The use of bio-mass: synergies and trade-offs between Climate Change and Air Pollution, in Italy

The Italian experience within the European context and the UN-ECE Convention on Long Range Transboundary Air Pollution

T. Pignatelli[1], I. D'Elia[1], G. Vialetto[1] , M. Bencardino[1], M. Contaldi[2]

(1) ENEA - Italian Agency for New Technology, Energy and the Environment
(2) APAT - Italian Agency for Environment Protection and Technical Services

Extended Abstract

Introduction

In the frame of the European Union, as well as, in the larger context of the UN-ECE Convention on Long Range Transbounday Air Pollution, in recent years, the need arose to approach simultaneously Climate Change and Air Pollution. The predominant role played by energy in the GHGs and air pollutants emissions urges the energy planners to take carefully into account energy policy choices, which might have benefits both on Climate Change mitigation and Air Pollution reduction. On the other hand, clear directions come from the European Commission, executive body of the European Union. In fact, at the European Council Meeting, held in Brussels, on March, 8-9, 2007, head of states and government have expressed the will to pursue the following targets, as a whole, within 2020:

1) 20% reduction in CO2 emissions
2) 20% share of renewable energies in overall EU energy consumptions
3) Increase in energy efficiency to achieve 20% saving in overall EU energy consumptions
4) 10% share of bio-fuels in overall EU Transport sector

At the same time, in the larger frame of the UN-ECE Convention on Long Range Transbounday Air Pollution (CLRTAP), the Gothenburg Protocol is under revision in order to establish stricter limits to the emissions of a number of air pollutants (SO2, NOx, NH3, VOC and PM2,5) with the final objective of reducing the impact of air pollution on the environment, in terms of acidification and eutrophication, and on human health, in terms of morbidity and mortality caused by the exposure of the population to ground level ozone and particulate matter.

Therefore, the energy experts have increased their efforts to include in the national energy plans new suitable sources to meet the requested targets on emission reduction. Among the measures considered there are: increased share of renewable energies (solar, wind etc.,), increased energy efficiency in engines and electrical appliances, energy saving measures and use of alternative fuels. Among these fuels, ethanol and methanol are considered a new option in the Transport Sector. Finally, the extensive use of bio-mass, both for use in the Residential Sector and for electricity production in Power Plants, is considered as an alternative option.

In this perspective, in Italy, the Italian Agency for New Technology, Energy and the Environment (ENEA) has carried out a study to explore the potential in emission reduction associated with an ambitious alternative energy scenario, in comparison with a business as usual (b.a.u.) scenario,

with the ultimate objective to achieve the environmental targets, set at international level (EU, Gothenburg Protocol and Kyoto Protocol).

Analysis Tool

The scenario analyses have been developed by the GAINS-Italy Model, an Integrated Assessment Model derived by the GAINS-Europe Model, in the frame of a joint research project carried out by ENEA and the International Institute for Applied System Analysis (IIASA), Laxenburg, Austria and supported by the Italian Ministry for the Environment, the Land and the Sea. The GAINS Model realizes a methodology usually referred as Integrated Approach, of which the flow diagram is shown in Fig. 1.

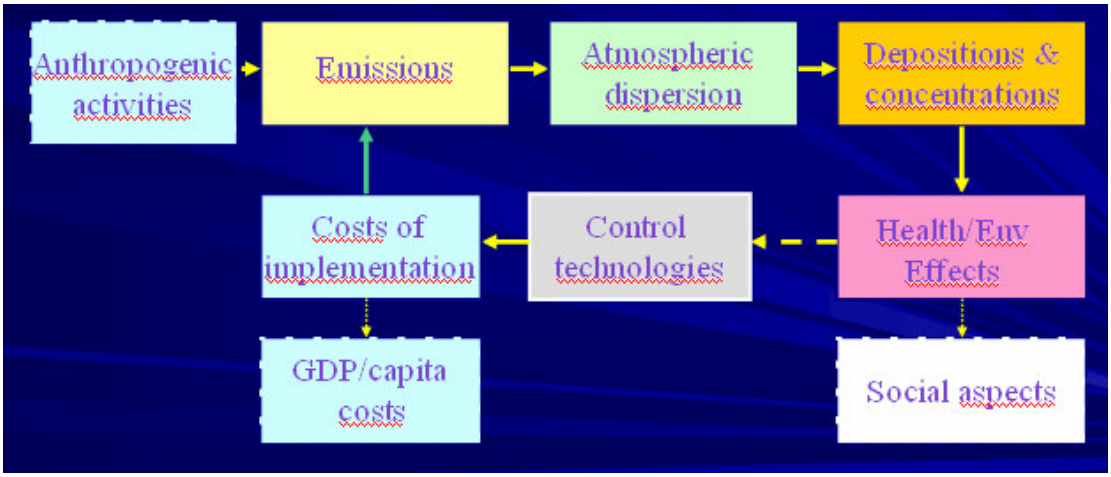

Fig. 1 – Flow chart of the Integrated Approach

The Integrated Approach considers simultaneously the functional relationships among the anthropogenic activities, the pollutant emission generation, the dispersion of the pollutants in the atmosphere and the chemistry of the atmosphere, the impact of the pollutants on the environment and on human health, the costs associated with the implementation of the abatement technologies. Through this approach, a comprehensive multi pollutant multi effect analysis can be carried out looking at the most cost-effective solution among several technical options.

The simplified flow diagram of the GAINS_Italy Model is shown in Fig 2. As input to the model, a detailed and comprehensive list of "activity data", like industry production, agriculture, livestock, solvent use and production etc, as well as, an extensive and complete energy scenario, expressed in terms fuel consumption by sector, along the time interval under analysis (typically 2000-2030), are set up by the model user. At the same time, a second dataset, concerning the penetration of the abatement technologies, in the time interval under analysis, so called Control Strategy, allow the user to take into account the constraints to the emissions, as established, for instance, in the Current Legislation (CLE scenario). As result of this complex input database, GAINS-Italy provides, as output, emission scenarios, cost analysis, depositions/concentrations maps, estimation of impact on ecosystems and human health,. For this latter impact, a correlation based upon epidemiological studies and statistical analyses, is used.

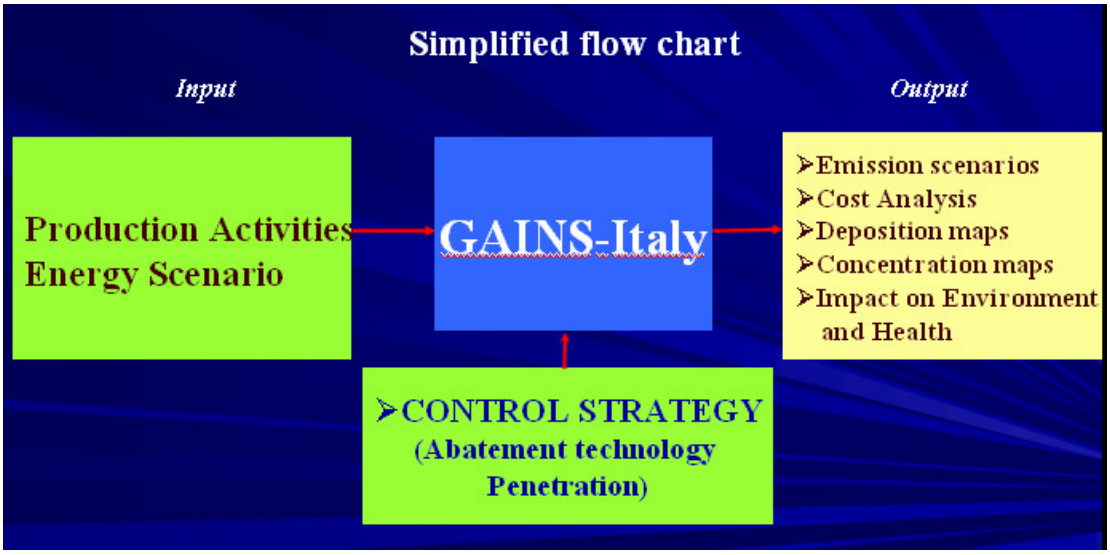

Figure 2 – Simplified flow chart of the GAINS-Italy Model

In this study, the analysis concerns the development of emission scenarios, only.

Analysis assumptions

This study is focused on the comparison of two emission scenarios. A reference "Baseline", scenario, which assumes business as usual (b.a.u.) energy projections, referred as Tende_.02 and an alternative scenario, referred as ALT_02, which assumes, in the energy scenario, an extensive introduction of higher energy efficiency in engines and appliances, energy saving, renewable energies, specifically high share of bio-mass in the residential sector, use of bio-fuels (ethanol and methanol) in the transport sector, as well as, a higher number electric vehicles, less use of coal and gas, as fossil fuels. The energy scenarios are developed by APAT (The Italian Agency for Environment Protection and Technical Services) using a proper energy model called MARKAL-Italy. Then the output of MARKAL is adequately converted to the GAING format, and finally taken as "exogenous" input data set to GAINS. The reference "Baseline" scenario is generally developed according to the directions given by the Italian Ministry for Economic Development.

All the other input data, agriculture production, livestock, industrial production etc., including the penetration, over time, of the abatement technologies (so called Control Strategy), are the same in the two emission scenarios under analysis, so that, any difference in terms of emissions, is due to the differences in energy projections, only.

Energy projection comparison

As a consequence of the assumptions seen above, in order to fully understand the results of this study, a careful comparison between the characteristics of the 2 energy scenarios is needed, first. Looking at figures 3 and 4, it is noted how the different characteristics of the scenario ALT_02, mainly have effects on the Industry, Residential, Road Traffic and Power Plant sectors. From a point of view of the fuel shares, the main differences are noted in coal, heavy fuel, diesel and gas. The ALT_02 scenario results in lower total energy consumption.

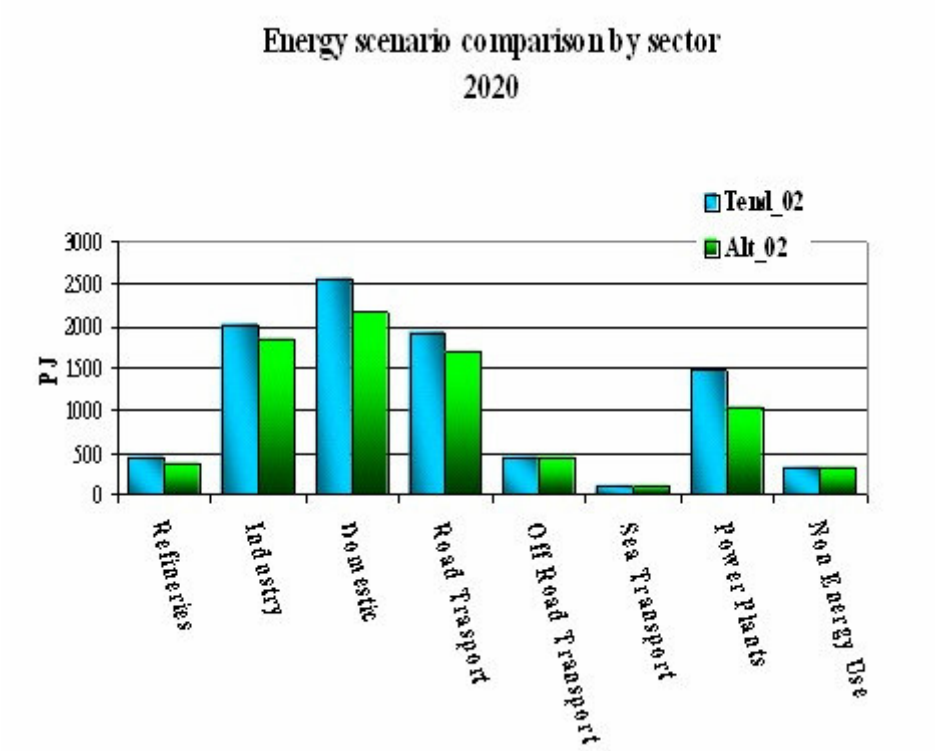

Fig. 3 - Comparison between the energy scenarios TEND_02 and ALT_02. Energy consumption by sector (PJoule), at 2020

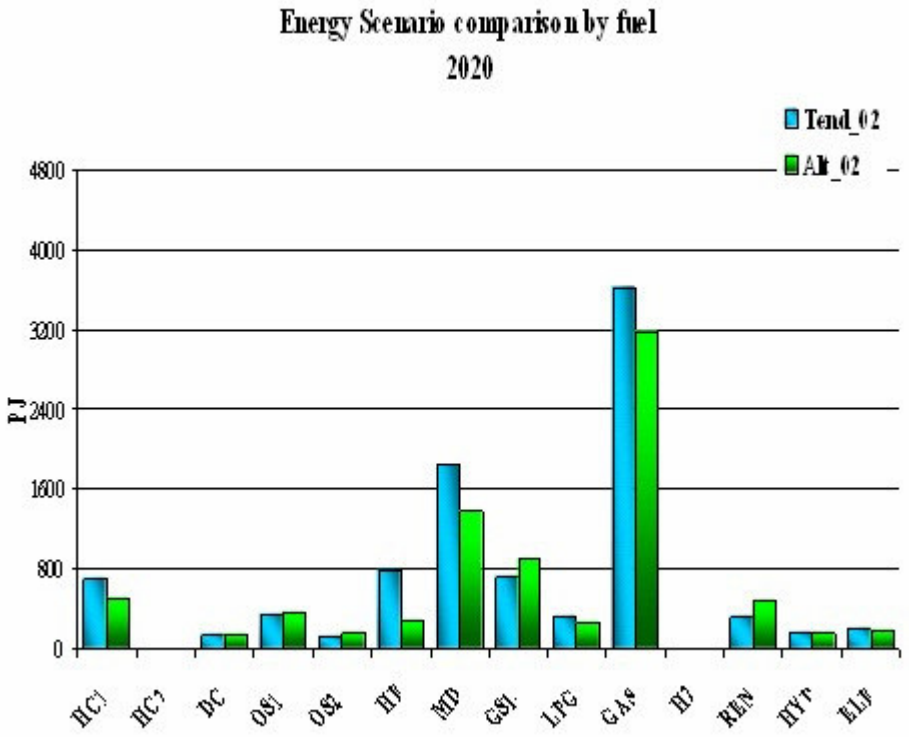

Fig. 4 - Comparison between the energy scenarios TEND_02 and ALT_02. Energy consumption by fuel (PJoule), at 2020

Emission Analysis

Taking into account the energy characteristics of the 2 scenarios, the resulting emissions are analysed, with specific attention to NOx, (as a problem of compliance with the EU Directives exists), PM and CO2. In figure 5, it is noted as the ALT_02 scenario results in lower NOx emissions, in total, notably after 2015, although in both the cases, the NOx ceiling, established at 2010 by the NEC Directive, is exceeded.

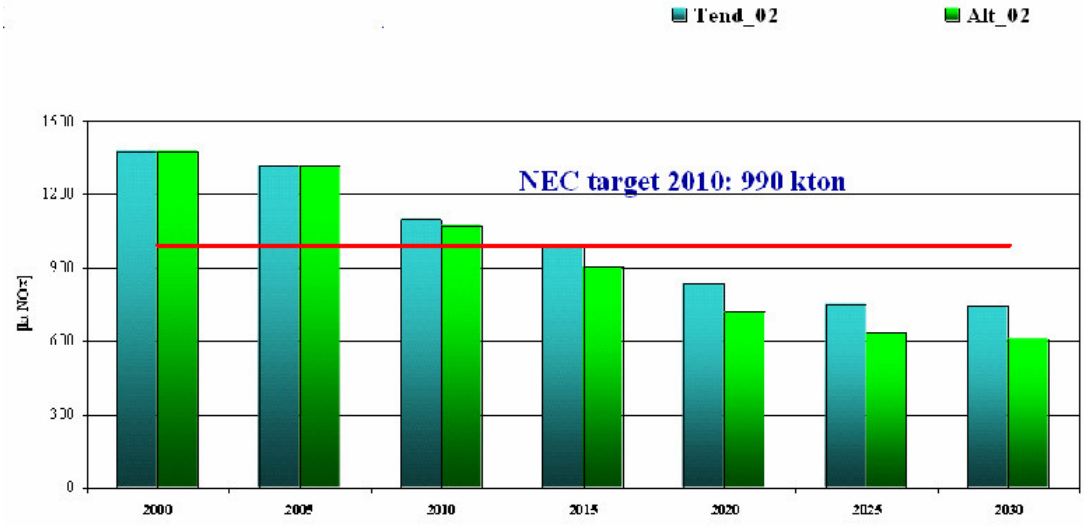

Fig. 5 – Comparison between emission scenarios TEND_02 and ALT_02.
Total NOx emissions (kt/year)

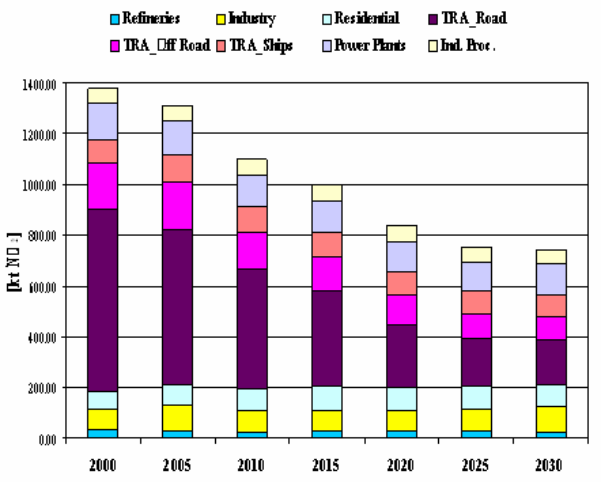

Fig. 6 – NOx emissions by sector in TEND_02 scenario

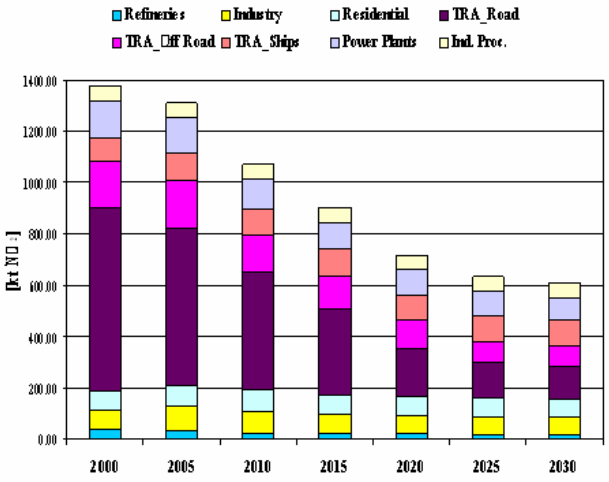

Fig. 7 – NOx emissions by sector in ALT_02 scenario

The analysis by sector, shown in figures 6 and 7, highlights how the most significant reductions are observed after 2015, especially in the Transport Sector, due to increased efficiency, bio-fuels and increased share of electric vehicles.

In figure 8, the total CO2 emissions are shown, compared between the 2 scenarios. It is noted as while in the TEND_02 scenario the trend is clearly increasing over time, in the ALT_02 scenario the trend is decreasing from 2010. In particular, al 2010, the reduction target established, by the Kyoto Protocol, would be achieved.

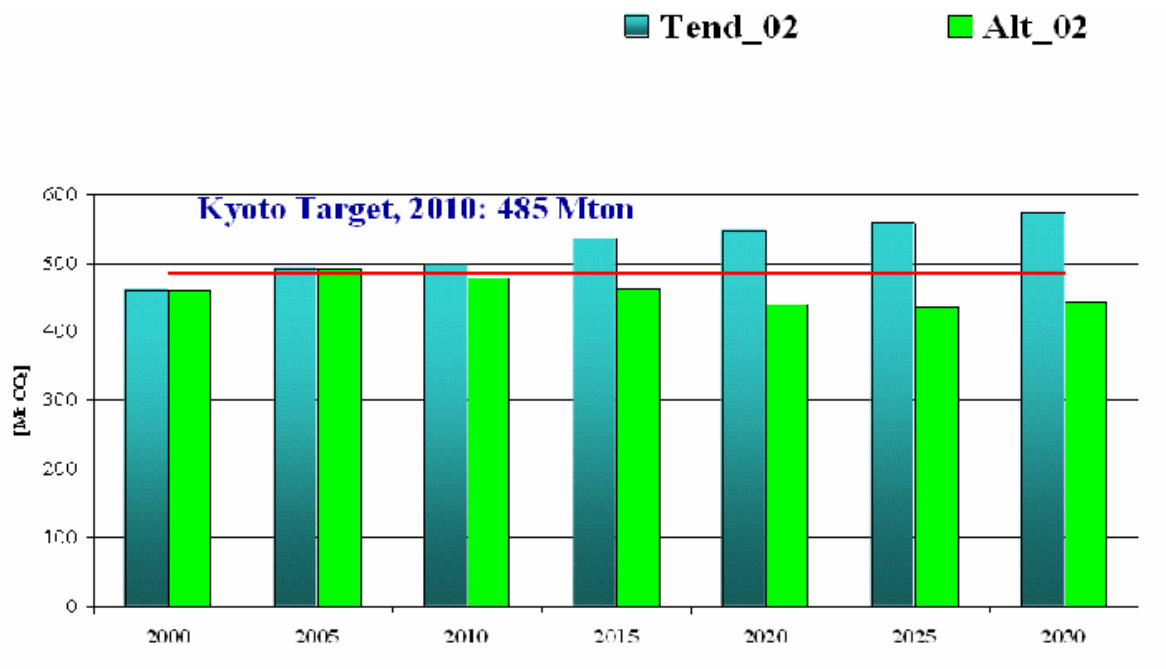

Fig. 8 – Comparison between the emission scenarios TEND_02 and ALT_02.
Total CO2 emissions (Mt/year)

For what concerns the PM emissions, reported in figures 10 and 11, respectively for TEND_02 and ALT_02. It is noted as in the ALT_02 scenario the PM emissions are even higher than in TEND_02, from 2010 on, mainly due to the contribution from the residential sector (wood burning), as shown by the light yellow segment in lower part of the bars. Considering the new expected ceiling on PM2,5 emissions, at 2020, in the revised NEC EU Directive, the reduction target established in the Thematic Strategy on Air Pollution of the European Commission, quantified in -47% the impact on human health for people exposure to PM2,5, the above result on PM emissions, in the ALT_02, scenario poses possible problems of compliance with the EU Directive and increased risk for human health, in Italy, in opposite trend with respect the envisaged impact overall Europe, according to the EU TSAP, as shown in figure 9 (maps developed by IIASA)

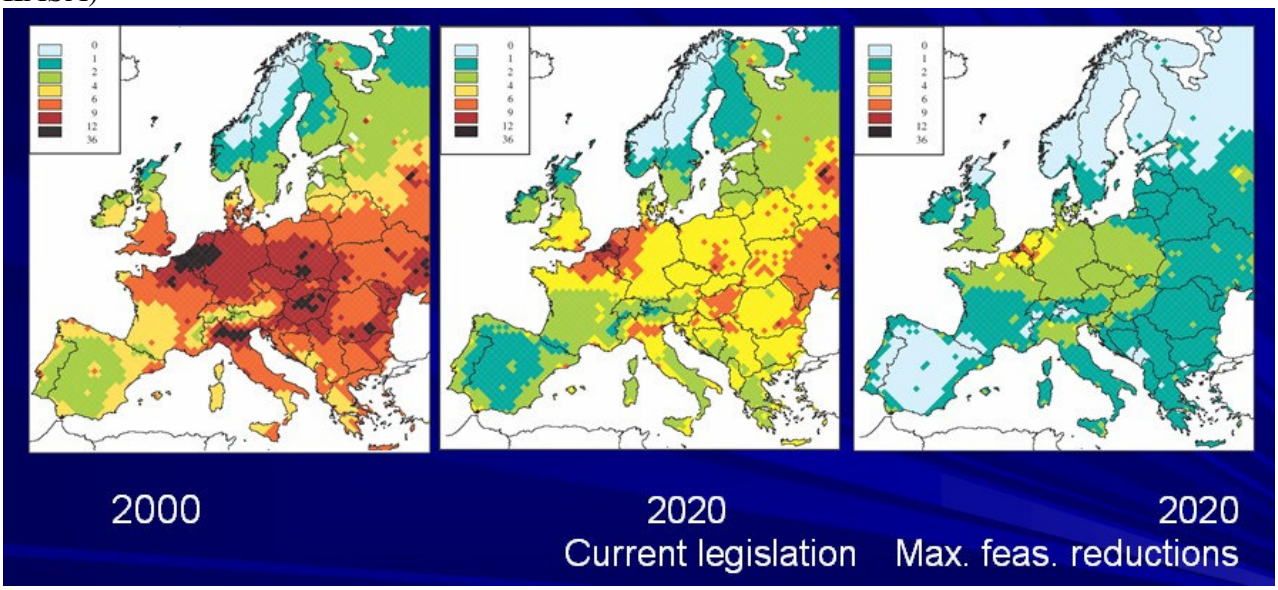

Fig. 9 – Impact on human health as in the TSAP of the EU Commission
Change in Life Expectancy Reduction between 2000 and 2020 (calculated by IIASA)

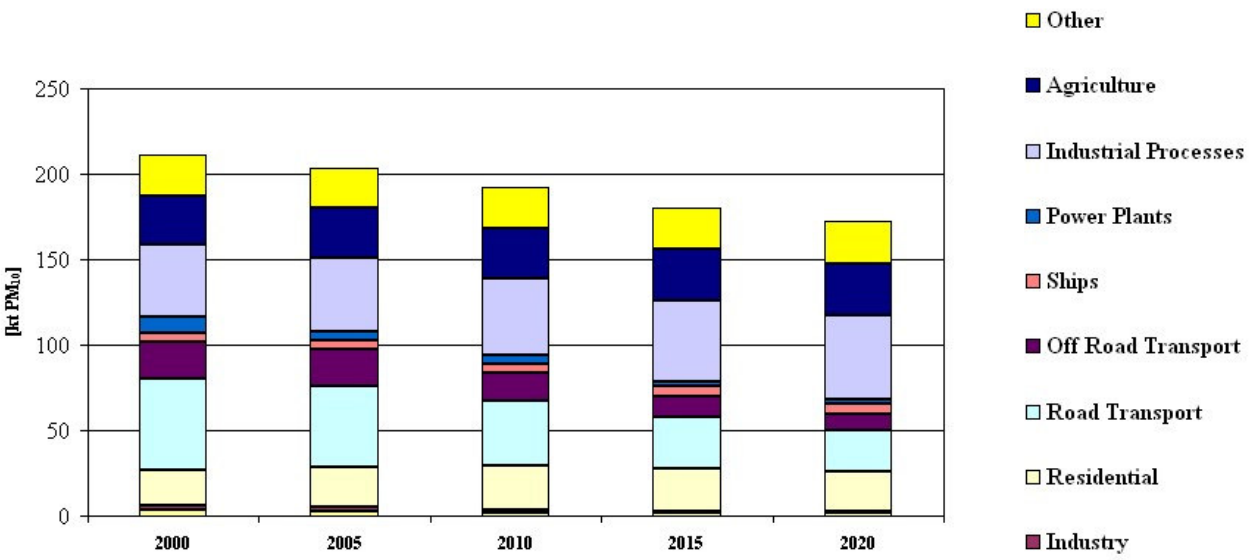

Fig. 10 – PM emission scenario TEND_02
Emissions by sector (kt/year)

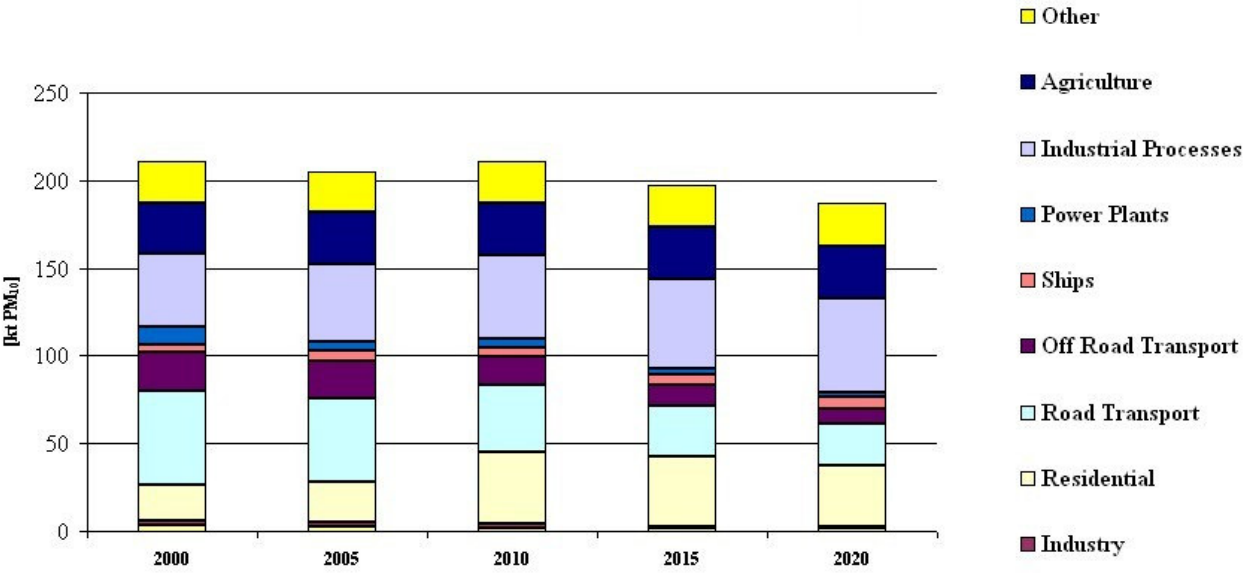

Fig. 11 – PM emission scenarios ALT_02.
Emissions by sector (kt/year)

Conclusions

Starting from the increased share of biomass in the energy scenarios, developed with the aim of achieving the environmental targets, established at international level, like the TSPA of the European Commission or the Kyoto Protocol, this study has shown how the increased use of biomass, while being helpful in reducing the CO2 emissions, on the other hand, causes increased emissions of PM. In turn, this means higher risk on human health, for the population exposed to higher PM2,5 concentrations, so outlining an opposite trend with respect what envisaged in the TSAP of the EU Commission. Considering that, in Italy, the increased share of biomass is mainly due to the increase in wood burning in stoves, for heating purposes, in the residential sector, the suggestion for the policy makers, coming from this study, is to encourage a faster penetration of the most advanced abatement technologies, in this specific sector, by introducing, for instance, fiscal subsidies on new appliances.