CHAPTER 1

CLIMATE CHANGE

Introduction

In 2009 growing expectations were placed on the 15th Conference of the Parties (COP-15), held to determine the elements of a new agreement meant to go into effect in the period following that (2008-2012) covered by the Kyoto Protocol.

In 2009, the issue of climate change was a focal point of attention on the part of both the general public and national and international institutions, with growing expectations placed on the results of the 15th Conference of the Parties (COP-15 Copenhagen 2009), held with the objective of determining the elements of the new agreement meant to go into effect in the period following that (2008-2012) covered by the Kyoto Protocol.

In terms of public opinion as a whole, there was noteworthy awareness of this issue on the occasion of the awarding of the Nobel Peace Prize to US President Barack Obama (which came in the wake of the Nobel Prize awarded in 2007 to the to IPCC and to Al Gore, former Vice President of the United States, for his film "*The Inconvenient Truth*"). Indeed, one of the stated motives for the award of the 2009 Nobel Prize to Barack Obama was the efforts of the US President to give his country "a more constructive role in meeting the great climatic challenges the world is confronting"[1].

At the G8 summit in Aquila in July of 2009, there was a unanimous consensus on the importance of keeping the increase in the average global temperature below 2°C, as well as on the need to set a global objective for a noteworthy, long-term reduction in emissions.

In terms of discussions between the different governments in preparation for the COP-15, during the G8 summit held in Aquila in July of 2009, the world leaders confirmed their intent to deal with the subject urgently and effectively, in an effort to arrive at an agreement in Copenhagen.

In the G8 forum, the leaders of industrialised countries have agreed on the need to keep global warming below 2°C compared to pre-industrial levels, as has long been requested by the European Union. Agreement was also reached on the objective of reducing global emissions by 50% by the year 2050, with a reduction of 80% by the developed countries, in order to keep global warming below 2°C (though the reductions will not be calculated from the year 1990). At the same time, the developing countries were also asked to reduce their current growth trends in emissions. And there was also a general consensus on the need to set medium-term objectives in keeping with the long-term goals and to reach a peak in global emissions as soon as possible. The active involvement of all the leading emitting countries, through quantified mitigation initiatives, is held to be an indispen-

[1] http://nobelprize.org/nobel_prizes/peace/laureates/2009/press.html

sable prerequisite for successfully dealing with climate change. The leaders have acknowledged the crucial role of technological development and know how in carrying out mitigation and adaptation initiatives in developing countries and in achieving economic growth with low levels of carbon dioxide emissions. With this in mind, and seeing that the mobilisation of adequate financial resources will be a key factor in arriving at an ambitious and widely endorsed agreement in Copenhagen, the world leaders have confirmed their intention to contribute to a joint effort for the procurement of the necessary funds (both public and private), through national initiatives and international instruments, including financial assistance. In the same period as the summit in Aquila, a meeting of the Major Economies Forum, or MEF, was held in the presence of the General Secretary of the United Nations, attended by all the leading countries in terms of emissions, meaning, in addition to the G8 nations, Australia, Brazil, Canada, China, South Korea, the European Union, India, Indonesia, Mexico and South Africa, in order to reach an agreement as wide ranging and relevant as possible on the key issues at the Copenhagen Conference.

Here too there was acknowledgement of the importance of limiting the average global temperature increase to 2°C, though, contrary to the G8, no agreement was reached on either the reductions to be achieved on a global level nor the level of funding to be made available. The leaders of the countries responsible for the most emissions, on the other hand, have decided to work together in the months leading up to the COP-15, in order to set a long-term global objective for reducing emissions by 2050. The leaders have agreed that all the countries must undertake suitable initiatives on the national level: the developed countries shall enact timely reductions of significant entity in the middle-term, while the developing countries shall undertake actions designed to guarantee a significant departure of emissions levels from the “business as usual” scenario.

The key role of the larger economies in promoting innovation was stressed, and the leaders proposed a global partnership as a way of accelerating efforts. Agreement was reached on the need for a noteworthy increase in public investment in research and devel-

opment, with the goal of doubling the level by the end of 2015. The leaders pledged that they would work to eliminate obstacles to the marketing of low-carbon-emission technologies while creating incentives to accelerate their development, spread and transfer, with an emphasis on the role of the private sector and international cooperation. There was also a broad consensus on the need to increase financing for the climate, from both public and private sources, as well as through carbon markets.

Basic climate trends

Globally

The increase in temperature observed in recent decades, both globally and in Europe, is unusual.

The warming of the global climate system currently stands as an undisputed fact, as shown by the increases observed in the average global atmospheric and oceanic temperatures, as well as the melting of the polar ice caps (especially in the Arctic), the shrinking of glaciers in the middle latitudes (including the covering of snow) and the rise in the average level of the oceans. The increase in the average temperature observed in recent decades, both globally and in Europe, is unusual in terms of both its extent and its rate of variation.

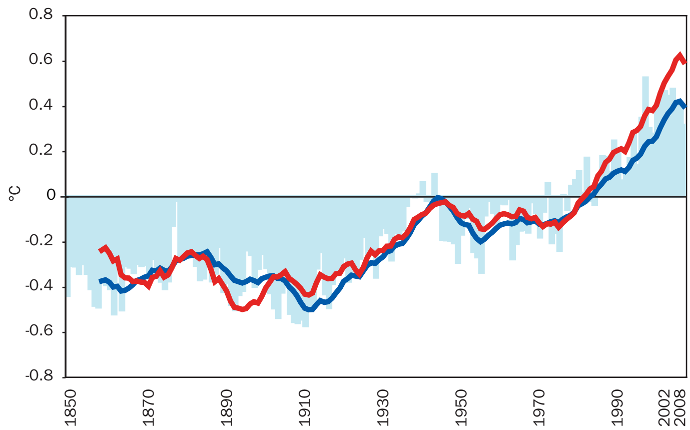
As of 2008, the overall increase in average global temperature (the land-ocean system) was 0.7°C compared to the pre-industrial level.

Based on the Fourth Assessment Report of the IPCC *(Intergovernmental Panel on Climate Change)*, the overall increase in average global temperature (the land-ocean system[2]) as of 2008 was 0.7°C compared to the pre-industrial level. The rate of warming, equal to 0.1°C per decade during the last 100 years, rose at 0.16°C per decade during the last 50 years. During the last century (1905-2005), the average temperature of the planet rose by 0.74°C, at increasingly higher rates: in the decades before 1950, the average rate of the rise was less than 0.06°C per decade, while, over the last 50 years, it increased to 0.13°C per decade, and more recently (the last few decades), it reached approximately 0.25°C per decade.
Analyses carried out by the East Anglia University, including figures

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

for 2008, show that, of the fourteen highest annual temperature levels registered from 1850, the first year for which instrumental temperature readings were recorded, thirteen fall within the period of the last fourteen years, between 1995 and 2008[3] (Figure 1.1).

Of the fourteen highest annual temperature levels starting from 1850, the year in which instrumental measurement of temperatures began, thirteen fall within the last fourteen years, between 1995 and 2008.

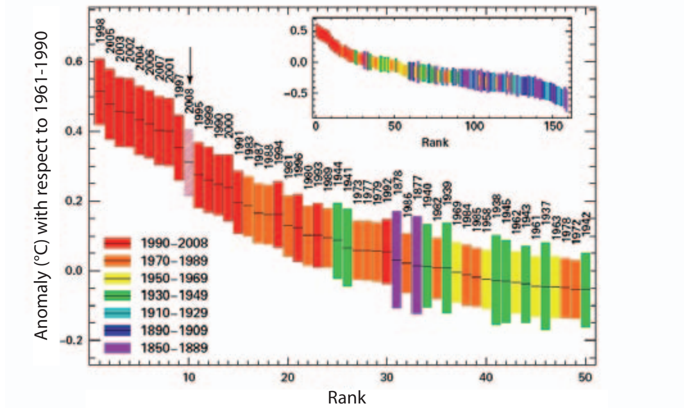


Legend: The lines represent the mobile averages over 10 years, calculated, respectively, for the "land-ocean" system (blue) and for the "land alone" system (red).

Figure 1.1: Series of the annual anomalies[4] in the average global temperature (land-ocean system) between 1850 and 2008[5]

Based on the estimates of the National Climatic Data Centre of the NOAA, the year 2008, together with 2001, was the eighth warmest year of the series starting from 1880, with an average global land-ocean temperature that was 0.49 °C higher than the average for the twentieth century.
The ranking of the 50 highest years in terms of average global surface temperature, as illustrated in figure 1.2 and published by the World Meteorological Organisation, shows the year 2008 in tenth place; as a rule, the ranking of the most recent years, between 1990 and 2008, in the leading positions is confirmed. Projections based on the six emissions scenarios of the IPCC for the

[3] EEA, http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041006175027 / IAssessment1202733436537/view_content
[4] Anomalies calculated for the reference period 1961-1990
[5] Source: Climatic Research Unit of the East Anglia University



Legend: The insert shows the ranking of the average global surface temperatures starting from 1850. The dimensions of the bars point to an interval of confidence of 95%

Figure 1.2: Ranking of the average global surface temperatures for the 50 warmest years[6]

Changes in climate variables also lead to increases in the frequency, intensity and duration of extreme events, such as floods, droughts and heat waves.

end of the 21st century forecast an increase of from 1.8 to 4.0 °C in global temperature by the period 2090-2099, as compared to the period 1980-1999[7]. As for trends in precipitation between 1900 and 2005, noteworthy increases were registered in the eastern portions of North and South America, in Northern Europe and in Northern and Central Asia, while there was reduced precipitation in the Sahel region, in the Mediterranean, in Southern Africa and in certain parts of Southern Asia. Changes in climate variables also lead to increases in the frequency, intensity and duration of extreme events, such as floods, droughts and heat waves. The frequency of intense precipitation events has risen in most portions of the earth's surface above water, in parallel with the warming trend and the heightened amount of water vapour in the atmosphere. The surface temperature of the seas, on a global level, 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. If policies of mitigation are not implemented, then, in all probability, there will be an increase in the frequency of heat waves and intense precipitation on our planet, together with a rise in the intensity of tropi-

[6] World Meteorological Organization (2009): WMO statement on the status of global climate in 2008. Report WMO, n. 1039, Geneva 2009

[7] IPCC, 2007, *Climate Change 2007 – Fourth Assessment Report-WGI*

cal cyclones, as well as a decrease in available water supplies in many semi-arid areas, such as the Mediterranean Basin, with noteworthy repercussions in terms of the environment, society and economics.

Europe

As of 2008, the temperature of the land-ocean system in Europe had increased by approximately 1.0 °C, and the temperature of dry land by 1.3 °C, over the pre-industrial levels, a greater rise than the global increase[8]. Projections point to an average temperature increase of between 1.0 and 5.5 °C by the end of this century. Based on the A1B scenario[9], for example, global climatic models estimate an average increase in temperatures between the periods 1980-1999 and 2080-2099 in a range of 2.3 to 5.3 °C in Northern Europe, while an increase of between 2.2 and 5.1 °C would be registered in Southern Europe and the Mediterranean regions[10]. Naturally, when different emissions scenarios are employed, the estimated intervals for temperature increase vary considerably. The greatest warming in Northern Europe is forecast for the Winter season, while the highest increases for the Mediterranean are expected in summer (Figure 1.3).

As of 2008, the temperature of the land-ocean system in Europe had increased by approximately 1,0 °C, and the temperature of dry land by 1.3°C, over the pre-industrial levels, a greater rise than the global increase.

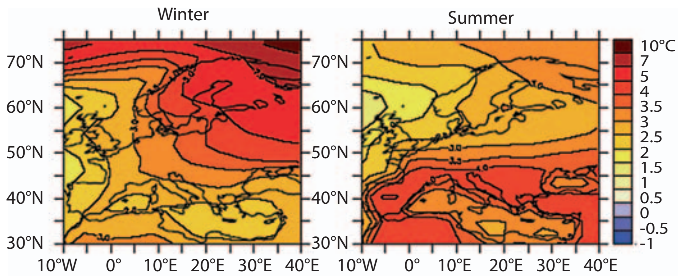


Figura 1.3: Variation in the average temperature in Europe between 1980-1999 and 2080-2099, estimated on the basis of the A1B emissions scenario[11]

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 a range of 2.2 and 5.1 °C in Southern Europe and the regions of the Mediterranean.

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

[9] Scenario characterised by extremely rapid economic growth, a global population that peaks around the middle of the 21st century, and then begins to decline, the rapid introduction of new and more efficient technology and a balanced distribution of the different sources of energy (IPCC, *Special Report on Emission Scenarios*, 2000)

[10] IPCC, 2007, *Climate Change 2007 – Fourth Assessment Report-WGI*

[11] Source: IPCC, *Fourth Assessment Report*

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

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

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 episodes distinguished by low temperatures. Projections point to a continuation of this trend in the future as well. In terms of precipitation in Europe, an increase of 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[12].
Based on the A1B scenario, global climate models estimate an increase between 0% and 16% in cumulated annual precipitation between the 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[13] (Figure 1.4). 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 where the lay of the land is complex. It has also 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.

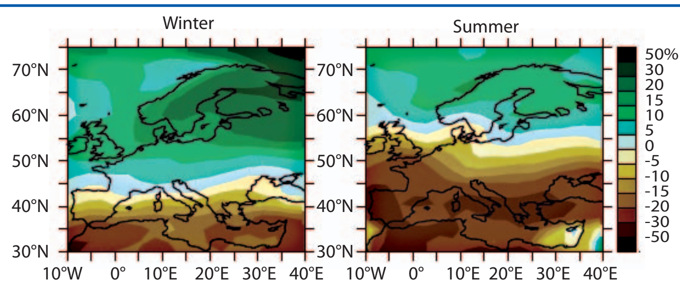


Figure 1.4: Percentage variation in cumulated precipitation in Europe between the periods 1980-1999 and 2080-2099, estimated on the basis of the A1B emissions scenario[14]

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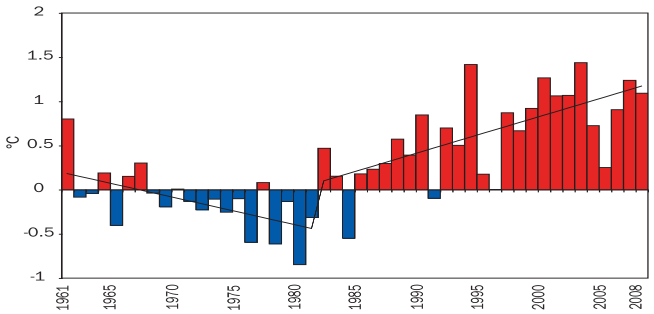
[12] EEA, 2008, *Impacts of Europe's changing climate – 2008 indicator-based assessment. EEA Report* n. 4/2008
[13] IPCC, 2007, *Climate Change 2007 – Fourth Assessment Report - WGI*
[14] Source: IPCC, *Fourth Assessment Report*

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[15].

Italy

Based on the CNR-ISAC studies (summarised in last year's "Key Topics"), the average annual temperatures in Italy have risen by 1.7°C over the past two centuries (working out to more than 0.8°C per century), though the most significant portion of this increase has occurred over the last 50 years, during which the increase has been approximately 1.4°C (making for a rate of approximately 2.8°C per century). Temperature trends in Italy are updated annually by ISPRA by establishing uniform criteria for the series of results recorded in the period 1961-2008 and applying statistical models, including non-linear ones, to identify and estimate trends. It is estimated that the average temperature in Italy fell between 1961 and 1981, at which point it rise through 2008, for an overall increase of approximately 1.0 °C (Figure 1.5)

Estimates of trends in average annual temperatures in Italy for the period 1961-2008 point to a decrease in the average temperature between 1961 and 1981, followed by an increase through 2008, for an overall rise of approximately 1.0 °C.



Legend: The staggered line represents the trend estimated with a "*sloped steps*" statistical model[16]

Figure 1.5: Anomalies in the average temperature in Italy[17]

Average annual anomalies in the average temperature between 1961 and 2008, as compared to the normal value calculated for the period 1961-1990, point to a decrease in the average temperature in Italy between 1961 and 1981, followed by an increase through 2008, for an overall rise of approximately 1.0 °C.

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

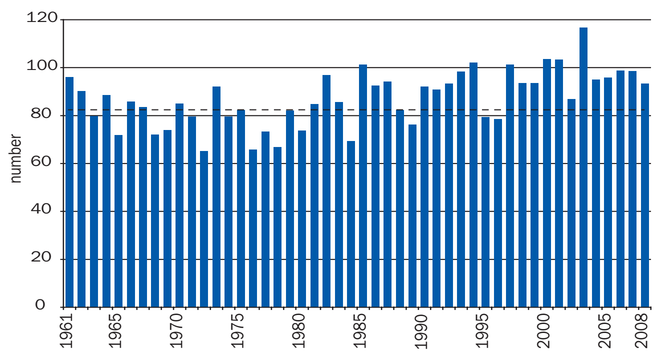
[16] Toreti A. and Desiato F., 2008, *Temperature trend over Italy from 1961 to 2004, Theor. Appl. Climatology*, doi 10.1007/s00704-006-0289-6

[17] Source: Italian Air Force data processed by ISPRA

The increase in the average temperature registered in Italy in recent decades is higher than the global average.

The increase in the average temperature registered in Italy in recent decades is greater than the global average. In the years 2007 and 2008 the anomalies compared to the thirty-year period 1961-1990 were, respectively, +1.24 and +1.09 °C, in contrast to a global average of 0.67 and 0.53 °C. The year 2008 was the seventeenth consecutive year to register a positive anomaly, and the anomaly was the fifth largest since 1961[18]. A detailed seasonal analysis of the trends for northern, central and southern Italy shows that the increase in average temperature was noteworthy throughout the country in Autumn starting from 1970 and in summer from 1980, while, during the entire period 1961-2006, there were significant increases in the north in Winter and in the central-southern regions in Spring[19]. The warming trend can also be observed in an analysis of extreme temperature levels. A trend analysis of the period 1961-2008 points to an estimated 12% average increase in "summer days"[20] (Figure 1.6), plus an average 42% in "tropical nights", compared to the climatological average[21] (Figure 1.7).

There was an estimated average increase of 12% in the number of "summer days" during the period 1961-2008, meaning days with a maximum air temperature of more than 25 °C.



Legend: The dotted line indicates the average normal value calculated for the period 1961-1990

Figure 1.6: Annual average number of summer days between 1961 and 2008[22]

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[18] ISPRA, *Gli indicatori del clima in Italia nel 2008*, Report from the State of the Environment Series, no. 12/2009, Year IV

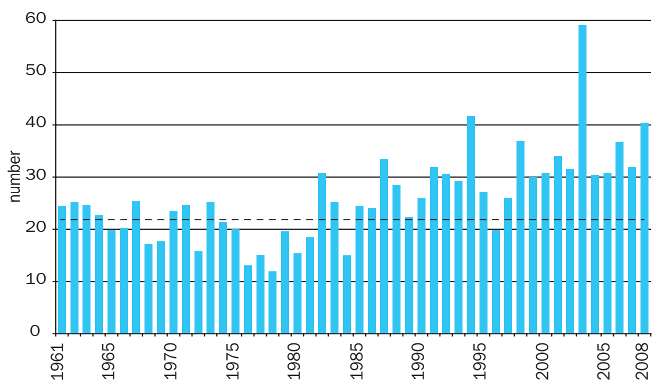
[19] Toreti A., Desiato F., Fioravanti G. and Perconti W., 2009, *Seasonal temperatures over Italy and their relationship with low-frequency atmospheric circulation patterns*, Climatic Change, doi 10.1007/s10584-009-9640-0

[20] Number of days with a maximum air temperature of more than 25 °C

[21] Number of days with a minimum air temperature of more than 20 °C

[22] Source: Stations of the network of the Italian Air Force data processed by ISPRA

There was an estimated annual increase of 42% in the number of "tropical nights" during the period 1961-2008, meaning nights with a minimum air temperature of more than 20 °C.



Legend: The dotted line indicates the average normal value calculated for the period 1961-1990

Figure 1.7: Average annual number of tropical nights between 1961 and 2008 [23]

In terms of long-term trends in precipitation, studies of the CNR[24] indicate that, "As a rule, the trends are negative, though only to a slight extent and often without much statistical significance. The magnitude of the reduction in precipitation is on the order of 5% per century; it would appear to be traceable primarily to Spring, the season for which a reduction of nearly 10% per century in precipitation was recorded"[25].

In analysing the most recent period, ISPRA has examined the annual and seasonal precipitation series for northern, central and southern Italy[26]. The annual series do not point to statistically meaningful trends, while the Winter series in northern Italy shows an average decrease of 1.47 mm/year in precipitation between 1961 and 2006 (Figure 1.8).

The precipitation series for Northern Italy shows an average decrease in precipitation of 1.47 mm/year between 1961 to 2006.

[23] Source: Stations of the network of the Italian Air Force data processed by ISPRA
[24] Brunetti, M. et al. 2006, Temperature and precipitation variability in Italy in the last two centuries from homogenized instrumental time series, International Journal of Climatology, vol. 26:345-381
[25] Nanni T. and Prodi F., 2008, Energia, no.1, 2008, pp. 66-71
[26] Toreti A., Desiato F., Fioravanti G. and Perconti W. 2009, *Annual and seasonal precipitation over Italy from 1961 to 2006, International Journal of Climatology*, doi 10.1002/joc. 1840

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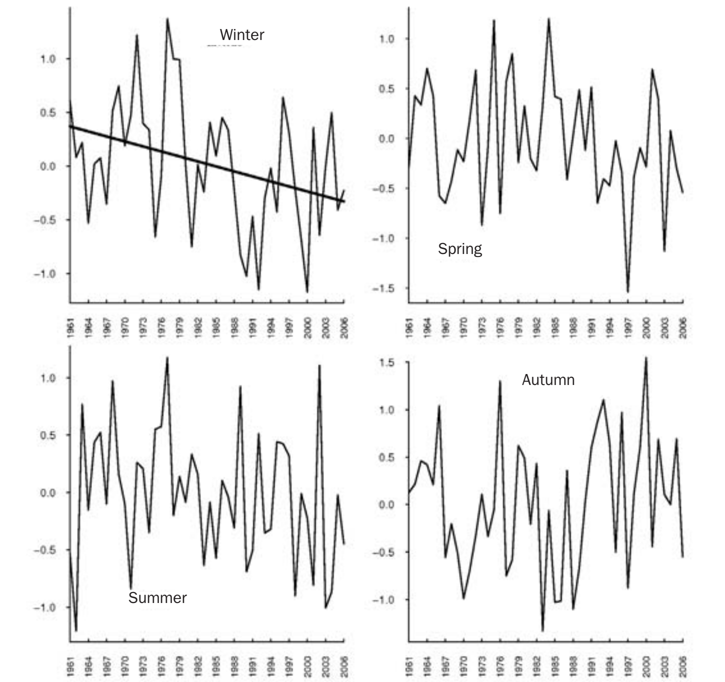


Legend: On the Winter graph, the vertical axis stands for the estimated linear trend

Figure 1.8: Series of standardised anomalies of seasonal precipitation in Northern Italy[27]

In order to determine whether there were any trends involving extreme precipitation events, the following indicators were analysed: "consecutive dry days" (CDD) index, meaning the maximum consecutive number of days with precipitation of less than 1 mm; "very wet days" (R95p) and the "extremely wet days" (R99p) indexes, meaning the number of days in the year when there is precipitation in excess of the 95th (99th) percentile of the climatological distribution of daily precipitation between 1961 and 1990; and the "simple

[27] Source: Toreti A., Desiato F., Fioravanti G. and Perconti W. 2009, *Annual and seasonal precipitation over Italy from 1961 to 2006, International Journal of Climatology*, doi 10.1002/joc.1840

daily intensity” index (SDII), meaning the annual precipitation divided by the number of days with precipitation greater than or equal to 1 mm. The CDD is pertinent to the duration of periods of drought, while the other indicators (R95p, R99p and SDII) provide statistical analyses of events of intense precipitation.
A preliminary analysis of these indexes on a sample group of approximately 50 stations shows no statistically significant trend between 1950 and 2006. However, the limited number of sufficiently continuous times series of controlled quality, plus the fact that they are distributed unevenly within the territory, make it impossible, for the moment, to determine whether or not there are significant trends concerning extreme precipitation events in Italy.

Impacts and vulnerabilities

Observations made on dry land and on the oceans show – as is illustrated by the Fourth Assessment Report of the IPCC - that many natural systems have been affected by regional climate change, and especially by increases in temperature.
On the global level, in keeping with the warming trend observed, most of the components of the cryosphere are undergoing a generalised reduction in their extension, and at an increasingly rapid pace in recent decades.
The level of the sea rose at a rate of approximately 1.7-1.8 mm a year during the last century, with increase of up to 3 mm a year during the last decade, and the consequences are being felt in many coastal regions. In marine and aquatic ecosystems, many changes in phenology and biogeography, meaning 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. Studies of land biological systems point to impacts of global warming over the last 30-50 years, such as the earlier occurrence of Spring and Summer phenological phase and the extension of the growth season in the medium and high latitudes, as well as increased vulnerability of certain species, with cases of extinction on the local level.
In recent years, repeated large-scale forest fires have been associated with drought episodes in the Mediterranean area and in North Africa, as well as in North America.

Observations on both dry land ad oceans show that many natural systems have been affected by regional climate changes, and especially by increased temperatures.

Climate change affects not only physical and biological systems, but also socio-economic sectors that depend on climate conditions, and which are already undergoing the consequences, such as farming, fishing, tourism, energy and health, as well as financial services and insurance.
Still, additional efforts are indispensable for reinforcing the basic knowledge on climate change and on the related impact on natural systems and socio-economic sectors, so as to be able to formulate suitable adaptation measures.
This is the direction taken by the initiatives of the IPCC, which recently stressed the need to improve the level of knowledge on impacts, vulnerability and adaptation by pursuing the regional analyses at greater depth. These evaluations shall be included in a specific section of the contribution of Working Group II to the Fifth Assessment Report, expected to be published in the early months of 2014.
In Europe as well, as shown by the latest report of the European Environment Agency on the impacts of climate change[28], many natural systems, plus a large number of socio-economic sectors, have already undergone the consequences of climate change, namely 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 energy and transport sectors. 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 instances of climate change already underway, and to moderate them, are taken[29].
In the decades to come, overall national water resources shall tend to decrease, on account of lower levels of precipitation and higher levels of evapo-transpiration, as well as the procurement of water supplies. The situation shall prove most critical in Southern Italy, were water supply is already under stress and have far-reaching

[28] EEA, 2008. *Impacts of Europe's changing climate – 2008 indicator-based assessment*. EEA *Report* no. 4/2008
[29] For more in-depth information, see the 2008 edition: Key Topics 2008 – Yearbook of Environmental Data. ISPRA, 2009

implications for farming, tourism, health, industrial production, urbanisation and, last but not least, the insurance sector.
The climate trends underway, and those forecast under the IPCC scenarios, shall shift to higher latitudes climatic and environmental conditions typical of the Mediterranean area. This means that the ecological and forestry systems, and the natural environments, of the Mediterranean shall tend to “migrate” towards western and northern central Europe. However, the pace of the climate change underway is far more rapid that the rate at which the vegetable species are able to colonise the new spaces, especially in the case of the dominant forest species: what can be expected, therefore, is a gradual “breaking up” of many ecosystems, resulting in modifications in the landscape, with noteworthy influences on the agriculture, tourism and leisure sectors, as well as on residential housing.
Even a limited increase in sea-level, along with an intensification of extreme events, such as exceptionally high surges, will aggravate to a noteworthy extent existing problems in coastal environments. A number of low-lying coastal plains (there are roughly thirty major ones, making for a total of approximately 1400 km of linear extension) could be flooded, in addition to which all the low-lying, sandy coastal areas (totalling approximately 4000 km) could be vulnerable to problems of acute coastal erosion, infiltration of salt water in coastal fresh-water tables and damage to the biodiversity of coastal wetlands, especially if their altitude already places such areas below sea level (as in the case of the entire upper Adriatic coastal zone). This problem could have significant effects not only in terms of a loss of biodiversity, with serious consequences for production activities in coastal zones, but, to an even greater extent, and recreational and tourist activities, even reaching the point of threatening historic, artistic and cultural resources, as in the case of Venice.
In addition to possible damage to natural resources, the environment, the surrounding territory and economic activities, there could also be impacts, secondary but worthy of note nonetheless, in terms of work and employment, and as regards social and medical wellbeing, especially for the part of the population most vulnerable to climate change.

This year the European Environment Agency has focussed particu-

The Alpine environment is one of the most vulnerable in Europe.

lar attention on the Alpine environment, one of the most vulnerable, and on the impact that climate change can have on water resources and on the socio-economic sectors that depend on such environments and resources[30].

The effects of climate change are already plainly visible from the observation of certain glaciers and the variations they have undergone. Like the majority of the glaciers on the European continent, the mass of the Alpine glaciers is decreasing (Figure 1.9).

The majority of the glaciers on the European continent are losing mass.

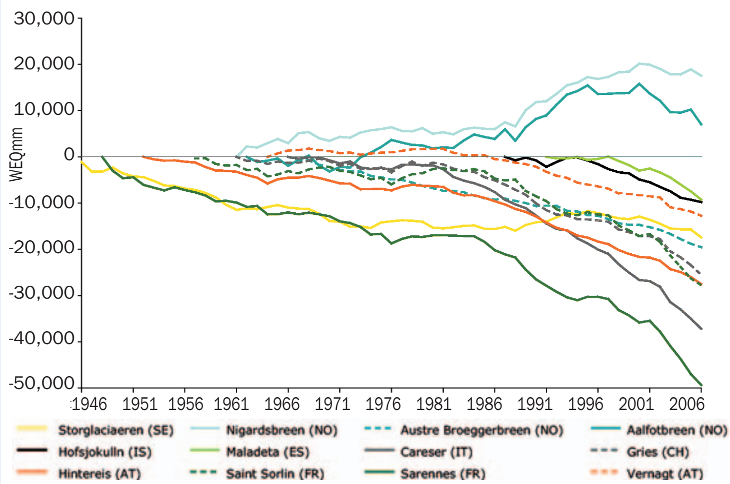


Figure 1.9: Balance of the cumulative net mass of European glaciers between 1946 and 2006[31]

Between 1850 and the end of the 1970's, the Alpine glaciers lost a third of their surface area and half of their volume. Starting in 1985, the trend was found to be accelerating, with 25% of the remaining glacial mass lost by the year 2000. During the exceptionally hot season of 2003, a further

Between 1850 and the end of the 1970's, the Alpine glaciers lost a third of their surface area and half of their volume. Starting in 1985, the trend was found to be accelerating, with 25% of the remaining glacial mass lost by the year 2000. During the exceptionally hot season of 2003, a further reduction of 5-10% was

[30] EEA, 2009, *Regional climate change and adaptation – The Alps facing the challenge of changing water resources*, EEA Report No 8/2009

[31] Source: EEA, 2008, *Impacts of Europe's changing climate — 2008 indicator based assessment.* EEA Report 4/2008, JRC Reference Report JRC47756. Joint EEA–JRC–WHO report

registered, making for a loss equal to roughly two-thirds of the glacial mass as of 1850.

reduction of 5-10% was registered, making for a loss equal to roughly two thirds of the glacial mass as of 1850.

The Norwegian coastal glaciers, which expanded up through the 1990's, have initiated a phase of retreat, due to lower levels of Winter precipitation and increased Summer melting.

The glaciers of the Svalbard Islands are losing mass at lower altitudes, while the glacial fronts of almost all glaciers are in retreat. Estimates for the Svalbard Islands as a whole show an overall negative balance, with unmistakable signs of accelerated melting, especially in the western area.

Recent studies point to a clear-cut rise in the annual reduction in average global glacial thickness, starting from the new millennium (0.5 m), as compared to the period 1980-1999 (0.3 m). The centuries-long retreat of Europe's glaciers can be traced primarily to increased temperatures in Summer.

The centuries-long retreat of Europe's glaciers can be traced primarily to increased Summer temperatures.

In the case of the Alpine region, a noteworthy increase in temperature was registered during the last century: approximately 2 °C, more than double the average rate of warming observed in the northern hemisphere. In addition, an upward trend in precipitation was observed in the northern Alpine zone, while precipitation decreased in the southern sector of the Alps[32].

With rising temperatures and changes in rates of rain and snow, therefore, global warming poses a serious threat to the Alpine hydrological system, as well as to the environmental, social and economic systems that depend on it[33].

A number of the effects of climate change observable both globally and in Europe can already be noted in Italy as well: erosion of coastal areas, desertification, melting of glaciers, scarcity of water, slope instability and risks to health are only some of the examples[34].

In Italy, the Alpine environment is considered to be one of the most vulnerable to climate change.

Give its sensitivity to increased temperatures and its limited adaptive capacity, the Alpine environment proves to be one of the most vulnerable in our country as well, in keeping with what

[32] EEA, 2009, *Regional climate change and adaptation – The Alps facing the challenge of changing water resources*, EEA Report No 8/2009

[33] Convenzione delle Alpi, Segnali alpini – Edizione speciale 2, 2009. *L'acqua e la gestione delle risorse idriche – Relazione sullo Stato delle Alpi*

[34] For a more detailed description of the impact of climate change on the Italian territory, see the 2008 edition: Key Topics 2008 – Yearbook of Environmental Data. ISPRA, 2009

has been observed in the rest of Europe[35].
Starting from the second half of the 19th century, Italian glaciers have undergone a phase of intensive contraction, resulting in the loss of 40% of their surface area: many minor glaciers have disappeared, while larger ones have broken down into smaller units[36]. Measurements of the glacial mass balance, indicating the algebraic sum of the mass of accumulated ice, the result of the snow precipitation, and the mass lost during the melting period, provides direct, pertinent information on the effect of the climate on glaciers, though the scope is limited, due to the reduced availability of adequate data from the past, except in the case of the Caresèr glacier (Figure 1.10).

The five glacial bodies considered show a general trend towards deglaciation and melting, developments common to much of the planet's glaciers.

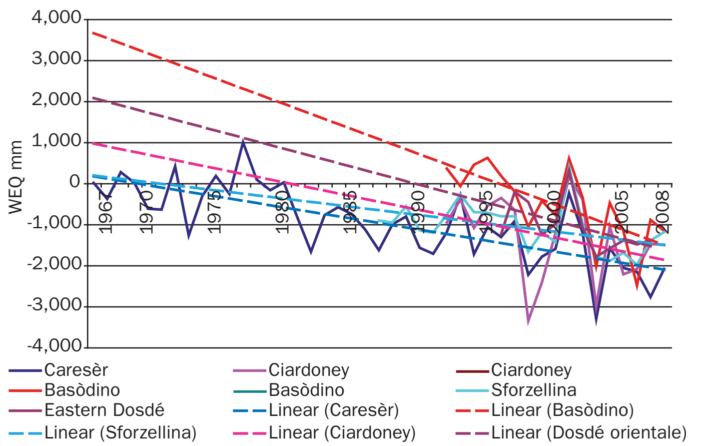


Figure 1.10: Net mass balance of the glaciers Caresèr, Ciardoney, Basòdino, eastern Dosdé and the Sforzellina, plus the related trend lines[37]

[35] APAT, Ministry of the Environment, Land and Sea, 2007. *Gli eventi preparatori della Conferenza – Sintesi dei lavori*
[36] Source: The Italian Glaciology Committee http://www.disat.unimib.it/comiglacio/comitatoglaciologico.htm
[37] Sources: Italian Glaciology Committee – Trent SAT Glaciology Committee, in collaboration with the Autonomous Province of Trent, Department of Civil Engineering and the Environment of the University of Trent, Tridentino Museum of Natural Science (Caresèr); Italian Meteorological Society (Ciardoney); Swiss Weather Service (Basòdino); Italian Glaciology Committee (Sforzellina and eastern Dosdè)

Figure 1.10 illustrates the changes that have occurred in 5 glacial bodies representing different climate sectors: the Basòdino glacier in the northwestern Alps, the Caresèr in the central Alps, the eastern Dosdè of the Piazzi-Campo chain in Lombardy, the Sforzellina on the Lombardy side of the Ortles-Cevedale and, finally, in the western Alps, the Ciardoney glacier. As is the case for most of the planet's glaciers, all the glacial bodies observed show a general tendency towards deglaciation, with an especially evident example being the trend for the Caresèr glacier, which has been consistently negative since back in 1981.

Figures 1.11, 1.12 and 1.13 illustrate the changes in the average minimum altitude of the fronts of a number of glacial units. At first, data was considered (starting from 1958) for a set of 1,028 individual glacial units (329 in the western Alps, 545 in the central Alps and 96 in the eastern Alps) while later, the focus was narrowed to a subset held to be significant, and open to variation from year to year. All the glaciers for which data were recorded have a surface area of more than 12 acres. Each glacier has distinctive characteristics (altitude, substrate, exposure, morphology etc.): depending on the type of glacial unit involved, an effective retreat does not always correspond to an evident increase in the minimum altitude of the front.

The rise in the minimum altitude in the western Alps is hard to ignore.

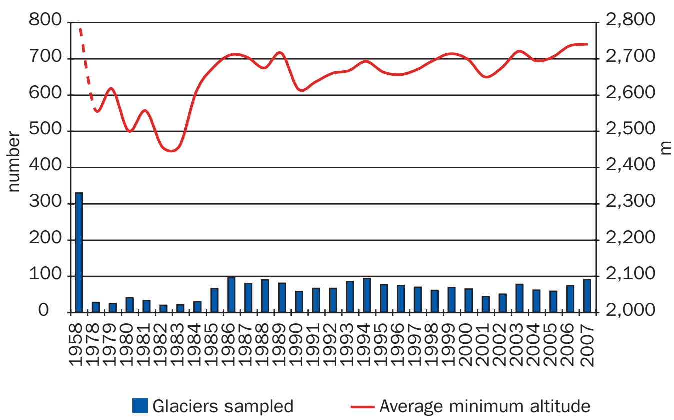


Figure 1.11: Changes in the average minimum altitude of the glacial fronts in the western Alps[38]

[38] Source: Italian Glaciology Committee data processed by ISPRA

In the central Alps, the tendency of the glaciers to retreat is confirmed by the overall trend, though with a number of discrepancies.

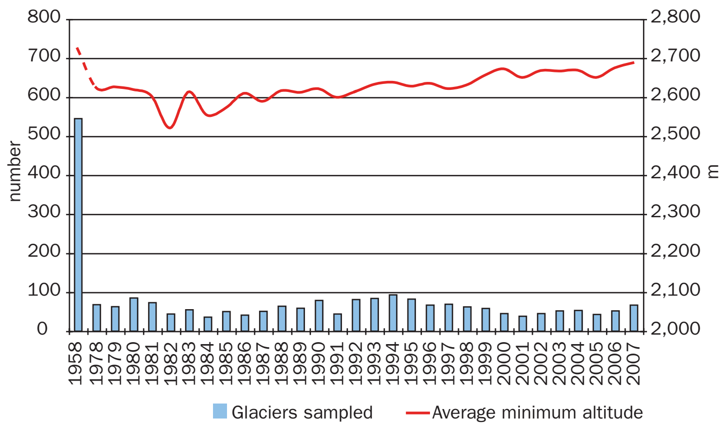


Figure 1.12: Changes in the average minimum altitude of the glacial fronts in the central Alps[39]

In the eastern Alps, the tendency of the glaciers to retreat is confirmed by the overall trend, though with a number of discrepancies.

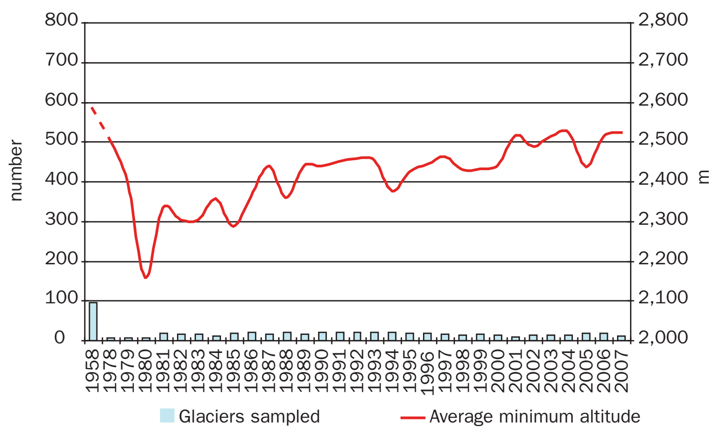


Figure 1.13: Changes in the average minimum altitude of the glacial fronts in the eastern Alps[40]

[39] Source: Italian Glaciology Committee data processed by ISPRA
[40] Source: Italian Glaciology Committee data processed by ISPRA

Changes in the glacial fronts point to an overall declining trend, meaning a rise in the average minimum altitude of the fronts.
The most recent changes show different trends in the three Alpine sectors: in the western Alps, the rise in the minimum altitude is fairly notable, while, in the central and eastern Alps, the withdrawal is demonstrated by the overall trend, though with a number of discrepancies[41].
Further scientific observation demonstrates, beyond any reasonable doubt, the impact of climate variations on the cryosphere and on the Alpine hydrological cycle, in the form of a reduction in the snow covering, a rise in the snow line and thawing of the permafrost, as well as variations in the outflow of watersheds and a decrease in available water resources.
These variations will have a particularly significant effect, and increasingly so in the future, on slope stability, biodiversity and the economic sectors that depend on water, especially tourism, energy generation and agriculture.
Winter tourism in the Alps is probably the economic sector that will suffer the heaviest losses on account of climate change, due to the reduced availability of snow in quantities sufficient for skiing. At present, the LAN, or Snow Reliability Line, meaning the average altitude above which precipitation in the form of snow, together with the temperature, guarantee at least 100 days a year when there are 30 cm of snow, is found at approximately 1,500 metres above sea level[42]. Of the 251 ski complexes in operation today in Italy, only 167, meaning 66%, have at least half of their surface located above the LAN, and can therefore be considered reliable in terms of the presence of snow (Table 1.1).

Climate variations have an impact on the cryosphere and on the Alpine hydrological cycle, reducing the snow covering, raising the snow line and thawing the permafrost, in addition to causing variations in the outflow of watersheds an d a decrease in available water resources.

In the Alps, winter tourism is probably the economic sector that will suffer the largest losses on account of climate change, due to the reduced availability of sufficient quantities of snow for skiing.

[41] ISPRA, 2009, Yearbook of Environmental Data 2009
[42] FEEM, 2008. *Cambiamenti climatici e strategie di adattamento in Italia – Una valutazione economica*

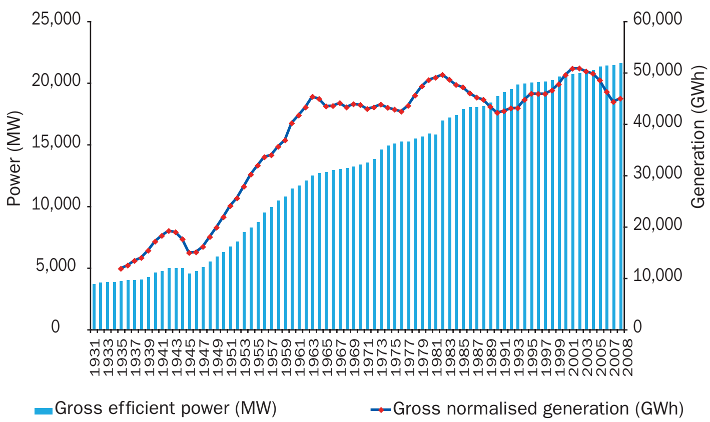
Table 1.1: Reliability of snow in Alpine ski resorts[43]

Region	Reliable ski resorts (with at least half their surface located above the LAN)	Total ski complexes
	no.	
Aosta Valley	22	25
Piedmont	30	54
Lombardy	21	33
Veneto	14	46
Trentino	25	34
Alto Adige	54	54
Friuli Venezia Giulia	1	5
ITALY	**167**	**251**

Looking at the energy sector, the impact of climate change on Alpine water resources plays a key role in the production of hydroelectric energy.

Under the various scenarios for temperature increases, and resulting rises in the LAN[44], a large part of the ski resorts could gradually lose reliable snow covering, leading to massive economic losses.
Looking at the energy sector, the impact of climate change on Alpine water resources plays a key role in terms of hydroelectricity generation, a fundamental economic resource for the entire area and a major factor in Italy's national energy balance, seeing that the presence of the glaciers in the Alps makes possible intensive use of water as a source of energy.
However, while in the past hydroelectricity was long Italy's main energy source, today it covers approximately 15-18% of the national demand for energy. At the same time, available hydroelectric capacity has risen significantly in absolute terms (Figure 1.14).

[43] Source: Ministry of the Environment, Land and Sea and the European Academy of Bolzano-EURAC, 2007. *Data and elaboration on the Italian Alpine and Pre-Alpine Ski Stations, Ski Facilities and Artificial Snowmaking*
[44] It is estimated that both the snow line and the line of snow reliability (LAN) can rise by 150 m for each °C of temperature increase. Assuming a constant upward trend, this would result in an increase of from 300 m to 600 m in the LAN altitude, due to an increase of from 2°C to 4°C in temperature



Legend: Hydroelectricity generation has been normalised to attenuate annual fluctuations[45]

Figure 1.14: Gross hydroelectricity generation and installed capacity in Italy through 2008[46]

Hydroelectricity was long Italy's main source of energy, but today it covers approximately 15-18% of the national energy demand. In absolute terms, however, available hydroelectric capacity has risen significantly.

The trend in hydroelectricity generation can provide noteworthy indications regarding variations in the hydrological cycle as a result of changing climate conditions, especially if consideration is also given to the development over time of the installed capacity for electricity generation. Installed capacity shows a constant increase, while electricity generation followed a parallel trend during the period 1931-1963, but later showed periodic fluctuations around an average level; the slightly upward trend did not appear to be precisely correlated to the available capacity.
In the short term, it is foreseeable that the melting of the glaciers will send much more water to the power plant turbines. But over the medium-long term, the gradual reduction and loss of the glaciers will pose a threat to an important source of renewable energy.

[45] Hydroelectricity generation was normalised under the criteria found in Directive 2009/28/EC (Annex II). Gross production, which includes the energy for pumping, reflects the production average for a period of five years
[46] Source: TERNA S.p.A. data processed by ISPRA

The increase in extreme events and hydrogeological risk could pose a threat to certain crops found in unstable, exposed areas, while higher temperatures and reduced water supply of water could have long-term negative consequences on Alpine crops.

With regard to agriculture, there is still little documentation on the impact of the climate change underway in the Alpine area. In the short to medium term, an increase in productivity can actually be observed, due to the fertilising effect of CO_2. However, the increase in extreme events and hydrogeological risk may pose a threat to certain crops found in unstable, exposed areas. At the same time, higher temperatures and reduced water supply could have long-term negative consequences on Alpine crops, including feed crops and pasture areas, with related effects on livestock breeding.

Pressures on the climate system

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

Without meaning to overlook the effects of natural phenomena, such as the variability of the intensity of solar radiation, the vast majority of the scientific community is convinced that "There are new and even more meaningful elements" for holding that "most of the observed warming over the last 50 years is likely to have been due to human activity"[47]; these results receive ample confirmation in the Fourth Assessment Report on Climate Change of the IPCC, which reiterated that, "warming of the climate system is unequivocal", and that human activities can be pointed to as the causes for this warming with a "very high confidence"[48].
With regard to 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 385 ppm in 2008, corresponding to a growth in carbon dioxide emissions from roughly zero to 31.2 billion tons, taking into account solely emissions from the use of fossil fuels in combustion processes and in cement production[49]. According to the IPCC assessments of the carbon cycle, between 1750 and 2000 an amount of fossil fuels equal to approximately 390 billion tons of carbon was extracted from below the ground and burned, producing, in turn, approximately 1400 billion tons of carbon dioxide. Of this quantity, 57% was

[47] IPCC, 2001, Climate Change 2001 – Synthesis Report
[48] IPCC, 2007, Climate Change 2007 – WG-I, WG-II, WG-III, Technical summary
[49] *Global Carbon Project* , 2008, *Recent carbon trends and the global carbon budget 2007*

absorbed by the oceans (in part dissolved in the water and in part absorbed by the phytoplankton) and by the vegetation on land (through chlorophyll photosynthesis and forest sinks), while the remaining 43% remained in the atmosphere, raising the concentration of carbon dioxide to a level that is the highest in the last 650 thousand years, and probably in the last 20 million years as well. The other greenhouse gases, such as methane, nitrogen dioxide and the fluorocarbons, have shown similar patterns of growth, with an even higher rate.

Italy is not exempt from this growth trend of greenhouse gas emissions: the most recent figures for the national inventory of greenhouse gas emissions show that emissions in equivalent tons of CO_2 went from 516.32 million to 552.77 during the period 1990-2007, making for an increase of 7.06%, whereas, according to the Kyoto Protocol, Italy should have brought its emissions down, during the period 2008-2012, to levels 6.5% lower than emissions in 1990, meaning to 482.76 MtCO_2eq.

From 1990 to 2007 greenhouse gas emissions in Italy went from 516.3 to 552.8 Mt CO_2 eq, for an increase of 7.1%. Under the Kyoto Protocol, Italy should have lowered its emissions, in the period 2008-2012, to levels 6.5% lower than emissions in 1990, meaning to 482.8 Mt CO_2eq.

Globally, Italy is responsible for no more than 1.51% of overall emissions generated by the use of fossil fuels in 2007, meaning that it ranks twelfth among the countries with the highest levels of greenhouse gas emissions[50].

Between 1990 and 2007, greenhouse gas emissions in Italy registered an overall growth of 36.45 million tons of carbon dioxide equivalent (Mt CO_2eq).

During this period, there were reductions in fugitive emissions, those due to accidental losses during the extraction and distribution of hydrocarbons (-3.51 Mt CO_2eq), as well as in emissions generated by manufacturing industries (-10.06 Mt CO_2eq), agriculture (-3.37 Mt CO_2eq), the use of solvents (-0.26 Mt CO_2eq) and industrial processes (-0.17 Mt CO_2eq), while there were increases in the emissions generated by waste (+0.52 Mt CO_2eq), the residential sector and services (+3.71 Mt CO_2eq.) and, to an even greater extent, those of the energy industries (+20.61 Mt CO_2eq) and the transportation sector (+25.47 Mt CO_2eq). The increasing trend has reversed starting from 2005: in 2006, a decrease of 1.87% in overall emissions

[50] IEA, 2009, *CO_2 emissions from fuel combustion. Highlights.* 1971-2007

Starting from 2005, a reduction in overall emissions was registered each year, for a decrease of 1.9% in 2006 and an additional reduction of 1.8% in 2007, compared to the previous year. Emissions from processes of combustion fell by 2.3%.

was registered, as compared to the previous year. In 2007, emissions showed an additional decrease compared to 2006 (-1.81%).

The reduction took place in almost all the sectors: energy industries (-1.04%; -1.75 Mt CO_2eq compared to the previous year), the residential sector and services (-6.94%; -6.07 Mt CO_2eq), waste (-1.32%; -0.25 Mt CO_2eq), fugitive emissions (-1.83%; -0.14 Mt CO_2eq), the manufacturing industry (-3.88%; -3.25 Mt CO_2eq) and the use of solvents (-0.64%; -0.01 Mt CO_2eq).

Only agriculture, transportation ad industrial processes moved in the opposite direction, showing growth in emissions compared to 2006 (agriculture: +1.59%; +0.58 Mt CO_2eq; transportation: +0.13%; +0.17 Mt CO_2eq; industrial processes: +1.06%; +0.38 Mt CO_2eq).

On the whole, total emissions fell by 10.21 Mt CO_2eq (-1.81%) in 2007, compared to the previous year, essentially on account of reduced emissions from combustion processes (-2.33%; -10.78 Mt CO_2eq) (Figure 1.15).

Between 1990 and 2007, there were increases in emissions from waste, the residential sector and services and, to an even greater extent, from the energy industries and transportation.

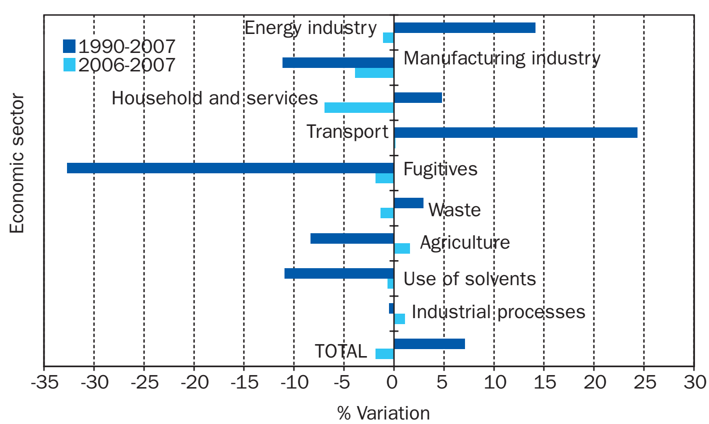


Figure 1.15: Percentage variation in emissions of greenhouse gases by economic sector for the year 2007, compared with the previous year and with 1990[51]

[51] Source: ISPRA

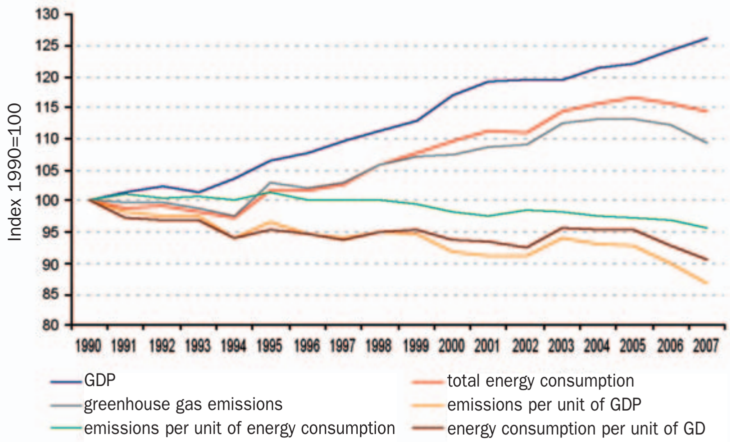


Figure 1.16: Trends of for the main economic, energy and emissions indicators[52]

A comparison of levels of greenhouse gas emissions with the figures for the main variables of economic growth show that, during the period 1990-2007, the growth in greenhouse gas emissions was generally slower than the growth of the economy, pointing to a relative decoupling of the two trends.

A comparison (Figure 1.16) between the levels of greenhouse gas emissions and of the main variables depicting economic growth (such as the GDP and value added) show that, for the period 1990-2007, growth in greenhouse emissions was generally slower than economic growth, pointing to a relative decoupling of the two trends[53].
In contrast, an analysis of levels of greenhouse gas emissions per total energy unit shows that emission levels in the 90's essentially followed those of energy consumption, with a decoupling arising only in recent years, due primarily to the use of natural gas in place of combustibles with higher carbon contents to produce electric energy and fuel industrial activities.
A decomposition analysis was carried out to determine the main

Greenhouse gas emission levels in the 90's essentially followed those of energy consumption, with a decoupling arising only in recent years, due primarily to the use of natural gas in place of fuels with higher carbon contents for electricity generation and industrial activities.

[52] Source: ISPRA
[53] If the economic variable shows positive growth while the growth rate of the environmental variable is less than or equal to zero, then it is said that an "absolute decoupling" has occurred. In contrast, when the growth rate of the environmental variable is positive, but lower than that of the economic variable, then a "relative decoupling" is at work (OECD, 2002)

factors underlying the variation in greenhouse gas emissions[54]. Specific consideration was given to the variation in greenhouse gas emissions for which economic activities were responsible in the period 1992-2006, with the use of three sets of data – environmental, energetic and economic – all collected on a consistent basis (meaning in accordance with the principles, definitions and classifications of national accounting)[55].
In breaking down the variation in greenhouse gas emissions in the period 1992-2006, the following factors were taken into consideration:

- the level of economic activity (to evaluate the effect of economic growth);
- the percentage weight of the different sectors of the economy (to assess the effect of changes in the production structure);
- the economic efficiency of fuel use (to assess the effect of changes in energy intensity per unit of product);
- the emission intensity of energy consumption (to assess the effects of changes in emission intensity).

The decomposition analysis indicates that the increase in emissions between 1992 and 2006, equal to approximately 24 million tons of CO_2 eq (Figure 1.17), is due exclusively to the "economic growth". And if the effects of economic growth had not been offset by those of the other components, the overall variation would have been approximately 30.8% instead of the actual 5.6%.
More specifically, the improvements in the two technological factors "emission intensity" and "energy intensity" should have led to a reduction of 20.7% in potential emissions. The factor "production structure" also played a significant role, though to a lesser extent, in reducing greenhouse gas emissions (-4.5%).

[54] Femia A. (ISTAT), Marra Campanale R. (ISPRA), *Production-related air emissions in Italy 1992-2006, a decomposition analysis*, in "*Environmental Efficiency, Innovation and Economic Performance*", edited by Anna Montini, Massimiliano Mazzanti, June 2010

[55] This type of analysis does not refer to the total emissions estimated by ISPRA using the IPCC methodology employed for the UNFCCC, but rather to a NAMEA type context (*National Accounting Matrix including Environmental Accounts*). The NAMEA classification method considers only emissions that can be traced to the production activities responsible for them, and it is consistent with the national economic statistics. As a result, no direct comparison can be established between the NAMEA data and the data used for UNFCCC

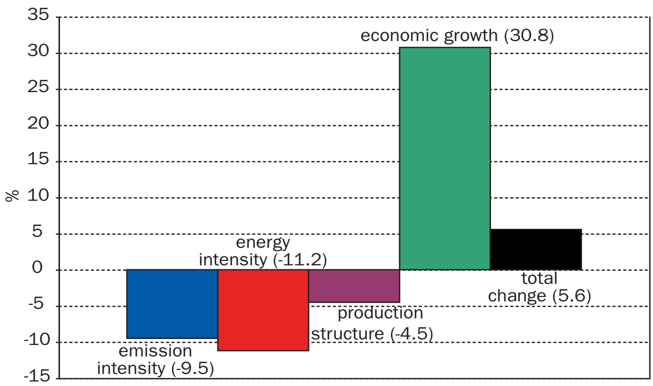


Figure 1.17: Variations between 1992 and 2006 in greenhouse gas emissions due to economic activities, broken down by determinants[56]

The decomposition analysis shows that the increase in emissions caused by economic activities, equal to 24 million tons of CO_2 eq between 1992 and 2006, was due exclusively to the "economic growth" factor.

An analysis of the annual variations shows that the overall change for 1992-2006 (-9.5%) traceable to "emission intensity" was arrived at, for the most part, by accumulating small annual increases in efficiency during the period (though, in a number of years, the annual variation in intensity was positive). This demonstrates that there was indeed an improvement, though admittedly a slow one, in the environmental efficiency of Italian industry, thanks to a decrease in emissions not involving the use of fuels (but, for example, the use of solvents); the switch to less polluting combustible fuels; the use of technologies that improve production processes, such as integrated technologies; the installation of devices that reduce *end-of-the-pipe* emissions. In contrast, the effect of the "energy intensity" is characterised by an irregular, unpredictable pattern that often features major changes from one year to the next, such as the increase of 3.4% in 2003 and the upward variations of 2005 and 2006, all of which suggests that the use of energy has become less efficient in recent years. This factor takes into account the effects of a number of possible real improvements, such as the introduction of less fuel intensive techniques and the removal from operation of machines or plants that waste energy. However, both the overall importance of the factor and its volatility can be explained, at least in

[56] Source: Processing by Femia A. (ISTAT), Marra Campanale R. (ISPRA) of ISTAT-ISPRA data

In 2007, greenhouse gas emissions in Italy exceeded the Kyoto objective by 70 Mt CO_2 eq.

Under the Kyoto Protocol, Italy should lower its emissions, during the period 2008-2012, to levels 6.5% below those of 1990, meaning to 482.76 Mt CO_2eq.
In 2007 greenhouse gas emissions exceeded the Kyoto target by 70 Mt (+14.5%).

According to the assessments of the European Environment Agency, Italy will be able to reach its objectives under the Kyoto Protocol only if, in addition to drawing on emission credits gained through LULUCF activities and acquiring quotas generated by the flexible mechanisms provided for under the Protocol, it implements additional measures to reduce emissions, above and beyond those already taken.

part, by the delocalisation of Italian production activities. In effect, an increasing number intermediate and final products of Italian industrial concerns are manufactured abroad, with only the very last phases performed in Italy. This means that the output is achieved without having to use all the energy necessary for "production" in the sector (in reality, frequently acquired abroad, as intermediate input, in the form of goods that are almost finished and the resold following a small transformation). In 2007 greenhouse gas emissions exceeded the Kyoto objective by 70 Mt CO_2 eq. (+14.5%). The increase in emissions was due primarily to the energy industry and transportation sectors.

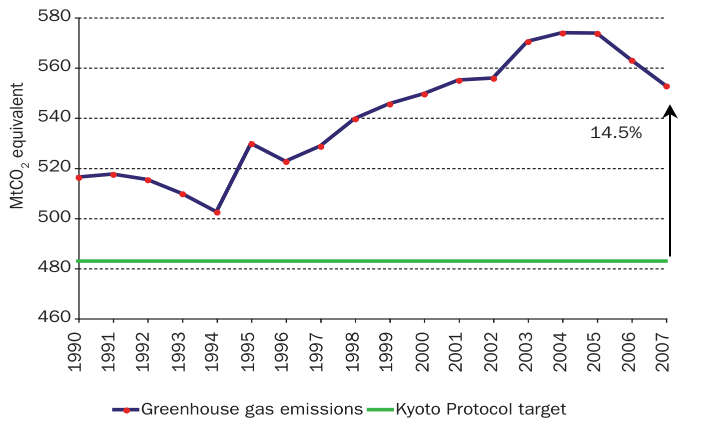
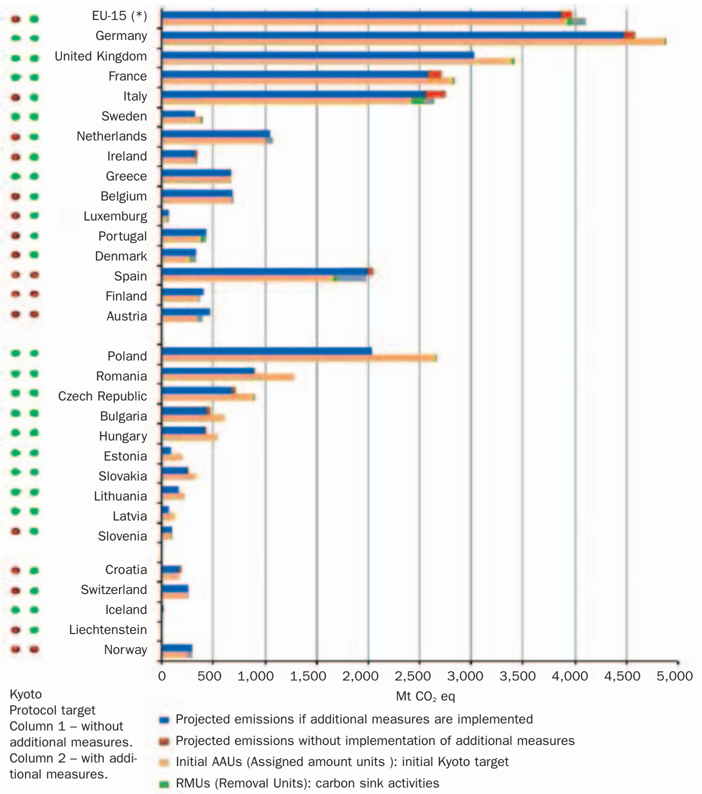


Figure 1.18: Total greenhouse gas emissions in Italy, compared with the Kyoto target[57]

According to the assessments in the report "*Greenhouse Gas Emission Trends and Projections in Europe* 2009 - *Tracking progress towards Kyoto targets*" of the European Environmental Agency, Italy will be able to reach the objectives set under the Kyoto Protocol only if, in addition to drawing on emission credits gained through LULUCF activities (*Land Use, Land Use Change and Forestry*) and acquiring quotas generated by the flexible mechanisms provided for under the Protocol, it implements additional measures to reduce emissions, above and beyond those already taken; such measures, however, must still be determined and enacted.

[57] Source: ISPRA



Note: The countries are divided into the groups EU15, EU12 (with the exception of Malta and Cyprus, which do not have objectives under the Kyoto Protocol) and non-EU countries. Within these groupings, the countries are ranked in ascending order, based on the absolute interval between the emissions forecast for the period 2008-2012 and their respective objectives under the Kyoto Protocol. The first coloured dot to the left of each country indicates the difference between the projected greenhouse gas emissions and the Kyoto objectives with only the measures already taken (excluding sink activities and the Kyoto mechanisms: CDM, JI), while the second coloured dot indicates the difference between the projection of greenhouse gas emissions and the Kyoto objectives in the event that additional measures are taken. The green and red dots indicate that emissions fall, respectively, below or above the levels required under the Kyoto Protocol.
(*): annual average emissions for the EU15, while the projections for the individual countries regard total emissions for the period 2008-2012 and the Kyoto objectives.
The projections for the period 2008-2012 are communicated by the member states (Belgium, Bulgaria, Denmark, Ireland, Italy, Luxemburg and Portugal) or estimated by the European Environmental Agency on the basis of the emissions of 2007 and the projections for 2010 and 2015, as communicated by the countries.
For each country, the upper bar represents the quantity of emissions permitted for the period of 2008-2012 (the initial objective under the Kyoto Protocol, plus the emissions estimate resulting from the reduction of emissions through sink activities and through the purchase of credits under the flexible mechanisms provided for in the Protocol). lThe lower bar represents the emissions projection for the period 2008-2012.
A country can reach its objective when its emissions (the upper bar) do not exceed its Kyoto objective (lower bar).

Figure 1.19: Comparison between the emissions forecast for the European countries for the period 2008-2012 and their targets under the Kyoto Protocol[58]

According to the EEA, at present only three member states (Austria, Finland and Spain) hold that they will not be able to meet their Kyoto target without taking further measures.

[58] Source: EEA, *Greenhouse Gas Emission Trends and Projections in Europe* 2009 - *Tracking progress towards Kyoto targets, forthcoming*

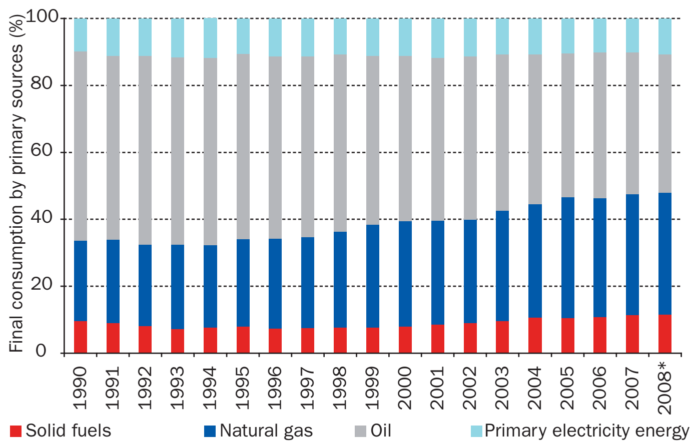
In terms of the goal of reducing green house gas emissions by at least 20% within 2020, compared to the levels of 1990, the EU is roughly halfway there, having registered, in the year 2007, a 9.3% reduction in emissions compared to 1990.

Energy prices fluctuations are one of the causes of the ongoing changes in the energy supply mix.

The energy sector is undergoing changes in the supply of primary sources, with growth in the consumption of natural gas, at the expense of oil products, and a contribution from renewable sources and cogeneration, plus, since 2001, consumption of solid fuels.

According to the European Environmental Agency, at present only three member states (Austria, Finland and Spain) feel that they will not be able to reach their Kyoto objective without taking further measures. In terms of the goal of reducing greenhouse gas emissions by at least 20% within 2020, as compared to the levels of 1990, assessments are still in the preliminary stage; taken as whole, the EU is roughly halfway there, having registered, in the year 2007, a 9.3% reduction in emissions compared to 1990.

Energy prices fluctuations are one of the causes of the ongoing changes in the energy supply mix, with natural gas playing an increasingly important role, at the expense of oil products, and with an upward trend in the contribution of renewable sources and cogeneration, plus, starting from 2001, renewed consumption of solid fuels, whose contribution to primary energy sources (including primary electric energy) went from 8.6% in 2001 to 11.5% in 2008.



Legend :* Provisional figures

Figure 1.20: Total consumption of energy by primary sources[59]

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

Despite changes in the mix of primary energy sources, our country's energy dependence remains high, having risen from 82.8% in 1990 to 85.5% in 2008, for an increase of 2.7%. With the goal of limiting the vulnerability of our economic system on account of this supply structure, the current Government has presented legislative measures meant to select locations for new nuclear power plants.

Despite the modifications in the mix of primary energy sources, our country's energy dependence remains high.

Starting from 1990, there was a constant upward trend in total final energy consumption, with the peak reached in 2005 (+20.7% compared to 1990). A reversal in the trend was observed from 2006 on, with a 4.1% drop in final consumption registered in 2008, as compared to 2005. Final total consumption for 2008 amounted to a 15.7% increase over 1990.

Starting from 1990, there was a constant upward trend in final energy consumption, with the peak reached in 2005 (+20.7% compared to 1990). A reversal in the trend was observed from 2006 on, with a 4.1% drop in final consumption registered in 2008, as compared to 2005.

The main sectors that contribute to the overall trend have shown falling consumption in recent years. In particular:

- industry has registered a decrease of 8.6% in energy consumption since 2004;
- the household and services sector shows 3.5% lower consumption than in 2005, though the level rose last year (+4.8% compared to 2007);
- in contrast to the other sectors, consumption for transportation has increased constantly since 1990 (+29.6% in 2008), with the sole exceptions of drops in consumption in 2005 and 2008, compared to the preceding years. Based on provisional estimates, the decrease in 2008 was 1.7%;
- consumption in the agriculture and fishing sector has declined constantly since 2005 (-3.9%).

With regard to the break-down of energy for final consumption (not including non-energy uses or bunker fuels), the household and services sector accounts for 34.4% of consumption, followed by the transportation and industrial sectors, at 34.2% e 29% respectively. The agriculture and fishing sector accounts for the remaining 2.5% of final consumption. The decrease in Italy's total energy consumption in recent years, together with the limited growth of its GDP, explain the significant reduction in energy intensity between 2005 and 2008 (-5.3%), following a series of decidedly high values (around 159 toe per millions of Euro) registered between 2003 and 2005. In 2007, Italy was the G20 country with the lowest total energy intensity, with GDP corrected for purchasing power parity, rating below the worldwide average and that of the OECD.

The decrease in Italy's total energy consumption in recent years, together with the limited growth of its GDP, explains the significant reduction in energy intensity between 2005 and 2008 (-5.3%).

In 2007, Italy was the G20 country with the lowest total energy intensity, with GDP corrected for purchasing power parity, rating below the worldwide average and that of the OECD.

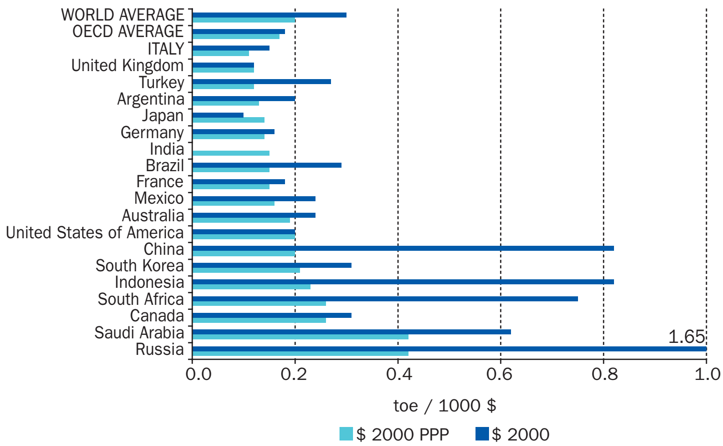


Figure 1.21: Total energy intensity of the G20 countries, with GDP measured in year-2000 dollars and corrected for purchasing power parity (PPP) (2007)[60]

Between 1994 and 2008 the electricity generation grew at a rate considerably higher than total energy consumption.
This result points to the growing role of electricity as a vector in the national energy system.

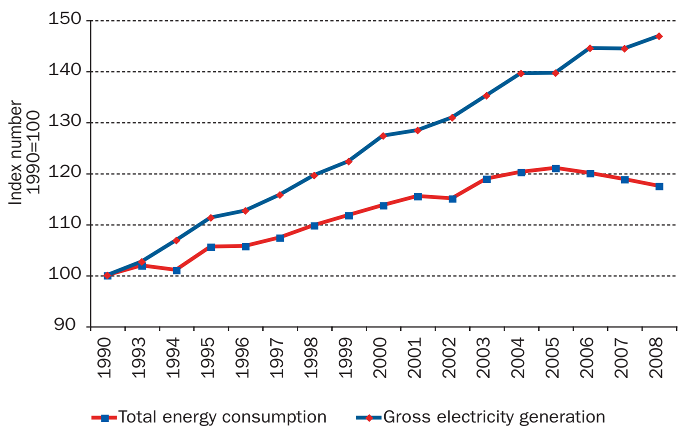


Figure 1.22: Total energy consumption and electricity generation (1990 = 100)[61]

[60] Source: International Energy Agency (IEA)
[61] Source: Ministry of Economic Development and TERNA S.p.A. data processed by ISPRA

Between 1994 and 2008, the rate of growth for electricity generation was considerably higher than that for total energy consumption. This result points to the growing role of electricity as an energy vector in the national energy system.
Looking at the regional break-down, final energy consumption varies considerably within the national territory. The figures for 2008 show that Lombardy consumes 21.6% of the national total, followed by Veneto at 10.1%, while Emilia Romagna and Piedmont account for respective levels of 9% and 8.4%, and other regions, such as Lazio, Tuscany, Apulia, Campania and Sicily find themselves in and around an average value of 6.1%. Taken as a whole, these nine regions consume 79.5% of the Italian total (Figure 1.23).

Between 1994 and 2008 electricity generation grew at a rate considerably higher than total energy consumption.

Regional final energy consumption reveals a highly varied structure within the national territory.

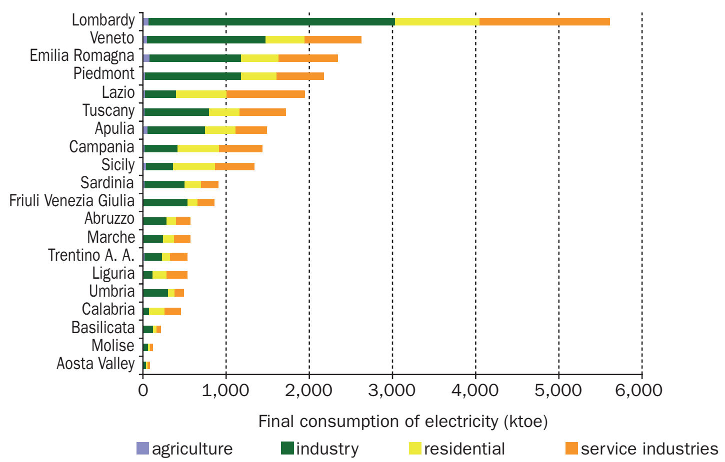


Figure 1.23: Final energy consumption by region and by economic sector (2008)[62]

Regional consumption of electricity reveals a highly varied structure within the national territory. Lombardy consumes 21.6% of the national total. Nine regions (Lombardy, Veneto, Emilia Romagna, Piedmont, Lazio, Tuscany, Apulia, Campania and Sicily) account for 79.5% of total Italian consumption.

The transportation system must respond to sharp rises in the demand for mobility. During the period 1990-2008, the demand for passenger transport increased by 34%, while the demand for domestic transport of cargo for distances of more than 50 km grew by 23.2% over the same period.

The transportation system must respond to sharp rises in the demand for mobility. During the period 1990-2008, the demand for passenger transport increased by 34%, while the demand for domestic transport of cargo for distances of more than 50 km grew by 23.2% over the same period.

[62] Source: ENEA data processed by ISPRA

Growth in passenger demand remained constant during the period 2000-2005, followed by increases over the following two years.
In 2008, there was a drop in the demand for transportation (-4.7% compared to 2007) (Figure 1.24).
The demand for passenger transportation continued to be met primarily by roadway transportation, the least efficient mode from an economic and environmental perspective. In 2008, automobiles, motorcycles and scooters covered 81.6% of passenger transportation demand.
Italy ranks second, after Luxembourg, in terms of the ratio of automobiles in circulation to the 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 1990-2008, the demand for passenger transport increased by almost 34%. Roadway transportation (automobiles, motorcycles and scooters) covered 81.6% of the demand for passenger transport (automobiles alone 73.8%) in 2008.

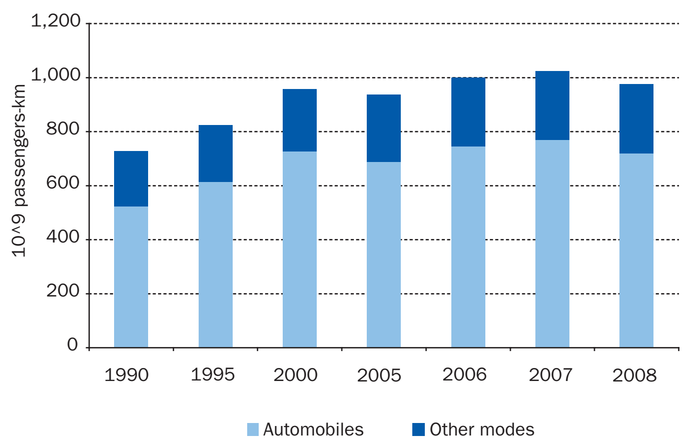


Figure 1.24: Demand for passenger transport[63]

The demand for passenger transport shows a growth trend from 1990 to the present (+23.2% in 2008, compared to 1990), being

[63] Source: Ministry of Infrastructures and Transport data processed by ISPRA

closely tied to the dynamics of economic development and the process of European integration (Figure 1.25).
Transportation of freight takes place primarily by truck, with the rate having remained fairly constant since 1990, at in and around 70% compared to the other modes of transport (68.2% in 2008). In 2008, domestic freight transport by sea and by railway accounted for respective percentages of 17.7% and 9.5, while air transport represented a marginal 0.4% of total transport.
The demand for freight transport showed noteworthy growth during the period 2000-2005, following by decreases in subsequent years. Roadway transport has increased by 0.9% compared to 2000. Under the category “other modes”, cargo transported by sea showed a significant increase (+43.8%) from 2000 on, while more modest growth was registered by railway transport (+3.9%). The increases for air transport and transport by pipeline were, respectively, 17.8% and 18.6%, compared to the year 2000.

Transportation of freight takes place primarily by truck, with the rate having remained fairly constant since 1990, at in and around 70% compared to the other modes of transport (68.2% in 2008).

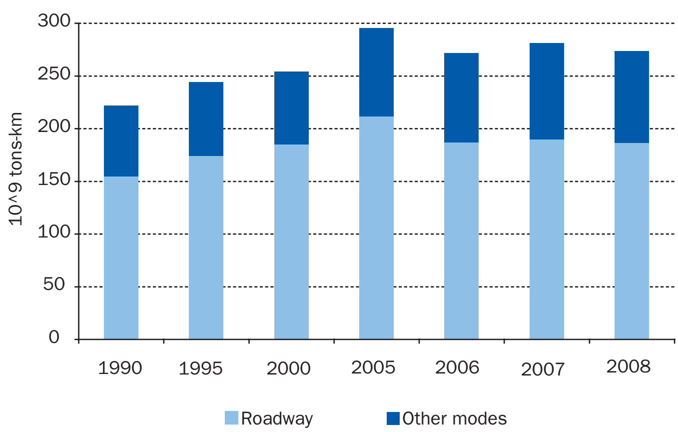


Figure 1.25: Demand for freight transport[64]

The demand for transport showed growth of 23.2% between 1990 and 2008. Furthermore, estimates for 2008 show that freight transport within the national territory occurs primarily by roadway travel (68.2%) while other modes, such as the transport of freight by sea and by rail, account for respective shares of 17.7% and 9.5% of total transport.

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

The main response measures involve mitigation (reducing greenhouse gas emissions) and adaptation to climate change underway.

The year 2009 saw publication in the Official Journal of the European Communities of all the legislative documents in the "Energy – Climate Change" package that was the subject of the historic agreement known as "20-20-20".

Response measures

The main measures of response to climate change involve mitigation, which means reducing greenhouse gas emissions, as well as adaptation, whose objective is to minimise the potential negative consequences of climate change and prevent related damage. Such measures are complementary.
As concerns mitigation measures, it is important to note that the year 2009 saw publication in the Official Journal of the European Communities of all the legislative documents in the "Energy – Climate Change" package that was the subject of the historic agreement known as "20-20-20", reached in the European Council on 18 December 2008; specifically:

- Directive 2009/28/EC on the promotion of renewable energy, which sets the binding objective for the EU of bringing the percentage contribution of renewable sources as a percentage of total energy consumption to 20% by 2020, with the effort distributed among the Member States; Italy's assigned objective is 17%;
- Decision 406/2009 on effort sharing, which sets the binding objective for the EU of reducing by 10% compared to the Community levels for 2005 greenhouse gas emissions in the sectors not regulated by 2003/87/EC; the burden of the effort is distributed among the Member States, with Italy assigned an objective of 13%;
- Directive 2009/29/EC on the revision and strengthening on the European emissions trading system, setting for the EU the binding objective of reducing greenhouse gas emissions by 21% compared to the levels of 2005 for the sectors governed by Directive 2003/87/EC;
- Directive 2009/31/CE on carbon capture and storage, a measure that establishes a legal framework for the geological storage of carbon dioxide, so as to ensure permanent containment of this substance and reduction to a minimum of possible risks to the environment and to human health.

On the subject of adaptation, in April 2009 the European Commission presented a White Paper entitled: "*Adapting to climate change: Towards a European framework for action*", with

the goal of making the EU less vulnerable to the impact of climate change[65].

The document lays out guidelines for action, structured around the following points:

- consolidation of basic knowledge regarding the risks and consequences of climate change;
- consideration on the impact of climate change on the main EU policies;
- integration of the different policy measures to obtain the best possible effect (for example, new forms of financing, including market-based programs, could be utilised to facilitate adaptation,);
- support of more wide-ranging international adaptation efforts;
- implementation of activities in collaboration with national, regional and local government bodies.

In operating terms, the White Paper states that:

- access to a wider range of data on the impact on the climate could facilitate decision-making processes;
- by 2011 a clearinghouse mechanism should be established for the exchange of information, making it easier to gain access to multiple sources of information on the consequences of climate change, on areas at risk and on successful practices;
- consideration of adaptation in formulating the primary policies of the EU.

By the end of 2011, the European Commission and the European Environment Agency plan to develop a series of instruments in support of adaptation policies, including:

- guidelines for the formulation of regional strategies of adjustment to climate change;
- sets of indexes of impact, vulnerability and adjustment;
- economic assessments of the costs and benefits of adjustment.

On the European level, in April 2009 the European Commission presented a white paper: "Adapting to climate change: Towards a European framework for action", with the goal of making the EU less vulnerable to the impact.

[65] Commission of the European Communities, 2009, *White Paper: "Adapting to climate change: Towards a European framework for action"*, COM(2009) 147 definitive, Brussels, 01/04/2009

In the countries of the European Union, a central role in strategies of mitigation has been given to implementation of the European emissions trading system established under Directive 2003/87/EC.

Mitigation

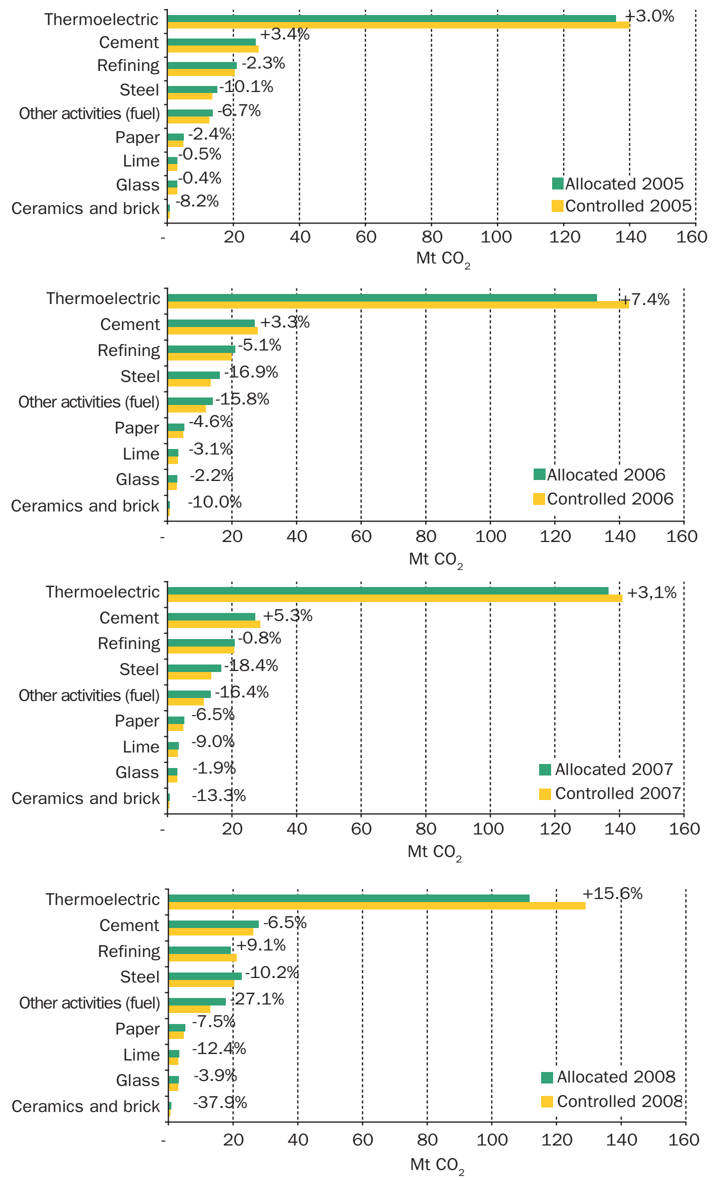
In the countries of the European Union, a central role in strategies of mitigation (meaning prevention of climate change by reducing emissions of greenhouse gas emissions and increasing absorption of carbon dioxide removals) has been given to implementation of the European emissions trading system established under Directive 2003/87/EC. This system entails the setting of a maximum limit (cap) on the greenhouse gas emissions of industrial plants falling under the directive. Emissions allowances are assigned to each eligible plant under a National Allocation Plan (NAP). Each allowance (an EAU, or European Allowances Unit) entitles the holder to emit a ton of carbon dioxide into the air during the year in question. CO_2 emissions allowances that are allocated but not used may be exchanged among operators on the European market. This system should give rise to a competitive market mechanism that leads to a reduction in emissions by industrial plants. Furthermore, the price at which emissions permits are traded on the European market shall provide a useful indicator of the effectiveness of the system and its capacity to signal to operators when allowances are in short supply.

The initial period of implementation of the emissions trading system (ETS) began on 1 January 2005 and concluded on 31 December 2007. In Italy, the quotas for the first period were assigned under the decree DEC/RAS/74/2006 of the Ministry of the Environment, Land and Sea. More recently, the National Committee for the Management and Implementation of Directive 2003/87/EC, consisting of representatives of the Ministry of the Environment, Land and Sea and of the Ministry of Economic Development, passed a ruling of 20 February 2008 assigning the quotas for the second period (2008-2012).

The final figures on greenhouse gas emissions are available for the years 2005 to 2008.

During the three-year period 2005-2007 (Figure 1.26), power stations and cement plants registered emissions levels higher than their respective allocations, while the levels observed for the remaining sectors were lower than the threshold set under the allocation plan. It can also be seen that, in a number of sectors (steel, other combustion activities, paper, lime, ceramics and

Considering the sum total of the quotas assigned and issued in the three-year period 2005-2007, the differential for greenhouse gas emissions by plants participating in the ETS system was +5.7 Mt CO_2 above the maximum threshold.



Legend:
The percentage figure represents the variation in CO_2 emissions, as compared to the assigned quotas.
"Allocated": CO_2 emissions quotas assigned to the plants.
"Controlled": quantities of CO_2 actually emitted by the plants.

Figure 1.26: Comparison of emissions allocated to emissions controlled for the three years of the first period 2005-2007, and for 2008, in the different industrial sectors[66]

In the first year of the second period (2008-2012), total emissions of CO_2 exceeded the assigned quotas by 9 Mt CO_2.

[66] Source: ISPRA

Considering the sum total of the quotas assigned and issued during the three-year period of 2005-2007, the differential for greenhouse gas emissions from the plants participating in the ETS system was +5,7 Mt CO_2 above the maximum threshold.

In the first year of the second period, (2008-2012), total emissions of CO2 exceeded the assign ed quotas by 9 Mt CO_2.

bricks), the reduction, in terms of the allocation, gradually increased over the three years. Total emissions were higher than the national allocation for the first two years (+0.8% in 2005 and +1.9% in 2006), while the quantity of emissions registered in the last year was slightly lower than the allocation (-0.2%).
Considered overall, meaning in terms of the sum total of the quotas assigned and issued during the three-year period of 2005-2007, the differential for greenhouse gas emissions from the plants participating in the ETS system was +5,7 Mt CO_2 above the maximum threshold.
With regard to the first year of the second period (2008-2012), total CO_2 emissions exceeded the assigned quotas by 9 Mt CO_2. Emissions were found to be higher than the assigned thresholds in the thermoelectric sector (+15.6%) and for refineries (+9.1%), while the other sectors recorded reductions of between 3.9% and 37.9%, as compared to their assigned thresholds.
Working from the emissions data declared by the plants taking part in the European emissions trading system, a number of assessments were run in an attempt to determine the environmental effectiveness of the system by estimating the reduction in CO_2 emissions that can be credited to its operations. Obviously there are no proven methods or past references for calculating this reduction: the estimates must take into account the past emission trend (baseline), as well as the actual parameters of the main economic and energy parameters for the period to which the emissions refer.
This type of assessment points to a total reduction of approximately 70 $MtCO_2$ in CO_2 emissions in Europe, for the year 2005, as a result of the operations of the ETS, an amount that corresponds to roughly 3% of the emissions recorded in Europe[67]. Using the same method, which essentially consists of a comparison between the actual emissions and the forecasts, with respect to benchmark year, ISPRA analysed the figures for the Italian plants

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[67] Ellerman A.D., Buchner B.K., *The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results, Review of Environmental Economics and Policy*, Volume 1, Number 1, Winter 2007

participating in the ETS during the first period (2005-2007)[68]. Three scenarios for annual growth in CO_2 emissions, starting from the base year, were used as references (0.5%, 1.0% and 1.5%). The estimates show that the trading of CO_2 emissions quotas by the production sectors that are part of the ETS system has a positive impact. In the specific case of the scenario considered most probable (annual emissions growth of 1.0%), it was estimated that emissions would be reduced by 9.1 Mt CO_2 in 2005, 10.0 Mt CO_2 in 2006 and 13.4 Mt CO_2 in 2007 (respectively 4.0%, 4.4% and 5.9% of the controlled emissions).

It is estimated that the operations of the ETS were responsible for a total reduction of approximately circa 70 $MtCO_2$ in CO_2 emissions in 2005 in Europe, corresponding to roughly 3% of the controlled emissions throughout Europe.

Worthy of note nationally is the growing role played by cogeneration, which makes it possible to increase the efficiency of the conversion of the energy available from primary sources. Since 1997, the net amount of electricity from thermal power stations produced through cogeneration has followed a trend parallel to that for total thermoelectric production: between 1997 and 2008 the average annual increase was approximately 5,424 GWh/year for electricity generated through thermal cogeneration, while the overall average increase in total electricity generated by thermal power plants was 5,487 GWh/year. The figures for the production of electricity alone remained almost constant during the period considered, with an average annual increase, between 1997 and 2008, of 64 GWh/year. These figures show that, since 1997, the need for new electricity generation from thermal power plants has been completely met through cogeneration (Figure 1.27).

Worthy of note nationally is the growing role played by cogeneration, which makes it possible to increase the efficiency of the conversion of the energy available from primary sources

As for the mix of the primary sources, it should be noted that the growing role of natural gas in thermal electricity generation has a positive influence on the trend in greenhouse gas emissions. 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 in thermoelectric production has a positive influence on trends in greenhouse gas emissions.

[68] Gaudioso D., Caputo A., Arcarese C., "*A preliminary assessment of CO_2 emissions abatement resulting from the implementation of the EU ETS in Italy*", proceedings of the workshop "eceee 2009 Summer Study", 1–6 June 2009, La Colle sur Loup, Côte d'Azur, France, http://www.eceee.org/conference_proceedings/eceee/2009/

The average annual increase in electricity generation between 1997 and 2008 was approximately 5,424 GWh/year for thermal electricity generation with cogeneration and 5,487 GWh/year for total thermal electricity generation, while the generation 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.

During the period 1996-2008, the specific average consumption of all fuels used for net electricity generation fell by 12.8% (-1.4% between 2007 and 2008).

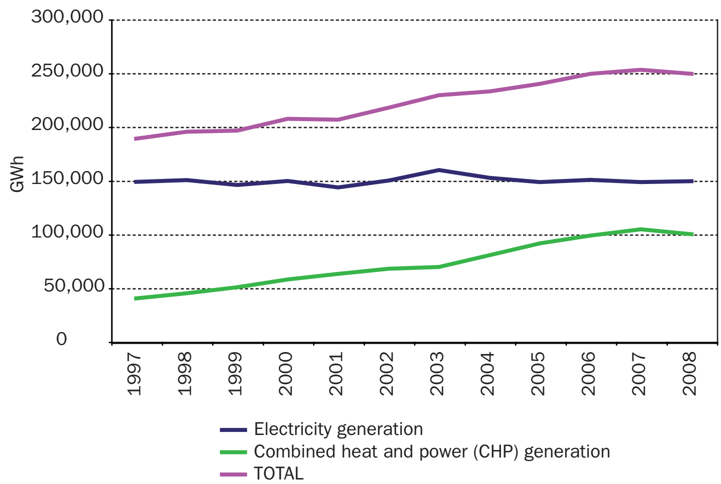


Figure 1.27: Net thermal electricity generation[69]

During the period 1996-2008 a decrease of 20.1% was registered in the specific average consumption of natural gas for net electricity generation. Derivative gases also showed a significant drop in specific consumption in 2008, for a decrease of 19.1% compared to 1996. Taking into consideration all the fuels used for electricity generation, specific average consumption fell by 12.8% (-1.4% between 2007 and 2008). Specific average consumption of all fuels for electricity generation was influenced by the use of oil products and solid fuel, which are less efficient than gas fuels. In fact, during the period considered, average specific consumption of oil products and solid fuel rose by respective figures of 11.1% and 10.4% (Figure 1.28).

[69] Source: TERNA S.p.A. data processed by ISPRA

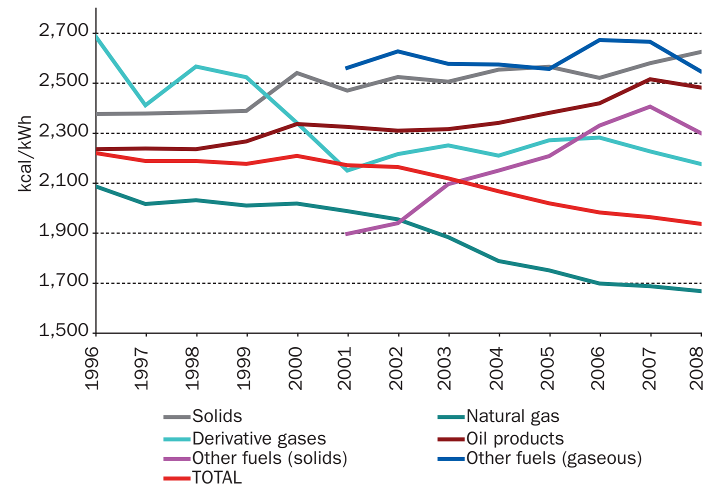


Figure 1.28: Average specific fuel consumption in the net electricity generation from fossil sources[70]

During the period 1996-2008 there was a decrease of 20.1% in the average specific consumption of natural gas, and a decrease of 19.1% in consumption of derivative gases. In terms of electricity generation in general, average specific consumption fell by 12.8%, while oil products and solid fuel rose by respective figures of 11.1% and 10.4%.

In terms of end-uses energy efficiency, Directive 2006/32/EC sets objectives for Member States regarding the efficiency of the end-uses of energy and energy services. The general national objective for energy savings is 9% within the ninth year of the implementation of the directive (2016). Under the provisions of art. 4, 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 actions that will make possible energy savings of 9.6% in 2016, as compared to average energy consumption between 2001 and 2005.

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

Of the measures referred to above, a key role is played by the system of white certificates, contemplated under art. 6 of Directive 2006/32/EC, and 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, subsequently supplemented by a Ministerial Decree of 21 December 2007, is to achieve energy savings that are to increase

The objective of the Ministerial decrees of 20 July 2004 and 21 December is to achieve energy savings that keep increasing, until they reach, in 2012, a level of 6 Mtoe a year.

[70] TERNA S.p.A. data processed by ISPRA

year after year, until they reach, by 2012, a level of 6 Mtoe a year through the introduction of obligatory quantities of energy savings for distributors of electricity and natural gas.

During the first four years of operation of the white certificate system, the certified energy savings were equivalent to the sum of the annual energy savings objectives set under the decree.

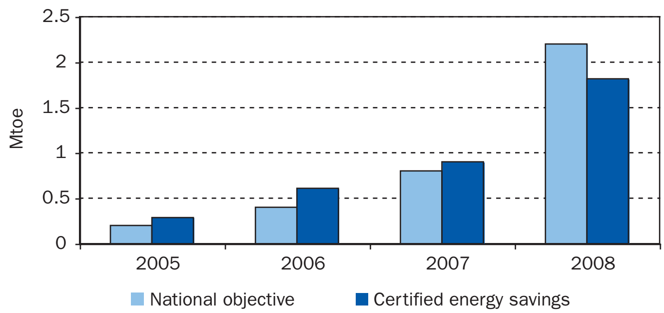
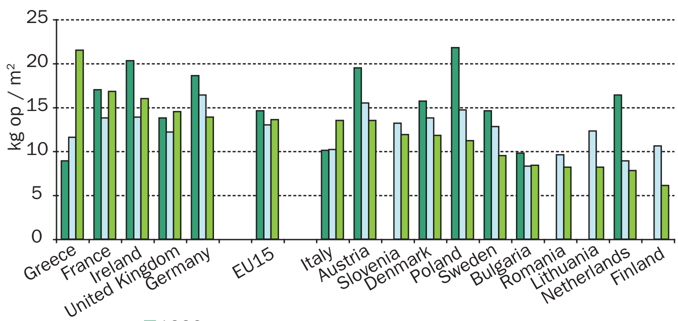


Figure 1.29: Comparison between national energy savings objectives and certified energy savings[71]

Figure 1.29 highlights the fact that, in the first four years of the system's operation, the certified energy savings were equivalent to the sum of the annual energy savings objectives set under the decrees referred to above, confirming that the system works. The majority of the measures for improving energy efficiency contemplated under the Action Plan for Energy Efficiency regard the residential sector, and specifically the energy needs of buildings (for hearting and cooling), as well as consumption by devices that are final energy users.
The potential for the first type of initiative is made clear by the data from 2005 on the energy consumption per surface area of EU15 buildings adjusted for climatic conditions. The data place Italy among the leading countries in terms of consumption per m^2, together with Germany, the United Kingdom Ireland, France and Greece. Other countries of the EU15, such as Austria, Denmark, Sweden, the Netherlands and Finland present levels of energy consumption lower than those registered for our country (Figure 1.30).

[71] Source: Italian Authority for Electricity and Gas, "*The Mechanism of Energy Efficiency Certificates from 1 January to 31 May 2009, Second Intermediate Statistical Report on the Obligatory Year 2008, drawn up in accordance with article 8, paragraph 1, of the Ministerial Decree of 21 December 2007*"

In 2005, the data for energy consumption per m², adjusted for climatic conditions, showed that Italy ranks among the leading countries in terms of consumption.



Note: The data for 1990 and 2005 were corrected to attenuate the effects of long-term climate variations in the individual countries. The year 2005 was also corrected for the average climate of the European Union, to take into consideration the temperatures in the different countries.

Figure 1.30: Energy consumption per m² in buildings[72]

In our country, the legislative process concerning energy certification of buildings is very lengthy. The principle was introduced in Italy under Law no. 10 of 9 January 1991, which addresses the various aspects of energy certification for buildings, but this law was never enacted.

In 1998, Legislative Decree no. 112 of 31 March 1998 transferred the administrative authority for the energy certification of buildings to the regional governments. Directive 2002/91/EC was transposed into Italian law with Legislative Decree no. 192 of 19 August 2005, recently revised and supplemented by Legislative Decree no. 311 of 29 December 2006.

On 10 July 2009 the Ministry of Economic Development published a decree containing guidelines for the energy certification of buildings. Starting from 25 July 2009, the regions that have not yet drawn up a regional law must follow the national guidelines. At present, only a few regions have established rules for the issue of energy certification. The decree defines the national guidelines for the energy certification of buildings, together with instruments of liaison, concerted effort and cooperation between the national government and regional governments, some of which

On 10 July 2009 the Ministry of Economic Development published a decree containing guidelines for the energy certification of buildings. Starting from 25 July 2009, the regions that have not yet drawn up a regional law must follow the national guidelines.

[72] Source: EEA/ODYSSEE data processed by ISPRA

have already established their own certification procedures, which shall be integrated with the national measure, respecting the distinctive characteristics of each regional law. The measure comes in the wake of Decree no. 59 of 2 April of 2009, issued by the President of the Republic to set the minimum energy requirements for new buildings and for the restructuring of existing ones.

An additional measure is expected to establish the professional profile of energy certifiers authorised to issue certificates.

Since 2006, there has been a noteworthy in Italy in the installed capacity for all renewable energy sources.

Electricity generation from renewable sources, nationwide, accounts for 18.8% of all the electricity generated.

Starting from 2006, a noteworthy increase was observed in the installed capacity for all renewable energy sources. In 2008, the gross efficient operating capacity was equal to 23,859 MW, making for an average annual growth rate of 6%. The increase in the capacity in 2008, compared to the previous year, was 1,552 MW. In 2008 electricity generation from renewable sources stood at around 59.7 TWh out of total electricity generation of 318.2 TWh, meaning that renewable sources account for 18.8% of total electricity generation. The break-down of overall production was characterised by annual fluctuations in the contribution by hydroelectricity, a result of meteorological conditions, as well as the growing contribution of non-traditional sources (wind power, geothermal energy, biomasses and waste). In 2008, hydroelectricity accounted for 69.7% of the electricity generated from renewable sources. In recent years, there has been a noticeable increase in the electricity generated from wind (from 117.8 to 4,861.3 GWh during the period 1997-2008) and from biomasses/waste (from 820.3 to 7,522.5 GWh). Electricity produced from geothermal sources also increased from 3,905.2 to 5,520.3 GWh during the period 1997-2008, though production from this source has remained essentially unchanged over the last three years. The contribution of photovoltaic systems remains negligible (193.0 GWh in 2008), though last year the quantity of electricity generated from that source increased by 395%.

Directive 2001/77/EC set a recommended objective of 22% as the portion of gross domestic consumption of electricity that should be generated from renewable sources (equal to approximately 75 TWh when gross domestic consumption stands at 340 TWh). Though this directive has since been rendered obsolete by

Directive 2009/28/EC, it still represents the only benchmark for assessing the generation of electricity from renewable sources. In calculating the target figure, electricity produced from renewable sources but imported from other European countries must also be considered. Based on the data provided by the GSE, in 2008 gross generation from renewable sources, including imports from abroad, amounted to 24% of the gross domestic consumption of electricity[73].

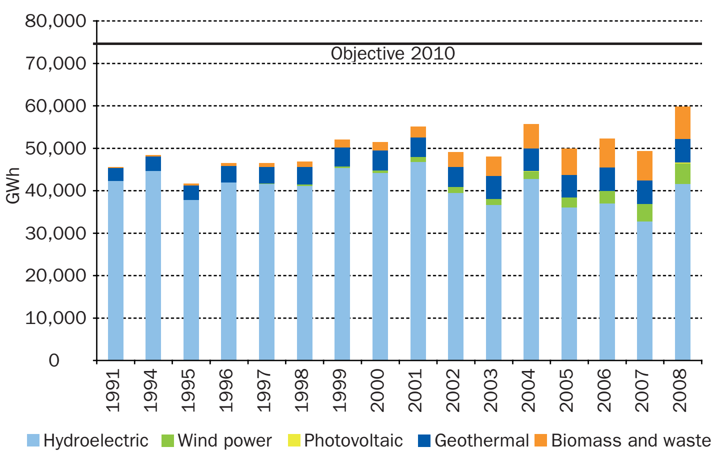


Figure 1.31: Gross domestic electricity generation from renewable sources[74]

On a national scale, electricity generation from renewable sources accounts for 18.8% of all electricity generated. Between '97 and 2008 there was a noticeable increase in the electricity generated from wind (from 117.8 to 4,861.3 GWh), as well as from biomasses/waste (from 820.3 to 7,522.5 GWh), and even, though to a lesser extent, from geothermal sources (from 3,905.2 to 5,520.3 GWh).

Based on the GSE data, imported electricity generated produced from renewable sources accounted for an average of 8% of gross domestic consumption of electricity between 2002 and 2008, while the contribution of electricity produced domestically from renewable sources averaged 14.7%.

[73] GSE, 2009, Statistics on renewable sources in Italy. Year 2008
[74] Source: TERNA S.p.A. data processed by ISPRA

In 2008 gross electricity generation from renewable sources, including electricity imported from abroad but produced from renewable sources, accounted for 24% of gross domestic consumption of electric energy.

Table 1.2: Electricity generated from renewable sources compared to gross domestic electricity consumption in Italy[75]

Year	G.D.C.[(1)]	Gross generation from RES[(2)]		Foreign from RES	Gross generation Renewable + Foreign from RES	
	TWh	TWh	% of G.D.C.	TWh	TWh	% of G.D.C.
2002	327.3	48.3	14.8	24.6	72.9	22.3
2003	337.2	47.1	14.0	26.5	73.6	21.8
2004	341.4	54.1	15.9	34.9	89.0	26.1
2005	346.0	48.6	14.1	9.7	58.3	16.9
2006	352.6	50.8	14.4	35.0	85.8	24.3
2007	354.5	47.9	13.5	38.2	86.1	24.3
2008	353.6	58.2	16.5	26.7*	84.9	24.0

Legend: (1) Gross Domestic Consumption: Gross national production – Pumping production + foreign balance
(2) Renewable Energy Sources
* Provisional figure

Hydroelectricity, concentrated in the regions of the Alpine arc, accounts for almost 69.7% of the electricity generated from renewable sources.

A regional analysis points to noteworthy differences in the energy sources used. Hydroelectricity, found primarily in the regions of the Alpine arc, accounts for 69.7% of the electric energy generated by renewable sources. Geothermal electricity generation, found only in the Tuscany region, represents 9.2% of the electricity produced from renewable sources. Biomasses account for 12.6% of the total, while wind and photovoltaic power registered a share of 8.5% 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 (98.4%). The increase of approximately 1,550 MW in installed power registered between 2007 and 2008 was due primarily to the development of wind power (823 MW) and photovoltaic power (345 MW), followed by biomasses and water power, at respective figures of 218 MW and 164 MW.

[75] Source: GSE data processed by ISPRA

Regionally, noteworthy differences can be observed in the renewable energy sources used. The primary renewable source used to produce electricity is hydroelectricity, concentrated in the Alpine arc, while production from wind and photovoltaic systems takes place in the southern regions and the main islands (98.4%).

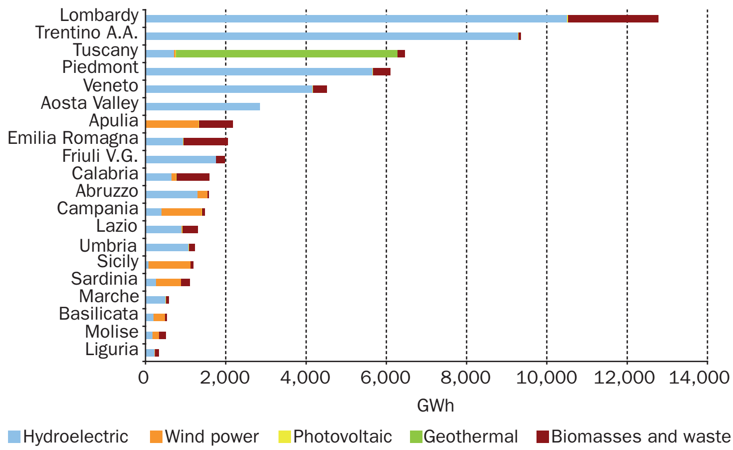


Figure 1.32: Regional analysis of gross electricity generation from renewable energy sources (2008)[76]

Directive 2009/28/EC stipulates what portion of final domestic energy consumption is to be produced from renewable energy sources by each country of the European Union as of 2020; these quotas include not only energy from renewable sources consumed for the production of electricity, but also renewable energy used for heating and transport. The Directive also makes it possible the statistical transfer from one Member State to another of a certain quantity of energy from renewable sources, as well as cooperation between the countries, or with non-EU countries, in the production of energy from renewable sources. The renewable–energy consumption objective assigned to Italy is 17% of final domestic consumption. In 2007, total renewable energy as a percentage of final consumption was equal to 6.9% (Figure 1.33).

Directive 2009/28/EC stipulates what portion of final domestic energy consumption is to produced from renewable energy sources by each country of the European Union as of 2020.

[76] Source: TERNA S.p.A. data processed by ISPRA

The renewable energy consumption objective assigned to Italy (Directive 2009/28/EC) is 17% of gross final consumption. In 2007 overall renewable energy as a percentage of final consumption was equal to 6.9%.

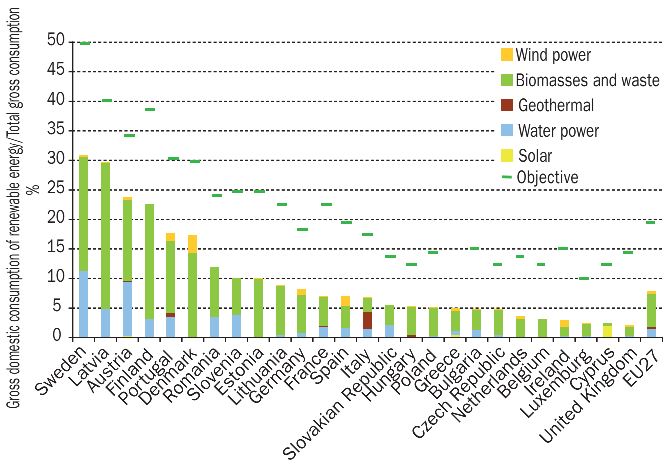


Figure 1.33: Energy consumption from renewable sources as a percentage of final consumption in the European countries (2007)[77]

Looking at the transportation sector, there was a constant increase in fuel consumption between 1990 and 2007 (+25.3% compared to 1990), with the only decrease registered between 2004 and 2005. Consumption levels appear to be characterised by brief periods of stabilisation, followed by resumption of the upward trend. The percentage of fuels with low environmental impact (natural gas, LPG, bio-diesel) out of total fuels shows irregular results, going from 5.6% in 1990 to 4.8% in 2007, with a peak value of 6.1% in 1995. Since 2000, consumption of these fuels has dropped by 13.8%.

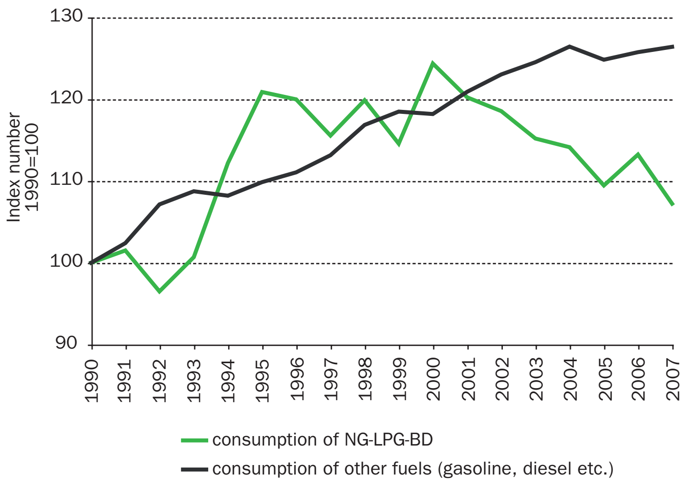
Variations in the percentages of the fuels consumed show that, while the classic fuels (gasoline, diesel fuel etc.) have increased constantly, levels of natural gas, LPG and bio-diesel have clearly been on the decline since 2000, apart from a few sporadic increases. As of 2007, the overall increase in the consumption of low-impact fuels, compared to 1990, was only 7.2%.

Based on the available data, it is clear that the progress made in

[77] Source: EUROSTAT data processed by ISPRA

the transportation sector through the implementation of technological measures involving engine efficiency are offset - and to a greater extent in Italy than in the other European counties, by growth in the demand for transportation, and especially the roadway mode, meaning that the environmental impact of the transportation 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 only a slight increase between 2005 and 2006.

The effects of technological measures are offset by the growth in the demand for transportation and especially the roadway mode.



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

Figure 1.34: Consumption of fuels for transportation (1990=100)[78]

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.

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

In 2007, the LULUCF sector was responsible for the capture of 70.9 Mt di CO_2 eq in Italy. Much of the absorption was due to forests.

In contrast to the increase in emissions of greenhouse gases resulting from various production activities and processes of deforestation, a noteworthy quantity of carbon dioxide has been removed from the atmosphere by the LULUCF sector, for quantities on the order of 0.2 billion tons of carbon during the period 1980-1989 and 0.7 billion tons of carbon during the period 1989-1998 globally[79]. In Italy, the LULUCF sector, which encompasses the different existing uses of the land (such as forests, cultivated land, meadows, urban settlements and wetlands), as well as changes in the designated use of land, was responsible for the capture of 67.5 million tons of carbon in 1990 and 70.9 million tons of carbon in 2007. However, only the portion removed from managed forests can be include in the accounting for the Kyoto Protocol, as stipulated under articles 3.3 (forestation, reforestation and deforestation) and 3.4 (forest management[80]).

[79] IPCC, 2000, *Land-use, Land-use change and forestry*, IPCC *Special Report*

[80] Italy chose only forestry management as an additional secondary activity, in accordance with art. 3.4 of the Kyoto Protocol; the other activities are the management of cultivated land, the management of pastureland and re-vegetation