1. CLIMATE CHANGE

Introduction

During 2007, the scientific community, political decision-makers and public opinion focused their attention on the issue of climate change, primarily as a result of the approval of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC). The conclusions of this document underlie a number of the first important political commitments in terms of reducing emissions and energy policies, in particular those undertaken by the European Union through the conclusions of the European Council of 8-9 March 2007. There is a growing need, therefore, for indicators suitable to representing the totality of the phenomena connected with this topic, both for the purpose of expanding knowledge and as a basis for mitigation and adaptation initiatives.

In 2007 the scientific community, political decision-makers and public opinion focused their attention on the issue of climate change.

1.1 Current climate trends

The increase in average global temperatures in recent years is a clear sign of the climate change underway. Two of the main conclusions reached by the Fourth Assessment Report of the Intergovernmental Panel on Climate Change[1] indicate that:

Global warming is unmistakable, and it is highly likely that anthropogenic emissions of greenhouses gases are the cause.

- the warming of the climatic system is unmistakable, as demonstrated by observations of increased temperatures of the atmosphere and the ocean, the melting of snow and glaciers and the global rise in the level of the seas;
- the increased concentration of greenhouse gases generated by human activity is most probably the main cause of the global warming observed since the middle of the 20th century.

The most recent analyses point to the fact that not all instances of global warming are alike. Alongside areas where the temperature has increased, there are others where a decrease has been observed. Recent worldwide analyses confirm the estimate of an average warming of the earth's surface of approximately 0.74 °C over the last century. The temperature increase has been especially pronounced in the most recent period; over the last 50 years, the rate of warming (+0.13 °C per decade) has nearly doubled, as compared to the last 100 years[2]. As far as Italy is concerned, the most recent estimates obtained by the Agency for the Protection of the Environment and Technical Services (APAT), through an analysis of the data contained in the SCIA System (National System for the Collection, Processing and Dissemination of Climatic Data), point to a decrease of 0.6°C in the average temperature between 1961 and 1981, followed by an increase of 1.54 °C through 2006, for an overall increase of approximately 0.94 °C in 45 years. No significant

Average warming in Italy was 0.94 °C between 1961 and 2006 and 1.54 °C between 1981 and 2006.

[1] IPCC (2007). *Climate Change 2007* – WG-I, *Technical Summary*
[2] IPCC (2007). *Climate Change 2007* – WG-I, *Technical Summary*

differences were registered between the various areas of the national territory, confirming that the variations in temperature are caused primarily by large-scale climatic factors[3]. The comparison between the national and global trends illustrates that average warming in Italy is more pronounced than the global average.

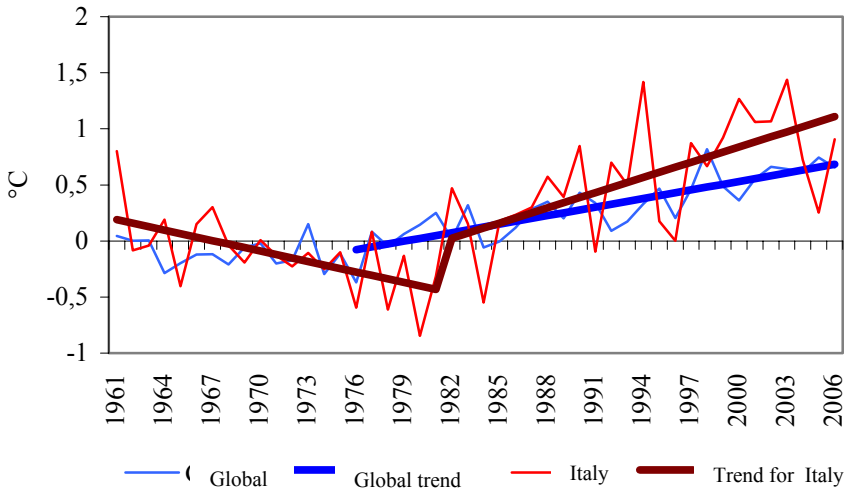
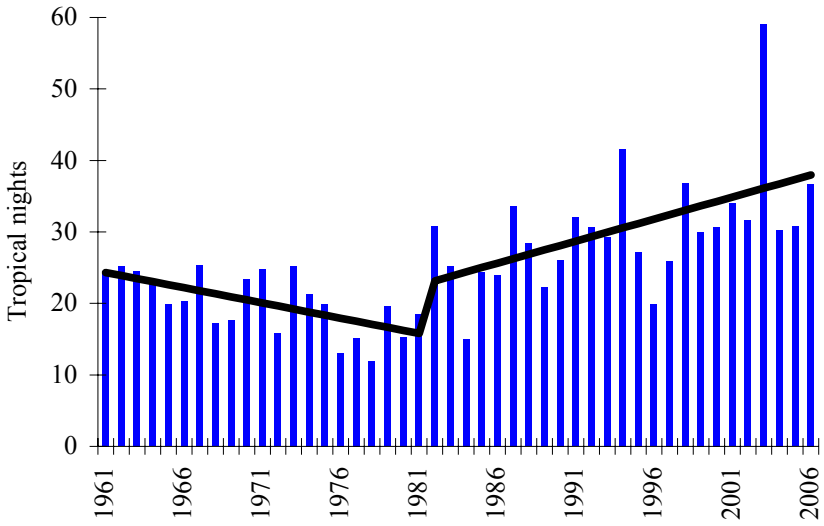


Figure 1.1: Mean temperature anomaly (with respect to 1961-1990 normals) series and estimated trend between 1961 and 2006. Global (blue) and national (red)[4]

The increase in the average global temperature in recent decades is a clear sign of the climate changes underway.
The average warming in Italy was 0.94 °C between 1961 and 2006 and 1.54 °C from 1981 to 2006.
A comparison of the national and global trend illustrates that average warming in Italy is more pronounced than the global average.

Globally, the upward trend is more pronounced for minimum night-time temperatures than for maximum daytime temperatures. For Italy, it is estimated that the average number of tropical nights (i.e. with minimum temperature ≥20 °C) increased by 21 nights during the period 1981-2006, and by 12.5 nights between 1961 and 2006. The increase in tropical nights in the last 27-28 years is connected to the increase in heat wave events. The average number of tropical nights in 2006 was higher than the normal levels during the reference period 1961-1990. In particular, 2006 was the fourth highest in the last 46 years[5].

[3] Toreti A. and Desiato F., 2007, *Temperature trend over Italy from 1961 to 2004. Theor. Appl. Climatology*. DOI 10.1007/s00704-006-0289-6
[4] Source: APAT and the University of East Anglia, in collaboration with the Hadley Center
[5] Toreti A. and Desiato F., 2007, *Changes in temperature extremes over Italy in the last 44 years, Int. J. Climatology, DOI 10.1002/joc.1576*



Globally the upward trend is more pronounced for minimum night-times temperatures than for maximum day-time temperatures. In 2006, the average number of tropical nights in Italy was higher than the normal levels in the reference period 1961-1990. In particular, 2006 was the fourth highest in the last 46 years.

Legend:
The jagged line shows the trend

Figure 1.2: Annual series from 1961 to 2006 of the average number of tropical nights in Italy[6]

As far as precipitation is concerned, national averages do not show significant variations in amounts, although they may be significant for specific areas and periods. On the global scale, however, an increase in intense precipitations since 1950 has been observed [7].

1.2 The impact of climate change

The conclusions of the IPCC[8] state that "observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, and especially temperature increases."

Many natural systems are showing the effects of regional climate change, especially in terms of increased temperatures.

The impacts on many physical and biological systems become increasingly evident; based on the available data, it can be held that there is a probability of roughly 8 out of 10 that climate changes are influencing natural systems, and especially water resources, coastal zones and oceans.

A number of examples of the changes underway, referred to by the IPCC[9], are listed on the following table with regard to the different environmental systems.

[6] Source: APAT
[7] IPCC (2007). *Climate Change 2007* – WG-I, *Technical summary*
[8] IPCC (2007). *Climate Change 2007* – WG-II, *Summary for policymakers*
[9] IPCC (2007). *Climate Change 2007* – WG-II, *Summary for policymakers*

Table 1.1: Examples of changes underway[10]

Snow, ice and frozen ground	Hydrological systems	Terrestrial biological systems	Marine and freshwater biological systems
• enlargement and increased number of glacial lakes	• increased run-off and earlier spring peak discharge in many glacier- and snow-fed rivers	• earlier timing of Spring events, such as leaf-unfolding, bird migration and egg-laying	• shifts in ranges of environmental parameters (ice cover, salinity, oxygen levels, circulation), plus changes in algal, plankton and fish abundance in high-latitude oceans
• increasing ground instability in permafrost regions, and rock avalanches in mountain regions	• warming of lakes and rivers in many regions, with effects on thermal structure and water quality	• poleward and upward shifts in ranges of plant and animal species	• increases in algal and zooplankton abundance in high-latitude and high-altitude lakes
• changes in some Arctic and Antarctic ecosystems, including those in sea-ice biomes, and also predators at the higher levels of the food chain			• changes in the ranges of environmental parameters and earlier migrations of fish in rivers

New effects of regional climate changes on natural and human environments are emerging, though they are often hard to distinguish, on account of adaptation and non-climatic drivers.

Based on satellite observations since the early eighties, the early "greening" of vegetation in Spring is held to be tied to the increased length of the growing seasons, due to warming.

In addition, the uptake of anthropogenic carbon since 1750 has caused the oceans to become more acidic, with an average decrease of 0.1 units in the pH level[11]. There is not yet sufficient documentation, however, on the effects of the oceans' acidification on the marine biosphere.

Other effects of regional climate changes on natural and human environments are also coming to the fore, though many are difficult to distinguish, on account of adaptation and non-climatic drivers.[12]

For example, the effects of temperature increases were documented in the following sectors:

- effects on the management of agriculture and forests at Northern Hemisphere higher latitudes, such as earlier Spring planting of crops, as well as alterations in the pattern of disturbances in forests due to fires and pests;
- factors regarding human health, such as heat-related

[10] Source: IPCC (2007). *Climate Change 2007* – WG-II, *Summary for policymakers*
[11] IPCC (2007). *Climate Change 2007* – WG-I, *Technical Summary*
[12]

mortality in Europe, vectors of infectious diseases in some areas and allergenic pollen in medium and high latitudes of the Northern Hemisphere;

- activities in the Arctic (e.g. hunting and travel over snow and ice) and in Alpine areas at lower altitudes (as in the case of mountain sports).

Finally, recent climate changes and variations are starting to have an effect on many other natural and human systems, though, according to the published literature, the impacts have not yet resulted in demonstrable trends. Examples include:

- settlements in mountain regions subject to a greater risk of glacier lake outburst floods on account of melting glaciers. In certain cases, the response consists of building dams and drainage works;
- in the African region of Sahel, warmer and drier conditions have reduced the length of the growing season, with a negative effect on harvests. In southern Africa, longer dry seasons and greater uncertainty of rainfall have given rise to adaptation measures.
- sea-level rise, together with human development, is contributing to the loss of coastal wetlands and mangroves, as well as to increased damage from coastal flooding in many areas.

According to the Green Paper of the European Commission on "Adapting to Climate Change in Europe – options for EU action" (COM(2007)354), the most vulnerable areas of Europe are:

- Southern Europe and the entire Mediterranean Basin, where the combined effect of high temperature increase and reduced precipitation has aggravated the situation in areas already suffering from shortages of water;
- Mountain zones, such as the Alps, where higher temperatures cause melting of glaciers and snow, with inevitable impacts on river flows;
- coastal zones, on account of sea-level rise, combined with the greater risk of storms;
- flood plains with high population densities, where the risk of storms, intense rainfall and flash floods causes damages to built-up zones and infrastructures;

The areas of Europe most vulnerable to climate change are:

- *Southern Europe and the entire Mediterranean Basin;*
- *the mountain zones;*
- *the coastal zones;*
- *highly populated flood plains;*
- *Scandinavia;*
- *the Arctic region.*

- Scandinavia, where much higher levels of precipitation are forecast, more frequently in the form of rain than snow;
- the Arctic region, where the variations in temperature are more notable than in other regions of the Earth.

For Italy, the results of the preparatory works for the National Conference on Climate Change[13] organised by the Ministry of the Environment, Land and Sea, together with APAT, have been used to draw up a framework of national priorities regarding the most probable areas of impact. Shown below is the table prepared by APAT to identify the most vulnerable environmental systems and economic sectors:

Table 1.2: Chart showing the areas most likely to be vulnerable to climate change[14]

AREAS OF IMPACT	**Climate variables**		***Workshop***				
	Temperature	Precipitation	Desertification	Glacier melting	Hydro-geological risk	Marine-coastal environment	Po Basin
Water resources	++	++	++	++	++	++	++
Marine and coastal environments	++	++	++	+	+	++	++
Mountain environment and cryosphere	++	++	-	++	+	-	-
Wetlands and aquatic ecosystems	++	++	-	-	+	++	++
Biodiversity and forests	++	++	++	++	++	++	++
Agriculture and fishery	++	++	++	+	++	++	++
Energy	++	++	-	++	-	-	++
Tourism	++	+	-	++	++	++	+
Health	++	++	-	+	++	-	-
Urban settlements	-	++	-	+	++	++	+
Infrastructures and transport	-	++	-	-	++	++	-
Artistic heritage	-	++	-	-	++	++	-

Legend :
++ very likely; + likely; - unlikely

In our country, therefore, climate change impacts are highly likely for water resources, biodiversity and forests, the soil and marine-coastal environments. The economic activities most vulnerable to climate change are agriculture and fisheries, as well as tourism.

In Italy, climate change impacts are highly likely for water resources, biodiversity and forests, soil, marine and coastal environments and economic activities such as agriculture, fisheries and tourism.

[13] APAT (2007). *Gli eventi preparatori della Conferenza*. Summary of the proceedings
[14] Source: APAT

Erosion and coastal flooding

The scenarios of the IPCC estimate the effect of the rise in the level of the Mediterranean Sea, as a result of thermal dilation, at approximately 38 cm by 2100. However, specific studies on the Italian-Mediterranean context indicate that our sea is not currently rising, primarily on account of increased salinity, which counterbalances the thermal dilation.

According to the IPCC scenarios, by 2100 the level of the Mediterranean will have risen by 38 cm. Our sea is not currently rising because the increased salinity counterbalances the effect of the thermal dilation.

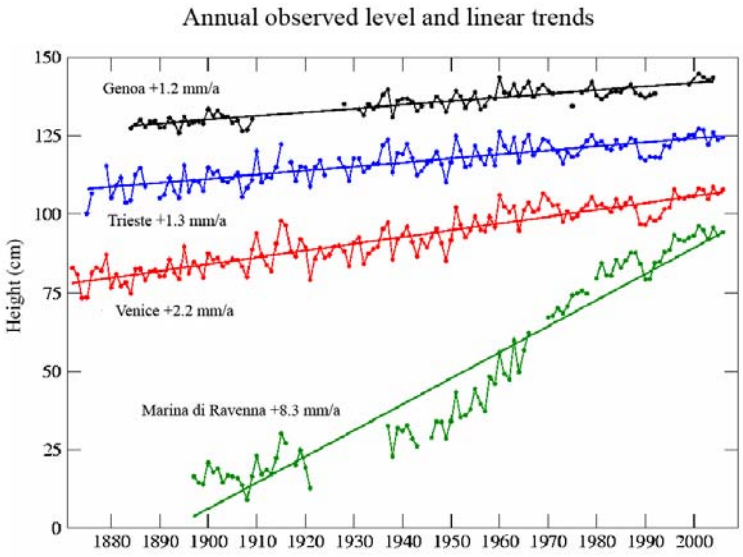
In the Mediterranean area, therefore, sea-level rise would not currently appear to be the main parameter for increased vulnerability of coastal areas to climate change (unlike the situation in Northern Europe), apart from sectors where anthropogenic and natural subsidence magnify the effect.
The sea-level rise produces not only a variation in the relationship between the land and the sea, but also a noteworthy increase in the salt table, making coastal areas extremely sensitive to this parameter. The most susceptible zones are sandy beaches with smaller surface areas and those lacking dune systems to their rear, as well as badly deteriorated beaches.

The most susceptible zones are sandy beaches without dunes. The northern Adriatic coast is the Italian area at greatest risk.

The Italian area at greatest risk is that found between the Ravenna area and the mouth of the Tagliamento River, along the northern Adriatic coast. These areas are subject to vertical movements compacting the soil (subsidence); in addition, they are extremely vulnerable to increases in the average level of the sea (eustatism).

The average annual level of the sea shows different trends in different areas: from 1.2 mm/year in Genoa to 8.3 mm/year in the Ravenna area.

An analysis of the mean sea level registrations (msl) at the coastal stations of Trieste, Venice, Ravenna and Genoa from the end of the 1800's to the present show results that vary considerably between different areas. The stations located on terrains not subject to subsidence, such as Genoa and Trieste, show a limited growth trend of roughly 1.2-1.3 mm/year. In Venice, on the other hand, the current growth rate for the msl is calculated at 2.2 mm/year, though it was much higher in the period between the 50's and the 70's. Of particular note is the case of Ravenna, where the annual average growth rate stands at 8.3 mm. In such cases, elevated pressure of human origin accounts for most of the subsidence recorded.



The Italian coastal area facing the greatest risk of erosion and flooding is that between the Ravenna area and the mouth of the Tagliamento River, on the northern Adriatic coast.
These areas are vulnerable to subsidence and to increases in the average sea level. Increases in the average sea level since the late 1800's range from 1.2 mm/year in Genoa to 8.3 mm/year in the Ravenna area.

Figure 1.3: Average sea levels observed at the measuring stations of Genoa, Trieste, Venice and Marina di Ravenna from the late 1800's to the present[15]

The categories of vulnerable "resources" consist of economic activities tied to beach tourism, the many SCI (Sites of Community Importance) coastal areas, the coastal dunes, the pine groves and the prized species of flora and fauna found along much of the Italian coast, as well as the roadway (streets and highways) and railway infrastructures in the vicinity of the current coast. Also at risk are the agricultural activities in the coastal plains (i.e. the Fondi plain) and fish-hatchery activities, which are typically located in transitional zones (i.e. the Goro lagoon).

The categories of "resources" vulnerable to erosion and flooding are the SCI coastal areas, costal dunes, pine groves and species of flora and fauna, plus roadway and railway infrastructures in the vicinity of the current coast.

[15] Source: Raicich, F. "*Scenari di sea level rise nel Mediterraneo*", presented at the workshop entitled "Cambiamenti climatici e rischio costiero" 27-28 June 2007, Palermo

Desertification

Processes of desertification are tied to current climatic trends, as well as to excessive exploitation and unsustainable management of soil resources.

In terms of their impact on the territory, current climate trends, as well as those forecast for the future, combine their effect with other factors of pressure tied to the excessive exploitation and unsustainable management of the land resources. Among these are cited crop-growing practices, the raising of livestock, the management of water resources and the heightened susceptibility of the environment to desertification not only in arid and semi-arid areas, as well as sub-humid pockets of the globe, but also in other areas subject to water shortages and conditions of stressful soil management.

Desertification, considered in its most intensive forms, affects more than 100 countries, threatening the survival of more than a billion people. In Italy, even though drought and desertification do not occur in as dramatic a fashion as in other areas of the planet, such conditions are becoming increasingly apparent in at least five regions (Sardinia, Sicily, Basilicata, Apulia and Calabria), while negative signs have also been observed in other areas of the central-northern regions[16]. Assessment of the intensity and extent of desertification is a difficult task, given the lack of a common method suitable for use on both the global and regional levels. The estimates vary, depending on the method of analysis used, ranging from a percentage of vulnerable areas equal to approximately 5.5% of the national territory (the preliminary map drawn up by the National Committee for the Fight against Desertification, as part of the process of formulating the National Action Program, 1999) to figures showing 3% of the territory to be highly sensitive to desertification while 32% presents an average sensitivity (the *Desertification Information System for the Mediterranean*[17] project, coordinated by the UNCCD, in collaboration with the European Agency for the Environment and the Foundation of Applied Meteorology, 2004).

1.3 The pressures on the climate system

Much of the warming observed during the last 50 years can be attributed to human activities.

Though the effects of natural factors, such as variations in the intensity of the solar radiation, are not neglected, the vast majority of the scientific community is convinced that "There are new and more significant grounds" for holding that "much of the warming observed over the last 50 years is attributable to human activities"[18]; extensive confirmation of these results has been provided by the Fourth Assessment Report of the IPCC[19].

[16] APAT (2006). *Environmental Data Yearbook*, 2006 edition
[17] http://dismed.eionet.eu.int
[18] IPCC (2001). *Climate Change 2001 – Synthesis Report*
[19] IPCC (2007). *Climate Change 2007 – WG-I, WG-II, WG-III, Technical Summary*

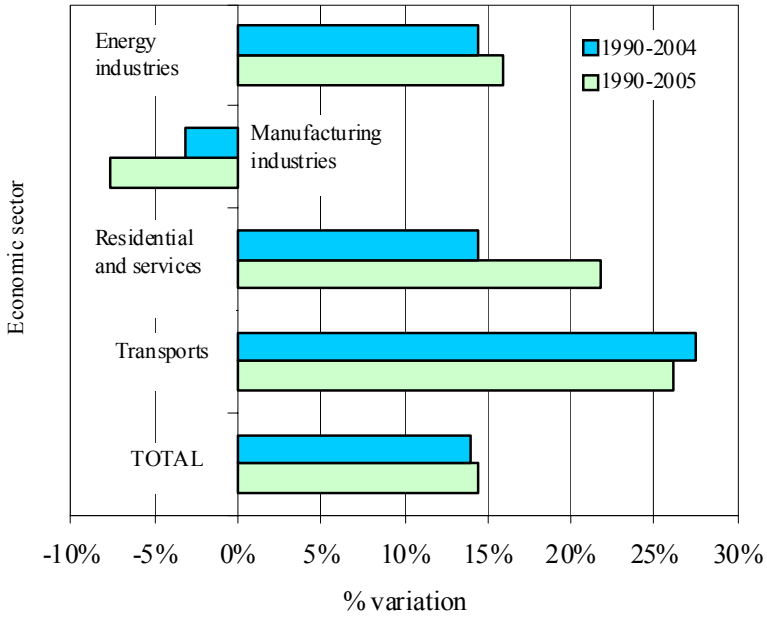
In terms of CO_2, the primary greenhouse gas, the average global concentration of carbon dioxide has risen from 280 ppm during the period 1000-1750 to 379 ppm in 2005, paralleling a rise in carbon dioxide emissions from practically zero to approximately 26.6 billion tons, taking into account only emissions generated by processes of combustion[20]. Similar, if not sharper, growth rates have been recorded for other greenhouse gases as well, including methane, nitrous oxide and fluorocarbons.

Italy is not exempt from this upward trend in the emission of greenhouse gases: the most recent figures of the national greenhouse gas emissions inventory show an increase from 516.85 to 579.55 million tons CO_2 equivalent during the period 1990-2005, corresponding to 12.1%, while, according to the Kyoto Protocol, Italy should reduce its emissions, during the 2008-2012 period, to levels 6.5% lower than those of 1990, i.e. to 483.26 Mt CO_2 equivalent.
Globally, Italy is responsible for no more than 1.74% of the overall emissions generated by the use of fossil fuels, meaning that it ranks ninth out of the ten countries with the highest levels of greenhouse gas emissions[21] .

Between 1990 and 2005 greenhouse gas emissions in Italy increased from 516,9 to 579,6 Mt CO_2, equivalent, for an increase of 12.1%. Under the Kyoto Protocol, Italy should reduce its emissions, during the 2008-2012 period to levels 6.5% lower than emissions in 1990: i.e. to 483.26 Mt CO_2. equivalent.

Between 1990 and 2005, overall emissions of greenhouse gases in Italy rose by 62.70 million equivalent tons carbon dioxide (Mt CO_2eq). During this period, there were decreases in the levels of emissions from the manufacturing industry (-6.96 Mt CO_2eq), agriculture (-3.36 Mt CO_2eq) and the use of solvents (-0.30 Mt CO_2eq), while emissions generated by waste (+1.41 Mt CO_2eq), industrial processes (+4.25 Mt CO_2eq), the residential and services sector (+16.91 Mt CO_2eq) and, to an even greater extent, the energy industry (+23.24 Mt CO_2eq) and transport (+27.50 Mt CO_2eq) rose. In 2005, as compared to the previous year, drops in emissions were registered for the manufacturing industries (-4.73%, equal to 4.15 Mt CO_2eq) and transport (-1.07%; 1.44 Mt CO_2eq), though these reductions were offset by increased emissions from the energy industries (+1.30%; 2.17 Mt CO_2eq) and, most of all, the residential and services sectors (+6.50%; 5.77 Mt CO_2eq). In 2005 energy processes as a whole registered an increase of 0.49% in emissions (2.34 Mt CO_2eq), as compared to 2004.

[20] IEA (2006). *CO_2 Emissions from Fuel Combustion*, 1971-2004
[21] IEA (2006). *CO_2 Emissions from Fuel Combustion*, 1971-2004

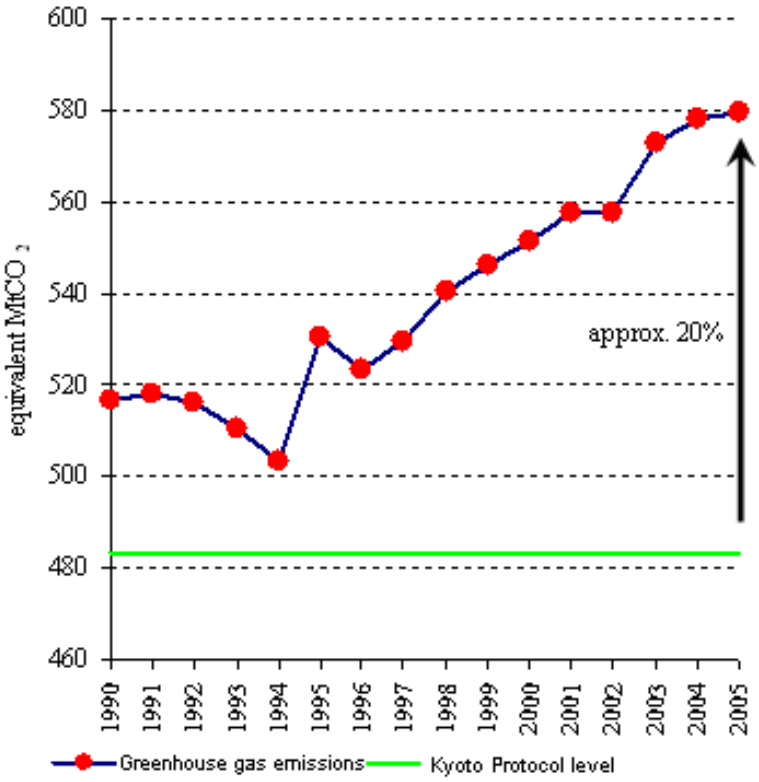


From 1990 to 2005, greenhouse gas emissions in Italy increased from 516.9 to 579.6 Mt CO_2,eq, a 12.1% rise (62.70 Mt CO_2,eq).
Increased emissions were registered from waste, industrial processes, the residential sector and services, and, to an even greater extent, from energy industries and transport, while there were decreases in emissions from the manufacturing industries.

Figure 1.4: Percentage variations in emissions of greenhouse gases by economic sector in the years 2004 and 2005, compared with 1990[22]

As a result of the increase in emissions from energy industries and transport, Italy is foreseen as not being able to achieve the Kyoto objective through domestic measures alone, meaning that it will have to draw on credits generated by forestry activities and by international cooperation initiatives (*Clean Development Mechanism, Joint Implementation*), as these are defined under the Kyoto Protocol. In 2005, emissions of greenhouse gases exceeded the Kyoto objective by slightly more than 96 Mt (~ +20%).

[22] Source: APAT



Under the Kyoto Protocol, Italy should reduce its emissions for the 2008-2012 period to levels 6.5% lower than those of 1990: i.e. to 483.26 Mt CO_2,eq. Greenhouse gas emissions for 2005 were slightly more than 96 Mt higher than the Kyoto objective (~ +20%).

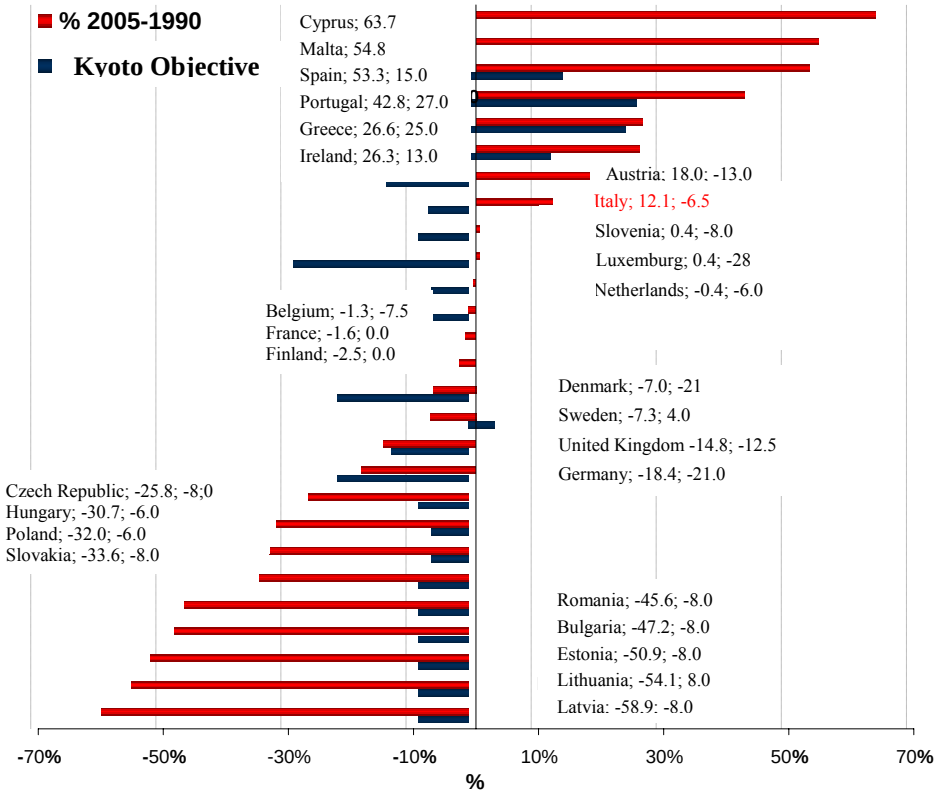
Figure 1.5: Total greenhouse gas emissions and level set for compliance with the Kyoto Protocol[23]

Within the European Union (EU15), the majority of the countries is not in line with the objectives set under the Kyoto Protocol.

Within the European Union (EU15), there is no question that the great majority of the countries are not in line with the objectives set under the Kyoto Protocol. Germany has met the objectives, while the United Kingdom, Finland, France and Sweden reduced emissions in 2005 beyond the objectives set for the period of 2008-2012.

As a rule, the newly admitted countries (with the exception of Slovenia) have reduced their emissions well beyond the Kyoto objectives. Cyprus and Malta, which are not included in Annex I of the Framework Convention on Climate Change (being developing countries), do not have obligations regarding the reduction of emissions.

[23] Source: APAT



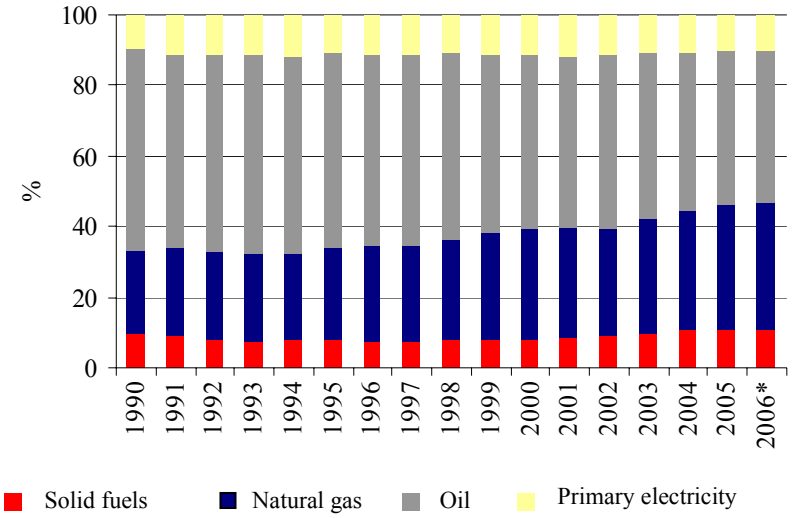
Within the European Union (EU15), the majority of the countries, including Italy, is not in line with the objectives set under the Kyoto Protocol. Germany has met the objectives, while Great Britain, Finland, France and Sweden reduced their emissions in 2005 beyond the objectives set for 2008-2012.

Figure 1.6: Comparison of the levels of greenhouse gas emissions in 2005, compared to the benchmark year of 1990, and the Kyoto objective for the period 2008-2012 in the European countries (EU27)[24]

The most recent data on the energy sector, in addition to confirming a number of the inherent characteristics of the national energy system, such as the performance levels above the European averages in terms of energy intensity and the ratio between final consumption and total consumption of energy, also point to a series of changes underway in the way in which energy is procured, such as the growing role of natural gas compared to petroleum products, as well as an upward trend in the contribution of renewable sources and cogeneration, plus, starting from 2001, renewed consumption of solid fuels, whose contribution to primary sources of energy (including primary electric energy) went from 8.57% in 2001 to 11.02% in 2006.

The national energy system is characterised by performance above the average European levels in terms of energy intensity and the ratio between final consumption and total consumption of energy, as well as a series of changes currently underway in the procurement of supplies.

[24] Source: APAT processing of UNFCCC data.

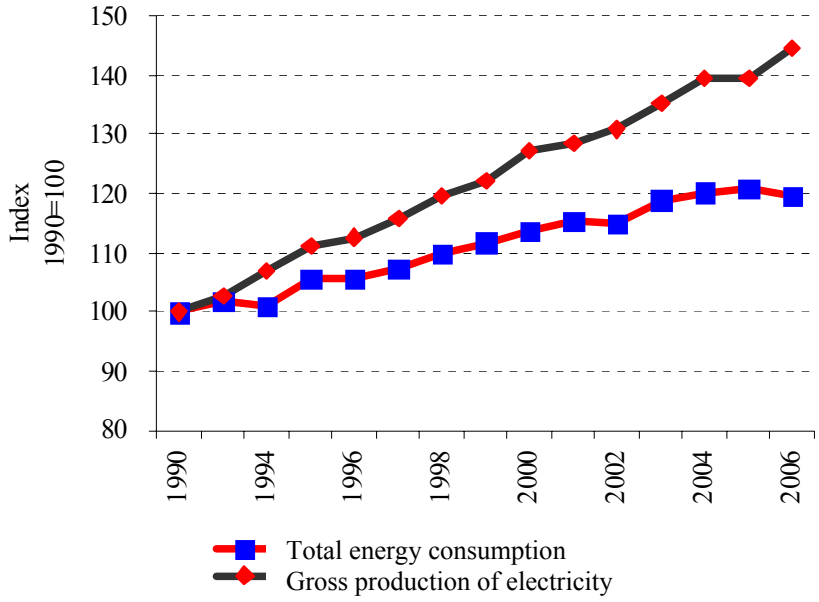


A series of changes are underway within the energy sector, in terms of the procurement of supplies, with growth in the consumption of natural gas compared to petroleum products, as well as in the contribution of renewable sources and cogeneration, plus, since 2001, in the consumption of solid fuels.

Legend: *Provisional figure
Figure 1.7: Total energy consumption by primary sources[25]

Results in the energy sector are influenced not only by fuel prices on the international market, but also by legislative and regulatory changes, such as the liberalisation of energy markets and the introduction of new forms of incentives for the production of electricity from renewable sources, in the form of a minimum quota of renewable sources for each electricity producer. As for final consumption of energy, between 2002 and 2005, a noteworthy increase was registered in consumption by the services and residential sectors (from 39.9 Mtoe in 2002 to 45.8 Mtoe in 2005), essentially on account of climatic factors, followed by a decrease in 2006, with final consumption falling to 44.4 Mtoe. These figures, combined with the limited growth in the GDP registered in recent years, underlie the increase in total energy intensity between 2002 and 2005 (+3.8%), which was followed by a significant reduction in 2006 (-2.9% between 2005 and 2006; +0.7% between 2002 and 2006). Between 1994 and 2006, the rate of growth for the production of electric energy was significantly higher than that for total energy consumption; especially worthy of note, from this perspective, are the figures for 2006. This result, if confirmed, points to a growing role for electricity as an energy carrier within the national energy system.

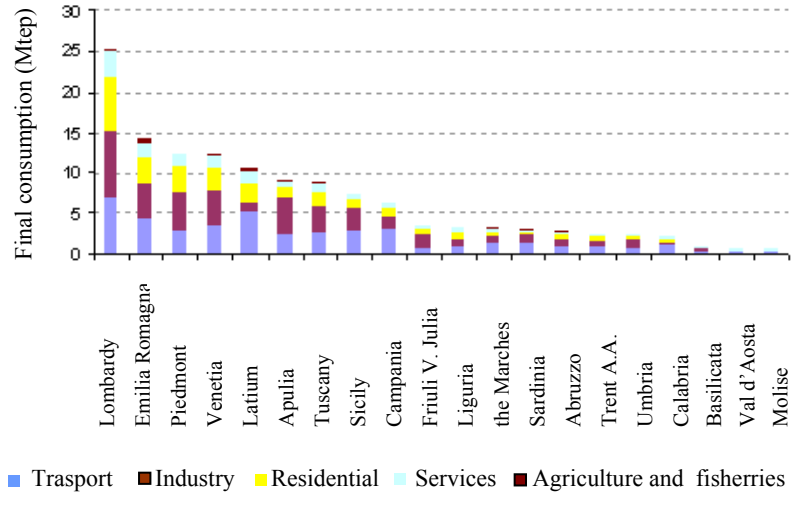
[25] Source: ENEA analysis of data from the Ministry of Economic Development



Between 1994 and 2006, the growth rate for the production of electricity was considerably higher than that for total energy consumption. Should this trend continue, it would point to a growing role for electricity as an energy carrier within the national energy system.

Figure 1.8: Trends in total energy consumption and production of electricity (1990 = 100)[26]

Figures for final energy consumption on the regional level point to an extremely varied structure within the national territory. Preliminary estimates for 2004 show that Lombardy consumes 19.3% of the national total; Emilia-Romagna, Piedmont and Venetia rank at an average figure of 9.8%; other regions, such as Latium, Apulia and Tuscany, register averages of around 7.2%. Taken as a whole, these seven regions account for 70.4% of total Italian consumption. Noteworthy shares of the total are also consumed by Sicily (5.8%) and Campania (4.9%)



Regional energy-consumption figures show an extremely varied structure within the national territory. Lombardy consumes 19% of the national total.
More than 70% of total Italian energy consumption is accounted for by only seven regions: Lombardy, Emilia Romagna, Piedmont, Venetia, Latium, Apulia and Tuscany.

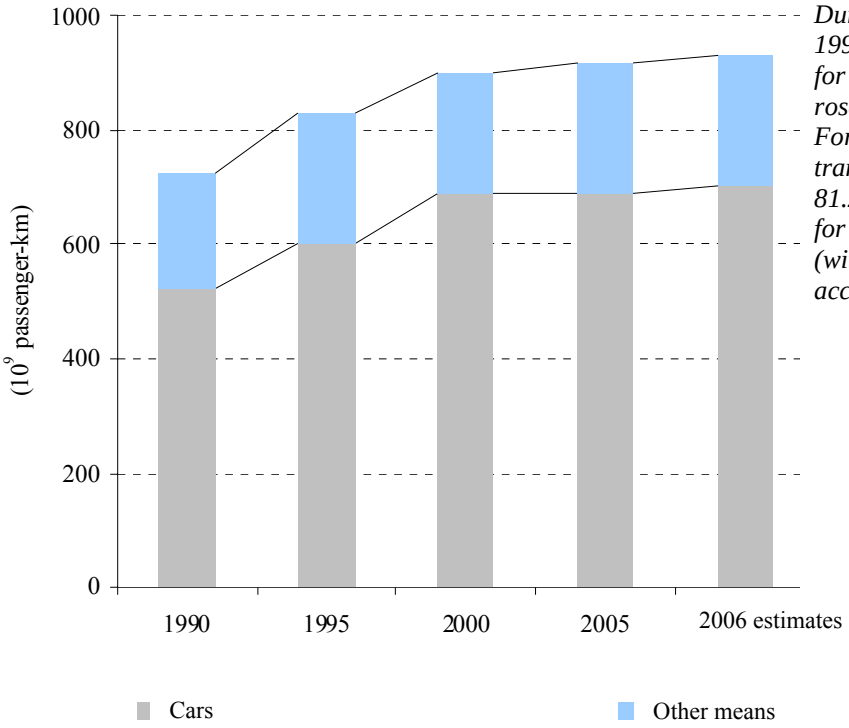
Figure 1.9: Final consumption of energy at the regional level by economic sector - Year 2004 (preliminary estimate)[27]

[26] Source: APAT analysis of data from the Ministry of Economic Development and TERNA

The transport system shows a trend pointing in the opposite direction from environmental sustainability. The demand for mobility continues to grow: during the period 1990-2006, the demand for passenger transport rose by 28.6%, while the demand for cargo transport rose by 31.9% during the same period.

During the period 1990-2006, the demand for passenger transport rose by nearly 29% and the demand for cargo transport by 32%.

The passenger demand continues to be satisfied primarily by the roadway mode of transport, the least efficient from an economic and environmental point of view. Private roadway transport alone (cars, motorcycles and scooters) accounts for 81.2% of the demand for passenger transport.



During the period 1990-2006, the demand for passenger transport rose by almost 29%. For 2006, roadway transport constitutes 81.2% of the demand for passenger transport (with automobiles alone accounting for 75.3%).

Figure 1.10: Trend of the demand for passenger transport [28]

[27] Source: APAT analysis of ENEA data

Cargo transport within the national territory takes place primarily on trucks (54.9% in 2006), with a noteworthy portion being handled by foreign carriers (14.7%). This last figure appears especially significant, in light of the constant growth registered since 1995, when the share of cargo transported by foreign carriers was 3.8%. Transport of cargo by sea and by railway account for respective shares of 16.1% and 9.9% of the total, while air cargo transport stands at a negligible 0.4%.
The demand for cargo transport shows especially rapid growth in the period 2003-2005, followed by a decrease in 2006.

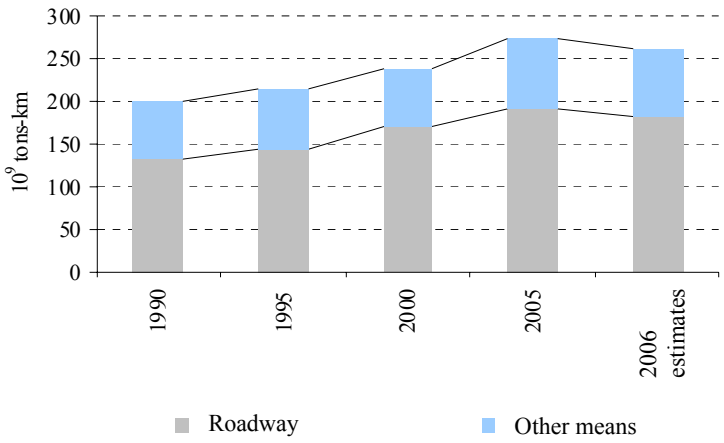


Figure 1.11: Trend of the demand for cargo transport[29]

Between 1990 and 2005, demand for cargo transport showed growth of more than 30% , while the figures for 2006 point to a decrease.
Estimates for 2006 further reveal that most cargo transport within the national territory travels by roadway (69.6%), while other modes, such as cargo transport by sea or by rail, account for respective shares of 16% and 10% of total transport.

Italy ranks second in Europe, coming after Luxemburg, in terms of the ratio of registered automobiles to the resident population, though it ranks first when motorcycles, scooters and commercial vehicles are included; worldwide, only the USA has a higher rate of motorisation, meaning the ratio of vehicles to inhabitants.

1.4 Response measures

The main response measures involve mitigation (meaning the reduction of greenhouse gas emissions) and adaptation to the

The main response measures involve mitigation (meaning the

[28] Source: Time series recalculated by the APAT, under uniform criteria, from data provided by CNT and Federtrasporti; the time series for the transport of cargo are influenced by variations in the data-collection method used by the ISTAT
[29] Source: time series recalculated by APAT under uniform criteria using data provided by CNT and Federtrasporti; the time series for cargo transport are influenced by changes in the ISTAT data-collection method

climate changes underway. Mitigation and adaptation measures can be complementary, interchangeable or independent. Recent evaluations of the IPCC make it clear that: "Under current policies for the mitigation of climate change and the related practices of sustainable development, global emissions of greenhouse gases shall continue to increase in the next few decades"[30]. Therefore, regardless of whatever measures of mitigation are implemented, adaptation measures shall be required as well, on account of the inertia of the climate system, as well as the changes already underway. It should also be considered that, on account of this inertia, the benefits of the mitigation measures taken today may manifest themselves only over the medium to long term, though the future potential of such measures is higher than that of the adaptation measures which we can implement today[31].

reduction of greenhouse-gas emissions) and adjustment to the climate changes underway.

Mitigation

Within Europe, the measures already taken to reduce atmospheric emissions by the energy sector, as well as those to be taken, should be considered within the policy framework recently defined by the European Council of 8-9 March 2007, which set the following objectives to be reached by the European Union by 2020:

a) reduction of greenhouse-gas emissions by 20% compared to 1990;
b) 20% of total energy consumption to be contributed by renewable sources;
c) reduction of energy consumption by 20% compared to forecasts;
d) 10% of total transport energy consumption to be contributed by bio-fuels.

The political framework defined by the European Council sets the following objectives for the EU by 2020:

- *reduction of greenhouse-gas emissions by 20% compared to 1990;*
- *20% of total energy consumption to be contributed by renewable sources;*
- *20% reduction in energy consumption compared to forecasts;*
- *10% of transport energy consumption to be contributed by bio-fuels.*

This approach, together with the objective of contrasting climate change, is meant to:
1) increase the security of energy sources;
2) ensure that the European economy is competitive;
3) promote an economy based on low carbon content.
Furthermore, the conclusions of the European Council lay down the commitment of limiting the increase in the average global temperature to a maximum of 2°C, as compared to pre-industrial levels.

[30] IPCC (2007). *Climate Change 2007* – WG-III, *Summary for Policymakers*
[31] IPCC (2007). *Climate Change 2007* – WG-III, *Technical Summary*

Of note nationally is the growing role of cogeneration, which increases the efficiency of the conversion of the energy available in primary sources. Since 1997, the figures for the portion of net thermoelectric energy produced through cogeneration run parallel to total thermoelectric production: between 1997 and 2006, the average annual increases for thermoelectric production through cogeneration and total thermoelectric production were approximately 6,480 GWh/year and 6,697 GWh/year respectively. The figure for overall production of electricity has remained essentially unchanged during the period considered, meaning that, since 1997, practically the entire supply of new electricity from thermoelectric plants has been produced through cogeneration.

Of note on the national level is the growing role of cogeneration, which makes possible greater efficiency in the conversion of the energy available from primary sources.

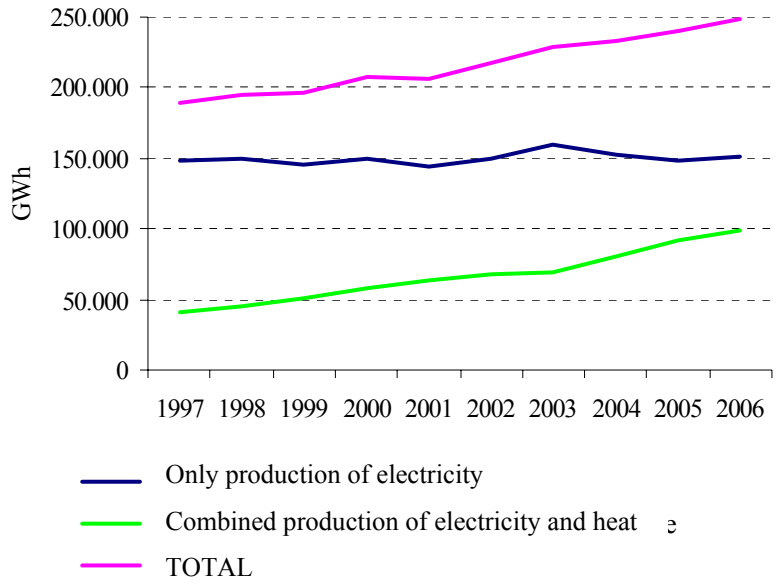


Figure 1.12: Net production of thermoelectric energy[32]

The average annual increase in the production of electricity between 1997 and 2006 was approximately 6,480 GWh/year for thermoelectric production through cogeneration and 6.697 GWh/year for total thermoelectric production, while overall production of electricity remained practically unchanged during the period in question.
These figures show that, since 1997, nearly the entire supply of new electricity has been produced through cogeneration.

A regulatory development of note in this sector is the recent transposition into Italian law of Directive 2004/8/EC, which promotes cogeneration through Legislative Decree no. 20 of 8 February 2007.

[32] Source: APAT analysis of TERNA data

In terms of the mix of primary sources, it should be noted that the growing role of natural gas in thermoelectric production has a positive influence on the trend of greenhouse-gas emissions. This is due not only to the lower emission factor of natural gas as compared to other primary sources, but also to the greater efficiency of combined cycles fuelled with natural gas, as compared to traditional steam cycles. During the period 1996 – 2006, a decrease of 18.7% was registered in the average specific consumption of natural gas for the net production of electric energy. Derivative gases also showed a noteworthy decrease in specific consumption for 2006, falling 15.2% compared to 1996. Looking at all the fuels used for the production of electricity, average specific consumption decreased by 10.6% (-1.8% between 2005 and 2006). The average specific consumption for the production of electricity relating to all fuels is influenced by the use of petroleum products and solid fuels, which have lower levels of efficiency than combustible gases. In fact, during the period under consideration, the figures for specific average consumption of petroleum products and solid fuels registered respective increases of 8.2% and 6.1%.

The growing role of natural gas in thermoelectric production has a positive influence of the trend of greenhouse-gas emissions.

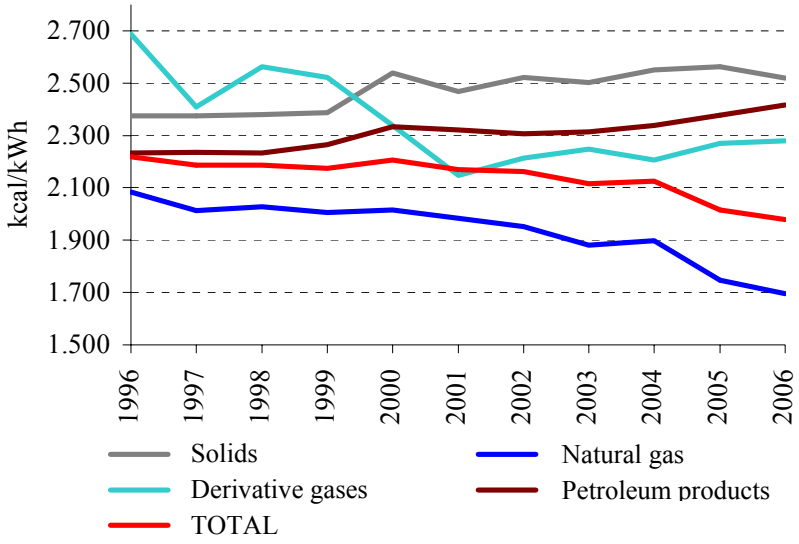


Figure 1.13: Average specific fuel consumption in the net production of electricity from fossil sources[33]

During the period between 1996 and 2006 there was a decrease of 18.7% in the average specific consumption of natural gas and a decrease of 15.2% in that of derivative gases. In terms of the overall production of electricity, average specific consumption decreased by 10.6%, compared to respective increases of 8.2% and 6.1% in petroleum products and solid fuels.

[33] Source: APAT analysis of TERNA data

In terms of energy efficiency of final uses, Directive 2006/32/EC sets the objectives for the efficiency of final energy uses and energy services for the member nations. The rough national objective for overall energy savings is 9% by the ninth year of the application of the Directory (2016). Under the provisions of art. 4, the member nations must implement effective measures designed to achieve this objective. In compliance with the directive, the Ministry of Economic Development presented the Action Plan for Energy Efficiency in July of 2007, identifying a series of actions that will make possible energy savings of 9.6% in 2016, based on average energy consumption between 2001 and 2005.

Based on Directive 2006/32/EC, the rough national objective for overall energy savings is 9% by 2016.

The production of electricity from renewable sources registered approximately 52.2 TWh in 2006, out of total electricity production of 313.1 TWh. The portion of total electric energy production generated by renewable sources is thus 16.7%. Production figures are characterised by annual fluctuations in the contribution of hydroelectric energy, tied to meteorological conditions, as well as growth in the contribution of non-traditional sources (wind, geothermal, biomasses and waste). In recent years (1997-2006), there has been a particularly noteworthy increase in the production of electricity from wind power (from 117.8 to 2,970.7 GWh during the period 1997-2006) and from biomasses/waste (from 820.3 to 6,744.6 GWh), as well as, though to a lesser degree, in energy of geothermic origin (from 3,905.2 to 5,527.4 GWh). The contribution of photovoltaic plants remains negligible (2.3 GWh in 2006, though this result should also take into account the production of electricity by photovoltaic roofs, which were not included in the statistics on the electricity sector, but produced 31 GWh in 2005). Despite the increase in the use of renewable sources in recent years, the figures on the production of electric energy from these sources do not appear sufficient for reaching the objective of approximately 75 TWh by 2010, as contemplated under Directive 2001/77/EC.

Production from renewable sources accounts for 16.7% of total production of electricity.
Despite the increase in the use of non-traditional renewable sources in recent years, the figures for the production of electricity from renewable sources are not sufficient for reaching the objective of approximately 75 TWh by 2010, as stipulated under Directive 2001/77/EC.
In the last few years (1997-2006), there has been a noteworthy increase in the production of electricity from wind power (from 117.8 to 2,970.7 GWh) and from biomasses/waste (from 820.3 to 6,744.6 GWh), as well as, though to a lesser degree, in energy of geothermic origin (from 3,905.2 to 5,527.4 GWh), while the contribution of photovoltaic energy remains negligible (2.3 GWh in 2006).

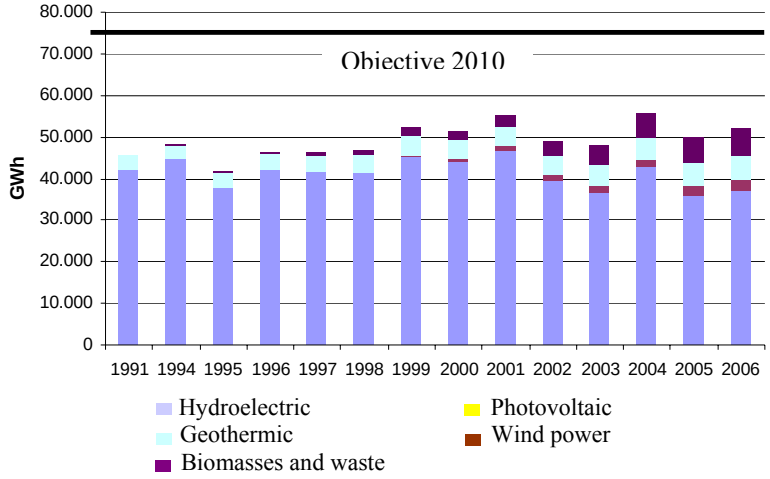


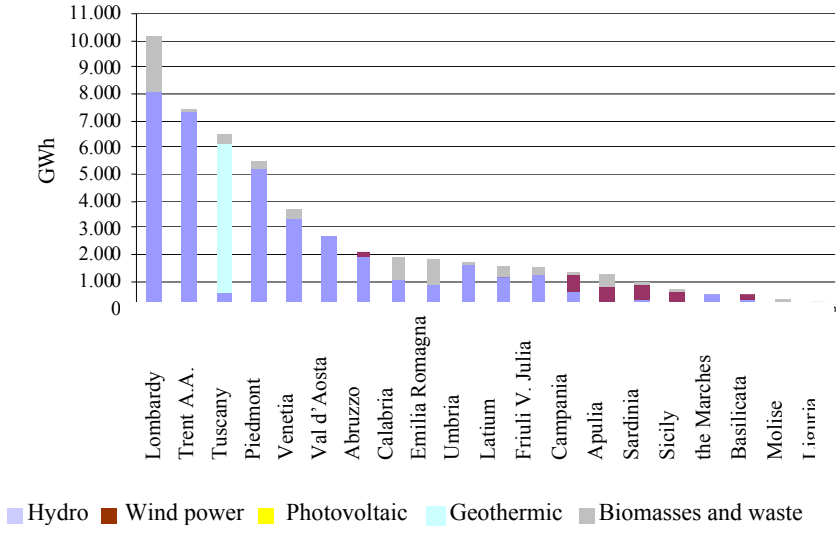
Figure 1.14: Overall production of electricity from renewable sources of energy[34]

Production from renewable sources constitutes 16.7% of total production of electricity. Since '97 there has been a noteworthy increase in the production of electricity from wind power (from 117.8 to 2,970.7 GWh during the period 1997-2006) and from biomasses/waste (from 820.3 to 6,744,6 GWh), as well as, though to a lesser extent, energy of geothermic origin (from 3,905.2 to 5,527.4 GWh).
But despite the increase registered in recent years, the figures on the production of electricity from these sources are not sufficient for achieving the objective of approximately 75 TWh by 2010, as contemplated under Directive 2001/77/EC.

There are noteworthy differences in the energy sources used in the various regions. Hydroelectric energy, concentrated in the regions of the Alpine arc, accounts for 70.8% of the electric energy produced by renewable sources. The use of geothermal energy is limited to Tuscany, which, on its own, accounts for 10.6% of the electric energy produced from renewable sources. Biomasses produce 12.9% of total production of electricity from renewable sources, while the portion generated by wind and photovoltaic plants is 5.7%, with almost all such production activities (99.1%) occurring the southern regions and on the major islands.

On the regional level, there are noteworthy differences in the renewable energy sources used. Hydroelectric energy, concentrated in the regions of the Alpine arc, accounts for almost 71% of the electric energy produced by renewable sources.

[34] Source: APAT analysis of TERNA data



On the regional level, there are noteworthy differences in the renewable energy sources used. The primary renewable source of electric energy, hydroelectric power, is concentrated along the Alpine arc (70.8%), while wind-powered and photovoltaic production are located in the southern regions and the islands (99.1%).

Figure 1.15: Overall production of electric energy from renewable sources on the regional level (2006)[35]

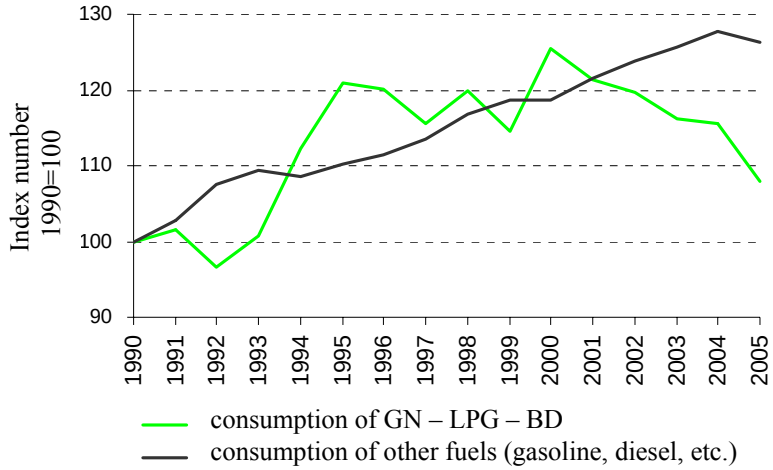
Of particular interest in terms of recent regulatory developments regarding renewable sources, and especially with respect to photovoltaic energy, is the Ministerial Decree of 19 February 2007, which lays down new criteria and procedures designed as incentives for the production of electric energy from photovoltaic solar plants. The measure will allow Italy to join the other European countries in the forefront of the sector by eliminating a portion of the lengthy bureaucratic procedures that weighed down the old "Energy Account".

The effects of technological measures regarding transport are offset by the growth in demand, especially for roadway transport.

The transport sector registered a constant increase in fuel consumption from 1990 to 2004 (+27.0% compared to 1990), followed by a slight decrease in 2005 (-1.5% compared to 2004). The percentage of fuels of low environmental impact (natural gas, LPG, bio-diesel) out of total fuels fluctuated, going from 5.6% in 1990 to 4.8% in 2005, with a peak of 6.1% in 1995.
The variation in the percentage consumption of fuels shows that, while the increase in classic fuels (gasoline, diesel etc.) has been constant, the levels of consumption of natural gas, LPG and bio-diesel have been irregular. Overall, the quantity of lower-impact fuels consumed in 2005 was 7.9% higher than the quantity consumed in 1990.
The available data show that, in the transport sector, the limited progress made through the enactment of technological measures regarding engine efficiency is offset - and to a greater degree in Italy than in the other European countries - by growth in the demand for transport, and especially the roadway mode, with the result that the environmental impact of the transport sector continues to grow. As for the quality of the fuels, it should be

[35] Source: APAT analysis of TERNA data

observed that the use of lower-impact fuels, in addition to being of marginal importance, follows a highly irregular pattern, with a constant decrease, since 2000, in the ratio of such fuels to total fuels consumed: a change in trend traceable primarily to reduced sales of LPG.



Use of lower-impact fuels has been highly irregular, with a constant decrease in their percentage of total fuel consumption since 2000.

Figure 1.16: Levels of consumption of fuels for transport (1990=100). (NG: natural gas; LPG: liquefied petroleum gas; BD: bio-diesel)[36]

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 vegetation, and especially by forests: 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, considered globally[37]. In Italy, the different forest reservoirs (epigeal and hypogeal biomass, necro-mass, forest bed and soil) were responsible for capturing 15.6 million tons of carbon in 1990 and 24.7 million tons of carbon in 2005, after accounting for losses from fires, natural uses and the mortality of the vegetation.

Between 1990 and 2005, the stock of carbon in Italian forests grew by 58%, due primarily to the expansion of forest surface area.

[36] Source: APAT analysis of data from the Ministry of Economic Development
[37] IPCC (2000). *Land-use, Land-use Change and Forestry*, IPCC *Special Report*

Adaptation

The Green Paper of the European Commission (COM(2007)354) stresses the global dimension of climate change, considering possible damage to Europe, together with the need to implement measures of adaptation. The Green Paper states that: "*Adaptation actions are taken to cope with a changing climate, e.g. increased rainfall, higher temperatures, scarcer water resources or more frequent storms, at present or anticipating such changesfuture. Adaptation aims at reducing the risk and damage from current and future harmful impacts cost-effectively or exploiting potential benefits. Examples of actions include using scarce water more efficiently, adapting existing building codes to stand future climate conditions and extreme weather events, construction offlood walls and raising levels of dykes against sea level rise, development of drought tolerant crops, selection offorestry species and practices less vulnerable to storms and fires development of spatial plans and corridors to help species migrate*".

The risks connected with climate change call for a series of timely actions, in order to avoid or reduce the costs that will be incurred if nothing is done. The recent Stern report on economic considerations tied to climate change[38], commissioned by the British Government, stressed that the economic impact of timely initiatives taken to limit climate change is estimable at around 1% of the global GDP per year, as compared to a figure of from 5% to 20% of the annual global GDP, should action not be taken.

The Stern report estimates the annual cost of initiatives to limit climate change at roughly 1% of the global GDP, compared to a cost of from 5% to 20% of the annual global GDP, if nothing is done.

Given this scenario, the EU plans to take a series of priority actions of adaptation, so as to avoid "*Unplanned measures of adaptation, possibly stop-gap actions to deal with the increasingly frequent crises and catastrophes, at extremely high costs and with possible risks for the social and economic systems of Europe, as well as its very security.*"

At the end of the National Conference on Climate Change, the Ministry of Environment, Land and Sea committed itself to drawing up a national strategy for sustainable adaptation to climate change and for the security of the territory by the end of 2008.

The Manifesto on the Climate[39], which summarises the proceedings of the Conference, sets a five-point program. The five points confirm Italy's commitment to comply with international agreements, and especially with the Kyoto Protocol, as well as the commitment to proceed with the additional reductions in greenhouse gases indicated by the

The Manifesto on the Climate and Sustainable Adaptation includes a commitment to the immediate formulation of a

[38] Stern N. (2006). *STERN REVIEW*: *The Economics of Climate Change*

[39] National Conference on Climate Change (2007), *Manifesto per il clima – Un new deal per l'adattamento sostenibile e la sicurezza ambientale*, http://www.conferenzacambiamenticlimatici2007.it/site/it-IT/Sezioni/Approfondimenti/manifesto.html, Rome 12-13 September 2007

European Union, equal to 20% by the end of 2020 and 60% by the end of 2050. Emphasis is also placed on the need to "coordinate measures of mitigation with those of adaptation to climatic change, immediately making the latter a part of sector-wide policies of economic development, as well as legislation and funding programs for major works".

National Plan for Adaptation, as well as the implementation of 13 priority actions.

Of particular importance is the commitment to "Immediately formulating a national plan for adaptation to climate change", involving institutions on all levels, together with the social partners, in a process that, taking into account international conventions (the Convention on Biological Diversity and the Convention on the Fight against Desertification, both dating from 1994), weighs the best strategies for initiatives in defence of the soil, the integrated management of coastlines, adaptations in tourism in Italy and the management of water resources.

Looking at the 13 priority actions for sustainable adaptation identified at the conclusion of the Conference, a number of these regard procedures for the production and consumption of energy, as well as the efficient use of water resources and the territory. Particular importance is placed on the need to provide incentives for saving energy and water resources, and on undertaking actions of sustainable management of the territory regarding climate change, urging that efforts be made to ensure the safety of Italy's coastline. Steps must also be taken in terms of healthcare policy, modifying healthcare strategies to include climate-related risks. Another factor of particular importance would appear to be the need to obtain greater knowledge of the critical problems connected with climate change.

Any response to climate change entails overcoming a series of obstacles tied to knowledge and outlook. The inherent uncertainty of any complex system, such as the climate system, is rendered even more acute by the scarce availability of many environmental parameters. Furthermore, an effort must be made to shift perceptions of the timeline for the effects of development decisions, which must be given a framework of decades in which to manifest themselves.

A number of adaptation measures (for example, the construction of defences against flooding and the raising of artificial embankments against the increase in the sea level) involve direct interventions on the environmental matrixes, the consequences of which must be carefully evaluated. Furthermore, adaptation efforts must compete with mitigation initiatives for resources; in actual fact, adaptation and mitigation are complementary, and should be viewed as two parts of a single, integrated response to the threat of climate change. The optimal mix of adaptation and mitigation must be determined on the basis of economic factors, such as cost-benefit analyses, though there can be no ignoring considerations of sustainable development and the ethical issues tied to this topic, especially as they effect future generations.

Adaptation and mitigation are complementary and should be considered as two parts of a single, integrated response to the threat of climate change.

In any event, there are measures of mitigation available for each

production and economic sector. By combining elements of mitigation and adaptation, these initiatives will not only contribute to reducing greenhouse-gas emissions, but they will also increase the resiliency of natural and human systems to the consequences of climate change, in addition to protecting natural assets, preventing damage to human systems and favouring sustainable development.