CHAPTER 1

CLIMATE CHANGE

Introduction

Climate change is no longer a mere scientific issue but a global emergency of increasing priority on the policy agendas of national and international institutions.

Climate change is no longer a mere scientific issue, but also a global emergency. For this reason it is given significant relevance on the policy agendas of national and international institutions.
In terms of scientific assessments, the IPCC[1] (Intergovernmental Panel on Climate Change) confirmed that "Warming of the climate system is unequivocal", indicating, "with *a very high confidence*, that the global average net effect of human activities since 1750 has been one of warming."
In terms of public awareness, noteworthy attention was given to this topic on the occasion of the awarding of the Nobel Peace Prize to the IPCC and to former Vice President of the United States Al Gore for his film "*The Inconvenient Truth*". Finally, significant progress has also been made in terms of international policy, in the framework of the negotiations at the 13th session of the Conference of the Parties (COP) of the UNFCCC (United Nations Framework Convention on Climate Change).

Important progress was made at the Bali Conference in terms of the negotiations on climate change.

One of the main results of the Conference was the approval of the *Bali Road Map*, a document which consists of a number of key decisions to guarantee a secure climate future. The *Road Map* includes the *Bali Action Plan*, which lays out the guidelines for a new process designed to lead to the full implementation of the Convention through long-term initiatives. These initiatives are based on five topics for negotiation: a shared vision for long-term cooperative action, mitigation, adaptation, the development and transfer of technology and the provision of financial resources.
A subsidiary body expressly established for the purpose has been assigned the task of leading the process to the full and effective implementation of the Convention through long-term actions running up to and beyond 2012. During the 14th session, held in Poznan (Poland) in December 2008, the Parties reached an agreement on the scheduling of the upcoming negotiating sessions, as well as on a number of important issues related to the enactment of the Kyoto Protocol. On that occasion, the Italian Minister

[1] IPCC (2007). Climate Change 2007 – Fourth Assessment Report-WGI.

of the Environment announced Italy's proposal to take advantage of the meetings of the G8, with the emerging countries included, to promote an agreement by the 15th session of the Conference of the Parties, to be held in 2009 in Copenhagen.

Basic climate trends

Globally

The increase in the average temperature observed in recent decades at the global and European level is unusual both in terms of its magnitude and rate of variation.

The EEA stated that "The global (land and ocean[2]) average temperature increase up to 2006 was 0.76 °C, compared to the pre-industrial level". Based on the fourth assessment report of the IPCC, "The linear warming trend over the last 50 years (0.13 °C per decade) is nearly twice that for the last 100 years". Analyses performed by the East Anglia University, and including data for 2007, show that twelve of the last thirteen years, from 1995 to 2007, rank among the thirteen warmest years since instrumental recording began (in 1850). The results of the observations provided by the European Environment Agency (EEA) make it possible to monitor the EU objective of not exceeding pre-industrial levels by more than 2 °C[3] (Figure 1.1).

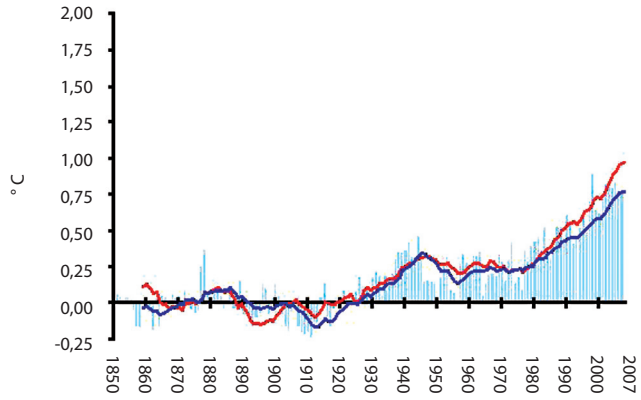
The increase in temperature, at the global and European level, is unusual.

Up to 2006, the overall increase in global average temperature (the land-ocean system) was 0.76 °C compared to the pre-industrial level.

[2] In this document, the term "land and ocean" indicates that the temperature was calculated by taking into account both the temperature of the air on dry land and the sea surface temperature, while the term "land" means that the reading refers only to the temperature of the air on dry land.

[3] EEA, http:// themes.eea.europa.eu/IMS/ISpecs/ISpecification20041006175027/IAssessment1202733436537/view_content

Of the 13 warmest years since 1850, twelve have been recorded since 1995.



Legend: The lines represent the moving averages over 10 years, calculated, respectively, for the "land and ocean" system (blue) and for the "land" system (red)

Figure 1.1: Global annual average temperature anomalies[4] (land and ocean system) from 1850 to 2007[5]

Projections based on the six emissions scenarios of the IPCC for the end of the 21st century estimate an increase in global temperature from 1.8 to 4.0 °C by 2090-2099 compared to 1980-1999[6].

As for precipitation trends between 1900 and 2005, a noteworthy increase was registered in the eastern part of North and South America, in Northern Europe and in Northern and Central Asia, whereas water shortages were observed in the Sahel region, in the Mediterranean, in Southern Africa and in certain parts of Southern Asia.

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[4] Anomalies calculated for the reference period of 1961-1990 and adjusted to the period 1850-1899 (defined as pre-industrial), in order to obtain an immediate visualisation of the increase in average temperature compared to pre-industrial levels.

[5] Source: European Environment Agency, EEA - Data from the Climatic Research Unit of the East Anglia University

[6] IPCC (2007). Climate Change 2007 – Fourth Assessment Report-WGI.

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Globally, the sea surface temperature rose by 0.038±0.011 °C per decade during the period 1850-2005, according to an estimate based on the HadSST2 dataset of the Hadley Centre.

Europe

The temperature of the land and ocean system in Europe up to 2006 increased by approximately 0.95 °C compared to pre-industrial levels. This increase was higher compared to the global increase. The change was especially marked in the southwest and northeast regions, and in mountainous zones[7].

Up to 2006, the increase in the temperature of Europe's land-ocean system was approximately 0.95 °C, compared to pre-industrial values. This increase was higher than the global increase.

Projections point to an average temperature increase of between 1.0 and 5.5 °C by the end of this century. Under the A1B scenario[8], for example, global climate models estimate an average temperature increase, between the periods 1980-1999 and 2080-2099, in a range of 2.3 to 5.3 °C in Northern Europe and of 2.2 to 5.1 °C in Southern Europe and the Mediterranean regions[9]. Naturally, when different emissions scenarios are employed, the estimated intervals for temperature increase vary considerably. The highest warming in Northern Europe is expected for the winter season, while the highest increase in the Mediterranean region is expected in summer (Figure 1.2).

[7] EEA, http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041006175027/IAssessment-1202733436537/view_content

[8] Scenario characterised by very rapid economic growth, population growth that peaks around the middle of the 21st century, and then declines, plus the rapid introduction of new and more efficient technologies, along with a balanced distribution of the various sources of energy (IPCC, *Special Report on Emission Scenarios*, 2000).

[9] IPCC (2007). Climate Change 2007 – Fourth Assessment Report-WGI.

Based on the A1B scenario, global climatic models estimate an average temperature increase, between the periods 1980-1999 and 2080-2099, in a range of 2.3 and 5.3 °C in Northern Europe and in a range of 2.2 and 5.1 °C in Southern Europe and the regions of the Mediterranean.

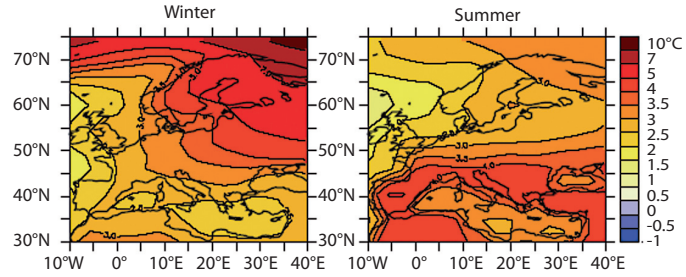

Figure 1.2: Variation in the average temperature in Europe between 1980-1999 and 2080-2099, estimated on the basis of the A1B emissions scenario[10]

Over the last 50 years, changes have been observed in the distribution of extreme temperatures, with an increase in the frequency and intensity of extremely hot events and a decrease in low-temperature episodes. According to the projections this trend will continue in the future as well.

During the 20th century, precipitation increased between 10% and 40% in the regions of Northern Europe, while it decreased by up to 20% in certain parts of Southern Europe.

In terms of precipitation in Europe, an increase between 10% and 40% was observed in the northern regions during the 20th century, together with a decrease of up to 20% in certain parts of Southern Europe[11].

Based on the A1B scenario, global climate models estimate an increase of between 0% and 16% in total annual precipitation between the two periods 1980-1999 and 2080-2099 for Northern Europe, with a decrease of between 4 and 27% in Southern Europe and the Mediterranean regions, showing peak levels in the summer season[12] (Figure 1.3). It should be kept in mind that projections of precipitation, unlike those of temperature, which are distributed fairly uniformly over space, can differ significantly even within relatively small horizontal distances, especially in regions characterised by a complex orography. It has also

[10] Source: IPCC, *Fourth Assessment Report*
[11] EEA, 2008. Impacts of Europe's changing climate – 2008 indicator-based assessment. EEA Report no. 4/2008.
[12] IPCC (2007). Climate Change 2007 – Fourth Assessment Report - WGI.

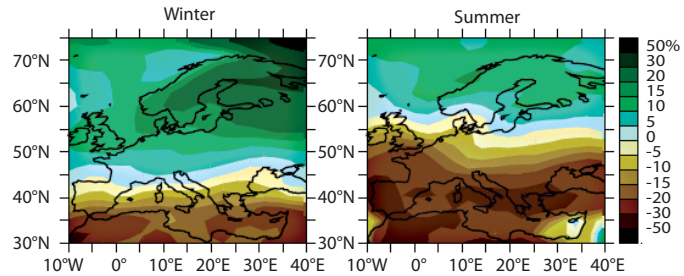

Figure 1.3: Fractional change in total precipitation in Europe between the periods 1980-1999 and 2080-2099, estimated on the basis of the A1B emissions scenario[13]

Based on the A1B scenario, the global climate models estimate an increase in the range of 0% to 16% in total annual precipitation between the periods 1980-1999 and 2080-2099 in Northern Europe, while a decrease of between 4% and 27% is expected for Southern Europe and the Mediterranean regions, especially during the summer season.

been estimated that the frequency and intensity of extreme precipitation events shall increase, especially in the northern regions, while there will be a rise in periods of drought, especially in Southern Europe.

Finally, the surface temperature of Europe's seas is increasing more rapidly than the rates observed in the rest of the globe, with the highest rates recorded in the seas of Northern Europe rather than the Mediterranean. Over the last 25 years (1982-2006), the rate at which the temperature of Europe's seas has risen has been roughly 10 times greater than the figure registered for the period 1871 to 2006[14].

Italy

Estimates of the average temperature trend in Italy over the last 200 years point to levels that were rather low up through 1860, with 1816 representing the coldest year of the entire period. A subsequent trend in the direction of increasingly high values was recorded, with 2003 proving to be the hottest year of the entire series[15] (Figure 1.4).

The average temperature in Italy has increased significantly over the last thirty years, with 2003 representing the hottest year of the entire series.

[13] Source: IPCC *Fourth Assessment Report*

[14] EEA, 2008. Impacts of Europe's changing climate – 2008 indicator-based assessment. EEA *Report* n. 4/2008.

[15] www.dta.cnr.it/dmdocuments/pubblicazioni/volume_clima_07/AT_03/3-20_nanni.pdf

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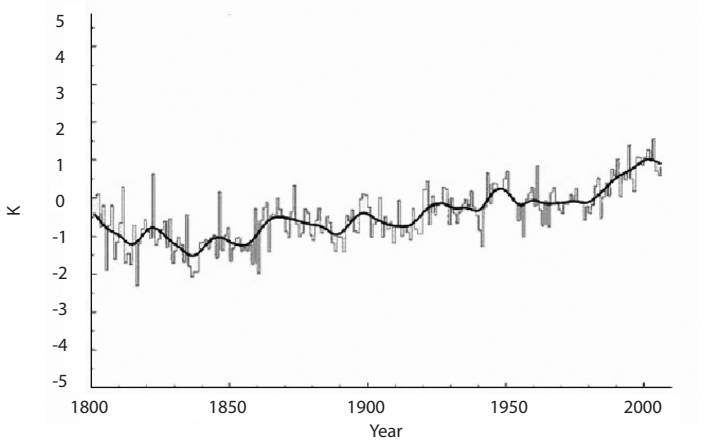


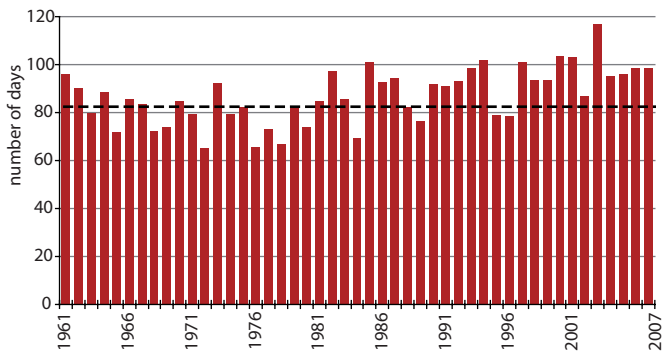
Note: The data are expressed in terms of anomalies compared to the period 1961-1990

Figure 1.4: Average annual temperatures in Italy during the period 1800–2006[16]

The trend of the average temperature in Italy during the period 1961-2007 was estimated by utilising non-linear models. The data processed consisted of a homogenized series of mean annual temperatures of 49 stations of the Italian Air Force network. The estimate shows that the average temperature in Italy decreased between 1961 and 1981, followed by an increase up to 2007, for an overall increase of approximately 0.94 °C.

The upward trend of the temperature in Italy is confirmed by an analysis of extreme temperature values. It is estimated that, during the years 1961-2007, there was an average increase of 14.8 "summer days"[17] (Figure 1.5) and an average increase of 10.4 "tropical nights"[18].

[16] Source: Nanni et al., 2006
[17] Number of days with a maximum air temperature of more than 25 °C.
[18] Number of days with a minimum air temperature of more than 20 °C.



Note: The dotted line represents the average normal value calculated for the period 1961-1990

Figure 1.5: Annual series of average number of summer days in Italy (1961-2007) [19]

There was an estimated average increase of 14.8 "summer days" during the period 1961-2007, meaning days with a maximum air temperature of more than 25 °C.

A seasonal analysis shows that the warming which has characterised the last twenty years has been especially noticeable in Summer and Spring, but less so in the other seasons. For example, in an analysis of the 49 stations of the Italian Air Force during the period 1961-2006, the summer series prior to 1981 (1980 for Central Italy) showed a phase of cooling followed by a period of marked heating, at a rate between 0.056 and 0.072 °C/year[20].

The average Italian series for annual precipitation during the last 200 years shows no noteworthy trends (Figure 1.6). Seasonal and annual precipitation trends are generally negative and limited in size, rarely proving to be statistically significant [21].

For example, an analysis of standardised precipitation anomalies performed on data from 59 stations of the Italian Air Force during the period 1961-2006 shows a downward trend of 0.015/year for Northern Italy during the winter season[22].

An analysis performed on data from 59 stations of the Italian Air Force during the period 1961-2006 shows a downward trend of 0.015/year for Northern Italy during the winter season.

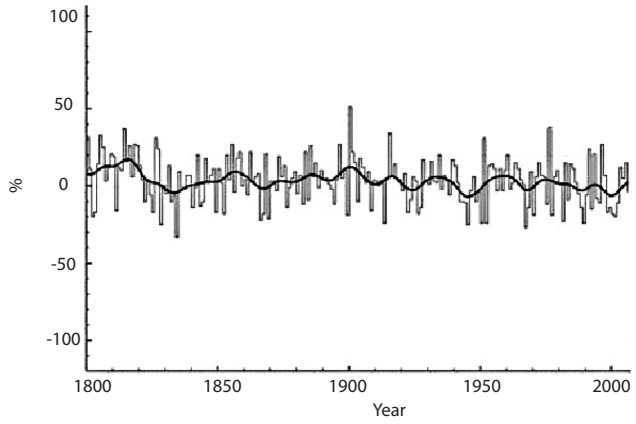
[19] Source: Italian Air Force data processed by ISPRA (former APAT)

[20] A. Toreti, F. Desiato, G. Fioravanti, W. Perconti, 2008, Seasonal temperature and precipitation over Italy from 1961 to 2006. European Conference on Applied Climatology, ECAC, 2008 – Poster Session.

[21] www.dta.cnr.it/dmdocuments/pubblicazioni/volume_clima_07/AT_03/3-20_nanni.pdf

[22] A. Toreti, F. Desiato, G. Fioravanti, W. Perconti, 2008, Seasonal temperature and precipitation over Italy from 1961 to 2006. European Conference on Applied Climatology, ECAC, 2008 – Poster Session.

The average Italian series for precipitation over the last 200 years shows no noteworthy trend.



Note: The figures are expressed as percentage deviations compared to the average values for the period 1961-1990

Figure 1.6: Annual average series of precipitation in Italy during the period 1800–2006[23]

Impacts of climate change

Globally

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

As indicated in the Fourth Report of the IPCC[24]: "Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases".

Most of the components of the cryosphere are undergoing a generalised reduction, and at an increasingly rapid pace in recent decades, in keeping with the increased warming observed. In the Arctic and in Antarctica, for example, ice shelves dating back thousands of years have begun to collapse, with a significant impact on mammals and on populations of marine birds. In the tropical Andes and in the Alps, glacier melting has resulted in a run-off increase in recent decades (Figure 1.7).

[23] Fonte: Nanni et al., 2006

[24] IPCC (2007). Climate Change 2007 – Fourth Assessment Report - WGII.

Over the last 65 years, Spring peaks in river flows have moved up to a point one or two weeks earlier in North America and in the northern portion of the Eurasian continent. At lower altitudes, a downward trend in the snow cover has been observed, affecting skiing sites, especially in the Alpine arc.

In certain cases the melting of the glaciers has lowered the temperature of seas, as has been demonstrated in the North Atlantic and in the Ross Sea.

Many coastal regions are suffering the effects of local increases in the sea levels, resulting from a combination of factors related to climate, geology and subsidence traceable to anthropogenic activities and other local characteristics. The sea level has risen at a rate of approximately 1.7-1.8 mm a year during the last century, with an increase of up to 3 mm per year during the last decade.

Globally, a yearly increase of approximately 1.7-1.8 mm was observed in sea level during the last century, while increases of up to 3 mm per year have been registered in the last decade.

The sea level rise, the increased height of waves and the greater intensity of storms are striking certain coastal regions without intense anthropogenic development, such as the polar areas, leading to processes of coastal erosion.

In marine and aquatic ecosystems, many changes in phenology and biogeography, related to the phases of the development of organisms and the distribution of species, are tied to increases in water temperature, as well as to changes in salinity, levels of oxygen and circulation. It is now clear the connection between the coral bleaching and the anomalies in the sea temperature, though it is difficult to distinguish the effect of temperature from non-climatic factors. The most widespread instance of deterioration occurred in 1998, destroying 16% of the world's coral, with an especially devastating effect in the Western Pacific and in the Indian Ocean.

Aquatic ecosystems are showing changes in the abundance of organisms and in productivity, as well as in ranges of expansion and phenological phases, in response to increases in temperature.

Studies of terrestrial biosystems point to impacts of global warming over the last 30-50 years, such as the earlier occurrence of Spring and Summer phenological phases and the extension of the growing season at the medium and high latitudes, as well as

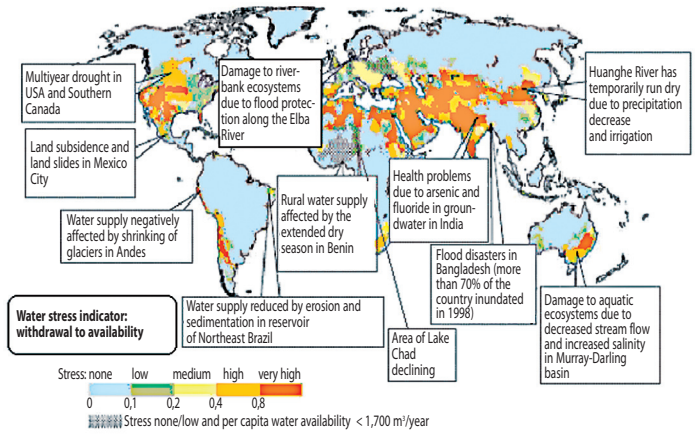
increased vulnerability of certain species, with episodes of extinction at the local level.
In the Northern Hemisphere, the intensity of vegetative activity increased by 12% in Eurasia and by 8% in North America between 1981 and 1999. In contrast, a downward trend in the production of biomass was registered in Southern Europe, tied to the decreased levels of rain, especially following the intense drought of 2003. In recent years, repeated large-scale forest fires have been associated with drought events in the Mediterranean area and in North Africa, as well as in California.
In the countries of the Sahel region, the increase in temperatures, together with lower levels of precipitation, have shortened the vegetation cycle, preventing the area's crop varieties from completing their cycle.

Starting from 1970, an increase in the average intensity of cyclones was registered in the majority of tropical basins.

In terms of extreme meteorological events, starting from 1970 an increase in the average intensity of cyclones has been registered in the majority of tropical basins, together with increases in the number and intensity of storms in the Atlantic. Starting from 1995, the number of intense storms in the Atlantic was more than double the level registered in the period 1970-1994.
On the Asian continent, extreme meteorological events associated with *El Niño* have been more intense and more frequent during the last 20 years. The damage caused by intense cyclones has increased significantly, especially in India, China, the Philippines, Japan, Vietnam and Cambodia, Iran and Tibet.
In recent decades, production of rice, corn and wheat has fallen in many areas of Asia, on account of increasingly stressful water conditions brought about by higher temperatures, a higher frequency of *El Niño* and fewer days of rain.
Extreme meteorological can also have repercussions on human health, in certain cases even leading to a rise in the mortality rate. In the summer of 2003, the hottest since 1500, the heat wave that hit Western and Central Europe was blamed for 25,000-30,000 deaths, a number far higher than all the heat-related deaths registered during the last century in Europe.

Economic losses traceable to natural disasters increased from 75.5 billion dollars in the 60's to 659.9 billion dollars in the 90's.

In terms of economic losses, the amount traceable to natural disasters rose from $ 75.5 billion US in the 60's to $ 659.9 billion US in the 90's. The private-sector data on insurance costs also



Water withdrawals: water used for irrigation, livestock domestic and industrial purposes (2000)
Water availability: average annual water availability based on the 30-year period 1961-1990

Legend: In the background there is a map of the water stress[25]

Figure 1.7: Examples of current vulnerability of water resources and their management[26]

In recent decades, the production of rice, corn and wheat has decreased in many areas of Asia on account of the growing stress placed on supplies of water by increases in temperature, increases in the frequency of El Niño and fewer days of rain.

point to increased losses during this period.

Europe

Based on the latest report of the EEA on the impact of climate change[27], many natural systems in Europe, as well as a large number of socio-economic sectors, have already undergone the consequences of climate change, in the form of loss of biodiversity, reduced quantities and quality of water resources, risks to human health, damage to farming and forestry activities, to tourism and to the sectors of energy and transportation.

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[25] Alcamo J., P. Doll, T. Henrichs, F. Kaspar, B. Lehner, T. Rosch, S. Siebert, 2003. *Global estimates of water withdrawals and availability under current and future business-as-usual conditions. Hydrological Sciences Journal* 48: 339- 348.
[26] Source: IPCC
[27] EEA, 2008. *Impacts of Europe's changing climate – 2008 indicator-based assessment.* EEA Report n. 4/2008.

Mountainous zones, the Mediterranean area, coastal regions and the Arctic represent the most vulnerable areas in Europe.

Between 1850 and the end of the 1970's, the glaciers in the Alps lost a third of their surface area and half their volume.

The most vulnerable areas of Europe are mountainous zones, the Mediterranean area, coastal regions and the Arctic, and this will increasingly be the case unless, in addition to a noteworthy reduction in global emissions of greenhouse gases, the measures needed to adapt to the impact of the effects of climate change already underway, and to moderate them, are taken.

In almost all the glacial regions of Europe, a generalised loss of glacial mass has been observed. Between 1850 and the end of the 1970's, the glaciers in the Alps lost a third of their surface area and half of their volume. An acceleration in the rate of glacial melting has been observed since 1985, resulting in loss of 25% of the remaining glacier. In the Northern Hemisphere, there has also been a decrease of 1.3% per decade in the snow cover over the last 40 years, especially in Spring and Summer.

The rates of variation in the sea levels in Europe during the 20th century ranged from –0.3 mm/year to 2.8 mm/year (Figure 1.8). It is highly probable that the upward trend in the sea level observed over the last 100 years is traceable primarily to an increase in the volume of ocean waters as a result of rising temperatures, though flows of water from melting glaciers play an increasingly important role.

Rates of variation in sea level in different areas of Europe ranged from -0.3 mm/year to 2.8 mm/year during the 20th century.

Note: Figures expressed in mm/year, corrected for postglacial movement of the earth and variations in the field of gravity

Figure 1.8: Change in the sea level at different tide gauges (1896-2004)[28]

Life cycles have been observed to arrive earlier in marine ecosystems, by as much as 4-6 weeks in the case of some species, while plankton have moved rightly 10° to the north, from the warm water of the Northeast Atlantic over the last 40 years.

[28] Source: EEA

An upward trend in the river flows has been observed in the northern areas of Europe, especially in Winter, while Southern Europe shows a slight decrease.

There have also been changes in the river flows over the last century. An upward trend has been observed in the northern areas of Europe, especially during Winter, while there has been a slight decrease in Southern Europe.
Figure 1.9 illustrates the flooding events that occurred in Europe during the ten-year period 1998 – 2008.

In the decade 1998-2008, the European areas most affected by flooding were Eastern Europe and the Balkans Peninsula, while the area of Italy most affected was its northwest portion.

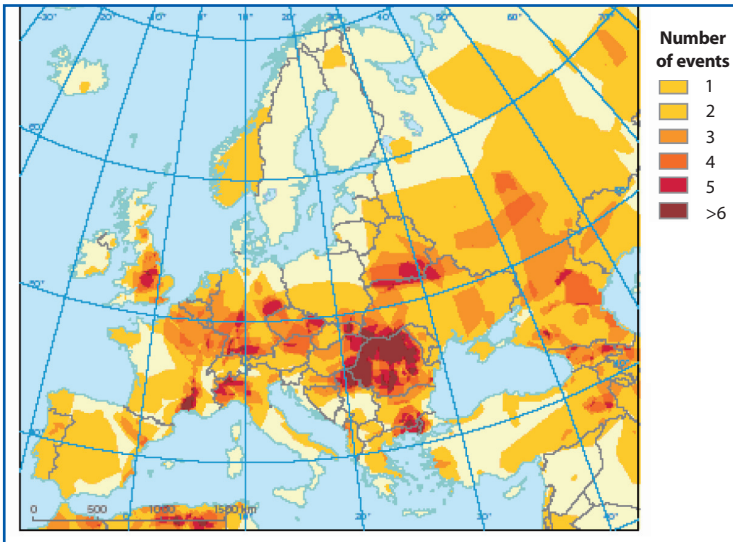


Figure 1.9: Number of flooding events in Europe from 1998 to 2008[29]

In terms of terrestrial ecosystems, it has been observed that many vegetable species are shifting further north, and towards higher altitudes. There have also been variations in the phenological phases: 78% of the figures regarding the development of leaves and blossoms show the dates moving up, while there is a noteworthy delay in only 3% of the cases. The spring and summer phenological events were found to be occurring an average of 2.5 days earlier per decade.
In agriculture, the growing season for crops showed an unmis-

[29] Source: EEA

takable trend towards lengthening between 1975 and 2007, though not to a uniform extent throughout Europe. The most significant changes (roughly 0.5-0.7 days a year) occurred in central and southern Spain, in central Italy, along the Atlantic coasts and in the British Isles, in Denmark and in the central portion of the continent, as a result of a decrease in Spring frosts and a gradual delay in Autumn ones.

Between 1975 and 2006 Europe showed unmistakable trends in the water supply, both upward and downward, with considerable geographic variations: the demand for water rose at an especially high rate (50-70%) in the Mediterranean area, while decreases were registered primarily in the northern and central regions of Europe.

Unmistakable trends in the demand for water were observed between 1975 and 2006: demand rose (50-70%) primarily in the Mediterranean areas, while decreases were registered predominantly in the northern and central zones of Europe.

Numerous epidemiological studies have quantified the impact of temperature on day-to-day mortality. In many European cities, mortality increases beyond a threshold temperature that varies, depending on geographic position[30].

As highlighted by the European Environmental Agency, a report recently published by the United Nations (UNEP FI, 2006) estimates that losses due to meteorological events are doubling every 12 years on a global level. Even though the dominant factors in the increased losses observed are socioeconomic, there can be no denying that ongoing developments in natural disasters constitute an important contributing cause. The average annual number of disastrous events related to the weather and climate in Europe rose by approximately 65% during the period 1998-2007, as compared to the 1980's, while the number of events not related to the climate, such as earthquakes, remained stable. There are no figures, however, of what portion of the increase is traceable to climate change of anthropogenic origin (Figure 1.10).

[30] World Health Organization, 2007 – Environment and health risks from climate change and variability in Italy.

The annual average number of events tied to the weather –climate in Europe rose by approximately 65% during the period 1998-2007, as compared to the 1980's, while events not related to climate, such as earthquakes, remained stable.

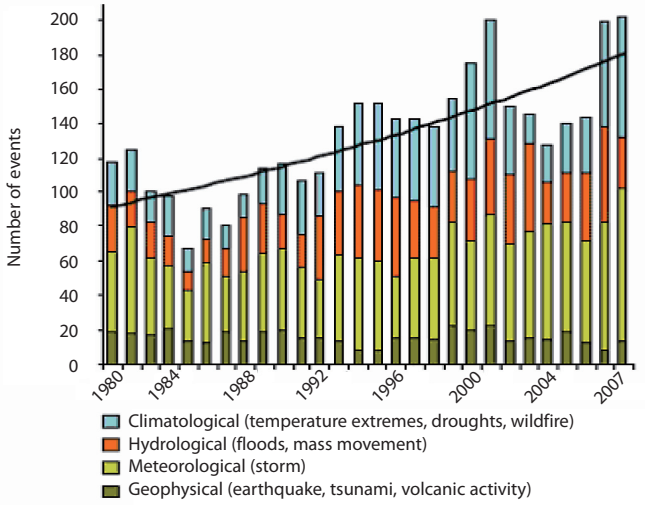


Figure 1.10: Natural disasters in Europe between 1980 and 2007[31]

For the most part, the effect of the foreseen impacts will be negative, resulting in significant economic losses.

Climate change in Europe will be accompanied by numerous economic consequences regarding services associated with the natural environment (including forestry and fishing), coastal areas, agriculture, tourism, energy, human health and the constructed environment. The observed or forecast effects vary by geographic area and sector of activity. The majority of the impacts foreseen will be negative, resulting in economic losses, though some effects may prove positive, as in the case of agricultural production in Northern Europe (Figure 1.11).

[31] Source: EEA

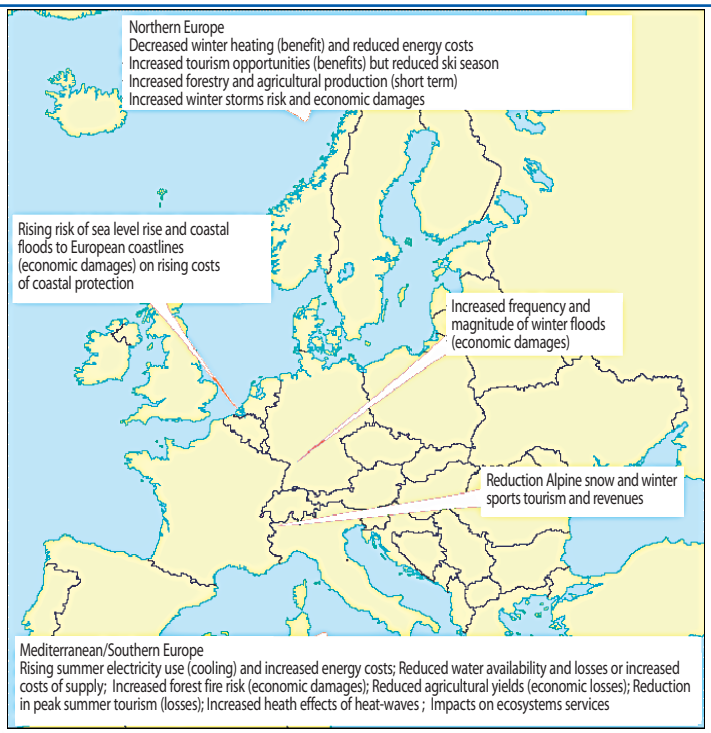


Figure 1.11: Examples of potential economic effects in Europe foreseen for the 21st century[32]

Climate change in Europe will have numerous economic consequences on services associated with the natural environment, on coastal areas, on agriculture, on tourism, on energy, on human health and on the constructed environment.

Italy

Italy is one of the European countries most vulnerable to the impact of climate change, whose effects on our territory and its resources are already visible today.

In recent decades, the gap between the demand for water in various sectors (residential, farming, livestock, industry, recreational activities etc.) and the available supply has grown ever larger. Underlying this problem are a variety of causes, often connected with unsustainable management, due to excessive exploitation and pollution of water tables, the growing demand

Italy is one of the European countries most vulnerable to the impacts of climate change.

[32] Source: EEA

Numerous glaciers distributed along the Alpine arc have been found to have withdrawn, between the early decades of the 20th century and the present, by distances ranging from 400 m to more than 1.5 km.

for water tied to the country's socioeconomic development, the inadequacy of the systems for obtaining and distributing water and excessively water-intensive methods of irrigation. Climate changes, which have already led, in some areas, to lower average annual precipitation, increased variability of precipitation in terms of space and time, higher temperatures and a noteworthy reduction in the snow and glacial reserves of the Alpine arc, only worsen the problem, accelerating the decrease in water supplies and the increase in demand[33].

Along the entire Italian Alpine arc, reductions of glacial reserves equal to the rest of Europe, if not greater, have been registered. As early as 1991, for example, the glaciers on the Piedmont side of the Gran Paradiso mountain had lost 50% of their surface area, compared to what they measured in the 19th century, and they shrunk even further in the years that followed. On the southern slopes of the Alps, the Lys glacier front, on Monte Rosa, withdrew by approximately 1,600 m between 1860 and 2006. Numerous other glaciers found in different points of the Alpine arc have shown significant retreat between the early decades of the 20th century and the present, falling back by distances ranging from 400 m to as much as 1.5 km[34].

Climate warming has unquestionably begin to have an effect on terrestrial biological systems, giving rise to changes such as earlier phenological phase and the migration towards higher latitudes of different animal and vegetable species. The more sensitive species face local extinction, following the disappearance of their ecological niches. In the central Alps, high-altitude vegetable species have been found to move to even higher areas, while observations in the central Apennines point to a tendency on the part of high-altitude ecosystems to adapt to increasingly arid conditions. In such cases, the specific composition has undergone changes of 10-20% in the last ten years, showing worrisome symptoms of a process of degeneration already underway.

[33] www.apat.gov.it/site/_files/CNCC2007Sintesilavori.pdf

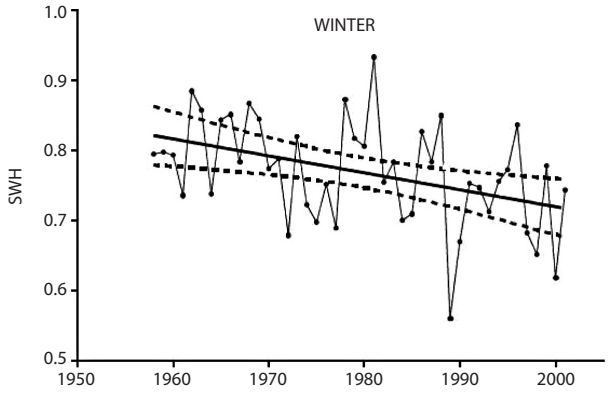
[34] www.conferenzacambiamenticlimatici2007.it/site/_Files/145517_Cambiamenti%20climatici.pdf

The Mediterranean sea level is rising at a rate of approximately 1.52 mm/year.

Coastal erosion and flooding caused by variations in the average sea level and by extreme events also have a major impact on the loss of biodiversity, not to mention economic losses tied to tourism. The rate at which the level of the Mediterranean Sea is rising (1.52 mm/year) is roughly half the global rate (2.85 mm/year), and interannual and spatial variations are quite high[35]. Coastal erosion in Italy has reached noteworthy proportions. Of the total 4,860 km of low-lying coastline, 1,500 km are at risk of erosion or flooding, meaning almost 20% of Italy's total coastal areas. The main causes are anthropogenic, but variations in the sea level and extreme tides caused by climate change could aggravate the situation along the coasts. Unfortunately, the information available to date on the Mediterranean Sea is not sufficient to describe the current trends, and meteorological forcing at regional scale results not only in significant internal variability, but also in deviations between Mediterranean and global trends.
An analysis of the average sea level is available for a limited number of locations in Italy. Genoa and Trieste, for example, show respective upward trends of 1.2 mm/year and 1.3 mm/year for the period 1880-2000[36]. During the second half of the 20th century, a decrease in the average intensity of tides during the winter months[37] (Figure 1.12), along with a reduction in extreme events, were observed only in the central portion of the Mediterranean Sea, including Southern Italy[38] (Figure 1.13).

[35] N. Pinardi, A. Navarra, 2007, *Variabilità del livello del mare nel Mediterraneo, il monitoraggio operativo e gli scenari climatici*. Presented at the Workshop "Cambiamenti climatici e rischio costiero", Palermo 27-28, June 2007.
[36] F. Raicich, 2007, *Scenari di sea-level rise nel Mediterraneo*. Presented at the Workshop "Cambiamenti climatici e rischio costiero", Palermo 27-28, June 2007.
[37] P. Lionello, A. Sanna, 2005, *Mediterranean wave climate variability and its links with NAO and Indian Monsoon*. Clim. Dyn., 25, 611-623.
[38] P. Lionello, J. Bhend, A. Buzzi, P. M. Della Marta, S. Krichak, A. Jansà, P. Maheras, A. Sanna, I. F. Trigo, R. Trigo, 2006, *Cyclones in the Mediterranean region: climatology and effects on the environment*. In P. Lionello, P. Malanotte-Rizzoli, R. Boscolo (eds) *Mediterranean Climate Variability*. Amsterdam: Elsevier (Netherlands).

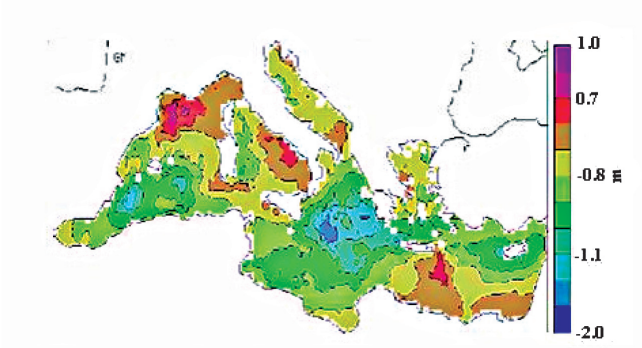
During the second half of the 20th century, a decrease in the average intensity of tides during the winter months was observed.



Legend: SWH= *Significant Wave Height* (expressed in meters)

Figure 1.12: Significant Wave Height[39]

During the second half of the 20th century, a decrease in the number of extreme events was observed only in the central portion of the Mediterranean, which lies off Southern Italy.



Note: Regression analysis of 44 years of maximum events in Winter

Figure 1.13: Extreme values of SWH (Significant Wave Height) [40]

[39] Source: Lionello and Sanna, 2005
[40] Source: Lionello et al., 2006

Agriculture in Italy is highly vulnerable to climate change and the attendant processes of soil deterioration and desertification.

Agriculture must definitely be counted among the economic sectors most vulnerable to climate change in Italy. Here, in fact, this sector places a particular emphasis on traditional products whose high quality cannot be separated from their territory of origin, making them highly vulnerable to change and the related processes of soil degradation and desertification. The potential impact of climate change on agriculture, tied to increased temperatures and variations in the frequency and intensity of extreme events, such as late frosts and droughts, have significant repercussions on the agro-food sector, which accounted for 15.5% of the GDP in 2006, equal to approximately 229 billion Euro[41].

Pressures on the climate system

Much of the warming observed in the last 50 years can be traced to human activities.

The vast majority of the scientific community is aware that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activity"[42], even though the effects of natural phenomena, such as the variability of the intensity of solar radiation, are also taken into consideration. The results of the IPCC's Third Report on climate change were confirmed in the Fourth Report[43].

As regards CO_2, the main greenhouse gas, the average global atmospheric concentration of carbon dioxide has risen from 280 ppm during the period 1000-1750 to 383 ppm in 2007. This trend is in line with the yearly emissions growth of carbon dioxide from roughly zero to 31.2 billion tons, taking into account only emissions from fossil fuels combustion and cement production[44]. The other greenhouse gases, such as methane, nitrous dioxide and the fluorocarbons, have shown similar patterns of growth, though at lower levels.

[41] www.apat.gov.it/site/_files/CNCC2007Sintesilavori.pdf
[42] IPCC (2001). Climate Change 2001 – Summary Report.
[43] IPCC (2007). Climate Change 2007 – WG-I, WG-II, WG-III, Technical summary.
[44] Global Carbon Project (2008). Carbon budget and trends 2007.

From 1990 to 2006 greenhouse gas emissions in Italy went from 516.9 to 567.9 Mt CO_2 eq, increasing by 9.9%.
Under the Kyoto Protocol, Italy should have reduced its emissions, in the period 2008-2012, by 6.5% of the 1990 level, down to 483.3 Mt CO_2eq.

Italy follows the same trend of greenhouse gas emissions: the most recent figures for the national inventory of greenhouse gas emissions show that emissions of CO_2eq rose from 516.85 million tons to 567.92 million tons during the period 1990-2006, for an increase of 9.9%, whereas, according to the Kyoto Protocol, Italy should have reduced its emissions, during the period 2008-2012, by 6.5%, compared to the 1990 level, down to 483.26 MtCO_2eq. Globally, Italy is responsible for no more than 1.67% of overall emissions generated by fossil fuels, meaning that it ranks ninth out of the ten countries with the highest levels of greenhouse gas emissions[45].

Greenhouse gas emissions in Italy registered overall growth of 51.02 million tons of carbon dioxide equivalent (Mt CO_2eq) between 1990 and 2006. During this period, there were reductions in fugitive emissions due to accidental losses during the production and distribution of hydrocarbons (-3.34 Mt CO_2eq), as well as in emissions by manufacturing enterprises (-6.83 Mt CO_2eq), agriculture (-3.94 Mt CO_2eq) and the use of solvents (-0.25 Mt CO_2eq), while emissions by industrial procedures rose (+0.24 Mt CO_2eq), along with those from waste (+0.73 Mt CO_2eq), the residential sector and services (+10.08 Mt CO_2eq.), energy producers (+22.33 Mt CO_2eq) and the transport sector (+28.66 Mt CO_2eq).

For the first time since 1996, overall emissions were lower in 2006, compared to the previous year, with a reduction of 1.73% in total emissions and 0.91% for combustion emissions.

The emission growth rates indicated above show an inversion of the trend that began in 2005. In fact lower emissions were registered in 2006 for most sectors, as compared to the previous year: industrial processes (-10.55%, equal to – 4,34 Mt CO_2eq), residential sector and services (-6.11%; -5.71 Mt CO_2eq), waste (-3.93%; -0.76 Mt CO_2eq), fugitive emissions (-3.29%; -0.25 Mt CO_2eq) and agriculture (-1.60%; -0.60 Mt CO_2eq). On the other hand, the energy industry remains stationary (-0.14%;-0.24 Mt CO_2eq), and there were increases in transportation (+0.92%; +1.22 Mt CO_2eq), the manufacturing industries (+0.47%; +0.39 Mt CO_2eq) and the use of solvents (+0.41%; 0.01 Mt CO_2eq). Overall, for the first time since 1996,

[45] IEA (2007). *CO_2 emissions from fuel combustion,* 1971-2005.

the figures for 2006 showed a reduction in emissions compared to the previous year: 1.73% (-10.02 Mt CO_2eq) for total emissions and 0.91% (-4.34 Mt CO_2eq) for emissions from combustion.

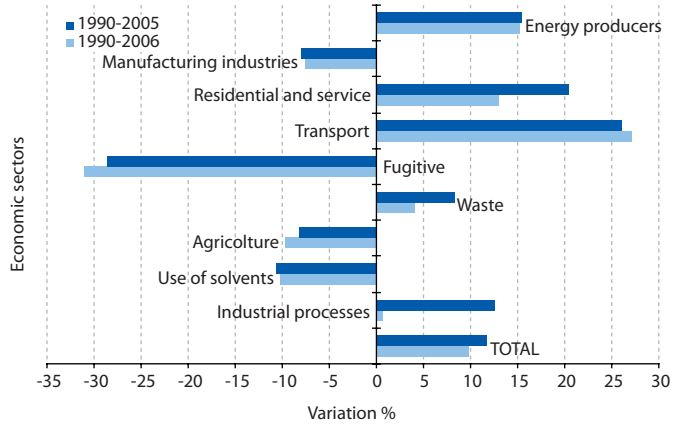


Figure 1.14: Percentage variation in emissions of greenhouse gases by economic sector for the years 2005 and 2006, compared with 1990[46]

Between 1990 and 2006, there were increases in emissions from waste, industrial processes, the residential sector and services and, to a greater extent, from energy industries and transport sector. Only emissions from manufacturing industries were lower than in 1990.

Given the upward trend in emissions from energy industries and the transport sector, Italy is not expected to reach the Kyoto target only with domestic measures. It will have to draw on credits generated by forestry activities and international cooperation initiatives (Clean Development Mechanism, Joint Implementation) as defined under the Kyoto Protocol. In 2006 greenhouse gas emissions were approximately 85 Mt greater than the Kyoto target (+ 17.4%).

[46] Source: ISPRA

Under the Kyoto Protocol, Italy should lower its emissions, during the period 2008-2012 to levels 6.5% below those of 1990, meaning to 483.26 Mt CO_2eq.
In 2006 greenhouse gas emissions were slightly less than 85 Mt above the Kyoto target (+17.4%).

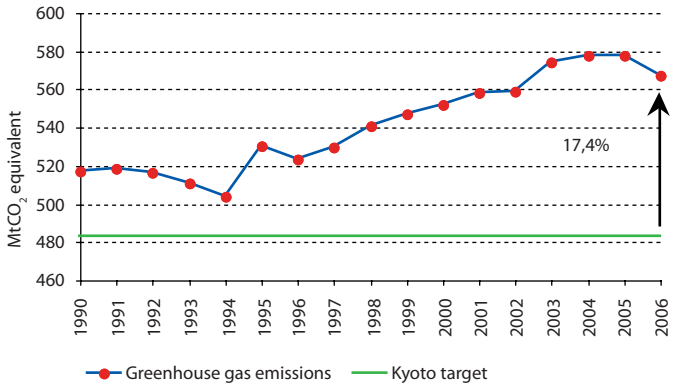


Figure 1.15: Total greenhouse gas emissions compared with the Kyoto target[47]

The majority of the countries of the European Union (EU15) are not in line with their Kyoto targets.

In the European Union (EU15) the majority of the countries are not in line with the objectives set under the Kyoto Protocol. Germany, Belgium and the Netherlands have met the objectives, while, in 2006, the United Kingdom, Sweden and France lowered emissions beyond the targets set for the period 2008-2012.
As a rule, the new Member States (*apart from Slovenia*) have reduced their emissions far beyond their Kyoto targets. Cyprus and Malta, which are not included in the Annex I of the UNFCCC (as developing countries), are not required to reduce emissions.

[47] Source: ISPRA

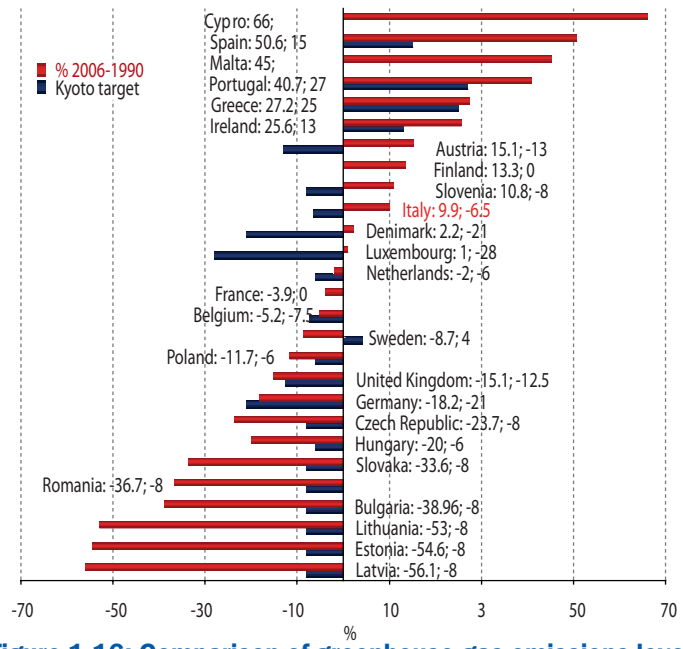


Figure 1.16: Comparison of greenhouse gas emissions levels in 2006 with the 1990 base-year and with the Kyoto target for the period 2008-2012 for EU Member States (EU27)[48]

The majority of the countries in the European Union (EU15), including Italy, is not in line with the Kyoto targets.
Germany, Belgium and the Netherlands have met these objectives, while, in 2006, the United Kingdom, Sweden and France reduced emissions beyond the targets set for the period 2008-2012.

Developments in the energy sector were primarily influenced, during 2007 and 2008, by fuel prices in the international markets, and especially the oil market. The price of a barrel of WTI light crude oil traded on the New York Mercantile Exchange (NYMEX) went from $ 60 in January of 2007 to $ 50 in February of 2007, and then to $ 100 in January of 2008 and to $ 150 in July of 2008, only to fall back to $ 70 in the month of October 2008. These fluctuations in energy prices reduced the effects, during the period considered, of new regulatory developments, such as the liberalisation of energy markets and the introduction of new forms of incentives for the production of electricity from renewable sources.

In recent years the price of crude oil has been characterised by significant fluctuations.

[48] Source: UNFCCC data processed by ISPRA

The energy price level is one of the causes of ongoing changes in fuel-supply trends, with natural gas playing an increasingly important role compared to petroleum products, while the contribution of renewable sources and cogeneration grows, as has the consumption of solid fuels since 2001. The contribution of solid fuels to primary energy sources (including primary electric energy) rose from 8.57% in 2001 to 11.13% in 2007.

The energy sector is undergoing changes in terms of supplies, with growth in the consumption of natural gas, reduction of oil products, and a greater contribution from renewable sources and cogeneration, plus higher consumption of solid fuels since 2001.

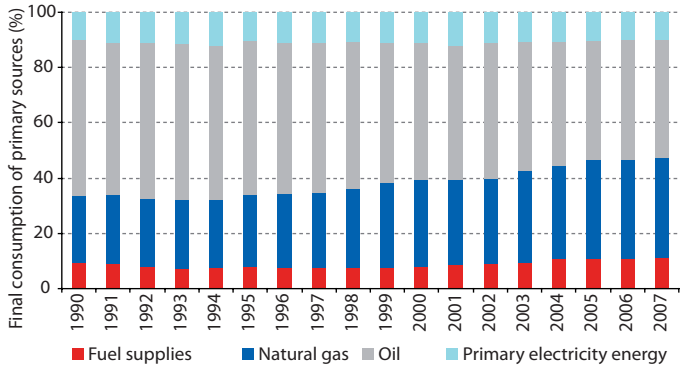


Figure 1.17: Total consumption of energy by primary sources[49]

Despite the modifications in the mix of primary energy sources, our country's energy dependence remains high, having risen from 82.8% in 1990 to 85.8% in 2007, for an increase of 3.6%. With the goal of limiting the vulnerability of our economic system, the current government is planning to revive the production of electricity from nuclear energy.

Starting from 1990, there was a constant upward trend in total energy consumption, with an increase of +19.9% in 2006. On the other hand, in 2007, there was a decrease of 3.3% compared to the previous year. The main sectors which exhibited strong growth since 1990 reduced their final consumption in 2007. The transport sector, the residential/tertiary sector and the industrial sector showed respective decreases of 0.4%, 4.2% and 2.6% compared to 2006. The agricultural sector also consumed 3.6% less than

The primary sectors that showed strong growth in final consumption since 1990 registered decreases in 2007.

[49] Source: Ministry of Economic Development data processed by ENEA

the preceding year. As for the break-down by sectors of final energy consumption (excluding non-energy uses and bunkers), the transport sector absorbed 34.3%, followed by the residential and industrial sectors, at respective levels of 32.8% and 30.4%.
The decrease in total energy consumption during the last two years, together with the limited growth of the GDP, explains the significant reduction in energy intensity between 2005 and 2006 (-2.6%) and between 2006 and 2007 (-2.3%), following a series of decidedly high values (around 159 tep per millions of Euro) registered between 2003 and 2005. However, Italy remains one of the G20 countries with the lowest total energy intensity, measured with GDP corrected for purchasing power parity, rating below the worldwide average and that of the OECD.

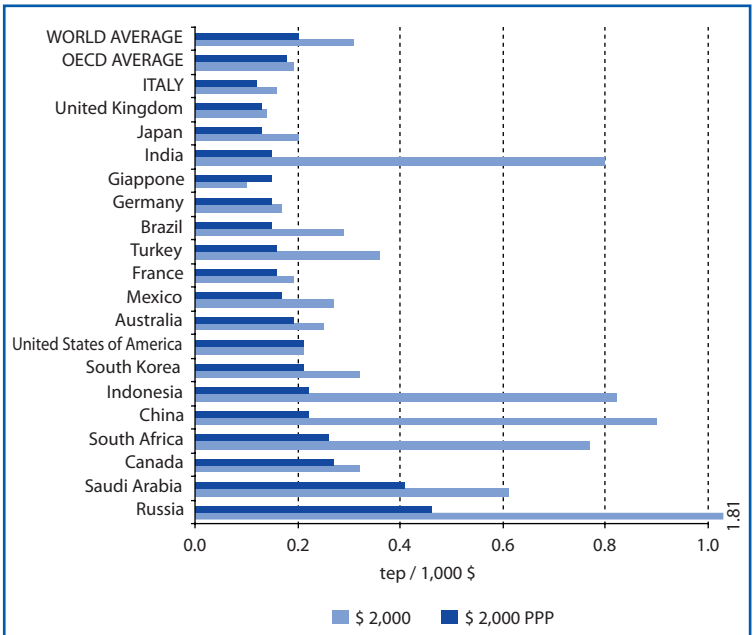


Figure 1.18: Total energy intensity of the G20 countries in 2006, with GDP measured in year-2000 dollars and corrected for purchasing power parity (PPP)[50]

Italy is one of the G20 countries with the lowest total energy intensity, when measured with GDP corrected for purchasing power parity, rating below the world average and the OECD average.

[50] Source: International Energy Agency (IEA)

Between 1994 and 2006 electricity production grew at a rate considerably higher than total energy consumption. In 2007 there was a slight decline, equal to 0.06%, compared to the previous year.
This result points to the growing role of electricity as an energy vector in the national energy system.

Between 1994 and 2006, the rate of growth for electricity production was considerably higher than that for total energy consumption. In 2007, electricity production showed a slight decrease, equal to 0.06%, compared to the previous year. This result points to the growing role of electricity as an energy vector in the national energy system.

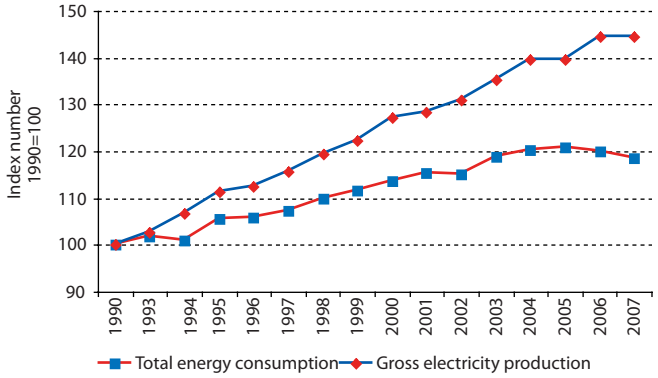


Figure 1.19: Total energy consumption and electricity production (1990 = 100)[51]

Final energy consumption varies considerably within the national territory. The figures for 2005 show that Lombardy accounts for 19.7% of national energy consumption, followed by Emilia Romagna at 10.8%, while Veneto and Piedmont account for respective levels of 9.3% and 9.2%. Other regions, such as Lazio, Apulia and Tuscany, account for an average value of 7.2%. Taken as a whole, these seven regions account for 70.6% of Italian energy consumption. Other regions accounting for significant portions of the total are Sicily (5.3%) and Campania (4.7%).

[51] Source: Ministry of Economic Development and TERNA data processed by ISPRA

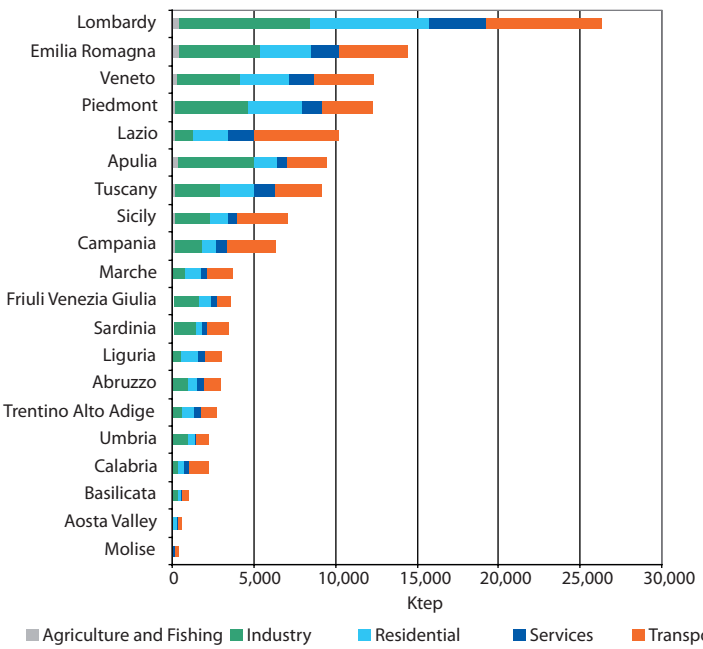


Figure 1.20: Final consumption of energy on the regional level by economic sector (2005)[52]

Regional energy consumption reveals a highly varied structure with the national territory. Lombardy consumes 19.7% of the national total. Seven regions - Lombardy, Emilia Romagna, Piedmont, Veneto, Lazio, Apulia and Tuscany - when taken together, consume more than 70% of the Italian total.

The transport system must address a sharp rise in the demand for mobility. During the period 1990-2007, the demand for passenger transport increased by 34%, while the demand for domestic freight transport for distances of more than 50 km grew by 27% over the same period.
Growth in passenger demand remained steady during the period 2000-2005, followed by fluctuations in 2006 and 2007.
The demand for passenger transport continued to be met primarily by roadway transportation, the least efficient mode from an economic and environmental perspective. In 2007, automobiles, motorcycles and scooters covered 81.5% of passenger transport demand.

[52] Source: ENEA data processed by ISPRA

Italy ranks second, after Luxembourg, in terms of the ratio of automobiles to resident population, but it is first when motorcycles, scooters and commercial vehicles are taken into consideration. Worldwide, only the USA has a higher rate of motorisation in terms of vehicles per inhabitant.

During the period 1990-2006, the demand for passenger transportation increased by almost 34%. Roadway transportation (automobiles, motorcycles and scooters) covered 81.5% of the demand for passenger transport (automobiles alone 73.8%) in 2007.

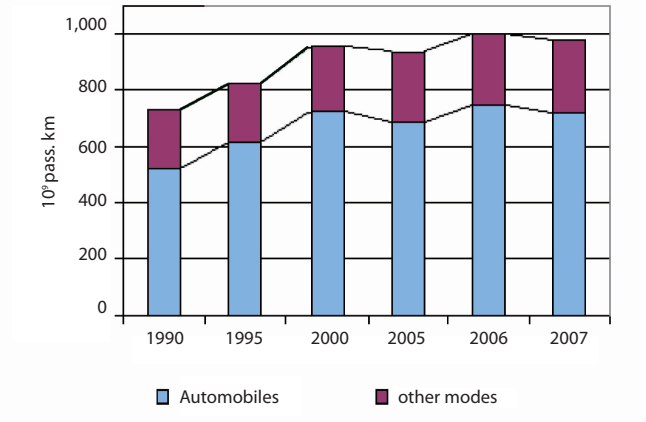


Figure 1.21: Demand for passenger transport[53]

The demand for passenger transport shows an upward trend from 1990 to the present, being closely tied to the dynamics of economic development and the process of European integration. Domestic transportation of freight by Italian carriers takes place primarily by truck (65% in 2007), with the rate having remained fairly constant since 1990.
Worthy of note, however, is a significant rise in roadway transport carried out by foreign carriers, estimated at approximately 20% of the total in 2006 and showing a constant growth trend since 1995, when the share of freight transport covered by foreign carriers was less than 4%. The national statistics do not measure this portion of roadway transportation, which is estimated by Eurostat.

[53] Source: CNT data processed by ISPRA

In 2007, domestic freight transport by sea and by railway accounted for respective percentages of 19.2% and 11%, while air transport represented a marginal 0.45% of total transport. The demand for domestic freight transport met by domestic carriers showed noteworthy growth during the period 2000-2005, following by a period of steady rates in 2006 and 2007. The sizeable rise in "other modes" after 2000 is due exclusively to increased transport of freight by sea, while the levels for railways and pipelines remained fairly stable. A portion of the increase is attributable to a revision in the estimation methodology used by ISTAT.

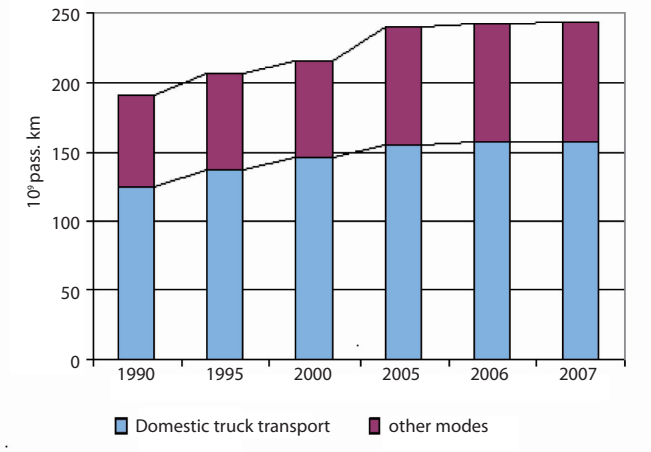


Figure 1.22: Demand for freight transport[54]

The demand for domestic freight transport by national carriers showed growth of 27% between 1990 and 2007.
Furthermore, estimates for 2007 show that freight transport within the national territory occurs primarily by roadway travel (65%) while other modes, such as the transport of freight by sea and by rail, account for respective shares of 19% and 11% of total transport.

Measures of response

The main climate change response measures involve mitigation (meaning a reduction in greenhouse gas emissions) and adaptation. Such measures can be complementary, interchangeable or independent. Recent assessments by the IPCC point to the fact that "With current climate change mitigation policies and related

The main measures of response to the climate change involve mitigation of (meaning a reduction in greenhouse gas emissions) and adaptation.

[54] Source: Past series recalculated by ISPRA under uniform criteria, using data from Ministry of Infrastructures and Transportation (National Accounting of Infrastructures and Transportation); the past series of freight transport is affected by variations in the data-collection methodology employed by ISTAT

sustainable development practices, global GHG emissions will continue to grow over the next few decades"[55]. Therefore, regardless of the mitigation measures implemented, adaptation measures will also be necessary, due to the inertia of the climatic system and the changes already in place. However it should be considered that, given the inertia of the climate system, the benefits of mitigation measures taken today will become effective over the middle term, but the future potential of such measures is higher than any adaptation measures that can be taken today[56].

Mitigation

The policy framework established by the European Council sets the following objectives for the EU by 2020:

- *20% reduction in greenhouse gas emissions compared to 1990;*
- *20% renewable sources accounting for total energy consumption;*
- *20% reduction in energy consumption compared to projections;*
- *bio-fuels accounting for 10% of transportation.*

In Europe, measures for reducing atmospheric emissions already undertaken in the energy sector, or to be undertaken, must fall within the policy framework recently set at the European Council of 8-9 March 2007, which established the following objectives for the European Union by 2020:

a) 20% reduction in greenhouse gas emissions compared to 1990 levels;
b) renewable sources accounting for 20% of total energy consumption;
c) 20% reduction in energy consumption, compared to projected levels;
d) bio-fuels accounting for 10% of energy consumption for transport.

In this way, in addition to countering climate change, three goals should be achieved:

1) the security of energy sources will be increased;
2) the competitiveness of the European economy will be ensured;
3) an economy with a low carbon content will be promoted.

The Conclusions of the Presidency of the European Council also include a commitment to limit the average increase in global temperature to a maximum of 2°C, as compared to pre-industrial levels.

On 18 December 2008, the European Commission reached, after intensive discussion among the Member States, an historic agreement on a package of proposals geared towards achieving the objectives set for 2020. The "Energy – Climate Change" package includes:

a) revision and extension of the European Emissions Trading

[55] IPCC (2007). *Climate Change 2007* – WG-III, Summary for policymakers.
[56] IPCC (2007). *Climate Change 2007* – WG-III, Technical summary.

System: the proposed directive stipulates that, as of 2020, the sectors subject to Directive 2003/87/EC have to reduce their greenhouse emissions by 21% compared to the levels of 2005;

b) establishment of a 10% reduction target, compared to 2005 levels, throughout the EU, for greenhouse gas emissions in sectors not regulated by Directive 2003/87/EC; this burden would be shared among Member States, and Italy's goal would be 13%;

c) introduction of burden-sharing among EU Member States for the renewable sources objective, with Italy being assigned an objective of 17%;

d) establishment of a legal framework for geological storage of carbon dioxide, in order to guarantee permanent containment of this gas and maximum reduction of health risks.

In Italy, cogeneration (Combined Heat and Power, CHP) is playing a growing role, which makes it possible to increase the conversion efficiency of energy from primary sources. Since 1997, the net electricity production through thermal cogeneration has followed a trend parallel to total electricity production from thermal power plants: between 1997 and 2007 the average annual increase was approximately 6,418 GWh/year for electricity produced through thermal cogeneration, while the overall average increase in total production from thermal power plants was 6,413 GWh/year. The figures for the production of electricity alone remained almost constant during the period considered. These figures show that, since 1997, the need for new electricity from thermal power plants has been completely met through cogeneration.

Of note within Italy is the growing role of cogeneration, which makes it possible to increase the efficiency of the conversion of the energy available from primary sources.

As regards the mix of primary sources, it should be noted that the growing role of natural gas used for electricity production in thermal power plants has a positive influence on greenhouse gas emission trends. This is due not only to the low emissions factor of natural gas, compared to other primary sources, but also to the greater efficiency of combined cycles fuelled by natural gas, as opposed to traditional steam cycles.

The growing role of natural gas used to produce electricity in thermal power plants has a positive influence on trends of greenhouse gas emissions.

During the period 1996-2007, the specific average consumption of natural gas for net electricity production decreased by 19.2%. Specific consumption of derived gases also showed a significant drop in 2007, for a decrease of 17.3% compared to 1996.

The average annual increase in the production of electricity between 1997 and 2007 was approximately 6,418 GWh/year for electricity produced through thermal cogeneration and 6,413 GWh/year for total production from thermal power plants, while the production of electricity alone remained almost constant during the period considered.
These figures show that, since 1997, the need for new electricity from thermal power plants has been met entirely through cogeneration.

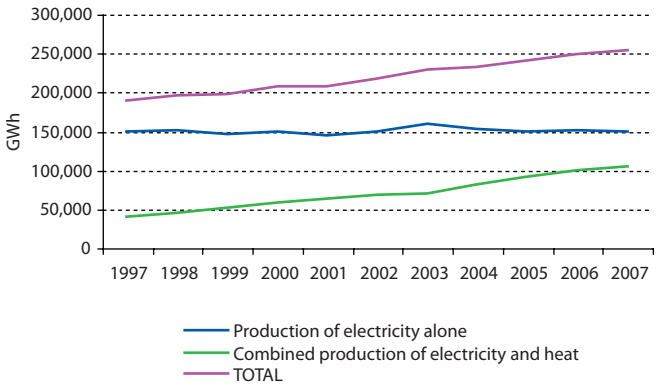


Figure 1.23: Net electricity production from thermal power plants[57]

Taking into consideration all the fuels used for electricity production, specific average consumption fell by 11.6% (-1.0% between 2006 and 2007). Specific average consumption of all fuels for electricity production was influenced by the use of petroleum products and solid fuel, which are less efficient than gaseous fuels. In fact, during the period considered, average specific consumption of petroleum products and solid fuel rose by 12.5% and 8.6% respectively.

Under Directive 2006/32/EC, the general national objective for energy savings is 9% by 2016.

Directive 2006/32/EC sets objectives for Member States regarding the efficiency of energy end-uses and energy services. the general national target for energy savings is 9% within the ninth year of the application of the directive (2016). Under the provisions of art. 4, the Member States must enact effective measures to achieve this objective. The Action Plan for Energy Efficiency, presented by Italy in July 2007, in fulfilment of art. 14 of the Directive, identifies a series of measures that will make possible energy savings of 9.6% in 2016, as compared to average energy consumption between 2001 and 2005.

[57] Source: TERNA data processed by ISPRA

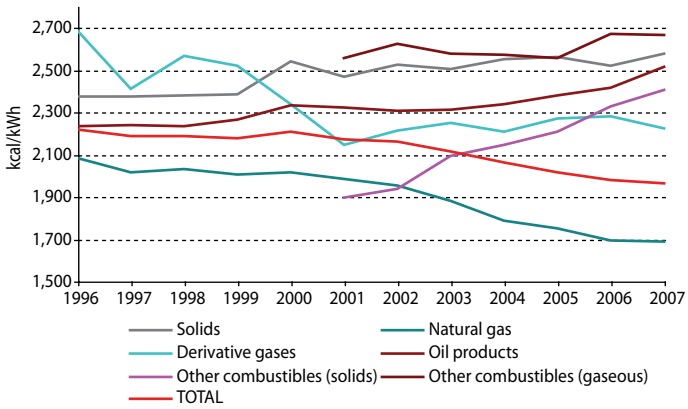


Figure 1.24: Average specific fuel consumption in the net production of electricity from fossil sources[58]

During the period 1996-2007 there was a decrease of 19.2% in the average specific consumption of natural gas and a decrease of 17.3% in consumption of derived gases. In terms of electricity production, average specific consumption fell by 11.6%, while petroleum products and solid fuel rose by 12.5% and 8.6% respectively.

In this framework a key role is played by the system of white certificates, contemplated under art. 6 of Directive 2006/32/EC, which Italy was the second country to implement, right after the United Kingdom, doing so through the Ministerial Decrees of 20 July 2004. The objective of the decrees is to achieve, by the end of the first five years of application (2005-2009), energy savings of 2.9 Mtep a year through the introduction of fixed amounts of energy savings to be achieved by electricity and natural gas distributors.

The objective of the Ministerial Decrees of 20 July 2004 is to achieve energy savings of 2.9 Mtep a year by the end of the first five years of application (2005-2009).

In 2007, the installed capacity of renewable energy sources increased by approximately 1,000 MW in 2007, for a growth rate of 4.7% on an annual basis. In 2007 the electricity produced from renewable sources was approximately 49.4 TWh, while total electricity production was 313.9 TWh, meaning that electricity from renewable sources accounts for 15.7% of total electricity production. The overall production trend was influenced by fluctuations in the share of hydroelectric energy as a result of meteorological conditions, as well as by the growing contribution of non-traditional sources (wind power, geothermal energy, biomasses and waste). In recent years (1997-2007) there have been noticeable increases in the produc-

[58] Source: TERNA data processed by ISPRA

tion of electricity from wind power (from 117.8 to 4,034.4 GWh during the period 1997-2007) and energy from biomasses/waste (from 820.3 to 6,953.6 GWh), as well as, though to a lesser degree, geothermal energy (from 3,905.2 to 5,569.1 GWh). The contribution of photovoltaic energy remains negligible (39.0 GWh in 2007, this figure does not yet include the electricity produced from photovoltaic roofs, which is not considered in the electricity sector statistics, though 18 GWh was produced in this way in 2007). Despite the increased use of renewable sources in recent years, the levels of electricity produced from such sources are not sufficient for reaching the objective of approximately 75 TWh by 2010, as called for under Directive 2001/77/EC.

A regional analysis points to noteworthy differences in the energy sources used. Hydroelectric power, produced primarily in the regions of the Alpine arc, accounts for 66.4% of the electricity produced by renewable sources. The geothermal electricity production, found only in Tuscany, represents 11.3% of the electricity produced from renewable sources. Biomasses account for 14.1%

Regionally, noteworthy differences can be observed in the renewable energy sources utilised. Hydroelectric energy, concentrated in the regions of the Alpine arc, accounts for almost 66.4% of the electricity produced from renewable sources.

Electricity production from renewable sources accounts for 15.7% of total electricity production. Between '97 and 2007 there was a noticeable increase in the production of electricity from wind power (from 117.8 to 4,034.4 GWh) and from biomasses/waste (from 820.3 to 6,953.6 GWh), as well as, though to a lesser extent, from geothermal power (from 3,905.2 to 5,569.1 GWh).
Despite the increases recorded in the production of electricity from these sources in recent years, the levels are not sufficient to reach the goal of approximately 75 TWh by 2010 set under Directive 2001/77/EC.

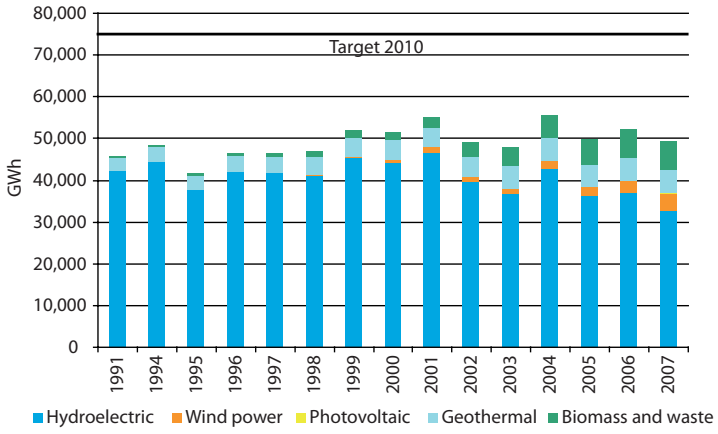


Figure 1.25: Gross electricity production from renewable energy sources[59]

[59] Source: TERNA data processed by ISPRA

of the total, while wind and photovoltaic power registered a share of 8.3% of the electricity produced from renewable sources, though almost all of this last type of production takes place in the southern regions and on the major islands (97.5%). The increase of approximately 1,000 MW in installed power registered between 2006 and 2007 was due primarily to the development of wind power in the South (more than 800 MW of the total increase, followed by biomasses and solar power, with 81 and 79 MW respectively).

As concerns the transport sector, there was a constant increase in fuel consumption between 1990 and 2004 (+27.0% compared to 1990), while levels have essentially remained constant during the last two years. The percentage of fuels with low environmental impact (natural gas, LPG, bio-diesel) out of total fuels shows irreg-

In the transport sector, the effects of technological advances are offset by rising demand, especially for roadway transport.

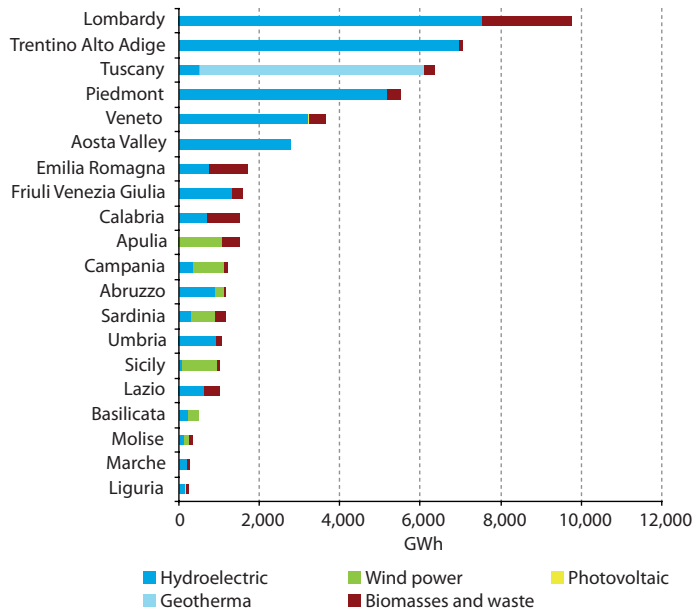


Figure 1.26: Regional analysis of gross electricity production from renewable energy sources (2007)[60]

Regionally, noteworthy differences can be observed in the renewable energy sources used. The primary renewable source used to produce electricity is hydroelectric power, concentrated in the Alpine arc, while production from wind and photovoltaic power takes place in the southern regions and the main islands (97.5%).

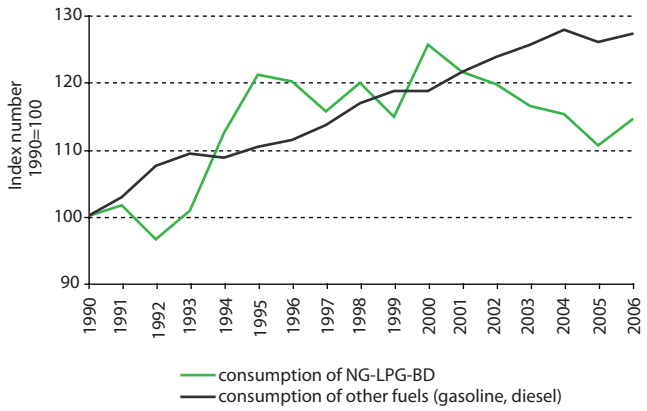
[60] Source: TERNA data processed by ISPRA

ular results, going from 5.6% in 1990 to 5.0% in 2006, with a peak value of 6.1% in 1995.
Variations in the percentages of the fuels consumed show that, while the classic fuels (gasoline, diesel fuel etc.) have increased constantly, levels of natural gas, LPG and bio-diesel have fluctuated. Compared to 1990, the quantities of lower-impact fuels consumed in 2006 was 14.3% higher.
Based on the available data, it is clear that the limited progress made in the transport sector through the implementation of technological measures involving engine efficiency are offset - to a greater extent in Italy than in the other European countries - by the growth in the demand for transportation, especially with roadway mode, meaning that the environmental impact of the transport sector continues to grow. As for the quality of the fuels used, it can be observed that the quantity of low-impact fuels, in addition to being of marginal importance, is often highly irregular, as demonstrated by the fact that, between 2000 and 2005 there was a constant decrease in the share of total fuels represented by low-impact fuels, followed by a slight increase between 2005 and 2006; these results are due primarily to a drop in sales of LPG, as well as an offsetting increase in the consumption of natural gas, starting from 2005.

Between 1990 and 2006, the stock of carbon in Italy's forests grew by 58%, due primarily to an expansion in forest surface area.

In contrast to the increase in greenhouse gas emissions resulting from various production activities and deforestation, a noteworthy quantity of carbon dioxide has been removed from the atmosphere by the LULUCF (Land Use, Land Use Change and Forestry) sector, worldwide about 0.2 billion tons of carbon during the period 1980-1989 and 0.7 billion tons of carbon has been removed from atmosphere during the period 1989-1998[61]. In Italy, the LULUCF sector, which encompasses the different existing uses of the land, such as forests, cultivated land, grassland, urban settlements and wetlands, accounts for the capture of 21.6 million tons of carbon in 1990 and 30.6 million tons of carbon in 2006.

[61] IPCC (2000). *Land-use, Land-use change and forestry*, IPCC Special Report.



Legend: NG, natural gas; LPG, liquefied petroleum gas; BD, biodiesel

Figure 1.27: Consumption of fuels for transport (1990=100) [62]

The use of low-impact fuels is subject to noteworthy irregularities: between 2000 and 2005 there was a constant decrease in their share of total fuel consumption.

Adaptation Plans in Europe and throughout the world

The United Nations has used the term adaptation with reference to a strategy geared towards minimising the negative consequences of climate change and preventing damage by limiting the vulnerability of the environmental and socioeconomic systems to climate change.

Adaptation is not an alternative to mitigation, which focuses on the causes of climate change in order to reduce emissions of greenhouse gases generated by human activities, but rather a complementary approach: the greater the commitment to mitigation, the smaller the effort in terms of adaptation, and vice versa.

Under the Framework Convention on Climate Change, the National Adaptation Programmes of Action, or NAPA, provide the LDCs (Least Developed Countries) with a procedure for identifying priority activities able to meet their urgent, immediate needs in terms of adaptation to climate change.

Adaptation and mitigation are complementary approaches: the greater the commitment to mitigation, the less the need for adaptation, and vice versa.

[62] Source: Ministry of Economic Development data processed by ISPRA

Many European countries have undertaken initiatives designed to promote adaptation to climate change, drawing up policies, strategies, plans and programs.

The rationale for the NAPAs is the limited ability of the LDCs to adapt to the negative effects of climate change. Their action is not based on long-term national policies, but on strategies implemented at the local level, in order to identify the priority initiatives.

Article 4.9 of the United Nations Convention acknowledges the specific needs and special situations of the LDCs, stipulating that the Parties are required to take into consideration, in the course of their initiatives, the needs and circumstances of the less developed countries in terms of financing and the transfer of technology. It should be noted that the level of implementation of the NAPAs relies on the aid that they will receive from the developed countries, in the form of financial resources and transfer of technology, taking into account the fact that socioeconomic development and the eradication of poverty are the first and most important priorities of the LDCs[63].

Adaptation is a relatively new topic on the political agenda of the European Union, though many countries have already launched initiatives with the aim to promote adaptation to climate change, drawing up policies, strategies and plans or sectorial programs, in order to ensure future sustainable development for their regions and avoid paying a very high price in terms of environmental damage, loss of human lives and economic costs.

One of the first initiatives of that kind in Europe was undertaken by Finland, which adopted in 2005 a "National Adaptation Strategy", with the objective of reinforcing and expanding the country's capacity to adapt to the impacts of climate change.

In the same year, the United Kingdom drew up an "Adaptation Policy Framework", a consultation procedure to collect information on adaptation activities and to supply a national reference framework that can be used for planning of future actions. The United Kingdom, where a legislative proposal (Climate Change Bill) was presented to Parliament in November of 2007 and converted into law in November of 2008, can be considered one of the first countries in the world to possess a binding, long-term framework for addressing the topics of mitigation and adaptation.

[63] http://unfccc.int/adaptation/items/4159.php

At present, the English Government has drawn up an "Adapting to Climate Change Programme", in order to arrive at a final draft of the "National Adaptation Programme" no later than 2012.
In 2006, other countries promoted national initiatives as well. France has drawn up a "National Strategy for Adaptation to Climate Change", which represents an intermediate step between the scientific diagnosis and the implementation of a plan of action containing precise measures to be enacted at different decision-making levels.
Spain is the only European country which has approved a full-fledged "National Adaptation Plan" designed to make adaptation to climate change an integral part of the planning strategy for the socioeconomic sectors and ecological systems.
Other countries, such as Portugal and the Netherlands, have drawn up plans pertaining more closely to specific sectors, focussing attention, respectively, on water resources and spatial planning.
Recently, Denmark also drew up its "National Adaptation Strategy", in addition to promoting research efforts in this area and establishing a special website providing information on climate change.
Countries such as Germany, Ireland, Norway and Belgium have undertaken a process that will allow them to draw up their strategies between the end of 2008 and 2012[64].

The National Conference on Climate Change organised by Italy in 2007 was a major opportunity for analysis and comparison not only of technical-scientific considerations, but also of social-economic repercussions, marking the start of a process that will allow our country to draw up a national adaptation strategy.

The situations of countries outside the European Union vary greatly and need to be taken into consideration, as stated in the recommendations issued by the European Commission and found in the Green Paper on adaptation, according to which an exchange of know-how and successful practices must be established not only between countries of the European Union, but also with the other industrialised coun-

Cooperation between the European Union and the other industrialised countries is necessary, in order to address shared problems by exchanging information and best practices regarding adaptation.

[64] EEA, 2008. *Impacts of Europe's changing climate – 2008 indicator-based assessment*. EEA Report no. 4/2008.

tries subject to the impacts of climate change[65].
The first step taken by the Canadian Government to address the topic of adaptation was the creation, in 2001, of the "Climate Change Impacts and Adaptation Programme", designed to promote basic knowledge of impacts and adaptation, in addition to developing skills and know-how in this field. Between 2001 and 2006 the Programme financed 130 research projects on vulnerability, impacts and adaptation in Canada. The "National Climate Change Adaptation Framework" was presented in 2005, providing the groundwork for joint efforts involving different organisational jurisdictions, in order to develop capabilities and tools suitable for drawing up detailed adaptation plans and implementing activities.
The "Climate Change Science Programme" is one of the main components of the climate program of the United States, consisting of an effort to increase scientific understanding of the climate and its potential impacts. As of 2008, it has produced twenty-one summary and assessments reports (some of them not yet complete) focussing on a variety of issues, not only scientific, in order to lay out the guidelines for public debate and policy decisions.
In 2004 the Australian Government initiated its "National Climate Change Adaptation Programme", a four-year program meant to be the starting point for dealing with the inevitable impacts of climate change. The "National Climate Change Adaptation Framework" was drawn up in 2007, illustrating the future agenda for cooperation between different regional Australian governments. A key point is to provide decision-makers with support in integrating climate change into policy decisions and practical initiatives at all levels and in all sectors. The Framework will guide the activities of the different organisational jurisdictions for the next 5-7 years.
In Japan, a committee was established in October of 2007 to study the impacts of climate change and adaptation. For eight months it organised a series of reviews of existing knowledge on the impacts of climate change in Japan. The conclusions of this review phase, published in June of 2008, point out the need to achieve adaptation that proves truly effective and efficient while drawing up a plan of adaptation at the national level.

[65] http://ec.europa.eu/environment/climat/adaptation/index_en.htm