The Green Deal is advantageous. Benefits for the economy and employment in Italy by 2030

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EStà – Economia e Sostenibilità (in English, Economy and Sustainability) - is an independent, non-profit research, training and consultancy centre that acts as a bridge between scientific knowledge, public and private policies and active citizenship. EStà promotes innovation in environmental, socio-economic and cultural systems to imagine and create a more sustainable and inclusive society.

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ITALIAN CLIMATE NETWORK

Italian Climate Newtork is a non-profit association created to tackle the climate crisis and ensure a sustainable future for Italy. The impacts on ecosystems, society and economic activities are an increasingly urgent problem that concerns us all, without exception. For this reason, the association works to ensure that the issue of climate change becomes a priority in the public debate and occupies a central role on the national political agenda. It is daily engaged in education, dissemination and advocacy activities, from projects in schools to participation in international climate negotiations, aiming to combine scientific rigour with the ability to address different audiences. Italian Climate Network collaborates with other associations, local groups, companies and public authorities, both at Italian and international level, in the belief that the response to this great challenge can only be collective.

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Index

Presentation

Is it possible to produce more wealth, have more jobs, and reduce greenhouse gas emissions? Is it possible to shift production and employment from areas that are '*bad*' for the environment to areas that produce very low levels of CO_2 equivalent? And is it possible to do this while at the same time increasing added value and employment?
This study, coordinated by the Italian Climate Network, and carried out by EStà – economia e sostenibilità, examined the conditions for these objectives to be jointly achieved and for Italy to have more wealth and more jobs in 2030 thanks to the Green Deal.

The analysis of the productive reality between 1990 and today tells us that the national problems are represented by industrial sectors in which little is invested in technological innovation (transport, storage, energy), by a low capacity for the evolution of the private transport system and by the poor energy performance of buildings.

In order to achieve the 2050 climate targets, Italy must almost double its investments and greatly increase its public efforts, starting in the next ten years. Investments in the period 2021 - 2030 in strategic sectors must rise from the 1,000 billion envisaged in the PNIEC (National Energy and Climate Plan, approved in 2019) to the figure of 1,780 billion. By 2030, transport needs an electrification rate of at least 30% of road vehicles; renewable energy of photovoltaic panels on about 4% of the existing residential stock; as well as an annual investment in the buildings for the residential and commercial-public sectors of 21 billion.

These efforts would result in higher GDP growth of about 8% by 2030 and an increase of 600,000 jobs, stable over the decade.

Numbers that would improve further if Italy were to focus on the most high-tech *green* areas. Through the statistical-econometric survey, it has been calculated that an additional annual investment of 7 billion euro in advanced green technology, compared with the same 7 billion euro invested in technology with low innovative content, would lead to a continuous growth in hours worked and GDP, so that by 2030 there would be an additional 400,000 jobs and about 70 billion euro of GDP (4.1%).
These numbers underline the need to increase spending on research and development and efforts to industrialise patents, so that Italy does not remain at the back of the innovation queue, limiting itself to buying *green* technology produced by others.

These efforts in the industrial sector should be accompanied by a significant increase in the carbon sink capacity of both agricultural land, through conservation agriculture techniques, and forests, through better forest management and timber utilisation.

These actions would have the dual benefit of reducing emissions and increasing natural removals, playing a strategic role in achieving full climate neutrality by 2050.

The economic efforts would not only have positive effects in terms of GDP and employment: the hidden (environmental and social) benefits are numerous: reduced air pollution and a positive effect on the health system as well as an increase in the health of soils and forests.

Introduction

Objectives and main results of the study

Is it possible to produce more wealth, have more jobs, and reduce greenhouse gas emissions? Is it possible to shift production and employment from areas that are '*bad*' for the environment to areas that produce very low levels of CO_2 equivalent? And is it possible to do this while at the same time increasing added value, i.e. the amount of wealth embedded in each individual good and service, and increasing employment?

This study, carried out by the Està - economia e sostenibilità association for the Italian Climate Network, analysed the conditions for these objectives to be achieved jointly and for Italy to achieve climate neutrality in its economy by 2050 with more wealth and more jobs.

As a first step, the study examined the current features of the national production system and the changes that have taken place since 1990.

The time series tell us that ***Italy has been able to improve the performance of its industries in terms of CO_2 equivalent emissions in recent decades.*** Contrary to what may be commonly thought, industries as a whole do not appear to be the main problem in our country today: over the last thirty years, the manufacturing industry as a whole has halved the tonnes of CO_2 emitted, partly as a result of a major economic crisis which, after a number of years, has led to a sharp rise in the number of people emitting CO_2.

As a result of a severe economic crisis that after 2008 caused the most backward, least profitable and most polluting production to disappear.
While the industry as a whole is dynamic, ***the main problems in Italy today are represented by industrial sub-areas in which little is invested in technological innovation (transport, storage, energy), and by other sectors, in particular passenger transport and the vast area of poor energy efficiency in buildings. Transport and buildings not only emit four times more than manufacturing industry as a whole, but have even seen their tonnes of CO_2 equivalent increase since 1990.*** And while companies - not just industrial ones – were reducing their impact, the households continued to have polluting cars and energy-inefficient buildings for their private use, raising the costs of climate change.

Given this present structure and these general trends in the recent past, ***the study tried to analyse Italy's needs and priorities for the future***, i.e. the sectors in which priority investment is needed and the related spin-offs in terms of wealth and employment. ***In order to do so, it compared the objectives and strategies of the main European documents*** (European Commission's *Long term strategy* 2018 - with related technical analysis; the EC 2019 *European Green Deal Communication*) ***with the data and measures envisaged at national level***[1] by the National Integrated Plan for Energy and Climate (NIPEC 2019). On the one hand, the need to focus on buildings, transport and energy production was confirmed, and on the other hand, the need to greatly increase public investment and efforts. Transport requires at least double the rate of electrification of road vehicles as forecast by the NIPEC for 2030 (i.e. 30% instead of 15% of the existing building stock) and buildings need an annual investment in the residential and commercial-public sectors of two and a half times the NIPEC assumptions (i.e. 20.7 billion). From a renewable energy point of view, the strategy of widespread electricity and electricity production mainly through photovoltaics (which is expected to provide 80% of electricity by 2050) appears to be the most appropriate way forward. The study shows that the increased final demand for electricity consumption by 2030 resulting from the decarbonisation of the residential and transport sectors could potentially be met jointly by installing photovoltaic panels on around 4% of the existing residential building stock within ten years.

The study therefore assesses the opportunities, employment spin-offs and increases in wealth that would be produced if investments and policies in the transport, building and energy sectors were followed in line with the final objective of Italy's climate neutrality by 2050 and the related intermediate objectives by 2030. Assessments have been made using multipliers of wealth produced and

1 *There* are *two important differences between European and national documents*. On the one hand, the *data base* of EU documents is hardly ever geo-localised and it is therefore necessary to use national sources. On the other hand, *the policies that* can be implemented at European level differ from those that can be implemented at national level; in particular, there is a significant difference between the ETS (European trading system) economic sectors and the ESR (Effort Sharing Regulation) economic sectors. The former, which include energy production industries, energy-intensive industrial sectors and aviation, are not subject to direct state intervention, while all the others remain subject to it. The reference Directive is 2018/410/EU and sets out the rules for the operation of the European Emissions Trading Scheme (EU-ETS) for the period 2021-2030.

employment effects developed by ISTAT and ENEA for different sectors. The results and details can be found in the final chapter, but in brief it can already be said that assuming the above multipliers and adapting them to the revision of investments needed to bring the reduction of climate-changing gases from 40% to 55% between 1990 and 2030, it is reasonable to assume that over the next decade we can see an increase in GDP growth of 8% and an increase of 600,000 jobs, stable over the period and concentrated in the construction, transport and renewable energy sectors. Employment impacts also need to take into account the loss of workers due to fossil fuel divestment. However, the simulations estimate the direct impacts of this divestment to be relatively small: about 5000 average annual work units (80% concentrated in the production/distribution of fossil energy and thermal energy for the residential and tertiary sectors) and a "permanent" decrease of just over 60,000 active work units (AWU).

The ***final chapter analyses another element of great importance for Italian policy choices and the related impact on employment: the technological innovation content of investments.*** In order to understand its importance, it is necessary to consider that each production chain is made up of a series of stages: a photovoltaic panel has to be conceived, designed, manufactured, sold, implanted, maintained and finally decommissioned. Each step in this chain corresponds to the production of added value and employment, but the quantity of added value and the quality of employment are higher in some phases (those with a higher technological content) and lower in others (installing panels on roofs does not have the same impact on wealth and employment as patenting and producing next-generation panels). To understand the implications of these realities, the study used an original statistical and econometric methodology, and conducted a simulation of the impact that the same amount of money would produce depending on the technological content of the investment. In particular, the study estimated that an additional annual investment of 7 billion lire in advanced *green technology,* compared to the same 7 billion invested in technology with a low innovative content, would produce an additional 400,000 jobs and about 70 billion of GDP (about 4.11%) in Italy by 2030. This is a further element of reflection and direction for the *policies* that the national system needs.

Methodology

The study investigated the various issues with the help of economists, engineers, architects, chemists, geographers, agronomists and experts from the world of work, and arrived at the above-mentioned substantive results through a number of methodological choices which are briefly summarised below.

First, it is necessary to underline how, in order to investigate the achievement of climate neutrality by 2050 for Italy, it has been necessary to recombine a series of ingredients, of which energy is clearly the most important, but not the only one. The study therefore also investigates ***the*** so-called carbon ***'sink' sectors*** (agricultural soils and forests), showing how serious action in this area is essential to achieve the final goal. To date, Italian forests continue to increase spontaneously their extent and CO_2 removal capacity, which has now constituted a carbon stock equal to all the annual CO_2 emissions of the entire EU-27. Practices aimed at consolidating these dynamics are of great importance in achieving decarbonisation. Similarly, quantitatively important objectives can be achieved through the spread of so-called conservation agriculture (see chapters 6 and 7).

Among the "emission" sectors, energy is both the most relevant in quantitative terms ***and the most complex to examine***. This study has attempted to do so by analysing it through both the ***production of goods*** and the ***consumption*** sub-sectors.
However, the scope of consumption is itself so large that it needs to be broken down into sub-sectors, and the study has dedicated specific analyses to the main ones: in Chapter 3 to the ***buildings*** sub-sector (households are large consumers of energy from air conditioning and, to a lesser extent, energy for lighting and electrical appliances, cooking and hot water) and in Chapter 4 to the ***transport*** sub-sector (through which both businesses and households produce large amounts of CO_2-eq).

Emission sectors other than energy production and fossil energy consumption, added together, account for about 20% of total greenhouse gases. They include non-energy intensive industries, the waste sector and the agricultural sector. The latter has impacts on both emissions and CO_2-eq reductions. Agricultural fields are naturally devoted to ***absorbing*** carbon, but farming and livestock breeding on the one hand directly produce climate-changing gases (nitrous oxide and methane in particular) and on the other consume energy and emit CO_2 through the use of agricultural machinery.

Having defined the field of physical phenomena and the sectors into which they can be classified, the study looked at ***the*** main ***regulatory aspects and institutional programmes*** for combating climate-changing gases, in order to understand the scope of the analysis and clarify the points of reference.
An initial reference was made by following the division produced by the EU between ***ETS[2] sectors*** (including energy producing industries, energy intensive industries and aviation) where EU action is required, and ***ESR[3] sectors*** (other transport, non-energy intensive industries - tending to be SMEs, buildings, waste, agriculture) where policies are the responsibility of individual states. This division has been kept in mind throughout the study, although economic data are not available in unbundled form between ETS and ESR sectors, leading to the need for some *ex-post* estimates.
A second reference was the aforementioned ***NIPEC***, the national integrated plan for energy and climate, produced by the Italian government in 2019 and containing measures to implement ESR policies in our country. The study confronted the NIPEC critically: it examined its analyses and measures and often made more advanced proposals, in line with a target of 55% CO_2-eq. reduction between 1990 and 2030, rather than with the current target of 40%, which is considered insufficient by the European Commission,

2 Emissions Trading System (ETS),
3 Effort Sharing Regulation (ESR)

which is now aiming at 55%, as well as by the European Parliament, which recently moved towards 60%.

At the same time, the study had to deal with another essential reference point and constraint: the ***statistical data available for economic analysis***, the most important of which were the ISTAT NAMEA data. The data produced a number of structural problems, linked both to the way in which they were combined and to the lack of sufficiently long and homogeneous time series. In order to overcome these problems, processes of reorganisation of the categories have been carried out (see chap. 1), trying to adapt the economic categories as much as possible to the environmental ones.

The normalised and recategorised data in Chapter 1, together with the NIPEC database and the multipliers on value-added and employment from ISTAT and ENEA, were used in Chapter 8 for calculations on investment, jobs and overall and sectoral wealth increases. In the same chapter, EStà used the most advanced statistical and econometric techniques to estimate the possible socio-economic impacts if investments were oriented towards more advanced hi-tech areas than the present.

The forecasting horizon assumed was almost unequivocally 2030 and not 2050 (except in the renewable energy analyses). This choice was dictated by methodological necessity. The history of this type of analysis is too recent to be able to hazard statistical or other forecasts over excessively long periods, and the complexity and interrelationship of the variables (as demonstrated by the Covid-19 pandemic) would in any case make the effort worthless. In support of this thesis, it should be noted that the European institutions themselves set 2030 as a first milestone against which to measure whether the path towards decarbonisation is going in the right direction and at the right speed, limiting themselves to general targets for the more distant dates that are less translatable into current plans.

A note on methods

Given the large margins of uncertainty already mentioned and the fact that it is not possible to predict the unpredictable, the study has taken the greatest possible precautions: declaring its limitations and equipping itself with the most solid and transparent system for making the best approximations, at the current stage of knowledge.
In any case, the figures proposed in this study are not intended as forecasts, but either as simulations of scenarios carried out - transposing the conditions and knowledge of today’s date to 2030 and, where possible, to 2050 - or as policy suggestions, constructed using the same method.

Finally, it is always worth remembering that an economic system - even if one does not want to consider its environmental implications – is more complex than a set of proposals on what to produce and how. Other very important variables, such as the behaviour of the demand for goods or the relationship with foreign countries, would deserve in-depth studies that are inevitably beyond the scope of this study.

STUDY DESCRIPTION

1 ANALYSIS of the current economic situation and identification of trends

2 COMPARISON with institutional policies

The National Integrated Energy and Climate Plan (NIPEC) 2030

Does it meet the EU 2050 targets?

3 GUIDELINES ON:

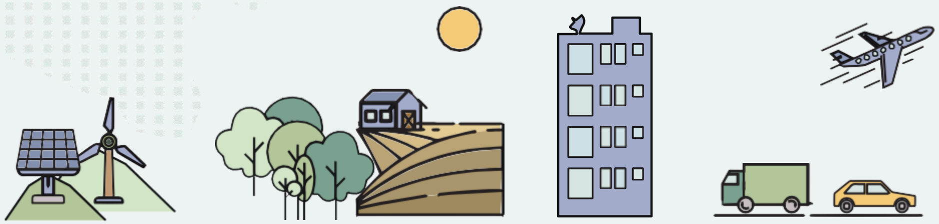
- Investments
- Cross-cutting policies
- Sector policies:

renewable energy development

forestry and agriculture

consumption of buildings

transport consumption



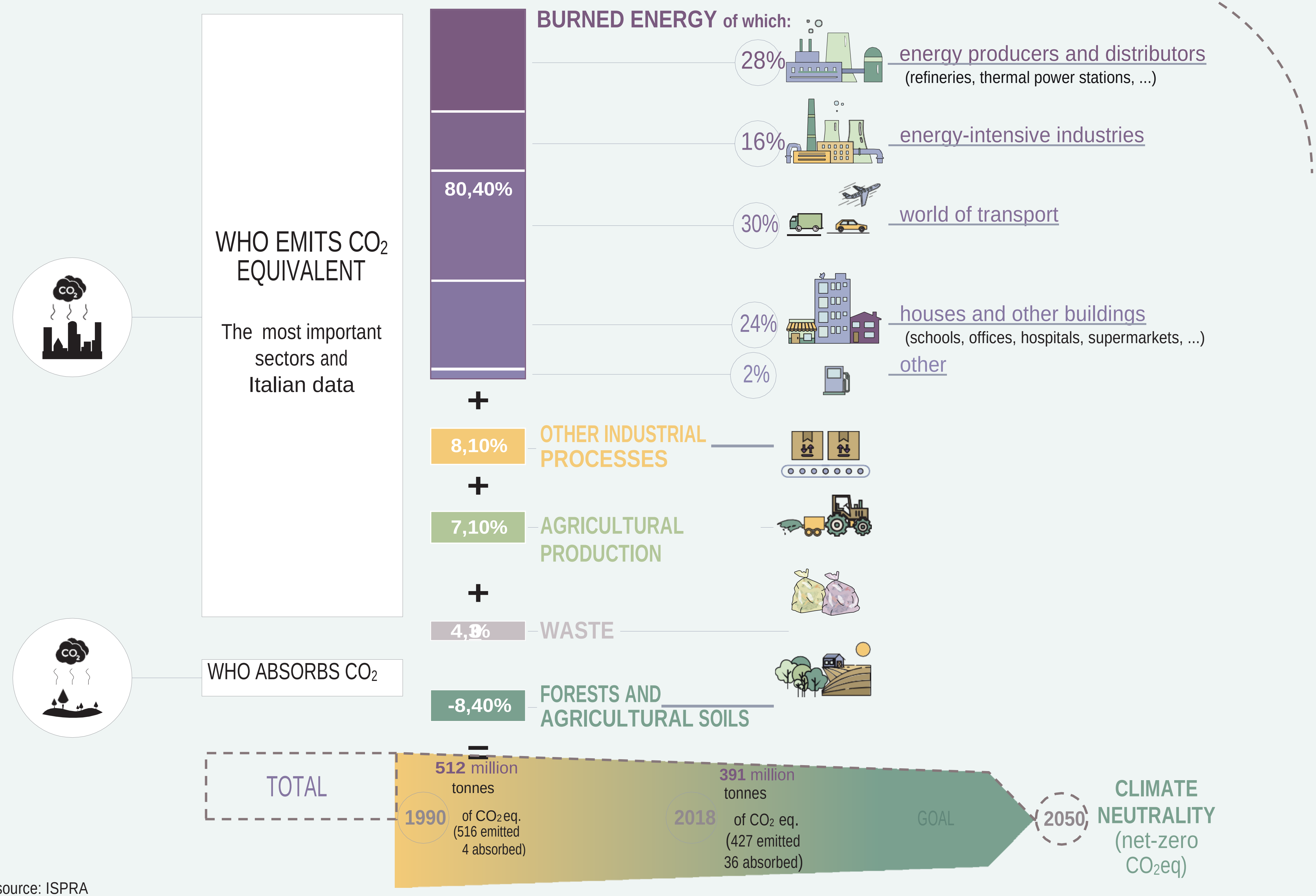
SURVEY PARAMETERS

Employment effects

Increased added value

Reduction in CO_2 equivalent

OBJECT OF THE INVESTIGATION



Data source: ISPRA 2020

part one:

EMISSIONS

Key points

The historical-economic analysis of the national structure shows that on the production side **Italian industry has reduced its** CO_2 eq. emissions by 40% **from 1990 to 2018**. This was also due to the post-2008 crisis, which drove the most backward and polluting companies out of the market. Overall, research, development, and investment in the most technologically advanced sectors have proved to be the best strategies for reducing climate impact, while at the same time increasing the wealth produced (i.e. added value, or GDP) and employment.

On the consumption side, **Italian households increased their** CO_2 eq. **emissions** between 1990 and 2018 in both the transport and building sectors.

On the **production side,** 75% of the industrial sector's climate impact is now concentrated in sectors that account for 11% of the sector's total wealth (added value) and 9% of employment.

On the **consumption side**, the transport sector (which includes passenger transport by households as well as freight and passenger transport by companies) and the building sector (primarily heating and cooling of households) now emit more CO2 eq. than the entire industrial sector. This is also due to the low climatic quality of the transport and air conditioning supply available to households in Italy.

Renewable energy in Italy is to be produced mainly through photovoltaic panels and solar power in general, which could cover 80% of energy production by 2050, thanks to the vast areas where panels could be placed. Solar production would be combined with energy saving and storage systems based on lithium and hydrogen batteries to provide the basis for full climate neutrality by 2050. Depending on the level of investment in research and development and in the industrialisation of advanced technology, Italy will be able to achieve not only the use of the goods necessary for the spread of renewable energy, but also a consequent level of production of the same goods. This dynamic would lead to better results in terms of added value and employment.

The construction sector is fundamental because Italy's heritage offers great opportunities for improvement as it lags far behind in terms of energy performance. In contrast to other sectors, in this case the job spin-offs, at least those related to the optimisation of envelopes and the implementation of the most advanced climate control systems, would be largely domestic. However, in this field, even more than in others, the commitments envisaged by the NIPEC seem insufficient.

The **transport sector** needs a thorough overhaul of the model currently in place in our country. There is growing interest in collective mobility, but the range of services on offer is dwindling, and the closest solution to achieving climate neutrality would appear to be the conversion of the fossil fuel-powered vehicle fleet to electric vehicles, combined with an increase in rail transport for the freight sector. As in the case of renewable energies, the impact in terms of employment and added value depends on the extent to which our country is able to produce, as well as use, the means necessary for the climate transition.

The waste sector appears to be the least significant, both in terms of the amount of climate-altering gases produced and the overall positive trend that have been taking place in recent years. The main problem appears to be the lack of plants for the treatment of separate waste collection, an issue that is particularly evident in the central and southern Italy. A growth in plants and separate collection consistent with the national average could lead to an increase of a few thousand jobs and a further reduction of a quarter of the sector's current emissions.

1. CO_2 in Italian companies between 1990 and 2018

A comprehensive change programme

Planning the *Green Deal* does not only mean 'planning' innovation, but also implies an ability to make targeted and conscious choices with respect to factors that affect society and the environment as a whole. In fact, the *Green Deal* involves a structural challenge comparable with that of the first industrial revolution. A challenge of this level cannot be left to the market alone, but rather deserves a plan for a new national structure (public-private) upon which to assess the investments needed to implement the *Green Economy*. The complexity of this techno-economic challenge would suggest, in the first instance, the creation of a *National Innovation System*, i.e. a "place" in which businesses and research (public and private) can coherently design a plan of investments with high technological intensity and increasingly reduced environmental impact, seeking to evolve the specialisation of the Italian economic system, which is currently underdeveloped and therefore capable of producing less additional wealth and less decarbonisation than other countries. ***Less technological sectors have recorded higher emission levels*** despite the fact that greenhouse gas emissions have decreased (insufficiently) since 1990 in the European Union. Policies, therefore, should prioritise measures aimed at modifying CO_2 emissions in the most polluting sectors, through the intelligent use of available and programmable technologies, together with measures to support goods and services with a lower climate impact[1].

Industrial supply must play a fundamental role, not so much and not only because of the environmental performance of its plants (overall a net improvement compared to 1990), but because the qualitative change in production, conditioned by *green* demand, would influence the production structure as a whole. ***Nevertheless, there is one aspect that has so far been underestimated, and that is the need to condition even the incompressible consumption[2] of households***. In fact, the CO_2 attributable to households is linked to this category of consumption (home, food, appliances...) which by their nature cannot be reduced beyond a certain threshold; otherwise, the overall acceptable well-being would be called into question. As can be seen in Figure 2, unlike the Italian economic system as a whole, there has been no significant reduction in the equivalent CO_2 emitted by households over the last 30 years.

1 Ferrari S., 2014, *Società ed economia della conoscenza,* Mnamon, Rome.

2 It is generally thought that primary goods (and as such 'incompressible') are not influenced by the historical-social context in which people live, since these goods are offered above all to satisfy mankind's physiological and survival needs (eating, drinking, protection from the cold, etc.). The boundary between primary and secondary needs is actually not only dictated by human physiological needs, but also by what is considered 'ordinary' by the society where we live and the ways in which needs are satisfied. Throughout history, economic and social progress has radically altered the quality of life. What is not considered a primary good in one era (e.g. running water in the home) may be considered a primary good in the next. In Western countries (Europe, the United States, etc.), running water in the home was a luxury good in 19th century homes, while it was a primary good in European homes in the second half of the 20th century. In many other parts of the world, running water in the home remains a luxury or voluptuary good even today. In conclusion, the set of primary goods is strongly determined by society.

For the *Green Deal to* be fully effective, a new generation of available 'uncompressible' consumer goods (i.e. those that households find it hardest to give up) would also be needed. Therefore, it would be desirable to have a specific public action to guide and facilitate households in the transition.

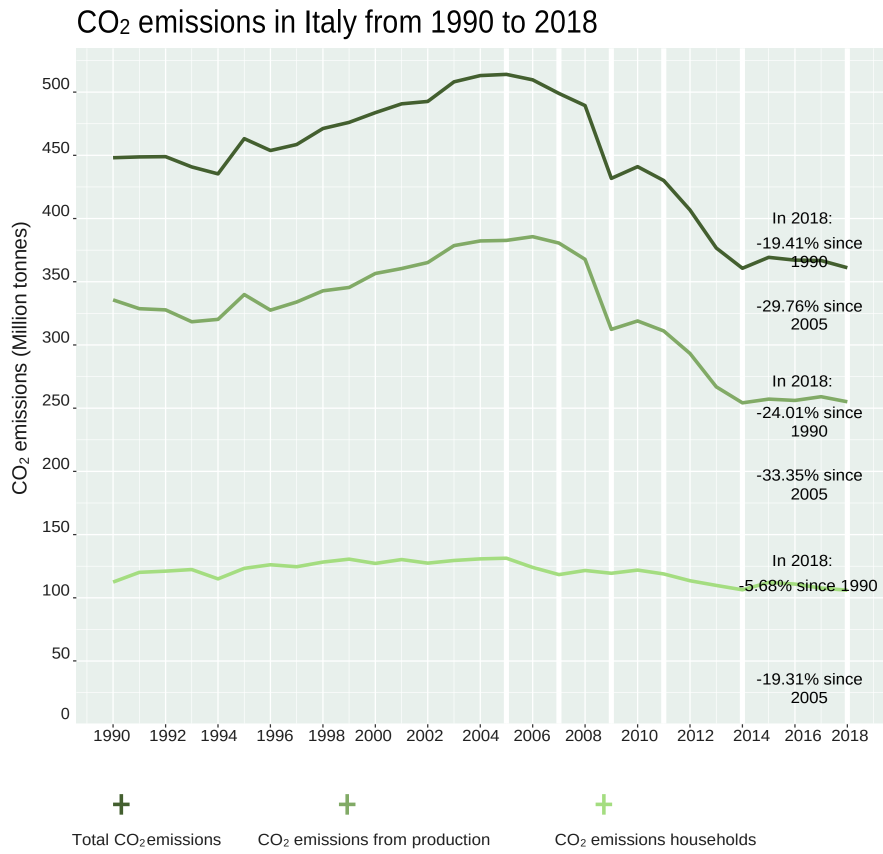


Figure 2 - CO_2 emissions by households and activities

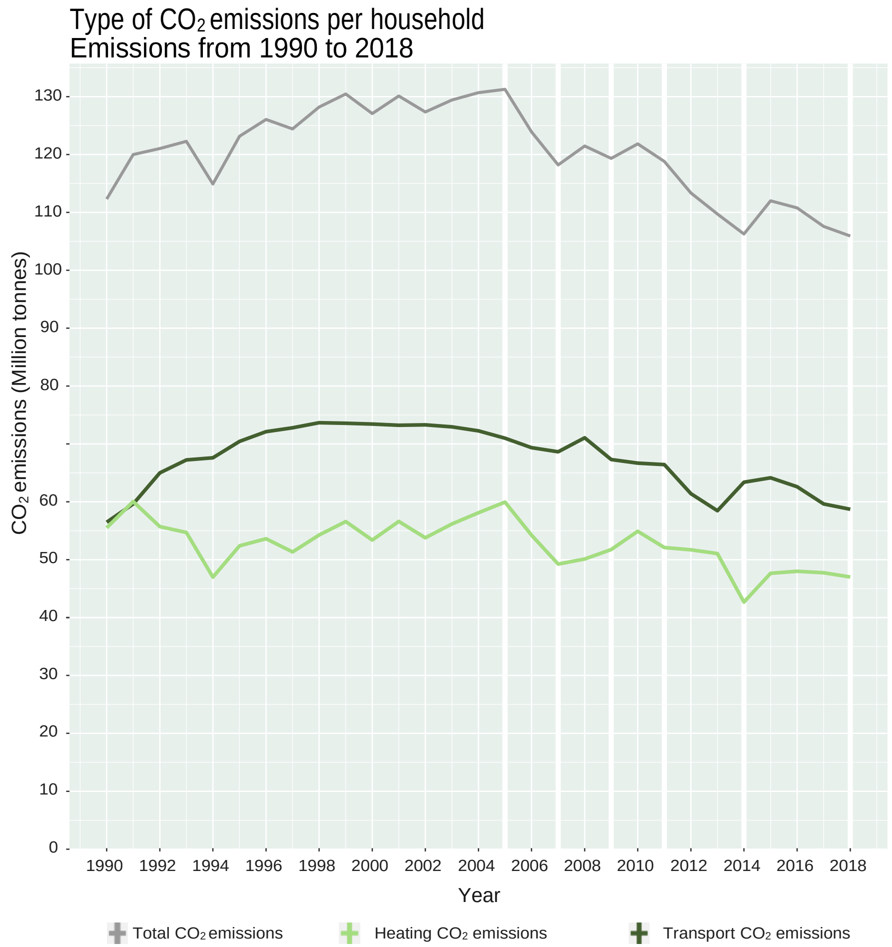


Figure 3 - Type of CO_2 emissions per households

These graphs underline another dynamic: the coupling of industrial production and CO_2 trends from 2008 to 2014 (the 2008 crisis reduced overall Italian production – probably affecting the most backward and polluting sectors – and at the same time decreased Co_2 emissions) ***and the tendency to decouple from 2014*** (from that year onwards the economic recovery, although not particularly significant, has led to an increase in GDP which fortunately has not been matched by a proportional increase in climate-changing gases emitted, a further indication that the most backward and polluting companies have been hard hit by the crisis).

Macro dynamics of the Italian production structure (1990-2018)

As a preliminary remark, it should be noted that the CO_2 equivalent emissions dealt with in this first chapter are, except where specifically indicated, **those attributable to the activities of businesses, while the following chapters will also deal with those attributable to households** (see in particular chapter 3, on buildings; chapter 4, dedicated to household transport; and the topic of the organic fraction of municipal solid waste, in chapter 5, dedicated to waste). **In Italy today, corporate emissions are estimated at around 70% of the total and household emissions at around 30%, with the former showing much sharper rates of decline than the latter**.

In terms of companies, greenhouse gases in our country, as well as in most European countries, are mainly attributable to the following production sectors (taken from ATECO – Classification of Economic Activity - codes): supply of electricity, gas, steam and air conditioning, manufacturing, transport and storage, agriculture-forestry and fishing[3]. These

3. NB The ISTAT database is based on production sectors (enterprises - classified by Ateco codes) and by households (which by definition are consumers) – 1) the overlapping of certain

sectors account for more than **4/5** of the CO_2 emissions of the total number of companies, and excluding agriculture, which is dealt with separately in Chapter 6, it is still **around 3/4**. Figure 4 shows the evolution of the percentage distribution of CO_2 emissions from 1990 to 2018 of the most polluting sectors (see footnote[4] for legend); in summary:

- Coke and refined petroleum products manufacture: increased from 8% to 6%;
- Chemicals manufacture and manufacture of basic pharmaceutical products and pharmaceutical preparations: not really representable because over time it is subsumed into other sectors, although it shows some resistance to CO_2 reduction;
- Rubber and plastic products manufacture and other non-metallic mineral products manufacture: from 13% to 9%;
- Metallurgy and fabrication of metal products excluding machinery and equipment: increased from 9 to 5%;
- Supply of electricity, gas, steam and air conditioning: remains stable at 35%;
- Transport and storage: increased from 9 to 16%.

Sector breakdown of CO_2 emissions from 1990 to 2018

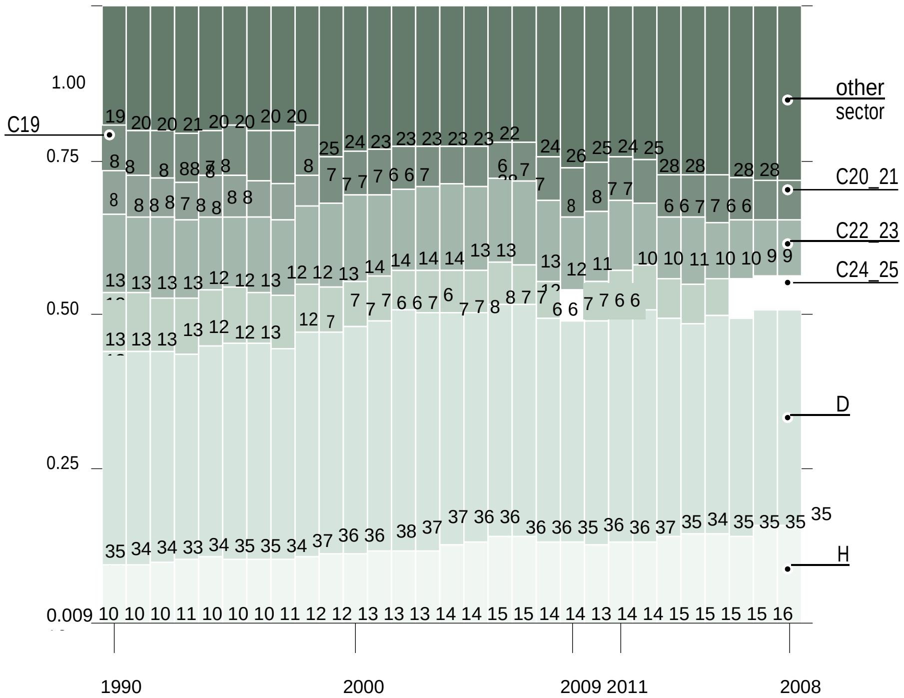


Figure 4 - Trend in CO_2 emissions of the main Italian sectors compared to 1990

It is clear from the graph that the ***transport sector*** (which does not cover the production of vehicles, but only the consequences of their use) ***has shown much greater resilience than others in reducing*** **CO_2**. The consolidation of ICT, in fact, has allowed the adoption of new organisational models for the procurement of intermediate goods, without geographical-temporal barriers, reducing warehousing to a minimum.

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categories (companies are also consumers of goods of other companies); 2) the classification of emissions from other important national bodies (ISPRA) follows partially different logics - in this part of the study the ISTAT subdivision has been maintained.

3 C.19 Manufacture of coke and refined petroleum products;
C.20-21 Manufacture of chemicals and manufacture of basic pharmaceutical products and pharmaceutical preparations;
C.22-23 Manufacture of rubber and plastic products and manufacture of other non-metallic mineral products;
C.24-25 Metallurgy and manufacture of fabricated metal products excluding machinery and equipment;
D Electricity, gas, steam and air conditioning supply; H transport, storage

These models adopt a *just-in-time* approach according to which a good is only produced when it already has a buyer, and is immediately transported. Medium-sized and large companies have in fact outsourced warehouse management, turning it into an activity at the service of the company’s business. This organisation of the value chain is particularly resilient[5]. The ***introduction of new technologies*** could clearly improve the environmental performance of the “transport-warehouse” (the wording here and in the tables below is the one used by the Ateco codes for the classification of economic activities), but it ***should also be accompanied by a re-organisation of the chain, at least in geographical terms.***

Returning to broader observations, the relationship in the Italian production system between a decrease in CO_2 and an improvement in technological specialisation (with positive repercussions on the increase in wealth produced) is also reinforced by the ***positive correlation between a decrease in CO_2 eq. on the one hand and an increase in expenditure for research and development and "technological" investments[6] on the other***, on which further reflections will be provided in the final chapter.

5 Further influencing the relationship between transport and CO_2 emissions are the changes that households are making in **their** purchasing patterns. Using Eurostat data it is possible to calculate that the percentage of Italian citizens who made at least one purchase on the internet during 2018 is around 36%, a figure that has certainly been on the rise since the Covid-19 crisis. This leads to an explosion of travel in urban and metropolitan areas and therefore an increase in congestion and emissions that is currently difficult to calculate. The issue of transport, and in particular the impact of household travel on energy consumption, will be further developed in Chapter 4.

6 Understood as those incorporating a high R&D content.

At this stage, we will simply say that the time series supports this hypothesis through both aggregate data (figure 5) and more specific sectoral analyses in figure 6.

The latter, compared with what has been written in the previous pages, shows in fact that ***in the sectors that show poor CO_2 trends (transport and storage) the ratio between R&D and investments remains low (the same happens with energy), while the sectors with a higher and growing technological intensity of investments (pharmaceuticals, chemicals and rubber) correspond to those that behave better with respect to climate-changing emissions.*** This would suggest an urgent need for R&D investments in the most polluting sectors, to at least start aligning them with the national average dynamics.

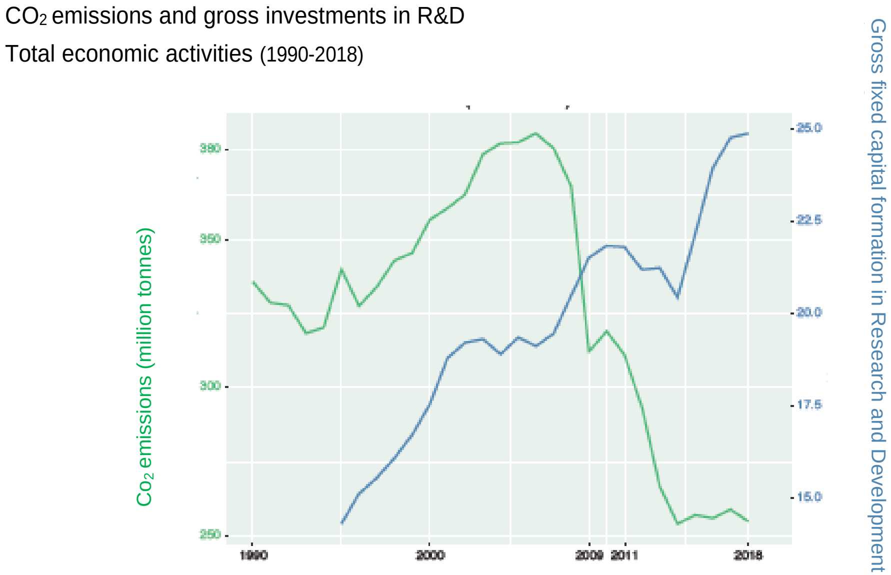


Figure 5 - CO_2 emissions and gross fixed capital formation in R&D

Technology intensity (R&D/Investment)[7] for the most polluting sectors								
Year	Total: Italian Economy	Transport and storage (H)	Energy (D)	Manufacture of coke and refined petroleum products (C19)	Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21)	Manufacture of chemicals (C20)	Manufacture of rubber and plastic products and other non-metallic mineral products (C22_23)	Manufacture of basic metals and fabricated metal products, except machinery and equipment (C24_25)
1995	4,9	0,4	0,2	0,2	34,7	14,6	4,6	3,8
1996	5,1	0,4	0,2	0,2	34,1	13,0	6,1	4,1
1997	5,2	0,4	0,3	0,2	31,3	10,4	6,0	4,5
1998	5,1	0,4	0,2	0,1	24,2	9,8	6,2	3,9
1999	5,1	0,4	0,3	0,2	26,4	9,4	5,1	4,3
2000	5,1	0,4	0,3	0,1	29,1	9,4	4,8	4,0
2001	5,3	0,4	0,3	0,1	32,9	10,1	5,4	4,1
2002	5,3	0,3	0,3	0,2	29,3	10,3	5,3	3,8
2003	5,3	0,4	0,2	0,2	29,3	9,0	4,9	4,2
2004	5,1	0,3	0,2	0,2	32,1	10,8	4,8	4,1
2005	5,2	0,3	0,3	0,2	30,5	11,1	5,4	4,6
2006	5,0	0,3	0,3	0,2	29,8	9,4	4,5	4,4
2007	5,0	0,3	0,2	0,2	30,6	9,7	4,9	3,8
2008	5,5	0,4	0,3	0,2	36,9	11,9	5,0	4,5
2009	6,4	0,3	0,1	0,2	39,0	12,2	7,7	5,7
2010	6,5	0,2	0,2	0,2	40,3	12,4	6,4	5,3
2011	6,6	0,1	0,2	0,6	38,1	11,6	5,8	5,6
2012	7,1	0,1	0,3	0,5	36,9	13,5	7,0	5,7
2013	7,6	0,2	0,3	0,7	33,4	12,5	7,1	6,9
2014	7,4	0,1	0,1	0,9	25,5	11,1	7,4	5,8
2015	8,0	0,5	0,3	1,3	31,2	11,3	10,1	5,8
2016	8,4	0,5	0,4	1,5	33,9	14,0	10,9	8,2
2017	8,4	* n.a.	* n.a.	* n.a.	* n.a.	* n.a.	* n.a.	* n.a.
2018	8,2	* n.a.	* n.a.	* n.a.	* n.a.	* n.a.	* n.a.	* n.a.

Our elaboration on ISTAT national accounts data
* n.a. = not available

Figure 6 - Technological intensity (R&D/Investment)[7] for the most polluting sectors and total economy.

7 R&D/Investment is an approximation of the technological content of investments. See Lucarelli S., Palma D. and Romano R., 2013, *Quando gli investimenti rappresentano un vincolo. Contributo alla discussion sulla crisi italiana nella crisi internazionale*, in Moneta e Credito, no. 67 (262).

Added value and employment

The two figures immediately below present the historical relationship between added value, greenhouse gas emissions and employment.
Although the level of added value is linked to many variables (investment, R&D, domestic and foreign demand), its dynamics would appear to be decoupled from that of CO_2 (Figure 7), also showing better resilience in conjunction with negative events.

Looking instead at hours worked[8], an interesting phenomenon emerges: the reduction in CO_2 would not affect hours worked. In fact, the fall in hours worked would appear to be more correlated with the fall in added value than with the reduction in CO2 emissions (Figure 8).

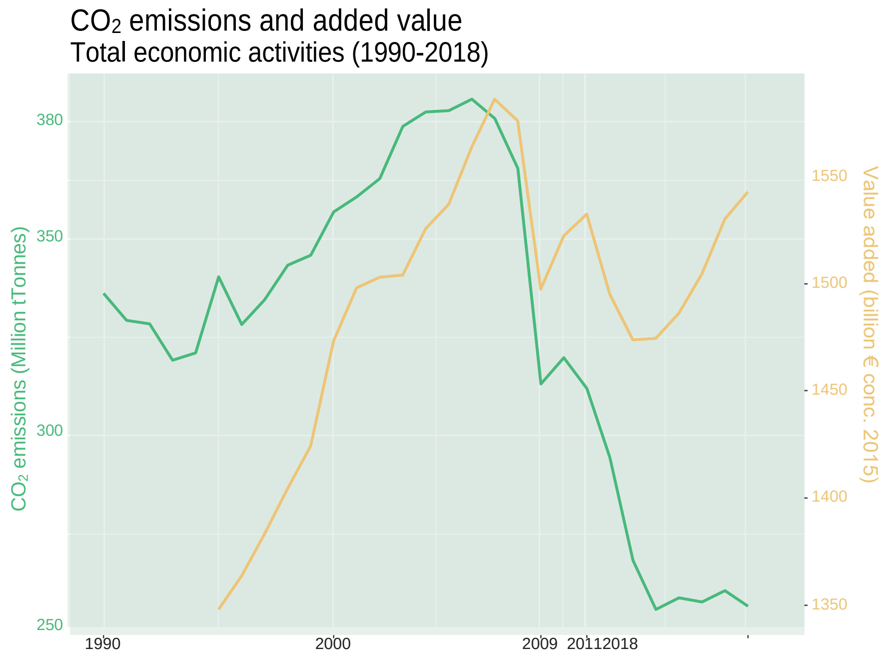


Figure 7 - CO_2 emissions and added value

8 We use this indicator because the so-called precariousness of work has undermined the labour force or employment index.

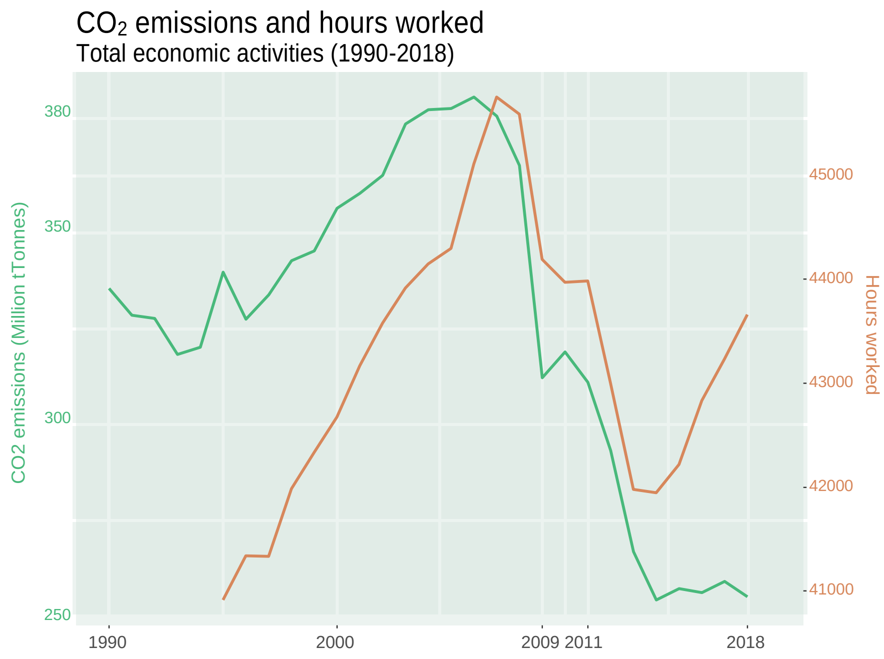
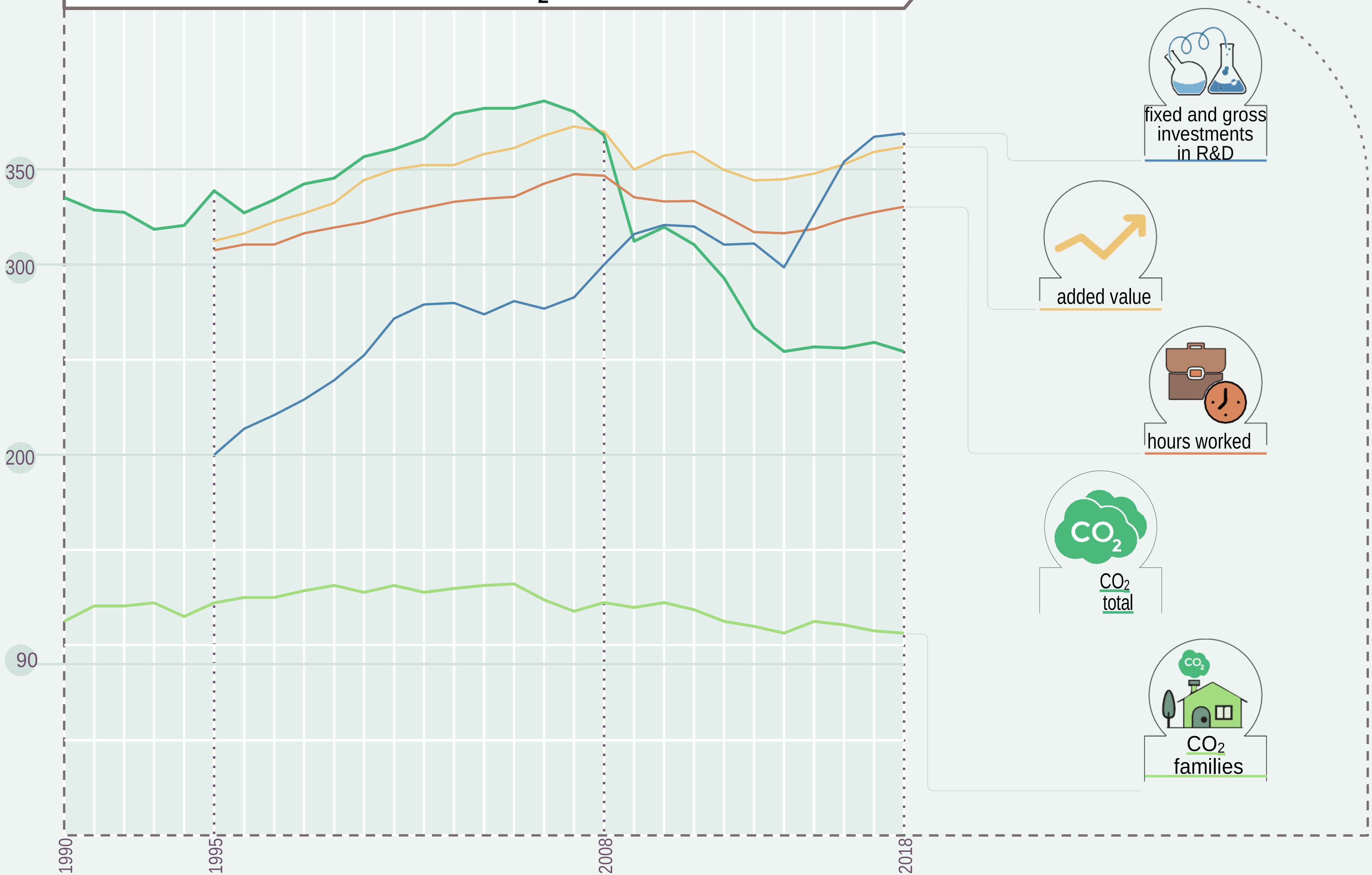


Figure 8 - CO_2 emissions and hours worked (in millions)

The sector breakdown of added value and employment suggests another important consideration. ***The most polluting sectors (the aforementioned C19, C20-21, C22-23, C24-25, D, H9), are responsible for 75% of the CO_2 emissions of industrial activities (which in turn are responsible for about 20% of total emissions), but these sectors produce "only" 11% of the added value and 9% of the employment of the industrial sector*** (of course, in absolute numbers, this added value and employment are still very significant figures), see Figures 9, 10. Given the strategic nature of the most polluted sectors, a targeted investment in them would improve the overall industrial structure and would most likely lead to a significant decrease in CO_2 and the strengthening of national research and development.

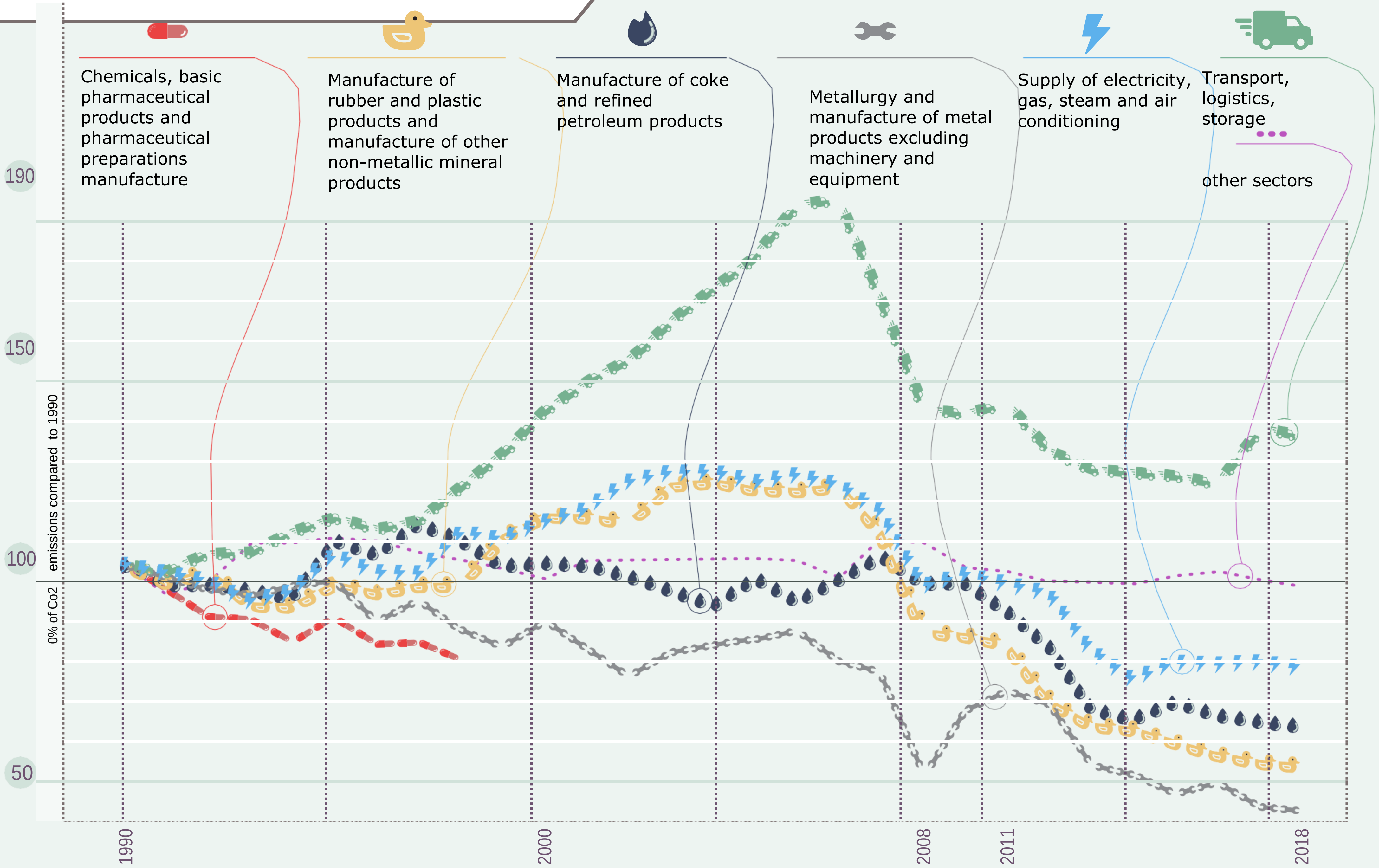
9 For further convenience, please note that:
C.19 Manufacture of coke and refined petroleum products; C.20-21 Manufacture of chemicals and chemical products and manufacture of basic pharmaceutical products and pharmaceutical preparations;
C.22-23 Manufacture of rubber and plastic products and manufacture of other non-metallic mineral products;
C.24-25 Metallurgy and manufacture of fabricated metal products excluding machinery and equipment;
D Electricity, gas, steam and air conditioning supply; H transport - storage

ECONOMIC SYSTEM and CO_2 - Italy 1990-2018



NB: The graph aims to make the trends of the various curves (taken from databases that originate in years that do not coincide) observable synoptically and legibly, so it sacrifices references to specific units of measurement.

TRENDS IN CO_2 EMISSIONS IN ITALY in the main production sectors



NB: After 1998, ISTAT broke up the Ateco C21 sector (chemical-pharmaceutical products) and regrouped its parts within other sectors.

2. Renewable energy

After having outlined in the first chapter the overall socio-economic dynamics of the national production system and some simulations derived from it, the second chapter of this study is focused on a sectoral analysis.

The renewable energy sector for electricity, heat and transport (biofuels + electromobility), in relation to the 2050 decarbonisation target, albeit not the only one, is undoubtedly the most important, and it is so for at least two reasons. The first reason is its quantitative relevance. Today, according to ISPRA, over 80% of climate-changing gas emissions derive from the combustion of fossil fuels in a series of production and consumption processes, the most important of which are energy production, high temperatures in certain industrial sectors, air conditioning (and other household services) and transport. The second reason is the technical and economic feasibility of making a complete switch from fossil fuels to renewable sources, thus reducing the production of climate-changing gases. Renewable energy production and storage techniques produce steady improvements at rapidly decreasing costs, and Italy has the physical characteristics for this process to take place effectively, especially in the photovoltaic electricity sector.

In the following lines the topic of renewable energies will be addressed in three distinct sections. In the first one the Italian situation to date will be presented, the second will briefly describe some of Italy's potentials, while the third will present a possible scenario, based on the critical analysis made by EStà, of some of the simulations produced by leading scholars. A mention of employment issues, which are discussed in greater detail in Chapter 8, will close the presentation. The scenario will then be summarised in the infographic at the end of this chapter and will be taken up in the final chapter on investment, employment and added value.

1. The current situation

1.1 Renewable *energy* sources for *electricity*

In Italy in 2019 the installed power from renewable sources will reach 55.2 GW (about 36.3 GW if we exclude the "historical" hydroelectric already installed in Italy equal to just under 19 GW). The historical dynamic says that in 2010 the share was slightly more than half (about 30GW). International comparison suggests that this figure is broadly in line with France, Spain and the United Kingdom, but significantly lower than the German one, which in 2019 reaches 125.3 GW. Going into the details of the sources, the photovoltaic power installed in Italy is 20.8 GW, wind power 10.6 GW and hydroelectric 18.9 GW. The share of biomass for specifically electrical use provides an additional 4.37 GW (source: ANIE Rinnovabili).
Overall, the share of national electricity demand covered by renewable sources was 35.9% in 2019. In absolute terms, this is the highest figure ever, but in percentage terms, it is lower than the maximum reached in 2014 with 38.6% (source: Terna).
The renewable electricity sector, as is well known, needs the development of a ***storage*** system to compensate for fluctuations in sources, as it is not possible to have a constant flow of energy from sun and wind. Excluding the share of storage provided by hydroelectric pumping, the proportion of storage provided by lithium-ion batteries is now growing steadily in Italy, as lead-acid, sodium-sulfur and other technologies have been reduced to very low values.
Covid-19 emergency data also demonstrated the resilience of the electricity grid. It is worth noting that in May 2020, thanks in part to falling electricity demand, renewables covered 52% of demand.

1.1.2 Renewable sources for *thermal* energy.

In Italy, thermal renewables provide a slightly higher amount of energy for consumption than electrical renewables as a whole, thanks mainly to biomass, which provides about three quarters of thermal renewables (including 7 million pellet stoves). In addition to biomass, there is a further installed thermal capacity, currently equal to 124 GW (Source: Cresme and GSE), given by both solar thermal and, above all, by the presence of 19.6 million heat pumps.

1.1.3 The *transport* sector

In this area, the Italian situation appears to be very backward. The latest available data (GSE 2017) quantify the percentage of renewable energy used in the transport sector at 6.5%, a figure obtained by adding ***biofuels*** to electricity. This is a lower percentage than the previous year (7.5%), which confirms transport as one of the most complicated sectors to convert.

This sector, in which electric mobility will dominate in the future, will be the subject of a specific chapter later in this study.

2. Potential

Due to its geographical position, Italy enjoys more solar radiation than many other European countries. On the other hand, the morphological characteristics of a significant part of its territory mean that it has less wind potential, although developments in *offshore* wind could boost electricity production here too.

As of today, Italy's energy model is not only environmentally unsustainable, but also largely dependent on foreign countries. In 2018, Italy imported 100% of the coal and more than 90% of the oil and gas needed to meet the country's energy demand, reaching an import share, compared to primary energy, of about 76.5% (Greenpeace, 2020). Consequently, replacing fossil energy with renewable energy also represents a potential for greater political control in a key sector, and a potential for economic savings.

3. Scenarios

In October 2014, the European Council adopted the '2030 climate & energy framework', which sets the new climate and energy framework. Following the upward revision in 2018 of the second and third targets, these are the targets set by the framework for the period 2021 to 2030:

- At least 40% reduction in greenhouse gas emissions (compared to 1990 levels)
- At least 32% share for renewable energies
- An improvement in energy efficiency of at least 32.5%.

Member States were therefore obliged to adopt integrated national energy and climate plans (NECPs) for the period 2021-2030, and to this end Italy prepared the aforementioned Proposal for an Integrated National Energy and Climate Plan (NIPEC), which however lowered the target for renewable energy sources to 30%.
Instead, the EC aims to responsibly increase emission reductions by 2030 to 55% below 1990 levels; less than the 60% recently expressed by the European Parliament, but still well above the 40% mentioned above.
The National Energy and Climate Plan therefore appears to be insufficient to achieve the intermediate objectives necessary to decarbonise our country by 2050. Starting from this consideration, the study has tried to make other simulations that are more appropriate to the final aim, contained mainly in the final chapter, but contextualised and partially anticipated in the present one.

There are already several scenarios for 2050 regarding renewable energies, and with respect to the situation in Italy, they have been produced by, among others, Greenpeace, Legambiente, and by the CNR (Meneguzzo et al. 2015), as well as institutional publications by the Italian Ministries of Economic Development, Environment, Land and Sea Protection and Infrastructure and Transport (contained in the NIPEC), and the European Commission (Long-term strategy to 2050 and related In depth analysis, the latter referring to the continental scenario). The main scenarios have been critically analysed by EStà and a summary has been drawn from this analysis, which is presented below and summarised in the infographic at the end of the chapter.

The role of electricity and the source mix

The assumption common to the various scenarios is the extensive development of the electricity sector, which will enable a number of consumptions currently relying on thermal energy (energy from production, air conditioning, transport, etc.) to be switched to a renewable source. Electricity will not, however, be able to completely replace other forms of renewable energy, and a share of solar thermal and biomass will have to be provided for. Lastly, electricity will need an extensive storage system.

EStà's simulation (see infographic) therefore envisages: a decrease in overall energy demand due to a gain in efficiency; meeting the remaining demand with around 86% of electricity and the rest with the sources mentioned, with 4/5 of this 86% being produced through the extension of photovoltaics (from roofs, but not only; ground-mounted installations will have to play an important role, with a focus on agrophotovoltaics) and only to a lesser extent through wind power; a storage system based largely on lithium batteries and hydrogen for the remaining part, in particular Power to Gas (P2G) for seasonal storage.

These calculations were based on projections by the European photovoltaic association, Solar Power Europe (SPE, 2020). Electrification of the energy sector, which includes power, heat and transport, can, according to the SPE report, lead to an electrification share of 86%. With respect to the ***source mix***, in the SPE report on the feasibility of the 100% renewable scenario, solar generates more than 60% of the EU's electricity by 2050. However, considering the characteristics of our country and a number of authoritative studies, this percentage has been adapted to the national context in the infographic and in the calculations on employment, added value and investments.

Although ***wind power*** is important, it does not appear to be able to offer too high a percentage contribution in our country; ANEV, the Italian wind energy association, estimates a conservative value for 2030[1]. A 2019 study by the European wind energy association (WindEurope) estimates a very high potential for wind production (equivalent to 38.7 Mtoe[2]), capable of satisfying 30% of European electricity demand.

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1 "As a precautionary measure, therefore, the achievable potential was derived, which is based on scientific criteria and data drawn from the experience of member companies. The results of the study identify 18.4 GW of wind power potential that can be installed by 2030, which would correspond to an annual electricity output of 40.1 TWh" https://www.anev.org/wp-content/uploads/2019/10/Anev_brochure_2019web.pdf

2 The Mtoe unit has been retained in some cases, as it is the reference point used in a large amount of data and references in the NIPEC.

However, 85% of this power is assumed to be in the seas of Northern Europe, while about 2.7 Mtoe could be located in the Eastern Mediterranean (Italy, Greece and Turkey)[3]. Assuming optimistically that one third can be attributed to Italy, by mid-century in Italy we could assume a total of ***2.6-3 Mtoe of wind power.***

Photovoltaics, on the other hand, has better prospects in Italy than in the European average. The potential extension of solar energy is indeed enormous, taking into account the possibility of covering roofs and building facades[4] and the possibility of setting up plants on the ground (abandoned industrial sites, former quarries, end-of-life waste dumps, but also on abandoned agricultural land). Medium- and high-temperature solar thermal power generated with concentrators could also play a role for some industrial applications.

Taking the NIPEC projections of final electricity consumption as a basis, the NIPEC targets require solar to contribute **24.1 % (6.3 Mtoe)** to their coverage in 2030. A coverage of 80% in 2050, on the other hand, would require solar to meet at least 40% of total electricity demand in 2030, i.e. **10.4 Mtoe** (i.e. at least **4.1 Mtoe** more than already projected by the NIPEC).

If the final demand for electricity evolves as predicted by the NIPEC, this objective is far from utopian and could be technically achieved by installing photovoltaic panels on about 10,000 existing buildings per year between 2020 and 2030, i.e. by equipping less than 1% of the existing residential stock with photovoltaic panels within ten years[5].

Consistent with this data, the infographic at the end of the chapter refers to an 80% share of photovoltaics in electricity demand by 2050. The same data were used for the calculation of investment employment and added value for the renewables sector in the final chapter.

Efficiency

Efficiency estimates have been made taking into account an intermediate value between the 34% predicted by Mark Jacobson’s studies at Stanford University and Solar Power Europe (SPE, the European Photovoltaic Association), which estimates a 14% cut in primary energy consumption[6].

N.B. In this study we have chosen a conservative approach, despite authoritative estimates (e.g. Fraunhofer Institute[7]) that efficiency gains of up to 50% are possible. The difficulties of the building sector in Italy suggest a cautious approach, reflected in the infographic.

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3 https://windeurope.org/wp-content/uploads/files/about-wind/reports/WindEurope-Our-Energy-Our-Future.pdf

4 IEA estimates from 2002, quoted on p. 14 by Meneguzzo et al. (2015), indicate that the area for solar panels of existing buildings at that time amounted to 764 km² on roofs and 286 km² on façades with an electricity production potential of 126 TWh (10.8 Mtoe). Considering that the minimum required amount of area for to panels is about 8 m² per building, there do not seem to be any space constraints for the installation of photovoltaic panels on 100,000 buildings over the next decade.

5 See previous note

6 "100% renewable Europe", Solar Power Europe, 2020

7 https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/2019/Report_Energy-Savings-Scenarios-2050.pdf

Other renewable sources

In addition to electricity, as mentioned above, other forms of renewable energy could play a role in a climate-neutral scenario by 2050. For example, medium- and high-temperature solar thermal energy generated with concentrators for some industrial applications. The contribution of biomass should also be considered, as it can continue to play a role, also in view of the recent introduction of highly efficient boilers with very low environmental impact.

Accumulation

Electrochemical storage systems are considered central in many studies. For example, in the Solar Power Europe analysis on the possibility of a 100% renewable Europe, it is assumed that ***lithium batteries*** will meet the majority of storage needs, reaching shares of between 67 and 70%. This predominant role is also justified by ongoing technological developments and the increasing possibility of reusing large lithium batteries, once their original purpose has been fulfilled, for uses requiring lower performance.

Another important mode of storage will presumably be based on **hydrogen**, given the falling prices of a technology until recently considered too expensive for large-scale investment. Hydrogen can play an important role especially through its conversion into methane via the P2G process to ensure seasonal storage. In September 2020, France and Germany announced a joint pact and an investment of €7 and 9 billion euros respectively by 2030 for the research and development of hydrogen storage, while Brussels underlined the need for a total European investment of 130 billion euros for the period. Italy is considering a role mainly through Enel and Snam (manager of an impressive infrastructure of reconvertible pipelines for the transport of hydrogen).

Employment prospects

As mentioned above, the topic will be dealt with in the final chapter of this study, in line with the suggested investment plan, but some contextualisation and preliminary considerations seem appropriate, given the decisive weight of the renewable energy sector in the climate neutrality process.

In particular, it seems useful to refer to a 2017 study by Hiroki Hondo and Yue Moriizumi in which the two authors studied the employment characteristics of nine different renewable energy generation technologies: two types of solar PV, wind, small-scale hydro, geothermal, woody biomass and three types of biogas. The analysis uses a renewable energy-focused input-output model developed to examine the environmental and socio-economic life-cycle impacts of generation technologies and policies. The analysis reveals that there are significant differences between the impacts of the nine technologies on employment. The total lifecycle job creation potential is estimated to be in the order of 1.04-5.04 person-years per GWh. As Mario Pagliaro points out: *"residential photovoltaics create 2.73 permanent jobs each year for every million kilowatt-hours generated (N.B. generated, not installed, the ratio between installed and generated kilowatt-hours is about 1 to 1000. Editor's note),* *the photovoltaic utility scale 2.84 jobs and wind power 1.84 jobs. The jobs are distributed between the construction phase and the operation and maintenance of the plants. However, while in the case of residential photovoltaics only 23% of employment opportunities and total resides in maintenance and 77% in plant installation construction, in the case of solar photovoltaic power plants 39.7% of jobs are created in the operation and maintenance phase because photovoltaic parks need to be constantly monitored by electrical engineers and maintained by qualified technicians"* (Pagliaro, 2018).

In the final chapter of this study, instead, the multipliers based on the specific Italian context were used, i.e. the multipliers based on the interaction between sectors (the input/output method) and the SAM multiplier (which also takes into account tax and redistributive effects). The calculations take into account the current Italian industrial fabric, but the results would be better if (see the simulation at the end of chapter 8) there were additional investment in R&D and technological innovation[8].

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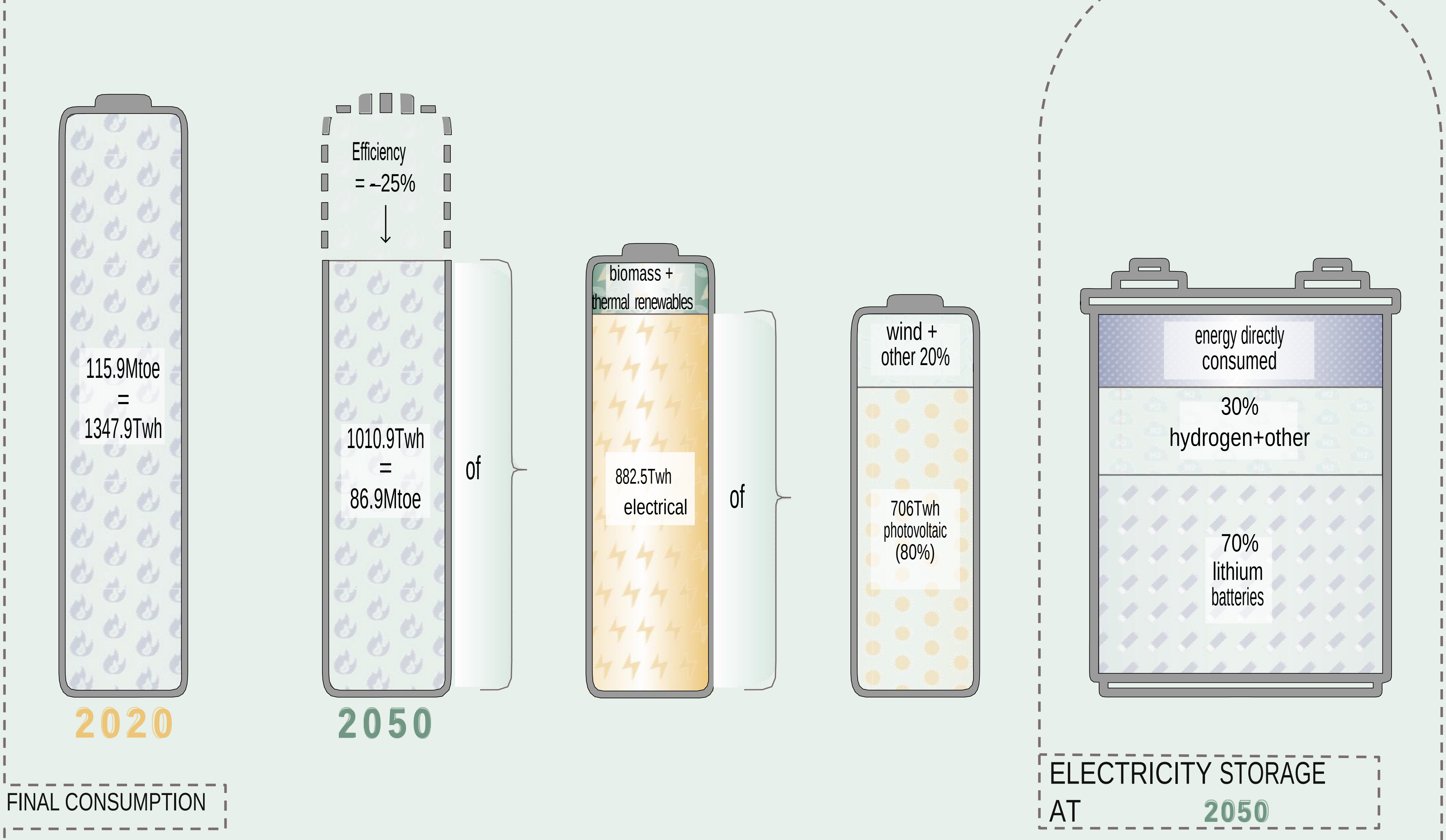
8 In order to understand the importance of research and development, it should be remembered that each production chain consists of a number of stages. A photovoltaic panel has to be conceived, designed, manufactured, sold, implanted, maintained and finally decommissioned. Each step in the chain corresponds to a production of added value and employment, but the quantity of added value and the quality of employment are higher in some phases (those with higher technological content) and lower in others. Patenting and producing new generation panels does not have the same impact on wealth and employment as installing them on roofs, which is the predominant activity in Italy today.

ENERGY CONSUMPTION IN ITALY: a roadmap for 2050



N.B. : Interconnections with other states are not taken into account.

SOURCES: Mark Jacobson: "clean rewenable energy and storage for everything (2017)" - Meneguzzo F., Pagliaro M. et al: "Renewable: a sultable energy transition roadmap (2016) " - Elaborations by Gianni Silvestrini and EStà (2020)

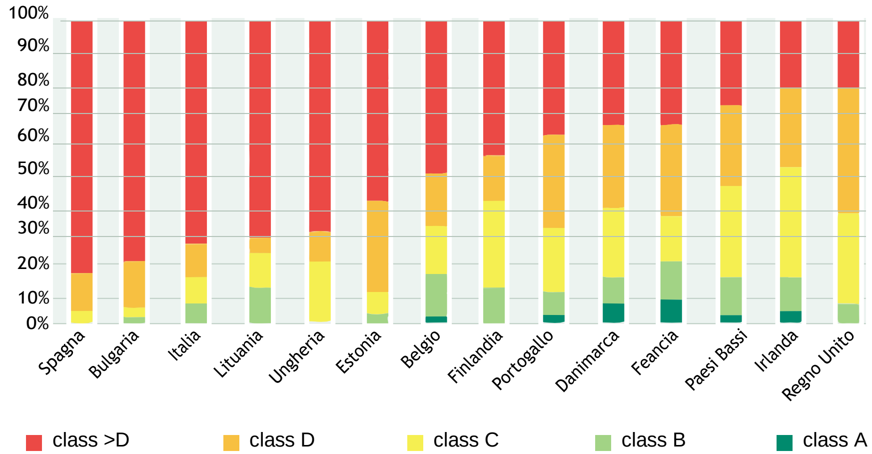
3. Buildings

1. The current situation

In Europe, 74% of buildings are used as dwellings, while this percentage rises to 89% in Italy. Looking at the graph of dwellings by energy class in the various countries, Italy is in third place with more than 70% of buildings characterised by low energy performance and an energy class higher than D (figure 12).

85% Houses in Italy with poor thermal insulation performance

The distribution of dwellings by energy class in European countries



Source: Buildings Performance Institute Europe

Figure 12, Energy class breakdown of dwellings in European countries (Foundation for Sustainable Development Outlook, 2019)

It is no coincidence that 81.4% of the existing residential buildings in Italy were built before 1990, the year before Law 10, which lays down some guidelines for regulating the energy efficiency of buildings, was issued. In 2014, ISTAT also published a report on the state of buildings and dwellings based on data collected in the 2011 census. It showed that there are 12,187,6981 residential buildings and that the average number of resident persons per building is 4.83.

1.1 Energy consumption

Available Eurostat data show that, despite a change in energy mix and variation over time, the primary energy demand of buildings (159.5 Mtoe in 2017) is even slightly higher than in 1990.

By comparing the final energy consumption with the useful floor area, it can be seen that there has been a steady reduction in the European average, while this value, at around 170 kWh/m2 per year, has remained almost constant in Italy from 2000 until 2014 (Figure 13). In the NIPEC there was a further update, and it was estimated that until 2018 the average annual consumption in residential buildings is about 145 kWh/m^2.

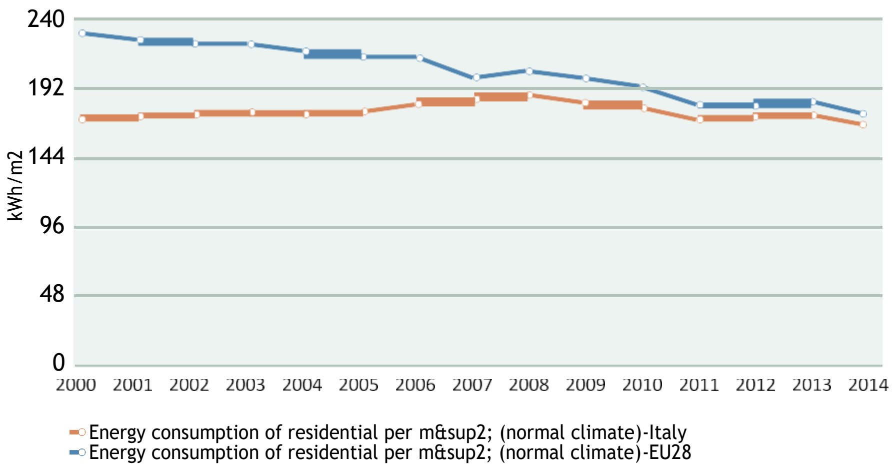


Figure 13 - Average energy consumption of Italian residential buildings and the European average from 2000 to 2014 (European Commission, 2016)

In the area of consumption for civil use of buildings, the residential sector (i.e. households) is responsible for 63.8% or 32.6 Mtoe in 2017. Again, consumption is higher than 1990 levels of around 26 Mtoe and there is a significant increase in the use of biofuels while natural gas remains the main source of energy accounting for over 50% of consumption in the residential sector.

According to 2017 data, final energy consumption in residential buildings is broken down into:

- 70% for air conditioning (heating and cooling);
- 11.8 for lighting and electrical appliances;
- 17.7% for cooking and hot water.

Although still not so significant to final consumption, the introduction of renewable energy production targets and the consequent incentive system to support this transition, since 2006[1] has generated in Italy and the rest of Europe a significant increase in energy production from renewable sources "on site" (Figure 14).

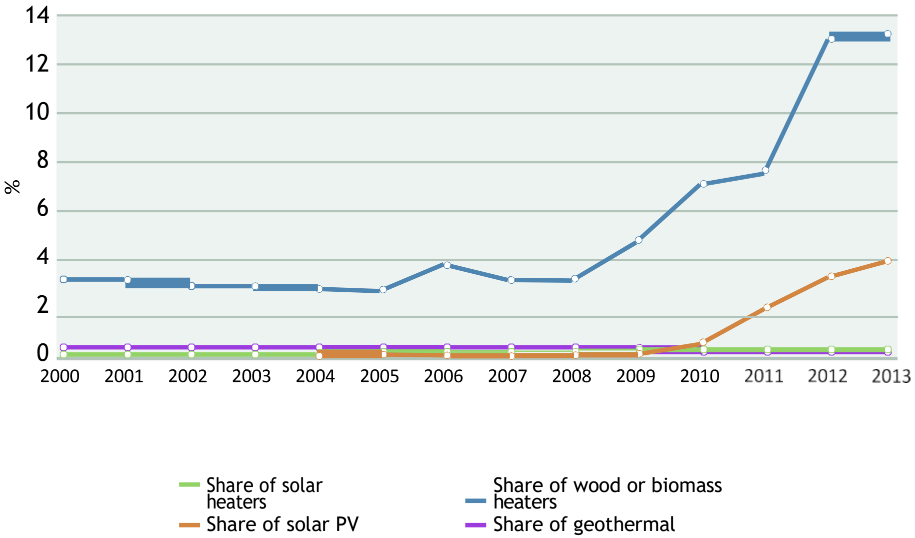


Figure 14 - Italian situation of on-site renewable energy production shown as a percentage of total building energy consumption (European Commission, 2016)

1.2 Investments

In Italy, in the housing sector, there has been a steady growth in investment in both new construction and extraordinary maintenance, which accounts for about 73% of investment in residential construction and 36.5% of all investment in construction.

Total investment in housing in 2019 is EUR 64,940 million and shows a 1.9% increase compared to 2018.

1 2006 was the year in which the first *Conto Termico* (Thermal Bill) was introduced with the Ministerial Decree of 6 February 2006, which provided incentives for photovoltaic systems.

The sphere of ***extraordinary maintenance*** of the existing housing stock saw a level of investments in 2019 of 47,395 million euros, representing approximately 37% of the value of investments in the construction sector (NB this estimate was made before the special conditions of 2020 that led to the introduction of the *110% Superbonus* whose effects will also be measurable depending on how much will remain structural. The introduction of this new percentage of IRPEF and IRES deduction was made with the mechanism of "driving" interventions, i.e. specific interventions necessary to access the bonus and drive other interventions to 110%. The decision to establish "leading" interventions will lead to acting on two key elements of the building to improve its quality and energy performance: the opaque surfaces of the building envelope and existing winter air-conditioning systems).

Within these interventions, specific activities related to energy requalification were carried out using ***tax bonuses,*** *which*, although they were introduced previously, were only really activated in 2011 thanks to the new legislation that allowed the deduction to be spread over 10 annual instalments. In 2011, the amount rose from €478 million in the previous period to €3.38 billion, and then there was a new significant increase in 2013, probably due to the legislation that increased the tax deduction from 55% to 65%. In the following years, an average expenditure of more than EUR 3 billion per year continued, albeit with slight variations. Overall, in the period from 2008 to 2016, about 3.21 million energy requalification projects were carried out, with a total expenditure of 20.91 billion

euros and an average expenditure per intervention of € 6,500. The benefits requested amount to 1.28 billion euros and the average deduction per intervention is 399 euros.
In 2020, as part of a maxi-economic manoeuvre to relaunch Italy after the Covid-19 emergency, the so-called “110% Superbonus” was introduced, increasing tax deductions up to 110% to be spread over 5 years for energy requalification expenses, anti-seismic measures and the installation of photovoltaic systems incurred from 1 July 2020 until 31 December 2024. While waiting to see whether the measure will be further extended or will even become structural, this will, in any case be, a further opportunity to pursue the future objectives set for the building industry. Also, this may boost the sector by bringing benefits to companies and professionals who carry out the work and individual citizens who will be encouraged to renovate their properties.

	Number of interventions	Amount spent		Deduction	
		amount	average	amount	average
Before 2011	28.546	478.654.748	16.768	26.397.738	925
2011	411.155	3.383.937.175	8.230	186.144.200	453
2012	422.340	2.900.236.112	6.867	159.543.566	378
2013	647.958	3.986.663.260	6.153	249.703.383	385
2014	503.662	3.283.674.102	6.520	213.476.568	424
2015	566.663	3.411.717.372	6.021	221.805.208	391
2016	629.541	3.646.006.779	5.502	225.209.891	358
Not available	4	11.133	2.783	614	154
Total	**3.209.869**	**20.908.900.681**	**6.514**	**1.282.281.168**	**399**

Figure 15 - Amount of expenses and deductions for energy requalification works, years 2008-2016 (Agenzia delle Entrate, 2019)

2. Future scenarios, current reality compared with institutional policies (the NIPEC)

Unlike in the case of renewable energies (see chapter 2), ***the NIPEC has made an effort to improve on the*** EU's ***energy efficiency*** targets. In the Italian plan, the European target of 32.5% was raised to an indicative share of consumption reduction by 2030 of 43% of primary energy and ***39.7% of final energy***.

The trajectory outlined for our country in the NIPEC, starting from consumption levels in 2020 of 142 Mtoe of primary energy and 116 Mtoe of final energy, allows for a reduction in gross domestic consumption in 2030 of 125.1 Mtoe and final energy consumption of 103.8 Mtoe. This projection was created in order to achieve the mandatory savings of 0.8% per year compared to the average final energy consumed in the three-year 2016-2017-2018, defined in accordance with Article 7 of the EED Directive of 11 December 2018, and to achieve the savings of 43% compared to the PRIMES 2007 scenario.

The building construction sector, as mentioned above, can contribute significantly to the overall energy efficiency of the country, as the residential sector alone was responsible for 26.8% of total final energy consumption in 2017. Maintaining this ratio and the annual savings rate of 0.8%, it is possible to estimate that the cumulative savings in the residential sector by 2030 could be around 13.78 Mtoe. Nevertheless, the NIPEC gives the building sector a bigger task than the two other sectors involved in energy efficiency (transport and industry) and raises the bar for construction to 18.24 Mtoe. ***According to the authors,*** to reach this quota, however, it is ***necessary to increase*** the ***percentage of*** annual ***energy savings*** in the sector from 0.8%, indicated by the NIPEC, to 1.06%, i.e. from 0.251 Mtoe **to *0.332 Mtoe per year***.

To evaluate the ***current rate of energy requalification*** and the consequent energy savings achievable in the near future with unchanged scenarios, the data collected by the incentive mechanism of energy efficiency interventions linked to the ***Ecobonus*** can be useful. In the period 2014-2018, more than 1,700,000 interventions were carried out, of which more than 334,000 in 2018 alone, divided into different types including:

- 138,790 requests for the replacement of windows and doors corresponding to savings of 32.76 ktoe;
- 25,267 for the insulation of the building envelope corresponding to a saving of 28.03 ktoe (N.B. the best savings/intervention ratio);
- 89,262 for the replacement of the winter air conditioning system corresponding to a saving of 26.57 ktoe.

The total investment amounted to €3.331 billion, in line with the trend in previous years seen in section 1.2, and generated savings, slightly down on 2017, of 1,155 GWh/year ***or 99 ktoe/year*** (Figure 16).

Intervention	n.	%	M€	%	Gwh/a	%
condominiums	477	0,14%	55,5	1,67%	18,3	1,58%
global upgrading	2.674	0,80%	249	7,47%	72	6,20%
envelope insulation	25.267	7,55%	901	27,05%	326	28,18%
Windows and doors replacing	138.790	41,45%	1.072	32,18%	381	32,97%
Solar screens	70.491	21,05%	128	3,84%	14	1,22%
solar panels for hot water	5.578	1,67%	36	1,09%	28	2,42%
Winter air conditioning	89.262	26,66%	873	26,20%	309	26,73%
building automation	2.307	0,69%	17	0,50%	8	0,69%
Total	334.846	100%	3.331	100%	1.155	100%

Figure 16 - Summary of energy requalification interventions carried out in 2018 by type (ENEA, 2019)

Period	Savings in GWh	Savings in Mtoe	Annual average in Mtoe
2014-2018	5.800	0,498	0,125
2011-2018	10.100	0,868	0,124
2007-2018	16.400	1,410	0,128

Another widely used incentive system is the ***Bonus Casa***. It includes interventions that, as part of broader renovation works not specifically aimed at improving the energy performance of the building, have not been incentivised with the Ecobonus mechanism. Even though it leads to lower energy savings, in 2018, ENEA received more than 300,000 requests for access to the incentive for more than 500,000 operations carried out, corresponding to an ***energy-saving of 0.061 Mtoe. Adding up the savings obtained in 2018 with the two systems, we reach a total value of 0.16 Mtoe, corresponding to almost half of the annual savings*** needed to reach the objectives of the NIPEC. These values, although quantitatively insufficient, qualitatively confirm the effectiveness of the boost induced by the incentive systems and highlight the potential savings that can be achieved.

In the near future, there will be an increasing need for technologies that can ensure low heating, cooling, and hot water (DHW) needs are met with high energy efficiency and the use of renewable sources. Many technologies are already available and in use that have played and continue to play a strategic role, such as heat pumps. In addition to encouraging the spread of ***new plant technologies*** increasingly high-performing, the focus should be on the ***building envelope***. From this point of view, technological progress has mainly focused on the materials used, i.e. insulation materials, glazing elements, and window frames. The contribution to the diffusion of building renovation interventions is fundamental because they are the ones that can currently give a consistent acceleration to the achievable energy savings and that at the same time are less widespread. After all, they are more expensive and with higher construction site problems and times. In order to tackle these problems and trigger a process of redevelopment of the existing Italian building stock, incentive mechanisms are an effective tool that have already led to considerable progress in recent years, as highlighted above, in fact, other mechanisms are not conceivable, since this sector is largely in the hands of private household ownership. Incentives, therefore, with deduction ceilings for expenditure on the building envelope that are adequate and that genuinely take into account the higher cost and the high level of problems involved in building these works, can continue to be the strategy for inducing energy requalification of the existing heritage. However, although the quantitative levels must be aligned with much higher targets than the current ones, as shown in the investment chapter of this study.

BUILDINGS and ENERGY EFFICIENCY

BUILDINGS AND ENERGY EFFICIENCY

THE ITALIAN SITUATION

RESIDENTIAL BUILDINGS= 12million

of which: 81.4% pre-1990

85% in class 'D' or worse

=26.8% CONSUMPTION OF FINAL ENERGY

CONSUMPTION ENERGY

- 70% air conditioning
- 11,8% lighting and electrical equipment
- 17,7% kitchen and hot water uses

SCENARIOS

CURRENT= **0.16 Mtoe** ANNUAL EFFICIENCY

Forecasted by the NIPEC= **0.332 Mtoe per year** corresponding to a target of **-39.7% efficiency (1990-2030)**

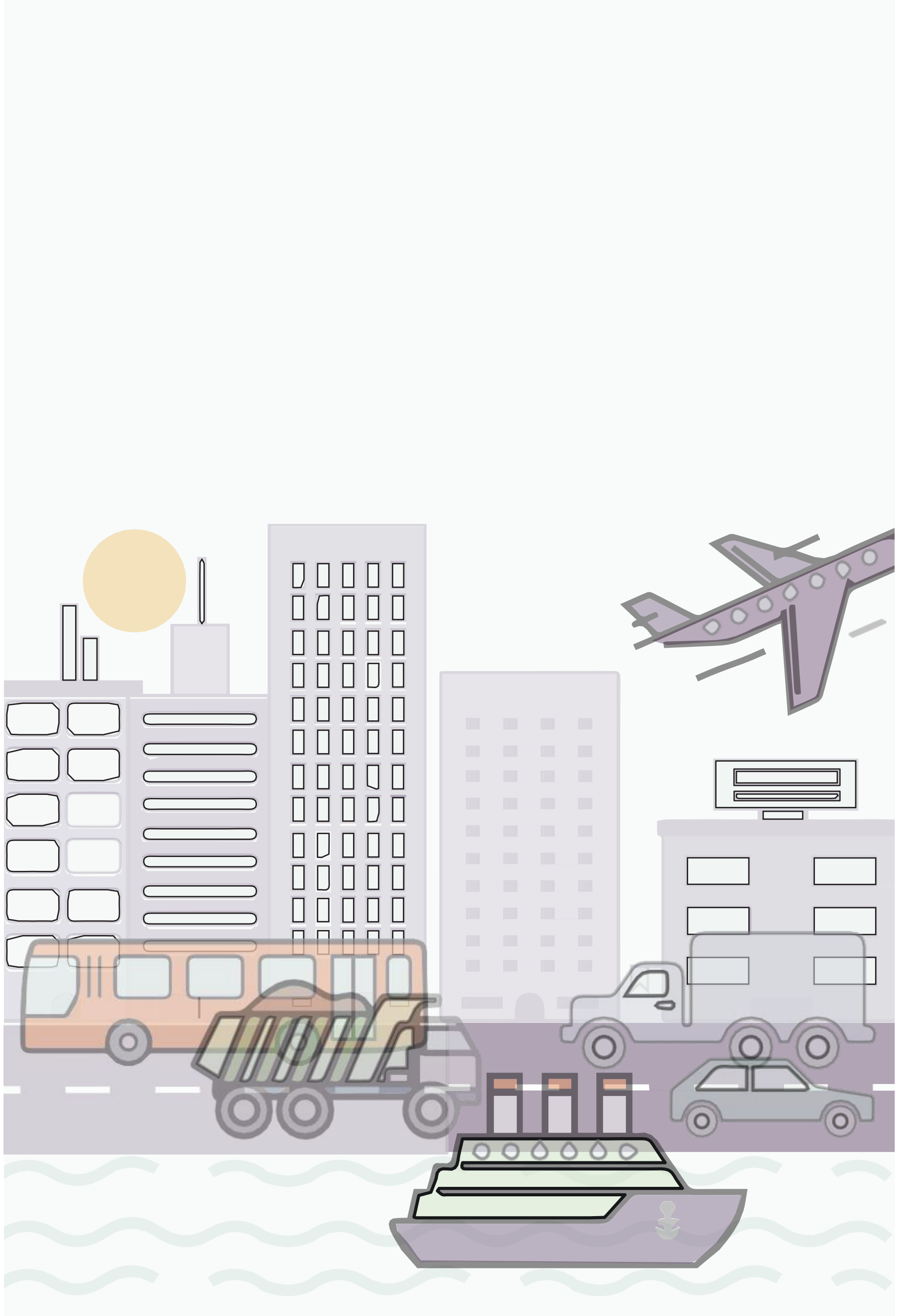
THE TREND

ECOBONUS= 334,000 interventions in 2018

HOME BONUS= 500,000 interventions in 2018

TOTAL ANNUAL ENERGY SAVING (2018 over 2017) = 0.16Mtoe

TOTAL INVESTMENTS EXTRAORDINARY MAINTENANCE = EUR 47bn in 2019



4. Transport

The transport sector is one of the most diverse sectors analysed in this study, which makes its examination and scenarios particularly complex. At the root of this complexity is the large number of variables to be considered. First of all, the sector is divided, depending on the players involved, between transport operated by households (passenger transport) and transport operated by companies (goods transport and, to a lesser extent, passenger transport[1]). This division runs through the various ***means*** available, the heaviest of which (particularly ships and lorries) are used mainly by businesses and the lightest (cars, motorbikes, etc.) by households. Other means have a less clear-cut division (train, plane). It is worth drawing attention to the fact that ***road transport is*** a cross-sectoral phenomenon, where both business travel (lorries, vans, etc.) and household travel (cars, buses, etc.) converge, and which alone accounts for more than four-fifths ***(81%) of total transport emissions.***

The main problems relating to company transport have already been discussed ***in the first chapter***. In that chapter, the interrelationship between the organisational model ***of companies and the logistics model*** was highlighted, with a trend over the years towards longer supply chains and a consequent increase in the number of means of transport (ships in particular). Referring to those pages for more details,

1The division between passengers and goods is about what is transported, whereas the division between households and enterprises is about who does the transporting (relevant difference for economic statistics).

in this chapter, the focus will be on the transport problems of ***households*** and the production of the vehicles available to them, with a brief final note on lorries.

A first problem concerns the ***travel pattern of private individuals***. The favourable cultural environment and the availability of *collective means of transport* influence the choice in favour of the latter, while in countries such as Italy these factors are less present, although the cultural attitude is slightly changing (***the number of those who choose public transport is growing***, according to Audimob, 2018 - from which all the data in the paragraph are taken - in 2008 it was 12.9%, in 2017 14.2%). ***In contrast to cultural attitudes, the availability of collective transport is deteriorating: the absolute number of buses operating in provincial capital municipalities fell between 2011 and 2016 from 15,000 to 13,000 units; the Italian public bus fleet is*** currently ***of advanced average age*** (12 years against an average of 7 in Europe), the Italian electric bus fleet is half the size of the Spanish fleet and a tenth the size of the German fleet, while over two-thirds of the public vehicles circulating in our country are still powered by diesel. Consistent with this backwardness of the public transport service, Anfia figures show that in 2019 there will be more than 39 million private vehicles circulating in Italy, with an average number of inhabitants per vehicle (1.6) that in the European Union is exceeded in negative terms (from an environmental point of view) only by tiny Luxembourg.

The demand for collective mobility in Italy is growing, but the public offer is declining in quantity and quality, so the majority of citizens continue to be driven to choose private transport.

Given this situation, the ***most effective intervention at the moment seems to be the replacement of means of transport, private and otherwise*** (think of fleets for public transport, waste handling, etc.)***, gradually eliminating the use of petrol and diesel***. This transformation is beginning to change the market for cars and light vehicles, while advanced experiments are under way for lorries and trains (the latter in particular on non-electrified routes); the timeframe for planes and ships- despite some results for very light electrically powered models - appear much longer. The same orientation towards powering with renewable energy sources guides the main proposals made by the NIPEC.

With regard to the ***spread of means of transport,*** the main trends appear to be as follows. A first point to consider is the rivalry between two different sources of energy with a lower environmental impact than fossil fuels: biofuels (and in particular biomethane) and electricity produced from renewable sources.
In Italy***, biomethane*** is developing thanks to a shift from incentives for electricity generation (which already entails a considerable burden on the bill for renewables) to incentives for fuel distributors. On the one hand, this change is making it possible to spread the production of "well-made biomethane", which is an important opportunity to revisit the agricultural model (even if the largest share now comes from organic waste management), it does however present some

problems from the point of view of its use. In fact, although Italy represents the first European market for the consumption of methane for motor vehicles, with about 1.1 billion cubic metres consumed, around 1 million vehicles currently in circulation and over 1,300 distributors, and if it is understandable that our country aims to maintain its presence in the methane supply chain (which explains how the NIPEC Climate Energy Plan hypothesises a doubling of gas-powered cars at the end of the decade), the real dynamics could be different and this solution does not seem to have strategic breath.

Indeed, the car world's effort is focused on the ***electric option***, which will increase from 60 models available in 2018 to 214 models that will be on the market in 2021[2]. One example of this trend is Volkswagen, one of the few true giants of car production. Despite the fact that until a few months ago the German manufacturer had announced substantial resources to launch several gas-powered models to complement the 19 currently on sale, Volkswagen decided in March 2020 to abandon the development of CNG cars and focus all its attention on electric cars. These trends would seem to be reflected in the consumption scenarios of Italian families. According to an analysis by the Motus-e Association (which includes some of the world's leading car manufacturers, such as Fca, Nissan, Volkswagen, Volvo, Renault and Tesla), in 2030 there will be fewer cars in Italy than there are today, 32 million from today's 39 million, and 4 million electric cars will travel, which by the end of the decade will account for 50% of sales and 12.5% of the total number of cars in circulation.

2 https://www.transportenvironment.org/publications/electric-surge-car-makers-electric-car-plans-across-europe-2019-2025

This estimate is consistent with the final version of the NIPEC, which foresees a gradual increase in new registrations of electric cars to reach the cumulative target of around 4 million pure electric cars or BEV[3] by 2030, which, when added to *plug-in* hybrids, would bring the total to around 6 million electric cars by 2030.

Further reinforcing the idea that electric cars, and not biomethane, will be the power source for an environmentally friendly future, are recent developments in terms of ***European regulations*** and subsequent investments. According to Transport&Environment, European companies invested 7 times more in electric cars in China in 2017-2018 than they did in the EU (€21.7 billion compared to €3.2 billion). However, because of the new EU regulations on CO_2 emissions from cars, which were adopted between 2018 and 2019, the situation was reversed in 2019, with 19 times more investment pouring into Europe than in the previous two years. Investment in the EU thus became more than three times that in China, with €60 billion invested in the production of electric vehicles in Europe. It is clear from the changing interest of car manufacturers that this sector is set to dominate. In addition, in terms of economics and overall environmental impact the figures provide further arguments in favour of this trend. On the economic side, lithium-ion batteries, whose costs were reduced by 87% between 2010 and 2019[4] and whose carbon footprint, linked to serious environmental and

3 The acronym Bev stands for Battery Electric Vehicle. These are cars without an internal combustion engine.

4 Italy has also joined the battery race with a plant built by the Seri/Faam group at the former Whirlpool site in Teverola, which should reach a capacity of 3 GWh by 2026, with investments of half a billion euro

social problems, is decreasing[5]. In terms of climate-changing emissions, analysing the entire life cycle of cars, electric vehicles are 17-30% less emissive than diesel and petrol vehicles (N.B.: this analysis by the European Environment Agency was carried out with the 2018 European electricity mix, but the more renewable sources become available, the greater the advantage of electric cars).

While electricity is already largely a matter of fact for rail transport (and where it is not, the replacement of fossil fuels by hydrogen is an ongoing trend), it seems to be a real prospect for industrial transport as well.
Trucks account for less than 2% of vehicles, but are responsible for 22% of CO_2 emissions in the European transport sector. Transport&Environment's 2020 report[6] shows that half of the distance covered by trucks in the EU could be covered by electric vehicles, thanks to ***new models currently on the market with a range of around 300 km (enough to cover nine out of ten trips).*** The study also predicts that the range of electric trucks will increase to 500 km in the medium term, enabling around two-thirds of the kilometres to be covered. Significantly, Daimler Trucks, one of the world's largest truck manufacturers, has committed in October 2019 to abandon the development of natural gas-powered trucks and to sell only zero-emission vehicles by 2039.
The infographic at the end of the chapter, taken from the above-mentioned report, shows the timing of the spread of electric vehicles according to the distances to be covered and their tonnage.

and it also includes a line for recycling batteries.

5 Tesla has said that it will eliminate the use of cobalt altogether for cars coming out of its new Shanghai plant by switching to lithium-iron-phosphate (LFP) batteries, which will also reduce car costs.

6 https://www.transportenvironment.org/publications/roadmap-electric-truck-charging

Priorities

In Italy, by far the most prevalent mode of private transport is the car, which accounts for 75% of passenger mobility (measured in millions of passengers per km) and 80% if motorbikes are included; private motor vehicles are closely followed by urban and suburban bus services, 12%. Railways, on the other hand, account for less than 6% of the demand for private mobility. By contrast, national and international road transport, measured in millions of tonnes per km, accounts for 70% of the total, maritime cabotage for 27% and railways for just over 10%[7].
This means that the priorities for Italy must necessarily focus on the massive electrification of the private vehicle fleet and the gradual transfer of long-distance commercial transport to rail. This was the basis for the calculations in the final chapter of this study, in respect of which an important industrial policy assumption must also be taken into account. Italy has a serious problem with car production: FCA has seen its share of car production fall sharply over

7 Data refer to 2014. See ISPRA, "Annuario dei dati ambientali" (2016) ch.4 tab.4.22 p.44 and tab. 4.25 p.49

time (from 2013 to 2019 it has halved, dropping - according to EStà's calculations based on OICA sources - to about a tenth of Volkswagen's) and today continues to be present at the international level not because of its innovative choices (FCA did not consider the electric car a priority, except to change its mind when its global competitors had acquired a strong advantage), but because of its policy of alliances. Under these conditions, Italians will be able to produce components for others (Germans first and foremost) and buy electric cars produced by others, but the stimulus to employment from domestic production of electric vehicles will not be particularly significant.

TRANSPORT

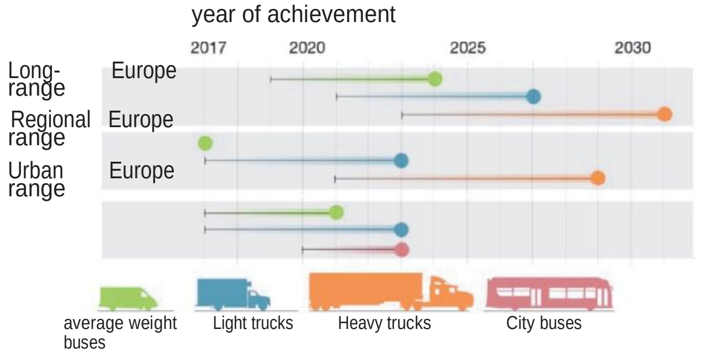
ROAD TRANSPORT (81% OF GREENHOUSE GASES)

ENTERPRISES

TRUCKS TODAY
2% of vehicles and
22% CO_2 in European transport

ELECTRIC TRUCKS

Times when battery electric vehicles will achieve parity in total cost of ownership with diesel vehicles



FAMILIES

PUBLIC TRANSPORT

- 2011=15,000 circulating buses
- 2016=13,000 circulating buses

ELECTRIC CARS

- 2019 = 10,566 sold in Italy
  39 million circulating
- 2030= 4 million sold 32 million circulating
  (Motus-e estimates)

(Source: Transport&Environment)

5. Waste

The ***most recent ISPRA inventory refers 4.1% of CO_2 equivalent emissions in Italy to the waste sector. These are almost entirely (89%) methane (CH4) emissions.*** The historical trend appears favourable: in 2001, waste in our country emitted a total of almost 24 million tonnes of CO_2 eq., which fell to 18.290 million in 2018. Of this, more than 2/3 (13.704 million) comes from solid waste disposal and another 3.370 million from wastewater treatment. Despite the good overall trend, detailed ISPRA data show that from 2015 onwards the decline in the amount of CO_2 eq. in this sector has stopped.

From an operational point of view, ***to date a sensitive issue remains the lack of plants for the treatment of the wet fraction***, a problem particularly visible in the regions of central and southern Italy where the lowest organic waste collection rate is recorded (in 2018 a value of 95.1 kg/inhabitant/year against a national average of 117.3 kg/inhabitant/year, which in central Italy rises to 119.2 and in the north to 123.9 - ISPRA 2019 data). Assoambiente estimates that in order to reach the 2035 targets on municipal waste defined in the European directives of the Waste Package (65% preparation for re-use and recycling of municipal waste - Directive 2018/851 - and reduction of the landfilling of municipal waste up to a maximum of 10% by weight of the total municipal waste produced - Directive 2018/850), with a scenario of stable waste production by then, it will be necessary to reach a level of separate collection of 80% (taking into account the rate of return with respect to the intercepted municipal waste), or about 23.7 Mton of municipal waste. Given the fundamental role of wet waste in the calculation of separate waste collection, it will be imperative, particularly in the central-southern regions, to increase the separate collection of the organic fraction (which today in Italy reaches about 75% of households) and plant capacity. In a scenario of an increase from 110 to 140 kg/inhabitant/year, about 22 anaerobic digestion (AD) plants of 90,000 tons/year each would be needed, as the shortage would be around 2 Mton of wet waste (according to CIC the current plant shortage is about 1 Mton). For the construction of the plants, Assoambiente estimates an investment requirement of 2 billion euros, 600 euros/tonne (Assoambiente, 2019). Applying a conservative coefficient, this figure could correspond to an employment of about 41200 workers per year for the construction of the plants and, calculating the additional tons of treatment provided by the 22 new plants - combined with the tons/employment conversion rates suggested by the CIC - 3000 new employees can be reasonably calculated for the management of the chain related to the organic fraction, including also all those who will be employed in the separate collection of the additional treated waste. From an environmental point of view, it can be estimated that this expansion of collection and recycling, by reducing the amount of undifferentiated organic waste (still 38% in Italy), could translate into a decrease of about 1% in greenhouse gas emissions.

WASTE

WASTE:

OVERVIEW

- 4,1% of total emissions (89% due to methane)
- 2/3 comes from solid waste to landfill, over 1/5
- 1/5 from wastewater treatment

PROBLEMS

LACK OF FACILITIES
to treat organic waste:

Italy currently lacks 22 anaerobic digestion plants of 90,000 tonnes/year each
(Assoambiente 2019 estimate)

they would employ:
41,200 annual workable units for construction
3,000 new jobs for management

THE VIRTUOUS CYCLE

SEPARATE COLLECTION

RECYCLING

ORGANIC FRACTION (WET)

compost | biogas | biomethane

part two:

ABSORPTIONS

Key points

Agricultural soils and forest soils have a very high CO_2 absorption potential. Well exploited, this could raise the offset of CO_2 eq. emissions from businesses and households (427 million tonnes in 2018) by tens of additional tonnes.
In the first metre of soil, a large amount of carbon is concentrated, which is released into the atmosphere and transformed into CO_2 through ploughing processes.

Deep ploughing during **agricultural practices** increases soil productivity in the short term, but has the opposite effect in the long term. In contrast, conservation agriculture, based on reduced tillage, soil cover and crop rotation, increases the capacity of agricultural soils to absorb carbon.

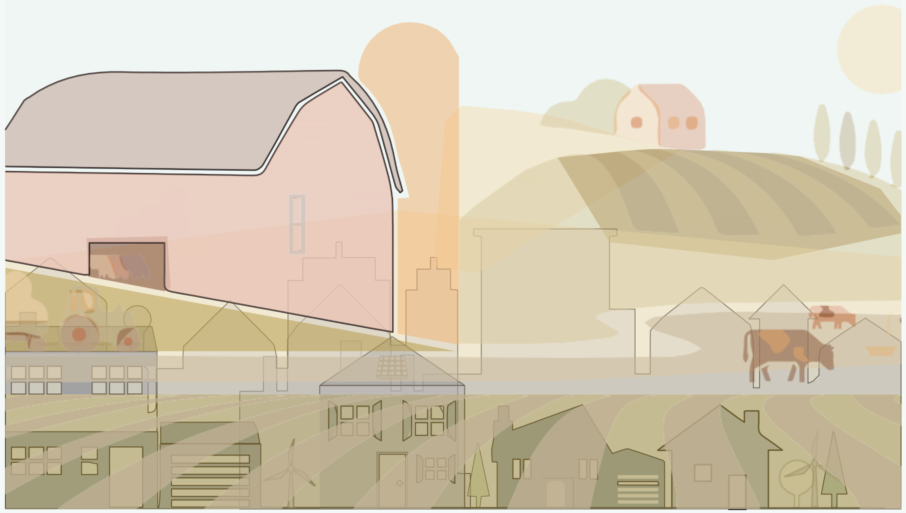
Taking into account the main variables (climatic zones of the Italian territories, type of crops, processing methods) an annual potential of 29 million tons of CO_2 further absorbed in case of a wide adoption of conservation agriculture practices on Italian soils can be estimated.

This absorption effect would gradually diminish over the decades, but considering the level of average national soil depletion, it would remain at significant levels at least until 2050.

The total carbon stored within Italian **forest areas amounts to** about 1.24 billion tonnes, corresponding to about 4.5 billion tonnes of CO_2 (almost equal to the annual emissions of the entire EU-27). The absorption effect increases over time due to the spontaneous growth of the Italian forest area (+ 84% from 1936 to 2015), which in turn is produced by the progressive abandonment of less productive agricultural areas.

This virtuous climate dynamic will inevitably diminish in the coming years, but the absorption effects of forests can be improved through better forest management and wood utilisation (particularly as construction and furniture timber).

A recent study (Nabuurs, Gert-Jan, et al. 2017) outlines the possibility of duplicating the absorption capacity of European forests through integrated interventions on the forms of management, use and regulation of the forest sector. In Italy, the increase of this function will have to pass also through the change of management forms, starting from the conversion of wide areas of coppice forest to high forest with a higher economic, functional and landscape value. The improvement of management forms in our country is currently hindered by the high fragmentation of land ownership.



4. Agricultural soils

The main greenhouse gases of agricultural origin are, in addition to carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O).
Methane is produced when organic matter is degraded in an oxygen-poor environment, i.e. in digestive processes (enteric fermentation), in the anaerobic degradation of livestock manure and in submerged rice cultivation. In Italy, the latter are concentrated in a limited area of the Po Valley, including the provinces of Pavia, Milan, Novara and Vercelli.
Nitrous oxide, on the other hand, is produced by the microbial transformation of nitrogen in soils and manure under both aerobic and anaerobic conditions, particularly when the available nitrogen exceeds the demand of the plants and under conditions of excess humidity.

In Italy, the agricultural sector makes a non-negligible contribution to global greenhouse gas emissions, contributing around 7.1% of the 391 million tonnes of CO2 equivalent (CO_2 eq) estimated for our country in 2018, putting the sector in third place after energy production and combustion and just below non-energy intensive industries (a further 1.9% should be added here, due to fossil energy burnt by agricultural inputs).

GHG categories	1990	1995	2000	2005	2010	2015	2016	2017	2018
Gg $_{CO2}$ equivalent									
1- Energy	423,555	436,219	457,280	485,343	426,136	357,289	353,493	348,508	344,328
2- Industrial Process and Product Use	40,484	38,374	39,198	47,263	37,069	33,265	33,477	33,939	34,724
3- Agriculture	34,709	34,846	34,107	32,040	30,147	30,299	30,831	30,625	30,187
4- LULUCF	-3,556	-23,647	-20,904	-35,104	-41,975	-43,610	-40,231	-21,360	-36,266
5- Waste	17,304	19,996	21,890	21,883	20,404	18,579	18,288	18,252	18,290
6- Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	**512,496**	**505,788**	**531,570**	**551,426**	**471,782**	**395,822**	**395,857**	**409,964**	**391,263**

Figure 17 - Greenhouse gas emissions in CO2 eq by source category (Source: Ispra 2020, National Inventory Report)

Role of agricultural soils in carbon absorption and process variables

Each year, 30% of the carbon dioxide emitted into the atmosphere is absorbed through the process of photosynthesis and converted into organic matter. Agricultural practices, while contributing to anthropogenic greenhouse gas emissions, have also (as does natural vegetation) the potential to store carbon in soil and plants. Soil is by far the compartment that holds the most carbon. ***It is estimated that as much as 75% of carbon is contained in the first metre of soil,*** compared to 11% in vegetation and 14% in the atmosphere. The density of C, expressed in terms of millions of grams of C per hectare (MgC/ha) varies according to a 'latitudinal gradient': higher densities of C are found in boreal ecosystems, where the dynamics of decomposition of C in the soil are (unfortunately less and less) mitigated by climatic factors; lower densities of C in tropical ecosystems.
The main input of C into the soil is the decomposition of litter, i.e. dead biomass, with a diameter of less than a certain threshold (usually 10 cm), lying - at different stages of decomposition - on the soil.

The loss of organic matter involves the release of CO_2 into the atmosphere due to the oxidation of organic matter. The speed of this process is influenced by:

- environmental conditions (temperature, precipitation, (an)aerobic conditions);
- soil characteristics (soil texture, microbial component, etc.);
- tillage practices.

While soil characteristics cannot be changed and environmental characteristics are affected by climate change, tillage practices are the result of choices and policies that can be guided by their effects and implementation costs. It is widely acknowledged that sound agricultural soil management - through improved crop rotations, crop residue management, application of organic soil conditioners and reduced or no-till practices - leads to multiple benefits in terms of *Soil organic carbon* (SOC) storage, crop yields, reduced runoff and hence water erosion, improved water quality, biodiversity protection and mitigation of the effects of extreme climate events.

Legislative initiatives and action plans for soil organic carbon management

Current legislation does not set any limits or regulations on the amount of organic carbon in the soil. However, during the 21st United Nations Conference of the Parties on Climate Change held in Paris in 2015, the French government launched ***the 4 per 1000 initiative "Soils for Food Security and Climate "***[1]***,*** a voluntary action plan that aims at supporting States and non-governmental stakeholders in their efforts to better manage SOC in agricultural soils and at achieving a 4 per thousand (0.4%) annual growth rate of SOC stocks in the top 40 cm of soil as compensation for global greenhouse gas (GHG) emissions from anthropogenic sources. With this target, considering that the annual GHG emissions from fossil fuel use for the period 2004-2013 were 8.9 Gt C and taking into consideration a global estimate of the soil C stock at 2 m soil depth of 2400 Gt, the ratio of emission target to SOC stock (8.9 / 2400) would be exactly 4% (4 per 1000). The initiative therefore aims at proving that agriculture can provide opportunities for climate change mitigation while ensuring food security through agricultural methods that meet local conditions (e.g. agroecology, agroforestry, conservation agriculture).

1(http://4p1000.org/)

The role and importance of agricultural practices

For over 2000 years, farmers have believed that it is essential to plough the land in order to obtain a good harvest, associating tillage with the increase in fertility that can occur in the short term due to the mineralisation of organic matter as a result of the stirring and aeration of the soil. But the more frequently the soil is ploughed, the faster the organic substance is lost and the more quickly its fertility is reduced. This process leads to the need to increase mineral inputs (especially nitrogen) which has a negative impact on the farmer's costs, creating a vicious economic and environmental circle.

One answer to these problems comes from the practices of conservation agriculture (or blue farming).
There are three pillars or principles that underpin this

agricultural practice:

1. reducing tillage;
2. maintaining a permanent soil cover with crop residues and/or cover crops;
3. diversification of plant species.

Underlying the first pillar is the fact that ***limiting and eliminating tillage*** reduces the destruction of soil aggregates, preserving the organic matrix from direct exposure to weathering and preventing erosion.

Maintaining a permanent cover also has positive effects on several components. Firstly, crop residues represent the starting matrix from which the biological processes will constitute the organic substance of the soil. Furthermore, their mulching effect reduces evaporation processes, increasing the natural water reserve of the soil itself, and erosion processes, protecting the soil from the impact of extreme weather conditions. Finally, residues represent a stock of carbon removed from the atmosphere, with mitigating effects on greenhouse gas emissions.

In place of crop residues, which are removed for various reasons (e.g. as animal bedding), the task of ground cover can be entrusted to so-called *cover crops or catch crops*. The cover crop effect is further enhanced by the introduction of woody species in the form of hedges, wood shavings and trees (*agroforestry*) on agricultural land.

The Census of Agriculture conducted in Italy in 2010 showed that in our country conservation agriculture (CA) was adopted by more than 52,000 farms for a total of 180,000 hectares under the conservation regime.

According to updated FAO estimates (2015), in Italy the number of hectares of CA has more than doubled (380,000 hectares or 2.5% of the total agricultural area as of 2018), a significant increase, although the share is still very low and its increase seems crucial for a relevant contribution to climate neutrality.

The potential of agriculture for carbon neutrality

Considering that the soil-vegetation carbon reservoir, although smaller than the oceanic and fossil carbon reservoirs, is the most important, also because it can be directly influenced by human action, Està - starting from some works of the French institute (INRA, 2019) - has developed a methodology that, based on the knowledge of the organic carbon content in Italian agricultural soils, intends to estimate the consistency of the role they can play in reducing greenhouse gas emissions.

The methodology is based on the best available databases and the steps summarised below:

1. Estimation of total organic carbon in the first 30 cm of Italian soils;
2. Estimation of the area of agricultural classes and estimation of their organic carbon content;
3. Calculation of the increase in organic carbon that Italian agricultural soils would experience if the criteria of the "4 per 1000" initiative were met;
4. Calculation of annual organic carbon increase

that Italian agricultural soils could suffer if conservation agriculture techniques were applied to at least some classes of agricultural land use, and consequent calculation of the share of carbon dioxide sequestered.

1) In order to estimate soil carbon, a subdivision of Italy into two climatic macro-zones, here called 'Northern Italy' and 'Southern Italy', was applied to the original database, with these results:

	Surface Italy	Surface Northern Italy	Surface South Italy	SOC Italy	SOC Northern Italy	SOC South Italy
TOTALS	301.175 Km2	161.044 Km2	140.132 Km2	1.75 Gt	1.00 Gt	0.75 Gt

2) The following table shows the proportions of level 2 for agricultural areas and level 1 for all other areas according to the CORINE Land Cover legend, for the whole national territory (LC_It), for Northern (LC_NIt) and Southern (LC_SIt) Italy. The same table also breaks down the proportions of soil organic carbon (SOC) for the same classes and geographical areas.

CLASSES OF COVERAGE	LC_It (%)	LC_NIt (%)	LC_SIt (%)	SOC_It (%)	SOC_NIT (%)	SOC_SIt (%)
Arable	53,1	60,1	46,8	52,7	59,9	45,3
Permanent crops	13,9	6,3	20,8	12,6	5,58	19,8
Stable meadows	2,6	3,9	1,5	3,5	5	1,8
Heterogeneous agricultural areas	30,2	29,7	30,8	31,2	29,4	33,1
TOTAL AGRICULTURAL	51,9	46,2	58,5	44,9	40,1	51,3
Man-made surfaces	5,5	6,3	4,5	4,8	5,4	4
Woods & semi-natural environments	41,3	45,7	36,2	49	52,8	44
Wetlands	0,2	0,3	0,1	0,2	0,3	0,1
Water bodies	1,1	1,5	0,6	1,1	1,5	0,6

The table shows that the organic carbon content of all agricultural areas is 40.1% of the total in northern Italy and 51.3% in southern Italy, compared to 52.8% and 44% for forests respectively.

3) The organic carbon content of each class and geographic area has been converted into CO_2 equivalent (CO_2eq), i.e. the corresponding amount of carbon dioxide retained in the soil and thus corresponding to a lack of greenhouse gas emissions. The same table also shows the amount of additional CO_2 eq corresponding to a theoretical increase in organic carbon of 4% sequestered in soils by agricultural management techniques.

4)

CLASSES OF COVERAGE	SOC_Italy (Gt)	$_{CO2eq\_Italy}$ (Gt)	4 per thousand $_{CO2eq}$ (Gt)
Arable	0,42	1,52	0,0061
Permanent crops	0,1	0,36	0,0015
Stable meadows	0,03	0,10	0,0004
Heterogeneous agricultural areas	0.25	0,90	0,0036
TOTAL AGRICULTURAL	0,79	2,89	0,0116
Artificial surfaces	0,08	0,31	0,0012
Forests & semi-natural environments	0,86	3,15	0,0126
Wetlands	0,0	0,01	0,0001
Water bodies	0,02	0,07	0,0003
TOTALS	1,75	6,44	0,0257

In order to make the simulation of the 4 ‰ increase in the organic substance of Italian soils more real, the application of some conservative agricultural practices to two classes of agricultural areas was considered: arable crops and permanent crops. *For arable crops, the simultaneous application of catch crops, rotation of different crops, minimum tillage and application of organic fertilisers was assumed. For permanent crops, the application of grass only was assumed.*

For each of these practices, the literature provides coefficients corresponding to the annual increases in CO_2 eq per hectare that they generate, for different climatic conditions. The application of these coefficients to the agricultural areas, as returned by the land cover maps, allowed to estimate the additional CO_2 eq sequestration that these practices would generate.

Conservation agriculture techniques	Northern Italy t $_{CO2eq}$. ha-1 yr-1	South Italy t $_{CO2eq.}$ ha-1 yr-1	
Catch crops	0,98	0,39	
Rotation species	0,98	0,39	
Reduced tillage&residue management	0,72	0,35	
Fertiliser application	0,62	0,33	
TOTAL COEFF. ARABLE CROPS	3,30	1,46	
Arable crops	4,473,424 (ha)	3,842,358 (ha)	**TOTALS**
Seizure of arable crops	0.015 Gt $_{CO2eq}$ yr-1	0.005 Gt $_{CO2eq}$ yr-1	0.02 Gt $_{CO2eq}$ yr-1
Grass in orchards & vineyards	5,36	3,93	
Area of permanent crops	469,522 (ha)	1,708,550 (ha)	**TOTALS**
Seizure of permanent crops	0.002 Gt $_{CO2eq}$ yr-1	0.007 Gt $_{CO2eq}$ yr-1	0.009 Gt $_{CO2eq}$ yr-1

The results show that the application of conservation agriculture practices in Italy would result in a total carbon dioxide sequestration of 29 million tonnes per year, of which 20 (i.e. the 0.02 Gt CO2eq yr-1 mentioned in the first total of the table) from arable crops and 9 (0.009 Gt CO2eq yr-1) from permanent crops. and 9 (0.009 Gt CO2eq yr-1) from permanent crops. This figure is particularly interesting considering that the most recent National Inventory Report (ISPRA, 2020) reports total emissions from agricultural activities in Italy of 30 million tonnes per year.

It should be noted that the annual increase in organic carbon according to the principles outlined above is not intended to be cumulative in a linear manner over time, as the soil is subject to a process of saturation that leads to a progressive slowdown in the absorption of organic matter, which in turn is subject to processes of mineralisation. However, given the extreme organic poverty of Italian soils, it is believed that saturation levels would not in any case be achievable in a timeframe such as that envisaged by the 2050 target (30 years).

From an economic point of view, the issue is more complex. A study carried out in 2015 compared the income margins obtainable from conservation agriculture with and without the support of the premiums provided by the Rural Development Programme (RDP). For the calculations, the premiums provided by the Veneto Region RDP were considered. The analysis shows how conservation agriculture, relying on mere market mechanisms, has a lower annual gross profit margin per hectare compared to conservation agriculture for two of the three crops considered - maize and wheat - and a higher margin for soybean (Bolzonella C., Boatto V. (2015), *All'agricoltura conservativa serve il sostegno pubblico*. In: "L'informatore agrario" 15/2015). In the same study, it is also noted that the results in terms of income of conservation agriculture become better than traditional agriculture where the former is the recipient of the support provided in the above-mentioned Psr

AGRICULTURAL SOILS and GREENHOUSE GAS in ITALY

AGRICULTURE IN ITALY TODAY:

- EMITS CH_4 and N_2O (in 2018 **30.187** million tonnes in Italy)
- Burns fuels and emits CO_2 (tractors, ...)
- Absorbs more CO_2 through **CONSERVATION AGRICULTURE**

CROP DIVERSIFICATION + MINIMUM GROUND MOVEMENT + LAND COVER

SCENARIOS FOR CONSERVATION AGRICULTURE IN ITALY

CONSIDERING
- climate zones
- carbon content in soils
- type of crops
- type of farming techniques

APPLYING:
CONSERVATION AGRICULTURE
- to all arable land
- to all permanent crops

WOULD RESULT
annual absorption of **29 million** tonnes of additional greenhouse gases

(20 from arable lands
9 from permanent crops)

7. Forests

The role of forests in mitigating the climate crisis is scientifically unequivocal. ***Globally, forests absorb about 2.4 Gt of carbon each year, or 24% of total fossil fuel emissions***. Together with the oceans, they contribute to reducing the fraction of all CO_2 emitted into the air to 44%, removing the remaining 56% of emissions from the atmosphere. At the same time, 10% of global emissions come from the destruction of forest ecosystems. This process affects tropical forests, while boreal and temperate forests have been expanding for about a century due to the abandonment of marginal agricultural activities, but this is not sufficient to offset emissions from forest clearance.

1. Forest condition and evolution

The growth phenomenon also concerns ***Italy***, where ***between 1936 and 2015 there was a substantial increase in forest area (+84.3%)*** and in the forestry coefficient. Almost all of the forest expansion is due to the abandonment of mountain and highland agricultural land in the Apennines and Alps. These growth rates, already weakening, cannot be sustained for long due to the progressive exhaustion of available wastelands.

Woodiness coefficient									
	1936	1985	1990	2000	2005	2010	2015	Variation 1985 (1990) -2015	Variation 1936 -2015
		ha						%	%
Wood	n.a.	7.200.000	7.589.800	8.369.400	8.759.200	9.028.139	9.297.078	29,1	
Other wooded land	n.a.	1.475.100	1.533.408	1.650.025	1.708.333	1.760.785	1.813.237	22,9	
Forest area	6.028.301	8.675.100	9.123.208	10.019.425	10.467.533	10.788.924	11.110.315	28,1	84,3
of which in protected areas	n.a.	n.a.	645.000	2.874.000	3.062.000	3.265.000	3.265.000	406,2	
Woodiness coefficient	20	28,8	30,3	33,3	34,7	35,8	36,9		

Evolution of forests in Italy (Source: Global Forest Resources Assessment 2015

In Italy there is a wide disparity between regions with high forest cover (>50% of their territory) such as Trentino Alto Adige, Liguria, Sardinia and Tuscany and others with very low forest cover such as Puglia and Sicily. The Po Valley regions show low forestry coefficients, despite the presence of inland mountain areas, proving the extreme exploitation of the plains, where forest areas are almost non-existent. Italian forests are almost entirely the result of natural expansion. Among the wooded areas only about 100,000 ha are plantations, of which 66,000 ha are poplar plantations. For the rest, forest types reflect the high Italian biodiversity due to the extreme variety of climates and microclimates.

The oak is the dominant species, the beech wood also exceeds one million hectares, followed by the chestnut tree forest with about 800,000 ha, and the alpine conifer formations are of great importance.

2. Carbon stocks and flows

According to the Second National Forest Inventory (INFC, 2005), ***the total carbon stored in Italian forests amounts to about*** 1.24 billion tons, corresponding to ***about 4.5 billion tons of CO_2 (almost equal to the annual emissions of the whole EU-27)***. Of this, about half is estimated to be contained in the organic and mineral fraction of soil. Considering the expansion of forest that occurred between 2005 and 2015 and corresponding to 4.9%, the growth of carbon stock and carbon uptake can be estimated. This is an estimate, as each forest type, corresponding to different habitats with different climates, results in different biomass development and soil organic carbon accumulation. However, as the 2015 data are not yet available, as the data from the third forest inventory 2015 have not yet been published, one can simply assume that each type of forest has grown by the same amount and apply the 4.9 % growth to forest carbon storage. This would result in a stock corresponding to 1,303,656,120.9 tonnes of CO_2 corresponding to 4,784,417,963 t. of CO_2, (exceeding thus the annual emissions of the EU-27).

The estimated ***annual carbon stock*** is more than 12 million tonnes in 2005, corresponding to approximately 46.2 million tonnes of CO_2. Following the above criteria, it is estimated that the value reached in ***2015*** was 13,233,924 tonnes of carbon yearly corresponding to **48,568,504t, of CO_2 absorbed**.
(around 11,5% of Italy's annual emissions).

Tuscany, Piedmont, Lombardy and Trentino-Alto Adige are the regions with the highest storage figures and the largest contribution in terms of organic CO_2 per year.

	Epigeous tree biomass (t/ha)	Necromass (t/ha)	Litter (t/ha)	Organic and mineral soil (t/ha)	Stock C tot (t/ha)	Annual organisation C (t/ha)
Abruzzo	54,4	1,9	2,5	81,2	140	1,3
Basilicata	46	0,9	1,8	86,9	135,6	1,1
P.A. Bolzano	83,2	3,6	9,2	75,3	171,3	1,5
Calabria	65,2	1,9	2,8	87,2	157,1	1,9
Campania	48,3	1,3	2	106,6	158,3	1,6
Emilia-Romagna	53,9	3,3	2,8	80,1	140	1,7
Friuli Venezia Giulia	73,6	3,7	2,7	79,3	159,3	1,9
Lazio	47,1	2	2,3	84,1	135,4	1,1
Liguria	55,1	5,5	3,3	67,6	131,4	1,6
Lombardy	60	3,4	5,1	92,1	160,5	1,7
Brands	40,1	1	1,8	88,3	131,2	1
Molise	50,5	1,5	2,1	101,5	155,6	1,3
Piedmont	53,2	5,3	2,8	75,4	136,7	1,6
Apulia	34,6	0,6	1,2	101,8	138,2	1,1
Sardinia	30,1	0,9	1,9	66,6	99,5	0,9
Sicily	34,5	1,1	1,7	96	133,3	1,1
Tuscany	53	3,6	2,6	71,4	130,6	1,5
P.A. Trento	81,2	3,8	7,4	98,9	191,3	1,8
Umbria	41,7	1,1	2,6	76,2	121,5	0,9
Aosta Valley	45,3	3,1	6,4	47,7	102,5	0,9
Veneto	67,9	3,5	4,7	82,6	158,7	1,9

(Source: MIPAAFT (2019). RAF Italy 2017-2018)

The discrepancy between the amount of carbon stored and organically stored annually by individual regions and the regional forest extension data reported above is due to the different forest types. The highest accumulation of organic matter per hectare is found in those typical of cool and mountainous climates such as spruces and beech woods.

3. Management

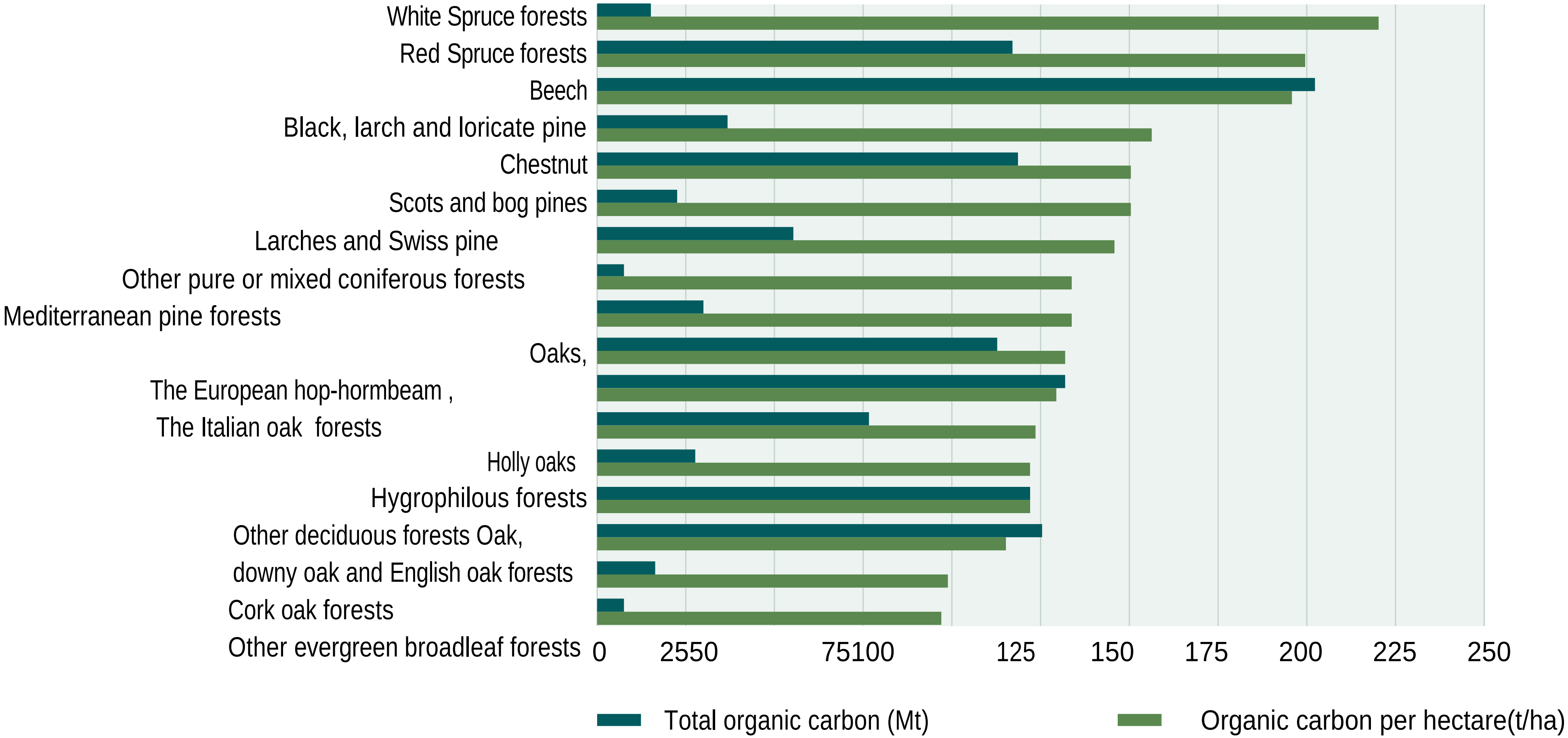


Figure 18 - Annual stocks and organisation by vegetation types. (Source: RAF)

Italian forests are all classified as 'managed'. Coppice is the prevailing form of governance, occupying 41.8% of the forest area of forests alone (IFNC 2005). This means that almost half of the Italian forest area is potentially usable for timber extraction under coppice management. On the contrary, 34.3% is currently governed by forestry. The remaining part is made up of areas of conversion from coppice to high forest, special productive formations (walnut, chestnut and cork trees) and unclassified areas. In reality, a considerable part of Italian forests is currently unmanaged. This can be deduced, for example, from an analysis of the distribution of the age classes of coppice and highland forests. Only a residual part is in fact in a juvenile stage, while the mature and aged stages prevail, testifying to a lack of harvesting. There is therefore a renaturalisation of managed forests. Abandoned coppices tend to reconfigure themselves as forests and the forest diversifies according to age and size classes.

Ownership structure is closely related to management. 66% of forests are privately owned, mostly by individuals. This ***ownership*** is ***very fragmented***, often the result of hereditary divisions. The limited surface area, together with the low profitability of forests, means that active management of forests is not economically viable for private owners.

On the other hand, ***there are examples of collective public property,*** such as the Magnifica Comunità di Fiemme and the Regole ampezzane in Trentino, ***which show major achievements*** in virtuous management of forests and in their valorisation.

4. Wood uses

The FAO report "Yearbook of forest products" 2017 shows data on wood consumption, extraction, export and import for all countries of the world for the main categories of use. Italy emerges as one of the main importers of wood products worldwide. For example, up to 2017 it is confirmed as the world's leading importer of firewood for about 70 million dollars per year.

What ***emerges is a country that,*** despite almost doubling its forestry assets in the last 80 years and despite a high demand for timber for all kinds of uses, including high value-added sectors (furniture, construction, etc.), is ***unable to meet its own needs***, and ends up buying some USD 3 billion worth of wood products abroad.

From ***an environmental point of view, this leads to a high emission of pollutants and climate-altering gases by the*** transport and logistics sector and an undoubted danger of supporting unclear markets without minimum sustainable management. The European Commission itself estimates that around 25% of imported timber is of illegal origin.

According to the Paris Agreement and EU Reg 2018/841, ***long-term uses, such as timber for construction or furniture, are included in the carbon sequestration counts*** and are strongly incentivised by being outside the limitations of forestry offsets1. ***This type of use,***

1Currently, EU Reg 841/2018 sets out the commitments of countries in the LULUCF sector to achieve the Paris targets for the period 2021-2030.

resulting from forest management, is therefore to be developed further.

The energy sector should also be considered, as wood is a renewable energy source which, despite the high eco-systemic damage in the event of massive use leading to high deforestation rates, is better in terms of emission quality than the consumption of fossil fuels, which release previously unavailable geocarbon into the atmosphere, thus resulting in a net addition of the latter to the biological cycle.

5. Strategies

To this day, photosynthesis remains the process of most efficient and cost-effective $_{CO2}$ absorption which the consequences of this process. Therefore, it is conceivable that the evaluation of a forest ecosystem service which is different from the traditional productive one, i.e. of a regulatory nature, such as the ***subtraction of CO_2 from the atmosphere***, will increasingly become a priority. It is ***conceivable that in the not too distant future this will become the main role, also economic, recognised for forests throughout the world.***

Several steps in this direction have already been taken. European Regulation 841/2018 for the first time includes the forestry sector within the emission budgets of the other economic sectors, while limiting by policy choice the expendable mitigation potential (11.5 M tonnes of CO_2 eq in a decade, compared to the approximately 40 that Italian forests absorb annually) precisely so as not to discourage emission reductions in the most polluting sectors.

One of the main innovations contained in the regulation is the inter-sectoral sharing mechanism, thanks to which, for the first time, the LULUCF sector (land use, land use change and forestry) can interact with the other non-ETS sectors regulated by the Effort Sharing Regulation, even though it cannot exceed 3.5% of total 1990 emissions over a five-year period.

According to European Regulation 841/2018, counting emissions and removals must include live biomass, dead wood and carbon stored in woody forest products. It is possible not to count carbon fluxes from soil and litter (the other two forest sinks recognised by the IPCC, which often contain more than half of the carbon in forest ecosystems), provided that it can be demonstrated that these compartments do not result in net emissions. Among the main innovations contained in the regulation are the offsetting mechanism between economic sectors, thanks to which for the first time LULUCF can interact with the other non-ETS sectors regulated by the Effort Sharing Regulation, and the achievement by 2030 of 0 emissions in the LULUCF sector, where agricultural emissions must be fully offset by forest removals and improved agricultural practices. It is then established that each state must identify a reference level of forestry sector removals for the five-year period 2021-25 to be updated for 2026-30. Annually, states commit to accounting for forest removals and emissions in a transparent, consistent, complete and timely manner.

accurate according to IPCC criteria. According to the regulation, emissions/removals resulting from active anthropogenic intervention must be accounted for. That is, they must relate only to managed forests and may exclude natural events that adversely affect performance over a period. If the sum of the removals in a five-year period, subtracting the reference level multiplied by 5, remains negative, i.e. with removals above the reference level, the State can account for this credit although it cannot exceed the quota of 3.5% of total emissions referred to 1990. The removals resulting from dead wood and wood uses (except paper) are not included in this accounting. This is intended to encourage the wood industry for durable storage sectors such as construction, while at the same time preserving the ecosystem functions of forests that deadwood provides, for example, for animal, fungal and microbial biodiversity. On the other hand, uses of wood for energy purposes are counted as net losses. As a renewable energy source, however, the impact is recovered in the energy sector, where such production is counted at 0 emissions. The 3.5 % from possible credits can be redirected to other sectors according to Reg 842 Effort sharing regulation. Possible allowances exceeding 3.5 % can instead be transferred to the next five years or to other states, in a flexibility mechanism (Pilli 2018).

As a result of political bargaining among Member States, a cap on offsetting from LULUCF to non-ETS has been set at 280 Mt $_{CO2}$ eq. within the Union for the whole decade. Italy's share is 11.5 tonnes CO_2 eq.

A recent compilation of 51 scientific studies has shown that in all sectors the substitution factor (CO_2 emissions avoided per kg of wood used to replace other materials) averages 1.2 kgC/kgC2. In fact, the count is not only limited to accounting for the amount of C stored in wood used for durable purposes, but also to the emissions avoided by not using other materials, starting with cement. Incentivising the production of European timber is also a way of limiting imports from equatorial countries that do not follow strict forestry regulations and are destroying an invaluable heritage.

A recent study (Nabuurs, Gert-Jan, et al. 2017) outlines the possibility of doubling the absorption capacity of European forests through integrated interventions on the forms of management, use CO_2 eq/year (***corresponding to about 13% of total*** European ***emissions***) to 1000 M t CO_2 eq/year (Nabuus et al 2017).

In Italy the increase in this function will also have to pass through a change in management forms. Starting from the conversion of large areas of coppice woodland to high forest with greater economic, functional and landscape value.

The ***ownership structure of Italy's woodlands, which is mainly private and very fragmented, is a*** significant ***obstacle*** to the promotion of active forms of management aimed at the intelligent use of the forest, which develops its potential as a carbon sink while

2https://www.aboutenergy.com/it_IT/topic/natura-non-ci-salvera.shtml while providing long-lasting products. ***Much of the experimentation in this sense will therefore have to involve the public sector, first and foremost as forest managers***. ***Secondly, however is also a priority to set up mechanisms to remunerate the ecosystem service of*** CO_2 absorption (through the Payment for Ecosystem Services instrument) purchased by the public for an essentially public good such as atmospheric composition but with significant economic spin-offs.

FORESTS and CO_2 ABSORPTION

FORESTS:

GROWTH: Italy = +84.3% between 1936 and 2015

They absorb 11.5% of Italy's CO_2 eq. each year, net of of emissions from the sector (fires...) have so far withheld the equivalent of the one-year issues of the Europe of 27

MAY Provide:

- additional CO_2 absorption
- furniture, construction timber... (which retain the absorbed carbon)
- biomass for heating with low greenhouse gas emissions

STRATEGIES

Well managed they can significantly increase their CO_2 eq. absorption capacities.
(Nabluus et al. 2017 estimate an average European figure of +12%)

- increase in forest management by the public operator
- preferences for domestic timber uses in construction, furniture
- remuneration of private sectors to protect the ecosystem service provided by forests to the climate (payment for ecosystem services)

part three:

INVESTMENT, ADDED VALUE, EMPLOYMENT

Key points

Both the analysis in the previous chapters and the analysis in PNIEC 2019 converge in indicating that the sectors of renewable energy (electrification and photovoltaics *above all*), buildings and transport are the areas on which investments should be concentrated over the next 10 years in order to achieve and employment.

The framework analysed by PNIEC 2019

In these sectors, under current legislation, the 2019 PNIEC estimates the existence of a volume of *inertial* annual investments (i.e. already existing and "dragged on" in subsequent years) of 78 bn euros per year (1014 bn between 2017 and 2030). Compared to this trend, the additional investments planned by the PNIEC for the period 2017-2030 amount to 186 bn over the entire period (on average about 14.3 bn per year). In addition to the efficiency/reconversion of energy production and distribution (61 bcm for district heating, production and the electricity grid), the additional investments planned by the PNIEC for the period 2017-2030 are mainly concentrated on the residential buildings sector (63 bcm), tertiary buildings (35 bcm) and transport (27 bcm).

The PNIEC simulates the macroeconomic effects of investment on additional wealth (in terms of VA, value added) and employment (in terms of ALU, active labour units). The simulations use two different multipliers (Input Output - I/O - and SAM) and distinguish between "temporary" and "permanent" impacts on labour units: the temporary increase in AWU refers to all the activities involved in the design, development, installation and implementation of the investments; these can be considered as short-term (direct and indirect) impact effects that will be exhausted when the investments are made and implemented. The "temporary" effect recalculated as an annual average therefore assumes that the implementation of the investments is continuous and homogeneous over time. On the other hand, the "permanent" effects (direct and indirect) are those resulting from the maintenance of the assets realised throughout their life cycle.

According to the I/O model, 14.3 bn average annual investments can produce, over the period 2017-2030, a total annual VA increase of 8 bn (+6.5% over the entire period or +104 bn cumulative) and a "temporary" increase in AWUs mn

employment over 13 years); the "permanent" effects amount to +13,000 AWUs over the entire period (from 37,700 to 50,700), minus the number of jobs lost due to the phasing out of fossil fuels (-6,100): the net "permanent" impact is therefore 6,600.
According to simulations using the SAM model, 14.3 billion average annual investments have a slightly lower impact on VA (7.1 billion average annual investments, 92.3 billion cumulative) and a significantly lower impact on employment (+79 thousand average annual AWUs, i.e. slightly more than 1 million additional employees over the entire period).

The additional investment needed.

However, the PNIEC refers to a CO_2 eq. reduction target of -40% (in the year 2050 compared to 1990), which is not in line with recent revisions of the target, which move it to
-55% according to the EC and -60% according to the European Parliament.

To achieve the emission reduction target consistent with the new EU target (-55%) **in the buildings sector, the** investment needed would thus be two and a half times the annual investment planned by the PNIEC for the residential and commercial-public sectors (20.7 billion). In this scenario, the residential/commercial-public sector would not only be able to eliminate its dependence on fossil fuels, but would also have an annual electricity production capacity 6.5 Mtoe higher than its needs. The higher final demand for electricity consumption resulting from the decarbonisation of the residential and transport sectors could potentially be met by installing photovoltaic panels on about 4% of the existing residential stock over ten years.

In the transport sector, Italy's priorities necessarily focus on the massive electrification of the private vehicle fleet and the gradual transfer of long-distance commercial transport to rail. Using the same assumptions about average mileage and average consumption as those implicit in the PNIEC estimates, it can be estimated that electrifying twice as many vehicles as planned (i.e. 30% instead of 15% of the existing fleet), together with adopting hydrogen technologies to the extent already envisaged by the PNIEC, would be the best way to achieve this.

PNIEC, could ensure at least the complete replacement of current diesel use. The PNIEC already estimates the largest financial effort for the conversion of vehicles in the transport sector: an additional 27 bn on top of the 31.4 bn already provided for under current policies (i.e. 58.4 bn per year cumulatively). A proportionate increase in investment would be needed to meet the new target.

In the **renewable energy** sector, PNIEC projections foresee an increase in renewable energy production by 2030, raising its share from 17.4% to 30%, a level slightly below the EU target (32%). To achieve the new EU target of a 55% reduction in emissions compared to 1990, the transition to renewable energy must therefore be significantly accelerated. Total energy production from renewable sources should reach 43% of total consumption by 2030 (instead of the 30% envisaged) and bring forward the 30% target (originally envisaged by the NEEAP only for 2030) by five years to 2025. Renovation of buildings with the aim of making a significant proportion of existing buildings 'nearly zero energy *buildings'* (nZEB), a more significant contribution of energy to the energy mix and the use of renewable energies are all part of this.

solar energy to civil thermal production and extensive electrification of transport would close this gap.

Taking the PNIEC projections of final electricity consumption as a basis, the PNIEC targets envisage solar contributing 24.1% (6.3 Mtoe) to their coverage in 2030. A coverage of 80% in 2050, on the other hand, would require solar to meet at least 40% of the total electricity demand in 2030, i.e. 10.4 Mtoe (i.e. at least 4.1 Mtoe more than already projected in the PNIEC).

If the final demand for electricity evolves as envisaged by the PNIEC, this goal is far from utopian, even if it requires a huge electrification effort in both the residential and transport sectors.

The increased final demand for electricity consumption resulting from the decarbonisation of the residential and transport sectors could potentially be met by installing photovoltaic panels on about 4% of the existing residential stock within ten years. The electricity needs of the residential/commercial/public sector would be more than fully met by self-production through photovoltaic panels (21 Mtoe compared to a residual electricity demand of

14.5 Mtoe), and the surplus of electricity production in this sector (6.5 Mtoe) would be more than sufficient to cover the increased demand, particularly from the massive electrification of private transport (4.9 Mtoe).

The **effects on employment and added value**
Assuming the multipliers used by the PNIEC and adapting them to the revision of investments required to achieve the 55% target for greenhouse gases (1990 - 2030), although it is not possible, with the methodologies adopted, to analyse the exact distribution of these effects over time, it is reasonable to assume that the new investments will result in an 8% increase in GDP growth by 2030 and an increase in the number of jobs.
600,000 jobs, stable over the decade and concentrated in the construction, transport and renewable energy sectors. The *revised* investment plan needed to achieve an emissions reduction of -55% (compared to 1990) by 2030 has a magnitude and economic impact six to eight times greater than originally envisaged in the PNIEC.

The impact of employment must also take into account the loss of employment as a result of disinvestment in fossil energy. The PNIEC simulations estimate, however, that the direct impacts of such disinvestment are, on average per year, relatively small. In fact, the I-O model estimates a "temporary" negative impact (i.e. linked to lower investments) of about **5000** average annual work units (80% concentrated in the production/distribution of fossil energy and thermal energy for the residential and tertiary sectors) and, when fully operational, a "permanent" drop of just over **60000 AWUs.**

The further potential of technological innovation
The interventions proposed above all refer to the current situation of the Italian production system, a production system that is nevertheless suffering from a backward trend in its ability to produce goods with a high technological content and, consequently, higher added value than traditional sectors. Since the end of the last century, and in recent years in particular, our country has in fact been accumulating a growing negative *gap* with the major EU countries in terms of its capacity for technological innovation and increase in wealth produced (VA).

Increasing research and development and industrialisation of high-tech products would therefore help our country to position itself in the process towards climate neutrality by producing goods with higher added value, which would otherwise have to be imported from abroad, and thereby increasing both the speed of emission reduction and the wealth produced and employment.

In particular, it is estimated that an additional annual investment of EUR 7 billion in advanced green technology, compared with the same EUR 7 billion invested in technology with a low innovative content, would produce about 400,000 jobs and about 4.1% more GDP by 2030.

8. The investments needed for carbon neutrality

The following three graphs take up three topics that are fundamental to the development of this last chapter: the less virtuous trend of households compared to the companies ('production activities') in terms of emissions dynamics (Figure 19); the weight of the different sectors in the total Italian emissions (Figure 20); the strategic sectors whose dynamics require specific interventions (Figure 21).

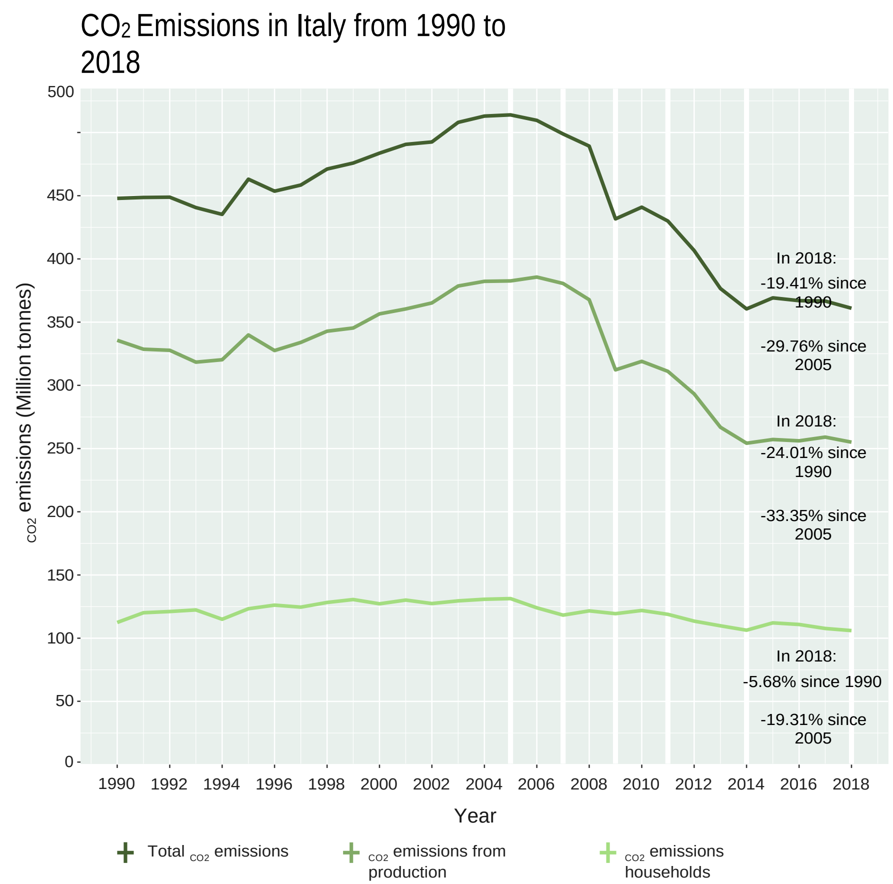


Figure 19 - CO_2 emissions by households and production activities

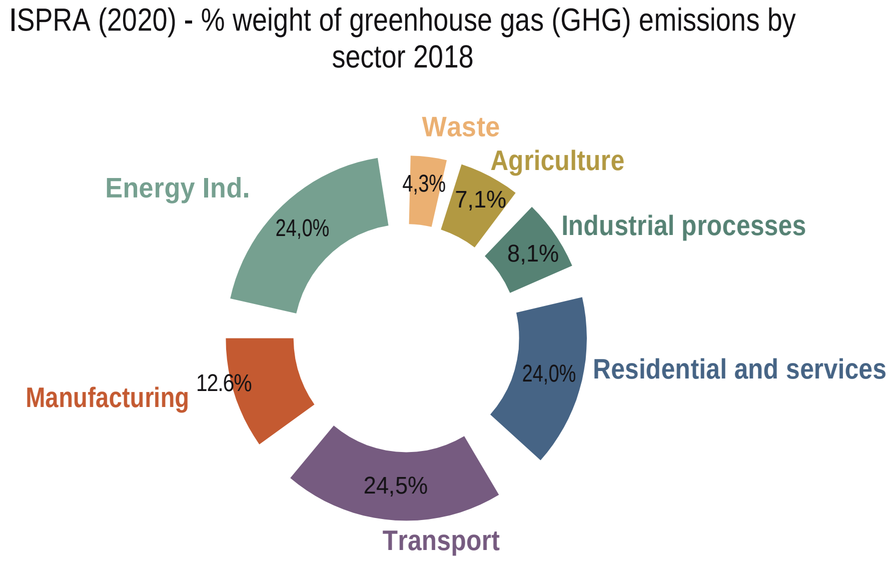


Figure 20 - the different sectors and the percentage weight in Italy's greenhouse gas emissions in 2018

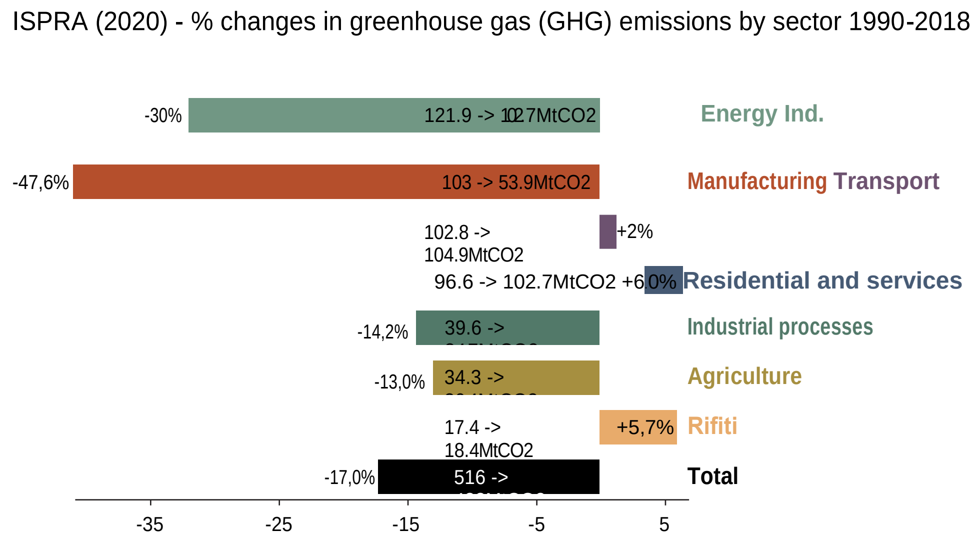


Figure 21 - Percentage changes 1990 - 2018 and absolute values of greenhouse gases in different Italian economic activities

The last figures highlight in particular the strategic role of two sectors in which households have a significant weight: transport and the 'residential and services' sector "(which is referred to as "buildings" in chapter 3 of this report).
Both sectors show in the 2018 survey an annual emission of more than 100 million tonnes of CO2 equivalent (about twice as much as manufacturing industries) and in the 1990 - 2018 trend an increasing trend in absolute values (while manufacturing industries halve them). The graph also shows a negative trend for the waste sector, but, as mentioned above, it emits less than one fifth of the other two sectors and has seen significant improvements in Italy in recent years.
In order to fully understand these data, it should be noted that the construction sector is largely attributable to households (the public and commercial part, called 'services', is clearly a minority compared to the 'residential' part), while the transport sector is mixed (transport accounts for 24.5% of total national climate-changing gas emissions; of this 24.5%, more than half - about 14.3% - is attributable to household transport, the remaining 10.2% to business transport).

Finally, the overall weight of the two sectors suggests that the energy producing industries sector should also be analysed in this concluding chapter. At the heart of the analysis is the need to replace current energy production, largely based on the use of fossil fuels, with production that by 2050 will have to be based solely on renewable energies, largely (80%) provided by photovoltaics. For this to happen, extensive electrification of areas currently served by photovoltaics is mainly required from fossil fuels (transport, buildings...) and electricity production from renewable sources. These considerations show the intersections and correlations of the sectors examined in the chapter.

For each of the three policy sectors (renewable energy, household transport and buildings), the chapter shows the results of studies on the investments needed to reach not the conservative target of -40% between 1990 and 2030 in terms of CO_2 eq. emissions, but the advanced target of -55% proposed by the European Parliament. The scenarios, planned interventions, investment amounts, multipliers on added value and employment proposed by the PNIEC, therefore analysed and, for each of the three sectors, updated values in line with the advanced target were estimated. The main results of this comparison, both in terms of method, absolute values and policy, are described in the following pages.

The investments and macroeconomic impacts envisaged by the PNIEC

In retrospect, the dynamics of the reduction of CO_2 equivalent[1] emissions in Italy was overall in line (after 2005) with the targets originally set at the Paris Conference (COP21) and seems likely to exceed them by 2030 (assuming, of course, that the policies outlined in the Plan are fully implemented.

1The impact of greenhouse *gas* (GHG) emissions on global warming is measured in a standardised way in millions of tonnes of CO2 equivalent (MtCO2eq), i.e. equating them to the effect produced by the same amount of carbon dioxide (CO2).

However, the European Parliament[2] and the European Commission want to **raise the 2030 target from -33% to -55% (the EC) and -60% (the Parliament) over 1990[3].** The revision of the target over a time horizon consequently halved (10 years instead of 20) implies for Italy a total reduction in emissions of **42.4%,** instead of -19.2%, over the next ten years (2020-2030) and thus entails a **substantial doubling of the percentage reduction effort in all sectors.** [4]. The revision of the emission reduction targets implies not only a substantial doubling of the investments envisaged (i.e. the concentration of the same investments over half the period), but also a concentration of the effort on the sectors that can contribute most to the result.

2 European Parliament (2019) https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-parliament-declares-climate-emergency

3 N.B. The PNIEC redraws the emission reduction targets from 2005 rather than 1990 to take account of subsequent agreements, in particular Directive 2018/410/EU, known as the Emission Trading System 2021-2030 (ETS), which defines a number of sectors subject to the ETS.
new legislation a reduction target of -43% compared to 2005 (and not compared to 1990). In addition to the -43% (compared to 2005) for the sectors regulated by the ETS Directive (energy industries, energy-hungry industrial sectors and aviation), the previous target of -43% for the non-ETS sectors (transport, residential, agriculture, waste and non-energy-hungry industry, tending to correspond to SMEs) remains in force.
-40% compared to 1990 (which -reduced to 2005 for homogeneity- becomes -33%).

4 The assumption in the estimated breakdown in Table 3 is that each sector will participate in meeting the new target in proportion to its percentage weight in total 2020 emissions minus 2 times the weight change projected in the PNIEC projections to 2030 (= *[TOTAL EMISSIONSxW20]-[2ΔW20-30]*).

Technological and infrastructural investments in the PNIEC

Under current legislation, the PNIEC estimates an **annual inertial investment volume** of 78 bn euros per year (1014 bn between 2017 and 2030). Compared to this trend, **the additional investments forecast by the PNIEC** for 2017-2030 amount to **186 bn over the entire period** (on average around **14.3 bn per year**).

In a nutshell, the interventions foreseen in the PNIEC are as follows:

- In the **residential sector** (private and commercial), the action focuses on energy efficiency measures in existing buildings through the dissemination of new technologies (thermal insulation, heat pumps, etc.);
- **In** the **transport sector**, interventions are focused on the gradual replacement of the vehicle fleet with low energy consumption/low CO_2 vehicles;
- Emission reductions attributed to **processes**
  The **industrial sector is** mainly concerned with the production of cement, lime and steel and fluorinated gases[5];
- In **waste** management, the decrease in emissions is related to the total quantities produced, the lower share of biodegradable substances sent to landfill and the percentage of methane recovered from landfill gas;
- **Renewable energies:** The PNIEC plans to achieve a renewable energy share of 30% of gross final energy consumption by 2030, broadly in line with the binding EU target (32%).

5 The containment effect of fluorinated gases resulted from the full implementation of EU Regulation 517/2014, which includes a ban on the use of certain gases with the highest global warming potential.

In addition to the efficiency/reconversion of energy production and distribution (district heating, power generation and grid) (**61 bcm**), the **additional investments** foreseen by the PNIEC for the period 2017-2030 focus mainly (67%) on the **residential buildings (63 bcm)**, **tertiary** buildings **(35 bcm)** and **transport (27 bcm)** sectors.

National Integrated Energy and Climate Plan Investments in technology, processes and infrastructure (2017-2030)						
Sector(2017-2030) [bn€].	Current policies	PNIEC additions (2017-2030) [bn€]	PNIEC totals (2017 - 2030) [bn€]	Current policies annual average [bn€]	PNIEC additions media annual [bn€]	PNIEC totals media annual [bn€]
Residential	117	63	180	9,0	4,8	13,8
Tertiary	55	35	90	4,2	2,7	6,9
Industry	27	6	33	2,1	0,5	2,5
District heating (distribution)	1	1	2	0,1	0,1	0,2
Transport (vehicles)	732	27	759	56,3	2,1	58,4
Electrical sector (installations of generation)	47	38	85	3,6	2,9	6,5
Electrical system (nets, accumulations)	30	16	46	2,3	1,2	3,5
Total	**1.009**	**186**	**1. 195**	**77,6**	**14,3**	**91,9**

Figure 22 - PNIEC, investments in technology, processes and infrastructure (2017-2030) (NB: unless otherwise indicated, the tables below are Està's re-elaborations of the original PNIEC tables)

The impacts of the PNIEC investments on economic activity and employment

PNIEC 2019 simulates the macroeconomic effects of estimated differential investment on economic activity (in terms of VA, value added) and employment (in terms of ULA, active labour units). Estimates are made using two different methodologies: (a) the analysis through the *input-output* (I/O) matrix of sectoral interdependencies applied to 63 ISTAT sectors of economic activity[6] and (b) the analysis with the social accounting matrix (SAM) elaborated by CEIS-ENEA[7], which in addition to the interdependencies between sectors of production (58), also takes into account the distribution of income among the factors of production (labour and capital), the activity of the Public Sector (taxes, transfers and public consumption) and the trade interchange with the Rest of the World. The simulations distinguish between "temporary" and "permanent" impacts on labour units: **the temporary increase in AWUs refers to the** whole of the activities of design, development, installation and implementation of the investments and can be considered as **short-term (direct and indirect) impact effects destined to end with the realisation and implementation of the investments themselves.** The "temporary" effect recalculated as an annual average therefore assumes that the implementation of the investments is continuous and homogeneous over time. **On the other hand, the "permanent" effects (direct and indirect) are those resulting from the maintenance of the assets realised throughout their life cycle**.

6ISTAT [2018]

7ENEA [2014].

According to the I/O model, **14.3 billion** average annual investments can produce, over the period 2017-2030, an increase in total annual VA of **8 billion** (+6.5% over the entire period or **+104 billion** cumulative) and a "temporary" increase in AWUs of **+126. 000** units per year on average (over 1.6 million employed in 13 years); the "permanent" effects estimated through the input-output matrix amount to **+13,000** AWUs over the entire period (from 37.7 thousand to 50.7 thousand) from which the work units lost due to the gradual abandonment of fossil fuels must be subtracted (-6.1 thousand): the net "permanent" impact is therefore 6.6 thousand units. According to simulations using the SAM model - which also take into account the multiplicative effects of aggregate demand and the demultiplier effects of taxes and foreign trade - **14.3 billion** average annual investments have a slightly lower impact on VA (**7.1 billion** average per year, **92.3 billion** cumulative) and a significantly lower impact on employment (+79,000 average annual AWUs, i.e. slightly more than 1 million more employed over the entire period).

Economic impacts of additional PNIEC investments compared to existing policies (annual averages)

(bn €)	Inv PNIEC	I/O multipliers		SAM multipliers	
	Additional to existing policies	Δ VA	Δ AWU	Δ VA	Δ AWU
	annual average	annual average € billion	average #miles per year	annual average € billion	average #miles per year
Total	**14,3**	**8,0**	**126,3**	**7,1**	**79,3**
Residential + tertiary	7,5	5,2	87,8	4,2	48,2
Industry	0,5	0,3	4,6	0,5	5,7
Transport (vehicles)	2,1	0,2	3,3	1,4	13,7
Energy	4,2	2,3	30,7	1,0	11,7

Figure 23 - Economic impacts of additional PNIEC investments compared to existing policies (annual averages)

Investments needed to reach the new EU target (-55% on 1990 by 2030)

The December 2019 PNIEC calibrates investments to the EU's 2030 emissions reduction target of -33% (compared to 2005). The new European reduction targets of -55% of emissions compared to 1990 would imply an **additional investment effort of 100 bn per year,** bringing total investments (including "current policy" investments) to **178 bn per year between 2020 and 2030** (compared to 92 bn per year in total as originally envisaged in the PNIEC). The investment review proposed here incorporates some specific and in some cases much more aggressive *policy* assumptions tha those of the PNIEC and concentrates additional investments to those already planned mainly in two sectors which, in the Italian context, appear to be strategic: the residential/tertiary sector and the transport sector (sectors which directly or indirectly generate almost half of total greenhouse gas emissions and which are the only sectors which, between 1990 and today, have not decreased but increased total emissions)[8].

a) In the **residential and tertiary sector**, it would be necessary to extend investments in energy efficiency and electrification of energy requirements in the residential and non-residential sectors (**51.3** billion compared to 20.7 billion in the PNIEC) through the application of nZEB (*near Zero Emissions Buildings*) standards to 0.4% of the existing building stock per year (and not only to new buildings as envisaged by the regulations in force): this is a much broader and more invasive intervention than that envisaged[9] , involving more than 25,00 buildings per year (10-12 mn m²), but capable of leading to the full decarbonisation of the sector and reducing its emissions in line with the new European targets over the decade.

b) In the transport sector, meeting the new EU target for greenhouse gas reductions requires an exceptional effort, much greater even than that which would be sufficient to meet the European requirements for a minimum share of renewables in energy consumption in the sector (22%, a target endorsed by the PNIEC). In order to achieve the EU target in terms of reduction of greenhouse gases (GHG), an electrification of the private vehicle feelt four times higher than that considered by the PNIEC (24mm vehicles instead of 6) would be necessary. In this case, taking into account the "multiplication factor" assigned by the EU legislation to the electric share[10] , the massive electrification of private road transport would lead the electric renewable share (1.6 Mtoe real or 6.5 Mtoe nominal) to exceed, alone, the EU target of total RES in the transport sector (23.5%11 against 22%). Together with the policies (already foreseen in the PNIEC) to transfer part of the commercial traffic currently on road to rail and the adoption of hydrogen-based propellants for long-distance heavy goods transport, the massive electrification of the private vehicle fleet would make it possible to eliminate the use of biodiesel by 2030 and replace private transport[12].

c) The extensive electrification of the building (residential /commercial /public) and transport sectors obviously requires an increase in electricity generation capacity, which would largely be covered by the investments already planned in the IPEC to expand the contribution of renewable sources to electricity production (16.1 Mtoe or 62% of total final consumption in the sector) in the surplus, from the increased autonomous generation in the residential sector (6.5 Mtoe).

8 According to the most up-to-date ISPRA data, the weight on total GHG emissions in 2018 was 24.5% for transport (+2% compared to 1990) and 24% for residential/services (+6% compared to 1990). See ISPRA [2020].

9 The reference is to the strategy outlined in STREPIN [2015].

10 In order to reach the RES targets on final energy consumption in the sector, the RED II and ILUC Directives associate "multiplication factors" to some types of renewable sources. The "multiplication factor" associated with the electricity share in transport is 4. See GSE [2019].

11 1.6 Mtoe real or 6.46 Mtoe nominal (= 1.616 x 4 'EU multiplication factor') out of a total final consumption of 27.5 Mtoe [Tab.21b below].

12 1.616 Mtoe real from electrification of private transport can fully replace 1.027 Mtoe of biodiesel and an additional 0.589 Mtoe of diesel/gasoline [Tab.19 below]

The total electricity production from renewable sources (22.6 Mtoe=16.1+6.5) would thus also be consistent with that needed to contribute to the new European emissions target of -55% (compared to 1990) by 2030.

Review Investments consistent with -55% GHG (2020-2030)

(bn €)	Current policies annual average	Adjustment of additional investments annual average	TOTAL investments annual average	TOTAL cumulative investments 2020-2030
	billion €/year			
TOTAL	**77,6**	**100,3**	**177,9**	**1778,8**
Residential+Tertiary	13,2	51,3	64,5	645,3
Industry	2,1	0,5	2,5	25,4
Transport (vehicles)	56,3	32,5	88,8	888,1
Energy	6,0	16,0	22,0	220,0

- Review of investments consistent with -55% GHG (2020-2030)

The impacts of planned investments on economic activity and employment

Over the entire 2020-2030 period, the total cumulative impacts on labour units would consequently also be of an order of magnitude double those simulated by the PNIEC (i.e. more than 3 million additional AWUs according to the input-output simulations and just over 2 million according to the SAM simulations). As can be seen in the table below, the highest unit impact (per billion investment) varies according to whichever of the two multipliers is chosen, assuming greater credibility to the SAM simulations (which are more attentive to overall changes in economic impact), the greatest spillover would be in the transport sector, followed by the energy sector and then the building sector (where the residential sub-sector is prevalent), while, as noted above, the greatest need for investment to achieve climate neutrality is concentrated in the building sector.

The relative importance of the 'temporary' for economic activation per billion invested (see Fig. 25). The horizontal comparison between the multipliers of the two models confirms that the overall VA multipliers are very similar (I/O= 0.531; SAM= 0.562), despite the different number of sectors of economic activity considered (63 and 58 respectively) and the lack of SAM estimates on some types of interventions (district heating and electricity system): **each additional billion of investment generates 532 mn (I/O) and 562 mn (SAM) of additional VA annually, respectively. On the** other hand, the employment impact estimated by the two models is different: that of the SAM model is significantly lower than that of I/O (**I/O 8470 AWU and SAM 6244 per billion of investment**). Neglecting the income distribution effects between wages and profits and the effects of direct and indirect taxation (absent in the I/O model and present in the SAM model) is therefore in aggregate apparently almost irrelevant to value added, but can instead induce significant differences in the estimates of employment effects. Significant differences between the two methodologies are also noted in the sectoral declination of the impacts (Fig. 25).

Multipliers for investments in technologies, processes and infrastructure PNIEC 2019	I/O multipliers		SAM multipliers	
	ΔVA/ΔI	ΔULA/ΔI	ΔVA/ΔI	ΔULA/ΔI
Total	**0,531**	**8,478**	**0,562**	**6,244**
Residential	0,659	12,045	0,268	3,922
Tertiary	0,750	10,833	1,133	11,327
Industry	0,600	10,000	1,043	12,328
District heating (distribution)	0,050	1,667		
Transport (vehicles)	0,105	1,579	0,671	6,584
Electrical sector (installations generation)	0,448	7,241	0,376	4,268
Electricity system (grids, storage)	0,727	7,273		

Figure 25 - Multipliers for investments in technologies, processes and infrastructures PNIEC 2019

However, the application of the implicit PNIEC multipliers allows an estimation of the order of magnitude of the economic impacts of the revised investments under the assumptions of this paper. The policies described in the previous sections involve more than **100 billion** additional average annual investments compared to those of the "current policies", concentrated on the thermal (residential and tertiary) and transport sectors[1] : the impact is therefore proportionally much larger than that predicted by the PNIEC. The additional expansive impact of the *revised* investments, with reference to the VA, is between **47.8 billion** (SAM) and **50.4 billion (I/O) on** average per year (against the additional 7-8 billion of the PNIEC) and the increase in employment between **592,999 (**SAM) and **769,000** (I/O**)** (compared to 79-126,000 in the PNIEC). However, the impacts on employment must also take into account the loss of employment resulting from fossil fuel divestment. The PNIEC simulations estimate, however, that the direct impacts of this disinvestment are, on average per year, relatively small. In fact, the I-O model estimates a "temporary" negative impact (i.e. linked to lower investments) of about **5,000** average annual work units (80% of which are concentrated in the production/distribution of fossil energy and thermal energy for the residential and tertiary sectors) and, when fully operational, a "permanent" drop of just over **6,000 AWUs. Although it is not possible, with the methodologies adopted, to analyse the distribution of these effects over time, it is reasonable to assume that they can be expected to result in a higher GDP growth of 8% and an increase of 600,000 jobs, stable over the decade, by 2030. In other words, the *revised* investment plan needed to achieve a -55% reduction in emissions by 2030 (compared to 1990) has a significance and economic impact six to eight times greater than that originally envisaged by the PNIEC.**

[1] This is 86 bn per year more than the original 14.3 bn additional bn of the NIPEC.

Economic impacts *revised* investments consistent with -55% GHGadditional to existing policies (annual average data)

(bn €)	Inv NIPEC	I/O multipliers		SAM multipliers	
	Additional to existing policies	Δ VA	Δ AWU	Δ VA	Δ AWU
	annual average	annual average € billion	average #miles per year	annual average € billion	average #miles per year
Total	**100,3**	**47,8**	**769,2**	**54,7**	**591,9**
Residential + tertiary	51,3	35,4	597,2	28,5	327,8
Industry	0,5	0,3	4,6	0,5	5,7
Transport (vehicles)	32,5	3,4	51,3	21,8	214,0
Energy	16,0	8,7	116,0	3,9	44,4

Figure 26 - Economic impacts of revised investments consistent with -55%GHG, additional to existing policies

Detailed analysis of interventions

Residential and tertiary sectors: the near-zero energy buildings (nZEB) option

Thermal efficiency in the private residential, commercial (tertiary) and public administration sectors can be achieved with a *mix* of interventions concerning: (a) the envelope (insulation, replacement of windows and doors), (b) thermal systems (heat pumps, gas boilers, condensing systems, multi-split systems, etc.) and (c) the autonomous generation of electricity through the installation of photovoltaic panels[13].

The most radical hypothesis of decarbonisation of buildings is the so-called *Nearly Zero Energy Building (nZEB*), introduced by the EPRB Directive (2010/31/EU), which also defined the minimum technical standards[15]. A Nearly Zero Energy Building (nZEB) is a building with *"very high energy performance, in which the very low energy demand is covered to a significant extent by renewable sources, produced on site (nearby)"*. The *nZEB* renovation ("deep renovation") therefore acts simultaneously on both efficiency gains (radical reduction of heat loss) and the replacement of traditional energy sources by renewables[16].

Looking ahead, however new buildings owned or used by public authorities will have to comply with nZEB specifications and similar obligations are expected to be extended to new residential buildings

13 For the technical characteristics of the above solutions see Technical working group at the Presidency of the Council, *"Decarbonisation of the Italian economy: Catalogue of energy technologies"* (2017)

14 The EPBD has been transposed in Italy with the D.L. 63/2013 (later converted into L. 90/2013); the applicable technical standards are defined in the DM of MISE 26/6/2015; the obligations of integration of renewable sources are instead contained in the D.L. 28/2011 (annex 3, par.1, l.c).

15 See STREPIN [2015] p. 22: *"(...) Any new or existing building that meets the following requirements will be considered a "near-zero energy" (nZEB) building: (a) overall average coefficient of heat transfer by transmission per unit of dispersing surface (transmittance); (b) summer equivalent solar area per unit of useful surface; (c) energy performance index for winter air conditioning (EPh), the useful thermal performance index for summer air conditioning, including any humidity control (EPc), the overall energy performance index (EPg), both total and non-renewable; the efficiencies of the winter air conditioning system (ηh), summer air conditioning system(ηc) and of production of domestic hot water (ηw) (...)"* The obligations of integration of renewable sources ex DM 28/2011 must also be respected.

from 2021[17]. **In order to meet the EU's new GHG emission reduction targets (-55% by 2030), it is not enough to regulate the construction of new buildings, also essential to attack the existing building stock with appropriate regulations and incentives.**

Even assuming that the efficiency gains assumed by the PNIEC on the energy consumption side are realistic (-5.7 Mtoe), it is in fact necessary to imagine, in the Italian context, a much greater effort on the side of replacing fossil fuels with renewables on the supply side. How much would the installation of photovoltaic systems have to be extended to the existing building stock in order to achieve a reduction in the use of fossil fuels of -8.3 Mtoe (from 14.5 Mtoe to 6.2 Mtoe) between 2020 and 2030?

Complete electrification and the full use of heat pumps has optimal effects only for new buildings: the installation of photovoltaic modules (with an average power of 20-26 W/m²) allows renewable energy coverage between 50%-70% of the demand for new buildings (40%-50% for offices). For existing buildings, the average coverage is only 10%-30% (15%-20% for offices)[18]. Applying these average metrics, we can therefore estimate a production potential of about 20 Mtoe per 10 million m² renovated. This would be

16 See L. 90/2013 and DM 26/6/2015 ("Minimum requirements") implementing Directive 2010/31/EU (paras. 1-2 Annex 1)

17 The concept of *"Nearly Zero Energy Building"* (nZEB) was introduced by the EPBD Directive 2010/31/EU (transposed in Italy with the D.L. 63/2013 conv in L. n.90/2013) and the technical characteristics of an nZEB building are specified in Italy by the DM MISE *"Requisiti minimi degli edifici"* of 26/6/2015. The nZEB certification refers to very high energy performance buildings, with very low energy demand, significantly covered by renewable sources (at least 50%) produced in-house or *nearby*. See ENEA [2019b].

It would be sufficient to install photovoltaic panels on 10,000 existing residential buildings (4-5 million m²) each year to achieve the fossil fuel reduction target[19]. However, the effort would not yet be sufficient to achieve emission reductions in the sector (**-21 Mtoe**) consistent with a 55% reduction in overall emissions. This latter target would require at least 25,000 buildings per year (about 11-12 million m²) to be "comprehensively refurbished". **To achieve the emission reduction result consistent with the new EU target in the residential sector, the required investments would therefore have to be at least 25% higher period 2014-2020 (51.3 bn per year instead of 41.5 bn), i.e. two and a half times the annual investments foreseen in the PNIEC for the residential and commercial sectors (20.7 bn).** In this scenario, the residential/commercial sector would not only be able to eliminate its dependence on fossil fuels, but would also have an annual electricity production capacity of **6.5 Mtoe more than it needs**, a surplus which, sold to the grid, could be redistributed in order to meet the increased demand of other sectors[21].

18 IEA estimates for 2002, cited on p. 14 by Meneguzzo et al. [2015], indicate that the panel area of existing buildings at that time amounted to 764 km² on roofs and 286 km² on façades with an electricity production potential of 126 TWh (10.8 Mtoe). Considering that the minimum required panel area is about 8 m² per building, there do not seem to be any space constraints for the installation of photovoltaic panels on about 100 thousand buildings.

19 See STREPIN [2015] Annex 1

20 The working hypothesis that will be explained in the next chapter is that this surplus is able to meet the increased demand for electricity resulting from the massive electrification of transport.

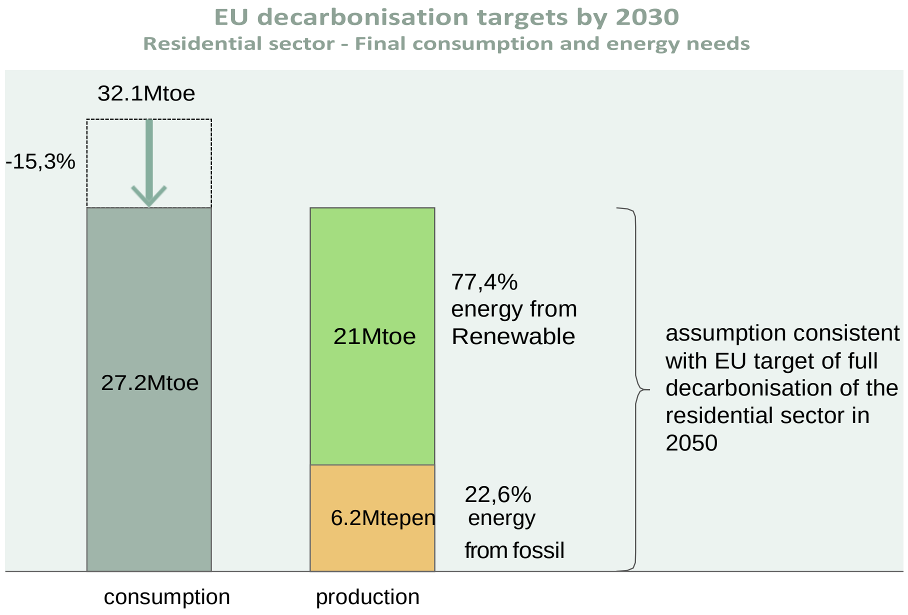


Figure 27 - EU decarbonisation targets for 2030. Residential sector - Final consumption and energy needs

Transport sector

Just under 92% of energy needs in the transport sector are derived from fuels derived from oil refining and, for much smaller and equivalent shares, from natural gas (2.8%), biofuels (2.8%) and electricity (2.6%). Of the hydrocarbons, diesel (**55.3%** of total consumption) and petrol (**19.6%**) are the main components. Broken down by mode of transport, most consumption is obviously concentrated on road transport (83.4%), followed by aviation (9% international and 2.1% domestic), inland navigation (2.3%) and, finally, rail transport (1.3%).

Despite the fact that the transport sector accounts for a quarter of total annual greenhouse gas (GHG) emissions, renewable energy sources (RES) still play a very marginal role: as a percentage of the sector's total gross consumption, RES contributed 6.5% (2.05 Mtoe) in 2016, and - with unchanged policies - the PNIEC expects this share to almost double (to 11%) by 2030, while the EU requires it to almost quadruple (to 22%) by then. The transport sector therefore requires a decisive strengthening of renewable transition policies for an effective decarbonisation policy.
The RED II Directive[22] stipulates that the share of renewable sources in the transport sector must be at least **22%** (or 6.05 Mtoe) of the sector's final consumption in order to reach the ambitious greenhouse gas (GHG) reduction targets. It has been

21 The RED II or *Renewale Energy Directive* (Dir 2018/2001 of the European Parliament and Council) which updated the previous RED Directive (Dir 2009/28/EC).

shown that, with unchanged policies, the PNIEC instead estimates that the coverage with RES of the sector's final energy consumption would tend to be only half of what is required by the EU in 2030. Compared to the trend, the PNIEC's target is therefore to double the target share of RES in the transport sector by 2030 (to **22%** instead of **11.2%**): by 2030, the use of renewable energy in the transport sector is to triple compared to 2016, from **2 Mtoe** to **6 Mtoe. Based on our analysis, the EU targets for RES in the transport sector in the RED II Directive are in line with the new emission reduction target (-55% instead of - 40% 1990 levels)**. The PNIEC states that the EU target can be achieved with a mix of renewable achieved with a mix of renewable sources, among which the largest of which the main contributions are, on the one hand, biofuels23 (including, in particular, biomethane) and the electrification of road and rail transport. electrification of road and rail transport. However, the definition of the scope of biofuels deemed "sustainable "[24] is still ambiguous and controversial.

Vegetable bio-diesel has a worsening impact on the generation of greenhouse gases[25] .

It also has perverse side effects of reallocating agricultural production (from human and animal consumption to production for energy use) and thus has indirect negative impacts on the absorption of greenhouse gases. indirect negative impacts on GHG

23 The RED I or Renewable Energy Directive (Directive 2009/28/EC, implemented in Italy by Legislative Decree 28/2011) defined biofuels as liquid or gaseous transport fuels derived from biomass, among which three macro-categories can be distinguished: (1) the "biodiesel" category (which includes biofuels generally blended with diesel and biodiesel in the strict sense, resulting from the processing of vegetable oils; (2) "biogasoline", which groups biofuels blended with gasoline (e.g.: bio-methanol, bio-ETBE, bio_MTBE, bio-TAEE, bio-butanol); (3) biofuels of gaseous origin such as biomethane, i.e. purified to meet the quality standards for natural gas feedstock. Not all biofuels released for consumption can be accounted for and counted towards the RES target. Only biofuels can be counted towards the target. Only so-called "sustainable" biofuels (i.e. biofuels that meet the criteria set out in the implementing measures of Directive 2009/30/EC of April 2009): biofuels that guarantee savings in GHG emissions generated by the entire production chain compared to emissions generated by the entire production chain compared to fuels of fossil origin. In order to biofuels produced from waste, residues, non-food oring material and Lignocellulosic biomass, the RED I Directive and the ILUC ILUC Directive allow to be counted with a "multiplication factor" twice as high as the other biofuels (called singlecounting) and are therefore referred to as "double counting".

removals resulting from land use change (known as ILUC impacts or Indirect Land Use Change)[26].

In line with the new RED II Directive (which corrects the previous RED I Directive[27] on this point), the PNIEC foresees a gradual reduction in the consumption of agricultural biofuels that may have undesirable ILUC impacts up to 0.7 Mtoe in 2030[28]. **In view of its characteristics and the negative impacts of its deployment, it would be desirable for agricultural biodiesel production to be reduced to zero by 2030**. As the final consumption of bio-diesel is entirely determined by road transport, the most aggressive working hypothesis is that its replacement could be pursued, not only with advanced new generation biofuels, but with an equivalent increase in the targets for the share of electric propulsion (and possibly new hydrogen-based propulsion technologies) in private and commercial road transport. A further hypothesis to focus on is the development of renewable, non-biological fuels such as hydrogen, which appears attractive for direct use mainly in heavy and marine transport (where current technologies do not allow electrification) and in rail transport for non-electrified routes. In addition to reducing emissions from fossil fuels, the adoption of hydrogen would also allow easier storage of excess capacity[29]. Infrastructure for *"multi-fuel"* distribution networks through *"fuel cells"* would also be instrumental in such developments[30].

In the PNIEC forecast scenario, a significant reduction in gross final consumption in the transport sector (-13.4% from 31.7 Mtoe to 27.5 Mtoe between 2016 and 2030) also contributes to achieving the RES target percentage share set by the EU for the transport sector (22%), a percentage decrease that is more than double that of the trend at constant policies (-5.8%). The policies envisaged by the PNIEC therefore act not only on the replacement of renewable sources with fossil fuels, but also on the basis of significant savings in consumption, largely resulting from the greater energy efficiency of the new sources and related technologies[31]. From this point of view, **accelerating the electrification of road transport (private and commercial) is undoubtedly the most powerful lever in the pursuit of decarbonisation objectives and would deserve much more aggressive public intervention and incentive policies (relevant infrastructure and scrapping) than those envisaged by the PNIEC.**

The final consumption of energy in the transport sector in Italy is largely related to road transport, the share of which, although decreasing over time, is constantly between 80% and 85% of the total[32].

26 See Globiom Report [2015].

27 In the new directive, the maximum percentage for biofuels of plant origin that can be counted towards RES targets is reduced from 7% to 3.8%

28 See PNIEC (2019) p. 59-60

29 See Silvestrini [2019].

30 See Lifegate [2013].

31 The different types of renewable sources are associated by the RED and ILUC Directives with "multiplication factors" that qualify their potential for improving energy efficiency in terms of relative effectiveness in the substitution of equivalent fossil fuels along the entire production chain: advanced biofuels are, for example, associated with a 'multiplication factor' equal to 2, while the most significant "multiplication factor" is associated with electrification of road transport, which is 4 (thus attributing a potential impact on energy efficiency even estimated to be double that of biofuels). See GSE [2019].

A similar dominance of road transport is, of course, also evident in terms of CO_2 [33] emissions (over 90% of which come from road transport). Passenger traffic accounts for 64% of CO_2 emissions, compared with 36% for commercial traffic. In Italy, by far the most prevalent mode of private transport is the car, which accounts for 75% of passenger mobility (measured in millions of passengers per km) and 80% if motorbikes are included; private motor vehicles are closely followed by urban and suburban buses, which account for 12%. Railways, on the other hand, account for less than 6% of the demand for private mobility. National and international road haulage, measured in millions of tonnes per km, accounts for 70% of the total, coastal navigation for 27% and railways for just over 10%[34].

This means that the priorities for Italy must necessarily focus on the massive electrification of the private vehicle fleet and the gradual transfer of long-distance commercial transport to the railways. Given the pervasiveness of car use in private mobility and the strong inertia of the socio-cultural factors underlying it, policies that simply discourage the use of private transport in favour of public transport are unlikely to be effective in the short to medium term. More promising, on the other hand, may be the adoption of very aggressive incentives for the accelerated scrapping of old private vehicles in favour of replacement with electric or hybrid vehicles.

In 2019, there were approximately 39.5 million passenger cars on the road in Italy (compared to 37.4 million in 2015)[35] and they accounted for 78% of the motor vehicles in circulation. The share of electrification of private transport envisaged by the PNIEC (5.9% of the sector's final consumption36 or **0.404 Mtoe**) is estimated to be achievable with the replacement of about 6 million vehicles with electric cars (1.6 mn BEVs) or plug-in hybrids (4.4 mn PHEVs), i.e. about 15% of the current fleet of cars in circulation. Using the same assumptions of average mileage and average fuel consumption as those implicit in the PNIEC[37] estimates, it can be estimated that **the electrification of twice as many vehicles as planned (i.e. 30% instead of 15% of the existing fleet), together with the adoption of hydrogen technologies**

32 The data shown in tab.21 are taken from the GSE report, *"Energy in the transport sector 2005-2018"* (July 2019) in which the total final energy consumption of the sector are significantly higher than those of the PNIEC (2019) which does not include consumption attributable to international aviation: with reference, for example, to 2017 the total final consumption reported by the GSE is 37.9 Mtep (tab.3 p.9), while in the PNIEC is 30.3 Mtep (tab. 13 p.61), i.e. lower than the consumption attributed by the GSE to road transport only.

33 In the transport sector, CO2 emissions account for 93-95% of total greenhouse gases (GHG).

34 Data refer to 2014. See ISPRA [2016] ch.4 tab.4.22 p.44 and tab. 4.25 p.49

35 Source: ACI *Open Vehicle Park*,www.aci.it

36 The share, for the purposes of RED II targets, is assessed with a 'multiplication factor' of 4, i.e. it is equivalent to a real share of 1.47% (0.404 Mtoe).

37 The PNIEC estimate can be reconstructed deductively by assuming (implicitly) an average annual mileage per vehicle of 10,000 km and an electric propulsion use of hybrid vehicles (PHEVs) equal to 1/3 of that of electric vehicles (BEVs). Assuming that electric vehicles (BEVs) have an average mileage of 6.5 Km/KWh or 1538 KWh per year (= 10000/6.5) and the hybrid vehicles 508 kWh/year: the 1.6 mn electric vehicles consume 2.46 TWh/year or 0.212 Mtoe/year (=[1538x1.6 mn/11.63) and the 4.4 mn hybrid vehicles (PHEV) 2.23 TWh/year or 0.192 Mtoe/year. That is 0.404 Mtoe/year total [Tab.20b in the text].

to the extent already envisaged by the PNIEC (0.280 Mtoe), could ensure at least the complete replacement of current diesel use (1.029 Mtoe)[38]. The magnitude of the effort needed to bring the transport sector's contribution to the new European emission targets (-55% compared to 1990) should instead be almost five times greater (-4.9 Mtoe) and would therefore require the electrification - within ten years - of about 24 million vehicles (i.e. over 60% of the current vehicle fleet).

The PNIEC already estimates the greatest financial effort for the conversion of vehicles in the transport sector: an additional 27 billion (i.e. 2.1 billion on average per year) in addition to the 732 billion already envisaged under current policies (i.e. a total of 779 billion over the decade or 58.4 billion on average per year) [Table 23]. **The adjustment to the new European GHG emission targets would, however, require an additional annual financial commitment of at least 32.5 billion per year against the 2.1 billion of the PNIEC** (8.3 billion for a more extensive electrification of the vehicle fleet and about 24.2 billion for the replacement of diesel).

Electricity production

Italy's total energy consumption (TEC) is represented by 47% electricity, 29% air conditioning and 24% transport powered by fossil fuels39. Italy has long been engaged in a process of gradual replacement of energy sources and has also shown a considerable ability to achieve significant targets in a relatively short time.The growing contribution of renewable energies is largely due to the very aggressive tax incentive policy adopted by Italian governments, which, however, had a strong driving force only until 2013 and has been much reduced in recent years. Looking to the future (and to the more ambitious targets set by the EU), it is therefore inevitable to reactivate even stronger and more targeted incentive policies.

PNIEC targets on renewables

The PNIEC projects a further acceleration in 2030 compared to the levels reached in 2016: the projections foresee a 58.6% increase in energy production **from** renewable sources by 2030, bringing the **share from 17.4% to 30%** (33.4 Mtoe out of 111.4 Mtoe of total consumption), a level slightly below the EU target (32%). The increase in the percentage share of renewables is expected to take place in a context of a progressive reduction in total consumption (-8.1%). The main contribution to the transition would remain from **electricity** production (16 Mtoe or 14.4% of total consumption) and domestic **heating/cooling** (15 Mtoe or 13.5% of the total), but a significant effort (+129%) is also expected from the **transport** sector, which would however continue to make a very modest contribution to the transition from fossil fuels to renewables (from 0.9% in 2016 to 2.1% in 2030). Although significant, the effort defined in the PNIEC is nevertheless insufficient in the light of the new EU emission reduction targets (-55% compared to 1990).

From the original PNIEC projections one can in fact

38 On the basis of the same PNIEC assumptions, but electrifying 12 million vehicles instead of 6 (3.2 mn BEVs and 8.8 mn PHEVs), the transport consumption satisfied by electricity would be 4.92 TWh/year (0.423 Mtoe) for BEVs and 4.47 TWh/year (0.383 Mtoe) for PHEV hybrids. In total: 9.39 TWh/year or 0.807 Mtoe which, added to the 0.280 Mtoe from hydrogen, would allow the total replacement of diesel (1.029 Mtoe).

39 Percentages refer to 2015 data

deduce that, on average per year, each Mtoe (million oil-equivalent energy) reduces emissions by -0.5 MtCO2eq in the power generation sector, by -1.2 MtCO2eq in the transport sector and by -0.3 MtCO2eq in the civil sector (private residential and commercial-public). **To achieve the new EU target of a 55% reduction in emissions compared to 1990 (-42.4% The overall production of energy from renewable sources should in fact reach 43% of total consumption by 2030 (instead of the 30% envisaged) and advance by five years, to 2025, the 30% target (originally envisaged by the PNIEC only for 2030).**

PNIEC (2019) - Energy from renewable sources (RES) targets

PNIEC - estimates of final energy consumption including savings from energy efficiency PNIEC - overall RES target to 2030 (Mtoe)

	2016	2017	2025	2030	Δ% 2016-2030
Total gross energy production from RES (numerator)	21,081	22,000	27,168	33,428	58,6%
Total gross energy production from RES-E	9,504	9,729	12,281	16,060	69,0%
RES-C final consumption for heating/cooling	10,538	11,211	12,907	15,031	42,6%
RES-T final consumption for transport	1,039	1,060	1,980	2,337	124,9%
Total gross final consumption of energy (denominator)	121,153	120,435	109,746	103,750	-14,4%

PNIEC (2019) - RES targets in % final energy consumption

PNIEC - estimated final energy consumption including savings from energy efficiency PNIEC - overall RES target in 2030 (Ktoe; % composition)

	2016	2017	2025	2030	Δ pct points 2016-2030
Total gross energy production from RES (numerator)	14,4%	18,3%	24,8%	32,2%	14,82
Total gross energy production from RES-E	7,8%	8,1%	11,2%	15,5%	7,63
RES-C final consumption for heating/cooling	8,7%	9,3%	11,8%	14,5%	5,79
RES-T final consumption for transport	0,9%	0,9%	1,8%	2,3%	1,39
Total gross final consumption of energy (denominator)	100,0%	100,0%	100,0%	100,0%	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Figure 28 - PNIEC 2019. Renewable energy targets (RES)

The effort to accelerate towards a higher percentage of energy produced (and consumed) from renewable sources, must be evaluated taking into account the results that can be obtained both in terms of **energy efficiency** (which can allow significant emission savings especially in the residential and commercial-public sector) and in terms of containing emissions in the **transport sector** (by radically reducing dependence on fossil fuels). Taking into account energy savings, the trend decrease in gross final energy consumption is obviously larger (-14.4% compared to -8.1% in 2016-2030), but the share of final consumption satisfied by renewable energy sources (RES), while increasing to 32% (from 30% in 2016-2030), remains well below the share compatible with the achievement of the new emissions targets set by the EU (43% of RES on total final energy consumption). An acceleration in the adoption of renewable sources **is therefore necessary in order to close the residual *gap* (from 32% to 43%). Renovation of buildings to make a significant share of existing buildings nearly zero *energy buildings* (*nZEB*), a more significant contribution of solar energy to civil energy production and an extended electrification of transport would close this *gap*.** Based on the PNIEC projections of final electricity consumption, the PNIEC targets foresee that solar will contribute **24.1%** (**6.3 Mtoe**) of the electricity consumption in 2030. A coverage of 80% in 2050, on the other hand, would require solar to meet at least 40% of total electricity demand in 2030, i.e. **10.4** Mtoe (i.e. at least **4.1 Mtoe** more than already projected in the PNIEC).

The analysis in the preceding paragraphs shows that, if the final demand for electricity develops as envisaged by the PNIEC, this objective is far from utopian, even if it requires a huge electrification effort in both the residential and transport sectors.

The increased final demand for electricity consumption resulting from the decarbonisation of the residential and transport sectors could potentially be met by installing photovoltaic panels on about 4% of the existing residential stock within ten years.

On the basis of the working hypotheses set out in the preceding paragraphs, the electricity needs of the residential/commercial/public sector would in fact be more than fully met by self-production via photovoltaic panels (21 Mtoe compared to a residual sector need of 14.5 Mtoe) and the surplus electricity production of this sector (6.5 Mtoe) would be more than sufficient to cover the increased demand, in particular that deriving from the massive electrification of private transport (4.9 Mtoe). The additional effort to convert energy production to renewable energies (16.1 Mtoe+6.5 Mtoe =22**.6 Mtoe**) would allow **energy production from renewable sources to** be **fully consistent with what is required of the sector to contribute to achieving the new EU target of -55% by 2030 (21.9 Mtoe)**.

PNIEC (2019) - Electricity sector - Targets for energy from renewable sources

PNIEC - estimates of final energy consumption including savings from energy efficiency PNIEC - electricity sector - overall target to 2030 (Mtoe)

	2016	2017	2025	2030
Renewable electricity production (numerator)	9,501	9,725	12,287	16,062
- water (effective)	3,646	3,113		
- water (normalised)	3,972	3,955	4,213	4,239
- wind (effective)	1,522	1,522		
- wind (normalised)	1,419	1,479	2,666	3,568
- geothermal	0,542	0,533	0,593	0,610
- bioenergy	1,668	1,660	1,376	1,350
- solar	1,900	2,098	3,448	6,285
Internal electricity consumption (denominator)	24,600	28,461	25,300	26,037
% share of total RES-E	38,6%	34,2%	48,6%	61,7%

RES targets in % final energy consumption

PNIEC - estimates of final energy consumption including savings from energy efficiency PNIEC-electricity sector - overall RES target in 2030 (Mtoe; % composition)

	2016	2017	2025	2030
Renewable electricity production (numerator)	38,6%	34,2%	48,6%	61,7%
- water (effective)	14,8%	10,9%		
- water (normalised)	16,1%	13,9%	16,7%	16,3%
- wind (effective)	6,2%	5,3%		
- wind (normalised)	5,8%	5,2%	10,5%	13,7%
- geothermal	2,2%	1,9%	2,3%	2,3%
- bioenergy	6,8%	5,8%	5,4%	5,2%
- solar	7,7%	7,4%	13,6%	24,1%
Internal electricity consumption (denominator)	100,0%	100,0%	100,0%	100,0%
% share of total RES-E	38,6%	34,2%	48,6%	61,7%

Figure 29 - PNIEC 2019 Electricity sector. Targets for energy from renewable sources

The further potential of technological innovation

The interventions proposed in this last chapter all refer to the current situation of the Italian production system, a production system that is nevertheless suffering from a tendency to lag behind in its ability to produce goods with a high technological content and, consequently, higher added value than traditional sectors. Since the end of the last century, and in recent years in particular, our country (even in its richest region) has in fact been accumulating a growing negative *gap* with the major EU of technological innovation capacity and increase in wealth produced (VA). Value added per employee is a good descriptive index for this dynamic, which the figure below tries to illustrate.

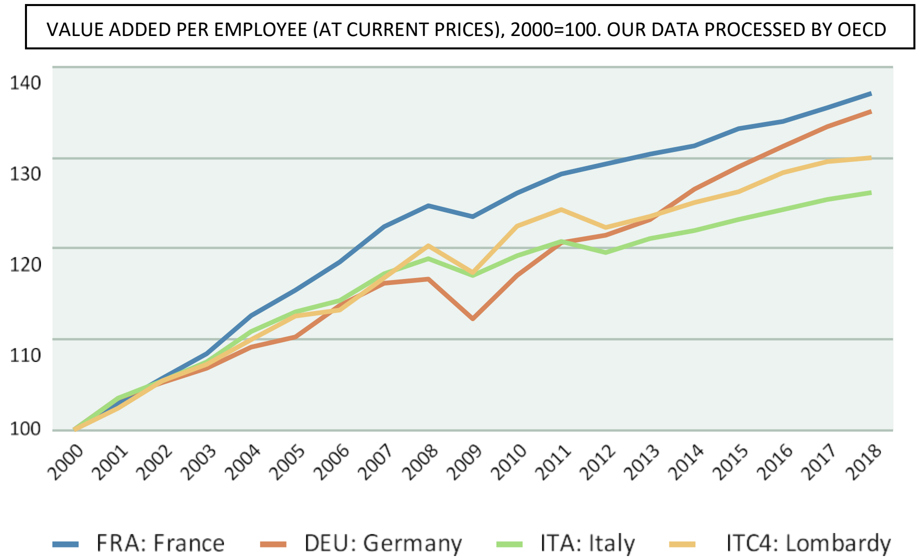


Figure 30 - Value added per employee, total activities, 2001 = 100 (Our data processed by OECD)

Increasing research and development and industrialisation of high-tech products would therefore help our country to position itself in the process towards climate neutrality by producing goods with higher added value, which would otherwise have to be imported from abroad, and thereby increasing both the speed of emission reduction and the wealth produced and employment.

The potential of high-tech investment choices is illustrated in the latter part ***the study proposes a technical forecasting model based on original statistical and econometric projections*** (the methodological assumptions are inspired by Hamilton, J. D. (1994). Time Series Analysis: Princeton University Press).

The study has chosen a number of minimal relationships whose aim is to obtain a coherent representation of the links between carbon dioxide emissions, the evolution of production, the evolution of added value and employment. These relationships have been structured to identify, at least qualitatively, the possible impacts caused by economic policy changes related to the implementation of the so-called *Green Deal,* at least as far as the investments envisaged by the PNIEC are concerned.

The specification adopted is therefore deliberately "elementary" and privileges the choice of linear or linearizable functions that allow an immediate passage from the theoretical model to the empirical model that can be estimated.

On the merits:

carbon dioxide emission has been expressed as a function of the combustion energy used:

CO_2 = *f1 (Combustion Energy)* (1)

in turn, the energy from combustion is a fraction of the total energy consumed; hence:

Combustion Energy = f2(Energy Consumed) (2)

energy consumption is related to production carried out. Since the model intends to evaluate separately the effects caused by changes in the quantity and those caused by changes in the quality of the output, the two elements are introduced as independent variables,

Combustion Energy = f3 (Production, Quality) (3)

come di consueto la produzione aggregata is conceived as the result of an engineering relationship linking output to the use of a number of inputs. One can therefore write:

Production = f4 (Input1, Input2, ... Inputn) (4)

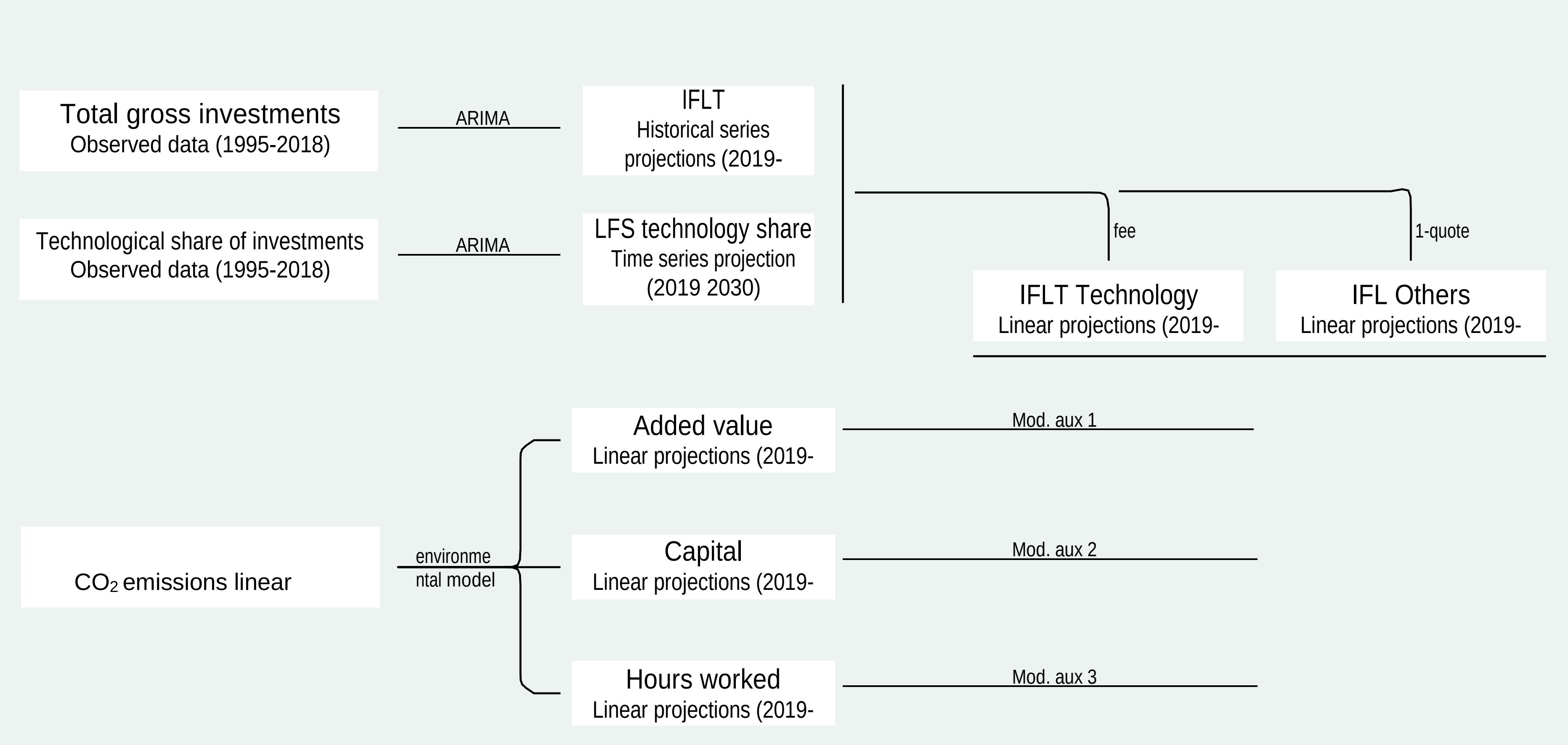
always on an abstract level, you may be interested in distinguish between two distinct ways in which qualitative change in production can be induced. On the one hand, progress may be the result of direct action by research and development; on the other hand, improvement may result from the process of dissemination of research, which is incorporated into the material goods that firms use as inputs (or consumers demand as consumer goods). It is therefore possible to highlight the following relationship:

Quality = f5 (Search, Embedded) (5)

The reports and estimated data were then incorporated into a predictive chain.

(NB GFCF: Gross Fixed Capital formation; TGFCF: Total Gross Fixed Capital Formation):

Green Deal simulation scheme (2020-2030)



Based on this model and this forecasting chain (further detailed in methodological terms in the appendix), the simulations based on alternative scenarios presented in the following lines were produced. The simulations reproduce possible allocations of a purely demonstrative investment value: half (7 billion per year) of the additional funding deemed necessary by the

National integrated energy and climate plan (PNIEC). The scenarios considered simulate a division of the EUR 7 billion into two portions: one dedicated to technological investments (here called '*green*') and one dedicated to other non-technological investments. The scenarios will also be compared with a *baseline* scenario in which no investment is simulated. The *baseline* scenario is used

as a lower bound for emission reduction projections: investments should contribute substantially to the process of reducing pollutants and without them the economy would have no additional levers for improving environmental sustainability.
The assumed distribution scenarios are outlined as follows:

(NB Investment in technology means spending on research and development, software and databases)

Scenario name	Percentage in technology (%)	Percentage in other investments (%)	Share in technology (billion €)
Baseline	0 %	0 %	0 bn €
Full-green	100 %	0 %	7 billion
Mixed-green	50 %	50 %	3.5 billion
No-green	0 %	100 %	0 bn €

The graphs presented after this part summarise the results of the simulations of added value, emissions and hours worked for each of the four scenarios considered.
Bearing in mind that forecasts are estimates, subject to constraints linked to the limited number of observations and the impossibility of "estimating" the behaviour of society and its institutions, the results of simulations must be interpreted with great caution.
However, it is possible to state that the results of the simulations do not deny the observations introduced in the descriptive analysis, presented in the first chapter.

The role and techno-economic significance of R&D cannot be denied, knowing that all technology allows for improvements and savings and that investments in environmental sectors appear to be the frontier with the greatest returns and opportunities (although it is not technically possible to separate the two areas, which are linked by a dialogue relationship, with analytical precision).

On ***a qualitative level, however, it is interesting to note that investment has different effects on emissions, added value and hours worked***. *In* particular, the simulations show that for emissions and value added, the *baseline* and *no-green* scenarios tend to coincide. This is compatible with the idea that there is not much difference between the status-quo and the implementation of an economic policy that allows PNIEC resources to be used for spill-over investment (rather than directed towards high technology).
However, it is not a foregone conclusion that a focused investment policy, looking at hours worked, is preferable. Indeed, in this case, the mere fact of investing would be sufficient to increase hours worked at the aggregate level (implying an improvement in the status quo, under any policy scenario).
Still on a qualitative level, the simulations seem to suggest another interesting reflection on the conduct of economic policy. The scenarios imply different expenditure mixes; the simulations show that the improvements induced by the growth of high-tech investment are less than proportional to expenditure growth with respect to emissions and value added, while they are constant with respect to hours worked.

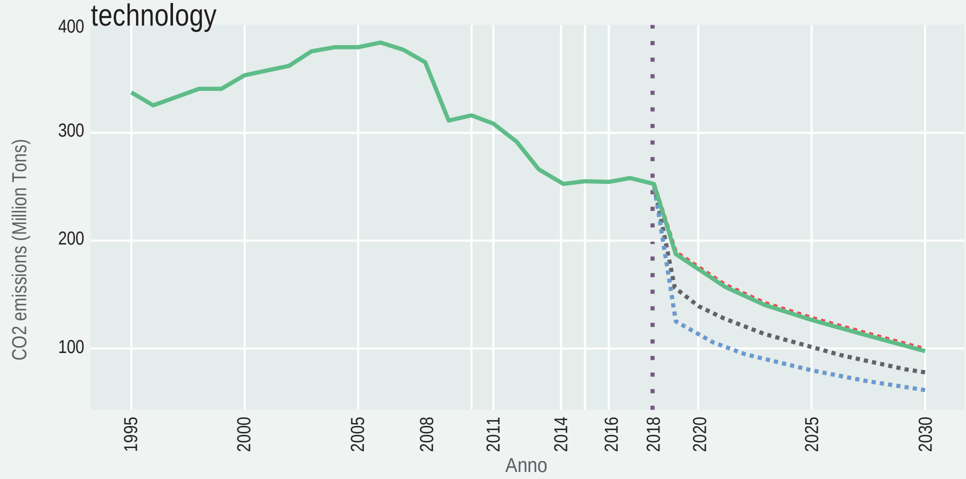
So, the improvement brought about by the change from the 20-80 mix (high technology and generic investment respectively) to 40-60 is more significant than that from 50-50 to 70-90, for emissions and value added. The same policy mix change would be irrelevant for hours worked.

This evidence would introduce the need for an assessment of a potential *trade-off* between the objectives. In fact, the objective of increasing the number of hours worked would push towards a more balanced mix of the policy portfolio, while the objective of reducing emissions or increasing value added would force the composition of expenditure in favour of the most extreme policy and therefore towards *full-green* (as is quite natural).

4 SIMULATIONS for 3 INDICATORS (economic-social-environmental)

Projected CO_2 emissions to 2030

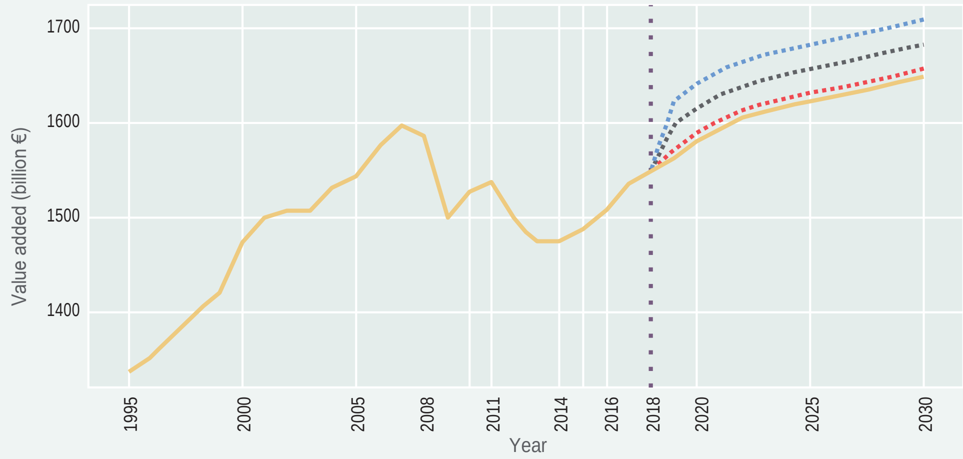
CO_2eq. Scenarios simulate the distribution of 7 billion per year in technology



Value added projection to 2030

V.A.

Scenarios simulate the distribution of 7 billion per year in technology



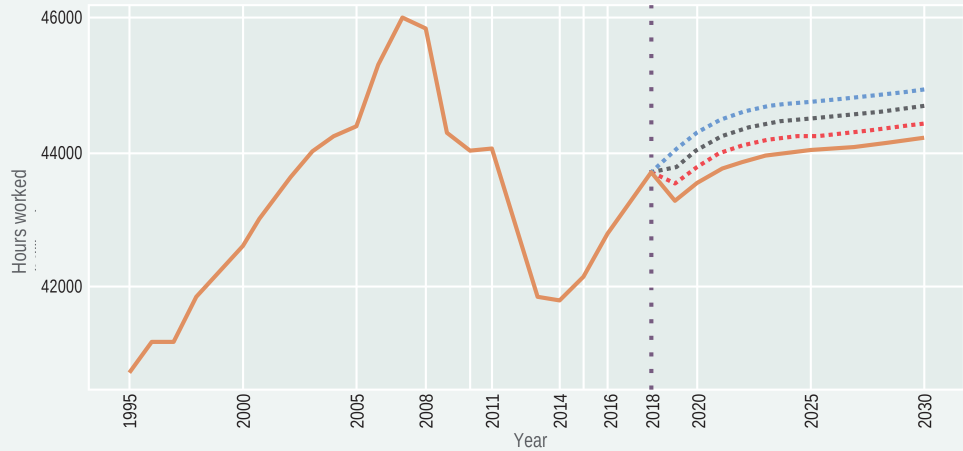
SCENARIO

- Baseline scenario
- No-green scenario
- Mixed-green scenery
- Full-green scenario

Projection of hours worked to 2030

h. worked

Scenarios simulate the distribution of 7 billion per year in technology



In detail, the graph (top left) of projected CO_2 emissions to 2030 shows how the national economic system from 1990 to 2018 has already reduced emissions to increasingly low levels (albeit at a rate that is largely insufficient to achieve carbon neutrality by 2050). This outcome - as mentioned in the first chapter - can be traced back to the technical evolution of the Italian production structure, which over the years has undergone a significant transformation, moving from an industrial structure in the classical sense (coexistence of industry and services) to an integrated service-industry structure. In ***order to have significant effects in reducing CO_2, spending on research and development is unequivocally the most appropriate economic policy***.

In any case, such a policy would not be immune from generating employment re-composition effects or the generation of new enterprises, but the present model cannot account for this.

Skipping to the commentary on the graph of value added (top right), we see a similar pattern to that of CO_2 emissions. ***Value added*** is still growing in each scenario (*Mixed-green scenario, Baseline scenario, No-green scenario* and *Full-green scenario*), but ***with a difference of around EUR 50 billion per year more in 2030, if the Full-green scenario is chosen over the No-green scenario***. *The* possible interpretation of this trend is that the higher growth in value added linked to R&D can be attributed to the emergence and/or consolidation of more technology-intensive activities, which remains a prerequisite for CO_2 reduction targets.

The projections of hours worked are encouraging. The full-green scenario, however, implies that the underlying transformation process is not labour-saving; on the contrary, it shows about one billion more hours worked per year than the no-green scenario. It is clear that the technical content would represent the technical evolution of both 'human capital' (increased knowledge) and an evolution of 'capital' (technological intensity).

All the projections give the ruling class an economic policy horizon with different levels of 'success'. Economic policy plays a fundamental role, and the more it is able to govern and participate in such a horizon, the more it will recover its 'normative' trait.

Milan, September 2020 - Associazione Economia e Sostenibilità

INVESTMENT, EMPLOYMENT, ENVIRONMENTAL EFFECTS

1 ECONOMIC AND SOCIAL EFFECTS

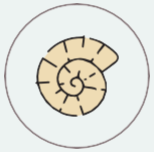
Investments of €7 billion per year (for a decade) in high green technology would produce:

a +4.1% increase in GDP

400.00 (additional) working units

The additional investments proposed by the study compared to the current PNIEC can lead to a **+8% annual increase in GDP by 2030** and stable additional employment in the order of **600,000 new jobs over the decade**, mostly in the construction, transport and renewable energy sectors

2 ENVIRONMENTAL EFFECTS



less air pollution due to reduced consumption of fossil fuels

improved soil health a

due to the use of carbon-conserving techniques

better forest health through more targeted management methods

N.B. on the method:

the following estimates are the result of three consistent and distinct working methods:

a. analysis of increased CO_2 uptake eq.

b. economic and social impact analysis of investments in different scenarios.

c. comparison between investments needed for the target – 55% CO_2 eq. (1990-2030) and investments foreseen in the N.I.P. E.C. and related to the target -40%.

Since it is not possible to take into account all the macroeconomic and social variables at play, these estimates cannot be considered a *'FORECAST'*,
but rather an analytical exercise of translating current realities into the future, reinforced by policies and investments consistent with the -55% target

It should also be noted that the word 'investment' refers both to direct public investment and to fiscal incentives provided to private actors to adapt their housing and transport facilities to climate targets.

Appendix

tables interpreting the relationship between technological investment and emissions - added value - employment.

Appendix A:

Statistical significance interpretation table

Statistical significance interpretation table		
Statistical significance	**Symbol**	**P-value**
Very high	***	$PV < 0.001$
Good	**	$0.001 < PV < 0.01$
Discreet	*	$0.01 < PV < 0.05$
Minimum	.	$0.05 < PV < 0.10$
Non-significance		$PV > 0.10$

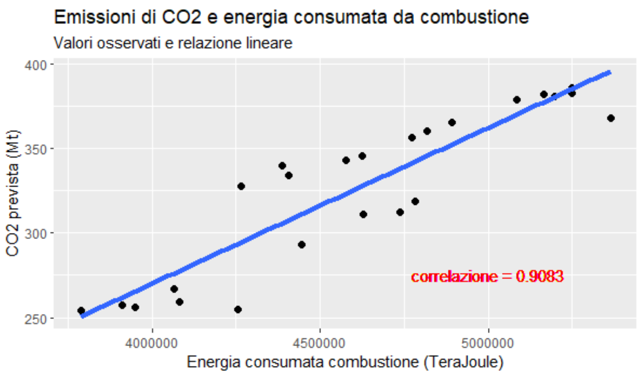
Appendix B:

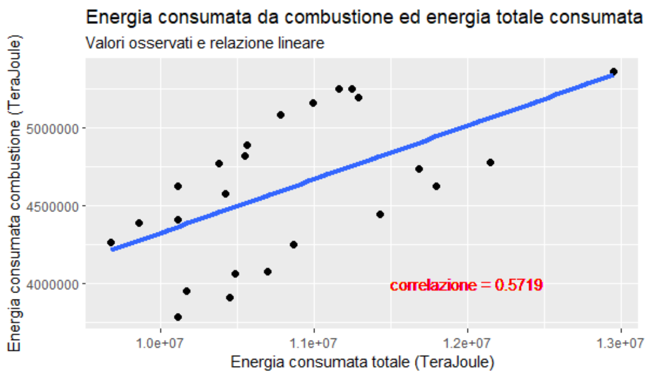
Linear relationships between system variables

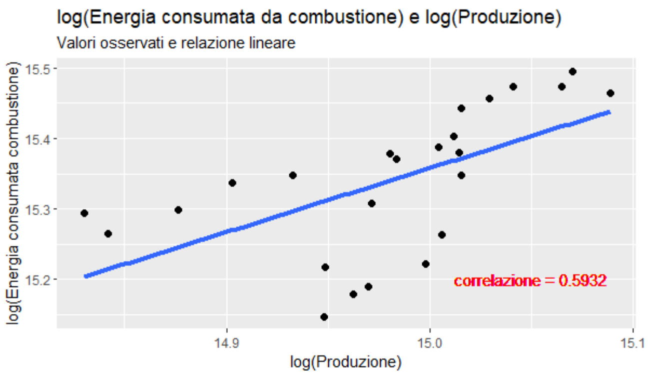
Dependent variable: CO_{2t}					
Variable	**Symbol**	**Estimated value**	**Standard error**	**P-value**	**Significance**
Intercept		-9.763	1220.75	0.0292	*
$EnergiaCombustione_t$		0.00009194	19.632	0.000000	***
Goodness of fit	R^2_{adj}	0.817		0.000000	***

Dependent variable: Combustion energy					
Variable	**Symbol**	**Estimated value**	**Standard error**	**P-value**	**Significance**
Intercept		880500	114400	0.4496	
Cons Total Energy		0.3445	0.1053	0.0035	**
Goodness of fit	R^2_{adj}	0.2966		0.003497	***

Dependent variable: Combustion energy					
Variable	**Symbol**	**Estimated value**	**Standard error**	**P-value**	**Significance**
Intercept		1.7421	3.9340	0.66222	
Prodcution$_t$		0.9077	0.2626	0.00225	**
adjustment	R^2_{adj}	0.3225		0.002247	***







Johansen test for co-integration of equity and GFCF					
Zero hypothesis	**Test statistics**	**Critic 10%**	**Critical 5%**	**Critical 1%**	**Decision**
	2.53	6.50	8.18	11.65	Non-rejection
$r \leq 2$	11.36	15.66	17.95	23.52	Non-rejection
$r \leq 1$ $r = 0$	25.62	28.71	31.52	37.22	Non-rejection

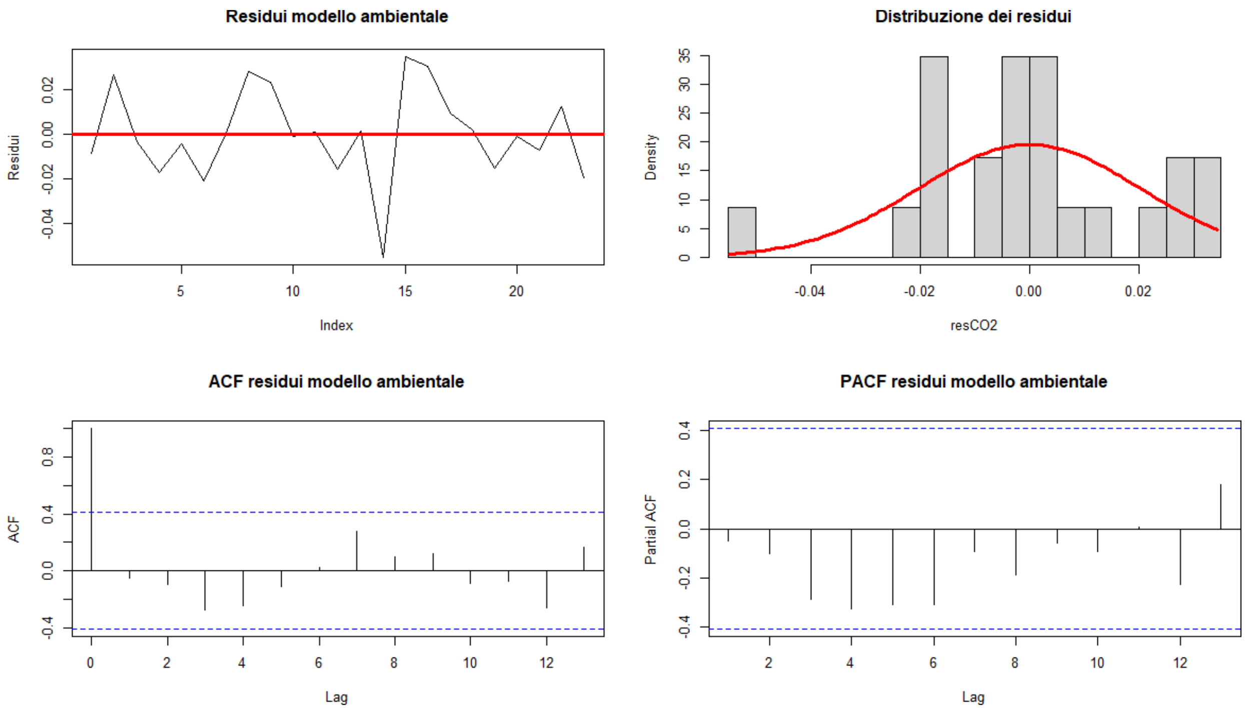
'r' identifies the number of cointegration relationships between the variables considered, in this case

- Net Capital
- Inv. Technology
- Inv. Non-technology

Appendix C:

Statistical diagnostics on environmental model residuals

Environmental model residual diagnostic tests				
Test name	**Diagnostics**	**P-value**	**Decision**	**Interpretation**
Ljung-Box	Autocorrelation	0.5524	Non-rejection	Non-autocorrelated residues
Dickey-Fuller	Stationarity	<0.01	Rejection	Stability of residues
Bera-Jarque	Normality	0.5976	Non-rejection	Normality of residues
Breusch-Pagan	Heteroschedasticity	0.07087	Non-rejection	Homoschedastic residues


Residui modello ambientale
Residui
Index
Distribuzione dei residui
Density
resCO2
ACF residui modello ambientale
ACF
Lag
PACF residui modello ambientale
Partial ACF
Lag

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