



# Trend analysis of greenhouse gas emissions in the Veneto Region

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## General Note



Article is recommended to print as color version in recycled paper. *Save Trees, Save Climate.*

## ABSTRACT

This study focuses on data of the greenhouse gases emissions in the Veneto Region taken from the regional inventory of atmospheric emissions (INEMAR) in the three periods 2005, 2007/08 and 2010. The analysis concerns CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>. It considers the main emissions activities of the SNAP97 nomenclature. Through this study we can observe how the situation relative to

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greenhouse gas emissions in the Veneto Region in the period 2005-2010 is improving. Although methane and nitrous oxide present far superior global warming potentials, the strong predominance of carbon dioxide in terms of quantity means that it turns out to be the gas mainly responsible for the greenhouse effect. In fact, by converting the three greenhouse gases into CO<sub>2</sub> equivalent, the emissions distribution per SNAP macro sector presents characteristics very similar to that of CO<sub>2</sub>. In this respect, the biggest issue is confirmed to be road transport emissions, with particular attention to be paid to passenger cars which produce almost 56% of CO<sub>2</sub> equivalent for the region.

**Keywords:** greenhouse gasses, emissions, CO<sub>2</sub>, INEMAR, Veneto

## 1. INTRODUCTION

At the end of the twenty-first session of the UNFCCC Conference of Parties, ended 12 December 2015, the 196 participating countries adopted the Paris Agreement on climate change, which will become legally binding if approved by at least 55 countries which, together, represent at least 55% of total greenhouse gas emissions. The parties must sign the agreement in New York between 22 April 2016 and 21 April 2017 and accept it as part of their legal systems.

The Agreement objective is to limit global warming to < 2 degrees Celsius (°C) above pre-industrial levels and to achieve zero anthropogenic greenhouse gas emissions by the second half of the 21<sup>st</sup> century. The parties also undertook to pursue efforts to limit the temperature increase to 1.5 °C (Pabitra Aryal, 2015; Shalin Shah, 2015; Calliari et al., 2016; Rajan, 2016).

Various scientific studies over the years have demonstrated how, as a consequence of human activity, such as fossil fuel combustion for energy purposes and agricultural and industrial processes, large quantities of gas, aerosol and dust particles are expelled into the atmosphere (Bernetti et al., 2004; Amruta Smit Thakkar, 2015; Akinnubi et al. 2016). The resulting mix of pollutants is very harmful to man and to the surrounding environment. Atmospheric pollution is mainly determined by the outflow of harmful substances from the source (emission), by their diffusion, transportation and partial transformation in the air (transmission), as well as by their concentration in the place of impact (immission). The further you travel from the source, the more the quantity of primary pollutants in the air tends to be reduced. In the second process, that of transmission, the pollutants emitted may undergo chemical transformation in the atmosphere, leading to the creation of new or secondary pollutants (such as ozone), with characteristics and effects that are partially or completely different. Furthermore, again in relation to the transmission process, it is important to note how this is also characterised by the transportation of pollutants by the wind, even to many miles away from their place of origin. This can contribute to air pollution in areas far from the sources of the pollutants. Therefore, the prevention and containment of emissions even in places where lower concentrations are detected is very important, insofar as the pollutants produced in such areas could contaminate other far more distant areas.

Pollution in a specific area may also be caused by another important factor: air stagnation, which, especially in valley floors, such as the Po Valley in Italy, generates the accumulation of pollutants caused by strong inversion in the winter, in particular during periods of high pressure and low rainfall. It is clear, therefore, that meteorology assumes an important role in the study of the concentration of air pollutants.

On a local level, the problem regards urban pollution, caused by building heating systems, traffic and industrial and power plants. Indeed, cities and towns are where the sources of environmental imbalance are most heavily concentrated, with direct consequences also on the health of residents.

## 2. MATERIALS AND METHODS

This study focuses on the so-called greenhouse gases, which are those gases present in the atmosphere transparent to incoming solar radiation to Earth, but capable of retaining, in significant quantities, the outgoing infrared radiation. Greenhouse gases thus contribute to maintaining a certain temperature on Earth, reducing heat dispersion which would otherwise make it much colder, creating, precisely, a greenhouse effect. These gases are partly natural in origin and partly produced by anthropogenic activity.

The effect of a gas on the greenhouse effect results from multiple factors: its radiative forcing, its concentration and the length of its atmospheric activity period.

In particular, the Global Warming Potential (GWP) represents the combined effect of the atmospheric activity period and the relative specific effectiveness in absorbing infrared radiation emitted by Earth. GWP is, therefore, a measure of how much a greenhouse gas contributes to global warming as compared to CO<sub>2</sub>. GWP is calculated by the Intergovernmental Panel on Climate

Change (IPCC) and is used as a conversion factor in the calculation of the emissions of all greenhouse gases in emissions of CO<sub>2</sub> equivalent.

The most important greenhouse gases present in the atmosphere are water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>) and sulphur hexafluoride (SF<sub>6</sub>). Other than these, there are others of exclusively anthropogenic origin that come under the category of halocarbons, or chlorofluorocarbons, whose emissions are regulated by the Montreal Protocol, an international treaty signed on 16 September 1987 and that came into force on 1 January 1989 and was revised on the occasion of the Conference of Parties in London in 1990, in Copenhagen in 1992, in Vienna in 1995, again in Montreal in 1997 and in Beijing in 1999. These gases are produced in quantities far inferior to those of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O and have very low atmospheric concentrations; however, they can have a very long lifespan and very high radiating forcing, as much as 3,000 to 13,000 times that of CO<sub>2</sub>.

From the considerations above, it can be understood how the GWP of a gas, together with its atmospheric concentration, determines its contribution to the greenhouse effect. Therefore, it can also be understood how the various gases that make up the atmosphere do not all contribute in the same way to creating the greenhouse effect: for example, molecules such as nitrogen (N<sub>2</sub>) or oxygen (O<sub>2</sub>), despite making up 98% of our atmosphere, are not capable of absorbing much radiation. The gases responsible for the greenhouse effect are those with an asymmetric molecular structure, such as methane (CH<sub>4</sub>), ozone (O<sub>3</sub>), water vapour (H<sub>2</sub>O), nitrous oxide (N<sub>2</sub>O) and fluorinated gases.

An aside must be made for carbon dioxide (CO<sub>2</sub>) which, despite having a low GWP, is nonetheless present in the atmosphere with much higher concentrations than other gases that may have much higher GWPs, and for this reason is considered one of the main causes of the greenhouse effect. Carbon dioxide interacts with the atmosphere both by means of absorption and natural emissions and via processes determined by human activity. In reality, the latter are much more limited in number than the natural processes, but are nonetheless sufficient to upset the balance of the entire system. Because of this disturbance, CO<sub>2</sub> tends to accumulate in the atmosphere, due to the fact that the ocean absorption processes are unable to compensate for the total inflow of carbon (C). The main causes of anthropogenic emissions are the use of energy from fossil fuels, i.e. petrol, coal and natural gas, which tends to increase CO<sub>2</sub> levels, as well as deforestation and changing the use of agricultural land that together lead to a reduction in the absorption capacity of the planet.

As concerns methane (CH<sub>4</sub>), it is the product of the anaerobic decomposition of organic matter and is currently deemed responsible for around 8% of the greenhouse effect. Its capacity to retain heat is 20 times that of carbon dioxide. Its average atmospheric concentration is increasing at an average annual rate estimated between 1.1% and 1.4%. The main sources of methane are swamp land, paddy fields, the fermentation of organic fertilizer, biomass combustion, the production and distribution of natural gas, carbon extraction and termites. As far as the most recent trends are concerned, there is an evident increase in methane emissions from landfills and the energy sector and, at the same time, there has been a reduction in emissions from the agricultural sector.

Finally, as regards nitrous oxide (N<sub>2</sub>O), this gas has a fairly low atmospheric concentration – around a thousand times less than that of CO<sub>2</sub> – however, it is 300 times more powerful in terms of heat retention. Despite its limited quantity, nitrous oxide concentration increased over the past few decades from 275 parts per billion (ppb) in the pre-industrial period to 312 ppb at the end of the last century. Most of the nitrous oxide in the atmosphere comes from microbiological processes. In land and water, the greatest source of N<sub>2</sub>O emissions are nitrification and denitrification processes.

### **Regional inventory of atmospheric emissions in the Veneto Region**

In terms of restricting greenhouse gas emissions, Italy has implemented the transposition measures of the EC Directive on the European Union greenhouse gas emissions trading scheme: Law no. 316 of 30/12/2004 (transposition of the EC Directive 2003/87/CE) and the Legislative Decree no. 30/2013 (transposition of the EC Directive 2009/29/CE).

In light of that disclosed thus far, it is clear that greenhouse gas monitoring and regulation are particularly important in order to make policies on air quality improvement consistent with those on tackling climate change. This study focuses on the estimated greenhouse emissions in the Veneto Region per production sector, focusing particularly on the three greenhouse gases: CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O.

The emissions estimates for the main greenhouse gases (CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O) in the Veneto Region are taken from the regional inventory of atmospheric emissions, hereinafter called 'INEMAR Veneto', a database managed since 2006 by the Regional Agency for Environmental Prevention and Protection in Veneto (ARPA Veneto), commissioned by the Regional Administrative Authority.

The inventory is one of the fact-finding tools that supports air quality management on a regional level, insofar as it gathers in a single database all atmospheric emissions estimates of a defined spatial and temporal unit, separated according to activity (e.g.

transport, animal husbandry, industry), territorial unit (e.g. region, province, municipality) and time period (year, month, hour, etc.), fuel used (petrol, diesel, methane, etc.), pollutant (NO<sub>x</sub>, CO, etc.) and type of emission (point source, fugitive, etc.).

The IT tool used to populate the Veneto regional inventory of atmospheric emissions is the INEMAR database (acronym taken from *INventarioEMissioni Aria*). Indeed, the Regional Administrative Authority has signed an inter-regional agreement for the use and development of the INEMAR database, shared with other Italian regions, with particular reference to those that are part of the Po Valley-Adriatic Basin (*Bacino Padano-Adriatico*, BPA), an area of northern Italy in which frequent episodes of severe atmospheric pollution occur, in particular concerning concentrations of fine particulate matter (PM<sub>10</sub>, PM<sub>2.5</sub>) in the winter and ozone (O<sub>3</sub>) in the summer.

INEMAR Veneto was initially developed as part of a series of cooperation agreements on the subject of atmospheric pollution which, from 2005, involved the regions of the BPA, including the Veneto Region. Subsequently, the Legislative Decree 155/2010, decree of transposition of the EC Directive 2008/50/CE, introduced the compulsory creation of an inventory by all Italian regions, to be updated every three years, and also in correspondence with the provincial timeline for the national inventory of atmospheric emissions managed by ISPRA (Higher Institute of Environmental Protection and Research), i.e. every five years (ISPRA et al., 2013).

The emissions estimates in the regional inventory are classified according to their SNAP97 nomenclature and the estimation methods refer to the CORINAIR guidelines, supplemented by regional studies and surveys and regularly updated in relation to the available edition of the Emission Inventory Guidebook EMEP/EEA.

As well as the macropollutants of interest in terms of atmospheric pollution problems (TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>2</sub>, CO<sub>2</sub>, VOC, NH<sub>3</sub>), INEMAR Veneto also included emissions estimates for three greenhouse gases: CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O for the main emissions activities of the SNAP97 nomenclature.

In particular, the latest edition of INEMAR Veneto, which provides an evaluation of the emissions produced in the year 2010 in the Veneto Region, divides the estimates into 210 activities, according to that set out in Tab. 1.

**Table 1**

List of SNAP97 activities whose emissions are estimated in the Veneto Region INEMAR 2010 edition

Code	Macro sector	no. Sectors	no. Activities
01	Combustion in energy and transformation industries	4	9
02	Non-industrial combustionplants	3	8
03	Combustion in manufacturing industry	2	18
04	Production processes	6	34
05	Extraction & distribution of fossil fuels and geothermal energy	2	3
06	Solvent and other product use	4	24
07	Road transport	5	14
08	Other mobile sources and machinery	9	14
09	Waste treatment and disposal	4	14
10	Agriculture	7	50
11	Othersources and sinks	7	22
	<b>Total</b>	<b>53</b>	<b>210</b>

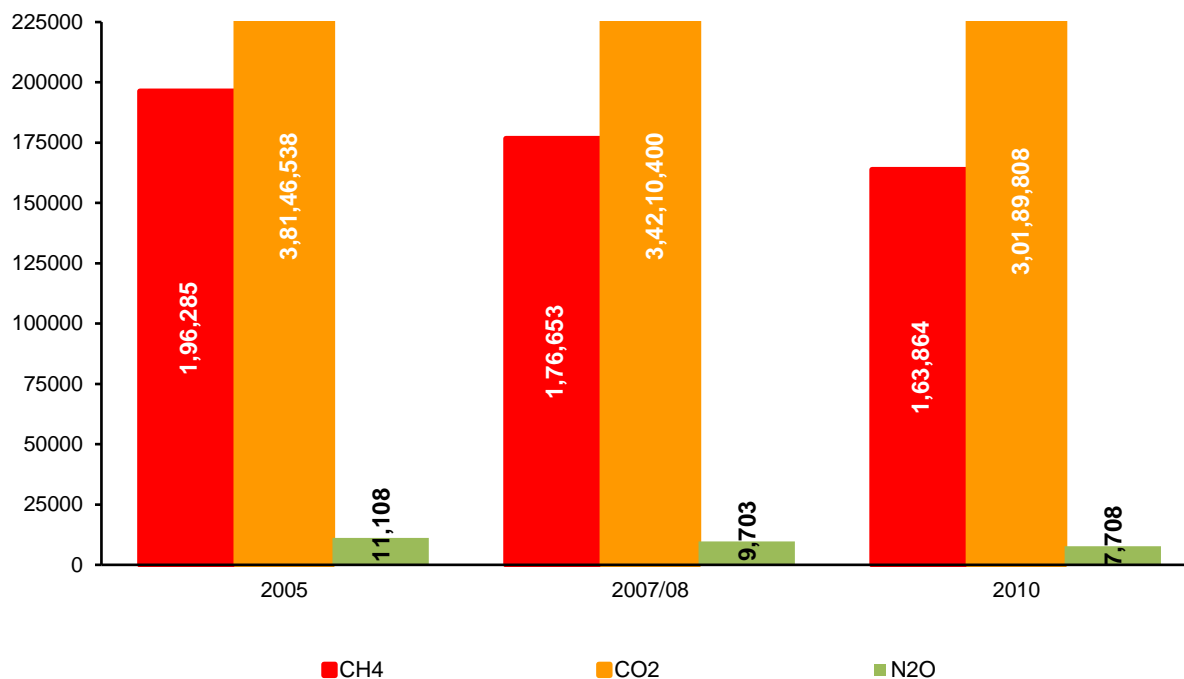
\*Classification according to "Selected Nomenclature for Air Pollution" (SNAP97) envisaged by the Coordination Information AIR (CORINAIR) project promoted by the European Union and developed by the European Environmental Agency with the aim of collecting data and information on pollutant emissions in EU countries.

### 3. RESULTS

Veneto, one of 20 Italian regions, located in the north east of the peninsular, has a population of 5 million distributed over a surface area of just over 18,000 km<sup>2</sup> and is a territory rich with anthropogenic activity of various natures (production and agriculture, important mobility infrastructures, diffused settlements).

### Greenhouse gas emissions estimates in the Veneto Region

Analysis of data collected in the INEMAR inventory in the three periods 2005, 2007/08 and 2010 demonstrates that CO<sub>2</sub> emissions are far more prevalent, compared to the other greenhouse gases taken into consideration, with over 30 million tonnes in the Veneto Region in 2010, as compared to 164,000 tonnes of methane and 7,700 tonnes of nitrous oxide.



**Figure 1**

CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O emissions in the Veneto Region (tonnes/year) – Years 2005, 2007/8 and 2010

Source: Veneto Region Data Processing – Regional Statistical System Section on definitive INEMAR data, Veneto Region 2005, 2007/8 and 2010.

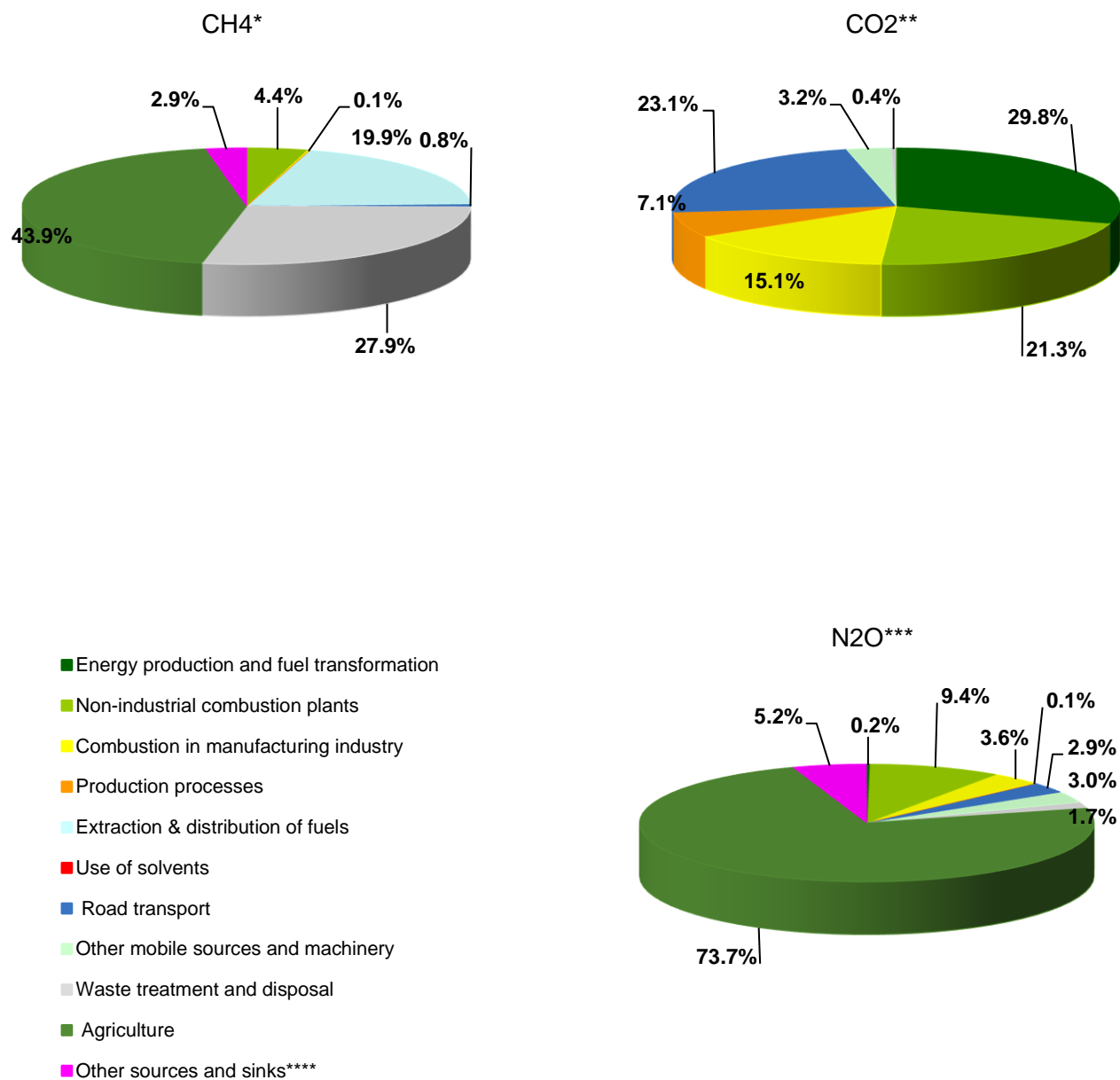
According to the regional inventory estimations, the emissions trend between 2005 and 2010 shows a decrease for the three principal greenhouse gases: -16% for CH<sub>4</sub>, -20.9% for CO<sub>2</sub> and -30.6% for N<sub>2</sub>O. This trend is indicative of the particularly difficult economic period experienced by the region, which affected both production and consumption.

**Table 2**

CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O emissions in the Veneto Region (% variations) - Years 2007/8-2005, 2010-2007/08 and 2010-2005

	2007-08/05	2010/2007-08	2010/2005
CH <sub>4</sub>	-10,0	-7,2	-16,5
CO <sub>2</sub>	-10,3	-11,8	-20,9
N <sub>2</sub> O	-12,6	-20,6	-30,6

Source: Veneto Region Data Processing – Regional Statistical System Section on definitive INEMAR data, Veneto Region 2005, 2007/8 and 2010.

**Figure 2**

CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O emissions per SNAP97 macro sector in the Veneto Region (%) – Year 2005

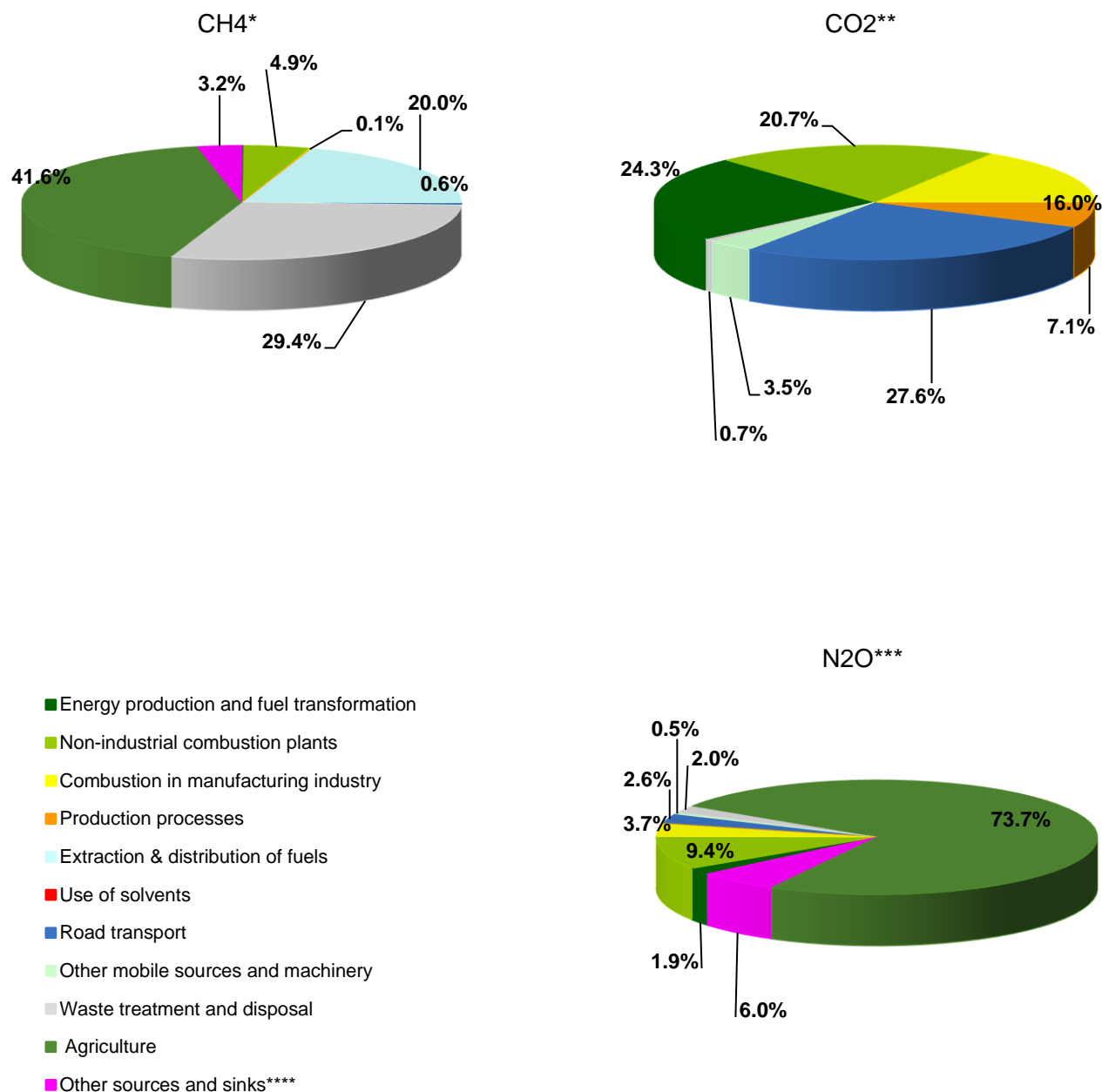
\*The macro sectors of "energy production and fuel transformation", "production processes", "other mobile sources and machinery" and "use of solvents" present either zero or insignificant levels of CH<sub>4</sub> emissions

\*\*The macro sectors of "extraction and distribution of fuels", "use of solvents" and "agriculture" do not present any CO<sub>2</sub> emissions

\*\*\*The macro sectors of "extraction and distribution of fuels", "production processes" and "use of solvents" do not present any N<sub>2</sub>O emissions

\*\*\*\*The macro sector of "other sources and sinks" is not counted in the sectoral distribution of CO<sub>2</sub> emissions, given that it presents negative emissions, i.e. absorption

Source: Veneto Region Data Processing – Regional Statistical System Section on definitive INEMAR data, Veneto Region 2005

**Figure 3**

CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O emissions per SNAP97 macro sector in the Veneto Region (%) – Year 2007/08

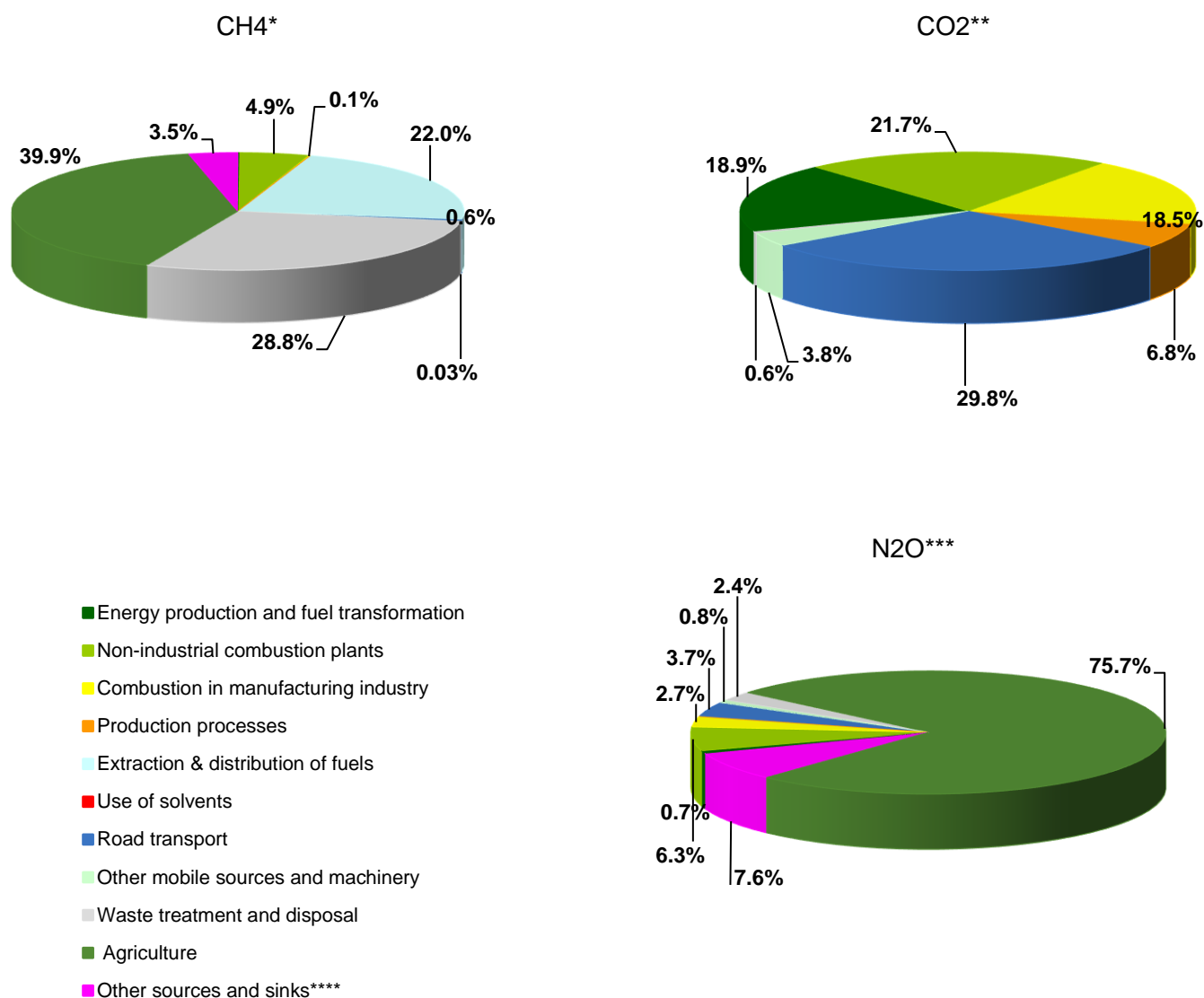
\*The macro sectors of "energy production and fuel transformation", "production processes", "other mobile sources and machinery" and "use of solvents" present either zero or insignificant levels of CH<sub>4</sub> emissions

\*\*The macro sectors of "extraction and distribution of fuels", "use of solvents" and "agriculture" do not present any CO<sub>2</sub> emissions

\*\*\*The macro sectors of "extraction and distribution of fuels", "production processes" and "use of solvents" present either zero or insignificant levels of N<sub>2</sub>O emissions

\*\*\*\*The macro sector of "other sources and sinks" is not counted in the sectoral distribution of CO<sub>2</sub> emissions, given that it presents negative emissions, i.e. absorption

Source: Veneto Region Data Processing – Regional Statistical System Section on definitive INEMAR data, Veneto Region 2007/08

**Figure 4**

CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O emissions per SNAP97 macro sector in the Veneto Region (%) – Year 2010

\*The macro sectors of "energy production and fuel transformation", "production processes", "other mobile sources and machinery" and "use of solvents" present either zero or insignificant levels of CH<sub>4</sub> emissions

\*\*The macro sectors of "extraction and distribution of fuels", "use of solvents" and "agriculture" do not present any CO<sub>2</sub> emissions

\*\*\*The macro sectors of "extraction and distribution of fuels", "production processes" and "use of solvents" present either zero or insignificant levels of N<sub>2</sub>O emissions

\*\*\*\*The macro sector of "other sources and sinks" is not counted in the sectoral distribution of CO<sub>2</sub> emissions, given that it presents negative emissions, i.e. absorption

Source: Veneto Region Data Processing – Regional Statistical System Section on definitive INEMAR data, Veneto Region 2010

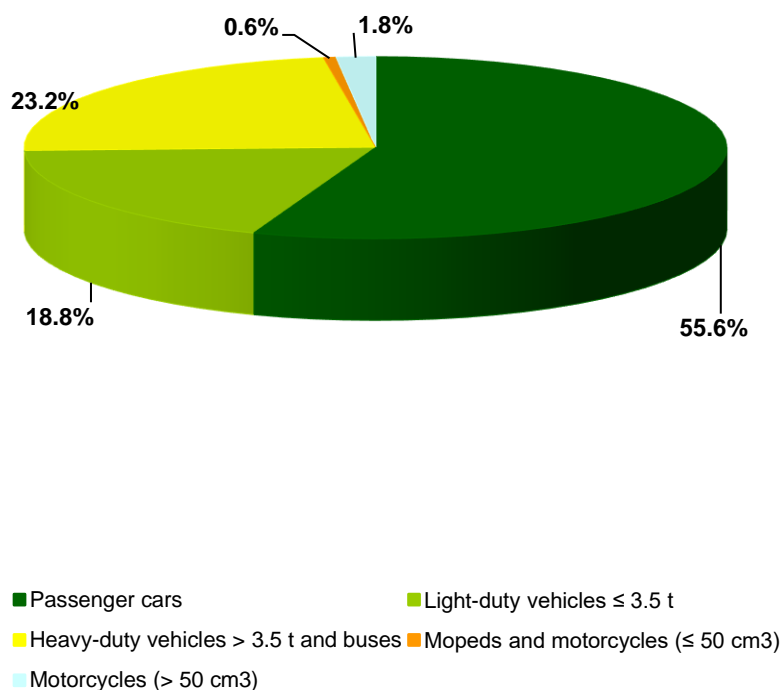
In 2010, the SNAP97 macro sectors that most greatly affect atmospheric emissions of the three greenhouse gases in the Veneto Region are agriculture, for both methane (CH<sub>4</sub>) and nitrous oxide and road transport, for carbon dioxide. In the case of CH<sub>4</sub>, the percentage contribution to emissions of the agriculture macro sector is shown to be almost constantly above 73%.

An aside must be made for carbon dioxide: in 2005, the most significant macro sector in terms of emissions was the energy production sector, which, however, recorded a significant decrease in the study period (gross production of electricity in Veneto, in fact, fell by 36.5% between 2005 and 2010), so far as to be replaced, in terms of relative weight, by the road transport macro sector, with a percentage that rose from 23.1% in 2005 to 29.8% in 2010.

Focusing our attention on the year 2010, it is interesting to analyse the distribution of the relative contributions of the SNAP97 within the macro sectors identified as being most responsible for emissions of the three greenhouse gases estimated in the Veneto regional inventory.

As far as carbon dioxide is concerned, the macro sector with the most emissions was identified as road transport: within this sector, passenger cars have the most impact, with almost 56% of emissions, followed by heavy-duty vehicles with 23% and light-duty vehicles with almost 19%. This data is certainly influenced by the large number of passenger cars on the roads, more than the pollution rate of individual vehicles, which, on the contrary, thanks to the most recent technology, present increasingly low average pollution levels. In this respect, the strategy identified to restrict CO<sub>2</sub> emissions involves, as well as further improvement of engine efficiency, the reduction of traffic by means of strengthening public transport services, and the promotion of transport sharing practices, such as car-sharing, car-pooling and the increased use of eco-friendly transport, such as bicycles, in urban centres, wherever possible.

The data for emissions estimates found in the INEMAR Veneto for the road transport macro sector are provided by ISPRA.

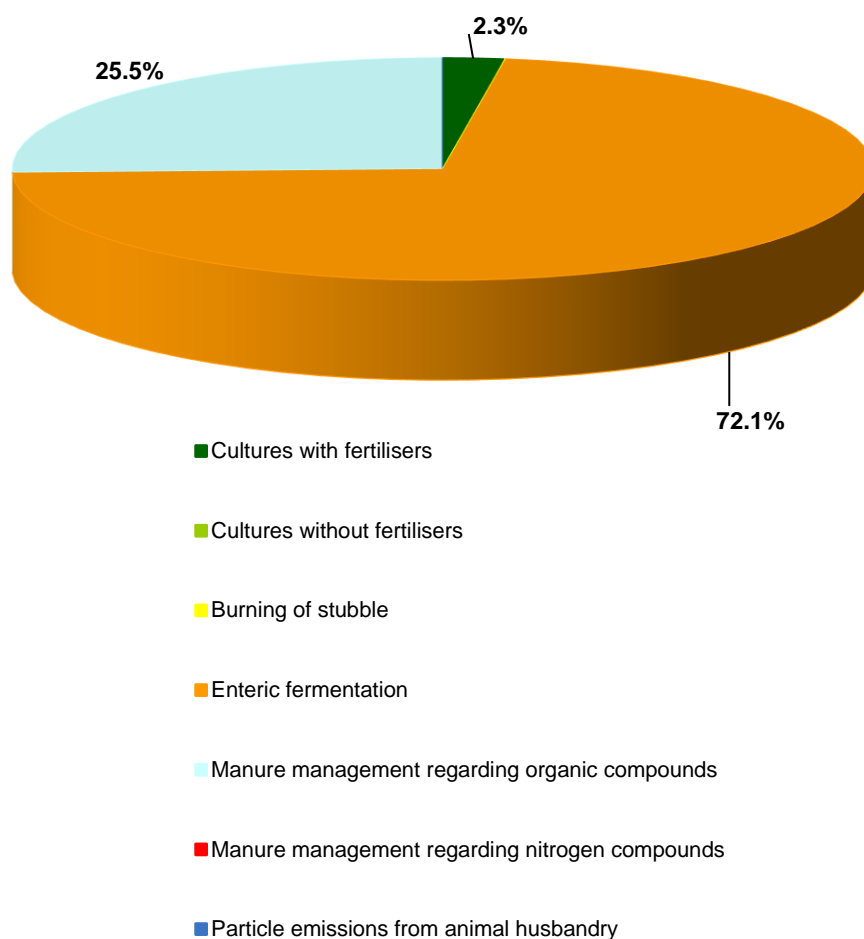


**Figure 5**

Road transport macro sector: CO<sub>2</sub> emissions per sector (thousands of tonnes/year). Veneto Region - Year 2010

Source: Veneto Region Data Processing – Regional Statistical System Section on INEMAR data VENETO REGION 2010

As concerns methane, the macro sector that makes the biggest contribution is agriculture. Within this macro sector, there are two sectors identified that, alone, emit more than 97% of the total methane produced by agriculture: enteric fermentation, with over 72%, and manure management regarding organic compounds, with 25.5%.



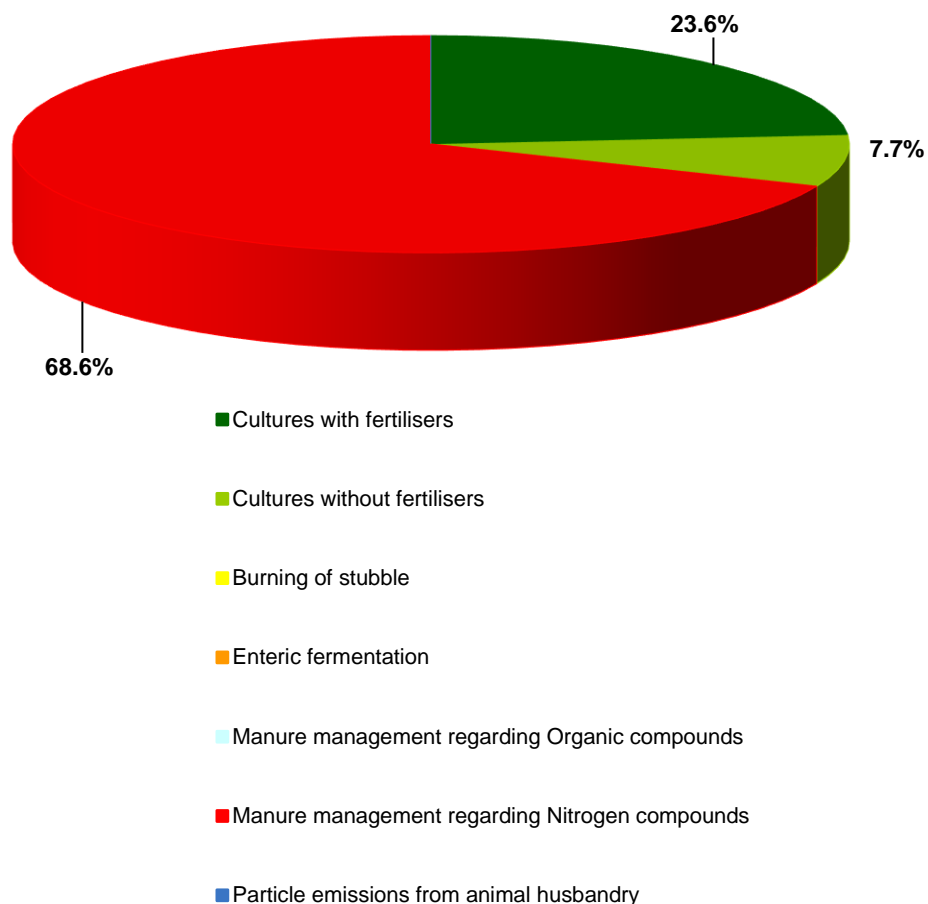
**Figure 6**

Agriculture macro sector: CH<sub>4</sub>\* emissions per sector (tonnes/year). Veneto Region - Year 2010

\*The sectors of "cultures without fertilisers" and "stubble burning", "manure management regarding nitrogen compounds" and "particle emissions from animal husbandry" present either zero or insignificant levels of CH<sub>4</sub> atmospheric emissions

Source: Veneto Region Data Processing – Regional Statistical System Section on INEMAR data, VENETO REGION 2010

Agriculture also had the highest emissions for nitrous oxide (APAT, 2005; ISPRA, Condor, 2011), even if, in this case, in contrast to methane, the sector that produces the most gas is waste management regarding nitrogen compounds, with almost 70% of the total agricultural emissions, followed by cultures with fertilisers, with around 27%.



**Figure 7**

Agriculture macro sector: N<sub>2</sub>O \* emissions per sector (tonnes/year). Veneto Region - Year 2010

\*The sectors of "burning of stubble", "enteric fermentation", "manure management regarding organic compounds" and "particle emissions from animal husbandry" present either zero or insignificant levels of N<sub>2</sub>O atmospheric emissions

Source: Veneto Region Data Processing – Regional Statistical System Section on INEMAR data, VENETO REGION 2010

As well as examining the three greenhouse gases separately, they can also be expressed in terms of CO<sub>2</sub> equivalent via the use of conversion factors to measure the capacity of a certain gas to absorb solar radiation in a certain period of time, relative to that absorbed by an equal quantity of CO<sub>2</sub> (carbon dioxide is used as a reference, thus is assigned a coefficient of 1). These coefficients are called Global Warming Potential (GWP). As we can see, methane has a GWP of 21 times carbon dioxide, whilst nitrous oxide has a GWP that reaches 310.

**Table 3**

Global Warming Potential (GWP\*) of CH<sub>4</sub>, CO<sub>2</sub> and N<sub>2</sub>O: conversion factors in CO<sub>2</sub> equivalent

Name	Formula	GWP
Methane	CH <sub>4</sub>	21
Carbon dioxide	CO <sub>2</sub>	1
Nitrous oxide	N <sub>2</sub> O	310

\*Global Warming Potential (GWP) is defined by the 'Intergovernmental Panel on Climate Change (IPCC) as an indicator that measures the contribution of the absorption of solar thermal radiation by a greenhouse gas over a certain period of time (e.g. 100 years, GWP100), as compared to the absorption of an equal quantity of CO<sub>2</sub> (that is used as a reference and is thus assigned a GWP value of 1). GWP are used as conversion factors in the calculation of all greenhouse gas emissions in CO<sub>2</sub> equivalent emissions.

Source: Intergovernmental Panel on Climate Change (IPCC)

Based on the GWP values, emissions estimates for the three greenhouse gases have been made in CO<sub>2</sub> equivalent for the three years of the study in the Veneto Region. Despite the high potential of methane and the even higher potential of nitrous oxide, carbon dioxide still prevails in final calculations, insofar as its atmospheric quantity is so great as to compensate for its lower equivalent warming potential in relation to the other two gases.

The overall emissions trend is progressively decreasing, thus displaying an encouraging trend. Furthermore, as is the case with CO<sub>2</sub>, the sector with the biggest impact changed over the three years: in 2005, it was energy production, with over 12.2 million tonnes of emissions a year; whilst in 2007/08 and in 2010, following the contraction of the energy sector, road traffic became the worst polluter with, respectively, 10.2 and 9.8 million tonnes a year.

**Table 4**

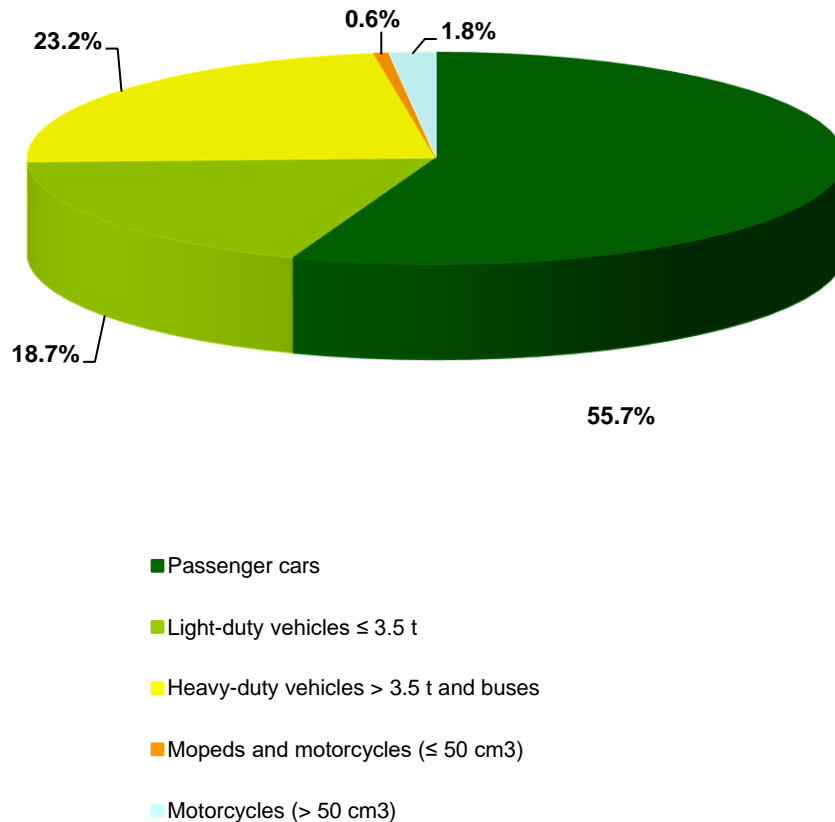
Total CO<sub>2</sub> equivalent emissions (tonnes/year\*) - Years 2005, 2007/08 and 2010

Macro sector code	Macro sectordescription	2005	2007/08	2010
1	Energy production and fuel transformation	12.241.937	8.948.030	6.166.540
2	Non-industrial combustionplants	9.222.918	8.045.838	7.371.097
3	Combustion in manufacturing industry	6.339.612	5.983.911	6.096.642
4	Production processes	2.898.527	2.599.635	2.223.937
5	Extraction&distribution of fuels	820.344	743.194	758.072
6	Use of solvents	0	0	0
7	Road transport	9.615.307	10.183.993	9.801.259
8	Other mobile sources and machinery	1.414.634	1.306.958	1.241.774
9	Waste treatment and disposal	1.367.124	1.416.722	1.241.071
10	Agriculture	4.348.712	3.760.012	3.182.717
11	Othersources and sinks	-2.557.223	-2.060.383	-2.062.642
	<b>Total</b>	<b>45.711.892</b>	<b>40.927.911</b>	<b>36.020.468</b>

\*Methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) were converted into CO<sub>2</sub> equivalent using their respective conversion factors (GWP) and then added together as CO<sub>2</sub> equivalent

Source: Veneto Region Data Processing – Regional Statistical System Section on INEMAR data, VENETO REGION 2010

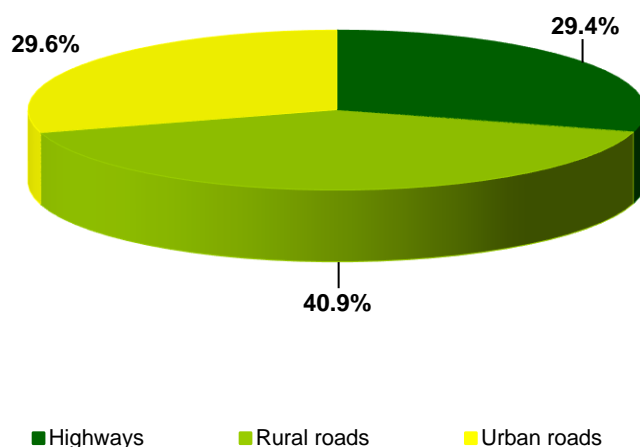
Focusing our attention on the macro sector that had the greatest emissions in 2010 in terms of CO<sub>2</sub> equivalent, namely road transport (APAT et al., 2003), the situation for carbon dioxide only serves to confirm that already highlighted, that is to say that the passenger car sector emits, alone, almost 5.5 million tonnes a year of CO<sub>2</sub> equivalent, which is almost 56% of the emissions of the whole macro sector. The sector with the second-greatest impact in terms of greenhouse gases is that of heavy-duty vehicles (>3.5 tonnes and buses) which, with 2.3 million tonnes of CO<sub>2</sub> equivalent, emits 23.3% of all road transport. Third place goes to light-duty vehicles (≤3.5 tonnes) which emit 18.7% of all macro sector emissions.

**Figure 8**

Road transport macro sector: CO<sub>2</sub> equivalent emissions per sector (tonnes/year). Veneto Region - Year 2010

Source: Veneto Region Data Processing – Regional Statistical System Section on INEMAR data, VENETO REGION 2010

Going into further detail in the road transport sector, we find three macro road types: highways, rural roads and urban roads. From the data, it emerges that the heaviest emissions come from rural roads, with almost 41%, followed by urban roads and highways, which share the remainder almost equally with 29.6 and 29.4% respectively. This predominance by rural roads can be explained by the significant amount of traffic that travels on such travel networks and by the increased average number of km/vehicle travelled by each vehicle. Indeed, each vehicle, despite travelling under more fluid running conditions compared to those typical of urban roads and thus with the engine operating more efficiently and therefore at lowest emissions per km, travels far further on rural roads per individual journey than the distance travelled on a typical urban trip, compensating for and even exceeding the total emissions per journey as compared to the average in towns and cities.



**Figure 9**

Automotive sector: CO<sub>2</sub> equivalent emissions per activity\* (tonnes/year). Veneto Region - Year 2010

\*In this case, the activity is understood to be the type of road on which the traffic travels

Source: Veneto Region Data Processing – Regional Statistical System Section on INEMAR data, VENETO REGION 2010

#### 4. CONCLUSION

Through this study we can observe how the situation relative to greenhouse gas emissions in the Veneto Region in the period 2005-2010 is improving.

Three greenhouse gases were evaluated, namely carbon dioxide, methane and nitrous oxide, characterised by different emission sources. Although methane and nitrous oxide present far superior global warming potentials, the strong predominance of carbon dioxide in terms of quantity means that it turns out to be the gas mainly responsible for the greenhouse effect. In fact, by converting the three greenhouse gases into CO<sub>2</sub> equivalent, the emissions distribution per SNAP macro sector presents characteristics very similar to that of CO<sub>2</sub>. In this respect, the biggest issue is confirmed to be road transport emissions, with particular attention to be paid to passenger cars which, despite having lower emissions factors as compared to light and heavy-duty commercial vehicles, represent the majority of vehicles in circulation and produce, indeed, almost 56% of CO<sub>2</sub> equivalent for the region.

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