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SEEA as a framework for assessing policy responses to climate change

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1. Introduction

Climate change is one of the major global challenges of our time. In the scientific world there is general consensus that economic and social pressures are contributing to climate change. Accelerating emissions of carbon dioxide, methane, and other greenhouse gases since the beginning of the 20th century have increased the average global temperature by about 0.74°C and altered global precipitation patterns (IPCC, 2007). Climate change is already affecting economic activities throughout the world. In the future, the impacts on society, the economy and the environment will only increase. There is thus a high demand for good statistics that can support the measurement and analysis of the drivers, the social and economic consequences of climate change and the related mitigation and adaptation measures (UNEP, 2008).

Several efforts have been undertaken by the statistical community to specify how statistics may be used for climate change related measurement, policy making, and to identify recommendations and actions to streamline the climate change aspect in official statistics (ABS, 2009). In this regard, the system of integrated environmental and economic accounts (SEEA) has been put forward as a framework to integrate relevant statistics on climate change.

This paper is an update and extension of the LG paper with the same name presented in Wiesbaden. The main goal of this study is to assess the policy relevance of SEEA

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with regard to climate change. We will focus on the two general (policy) responses that can be used to address climate change, namely mitigation and adaptation. Mitigation refers to measures that reduce greenhouse gases in an effort to slow down the climate change process. It is a human intervention to reduce the sources or enhance the sinks of greenhouse gases. When it will not be possible to (completely) reverse the ongoing global warming, adaptation will be necessary to reduce the negative impacts of climate change. We will show that SEEA provides a coherent information system that can be used to monitor, understand and analyse the relation between the economy and climate change essential for developing both mitigation and adaptation strategies. This will be done by addressing numerous relevant policy questions and demonstrating how SEEA can deal with these issues.

The many policy applications presented in this study can be used for volume III of SEEA (the application part), where climate change will be one of the central issues (Harris, 2008). All examples presented in this study are from the Dutch environmental and national accounts[1]. In the coming months, other NSO's and international organisations will be invited to improve and add other relevant applications. Subsequently, the editor of SEEA may use this document in the compilation and writing of SEEA volume III.

This study is structured as follows. In paragraph 2, first the general relationship between climate change and the economy is discussed within the context of the DPSIR (Driving forces-Pressure-State-Impact-Response) model. In paragraph 3 the three major policy issues with regard to climate change will be discussed. It will be shown that SEEA as an integrated framework can provide the necessary information to address two of these important policy issues. This will be illustrated in paragraph 4 where several important applications of SEEA with regard to climate change will be presented. The examples will be structured according to the two main policy areas, namely mitigation and adaptation. Paragraph 5 will round up with some conclusions.

2. Climate change and the economy

Climate change and the economy are closely interconnected (Figure 2.1). There is abundant scientific evidence that the emission of greenhouse gases (GHG) caused by economic activities contributes to climate change (e.g. IPCC, 2007). Combustion of fossil fuels, deforestation, but also specific agricultural activities and industrial processes are the main drivers of the increased emission of greenhouse gases. Enhanced concentrations of greenhouse gases in the atmosphere will by radiative forcing increase global temperatures. Likewise has climate change a direct impact on all kind of economic processes. These impacts may be both positive and negative, but it is expected that the overall impact will be primarily negative. Policy makers may respond to the climate change by mitigation and adaptation measures, which in turn directly or indirectly influence economic activities.

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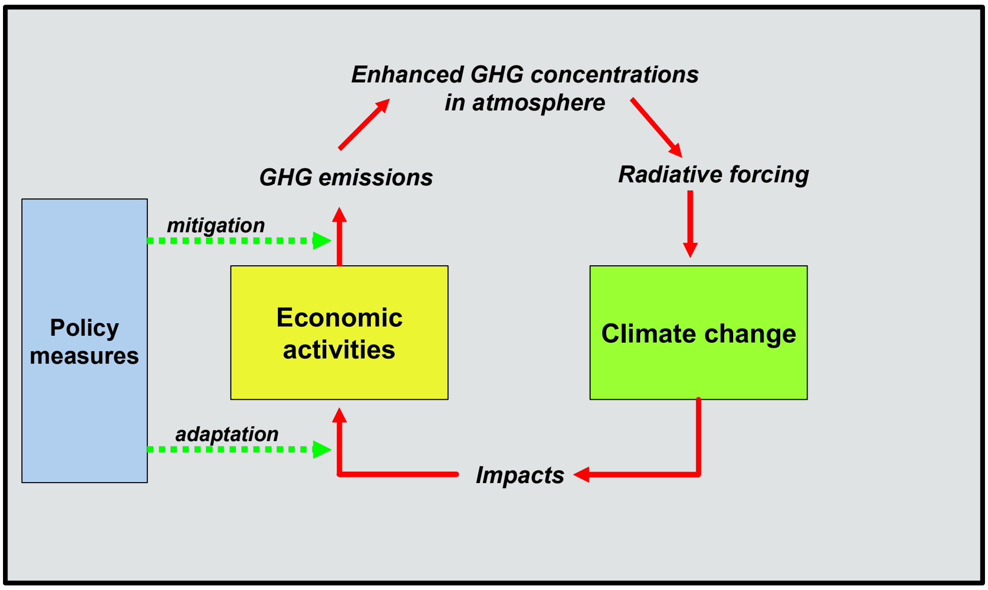
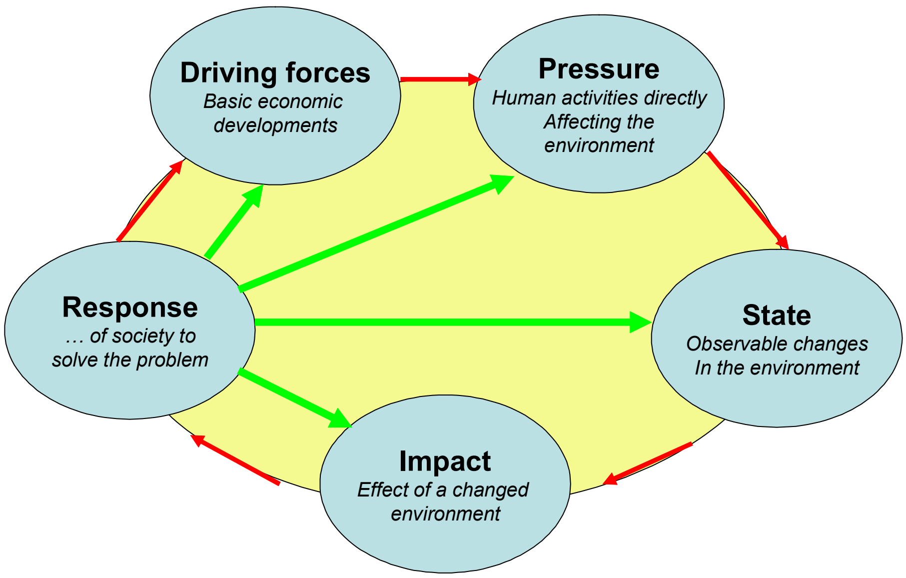
[1] The examples were taken from publications covering several years (CBS, 2008; 2009; 2010). In addition some new preliminary data examples are presented. As the accounts are updated every year, the data from the different examples may not always be consistent with each other.

Figure 2.1: The interrelationships between the economy and climate change



A common way to assess and manage environmental problems is the so-called Driving forces-Pressure-State-Impact-Response framework (DPSIR)[2] (Figure 2.2). Driving forces are the socio-economic forces driving human activities, which increase or mitigate pressures on the environment. Pressures are the stresses that human activities press on the environment. State, or state of the environment, is the condition of the environment. Impacts are the effects of environmental degradation on society, the economy and ecosystems. Responses refer to the responses of society to the environmental situation. This framework is very helpful to organise information on the state for the environment, both for researchers, policy makers and the general public. Specific indicators can be complied for each part of the DPSIR framework. Here, we will describe climate change and its relations with the economy using the DPSIR model.

Figure 2.2: the DPSIR framework



[2] The DPSIR framework is widely applied internationally, among others by the EEA, UNEP and the OECD.

Driving forces of climate change

Basic economic developments are the main drivers behind human induced climate change. Increased production of goods and services, changes in the production structure, increased transportation, a higher demand for all kind of consumer goods, all contribute to a higher pressure on the atmosphere with regard to the greenhouse gas concentration. Particularly important is of course the ever increasing demand for energy. At present the world's economy runs on fossil fuels. The combustion of coal, oil and natural gas and derived products provide energy to nearly all economic activities. The emission of CO_2 is a residual product of burning these fossil fuels. Also changes in land use pattern, deforestation and land clearings are important driving forces leading to a rise in CO_2 emissions.

Pressure: greenhouse gas emissions

The pressures related to climate change are the greenhouse gas emissions caused by economic activities[3]. CO_2 is by far the most important greenhouse gas, and originates mainly from the combustion of fossil fuels and biomass. However, also other greenhouse gases like methane, nitrous oxide and halocarbons contribute to climate change. Methane is mainly produced by domesticated animals such as dairy cows, pigs etc, rice growing, gas flaring and mining activities. Nitrous oxide mainly originates from agricultural land management, animal manure management, combustion of fossil fuels, and the production of fertilizers and nitric acids.

State

The state of the environment with regard to climate change is the condition of the atmosphere and hydrologic system of the earth. This state can be described using the so-called essential climate variables (ECV's) (GCOS, 2009; UNEP, 2008). Within the atmospheric domain these are air temperatures, air pressure, precipitation rates, surface radiation budget, but also the concentration of the different greenhouse gases. In the oceanic domain these are sea surface temperatures, salinity, sea level, sea ice, ocean current etc. In the terrestrial domain these are river discharge, ground water levels, lake water levels, land cover (including vegetation type), glaciers, etc. The essential climate variables directly support the work of UNFCCC and IPCC.

The impact of climate change on the economy

Climate change has the potential to create a wide range of economic impacts. In all likelihood all sectors of the economy will be affected. Some impacts will gradually affect economic processes, such as the effect of increasing temperature on energy demand, whereas others may come as a shock, such as sudden floods or forest fires. Impacts may be either negative or positive. For example, agriculture may become more productive or tourism may flourish in areas experiencing higher temperatures. On a global level, the negative impacts will generally outweigh the economic benefits. Beside industry specific impacts, the economy as a whole may be at risk in certain areas due to an increase in sea level and an increase in runoff by rivers. Coastal zones usually contain large human populations and a high concentration of economic activities. Flooding and extreme storm events may seriously disrupt economic activities and cause loss of produced capital.

[3] This includes emissions from households, as these are the result of final consumption.

Responses to climate change

There are different (policy) responses to address climate change. Policy may focus on either the drivers, pressures, state or the impacts (see Figure 2.2). Policy measures will thus also influence the economic system. They may lead to extra costs for companies and households which may reduce economic growth. On the other hand, innovation in new technologies and new investments in infrastructure and knowledge may create new opportunities for economic development. In the next section, the policy responses with regard to climate change will be discussed in more detail.

3. Climate change policies and SEEA

Climate change is high on the political agenda at all levels. More and more, policy makers are taking climate change issues into account and are integrating them into their national and international policies. Basically, policy makers are facing three major questions, namely a) to what extent is human induced climate change actually taking place, b) how can we most efficiently reduce our greenhouse gas emissions, and c) what actions need to be taken to minimize the impacts of climate change. Below, we will discuss if and how SEEA can contribute to deal with these important issues.

1) To what extent is human induced climate change actually taking place ?

Although there is abundant scientific evidence that human induced climate change is taking place, this is still questioned by a considerate number of people. Also, it is not clear how fast climate change will take place and what particular regions will be affected most. Policy makers thus need good solid information to what extent human induced climate change is actually taking place. They need this information not only to justify the policies they develop in this area and the financial resources they need for this, but also for efficient policy making.

It is important to stress that SEEA can not be used to address this important issue. Although SEEA accounts for the contribution of GHG emissions by economic activities, it cannot be used to resolve the question how much the increased atmospheric GHG concentrations contribute to radiative forcing and actual climate change. As described in the previous section, other statistics are needed here, such as the essential climate variables (ECV's), to describe the state of the environment with regard to climate change. With this kind of information, scientific researchers may provide answers to this complicated issue.

2) What actions are needed to reduce the emissions of greenhouse gases ?

Mitigation refers to measures that reduce greenhouse gas emissions in an effort to slow down the climate change process. It is thus aimed at influencing the divers (i.e. economic activities) and reducing the pressure (i.e. emissions of greenhouse gases). The effects of climate change can be abated by reducing the emissions of greenhouse gases, either by reducing the level of emissions-related economic activities or by shifting to more energy-efficient technologies that would allow the same level of economic activity at a lower level of emissions. Furthermore, carbon sinks can be enhanced, for example, by preserving forested areas and expanding reforestation. Policy instruments with regard to mitigation include among others carbon taxes, or taxes on the use of fossil energy, subsidies for energy saving or renewable energy production, tradable emission permits or the introduction of relations and efficiency standards.

SEEA provides all the tools needed for developing and monitoring mitigation policies. The pressure with regard to the GHG emissions related to economic activities are fully described by the air emission accounts. The (economic) driving forces are described by the national accounts, complemented by information from the energy accounts, agricultural accounts and land cover accounts. In addition SEEA provides detailed information on important policy instruments, such as environmental taxes, environmental subsidies and emission permits. Finally, environmental protection expenditure data and information from the environmental goods and service sector allow all kinds of cost benefit analyses with respect to mitigation policies.

3) What actions are needed to deal with the consequences of global warming and minimize the impacts ?

Adaptation is adjustment in natural and human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation measures primarily aim to reduce the negative impacts of climate change. Examples of policy measures with regard to adaptation include the construction of dikes and seawalls to protect against floods and hurricanes, subsidies to promote a shift in agriculture and the promotion of climate-proof building techniques.

The SNA provides a coherent data framework that can be used to analyse the impacts of climate change on the economy. SEEA is particularly useful to record changes in natural resources that may be affected by climate change. Furthermore, specific satellite accounts for tourism, agriculture and health can be helpful to determine the economic effects for these sectors, which will be particularly vulnerable with regard to climate change. In addition, SEEA may also provide detailed information on important policy instruments for adaptation and the costs en benefits of adaptation policies.

4. Policy uses of SEEA with regard to climate change issues

This section attempts to give examples of various applications and policy uses of SEEA with regard to climate change. This is done by addressing some specific policy questions with regard to climate change mitigation and adaptation. It is shown how data provided by SEEA can answer these questions, when possible by providing some relevant examples. It should be noted that the list of relevant policy questions is by no means exhaustive, as numerous other relevant issues can be addressed using SEEA. However, the examples presented here provide a good overview of the possibilities of SEEA with regard to assessing the policy responses to climate change.

Broadly speaking there are two sorts of applications that will be described here. The first of these concerns the development of sets of indicators and descriptive statistics. The second shows how specific policy analyses can be based on the results from SEEA. Policy analysis usually requires more specialised expertise in the techniques of economic analysis and modelling. Both kind of applications will be covered in the applications of SEEA presented in this section.

Most applications of SEEA presented here deal with mitigation rather than adaptation issues. This is because at present policy still usually focuses at reducing GHG emissions. The impacts of climate change on the economy are still relative minor (or difficult to discern) and the development of adaptation policies is still a rather new policy area. However it is expected that when in the coming years and decades de effects of climate change become more apparent, adaptation policies will become more important.

Two important policy issues are not specifically discussed below. First, bench mark studies by doing country comparisons can be made for most of the applications presented here and will, therefore, not be discussed separately. Secondly, some of the policy questions addressed below may also be of interest on a regional level. When the accounts from SEEA are compiled on a regional level, these kind of applications are also feasible.

4.1 Mitigation

In this section four important issues with regard to developing mitigation policies will be addressed. First, the monitoring and understanding the driving forces of climate change, next energy saving and renewable energy production, subsequently the important policy instruments for mitigation, and finally the costs and benefits of mitigation policies.

4.1.1 Understanding the driving forces of climate change

In order to design effective mitigation policies, one must have a good conception of the economic driving forces of climate change. The *air emission accounts* can be used to analyse the environmental implications, in term of greenhouse gas emissions, of production and consumption patterns (Eurostat, 2009). Because of their compatibility with the national accounts greenhouse gas data can be directly linked to the economic drivers of global warming.

There are two main ways of accounting for environmental pressure: the producer and consumer approach. The first considers all direct greenhouse gas emissions arising from national production and distinguishes and compares the environmental performances of different industries. National policies and targets, as well as worldwide reduction of GHG emissions are usually based on the production approach. Second, the consumer approach considers the direct and indirect air emissions arising along the international production chains of all products consumed nationally, and compares the air emissions caused by the final use of different product groups. The consumption perspective is particularly important given that trade is growing much faster than both world population and GDP. Below it will be shown that SEEA can contribute to both the producer and consumer approach.

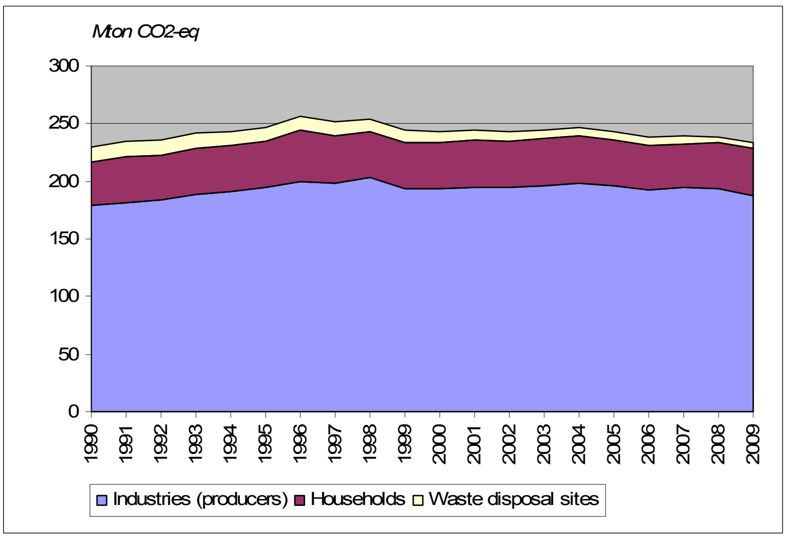
A. Greenhouse gas emissions by industries and households (producer approach)

The production approach can be investigated directly using the air emission accounts (Eurostat, 2009). These accounts provide information how much economic activities contribute to climate change and where in the national economy these emissions occur. Accordingly the 'hotspots' in the production patterns may be identified. In addition, due to the compatibility with the national accounts framework, the GHG emissions can be directly linked to the output of the economic activities allowing the comparison of different industries environmental performance by looking at decoupling or the calculation of emission intensities (eco-efficiency). Besides producers, also households directly contribute to greenhouse gas emissions. These issues are illustrated below by addressing several relevant policy questions.

1. How much do economic activities directly contribute to GHG emissions ?

SEEA, or more in particular the air emissions accounts, provide the total GHG emissions by economic activities. These include all emissions caused by the residents of a country, regardless where the emissions take place. The total emissions by the economy is an important indicator as this figure can be directly compared with all kind of macro economic parameters from the national accounts, such as GDP, total labour force etc. In figure 4.1 the total GHG emissions are shown for the Netherlands for the period 1990-2009. In 2009 the Dutch economy was responsible for a total emission of 234 Mton CO_2-eq. Since 1990 these emissions have increased with 2 percent. Also shown here are the main economic activities contributing to the total emissions, namely producers (industries), households and waste disposal sites.

Figure 4.1: Total greenhouse gas emissions by economic activities



2. How do the emissions by the economy relate to Kyoto based emissions ?

The GHG emissions by the economy, as provided by SEEA, differ from the total emissions on a national territory (actual emissions) or the emissions calculated according to the accounting rules of the IPCC. This is because different concepts and calculation methods underlie the different emission data. Bridge tables provide insight in the relations between the different emission concepts. Table 4.2 shows the bridge table for the Netherlands.

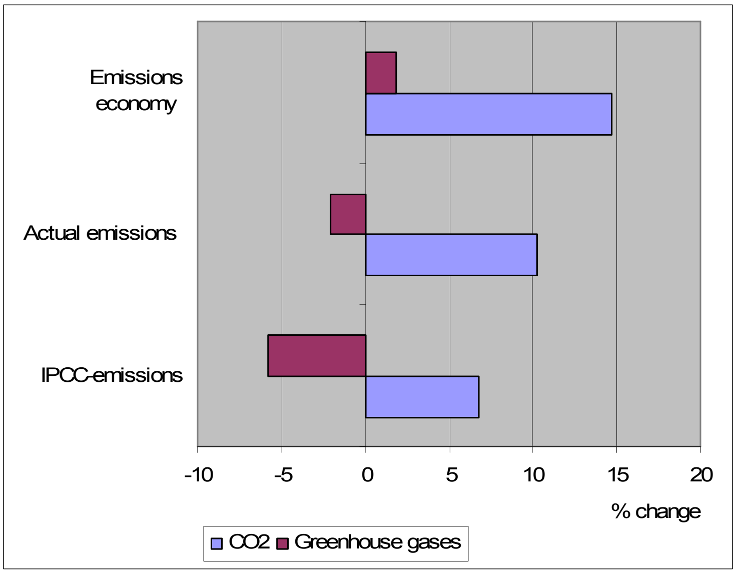
Table 4.2: Bridge table for greenhouse gas emissions in the Netherlands

	1990	1 995	2 000	2 005	2 007	2 008	2009*
	Mton CO_2-equivalents						
1. Stationary sources[1)]	187	197	185	183	177	178	174
2. Mobile sources	34	36	40	42	42	43	42
3. Mobile sources according to IPCC	31	34	37	39	39	40	38
4. Short cyclic CO_2	6	6	8	10	9	11	11
5. Total, IPCC (excl. LULUCF) = 1 + 3 - 4	**212**	**225**	**215**	**212**	**207**	**207**	**201**
6. Land Use, Land-Use Change and Forestry (LULUCF)	3	3	3	3	3	3	3
7. Total, IPCC (incl. LULUCF) = 5 + 6 (Kyoto-protocol)	**215**	**228**	**218**	**215**	**210**	**210**	**204**
8. Actual emissions in the Netherlands = 1 + 2	**221**	**233**	**225**	**225**	**219**	**220**	**216**
9. Residents abroad	14	20	25	25	26	25	24
10. Non-residents in the Netherlands	5	5	6	7	6	7	6
11. Total emissions by residents = 8 + 9 - 10	**230**	**247**	**244**	**243**	**239**	**239**	**234**

1) Stationairy sources are inclusive short-cyclic CO2

Besides explaining the differences between these different emission concepts, bridge tables also make apparent to policy makers the differences in emission development when these different concepts are applied. For instance, the emission of greenhouse gases in the Netherlands according to the IPCC definition fell by almost 6 percent between 1990 and 2009 (Figure 4.3). This puts the Netherlands on course to realise its Kyoto targets. However, the emission of greenhouse gases generated by the Dutch economy rose by 2 percent in the same period. This is because emissions by international transport is only partly included in the Kyoto figures. Precisely in this period, international transport grew rapidly in the Netherlands, pushing up greenhouse gas emissions.

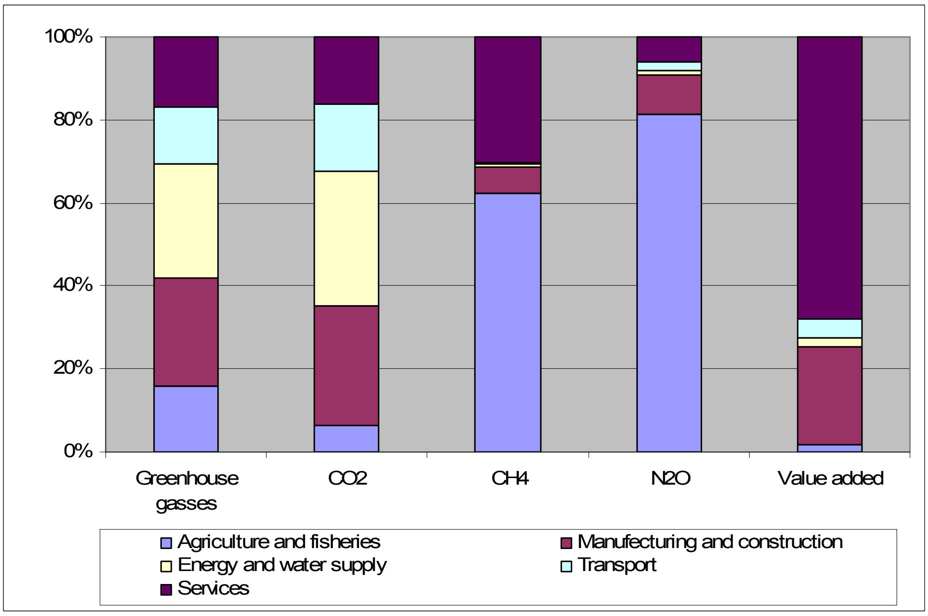
Figure 4.3: Change in CO_2 and GHG emissions between 1990 and 2009 according to different definitions.



3. How much do single industries contribute to GHG emissions ?

In SEEA the air emissions are broken down by the direct emitters, i.e. industries, households and other sources, according to the same classifications as the national accounts. This allows insight how much individual industries contribute to global warming. Accordingly, the most important emitters can be identified. Figure 4.4 shows the industries percentage share in the total GHG emissions for the Netherlands. The most important emitters of greenhouse gases are the energy companies, manufacturing and the transport sector. On a more detailed level it can be shown that particularly the chemical industry, refineries, cattle breeding and the air transport sector are important emitters. This kind of information cannot be obtained from emission inventories.

Figure 4.4: Contribution of industries to GHG emissions and value added, 2009



As the GHG emissions directly relate to the production system of a given country, the emission percentages can also be compared to economic variables, such as value added or the number of employees. Figure 4.4 shows for example that services contribute 68 percent to the total value added but contribute only 16 percent of the greenhouse gas emissions.

4. How much does international transport contribute to GHG emissions ?

International transport activities are an important source of CO_2 emissions. As international trade is expanding, this emission source is becoming more important. Emissions from international transport are excluded from national targets according to the Kyoto protocol. Emissions originating from fuel bunkering are only recorded as an 'pro memoria item' in the UNFCCC reports. An important feature of SEEA is that emissions from international transport are accounted for and allocated to the country and industry that is responsible for these emissions.

Figure 4.5: Development of CO_2 emissions for different means of transport.

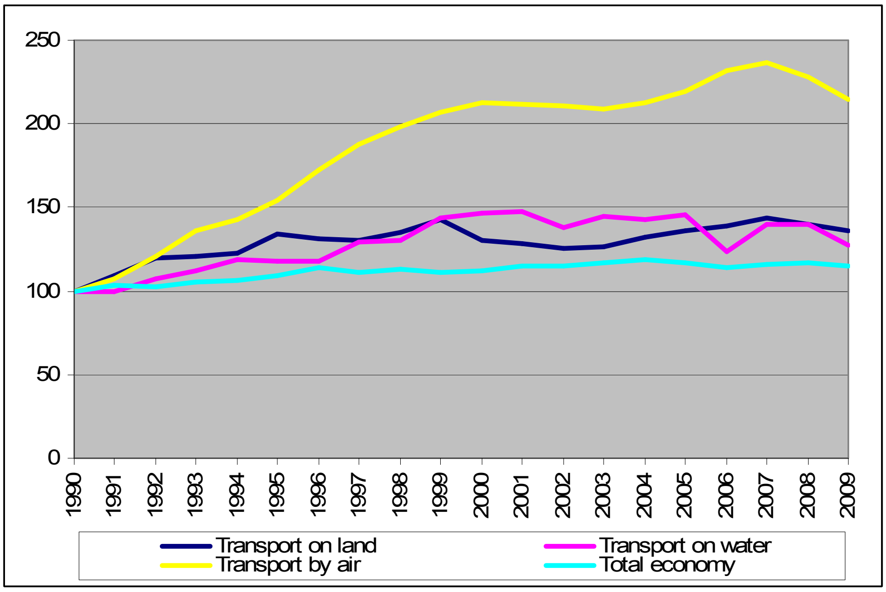


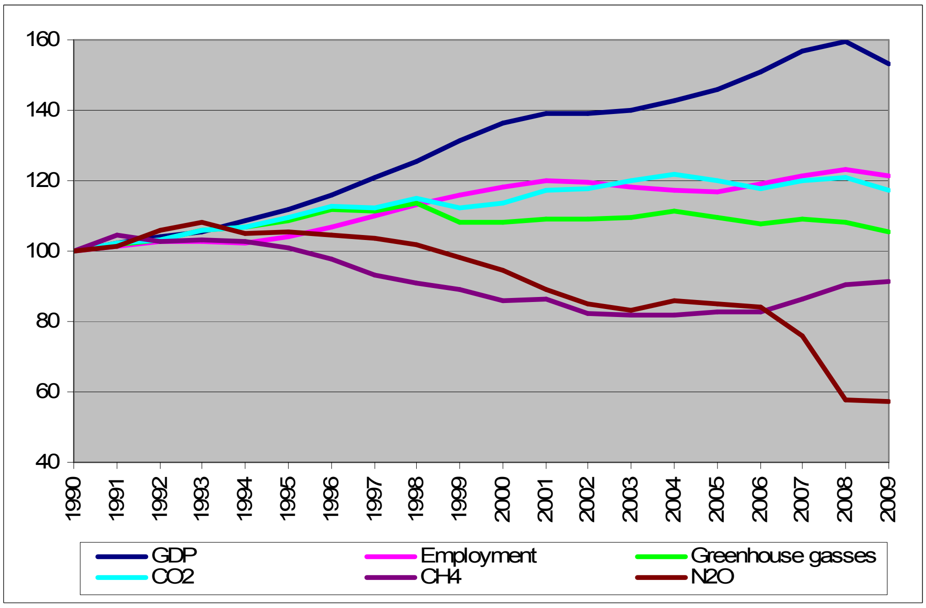
Figure 4.5 shows the emissions caused by different means of transport (in the Netherlands and abroad). Transport activities, and their related CO_2 emissions, often take place beyond the Dutch border. Globalisation has caused the emissions of the Dutch transport industry to increase much more rapidly than the emissions of residents (total economy). Emissions from air transport have more than doubled in this period. This can be explained by the increase in international transportation activities in the last nineteen years.

5. Are the production induced GHG emissions decoupling with respect to economic growth ?

Decoupling of environmental pressures is an important policy issue. Decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force (e.g. GDP) over a given period. Decoupling can be either absolute or relative. Absolute decoupling is said to occur when the environmentally relevant variable is stable or decreasing while the economic driving force is growing. Decoupling is said to be relative when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable. To correctly interpret decoupling some addition information is needed, for example from a structural decomposition analyses (see policy question 7 below), which explains the causes of the change in emissions over time.

A typical visual presentation of decoupling is to show indexed time series of an economic variable in comparison to one or more environmental pressure variables. In figure 4.6 the relationship between economic growth and GHG emissions is shown for the Netherlands. The graph indicates that relative decoupling took place in the Netherlands in the 1990-2009 period: i.e., the growth rate of GHG from production processes was lower than the GDP growth rate. Absolute decoupling only took place for methane and N_2O emissions. Decoupling graphs can also be shown for individual industries.

Figure 4.6 Development of Greenhouse gas emissions and GDP in the Netherlands (1990=100)



6. Which industries are most emission intensive and how does this change over time?

Eco efficiency is a prominent concept in environmental policies. Air emission accounts in combination with economic parameters (production output or value added) can be used to calculate GHG intensities. The emission intensity is thus an indicator relative to its monetary value added. Emission intensities can be used to compare industries within one economy to identify the most eco-efficient ones, to compare across countries to identify the best performers or to monitor development over time to assess improvements in eco efficiency (Eurostat, 2009).

Figure 4.7: Industries with the highest greenhouse gas intensities

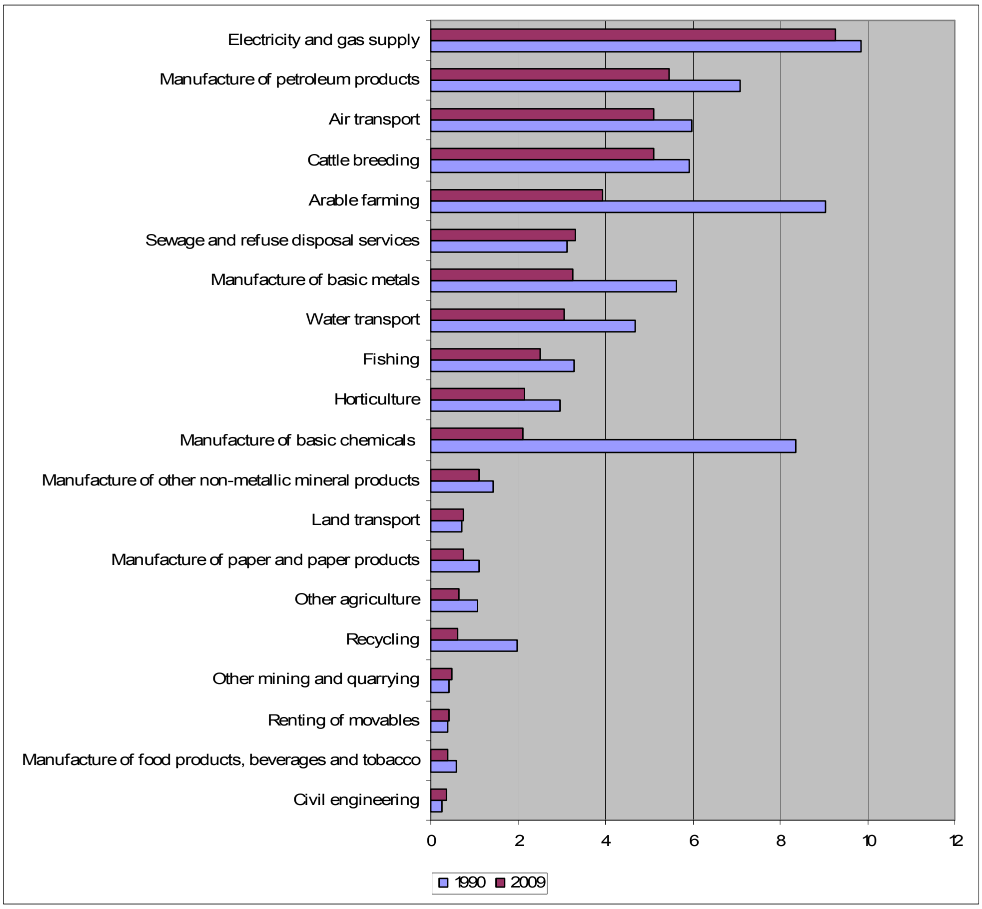
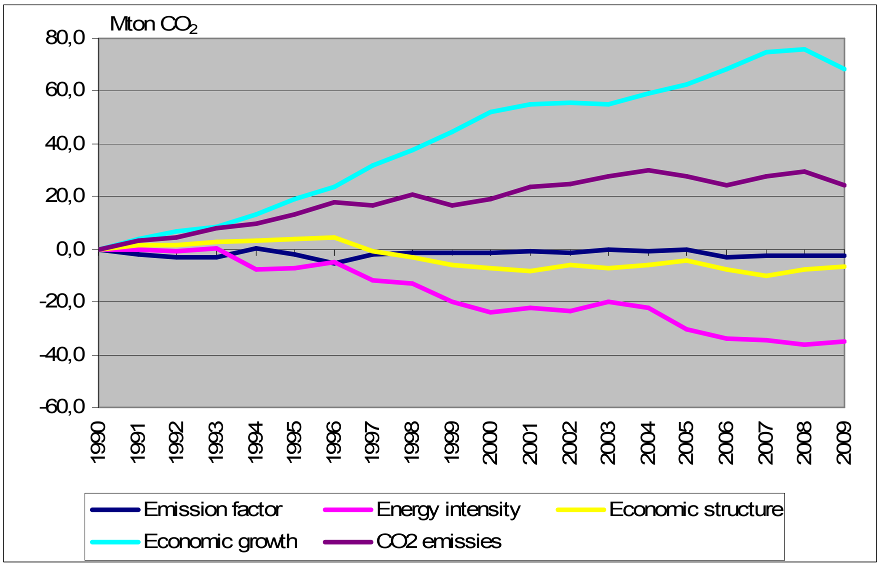


Figure 4.7 shows the twelve industries with the highest GHG emission intensities for the Netherlands (here defined as GHG emissions per unit value added). Electricity supply, refineries and cattle breeding have the highest GHG intensity. Services (not shown) generally generate the least GHG emissions per unit value added. Between 1990 and 2009 arable farming and the manufacture of basic chemicals have significantly improved their eco efficiency. For the economy as a whole, the GHG intensity decreased with 34 percent between 1990 and 2009.

7. How can the change in GHG emissions over time be explained ?

A change in the level of GHG emissions by economic activities over time can have different causes. First of all, an overall increase in economic growth could have induced more GHG emissions. A change in the energy mix (the energy products used in the production process) will also influence the level of emissions. In addition, the economic structure could have changed, for example due to a change in the input output relations of the intermediate use or a change in composition of the final demand for products and services. Finally, eco efficiency improvements of the production process can decrease the GHG emissions. Structural decomposition analysis enables detailed accounting for changes in emissions. Factors relating to the mix of fossil fuels, the share of fossil fuels in total energy consumption, the energy required to produce a unit of GDP, GDP per capita, and population can be brought together in a framework that allows the contribution of changes in each factor to be related to changes in total emissions. Decomposition analysis can also be done for individual industries.

Figure 4.8: Structural decomposition analysis of CO_2 emissions

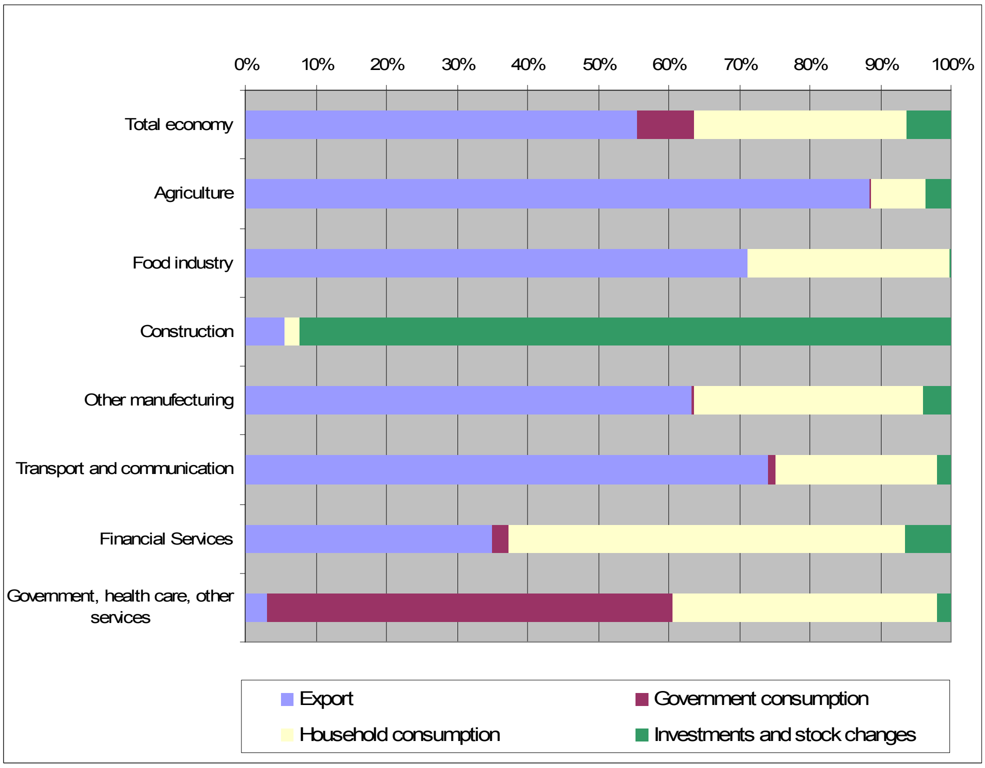


In figure 4.8 the development of the CO_2-emissions has been decomposed into an emission intensity effect (the effect of the improvement of the emissions per unit energy), energy intensity effect (the effect of the improvement of the energy per unit output), a structural effect (the effect of shifts in the structure of the economy) and the final demand effect (the effect of economic growth). As the figure shows, the effects of economic growth are the largest driving forces of emissions which are only partially negated by an increase in the efficiency (emission intensity and energy intensity effect). The figure basically shows that emissions would have been about 56% higher, if there had been no changes in efficiency and structure. Particularly the improvement of the energy intensity (energy saving) has reduced the increase in CO_2 emissions.

8. What are the economic drivers behind the change in GHG emissions ?

The ultimate driver of economic production is the demand for goods and services by households, governments, exports or investments. Using input-output kind of analyses, the GHG emissions caused by the production can be attributed to these different final demand categories. Accordingly, the question is answered for who, or for what purpose, do economic activities emit GHG's.

Figure 4.9: Allocation of CO_2 emissions by domestic production to final demand categories, 2007

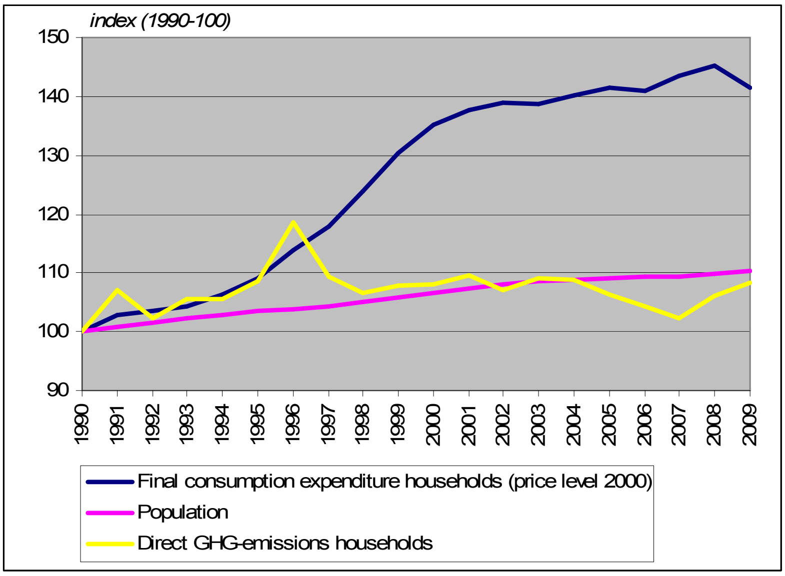


In figure 4.9 the CO_2 emissions by Dutch economic activities have been allocated to the final demand categories. More than half of the total CO_2-emissions caused by the Dutch economy is related to exports. One third of the emissions can be attributed to final consumption of households, and respectively 8 and 6 percent to final consumption of government and investments. CO_2-emissions caused by Dutch agriculture and transport are mainly related to export activities. Financial services emit CO_2 mainly for the benefit of household consumption.

9. How much do households directly contribute to GHG emissions ?

Households directly contribute to the emission of GHGs by consuming energy products for their heating their houses, cooking and generating warm water, and by using motor fuels for driving cars. The air emission accounts provide information on the level of these emissions and provide the opportunity to compare these with monetary information from the national accounts.

Figure 4.10: Change in direct GHG emissions by households, population and consumer expenditure

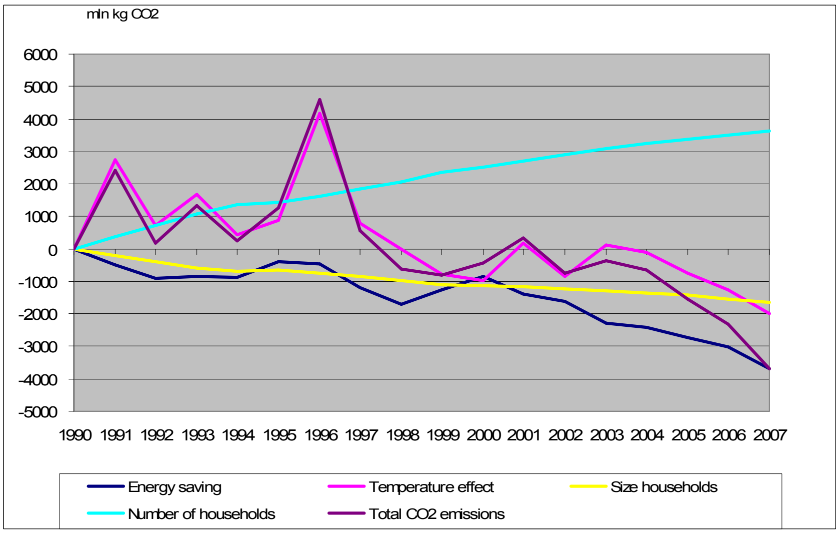


In the Netherlands households were responsible for 40,5 Mton of GHG emissions in 2009, which is 17 percent of the total emissions by economic activities. The development of these emissions can directly be compared with population growth or consumer expenditures (Figure 4.10). It turns out that population and final consumption by households are growing faster than the emissions .

10. How can the change in direct GHG emissions by households be explained?

The causes for the change in emission levels by households can be further analysed by decomposition analysis. For example, the emissions from stationary sources (emissions generated in and around the house) can be decomposed into several factors, including the number of households, the average size of households, the effect of the average temperature and an energy saving effect.

Figure 4.11: Decomposition analysis for CO_2 emission by households (stationary sources).

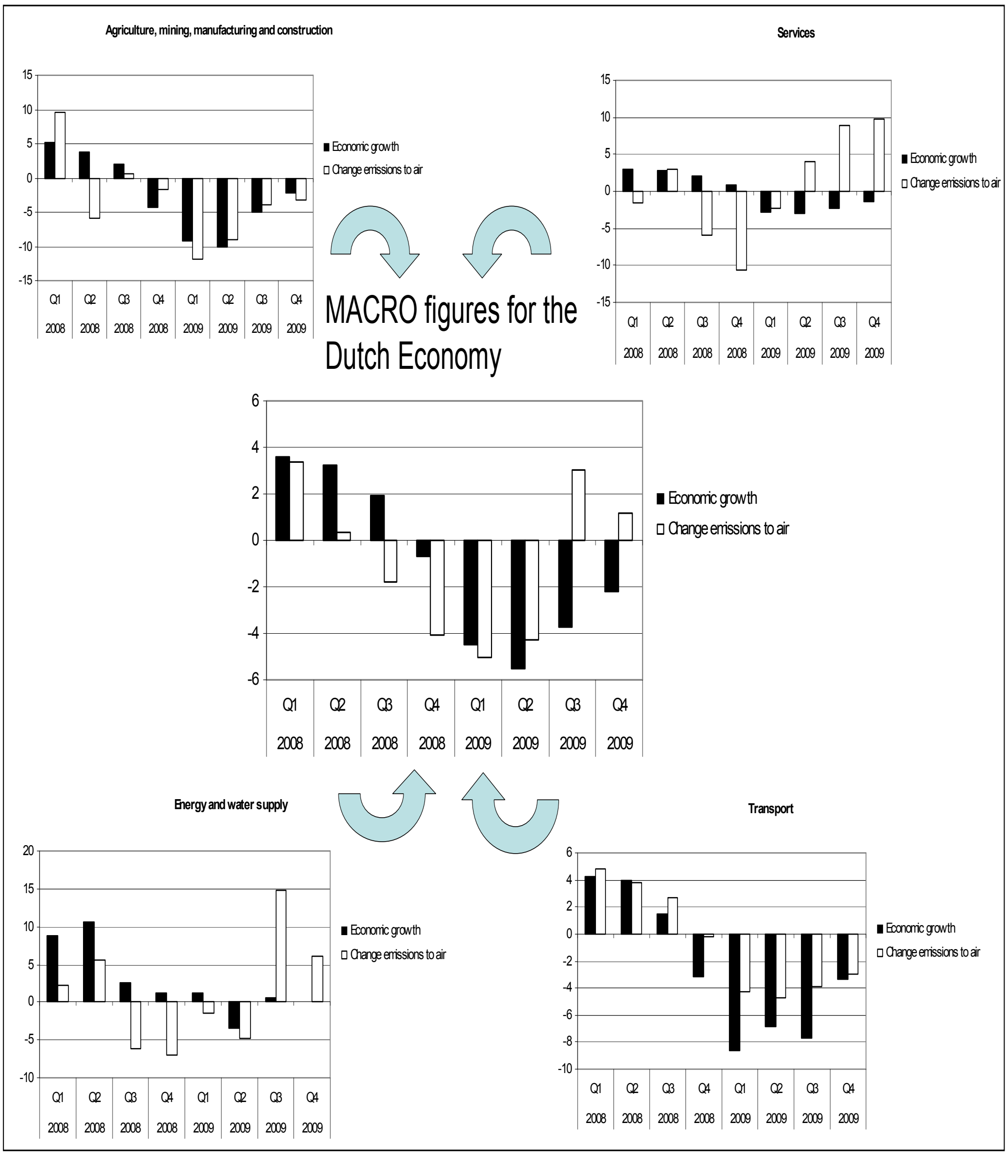


A decomposition analysis for the Netherlands shows that the gradual increase of the number of households would have caused an increase of the level of CO_2 emissions of 3,8 Mton (Figure 4.11). All other factors had an decreasing effect on the emissions. The weather conditions (average temperature in the winter months) has a dominant effect on the development of the emissions. Most interesting for policy makers is probably the effect the energy saving that can be deduced form this analysis. According to the results this was responsible for reducing the emissions with 3.5 Mton for the period between 1990 en 2007. A similar decomposition analysis can also be done for mobile sources (cars), decomposing the level of emissions into several factors, including population growth, car ownership (number of cars per person), traffic intensity (number of kilometres driven per car) and a CO_2 efficiency effect (emissions per kilometre).

11. What can short term changes in CO_2 emissions in relation to changes in GDP tell?

Air emission data can also be compiled on a quarterly basis. Quarterly based CO_2 emission data may help to timely detect breaking points in currently estimated trends for emitted greenhouse gases. As the data are compatible with national accounts, CO_2 emissions directly can be linked to economic output allowing the comparison of different industries' environmental performance. This information would support national policy and if necessary policymakers could respond more timely to detected changes.

Figure 4.12: development in CO_2 emissions and economic growth during the last financial crisis[4].



As an example, an analysis of the development of the CO_2 emissions during the last financial crisis is presented her (Figure 4.12). Comparing the economic growth data with the changes in CO_2 emissions reveals that the decrease in emissions started earlier (third quarter of 2008) than economic growth (fourth quarter of 2009). In addition, emissions of the total economy started to increase already in the second half of 2009, where economic growth is still negative. Detailed information from the different industrial sectors helps to explain the observed changes.

B) Carbon footprint (GHG emissions from a consumption perspective)

Instead of allocating the burden of reducing emissions to the producer of emissions (the polluter pays principle), this burden can also be allocated to consumers (consumer should pay principle). The underlying idea is that consumers initiate production processes with their consumption. The consumer approach for GHG emissions is nowadays better known as the carbon footprint concept.

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[4] Preliminary results. This study is financed by a grant from Eurostat.

The concept of a carbon footprint[5] has captured the interest of businesses, consumers and policy makers alike. It can be defined as the direct and indirect greenhouse gas emissions required to satisfy a given consumption. In recent years a lot of research has been carried out to calculate carbon footprints for different applications (see for example EXIOPOL and WIOD projects, several national initiatives and numerous scientific papers).

The environmental accounts are particularly suitable to investigate the consumer perspective and calculate carbon footprints. By applying environmentally extended input-output analyses, which combines data from the air emissions accounts with symmetric input-output tables from the SNA, emissions embodied in global trade can be calculated.

There are many application of carbon footprints (see also Minx et al, 2009). Here we will discuss only a few. Other interesting applications include the compilation of the carbon footprint of industries or households, a decomposition analyses of the national footprint (i.e. determining the drivers behind a change in the footprint), and de analysis of regional and local carbon footprints.

12. What is the national carbon footprint (total, per capita) ?

An important environmental application is the calculation of the carbon footprint of nations. The national carbon footprint it can be expressed as the total greenhouse gas emissions needed to satisfy the total consumption of an economy. In the international climate policy context, carbon footprints have been discussed in the wider field of responsibility of climate change and the implications of target setting (Minx et al. 2009). Closely related is the question whether a country's production or consumption should be the basis for this responsibility assessment.

The national footprint can be deduced from the environmental balance of trade. The environmental balance of trade is defined as the pollution imported via the export of goods and services minus the pollution exported via the import of goods and services. The emissions that can be attributed to domestic consumption (national carbon footprint) are subsequently given by deducting the environmental trade balance from the emissions by residents.

Table 4.13: Environmental balance of trade for GHG emissions and national carbon footprint, 2009.

	Total	CO_2	CH_4	N_2O
	Mton CO_2-equivalents			
1. Emissions attributed to imports	99	70	20	10
2. Emissions attributed to exports	103	86	9	8
3. Emission balance of trade = 2-1	**3**	**16**	**- 11**	**- 2**
4. Emissions by residents	232	203	17	12
5. Global emissions from Dutch consumption needs (national carbon foorprint) = 4-3	**228**	**187**	**28**	**14**

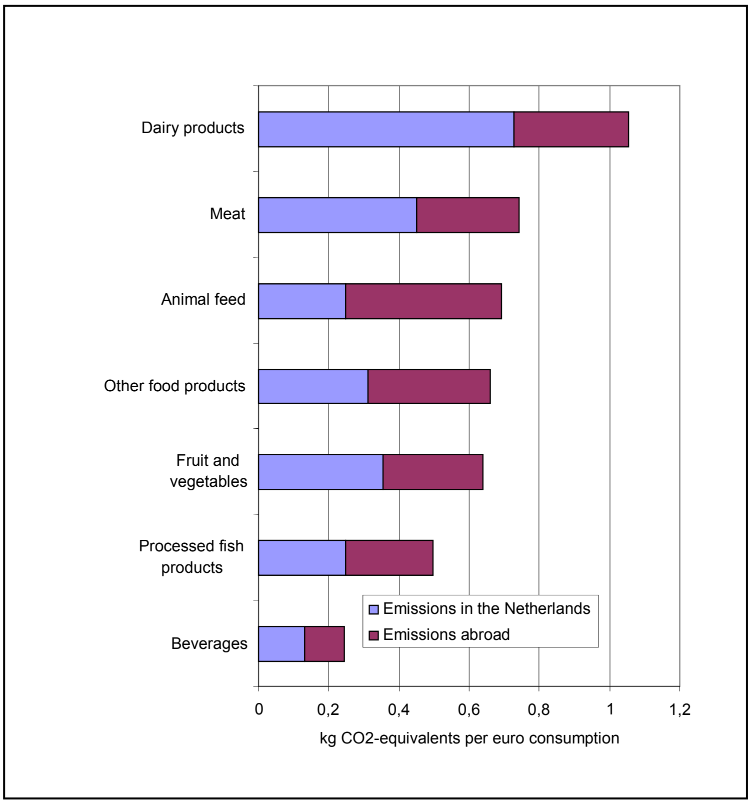
[5] The term carbon footprint is a bit of a misnomer: it refers to the mass of accumulated CO_2 emissions through a supply chain, not some sort of measure of area.

Table 4.13 shows the GHG's emitted to produce imports to the Netherlands and the GHG's emitted in the Netherlands to produce exports. The difference is presented as the environmental balance of trade. Adding the net emissions by residents provides the environmental consumption or the National carbon footprint. The GHG emissions per unit output of an industry are based on the production technologies applied in different regions of the world[6]. The preliminary GHG balance of trade for the Netherlands with the rest of the world was slightly positive in 2009. A positive balance indicates that greenhouse gases emitted domestically during the production of export products are higher than the greenhouse gases emitted abroad during the production of goods and services imported by the Netherlands. As a result of this positive balance, the carbon footprint, i.e. the global emissions as a result of Dutch consumption needs, was equal to 228 Mton GHG emissions, or circa 13800 kg CO_2-eq. per capita, which is slightly less than the emission by Dutch residents.

13. What are the production wide emission intensities of product groups ?

Similar to the production perspective, emission intensities can be calculated for the consumer perspective by dividing all emissions arising along the production chain by the value of the respective products (Eurostat, 2009). Policy makers may compare the production wide GHG emissions across products. A shift of consumption patterns towards those services and products with low GHG intensities bears an opportunity to reduce overall consumption related GHG emissions whilst total monetary expenditure for final use remains constant or even increases. This information is also interesting for consumers who want to assess the impact of their consumption behaviour.

Figure 4.14: GHG intensity for some food products, 2006



[6] For more details on the methodology see Edens et al., 2010

As an example figure 4.14 shows the GHG intensity for some food products. Also shown is the part of the emissions originating within the Netherlands and the part originating abroad. Dairy products are the most emission intensive, followed by meat and animal feed.

14. Are emission intensive activities being transferred abroad (carbon leakage) ?

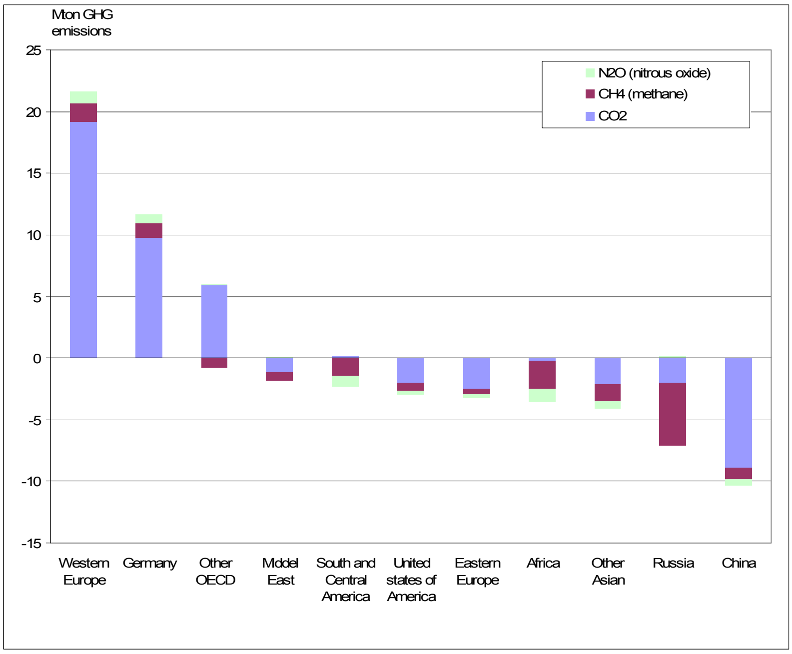
Environmental pressures can be 'exported' by reallocating CO_2-intensive industries abroad. Industries that produce CO_2-intensive products may go abroad because of more lenient environmental regulations. These products are then simply imported. This mechanism will lead to decreases in the national CO_2 figures because the CO_2 emitted in production processes abroad to produce our imports are not taken into account. This process is sometimes referred to as "carbon leakage" or the "pollution haven hypothesis" (PHH). The hypothesis is basically that developed countries specialize in clean production and start to import the 'dirty' products from developing countries.

Using the results of the environmental trade balance, carbon leakage can be investigated by looking at the global environmental pressures that occurs as a result our final consumption requirements. When a shift takes place in the share of emissions embedded in imports relative to the share of emissions from domestic production for final consumption, it can be concluded that the specific activity has relatively been reallocated abroad.

15. What countries are polluting for the national consumption ?

The emission trade balance can also be calculated for the different trading partners of a country. These trade balances show which countries are polluting for the domestic consumption (negative balance) or for what countries domestic production is polluting (positive balance). For the Netherlands the trade balance with different countries and regions is shown in figure 4.15.

Figure 4.15: Emission trade balance broken down into individual GHG, 2009

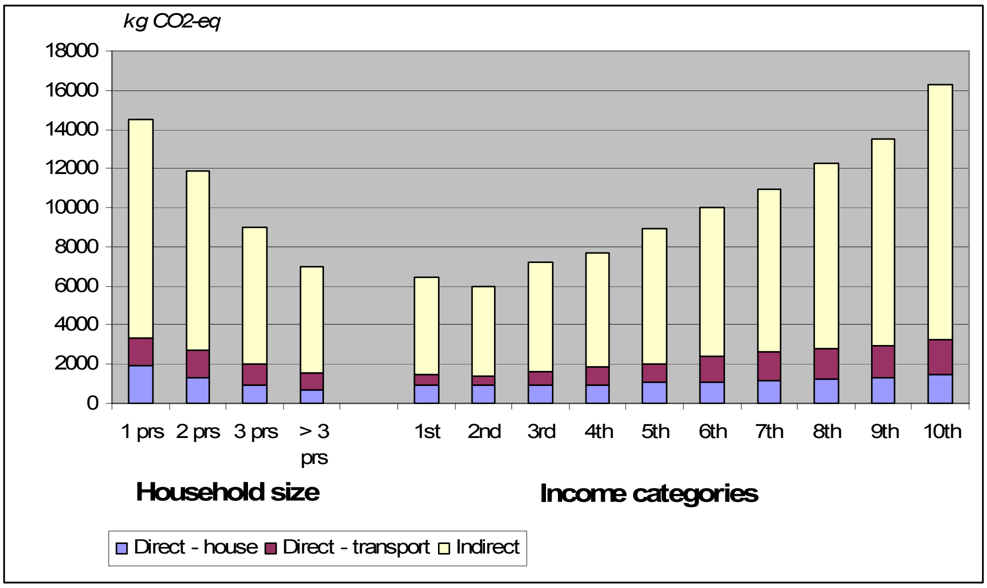


Especially non-OECD regions such as China, Russia, other Asia, and Africa show a negative trade balance. The individual balances can be broken down into three effects: an intensity effect that measures differences in emission intensity, a volume effect that measures the difference in value between imports and exports, and a composition effect that measures differences in the composition of imports and exports.[7] The negative trade balance with China is primarily caused by the intensity effect: the balance would have been significantly reduced if China had used Dutch production technology with the corresponding lower emissions coefficients. The trade balance is also driven to a large extent by the volume effect which shows that the Netherlands is a net importer from China. The positive balance with Germany is primarily the result of the volume effect which expresses that the Netherlands is a large exporter to Germany. The composition effect also plays a major role, which reflects that Dutch exports consist of emission-intensive products such as chemicals and horticulture products, whereas imports from Germany consist on average of less emission intensive products.

16. How do the GHG emissions vary between different household types?

Household consumption is an important driver of GHG emissions. Beside direct emissions (see policy question 9), households contribute to global warming by consuming products and services for which GHG emissions have been emitted during their production process. The direct and indirect emissions from household consumption can be further investigated by looking at different household characteristics. This can be done by using information from SEEA in combination with data from the SNA and budget surveys. Accordingly, several different household characteristics can be analyzed, such as the size of households, gender and age composition, income, regional aspects etc. This kind of information may help policy makers and researchers to better understand present but also future developments in GHG emissions and to develop measures that may influence consumption patterns to reduce GHG emissions.

Figure 4.16: GHG emissions per capita for different household sizes and income categories, 2007.



[7] The cross-section into a composition and volume effect is slightly distorted due to model used (Edens et al.2010).

Figure 4.16 shows as an example the GHG emission per capita for different household sizes and income categories (income deciles). GHG emissions per capita decreases with household size. With respect to rising income we see a clear increase in emissions per capita. Higher expenditure causes higher direct and indirect GHG emissions. In relative terms, the direct emissions decrease with increasing household size and income.

4.1.2 Energy consumption and renewable energy production

Combustion of fossil energy is by far the most important source of greenhouse gases. Mitigation policies thus often focus on energy production and consumption. Important mechanisms to reduce GHG emissions are increasing the energy efficiency of production processes, changing the energy mix in order to emit less CO_2, increasing the production of renewable energy and promoting energy savings by households. The energy accounts can be used to analyse the energy consumption and production of both fossil and renewable energy sources. Below some examples are discussed how SEEA can contribute to these policy issues.

17. What is the energy saving rate of the economy and individual sectors ?

Improving the energy efficiency is a major policy issue. Energy saving is a focal point of energy and environment policies because it can make a very significant contribution to improving both environmental sustainability (climate change) and competitiveness (energy security, energy supply, energy prices). National governments often have set several energy savings targets, both for a country as a whole as for individual sectors. It is thus very important to monitor energy saving rates. A decomposition analyses on the energy use data from the energy accounts provides a relatively easy method to calculate these saving rates in a consistent way, both for the economy as a whole as for individual industries.

Figure 4.17: Energy saving rate for the Dutch economy, calculated from using decomposition analysis

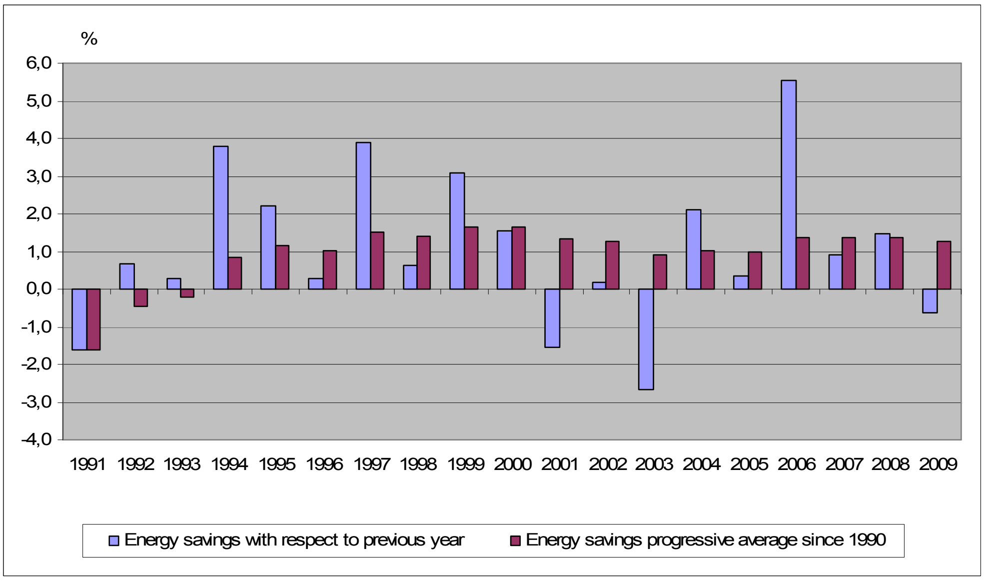


Figure 4.17 shows the energy savings rate using decomposition analysis for the Netherlands[8]. Since 1990 large energy savings have been achieved by the economy (on average 1,3 percent each year). The measures that have been taken comprise of improved energy management, optimizing existing processes, introduction of new technologies and implementation of combined heat and power stations. When looking at individual industries, these energy savings were realized particularly in the chemical industry, horticulture, basic metal industry and the electricity companies.

18. What is the relation between energy consumption and CO_2 emissions ?

One possible mechanism to reduce the emissions of CO_2 is to change the energy mix of production processes. A change in the energy mix can be explored by looking at the carbon intensity of energy (emissions per unit energy). The carbon intensity of energy for the economy or for different industries can easily be calculated by combining the air emissions accounts and energy accounts.

Figure 4.18: Carbon intensity of energy for the Dutch economy, some industries and households.

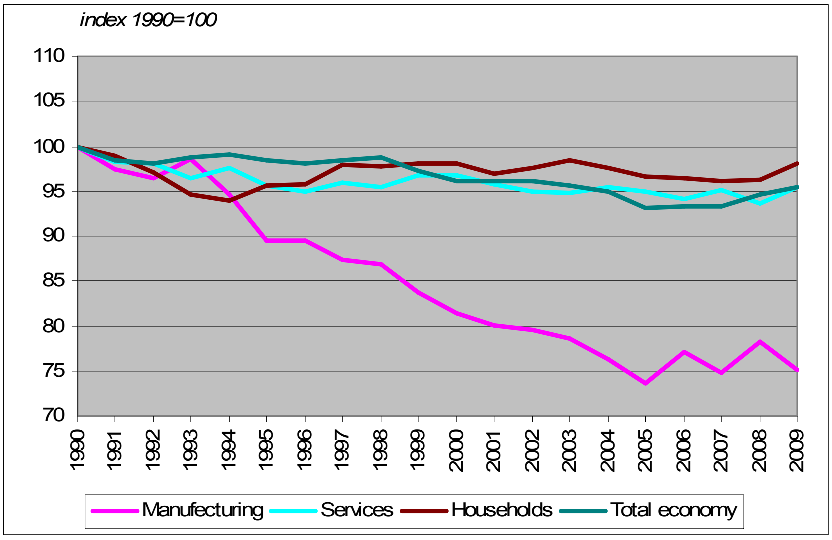


Figure 4.18 shows the development of the carbon intensity of energy for the Netherlands. Overall the carbon intensity decreased between 1990 and 2009. This is because the use of coal relatively decreased while the use of natural gas increased. Also, the use of renewable energy increased. In manufacturing the carbon intensity decreased most.

19. What is the share of renewable energy consumption ?

The share of the use renewable energy in total domestic energy consumption is in many countries an important policy target[9]. Using data from the energy accounts, this indicator can be calculated for the economy as a whole.

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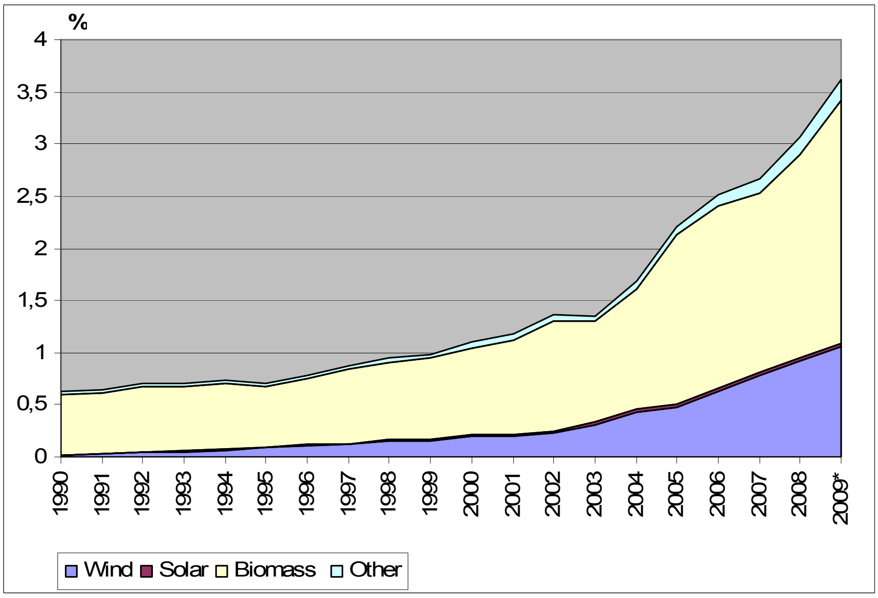
[8] At present, the official energy saving rate for the Netherlands as a policy target is calculated using a different method. Both methods, however, show similar results.

[9] In the Netherlands the renewable energy target is based on energy consumption as compiled in the energy balances. Therefore, the results presented here are not comparable with the Dutch policy targets.

Figure 4.19: Share of renewable energy consumption.

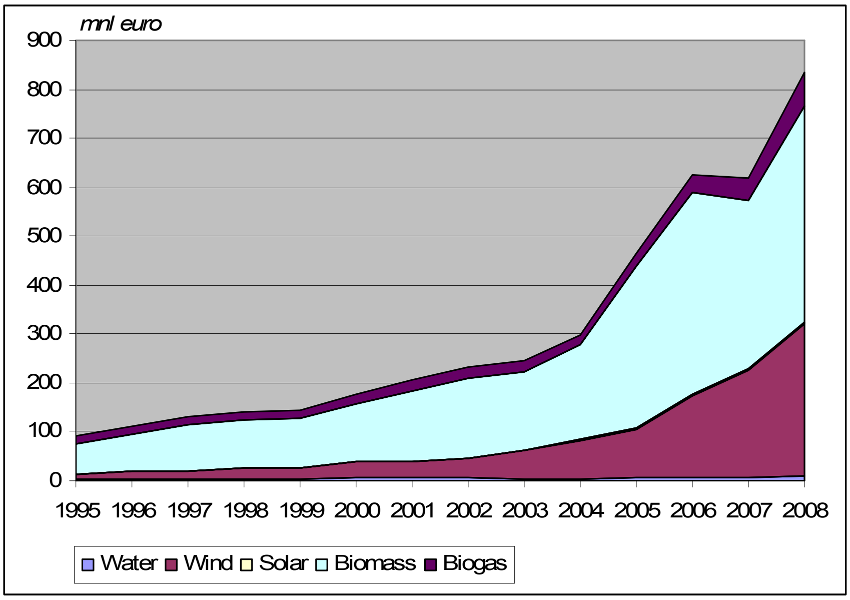


In the Netherlands, the use of renewable energy with respect to total energy consumption increased from 0,6 percent in 1990 to 3.6 percent in 2009 (Figure 4.19). This was primarily achieved by the increase of the use of biomass. Also, the electricity generated by wind mills is increasing steadily.

20. How much is renewable energy production contributing in monetary terms ?

Renewable energy production can also be expressed in monetary terms. From an economic-environmental point of view it is interesting how much renewable energy production contributes to total economic production, how this changes in time and what factors influence this development. Also, it can be shown what industries are involved in renewable energy production.

Figure 4.20: Gross output of renewable energy production (current prices).

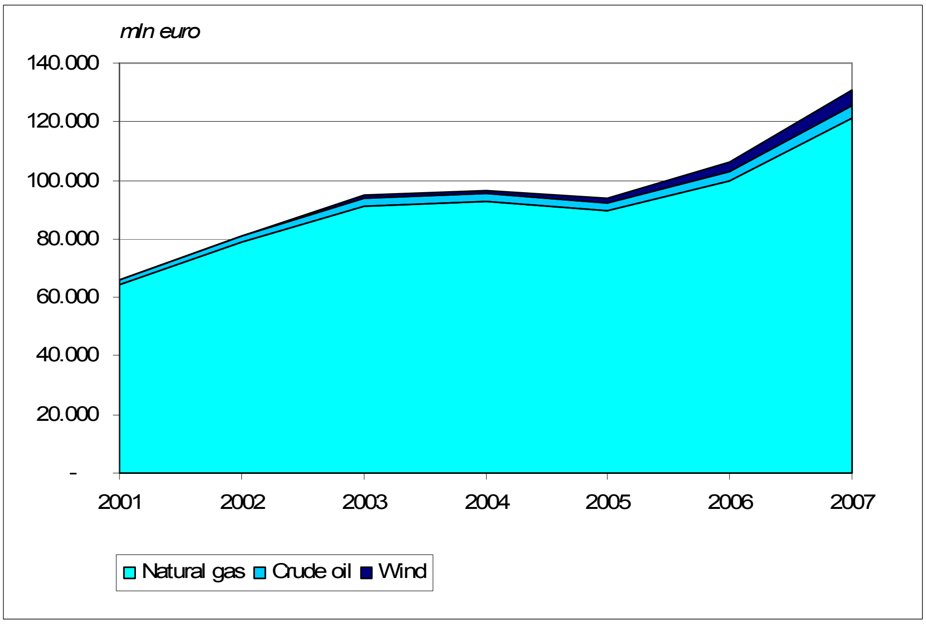


The gross production of renewable energy in monetary terms increased with 800 percent in the period 1995-2008 (Figure 4.20). This is partly the result of increased physical production (212 percent) and partly the result of higher energy prices (92 percent). Also the average methods of the renewable energy production has changed over the years, as less renewable heat and more renewable electricity was produced.

21. What is the relative importance of renewable energy resources with respect to their fossil counterparts ?

In the System of National Accounts, fossil energy resources are recorded as non produced assets in the national balance sheet. However, for renewable energy also a resource rent can be calculated (for a detailed discussion see van Rossum, 2010). Accordingly, also renewable energy resources can be valued. Recording non-renewable energy resources (hydropower, wind, solar) on the national balance sheet will make their relative importance to the economy with respect to their fossil counterparts explicit. Wind energy in the Netherlands can be valued at approximately 5.1 billion euro in 2007. In 2003 this value amounted only 500 million euro.

Figure 4.21:Valuation of energy resources in the Netherlands



The total picture of all energy resources in the Netherlands is shown in figure 4.21. In 2007 wind energy wealth surpassed the total value of crude oil reserves in the Netherlands. The worth of natural gas reserves is still 20 times higher than that of wind energy resources. In the near future, the depletion of fossil energy reserves and the shift to renewable energy technologies will most likely bring about substantial changes in the total wealth represented by energy resources in the Netherlands.

4.1.3 Policy instruments for mitigation

A wide variety of policy instruments can be applied by governments to create incentives for mitigation action, such as regulation, taxation, tradable permit schemes, subsidies, and voluntary agreements. For policy makers, it is important to consider the environmental impacts of policies and instruments, their cost effectiveness, institutional feasibility and how costs and benefits are distributed. SEEA provides detailed accounts for these policy instruments, allowing their monitoring, evaluation and analysis of their efficiency. Below several applications are presented for the three major economic instruments with regard to climate change, namely environmental taxes, environmental transfers (subsidies) and emission permits.

A) Environmental taxes

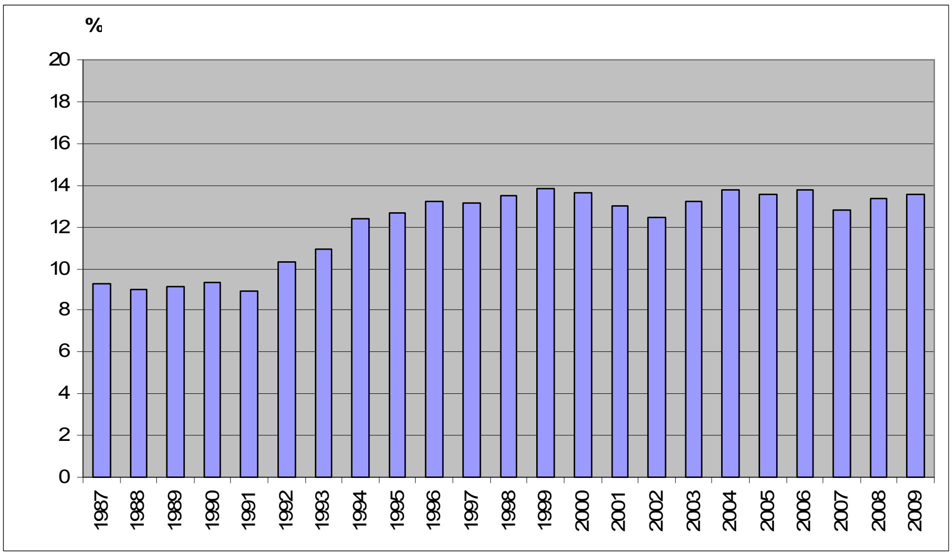
Environmental taxes provide an important policy instrument to change behaviour and to reduce environmental externalities. At the same time environmental taxes raise public revenues, which can be used to cut labour taxes. Assuming that direct taxes on labour affect employment negatively, environmental taxes can generate a both better environmental protection and higher employment. Increasing the share of environmental taxes also complies with the 'polluter pays principle'. With regard to climate change several environmental taxes are relevant. First, carbon taxes directly tax the emissions of CO_2. Greenhouse gas emissions may also be indirectly taxed by a tax on energy use, for example excises on motor fuels or an energy tax on the use of electricity. Finally, activities that cause greenhouse gases may be taxed, such as transport. These taxes provide an important tool to achieve mitigation targets. Many countries have set up energy taxes or CO_2 taxes as an economic instrument aimed at implementing environmental liability and achieving the Kyoto Protocol objectives. The accounts for environmental taxes in SEEA provide an overview of all taxes relevant for climate change mitigation.

22. What is the share of energy taxes in the total tax revenue ?

Environmental tax reform aims to shift the tax burden away from taxes on income and capital and towards taxes on consumption, pollution, and inefficient use of energy and resources. This shift can be monitored by looking at environmental taxes as a percentage of total taxes and social contributions. By specifically looking at energy taxes and transport taxes this can be specified for climate change. A change over time thus indicates to what degree an environmental tax reform with respect to taxing energy consumption is actually taking place.

Figure 4.22 shows this indicator for the Netherlands. From 2000 onwards this percentage remained more or less constant. Nor major tax reforms were undertaken in this period to shift the tax burden towards taxes on energy use. New initiatives, such as the introduction of a tax on airline transport or the raise of the energy tax tariffs, have had little effect.

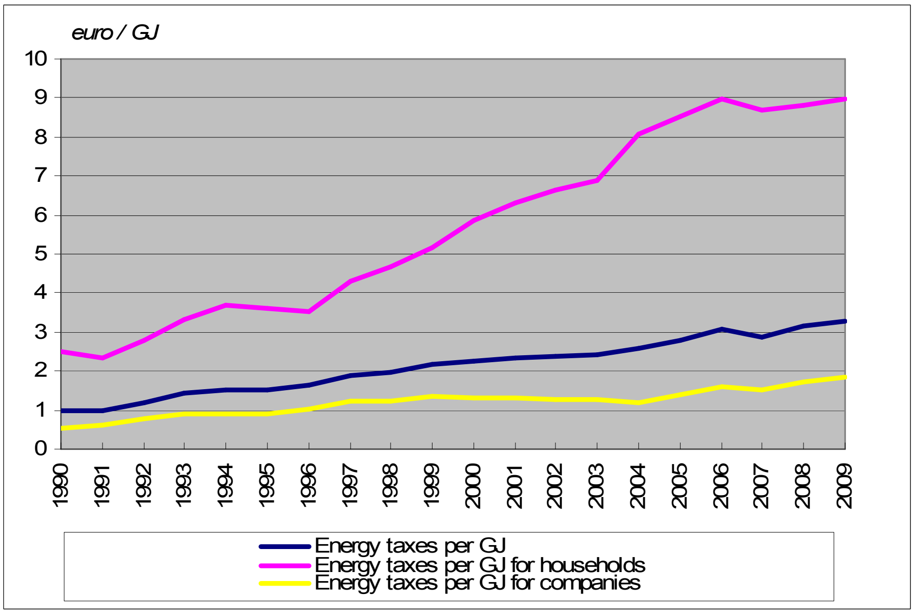
Figure 4.22: Share of energy and transport taxes in the total tax burden



23. How much is energy consumption taxed ?

Energy consumption is the most important source for greenhouse gas emissions. By comparing the energy consumption and the taxes on energy it can be established how much energy use is taxed and how this changes over time. The implicit tax rate on energy measures the development of the average burden of taxes on energy consumption.

Figure 4.23: Implicit tax rate on energy for the Dutch economy (in current prices)

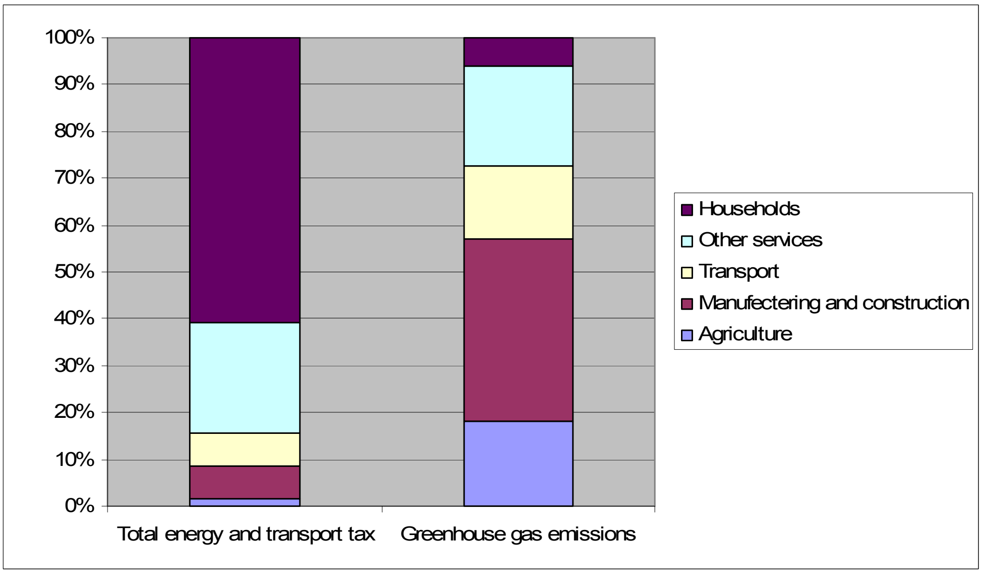


For the Netherlands, the implicit tax rate more than tripled between 1990 and 2008 (Figure 4.23). Households pay much more taxes per unit energy than companies. This is because the tax tariffs for energy are lower than for large scale users are lower than for small scale users.

24. To what extent does the 'polluter pay principle' apply ?

The energy and transport taxes are paid by different industries and households. The taxes actually paid is determined by the amount of energy used, the different tax rates and possible tax exemptions for certain economic activities. By comparing the share of tax paid with the share in the greenhouse gas emissions the polluter pays principle can be tested. For the Netherlands this is shown in figure 4.24[10]. Households pay more than 60 percent of all taxes relevant to abate climate change, but contribute only 23 percent to GHG emissions. Manufacture and agriculture, on the other hand, only pay relative small amounts of taxes but are large contributors to GHG emissions. The main cause for these differences are the reduced tax rates for bulk consumers of energy. Also some activities such as water transport, air transport or horticulture are exempt of fuel taxes or pay a reduced tax rate.

Figure 4.24: Comparison of the total energy and transport taxes and the GHG emissions for different industries.



B) Environmental transfers (subsidies)

Like taxes, environmental transfers (subsidies) are an important economic policy instrument for climate change mitigation. Instead of 'punishing' industries and households for emitting large amounts of GHGs, they are encouraged by financial incentives to emit less. Accounts for environmental transfers (subsidies) provide an overview of all environmentally motivated subsidies, classified by environmental domain (CEPA) and the receivers of the subsidies (ISIC, households). There are generally three categories that are interesting with regard to climate change, namely 1) subsidies related to energy saving, 2) subsidies for the production of renewable energy, and 3) other subsidies with regard to climate change mitigation, which are mainly subsidies that aim to reduce the other greenhouse gases (methane and N_2O) and innovation subsidies.

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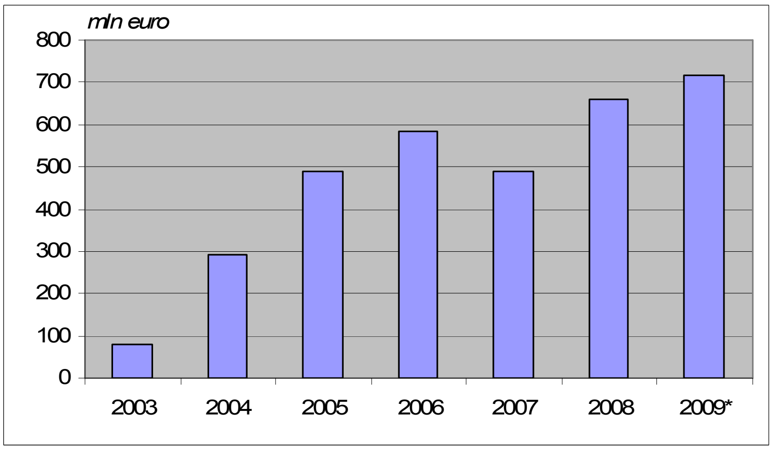
[10] In this analyses the emissions for the production of electricity have already been attributed to the end user of the electricity based on the physical energy use per sector.

25. What is the total amount of subsidies for climate change mitigation ?

Subsidies relevant for climate change mitigation are usually scattered among (or constitute only a part of) a large number of subsidy schemes that can be found in the government budgets. In addition, there are preferential tax treatments that can not be directly found in these budgets. The accounts on environmental subsidies in SEEA provide information of the total amount of subsidies for climate change mitigation and how this amount changes in time. Figure 4.25 shows the total of subsidies for renewable energy in the Netherlands. Since 2003 these subsidies have increased to 700 million euro in 2009.

Figure 4.25: Subsidies for renewable energy production



26. Who are the main beneficiaries of these subsidies ?

In SEEA the environmental subsidies are disaggregated to the industries and households that receive the subsidies. Accordingly, it can be determined who are the main beneficiaries of the subsidies for climate change mitigation. In the Netherlands energy companies (renewable energy) and farmers (wind mills, CHP plants) are industries that receive a large share of the environmental subsidies aimed to reduce GHG emissions.

27. How cost efficient are the subsidies for climate change mitigation ?

Data from the accounts for environmental transfers allow all kind of efficiency analyses or cost-benefit analyses. This is because when data on subsidies are available over longer time series, they can be compared at industry level with all kind of other environmental data like energy consumption, renewable energy production or GHG emissions or economic data. An example are subsidies for windmills and solar panels. These data can be directly compared with the production on renewable energy or emission reductions taking place. Also the efficiency of different subsidy schemes can be assessed. This is very important information for policy makers as they can, based on these results, decide how to optimally allocate the scare resources available.

C) Emission permits

Emission trading (also know as 'cap and trade') is a relative new policy instrument for governments to support mitigation strategies. It is a market-based approach used to control pollution by providing for achieving reductions in the emissions of

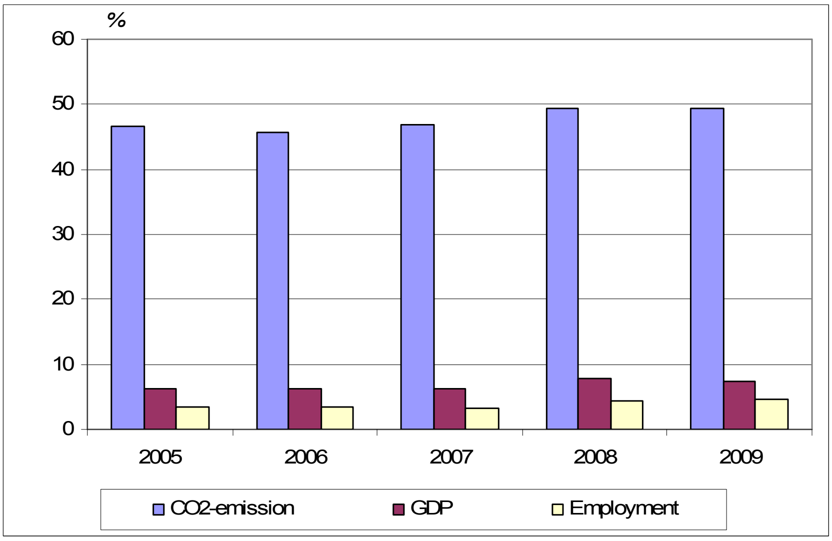
GHG's. In 2005 emission trading for CO_2 was introduced for Europe (ETS) and similar trading schemes have been set up in other parts of the world. In SEEA emission permits are accounted for in both physical and monetary balances. These balances show the opening stock, changes in stock (permits grandfathered, purchased, sold, surrendered), and closing stock. Also, a distinction is made between the different kind of permits (AAU's. ERU's, CER's).

For politicians and other decision-makers, information on the CO_2 permits is very policy relevant (see also Olson, 2008). The description of the flow of CO_2 permits within the SEEA framework would make it possible to analyse the relationship between CO_2 permits and other environmental domains, e.g. the use of energy and air emissions, whereas the link to the national accounts enables analyses of the relationship between the economic activity and the CO_2 permits, e.g. output, gross value added, employment etc. The description of the physical flow of permits is also crucial in order to understand the relationship between CO_2 emissions caused by a country's economic activities and the way the country complies with emission reduction targets, e.g. the Kyoto-protocol. Below, a few relevant policy questions are addressed.

28. How much of the national CO_2 emissions are covered under de emission trading system ?

Currently only companies who emit large amount of CO_2 from certain industries are obliged to participate in the ETS. Some economic activities, such as air transport en water transport, have been exempted to participate so far, but this may change in the future. For the Netherlands ETS companies in 2008 caused approximately 50 percent of total CO_2 emissions of the Dutch economy, while their combined contribution to GDP was just 6.4 percent (Figure 4.26). More detailed information shows that, for example, 65 percent of the chemical industry participates, 96 percent of the electricity companies, but only 10 percent of agriculture.

Figure 4.26: Share of ETS companies in the CO_2 emission, GDP and employment.



29. Who has to buy and who can sell permits ?

Companies that are obliged to participate in the ETS have to meet a certain emission target at the and of the year. If their emissions are larger than the emission permits initially allocated to them, they have to buy additional permits. The balance for emissions permits identifies the industries that had a shortage of permits and had to buy permits and the industries that had a surplus and could sell permits.

Figure 4.27: Allocated emission allowances and actual CO2-emissions ETS sector, 2009

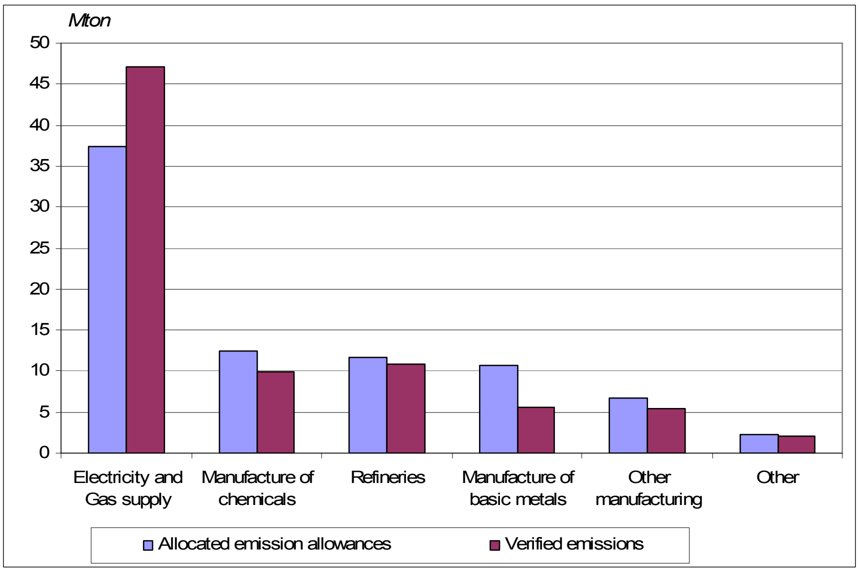
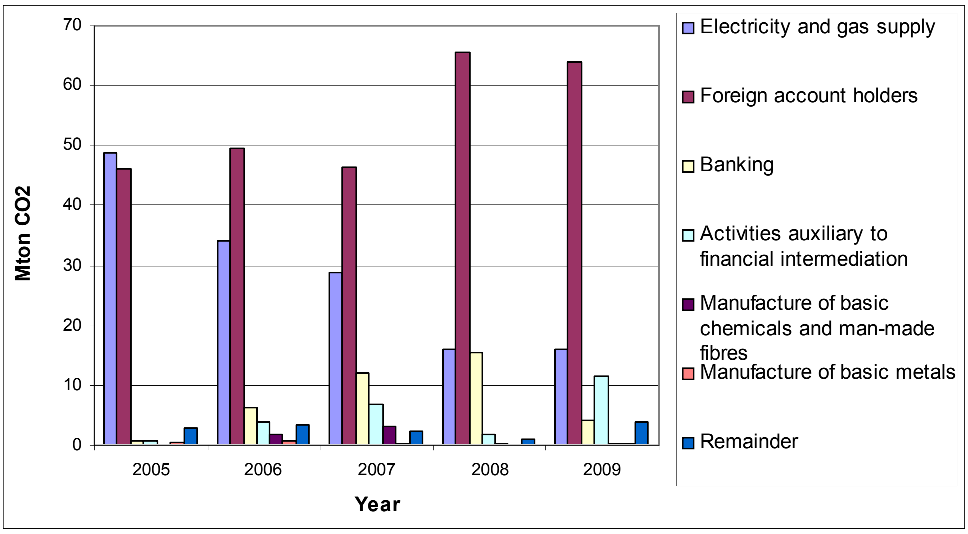


Figure 4.27 shows the allocated emission permits and the verified emissions for certain industries for the Netherlands. In 2009, the ETS companies together emitted 81.1 Mton of CO_2. That is close to the amount of emission allowances the companies received at the beginning of the year. The small surplus is largely explained by the economic recession which caused emissions to drop Particularly the energy companies had a large shortage. Other industries still had a surplus, indicating that the emission permits allocated by the government is still more than they needed.

30. Who is actually trading with the permits ?

Not only companies obliged to participate in the ETS can trade in emission permits, but also financial institutions, other companies and individual citizens. Also, permits can be bought and sold abroad. The emission permit balances show what is the trade in volumes, what is the value of the trade, what is traded internally and what are the imports and exports of the permits. Accordingly, policy makers can evaluate the functioning and efficiency of the emission trading system. Figure 4.28 shows the volume of trade in emission permits in the Netherlands. It shows that particularly foreign account holders, i.e. account holders that are not residents, are trading with permits.

Figure 4.28: Volume of emission permits traded in the Netherlands



31. How is the government achieving its emission target ?

The Kyoto Protocol demands that signed countries cut back their greenhouse gas emissions. These countries are expected to meet their reduction targets primarily through national policy measures. However, as an additional means the Kyoto Protocol introduced three market-based mechanisms leading to the creation of a "carbon market." This carbon market is believed to be crucial in the cost-effective reduction of greenhouse gas emissions worldwide. The three Kyoto mechanisms are emission trading (discussed above), the Clean Development Mechanism (CDM), and Joint Implementation (JI). JI enables industrialized countries to carry out joint projects while CDM involves investment in sustainable development projects that reduce emissions in developing countries. These mechanisms are supposed to stimulate sustainable development through technology transfer and investment and may help to meet targets by reducing emissions, or alternatively removing carbon from the atmosphere, in other countries in a cost-effective way.

The balance for emission permits for the government provides insight how a country is achieving its emission targets. The balance for the government shows a) the part of the economy under the 'cap and trade' system (ETS), b) the part of the economy not participating the emission trading system and c) additional emission permits acquired by JI or CDM projects.

4.1.4 Costs and benefits of climate change mitigation policies

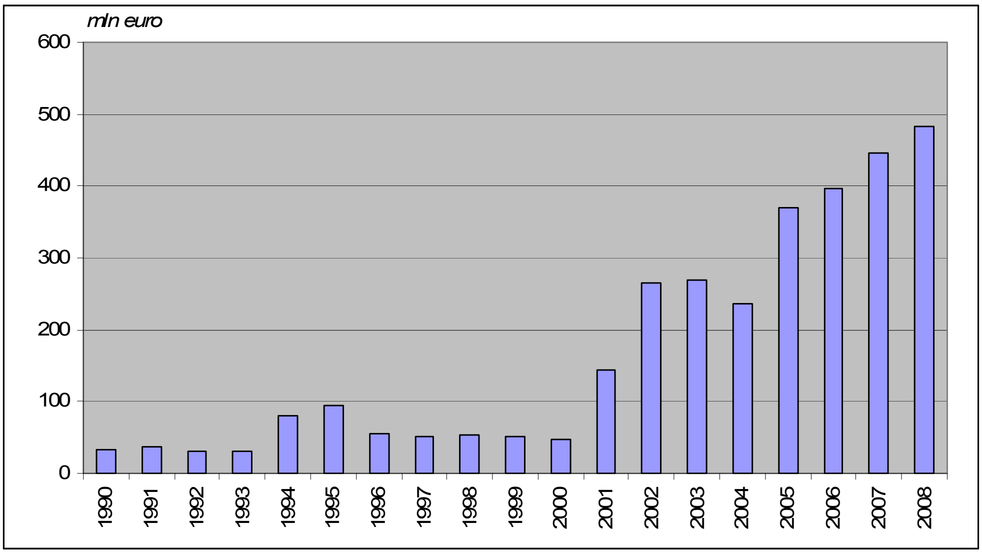
Mitigation policies bring along a financial burden on the economy. However, they also can bring economic benefits by stimulating new economic activities. SEEA accounts for both the costs and benefits and shows how these affect the different parts of the economy. Information on the costs and benefits can be found in the environmental protection expenditure accounts (EPEA), the resource use and management expenditure accounts (RUMEA) and the accounts for the environmental goods and services (EGSS).

32. How many economic resources are used for mitigation ?

Spending on environmental protection and resource management is a burden which needs to be monitored. The main objective of the environmental protection expenditure accounts (EPEA) and the resource use and management expenditure accounts (RUMEA) is to assess the economic resources a nation devotes to environmental protection or resource use and management. As for the national accounts, the final aggregate (national expenditure for environmental expenditure or resource use and management) is mainly useful for international comparisons. More useful for policy analysis are the various components of national expenditure, the national expenditure by environmental domain and the changes over time. In addition, the accounts show who finances the expenditure, what are the consequences for production and employment, and what is the net cost burden for the different industries. EPEA and RUMEA allow to follow shifts in policy focus, effective application of the polluter pay principle and can be used as a basis for cost-efficiency analysis.

Gross capital formation (investments) is an important constituent of the expenditure for environmental protection and resource use and management. As an example, figure 4.29 shows the investments in windmills for the Netherlands. Since 2001 these investments have increased sharply.

Figure 4.29: Investments in windmills



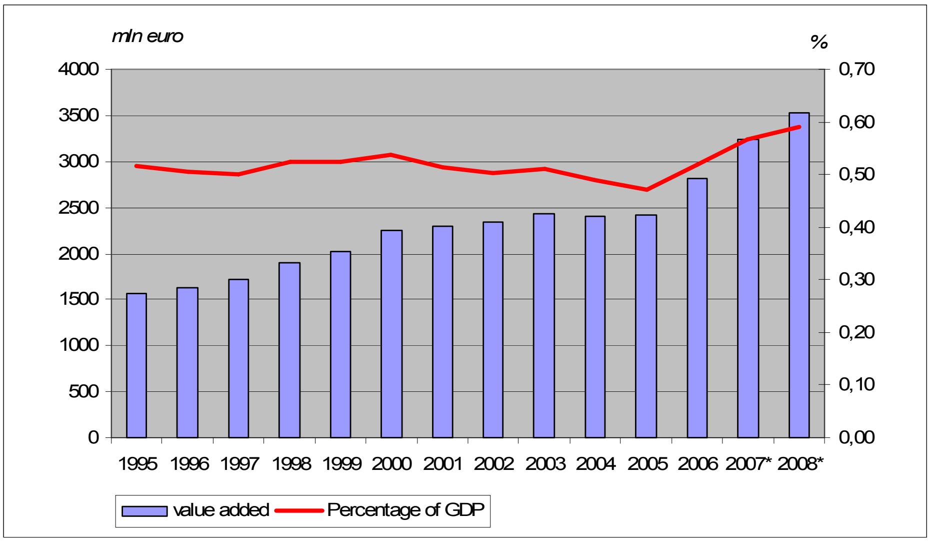
33. How much are mitigating activities contributing to economic growth ?

While mitigation policies may impose substantial costs, they also may create economic opportunities. Entirely new industries, such as producers of renewable energy or producers of energy saving equipment, may arise to fill the need for climate change mitigation. The accounts for the environmental goods and services sector help to identify the these economic opportunities with regard to production, value added, and labour created.

Particularly relevant with regard to climate change mitigation are companies specialised in producing energy saving equipment, producers of renewable energy and insulation. In addition there are companies and parts of the government that work on climate change issues such as mitigation policies and related water management. Figure 4.30 shows the value added created by these companies and their share in GDP. Since 1995 the value added (in current prices) has increased.

However, the share in GDP has remained more or less constant but started to increase in 2006.

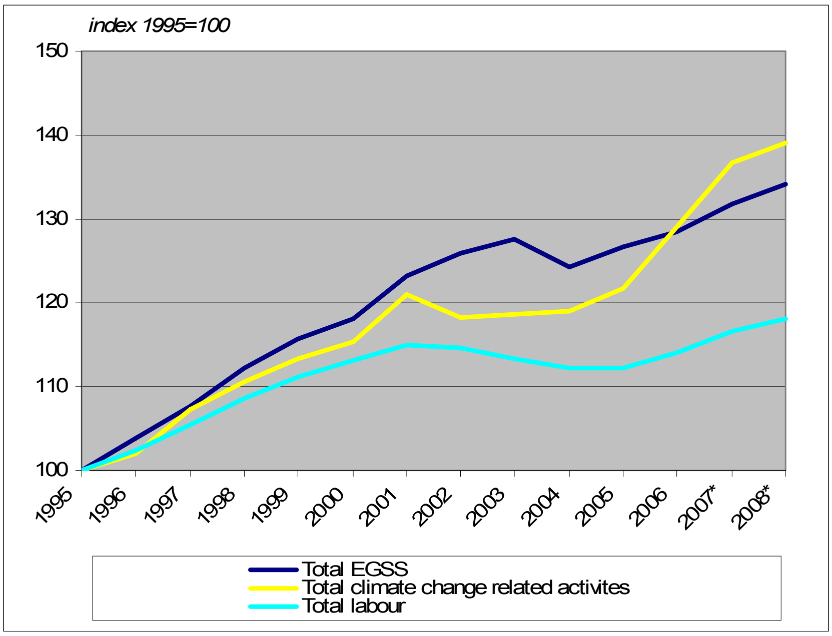
Figure 4.30: Value added and share in GDP for companies specialised in producing energy saving equipment, producers of renewable energy and insulation activities.



34. How much are mitigating activities contributing to the creation of green jobs ?

The creation of green jobs is high on the political agenda. In the Netherlands, employment in sectors related to climate change mitigation increased with 39 percent in the period 1995-2009 (Figure 4.31). This is more than the increase in total employment an also more than the growth of the EGSS sector. Producers of energy-saving products and sustainable energy systems even grew by more than 200 percent. The market for suppliers of energy-saving products and sustainable energy systems is very diverse, including all sorts of products such as energy advice, energy engineering, heat pumps, insulation products and geothermal energy systems. The market growth has been stimulated by the emergence of many newcomers on the market. Small companies are growing faster than large ones.

Figure 4.31: Development of employment of activities involved in climate change mitigation.



4.2 Adaptation

In this section three important issues with regard to developing adaptation policies will be addressed. First, assessing the impacts of climate change, next the policy instruments for adaptation, and finally the costs and benefits of adaptation policies.

4.2.1 Assessing the impacts of climate change on the economy

Understanding the economic system is essential for adapting to climate change. Vulnerability of the economy to climate change depends on the interactions between changing economic conditions and climate hazards. The feasibility of the adaptation options requires economic analyses of the underlying barriers and opportunities. Therefore, economic conditions must be described in enough detail to evaluate the merits of policy options.

Assessing the impacts of climate change faces a fundamental challenge of complexity. The set of mechanisms through which climate may influence economic outcomes, positive or negative, is extremely large and difficult to investigate. For example, a decrease in agricultural output or value added may be induced by climate change. However, climate change is only one driver among many that will shape agriculture in future decades. Other factors, such as technological developments, socio-economic factors or other environmental issues could have a similar large impact.

In principle, SNA and SEEA contain all the necessary economic information to monitor the impacts of climate change on the economy or to evaluate potential impacts in the future. As discussed, climate change may impact directly (on indirectly) the availability of natural resources. Therefore, asset accounting can be very useful to quantify these impacts. Asset accounts for natural resources in SEEA describe the stocks and changes in stocks both in physical and monetary terms. Several of the natural resources within the SEEA asset classification are relevant to climate change issues. However, for all the potential impacts it will be difficult to attribute the observed changes in stocks directly to climate change, as they may be influenced by other causes as well (Bordt and Smith, 2008).

35. What is the impact of climate change on economic activities ?

The overall impact of climate change on the economy can not be directly deduced from SEEA or the SNA. However, the framework can be used to monitor specific economic activities. What economic activities will be particularly vulnerable for climate change may vary from country to country. For example, in the Netherlands agriculture (flooding due to excessive rain in winter, water shortages during summer), energy producers (less cooling water due to warmer surface water), transportation (low river levels in summer may hamper inland shipping) and tourism (decrease of water quality, extreme weather conditions) are economic activities that may face problems by 2050 (VROM, 2007). By monitoring these activities in relation to other economic developments the impact of climate change may be determined.

36. What is the impact of climate change on natural resources ?

Climate change will affect the availability of natural resources. Examples are fish stocks, forests, and other biological resources. Particularly relevant with respect to a changing climate will be the availability of water resources for drinking water or for agricultural production. Areas in which runoff is expected to decline are likely to face a reduction in the value of the services provided by these resources. Asset accounts for water describe the stocks of water at the beginning and end of an accounting period and the change in these stocks due to natural causes (precipitation, evapotranspiration, outflows etc.) and human intervention (abstraction and returns).

Environmental accounts, and in particularly asset accounts, are very suitable to record changes in natural resources. These accounts can thus be used to monitor, for example, water resource availability and issues related to water scarcity. Valuation techniques may make the economic importance of these resources more directly explicit.

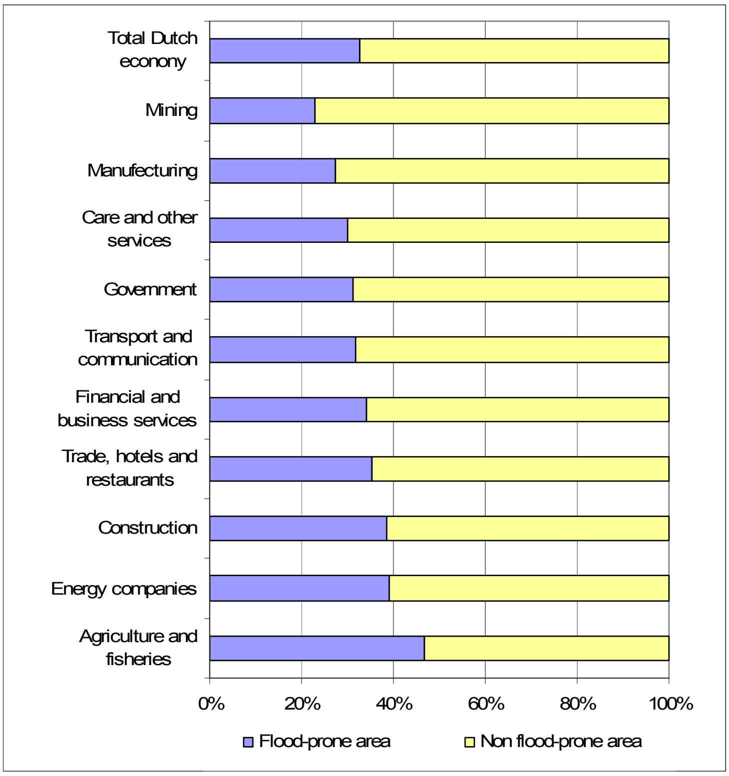
37. What is the potential economic impact of a sea level rise ?

Environmental and national accounts may also be used to determine the potential economic impact caused by climate change. An example is the potential impact of a rise in sea level for coastal areas. A low-lying country as the Netherlands, for a significant part situated below sea level, is particularly vulnerable to the expected rise in sea level. In addition, the Netherlands are a delta system where three major rivers (Rhine, Meuse, Scheldt) come together and flow into the sea. Enhanced runoff may threaten a large part of the country.

Figure 4.32: Flood prone areas in the Netherlands.

A study for the Netherlands has shown that one third of gross domestic product is generated in areas at risk for flooding. Nearly 2 million full time jobs of employees, about one third of total employment in the Netherlands, are found in flood-prone areas (Figure 4.33). Most full-time jobs in flood-prone areas, approximately 950 thousand, are found in the sector commercial services. The sector commercial services is relatively important in the Randstad region, where most of these areas are situated. Besides, a large proportion of horticultural, public utility and construction companies are situated in areas at flood risk. Energy companies are often located in water-rich regions, because they require substantial volumes of cooling water. This kind of information is very useful for cost-benefit analyses when analyzing adaptation measures.

Figure 4.33: Share employment (in labour years) per sector, 2007



4.2 Policy instruments for adaptation

As climate change adaptation is a relative new policy issue, the government mechanisms and policy instruments for dealing with climate change are still in the process of developing. Policy instruments relevant for adaptation include insurance schemes, price signals (e.g. water pricing and water markets), regulatory incentives (building standards,), subsidies (R&D incentives. etc.).

In SEEA some of the policy instruments for adaptation may be addressed in the accounts for taxes or environmental transfers. However, there are some definitions and classification issues that still have to be dealt with. With the proper definitions and classifications there is not reason why it could not be included in the SEEA framework.

4.3 Costs and benefits of climate change adaptation

Adaptation policies bring along a financial burden on the economy. However, there may also be benefits involved as new economic opportunities arise. SEEA, together with SNA, may account for both the costs and benefits and show how these affect the different parts of the economy[11].

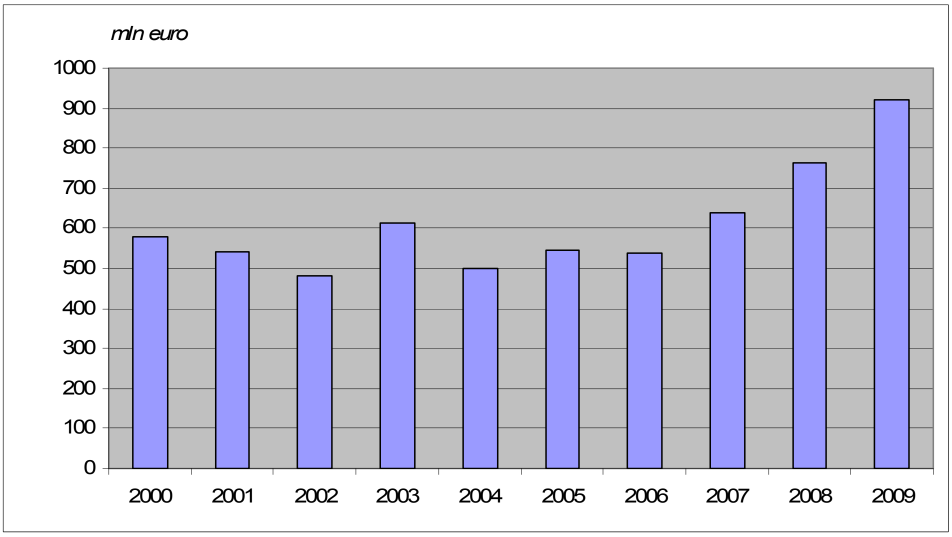
[11] The experience in compiling accounts specifically for adaptation is still very limited. However, there are no fundamental reasons why SEEA and SNA can not be used as a framework to accounts for adaptation expenditure in the same way as expenditure for mitigation.

Costs for adaptation include expenditure for planning, preparing for, facilitating and implementing adaptation measures, including transition costs (IPCC 2007). Adaptation costs with regard to climate change are often difficult to determine. Adaptation is often one of the motives why industries or governments make certain investments. In addition, a structural change occurring within the economy (for example for agriculture) may have different causes, climate change being one of them. To illustrate this, the expenditure of governments on adaptation is discussed more in detail below.

38. How much does a government spend on climate change adaptation ?

Public policy plays an important role in facilitating adaptation to climate change. Many governments are setting up special programmes for climate change adaptation. In government budgets these programmes can be identified. However, there are also certain expenditures that are only indirectly related to climate change adaptation. A good example is the expenditure on dikes and seawalls in the Netherlands. The maintenance of this water related infrastructure has been an important task of the Dutch government in order to protect the land and its people against the high floods of the sea and rivers. These maintenance works, which have been ongoing for centuries, clearly cannot be attributed to human induced climate change. However, when sea level starts to rise and extreme weather conditions become more frequent, these expenditure for may start to rise. It is therefore very useful to monitor these expenditures with regard to climate change adaptation. Figure 4.34 shows the expenditures by the Dutch government on the maintenance of dikes and seawalls. In the last three years these expenditures started to increase, which is directly related to a special government programme to anticipate for future high water discharge by rivers.

Figure 4.34: Expenditures by the Dutch government on the maintenance of dikes and seawalls.



5. Conclusions

Climate change and the economy are closely interconnected. The System of Integrated Economic Environmental accounts, together with the System of National Accounts and related satellite accounts, has the potential to bring together in one consistent analytical framework all relevant information with regard to the relationships between the economy and climate change, that can be used for climate change policy and decision making. The accounts ensure coherence in data, as they are all part of one accounting framework based on the same concepts, definitions and classifications.

It is important to note that SEEA cannot be used for direct climate change assessment. In order to determine to what extent human induced climate change is actually taking place, other statistics are needed, such as the essential climate variables (ECV's). With this kind of information scientific researchers can address this important issue.

However, SEEA as an integrated framework is particularly suitable to asses the policy responses to climate change. It provides all the essential information to monitor, understand and analyse the relation between the economy and climate change essential for developing both mitigation and adaptation strategies. SEEA provides insight in both the economic drivers of climate change as the impacts on the economy. In addition, detailed accounts are available for the relevant policy instruments, like taxes, subsidies and emission permits. Finally, SEEA accounts for the costs and benefits of climate change policies and shows how they affect the different parts of the economy. The numerous applications presented in this study provide a good overview of the many possibilities of SEEA with regard to assessing the policy responses to climate change.

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