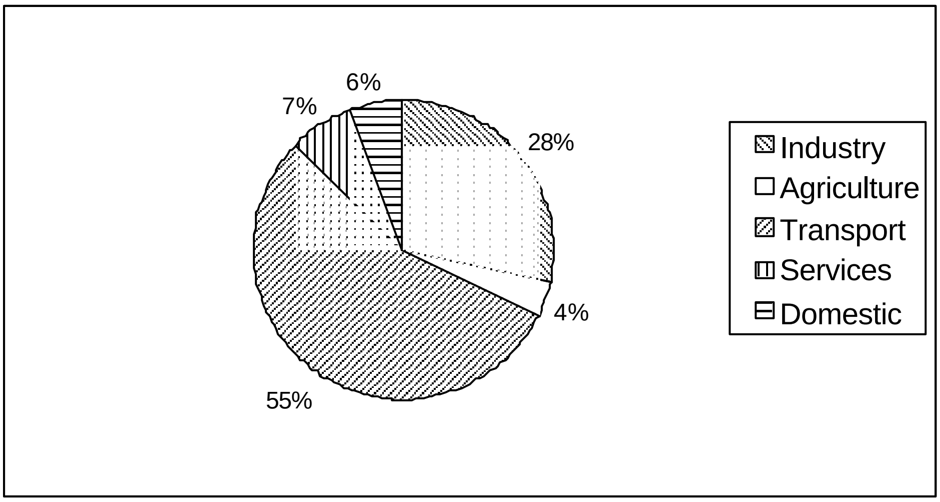


Figure 3.5 The most important demand categories, expressed as a share of primary energy consumption in vision B

Natural gas still plays an important, although a relatively modest, role in the energy mix: flexible peak power generation capacity (highly efficient gas turbines and fuel cells) cover the remaining part of the power production. This makes the large contribution of the intermittent wind and solar-driven power generation capacity feasible. CO_2 removal and subsequent storage is not considered for this capacity due to the relatively small capacity and low load factors.

Finally, part of the gas supply is covered by Coal Bed Methane, which is produced by injecting CO_2 in deep coal layers. Overall, the use of methane is carbon neutral, since roughly two units of CO_2 are needed to produce one unit of methane. The potential of CBM in the Netherlands territory is supposed to be considerable.

In order to operate such a system some CO_2 removal capacity is needed at large scale energy conversion systems. Part of the CO_2 is recovered at ammonia production plants and other industries where hydrogen is needed and CO_2 is a by-product. Partly, CO_2 is collected from the bio-refineries. As a consequence, CO_2 storage (10 Mton) is less important than in vision A. It is only applied in industrial centres (such as the Rijnmond area) and at baseload power generation capacity.

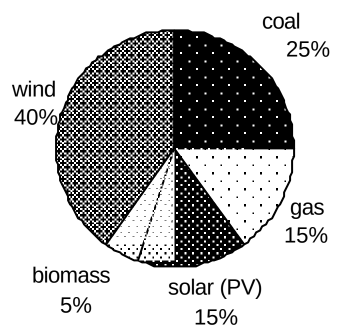


Figure 3.6 Primary sources for electricity production in vision B

Non-CO_2 greenhouse gases

A number of important contributors to non-CO_2 greenhouse gas emissions (when expressed in greenhouse gas equivalents) is almost reduced to zero. Fluorinated gases (HFCs, PFCs and SF_6) are still used in a number of applications where no competitive alternatives have been developed. However, the total contribution of fluorinated gases to global warming is a very small. Industrial emissions of N_2O are reduced significantly by improved combustion equipment and are brought back to negligible levels.
Emissions of traffic, also largely N_2O, are reduced to zero due to a Fuel Cell Vehicle fleet. Fluorinated gases in airco applications in cars are replaced by suitable alternative technologies.

Emissions of CH_4 and N_2O linked to the agricultural sector remain to some extent. Various measures that interfere with the feeding and raising of cattle are considered unacceptable and cattle raising is replaced from the intensive production systems (in which emissions can be more easily controlled by technical measures) to outdoors or open stables. This is, in particular, the case for CH_4 emission. N_2O emissions remain, but far less than in the current context, due to strong reductions in the use of fertilisers.

International aspects

Less emphasis lies on free trade and global competition than in the A vision. Still, the Netherlands is part of a united Europe. So, for example, a fully integrated European grid is expected to be in place. This facilitates the import of considerable "green" electricity from neighbouring countries. Important suppliers could be the UK, with surplus tidal and wind-power capacity and Scandinavia with hydro- and bioelectricity. However, the growth of the export of chemicals and agricultural products, for example, is considerably lower than in the A vision. Trading emission rights is an option that is not preferred in the context as described here and the main standpoint is that the industrialised nations should reduce their own greenhouse gas emissions to required levels within their own borders.

One of the most striking consequences of the large-scale use of renewable energy sources is the unavoidable importance of imported bio-energy. The estimated 5 million hectares needed to produce biomass abroad is therefore only acceptable when strict ecological and societal standards are met in the exporting regions. On the other hand, the (positive) economic injections for bio-energy supplying nations could be considerable.

The energy balances are enclosed in the appendix.

Some key technologies in vision B

Although a large number of options and technologies play a role in the "B - energy system" of 2050, a few key options can be highlighted:

Transport

Energy use for transport has come to form a major part of the energy demand. Through catalytic oxidation or reforming hydrocarbons and alcohols in the vehicle are made suitable for use in fuel cells. Fuel-cel vehicles (FCVs) are more efficient than Internal Combustion Engine vehicles. However, including the production energy of the fuel used, the overall energy balance for some vehicles (e.g. the truck) is negative. Nevertheless, for alcohols derived from renewable energy sources, the CO_2 balance is positive. Very important other characteristics of the FCVs is the potential contribution in reducing other emissions such as NO_x, dust and N_2O, which result in highly improved (urban) air quality.

Energy system

Electricity production from wind and solar energy. The contribution of solar and wind energy to the electricity production is maximised: 15.000 MWe of wind power, largely placed in off-shore wind parks, and structural application of photovoltaic energy in the built-up environment, make a considerable contribution to the primary energy supply. Due to the intermittent character of solar and wind, and some storage capacity (batteries at local level for PV, compressed air facilities in combination with wind park) and peak power generation capacity (natural gas fired gas turbines and fuel cells) are required to guarantee a stable electricity supply. Integration in the European grid and the large-scale application of those renewables as keep the need for peak power capacity are, however, quite limited though.

Electricity production

Electricity production from wind and solar energy; the contribution of solar energy and wind energy to the electricity production is maximized. 15.000 MWe of wind power, largely placed in off-shore wind parks, and structural application of photovoltaic energy in the built-up environment, make a *considerable contribution to the primary energy supply. Due to the intermittant character of solar and wind,y some storage capacity (batteries at local level for PV, compressed air facilities in combination with wind park) and peak power generation capacity (natural gas fired gas turbines and fuel cells) are required to guarantee a stable electricity supply. Integration in the European grid and the large-scale application of those renewables as keep the need for peak power capacity quit limited though.*

Built-up environment

Energy-efficient dwellings: Compact cities and buildings, high insulation grades, heat recovery equipment and widespread application of solar heating keep the final energy demand of the built-up environment (both dwellings and offices) at very low levels. Passive solar heating and solar collectors cover a major part of the remaining heat demand.

3.4 Comparing the energy systems

In both visions the predefined 80% reduction goal, with respect to 1990, is achieved. However, there is an import difference in the way this goal is achieved. Figure 3.7 shows the development of emissions for both visions in ‘a business as usual’ context. This figure also shows the contribution to the reduction of greenhouse gas emissions of energy and material efficiency, sustainable energy and CO_2 storage. This chapter briefly summarises the main aspects of the two visions.

Energy demand

Vision A: Strong growth of industrial production capacity, luxury dwellings in suburban areas and strong growth of individual transport and air traffic are dominant developments affecting the energy demand. With a total population of 16 million people the total energy demand amounts to 2000 PJ; industry and transport are the dominant sectors in energy use.

Vision B: More limited growth of industrial production, considerably increased material efficiency, compact cities with highly energy-efficient dwellings, more intensive use of public transport limit the energy use. On the other hand the population in the Netherlands has grown to 19 million, compared to 16 million in A. Total energy demand amounts to over 1700 PJ; energy use is dominated by the transport sector and to a lesser extent by industry.

Industry

Vision A: Substantial improvements in energy efficiency through new industrial processes. Largely driven by the need to reduce production costs and improve product quality. Industrial capacity is organised in integrated industrial complexes with very efficient Combined Heat and Power generation and optimal waste heat utilisation. Improved material efficiency is obtained as well.

Vision B: Far-reaching improvements in energy efficiency obtained by far-reaching measures, including expensive options to reduce energy consumption. Well-developed recycling schemes and adapted products lead to substantially increased material efficiency (up to 40% compared to baseline levels). Industrial production capacity is concentrated in integrated complexes with highly efficient CHP generation and heat cascading.

Built-up environment

Vision A: Luxury, large dwellings in suburban areas. Strong growth of the service sector. Considerable improvements in energy efficiency through good insulation. Energy demand especially covered by electricity & heat pumps and passive solar energy and solar heating systems.

Vision B: Compact cities and very energy-efficient, compact dwellings. The service sector is a dominant sector in the economy. Offices are highly energy efficient. Energy demand is covered especially by heat distribution, solar heating and large-scale application of PV.

Transport

Vision A: Dramatic increase of air and freight traffic in general. Strong growth of individual transport. Minor role of public transport. Cars and trucks powered by very efficient and clean fuel-cell vehicles fired by hydrogen. Efficient aircraft are fuelled by synfuels produced from CO_2-neutral biomass.

Vision B: Increase in the need for transport in general, but major role for public transport in passenger transport, as well as using trains for freight. Cars and trucks powered by efficient and very clean fuel-cell vehicles fuelled by bio-alcohols.

Agriculture and land use

Vision A: Highly intensive agricultural production on a limited surface of land. Very efficient greenhouse sector and intensive cattle raising in “closed stables”. Considerably increased land use for suburban developments (comfortable dwellings in park-like environment). Increased land use for industry and infrastructure (roads, airports). Other land areas are important for recreational purposes.

Vision B: Ecological and more extensive agricultural practice. Integration of functions: agriculture and recreation, as well as energy production; land is also used for biomass production for energy and feedstock. Compact cities and large-scale application of public transport.

Non-CO_2 Greenhouse Gases

Vision A: Far-reaching reductions in HFCs by application of alternative compounds, elimination of N_2O emission of combustion related emissions by application of Fuel Cell Vehicles and other industrial processes. Sharp reductions of N_20 and CH_4 emissions in agriculture by closed stables and greenhouses.

Vision B: Far-reaching reductions in HFCs by application of alternatives, elimination of N_2O emission of combustion-related emissions by application of Fuel Cell Vehicles. Sharp reductions of N_20 emissions through less intensive agriculture. Some remaining CH_4 emissions related to cattle raising.

Energy supply

Vision A: Energy supply dominated by coal and biomass. Furthermore, a diverse mix including nuclear, natural gas & Coal Bed Methane and wind power. Mineral oil remains of importance for the chemical industry.

Vision B: Energy supply is dominated by biomass (large-scale import of raw biomass and biofuels from other parts of the world). About 15% of the primary energy come from indigenous biomass and (organic) wastes. Remaining part of the energy supply covered by wind, solar energy, coal (Coal Bed Methane) and natural gas.

The energy system

Vision A: A completely revised energy infrastructure with a large-scale hydrogen distribution network and a network of CO_2 pipelines for collection and storage of CO_2. CO_2 removal is applied principally during hydrogen production and power generation from coal and in a number of heavy industries. The energy supply (power, fuels, and heat) is dominated by large-scale capacity. Energy production is to a large extent integrated in industrial complexes for optimal utilisation of waste heat. The energy supply in the built-up environment is dominated by electricity, application of heat pumps and support of passive solar energy.

Vision B: A more traditional energy infrastructure remains in use: large-scale heat distribution is used for compact cities. CHP generation and heat cascading is widely applied in integrated industrial complexes. The dominant role of wind and solar energy in the electricity supply requires storage capacity (batteries in the built-up environment, compressed air for wind parks) and flexible, gas-fired power generation capacity. PV and solar heating are widely applied in the built-up environment.

Electricity

Vision A: Electricity production dominated by coal with CO_2 removal and storage, and nuclear energy. The remainder is covered by natural gas + Coal Bed Methane, and wind power.
Vision B: Electricity production is covered for more than 50% by wind and solar (PV) energy. Supportive peak-power generation capacity on the basis of natural gas and CO_2-neutral Coal Bed Methane.

Fuels

Vision A: Large-scale production of hydrogen from coal as well as from biomass. Biomass is also the CO_2-neutral feedstock for production of synfuels, particularly for use in air transport. Substantial import of bio-energy.

Vision B: Vehicles are fired by bio-alcohols produced from indigenous biomass and large-scale import of biomass and fuels from various world regions. Biomass is also used for production of synfuels, for use in the air transport sector and as feedstock in the chemical industry.

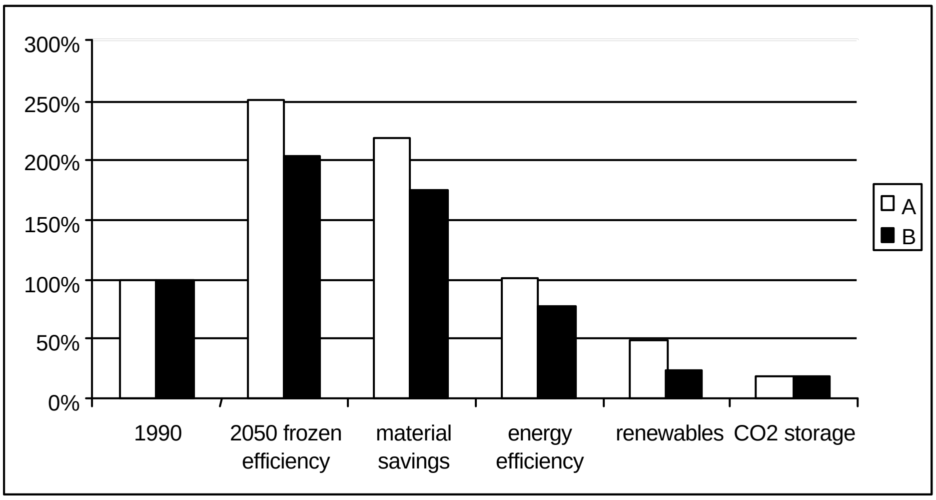


Figure 3.7 The contribution of different kind of measures to reduce greenhouse gas emissions with respect to the "business as usual scenario" for both visions

4. A DAY IN THE LIFE OF …

4.1 Jian Average in Vision A

As on every working day, Jian's audio centre wakes him from a deep sleep. Today it's Prodi's greatest hit, a composer from the turn of the 21st century that booms out of the speakers. The electronic climate control system buzzes as it switches up to 22 degrees Celsius. John's hand feels in vain for Noekie next to him. An unpleasant empty feeling sweeps through his body as the reality hits home. Noekie left a month ago for Terrausisus, a CO_2 station in the Pacific Ocean, 8 km deep. It's a wonderfully prestigious project for extending CO_2 storage with the help of manipulated bacteria and algae. A great opportunity which she just couldn't miss. A position in Terrausisus is the guarantee for top assignments and income. In a year's time she will be able to buy her own explorer-heli. Then they will be able to see each other occasionally in the weekends.

Plagued by these chilly thoughts, Jian takes an extra warm shower. He uses the voice recognition system in the shower to ask the wireless world system what the possibilities are of getting to Maxima Aqua airport at 8 am using the motorway. He books the 7.35 option and the voice pattern scanner authorises the system to debit 100 Euro from his account. Jian grabs the take-away beaker from the coffee machine, while the last drops hiss onto the hot plate. The coffee machine switches itself off immediately. With the computer warning him that the route booked must be started in 4 minutes, Jian grabs a defrosted sandwich from the microwave and runs to his car.

It will not be a relaxing day. His personal chip-box shows a long list of appointments. Last week's incident with the Boeing 999 will be evaluated today. Due to a fault in the guidance system, the Boeing roared past the undersea land link. Luckily the emergency circuit was able to stop the aircraft from shooting off the offshore runway.

The new and extremely expensive airport in the North Sea could not afford an accident. The crash in 2022 in Hong Kong's offshore airport had led to a ban on extensions of this sort of airport. Lack of space, the explosive growth of air traffic, and new efficient and safe-landing techniques, made offshore airports extremely cost-effective in the Netherlands. The incident last week showed that large-scale accidents were still not impossible. He didn't see any reason to panic; however, Maxima Aqua airport, with 20 million passengers a year, is one of the largest and safest in the North Sea. Air traffic accidents are rare, but when they happen, with current aircraft holding 3500 passengers, they are catastrophic. This is why the media pounce on every incident like a bunch of lunatics. It would be a difficult job to keep this incident within proportions considering the eager press people who had been able to follow everything via the public watch system (pws), the electronic and public successor to the so-called "black box".

The noise of his car coupling onto the magnet system of motorway 12 from The Hague to Maxima Aqua roused Jian from his thoughts. While he bites into his sandwich and sips his coffee, his car swishes through the green parks of The Hague. The vehicle speeds along the full 12-lane road through the guiding gates. The characteristic towers of The Hague slowly disappear from view. The green sub-city landscape slowly changes into an open landscape with grazing land full of kangaroos and ostriches. Every now and then an office block spoils the view. It flashes through Jian's mind that Noekie loves kangaroo burgers. A year ago on their honeymoon in orbit they had hilariously eaten a kangaroo burger, orbiting around the earth. It was still original to have a honeymoon in space then; now masses of couples queue up at the launching base in Reims to tie the knot in space. Impulsively, he decides to ask for a virtual meeting in the recreation centre in Maxima Aqua. The thought of the session mildly excites him.

His car nears the 16-lane entrance channel to Maxima Aqua in the dunes of Egmond-on-Sea, which swallow up the traffic like a huge funnel. Five minutes later Jian steps out of his car and walks through the welcoming chip-ID-gate into the airport. Since the city centres have been closed off with chip ID-gates to keep out the homeless, the tramps have sought refuge outside the city centres. The airport was forced to install such gates to keep out the tramps. Jian too had decided to fit his property with this sort of gates. The problem was becoming a threat to the suburbs of The Hague. Suddenly journalists appear from all directions. The worst rats crawl through every hole, growled Jian to himself. They had just bought an air ticket, of course, to get through the ID-gate. Under a barrage of questions from hungry journalists, Jian runs to his office.

A minute later Jian's request reaches Noekie's post box from the virtual control centre. The bellowing ID-signal of Jian's virtual request wakes Noekie from her deep sleep. Slowly the meaning of the message gets through to Noekie. With a deep-irritated sigh she cuddles up to the warm body next to her.

4.2 Jeanette Average in vision B

My distraught mother meets me at the door. Jeanette, there's a strange man in my house, she calls. I try to calm her down, unsuccessfully. There is no point in explaining the real situation. They had drilled that into me a hundred times in the government-sponsored study programme for contrary youth. I give her an arm and take her into our house. Eight years ago a lean-to home was built next to our house for my parents in the framework of parental care system. This is also the reason that we got a permit to live on the more spacious city outskirts. Since then my mother has really deteriorated, both mentally and physically. It has pained me to see the deterioration take place slowly before my eyes.

When mother has calmed down I go, leaving her with Yan. I walk quickly back to my parent's house to find my bewildered father in the living room, a tear running down his cheek. Your mother is all mixed up, Jeanette. She has smashed our entire dinner service. Shocked, I see a robot bin in between the separator bins bulging with broken solar panels and earthenware. My father looks at me with an expression of guilt and tears in his eyes. I didn't know which code to use on the recycle net to get them taken away. I put an arm around him and enter the removal code to the waste robot without him noticing. With one press on the fingerprint-reader the system adds 30 waste points to my account and tells me that I can use an extra 100 points this month without extra costs.

My father hopes that she will get much better when we finally go on our longed-for air trip to Crete next week. Holiday flights within Europe are not freely available. It is only possible to get a ticket with a medical certificate or a lot of environmental compensation points. My parents have saved up their compensation for years by setting the regulated thermostat from the city grid a couple of degrees lower. Finally, after six years, we got the required permission: myself and my father on environmental compensation grounds and my mother with a medical certificate due to her heart problem. I was beginning to think that these two would not have a chance any more to enjoy this experience.

I tap a jug of hot water from the city grid and set some nettle tea. In the grinder I see the rest of a meal which I made for them: Chinese leaf lettuce with wild potatoes and chestnuts. The Chinese leaf lettuce and potatoes come from the vegetable garden in our neighbourhood. We found the chestnuts on Sunday, when no cars were allowed to drive, in the Zuidlaardermeer national park. My parents really had to get used to the fact that we eat mainly vegetarian food. Large-scale anti-meat campaigns, like the anti-smoking campaigns in the previous century, made eating of meat shameful. Sometimes I still fancied a piece of meat, but don't dare to buy it out of pure shame, as if it were a sex magazine. Actually it is healthier without meat, and more animal friendly. Unconsciously, my mouth starts to water when I think of a beefsteak in Crete. In Crete meat is abundantly available and there are no taboos.

It's strange how the caring role of parents and children is swapped so imperceptibly, I think to myself as I leave the house a while later. My NSM beeps to remind me that it is time to collect Malin and Nika from the academy. The Groningen rail system takes me quickly to the centre of this busy city, which has quickly grown into a compact municipality of 350,000 inhabitants. Immigrants have been flooding into this popular northern city ever since the magnet train connected it to the cities in Western Holland in the twenties. The city train flashes past the large blocks of flats and office towers. A moment later I recognise my son Wim's office block. Wim works in a data-mine with data on integral mineral cycles. I'm looking after their two children Nika and Malin, as he and his wife are away for the weekend on the Schiermonnikoog island.

The academy is in an educational city quarter. Malin and Nika greet me enthusiastically as they run out of the building. Malin proudly lets me see her Dido transparency. She presses the button and the last drawing is shown on the transparency. For grandma, she says mischievously. Nika quickly reserves three seats in the city train. After a 10-minute wait it stops right in front of us, giving us a fast, warm ride back home.

Appendix 1: primary energy mix in vision A

		Primary energy carriers in PJ Coal	Crude Oil	Nat. Gas	Nuclear	Solar (PV)	olar (therm	Biomass	Wind	Import	Total
Industry	steel	54	0	1	1	0	0	1	0	0	57
	non-ferro	18	0	3	6	0	0	4	2	0	34
	chemical	10	122	2	4	0	0	246	1	0	386
	refineries	0	81	0	0	0	0	0	0	0	81
	fertilizer	0	21	0	0	0	0	0	0	0	21
	cement	0	0	0	0	0	0	0	0	0	1
	paper	9	0	2	3	0	0	2	1	0	17
	light industry	48	0	9	16	0	0	10	5	0	88
Agriculture	Meat cattle	1	0	0	0	0	0	0	0	0	1
	dairy	5	0	1	0	0	0	7	0	0	13
	calves	0	0	0	0	0	0	0	0	0	0
	pigs	0	0	0	0	0	0	0	0	0	0
	poultry	0	0	0	0	0	0	0	0	0	0
	horticulture	3	0	1	1	0	0	1	0	0	5
	arable	2	0	0	1	0	0	0	0	0	3
Transport	personsal cars	54	0	14	0	0	0	93	0	0	161
	rail persons	2	0	1	0	0	0	4	0	0	7
	air transport persons	23	0	6	0	0	0	40	0	0	69
	vans	50	0	12	0	0	0	85	0	0	147
	small trucks	49	0	12	0	0	0	83	0	0	144
	truck-trailer	106	0	27	0	0	0	183	0	0	316
	air freight	0	0	0	0	0	0	0	0	0	0
	inland waterways fr	10	0	2	0	0	0	17	0	0	30
Services	buildings	111	0	35	37	0	32	23	12	0	250
Domestic	surface	0	0	34	0	0	77	0	0	0	111
	number of dwellings	29	0	5	10	0	0	6	3	0	53
	TOTAL	584	224	167	79	0	109	804	26	0	1994

Appendix 2: primary energy mix in vision B

Industry			
Agriculture			
Transport			
Services			
Domestic			