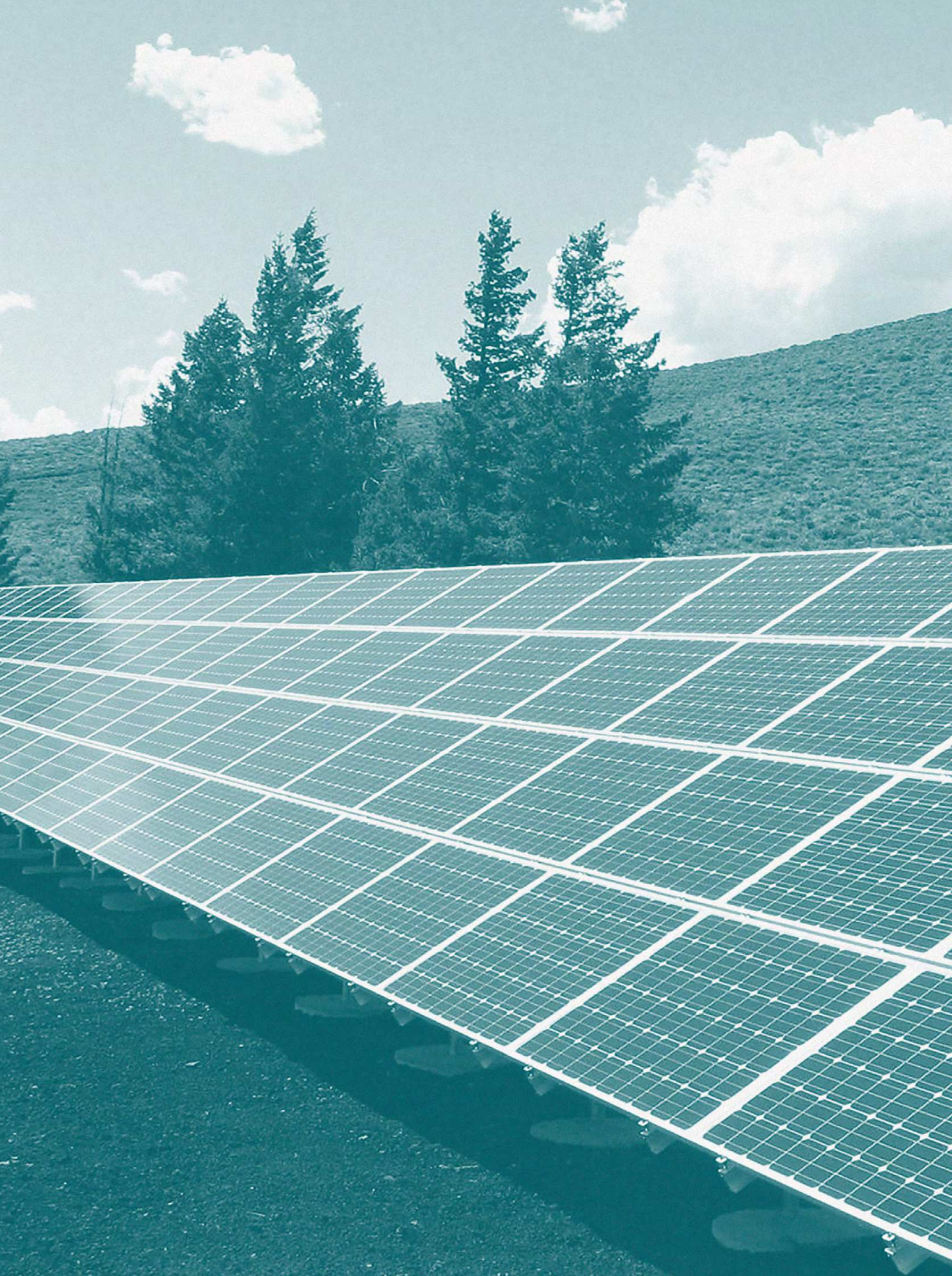


1

Climate Change

Climate change is happening and undoubtedly comprises the most serious global environmental issue, with severe consequences for ecosystems and most aspects of human life and activity, which are expected to worsen in the years to come. Recognizing the role of increased emissions of greenhouse gases (GHGs) from anthropogenic activities in the observed temperature rise, the international climate action for their control in order to mitigate climate change, has intensified during the last two decades.

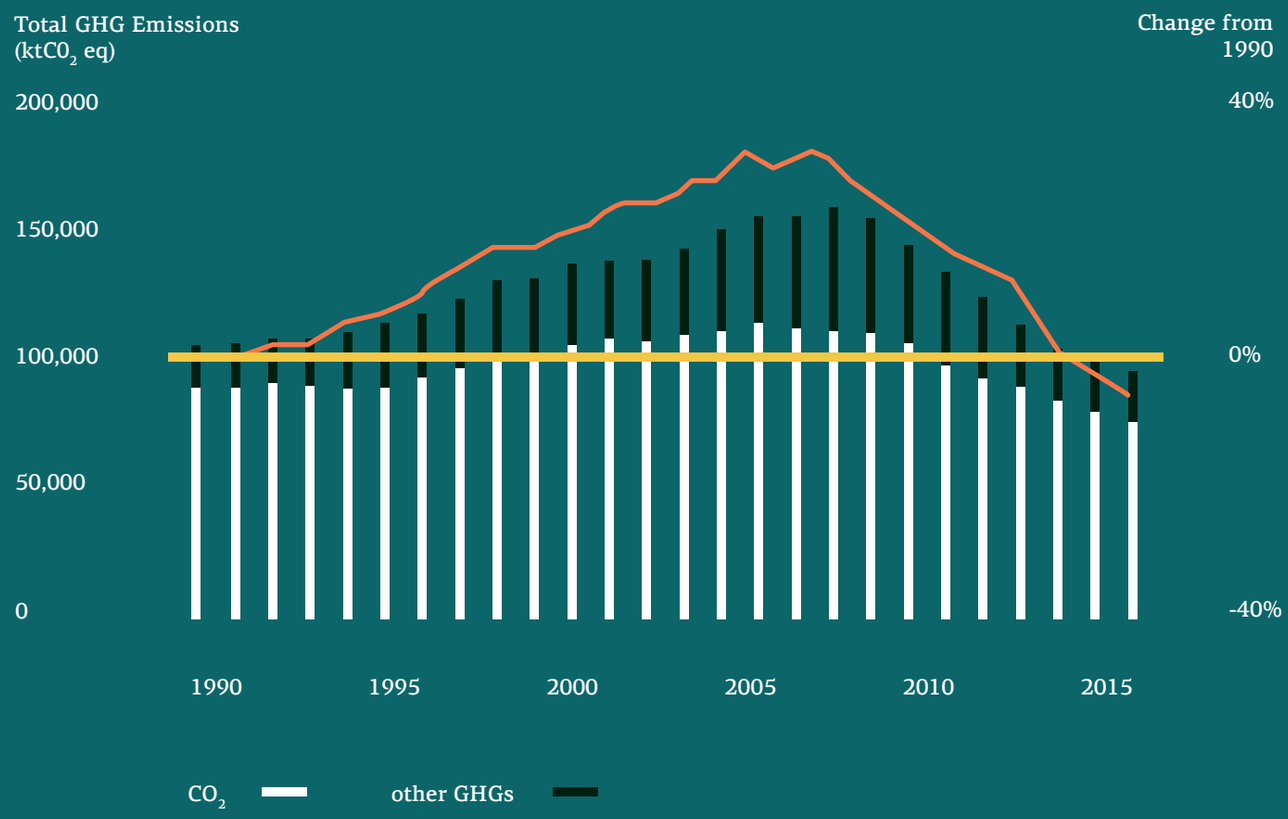
Even if mitigation efforts succeed, given the long lifetimes of GHGs, some change in the climatic conditions is inevitable and as a result additional action towards adaptation to climate change is required. Adaptation includes the assessment of foreseen climate change impacts and pertinent actions - at local and international levels - to prevent them or limit their severity. The Mediterranean area is rather vulnerable to climate change, being already sensitive to high temperatures and droughts, which are anticipated to further aggravate in the future.
Besides the "average" levels of climatic variables, an increase in the frequency and intensity of extreme events is expected to impact health, ecosystems and key sectors of the economy, such as agricultural production and tourism. In this framework, it is important to monitor and assess GHG emissions, changes of climatic parameters and related extreme events. Reporting and analysis of measures aiming at climate change mitigation and adaptation is equally important.

1. Greenhouse Gas Emissions and Mitigation Measures

This report provides information regarding GHG emissions reported by Greece under the United Nations Framework Convention on Climate Change (UNFCCC). Emission data, total and by GHG, are analyzed for trends and regarding the contribution of various activity sectors. The changes of their intensity with respect to main demographic and macroeconomic indicators is also presented. During 2015, which is the latest year of reporting, the national total of GHG emissions was 95.7 Mt of CO_2eq, reduced by 7.1% since 1990. Calculations do not take into account the sector of land-use, land-use change and forestry (LULUCF), which has a favorable impact on the removal - emission net balance. If LULUCF were included, the reduction of GHG emissions, with respect to the base year would rise to 8.3%. Greece has fulfilled the target regarding the first period (2008-2012) of commitment to the Kyoto Protocol and is on track to achieve the EU target for reduction of emissions deriving from sectors not covered by the emissions trading system.

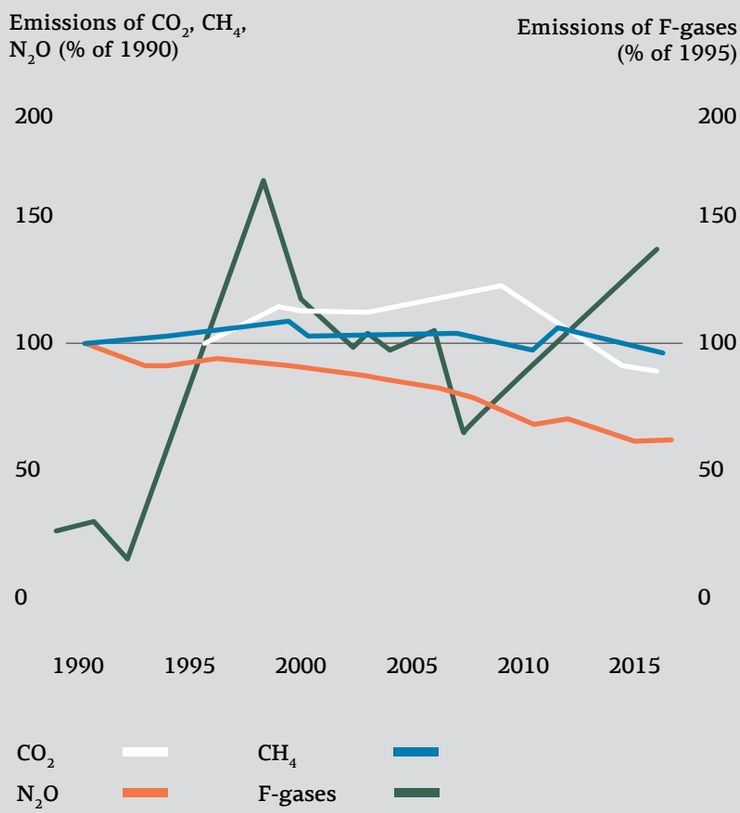
Graph 1.1. displays the change of equivalent CO_2 emissions during 1990-2015. CO_2 emissions comprise the largest part (78.3% in 2015). It appears that in Greece, GHG emissions are not fully decoupled from economic growth - as it is the case in the EU - since up to 2007 an upward trend is observed, with emissions largely exceeding those of the base year, while in the following years (2008-2015), a significant drop (27.3%) is recorded.

Graph 1.1.
GHG emissions in Greece (without LULUCF), as equivalent CO_2 (CO_2 eq) emissions and % change from 1990



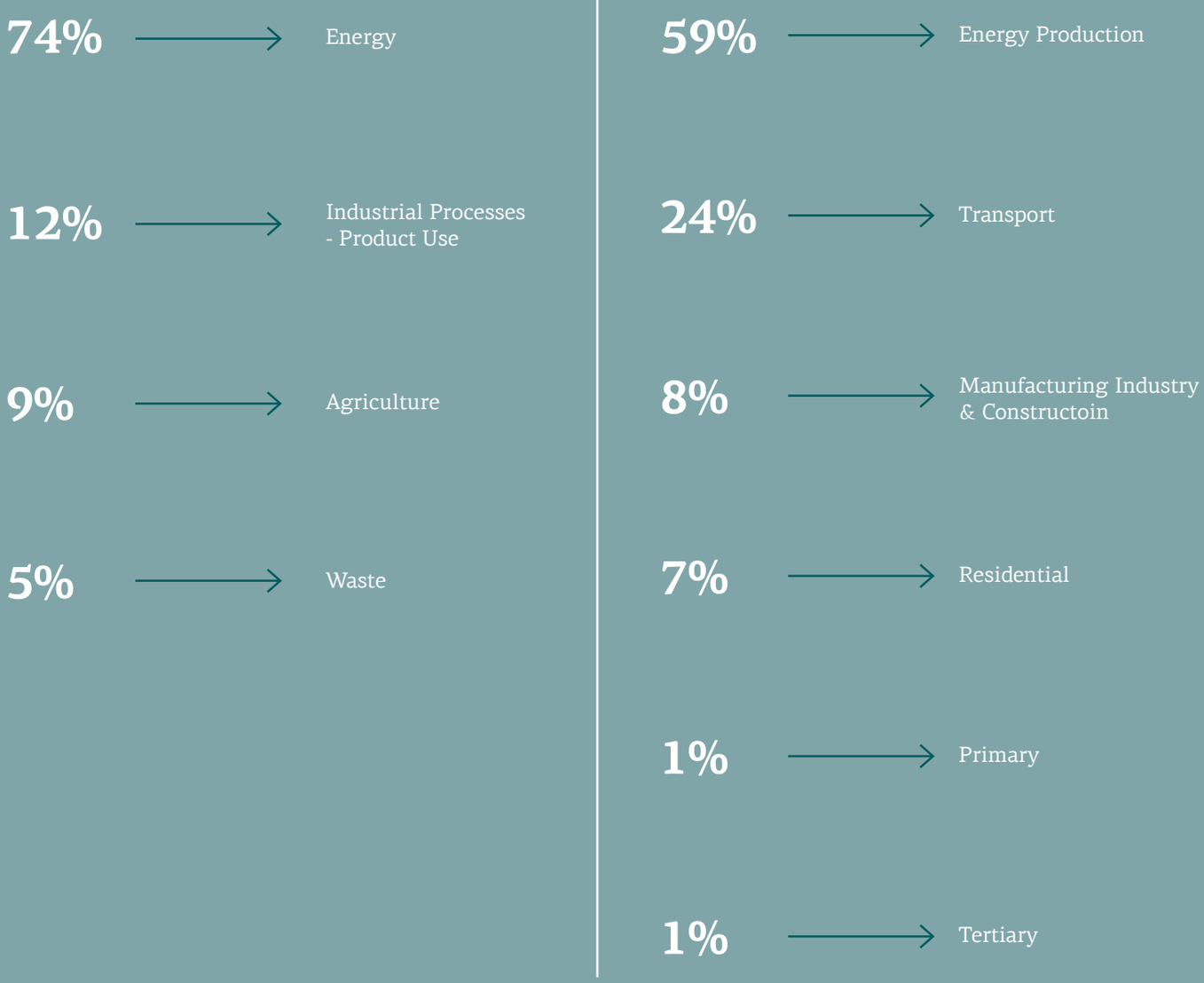
The effect that the reduction of CO_2 emissions (10.1% since 1990) bears on the total GHG reduction is moderated by the comparatively smaller (6.3%) reduction of CH_4 emissions (10.7% of total emissions in 2015), as well as the increase (42.7% since 1995) of emissions of fluorinated gases (F-gases), which now constitute a 6.3% of the total. Hydrofluorocarbons (HFCs) is the subgroup with the largest contribution among F-gases. Nitrous oxide (N_2O) emissions have decreased by 39.3% since 1990 and account for 4.7% of the total in 2015. Emission trends by greenhouse gas are presented in Graph 1.2.

Graph 1.2.
Emission trends in Greece (without LULUCF) by GHG

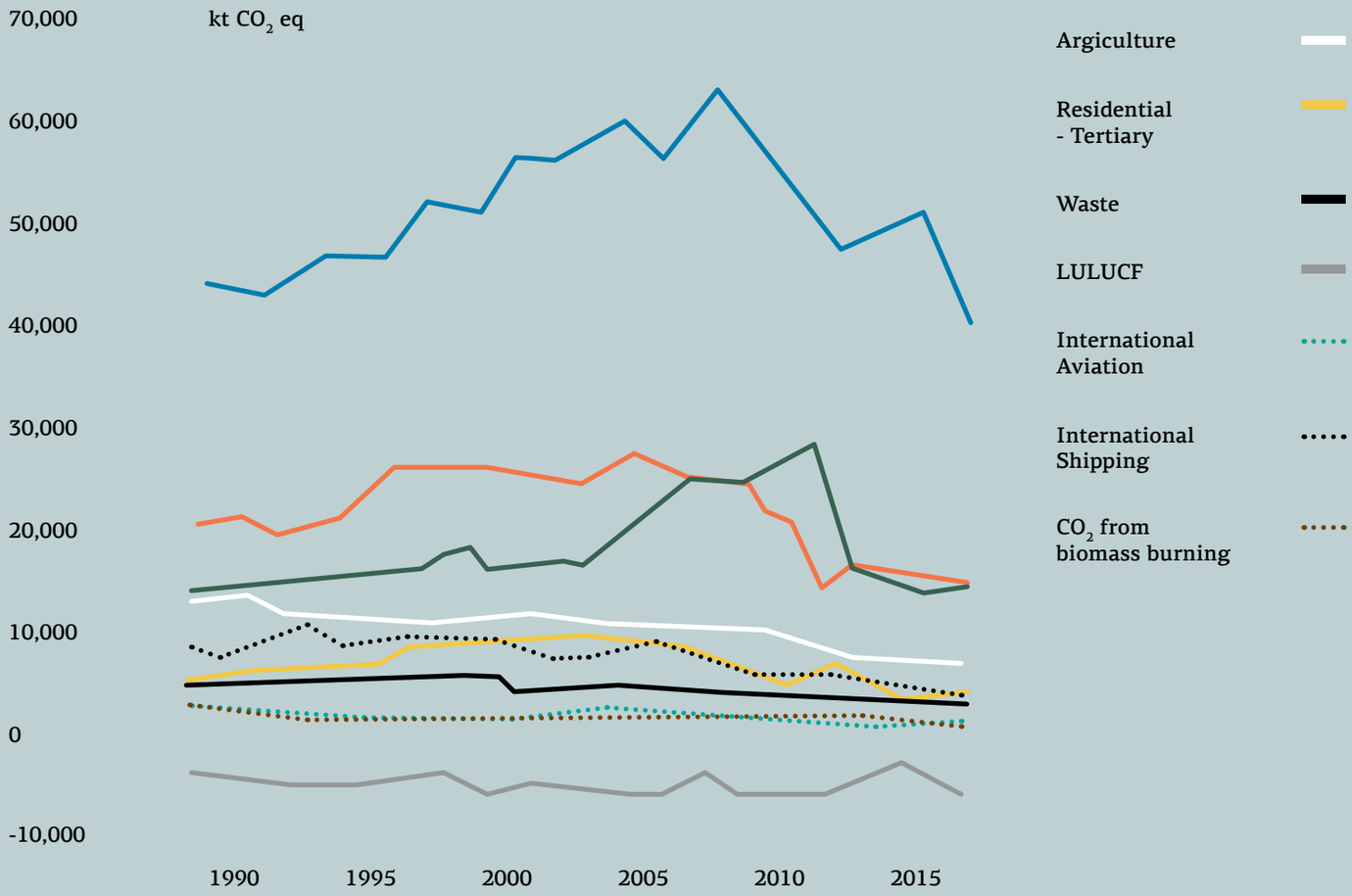


The largest part of GHG emissions derives from the energy sector (74.2% το 2015, without LU-LUCF). Emissions from energy in 2015 were 7.6% lower than those of 1990 and at their lowest level ever since. The increase observed up to 2000 was followed by a stabilization period through 2007. From 2007 to 2015, the reduction of energy emissions has reached 34.3%. The drop observed for total GHG emissions from the energy sector during 2007-2015 is also recorded for the majority of specific energy sectors, with emissions from energy production diminishing by 31.3% and from transport by 26.3%. In comparison with the base year (1990), transport emissions have increased by 17.8%, while energy production emissions have been reduced by only 5.4%. The contributions of main and energy-specific sectors, to total (without LULUCF) GHG emissions and GHG emissions from energy, respectively, are summarized in Graph 1.3.

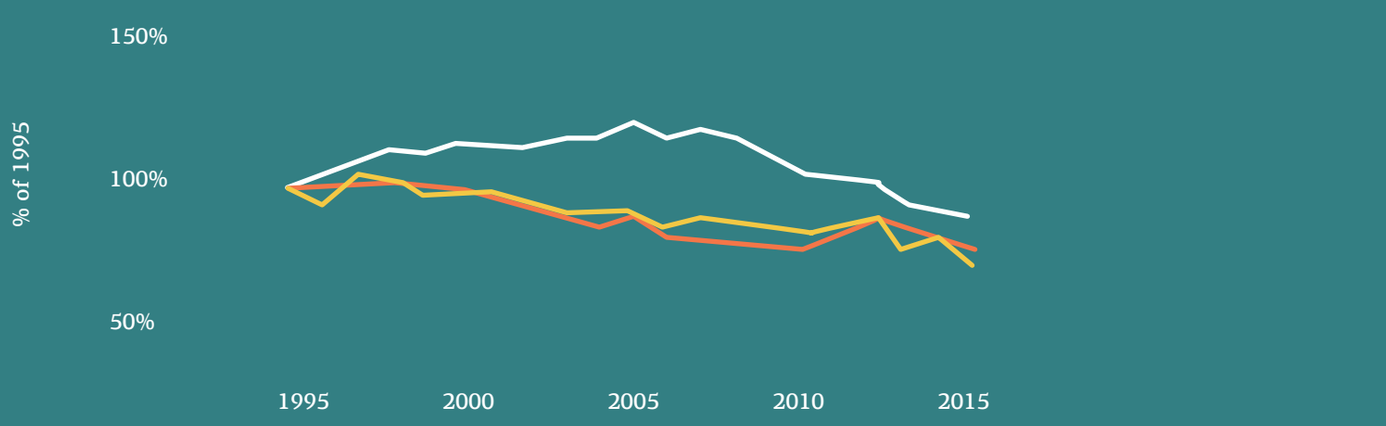
Graph 1.3.
Share of sectors in total (a) and energy-specific (b) GHG emissions for 2015



Graph 1.4.
GHG emissions by sector. Dotted lines represent sectors whose emissions do not count towards the national GHG totals (memorandum items). Respective emissions from energy use are included in industrial and agricultural totals.



Graph 1.5
Change of GHG emissions per capita, of GHG emissions intensity per GDP unit (constant prices of 2010) and of GHG emissions intensity per unit of generated electricity



The industrial processes and product use (IPPU) sector produced 12.4% of 2015 emissions (without LULUCF). Even if emissions have increased by 6.0% since 1990, when compared to the first years of the previous decade, a large reduction is observed, especially for emissions from chemical and mineral industries. Emissions from the agricultural sector cover the 8.7% of the total (without LULUCF) in 2015, having decreased by 17.9% in comparison with the base year. The reduction is mainly attributed to the moderation of N_2O emissions, mainly related to decreased fertilizer use. The waste and waste management sector accounts for 4.7% of total GHG emissions (without LULUCF) in 2015. Emissions from the sector have decreased by 7.8% since 1990, as a result of reducing emissions from waste water treatment and controlling the increase of methane emissions from solid waste disposal. The LULUCF sector has been a net GHG sink in Greece, constantly over the period 1990-2015. Since 1990, the sink capacity of LULUCF has increased by 44.2%, mainly due to increased net removals from forest land, even though the cropland category is becoming a net emission source in the last years. Emission trends of specific sectors during 1990-2015 are displayed in Graph 1.4.

GHG emissions per capita (without LULUCF), since 2013 have fell below 10 tons of CO_2eq per year. The index value for 2015 (8.9 ton) is 12% lower than in 1990 and comparable to the European average (8.5 ton). During the period of 1995-2008, the GDP increase of 57% was accompanied by a 20.7% increase of GHG emissions and as a result the intensity of emissions by GDP unit decreased by 23%. In the following period (2009-2015), the intensity has remained relatively stable, as the reduction of GHG emissions by 23.1% is combined with - and partially attributed to - the economic recession, evidenced by the 23% loss of GDP (in constant 2010 prices) in the same period. Regarding the intensity from electricity and heat production, a reduction is observed even before the onset of the recession, emphasizing the gradual shift of the electricity production sector to low emission fuels and efficient production technologies. Results are displayed in Graph 1.5.

Within the scope of national commitments toward UNFCC, the Kyoto Protocol and EU emission reduction targets, a wide range of measures has been adopted and implemented. Special consideration has been given to the energy sector with the modernization of conventional power plants and promotion of renewable energy sources for electricity production, as well as to the residential-tertiary sectors with measures for the improvement of the energy efficiency of buildings. According to projections from the 7th National Communication under the UNFCCC, by the Greek Ministry of Environment and Energy (2018), the total potential reduction of GHG emissions by 2020 as a result of adopted and implemented sectoral policies at the national level is expected to reach 34.8 Mt of CO_2eq.

2. Climate change impacts and adaptation

Notwithstanding the climate change mitigation action at the international and national stages, and the observed reductions of emissions, in the path of the following decades important changes are expected for key climatic factors and regarding the frequency and intensity of extreme weather events.

According to the calculations of anthropogenic impacts on climate, under the two extreme climate change scenarios (B2 and A2), which are analyzed in this study, it is expected that by the end of the 21st century rainfall will be reduced between 5% and about 19%, at a national level. Moreover, air temperature will rise between 3.0 °C and 4.5 °C, respectively. The projections of the balanced scenario A1B regarding the changes in precipitation and mean air temperature, between periods 2071-2100 and 1961-1990 in the Greek region are displayed in Picture 1.1.

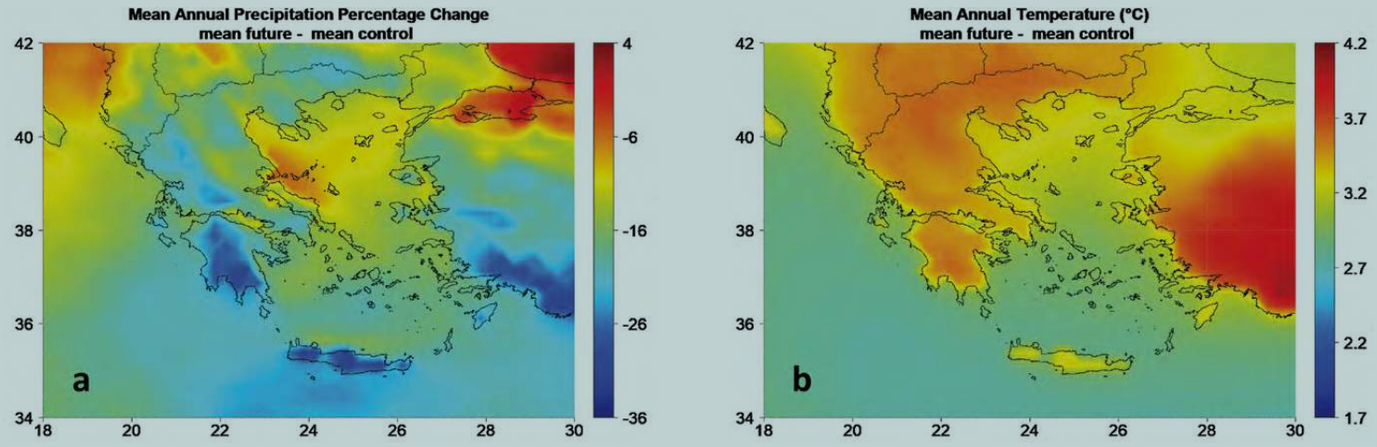
In general, simulations predict important shifts in numerous climatic parameters, including relative humidity, cloud cover, incoming shortwave radiation and wind speed. It is of importance for the utilization of RES that incident solar radiation is expected to increase (by 2.3-4.5 W m^{-2}) nationwide, along with the increase of wind speeds (by about 10%), until the end of the century.

The severity of climate change impacts is probably more related to shifts in the frequency of extreme weather events than to changes in the “mean climate”. The study presents simulation results for expected variations in the frequency and intensity of events related to extreme temperatures and rainfall/droughts, according to the A1B scenario.

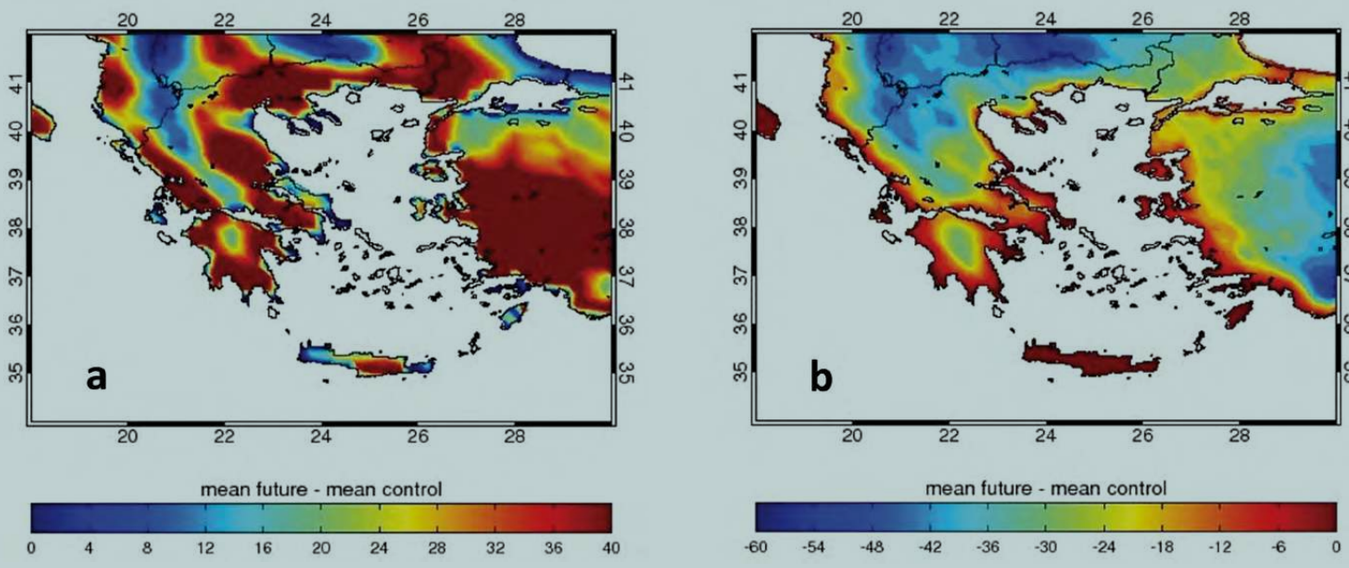
The mean maximum summer temperature is expected to rise by 5 °C, by 2071-2100. Significant countrywide changes are foreseen in the number of heat events - days with maximum temperature >35 °C - which are a cause of thermal discomfort for the population, especially in urban areas (Picture 1.2a.). It has been estimated that the coolest summers in 2070 - 2100 will be as warm as the warmest summers of the past (for example, in Athens, the 1987 summer will be considered relatively mild in the future).

Furthermore, all regions of Greece are expected to experience higher minimum winter temperatures, by approximately 3.5 °C, in 2071-2100, with the increase being larger in the mountainous areas. A decrease in the number of night frosts is expected (Picture 1.2b.), with implications for sensitive crop productivity. The increase of electricity demand for cooling in summer is an important side effect of the expected temperature increases. Especially at low-altitude continental areas of Greece an excessive demand is predicted for an additional 40 days per year, in the period 2071-2100 (increments will be less intense in the islands and in mountainous areas). The reduction of heating energy demand during winter will be a positive effect. Because of the later-in-autumn and earlier-in-spring occurrence of first and last frosts, respectively, the growing season is expected to be elongated.

Picture 1.1.
Percentage change of mean annual precipitation (b) and change of mean air temperature (°C) (b), in 2071-2100, relative to 1961-1990 (scenario A1B)

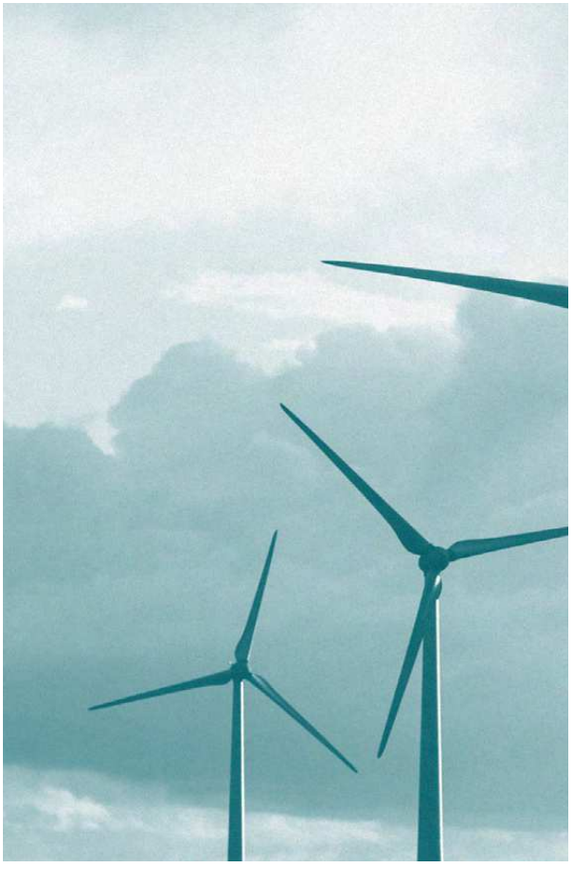


Picture 1.2.
Change in the number of days with maximum temperature >35 °C (a) and change in the number of night frosts (b) in 2071-2100, relative to 1961-1990 (scenario A1B)



Changes are also expected regarding extreme rainfall values. In Eastern Greece and Northwestern Macedonia, the maximum amount of precipitated water in up to three days is expected to increase by up to 30%, while in Western Greece to diminish by up to 20% (Picture 1.3a.). The increasing trends combined with the concurrent decrease in total annual precipitation indicate that more frequent and more intense rainfall events will occur in short periods, with a higher risk for flash floods. On the contrary, the largest increases in the duration of dry periods are expected in Eastern Continental Greece and Northern Crete where 20 and 40 additional dry days are foreseen by 2021-2050 and 2071-2100 (Picture 1.3b.), respectively. The change of climatic conditions will extend the number of days with very increased fire risk by 40 by 2071-2100 in the whole of Eastern Greece, while smaller increases are predicted for Western Greece.

The effects of these changes do not only affect the natural environment, where in the case of forests and biodiversity the ramifications will be severe, but also the economic activity, with tourism being an exemplary case where important adjustments are foreseen. The total cost of climate change for the Greek economy is significant and includes direct sectoral impact costs, indirect costs and costs deriving from between-sector impacts. The Climate Change Impacts Study Committee of the Bank of Greece, in its study on the Environmental, Economic and Social Climate Change Impacts (2011) has estimated costs for no-action, mitigation action and adaptation action scenarios.
The results of the committee's assessment indicate that:
⇢ For the no-action scenario, cumulative costs up to 2100 for the Greek economy, expressed as base year GDP reduction, will reach 701 billion € (2008 constant prices).
⇢ For the mitigation action scenario, cumulative costs will include the costs of measures for GHG emissions reduction (142 billion €) and the costs of the residual climate change (294 billion €). Thus, the total costs will be by 265 billion € lower than those of the no-action scenario.
⇢ For the adaptation action scenario, the costs from non-addressed impacts of climate change are estimated at 510 billion €. Taking into account the costs of adaptation measures (67 billion €), total savings of 124 billion €, with respect to the no action scenario, are estimated.



Picture 1.3.
Percentage change in annual maximum consecutive 3-day preciptation (a) and changes in the maximum duration of dry spells (b) in 2071-2100, relative to 1961-1990 (scenario A1B)