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Time for Transition

an exploratory study of the transition to a carbon-neutral economy

DeNederlandscheBank
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Central bank and prudential supervisor of financial institutions

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Guido Schotten, Saskia van Ewijk, Martijn Regelink, Diederik Dicou and Jan Kakes[1]

1 With thanks to René Bierdrager for statistical support and to Steven Poelhekke, Robert Vermeulen and Jakob de Haan for their comments.

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Foreword

Economic activity and energy consumption are inextricably linked. Given this, changes in energy systems can have a major impact on the economy and financial stability. This is particularly true in the case of the Netherlands, which is still dependent on polluting energy sources to a significant extent. We are currently in the early stage of a major energy transition: the global challenge of switching to a carbon-neutral energy system in time.

Achieving this energy transition will require great skill. It is by no means certain that the transition will take place in a controlled manner. Large parts of the production and infrastructure of the Netherlands are associated with the use of fossil fuels. A sudden transition to a carbon-neutral energy system may harm economic growth and affect financial stability due to the depreciation of existing assets. Conversely, a transition that lacks sufficient decisiveness may result in a failure to achieve the climate targets, which may ultimately have much greater consequences for the economy and society.

In view of this, central banks and supervisors of the financial sector around the world are paying more and more attention to energy and climate policy. De Nederlandsche Bank (DNB) sees energy transition as one of the greatest challenges that the economy faces in the long term. Moreover, there are still a great many uncertainties, and opinions on the best way to achieve the climate targets agreed in Paris vary considerably. That said, there is a strong consensus that inaction is no longer an option.

DNB does not have a long tradition of conducting research or providing policy advice in the area of energy and climate change. With a view to participating in this debate from a well-informed perspective, the authors studied literature, performed their own analyses and made use of many

experts, with whom they held interviews and an expert meeting.[2]
The authors are greatly indebted to all these discussion partners for their assistance and valuable insights.

This Occasional Study is a first attempt to define relevant questions and provide tentative answers where possible. There are many questions that are still unanswered, and this study does not in any way claim to be the last word on the subject of energy or climate policy. DNB intends to conduct further research in this area and report on this research through various channels, based on the realisation that energy and climate change will dominate the policy agenda for a long time to come.

2 PBL Netherlands Environmental Assessment Agency, Social and Economic Council of the Netherlands (SER), Eneco, Nuon, GasTerra, DSM, Greenpeace, McKinsey, Shell, Natuur & Milieu, CPB Netherlands Bureau for Economic Policy Analysis, GroenLinks, University of Groningen, APG, the Ministry of Economic Affairs, Erasmus University Rotterdam, and the Sustainable Finance Lab.

1 Energy and the economy

Energy and the economy are inextricably linked. Energy is required for the production and distribution of almost all goods and services, ranging from fuel used for transport and heating purposes to electricity used to power machinery and computers. This chapter looks at the most important factors that affect energy use: prosperity, the price of energy and government policy.

Economic development and energy use

Higher levels of income are generally associated with higher levels of energy use. This is not a linear relationship, however. Generally speaking, the relationship between energy use and income follows an S curve: at lower levels of income, growth in energy use outstrips growth in income, whereas the curve levels off when income levels are higher. This applies in the case of individual households and to the economy as a whole.[3]

This S curve reflects the fact that during the early stages of economic development, certain products, such as heating, refrigerators and cars, come within the reach of more and more consumers. This leads to a sharp rise in energy use. As income continues to increase, the increase in energy use levels off. This is because in later stages of economic development most households already have the aforementioned products. Moreover, as incomes rise, an increasing share of consumption is accounted for by services, which are usually less energy intensive.[4]

A similar trend can be seen as regards the production of goods. In early stages of economic development, production becomes more energy intensive due to industrialisation. As economic development continues, the services sector gradually becomes more important, leading to a decline

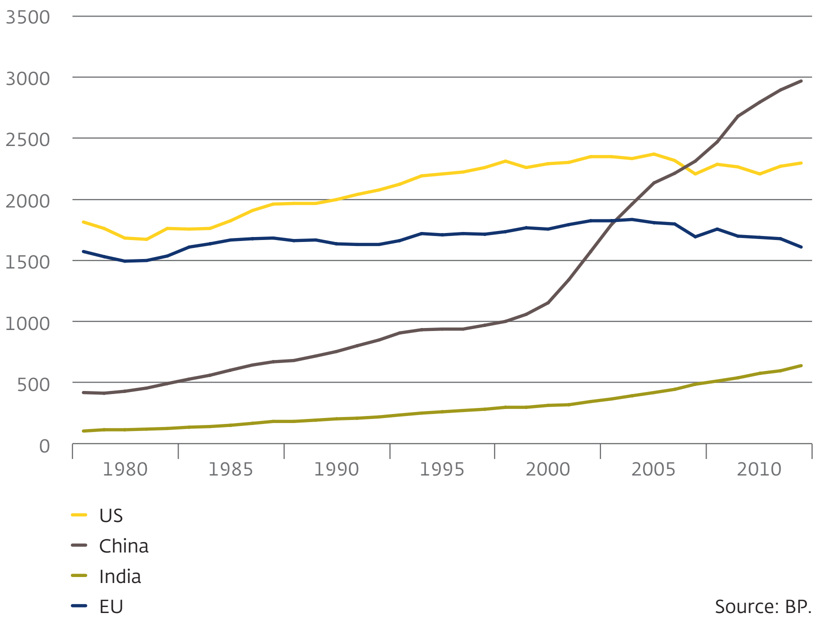
3 Wang et al. (2014), Fouquet (2014), Meier et al. (2012) and Wolfram et al. (2012).
4 Gertler et al. (2013).

in the energy intensity of gross domestic product (GDP). Once a certain level of prosperity has been reached, all sectors become less energy intensive.[5]

In line with the above, there has been a sharp rise in energy use in emerging economies such as China and India in recent decades (Chart 1.1). This trend is expected to continue in the next few decades.[6] Although China now uses

Chart 1.1 Energy use in four regions, 1980-2014

In Mtoe (million tonnes of oil equivalent)



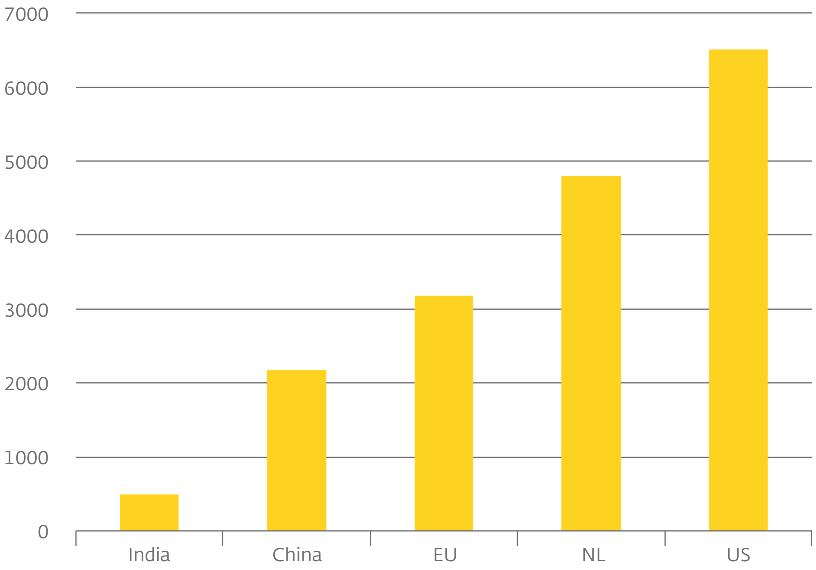
Source: BP.

5 Medlock and Soligo (2001) and Benthem and Romani (2009).
6 Wolfram et al. (2012).

more energy than any other country in the world, energy use per capita is still much lower in China and other emerging economies than in the EU and the US (Chart 1.2). 13

Chart 1.2 Energy use per capita in five regions, 2014

In Mtoe per capita

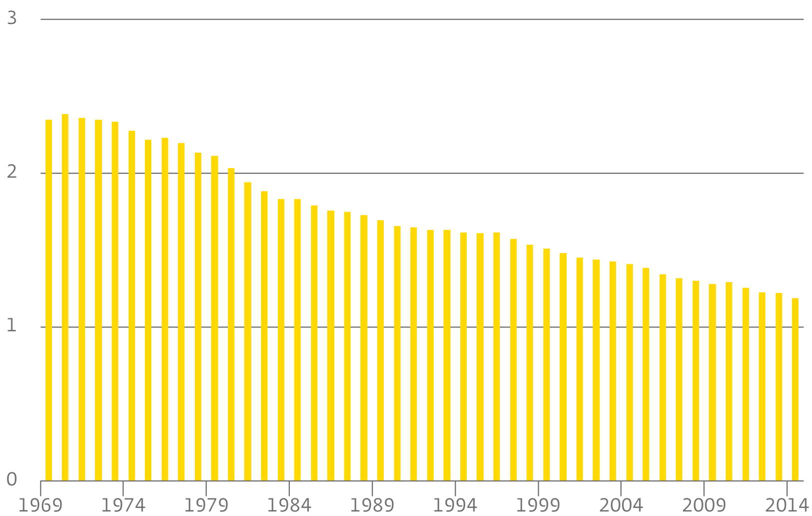


Source: BP.

In Western countries, energy use has not risen as quickly as production for some time, leading to a decline in energy intensity (Chart 1.3). This is partly attributable to energy conservation policies, motivated by the high energy prices seen during the oil crises in the 1970s, and later by growing concerns about the climate (see also Chapter 4). Since 2000, the GDP of OECD member countries has increased by 26%, yet energy use has remained broadly unchanged.

Chart 1.3 Energy intensity of OECD countries

In Mtoe, percentage of real gross value added



Source: BP and OECD.

Energy prices and energy use

Energy prices have an impact on the consumption and investment decisions made by households and businesses. Prices of energy carriers and energy-intensive products influence demand for energy through a number of channels. The relationship between energy prices and energy use is complex because energy is used in the production of almost all goods and services and because energy is required in order to use certain products, such as cars and electrical devices.

Higher energy prices lead to lower energy consumption owing to income and substitution effects.[7] The income effect results in a decline in demand for all products, and hence also demand for energy (all other things being equal). The scale of this effect depends on the share of the consumption basket made up of energy, energy-intensive products and energy-consuming products. Under the substitution effect, an increase in energy prices makes the consumption of energy, energy-intensive products and energy-consuming products less appealing than other forms of consumption.[8] The scale of this effect depends on the availability of suitable substitutes.

The way in which demand for energy responds to changes in energy prices also depends on whether a long-term or short-term view is taken. For example, when petrol prices increase the initial response of consumers is to reduce the amount of driving they do. In the longer term, they may decide to purchase a more fuel-efficient car. Energy prices that remain high over

7 Fouquet (2013).
8 As energy is used in the production of almost all goods and services, rising energy prices also lead to increases in the prices of other products, although these increases are not as great as the increases in prices of energy products. As a consequence, the substitution effects described above still persist.

the long term encourage households to take energy conservation measures, as a result of which demand for energy may fall in the long term.

A similar situation applies in the case of production. In the short term, the only ways in which they can respond to rising energy prices are by passing on the increases in the prices of their end products or by reducing their profit margins. In the longer term, however, producers can adjust their production processes in response to higher energy prices. The degree to which this occurs depends on the existence of opportunities for substituting other factors of production and their prices. Research has shown that the elasticity of substitution between energy and other factors of production is small compared with the elasticity of substitution between labour and capital.[9]

Improvements in energy efficiency do not generally result in energy savings on the same scale. If, for example, the costs of using electrical devices declines due to energy conservation measures, there will be an increase in the use of such devices. This is referred to in economic literature as the rebound effect. In most studies, the size of this effect is estimated to be between 5% and 40%.[10]

The economy also becomes more energy efficient if there is a shift from more energy-intensive to less energy-intensive businesses and industry sectors. Higher energy prices contribute to this effect, as energy-efficient businesses become increasingly competitive as energy prices rise. Higher energy prices also encourage consumers to consume less energy-intensive products, which also contributes to the shift in the production structure to less energy-intensive industry sectors.

9 Van der Werf (2008), Paltsev et al. (2005) and DNB (2011).
10 Gillingham et al. (2016), Greening et al. (2000) and Sorrell (2009).

Energy and the government

Traditionally, there has been a great deal of government intervention in the area of energy use. This intervention is aimed at achieving various objectives:

- reliability (security of supply, reducing international dependence);
- affordability (for consumers, and also with respect to the international competitiveness of the corporate sector);
- sustainability of the energy supply (reducing the negative impact of energy consumption on the environment, climate and public health).

A trade-off is made between these different objectives. Over the years, there has been a shift in the preferences of Western European governments. For example, the oil crises of the 1970s led to a greater emphasis on energy security within Europe. This led to the emergence of nuclear power. The level of economic development also plays a role in the selection of specific objectives. More developed economies tend to pay greater attention to sustainability, even if this is at the expense of affordability. By contrast, many emerging economies provide large energy subsidies aimed at supporting purchasing power.[11]

In the Netherlands, energy policy is increasingly focused on combating climate change due to carbon emissions.[12] As the social costs of carbon emissions are not incorporated in energy prices, the use of fossil fuels is higher than is socially desirable (negative external effects). In theory, the government can overcome this market failure by including these social costs in the price of energy, for instance in the form of an energy tax.

11 IMF (2015).
12 Ministry of Economic Affairs (2016).

In practice, the need to ensure international coordination makes it difficult to design an effective energy policy. International coordination is necessary owing to the cross-border external effects of energy use and in order to create a level playing field for internationally competitive businesses. Coordination is hampered due to the fact that the energy policies of different countries have different priorities. Moreover, the benefits of climate policy are uncertain, global and in the distant future, whereas the costs are local and are incurred in the near future. That said, the more urgent the climate change problem becomes, the greater the willingness to agree to international coordination, as demonstrated by the recent Paris climate change agreement (see Chapter 4).

Policy instruments for reducing carbon emissions

The government has various policy instruments at its disposal that it can use to reduce carbon emissions. The government can regulate emissions directly by means of statutory energy performance standards or agree covenants with specific industry sectors. The disadvantage of such instruments is that certain decisions are made by the government rather than the business, which can potentially lead to emission reductions not being achieved in the most cost-effective way. Direct regulation also has potential rebound effects, resulting in lower reductions in emissions.

Subsidies aimed at making the generation and use of renewable energy more appealing also have drawbacks, including rebound effects. Moreover, subsidies do not tackle the problem directly. Although subsidies make renewable energy more appealing they do not affect the interrelationships between energy sources in the remainder of the energy mix, whereas carbon emissions can also be reduced by replacing more polluting fossil fuels (e.g. coal) with less polluting fuels (e.g. gas).[13] Finally, subsidies lead to higher taxes in other parts of the economy, which may have a distortionary effect.

Carbon pricing is more effective as this enables the costs and benefits of reducing emissions to be weighed up immediately.[14] Carbon pricing can take the form of a carbon tax or a system for trading carbon emission permits. One such emissions trading scheme is the European ETS (see box 4.2). Emissions trading also takes place in the US and Canada at a regional level, and China intends to introduce an emissions trading scheme in 2017.

There are benefits and drawbacks associated with carbon taxes and emissions trading. A carbon tax provides certainty as to the costs of emissions (at a micro level), but provides no certainty regarding the reduction in emissions. Emissions trading provides certainty as regards the amount of carbon emissions, but it provides no certainty as to the costs of reducing emissions, which makes investment decisions more difficult. To reduce the uncertainty regarding the carbon price, a hybrid model could be used in which emissions trading is linked to a minimum (or maximum) carbon price. In this model, emission permits are withdrawn from the market (or placed on the market) if the emissions price falls below a specific level (or rises above a specific level).[15] This provides more certainty as to the price, but this is at the expense of certainty regarding the reduction in emissions.

Emissions trading is more suitable for large energy users. Obviously, it would not be practical for individual households and small businesses to be active in the emission permit market. A significant drawback associated with emissions trading is that supplementary policy aimed at reducing emissions (such as

13 See Chapter 3 for a discussion of the characteristics of different energy carriers.
14 Parry and Pizer (2007).
15 Goulder (2010).

subsidies for renewable energy or energy efficiency standards) has no effect because the level of emissions is already fixed by the number of emission permits. Supplementary policy would lead to less demand for emission permits, which would reduce the price of emission permits and thus bring about an increase in emissions ('waterbed effect'). The drawback associated with a carbon tax is that this tax would have to be increased constantly in order to bring about a drastic reduction in emissions, and there may be political limits to this. In an emissions trading scheme, emission prices increase automatically when the scheduled reduction in the emission cap takes place.

In theory, global carbon pricing is the best way of reducing emissions as efficiently as possible, but it is not yet feasible owing to problems in the area of international coordination. In practice, policy is suboptimal; owing to substitution and income effects, the policy adopted by one country (or region) in order to reduce emissions may have the unwanted effect of increasing carbon emissions in other countries (carbon leakage, see Box 1.1). It is therefore crucial that in future there is greater international coordination in respect of dealing with the problem of climate change.

Box 1.1 Carbon leakage

Carbon leakage can occur through a number of channels:

(1) The energy markets channel: if climate policy in a small number of countries reduces global demand for fossil fuels, world fossil fuel prices will fall. In response to this, the use of fossil fuels will increase in other countries due to income and substitution effects.

(2) The competition channel: if energy costs rise in some countries in response to climate policy, businesses in those countries may relocate production to countries that do not have a climate policy. This leads to a fall in production, employment and investment in countries with a climate policy while global carbon emissions remain unchanged. This applies in particular to globally operating industries in which energy costs make up a large proportion of total costs.

(3) The green paradox: countries with large fossil fuel reserves may be motivated to sell as much fossil fuels as possible in the short term, in anticipation of the introduction of stricter climate policy in the future. This leads to an increase in supply and lower prices, which create incentives to consume more fossil fuels and invest less in energy conservation and renewable energy.[16]

Calculating the precise amount of carbon leakage is difficult. Model simulations suggest that between 5% and 30% of the reduction in carbon emissions is cancelled out by carbon leakage through channels 1 and 2.[17] The amount of carbon leakage is mainly dependent on the supply elasticity of fossil fuels and the degree to which domestic production competes with imported goods.[18] Most carbon leakage occurs through the energy markets channel.[19] The recent fall in global oil prices can be partially attributed to lower demand in OECD member countries as a consequence of their energy policies. The low price of oil led to an upswing in oil consumption in 2015.[20]

16 Van der Ploeg and Withagen (2015) and Sinn (2012).
17 Bohringer et al. (2012).
18 Boeters and Bollen (2012).
19 Fischer (2015).
20 IAE (2014) and EIA (2016).

2 The role of energy in the Dutch economy

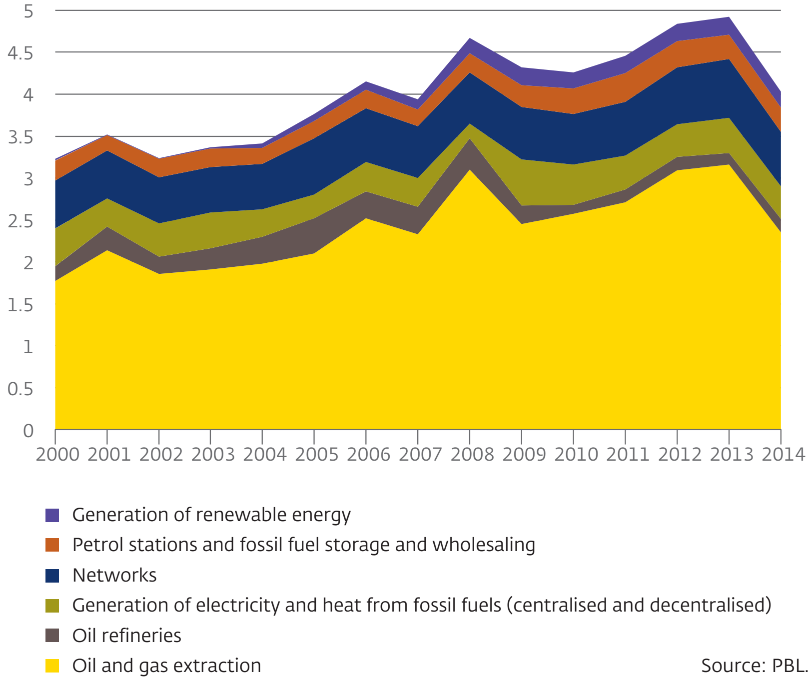
This chapter describes the empirical role of energy in the Dutch economy along three dimensions: (1) the direct contribution to GDP and employment; (2) energy as a factor of production; (3) consumption of energy products by households. The chapter concludes that the Netherlands is more energy intensive than most other European countries. For this reason, the transition to a sustainable energy supply will potentially have a more far-reaching impact in the Netherlands.

Energy sector is large but does not employ many people

The Netherlands has a large energy sector compared to other European countries. In 2014, energy-related activities contributed 4% of GDP (Chart 2.1). This corresponds to some EUR 27 billion. Oil and gas extraction made the largest contribution (2.3% of GDP). This contribution depends heavily on temperatures in the winter months, since Dutch gas extraction plays an important part in absorbing peak demand for gas in Northwest Europe. In 2014, natural gas extraction was down by one quarter compared to the previous year. This decrease was due to the relatively mild winter, restrictions on gas extraction related to earthquakes in the Dutch province of Groningen, and a decline in the use of natural gas in the production of electricity (see also Chapter 3). Although renewable energy currently makes up only a small share of value added, this share has grown rapidly. Since the turn of the century its share has increased tenfold, to 0.2% of GDP in 2014.

Chart 2.1 Contribution of energy exploitation activities

Contribution to GDP (percentage)



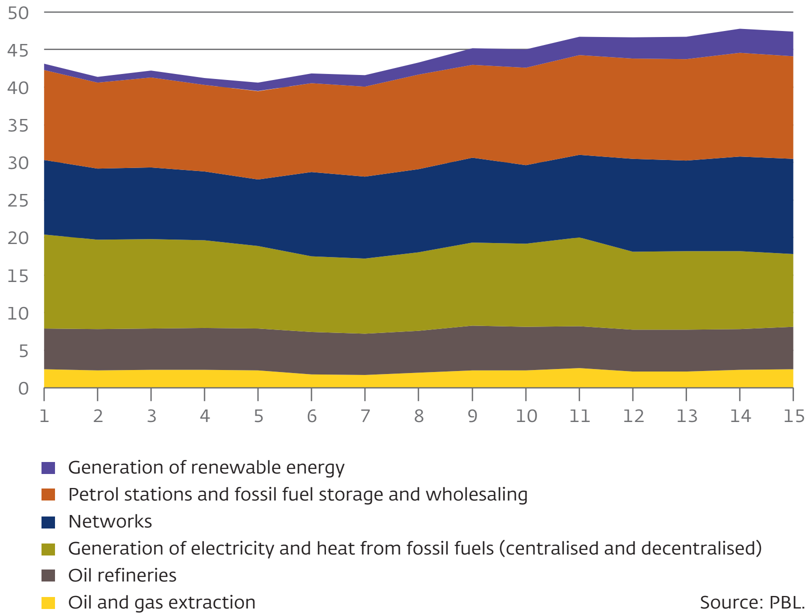
Source: PBL.

Moreover, the Netherlands plays an important role as an exporter of energy. Besides exporting its own gas, the Netherlands also acts as a trading hub for gas from other countries. In addition, the Port of Rotterdam plays a key role in crude oil trading and refining. Furthermore, a great deal of coal is imported for transit to Germany. The Netherlands is currently less dependent on foreign countries for its energy supply than most other Western countries (see box).

Being a capital-intensive sector, the energy sector is not extremely important in terms of employment. In 2014, total employment in the energy sector amounted to 47,000 FTEs (PBL, 2015). Despite the crisis, employment increased by 10% between 2007 and 2014[21] (Chart 2.2). This increase is largely due to the increase in renewable energy activities, which are more labour-intensive. In addition, energy conservation helps to create jobs in other industry sectors, for example in the area of home insulation in the construction sector.

Chart 2.2 Employment in energy-related activities

Number of direct jobs (in thousands of full-time jobs)



Source: PBL.

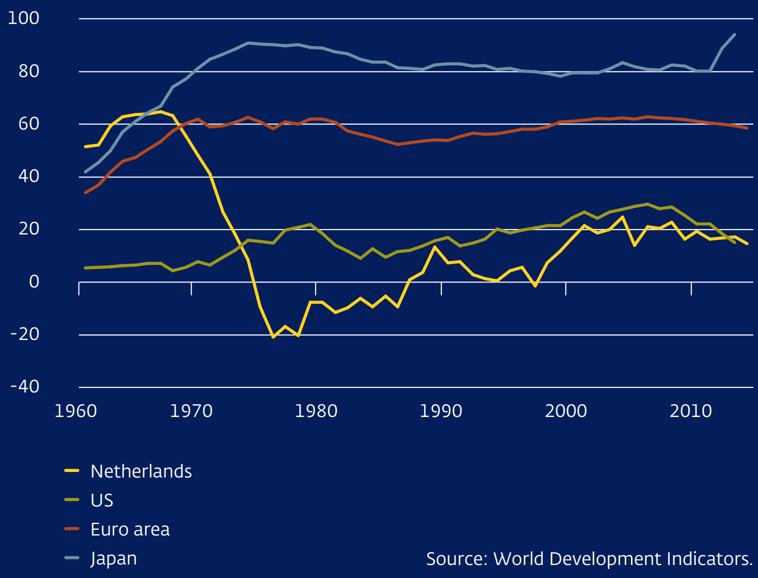
21 PBL.

Box 2.1 Energy dependence of the Netherlands

The Netherlands is less dependent on foreign imports than other European countries owing to the presence of natural gas. Most Western countries are net importers of energy and are therefore dependent on other countries for much of their energy supply (Chart 2.3). The Netherlands is also a net importer, although its energy dependence is much lower than that of other European countries owing to the presence of natural gas. Following the discovery of substantial reserves of natural gas, the Netherlands even became a net exporter of energy in the 1970s. However, declining gas production and growing consumption of imported oil products meant that the Netherlands became a net importer of energy again in the mid-1980s. Owing to the relatively low level of energy dependence, changes in the oil price do not have as much of an impact on the current account in the Netherlands as they do in most other EU member states.

Chart 2.3 Energy dependence

Net imports as a percentage of total energy consumption



Source: World Development Indicators.

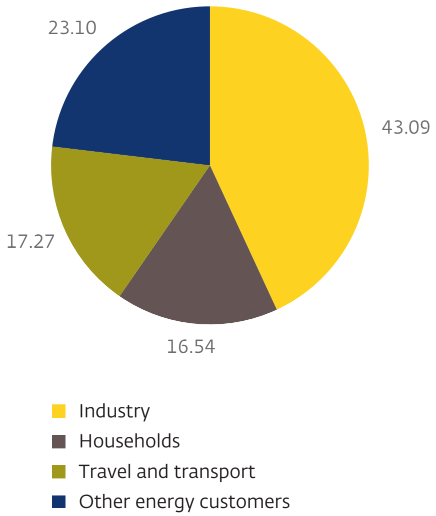
Sharp fall in energy use of businesses

The energy sector supplies energy to businesses and households. Businesses use the most energy in the Netherlands, with manufacturing accounting for a notably high share (43%; Chart 2.4). The share accounted for by households (excluding transport) is 17%, which is the same as the share accounted for by transport (businesses and households combined). Trade, services, agriculture and the government account for the remaining 23%.[22]

22 The data concerning the use of energy for transport does not make any distinction between households and businesses.

Chart 2.4 Energy use by sector, 2013

Percentage share



Source: Statistics Netherlands.

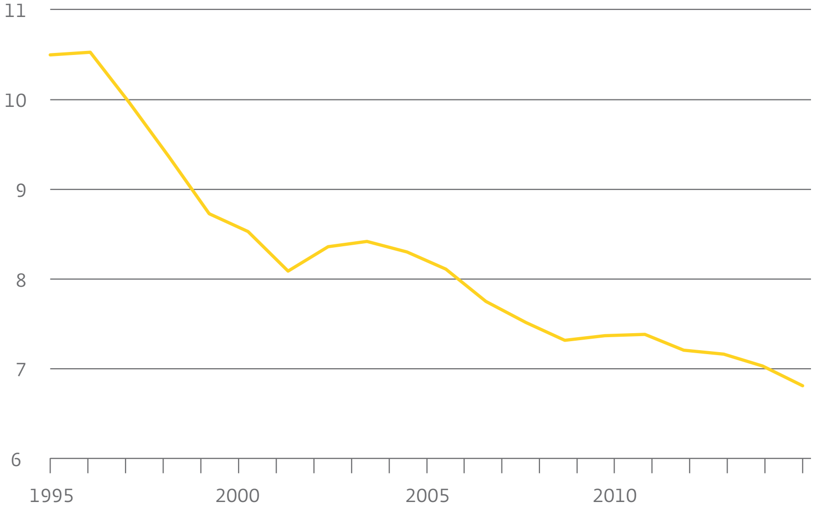
The energy intensity of the Dutch private sector decreased by one third between 1995 and 2014, which corresponds to a decline of approximately 1.5% per year (Chart 2.5).[23] Such a decline could be attributable to energy conservation within industry sectors or to a shift in the sectoral structure to less energy-intensive industry sectors. Own calculations based on a shift-share analysis of 63 Dutch industry sectors revealed that the decline in energy intensity between 1995 and 2014 was entirely attributable to energy

23 The data used here relates to direct energy consumption as a percentage of value added at constant prices (2010) for the private sector excluding energy companies. Energy consumption is calculated on the basis of the input-output tables contained in the national accounts published by Statistics Netherlands.

conservation.[24] In fact, shifts in the sectoral structure resulted in a slightly more energy-intensive economy on balance. This was largely down to a slight increase in the share of the most energy-intensive industry sector: the chemical industry.

Chart 2.5 Energy intensity

Dutch private sector (excluding energy sector), percentage of real gross value added



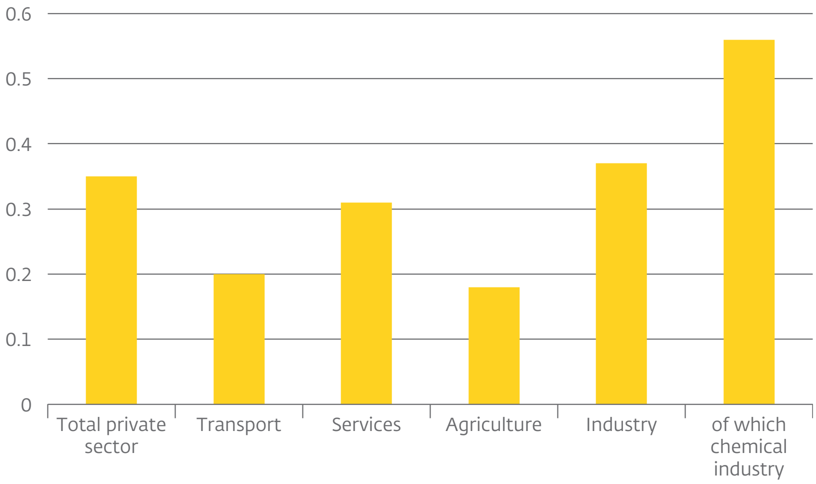
Source: Statistics Netherlands, input-output tables in Dutch national accounts, and DNB's own calculations.

24 Of the total change in energy intensity (-3.6), -3.5 is attributable to the energy conservation effect, while the composition effect increases energy intensity by 0.1 and the interaction term between the sectoral composition and energy conservation is -0.1.

The main causes of the decline in energy intensity are higher energy prices and measures related to climate policy.[25] The sharpest decline has been seen in industrial sectors (Chart 2.6). Energy intensity has fallen sharply, particularly in the most energy-intensive industry sector, namely the chemical industry, where it has more than halved. In industry, the high level of energy intensity means that price incentives designed to promote energy conservation have a relatively strong effect, and the government has also concluded covenants on energy conservation with industry. Moreover, much of industry comes under the European emissions trading system (ETS), which allocates free permits to large industrial businesses if they comply with specific benchmarks for energy-efficient and carbon-efficient production.

Chart 2.6 Energy conservation

Change in energy intensity, 1995-2014



Source: Statistics Netherlands, input-output tables in Dutch national accounts, and DNB's own calculations.

25 IEA (2013) and PBL (2015).

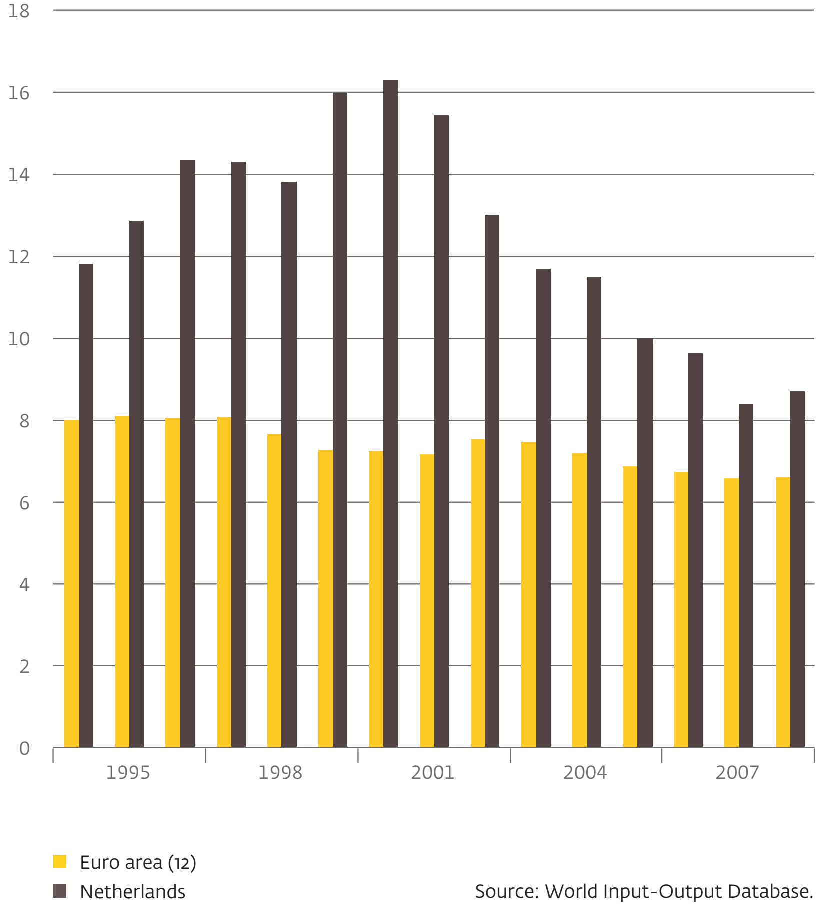
In the agricultural sector, greenhouse farming is responsible for most energy use, which it uses chiefly for heating and lighting. In an effort to retain the reduced energy tax rate, the greenhouse farming sector has committed to achieving energy conservation goals. For a long time energy intensity was declining owing to the growing use of combined heat and power (CHP, also known as cogeneration) and energy-efficient greenhouses, but this has stagnated recently owing to a fall in the use of CHP due to high gas prices and low electricity prices.[26] In the transport sector, vehicle emissions standards and European air quality directives have contributed to a decline in energy intensity. In the services sector, which is the least energy-intensive sector, most energy consumption is related to heating. Insulation measures in particular have contributed to energy conservation in this sector.[27]

26 Thanks to CHP, energy production in the agricultural sector has risen sharply, from zero in 1995 to EUR 458 million in 2014. This fact has not been taken into account in the calculation of energy conservation in Chart 2.6. If it were taken into account (by taking net energy consumption, and not gross energy consumption, as a starting point), energy conservation in the agricultural sector during the period 1995-2014 would amount to 40% instead of 18%.

27 PBL (2015).

Chart 2.7 Energy intensity of Netherlands and euro area

Private sector (excluding energy sector), percentage of real gross value added



Source: World Input-Output Database.

Dutch economy is relatively energy-intensive

Although the Dutch economy has seen a greater decline in energy intensity than the rest of the euro area, it is still more energy intensive than the rest of the euro area (Chart 2.7).[28] Interestingly, at sector level the average intensity of the agricultural sector and the chemical industry is much higher than in the rest of the euro area (Chart 2.8). The high energy intensity of agriculture is due to the fact that the Netherlands is specialised in greenhouse farming, where energy consumption is high. In the Dutch chemical industry, the high level of energy intensity is largely attributable to the energy intensity of the petrochemical industry.[29]

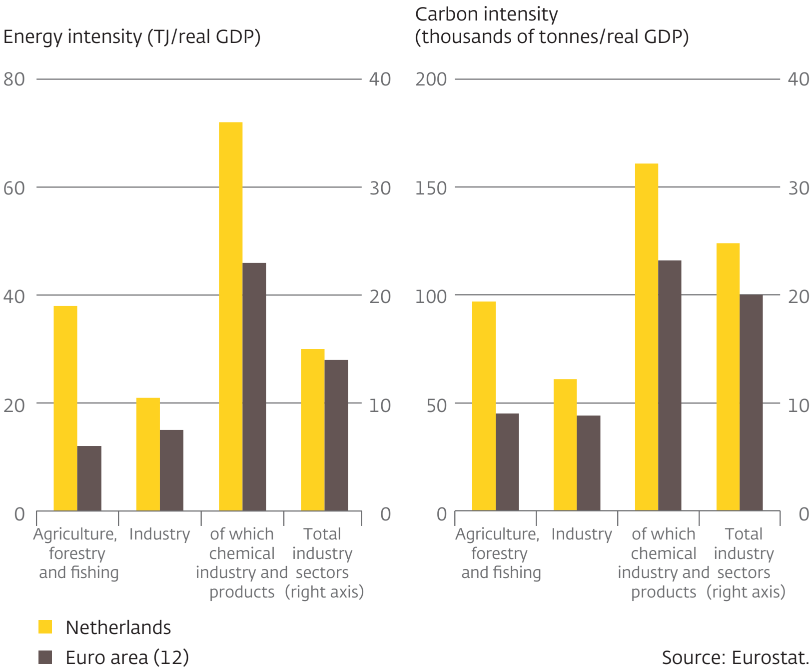
The Netherlands is even more out of step with the rest of the euro area when it comes to greenhouse gas emissions. Owing to the intensive use of fossil fuels (oil and gas, see Chapter 4) and the low share of renewable energy and nuclear power, the Dutch energy mix is relatively polluting compared to the energy mix of the euro area. In 2012, emissions per unit of energy were 18% higher in the Netherlands than in the euro area as a whole. As a consequence, Dutch industry sectors are relatively carbon intensive. This suggests that policy aimed at reducing carbon emissions is able to have a relatively strong effect on the economy (and competitiveness) of the Netherlands.

28 Based on the World Input-Output Database (WIOD). These figures are only available for the years 1995-2009 and do not correspond exactly with the figures contained in Chart 2.7. That said, calculations based on the WIOD data confirm the view that the decline in energy intensity is due to energy conservation and that there has been a shift in the sectoral structure of the economy, resulting in a slightly more energy-intensive economy. Energy intensity is measured here as energy consumption in kilojoule divided by value added in constant prices (in euros).

29 Mulder and De Groot (2011).

Chart 2.8 Energy intensity and carbon emissions, 2012

Percentage of real gross value added



Source: Eurostat.

Fall in energy used by households

In recent years there has been a decline in energy consumption by households, which is mostly attributable to energy conservation. Energy consumption by households consists largely of gas used for heating, petrol used for transport, and electricity used for household appliances. Petrol consumption decreased for many years thanks to more fuel-efficient vehicles (due to stricter EU standards) and stagnating growth in the volume of traffic during the financial crisis.[30] The fact that petrol prices were much higher until recently may also have contributed to the decrease in petrol consumption. In 2015, by contrast, there was an increase in motor fuel consumption for the first time in years, which was caused in part by the fall in petrol prices and the economic recovery.

Gas consumption has been low in recent years owing to the mild winters. In addition, energy conservation has resulted in a structural decline in gas consumption per home. Moreover, electricity consumption stopped rising recently, as a result of European energy requirements for household appliances.[31]

Together, gas, electricity and petrol account for some 10% of consumer spending by households. This share increased from 8% in 2003 to 12% in 2014 as a result of rising energy prices, but fell in 2015 due to lower oil prices. Consumer prices for energy have been considerably less volatile than prices on global markets or wholesale prices. This is because taxes and other specific energy levies make up over half of the total price charged to consumers for energy.

30 No distinction can be made in the figures between petrol consumption for business purposes and petrol consumption for private purposes.
31 PBL Netherlands Environmental Assessment Agency (2015).

Fall in emissions related to Dutch consumption

Besides direct energy consumed by households, energy is also used by businesses in the production of all other products consumed by households. By linking global input-output tables to data on carbon emissions per industry sector, it is possible to estimate the consumption-related emissions, i.e. the amount of global emissions related to total Dutch consumption.[32]

There has been a sharp fall in consumption-related emissions since 2003 (Chart 2.9).[33] This is attributable to declining energy consumption by households and to efforts around the world to limit emissions from the production of consumer goods. Consumption-related emissions fell faster following the onset of the financial crisis, owing to a decline in consumer spending due to the economic situation.

In the case of the Netherlands, carbon emissions released during production exceed consumption-related emissions (Chart 2.9). This is because the Netherlands is a net exporter of goods and services and it also has a relatively carbon-intensive production structure. In this respect, the Netherlands stands out from the other EU15 countries, where consumption-related emissions exceed production emissions (Chart 2.9). Within the EU15, the difference between consumption-related emissions and production emissions grew during the run-up to the financial crisis. Emerging economies such as China produce a relatively large amount of carbon-intensive products because in their stage of economic development manufacturing accounts for a relatively large share of the economy (Chart 2.9). That said, there are signs that climate

32 OECD calculation based on linking IEA data (CO_2 emissions from fuel combustion, 2014) to the OECD Inter-Country Input-Output (ICIO) system. See OECD (2015).
33 The total carbon emissions resulting from total Dutch consumption (including energy consumption) was calculated using global input-output tables. Source: OECD.

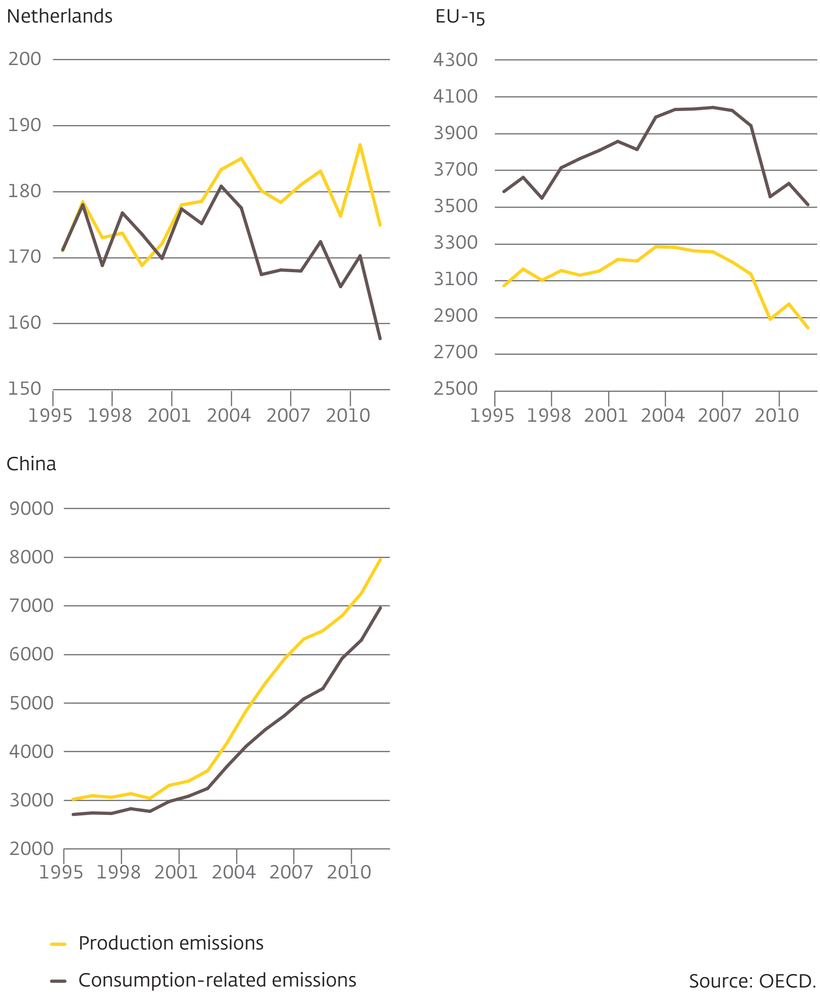
policy, by leading to higher electricity prices, has been partly responsible for production being moved outside the EU.[34] [35]

34 Ecorys (2013).

35 There are also indications that a less strict climate policy can attract foreign direct investment in some sectors (see Poelhekke and Van der Ploeg, 2012). This applies in particular to the mineral extraction, refinery, construction and food sectors. In the case of other sectors, a positive correlation has been found between climate policy and foreign direct investment. This suggests that certain multinationals might be unwilling to invest in countries with little or no climate policy out of concern for their reputations.

Chart 2.9 Carbon emissions

Index: 1995 = 100



Source: OECD.

3 The functioning of energy markets

Energy carriers such as oil, gas, coal and electricity differ in terms of their specific physical characteristics, the way in which they are produced and distributed, and how they are used. The markets for energy carriers are not independent of each other, however, because energy carriers can be substituted for each other to a certain extent. These interactions are strengthened by developments such as growing trade in liquefied natural gas (LNG trading), lower transport costs and stronger connections between countries. Consequently, developments in other countries are having a growing impact on the national energy supply. This dynamic needs to be taken into account in policy focusing on the energy mix.

The global oil market

Oil is easy to transport and store, making it a highly suitable energy carrier for the transport sector. Oil is also used in heavy industry owing to its high combustion temperature, and it is used as a raw material in the production of plastics, for example. Oil can also be used to generate electricity, but this is relatively uncommon owing to the relatively high costs.

The fact that oil is easy to transport means that the oil market is a global market. Generally speaking, the price of oil fluctuates sharply (Chart 3.1). Oil demand and supply are relatively price inelastic in the short term.[36] In the short term, consumers are unable to adjust their oil consumption to a great extent. On the supply side, bringing new sources of oil into production takes time. In addition, as most of the costs of oil production relate to upfront investments (in exploration and infrastructure), extracting oil from existing sources can still be profitable even when prices are down. This implies that following a supply or demand shock prices will have to change substantially in order for rebalancing to be achieved. Moreover, there are indications that

36 Hamilton (2008).

price volatility has increased over the past ten years owing to an increase in financial speculators on the oil futures markets.[37]

Chart 3.1 Brent oil price

Daily figures, USD per barrel

Source: Thomson Reuters Eikon.

37 Beidas-Strom and Pescatori (2014).

Oil is found in a limited number of countries, which makes the oil market vulnerable to geopolitical tensions. In 1960, the most important oil producing countries came together to form OPEC. For many years, OPEC's member countries (and Saudi Arabia in particular) tried to keep the oil price at a stable, high level by maintaining spare capacity and adjusting oil production. Oil producers in non OPEC member countries are mostly private businesses that are price-takers in the oil market and frequently operate at full capacity.

There has been a gradual decline in OPEC's power, however, and currently OPEC member countries produce approximately 40% of the global supply. This figure was 80% at the time OPEC was established. The recent fall in the oil price is partly attributable to the fact that Saudi Arabia is no longer prepared to support the price by limiting production. Instead, the country is trying to force producers with higher production costs out of the market (in particular shale oil producers in the US). Although investments in test drilling and oil extraction have declined in response to the fall in prices, it will take some time for this to result in a fall in production. That said, the production of shale oil in the US could fall in the relatively near future as shale oil sources have a much shorter lifespan than traditional oil wells. In the case of shale oil, extraction rates start to decline after 3-5 years, whereas this decline starts after 9-12 years in the case of traditional oil wells.[38]

Oil demand is linked to actual and expected economic growth to a significant extent. The rise in global oil demand since 2000 was mainly caused by rapid economic growth in China and other emerging economies. There has recently been a slowdown in growth in oil demand from China, which can be attributed to the decline in economic growth and to energy conservation measures.[39]

38 Sandrea and Sandrea (2014).
39 IEA (2015).

The rate of economic growth in China is expected to continue to decline over the next few years.[40] In OECD member countries, demand for oil has been declining for some time, owing to the recession and energy conservation.

Gas markets: flexibility and convergence

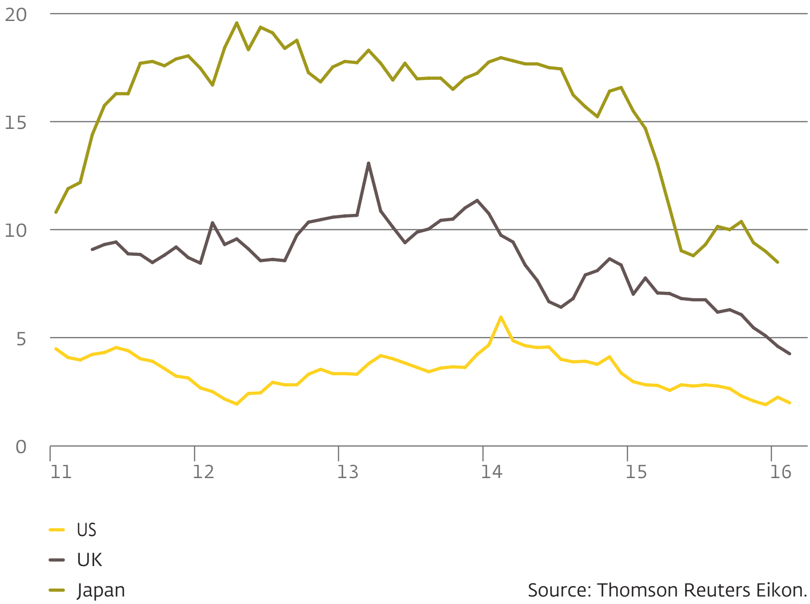
Natural gas is widely used for heating purposes, in industry and to generate electricity. As it is easy to make short-term adjustments to electricity production in gas-fired power stations, gas plays a key role in absorbing fluctuations in electricity production.

There is no global market for gas. Transporting natural gas through pipelines is relatively expensive and inflexible, and this forms an impediment to intercontinental trade. Instead of a global market, there are three major regional markets: Europe/Russia, North America and Asia. Gas prices vary sharply between these regions (Chart 3.2). Historically, gas prices on these markets were fixed in long-term supply contracts and were linked to the oil price. Market liberalisation has resulted in much more flexible prices that reflect market developments (see box 3.1).

40 De Haan and Poelhekke (2016).

Chart 3.2 Natural gas prices

Monthly figures, USD



Source: Thomson Reuters Eikon.

Box 3.1 Ending the link between oil and gas prices

Following the discovery of large natural gas reserves in the Netherlands at the end of the 1960s, it was decided that the price of natural gas would be based on the price of oil. This methodology was subsequently adopted by many other countries. In recent years, however, gas prices have been set in virtual trading points that were launched following the liberalisation of the energy markets. Owing to a sharp increase in the supply of gas (LNG and shale gas in the US), these gas prices started diverging from the gas prices set in long-term supply contracts, which are linked to oil prices.

In Europe, only one third of European gas consumption is still linked to the oil price (European Commission, 2015). In Asia the prices of imported LNG are still largely linked to oil prices in long-term futures contracts, although an increase in gas trading on day-ahead markets (without a direct link to the oil price) has also been seen there.

At the same time, the regional gas markets are becoming more closely interlinked due to the increase in overseas shipping of LNG. Shipping LNG makes it easier to import gas without large-scale investments in infrastructure. The costs of shipping LNG over long distances are becoming competitive compared to those of transporting gas by pipelines.

The most important natural gas producers are the US and Russia, each of which is responsible for approximately one fifth of global natural gas production. The sharp increase in the supply of shale gas in the US has led to relatively low gas prices. The US is now self-sufficient in gas. In Europe, the main gas producers are Norway, the Netherlands and the UK, and gas is also imported from Russia. In Asia, imports of LNG account for most gas consumption. The relatively high gas prices in Asia are linked to the sharp increase in demand for gas in Japan due to the Fukushima nuclear disaster, and to demand from China to fuel its rapid economic growth.

The usage of gas for heating purposes creates an important seasonal pattern. In the EU, gas consumption in the peak winter months is roughly twice as high as in the off-peak summer months. Substantial stocks of gas are stored in Europe during the summer in order to absorb the sharp increase in consumption in the winter. In addition, Dutch production (and Russian production to a lesser extent) is ramped up in the winter months in order to meet the increase in European demand.

Coal market under pressure

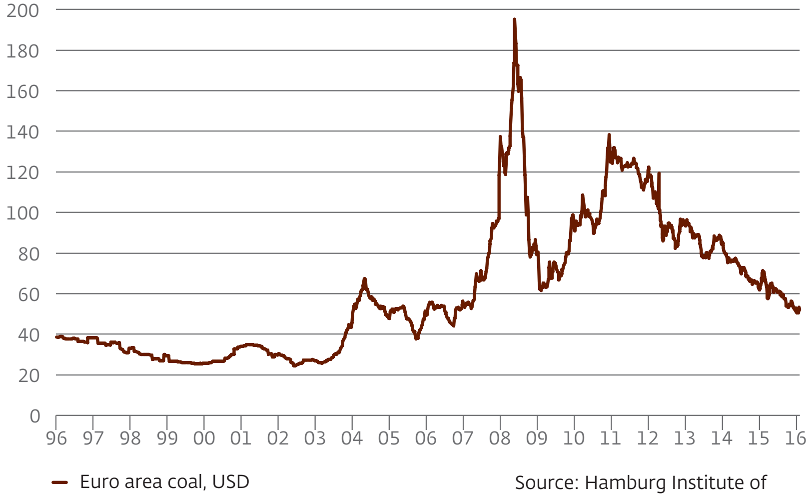
Coal is used primarily in the metal and iron industries (coke) and in electricity production (coal). Historically, most coal markets were national markets. There are over 50 countries with coal reserves, which implies that coal supplies are very secure. Falling transport costs contributed to the sharp increase in international coal trading in recent decades. Today, most EU member states import much of the coal they require as coal extraction is no longer cost-effective in their own countries. The increase in international trade means that coal prices are determined by global developments to an increasing extent. There are roughly two major regional markets: the Atlantic region and the Pacific region. In the Atlantic region, Russia, South Africa and Colombia have traditionally been the largest exporters, exporting mostly to Europe. In the Pacific region, Australia and Indonesia are the largest exporters, exporting mostly to Japan, Korea, China and India.[41]

Coal is mostly traded under long-term futures contracts, although spot markets are slowly growing in importance in this sector, too. Compared with other energy carriers, the trend in the price of coal has usually been relatively stable, with the exception of the sharp price increase seen in 2007/2008 and the subsequent decline in prices (Chart 3.3).

41 IEA (2012).

Chart 3.3 Coal prices

Daily figures, price index: 2010 = 1000



Source: Hamburg Institute of International Economics (HWWI).

As coal is the most polluting energy carrier in terms of carbon emissions, climate policy has a relatively strong impact on demand for coal. As a consequence, demand for coal has fallen in many Western countries.[42] More recently, however, the combination of the low price of carbon emission permits and a sharp fall in coal prices led to an increase in the use of coal in a number of countries, including the Netherlands and Germany (see Box 3.2). The decline in the coal price is partly attributable to the rise of shale gas in the US, which has helped to make the US a major exporter of coal, in particular to Europe.

42 IEA (2014) and IEA (2015).

Box 3.2 'Energiewende'

Germany's energy policy, also known as the 'Energiewende', is based on quantitative targets that are to be met by different parts of the energy system by 2050. The official main goals, from which other goals are derived, include reducing greenhouse gases and phasing out nuclear power. In practice, industry policy and increasing the share of renewable energy play a prominent role.[43] The EEG levy forms an important part of the 'Energiewende'. Suppliers of renewable energy receive a fixed amount for the power they generate, which is subsequently sold on the wholesale market, usually at a lower price. The costs of this are funded by means of a levy included in electricity bills (EUR 16 billion in 2013). Partial exemptions apply for energy-intensive industries. Almost half of the total supply of renewable energy comes from households and cooperatives, which significantly helps to increase support for renewable energy among the public.

Although the 'Energiewende' has resulted in a sharp increase in renewable energy, a number of reservations can be made concerning its success.[44] For example, greenhouse gas emissions have increased in recent years, despite the growth in renewable energy. This increase is linked to a rise in the use of coal owing to the low prices of coal and emission permits. Moreover, adjustments to subsidies for solar panels to reflect the steep drop in costs were not made quickly enough. Consequently, investments in solar energy became lucrative and increased sharply. The costs were higher than necessary due to the excessive subsidies, and consequently the EEG levy had to be increased sharply. The households that profited

43 Boot and Notenboom (2014).
44 Boot and Notenboom (2014).

from the large subsidies were mostly wealthy households, whereas less wealthy households helped to fund these subsidies through the levy included in their energy bills, leading to sizeable redistribution effects that damaged public support for the 'Energiewende'.[45]

In Asia, coal consumption and production has risen sharply in response to economic growth, and today China is the world's biggest user of coal. In China, too, growth in coal consumption is, to an increasing extent, constrained by policy aimed at reducing emissions and improving air quality. As a consequence of this and China's economic transition, in 2014 global coal demand stopped rising for the first time since the 1990s and there was a further fall in the price of coal.

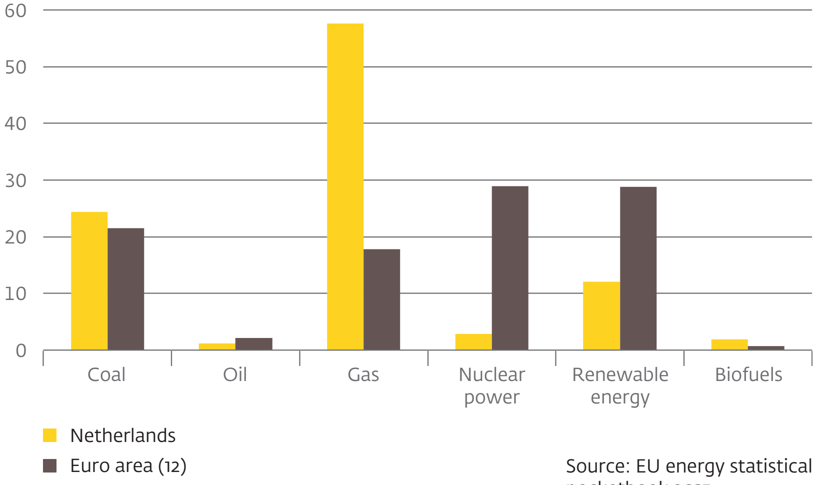
Electricity and renewable energy

In Europe, most electricity is generated using gas, coal, nuclear power and renewable energy (Chart 3.4). In the Netherlands, a large proportion of the electricity supply has traditionally been generated using gas (58%, compared with 18% for the euro area as a whole). There has been a sharp rise in the share of renewable energy in the euro area in recent years, but the Netherlands has not kept pace with this trend (see Chapter 4). Nuclear power plays a key role in the electricity supply in Europe, but it does not do so in the Netherlands.

45 Notenboom and Ybema (2015).

Chart 3.4 Electricity generation by energy carrier, 2012

Percentage



Source: EU energy statistical pocketbook 2015.

Specific characteristics of the electricity market include the fact that demand for electricity must be met at all times in order to avoid power cuts, as well as the high costs associated with storing electricity. These characteristics may cause problems if there is an increase in the production of renewable energy because the possibilities for generating electricity using wind power and solar energy fluctuate sharply in response to changing weather conditions. Moreover, in the case of solar energy, an increase in decentralised generation may lead to coordination problems in the electricity grid.[46]

46 Many ideas exist for ways of using technology to solve these problems: smart grids that can provide consumers with variable price incentives, the use of fuel cells and hydrogen, and the use of batteries in electric cars as spare capacity. Such solutions require technological advances and investments in grids and other infrastructure.

Owing to the high cost of transport and the low level of interconnection between the grids of different countries, within the EU the electricity markets have traditionally operated as national markets. Recently, however, the possibilities for trading between European countries have increased thanks to the construction of physical connections between electricity grids. As a result, the sharp increase in capacity in Germany (due to subsidising renewable energy) has put downward pressure on Dutch energy prices during the past two years.

The investment decisions that electricity suppliers have to contend with are complex. The ratio of fixed costs (capital, land, permits) to variable costs (especially fuel) depends to a great extent on how the electricity is generated. Coal-fired and gas-fired power stations have relatively low fixed costs and high marginal costs. In the case of wind power and solar energy, by contrast, the fixed costs are relatively high but the variable costs are negligible. Nuclear power stations also have high fixed costs and relatively low variable costs. As it can take more than ten years before a power station is operational, and power stations usually have a useful life of many decades, investments in power stations are often surrounded by great uncertainty.

Owing to technological advances and economies of scale, there has been a sharp fall in the cost of electricity generation using wind power and solar energy (fall of 5% and 10% per year, respectively).[47] This trend is expected to continue. As a consequence, generation using renewable energy is becoming increasingly competitive compared to the use of fossil fuels.

47 MIT (2015).

4 Transition to a carbon-neutral energy supply

A radical transition to a carbon-neutral energy system needs to take place in the coming decades if global warming is to be stopped. The Paris climate change agreement reflects the global consensus regarding this goal. The best way of achieving this goal, however, is still the subject of much debate.

This chapter explores the possibilities for shaping the transition to a carbon-neutral energy supply.[48] The first section briefly describes shifts that have previously occurred in the energy system. Next, the intended energy transition and possible ways of reducing carbon emissions are considered. Finally, the relationship between existing Dutch energy policy and the objectives of the Paris climate change agreement is discussed.

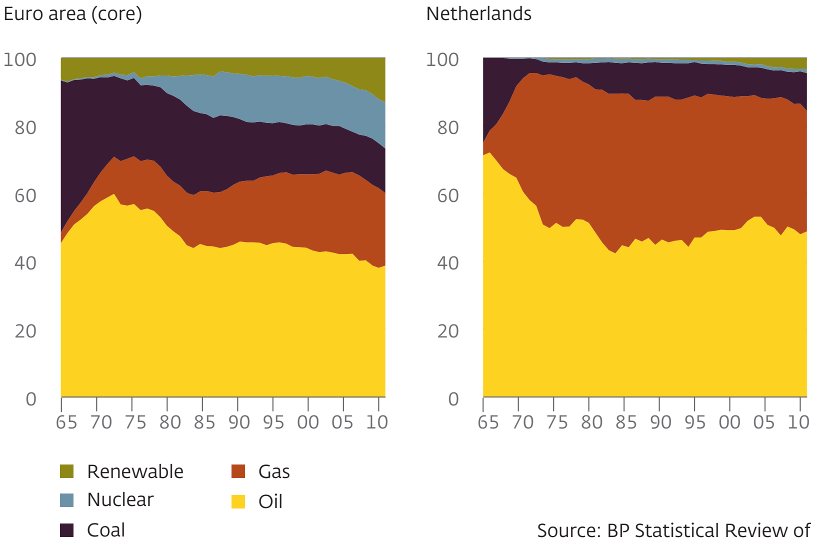
Energy mix constantly in transition

The energy mix is not static. Energy sources can gain or lose importance as a result of economic developments, technological innovations and shifting energy policy objectives. Since the 1960s, the most commonly used energy sources in Europe have been oil and gas (Chart 4.1). The oil crises of the 1970s drew attention to security of supply, which is related to the fact that most oil comes from a small number of regions, which are sometimes unstable. This contributed to the rise of nuclear power in the 1980s. The share of renewable energy has risen sharply over the past ten years. The growth in the shares of gas, nuclear power and renewable energy in the European energy supply has primarily been at the expense of the share of coal.

48 This chapter is partly based on insights obtained during the DNB expert session, 'Risks related to the sustainable energy transition', held on 8 February, and on interviews conducted with various experts in the area of energy policy.

Chart 4.1 Energy mix

Percentage of total energy consumption



Source: BP Statistical Review of World Energy 2015.

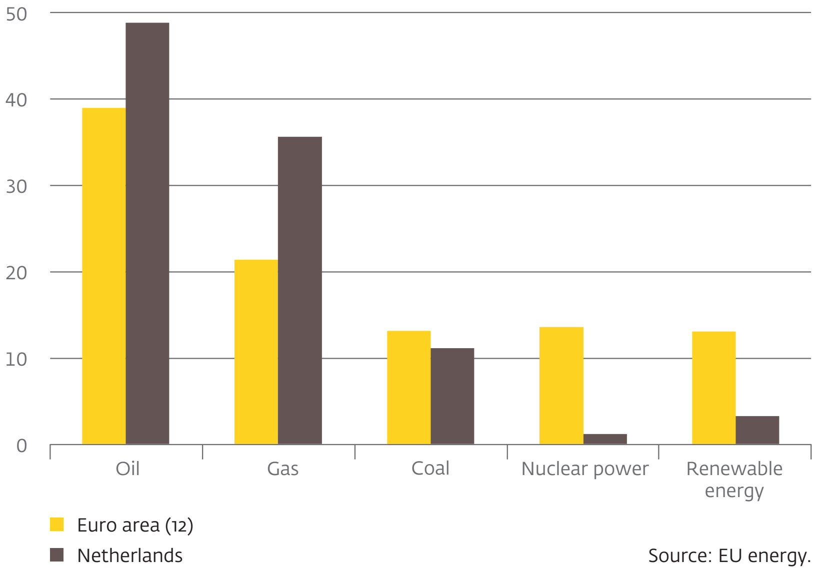
The share of natural gas in the energy mix in the Netherlands is more than one and a half times as large as its share in the energy mix of the euro area (Chart 4.2). Following the discovery of natural gas in Slochteren in the 1960s, major investments were made in gas heating infrastructure and gas-fired power stations.[49] Furthermore, the Dutch energy supply is relatively oil-intensive, which is partly attributable to the chemical and petrochemical industries and the relatively large size of the transport sector. Nuclear power and renewable energy account for a relatively small share of the

49 Statistics Netherlands (2011).

Dutch energy supply. This is due to the fact that gas is widely available, to social preferences and to geographic circumstances. The Netherlands is very flat, making hydropower impossible on a large scale, and it has few thinly populated areas, which means that the construction of windmills and nuclear power stations meets with a great deal of opposition. The share of coal in the energy supply of the Netherlands is slightly lower than the share of coal in the euro area as a whole.

Chart 4.2 Share of energy mix, 2014

Percentages



Source: EU energy.

Combating climate change requires energy transition

Limiting the impact of climate change requires a radical change in the energy mix in the next few decades. Recently, in the Paris climate change agreement, 195 countries agreed to reduce carbon emissions to a level that limits the global temperature increase to well below 2 degrees Celsius by 2100 compared with pre-industrial levels, while urging efforts to limit the increase to 1.5 degrees Celsius (the global temperature has already increased by 1 degree Celsius). Limiting global warming implies that global net carbon emissions will have to fall to zero in the course of this century (see box 4.1).

Box 4.1 Climate targets require net carbon neutrality

The use of fossil fuels releases carbon emissions, which contribute to global warming.[50] Combating climate change can be viewed as an economic trade-off: the costs of climate policy have to be weighed up against the costs of climate change. Global warming is expected to lead to more extreme weather phenomena, such as severe rainstorms and heat waves, damage to the environment and the food supply, and more conflicts and migration. While it is difficult to estimate the precise costs of climate change, it can be assumed that the damage done to natural systems will become catastrophic and irreversible once global warming goes beyond a certain point.[51] The goal of the Paris climate change agreement is designed below this point to ensure a margin of safety.

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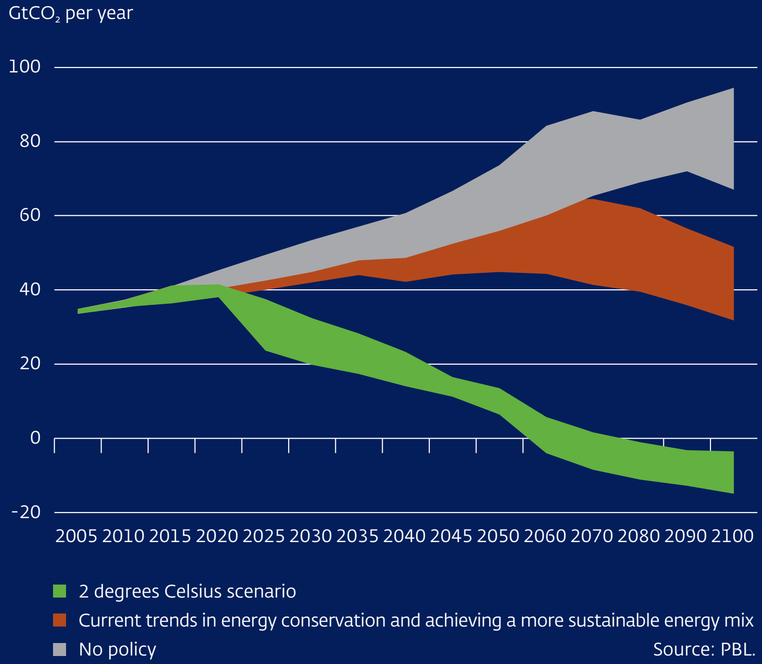
50 Carbon dioxide is the most important greenhouse gas, but it is not the only gas that contributes to global warming. All greenhouse gas emissions need to be reduced in order to combat climate change. The most relevant gas besides carbon dioxide is methane, with emissions coming primarily from livestock farming. Although the level of carbon emissions is much higher than the level of methane emissions, methane has a much higher global warming potential. This study focuses primarily on carbon dioxide in the form of carbon emissions, but methane is also mentioned where relevant.

51 IPCC (2014).

Chart 4.3 Carbon emissions



Source: PBL.

Carbon emissions remain in the atmosphere for a long time. In order to stop further climate change, net carbon emissions (i.e. after capturing or being broken down in nature) will have to fall to zero by a certain moment in time. In other words, the goal of limiting climate change implies that only a small amount of carbon dioxide can still be emitted worldwide. This 'carbon budget' plays a prominent role in the carbon bubble hypothesis (see Chapter 5).

The extent to which carbon emissions need to be reduced in order to achieve the Paris climate change goal is uncertain (see green zone bandwidth in Chart 4.3). Emissions will probably have to peak in the next decade, after which they should decline rapidly.[52] However, if current global trends regarding energy conservation and increasing the sustainability of the energy mix continue, carbon emissions will continue to increase for many decades (brown zone).

This implies that climate policy must be revised substantially in order to achieve the goal.

It should be noted that the carbon emissions referred to are net emissions. Negative emissions are, in principle, possible, as the earth absorbs carbon dioxide at a very slow rate. This process can be accelerated to a limited extent by planting trees, for example.[53] [54] The possibility of negative emissions is relevant as in some cases reducing emissions is impossible or extremely expensive. This is the case when it comes to the aviation industry, some industrial processes, and also the production of methane in livestock farming. The possibility, necessity and costs of negative emissions are dependent on technological advances, and are therefore uncertain.

There is a broad consensus that the ambition of the Paris climate change agreement implies there is a final model in which there is net

52 Tavoni et al. (2015).
53 Various radical ideas have been proposed for removing carbon dioxide from the air or the oceans, for example by means of large-scale chemical or physical processes. The drawback of these ideas (which are often referred to as climate engineering or geoengineering) is that they have not yet proved to be effective on a full scale, and they may also have unknown unintended side effects (IPCC, 2011).
54 Research by the IPCC has concluded that afforestation can reduce carbon emissions by up to 1.1 - 1.6 GT per year (IPCC, 2000). In 2014, global emissions amounted to 36 GT.

carbon neutrality in the second half of this century. There is much less agreement concerning what this final model is and how it is to be achieved. The emission of carbon dioxide is a function of demand for energy and the extent to which such energy is generated in a carbon-neutral manner. Current projections assume a sharp rise in demand for energy in the next few decades, particularly from emerging economies (see Chapter 1 for a discussion of the relationship between demand for energy and the level of economic development).[55] Based on current trends regarding energy conservation and increasing the sustainability of the energy mix continue, the world is a long way from achieving the climate change goal (see brown zone in chart 4.3). In order for emissions to fall to a level that is consistent with achieving the climate change goal, additional emissions linked to further economic growth must be kept to an absolute minimum and a downward trend has to set in quickly. Realistically, it will be necessary to accommodate some growth in emissions in emerging economies. This means that advanced economies will need to ensure emissions start to fall rapidly in the near future. The challenge here is to reduce emissions without directly damaging growth in economic activity.[56] This can be achieved by focusing efforts on energy conservation or making the energy mix less carbon intensive.

Moreover, even if renewable energy production can be increased at the fastest possible rate, this will still not be fast enough to bring about a sustainable trend in emissions on time. The rate at which renewable energy

55 IEA (2015b).
56 Emissions are a function of economic activity, the energy intensity of this economic activity and the carbon intensity of the energy consumed. Emissions can be reduced by adjusting the first factor (i.e. by means of economic contraction), but this strategy is not realistic (see also the discussion at the end of this section). Reducing emissions by adjusting either of the other two factors may harm growth indirectly because of the costs involved, but the impact on growth will be much smaller, particularly if the transition is not too sudden (see Chapter 5 for a detailed discussion).

58 production can be increased is limited by two factors. First, the generation of renewable energy almost always takes place above ground. This has spatial consequences, which are not always socially acceptable and often involve a lengthy planning application procedure. Second, the use of fossil fuels cannot be phased out very quickly. Renewable energy is available almost exclusively in the form of electricity, which only accounts for some 18% of energy consumption (2013 figures). Increasing this share implies a far-reaching electrification of the energy system, including the built environment, transport and industry. This transition will take decades.[57]

Further reductions in emissions are therefore also necessary to achieve the climate change goal even if maximum efforts are made in the area of renewable energy. How to achieve this further reduction in emissions is a subject of debate. One obvious possibility is to make major efforts to reduce energy intensity. The drawback of this is that achieving further energy savings is associated with higher costs, because the easiest savings are achieved first. Given this, some parties advocate the use of bridging technologies, i.e. technologies that, while not sustainable, result in a less carbon-intensive energy mix. The use of bridging technologies is controversial, however, as opponents argue that their use detracts attention from the need to achieve a transition to a genuinely sustainable energy system. In addition, the most important bridging technologies (gas, CCS, nuclear power) have drawbacks or are surrounded by uncertainties.

The least controversial bridging technology is to make as much use as possible of gas, at the expense of oil and coal in particular, within the fossil fuel mix. The advantage that gas offers as a bridging technology is that it is an existing technology and can therefore be expanded rapidly.

57 See IEA (2011). Even in scenarios of rapid technological change, the electrification of the energy supply, in particular the transport sector and heating, will still take decades.

A less certain bridging technology is carbon capture and storage (CCS), a process in which the carbon dioxide released when fossil fuels are burned is captured and stored underground, for example in empty gas fields. So far, this technology has not been applied on a wide scale and is not very cost-effective. The extent to which CCS can make a meaningful contribution in terms of reducing emissions is therefore uncertain. Additionally, there are concerns about the safety of carbon storage. Carbon dioxide is a poisonous gas, and a leak (due to a technical failure, human error, earthquakes or a terrorist attack) could be disastrous. Moreover, if there is a major leak the carbon dioxide could end up in the atmosphere. Although CCS could, in theory, make a major contribution towards reducing emissions[58], these concerns raise questions about the extent to which the use of CCS on a large scale would be accepted by society.

Finally, nuclear power is also frequently mentioned as a potential bridging technology. Public opposition to nuclear power is high, however, owing to the safety risk and issues regarding nuclear waste processing and storage and the decommissioning of power stations. Furthermore, the stringent safety requirements that nuclear power stations have to meet and the complex legal environment make nuclear power relatively expensive.

To achieve the ambitious climate change goal agreed in Paris while accommodating economic growth, major efforts will probably be required in the areas of greater sustainability, energy conservation and bridging technologies.[59] The debate concerning the best mix of these three elements reflects different interests and preferences, and it is a difficult debate to settle because there is considerable uncertainty regarding the technological

58 A combination of bioenergy use with CCS (BECCS) could potentially lead to negative emissions.
59 Boot (2015).

and economic possibilities. From an economic perspective, the best approach would be to minimise the costs of the intended energy transition by not deciding on a solution beforehand. If bridging technologies are excluded from the policy mix, it is likely that achieving the climate change goal will be impossible or will cause serious damage to the economy as in that case emission reductions would have to be achieved by reducing the level of economic activity. While advanced economies are unlikely to be willing to make such sacrifices in terms of their prosperity, there is virtually no chance that poor countries would be prepared to do so.

Dutch energy policy focused primarily on implementing Energy Agreement

The ambitions of the Paris climate change agreement have not yet been translated into specific targets. Within the EU, the member states had already agreed on three key targets for 2020. These key targets related to greenhouse gas emissions (20% cut compared to 1990 levels), renewable energy (raising share to 20% of final energy consumption) and energy efficiency (20% improvement). Furthermore, the EU member states have agreed to cut carbon emissions by 40%, increase the share of renewable energy to 27% and achieve a 27% improvement in energy efficiency by 2030. At a European level, a target of cutting greenhouse gas emissions by 80-95% compared to 1990 levels has been agreed. This target has not yet been translated into specific policy (such as a carbon cap in the ETS).

In the Netherlands, the European targets have been translated into the Energy Agreement between the government, social partners, the energy sector and environmental organisations. The main agreements concern increasing the percentage of renewable energy (to 14% in 2020 and 16% in 2023), improving energy efficiency by 1.5% every year, and creating 15,000 jobs. No national target has been agreed for reducing carbon emissions, however.

The Energy Agreement refers to the ETS (see box 4.2), in which the relevant parties have agreed to lobby for a pathway towards an 80-95% reduction in emissions by 2050. Additionally, it has been agreed that a number of old coal-fired power stations will be shut down, in exchange for which the coal tax will be abolished for electricity production at the same time.

Box 4.2 European emissions trading system (ETS)

Since 2005, the ETS has regulated the emissions of some 11,000 businesses, which jointly account for 45% of European greenhouse gas emissions. Some 450 businesses in the Netherlands are covered by the ETS, most of which are large, energy-intensive businesses in the industrial and electricity sectors. In 2012, aviation also came within the scope of the ETS. The number of emission permits allocated to a business is determined by factors such as past production levels and benchmarks of the carbon intensity of production processes. Industrial businesses that are exposed to international competition are allocated free emission permits if they comply with specific benchmarks for energy-efficient and carbon-efficient production.

Since the introduction of the ETS, the carbon price (i.e. the price of the right to emit one tonne of carbon dioxide) has fallen sharply, from EUR 30 in 2008 to EUR 4 in 2013 (Chart 4.4). Although there was a slight rally in the carbon price recently (rising to EUR 8), it is still extremely low. The low carbon price is linked to a surplus of emission permits. The economic crisis led to a decline in production at many businesses, which automatically resulted in levels of emissions falling below the number of emission permits available. Energy conservation policy has also contributed to the high number of unused emission permits. Moreover, since 2008 it has been possible to 'bank' unused emission permits for use in subsequent years, resulting in the build-up of a large surplus. At the end of 2013, the number of unused emission permits in the market exceeded the total number of emission permits required for all ETS emissions that year. In view of this, the auction of new emission permits in 2014 was postponed. In 2019 a market stability reserve will come into operation that will automatically remove emission permits from the market if there is a surplus of unused emission permits.

Chart 4.4 Emission rights prices in European emissions trading system (ETS)

Price in euros

Source: Thomson Reuters Eikon.

The current low price of emission permits is a problem as it means the ETS is currently failing to act as an incentive for investments in renewable energy and energy conservation. In addition, the sharp fall in carbon prices has contributed to uncertainty about the future price of carbon, which is a further disincentive for investing in renewable energy. Furthermore, the low carbon price in the ETS has led to increased calls for additional policy instruments, such as subsidies and statutory standards. Moreover, the ETS only regulates emissions by a number of specific sectors (industry, energy and aviation), meaning that other instruments have to be used to reduce emissions in the built environment, transport and agriculture.

Achieving these objectives has proved difficult, and so far less progress has been made than had been planned. In 2013, the share of renewable energy in the Netherlands stood at 4.5%, which was one of the lowest shares of all European countries. Although there has been a rapid rise in generation using renewable energy, PBL Netherlands Environmental Assessment Agency (PBL) asserts that the target of 14% in 2020 will probably not be achieved. Delays have arisen, due in part to public opposition to windmills and to projects taking longer than expected. According to PBL, insufficient progress has also been achieved in the area of energy conservation and the target for 2020 seems to be becoming out of reach.[60]

Although the Energy Agreement has increased the pace of the energy transition, the design of the policy can be questioned. The Energy Agreement focuses mainly on derived objectives in the area of energy conservation and renewable energy, and not on the ultimate goal of

60 PBL Netherlands Environmental Assessment Agency (2015).

reducing carbon emissions. The low prices of emission permits and coal have resulted in energy companies using more coal and less natural gas in electricity production, also in Germany (see box 3.2 headed 'Energiewende' in Chapter 3). Despite the efforts made under the Energy Agreement, in the second quarter of 2015 carbon emissions were up 4% compared to one year previously. In this way, the emphasis on derived objectives creates inefficiencies, making the costs of the energy transition higher than necessary. Because there is no unambiguous carbon emissions target or related carbon pricing system, the costs of the different options for energy conservation and changes in the energy mix are not assessed effectively.

Furthermore, the strong focus on short-term targets may result in less attention being paid to the need to achieve further reductions in the long term. The SDE+ grant scheme is a key instrument for achieving targets for sustainability and energy conservation.[61] Businesses and other organisations can apply for grants for renewable energy projects. A limited budget is available (EUR 8 billion in 2016), and grants are allocated primarily on the basis of the extent to which a proposal contributes in a cost-effective manner to achieving the targets for 2020. The benefit of this is that the Netherlands spends less on promoting renewable energy than other countries.[62] The drawback, however, is that in the current set-up grants for rolling out existing cheap technologies are provided at the expense of grants for fundamental research.[63] Although fundamental research does not contribute directly to achieving the targets for 2020, it is crucial for achieving the long-term objective of achieving further reductions in carbon emissions after 2020.

61 The SDE+ grant scheme is funded by a levy on energy consumption. The costs of the scheme are paid for by businesses and households, with both groups paying 50%. As the levy is degressive, businesses that are large energy users provide only a very small amount of the funding.
62 CEER (2015).
63 Boot (2015, pp. 120-122).

The fact that results lag behind expectations increases uncertainty for businesses and investors because it is not clear how much energy policy will change, and what form such changes will take, in order to achieve the objectives. As investments in the energy supply often have a very long life (as much as 40 years in the case of coal-fired power stations, for example), it is important that investors know which types of energy carriers will be permitted in the future and which types will be heavily taxed. A prime example of this is provided by the investment of billions in coal-fired power stations in the Netherlands in recent decades. Even though a number of power stations have just come into operation, a study is currently being carried out to determine whether these power stations will have to be forced to shut down in the near future in order to reduce coal consumption.

The uncertainty faced by businesses and investors has been further increased by the ambitious Paris climate change agreement, which made clear that the targets contained in the Energy Agreement are merely a first step towards more radical policy. The Energy Agreement only covers the period up to 2023, however. That said, the recently presented Energy Report ('Energierapport', Ministry of Economic Affairs, 2016) contains a number of impetuses for a long-term view, such as a stronger focus on reducing carbon emissions. The report does not make any clear choices yet, however, pending a national dialogue with stakeholders.

5 Carbon bubble? Financial risks related to a sudden energy transition

The costs of a gradual energy transition will probably be manageable. The adjustment costs will be much higher, however, if the transition does not start soon enough and has to take place quickly. Moreover, in a scenario where the energy transition is abrupt, there may be a sudden downward revaluation of carbon-intensive businesses. Financial institutions may also be affected by this through exposures in their balance sheets.

This chapter examines the size of this risk to the Dutch financial sector by identifying the exposure to fossil fuel producers and other carbon-intensive sectors.

Risk of a sudden fall in value of carbon-intensive businesses

It is likely that the much-needed energy transition can be controlled if it is able to take place gradually.[64] Different capital goods will be required in a green economy, but most existing capital goods have a replacement ratio that falls within the horizon of a gradual transition. In this scenario, businesses are able to take current climate policy into account when considering new investments. Nevertheless, a great many uncertainties remain, particularly with regard to technological advances (e.g. increasing flexibility/expanding storage options for electricity, CCS).

There is a risk that it will take quite some time for governments and private parties to take action aimed at achieving the climate change goal agreed in Paris. A sudden, forced intervention aimed at imposing a faster energy transition would result in high adjustment costs and, moreover, would cause a negative shock to economic growth.[65] In this scenario, financial institutions are exposed to risk in various ways. First, they may be directly affected by

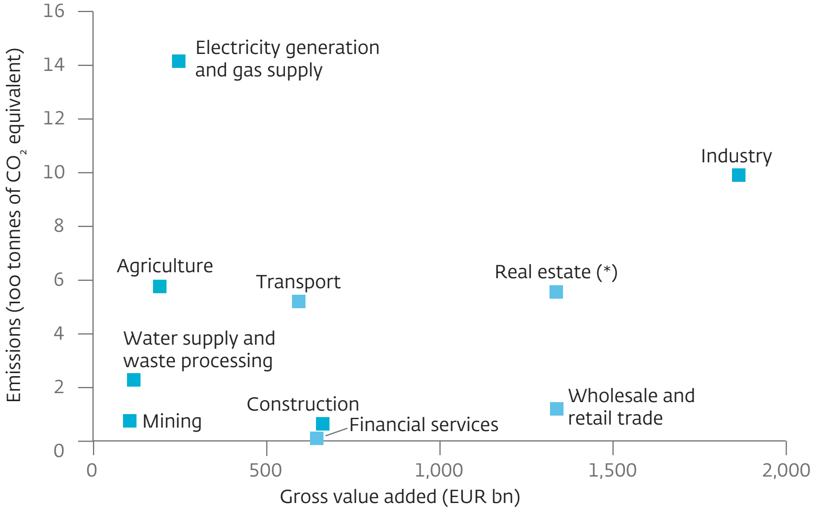
64 Stern (2008) and Acemoglu et al. (2012).
65 ESRB (2016).

a downward revaluation of the carbon-intensive assets in their balance sheets. Second, a sudden transition may be accompanied by a negative shock in the energy supply and an increase in energy costs, which would act as a brake on economic growth in all sectors, including the financial sector. Third, a transition taking place too late may lead to more severe climate change (natural disasters), which may have an impact on insurers and reinsurers, for example.

This chapter contains a detailed discussion of the specific risk of a sudden downward revaluation, or the bursting of a 'carbon bubble', in this scenario. According to the carbon bubble hypothesis, financial markets overestimate the value of fossil fuel reserves because the amount of carbon that can still be emitted is limited by ambitions in the area of climate change (see Chapter 4). If these reserves could no longer be profitably extracted from the ground, they would become stranded assets.[66] The question here is whether the financial markets priced in this development (see box 5.1). Besides reserves, other carbon-intensive assets, such as drilling rigs and distribution networks, may also experience a sudden fall in value. Stranded assets may therefore consist of more than merely reserves. The effect will not be limited to the oil, gas and coal sectors. Businesses active in other carbon-intensive sectors, such as electricity production, heavy industry, agriculture, real estate and transport, may also have to contend with write-offs. Assets that are dependent on fossil fuels, such as coal-fired power stations, blast furnaces or greenhouse farms, may no longer be profitable. Chart 5.1 provides an impression of the size and vulnerability of various sectors.

66 According to estimates made by McGlade and Ekins (2015), a target of limiting global warming to 2 degrees Celsius means that approximately 35% of existing oil reserves, 50% of gas reserves and 90% of coal reserves can no longer be used. This impact may be mitigated in part by the development of bridging technologies, such as CCS, provided there is sufficient public support (see Chapter 4).

Chart 5.1 Carbon emissions and size of sector (EU 28), 2012



* Real estate emissions include heating and cooling of households.

Source: Calculations based on Eurostat data, Schoenmaker and Van Tilburg (2016).

Box 5.1 Have the financial markets priced in new climate policy?

An important question concerns the extent to which the market has already priced in new climate policy. Correctly pricing in climate policy reduces the risk of sudden write-offs. Changes in climate policy, such as agreements reached in Paris, have not yet had a marked effect on the share prices of fossil fuel producers. This effect is also difficult to isolate from other effects, such as falling commodity prices. That said, there has already been a marked change in the value of coal companies (Chart 5.2). This suggests that the reserves and production resources of the most polluting energy producers have already been depreciated.

Chart 5.2 Share price indices: oil and gas companies vs coal companies

Index: 3 January 2011 = 100

Note: These indices are based on CarbonTracker.org's list of the 100 largest publicly traded oil and gas companies and the 100 largest coal companies. They have been calculated on the basis of the underlying value of the relevant equities (weighted), using data published by Bloomberg.

The degree to which writing off reserves and carbon-intensive assets results in the loss of value of the affected businesses depends on how quickly the energy transition needs to take place. In the case of fossil fuel producers, shareholder value depends chiefly on proven reserves, which are used within the next 10 to 15 years.[67] Moreover, most oil and gas reserves are controlled by the governments of oil and gas producing countries. The loss of value of carbon-intensive assets, such as production resources, could have a greater impact on the value of other businesses, owing to the longer useful life of such assets. If the change is sudden, the total loss of value may be significant.

Exposure of Dutch financial sector fossil fuel producers

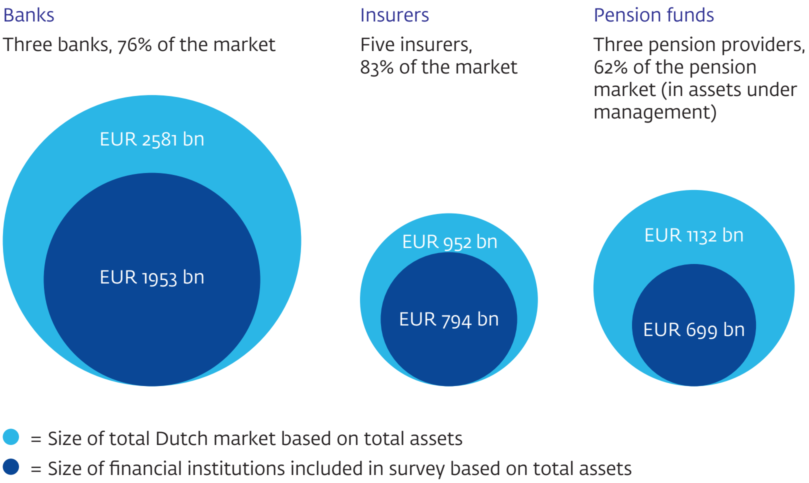
In an effort to estimate the risk that a potential carbon bubble poses to the Dutch financial sector, the exposures of banks, pension funds and insurers to selected sectors were mapped out. Financial institutions submit regular reports to DNB that contain information on direct exposures to the energy sector (oil, coal and gas). In 2014, DNB provided information on this matter in response to Parliamentary questions (DNB, 2014). The picture presented by the regular reports is too limited to provide a full impression of the exposures of institutions to a fall in the value of fossil fuel producers, however. Moreover, less tangible vulnerabilities, such as reputational risk, are difficult to determine precisely. For example, customers and stakeholders may have concerns about some exposures even if these exposures only entail small financial risks.

In order to gain a better picture of the exposures of the Dutch financial sector, at the start of 2016 DNB conducted a targeted survey of the largest banks, pension funds and insurers. Although the survey did not include smaller institutions, it did cover a large portion of the Dutch financial sector (Chart 5.3).

67 Meyer and Brinker (2014).

Discussions were also held on financing and investment policy and on ways in which institutions take climate change into consideration.

Chart 5.3 Survey sampling among financial institutions

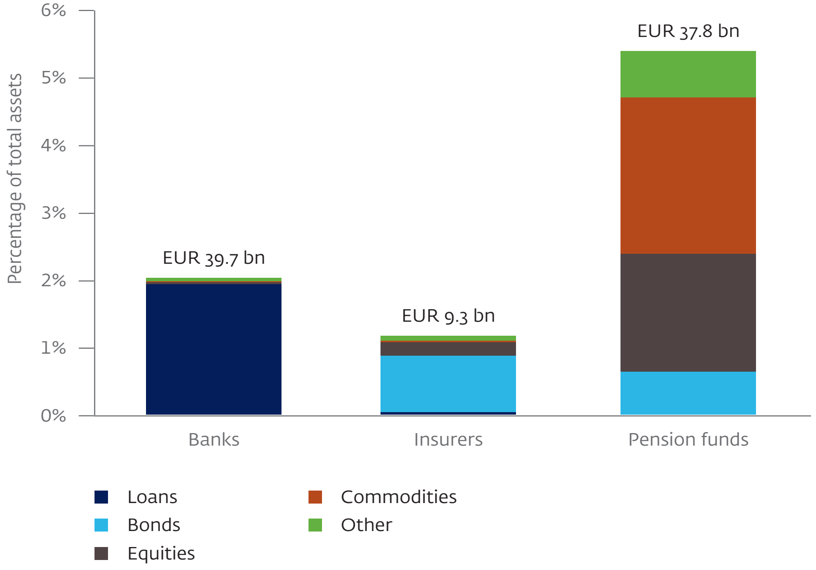


Note: The reference date of the reported data is 30 September 2015. Total assets are reported for banks and insurers. The reported data for pension funds consists of the total assets under management of the three largest pension providers that focus primarily on the Dutch pension market. Besides managing their own investments, the insurers manage investments for third parties. Third party monies not recognised in an insurer's balance sheet have not been included in the exposures shown above as the insurer is not the party chiefly exposed to the risks related to such investments.

The exposures to fossil fuel producers (oil, gas and coal) that were asked about in the survey cover the entire value chain. This category therefore consists of oil and gas companies as well as their suppliers and service providers, coal mining companies, and directly related infrastructure (such as pipelines). Chart 5.4 provides an overview of exposures to this sector.

Chart 5.4 Exposures to fossil fuel producers, broken down by asset class

Percentage of total assets, institutions covered in survey

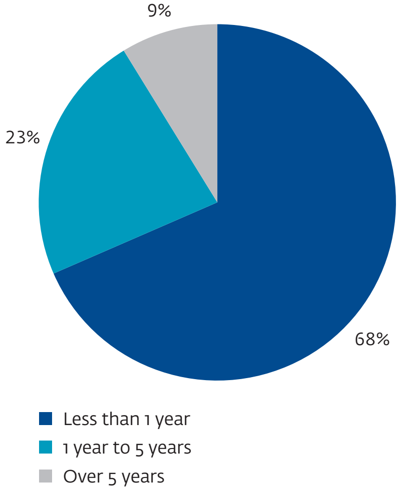


Note: 'Loans' consists of traditional corporate loans and trade finance to parties engaged in fossil fuel trading. 'Equities' consists of investments in equities, equity funds and derivatives. 'Bonds' consists of corporate bonds and bonds issued by state-owned companies. 'Commodities' consists of direct investments in commodities, futures contracts and fund investments in commodities. 'Other' consists primarily of investments in private equity, hedge funds and public/private infrastructure investments.

Banks are involved almost exclusively as lenders. Generally speaking, the loans currently have a low risk profile. A large proportion of the loans (approximately 50%) concern trade finance with a very short term and for which security (e.g. collateral) is provided. The risks related to project financing are also clear-cut: the terms are short (often no more than five years) and the loans are usually senior loans secured by collateral. This means a low risk for lenders, even in the case of loss-making projects. Chart 5.5 shows the terms of bank loans to oil, gas and coal producers.

Chart 5.5 Terms of bank loans to producers of fossil fuels

Total outstanding loans = EUR 37.9 bn



Insurers mainly have exposures to fossil fuel producers in the form of corporate bonds. The total investments amount to 1.2% of aggregate total assets. As a consequence, insurers are significantly less exposed to fossil fuel production than banks and pension funds.

Pension funds invest in the equities and bonds of businesses active in fossil fuel production, and in private equity, hedge funds and infrastructure investments (in Chart 5.4 these are included under ‘Other’). Pension funds also have substantial investments in commodities. This makes them more sensitive to downward risks than banks and insurers. On the other hand, it is also easier for pension funds, and harder for banks and insurers, to capitalise on the upward potential of businesses that benefit from climate policy. Currently, however, such businesses make up only a small proportion of the portfolios of pension funds (direct investments in renewable energy account for approximately 0.3% of total assets).

Finally, the survey also asked about exposures in the form of government bonds and related bonds (bonds issued by state-owned companies) issued by a selection of oil, gas and coal producing countries.[68] The government budgets of these countries are the most heavily dependent on income from fossil fuels. These exposures are small: the combined exposure of all institutions included in the survey is EUR 2.1 billion.[69]

Exposure of Dutch financial sector to carbon-intensive sectors

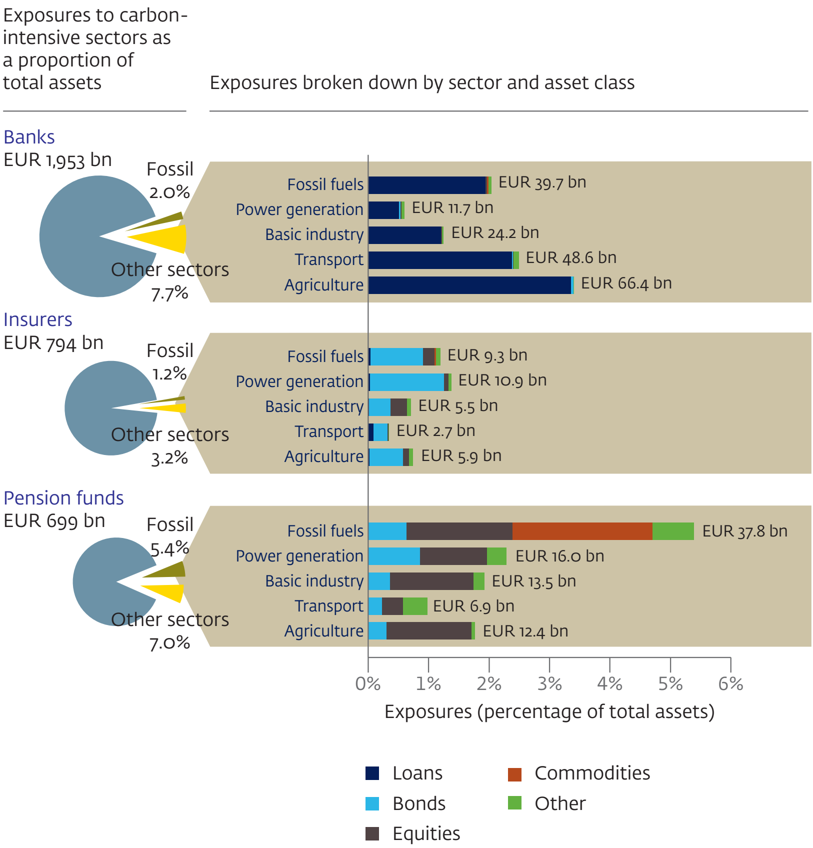
The survey also covered exposures to a number of carbon-intensive sectors (Chart 5.6). These sectors are power generation (in particular electricity companies), basic industry (chemical, cement, metal and mining, paper and pulp[70]), transport and agriculture. In the case of banks, and insurers to a lesser extent, the exposures to these sectors are much larger than the exposures to fossil fuel producers. Banks are once again almost exclusively involved as lenders, whereas insurers invest primarily in corporate bonds.

68 The selection was based on the list published by the IMF (2015), supplemented by own calculations, and consists of the following countries: Algeria, Angola, Azerbaijan, Bahrain, Iran, Iraq, Kazakhstan, Kuwait, Libya, Nigeria, Oman, Qatar, Russia, Saudi Arabia, Turkmenistan, United Arab Emirates, Venezuela and Yemen.

69 The exposures of banks, insurers and pension funds amount to 0.03% (EUR 495 million), 0.04% (EUR 344 million) and 0.18% (EUR 1,269 million), respectively, of total assets.

70 Half of all global direct emissions in the industrial sector are produced by chemical, cement and metal producers and mining companies (IPPC, 2014).

Chart 5.6 Exposures to carbon-intensive sectors as a proportion of total assets, broken down by sector and asset class



Note: 'Fossil fuels' consists of exposures to oil, gas and coal producers, as well as direct suppliers (e.g. the offshore industry) and services, direct distribution channels (e.g. pipelines) and fossil fuel traders. 'Power generation' consists of exposures to electricity generation using fossil fuels. 'Basic industry' consists of exposures to the chemical, cement, metal and wood/paper industries. 'Transport' consists of exposures to aviation, road transport and maritime transport (rail transport has not been taken into consideration due to its low carbon intensity). 'Agriculture' consists of exposures to producers of agricultural products (arable and livestock farming) and packaged foods (fisheries have not been taken into consideration due to their low carbon intensity).

Pension funds also have substantial exposures to electricity companies, although these exposures are not as large as the exposures to fossil fuel producers.

These sectors will probably have to make major changes as part of the wider process of transitioning to a sustainable energy supply. Given the size of the exposures, this could potentially involve substantial risks.

It is conceivable that climate policy could also affect real estate valuations. Increasing attention is being paid to assessing the energy efficiency of real estate projects, because such projects run the risk of being impossible to let or sell if energy efficiency requirements become stringent. In order to better understand these risks, the survey asked about the financial institutions' exposures to real estate with a mediocre to poor energy label (D to G). Two banks and one pension fund were able to provide some initial information, which revealed that a significant portion of their real estate portfolio could be affected by climate policy. This is because some 43% (EUR 74 billion) of the collateral (mostly in the form of mortgages) of the real estate portfolio for which the energy label is known (EUR 171 billion) has a mediocre to poor energy label (D to G).

Based on the existing exposures of the Dutch financial sector, very few predictions can be made as to which vulnerabilities may arise if, during the transition process, sectors that cannot be directly linked to fossil fuel consumption are also affected. Eventually, all sectors may have to contend with adjustment costs. While it is difficult to quantify such indirect risks at this moment in time, in the case of the Netherlands such risks could be sizeable because the Dutch economy is relatively energy intensive (see Chapter 2).

Energy transition as part of risk management at institutions

To what extent do institutions take account of the risks of a carbon bubble in their risk management? Generally speaking, as far as their existing exposures are concerned, financial institutions do not believe there are any major risks related to climate policy that take the form of a carbon bubble. Although it is widely acknowledged that climate policy will be stepped up in the next few decades, financial institutions see this as a gradual process that they can respond to. They also expect that fossil fuels will continue to be required for the next few decades, although they expect there will be a shift from coal and oil to gas.

Nevertheless, when new investments and loans are made, climate risks are taken into consideration as part of a wider risk assessment. Institutions run reputational risk if customers and other stakeholders have concerns about certain exposures. Moreover, liability risks may arise due to claims for damages being presented to parties held responsible for climate change, for example in their role as financiers. Several large pension funds have announced that they intend to invest in a more sustainable manner, while the Dutch banks recently issued a climate statement (Dutch Banking Association, 2014). Insurers are also responding, because in their role as asset managers they have to deal with clients (including pension funds) that want to invest in a more sustainable manner.

Institutions currently still consider investments in renewable energy projects to be risky. The supply of such projects is limited, and returns are largely dependent on government policy, which is currently considered to be too unpredictable in many countries. In addition, many countries provide subsidies for the use of fossil fuels, which could undermine the effectiveness of stimulus measures aimed at promoting renewable energy.

Implications for rule-makers, supervisory authorities and market participants

Enabling the financial sector to mitigate transition risks requires that government policy is timely and predictable and that there is more transparency concerning such risks. This will enable affected businesses to adjust their investments gradually, and hence avoid excessive loss in value. It is also important that government policy is consistent and not subject to ad-hoc changes, which can suddenly render sustainable investments unprofitable, for example.

Climate risks need to be made more transparent so that the transition process can be structured properly. This requires that there are unambiguous standards, which need to be applied by all relevant parties and also help to price climate risk more realistically. The work of the FSB task force headed by Michael Bloomberg, which is scheduled to come up with proposals for reporting on climate risk by businesses in late 2016, will make a useful contribution in this area (see box 5.2).

Box 5.2 Towards a single international disclosure standard for climate risk

The lack of transparency regarding the extent to which businesses are exposed to climate risks makes it difficult to form a good picture of these risks. Climate risks will change due to climate policy and to changes that businesses decide to make in preparation for the changeover to a sustainable economy. Greater transparency is crucial for policymakers and investors, and also helps to bring about a gradual transition.

A great many standards currently exist for disclosing exposures of businesses to climate change, but they are difficult to compare with one another. The development of a single generally accepted disclosure standard should solve this problem.

In response to a request from the G20, the Financial Stability Board (FSB) established the Task Force on Climate-related Financial Disclosures at the end of 2015. This task force consists of representatives from the private sector and is chaired by Michael Bloomberg. Its first task is to decide on the precise scope of the climate change disclosure standard and which businesses will be required to report information. Possible elements include a carbon footprint disclosure standard for businesses and a description of measures taken by businesses in the context of the transition to a sustainable economy. The task force intends to present its recommendations by the end of 2016.

Such reports by businesses on their carbon footprints and planned changes, for example, should make it easier for financial institutions to take climate risks into consideration in their lending operations and when selecting investments. Given the uncertainty surrounding the energy transition, an option could be to develop stress tests, using improved data, that focus specifically on climate risks. Where necessary, the supervisory authority may impose capital requirements or exposure limits based on these stress tests. Besides the possible risks to financial stability, there may also be concentration risks at individual institutions that need to be followed up by the supervisory authority.

The financial sector can play a facilitating role in making the economy more sustainable by imposing criteria for carbon-intensive industry. For example, financial institutions, as shareholders, may set criteria for the businesses they invest in, and in this way they can mitigate the risks related to an energy transition.

6 Conclusions and policy recommendations

The Paris climate change agreement has shifted the question from whether there will be a transition towards sustainable energy systems to how this transition should be brought about. The debate regarding this question is far from being settled owing to uncertainty regarding the technological possibilities, and, furthermore, painful choices need to be made. The ambition of limiting global warming to less than 2 degrees Celsius implies that the transition to a carbon-neutral economy must be completed well before the end of this century, i.e. within the expected service life of the homes and offices we are building today.

As yet, the world is far removed from that objective. In recent years, the link between energy consumption and economic growth has clearly been broken, but only a fraction of the energy used is generated sustainably. Carbon emissions recently rose again after several years of decline. The Dutch economy specialises in carbon-intensive processes, making it vulnerable to climate policies, which might damage its competitiveness. In addition, the more rapid the transition, the greater the likelihood of abrupt adjustments.

Importance of long-term view

In view of the above, it is important to start down a plausible and practicable path towards a carbon-neutral economy in good time. Investors and businesses currently face a great deal of uncertainty, as it is unlikely that the short-term targets in the Energy Agreement will be achieved and the ambitions of the Paris climate change agreement have not yet been translated into policies. There needs to be a long-term view on the intended transition that specifies clear goals and transition paths for various sectors, and devotes attention to infrastructural issues (electrification of energy systems, integration of sustainable generation).[71] A consistent, plausible long-term policy enables businesses and households to gradually adjust their investments, preventing excessive loss in value.

Ideally, such a vision also encompasses an innovation agenda shaping the future of the most energy-intensive sectors (chemical, agricultural and metal) in a carbon-neutral economy. It is not a matter of removing such activities from the Netherlands or Europe; the question is, rather, how those sectors can make the intended transition without loss of value added or employment. Considered from this perspective, launching a long-term strategy may even create opportunities: the first businesses that are able to complete the transition may end up as future winners.

A long-term view could also guide the public debate about power generation. Although renewable energy is popular when considered in abstract terms, in practice matters are more problematic. There is public opposition to onshore wind power generation and to bridging technologies such as CCS and nuclear power. Ruling out or limiting these options in advance may mean that the ambitions of the Paris climate change agreement can be realised only through energy savings that have a significant impact on economic activity. Whether large sections of the population are prepared to make such a sacrifice remains to be seen.

71 As part of this, consideration could also be given to creating a statutory basis for a long-term target for climate policy. In neighbouring countries such as Germany and the UK, such long-term targets prove helpful in setting priorities and streamlining national policy for the energy transition.

Cost-effective policy to reduce carbon output

The intended energy transition presents a major task for society. It is particularly important that climate policy costs are minimised. To achieve this, greater emphasis must be placed on emission reduction as the fundamental objective. In addition, the existing policy mix in the Netherlands (and Europe) has focused mostly on derived objectives, such as energy conservation and increasing the share of renewable energy. While these options should not be ruled out, they need to be incorporated into a more comprehensive strategy in which the emissions target is put first.

There is a broad consensus that adequate carbon pricing is essential to achieve this focus on reducing emissions. In addition, supplementary policy (covenants and subsidies) can be used to help guide the transition and encourage desirable developments, such as the development of new technologies. This supplementary policy must be designed in a way that enables adequate carbon pricing, e.g. by combining subsidies with the withdrawal of emission permits from the market.

Adequate carbon pricing requires a reform of the ETS. The market stability reserve, which will come into operation in 2019, may help to provide businesses and investors with greater certainty regarding the carbon price. This is a step in the right direction, but more is needed in order for the ETS to work properly. One option is to speed up the rate at which the carbon cap is reduced, in line with the ambitions of the Paris climate change agreement. The carbon cap can also be adjusted downwards if emissions fall more quickly than expected. This would mean supplementary policy would not be affected by the 'waterbed effect' to the same degree. Benchmarks used as a basis for allocating free emission permits should also be adjusted more quickly.

In the case of industry sectors that currently fall outside the scope of the ETS, carbon pricing is probably the most effective way of reducing emissions. Emissions could be reduced either by making the relevant businesses subject to the ETS or by means of a direct tax on emissions. A first step could be to revoke exemptions from energy tax for large energy users. This will require European agreements to prevent tax competition and create a level playing field for European businesses.

Transparency concerning risks

Finally, it is vital that climate risks are made more transparent. Although a scenario of controlled transition would appear to be feasible, provided that the first steps are taken soon and all available technologies are used, the uncertainties are quite substantial. Furthermore, it is currently unclear whether the ambitions of the Paris climate change agreement will effectively be transformed into a global energy transition on time. Therefore, there is a risk that the transition is abrupt or – worse – may not happen at all.

Clarity about the exposure to this risk requires unambiguous standards, which need to be applied by all relevant parties and help put a realistic carbon price on climate risks. Detailed carbon footprint reports and energy transition plans will make it easier for financial institutions to take climate risks into account during the transition process.

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