Energy consumption

Energy consumption in mainland Norway

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RAPPORT

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Preface

Energy consumption is a broad topic that can be difficult to grasp in all its complexity and scope. In this report, the Norwegian Water Resources and Energy Directorate (NVE) aims to describe the key development trends in energy consumption in mainland Norway and to explain commonly used energy consumption concepts and terminology. The purpose of this report is to provide the reader with a better understanding of the energy consumption in Norway.

The Norwegian Water Resources and Energy Directorate is planning regular future editions of this report, dealing with relevant issues within energy consumption. We hope that readers find this report both useful and informative.

Oslo, March 2012

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Glossary

Term	Explanation
NVE	Norwegian Water Resources and Energy Directorate
Energy consumption	Consumption of all types of energy products (electricity, district heating, oil, gas etc.)
Electricity	Electrical power, electrical energy
Final energy consumption	Energy consumed in buildings, industry and transport in mainland Norway. Excludes energy consumed in the energy sector.
Gross energy consumption in mainland Norway	Total of final energy consumption and energy consumption in the energy sector.
Energy sector	Producers, distributors, retailers etc. of energy, oil, gas, district heating, electrical power etc.
Petroleum sector	Producers, distributors, retailers etc. of oil, gas and refined petroleum products.
Stationary energy consumption	Energy used in buildings, industrial processes and in the energy sector.
Energy consumption in transport	Energy for motorised vehicles and means of transport.
Transport	All types of passenger and goods transport, both private and commercial.
Energy-intensive industry	The metals industry, chemical products and pulp and paper industries.
Other manufacturing industries	Non-energy-intensive industries.
General consumption	Energy/electricity consumption in households, service industries, primary industries, building and construction and other manufacturing industries.
Temperature-corrected energy consumption	Actual energy consumption corrected to what it would have been under 'normal' year outdoor temperatures.
Smart metering (AMS)	Advanced metering and management system
Energy intensity	A measure of the amount of energy used per unit. For example, energy consumption per person.

Summary

The purpose of this report is to describe trends in energy consumption in mainland Norway, with an emphasis on key trends within the largest consumer groups[1]. We also explain common terms and concepts in the field of energy consumption. Finally, we look at forecasts for future energy consumption, produced by bodies outside NVE.

Total final energy consumption in mainland Norway in 2009 was 207 TWh. The most important end-user groups are households, service industries, manufacturing industry and transport. In addition, the energy sector in mainland Norway[2] consumed 15 TWh. Energy consumed in the energy sector is not considered as final consumption, as the energy is used to produce new energy products. The long-term trend in energy consumption in mainland Norway is that fuel in the transport sector and electricity for the energy sector increases, while energy consumption in other sectors flattens out.

The main reason for an increased use of fuel in the transport sector is the rise in the number of motorised machinery and vehicles inmainland Norway. This has caused a rise in gasoline and diesel consumption of 75 per cent since 1976. The petroleum sector is the largest consumer of energy within the energy sector in mainland Norway, and electricity from onshore to platforms in the North Sea and to new shoreside installations has led to a rise in electricity consumption from 1 TWh in 1995 to 5 TWh in 2009.

The energy consumption in households showed a flat trend from 1996 to 2009, after many years of growth. The main reasons are a warmer climate, higher energy prices, the use of heat pumps and more energy-efficient buildings. In the service industries, the growth in energy consumption has slightly decreased since the late 1990s, for much the same reasons as for households. In manufacturing industries the energy consumption have flatten out mainly due to the closure of energy-intensive businesses and the establishment of new more energy-efficient businesses.

Electricity is the most used energy products in Norway, covering more than 70 per cent of the energy consumption for stationary purposes in mainland Norway.Stationary purposes means consumption in households, commercial buildings, manufacturing industry and the energy sector, as opposed to transport, which is referred to as a mobile purpose. In addition to electricity, consumption of gas has also increased substantially since the mid-1970s. In mainland Norway, gas is used primarily in industry and the petroleum sector. Theconsumption of heating oil has however decreased heavily and has been replaced by electricity and district heating.

NVE does not produce forecasts of energy consumption, but analyses carried out by other bodies point to a future trend in stationary energy consumption in mainland Norway that is comparable to recent trends. It is expected a continuing flat trend in energy consumption in households and manufacturing and a low growth in energy consumption in the service industries.

In housing and commercial buildings, it is expected that energy efficiencies and strict new building regulations will bring about a significant future reduction in energy consumption per square metre. In manufacturing industries, it is expected that industries such as wood processing and ferroalloy production will find conditions more challenging, while industries such as silicon metal production will grow, resulting in a net flat trend in future energy consumption in the sector as a whole. In the petroleum sector, on the other hand, continued growth in electricity consumption is expected in the next few years, due to the electrification of new platforms and enlargement of existing shoreside installations.

[1] The time series used in the report primarily cover the years 1976 to 2009, which is the period for which we have complete figures.
[2] The energy sector in mainland Norway includes the production of electricity, the production of district heating, shoreside installations in the petroleum sector, refineries and oil and gas platforms that take power from onshore.

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1 Energy consumption in mainland Norway

Total final energy consumption in mainland Norway in 2009[3] was 207 TWh. In addition, the energy sector in mainland Norway[4] consumed 15 TWh. The long-term trend is that the consumption of fuel for the transport sector and electricity for the petroleum sector increases, while energy consumption in other sectors flatten.

1.1 Gross energy consumption in mainland Norway

Gross energy consumption in mainland Norway includes final energy consumption and energy used for producing other energy products. Energy used for international sea and air travel and own-produced energy on the Norwegian Continental Shelf are not included. Final energy consumption is energy for lighting and heating in houses and commercial buildings, for the manufacture of goods in industry and for domestic transport. Energy consumed in the energy sector is not considered to be final consumption, since the energy is used to produce new energy products.

Total energy consumption in mainland Norway in 2009 was 222 TWh, which is an increase of 40 per cent since 1976. From Figure 1.1 it is apparent that energy-intensive industry, households and the transport sector are the largest consumers of energy in Norway, and that the largest increase in energy consumption is in the transport sector. Increasingly more installations in the petroleum sector have been electrified in recent years, which has led to greater energy transfer from the mainland to the energy sector. In this report, energy consumption in commercial buildings, in building and construction, and in works buildings in primary industries is merged with energy consumption in the service industries.

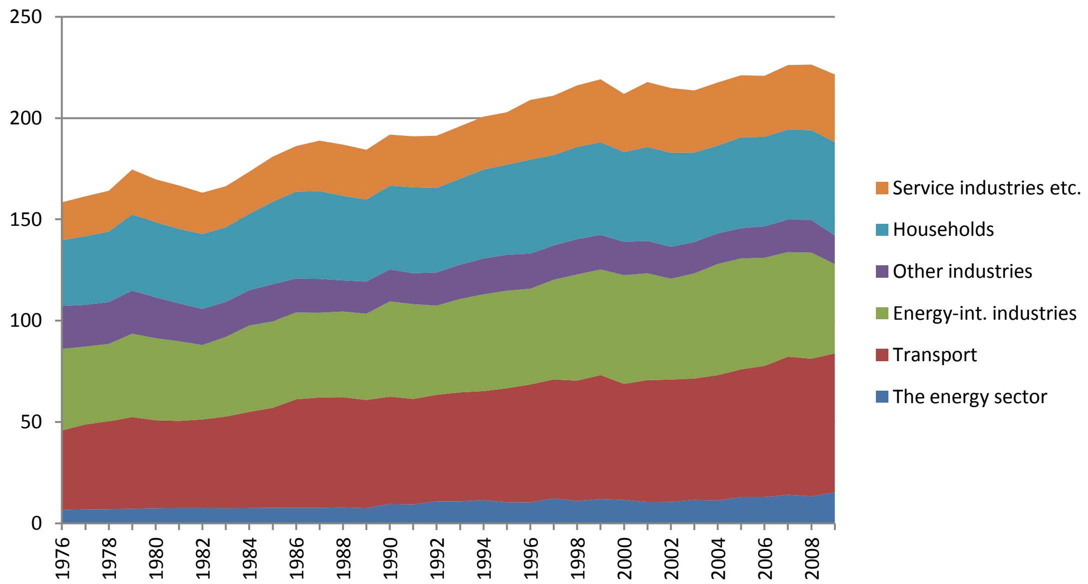

Figure 1.1 Energy consumption by sector in mainland Norway. 2009. Source: Statistics Norway/NVE

[3] Final energy consumption corresponds to domestic final energy consumption in Statistics Norway's Energy Balance Sheet, excluding energy consumed as a raw material.
[4] The energy sector in mainland Norway includes the production of electricity, the production of district heating, shoreside installations in the petroleum sector, refineries and oil and gas platforms that take power from onshore. Energy products consumed as raw materials for producing new energy products (conversion) are not included. See the Energy Balance Sheet.

When we talk about energy consumption in this context, we mean gross consumption of all types of energy converted to kWh. Energy products can be divided into seven main groups: electricity, district heating, heating oil, coal, gas, bioenergy and gasoline/diesel. The first six of these are mainly used in buildings and industrial processes, while gasoline and diesel are used as fuel for transport.

Box – energy content:

In order to compare energy products, all energy products are converted to kilowatt hours (kWh). For energy products other than electricity and district heating, we calculate the energy content on the basis of the theoretical energy content of the energy product. The energy content of an energy product will vary, but Statistics Norway uses average values to convert to kWh. Below are the conversion factors for the most used energy products. Electricity and district heating are sold in kWh.

Coal and coke	7,800 kWh/tonne
Natural gas	11,800 kWh/1,000 Standard cubic metres (Sm^3)
Gasoline	12,200 kWh/tonne
Diesel and light fuel oil	12,000 kWh/tonne
Wood fuel	4,800 kWh/tonne = 2,200 kWh/solid m^3

Energy consumption in mainland Norway is divided in four primary purposes. Three stationary purposes: buildings, industrial processes and the production of energy products, and one mobile purpose in the shape of transport. Buildings includes lighting, heating and electrical equipment in houses and commercial buildings. In 2009, 83 TWh were used for this purpose, corresponding to 37 per cent of domestic energy consumption. Industrial processes include the production of manufacturing goods, and 55 TWh were used for this purpose in 2009. Energy products approximating 15 TWh were used to produce energy products in mainland Norway in 2009, the majority in the petroleum sector. The last primary purpose includes fuel for all types of motorised vehicles and means of transport in mainland Norway. This consumed 69 TWh, corresponding to 31 per cent of all energy consumption for this purpose in 2009.

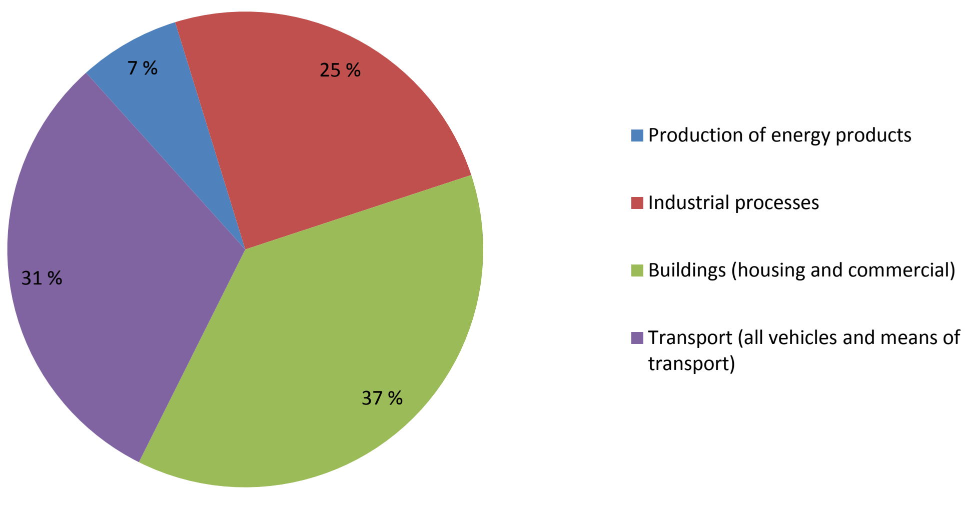

Figure 1.2 Energy consumption by primary purpose in mainland Norway. 2009. Source: Statistics Norway/NVE

1.2 Mobile energy consumption

1.2.1 Fuel for transport is increasing

Energy consumption for transport constitutes an increasingly large share of total energy consumption in Norway and it is apparent from Figure 1.3 that fuel consumption has increased greatly in the last 30 years. This is the result of more vehicles and means of transport. Since the mid-1970s, the consumption of gasoline and diesel in Norway has risen by 75 per cent. In addition, a certain amount of electricity is used for the railways and some gas for ferries and buses.

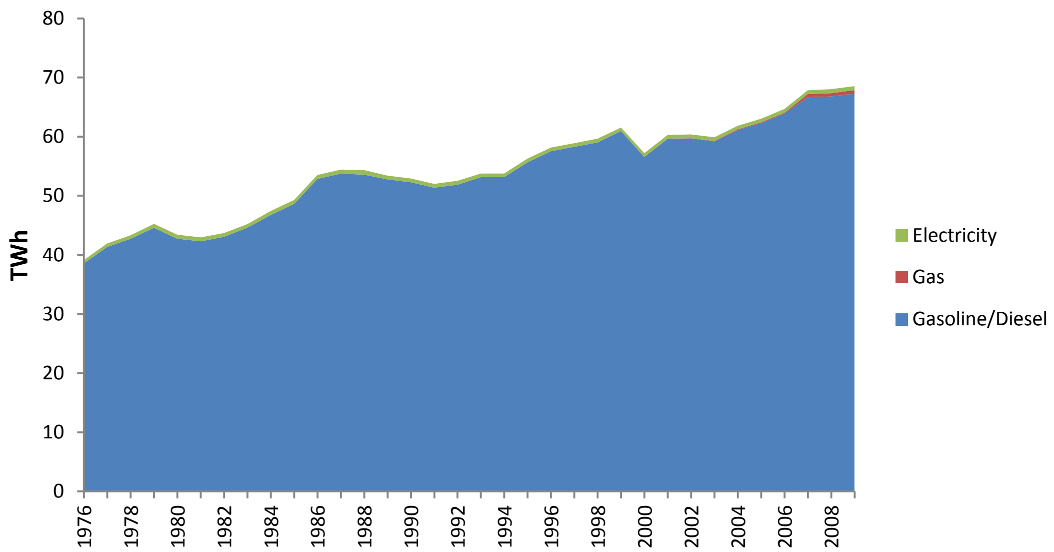

Figure 1.3 Energy for transport by energy products. Annual figures, TWh. Source: StatisticsNorway

1.3 Stationary energy consumption

Energy for buildings, industrial processes and the production of energy products is called stationary energy consumption, as opposed to mobile energy consumption. The rest of this report concentrates on stationary energy consumption in mainland Norway.

1.3.1 Stationary energy consumption is levelling off

While energy consumption for transport is steadily increasing, statistics show that energy consumption for stationary purposes such as lighting and heating in buildings in industrial processes has levelled off since the late 1990s. For housing and commercial buildings, the levelling off can be explained by factors including better buildings, a warmer climate, higher energy prices, heat pumps and energy-efficiency measures, while in industry it can be explained by structural changes[5], technology improvements, higher energy prices and energy-efficiency measures.

Figure 1.4 shows the trend in stationary energy consumption in mainland Norway since 1976. Following long-term growth in energy consumption, it is apparent that it has levelled off since 1998. Households and manufacturing in particular have contributed to this. In addition, energy consumption in the service industries (commercial buildings) has grown little in the last 10 years.

In 2009, the financial crisis contributed to a fall in energy consumption in energy-intensive industries of 20 per cent, but provisional figures for 2010 show that activity is on the way up again. 2010 was an extremely cold year in Norway, which caused energy consumption in households and service industries to increase greatly from 2009.

Domestic energy consumption in the petroleum sector has however risen greatly. Figure 1.4 shows that the petroleum sector's energy consumption has grown markedly since the early 1990s. This is due to new shoreside installations that use electricity, and platforms in the North Sea that take electricity from onshore.

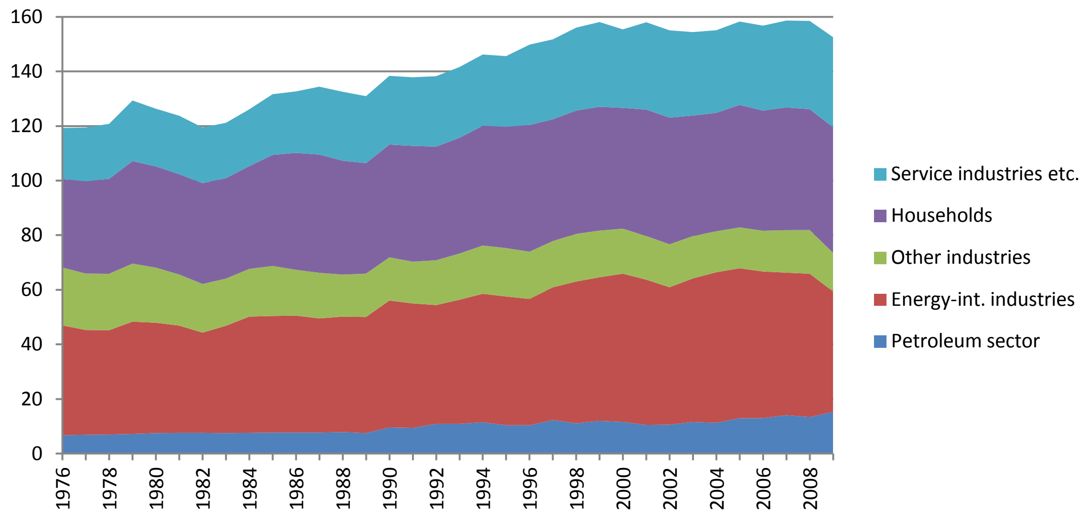

Figure 1.4 Stationary energy consumption in mainland Norway by sector. Source: Statistics Norway

[5] Structural changes here means changes in the composition of business activities, through the closure of old companies/plant and the establishment of new more energy-efficient ones, and through individual less energy-intensive businesses growing more rapidly than the energy-intensive manufacturing industries.

Box – units

Energy can be measured in different units. In this publication, we use kilowatt hours as our unit of energy. Power is measured in watts (W) and energy in watt hours. Using one watt in one hour is consumption of one watt hour. Household consumption is typically measured in kilowatt hours (kWh), which is one thousand watt hours. When we analyse total energy consumption in Norway, it is more appropriate to use larger units, such as TWh.

Kilowatt hours	kWh	
Megawatt hours	MWh	thousand kWh
Gigawatt hours	GWh	million kWh
Terawatt hours	TWh	billion kWh

An average household uses 20,400 kWh of energy per year. Of this, some 16,000 kWh is electricity. For comparison, the largest power-intensive companies use several TWh per year.

1.3.2 Electricity is the most used energy product for stationary purposes

Figure 1.5 shows an overview of stationary energy consumption in mainland Norway since 1976, and we can see that electricity is the most used energy product. More than 70 per cent of stationary energy consumption in mainland Norway is covered by electricity.

The consumption of gas has risen steeply since 1976. Gas is used primarily in industry and the petroleum sector. New factories and enlargements to existing plant are the reason gas consumption has risen so much since the 1970s. The use of heating oil has conversely fallen greatly. The fall can be explained by a switch from heating by oil to increased use of electricity, district heating and bioenergy.

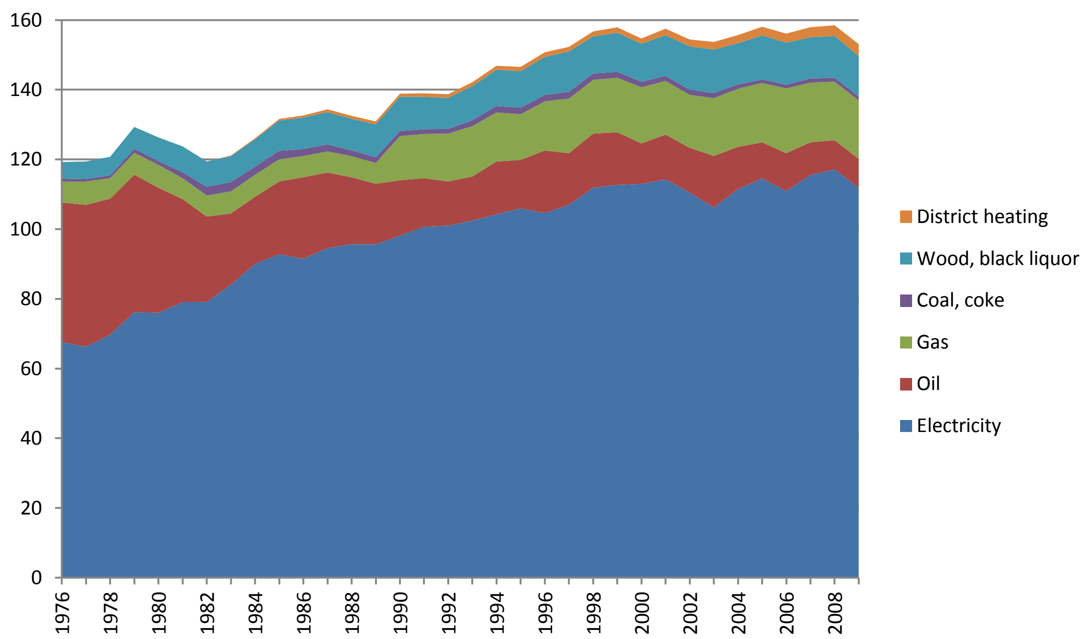

Figure 1.5 Stationary energy consumption in mainland Norway by energy products. Source: Statistics Norway

Box – energy consumption in mainland Norway

Electricity covers more than 70 per cent of total stationary energy consumption in mainland Norway. In buildings, electricity covers a full 80 per cent of energy consumption.

Since 2000, on average, 124 TWh has been supplied per annum to consumers in mainland Norway. Around 8 per cent, or 10 TWh, of this is lost in the power grid. This means that 114 TWh reaches the consumers. This is called the net consumption of electricity and is the total of final consumption of electricity and what is used in the energy sector.

Energy-intensive industry and the petroleum installations consume around 45 TWh in a normal year, equating to around 40 per cent of Norwegian net consumption.

The rest of the electricity, 69 TWh, is used for so-called ordinary supply. Ordinary supply includes households, the service industries, the primary industries, building and construction and other industries.

In part due to the financial crisis, in 2009, energy-intensive industries used about 20 per cent less electricity than in the year before. In 2010, consumption went up again. 2010 was also the coldest year in Norway in 70 years, which resulted in a record-high consumption in ordinary supply.

1.3.3 Stationary energy consumption has three primary purposes

Stationary energy consumption has three primary purposes. Within each of these three primary purposes are a number of sub-groups of energy consumers. There follows a brief description of which consumer groups are included in these three primary groups.

In buildings, energy is required for lighting, heating and electrical equipment. The building stock in Norway consists of housing and holiday homes, as well as commercial buildings in the service industries, industrial buildings, the primary industries and the construction sector. In 2009, around 83 TWh[6] of energy was used in Norwegian buildings. This broke down into 46 TWh for housing and holiday homes, 29 TWh for commercial buildings in the service industries, around 4 TWh for industrial buildings and 4 TWh for commercial buildings in the primary industries and the construction sector. There is some uncertainty concerning the exact size of the consumption.

In industry, great quantities of energy are required to manufacture the products that are made. In 2009, 55 TWh of energy was used for industrial processing, broken down into 44 TWh in energy-intensive industries and 11 TWh in other industries. Other industries comprise many smaller businesses where it is difficult to distinguish between energy for buildings and energy for processing, so there is uncertainty about how much is used for each.

In 2009, 13 TWh of energy was used to operate shoreside installations in the petroleum sector and platforms which take electricity from onshore. 8 TWh of this was refinery gas used in Norway's two oil refineries, while 5 TWh was electricity.

[6] This is actual consumption of energy. Not temperature-corrected.

1.3.4 Warmer climate leads to lower energy consumption in buildings

For buildings, energy consumption is normally divided into two different purposes: heating and electricity-specific. The distinction is important because the energy requirements for heating, i.e. space heating, hot water and ventilation air, can be covered by energy products other than electricity. Conversely, technical equipment and lighting can normally only be powered by electricity.

Space heating comprises 55-60 per cent of energy consumption in houses and 40-50 per cent of energy consumption in commercial buildings. Since there is wide variation in the types of commercial buildings, there is also wide variation in energy consumption. The amount of energy used for space heating varies in line with the building's external and internal temperatures. Space heating makes up a high proportion of total energy consumption in buildings, and changes in the outdoor temperature significantly affect energy consumption in buildings.

Figure 1.6 shows the trend in annual average temperatures in Norway since 1960. It can be seen that, whereas there were consistently low average temperatures in Norway in the period 1960-1990, the period 1990-2009 was notably warmer. The period 2002-2008 in particular is distinctive for its annual temperatures well above the average for the period 1960-2010. This is an important reason for energy consumption in households and service industries having levelled out.

Calculations made by NVE and Statnett[7] show that energy consumption in Norwegian buildings was 2-4 TWh lower than in a normal year[8] in each of the years since 1997 due to the milder climate. Provisional figures indicate that 2010 broke the trend of recent years and was the coldest in many years. This caused the consumption of energy for heating to increase markedly in that year, demonstrating the major significance of outdoor temperatures on energy consumption in buildings.

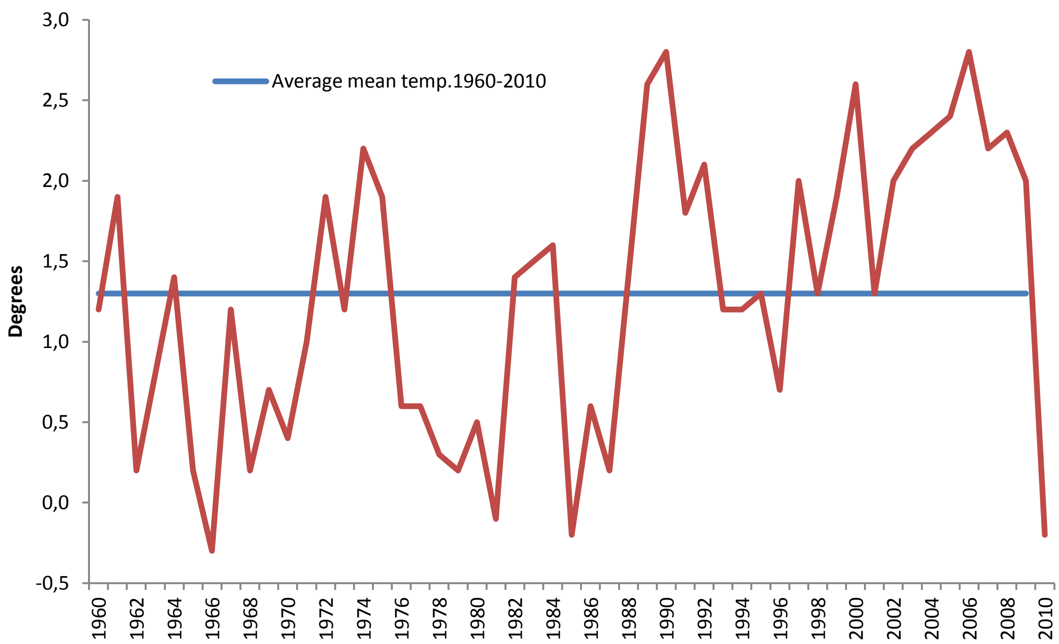

Figure 1.6 Mean temperatures in Norway. 1960 – 2010. Source: The Norwegian Meteorological Institute

[7] Statnett – Grid Development Plan for 2010
[8] Normal year here refers to the average temperature for Norway from 1960 to 2010. This was 1.3ºC.

1.3.5 Higher energy prices make energy efficiency more profitable

Despite the annual average temperature having been, on the whole, higher than the norm since 1990, there are major variations over the year. The outdoor temperature is considerably lower in winter than in summer, which leads to higher energy consumption in buildings in winter than in summer. This is apparent in Figure 1.7, which shows monthly electricity consumption of ordinary supply since 2000. We can see that electricity consumption is regularly twice as high in January as in July.

From Figure 1.7, we also see that the price of energy is generally considerably higher in autumn and winter than in spring and summer. Increased consumption and higher prices mean that energy costs for consumers are especially high in winter. It is therefore particularly profitable to make energy-efficiency improvements that reduce the need for heating in the cold part of the year.

The relationship between high consumption and high electricity prices was especially evident in the winters of 2002/2003, 2009/2010 and 2010/2011. Many consumers accordingly had very high bills during these winters. In the chapters on energy consumption in households and commercial buildings, we describe measures to assist in reducing heating needs.

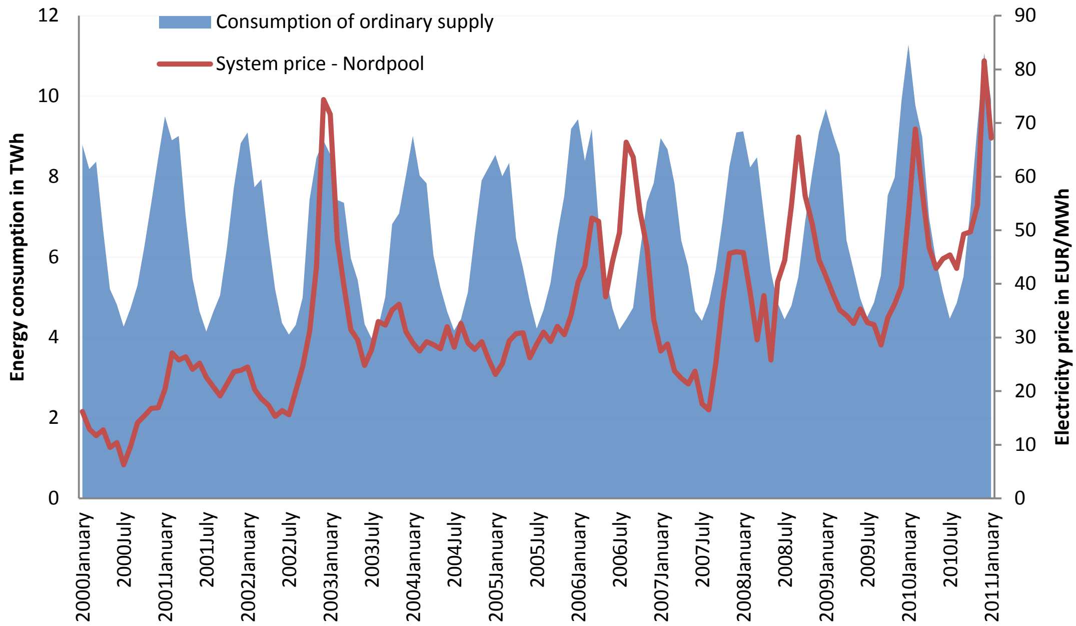

Figure 1.7 Monthly power consumption and energy prices for ordinary supply. Source: Statistics Norway/Nordpool

1.3.6 Smart metering (AMS)

A smart meter is a new type of electricity meter which is to be installed in all buildings in Norway by the end of 2016. It has three main functions:

1. Metering – registration of electricity consumption with the option of storing data in the meter
2. Communication – data from the meter to the grid company, information from the grid company to the consumer etc.
3. Control – the grid companies can remotely control electricity consumption by end-users in power shortage situations. In addition, end-users can control electricity consumption in their own buildings by connecting a communication module from the smart meter to electrical equipment in the building. See Figure 1.8.

One key function is two-way communication between consumers and the grid companies. The meter registers actual electricity consumption which is sent to the grid company, and the consumer can then receive data about prices and consumption in return. It will also be possible to connect the meter to displays, websites or a mobile phone to allow the consumer to keep track of his electricity consumption. The meter can also be linked to a control system in the building so that energy-intensive devices can be turned off during the hours when electricity is most expensive.

The smart meter measures actual electricity consumption by the consumer at least every hour and will make it possible and beneficial to defer some electricity consumption to times of the day when prices are lower. Electricity consumption under ordinary supply is highest in the morning and afternoon and this means that electricity prices are highest during these periods. By using the control options in the smart meter, some consumption such as water heating can be moved to times of the day when prices are lower and yield a saving for the consumer. This also results in a lower load on the power grid.

The smart meter will also be a good tool for monitoring energy consumption in the building and in this way identify beneficial energy-efficiency measures. The measurement of actual energy consumption will be able to give building owners more confidence in the benefits of investing in energy-efficiency measures. Smart meters can therefore provide a sound basis for energy service providers who take a financial risk by investing in energy-efficiency measures[9].

Figure 1.8 illustrates how smart meters work and are used to communicate between consumers, grid companies and service providers.

With regard to the effects of smart metering, there are several ongoing surveys. According to the EU Commission, 8 EU member states have found that the introduction of smart metering is capable of reducing energy consumption. The size of the reduction depends on how consumers are presented with information on electricity consumption and prices, and hence able to choose proactively whether to alter or reduce their consumption. Consumers must also be willing to invest in equipment that makes it possible to displace or reduce electricity consumption.

[9] Energy service providers can for example offer energy performance contracting (EPC), or third party financing (TPF), under which a bank or financial institution lends money to implement the measures.

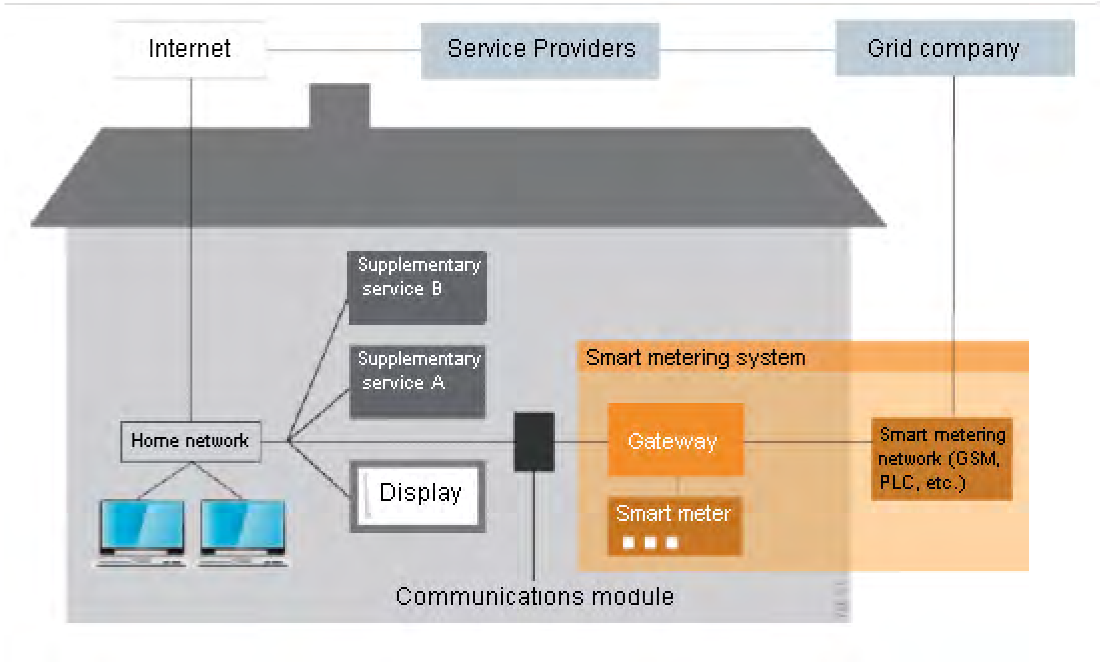

Figure 1.8 Illustration of how smart metering will/could work. Graphic: NVE

2 Energy consumption in households

Total energy consumption in households has levelled off, and energy consumption per household has been reduced since the mid 1990s. Factors explaining this trend include a warmer climate, higher energy prices, heat pumps, more energy-efficient devices and better insulated homes.

2.1 Energy consumption in households is levelling off

Energy consumption in households increased from the mid 1970s to the mid 1990s by some 2 per cent per annum, but from 1996 to 2009 consumption levelled off and fluctuated between 44 and 46 TWh per annum. This is illustrated in Figure 2.1. Provisional figures show that energy consumption in households in 2010 was somewhat higher than the average of recent years.

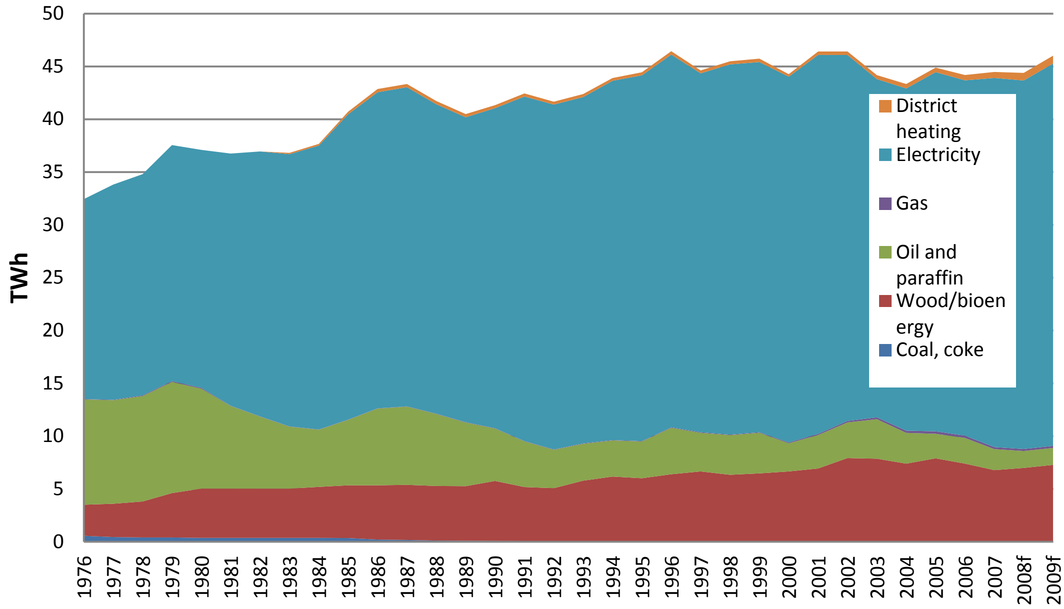

Figure 2.1 Trend in stationary final consumption in households by energy products. Source: Statistics Norway

It is difficult to identify a single cause of the levelling off in household energy consumption from 1997 to 2009, but various explanatory factors may be suggested:

- Climate change has led to higher temperatures. The period 1990-2009 was generally warmer than normal. The years 2002 to 2008 stood out as particularly hot.

- Heat pumps help reduce the need for purchased electricity for much of the year, but it is difficult to establish how much.[10]
- An improved building code (TEK) can lead to reduced energy consumption. TEK sets out energy requirements for buildings, and covers all new building and major refurbishments of existing buildings. The exact size of the impact of TEK is uncertain.
- Energy prices have risen since 1990, which may have led to increased awareness of and changes in energy consumption. This may have included behavioural changes or investments in energy-efficiency measures.
- Much has been done to increase consumers' knowledge and ability to influence energy consumption. Tools provided by Enova have contributed to this.

2.2 Demographic trends affect energy consumption in households

In order to analyse trends in energy consumption, it is usual to look at drivers behind the energy consumption. Drivers are factors that affect energy consumption. Population development is a driver for household energy consumption since population growth normally leads to higher energy consumption. Table 2-1 shows the trend in different demographic drivers and how they affect energy consumption.

The table shows that all the demographic factors point to increased energy consumption in households. Living areas per person and per household are increasing and both of these are pushing total energy consumption up. At the same time, we can see that the number of persons per household is falling while the population is increasing which is leading to a growth in the number of households. This is also causing increased energy consumption. Final consumption expenditure of households is also increasing which might point to increased energy consumption. In spite of this however, energy consumption in households is levelling off.

Table 2-1 – Demographic drivers for energy consumption in households

Driver	Trend	Direction the driver pushes energy consumption
Population	Increased since the 1990s	↗
Number of households	Heavy increase since the 1990s, more than population growth	↗
General household consumption	Heavy increase since the 1990s, more than population growth	↗
m^2/household	Steady increase since the 1990s	↗
m^2/person	Steady increase since the 1990s, more than m^2/household	↗
Person/household	Fallen since the 1990s	↗
Change in type of living accommodation	Proportion living in blocks of flats is increasing more than other categories. Indicates a trend towards smaller homes.	

[10] Energy consumption in buildings is not necessarily reduced, but the energy is acquired from the surroundings instead of from the power grid

The total energy consumption has levelled off, while demographic factors indicate that it should have risen. This means that unit energy consumption has fallen. Figure 2.2 illustrates this trend. Energy consumption relative to private consumption has fallen, and energy consumption per household and per heated square metre of housing have also declined considerably since the 1990s. Per capita energy consumption has also fallen, but less than the other indicators

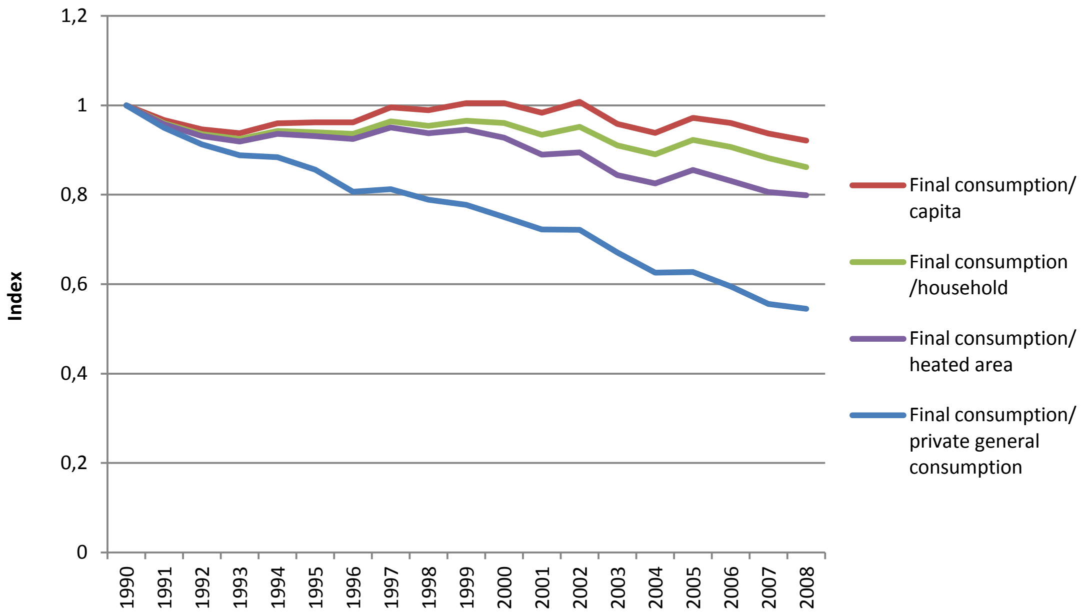

Figure 2.2 Trends for a selection of indicators of energy consumption in households, 1990=1. Climate-corrected. Source: Institute for Energy Technology/Odyssee

As mentioned in Chapter 2.1, outdoor temperature is another key factor for energy consumption in households. We saw in Chapter 1 that temperatures in the period 1997-2009 were above the norm of the last 50 years. This probably caused a lower heating requirement for housing. But in 2010, the temperature was far below the norm and this brought with it a strong increase in energy for heating houses. 55-60 per cent of household energy consumption is used for space heating and is temperature-dependent. This proportion is higher in winter and lower in summer. If we temperature-correct[11] energy consumption, we find that annual energy consumption in households from 1997 to 2009 was on average nearly 2 TWh lower than normal due to the higher temperatures. This indicates that some of the reduction in energy consumption we have seen in recent years is connected with higher temperatures and thus lower heating requirements.

[11] Temperature-correction of energy consumption means adjusting energy consumption to what it would have been in the event of normal temperatures. In warmer periods, actual energy consumption will be lower than temperature-corrected consumption, since we will have used less than we would have done at normal temperatures.

2.3 Electricity is the most used energy product in households

Figure 2.3 shows that electricity is the dominant energy product in households. From Figure 2.1, we saw that there has been a large increase in electricity consumption in households since 1976. Electricity has partly replaced heating oil and paraffin, whose use has fallen off considerably since the 1970s. There has also been an increase in the use of district heating and gas, but these energy products still constitute a small share of total energy consumption in households. Consumption of biofuels on the other hand has risen considerably since 1976. The proportion of wood fuel in households' energy consumption rose steadily through the period, although levelling off since 2005. This may be due to heat pumps replacing some wood burning in households.

2003 saw a fall in the use of electricity and a rise in the use of other energy products such as wood and heating oil. This may be due to factors such as high electricity prices caused by low reservoir levels in the winter of 2002/2003 and increased attention in the media to energy prices and consumption. Since 2003, households' consumption of electricity have risen again.

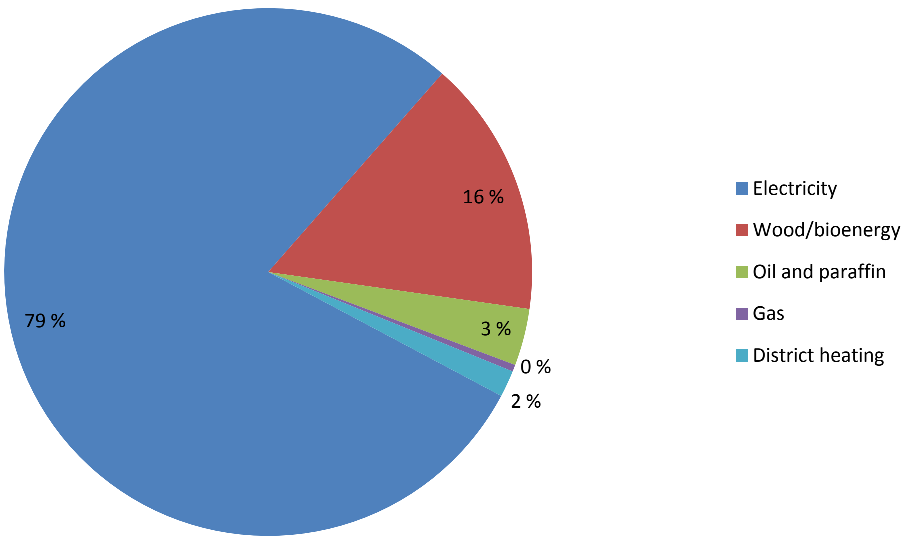

Figure 2.3 Energy consumption in households by energy product. 2009. Source: Statistics Norway.

2.4 70 per cent of energy used in houses is for heating

End consumption by purpose is a termed that is used to describe how energy is used for different purposes in Norwegian households, averaged over the housing stock. In general terms, we can distinguish between heating purposes and electricity-specific purposes. End use changes over time and from housing type to housing type.

The distribution between electricity-specific purposes and heating purposes changes over time. White goods and some other electrical devices are replaced relatively frequently and the number of devices is increasing rapidly. An increasing proportion of electricity is used for the operation of home entertainment equipment, such as flatscreen TVs and PCs. At the same time, a technological development is taking place and each device is becoming increasingly efficient. Some factors are pulling energy consumption upwards, while others are pushing it downwards.

Energy for heating is being reduced over time through better insulation in new and existing buildings. More new and more stringent building regulations are likely to bring about a reduction in the share of energy used for heating. At the same time, higher indoor temperatures and larger houses are helping to increase energy consumption. The net effects of all these factors are uncertain, but it appears that the relative share of energy for electricity-specific purposes is on the increase and the share of energy for heating is correspondingly declining. Figure 2.4 shows an estimate of end-use consumption for heating and electricity-specific purposes in households.

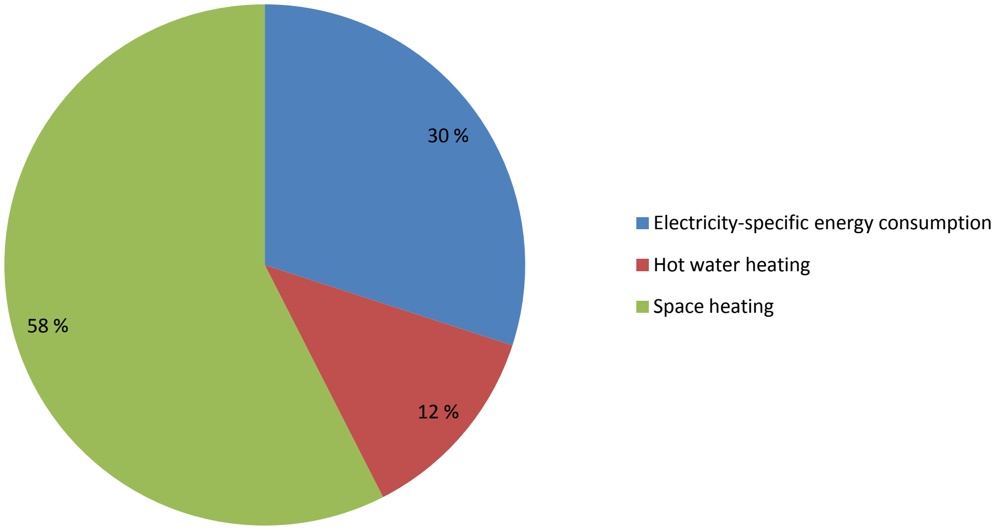

Figure 2.4 End-use consumption of electricity in households, estimated shares. Source: NVE

Box – end-use consumption by purpose in households

Energy consumption is often divided into consumption for heating purposes and electricity-specific consumption.

Electricity-specific energy consumption refers to electrical consumption for devices that can only be powered by electricity, such as lighting, washing machines, refrigerators, TVs, coffee makers, etc. This energy consumption represents about 30 per cent of the total energy consumption in households.

Heating purposes, on the other hand, can be met by all energy products, including petroleum products, wood fuel, wood pellets, briquettes, solar heating and heat pumps. Which energy products can be used depends on the heating equipment available in the individual house. Around 55-60 per cent of energy consumption in households is used on space heating, and around 10-15 per cent on water heating.

2.5 Two-thirds of houses have several heating systems

Since heating can be done using different energy products, there is competition between the different energy products in this market. This is usually referred to as the ‘heating market’. Some houses have several types of heating equipment, giving them the option of choosing the energy product that produces heating at the lowest costs or as supplementary heating in cold periods. The possibility to switch between energy products is referred to as energy flexibility.

The heating systems in Norwegian housing are regularly surveyed by Statistics Norway. Of Norway's 2.2 million households, a third has one heating system, while the remaining two-thirds have two or more heating systems. Most households that have only one system have electrical heating. In households that have two or more systems, electricity and wood is the dominant combination. 70 per cent of all the households have the option of using wood fuel and 16 per cent have oil/paraffin-fired stoves. Nearly 20 per cent have central heating.

Table 2-2 Heating systems in households (percentages). Source: Statistics Norway

Households with different types of heating equipment. 2001, 2004 and 2006. Percentages	2001	2004	2006
Electric heaters or heating cables	97	97	98
Oil/paraffin stoves	15	11	16
Wood stoves/open fires	69	65	69
Pellet stoves	..	..	0
Open fires	..	..	13
Closed wood stoves	..	..	67
Combination wood and oil stoves	10	8	7
Oil/paraffin stoves and/or combined oil and wood stoves	20	17	19
Wood stoves and/or combined oil and wood stoves	72	68	70
Proportion with only open fires+miscellaneous heating, without wood stoves	..	..	2
Shared or own central heating, excluding district heating	7	9	9
Shared central heating, without district heating	5		4
Own central heating	2		5
District heating	1	1	1
Total heat pumps	..	4	8
Air-to-air heat pumps	..	3	7
Other types of heat pumps	0	1	1
Heat recovery			5
Gas stoves			2
Other	2	2	..

Water baseed heat distribution systems provides flexibility in heating, by allowing for the heat source to be switched, for example, from an electric boiler to a biofuel boiler. Hot water central heating is used primarily in flats. The proportion of new houses with hot water central heating has increased considerably in recent years and the proportion of floor space covered by hot water central heating systems in 2010 was 35 per cent. A 2009 survey by market analysis company Prognosesenteret among members of the Norwegian Association of Plumbing, Heating and Ventilating Contractors, showed that heat pumps, combined with water based heating, were the first choice among owners of new detached houses. For renovations/refurbishment, however, only 34 per cent chose water based heating.

Heat pumps are also becoming more widely used. In households, air-to-air heat pumps are the most common heat pumps, but geothermal-water and air-water heat pumps are also used. According to an Enova survey, a third of Norwegian detached houses have heat pumps. There is uncertainty about the net energy contribution from heat pumps in households, it is probably around 1 to 2 TWh per annum. The consumption of environmental heat is not metered and does not appear in the energy statistics, unlike the electricity that is necessary to run the heat pumps.

Heat pumps will normally reduce the consumption of electricity, but at low temperatures, as in 2010, air-to-air heat pumps do not make a much larger contribution to space heating than other heating systems. At very low temperatures some air-to-air heat pumps may even have a lower output than other electrical heating systems, since the pump is not designed for cold conditions. The heat pump uses a lot of energy to heat up the outside air. In addition, the external part must be defrosted in cold weather, otherwise moisture in the air can freeze on the heat exchanger, causing loss of heat to the surroundings. The low temperatures in 2010 may have caused that the heat pumps did not help reduce consumption of electricity. In Chapter 6.4, heat pumps are described in more detail.

Boilers are used in buildings with water based heating systems. There are different types of boilers and, depending on the type, they heat water using electricity, gas, oil or bioenergy. An electric boiler uses electricity to heat the water. Boilers are most often found in appartment buildings that have water based central heating system.

Wood stoves are installed in many Norwegian houses and holiday homes. In 2009, the consumption of wood in Norwegian households and holiday homes corresponded to a theoretical energy content of around 7.3 TWh. This figure needs to be corrected for the efficiency of the stoves the wood was burnt in in order to be comparable with electric heating. Energy actually derived from wood in households and holiday homes in 2009 was around 3.9 TWh. Figures from Statistics Norway show that an increasing proportion of wood is being burnt in new and more efficient stoves; see Figure 2.5.

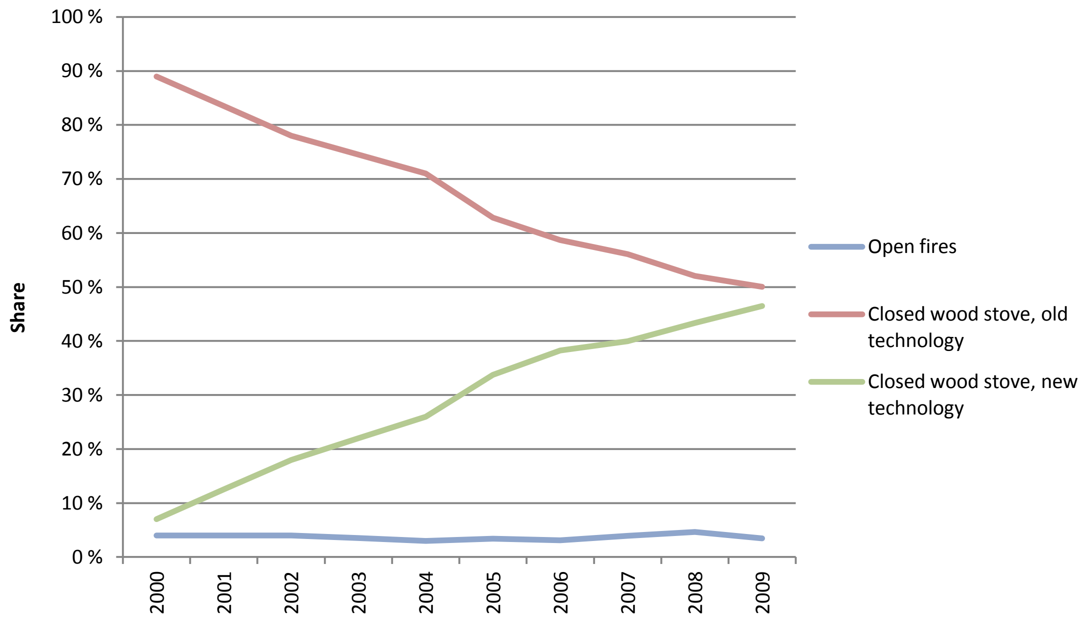

Figure 2.5 Share of wood used in different types of stoves. Source: Statistics Norway

2.6 Conversion and energy-efficiency options

Energy consumption in households can be both reduced and converted. In this chapter, we describe some of the most common energy-efficiency measures and conversion measures.

A broad classification of different efficiency measures is shown in Table 2-3. The list is not complete. The best measures to take for the individual building depend on its characteristics, including existing building materials and insulation, but in general, as mentioned in Chapter 1, it is most profitable to reduce the need for heating. This is because heating is the largest energy expenditure in houses (see Box – end-use consumption in housholds) and the fact that heating requirements are greatest when energy prices are highest.

Table 2-3 Energy-efficiency options in households. Source: Klimakur 2020

Energy-efficiency measures	
Insulation and draught-proofing:	Insulation of roofs, lofts, floors, walls and windows. Draught-proofing around doors and windows.
Energy management:	Automated control of heating and lighting, such as control systems connected to panel heaters.
Best available technology (BAT):	Energy management: Select the best available technology, such as A++ labelled white goods, energy-efficient computers (Energy Star) and low-energy lightbulbs.
Build-in energy-efficiency:	It is often profitable for the initial build to use low-energy solutions such as "A class" energy labelling or passive house technology.

Conversion measures involve switching from one energy product to another. Table 2-4 shows a range of options for converting from fossil fuels to other, more climate-friendly energy products. Different solutions will be beneficial in different buildings, depending on the existing heating systems. Having water based central heating system allows for more conversion options than localised heating sources, such as paraffin stoves.

Table 2-4 Conversion options in households. Source: Klimakur 2020

Conversion from:		**Converted to:**	
Fuel	**Technology**	**Fuel**	**Technology**
Heating oil	Oil-fired boiler	a) District heating	Heat exchanger
		b) Electricity	Air-to-water or water-to-water heat pump
		c) Solar heating and electricity	Solar collector and heat pump
		d) Woodchips or pellets	Biofuel boiler
		e) Electricity	Electric boiler
		f) Bio heating oil	Oil-fired boiler
		g) Biogas	Gas-fired boiler
Paraffin	Paraffin stove	a) Electricity	Air-to-air heat pumps
		b) Pellets	Pellet stoves
		c) Wood fuel and electricity	Clean-burning wood stoves and panel heaters
Natural gas and liquefied gas	Gas-fired boiler	a) Biogas	Gas-fired boiler

Analyses made for Klimakur 2020[12] show there are potential efficiency gains in the household sector of approx. 6 TWh by 2020. Similarly, there is potential for converting nearly 2 TWh of fossil fuel consumption by 2020. The conversion measures represent a saving of around 500,000 tonnes of CO_2 equivalents.

2.7 Holiday homes

The number of holiday homes is increasing rapidly and they are becoming larger and of a higher standard. Energy consumption in holiday homes is included in the survey of household energy consumption in Statistics Norway's statistics and comprises an increasing share of households' total energy consumption, even though this share remains low.

Electricity consumption in holiday homes increased from some 0.7 TWh in 1993 to around 1.6 TWh in 2009, more than twice as much. This is due to more and larger holiday houses, see Figure 2.6. In the same period, the number of holiday homes increased by 15 per cent, to more than 294,000 in January 2010. An increasing number of holiday homes are connected to the electricity grid, which will further increase electricity consumption in this segment.

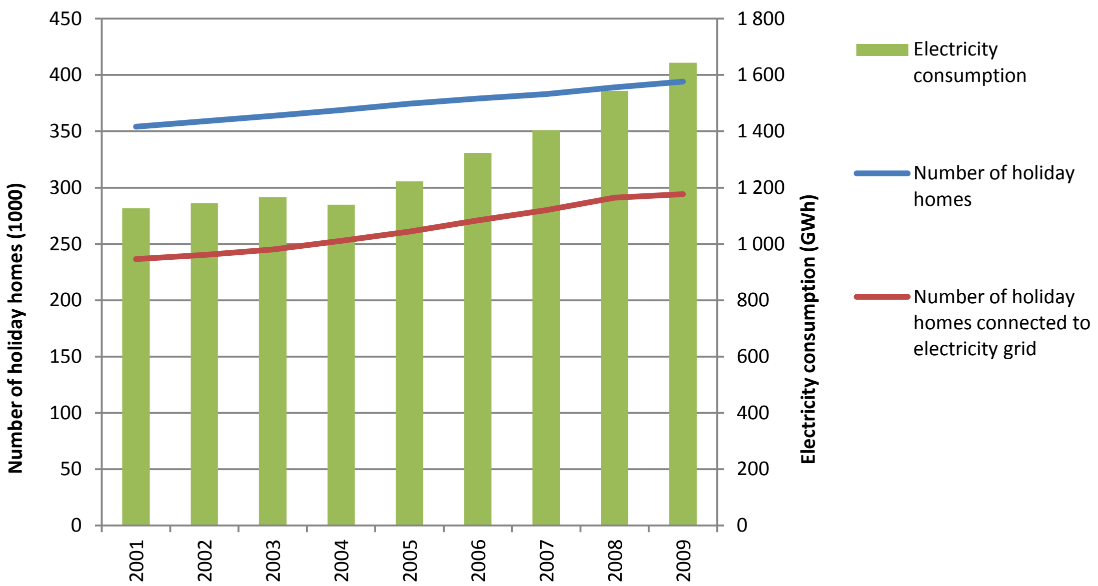

Figure 2.6 Numbers of holiday homes and their electricity consumption. Source: Statistics Norway and NVE

Wood fuel consumption in holiday homes in 2009 was 206,000 tonnes, equivalent to theoretical energy content of approx. 1 TWh.

[12] Measures and instruments for reduced emissions of climate gases from Norwegian buildings, http://www.nve.no/Global/Publikasjoner/Publikasjoner%202010/Rapport%202010/rapport2010_04.pdf

3 Energy consumption in commercial buildings

The total energy consumption in commercial buildings (excluding industrial buildings) was 33 TWh in 2009. The growth has fallen off since the mid-1990s following years of large increases. The explanation for this trend in recent years may include a warmer climate, higher energy prices, more energy-efficient buildings and better use of buildings' technical systems.

3.1 Total energy consumption in commercial buildings is growing less

Commercial buildings include all buildings used for business purposes, that is, non-residential private and public buildings. In this chapter, we describe energy consumption in commercial buildings in the service industries, building and construction and the primary industries. Commercial buildings used in the manufacturing industries are dealt with in Chapter 4.

In total, in 2009, 29 TWh of energy was consumed in commercial buildings in the service industries, and 4 TWh in commercial buildings in the building and construction and agriculture sectors. This is an increase of 80 per cent over 1976, which is the first year for which we have measurements for total energy consumption in commercial buildings. Since 1996 however growth in total energy consumption has been falling off. Whereas, from 1976 to 1996, there was average annual growth in energy consumption of nearly 3 per cent per annum, growth fell back to 1 per cent per annum from 1996 to 2009. This trend is illustrated in Figure 3.1.

The figures for energy consumption in commercial buildings are more uncertain than for households and manufacturing, since few thorough surveys have been done of actual energy consumption within this consumer group. Statistics Norway's figures are based on sales statistics of energy products, but there is still great uncertainty. This may account for some of the large annual fluctuations in energy consumption in commercial buildings. See Figure 3.1.

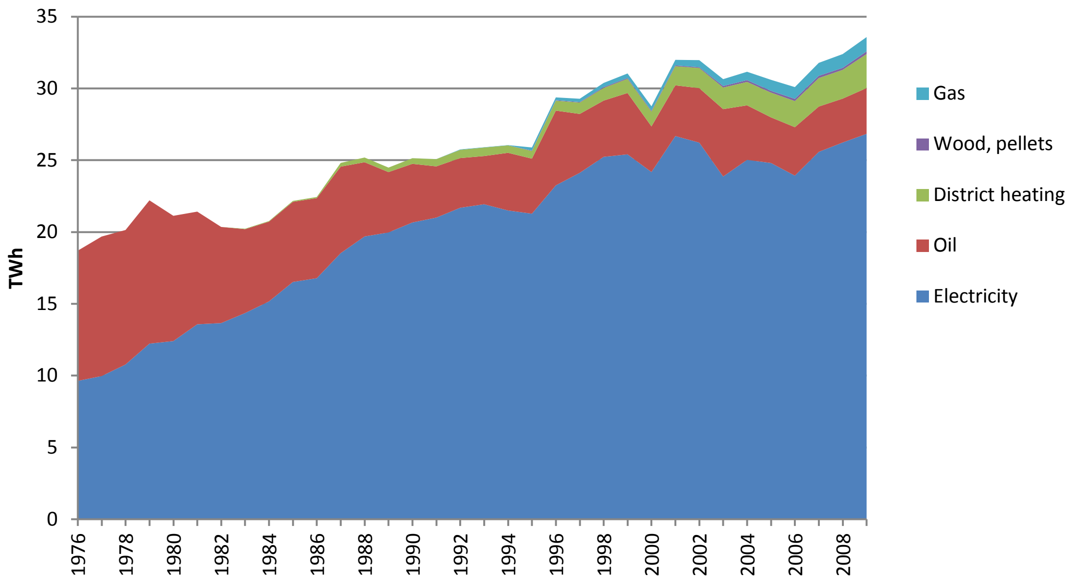

Figure 3.1 Energy consumption in commercial buildings in the service industries, building and construction and the primary industries. Source: Statistics Norway

Just as in households, energy consumption rose steeply in commercial buildings in 2010, while the year's outdoor temperature was low. This is evidence that outdoor temperatures greatly affect energy consumption in commercial buildings too. Similarly, the warm climate from 1997 to 2009 may have helped reduce energy consumed for heating commercial buildings during this period. In addition, factors such as more energy-efficient buildings, more automated technical solutions, better monitoring of energy consumption in buildings, better space usage and heat pumps may have dampened the growth in energy consumption in commercial buildings.

3.2 District heating and electricity have replaced oil

Figure 3.1 shows that the use of district heating in commercial buildings has increased notably in the last 20 years, but electricity remains the most used energy productproduct. From Figure 3.2 we can see that 80 per cent of energy consumption in commercial buildings was covered by electricity in 2009, while district heating covered 7 per cent. The use of oil has fallen off considerably since 1976, being replaced by electricity and district heating.

In 2009, oil products (heating oil and paraffin) accounted for 9 per cent of total energy consumption in commercial buildings. The consumption of oil fluctuates somewhat, and in cold winters typically goes up. It is also connected with the price of electricity, since, where possible, consumers are able to switch from electricity to oil when energy prices are very high. We saw this trend in the cold winter of 2009/2010.

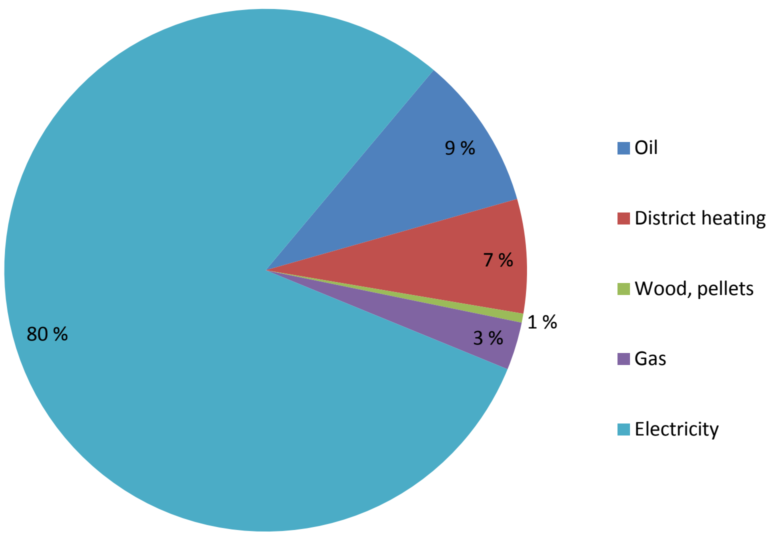

Figure 3.2 Energy consumption in commercial buildings by energy products. 2009. Source: Statistics Norway

3.3 Wide variations in energy consumption

The designation "commercial buildings" includes many types of buildings with very different energy needs. Commercial buildings include kindergartens and schools which use energy primarily for lighting and heating during school hours, office buildings, and hospitals which work around the clock and use very energy-intensive equipment.

Figure 3.3 provides an overview of different types of commercial buildings and annual energy consumption per square metre. The figure shows that hospitals, with long operating hours and very energy-intensive technical equipment, have energy consumption per square metre that is twice as great as kindergartens and schools, which have shorter working hours and less technical equipment.

In commercial buildings, most of the energy is used for operation of the buildings, electrical equipment, cooling, lighting, fans and space heating, hot water and ventilation. Energy consumption in commercial buildings depends on the type of activity in the building, the building's hours of operation, its age, geographical location, electrical equipment and other similar factors.

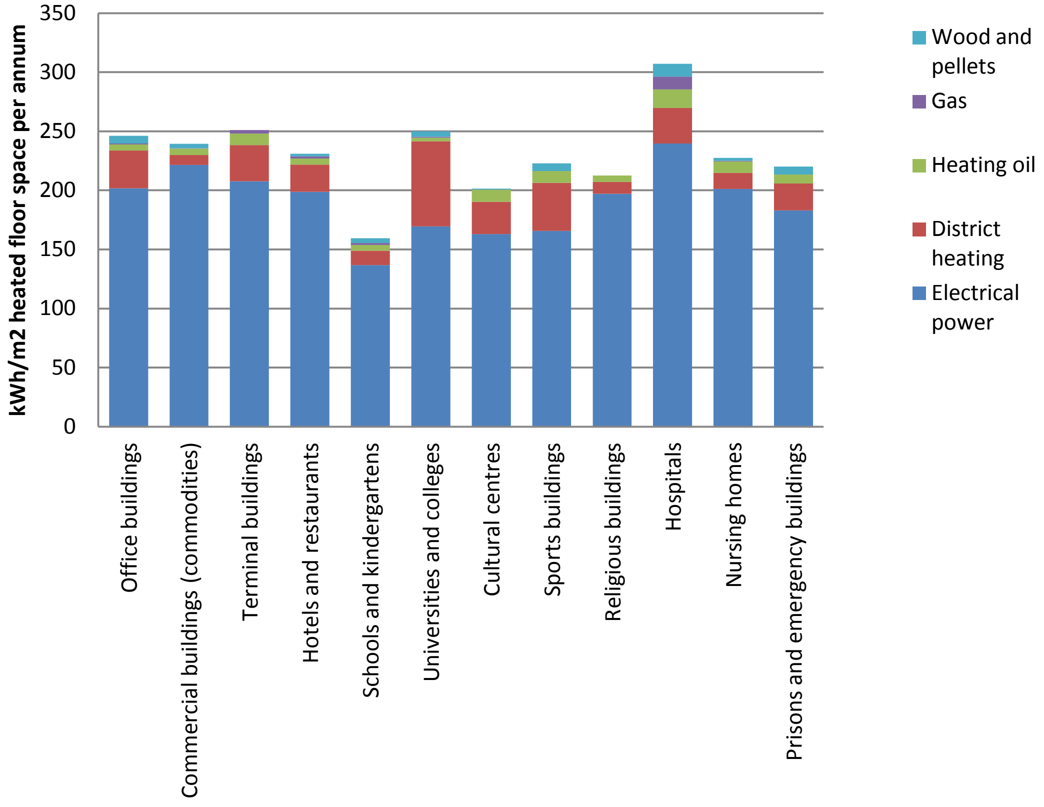

Figure 3.3 Energy consumption in different industries in the service sector, provisional figures, 2008. Source: Statistics Norway

3.4 Energy flexibility in commercial buildings

Energy flexibility refers to the extent that the consumer has the possibility of switching from one energy product to another. High energy flexibility is beneficial, because it permits switching from one energy product to another in the event one of them become scarce or expensive. For example, it is financially advantageous to be able to switch to bio energy or oil when electricity prices are high.

In 2009, Statistics Norway performed a survey of energy consumption in commercial buildings in the service industries. Figure 3.4 shows the proportion of different types of heating apparatus in the buildings included in the survey. Many buildings had several types of heating apparatus, making the total greater than 100 per cent. We can see that 50 per cent had central heating, 15 per cent had district heating and 10 per cent had different types of heat pumps. In these buildings, heat was normally distributed around the building by a water based heating system. Heat pumps are often geothermal heat pumps that get their heat from groundwater or underground rock. A water based heating system provides energy flexibility by making it possible to switch from one energy product to another, whether by using already installed equipment (for example, oil/electric boiler) or through subsequent conversion of the heating system.

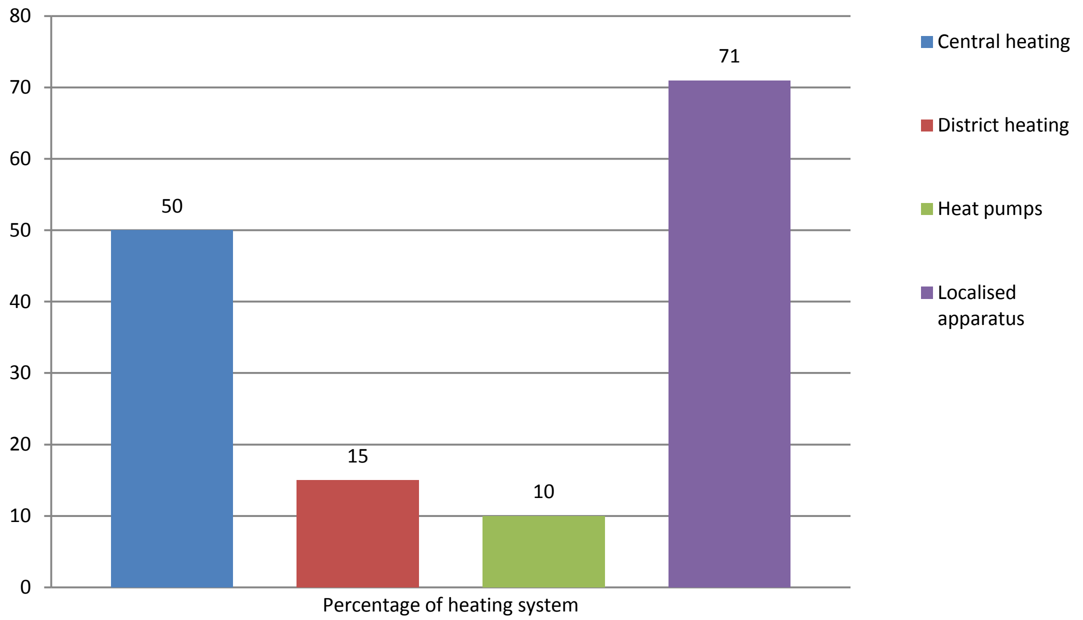

Figure 3.4 Heating systems in commercial buildings in the service sector. Source: Statistics Norway

The alternative to water based heating systems is localised heating, which can typically only use one type of energy product. Panel heaters are an example of localised heat sources, and these can only use electricity as an energy source. From Figure 3.4, we can see that a full 71 per cent of the buildings had one or more types of localised heating. Many had localised heating in addition to other heating systems, which offers high energy flexibility since the consumer can rapidly switch from one energy product to another.

3.5 Conversion and energy-efficiency options

Energy consumption in commercial buildings can be reduced and converted, in the same way as in households.

A broad classification of different efficiency measures is shown in Table 3-1. The measures it is beneficial to take in individual buildings depend on the building's technical condition and existing heating and control systems. Analyses performed in connection with Klimakur[13] show that there is potential for reducing energy consumption in commercial buildings by nearly 5 TWh by 2020.

Table 3-1 Energy-efficiency options in commercial buildings. Source: Klimakur 2020

Energy-efficiency measure	
Insulation and draught-proofing:	Insulation of roofs, lofts, floors, walls and windows. Draught-proofing around doors and windows.
Energy management:	Automated control of heating and lighting, such as control systems connected to panel heaters.
Best available technology (BAT):	Energy management: Select the best available technology, such as A+ labelled white goods, energy-efficient computers (Energy Star) and low-energy lightbulbs.
Building energy-efficient	In new buildings it is often profitable to build "A labelled " or passive buildings.

Conversion measures involve, for example, converting from fossil energy to non-fossil energy, such as bioenergy. Table 3-2 shows a range of options for converting from fossil fuels. Different solutions will be beneficial in different buildings, depending on the existing heating systems.

Analyses performed in connection with Klimakur show that it is possible to convert some 2.5 TWh of fossil fuel to other energy products by 2020. The conversion measures represent a saving of around 670,000 tonnes of CO_2 equivalents.

Table 3-2 Conversion options for commercial buildings. Source: Klimakur 2020

Conversion from:		**Converted to:**	
Fuel	**Technology**	**Fuel**	**Technology**
Heating oil	Oil-fired boiler	a) District heating	Heat exchanger
		b) Electricity	Air-to-water or water-to-water heat pump
		c) Solar heating and electricity	Solar collector and heat pump
		d) Woodchips or pellets	Biofuel boiler
		e) Electricity	Electric boiler
		f) Bio heating oil	Oil-fired boiler
		g) Biogas	Gas-fired boiler
Natural gas and liquefied gas	Gas-fired boiler	a) Biogas	Gas-fired boiler

[13] Measures and instruments for reduced emissions of climate gases from Norwegian buildings, http://www.nve.no/Global/Publikasjoner/Publikasjoner%202010/Rapport%202010/rapport2010_04.pdf

4 Energy consumption in the manufacturing and petroleum sectors

Following long-term growth in energy consumption in manufacturing industries, consumption has levelled off since 2000. This trend can be explained by the closure of a number of energy-intensive businesses, changes in the composition of the sector and more efficient energy consumption. In the petroleum sector, in contrast, recent years have seen strong growth in energy consumption.

In Chapter 0, we wrote that stationary energy consumption in Norway had three primary purposes: buildings, industrial processes and the production of energy products. This distinction is important, because, while energy consumption in buildings depends on factors such as outdoor temperatures and population trends, the energy consumption in traditional land-based manufacturing industries and in the petroleum sector is essentially determined by how much the companies produce. Since traditional manufacturing industries and the petroleum sector have comparable energy consumption, we have opted to deal with them together in this main chapter.

4.1 Three energy-intensive industries

In 2009 there were more than 17,000 industrial companies in Norway, with total energy consumption of 60 TWh[14]. The manufacturing of pulp and paper, chemical products and metals accounted for 76 per cent of this consumption. These industries are often referred to as energy-intensive industries[15]. Figure 4.1 illustrates their dominance of energy consumption in Norwegian industry in general.

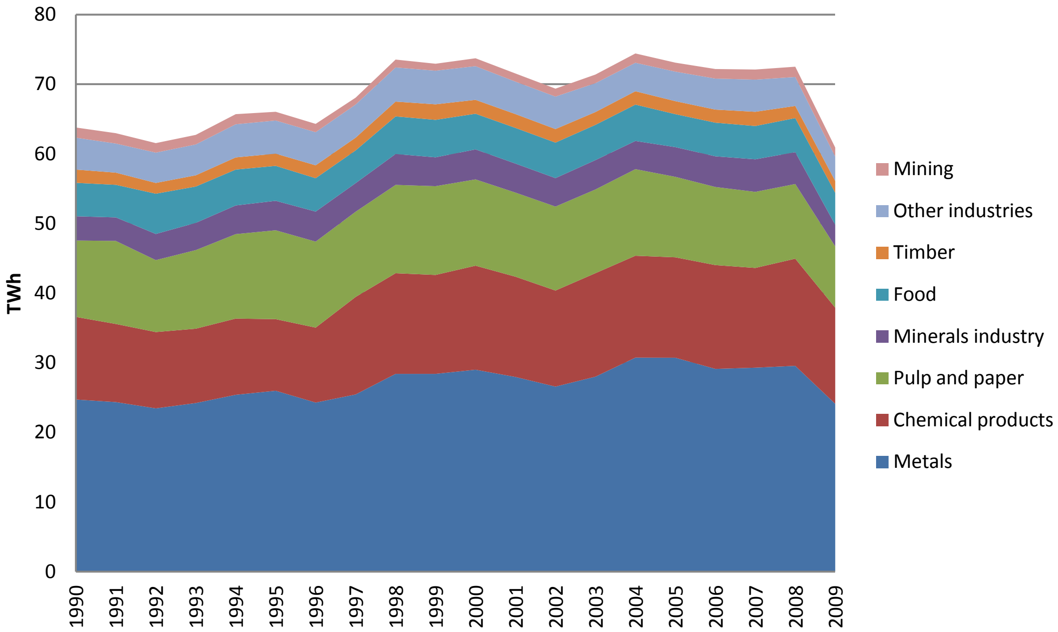

Figure 4.1 Energy consumption in manufacturing industries by sector. Source: Statistics Norway

[14] In this report, energy consumption in the refineries is included in the petroleum sector.
[15] In Statistics Norway's note 2010/3, energy-intensive industry was limited to the manufacturing of metals, chemical products and pulp and paper.

From Figure 4.2, we can see that electricity is the dominant energy product in manufacturing industries. In 2009, electricity accounted for 69 per cent of the total energy consumption in Norwegian manufacturing industries. We can nonetheless see that a lot of other energy products were used, including gas, heating oil and bioenergy (wood waste, black liquor and other waste). A high proportion of these energy products were consumed within the electricity-intensive industries. These industries may therefore be more properly called energy-intensive industries.

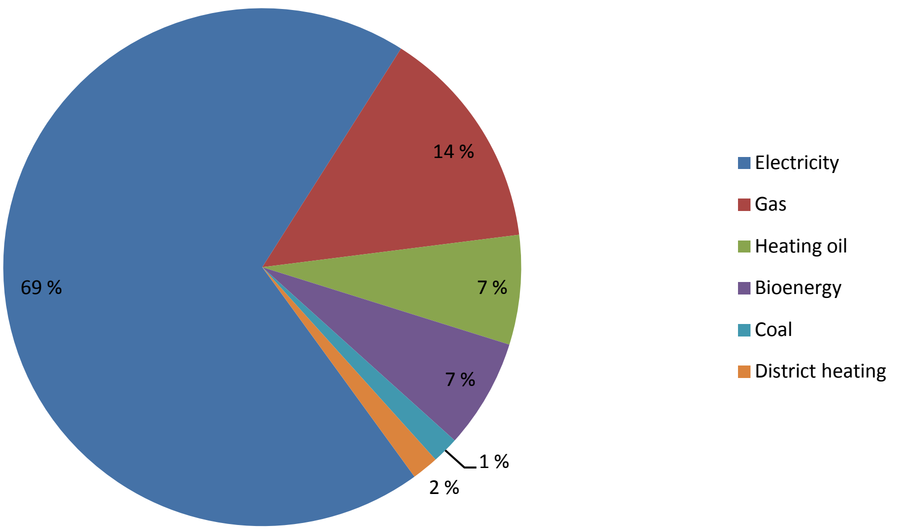

Figure 4.2 Energy consumption in manufacturing industries by energy product. 2009. Source: Statistics Norway

4.2 Structural changes[16] have led to lower energy consumption

Following a rise in manufacturing industries' energy consumption up to the end of the 1990s, from 2000 the consumption has levelled off. This is illustrated in Figure 4.1. One key reason for this energy consumption trend is the closure of companies within energy-intensive industries.

Since 2000, within the energy-intensive industries, 16 factories or installations with a combined energy consumption of approx. 8 TWh have closed down. Of this, some 7 kWh was electricity. In the same period, new companies have started up and existing installations have been expanded, for a total increase in energy consumption of around 4 TWh. This means that there has been a net fall in energy consumption in energy-intensive industries of about 4 TWh since 2000.

Many of the closures have been in the pulp and paper and metals industries. The best known were Norske Skog's closure of Union in Skien, and Hydro's shutting down of the Søderberg installation on Karmøy.

[16] In this context, structural changes refers to changes in the composition of the manufacturing sector through the closure of old companies and the establishment of new ones, and through some manufacturing industries growing faster than others.

Among new industrial installations, Hydro's prebake plants, Elkem's new solar/silicon factory at Fiskå and REC Scanwafer's factories are the most familiar. Hydro's prebake installations have largely replaced the old Søderberg ovens and laid the groundwork for more energy-efficient and profitable production of primary aluminium.

In addition to the changes within energy-intensive industries, there have been structural changes, so that non-energy-intensive industries, such as building of ships and boats and engineering have grown more rapidly since 2000 than the energy-intensive industries. The result has been a general decline in energy consumption per produced unit in Norwegian manufacturing industries. This is illustrated in Figure 4.3**.**

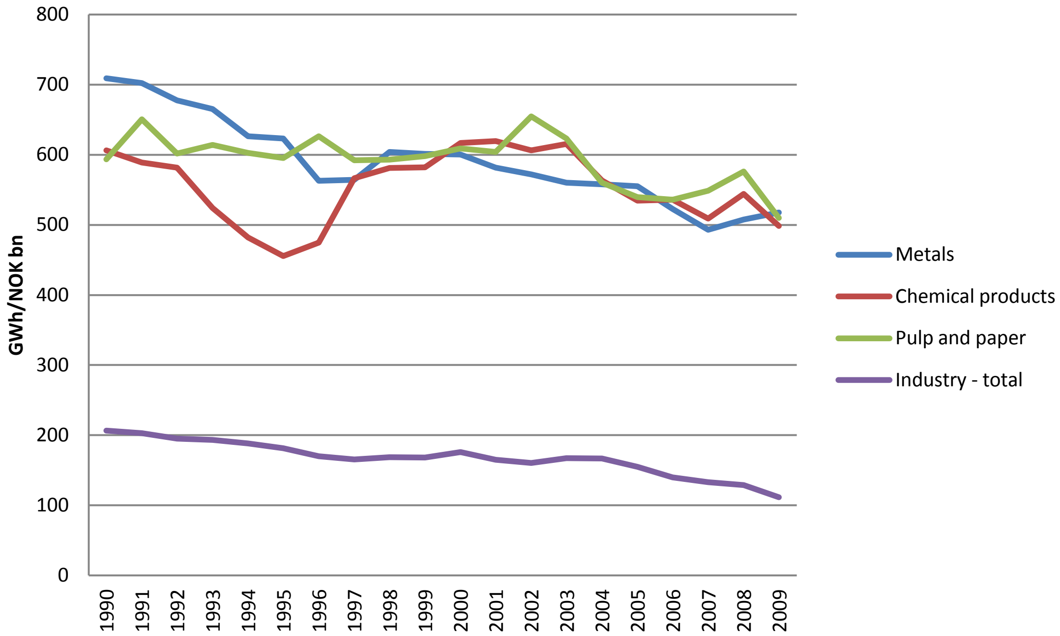

Figure 4.3 Energy consumption in GWh by production value in NOK billions. Fixed prices. Source: Statistics Norway

Another factor that has helped reduce energy consumption is energy efficiency. We do not have data for the total effect of energy efficiencies made in the Norwegian manufacturing sector, but we do have data from the two best-known public programmes for energy efficiency in the manufacturing sector. These are Enova's programme for efficient energy consumption in manufacturing industries and NVE's programme for energy efficiency in pulp and paper (PFE). By 2010, Enova had achieved a contractually binding saving of 4.4 TWh in manufacturing industry since the programme started in 2002. Although, with a project implementation times of 4-5 years, only around half of Enova's saving has actually been realised so far.

In NVE's PFE programme, pulp and paper companies commit to energy-saving measures aimed at exempting them from statutory electricity consumption taxes. From 2007 to 2009, this yielded an energy saving of 300 GWh per annum. In addition to the national energy efficiency programmes, companies have made many energy efficiencies of their own accord.

4.3 Doubling of manufacturing industries' energy prices since 2000

Since 2000, the price of energy products that industry buys has doubled. Since electrical power comprises the majority of purchased energy, it is the price of this energy product that has most significance for manufacturing industries' energy costs. The trend in energy prices is illustrated in Figure 4.4.

Within energy-intensive industries, the price rise is partly to do with old nationally imposed power contracts expiring and being replaced with contracts on market terms. For the metals, the consequence of this is that the electricity price has risen from NOK 0.12/kWh in 2000 to nearly NOK 0.24/kWh in 2009. This price includes grid charges. Since many of the major energy-intensive companies are connected to the central grid, they only pay NOK 0.025-0.030/kWh in grid charges. Energy-intensive industries do not pay statutory electricity consumption taxes.

The rise in energy prices has probably contributed to a number of energy-intensive companies having closed down in recent years, and to an increased focus on energy efficiency in the manufacturing sector. Higher energy prices and Enova subsidies have made many energy-efficiency projects in the manufacturing sector profitable.

Energy-intensive industries depend on long-term power contracts in order to be able to invest in new production equipment. However, an uncertain world makes it risky to enter into new commercial power contracts. In order to reduce this risk, in 2010 the Government set up a fund of NOK 20 billion that energy-intensive companies can use as security when signing new long-term power contracts.

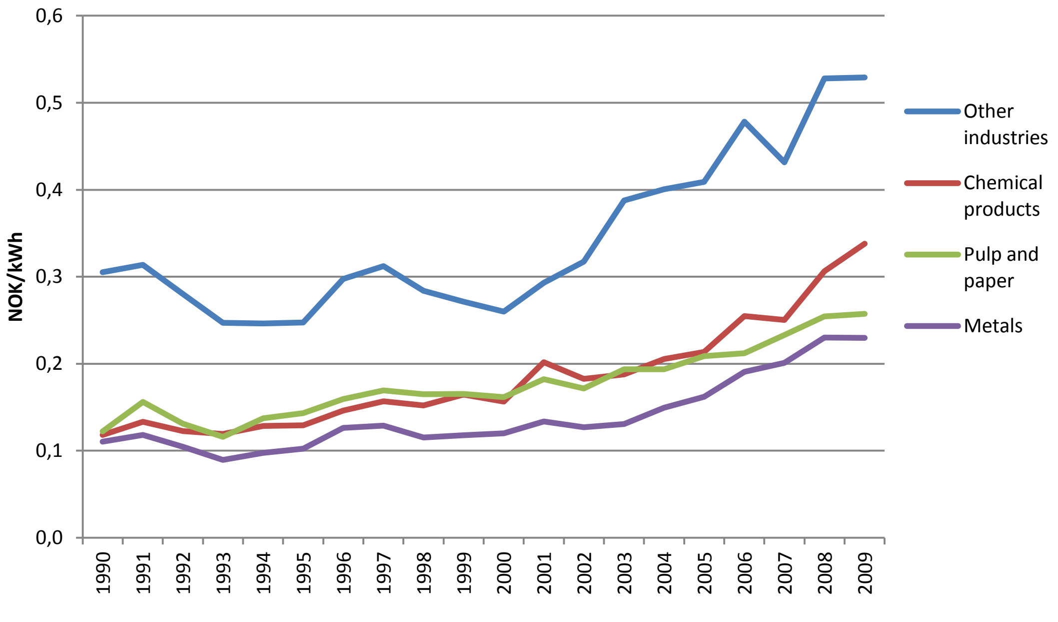

Figure 4.4 Average prices for all energy products used in manufacturing industries. Source: Statistics Norway

4.4 Other manufacturing industries

In this report, other manufacturing industries refer to a range of different industrial activities, from food processing, timber and minerals industries to engineering and building of ships and boats. Mining is also often placed in this group.

In 2009, 14.4 TWh of energy was consumed by the 'other manufacturing industries' group, a reduction from 16 TWh in 2008. The financial crisis is likely to have affected many of the companies in this category.

Most of the companies in this category use far less energy to produce goods than the companies in the energy-intensive industries, and are therefore referred to as non-energy-intensive businesses. However, even within this group, some companies do have relatively high energy consumption. Mining, food processing, timber and minerals industries include companies with relatively high energy consumption.

Even though other manufacturing industries only account for 24 per cent of industrial energy consumption, the group represents 75 per cent of production value.

4.5 4 TWh energy used in industrial buildings

We know little about energy consumption in the buildings used in the manufacturing sector, but statistics collected by Statistics Norway in 2009 and 2010 indicate that energy consumption in industrial buildings is in the order of 4 TWh per annum. Most of these industrial buildings are within the 'other manufacturing industries' group, or non-energy-intensive industry, but there are also administration buildings connected with the companies in the energy-intensive industry.

It is often difficult to distinguish between energy used for lighting and heating in industrial buildings and energy used to power the industrial processes. But analyses of Statistics Norway statistics show that, in the largest energy-intensive businesses, less than 1 per cent of total energy consumption is used for lighting and heating of buildings, while this rises to 20-30 per cent of total energy consumption for smaller companies in other manufacturing industries. Many smaller industrial companies share premises with other types of business, such as service companies. The buildings are not significantly different from other buildings in the area.

4.6 Energy products used as raw materials in manufacturing industries

Energy products can also be used as raw materials for producing goods. This means that the energy product is not being used to power the process, but is one of the input factors in the product itself. In Norwegian manufacturing industries, for example, natural gas is used to create methanol, coal and coke to create cement, and wood is used to make paper and wood products.

Figure 4.5 shows an estimate of how much energy, in TWh, was used as raw materials in 2009. We can see that the most important energy product measured by energy content is gas, which includes wet gas used for making ethylene and natural gas for making methanol. Wood in Figure 4.5 includes all wood used in industry, but, as explained earlier, some of this is fuel.

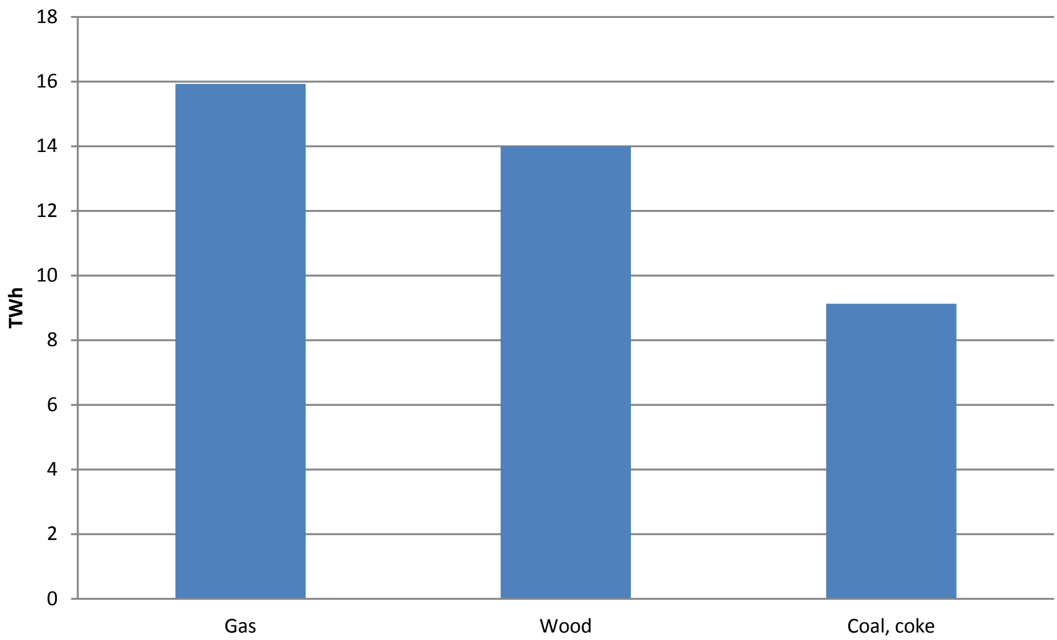

Figure 4.5 Energy products used as raw materials in manufacturing industries. 2009. Source: Statistics Norway

Energy products used as raw materials in manufacturing industries represent a considerable amount of energy, but their use is not defined as final consumption of energy. We have therefore opted to omit this energy consumption from our overview of total energy consumption in Norway and have dealt with it separately in this chapter.

4.7 The petroleum sector is a new energy-intensive industry in mainland Norway

The petroleum sector is in the process of establishing itself as a substantial energy-intensive industry in mainland Norway, since increasingly more installations are being electrified by power from onshore. In 2009, 9 petroleum installations received energy from mainland Norway, and in total they used 13 TWh of energy[17]. Of this, 5 TWh was electric power and the rest was refinery gas used in the refineries at Slagentangen and Mongstad.

Shoreside installations in the petroleum sector include the gas terminals/processing installations at Kårstø, Sture, Kollsnes and Mongstad, and the Snøhvit LNG plant at Melkøya in Finnmark. Added to which are the two previously mentioned refineries at Mongstad and Slagentangen. In the North Sea, the Troll platform and Ormen Lange field are supplied with power from onshore.

Figure 4.6 shows the trend in energy consumption from mainland Norway to the petroleum sector from 1990 to 2009. We can see that, whereas gas consumption in the refineries remained relatively stable during this period, electricity consumption increased considerably.

[17] Energy products used as raw materials in the production of other energy products are not included in these figures.

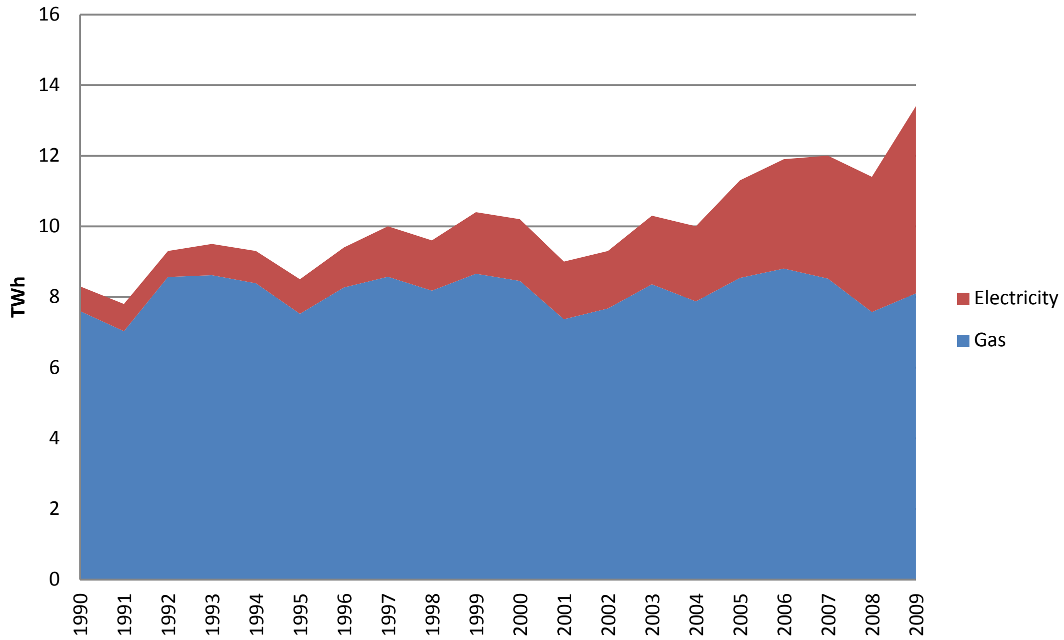

Figure 4.6 Energy supplied from mainland Norway to the petroleum sector. Source: Statistics Norway/NVE

In 2010, Statoil began operation of a combined heat and power plant at Mongstad. The CHP plant will run on natural gas from the North Sea and recovered refinery gas from the refinery at Mongstad. At full operation, the plant will produce 2.3 TWh of electricity and more than 3 TWh of heat. The heat will be used in the refinery, while the electricity will be partly used in the refinery and partly transported on the power grid to the plant at Kollsnes, the Troll platform and the Gjøa platform.

5 Energy products and technology

Even though electrical power is the dominant energy product in Norway, other energy products are also used, such as district heating, oil products, heat from outside air and bioenergy. The scope of their use depends on factors such as temperature, the price of different energy products and availability. The different energy products provide in combination a more flexible energy system.

5.1 Energy content and efficiencies

How much energy individual energy products contribute depend on the energy content of individual products, and the technology that is used. For example, the energy contribution from wood burnt in an old stove is lower than wood burnt in a modern closed wood stove. How much energy is obtained from an energy product is referred to as the efficiency of the technology. For households and commercial buildings, this means the efficiency of the heating systems in the buildings. For transport, it means the efficiency of the vehicle's engine.

Table 5-1 lists the energy content of the most common energy products and average efficiencies of the most common technologies in the different sectors. It is notable that only a small amount of the theoretical energy content of gasoline and diesel is extracted by engines used in present-day vehicles. At the same time, we can see that there are large differences in efficiency between old and new wood stoves. New wood stoves extract a full 75 per cent of the energy content of the wood, while old stoves extract only 50 per cent of the same energy.

Table 5-1 Theoretical energy content[18] and efficiency for different energy products. Source: Statistics Norway, Energihuset, NVE, Norsk Ved

			Efficiencies		
Energy product	**Theoretical energy content (MWh)**		**Industry and mining**	**Transport**	**Other consumption**
Natural gas (2007)[1]	11.0	MWh/tonne	0.95	..	0.95
LPG	12.8	MWh/tonne	0.95	..	0.95
Gasoline	12.2	MWh/tonne	0.2	0.2	0.2
Paraffin	12.0	MWh/tonne	0.8	0.3	0.75
Diesel, gas oil and light fuel oil	12.0	MWh/tonne	0.8	0.3	0.8
Waste	2.9	MWh/tonne			
Pellets and briquettes					0.85
Wood	4.8	MWh/tonne	0.65	-	0.15 (open fire) 0.5 (old wood stove) 0.75 (new wood stove)
District heating			0.85		0.85
Electricity			1	1	1

[18] Internationally, it is common to express energy contents in Joules. In this report, we have chosen to use kWh, since this is the most commonly used unit in stationary energy consumption in Norway.

5.2 Temperature trends

Trends in sales of different energy products are linked to outdoor temperatures and the price of energy products. Cold weather causes an increase in energy consumption, but how much consumption of the different energy products changes also depends on the prices of the individual energy products.

In 2010, outdoor temperatures were below normal. This led to increased sales of both electricity and other energy products used for heating, such as wood fuel and oil products. High electricity prices made consumers switch some of their consumption to alternative energy sources. It is apparent from Figure 5.1 that it was colder than normal in 2010 in January, February, November and December. This was true across Norway, with the exception of Northern Norway.

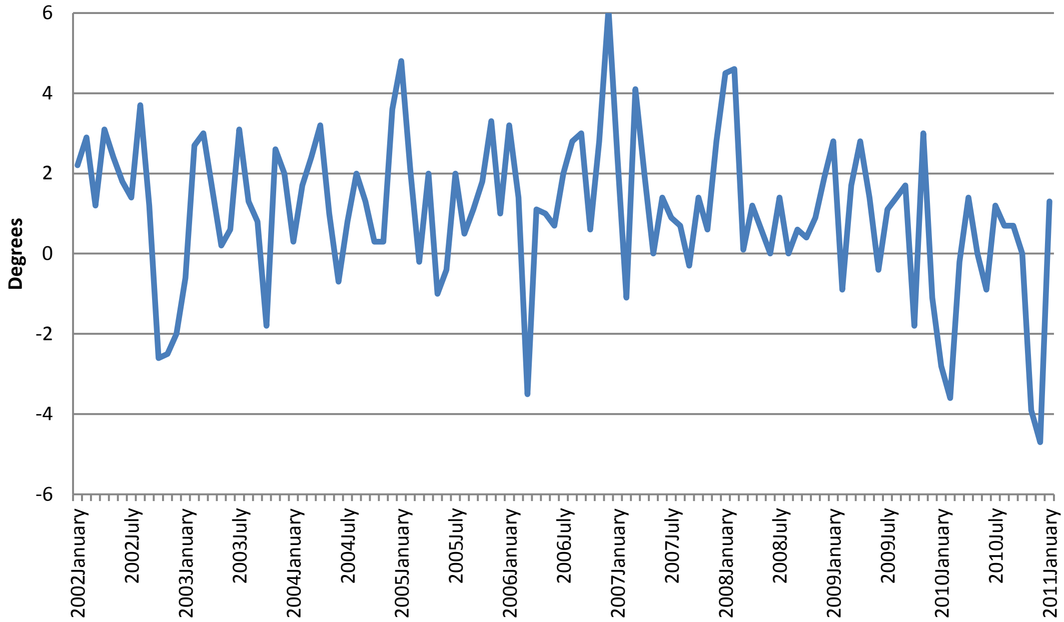

Figure 5.1 Deviations from normal temperatures 2002-2010. Source: Met

5.3 Trends in sales and prices of different energy products

5.3.1 Wood and woodchips

Annual consumption of wood, wood waste and other bioenergy corresponds to an energy amount of 10-12 TWh. See Figure 5.2. Generally, wood is used in households, while wood waste and woodchips are used in industry. Industry's consumption is more even than that of households. In households, we saw a peak in wood consumption in the winter of 2002/2003, due to high electricity prices and a strong focus on reducing electricity consumption.

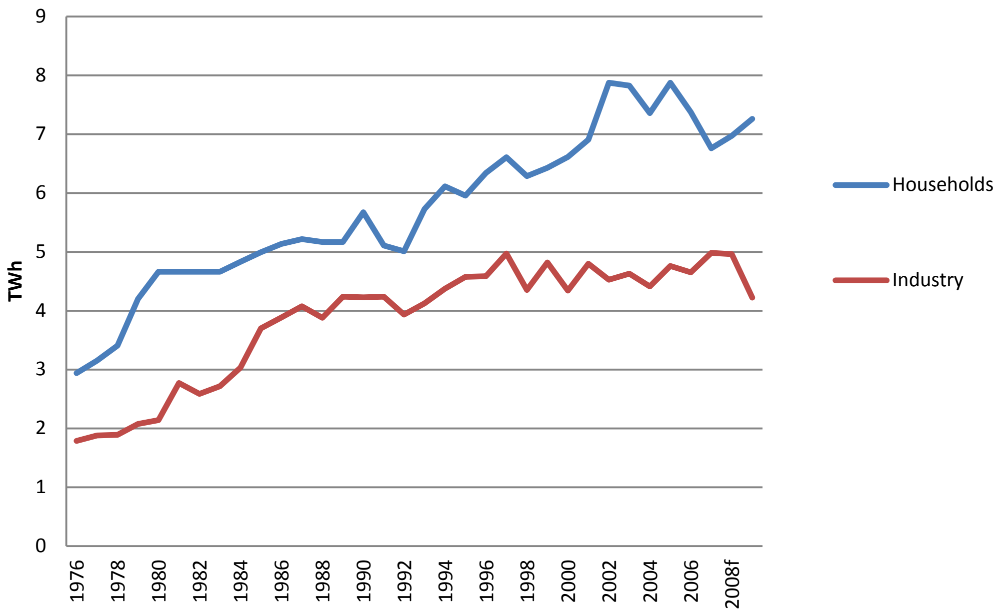

Figure 5.2 Trends in the use of wood and other bioenergy. Theoretical energy content. Source: Statistics Norway

The energy extracted from wood depends on factors such as the species of tree, moisture content, stove efficiency and burning techniques. Dry wood should have a moisture level of less than 20 per cent of the total weight. Birch is the most commonly used firewood in households, while spruce is the most common wood in industry. Per solid cubic metre of dry wood, birch has an energy content of 2,589 kWh, while spruce has 1,968 kWh. Table 5-2 list the energy content of the most common tree species in Norway

Table 5-2 Energy content of tree species in dry state (17% moisture). Source: Norsk Ved

Species	kWh per solid cubic metre of wood
Beech	2,952
Ash and oak	2,848
Rowan	2,796
Birch	2,589
Pine	2,279
Aspen	2,071
Spruce	1,968
Grey alder	1,864

The efficiency of the stove used is at least as important as the energy content of the different tree species. A modern clean-burning woodstove can utilise up to 75-80 per cent of the wood's energy content, while an old, traditional stove has an energy efficiency of around 50 per cent. Utilised energy is the theoretical energy content of the wood, corrected for the stove's efficiency. The total efficiency is higher in households than in holiday homes, since there is a greater proportion of efficient stoves in households. This is illustrated in Figure 5.3, which shows theoretical and utilised energy of all wood burning in households and holiday homes.

In addition to the quality of the stoves themselves, the way the wood is burnt has a big effect on its energy output. It is important to burn with a good draught in order to get as much heat as possible out of the wood.

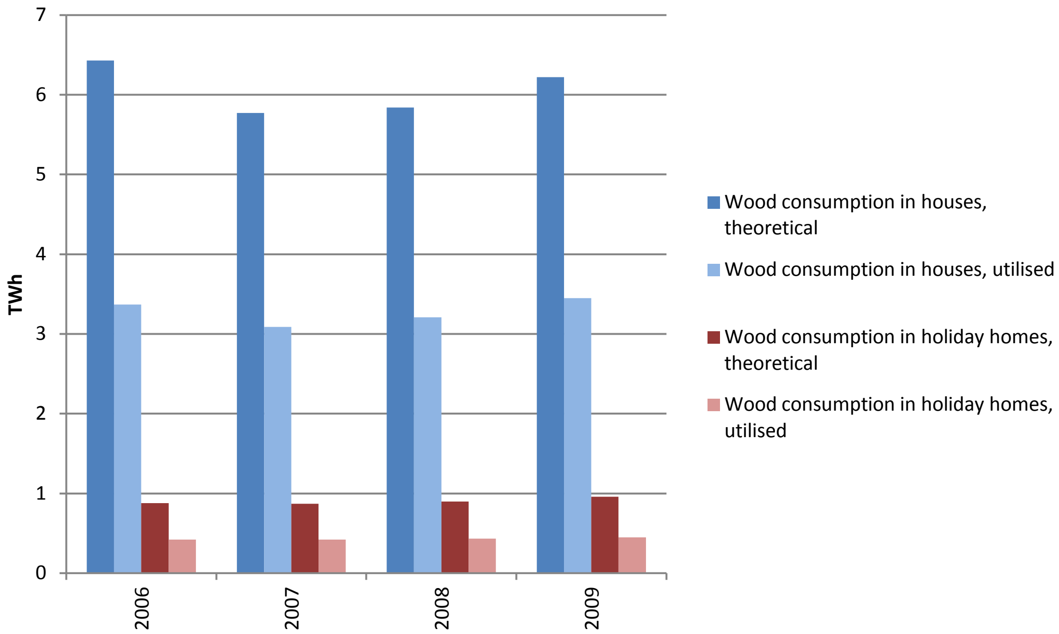

Figure 5.3 Theoretical and utilised energy from wood burnt in households. Source: Norsk Ved/NVE

Since the amount of energy that can be obtained from the wood varies, this also affects how profitable it is to heat using wood. From Figure 5.4 we can see that birch purchased in 40 litre sacks and burnt in an old stove results in a price of NOK 1.60 per kWh of utilised energy in the winter of 2009, while birch purchased by the cord and burnt in a new clean-burning stove results in a price of less than NOK 0.70 per kWh. This includes delivery to the consumer. The price of electricity was a little more than NOK 1.00 per kWh, including grid charges and other charges, in the same winter.

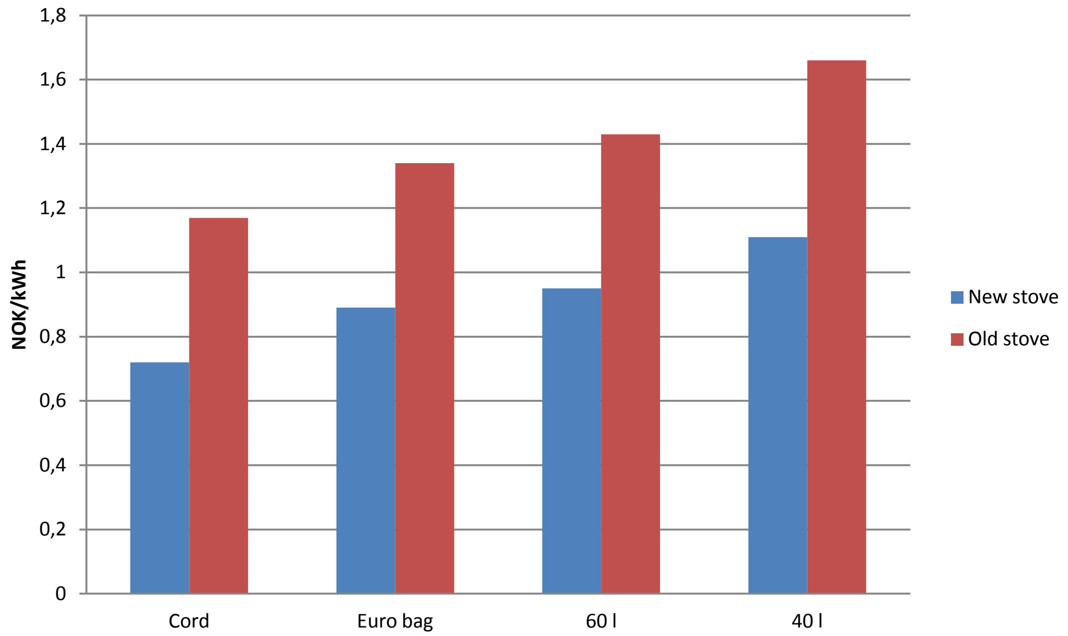

Figure 5.4 Price of utilised energy in NOK/kWh for birch sold in different volumes. 2009. Source: Norsk Ved/NVE

5.3.2 Other bioenergy

Other bioenergy covers wood pellets and briquettes. There has been an increase in the sale of pellets in Norway, with sales of nearly 43,000 tonnes in 2009, a doubling since 2005. Briquettes have also seen a strong increase in sales, and was about 41,500 tonnes in 2009.

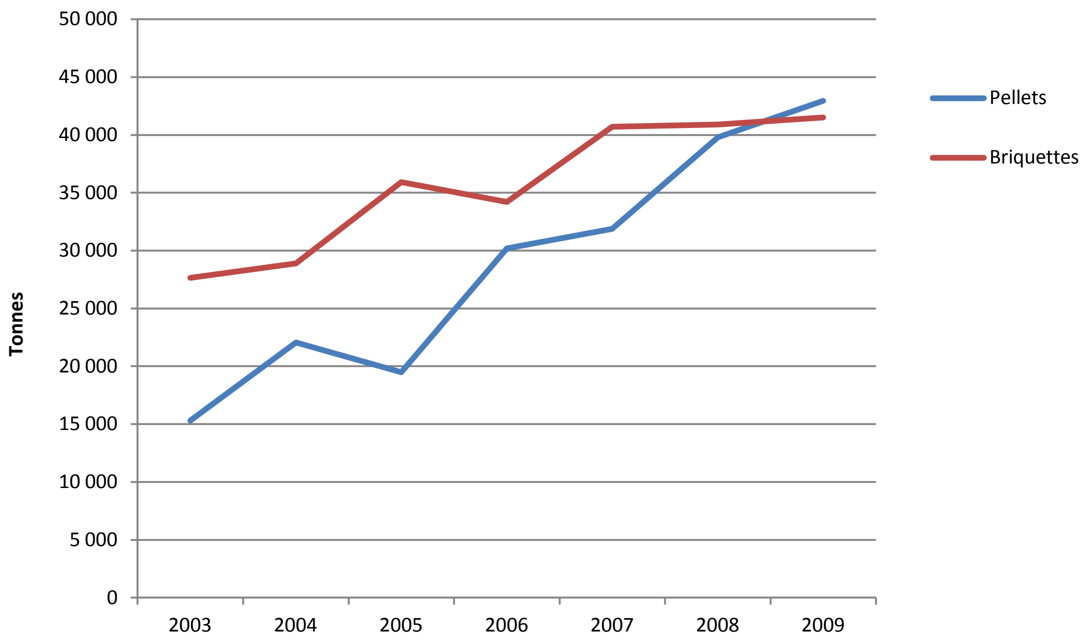

Figure 5.5 Trends in the sale of pellets and briquettes in Norway, 2003-2009. Source: Norsk Bioenergiforening

Figure 5.6 shows the trends in pellet and briquette prices. The prices are average prices, weighted for turnover volume of the different lots sold. While the prices of pellets have generally been rising, the price of briquettes in small "household packs" fell from 2004-2009. The price of briquettes in bulk, on the other hand, has risen by 60 per cent since 2004.

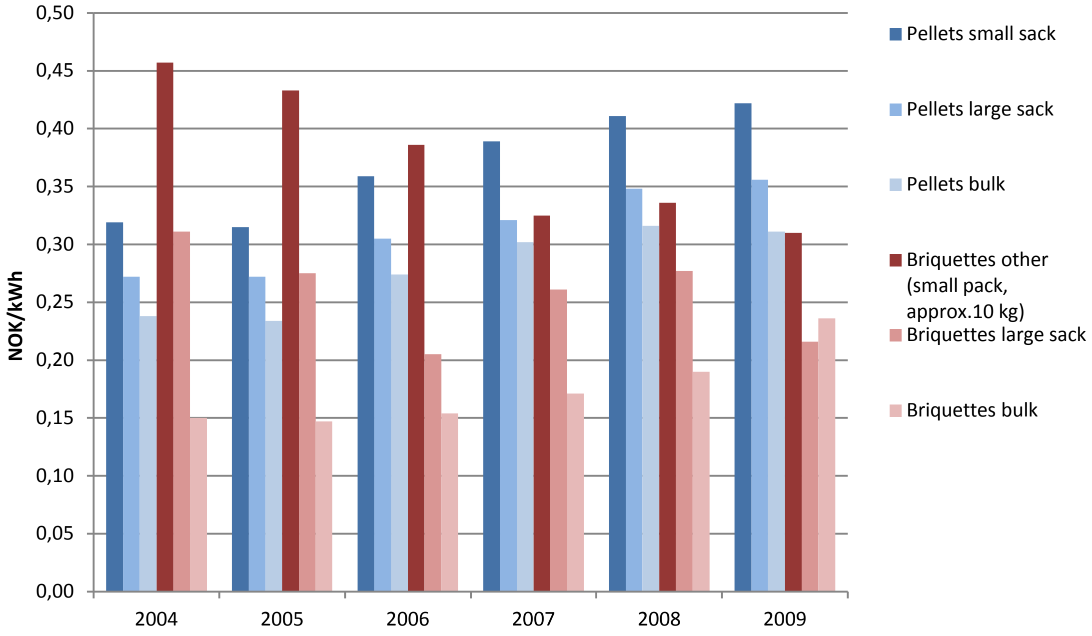

Figure 5.6 Trends in prices of pellets and briquettes, excl. VAT, 2004-2009. Source: Norsk Bioenergiforening

5.3.3 Oil products

In 2009, the total stationary consumption of heating oil and paraffin was nearly 7.8 TWh. The use of oil and paraffin has fallen heavily since the oil crises in the 1970s. See Figure 5.7. In households, there has been a transition from heating oil to other energy products.

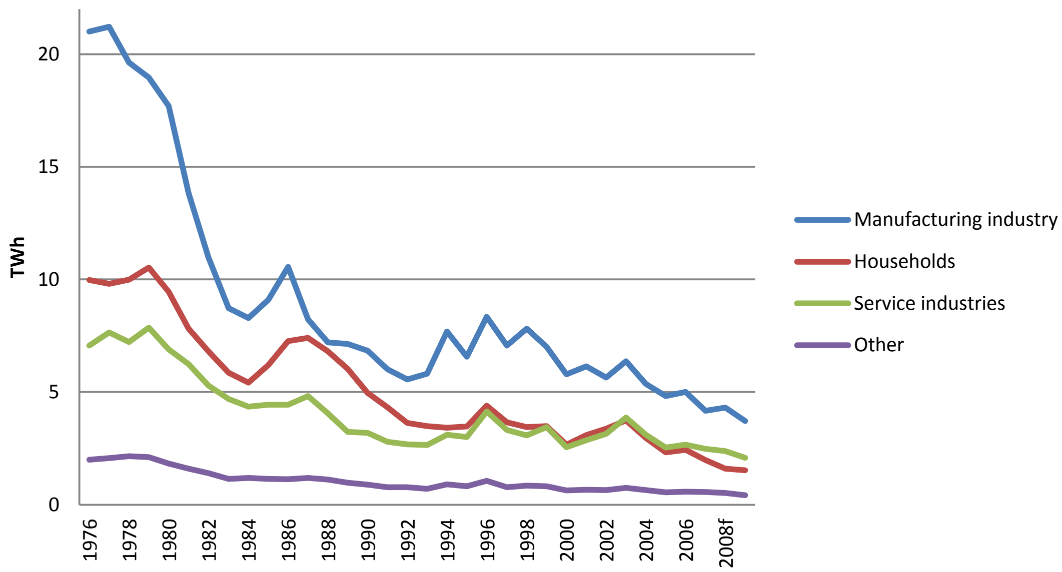

Figure 5.7 Trends in the use of oil products. Source: Statistics Norway

A large proportion of the oil products, approx. 3.3 TWh in 2009 and 4.2 TWh in 2010, were used in households and commercial buildings as heating oil and paraffin for heating.Figure 5.8 shows the trend in paraffin for heating among the largest consumers from 1995 to 2010.

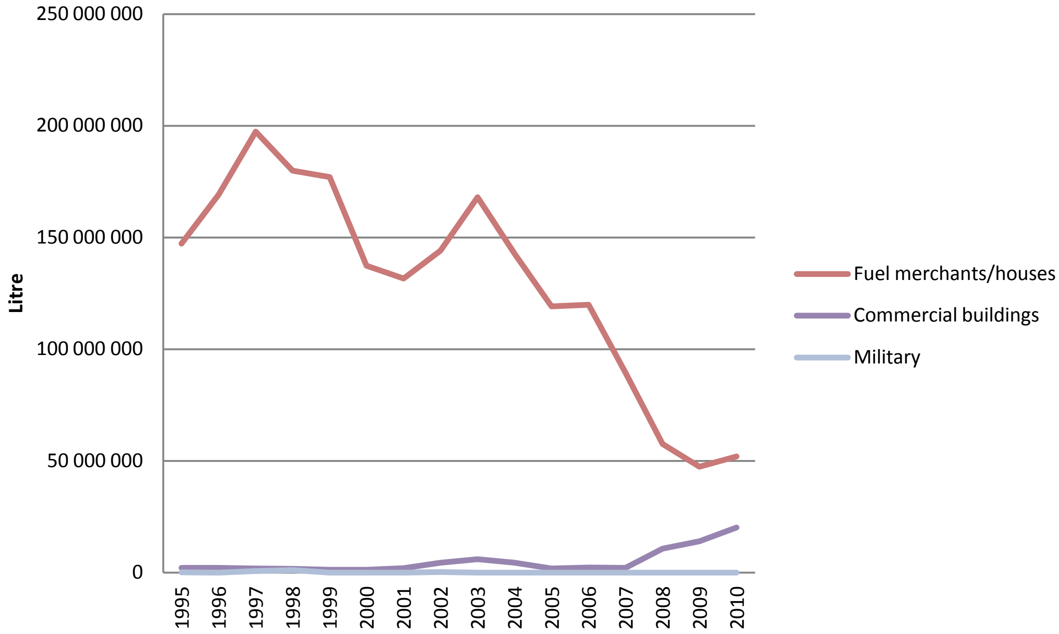

Figure 5.8 Sales of paraffin for heating to households, commercial buildings and the public sector. Source: Statistics Norway

Heating oil is used in both households and commercial buildings. In 2009, consumption was around 2.8 TWh, but this rose sharply to around 3.5 TWh in 2010. The increase is shown in Figure 5.9We can see that the largest increase was in commercial buildings

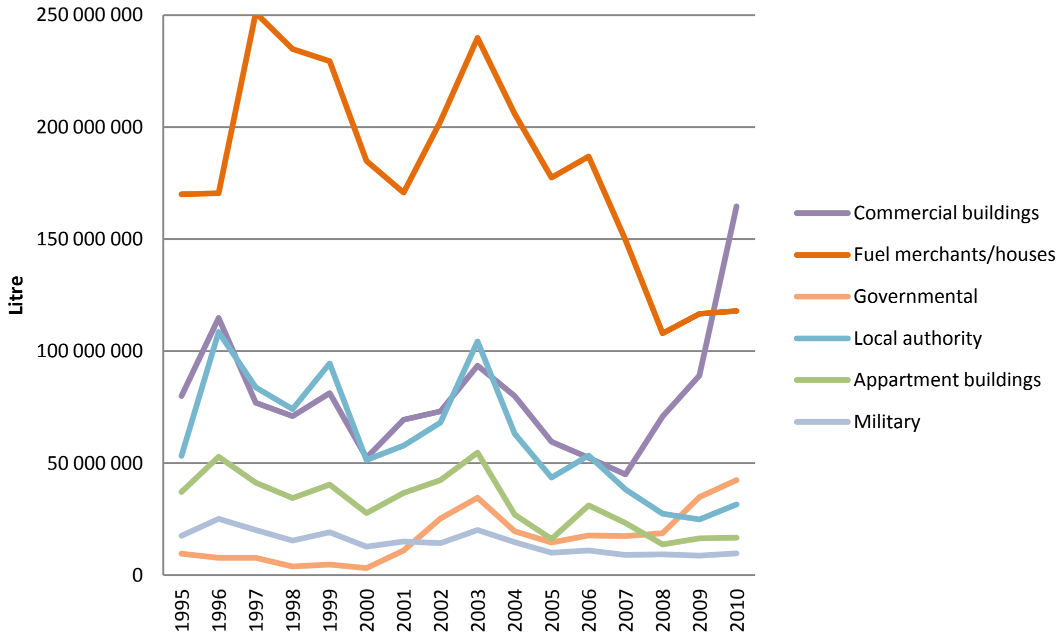

Figure 5.9 Sales of light heating oil in households, commercial buildings and the public sector. Source: Statistics Norway

From Figure 5.10 we can see that commercial buildings had greater fluctuations than other consumers. This is because they use oil as an alternative to electricity when it is cold and electricity prices are high. For the professional sectors in particular, the use of heating oil is closely linked to the price of electricity.

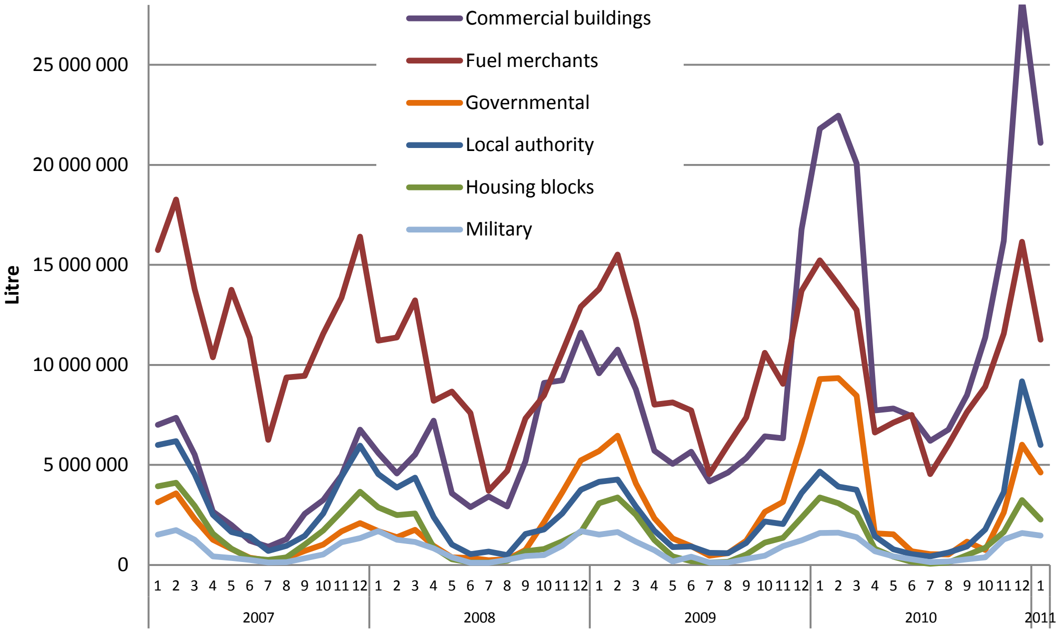

Figure 5.10 Sales of heating oil in the last four years. Variations through the year. Source: Statistics Norway

5.3.4 District heating

The use of district heating has grown considerably in recent years, from around 1 TWh in 1990 to nearly 3.5 TWh in 2009. Growth has occurred in particular in the service industries. Figure 5.11 shows the distribution of delivered district heating.

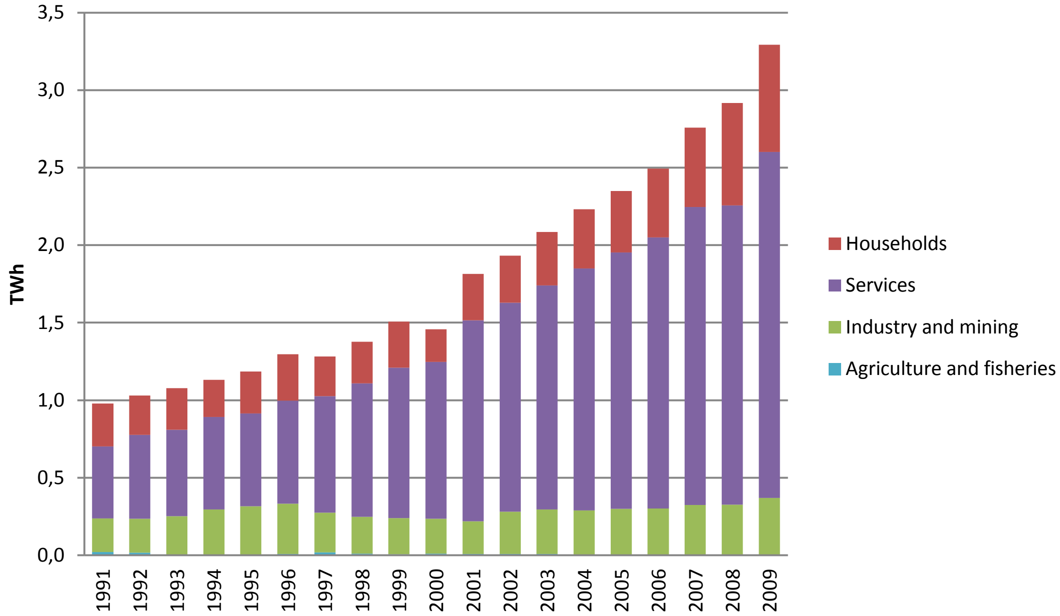

Figure 5.11 Delivered district heating, 1991-2009. Source: Statistics Norway

5.4 Heat pumps and heat from the surroundings

A heat pump is a machine that "pumps" or moves heat from a source at a low temperature to a location at a higher temperature by using energy. Heat pumps are usually used in Norway to draw heat from the outside air or groundwater in order to heat rooms in buildings. The process generally use an electricity-operated compressor in order to transfer the heat. The same principle applies to ventilation units that are used for cooling, but in that case the process works in the other direction by transferring heat from indoors out into the air. Heat pumps move heat and can therefore be used for both cooling and heating.

A heat pump used for heating has an efficiency (called the 'performance factor') that depends on the temperatures on the cold and warm sides of the pump and how the heat is acquired and delivered. A performance factor of 3 means that the system delivers three times as much energy as that of the electrical input into the heat pump. The compressor in the heat pump uses, for example, 10,000 kWh of electricity during a year and delivers 30,000 kWh as heat or cooling in the building. The electricity to run the compressor is converted into heat in the system, so that 20,000 kWh is taken from the environment in the above example. As a rule, the actual performance will be lower than that stated by the supplier, since the value the supplier states is often for specific test conditions. Typical test conditions are outside air or groundwater at 7 degrees Celsius.

The performance of heat pumps was investigated by the Norwegian and Swedish Consumer Councils in 2004. For Norwegian climate zones, the annual performance factor varies from 1.7 to 3.3, depending on local conditions. The survey indicates that higher performance may be expected along the south-west coast than in inland eastern Norway. The annual performance factor for the Oslo and Mid-Norway areas is some 15 per cent lower than for the south-west coast. The heat pumps that utilise air as a heat source are much more dependent on local climatic conditions than groundwater pumps.

Heat pumps that take heat from the ambient air (air-to-air heat pumps) are less efficient when the need for heat is greatest, i.e. when it is coldest. On the coldest days, the performance factor can fall as low as 1.0. The main reason for this is that heat pumps are designed for specific temperature ranges and it requires a lot of energy to raise the temperature in the system from, say, -20° to +20°. In addition, the external part must be defrosted in cold weather, otherwise moisture in the air can freeze on the heat exchanger, thus leading to a loss of heat to the surroundings. The reason that moisture freezes on the external part (from about +5° outside temperature) is that the cooling medium in the heat pump is at a temperature 5°-10° lower than the surroundings.

In 2005, NVE reported on the contribution of heat pumps to reduced energy consumption in Norway. The report concluded that the technical potential for all types of heat pump at the turn of the millennium, for both heating and cooling, was approx. 35-40 TWh. In 2007, Vista Analyse made a projection of the contribution from heat pumps to the year 2020. They concluded that it would be possible to supply 6-7 TWh of heat from heat pumps in 2020. Both surveys stress that the results are subject to uncertainty.

However, a new survey of heat pumps, carried out by Statistics Norway in 2010, shows little overall net output from heat pumps in Norwegian households. Some customers saved a lot of electricity by installing a heat pump, while others used more electricity. Among those who used more electricity, the main reasons for the increase were the change from heating by wood to heating by heat pump, higher indoor temperatures and the use of the heat pump for cooling in summer.

The sale of heat pumps has increased in recent years, partly due to public subsidy schemes. Up to 2001, only a few hundred heat pumps were sold each year, but in recent years there has been a marked increase, from fewer than 10,000 units per year to more than 80,000. See

Figure 5.12 below. More than 90 per cent of the heat pumps sold are of the air-to-air type and these are used primarily in households.

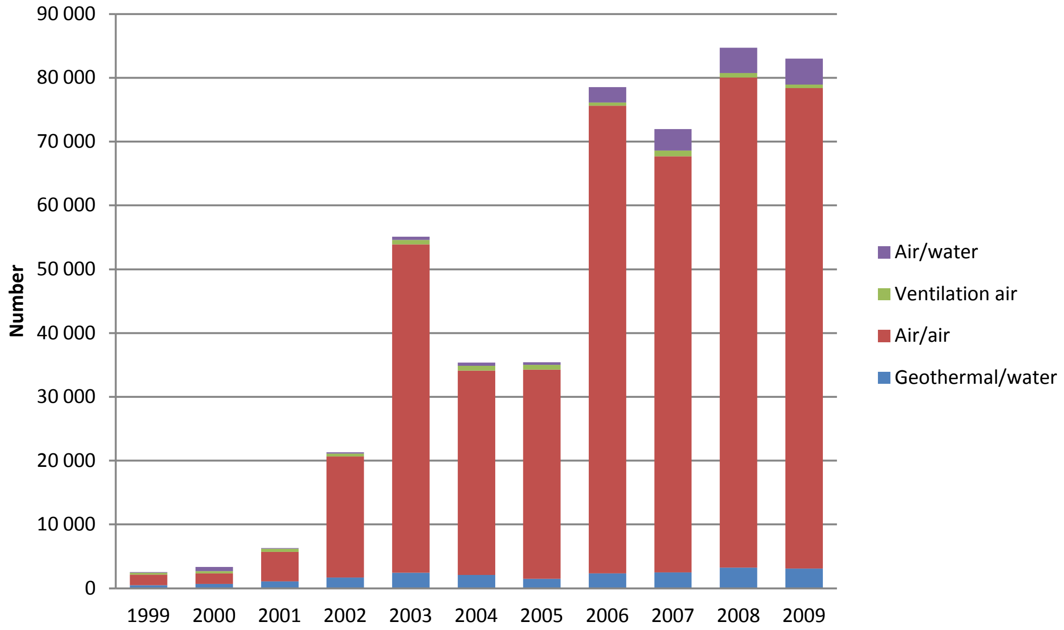

Figure 5.12 Trend in sales of heat pumps. Units per year. Source: NOVAP

6 Electricity consumption by county

New installations and the closure of old ones in the energy-intensive industries and the petroleum sector have brought about major changes in electricity consumption in the affected Norwegian counties. However, consumption in households and the service industries appears to show the same flat trend in all counties.

6.1 Large variations in energy consumption in different counties

Even though overall stationary energy consumption in Norway has levelled off since the late 1990s, there have been large geographical differences. Table 6-1 presents an overview of trends in electricity consumption by county[19] in Norway and we can see that, while the counties of Østfold, Telemark, Sogn og Fjordane and Nord-Trøndelag have seen a marked fall in consumption since 2000, counties such as Hordaland and Møre og Romsdal have experienced a considerable upswing in the same period. This rise in Hordaland and Møre og Romsdal essentially derives from new installations and increased consumption in energy-intensive industries and the petroleum sector, while the fall in Østfold, Telemark, Sogn og Fjordane and Nord-Trøndelag comes correspondingly from closure of energy-intensive businesses.

Table 6-1 Total electricity consumption[1] by county. Source: Statistics Norway

County	2000 TWh	2008 TWh	percentage change
Østfold	7.3	6.4	-12.3
Oslo and Akershus	15.2	16.2	6.5
Hedmark	3	3	0
Oppland	3.2	3.5	9.4
Buskerud	5.6	5.5	-1.8
Vestfold	3.5	3.6	2.9
Telemark	7.2	5.9	-18.1
Aust-Agder	1.9	1.8	-5.3
Vest-Agder	5.8	5.8	0
Rogaland	10.9	11.4	4.6
Hordaland	11.4	12.9	13.2
Sogn og Fjordane	6.7	6.4	-4.5
Møre og Romsdal	6.5	10	53.8
Sør-Trøndelag	5.3	5.5	3.8
Nord-Trøndelag	4.3	3.4	-20.9
Nordland	9.5	9.9	4.2
Troms	3.5	3.5	0
Finnmark	1.6	1.5	-6.3

[1] Total electricity consumption in all sectors, households, service industries, manufacturing industry and the petroleum sector.

[19] There are figures available for electricity consumption by county back to 1996. For total energy consumption by county, the data only goes back to 2005.

6.2 Flat trend in general consumption in all counties

If we exclude electricity consumption in industry and the petroleum sector and only look at consumption by households and the service industries in the individual counties, another trend is apparent. Consumption of electricity in households and service industries (which makes up the majority of general consumption) has exhibited the same flat trend regionally as nationally since 2000. This is illustrated in Figure 6.1. We can see that, in the counties with the highest populations, such as Oslo and Akershus, Hordaland and Rogaland, electricity consumption in households and service industries is at roughly the same level in 2008 as in 2000. Annual variations in consumption correlate to a large degree with variations in temperature.

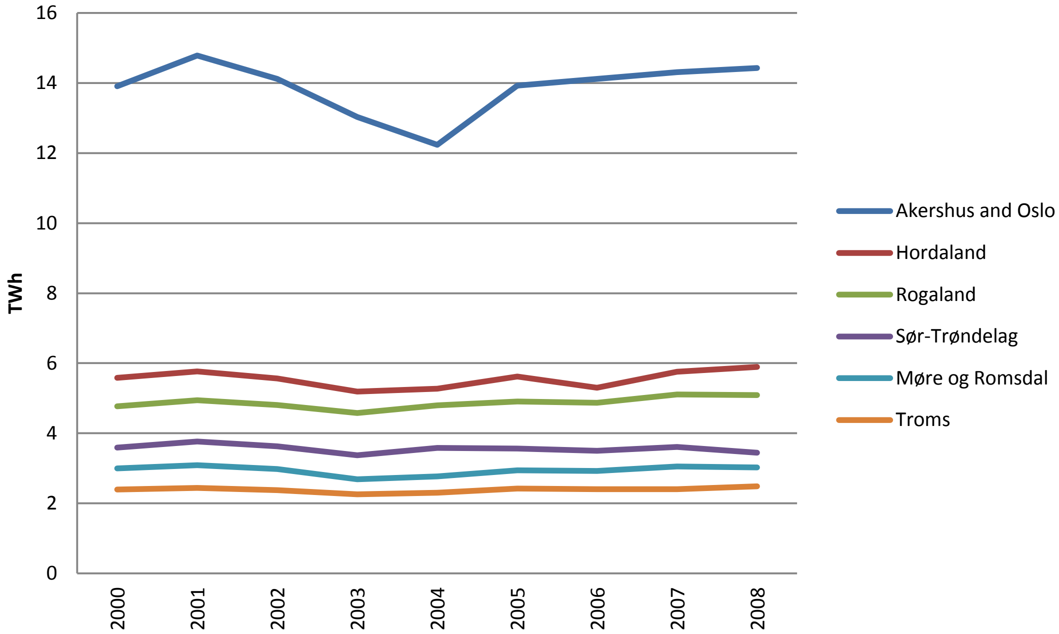

Figure 6.1 Electricity consumption in households and service industries for selected counties[1, 2].Source: Statistics Norway

[1] The same figures as in Table 6-1, excluding manufacturing and the petroleum sector.

[2] In this graph, we have merged Oslo and Akershus because it appears to be difficult to break electricity consumption down between these two counties precisely.

7 Forecasts of stationary energy consumption in mainland Norway

Macroeconomic analyses point to future growth in stationary energy consumption in mainland Norway due to economic growth and increased population. Various sectoral analyses on the other hand estimate flat or falling trends in energy consumption. The rationale for this is a tightening of the energy parameters in the Norwegian Building Code (TEK), but energy savings may also be of significance.

7.1 Methods for forecasting energy consumption

NVE does not produce its own forecasts for energy consumption; what follows is a description of forecasts produced by other expert organisations. This provides a pointer to how the different organisations expect stationary energy consumption in mainland Norway to develop in the future.

What we mean here by 'forecasts' are estimates of what energy consumption in Norway will be at some point in the future. The latest forecasts estimate what energy consumption will be in 2020, 2025, and right up to 2050, given various assumptions about future developments in society. There are several ways of predicting energy consumption. One commonly used method is to take historical trends for energy consumption in different sectors and extend the time series forwards, based on assumptions about developments in various energy-related factors, such as economic development, population growth, the floorage of housing and commercial buildings etc. It is also common to adjust the forecasts based on specific data about the individual sectors, for example, companies relocating out of Norway, or changes in the building code.

There have been a number of analyses of stationary energy consumption in Norway published in the last two years. The best known analyses are:

- The white paper on long-term perspectives for the Norwegian economy analyses trends in the Norwegian economy to 2060. Since energy is a key aspect of the Norwegian economy, this topic was also treated in the white paper.
- Klimakur – workgroup from several governmental bodies: Forecasts for energy consumption to 2020.
- Institute for Energy Technology: a study of future energy consumption to 2050 and a study of the impact on the Norwegian energy system of climate change to 2050.
- Statnett – annual grid development plans: scenarios for future electricity consumption.
- McKinsey: study of energy efficiency measures in industry.

In this chapter, we first describe forecasts of total energy and electricity consumption in Norway, and then look more closely at forecasts for energy consumption in housing and commercial buildings, manufacturing industry and the petroleum sector.

The white paper on long-term perspectives for the Norwegian economy is one of the key documents with regard to forecasts of energy consumption in Norway. This is because this report largely sets out the premises for the official view of trends in core economic variables, such as GDP. Along with Statistics Norway's forecasts of population trends, the white paper provides important variables for estimating future energy consumption.

Figure 7.1 shows how Statistics Norway envisages the population growing in future. If the option they refer to as medium growth in the figure occurs, Norway's population will grow by nearly 1 million up to 2030, from 4.85 million in 2010 to 5.8 million in 2030. This corresponds to population growth of 20 per cent up to 2030. There is normally a correlation between population trends and trends in the economy and energy consumption, so Statistics Norway's forecasts for population growth are a key variable for estimating future energy consumption.

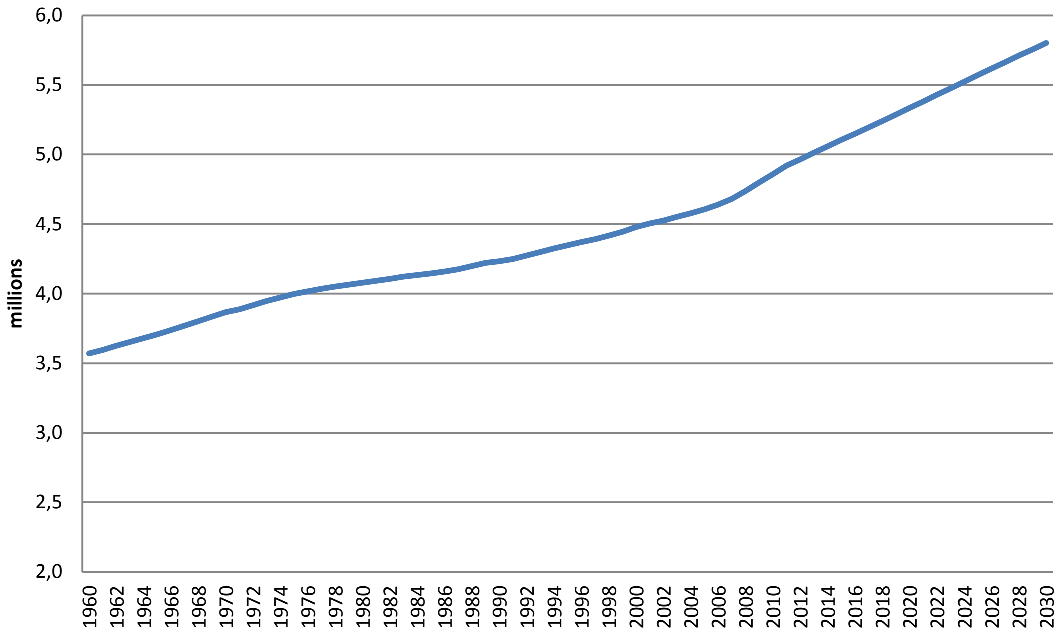

Figure 7.1 Population of Norway. 1960 – 2030. Forecast – medium growth. Source: Statistics Norway

In the white paper, the Ministry of Finance has made forecasts of key economic parameters using the MSG model. The model bases its estimates for future trends on changes in demographic and economic variables such as economic activity, population trends and the composition of business and industry. In Table 7-1, we can see how they estimate per capita GDP will grow up to 2060. The Ministry of Finance also assumes that economic growth and population growth will lead to a growth in energy consumption, but takes account of the possibility of technological developments and changes in the composition of business and industry limiting this growth.

Table 7-1 Annual growth in percentage of GDP per capita in mainland Norway. Source: White paper on long-term perspectives for the Norwegian economy

	1970-2007	2007-2060
GDP of mainland Norway per capita	2.4	1.7

7.2 Forecasts of total energy consumption

Based on figures from the Ministry of Finance and Statistics Norway, a reference scenario for total energy consumption in Norway up to the year 2020 has been produced for **Klimakur**. Klimakur is a project involving individuals from various government bodies whose task is to evaluate measures and instruments for reaching the objective of the cross-party parliamentary climate agreement on reduction in Norwegian greenhouse gas emissions. In this connection, they also looked at trends in energy consumption.

The result of the general forecast[20] for Klimakur is a **growth in total energy consumption of 0.5 per cent** per annum from 2007 to 2020. This includes both energy consumption in mainland Norway and on the Norwegian continental shelf, but excludes the use of energy products as raw materials. Commercial buildings within the service industries and petroleum installations that take power from onshore are expected to be the biggest contributors to growth in stationary energy consumption in mainland Norway in future. This entails growth in energy products such as electricity and district heating. It is however assumed that households and manufacturing industry will see low growth in energy consumption. Table 7-2 shows how the consumption of different energy products changes in line with Klimakur's forecasts.

Table 7-2 Forecast of consumption of different energy products. (including Norwegian continental shelf). Source: Klimakur – main report

Energy products	1990 TWh	2007 TWh	2020 TWh	Annual growth 2007-2020
Wood, wood chips and black liquor	9.8	12.3	15.4	1.80%
Gas[1]	42.5	78.6	76.8	-0.20%
Gasoline	27.4	22.5	14.9	-3.10%
Middle distillates[2]	40.9	53.1	69.9	2.10%
Waste and landfill gas	1.6	3.4	4.2	1.80%
Electricity and district heating	98.6	117.8	125.7	0.50%
Total energy consumption	220.8	287.7	306.9	0.50%

[1] Gas here includes natural gas and liquefied gas used both on the continental shelf and in mainland Norway

[2] Middle distillates include diesel, marine gas oils and fuel oil and are used primarily for transport.

[20] Sectoral forecasts were also made in Klimakur, based on detailed data for the individual sectors. The sectoral forecasts deviates somewhat from the overall forecast. The biggest difference is within office/service buildings in the service industries where the sectoral forecast estimates lower growth in energy consumption up to the year 2020.

Statnett creates forecasts for future **electricity consumption** and employs scenarios to illustrate how different driving forces interact and push trends in different directions. They have 3 scenarios for trends up to the year 2025;

- scenario 1: low growth in the global economy
- scenario 2: wind power and steady global economic growth
- scenario 3: export and exchange (strong growth in the global economy)

Each of these scenarios produces different rates of growth in electricity consumption in the individual consumer groups.

The 'low growth' scenario describes a future of low global economic growth. This leads to annual growth in energy consumption in ordinary supply[21] of 0.5 per cent per annum and a flat trend in electricity consumption by energy-intensive industry[22].

The 'windpower and consumption growth' scenario describes a situation in which the world economy grows steadily. Good subsidy schemes for renewable energy in Norway produce considerable development of new energy sources resulting in moderate electricity prices. The relatively low electricity prices mean that efforts within energy efficiency are weakened and electricity use in general consumption increases by 0.8 per cent per annum. Consumption in the energyintensive industry is nearly unaltered in this scenario. But electricity consumption within the petroleum sector is estimated to rise strongly from the current level of 4-5 TWh to a level of around 12 TWh in 2025. This will depend on extensive electrification of plant both onshore and offshore.

The 'export and exchange' scenario describes a future of strong economic growth, high demand for electricity and high electricity prices. The laying of cables from Norway to other countries results in high electricity prices in Norway as well. The high electricity prices in this scenario lead to an intense focus on energy efficiency and strong demand for technologies such as heat pumps. Extensive focus on energy efficiency and high energy prices mean that electricity use in general consumption rises by just 0.1 per cent per annum. Consumption in the energyintensive industries rises somewhat due to the favourable conditions in the world economy, but industries such as wood processing will suffer under the high costs. Electricity consumption in the petroleum sector increases to around 7 TWh.

In 2009, **the Institute for Energy Technology** produced a forecast for Enova of **stationary energy consumption** up to 2050. They used different economic and demographic variables to predict energy consumption in the three primary sectors: manufacturing industries, the service industries and households. Under their base scenario, the result was that overall stationary energy consumption would be 4 per cent higher in 2020 and 16 per cent higher in 2050, than in 2007. They anticipate that energy consumption in households and commercial buildings in the service industries will increase by 14 TWh and 16 TWh respectively from 2007 to 2050, while energy consumption in manufacturing industry will fall slightly in the same period. The rationale for manufacturing industry using less energy is primarily that activity within pulp and paper and ferroalloy production will fall.

[21] Ordinary supply includes households, commercial buildings and other manufacturing industries.
[22] Energy-intensive industry includes pulp and paper, chamical products and the metals industry.

7.3 Forecasts of energy consumption in different sectors

In addition to forecasts of total stationary energy consumption in Norway, forecasts have been produced of future energy consumption within individual sectors. These studies investigate more deeply problems that are specific to the individual sectors. Some of the studies are discussed below.

7.3.1 Forecasts of energy consumption in housing and commercial buildings

In the analyses referred to in Chapter 7.2, there is an expectation of growth in general consumption of between 0.1 and 0.8 per cent per annum in the future. The highest growth is expected in commercial buildings and the lowest in households, matching the trend seen in these groups in recent years.

Since **outdoor temperatures, the building code[23] and energy efficiency measures** are so significant for energy consumption in buildings, a number of analyses have been performed investigating how these factors will affect energy consumption in housing and commercial buildings in the future. We present below the results of two analyses performed by the Institute for Energy Technology and comment briefly on a climate analysis performed by Statnett, but we emphasise that these analyses are not exhaustive in terms of the progress made in this area in recent years. Some analyses we have seen outline a continuing warm climate and further tightening of the building code, and both these aspects contribute, in the longer term, to moderate demand for energy by households and the service industries.

The **Institute for Energy Technology**, in its 2009 forecast of **stationary energy consumption** (see Chapter 7.2), has come up with an alternative scenario, with a strong focus on energy efficiency in buildings. While their base scenario anticipates growth in energy consumption by households and commercial buildings in the service industries of a total of 30 TWh up to 2050, a tightening of the energy restrictions in the building code and a strong focus on energy efficiency may produce close to zero growth in energy consumption in buildings in the future. Figure 7.2 illustrates how this may turn out for households.

It is a tightening of the energy restrictions in the building code that will produce the largest impact on energy consumption in buildings, in the shape of reduced energy for heating. The EU Directive on the Energy Performance of Buildings specifies that, by the end of 2020, new buildings must be 'near zero energy' buildings, and this may influence the energy parameters in the Norwegian Building Code. Norway defined energy parameters for buildings in 2007, which were revised in 2010. A further tightening of the parameters up to 2020 may produce the outcomes that the Institute for Energy Technology outlines in its 2009 analyses.

With respect to further tightening of the building code, the talk is now of low energy houses and passive houses. Low energy houses entail a reduction in heating requirements of 70-80 per cent relative to the current average, and in passive houses the heating requirement must be minimal. From Table 7-3, we can see that even the present building code (TEK10) represent a considerable reduction in energy consumption relative to the average of the current building stock and will therefore help dampen demand for energy in buildings in the future. But the transition to the TEK10 code is happening slowly, and only a proportion of the building stock, approx. 20% of houses and 30% of commercial buildings, will be renovated by 2030.

[23] The building code applies to new buildings built after the new code comes into force and existing buildings that are renovated for a cost of more than 25 per cent of the building's value or for more than 25 per cent of the building's volume.

Table 7-3 Energy parameters for buildings. Annual energy consumption. Source: TEK 10, NS 3700 and NS3701

	Houses	Commercial buildings
Average of existing buildings	approx. 200 kWh/m^2	approx. 250 kWh/m2
Current building code (TEK10)[1]	120 kWh/m^2	150 kWh/m2
Low energy level	95 kWh/m^2	115 kWh/m^2
Passive house level[2]	70 kWh/m^2	80 kWh/m^2

[1] The building code applies to new buildings and buildings renovated after introduction of the new code

[2] Passive houses involve the use of passive measures such as extra insulation and draught-proofing to reduce the heating needs in buildings.

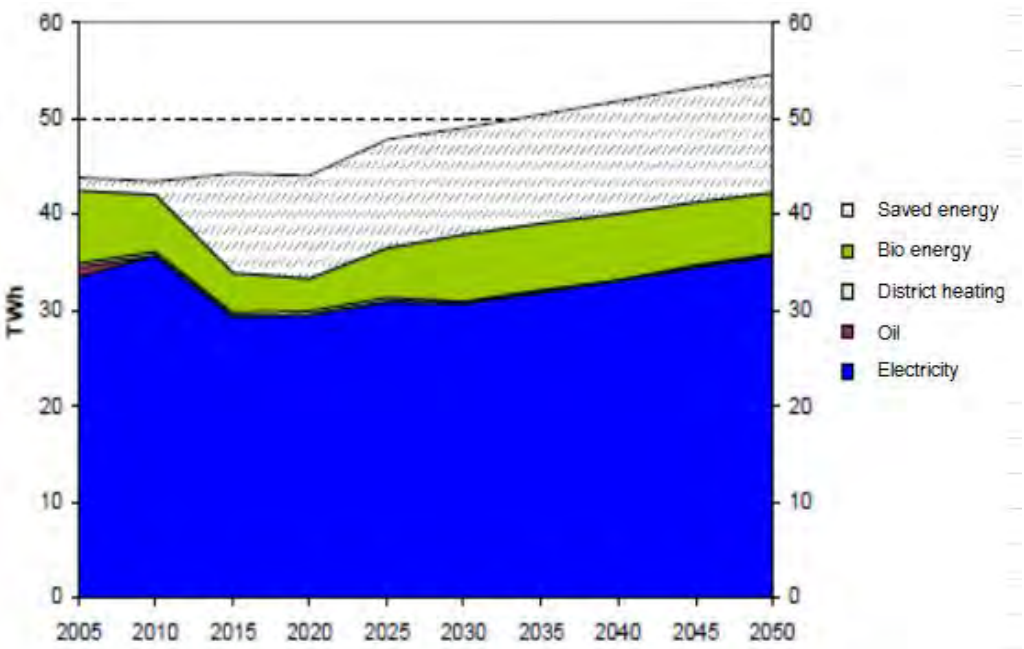

Figure 7.2 Energy consumption in households with a strong focus on energy-efficiency measures. Source: Institute for Energy Technology

An analysis carried out for the building sector in Klimakur shows that the introduction of passive housing as a regulation from 2015 would bring about a fall in energy consumption in houses and commercial buildings by 2020 and 2030. When and if low energy and passive houses are introduced as standard in the building regulations will have a large impact on energy consumption in future buildings.

Climate trends will also be highly significant for energy consumption in buildings. The **Institute for Energy Technology** has carried out a study in which they have examined the impacts of a warmer climate in Norway, by which is meant a temperature increase of 1-4 ^{0}C over the present level. The temperature increase will vary between regions and over the year. A warmer climate will lead to a reduced need for heating and an increased need for cooling, but according to the Institute for Energy Technology's calculations the reduction in heating will be much larger than the rise in the need for cooling. They have calculated that a warmer climate could reduce the heating requirement in the Norwegian building stock by 9 TWh in 2050, relative to a more 'normal' climate. They have calculated that the corresponding cooling requirement will increase by 0.4 TWh.

Statnett has similarly analysed the climate's effect on **electricity consumption** and concluded that the levelling off of consumption in ordinary supply from 1996 to 2009 was partially due to milder winters. They assume that this trend in electricity consumption will continue as a result of a warmer climate.

7.3.2 Forecasts of energy consumption in industry

Most analyses of future **energy consumption in Norwegian industry** point to a flat trend, or occasionally to a slight decrease. Wood processing in particular is predicted to have a difficult future, in an increasingly paperless society. The wood processing industry currently consumes approximately 10 TWh of energy per annum, of which half is from electricity. A number of companies in this sector have closed down in the last ten years. Lower activity in the wood processing industry will lead to lower energy consumption.

In the metals industry, it is assumed that all Søderberg ovens for the production of primary aluminium will be phased out. The last Søderberg plant to be phased out was Hydro's on Karmøy, which led to a reduction in electricity consumption of approximately 2 TWh. The closure of Søderberg plants will, in isolation, lead to a reduction of energy consumption for the production of primary aluminium. In addition to this, there is expected to be a transition from ferroalloy production to silicon production. This is because of high demand for silicon in the solar cell industry. How this will affect energy consumption in these businesses is uncertain, but both the Institute for Energy Technology and McKinsey point to a relatively flat trend in energy consumption for this sector.

In several environments, it is assumed that the non-energy-intensive industries will experience the greatest growth in Norwegian industry in the future. Since these industries use relatively little energy compared with the energy-intensive industries, this will not lead to any major upswing in total energy consumption. In this context, it is important to note that a tightening of the building code will also affect energy consumption in industrial buildings and help dampen growth in energy consumption in industry.

Anticipated development trends for Norwegian industry are illustrated in a figure in **McKinsey**'s potential study of Norwegian industry. See Figure 7.3. This study was performed in 2009, using 2007 as the base year for forecasts. Since 2007, there have been several closures within the wood processing and metals industries, to the effect that energy consumption in 2010 is lower than in 2007. The column on the right of Figure 7.3 shows the reference scenario in McKinsey's study, which they assume to be the most probable estimate of energy consumption in Norwegian industry in 2020. The column in the middle shows an estimated energy consumption trend without any form of technological progress in industry.

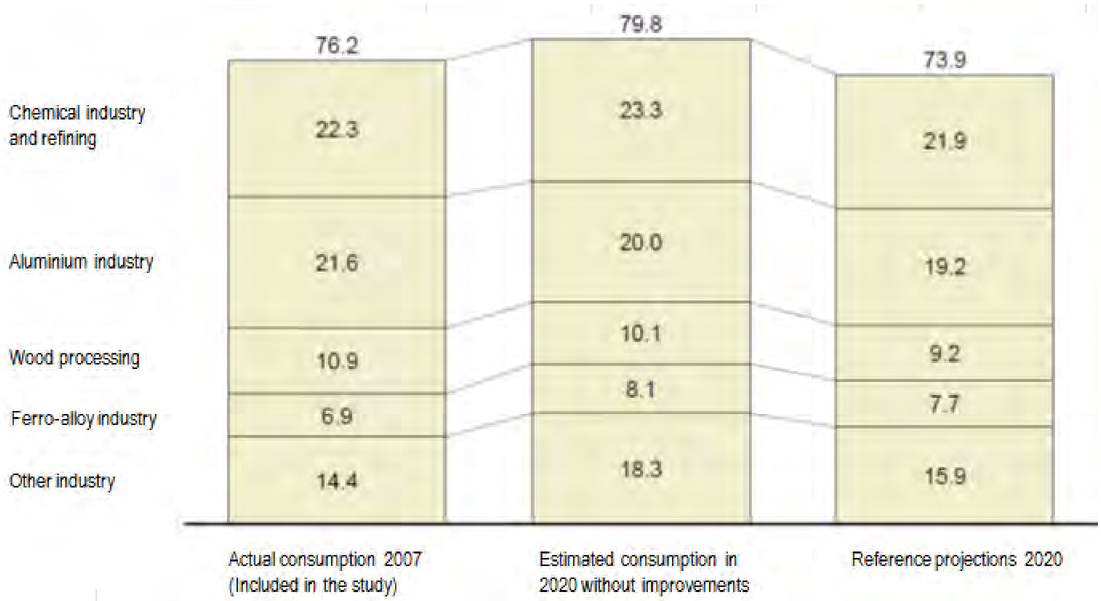

Figure 7.3 Energy consumption in Norwegian industry. Source: ENOVA/McKinsey

7.3.3 Forecasts of energy consumption in the petroleum sector

Developments in subsea technologies and cable technologies have made it possible to supply **petroleum installations** offshore with power from the mainland and install processing plants onshore. This has lead to a strong upswing in electricity consumption in petroleum sector. In Chapter 4, we noted that electricity consumption had increased from around 1 TWh in 1995 to around 5 TWh in 2009. In 2010, electricity consumption in this sector had risen to nearly 6 TWh, due to increased activity in the Troll/Kollsnes and Ormen Lange fields and the Snøhvit plant. In addition, from late 2010 Statoil Mongstad started up a turbine in its gas-fired power plant. This power plant produces electricity for their own installations as well as the Gjøa platform in the North Sea. Further, BP Norge has stated that the Valhall platform in the southern part of the Norwegian sector of the North Sea, will receive electricity from onshore as it comes onstream in the second half of 2011.

In terms of future developments, **Statnett** states in its grid development plan for 2010 that the Goliat platform in Finnmark is to be part-electrified, and development of the installations at Snøhvit, Ormen Lange and Troll is to be evaluated. On this basis, Statnett has produced a forecast for future energy demand. Under the base scenario, they anticipate electricity consumption in the petroleum sector of around 7 TWh in 2020, but this does not include consumption by the refineries. Electricity consumption by the refineries was around 0.6 TWh per annum up to 2011, but the new gas-fired power plant at Mongstad may mean the refinery switching from gas as its energy source to using electricity and excess heat from the gas-fired power plant as energy sources. At full operation, the power plant at Mongstad is capable of supplying 2.3 TWh of electric energy (source: Statoil).

Figure 7.4 shows how electricity consumption in the petroleum sector has grown and how Statnett anticipates it may grow in the future. Some of the projects under assessment are included in Statnett's base scenario for future electricity demand. We can see that demand is expected to increase most in the next few years, and then to tail off when the fields/installations are producing less.

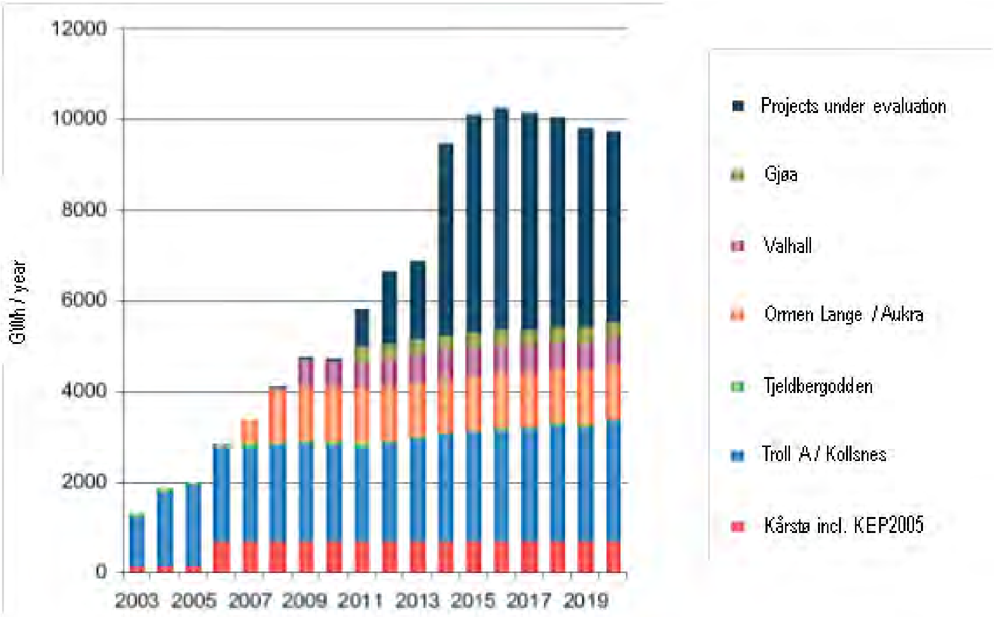

Figure 7.4 Forecast for future electricity consumption in the petroleum sector. Source: Statnett

7.4 Summary – forecasts

Macroeconomic analyses, performed by the Klimakur project group and Statnett among others, point to a growth in stationary energy and electricity consumption in mainland Norway in the future. For housing and commercial buildings, which make up the majority of general consumers in the electricity statistics, the macroanalyses anticipate annual growth in electricity consumption of between 0.1 and 0.8 per cent. The growth is expected to be strongest in the commercial buildings segment.

Meanwhile, a number of sectoral analyses, performed by the Institute for Energy Technology and for Klimakur and others, describe a scenario in which a warmer climate and a more stringent building code will reduce the need for heating in buildings. Relatively strict energy parameters have already been introduced in the applicable building regulations as of 2010, and the EU Directive on the Energy Performance of Buildings has introduced a requirement for near zero energy buildings by the end of 2020. Together with an anticipated warmer climate, this may produce a levelling off or fall in energy consumption in buildings in the future.

The estimates that have been made for trends in the energy consumption of industry anticipate a flat or falling trend in demand. The decline in the level of activity in the wood processing industry and a trend towards less energy-intensive technologies are proposed as arguments for this fall in energy consumption. In addition, a more stringent building code will reduce the need for heating in industrial buildings as well.

The only sector where there appears to be general consensus on a rise in energy/electricity consumption is the petroleum sector. The development of existing installations and the prospective electrification of new installations is likely to increase this sector's electricity consumption by several TWh. This consumption will increase by a relatively large amount in the initial years and then tail off when production at the installations declines. Nonetheless, this sector will only account for 5-7 per cent of overall energy and electricity consumption in mainland Norway.

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