RNC2050

ROADMAP FOR CARBON NEUTRALITY 2050 (**RNC**2050)

LONG-TERM STRATEGY FOR CARBON NEUTRALITY OF THE PORTUGUESE ECONOMY BY 2050

REPÚBLICA PORTUGUESA
AMBIENTE E TRANSIÇÃO ENERGÉTICA

FUNDO AMBIENTAL
Environment Portugal

apa
portuguese environment agency

EN

ROADMAP FOR CARBON
NEUTRALITY 2050
(**RNC**2050)

**LONG-TERM STRATEGY
FOR CARBON
NEUTRALITY OF THE**
PORTUGUESE ECONOMY
BY 2050

R 262/2019
2019.06.06

SUMMARY

PREFACE

The signature of the Paris Agreement was one of the first official acts in which I had the privilege of participating as Minister of the Environment, responsible for the climate portfolio. A year later, at the COP 22 in Marrakech, the Prime-Minister committed to achieve carbon neutrality by 2050, in a pioneering act of leadership, placing Portugal among those who advocate greater ambition in climate action.

Our political orientation has been structured with a long-term vision, coupled with immediate action, around three interconnected axes: the valorisation of territory and habitats, a more circular economy and the decarbonisation of society and energy transition, with the ultimate objective being the promotion of wealth and wellbeing.

The 2050 Carbon Neutrality Roadmap for Portugal (RNC2050) was developed in alignment with the territorial dimension included in the National Spatial Planning Policy Program and incorporating the orientations of the Circular Economy Action Plan. I also highlight the unprecedented participation of the civil society, which was guaranteed throughout the different phases of the elaboration of the RNC2050 and allowed for a wide public discussion of its results.

The RNC2050 sets the path to carbon neutrality in a sustained manner, establishes the main guidelines and identifies cost-effective options to achieve this end in different socio-economic development scenarios

Accomplishing carbon neutrality in Portugal implies reducing greenhouse gas emissions by more than 85%, compared to 2005, and ensuring an agricultural and forestry carbon sequestration capacity of around 13 million tonnes. As Portugal is one of the countries that is most potentially affected by climate change, ensuring a sustainable and resilient agriculture and forest, and fighting desertification, are the biggest challenges we face, They must be coordinated with territorial cohesion and the protection of biodiversity, in order to ensure we achieve the said neutrality.

In line with the results of the IPCC Report on 1.5 ºC, it is by 2030 that the largest effort to reduce emissions will be placed, and this ambition has already been translated into the 2030 National Energy and Climate Plan, with a clear focus on energy transition and sustainable mobility.

The RNC2050 demonstrated that carbon neutrality can be achieved with positive impacts on the economy and employment. The transition to a carbon neutral economy, together with the energy transition that is needed, implies a significant investment, being necessary to ensure social justice in the way investments are funded. In order to promote investments towards a carbon neutral economy, Portugal initiated, in 2019, a debate about sustainable finance, which has led to the Letter of Commitment to Sustainable Financing in Portugal, that was subscribed by the large majority of the Portuguese financial sector.

Achieving carbon neutrality implies changing from a linear, fossil fuel-based economic model to a circular, carbon-neutral model. It implies a profound transformation of society as we know it. This is a process that brings challenges, but above all opportunities, and only with everyone's contribution will be possible to operate a just and cohesive transition.

We have no time to hesitate. We can be flexible in solutions, but we cannot have margin on the set goals. Effective and ambitious climate action is key.

We must act before it is too late. The path to carbon neutrality is the path of the future.

João Pedro Matos Fernandes
Minister of the Environment and Energy Transition

ROADMAP FOR CARBON NEUTRALITY 2050 (**RNC**2050)

LONG-TERM STRATEGY FOR CARBON NEUTRALITY OF THE PORTUGUESE ECONOMY BY 2050

1.
FRAMEWORK

INTERNATIONAL AND EUROPEAN FRAMEWORK

The Paris Agreement[1], adopted in 2015, sets three overall objectives, namely, to limit the average global temperature increase to well below 2 °C and to pursue efforts to limit the average global temperature increase to 1.5 °C, acknowledging that this would significantly reduce the risks and impacts of climate change; increase the ability to adapt to the adverse impacts of climate change and promote climate resilience and low carbon development; and to make financial flows become consistent with resilient and low carbon development trajectories.

The Paris Agreement further stipulates that, to attain these objectives, it will be necessary to achieve carbon neutrality in the second half of this century, establishing that all Parties to the Agreement must prepare and communicate in a successive and progressively more ambitious manner their Nationally Determined Contributions (NDC) to the global effort to reduce greenhouse gas (GHG) emissions. In this context, all Parties are invited to submit, by 2020, their long-term development strategies with low GHG emissions[2].

This agreement marks a new era of global mobilisation to address climate change and represents a paradigm shift in the implementation of the United Nations Framework Convention on Climate Change (UNFCCC), with explicit acknowledgement that only with everyone's contribution is it possible overcome the challenge of climate change.

Limiting the increase in global average temperature to 1.5 °C, in line with the most ambitious objectives of the Paris Agreement, requires an unprecedented transformation of modern societies and urgent and profound emission reductions in all sectors of activity, as well as changes in behaviour and the involvement of all parties.

The Special Report of the Intergovernmental Panel on Climate Change (IPCC) on the impacts of an average global temperature increase of 1.5 °C above pre-industrial levels is decisive in affirming that human activities have already caused approximately 1 °C of global warming over pre-industrial levels, with a likely range of 0.8 °C to 1.2 °C, and that, with current expected trends in global emissions, the 1.5 °C level will be reached between 2030 and 2052.

Limitation of the average global temperature increase to 1.5 °C in relation to the pre-industrial period is crucial as it may prevent irreversible impacts of global warming. The difference between an increase of 1.5 °C and 2 °C is significant in terms of impacts and consequences for ecosystems and the economy, especially given that these are global average values and that the average temperature increase in more vulnerable areas of the planet could be even higher. The impacts of recent extreme events such as heat waves, droughts, floods and forest fires demonstrate the significant vulnerability and exposure to climate variability of some ecosystems and many societies.

1 https://unfccc.int/sites/default/files/english_paris_agreement.pdf

2 Decisão 1/CP.21: https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

The IPCC Special Report states that, in order not to exceed 1.5 °C of global temperature increase, global net anthropogenic CO_2emissions should fall until 2030 by about 45% from 2010 levels, reaching carbon neutrality by 2050. To keep the average global temperature rise below 2 °C, global CO_2 emissions must decrease by around 25% by 2030 and carbon neutrality will have to be reached by 2070. Emissions of other greenhouse gases also have to decrease significantly, to limit the temperature rise to either 1.5 °C or 2 °C. These are global goals to be achieved by the countries of the world in general.

Maintaining the average global temperature increase within the limit of 1.5 °C is still possible but requires unprecedented change and urgent action to avoid the worst of its expected impacts and the costs associated with adapting our societies and economies to those impacts. The reduction of future damage will depend on the level of global warming that it is possible to avoid, and therefore on the rapid reduction of GHG emissions. In this context, it is crucial that as many countries as possible that are net emitters of GHG today achieve carbon neutrality as soon as possible.

It is widely acknowledged, and reinforced by the conclusions of the IPCC Special Report, that the later that measures known to be necessary and unavoidable are taken, the greater the costs of delayed action, and the more significant and rapid the GHG reductions will have to be in the post-2030 period.

In 2014[3] the European Union (EU) defined its goal for GHG reduction in the period from 2021 to 2030 by setting a binding target of at least 40% internal reduction of GHG emissions throughout the economy by 2030, compared with 1990 levels.

This goal was embodied in the first EU Nationally Determined Contribution (NDC) for the 2030 horizon under the Paris Agreement commitments and underpinned the preparation of the 2030 Climate and Energy legislative framework. This Climate and Energy framework includes the EU-level policy targets and objectives for the period of 2021-2030, including at least a 40% reduction in GHG emissions (compared to 1990); at least 32% of energy derived from renewable sources[4]; and an improvement of at least 32.5% in energy efficiency[5].

The European Commission presented the Communication “A Clean Planet for All”, in November 2018, which proposes a long-term strategic vision for a thriving, modern, competitive economy that permits the achievement of zero net GHG emissions by 2050, providing the basis for the EU’s long-term development strategy to be submitted to the UNFCCC under the Paris Agreement.

The analysis conducted by the Commission indicates that the policies and objectives already established in the EU will allow a reduction of its GHG emissions by around 45% by 2030 and around 60% by 2050. However, this figure falls far short of the 80-95% reductions in GHG emissions that will be required for the EU to reach the target of carbon neutrality by 2050 and contribute adequately to the long-term temperature objective set by the Paris Agreement.

3 European Council, dated 24 October 2014

4 Directive (EU) 2018/2001 of the European Parliament and the Council, dated 11 December 2018, on promotion of the use of energy from renewable sources (reformulation)

5 Directive (EU) 2018/844 of the European Parliament and the Council, dated 30 May 2018, amending Directive 2010/31/EU regarding the energy performance of buildings and Directive 2012/27/EU on energy efficiency

The EU's long-term strategy is seen to be crucial for outlining the best course for meeting the goal of achieving carbon neutrality by 2050 in the EU, through a socially fair, cost-effective transition that ensures the active participation of citizens, presenting a clear message of a paradigm shift in terms of production and consumption models, changes in the way of viewing financial flows and research, innovation and knowledge, and aligning action in key areas, from energy - with particular focus on the importance of renewable energy and energy efficiency - to mobility, the role of buildings and industry and suitable agroforestry management.

INTERNATIONAL OVERVIEW OF THE COMMITMENTS TO CARBON NEUTRALITY

The carbon neutrality commitments already made by a number of countries, both developed and developing, vary in terms of their definition of neutrality, the date to achieve zero net emissions and the legal strength of the commitment to achieve the targets established.

Several countries have already adopted the commitment to carbon neutrality by 2050, especially those that enshrined this commitment in legislation:

- Norway aims to achieve carbon neutrality by 2030, by having recourse to international credits, formalised in a Parliamentary Agreement;
- Sweden aims to achieve carbon neutrality by 2045, with a 15% offset limit and excluding aviation and shipping, formalised in legislation;
- Denmark aims to achieve a low carbon society by 2050, formalised in legislation, and a strategy that refers to carbon neutrality on that timescale.

The EU, Spain, France, the United Kingdom and New Zealand are currently preparing commitments to carbon neutrality by 2050, and many others are expected to adopt this commitment in the preparation of their long-term strategies, to be submitted under the Paris Agreement by 2020.

Between November 2016 and February 2019, 11 countries submitted their long-term strategies to the UNFCCC Secretariat. Of these, four are EU Member States: Germany and France (submission in 2016 and re-submission in 2017); the United Kingdom and the Czech Republic (2018).

Through the "2050 Pathways"[6] platform, a multilateral initiative set up to support the achievement of long-term zero GHG commitments, 19 countries (including Portugal) and 32 cities have committed to developing long-term development strategies, with low emissions and climate resilience.

6 https://www.2050pathways.org/

NATIONAL COMPLIANCE

In 2016, the Portuguese government pledged to ensure neutrality of its emissions by the end of 2050, outlining a clear view on intense decarbonisation of the national economy, as a contribution to the Paris Agreement and in line with the most ambitious efforts under way at an international level.

The commitment to reach carbon neutrality by 2050 means achieving a neutral balance between GHG emissions and carbon sequestration, for which substantial reductions in emissions and/or substantial increases in national carbon sinks will be required, which have to materialise between now and 2050. The national commitment does not foresee having recourse to international carbon credits to achieve the carbon neutrality goal.

In order to achieve this goal, the 2050 Carbon Neutrality Roadmap (RNC2050) has been developed, identifying the main decarbonisation vectors in all sectors of the economy, the policy and measures options and the emission reduction path to achieve this end, in different scenarios of socioeconomic development. All sectors must contribute to reducing emissions, increasing efficiency and innovation, promoting improvements, notably in buildings, agriculture, waste management and industry, with the energy system making the greatest contribution, particularly as regards electricity generation and transport.

RNC2050 is also the national strategy for long-term low-GHG development to be submitted to the UNFCCC, in accordance with the Paris Agreement, and to the European Commission, in accordance with the EU Regulation on Governance of the Energy Union and Climate Action.

The elaboration of RNC2050 was carried out in parallel with the preparatory work for the National Energy and Climate Plan (PNEC), which will be the main energy and climate policy instrument for the decade 2021-2030, setting new national targets for the reduction of GHG emissions, renewable energy and energy efficiency in line with the objective of carbon neutrality.

The PNEC emerges within the framework of the obligations laid down by the Regulations of Governance of the Energy Union and Climate Action, which provide for all Member States to draw up and periodically submit to the European Commission a PNEC that establishes national targets and objectives for GHG emissions, renewable energy, energy efficiency, energy security, internal market and research, innovation and competitiveness, as well as a clear approach regarding how to achieve them.

Portugal is a country with a proven record on climate policy, having met the goals defined in the Kyoto Protocol targets and is on course for compliance with the 2020 goals for emissions reduction, energy efficiency and promotion of sources of renewable energy.

Looking towards 2030, the first step towards achieving the 2030 European Climate and Energy Package at a national level was taken in 2015 with approval of the Strategic Framework for Climate Policy (QEPiC), with a vision of decarbonising the economy and placing the country in better conditions to meet the challenges created by the Paris Agreement.

The QEPiC established an integrated, complementary and articulated framework of climate policy instruments for the horizon 2020/2030, in liaison with air policies, with the approval of the National Climate Change Program (PNAC 2020 - 2030), which identifies the guidelines for policies and measures that can ensure achievement of the new emissions reduction targets for 2020 and 2030, and the National Climate Change Adaptation Strategy (ENAAC 2020).

It was then established that Portugal should reduce its GHG emissions from -18% to -23% by 2020 and from -30% to -40% by 2030, compared to the 2005 figures, contingent on the results of the European negotiations, and sectoral targets for the reduction of GHG emissions were also defined.

The establishment of these targets was underpinned by the National Low Carbon Roadmap 2050 (RNBC), which was the first long-term modelling exercise of national emissions, carried out at a national level. In the Roadmap, it was stated that it was possible to achieve national emissions reductions of between -50% and -60%, compared to 1990, which corresponds to a reduction of -60% to -70% in the energy sector compared to 1990[7]. It can be seen that the potential for reducing emissions that was modelled at that time is already outdated, essentially as a result of faster than anticipated developments in technology.

PROGRESS MADE IN REDUCING NATIONAL GREENHOUSE GAS EMISSIONS

Following the rapid growth in GHG emissions seen during the 1990s, Portugal reached its peak of national emissions in 2005, after which they recorded a significant and sustained fall, and since then have consolidated a trend of decarbonisation of the national economy.

In fact, in 2005 it was verified that emissions increased by about 44% compared to 1990 levels. In 2017, according to the most recent update of the 2019 National Emissions Inventory, GHG emissions, without considering emissions due to land use changes and forests (LULUCF), are estimated at about 70.7 Mt CO_2eq, representing an increase of around 19.5% compared to 1990.

Considering the LULUCF sector, total emissions in 2017 are estimated at 78.0 Mt CO_2eq, corresponding to an increase of 29.2% over 1990. This marked growth is related to the rural fires that occurred in the tragic year of 2017, a situation associated with a particularly dry year, the high recorded temperatures that occurred outside the normal summer period (the largest rural fires occurred in June and October), and unusually strong winds, such as Hurricane Ophelia that struck the coast of the Iberian Peninsula in October 2017.

FIGURE 1

Evolution of national greenhouse gas emissions (GHGs) 1990-2017 (Mt CO_2eq)

7 Corresponding to a reduction in national emissions of between -65% and -70%, compared to 2005, and a reduction of -70% to -80% in the energy sector compared to 2005.

An analysis of GHG emissions per unit of Gross Domestic Product (GDP) shows that a decoupling trend between GDP and emissions started in 2005, resulting from decarbonisation of the economy, that is, an economy with less carbon emitted for each unit of produced wealth that is being maintained.

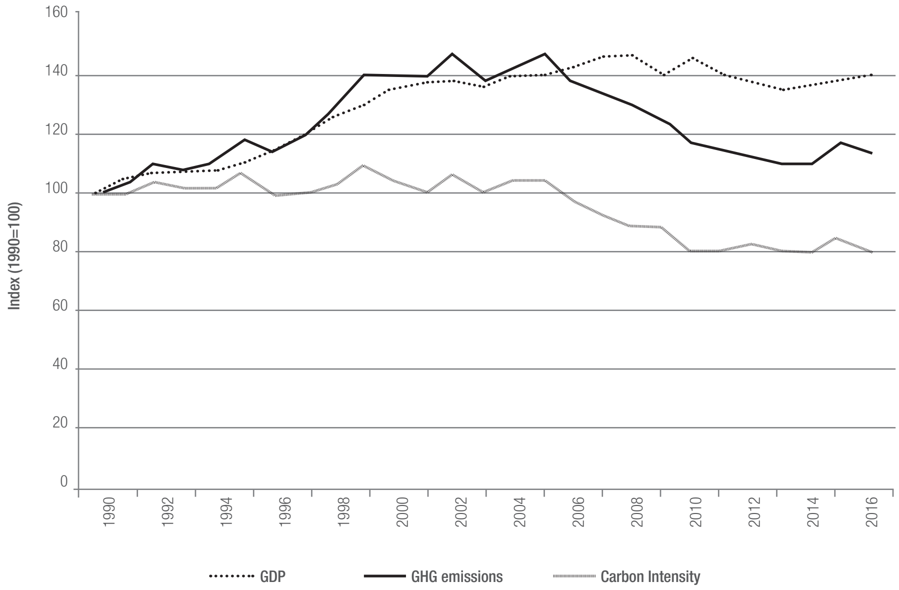


FIGURE 2

Evolution of the carbon intensity of the national economy

Several factors underlie this trend, such as the significant growth of energy produced from renewable energy sources (mainly wind and water), and the implementation of energy efficiency measures, as well as the replacement of more polluting energy sources such as fuel oil by natural gas, with the construction of more efficient combined cycle power plants and cogeneration units.

Public policies on climate change are now an integral part of a series of sectoral policies in Portugal. Indeed, in areas such as energy and industry covered by the European Emissions Trading Scheme (ETS), the 'carbon dimension' is now part of the strategic and economic considerations of the companies concerned. In agriculture and forestry there is also a growing awareness of the important contribution that the sector can make in terms of mitigating GHG emissions. In areas with major challenges such as transport, steps have been taken to decarbonise vehicle fleets and an electric mobility network has been set up and electric vehicle support schemes introduced with the aim of reinforcing incentives for the introduction of vehicles of this kind. Similarly, in the area of the freight transport system, in particular maritime and inland waterways transport, important steps have been taken in line with the Strategy for Increasing Port Competitiveness - Horizon 2026, where national ports are an essential pillar for sustainable economic development, with progress in the adaptation of their infrastructures to increasing ship size and overall demand, as well as adjustment for the promotion of inland waterway transport, in parallel with increasing electrification of equipment and the introduction of supply systems of liquefied natural gas (LNG). The implementation of the Single Logistics Window, which will lead to process dematerialisation and the monitoring of goods with tracking and tracing processes, will contribute significantly to the promotion of an efficient logistics chain as an aggregating and fundamental tool in a modal division of transport of goods with lower carbon intensity.

The Portuguese experience shows that ambitious climate policies can go hand in hand with economic growth, job creation, people's health and the environment. Nowadays, Portugal is already producing more wealth with less emissions and this is the way forward to continue building a strategy towards carbon neutrality and a carbon neutral economy.

2.
VISION AND FUNDAMENTAL PRINCIPLES

In 2016, at the 22nd Conference of the Parties to the United Nations Convention on Climate Change in Marrakech, Portugal set itself the goal of achieving Carbon Neutrality by 2050, outlining clear guidelines with regard to intense decarbonisation of the national economy, contributing to the most ambitious objectives set in the framework of the Paris Agreement.

This RNC2050 sets out the vision and trajectories and identifies guidelines for the policies and measures needed to achieve this goal. RNC2050 is also Portugal's Long-Term Strategy to be submitted to the EU and the UNFCCC under the Paris Agreement.

The transition to a carbon neutral economy requires timely long-term planning that allows advantage to be taken of opportunities associated with the inherent transformation of the economy and to establish the basis of trust among all the citizens and economic agents that this change is possible, advantageous and timely.

RNC2050 provides insight into key future trends and the necessary economic and social transformations, involving all sectors of the economy and society, in order to achieve the goal of carbon neutrality by 2050, through a socially fair and efficient transition in terms of costs, strengthening the competitiveness of the national economy, promoting job creation and enhancing co-benefits associated in particular with air quality and human health. This transition must also be a factor of valorisation of the country and a contribution to national cohesion. In this context, RNC2050 was elaborated in conjunction with the principles established in other important circular economy strategies, particularly by following the guidelines set forth in the Circular Economy Action Plan, and in the planning and spatial planning of the country, specifically the proposal of the National Program of Spatial Planning Policies, without prejudice to the different time horizons.

Achievement of the objective of carbon neutrality in 2050 is based on a strategic vision aimed at promoting decarbonisation of the economy and the energy transition towards carbon neutrality by 2050, as an opportunity for the country, based on a democratic and fair model of national cohesion that enhances the generation of wealth and the efficient use of resources.

Realisation of this strategic vision rests on eight key premises, described in more detail in the following sections:

i) iPromote the transition to a competitive, circular, resilient and carbon neutral economy, generating more wealth, employment and well-being;

ii) Identify decarbonisation vectors and lines of action that underlie the route to carbon neutrality by 2050;

iii) Contribute to resilience and the national capacity to adapt to climate change vulnerabilities and impacts;

iv) Stimulate research, innovation and knowledge production in key areas to achieve the goal of carbon neutrality;

v) Guarantee financing conditions and increase investment levels;

vi) Ensure a fair and cohesive transition that contributes to valorisation of the country;

vii) Ensure effective conditions for monitoring progress towards the goal of carbon neutrality (governance) and ensure the adoption of carbon neutral objectives in the sectoral areas;

viii) Involve society in the challenges of climate change, focusing on education, information and awareness raising, contributing to increasing individual and collective action.

This vision will necessarily have to be translated into the various sectoral policy strategies and instruments in energy, transport, trade, services, industry, waste, agriculture and forests, taking into account the decarbonisation vectors identified and to be pursued by the country over the next 30 years.

3.
THE TRANSITION TO A COMPETITIVE, CIRCULAR, RESILIENT AND CARBON NEUTRAL ECONOMY

The current economic model is based on the exploitation of resources (extraction of fossil fuels, raw materials, soil and water), which are transformed, used and returned to the environment as waste or emissions to the atmosphere. This linear economic model is not sustainable and is the basis of most of the environmental problems: air, water and soil pollution; the impermeability and expansion of urbanised areas, the need to continuously expand the areas dedicated to agriculture, livestock and forestry, and the consequent reduction of biodiversity, deforestation and destruction of natural habitats.

The challenge of carbon neutrality thus fits into the broader theme of how to survive and thrive on a finite planet, as a species that continues to grow in population and legitimately desires to achieve increasing standards of comfort and security, without, in this process, creating disruptions that jeopardise the survival of the human species and all the other species that share the planet with us. One, and perhaps the greatest, of these ongoing disruptions is climate change.

Part of the response to the challenge of climate change lies in the use of renewable energy sources, greater efficiency and circularity in resource use and the reinforcement of carbon sinks. Renewable energies already have the potential to replace a very significant part of fossil fuels and thus eliminate emissions and other pollution associated with their exploitation and use, noting also, in this context, the new challenges and contributions of oceanic renewable energy. Increasing economy circularity and efficiency will make it possible to do more with less resources, reduce raw material consumption and transform a waste chain into a new material chain. Reinforcing carbon sinks will have an extremely important impact on reducing the concentration of carbon dioxide in the atmosphere and on climate regulation.

This profound transformation of society is not only compatible with the goal of carbon neutrality, but in fact will be one of the engines to achieve that neutrality.

The goal of decarbonisation must also be addressed in the context of adaptation to climate change. The more marked these changes, the greater the costs that the country will have to bear with the disruption of agriculture, with fires, with degradation of the coastline, with the health and safety of people, particularly during heatwaves and other extreme climate events. Carbon neutrality, as a goal shared by all countries, will be the engine for limiting the extent of climate change and thus the key factor for limiting the volume of losses associated with the damage it would cause.

In the economic sphere, both the objective of carbon neutrality and adaptation to climate change can and should be seen not only as a cost to be avoided for the economy, but also as an opportunity for the country, with the creation of new sectors, clusters, business models, and for conversion of current linear production lines into an economic circularity.

In this context, it will be essential to ensure a stable and competitive regulatory framework, that guarantees the involvement and commitment of the main actors, public and private, with implementation of the measures necessary to achieve the defined objectives, thus providing stability for investors in the most diverse sectors.

Decarbonisation should be based on principles of technological diversity, removing any regulatory constraints, perverse subsidies and other restrictions that create distortions in the workings of the market (which should promote more efficient and competitive solutions but taking into account the entire value chain of each solution).

It should be noted that the strategic vision of achieving carbon neutrality based on the eight premises set out above constitutes an important contribution to the achievement of the Sustainable Development Goals, namely SDG 13 - Climate action defined as one of the Priority Objectives for Portugal in the context of the 2030 Agenda for Sustainable Development. The development model proposed in this strategic vision will also contribute to meeting the goals associated with other SDGs, of which we highlight SDG 1 - Eradicating Poverty, SDG 3 - Quality Health; SDG 4 - Quality Education; SDG 8 - Decent Work and Economic Growth; SDG 9 - Industry, Innovation and Infrastructure; SDG 11 - Sustainable Cities and Communities; SDG 12 - Sustainable Production and Consumption and SDG 15 - Protecting Life on Earth.

4.
TRAJECTORIES FOR CARBON NEUTRALITY BY 2050

The objective of carbon neutrality means equating the level of GHG emissions with the carbon sink level by the year 2050 (net emissions equal to zero). This will require substantial emissions reductions and/or substantial increases in national carbon sinks, which should be implemented between now and 2050.

Portugal's average annual emissions in the decade 2007-2017 were 69 Mt CO_2 (54 to 74 Mt CO_2). When broken down by sector, national emissions are distributed by: 25% in energy production, 25% in transport, 23% in industry, 10% in agriculture, 8% in other energy uses; and 8% in waste.

Carbon sinks are the result of some land uses, notably in agriculture, pastures, forests and scrubland, and, during this period, they absorbed from the atmosphere about -8.5 Mt CO_2 (from -13 to +7 Mt CO_2), or about -12% of the emissions from the other sectors[8].

The net total of emissions and carbon sinks is therefore currently 60 Mt CO_2, and this is the order of magnitude that will have to be reduced by 2050 in order to achieve carbon neutrality.

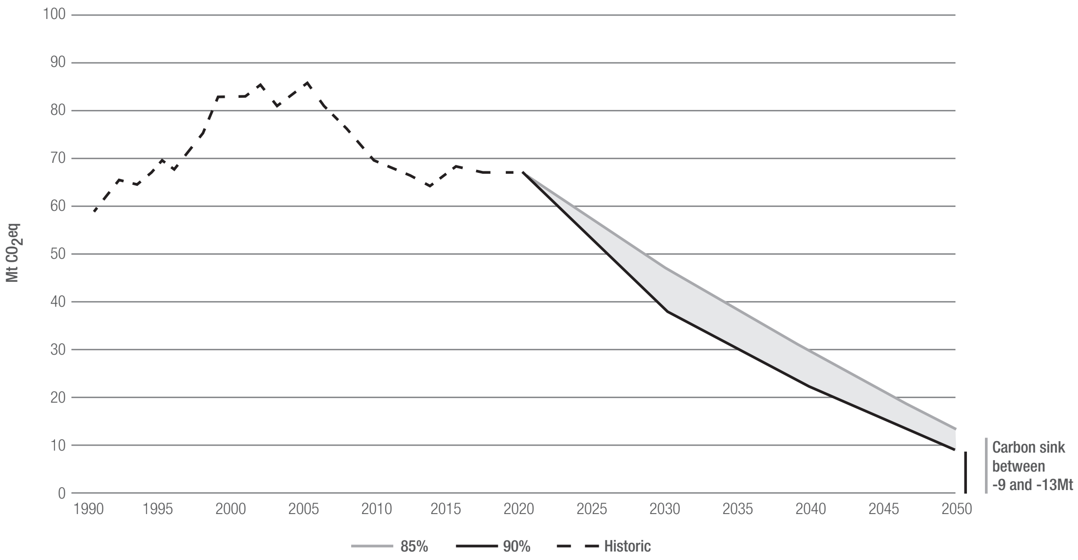
The potential for reducing emissions and increasing carbon sinks is not the same in all sectors of the economy and for all greenhouse gases. In some sectors, technologies are available and are cost-effective, while in others very large reductions are not possible (without reducing the sector's activity) or are extremely expensive.

Also, the cost of each technology is not constant over time, and it is expected in most cases that the technologies currently most innovative and still relatively expensive will become progressively more cost-effective over time.

The identification of GHG emission trajectories to achieve carbon neutrality is supported by modelling exercises that cover all sectors of the economy with significant contributions to national total emissions and all the important GHGs. It was also intended to evaluate whether there is technological and economic viability for the Portuguese economy to reach carbon neutrality by 2050, using only technologies and processes known today (albeit with different technological maturity).

RNC2050 is based on three alternative macroeconomic scenarios for development of the Portuguese economy and on two sets of objectives for each scenario. In the first set of objectives, it was sought to evaluate the evolution of emissions in a scenario of maintenance of the current trend of climate policies in force, representing a significant decarbonisation trajectory of the national economy. In this case, the economy grows and reduces emissions, but this reduction is mainly due to the introduction of more efficient and/or less emitting technologies (e.g. renewable energy sources or electric vehicles) through their cost-effective potential and the progressive reduction of their cost. In the second set of objectives, it was sought to evaluate the evolution of emissions in a carbon neutral scenario, translated into a trajectory of reduction of emissions of the energy system of -60% by 2030 and -90% by 2050 compared to 2005.

8 It should be noted that the size of the national carbon sink varies greatly between years, mainly due to the influence of the rural fires each year. In 2017, when the fires were exceptionally dramatic, this sector was not as it usually is a carbon sink, but rather an additional source of emissions (at around 7 Mt CO_2). Excluding that year, the average over the last decade would be -10 Mt CO_2.



NOTA: The emissions trajectory includes net emissions from agriculture and agricultural lands, taking into account their carbon sink role. The value of the carbon sink does not include this component for pastures and other agricultural lands.

FIGURE 3

Emissions reduction trajectory from 85% to 90% by 2050 compared to 2005

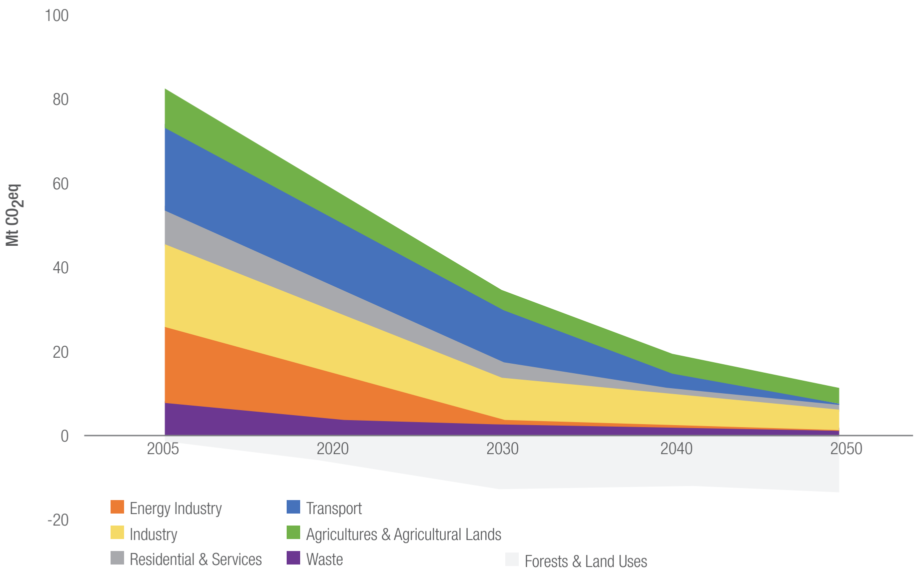


FIGURE 4

Sectoral contribution to the GHG emissions reduction trajectory by 2050

TABLE 1a: Potential emissions reduction in relation to 2005 resulting from the modelling exercise.

SECTORS	2030	2040	2050
Energy	80%l81%	92%	96%
Industry	52%l48%	59%l60%	73%l72%
Buildings	48%l49%	73%l74%	85%
Transport	43%l46%	84%l85%	98%
Agriculture and land uses	36%l39%	37%l49%	38%l60%
Waste and wastewater	57%l58%	69%l71%	77%l80%

The scenarios modelled offer support for the technological viability of carbon neutrality by 2050, based on a trajectory of emissions reductions of -45% to -55% by 2030, -65% to -75% by 2040 and -85% to -90% by 2050, compared to 2005, assuming a carbon sink value of between -9 and -13 Mt CO_2.

From the modelling performed it is clear that:

- Given the scale of the challenge (zero net emissions by 2050) all sectors will be called upon to contribute, either by reducing their emissions or by increasing their carbon sink capacity.
- The potential reduction of each sector is different, that is, the contribution that each sector can make to reduce emissions is not equally cost-effective.
- It is possible to identify the main vectors and technologies that, with current knowledge, will allow a decarbonisation trajectory to be achieved.

From the broadest view of the results, two main and complementary decarbonisation vectors stand out clearly: reduction of the carbon intensity of electricity produced in Portugal; and replacement of fossil fuels by electricity in most sectors of the economy (electrification of the economy).

Energy production and consumption will therefore become based on endogenous and renewable sources of energy, which in itself constitutes the biggest transformation of the energy paradigm in Portugal since the industrial revolution, reinforcing the path that Portugal has been following in recent years.

Also, with the horizontal nature of most sectors of the economy, we can highlight very significant gains in energy efficiency and resource use efficiency, which will allow the economy to grow, while reducing primary and final energy consumption as well as consumption of materials, also with a logic of greater circularity.

In electricity generation the transformation will be profound (99% reduction in GHG emissions compared to 2005) and will be achieved with significant investments in new renewable capacity, in particular wind and photovoltaic energy, and in a big reduction or abandonment of electricity produced with fossil fuels such as coal, fuel oil and natural gas, supported by a resilient, flexible and modern system.

Decarbonisation of the transport sector will be almost total (98% reduction in GHG emissions compared to 2005) and will be based fundamentally on strengthening the role of the public transport system and replacing current fossil fuel vehicles with a mainly electric fleet. The use of hydrogen and advanced biofuels will also play an important role in replacing current fuels. The conversion of mobility in private vehicles into other forms of mobility (public, active, shared, autonomous) will significantly increase the volume of passengers or goods transported, without the need to increase fleets, particularly that of private cars.

Both residential and service buildings will also make a significant contribution to decarbonisation (reductions of over 96% compared to 2005), due to an almost total electrification of energy consumption, further supported by large energy efficiency gains through reinforcing the insulation of buildings, the use of solar heating and heat pumps.

In industry the reductions will be less significant but still quite large. Reductions of around 80% will be possible in emissions from burning fuels, through electrification, biomass use and efficiency increases, while for emissions that result from industrial processes the potential is much more limited (less diversity of cost-effective technologies available), and therefore emissions reductions are expected to be around 60%, which translates into an overall emission reduction potential of around 73%.

The use of fluorinated gases will be reduced by 54% by 2050, compared to the emissions values observed in 2005. This is due to the reduction imposed by implementation of the Kigali Agreement and the European Regulations, which restrict the production, consumption and market availability of Hydrofluorocarbons (HFCs).

Emissions from agriculture, particularly those from animal production, have a lower potential for reduction, and this sector will reduce its emissions by 9% to 30% by 2050. Possible options include improvements in animal feed and manure management systems, and reduced fertilisation and water needs boosted by biological and precision agriculture, respectively. Agricultural land and pastures have the potential to cease being a source of emissions and become sources of sequestration, through conservation agriculture, by replacing mineral fertilisers with organic fertilisers and sowing improved and biodiverse pastures. Considering emissions from agriculture and from agricultural lands and pastures as a single system, the potential for emissions reduction rises from 40% to 60%.

Other land uses, including forests, can significantly increase current sequestration levels to around 11-13 million tonnes of CO_2, and for this to happen, it is essential to control areas set on fire annually and to achieve productivity increases across forestry species in general.

For waste and wastewater, reductions will be more significant (around 75% compared to 2005) due to a sharp increase in the circularity of the economy, the elimination of organic waste in landfills and the reduction of total and organic waste produced per capita. Some of the alternative destinations for these wastes (biological treatment and composting) may, for the same reasons, increase, but their effect on total emissions will remain small.

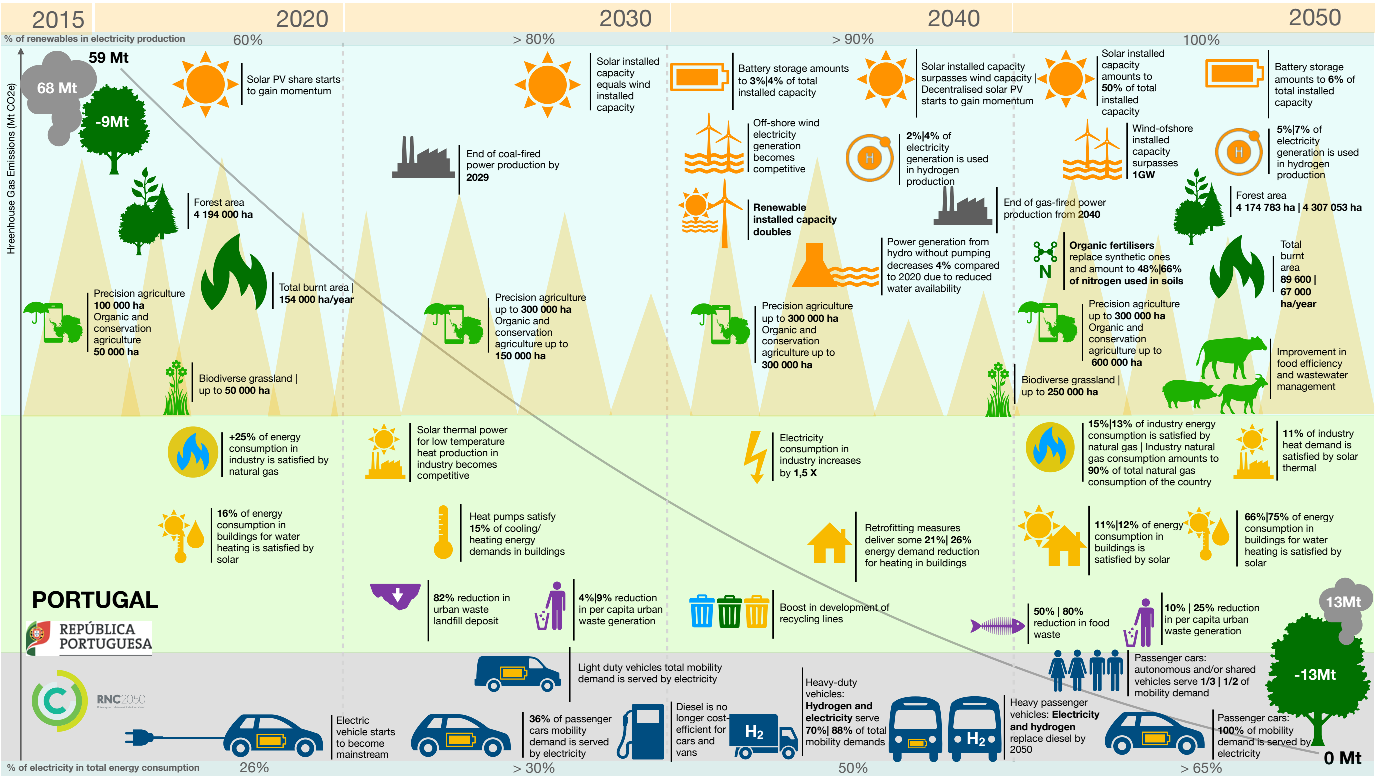


FIGURE 5

Overall narrative of carbon neutrality by 2050

The tables presented in the following sections and chapters show the results of the carbon neutrality trajectories of the Peloton and Yellow Jersey scenarios (PLIYJ) and, for a question of simplicity, only the results of the Yellow Jersey scenario are presented graphically. It should be noted that these results reflect the modelling response, taking into account the assumptions defined, and serve as a basis for informing the policy choices made in the context of RNC2050 and PNEC 2030.

METHODOLOGICAL APPROACH OF THE ROADMAP FOR CARBON NEUTRALITY 2050

The RNC2050 methodology had as its starting point the development of coherent socioeconomic scenarios, based on common narratives of possible evolutions of Portuguese society by 2050 based on the evolution of macroeconomic and demographic parameters over this time horizon. These scenarios were widely discussed with the various stakeholders.

As there is no single model for projecting emissions for all sectors and gases in an integrated manner, a methodologically separate approach has been adopted for each of the four major sectors:

1) Energy system. GHG emissions were estimated based on the TIMES_PT optimisation model which includes, in an integrated manner, the entire Portuguese energy system starting from energy generation, transport and distribution through to consumption in the end-use sectors such as industry, transport, residential, services and agriculture in their multiple uses (heating, cooling, lighting, electrical equipment, passenger and freight mobility, among others).

2) Agriculture, forests and other land uses. GHG emissions were estimated based on different assumptions aligned with the narratives of the socioeconomic scenarios, from which the respective evolutionary trends of the crop and animal sector, and their emissions, were established. This sector includes animal emissions and manure management systems, fertiliser use, rural fires, and the emissions or sequestration of different land uses.

3) Waste and wastewater. GHG emissions were estimated based on projections of the volume of municipal waste and domestic wastewater generated each year, considering the resident population, and the impact of the policies already adopted. This sector includes emissions from the disposal and treatment of urban and industrial solid waste and wastewater.

4) Fluorinated gases. GHG emissions were estimated based on the implications of implementation of the Kigali Agreement and the European Regulations that foresee the phasing out of some of these gases over coming decades. This sector includes emissions from the use of fluorinated gases in refrigeration and air conditioning equipment, fire protection systems and electrical switches.

Estimated GHG emissions for each sector were subsequently aggregated to calculate national total emissions. The base year for the modelling in TIMES_PT is 2015.

In all sectors, GHG emissions estimation follows the methodologies presented in the national emissions inventories, which comply with the emissions calculation guidelines of the 2006 Intergovernmental Panel on Climate Change and relevant UNFCCC decisions for calculation of emissions and reporting emissions projections.

SCENARIOS CONSIDERED IN THE 2050 CARBON NEUTRALITY ROADMAP

For RNC2050, 3 scenarios were built:

Scenario Off-Track: Scenario that retains the essentials of the economic structure and current trends as well as the decarbonisation policies already adopted or in force.

Scenario Peloton: Scenario of socioeconomic developments compatible with carbon neutrality with the development and application of new technologies that, however, do not significantly change either the production structures or the population's lifestyles. It foresees a modest incorporation of circular economy models and the maintenance of population concentration in the Metropolitan Areas.

Scenario Yellow Jersey: Scenario of socioeconomic evolution compatible with carbon neutrality, characterised by a structural and transverse change in production chains, made possible by the combination of a series of technologies of the 4th Industrial Revolution. It foresees a more effective incorporation of circular economy models and greater growth of the importance of medium-sized cities.

OFF-TRACK

- Uncompetitive Portugal
- Population continues declining
- Popoulation concentrated in metropolitan areas, depopulation of the countryside and medium-sized towns
- Maintenance of current production structures
- Low level circularity
- Mobility patterns similar to current ones (low adherence

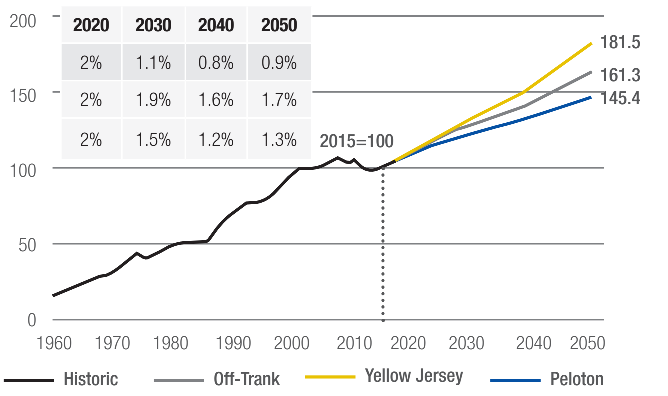
PELOTON

- Competitive Portugal
- Population with less pronounced decrease due to the effect of migratory balance
- Population concentrated in Metropolitan Areas
- Conservative evolution of current production strutures but with techonological development and increased efficiency
- Moderate circularity of the economy
- Moderate adherence to new forms of mobility (shared and low-impact)
- Conservation and biological agriculture and precision agriculture

YELLOW JERSEY

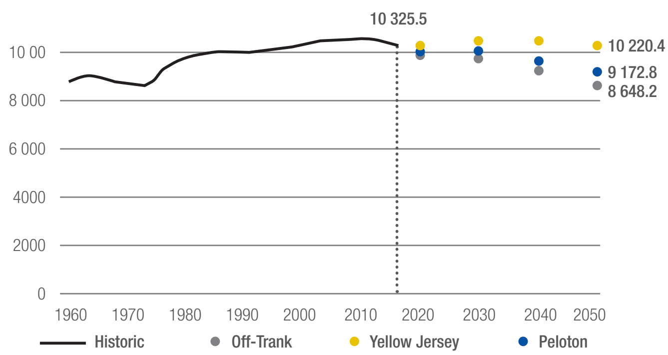
- Very competitive Portugal
- Population stable, due to equilibrium of the physiological balance and substantially increase of the migration balance
- Growth of medium-sized towns and reduction of population concentration in metropolitan
- Higher degree of decentralization and digitization of the energy system
- Greater entrepreneurship
- Grater circularity of the economy
- High penetration of new forms of mobility (shared and low-impact)
- Predominance of biological abd conservation agriculture and precision agriculture: valorisation of externalities (ecosystem services)

GDP growth rates (%)

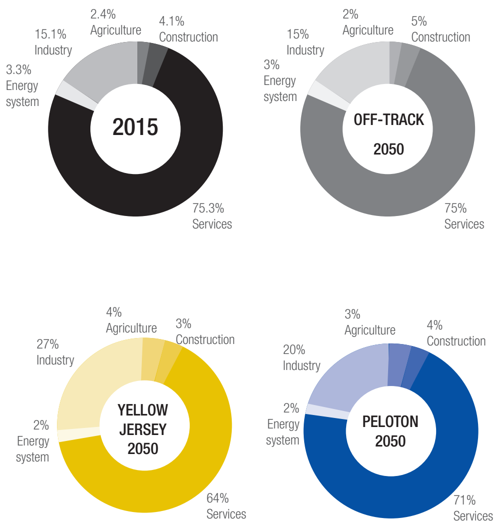


2020	2030	2040	2050
2%	1.1%	0.8%	0.9%
2%	1.9%	1.6%	1.7%
2%	1.5%	1.2%	1.3%

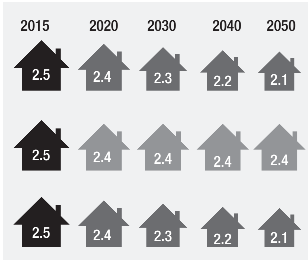
Resident population (thousand)



GVA sectoral structure



Aggregate Dimension



In the Peloton and Yellow Jersey scenarios, two variants were also considered, one in which the economy evolves without imposing a GHG emission reduction target (called 'without neutrality') and a variant in which the economy evolves with the imposition of a GHG emissions reduction target (called 'with neutrality').

SENSITIVITY ANALYSES

An exercise of this nature and with this time horizon always entails a considerable level of uncertainty, not only in the kind of development that the population, society and the Portuguese economy will experience, but also in the preferences and sensitivity of consumers, and in the technological gamut that is available to bring about decarbonisation.

The modelling performed was based on a wide range of technologies, complemented by assumptions regarding the evolution of the investment, operation, maintenance and decommissioning costs of these technologies. Only technologies that are already available or in a pre-commercial phase were considered. Cost assumptions were drawn from recent historical trends and specific studies of these sectors or technologies. However, consideration was not given to technologies that are promising but have not yet been proven in the context of the real economy and the emergence of disruptive technologies between now and 2050, that are completely unknown today, cannot be disregarded.

As a way to test the robustness of the emission trajectories to these uncertainties, some sensitivity analyses were performed for the most critical factors for the evolution of national emissions, revealing the impact of variations in some of the assumptions (for example, in technology costs) on the final modelling results. As expected, the results were different, but the decarbonisation vectors and the potentials of each sector were substantially the same, which suggests a high degree of robustness in the results achieved.

This uncertainty can be viewed as a limitation of such an exercise, but it is also a factor of optimism: if decarbonisation is possible with current technologies, the emergence of new technologies will only make this goal simpler and/or more cost-effective than what is estimated today.

The technical work that supported the elaboration of RNC2050 was developed by a multidisciplinary team, consisting of several national experts from various fields of knowledge. The various technical reports and information about the process can be found on the website of the Portuguese Environment Agency, I.P., the entity responsible for the general coordination of RNC2050.

INVOLVEMENT OF SOCIETY IN THE PREPARATION OF THE 2050 CARBON NEUTRALITY ROADMAP

As the transition to carbon neutrality is an ambitious challenge and requires the broad and participatory involvement of all the agents, the elaboration of RNC2050 was also a broad process of sectoral involvement and mobilisation of society throughout different stages and with different objectives.

The construction of the macroeconomic scenarios that underlie the whole prospecting and modelling exercise went through different iterative phases that allowed the gathering of contributions from various national institutions and experts, which gave rise to the three scenarios considered.

The cycle of technical workshops had the main aim of understanding the role of the circular economy in the future of different sectors, as well as informing the emissions modelling work over the time horizon up to 2050 through stakeholders' perceptions regarding the configuration of the sectors' value chain and of the evolution of some of the main assumptions and trends. This cycle included the following sectoral workshops: mobility; forestry activities; agri-food; construction; cities; energy; waste and wastewater.

At the same time, a cycle of thematic events was held on the decarbonisation of society, with a total of four sessions focused on the themes of Mobility; Forestry Activities; Energy Transition; Fair Transition. An event dedicated to sustainable financing will also be held.

The preliminary results of the Roadmap were divulged for public consultation for a period of 3 months, which began in Lisbon with the public presentation of these results, and about 80 contributions were received at the event. A series of joint public presentation sessions of RNC2050 and the 2030 National Energy and Climate Plan were also held in Coimbra, Porto, Évora, Faro and Funchal.

STRATEGIC ENVIRONMENTAL EVALUATION

As a key framework element of national climate policy that has an impact on all sectors of the economy, including the development of potential sectoral plans and strategies towards carbon neutrality, it was considered appropriate to carry out a Strategic Environmental Evaluation of RNC2050.

Thus, the legally prescribed procedure was followed, after consulting the Entities with Specific Environmental Responsibilities and performing the public consultation. After receiving and duly considering the contributions received, the process culminated with the issuance of the Environmental Statement on Strategic Evaluation.

4.1. ROLE OF THE ENERGY SYSTEM IN THE TRANSITION TO CARBON NEUTRALITY

The energy system covers in an integrated manner energy production, transport and distribution and final energy consumption in the various sectors (industry, transport, residential and services and agriculture).

It is possible to identify, with current technologies and knowledge about their future evolution, neutrality trajectories with cost-effective options to achieve emissions reductions of around 60% by 2030 and 90% by 2050 (compared to 2005). These trajectories express a mix of technologies that minimises the cost to the national energy system, through progressive technological substitution, that begins with the sectors/technologies for which the transition is most cost-effective and progressively expands to more expensive sectors/technologies, until the desired emissions reductions are achieved. No support, fiscal or otherwise, was considered for any technology.

As a consequence, we will see a significant change in the primary and final energy balances, the technological profile of energy production and consumption and the sectoral dissociation from emissions.

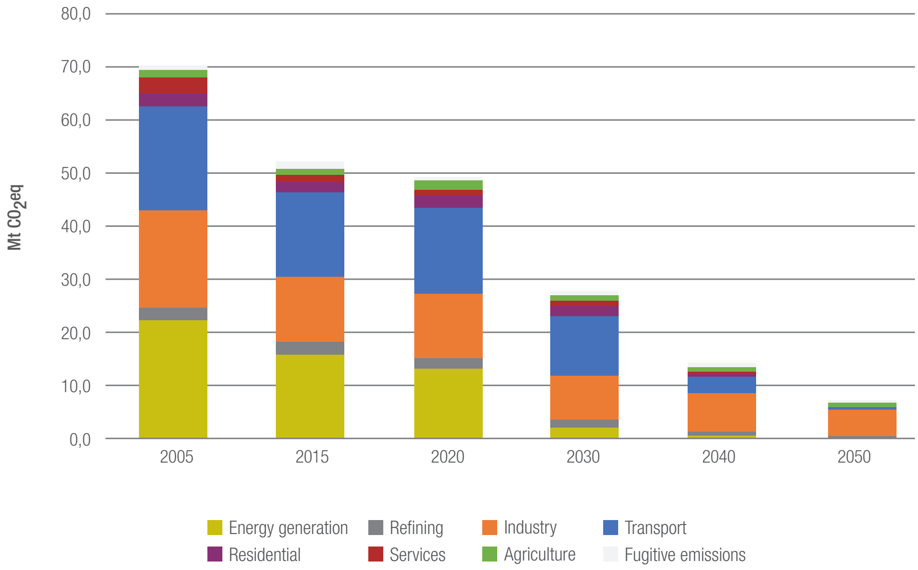


FIGURE 6

Evolution of energy system emissions up to 2050

In the energy system, transport and the power generation sector have the greatest potential for reducing GHG emissions in the decade of 2020-2030, and decarbonisation of buildings and industry will be more intense, respectively, in the decades of 2030-2040 and 2040-2050.

TABLE 1b: Evolution of energy system emissions, up to 2050

TOTAL ENERGY SYSTEM	2005	2015	2020	2030	2040	2050	Δ 2050/2005
	71.44	**52.94**	**49.73**	**28.24 ǀ 28.15**	**14.15**	**7.11**	**-90%**
Power generation	23.04	16.01	12.94	1.18 ǀ 2.2	0.36	0.17	-99%
Refining	2.47	2.37	2.22	1.87 ǀ 1.33	0.76 ǀ 0.8	0.18 ǀ 0.19	-93% ǀ -92%
Industry	18.34	12.73	12.45	9.48 ǀ 8.72	7.34 ǀ 7.6	4.99 ǀ 5.11	-73% ǀ -72%
Transport	19.59	16.19	16.27	10.61 ǀ 11.18	3.19 ǀ 2.91	0.47 ǀ 0.42	-98%
Residential	2.72	2.08	2.43	2 ǀ 2.01	0.73 ǀ 0.71	0.09 ǀ 0.11	-97% ǀ -96%
Services	3.17	1.14	1.18	1.07 ǀ 0.89	0.32 ǀ 0.3	0.00	-100%
Agriculture	1.45	1.14	1.16	1.12 ǀ 1.15	1.09 ǀ 1.08	1.08 ǀ 0.97	-26% ǀ -33%
Fugitive emissions	0.66	1.27	1.08	0.91 ǀ 0.65	0.37 ǀ 0.39	0.13 ǀ 0.14	-81% ǀ -79%

Unit: Mt C02eq.

In fact, the path towards carbon neutrality will lead to a much wider use of endogenous renewable energy resources of which over two thirds are sun and wind, accounting for over 80% of primary energy consumption by 2050. The national energy system thus moves from an essentially fossil base to an essentially renewable base by 2050, with positive consequences for the energy bill, the trade balance and the reduction of energy dependency, which drops from the current 78% of dependence on foreign countries to less than 20% in 2050.

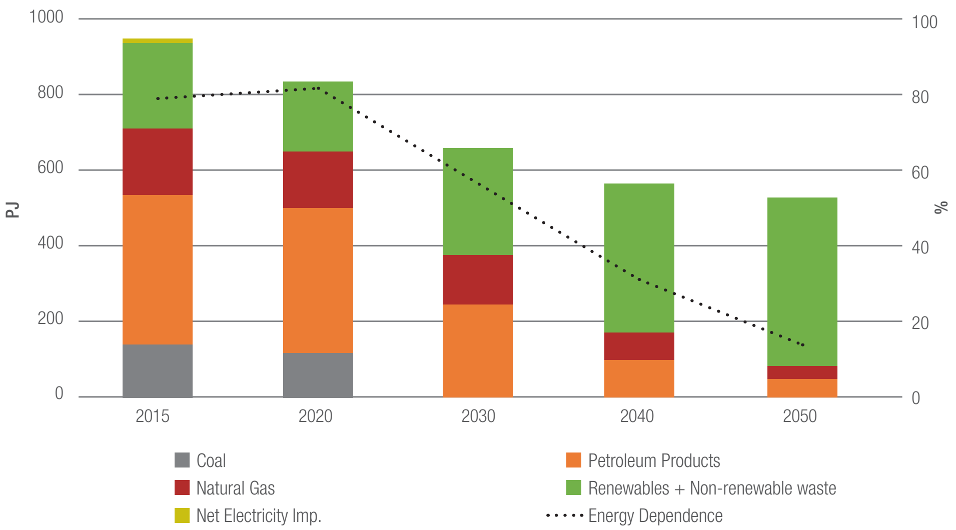


FIGURE 7

Evolution of primary energy consumption, up to 2050

In 2050, energy dependency will be less than 20% (compared to 78% in 2015).

TABLE 2: Evolution of primary energy consumption, up to 2050

TOTAL PRIMARY ENERGY	2015	2020	2030	2040	2050
	938.61	**822.10**	**629.85 I 654.01**	**536.19 I 555.7**	**493.36 I 524.15**
Coal	136.43	115.85	0.37	0.39 I 0.44	0.43 I 0.44
Petroleum Products	395.53	376.39	241.38 I 242.06	108.38 I 94.82	57.33 I 46.52
Natural Gas	171.55	147.29	123.71 I 132.61	70.9 I 77.61	33.91 I 30.05
Renewables + Non-renewable waste	226.94	182.58	264.39 I 278.96	356.52 I 382.83	401.68 I 447.13
Net Electricity Imp.	8.16	0.00	0.00	0.00	0.00
Unit: PJ					
Energy Dependence	78	80	58 I 57	34 I 31	19 I 15
Unit: %					

Achieving this level of reductions will also be supported by decarbonisation of final energy consumption, where there will be increased integration of renewable energy sources and increasing electrification of energy consumption, visible from 2030 onwards, and these are the main vectors of decarbonisation. In 2050, between 66% and 68% of final energy consumption will be met by electricity and there will be a sharp reduction in the consumption of petroleum products, explained by the technological change that will take place, especially in the car fleet.

The emergence of new energy vectors, such as hydrogen, is gradually coming to fruition, reaching an overall contribution of 4% in final energy consumption by 2050, but which will be an important decarbonisation vector in some sectors with few alternative technological options, such as heavy passenger and freight transport, a sector which will represent, in 2050, 40% to 68% of the demand for heavy transport.

This hydrogen will be produced mainly by alkaline electrolysis using renewable electricity, and by 2050, 5% to 8% of all electricity produced will be used for hydrogen generation.

With a more limited role, other renewable sources, such as solar heating and biomass, will also play an important role, for example, in heat generation.

Biomass is also emerging as one of the decarbonisation vectors. Overall, its consumption will grow until 2030/35, falling later to below current levels, with the emergence or increase of other more competitive energy vectors.

It is in the industrial sector that the consumption of biomass is most evident, replacing, among other sources, petroleum coke. Decentralised cogeneration and dedicated heat production plants near the collection sites will allow the most cost-effective use of the resource and also contribute to sustainable forest management.

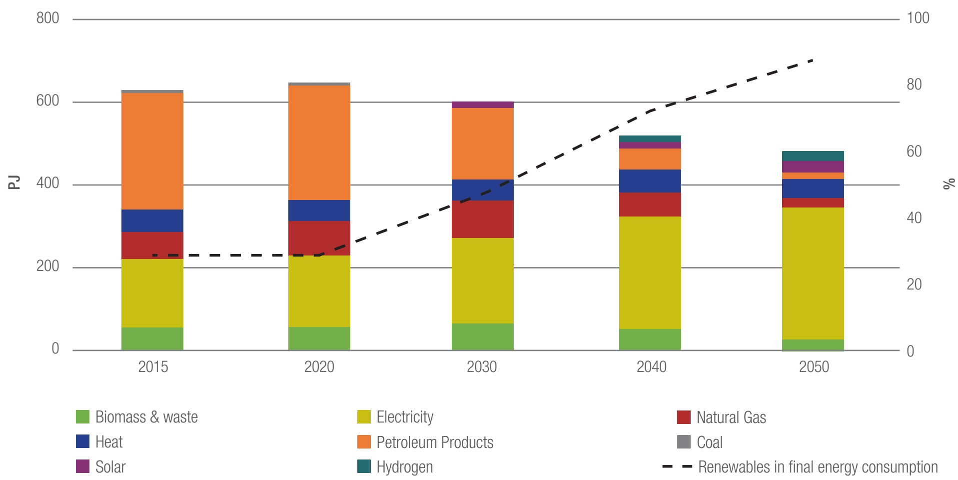


FIGURE 8

Evolution of final energy consumption, up to 2050

In 2050 there will be over 85% of renewable energy in final energy consumption.

TABLE 3: Evolution of final energy consumption, up to 2050

FINAL ENERGY	2015	2020	2030	2040	2050
	632,71	**660.69 I 651.06**	**597.63 I 601.98**	**506.92 I 519.15**	**459.8 I 477.63**
Biomass and waste	56.35	53.06	65.48 I 67.64	48.98 I 50.68	18.05 I 25.52
Electricity	165.09	173.59 I 173.41	193.41 I 199.35	264.74 I 269.7	307.58 I 316.72
Natural Gas	67.79	80.37 I 80.4	99.56 I 94.3	56.42 I 61.5	33.5 I 29.61
Heat	50.87	53.58	47.36 I 50.15	53.89 I 56.25	42.96 I 42.93
Petroleum Products	288.68	294.44 I 284.96	180.21 I 178.04	63.02 I 51.23	24.51 I 17.27
Coal	0.57	0.33	0.36 I 0.37	0.39 I 0.41	0.43 I 0.44
Solar	3.36	5.33	9.99 I 10.85	14.86 I 15.68	19.79 I 23.65
Hydrogen	0.00	0.00	1.25 I 1.29	4.61 I 13.71	12.99 I 21.49
Unit: PJ					
Renewables	28%	29%	46% I 47%	71% I 72%	86% I 88%

The increased efficiency of the energy system underlying this transformation will allow a reduction in primary energy consumption from -44% to -47% compared to 2015, and in final energy from -25% to -28% compared to 2015, despite economic growth and increased demand.

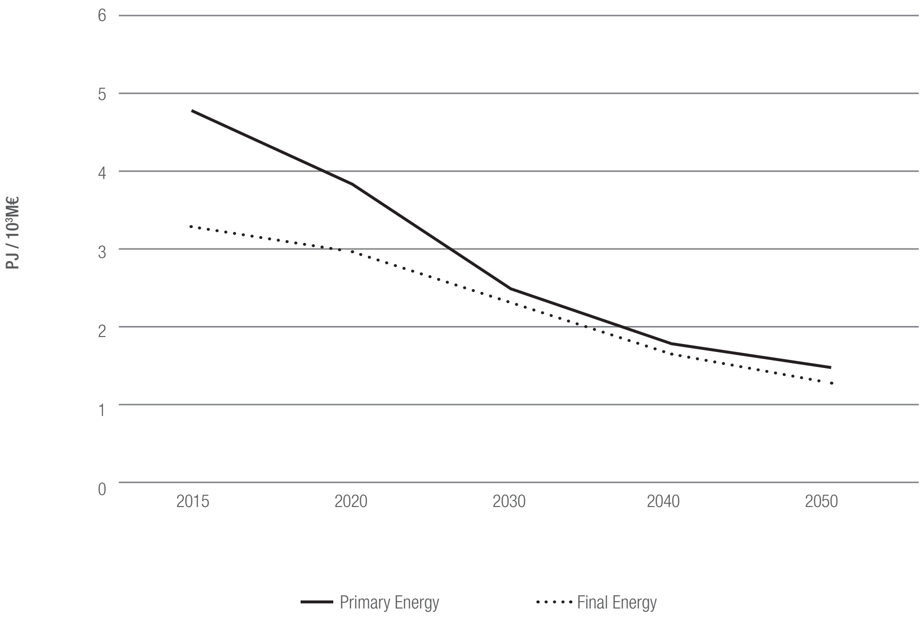


FIGURE 9

Evolution of the energy intensity of primary and final energy consumption, up to 2050

In 2050 the energy intensity of the economy falls by more than 50% compared to today.

TABLE 4: Evolution of the energy intensity of primary and final energy consumption, up to 2050

ENERGY INTENSITY	2015	2020	2030	2040	2050
Primary Energy	4.8	3,8	2.5	1.9 I 1.8	1.6 I 1.5
Final Energy	3,3	3.0	2.4 I 2.3	1.8 I 1.7	1.4 I 1.3

Unit: PJ/10³ M€

Main decarbonisation drivers in the energy sector:

- Renewable endogenous resources;
- Energy efficiency;
- Electrification;
- New energy vectors, e.g. hydrogen.

4.1.1 Power generation sector

The power generation sector is currently one of the leading national GHG emitters (around 29%) and as such shall be one of the major contributors to decarbonisation. Moreover, given the expected role of electrification in decarbonisation of the remaining sectors, emissions from power generation will also have a very significant indirect contribution to make to decarbonisation of the economy as a whole. These two contributions to a carbon neutral society point to the need to progressively discontinue the use of fossil fuels in power generation, in particular coal, and Portugal has already made a commitment to cease coal-based power generation by 2030.

Increasing demand caused by the growing electrification of various sectors of society will dictate the need for a substantial increase in renewable power production capacity by 2050.

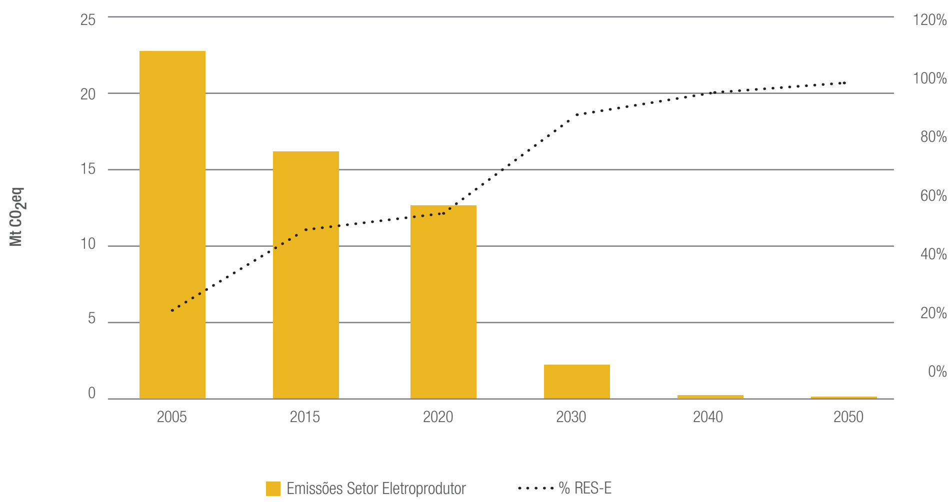


FIGURE 10

Evolution of emissions from the power generation sector and % of incorporation of Renewable Sources of Electricity (%RES-E)

Total decarbonisation of the power generation sector by 2050.

In 2050, 100% renewable sources in electricity generation.

TABLE 5: Potential evolution of emissions from the power generation sector and % of incorporation of Renewable Sources of Electricity (%RES-E)

	2005	2015	2020	2030	2040	2050	Δ 2050/2005
Power Generation Sector Emissions	23.04	16.01	12.94	1.18 | 2.2	0.36	0.17	-99%
Unit: MT C02eq.							
Renewables in Electricity Generation (RES-E)	28%	53%	59%	94% | 90%	97%	100%	
Unit: %							

This transition is facilitated by the reduction in the cost of renewable-based technologies for electricity generation that has been observed in recent years, especially in technologies associated with solar photovoltaics. In fact, it is this cost reduction, coupled also with an expected rapid fall in the cost of storage solutions, that will allow renewable energy to have a participation close to 100% in electricity production in 2050.

Photovoltaic solar technology will be most clearly established by increasing its importance and reaching 13 GW centralised and 13 GW decentralised by 2050. Onshore wind energy is also increasing its share significantly (almost 2.5x). These two technologies have a cost-effective potential to jointly supply 50% of the electricity generated in 2030 and 70% in 2050. However, these technologies, due to their daily and inter-annual variability, pose challenges in terms of dependability and security of supply that it is essential to be aware of and for which new solutions are emerging, be they technological in terms of battery storage and hydrogen production. or hybrid solutions, or in terms of network management, which should be endowed with greater intelligence and flexibility. Interconnections with the EU power grid and with other markets will also have an important role to play in the management and security of supply of the national power system.

Maintaining some natural gas capacity in the national power system until 2040, even if marginally used, ensures the necessary backup to bring about the transition to a renewable-based power system, allowing time for the development and installation of technological storage solutions.

In this context, batteries will become a cost-effective technology that is necessary for stability of the system as early as 2025 (187 MW), coupled with a renewable sun and wind capacity that will exceed 16 GW. However, it is from the 2030s onwards that the weight of this technology gains expression, reaching values between 0.6 and 1.0 GW in 2030 and growing by 4 GW up to 2050, accounting for between 7% and 8% of the total installed capacity in a 100% renewable system.

Along with batteries, mostly associated with decentralised solar energy, hydroelectric production using pumped water will also continue to play an important role in regulating the power system. The existing capacity together with the investments in progress means that in 2030 there will be 3.4 GW of pumped hydroelectric capacity.

Together, batteries and pumped hydroelectric, in 2050, will account for 7.5 GW, about 14% of total installed capacity, offering storage and facilitating efficient management of the electric supply/demand equilibrium.

Electrification of the economy will require an expansion of the transmission and distribution network which should be linked to efficient consumption management (e.g. in industry) and allow the creation of new business models and solutions that contribute to the flexibility of the system.

New regulatory models will allow new players to enter the electricity market, such as energy production cooperatives and energy communities. The increase in installed capacity of decentralised solar to 2.3 GW by 2030 and 12 to 13 GW by 2050 demonstrates the cost-effectiveness of decentralisation in solar electricity generation, allowing one to envisage the important role of producers/ consumers in the future. Families and other small producers may account for more than 20% of total electricity production. Of course, this vision requires the development of smart distribution networks and new locally based business models.

Decentralisation of electricity generation combined with its increased efficiency will contribute to a reduction in grid losses, reaching around 5% by 2050, compared to the current 9%. This fall in grid losses attenuates the increasing consumption of hydroelectric pumping and battery storage.

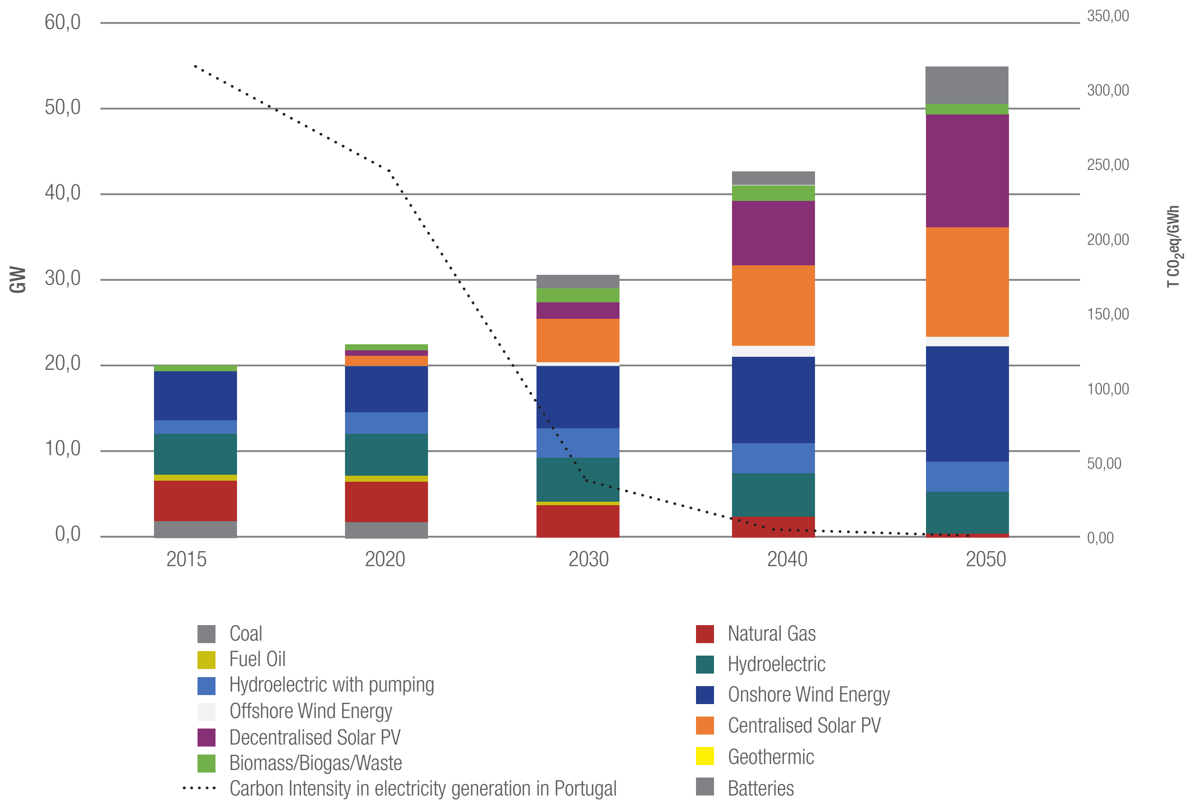


FIGURE 11

Evolution of installed capacity of the power generation sector (including cogeneration) and the carbon intensity of electricity generation

The carbon intensity of the electricity produced in Portugal goes from the current 315 $tCO_2eq./GWh$ (in a dry year) to about 1.6 $tCO_2eq./GWh$ in 2050.

TABLE 6: Evolution of the installed capacity of the power generation sector (including cogeneration) and carbon intensity of electricity production

INSTALLED CAPACITY	2015	2020	2030	2040	2050
	19.9	**22.5**	**29.3 I 30.3**	**42 I 42.4**	**53.2 I 54.5**
Coal	1.8	1.8	0.0	0.0	0.0
Natural Gas	4.8	4.9	3.5 I 4	2.3 I 2.4	0.2
Fuel Oil	0.8	0.7	0.2	0.1	0.0
Hydroelectric	4.6	4.6	5.1	5.1	5.1
Hydroelectric with pumping	1.6	2.5	3.4	3.4	3.4
Onshore Wind Power	5.0	5.2	8 I 7	10	12 I 13
Offshore Wind Power	0.0	0.0	0.3 I 0.4	0.3 I 1.2	0.2 I 1.3
Centralised Solar PV	0.3	1.4	4.6 I 5	9.9 I 9.3	14.4 I 13
Decentralised Solar PV	0.2	0,5	2.3	7.1 I 7.6	12 I 13
Geothermal	0.0	0.1	0.1	0.1	0.0
Biomass/Biogas/Waste	0.8	0.9	1.4 I 1.6	1.4	1.8 I 1.4
Batteries	0.0	0.0	0.6 I 1.2	2.3 I 1.3	4.1 I 4
Hydrogen	0.00	0.00	1.25 I 1.29	4.61 I 13.71	12.99 I 21.49
Unit: GW					
CARBON INTENSITY OF ELECTRICITY PRODUCED IN PORTUGAL	315	245	20.47 I 36.75	4.46 I 4.28	1.69 I 1.6
Unit: t C02eq./GWh					

NOTE: As explained earlier, the results presented reflect the modelling response, taking into account the assumptions made, and serve as a basis for informing policy options, notably in the context of PNEC 2030, so there may be differences between the modelling results and the policy options to be pursued.

Main decarbonisation drivers in the power generation sector:

- Evolution to a production base that uses solar (centralised and decentralised), wind (onshore and offshore) and hydroelectric (with and without pumping);
- End of electricity production based on coal by 2030 and, in a second phase, end of electricity production based on natural gas after 2040;
- New storage solutions (batteries and hydrogen);
- Greater network intelligence and flexibility.

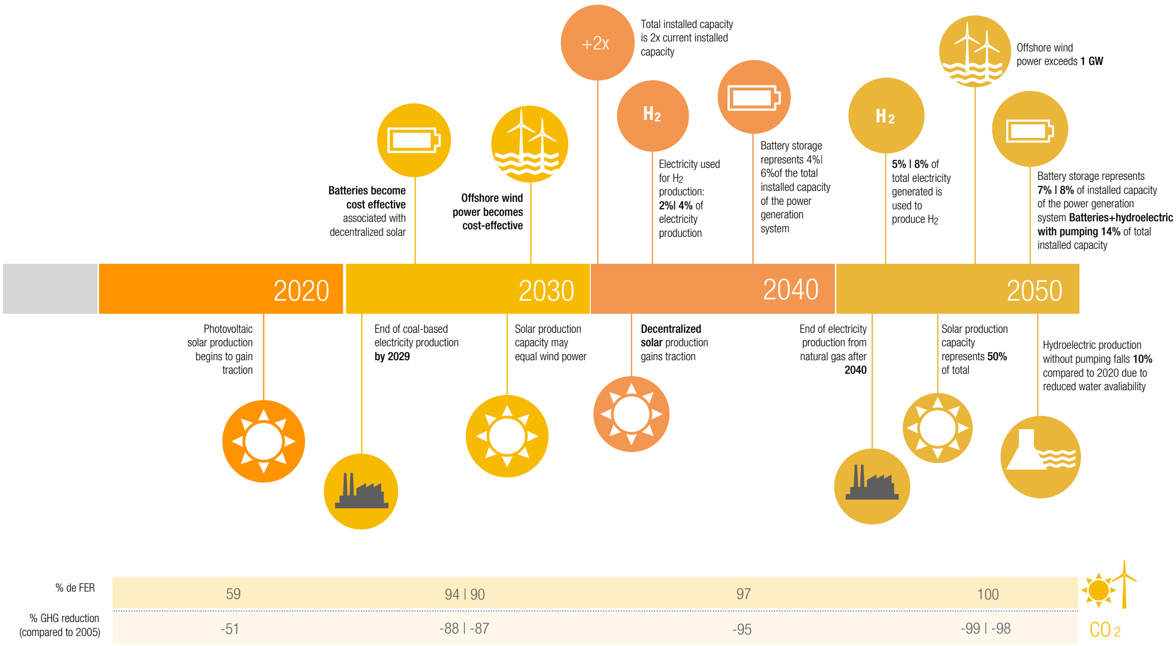


FIGURE 12

Narrative of carbon neutrality by 2050 of the power generation sector

4.1.2 Mobility and transport

The transport sector is, together with the power generation system, one of the main national emitters (representing about 25% of emissions) and is the sector with the highest growth in emissions in recent decades. This sector includes road, rail and maritime transport and aviation (only its national components) and can be divided into passenger and freight transport.

The road subsector accounts for 96% of transport emissions, with national rail, aviation and shipping accounting for only 4% of emissions. Car use accounts for 60% of emissions in relation to the total for road transport.

This is also the sector with the highest energy intensity and the largest indirect contribution to primary energy imports and associated energy dependence. These transport modes have quite low usage efficiency rates, with values of about 1.2 passengers per private vehicle and average public transport occupancy between 17% and 24% (percentages below the European average), leaving room for significant efficiency gains.

Thus, this is a sector in which it is urgent to reverse the growing trend in emissions, moving towards almost total decarbonisation by 2050.

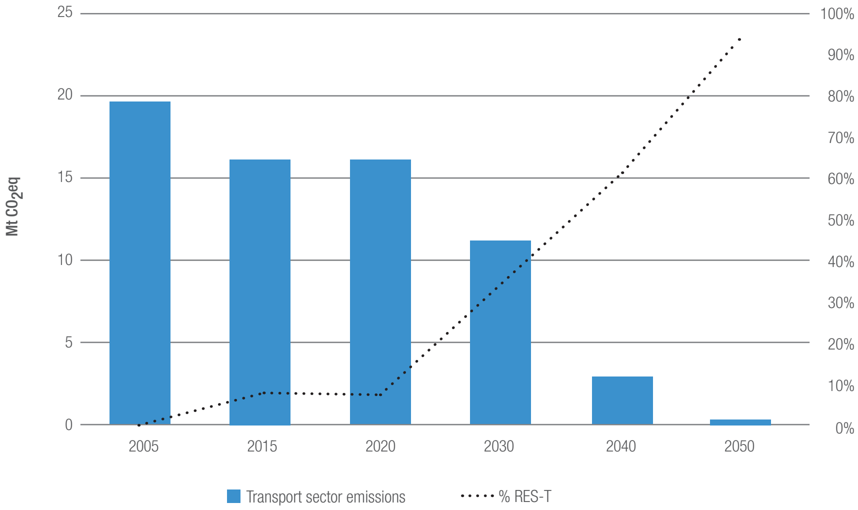


FIGURE 13

Evolution of transport sector emissions and percentage of incorporation of renewables in transport (%RES-T)

Incorporation of renewables in the transport sector of over 35% in 2030, 60% in 2040 and 90% in 2050.

TABLE 7: Evolution of transport sector emissions and percentage of incorporation of renewables in transport (%RES-T)

	2005	2015	2020	2030	2040	2050	Δ 2050/2005
Transport Sector Emissions	19.59	16.19	16.27	10.61 I 11.18	3.19 I 2.91	0.47 I 0.42	-98%
Unit: MT CO_2eq.							
Renewables in Transport	0%	7%	8%	36% I 34%	58% I 61%	96% I 94%	
Unit: % (no multipliers from 2030)							

In this sector, the availability of technology solutions with better environmental performance and the offer of shared solutions with significant efficiency gains make it possible to substantially reduce emissions in a cost-effective way, even in the context of increasing demand.

The growing adherence expected for the use of low-impact and active modes in urban centres, together with proactive land use planning that allows for greater discussion and use of the public transport system, will form the basis of a veritable revolution in this sector, and these vectors are essential for its decarbonisation. In 2050, between 8% and 14% of short-distance mobility is expected to be made using low-impact modes.

It is therefore essential to reinforce the supply of public transport systems, and to expand the networks (metro and rail) and their multimodal integration. All these changes will be part of a very diverse and decarbonised transport ecosystem, in which complementarity and modal articulation, coupled with even greater digitisation, will lead to progressively greater gains in efficiency.

Electrification, based on renewable sources, throughout all end-consumer sectors will soon allow a relatively rapid transition from the current internal combustion engine vehicles to electric vehicles, with electricity reaching around 70% of total transport energy consumption by 2050.

In a transitional phase, hybrid vehicles will play an important role in decarbonisation, mainly in individual transport, and advanced biofuels, especially in heavy long-distance intercity transport of passengers and freight by road, where the distances travelled are longer. However, as time goes by, biofuels may become irrelevant in the road sector, given the greater competitiveness and cost-effectiveness of electric traction and other energy vectors such as hydrogen, while maintaining some of their importance in sectors such as aviation.

In light passenger transport, diesel will no longer be cost-effective by 2030 and petrol by 2040, in both cases being replaced by electric vehicles. Electricity will satisfy more than 30% of the mobility demand in 2030, with a potential to reach 100% by 2050.

As a complement to the use of electric vehicles, forms of shared and/or autonomous mobility will enable huge efficiency gains, with higher utilisation rates for each vehicle (more passengers per trip and more trips per day). This type of model will ensure half of mobility demand by 2050, which will allow accelerated decarbonisation of the sector.

In the case of heavy vehicles, the possibility of introducing new fuels such as hydrogen (H_2) or new dynamic propulsion technologies (e.g. overhead contact lines or induction systems) is expected. However, implementation of these solutions will depend on the development of core infrastructures, and their investment and operating costs are still subject to a high degree of uncertainty, given the small number of pilot projects underway.

These two energy vectors will account for almost all heavy passenger and freight mobility by 2050.

For the shipping sector, the main solutions include energy efficiency measures, and also the use of LNG and biofuels for medium and long distances. Electrification, through the introduction of hybrid and electric propulsion systems, is mainly dedicated to inland waterway short-distance passenger transport. Also noteworthy is the electrification of quay equipment and the provision of an “Onshore power supply” for vessels. It is also worth mentioning the implementation of Portugal’s promotion strategy as an LNG hub region for the freight and tourism shipping segments (cruise ships), with international and national impact on decarbonisation, in particular on maritime connections between the mainland and the archipelagos of Madeira and the Azores.

Nationwide aviation should also become substantially electrified by 2050, as electric aeroplanes are expected to be a cost-effective solution for distances of up to 1500 km. For greater distances (e.g. transport from the mainland to the Autonomous Regions of Madeira and the Azores), the use of hybrid aircraft is expected, which may use biokerosene for takeoff and landing.

These technological changes in mobility give rise to very significant efficiency improvements with an impact on final energy consumption, generating by 2050 a reduction in the energy intensity of passenger and freight transport of -81% and -84% respectively (energy consumed per passenger transported - pkm) and -73% to -75% (energy consumed per tonne of goods transported - tkm).

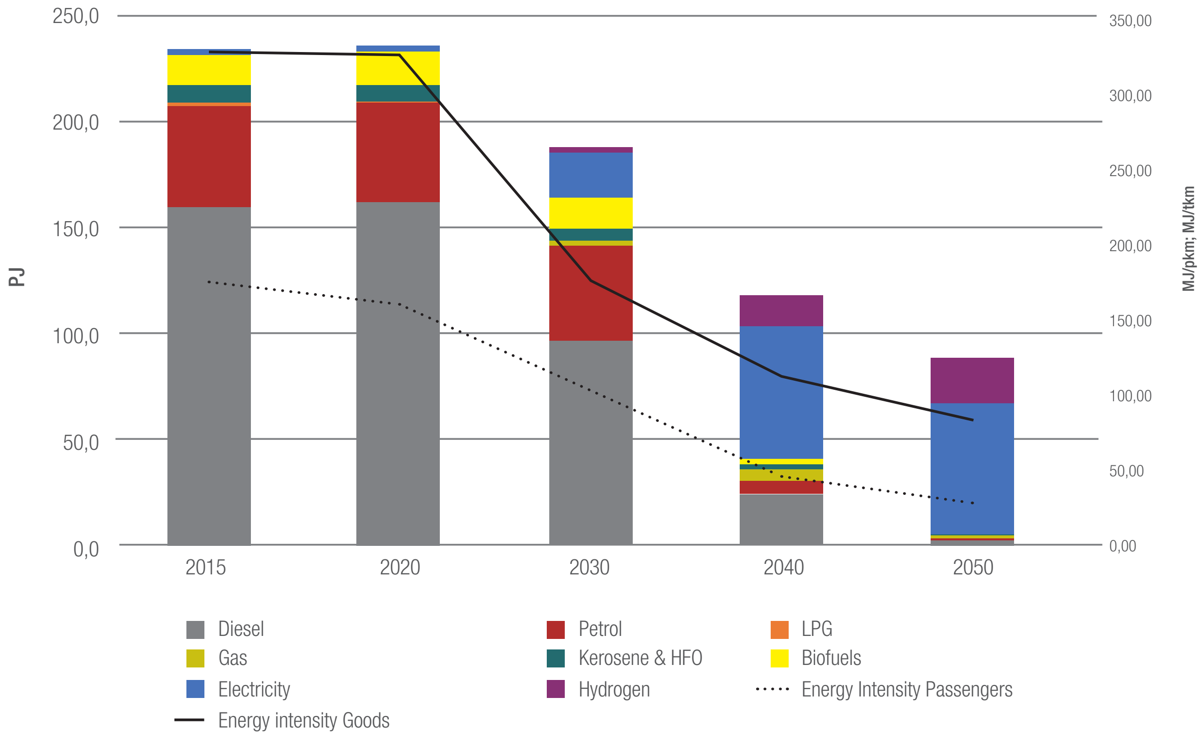


FIGURE 14

Evolution of final energy consumption and energy intensity in the transport sector

Reduction in the energy intensity of passenger and freight transport, respectively, from -81% to -84% and -73% to -75% by 2050.

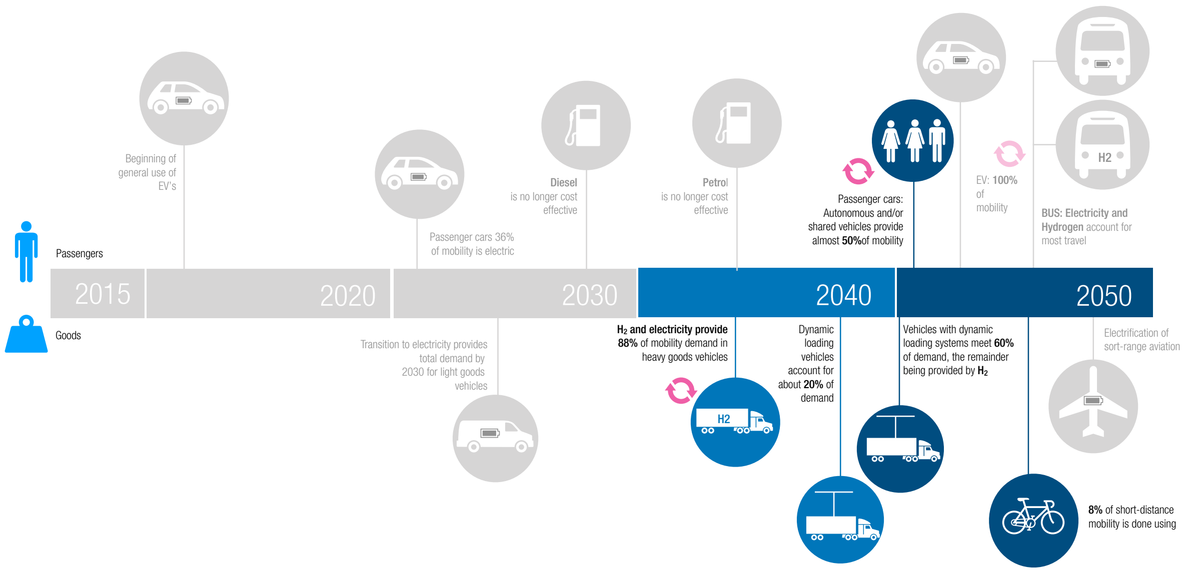
TABLE 8: Evolution of final energy consumption and energy intensity in the transport sector

FUEL	2015	2020	2030	2040	2050
	233.51	**235.95**	**179.67 I 187.15**	**113.57 I 117.44**	**85.63 I 89.14**
Diesel	161.07	161.98	92.36 I 96.68	30.11 I 25.34	1.41 I 3.73
Petrol	47.58	48.44	43.4 I 46.37	6.79 I 8.57	0.00
LPG	1.65	0.01	0.00	0.00	0.00
Gas	0.55	0.60	1.07 I 1.71	2.66 I 2.73	3.21 I 0.97
Kerosene & HFO	7.21	6.52	5.77 I 5.78	3.25 I 2.49	2.41 I 1.14
Biofuels	14.37	15.81	14.24 I 13.77	6.16 I 3.73	0.29 I 0.44
Electricity	1.08	2.59	21.58 I 21.57	59.98 I 60.86	65.33 I 61.36
Hydrogen	0.00	0.00	1.25 I 1.29	4.61 I 13.71	12.99 I 21.49
Unit: PJ					
ENERGY INTENSITY					
Passengers	1.73	1.57	1.04 I 1	0.51 I 0.48	0.32 I 0.28
Goods	3.27	3.21	1.81 I 1.78	1.26 I 1.12	0.88 I 0.81
Unit: MJ/pKm					

The circular economy is key to decarbonisation of the transport and mobility sector, as the success of shared mobility models is essential to leveraging the technological changes foreseen for mobility (e.g. autonomous vehicles) and can lead to emissions reductions of up to 25 % in 2050. The most significant impact of circularity refers to the significant increase in the use of public transport, which leads to a reduction in total transport energy consumption of between 3% and 2% in 2030 and 2050, respectively.

Main decarbonisation drivers in the transport sector:

- Greater efficiency and reinforcement of public transport systems;
- Active and low-impact mobility;
- Greater efficiency, associated to shared mobility and autonomous vehicles;
- Electrification;
- Biofuels and hydrogen.



% of electrification	1	12	52	69
Power consumption (PJ)	236	187	117	89
% GHG reduction (compared to 2005)	-17	-43	-85	-98
% de FER (excludes national and international shipping and aviation)	-	34	61	94

FIGURE 15

Narrative of carbon neutrality of the transport sector up to 2050

4.1.3 Industry and industrial processes

The industrial sector is made up of a wide range of activities and processes, including sectors such as refining, pulp and paper production, glass, ceramics, cement and lime, iron and steel, chemicals, among others. Their emissions derive from the consumption of fossil fuels and, in some sectors, emissions from the chemical processes involved. Industrial emissions in 2015 accounted for about 19% of national emissions, of which 62% are associated with the burning of fossil fuels and 38% associated with process emissions. This is a particularly regulated sector as it is covered by the European Emissions Trading Scheme (ETS), the sector's main decarbonisation instrument, which applies to 74% of the industry's emissions.

The evolution of the different industrial sectors is influenced by various market trends and dynamics that may lead to an adjustment of production logics and consequently influence the associated emissions. Changes in consumption patterns or factors such as the buoyancy of the construction sector, reduced use of plastics in packaging, increased recycling rates or substitution of fuels in transport, among other factors, can impact the value chain and lead to readjustment of the industry, which is a challenge for this sector.

Industry will be one of the sectors with the greatest challenges for decarbonisation, given the still limited range of technological options that allow emissions to be reduced, particularly emissions from industrial processes.

Despite these aspects, the domestic industry will also undergo profound transformations, reducing its emissions by about 70% (compared to 2005).

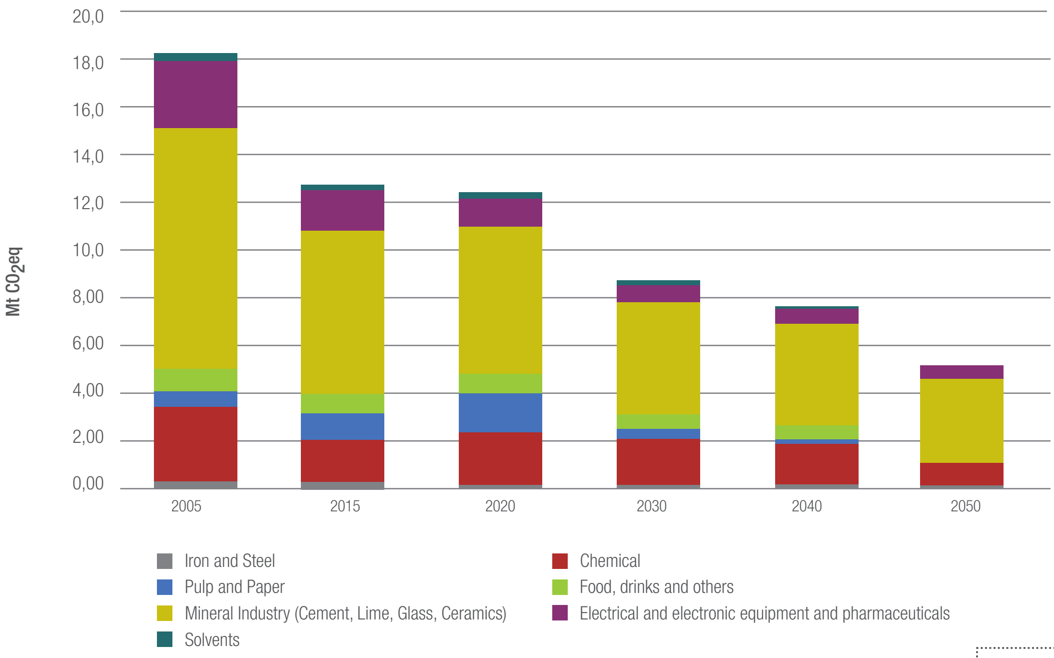


FIGURE 16

Evolution of industrial sector emissions

Industry emissions reduced by -72% to -73% by 2050.

TABLE 9: Evolution of industrial sector emissions

INDUSTRY	2005	2015	2020	2030	2040	2050	Δ 2050/2005
	18.34	**12.74**	**12.46**	**9.48 I 8.72**	**7.34 I 7.6**	**4.99 I 5.11**	**-72% I -73%**
Iron and Steel	0.23	0.25	0.19	0.21 I 0.22	0.23 I 0.26	0.25 I 0.26	14% I 10%
Chemical	3.25	1,76	2.13	1.9 I 1.83	1.75 I 1.54	1 I 0.74	-77% I -69%
Pulp and Paper	0.66	1.17	1.75	0.72 I 0.43	0.2 I 0.18	0.09 I 0.09	-85%
Food, drinks and others	0.91	0.81	0.74	0.75 I 0.68	0.54 I 0.61	0.01 I 0.01	-99%
Mineral Industry (Cement, Lime, Glass, Ceramics)	10.18	6.83	6.24	4.97 I 4.7	4.22 I 4.25	3.21 I 3.53	-65% I -68%
Electrical and electronic equipment and pharmaceuticals	2.87	1.73	1.23	0.8 I 0.75	0.33 I 0.61	0.38 I 0.45	-84% I -87%
Solvents	0.23	0.19	0.20	0.12 I 0.11	0.08 I 0.05	0.05 I 0.03	-89% I -79%

Unit: Mt C02eq.

With a power generation system strongly based on renewable energy, prospects for strengthening the use of electricity are also opened for industry. This potential exists in the electrification of some processes and industries, particularly in the less energy-intensive ones, and in the use of biomass and waste (which will increase 3.5x compared to current values), replacing the use of petroleum products from 2030 onwards.

Natural gas emerges as a transitional fuel, increasing its share by 2030 and falling thereafter, as some processes are electrified.

Along with electrification, high temperature heat from renewable cogeneration and solar heating for low/medium temperature heat needs are the main decarbonisation vectors.

Options such as electric ovens, increased robotisation and the transformation of some sectors into a more digital 4.0 industry drive electricity consumption 2x higher than current consumption in the sector and also contribute to decarbonisation in line with carbon neutrality by 2050.

Carbon capture and storage is an important option in decarbonisation of the energy system. In Portugal, this technological option could only have technical and economic viability in the cement sector, however. But the evolution of national cement production may not be large enough to justify the creation of a CO_2 transport and subsequent storage network, from an economic point of view.

In the same vein, and with current knowledge, the bioenergy options with carbon capture and storage are not seen to be cost-effective in light of current knowledge. However, acknowledging that these are also priority areas for fostering research and innovation at a European level, this scenario could change, and therefore the development of these technologies should be monitored.

Carbon capture and use for production of e-fuels was considered but is not seen to be cost-effective over this time horizon, and this technology would always have associated emissions.

Thus, there is a great need for innovation and the creation of new business models in the industry. Reinforcing the perspectives of the circular economy and resource efficiency assumes a determinant character in the path to be followed to identify and create innovative, efficient and green solutions, with emission close to zero.

The focus on industrial symbioses and the reuse of resources with greater incorporation of secondary materials and increased recyclability of the products produced may bring gains on a medium and long-term time horizon.

All these factors allow, in addition to decarbonisation, very significant gains in energy efficiency in the industry, resulting in a reduction in energy intensity of the sector from -52% to -64% in 2050, compared to 2015 (industries of coke manufacturing and petroleum products and electricity and gas production not included).

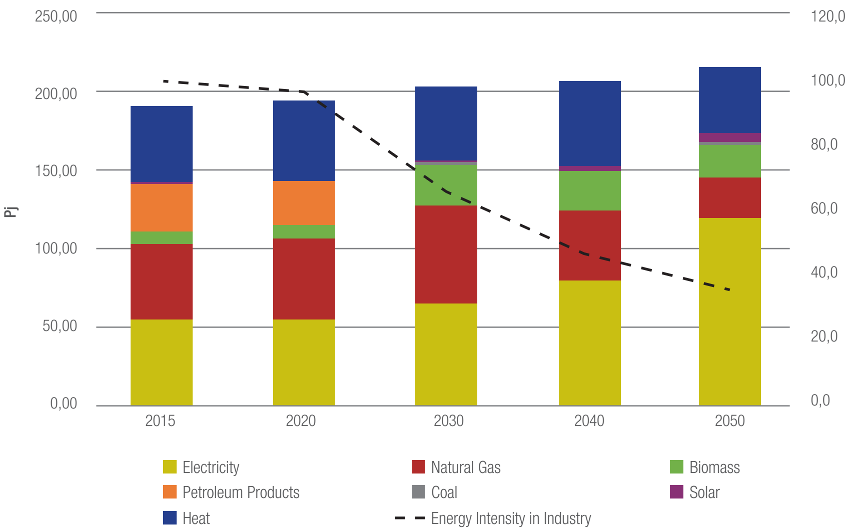


FIGURE 17

Evolution of final energy consumption and energy intensity in industry by 2050

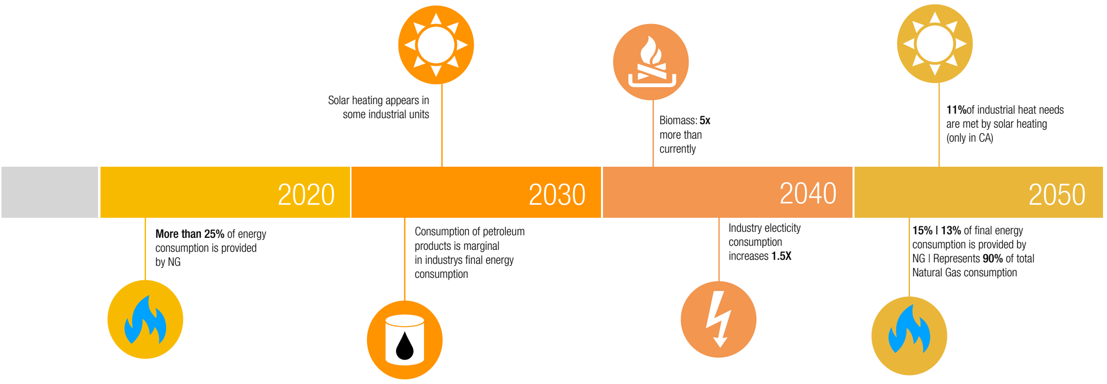
Reduction of energy intensity in industry by -52% to -64% by 2050.

TABLE 10: Evolution of final energy consumption and energy intensity in industry

FINAL ENERGY CONSUMPTION INDUSTRY	2015	2020	2030	2040	2050
	233.51	**235.95**	**179.67 I 187.15**	**113.57 I 117.44**	**85.63 I 89.14**
Electricity	56.31	55.52	59.28 I 65.32	77.04 I 80.32	104.69 I 119.51
Natural Gas	46.61	50.40	67.71 I 62.49	39.66 I 45.18	28.84 I 26.92
Biomass	8.60	9.60	24.77 I 26.01	23.38 I 24.37	16.06 I 21.04
Petroleum Products	30.67	27.81	0.32	0.21 I 0.23	0.20
Coal	0.57	0.33	0.36 I 0.37	0.39 I 0.41	0.43 I 0.44
Solar	0.00	0.00	0.52 I 1.39	1.23 I 2.15	1.28 I 5.94
Heat	48.48	51.55	45.16 I 48	51.92 I 54.41	42.05
Unit: PJ					
ENERGY INTENSITY					
Industry	100.00	96.27	75.47 I 65.78	59.43 I 47.17	47.76 I 35.53
Unit: (2015=100)					

Main decarbonisation drivers in the industrial sector:

- Energy and resource efficiency;
- Electrification;
- Solar heating and biomass;
- Innovation and new business models (e.g. bio-refineries);
- Industrial symbioses and resource reuse.



% of electrification	28	30 I 32	40 I 39	54 I 55
Energy Consumption (PJ)	195	198 I 204	194 I 207	194 I 216
% CHC reduction (compared to 2005)	-32	-48 I -52	-60 I -59	-73 I -72

FIGURE 18

Narrative of carbon neutrality of the industrial sector by 2050

4.1.3.1 Refining and petrochemical industry

As a consequence mainly of the change in the mobility paradigm, the refining sector is expected to evolve into other forms of production and product diversification, such as hydrogen production in the post-2030 period and, potentially, reconversion to bio-refineries, witnessing a significant change in the current production system with a reduction of -64% and -66% of the crude oil processed in 2040 and -87% and -88% in 2050, depending on the scenario analysed.

The development of e-fuels is currently not seen to be cost effective, limited by the process costs and costs associated with CO_2 capture, compared to other energy system mitigation options. As mentioned above, this technology will always be associated with CO_2 emissions.

4.1.3.2 Glass

According to the scenarios studied, the increased use of glass as a substitute for plastic packaging (notably PET) contributes to the sector's increased production, albeit moderately due to relatively low plastic/glass substitutability. However, the circular economy coupled with optimised packaging collection and design processes makes it possible to achieve very high levels of incorporation of glass containers in the manufacturing process - between 65% and 75% in 2050 (vs. 50% today). An increase in energy efficiency and the emergence of electric ovens are expected by 2040 in some units that will allow the sector to reduce energy intensity: between -24% and -29% in 2050 compared to 2015.

4.1.3.3 Ceramics

The structural ceramics subsector (tiles, bricks, floors) faces, in the scenarios analysed, some competition from the greater introduction of other materials in the construction sector (e.g. wood, cork) associated with a paradigm shift in construction, which has already begun to favour materials that are carbon reservoirs. Also, the reuse of ceramic products will contribute to changes in this activity. Decarbonisation of the sector is essentially affected by slightly increasing electrification and the use of biomass.

4.1.3.4 Chemical products

The transformation and modernisation of the sector is expected to include the manufacture of synthetic/artificial and bioplastic fibres and greater use of secondary raw material. Decarbonisation of this subsector is mainly based on very significant electrification associated with its modernisation, with this vector representing almost 90% of final energy consumption in 2050, compared with 45% today.

4.1.3.5 Iron and steel

The scenarios analysed point to an increase in iron/steel production due to the high openness of the sector to foreign competition and its incorporation in growing industries, such as that of renewable energy. In addition, a larger circular economy will allow the sector to have more effective and efficient access to raw materials. The current electrification of the sector does not anticipate important energy transformations, despite a continued focus on energy efficiency.

4.1.3.6 Cement

The sector may be the subject of some competition due to the substitution of cement with alternative construction materials, associated with changes in the construction sector, which also involves a significant increase of productivity in the use of materials.

Decarbonisation of the sector occurs mainly due to reduced incorporation of clinker in cement production (gradual reduction to a maximum of -10% by 2050 compared to current levels) and the incorporation of alternative fuels such as those derived from waste, vegetable waste and others. In addition, recovery of part of the residual process heat will enable the industry to increase its energy efficiency.

New technologies such as the emergence of Oxyfuel furnaces with CO_2 capture may be an alternative in the future, although their viability has not yet been seen to be cost-effective today.

4.1.3.7 Pulp and paper

There may be a change in the productive structure of the sector with a reduction in the production of printing paper, as a result of digitisation, and an increase in the production of tissue and packaging paper, in the latter case as a result of the replacement of plastic packaging and an increase in digital commerce.

The circular economy contributes to an optimised paper collection process and increased pulp production from secondary fibre (between 50% and 70% by 2050). The sector continues its path towards decarbonisation with heat consumption deriving from black liquors and electrification of some processes, which leads to a reduction in energy intensity of -23% to -28% by 2050 compared to 2005.

The sector is also expected to diversify its production, e.g. through a focus on bio-refineries, although at present the cost of technologies such as the Fischer-Tropsch process does not yet make them cost effective.

4.1.3.8 Other industries

There is an increase in the industry associated with the manufacture of computer, communication, electronics and optical equipment; pharmaceutical products; electrical equipment and other industries with high technological potential. The increasing use of robots contributes such that 70% of the demand for energy services in the sector is associated with machinery, compared to the 32% estimated today. Decarbonisation is due to increased electrification, which replaces petroleum products, and the use of solar heating for low and medium temperature heat generation.

4.1.4 Buildings - residential and services

Buildings are currently responsible for 5% of national GHG emissions. Buildings, which include the residential and service sectors, are major energy consumers, currently accounting for about 30% of final energy consumption, and are one of the most important sources of CO_2 emissions. In buildings, energy is consumed for the provision of energy services such as space heating and cooling, lighting, refrigeration and cooking, sanitary water heating, among others.

Despite the expected increase in demand for cooling services, due to rising average temperatures, and for other electrical uses associated with servers, clouds, etc., these sectors still show high potential for reducing emissions, which will already start to be felt over the next two decades.

Thus, emissions reductions are estimated for 2050 in the residential sector at -97% and -96% and 100% in the services sector (compared to 2005), with the incorporation of renewable energy in heating and cooling to be 66% and 68%.

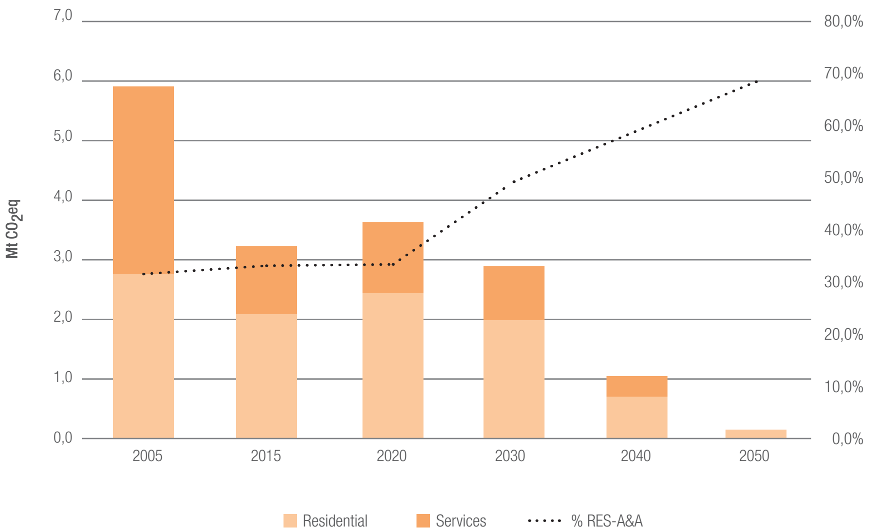


FIGURE 19

Evolution of emissions from the residential and services sectors and percentage of incorporation of renewable energies in heating and cooling (%RES-A&A)

Total decarbonisation of the residential and service sectors by 2050.

TABLE 11: Evolution of emissions from residential and services sectors and percentage of incorporation of renewable energies in heating and cooling (%RES-A&A)

BUILDINGS	2005	2015	2020	2030	2040	2050	Δ 2050/2005
	5.89 I 71.44	**3.22 I 52.94**	**3.6 I 49.73**	**3.07 I 28.15**	**1.05 I 14.15**	**0.09 I 7.11**	**-98% I -90%**
Residential	2.72	2.08	2.43	2 I 2.01	0.73 I 0.71	0.09 I 0.11	-97% I -96%
Services	3.17	1.14	1.18	1.07 I 0.89	0.32 I 0.3	0.00	-100%
Unit: Mt C02eq							
Renewables in Heating and Cooling (%RES-A&A)	32%	34%	34%	41% I 49%	60% I 58%	66% I 68%	

In the residential and service sector, an increase is expected in residential thermal comfort, both in heating and cooling (by 2050, thermal comfort will triple in heating and double in cooling compared to the current situation). This increase in comfort comes from the continued trend of electrification in the sector (electricity is already the main energy vector today), the use of more efficient equipment (e.g. heat pumps), the increased use of insulation materials and higher rates of urban rehabilitation (e.g. replacement of windows). Insulation measures are estimated to reduce heating energy consumption by 26% by 2040 and around 50% by 2050 in the residential sector, so this increase in comfort does not result in a direct increase in final energy consumption.

A continued focus on urban rehabilitation will provide the opportunity for the incorporation of improvements in energy and water efficiency, the incorporation of low carbon materials and renewable energy sources, contributing to the fight against energy poverty.

A sharing economy contributes to a lower possession rate of some equipment - relocation of the demand to services (e.g. laundry, kitchen). On the other hand, increased working from home involves increased use of air conditioning, lighting and other equipment - relocation of demand to the residence.

In 2050 there is also the possibility of a decrease in energy consumption per m^2 in residential buildings from -7% to -20% compared to today, explained by the adoption of high-performance electrical equipment such as LEDs for lighting and equipment of higher energetic efficiency classes.

Natural gas remains an option in housing in the time horizon until 2040, virtually disappearing over the following decade. Biomass usage options follow the same trend, although their importance is different in urban and rural areas (more decentralised).

Particularly in the services sector, there is a prospect of extensive electrification accompanied by solar heating for water heating and the predominance of heat pumps for heating spaces, these being the most cost-effective options for decarbonising buildings

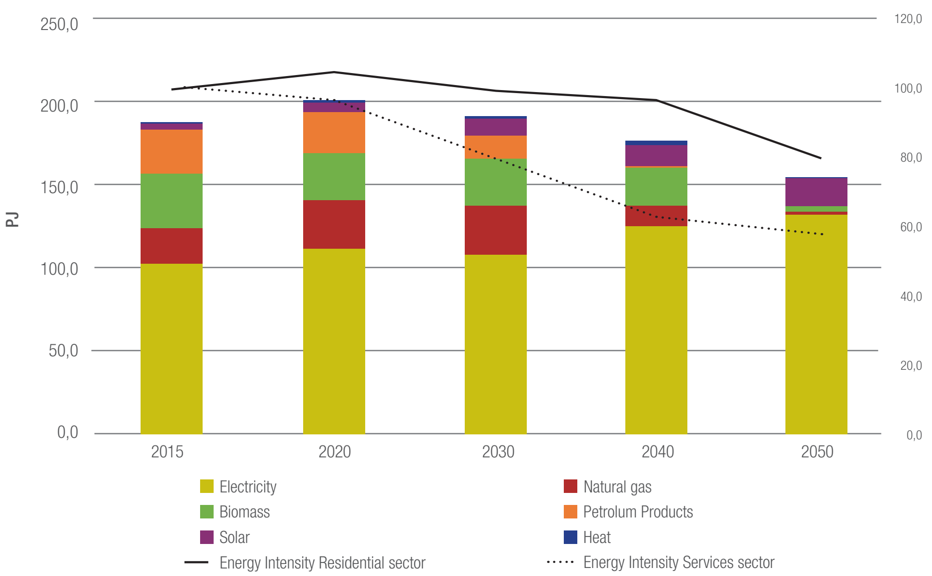


FIGURE 20

Evolution of final energy consumption and energy intensity in buildings (residential and services)

Reduction of energy intensity of residential and service buildings respectively from -7% to -20% and from -42% to -43% by 2050.

TABLE 12: Evolution of final energy consumption and energy intensity in buildings (residential and services)

FINAL ENERGY CONSUMPTION	2015	2020	2030	2040	2050
	188.46	**201.64**	**194.55 I 192.97**	**176.67 I 177.64**	**156.57 I 156.34**
Electricity	104.62	112.55	109.58 I 109.52	124.83 I 125.56	134.69 I 132.99
Natural Gas	20.45	29.24	30.65 I 29.87	13.97 I 13.28	1.33 I 1.31
Biomass	33.27	28.79	28.02 I 28.29	21.76 I 23	1.7 I 4.03
Petroleum Products	25.60	24.29	15.23 I 14.27	1.08 I 1.01	0.00
Solar	3.36	5.33	9.46	13.63 I 13.53	18.51 I 17.71
Heat	1.16	1.44	1.61 I 1.56	1.39 I 1.26	0.34 I 0.3
Heat	48.48	51.55	45.16 I 48	51.92 I 54.41	42.05
Unit: PJ					
ENERGY INTENSITY					
Residential	100.00	105.36	108.69 I 101.34	105.88 I 96.76	93.29 I 80.05
Services	100.00	96.19	83.1 I 80.74	66.46 I 64.66	57.74 I 56.72
Unit: (2015=100)					

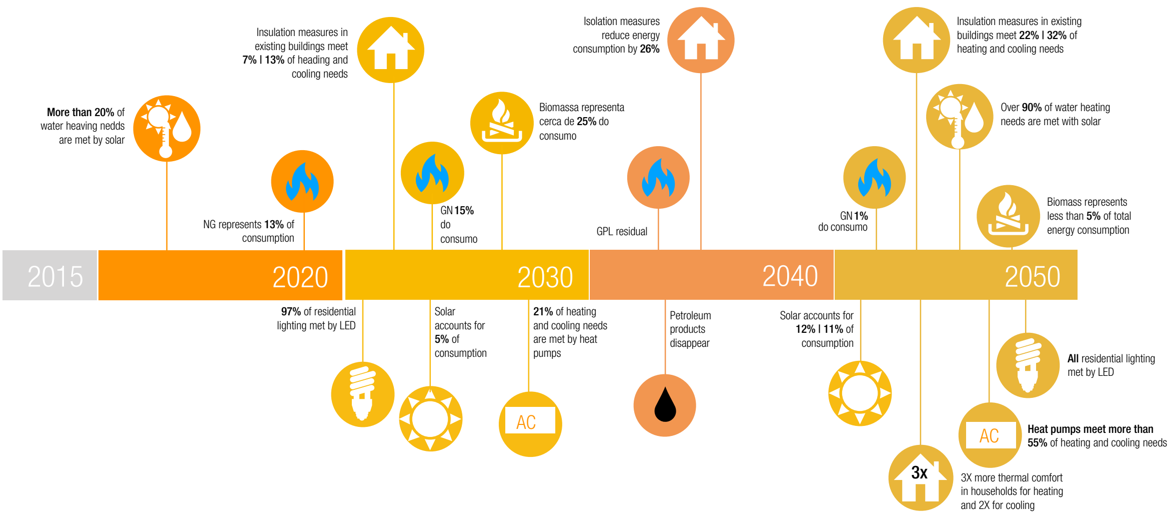
The perspective of net zero energy buildings and Positive Energy Districts (PED) are aspects that will mark the future of buildings. A range of opportunities can be anticipated around these concepts, not only of an energy and digital technology base, but of new business models, integrated into the broader concept of smart cities.

Another factor to consider in buildings is the adoption of nature-based solutions that can partially coat the envelope of buildings, and that can contribute to alter the building's energy balance. Also, urban farming, whether on the rooftops or in the basements of buildings using hydroponic and aeroponic systems, seems to be a trend in cities with a positive impact on their energy performance.

Increasingly, building management models focus not only on the building itself, but on the local system in which it is situated, with a positive impact, whether through the possibility of own production, or shared consumption and locally based business models, integrating energy and other resources, such as water and food production. These aspects are important for shaping the future of residential and service buildings, especially in cities.

Main decarbonisation drivers in the residential and service sectors:

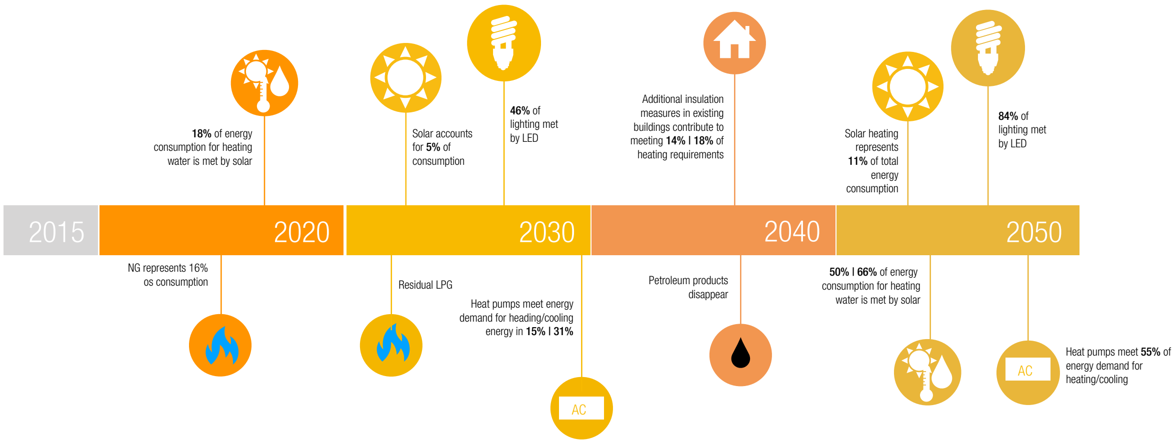
- Energy efficiency;
- Electrification;
- Insulation and rehabilitation;
- Solar heating and heat pumps



% of electrification	41	44	62 I 63	84 I 83	
Energy Consumption (PJ)	113	109 I 110	103 I 106	86 I 89	
% Redução de GEE (face 2005)	-11	-27 I -26	-73 I -74	-97 I -96	CO_2

FIGURE 21

Narrative of carbon neutrality of the residential sector until 2050



% of electrification	75	73 I 74	82	88
Energy Consumption (PJ)	89	86 I 83	74 I 71	70 I 67
% CHC reduction (compared to 2005)	-63	-66 I -72	-90 I -91	-100

CO_2

FIGURE 22

Narrative of carbon neutrality of the services sector until 2050

FLUORINATED GASES

Since 2005, emissions of fluorinated gases have increased significantly, implying an increase in their importance in the calculation of total GHG emissions in Portugal, from just 1.4% in 2005 to about 4% in 2015.

Emissions of these gases result mainly from their use in refrigeration or air conditioning equipment, fire protection systems, truck and trailer refrigeration units, and electrical change-over switches and are therefore found throughout various sectors of the economy.

Demand for these gases will grow, as it is closely linked to the sectors that use them most, residential (e.g. increased heating/air conditioning) and services (e.g. refrigeration equipment in supermarkets), mobility (e.g. air conditioning in vehicles) and industry (e.g. refrigeration equipment), which will grow significantly by 2050.

The reduction in emissions of fluorinated gases is marked by the withdrawal of such gases imposed by the reduction targets set at community and international level, through restrictions on the marketing of equipment with fluorinated gases with a high global warming potential, thus making room for use of other refrigerant gases, such as natural refrigerants and hydrofluorolefins.

The Montreal Protocol Amendment, related to Ozone Depleting Substances, known as the Kigali Amendment, introduced a goal of gradually reducing the consumption and production of HFCs, aiming to reduce the contribution of these substances to climate change. The Kigali Amendment stipulates that emissions of fluorinated gases should be reduced over time compared to the 2011-2013 reference period. Thus, it sets a reduction target of -10% by 2019; -40% by 2024; -70% by 2029; -80% by 2034; and -85% by 2036.

With the increasing electrification of various sectors of the economy, sulphur hexafluoride (SF6), with a high heating potential, may become important, as it is currently the most widely used fluorinated gas in the manufacture of electrical equipment essential for the extension of electrical networks. There are currently no alternatives to the use of this gas, but it is nonetheless expected that a viable alternative to SF6 with a lower greenhouse effect will be developed before 2040, so it is essential to invest in the development of new fluids for these applications.

At a national level, it can be seen that the level of fluorinated gas emissions does not differ much between the scenarios studied, showing a trend of a strong reduction of their emissions by 2040, from which time this reduction may be slower.

4.2. ROLE OF AGRICULTURE, FORESTS AND OTHER LAND USES IN THE TRANSITION TO CARBON NEUTRALITY

In 2015, GHG emissions from agriculture represent about 10% of national emissions, totalling 6.8 Mt CO_2, and mainly involve methane (CH4), corresponding to 40% of national emissions of this gas, and nitrous oxide (N2O) which in this case represents 73 % of the total national emissions of this gas. The most important emission sources originate from the animal sector, and represent 83% of agricultural emissions (enteric fermentation, livestock effluent management, direct manure spreading on pastures and application of livestock effluents on agricultural lands). The remaining 17% refer to the use of mineral fertilisers, lime correctors and crop residues not removed from agricultural lands.

Emissions from agriculture have been increasing since 2013, mainly as a result of the increase in livestock numbers, particularly non-dairy cattle.

The component associated with agricultural and pasture uses in 2015 represented about 0.7 Mt CO_2e of emissions, resulting from the kinds of practices used and the conversions between the different use categories to these categories over the last 20 years. Considering this component, thus associating all activities and impacts on the land of this sector, agricultural emissions in 2015 represented 11% of total emissions.

The component of land uses associated with forest occupation are normally large carbon sinks. This is how, in 2015, forest lands obtained a net sequestration of 11 Mt CO_2e. However, in the Portuguese case, this carbon sink potential is greatly affected by the impact of rural fires, which reveals itself directly in net GHG emissions when they are large fires, and indirectly in decisions to maintain or change the land use, by the farmers. Other land uses (urban areas, wetlands or swamps) are generally sources of emissions, which results in a positive carbon sequestration balance of around 9 Mt in 2015.

The evolution of emissions associated with agriculture and forests is highly dependent on the introduction of structural changes and the types of management used. The evolution of the Common Agricultural Policy (CAP) is one of them. The current proposal seeks more effective climate action and better protection of the environment and biodiversity by the agricultural sector. In order to bring about reductions in emissions and increase sequestration, there should be a focus on a green scheme that translates into more equitable payments to farmers, oriented towards the environment, climate change and the country. Also, there is potential for achieving emissions reductions in the livestock sector, through improvements in feed digestibility and the livestock effluent management systems.

The contribution of biodiverse pastures is very important for net sequestration associated with agricultural land uses in 2050, and the expansion of biological and conservation farming and precision agriculture will allow a reduction of emissions associated with animal effluents and fertiliser use.

In the forests, a reduction in the annual average burned area should be given prominence, through improvements in land management and planning and greater investment in the management of stands, in particular in fire prevention and fighting. New afforestation and reforestation are mostly implemented with production species (cork oak, pine and eucalyptus) or with protection and conservation species (native hardwoods), depending on the scenario considered.

Also, in the context of the definition and implementation of investment support policies, it is recommended to reinforce the distribution of support for ecosystem services and the maintenance of forest biodiversity.

TABLE 13: Evolution of emissions/sequestrations of the agriculture, forests and other land uses sector.

AGRICULTURE, FORESTS AND OTHER LAND USES	2005	2015	2020	2030	2040	2050	Δ 2050/2005
TOTAL AFOLU	**8.25**	**-1.69**	**3.01**	**-2.84 I -4.55**	**-4.21 I -7.02**	**-5.73 I -9.44**	**-169% I -214%**
Agriculture	6.77	6.79	6.79	6.42 I 6.3	6.33 I 5.52	6.19 I 4.74	-9% I -30%
Enteric Fermentation	3.6	3.57	3.57	3.39 I 3.32	3.41 I 2.99	3.43 I 2.69	-5% I -25%
Livestock Effluent Management	0.92	0.91	0.91	0.89 I 0.88	0.83 I 0.77	0.77 I 0.66	-17% I -29%
Rice Production	0.15	0.14	0.14	0.13	0.13	0.12 I 0.13	-19% I -12%
Agricultural Lands	2.02	2.07	2.07	1.89 I 1.85	1.84 I 1.52	1.75 I 1.12	-13% I -44%
Burning of Agricultural Waste	0.05	0.06	0.06	0.06	0.07 I 0.06	0.06	21%
Liming	0.03	0.05	0.05	0.05	0.06	0.07	136%
Land Uses	1.48	-8.48	-3.78	-9.25 I -10.85	-10.54 I -12.54	-11.92 I -14.18	-903% I -1055%
Forested Land	-2.22	-11.4	-8.67	-12.7 I -13.51	-14.03 I -15.01	-15.4 I -16.45	592% I 640%
Agricultural Land	1.36	0.63	0.8	0.63 I 0.62	0.62 I 0.59	0.61 I 0.56	-55% I -59%
Pastures	1.7	0.13	0.13	-0.75 I -0.89	-0.73 I -1.11	-0.69 I -1.32	-141% I -178%
Wetlands	0.43	0.43	0.37	0.38	0.39	0.39	-8%
Urban land	1.95	2.64	2.18	2.30	2.36 I 2.34	2.4 I 2.37	23% I 21%
Scrubland and other land uses	-1.73	-0.9	1.41	0.88 I 0.26	0.85 I 0.27	0.77 I 0.28	-144% I -116%
Agriculture, agricultural land and pasture	9.83	7.55	7.72	6.3 I 6.02	6.22 I 4.99	6.11 I 3.98	-38% I -60%
Forest and other land uses	-1.58	-9.24	-4.71	-9.14 I -10.57	-10.43 I -12.01	-11.84 I -13.42	651% I 751%

Unit: Mt CO2e

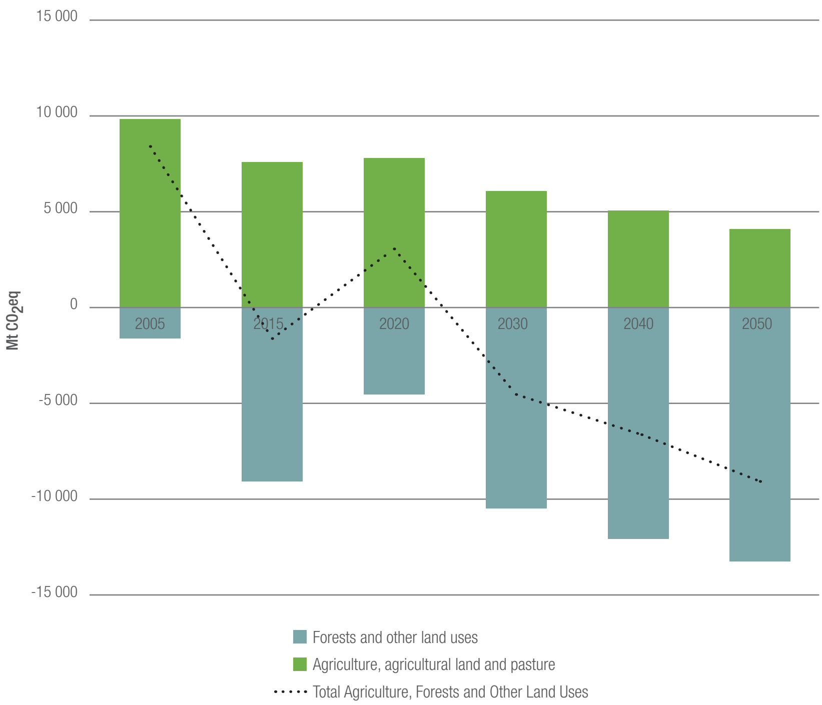


FIGURE 23

Evolution of emissions of the agricultural, forests and other land uses sector.

It should be noted that emissions reduction in agriculture is occurring at a slower rate than in other sectors, inherent to the characteristics of the associated biophysical systems, which means that its weight in national emissions will be between 29% and 34% by 2050, depending on whether one considers or not the contribution of land uses.

Below are details of the decarbonisation vectors for agriculture and forests, which will have a net sequestration role in 2050.

EMISSION REDUCTION IN LIVESTOCK PRODUCTION AND PASTURES

For the reduction of emissions in livestock production and pastures (enteric fermentation, effluent management, spreading manure on pastures, organic matter in pastures), a fundamental contribution will be made by changes in the numbers of the various species, the animal diet and the digestibility of the animal feed, the animal manure and effluent management systems used in intensive livestock and increased organic matter content in the land used for pasture.

The changes in the animal diet and feed digestibility will make livestock farming more efficient and reduce the emissions per head, notably by changing the specific composition of the pasture and forage, by increasing the fat content of the feed used and/or the use of food additives, productivity improvements through genetics and the increased use of supplements in the feed.

The changes in the animal manure and effluent management systems used in intensive livestock will be marked by the progressive shift from systems with more emissions (e.g. anaerobic lagoons) to systems with lower emission factors (e.g. tanks and composting).

The adoption of these kinds of livestock management practices and changes has the potential to reduce emissions by -177 kt CO_2e in 2030, -374 ktCO_2e in 2040 and -564 ktCO_2e in 2050.

Not less important, it will be necessary to ensure an increase in the organic matter content of the land area used for pasture, focusing in particular on areas with sown, improved, permanent and biodiverse pastures in order to increase their sequestration capacity. This will require an increase of around 400% in the area of biodiverse pastures compared to 2005 (from 50,000 ha to 250,000 ha) resulting in net sequestration of 0.76 Mt in 2050, and there is potential for this in Portugal.

EMISSION REDUCTION IN CROP PRODUCTION AND AGRICULTURAL LAND

To reduce emissions in crop production and agricultural land (use of fertilisers, organic materials in agricultural soils) a fundamental contribution will be made by changes in the total agricultural area and the area of different crops, the replacement of mineral fertilisation by organic fertilisation, a reduction of the total amounts of fertiliser used and an increase in the organic material content of agricultural lands.

Changes in the total agricultural area and in the area of different crops will mainly be due to the opening of agricultural markets to countries outside the EU, with consequences for the production of the crops for which the country has the most competitive advantages, such as vegetables, dried and fresh fruits and olives.

Replacing mineral fertilisers with organic fertilisers will increase the use of compost from livestock waste and/or organic waste from other sources (e.g. agribusiness). Replacement with organic fertilisers, especially composting, is expected to reach 180,000 ha by 2050. On the other hand, it is also estimated that the total amount of fertiliser used per unit area will be reduced through the expansion and development of precision agriculture techniques, totalling 300,000 ha in 2050, which will lead to a 58% reduction in the use of synthetic nitrogen compared to 2005.

Finally, it will be necessary to ensure an increase in the organic matter content of agricultural lands and a consequent increase in sequestering capacity, notably by increasing the area under conservation (or regenerative) agriculture, reaching 180,000ha by 2050 and by increasing the area under biological farming and/or replacement of mineral fertilisation with organic fertilisation.

All these measures will lead to total reductions of -177 ktCO_2e in 2030, -331 ktCO_2e in 2040 and -639 ktCO_2e in 2050.

REDUCED EMISSIONS AND INCREASED SEQUESTRATION IN FORESTS AND OTHER LAND USES

In 2015, forests sequestered 11 Mt CO_2e. For the reduction of emissions and increase of forest sequestration and other land uses, a fundamentally contribution will be made by a big reduction in burned areas and the use given to these areas after the fire, improvements in forest management and consequent increases in average productivity, the rate of new afforestation (expansion of the forest area from other land uses) and the expansion rate of other land uses.

It will therefore be necessary to ensure a large reduction in burned areas, from an average of about 164,000 ha/year between 1998 and 2017 to 70,000 ha/year by 2050 (i.e. a 60% reduction), to be careful about the use given to these areas after the fire, ensuring smaller total areas affected by fires, considering the suitability of the species used in reforestation, reducing the deforestation caused by fires (forests converted into scrubland) and making greater use of fire prevention techniques, including increased use of small ruminants to reduce combustible material.

On the other hand, there is a series of actions that will allow improvement of forest management and achieve consequent increases in average productivity, such as improving management and increasing fire prevention, using more productive and better adapted varieties and increasing density, of either production or protection species.

Finally, it will be necessary to increase the rate of new afforestation to 8,000 ha/year (expansion of the forest area from other land uses) and to reduce the rate of expansion of other land uses, particularly from urbanised areas, flooded areas (including dams) and scrubland.

TABLE 14: Evolution of the area of different land uses

LAND USE	2015	2020	2030	2040	2050	Δ 2050/2005
NATIONAL TOTAL	9.24	9.24	9.24	9.24	9.24	0%
Forested Land	4.36	4.19	4.19 I 4.23	4.18 I 4.27	4.17 I 4.31	-4% I -1%
Maritime pine	1.18	1.10	1.08 I 1.05	1.07 I 1.01	1.06 I 0.97	-10% I -18%
Cork Oak	0.93	0.94	0.95 I 0.98	0.96 I 1.02	0.97 I 1.06	4% I 14%
Eucalyptus	0.85	0.78	0.8 I 0.74	0.81 I 0.71	0.83 I 0.67	-3% I -21%
Holm Oak	0.60	0.60	0.59 I 0.61	0.59 I 0.63	0.59 I 0.65	-2% I 9%
Oaks	0.21	0.21	0.2 I 0.23	0.2 I 0.25	0.2 I 0.27	-6% I 28%
Other leafy trees	0,35	0.36	0.34 I 0.38	0.33 I 0.4	0.31 I 0.42	-10% I 21%
Stone pine	0.21	0.21	0.21 I 0.21	0.21 I 0.22	0.21 I 0.23	2% I 10%
Other resinous trees	0.03	0.01	0.01 I 0.02	0 I 0.03	0 I 0.03	-90% I 21%
Agricultural land	2.39	2.39	2.25	2.17 I 2.11	2.16 I 1.99	-10% I -17%
Pastures	0.66	0.60	0.66 I 0.66	0.8 I 0.57	0.96 I 0.49	46% I -26%
Wetlands	0.20	0.20	0.21	0.21	0.21	8%
Urban land	0.50	0.52	0.55	0.56 I 0.56	0.57 I 0.56	15% I 13%
Scrubland and other land uses	1.14	1.33	1.39 I 1.34	1.31 I 1.53	1.17 I 1.68	3% I 48%

[1,000,000 ha]

Main decarbonisation drivers in the agriculture, forests and other land uses sector:

- biological, conservation and precision farming;
- biodiverse pastures;
- improved digestibility of animal feed;
- improved livestock effluent management;
- reduced use of synthetic fertilisers and their replacement with organic compost;
- reduction of burned area;
- improved forest productivity.

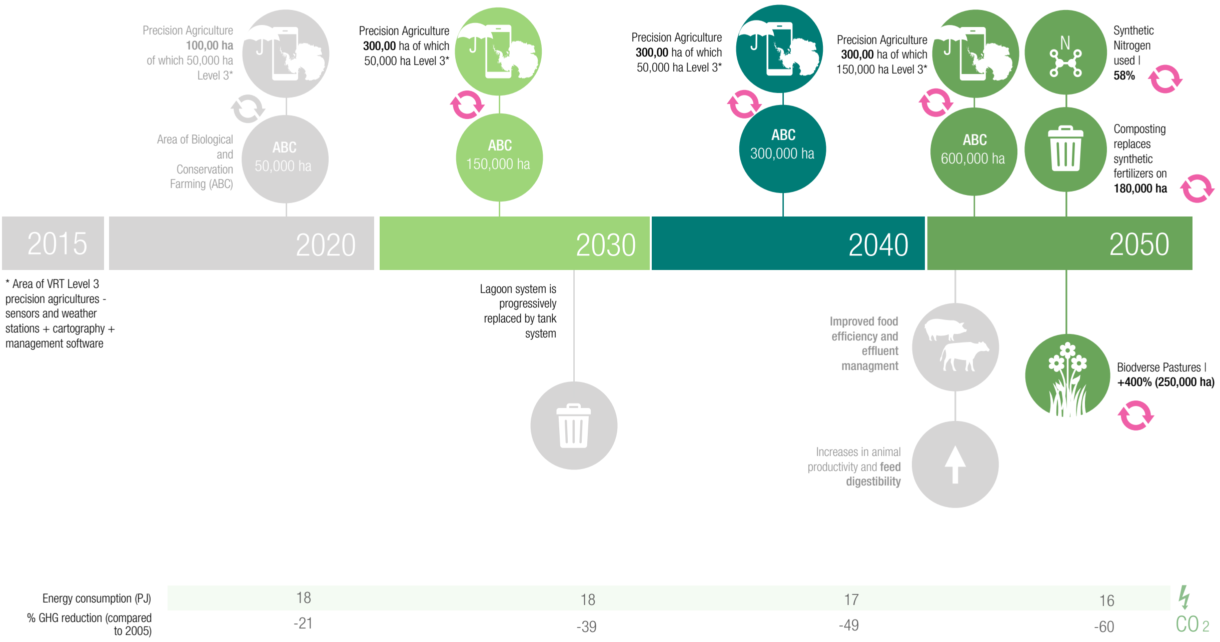


FIGURE 24

Narrative of carbon neutrality of the agriculture and agricultural land sector until 2050

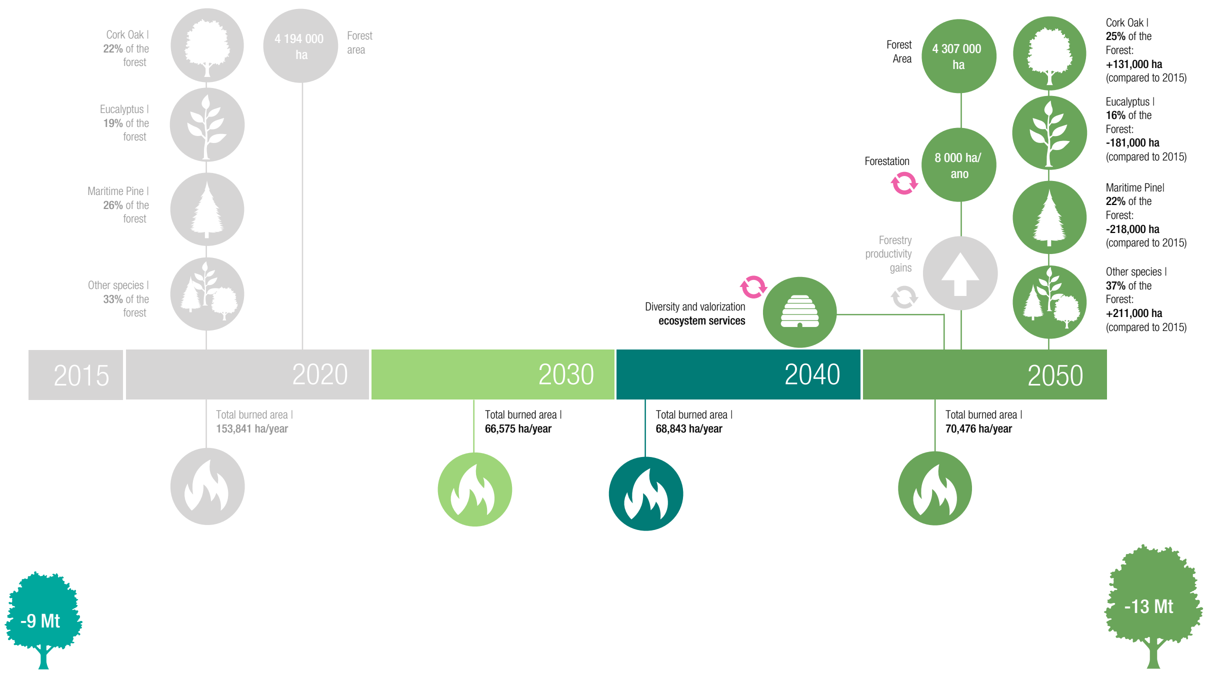


FIGURE 25

Narrative of carbon neutrality of the forests and other land uses sector until 2050

4.3. ROLE OF WASTE AND WASTEWATER IN THE TRANSITION TO CARBON NEUTRALITY

GHG emissions from this sector originate from solid waste and wastewater treatment systems (urban and industrial in nature). Energy recovery from waste is considered in the energy sector and only incineration of waste without energy recovery is included in this sector.

The waste and wastewater sector accounted for about 9% of total emissions in 2015, with landfill disposal representing the largest share of GHG emissions (76%), followed by wastewater treatment. (23%), with emissions from biological treatment of municipal waste and incineration below 1%. Since 2005 there has been a continuous and consistent reduction in GHG emissions from waste and wastewater.

One of the particular characteristics of emissions from the waste and wastewater sector is the dominant importance of methane emissions in total GHGs, accounting for 88% of the sector's emissions in 2015. The sector's contribution to national methane emissions is 57%.

These methane emissions are linked to the anaerobic decomposition processes of organic matter present in both waste and wastewater, so reducing GHG emissions in this sector will mean reducing the weight of methane emissions related to anaerobic fermentation processes.

Emissions from Urban Waste (UW) landfills result from the slow degradation of organic waste present in the UW, which continue to produce GHG, and it is assumed that half of the biogas volume released during this process corresponds to methane, until the amount of fermentable carbon in them is depleted, which occurs over several years. Thus, annual emissions depend not only on the organic waste deposited each year, but on the accumulated waste over several decades. Therefore, to achieve significant reductions by 2050, a rapid reduction of landfilling with new organic waste is essential, especially in the next 5 to 10 years.

A reduction of the production of UW per capita and landfilling of only 10% of the UW produced in 2035, as a result of national and Community targets, will lead to a reduction of -82% of UW landfill in that year, compared to current values.

By 2050, the amount of waste generated per capita should be further reduced; gradually increasing separated collection of recyclable waste, reaching 65% in 2035, including bio-waste; and greatly reducing the amount of landfilled waste (-60% and -85% of organic waste compared to 2005), which will lead to a significant reduction in landfill emissions by -79% to -82% by 2050, compared to 2005.

In 2050 there will also be a significant reduction in GHG emissions from wastewater, from -77% to -78%, compared to 2005.

As a consequence of these GHG emissions reductions and considering that wastewater and landfills generate most emissions within the waste and wastewater sector, it is concluded that there will be a sharp decrease in GHG emissions in this sector in 2050, between - 77% to - 80% compared to 2005.

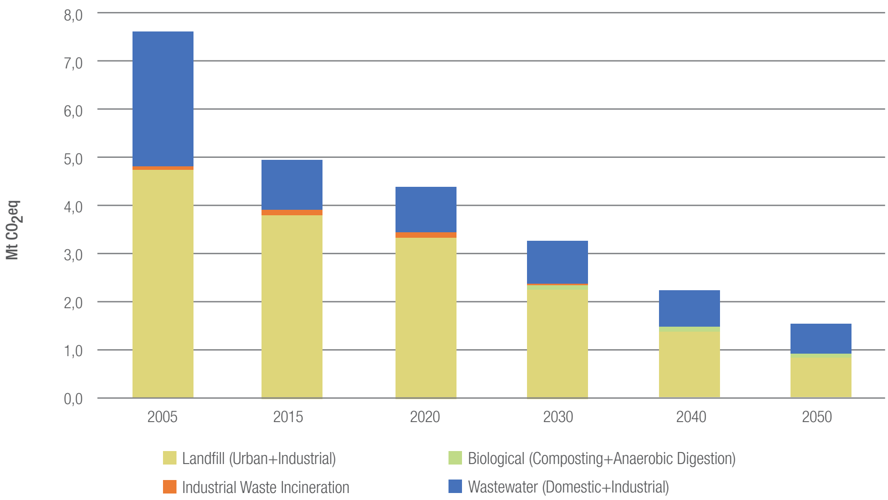


FIGURE 26

Evolution of emissions from the waste and wastewater sector

Significant reduction in landfill emissions between -79% to -82% in 2050, compared to 2005.

TABLE 15: Evolution of emissions from the waste and wastewater sector

TOTAL WASTE AND WASTEWATER	2005	2015	2020	2030	2040	2050	Δ 2050/2005
	7.70	4.95	4.4 I 4.38	3.32 I 3.26	2.36 I 2.23	1.75 I 1.55	-77% I -80%
Landfill (Urban + Industrial)	4.81	3,89	3.41 I 3.38	2.38 I 2.3	1.51 I 1.4	1 I 0.85	-79% I -82%
Biological Treatment (Composting + Anaerobic Digestion)	0.02	0.04	0.04	0.06	0.07	0.07	207% I 222%
Industrial Waste Incineration	0.01	0.02	0.02	0.03	0.03 I 0	0.03 I 0	213% I -88%
Wastewater (Domestic + Industrial)	2.86	1.00	0.93	0.85 I 0.87	0.76 I 0.75	0.65 I 0.62	-77% I -78%

Unit: Mt CO_2eq

Part of the methane produced by landfills can be recovered and burned with energy recovery, which is an emissions reduction measure. The methane recovery rate is therefore expected to increase from the current 32% to 44%, allowing a significant reduction in these emissions by 2050. Indeed, if, on the one hand, there will be less methane production, on the other hand the relative percentage of recovery of methane versus the methane generated will be increasing. As a result, efficiency improvements in this area could constitute significant reductions in methane emissions.

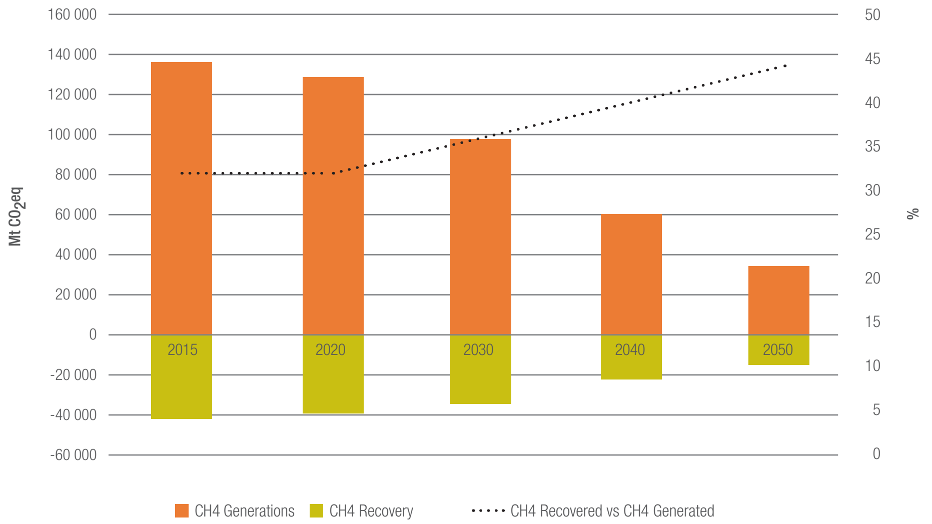


FIGURE 27

Recovered CH4 versus CH4 generated in landfills

TABLE 16: Recovered CH_4 versus CH_4 generated in landfills

TOTAL WASTE AND WASTEWATER	2015 4.95	2020 4.4 I 4.38	2030 3.32 I 3.26	2040 2.36 I 2.23	2050 1.75 I 1.55
CH_4 generated	135,736	128,879	97,934	59,707	34,897
CH_4 recovered	-44,029	-41,294	-35,235	-23,832	-15,303
Unit: t CO_2eq.					
CH_4 recovered versus CH_4 generated	32%	32%	36%	40%	44%

There is also a downward trend in the quantities of UW produced, either by a reduction of the population or by a reduction in production per capita from 8% to 24% by 2050 (compared to 2015) depending on the scenario considered.

Separated collection of bio-waste and the consequent increase in biological treatment systems are expected. The reduction in GHG emissions will be greater the greater the reduction in municipal waste production per capita, the greater the reduction in food waste and increase in local composting solutions, resulting from greater assumed circularity.

Developments in the wastewater, urban and industrial waste sector are not significant compared to the current value, which is already quite favourable for the population served by drainage systems and secondary treatment systems.

As already mentioned with regard to biogas recovery in landfills, the production and recovery of biogas generated in anaerobic digestion sludge treatment systems is of significant importance in the context of emissions from the domestic wastewater treatment sector, although in significantly lower quantities, with around 14,000 tonnes of methane produced in both 2015 and 2050.

Main decarbonisation drivers in the waste and wastewater sector:

- Reduction of waste production per capita;
- Reduction of the organic portion of municipal waste due to improved selective collection and reduced food waste;
- Elimination of municipal waste disposal in landfills, through:
    - Collection of bio-waste and priority of biological treatment, with compost production;
    - Increased separated multi-material collection and development of recycling activities.

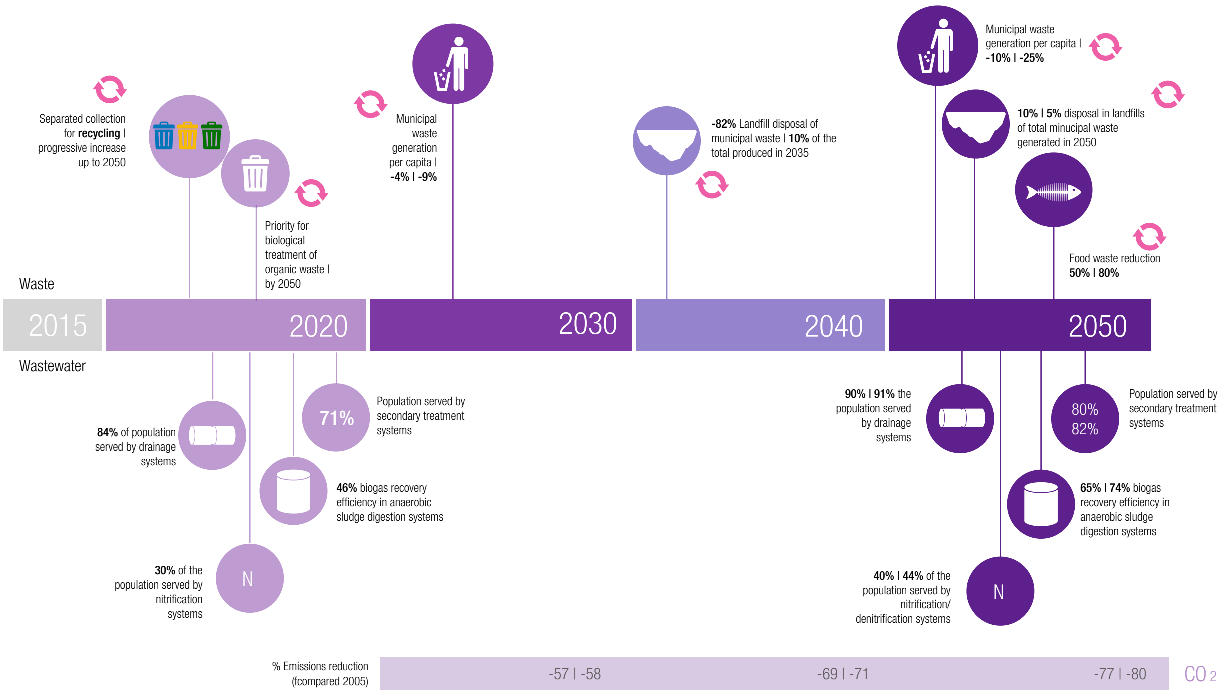


FIGURE 28

Narrative of carbon neutrality of the waste sector by 2050

4.4. ROLE OF THE CIRCULAR ECONOMY IN THE TRANSITION TO CARBON NEUTRALITY

The circular economy is a fundamental and structuring element of the transition that underpins the trajectories of carbon neutrality of the Portuguese economy. Thus, it was considered an integral part of the narrative of the socioeconomic scenarios developed and was reflected in the sectoral assumptions that support the modelling of GHG emissions.

The role of the circular economy has been the subject of greater scrutiny in the context of the value chain of a number of sectors considered to be important for the success of the neutrality objective and for which an important impact of circularity is envisaged - mobility, agri-food, forestry activities, construction and waste.

In the Mobility sector, the transitions induced by the circular economy point to lower use of individual transport and growth in multimodal shared integrated mobility services (at both public and private transport levels) and greater fairness in access to mobility services and an increase in the occupancy rate of cars.

Thus, new business models emerge that replace the supply of goods (vehicles) with the provision of services and ownership through use.

On the other hand, increasing supply chain digitisation (more online shopping, more reverse logistics) increases demand for goods mobility, as well as increasing the pressure on this sector and, as a counterbalance, it is necessary to increase the load factor of light and heavy goods vehicles, the fleet's autonomy and its technological replacement rate, thereby improving the efficiency of the vehicles (for passenger and goods, light and heavy).

These concerns allow us to have more competitive business models, with lower operating costs and less impact on GHG emissions.

Potentially, the circular economy could lead to a reduction of GHG emissions from the transport and mobility sector of -4%|-25% by 2050.

In the agri-food sector, the adoption of regenerative and more resource-efficient agricultural practices (water and energy) and new food consumption habits and lifestyles (e.g. greater nutritional suitability of the diet; urban and peri-urban production; and local supply, particularly of vegetables; bulk purchases) promote a reduction of waste production and its organic portion (via reduced food waste), as well as reducing emissions.

The expansion of biological and conservation farming and precision agriculture, as well as permanent pastures, will reduce emissions associated with fertiliser use and animal effluents, and increase carbon sequestration resulting from increases in organic matter content in the soil. In addition, other environmental benefits are induced, such as the preservation of natural and ecological resources, promotion of biodiversity and/or improvements in animal welfare.

The use of compost to replace the use of synthetic nitrogen fertilisers is also a circularity measure to be considered in this sector.

These circularity strategies lead to a reduction in GHG emissions from the agricultural sector between -16%|-37% by 2050.

In the forest sector, the increase in active afforestation, the promotion of more efficient forestry practices in the use of resources and risk management, and the valorisation of ecosystem services, leverage and sustain a growing role for the bioeconomy, with an impact on carbon retention and on the net balance of emissions.

Future productivity gains may arise from better forest management practices and less fire losses, as forest area expansion is expected to be limited by 2050 (which means a reduction in forest area relative to 2015).

The forest sector is a value chain that already has a high degree of circularity, and forests play an inevitable role in achieving carbon neutrality. Thus, it can be seen that investment in forests to increase biological carbon sequestration could lead to gains of over 40% by 2050 (compared to a non-circular scenario).

In construction, increased urban rehabilitation, with the reuse of construction components, reclaimed or recycled materials, and the use of “empty” built public spaces, passive buildings with a zero energy balance (NZB: Net Zero Energy Buildings), multifunctional and shared buildings with reduced built area, as well as the use of new, more sophisticated, more energy efficient and durable materials, and of renewable materials with a smaller carbon footprint (e.g. wood and cork) are circularity strategies to be pursued.

In the waste sector, circularity strategies make it possible to reduce per capita waste production and its organic portion, mainly by reducing food waste and the use of plastics, with the prospect of increasing biomass collection (giving priority to biological treatment with compost production), increased multi-material separated collection and development of recycling chains and the elimination of disposal of municipal waste in landfills.

The circular economy can lead to a reduction in GHG emissions from waste management (including energy recovery from municipal waste) of -69% to -72% by 2050.

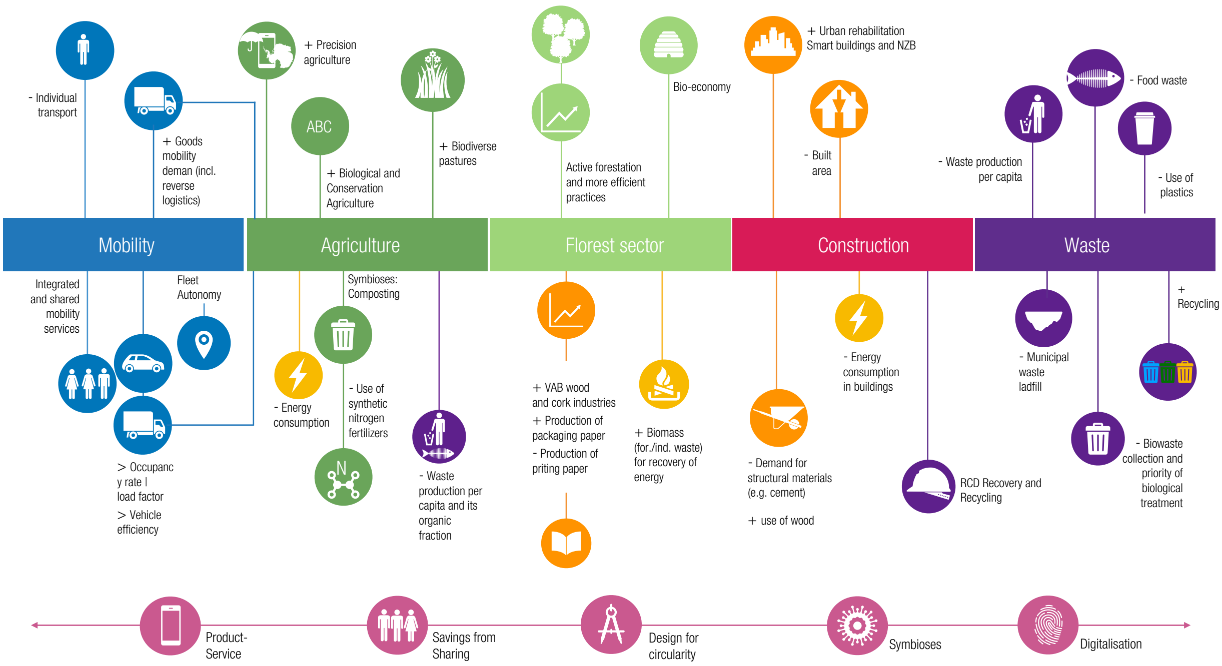


FIGURE 29

Role of the circular economy in modelling

4.5. CO-BENEFITS OF CARBON NEUTRALITY FOR AIR QUALITY AND PUBLIC HEALTH

GHGs do not have a direct effect on the health of humans or ecosystems. However, many of the processes that emit GHG are also responsible for emissions of other air pollutants that cause other environmental problems, such as degradation of air quality, acidification and eutrophication, causing damage to ecosystems with the consequent loss of biodiversity. and human health problems, particularly respiratory and cardiovascular problems.

Nowadays air pollution is one of the greatest environmental health risks, and the World Health Organisation identifies particulate matter (PM), nitrogen oxides (NO, NO_2 and NO_3), sulphur oxides. (SO_2 and SO_3) and tropospheric ozone (O3) as the most harmful air pollutants. Ozone, unlike other pollutants, is not emitted directly, but is a pollutant that forms in the atmosphere in the presence of other pollutants, such as nitrogen oxides.

PM originates from a variety of sources, but mainly from burning fossil fuels, and is the most harmful pollutant. The smaller these particles are, the more likely they are to penetrate deep into the respiratory tract and the greater the risk of inducing negative effects. Smaller inhalable particles (PM10 and PM2.5) reach the lungs and the finest, PM2.5, can even enter the bloodstream.

Nitrogen oxides mainly come from road traffic. In big cities, they are primarily responsible for the poor quality of the air. Sulphur oxides do not presently pose a serious air quality problem, as a result of various measures such as, for example, reducing the sulphur content of fossil fuels.

In Portugal, notwithstanding the improvement in recent years, air quality problems still persist in some places, notably in densely populated urban areas where concentrations are frequently seen to exceed some human health thresholds for nitrogen dioxide (NO2) and PM10. There are also areas where values above the long-term ozone target often occur.

Climate change, by affecting weather conditions, including the frequency of heatwaves and periods of high atmospheric stability, will tend to prolong periods when ozone levels are high and may lead to increased concentrations of PM, contributing to the degradation of air quality and increasing the risk of diseases associated with air pollution. It is estimated that 6,000 people die prematurely each year in Portugal due to air pollution.

A sound air quality policy is the answer to a legitimate claim of citizens in terms of health and well-being, preventing premature deaths, and bringing economic benefits from improved productivity, reduced external health costs and offers, in a circular economy context, opportunities for technologies and services.

The decarbonisation vectors will have an impact on economic activities and consequently on the generation of air pollutant emissions, and it is therefore expected that the goal of carbon neutrality will bring the co-benefit of improved air quality, with positive effects on human health, in particular as regards respiratory diseases. This effect will be particularly significant in cities due to the transformation that will take place in terms of mobility, with the emphasis on public transport, decarbonisation of the fleets and the increase in active, shared and sustainable multimodal mobility, as well as electric mobility and other zero emission technologies;

Positive ecosystem impacts are also expected, where air pollution pressures hinder vegetation growth and cause damage to agriculture and biodiversity.

On the other hand, the increase in biomass consumption for electricity production and industrial processes is seen as a trade-off for air quality, with a possible impact on the increase of emissions from non-methane volatile organic compounds (NMVOC) and fine particles (PM2.5).

According to the Intergovernmental Panel on Climate Change special report on the impacts of 1.5 ºC global warming, ensuring this limit will have the practical consequence of significantly reducing the risks and impacts of climate change. While it is undeniable that climate change impacts are already taking place on a global scale, the only manner to vary the degree to which they will be felt in the future is to achieve significantly reduced emissions globally.

5. CONTRIBUTING TO NATIONAL RESILIENCE AND CAPACITY TO ADAPT TO CLIMATE CHANGE VULNERABILITIES AND IMPACTS

According to the European Commission[9] total economic losses resulting from meteorological and other extreme weather events in Europe between 1980 and 2016 amounted to over EUR 436 billion, and in Portugal this figure was around EUR 7 billion. Coastal regions could suffer economic losses of about EUR 39 billion a year by 2050 and up to EUR 960 billion a year near the end of the century.

In Portugal, damage from extreme weather events has been felt in coastal erosion, storms, rural fires and drought. The cost of the severe storms that have been experienced in recent years, such as the Hercules storm that struck the country in 2014, amounted to about 17 million euros and the cost related to the March 2018 storms on the Portuguese coast are estimated at approximately 1.4 million euros. The amounts associated with other weather events were around 60-140 million euros a year, associated with rural fires (not counting the 2017 fires). The drought in 2005 had an estimated cost of around 290 million euros and the 2012 drought brought losses mainly in terms of agricultural production shortfalls, with estimated costs of over 200 million euros[10], fand a figure for the most recent drought (2017-18) still has to be calculated.

It is also important to note that climate impacts will be unevenly distributed at a European level. Southern European countries have greater vulnerabilities and fewer opportunities with climate change, compared to the other subregions of the European continent, and will suffer more from the effects of heat-related human mortality, water restrictions, loss of habitats, energy requirements for cooling and rural fires.

The PESETA II[11], project, which aims to increase knowledge about regional and sectoral patterns of climate change in Europe by the end of the century, effectively concludes that economic losses associated with climate change impacts have a very asymmetrical geographical distribution, with a clear bias towards the southern European regions. For example, in a scenario in which the average temperature rises by 2 °C by the end of the century, the study concludes that welfare losses in terms of GDP range from 0.2% in the Northern European region to 3% for Southern Europe for the last third of this century.

The national effort to reduce emissions, as part of a broader global action framework, will help to allow adaptation costs to be reduced significantly, with clear economic savings.

With a view precisely to emphasising the implementation of adaptation measures and mobilising the various current financial instruments and shaping the framework for those in the future, the Climate Change Adaptation Action Program (P-3AC) with a 2030 time horizon, has been prepared, defining the priority intervention areas in response to the main vulnerabilities and impacts of the climate changes identified for our country:

9 Report to the European Parliament and the Council on execution of the EU's strategy for adaptation to climate change (COM(2018) 738 final)

10 Information based on the work of the Commission for the Prevention, Monitoring and Monitoring of the Effects of Drought and Climate Change, created under the Resolution of the Council of Ministers no. 37/2012, of 27 March.

11 Available at: http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=7181

1. Increased frequency and intensity of rural fires
2. Increased frequency and intensity of heatwaves
3. Increased frequency and intensity of periods of drought and water scarcity
4. Increased susceptibility to desertification
5. Increased maximum temperature
6. Increased frequency and intensity of extreme precipitation events
7. Higher sea levels
8. Increased frequency and intensity of extreme phenomena that cause coastal removal and erosion

It should be noted that there is a series of decarbonisation measures and options with clear synergies in adapting to the effects of climate change, such as, for example, measures contributing to forest and agricultural sequestration (increasing soil organic matter and its water retention capacity, combating desertification), natural-based solutions (installing roofs and other green infrastructures in urban areas, renaturalisation of impermeable areas, etc.) but also measures in the area of energy efficiency, as they contribute to reducing total energy consumption and thereby reduce the vulnerability of the energy system to pressures arising from extreme events.

On the other hand, the impacts of climate change should be taken into account in mitigation options, notably as regards future water availability, heating and cooling needs and the risk of rural fires. For example, the scenarios analysed under RNC2050 accommodate the decreasing availability of water for electricity production expected in the RCP 4.5 climate scenario. In this context, it has been estimated that water production will, on average, decrease by 9% by 2050, compared to 2020, considering, in particular, a hydraulic index of 0.8.

In this regard, it is also particularly important to note that the determining factor in forest carbon sink capacity - a decrease in the annual average burned area - will be hampered in a scenario of worsening of the effects of climate change.

It is therefore undeniable that the implementation of adaptation measures becomes one of the critical factors for the carbon neutrality targets, as regards both emissions reduction and sequestration capacity. Similarly, carbon neutrality is one of the guarantors of adaptability, as it will only be possible if CO_2 levels in the atmosphere do not exceed a certain threshold, beyond which adaptation is no longer possible and society as we know it will cease to exist. The synergies for mitigation and adaptation that occur in various measures are another sign that integrated action between the two strands in all components of society is effectively needed.

6.
STIMULATING RESEARCH, INNOVATION AND KNOWLEDGE PRODUCTION

Research, innovation and knowledge production are key to the process of defining sound policies and adapting to climate change. The participation of science takes place at the most diverse levels:

- by monitoring and tracking climate change and modelling future climate change and its impacts;
- by accurately estimating the emission or sequestration levels that each process or sector produces and the monitoring and follow-up of these emissions over time, while also considering new important sectors or areas, in line with the development of scientific knowledge, according to the IPCC guidelines for developing production processes or new technologies that lead to a strong reduction in emissions or a strong increase in sequestration;
- by developing dissemination strategies and/or business models that allow the transfer of the best technologies and their adoption by economic sectors and households;
- by ex ante and ex post evaluation of policies and measures and their effectiveness in reducing emissions, and in their environmental dimension, but also by assessing their economic impact on employment and prediction of the sectors or territories affected positively and negatively by these policies;
- by designing incentive systems that facilitate the adoption of less emitting practices and technologies or of disincentive policies that deter the continuation or adoption of more emitting practices;
- by identifying long-term decarbonisation strategies and vectors for carbon neutrality.

In turn, the process of defining carbon neutrality trajectories informs the science agenda about the areas, sectors and technologies for which the identification of decarbonisation solutions is most significant, and therefore most effective, and/or that are the areas in which decarbonisation is now more conditioned or less cost-effective and therefore more difficult to achieve.

It is also important to ensure a connection between research, development and innovation and the production system, enabling the development of real-world prototypes and pilot projects and, in a second phase, accelerating the transfer of this knowledge to the production system and/or the households, to ensure that the decisions taken at any given time are those best suited to the goal of decarbonisation, but also those that lead to the best results in terms of job creation and value for society.

Therefore it is important to promote the science and knowledge of climate change at a national level, to stimulate research and development of low carbon technologies, practices, products and services that contribute to climate change mitigation and adaptation, and above all to promote eco-innovation. It is also crucial to develop a climate change knowledge base that supports public policy decision-making in this area and facilitates public education and knowledge transfer.

The Research and Innovation thematic agendas of the Science and Technology Foundation, I.P. for Climate Change, circular economy, sustainable energy systems, urban Science and Industry and cities of the future are precursors of the mobilisation needed to ensure the transition to a carbon neutral society.

7. GUARANTEE FINANCING CONDITIONS AND INCREASE INVESTMENT LEVELS

7.1. INVESTMENT

Maintaining the competitive dynamics of the national economy against a backdrop of major trends such as digitisation, decentralisation and decarbonisation, but where the role of the circular economy and resource use efficiency, as well as demography, are also felt, this will soon lead to a significant volume of investment over a considered timeframe, making it possible to achieve significant emission reductions (around 65% compared to 2005 in 2050), but still far from the objective of carbon neutrality.

Part of this investment will always occur because it is a result of the normal functioning of the market economy, accompanied by appropriate public policies. Given the technological upgrades and the expected evolution of their costs, it can be foreseen that the 'replacement' of technologies will be a replacement with different characteristics (e.g. diesel vehicles will not be replaced by other diesel vehicles but by electric vehicles or by new forms of mobility).

Carbon neutrality and energy transition will encourage a deeper and faster transformation of society, more focused on less emitting technologies, with consequences for multiple aspects of the economy, the citizens' daily life and social organisation. Thus, the investment attributable to the objective of carbon neutrality is only a fraction of the overall investment that the Portuguese economy will have to make over time in order to remain competitive.

This transformation will have to be accompanied by a significant investment, which will take place in all sectors of society, and will, according to its type, be shared between investments by households (e.g. efficient household appliances, electric cars, home insulation, etc.), by companies (e.g. renewable energy sources, hydrogen trucks, electric furnaces and boilers, etc.) and by the State (e.g. electric public transport, decarbonisation of public buildings and the fleet, etc.). The private sector and households will be responsible for the vast majority of these investments.

The state will always play a key role in shaping and adapting the regulatory, tax and incentive system that will provide clear long-term signals to facilitate the necessary investments and avoid obsolete assets.

The overall aggregate amount of investment by 2050 will be close to EUR 1 trillion - of which around EUR 930 billion will be realised in any case as a result of the normal dynamics of modernisation of the economy, catalysed by ongoing policies to ensure the functioning of the energy system - which translates into an annualised value of EUR 27 to 29 billion.

The additional investment needed to achieve carbon neutrality will be around EUR 85 billion for the entire period, i.e. around EUR 2.1 to € 2.5 billion per year (around 1.2% of GDP). In addition to the reduction of emissions that, in the energy system, increases from 70% to 90%, this investment will also lead to substantial energy efficiency gains and reduced energy dependence, which will have major (positive) implications for reduction of the energy bill.

TABLE 17: Volume of additional investment for neutrality in the energy sector in the period 2016-2050

INVESTMENT	2016-2030	2031-2040	2041-2050	2016-2050
OVERALL TOTAl	**406.6 I 431.3**	**263.4 I 273**	**281.8 I 313.1**	**951.8 I 1017.4**
Overall investment without neutrality	395.9 I 416.6	229.7 I 235.1	249.9 I 279.9	875.5 I 931.6
Electricity	22.4 I 22.1	16.6 I 19.6	14.7 I 16.9	53.8 I 58.6
Transport	193.7 I 201.3	74.5 I 62.3	96.6 I 105.3	364.7 I 369
Buildings	165 I 176.4	124 I 138.3	125.8 I 144	414.8 I 458.7
Industry	14 I 16	14.4 I 14.7	11.7 I 12.8	40 I 43.5
Others energy	0.7 I 0.8	0.2 I 0.1	1.2 I 0.9	2.1 I 1.7
Additional to achieve neutrality	10.8 I 14.7	33.7 I 37.9	31.8 I 33.2	76.3 I 85.8
Electricity	1.2 I 2.2	9 I 11.3	10.2 I 7.6	20.5 I 21.1
Transport	5.1 I 6.2	17.3 I 17.6	7.6 I 8.2	30 I 32
Buildings	3.1 I 4.8	5.6 I 6.1	9.6 I 11	18.4 I 21.9
Industry	1 I 1.3	1.2 I 0.9	1.8 I 4.4	3.9 I 6.6
Others energy	0.3 I 0.2	0.6 I 2	2.5 I 2	3.5 I 4.1

[1,000 M€ in 2017; amounts take into account discount rates]

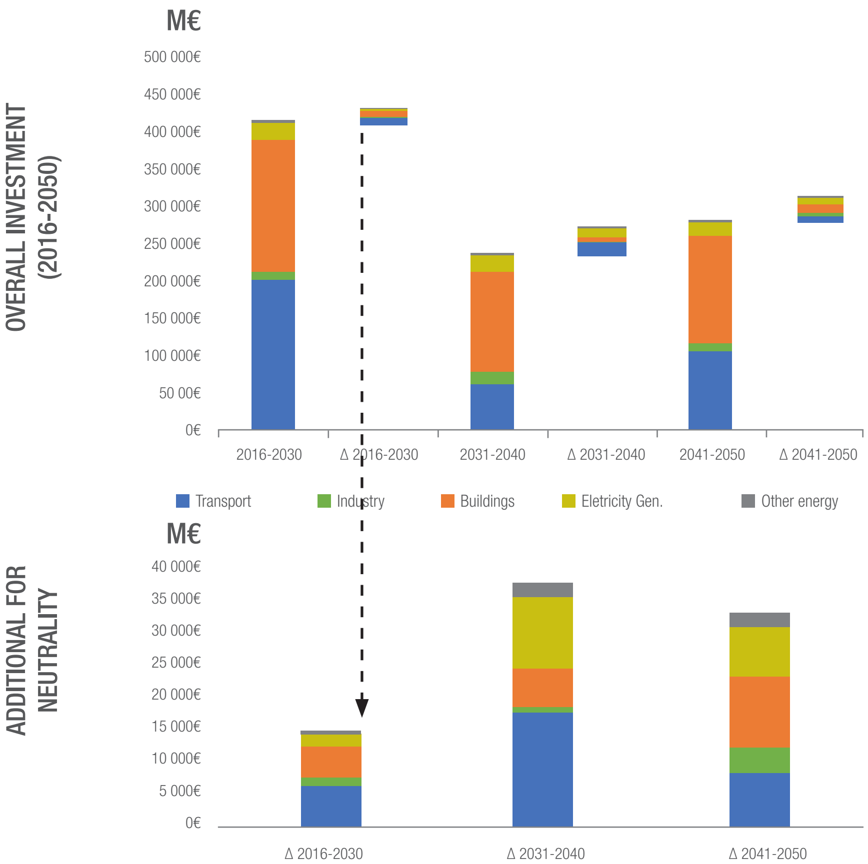


FIGURA 30

Volume de investimento adicional para a neutralidade no setor energético no período 2016-2050

This additional investment volume for neutrality is in line with the estimated amounts of the European Commission for the EU, in its long-term strategy.

QUADRO 18: Volume of investment in selected technologies and the energy sector in the period 2016-2050

INVESTMENTS IN SELECTED TECHNOLOGIES	2016-2030	2031-2040	2041-2050	2016-2050
TOTAL	**406.6 I 431.3**	**263.4 I 273**	**281.8 I 313.1**	**951.8 I 1017.4**
Electricity	23.7 I 24.3	25.6 I 30.9	25 I 24.6	74.3 I 79.8
Hydroelectric	7.3	0.0	0.0	7.30
Onshore Wind Power	4.8 I 3.2	9.1 I 10.6	5 I 6.5	18.9 I 20.3
Offshore Wind Power	1.4 I 2	0 I 3.5	0 I 0.7	1.4 I 6.2
Decentralised solar	3.6	9.3 I 10.7	12.9 I 11.2	25.9 I 25.5
Centralised Solar	5.8 I 6.3	6.8 I 5.6	6 I 5.2	18.5 I 17.1
Batteries	0.1 I 0.2	0.4	1.00	1.5 I 1.6
Other technologies	0.7 I 1.6	0.1	0.0	0.9 I 1.7
Transport	198.8 I 207.6	91.8 I 80	104.2 I 113.5	394.8 I 401
Electric vehicles (BEV + PHEV)	61.3 I 63.4	60.2 I 45	76.2 I 85.8	197.7 I 194.1
H2-powered Lorries + Buses	0.4 I 0.5	1.3 I 3.7	4.2 I 4.4	6 I 8.5
Electric lorries	0.1	11.2	6.2 I 4.6	17.5 I 15.9
Other technologies	137 I 143.6	19.1 I 20.1	17.6 I 18.7	173.6 I 182.5
Buildings	168.1 I 181.3	129.6 I 144.4	135.4 I 154.9	433.2 I 480.6
Insulation	4.4 I 7.4	4.5 I 5.4	8.8 I 10.6	17.8 I 23.3
Heat Pumps buildings	2	4	5.3 I 4.9	11.5 I 11
Other technologies	161.9 I 172.1	120.7 I 134.7	121.3 I 139.5	404 I 446.3
Industry	15 I 17.2	15.5 I 15.7	13.5 I 17.2	44 I 50.1
Electric furnaces and boilers	0.3 I 0.4	0.3 I 0.4	1.9 I 2.2	2.5 I 2.9
Other technologies	14.7 I 16.9	15.2 I 15.3	11.5 I 15	41.4 I 47.2
Others energy	1.1 I 0.9	0.8 I 2	3.7 I 2.9	5.6 I 5.9

[1,000 M€ in 2017; amounts take into account discount rates]

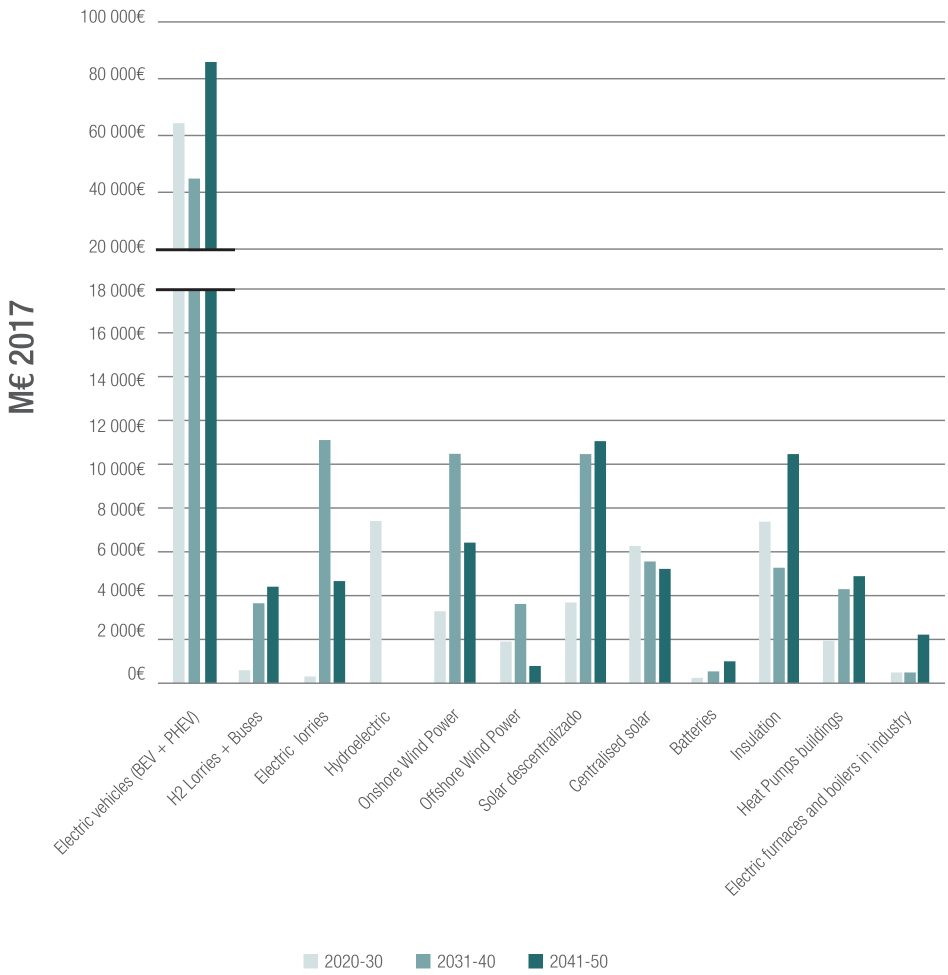


FIGURE 31

Volume of investment in selected technologies and the energy sector in the period 2016-2050 (M€2017)

In the power generation sector, the end of fossil fuels and the increase in demand caused by the growing electrification of the economy will dictate the need to make significant investments in increasing renewable capacity and, as existing renewable capacity reaches the end of its useful life, in its replacement (part of the country's existing wind and solar capacity reaches the end of its useful life before 2050 and will have to be replaced by new capacity). In this sector, it is anticipated that more than half of the required investment will be for the installation of solar capacity, more focused in a first phase on centralised solar plants and in a second phase on decentralised production (e.g. roofs of residential and service buildings) of photovoltaic energy. There will also be significant investments in wind power, very much focused on onshore wind power (wind turbines installed on land) and the introduction, in the second half of this period, of offshore wind power (wind turbines installed on ocean platforms). In the case of industry, investments will be associated with the energy transition, highlighting the focus on energy efficiency and electrification, namely with the adoption of electric furnaces and boilers.

The mobility and transport sector will be one of those that will have greater technological substitution and will be the sector that concentrates about 40% of the investment. This level of investment is associated with a major transformation of the passenger car fleet and the vehicles used for heavy passenger or freight transport. This high level of investment is due both to the imperative of reducing emissions and the relatively short useful life of the assets involved. In this context, the purchase of light passenger cars powered by electricity and heavy transport (goods and heavy vehicles) powered by electricity or hydrogen will be important.

In the residential and service building sector, most of the investment will be related to the renovation and replacement of electrical equipment with more efficient equipment, being low cost but very important equipment, and therefore requiring significant investment. Also of note is the need for substantial investments in building insulation, which will simultaneously increase thermal comfort and reduce the need for heating in the winter and cooling in summer, and the use of heat pumps, which are the most efficient way to provide this heating/cooling service. It is also noted that, due to climate change itself, these needs are likely to be aggravated by 2050, with predictable increases mainly in summer cooling needs.

In agriculture and forests, the reduction in emissions and increase in sequestration will be dependent on a significant reduction in burned areas and a range of other measures such as precision agriculture, conservation farming, biological farming and the use of composting, which will allow a reduction in emissions from synthetic fertilisers and their replacement with organic fertilisers, a reduction in emissions from livestock systems by increasing the quality of the diet and installing biodiverse pastures and by increasing sequestration through active afforestation and increases in average forest productivity. The overall amount of additional investments in some of the technologies identified, which can lead to reductions in fertiliser emissions and increases in sequestration on agricultural land, pastures and forests, amounts to around EUR 570 million over the period 2021-2050, equivalent to an annual amount of around 19 million euros.

TABLE 19: Volume of investment in technologies in the agriculture and forestry sector in the period 2016-2050

INVESTMENTS IN MITIGATION TECHNOLOGIES	2021-2030	2031-2040	2041-2050	Σ 2021/50
TOTAL AGRICULTURES, FORESTS AND OTHER LAND USES	**138.8**	**206.6**	**231.2**	**568.6**
Agriculture and agricultural land	56.0	77.5	99.0	232.6
Precision agriculture	53.8	73.0	99.0	219.0
Compositing	2.3	4.5	6.8	219.0
Pastures	66.8	11.1	11.1	89.0
Permanent biodiverse pastures	66.8	11.1	11.1	89.0
Forests	8.0	118.0	121.0	247.0
Forestation	8.0	118.0	121.0	247.0
[€ million]				

The nature of the waste and wastewater sector, in particular its importance as a public service, and existing and foreseeable environmental constraints on its future operation and performance, establishes an investment effort that has much more to do with regulation of the sector and existing environmental regulations and much less to do with measures to combat climate change.

In a very important way, the former compete for the fundamental objectives of the latter. For example, in the case of industrial wastewater, the effort to reduce GHG emissions involves generalising the secondary treatment of organic effluents.

This guidance has very positive consequences in terms of GHG emissions, and it seems distorted to refer to this investment effort as being for decarbonisation when it actually follows a trend of the first generation of environmental measures. On the other hand, the continuity of infrastructures, in particular with regard to existing buildings, drainage networks and treatment or final destination infrastructures, leads us to believe more in the maintenance of paradigms and continuous evolution than in disruptive technological changes in the sector. Moreover, the circular economy and organic load generation measures (for example, the reduction of unit production of organic waste and food waste) are very difficult to calculate and cannot be attributed, directly and mostly, to the policies and measures to combat climate change.

It is in this sense that it was considered that the mention and analysis of costs associated with the waste and wastewater sector is not important in the context of the objectives of RNC2050.

7.2 SAVINGS ON FOSSIL FUEL IMPORTS

The transition to a carbon neutral economy will be supported by increased use of endogenous renewable energy sources, which will reduce energy dependence from abroad from the current 78% to figures below 20%.

In 2015, Portugal consumed about 704 PJ of coal, natural gas and petroleum products. These fuels are either entirely imported (oil, coal and natural gas) or produced from imported raw materials (diesel, petrol, among others). With the achievement of a carbon neutral economy, this energy consumption will be reduced by about 90% by 2050 compared to 2015.

Purchasing these fuels is an important cost for the Portuguese economy and one of the factors that most penalises the Portuguese trade balance. In 2015, it represented more than 35% of the import balance of the balance of trade.

Carbon neutrality will thus allow substantial savings on the purchase of fossil fuels on international markets, with the estimated savings compared with consumption in 2015 exceeding the costs as of 2035.

Cumulative overall savings in the period 2020-2050 amount to around EUR 43 billion, which translates into an annualised amount of EUR 1.2 billion (about 0.6% of GDP). The additional savings with carbon neutrality amount to about EUR 10 billion for the whole period, or about EUR 275 million per year (about 0.1% of GDP).

The energy transition based on endogenous renewable energy sources represents, in the case of an open economy that is still heavily dependent on fossil fuel imports as the national economy is now, an important opportunity to reduce energy dependency and redirect resources that are currently used to purchase fossil fuels - and thus leave the national economy - for investment in the economy.

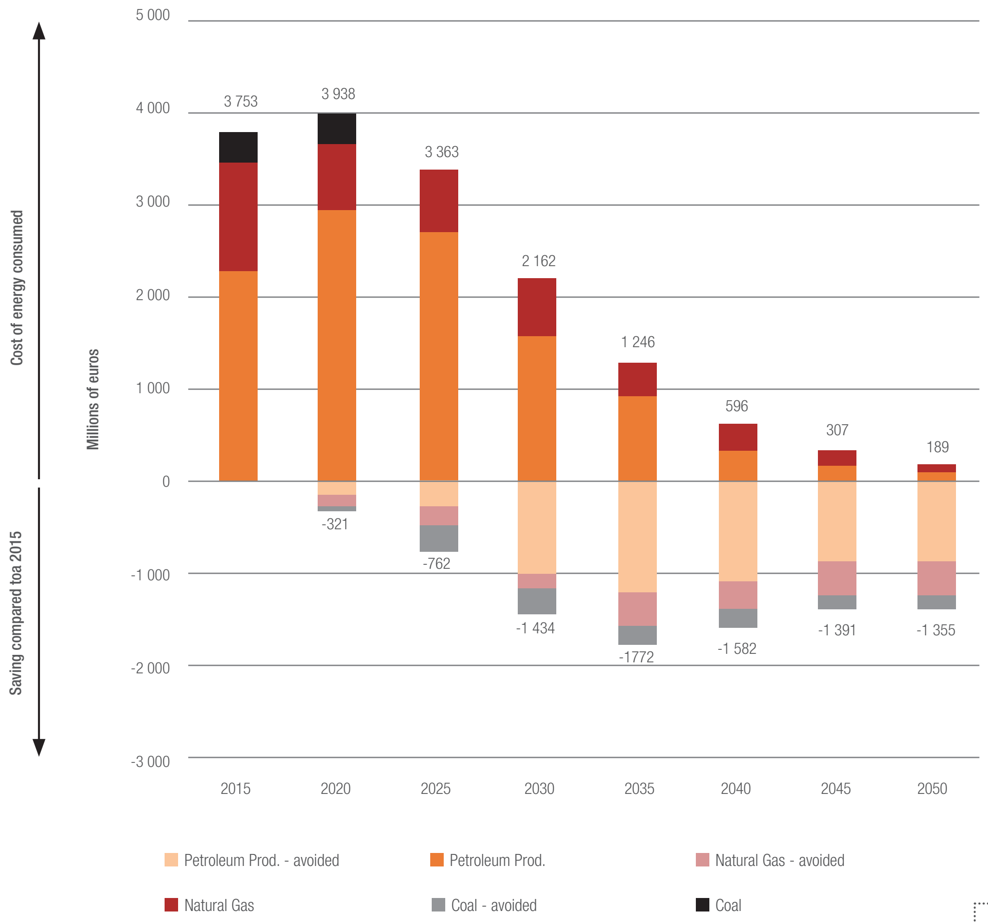


FIGURE 32

Costs and savings with import of the main fossil fuels

7.3. FINANCING

Financing the transition to a circular, carbon neutral society, in its many aspects, is crucial to the success of the national goal of achieving carbon neutrality by 2050.

To this end, it is necessary to ensure that climate policy is financed in a sustainable manner and that it is implemented efficiently, equitably and in line with the country's long-term objectives, avoiding financing investments that are not in line with this objective and enhancing the creation of new clusters in the country. It is therefore important to foster the development of a favourable environment for sustainable financing[12] and greater involvement of the financial system.

EUROPEAN FINANCING INSTRUMENTS

The financing of climate policy in Portugal has the support of several Community funds and should be properly articulated with the available mechanisms, in order to effectively maximise the benefits from them. Many of these funds and financial resources have already been redirected within the 2014-2020 Community framework to focus on projects with positive contributions to climate change mitigation or adaptation.

The 2021-2027 Multiannual Financial Framework will be one of the main sources of financing for

the decarbonisation of the economy in the next decade. As proposed by the European Commission, 25% of the overall expenditure budget should be devoted to climate action, which could mean an allocation to this area of around EUR 320 billion in the period in question.

Also noteworthy is the Action Plan for Financing Sustainable Growth, adopted by the European Commission, which aims to reorient capital flows towards sustainable investments, manage the financial risks arising from climate change and promote transparency and a long-term vision in economic and financial activities. A number of actions will emerge from this plan, including the creation of a common system for the classification of sustainable activities which will then be used by all Member States.

Also on the question of support for research and innovation in the digital industry area and for innovative low carbon technology demonstration projects, there are several programs at a European level for the next decade, such as the Horizon Europe Program, the LIFE Program - Program for the Environment and Climate Action, and the Innovation Fund - NER 450.

InvestEU is a new EU instrument for mobilising public and private financing for strategic investments under European policies and includes meeting investment sustainability requirements, helping to guide capital flows towards sustainable investment. This instrument covers various policy areas, such as sustainable infrastructure, research, innovation and digitisation, small and medium-sized companies and social investment and skills.

The Connecting Europe Facility (CEF) will enable the funding of energy, transport and digital infrastructure projects and the PAC, of which 40% will contribute to climate action, with a view to leading the transition to more sustainable agriculture.

With regard to adaptation, the Cohesion Policy which supports sustainable development through investments in adaptation to climate change and risk prevention, as well as environmental protection and infrastructure measures, should be highlighted. In this context, the European Regional Development Fund shall invest between 30% and 50% in innovation-related projects, and at least 30% in projects that combat climate change and contribute to the circular economy, and between 6% and 10% shall be allocated to the area of sustainable urban development.

12 According to the European Commission's action plan, 'sustainable financing' generally means 'a process by which environmental and social considerations are properly integrated into investment decisions, leading to increased investment in sustainable and long-term activities'. More specifically, environmental issues are related to climate change mitigation and adaptation, as well as to the wider environment and related risks (e.g. natural disasters). The term 'social considerations' covers issues of inequality, inclusiveness, labour relations, investment in human capital and communities. Social and environmental considerations are often intertwined, as climate change in particular can exacerbate existing systems that promote inequality. The governance of public and private institutions, including issues such as their management structures, labour relations or executive compensation, will have a key role to play in ensuring that social and environmental considerations are included in the decision-making process."

NATIONAL FINANCING INSTRUMENTS

The national climate policy also benefits from the allocation of an important group of revenues generated by the climate policies themselves, highlighting the revenues from auctions under the CELE regime, allocated to the Environmental Fund, which plays a prominent role as the main national instrument for financing climate action, in its mitigation and adaptation dimensions.

The use of CELE revenues for the purpose of combating climate change is a fundamental principle that has been applied by Portugal since 2012 and should be maintained and reinforced, in particular to support the implementation of sectoral actions, in line with the established policy guidelines in RNC2050, PNEC 2030 and P3AC.

Also at the national level, the National Investment Plan, which embodies decarbonisation of the economy as one of the structuring areas, should be highlighted for the next decade, with more than 66% of investment in areas contributing to these objectives.

At the level of public funding, there are also other national funds directed to support decarbonisation of the economy and the energy transition, offering financing possibilities that are available to both the public and private sectors, most notably the Innovation, Technology and Circular Economy Fund, the Energy Efficiency Fund, the Energy Sector Systemic Sustainability Fund, the Innovation Support Fund, the Blue Fund and the National Building Rehabilitation Fund.

In addition to these, there are a number of other important financing instruments such as the Energy Efficiency Credit Facility, the “Efficient House 2020” Program, the Urban Rehabilitation and Revitalization 2020 Financial Instrument, the Rehabilitate for Lease Program and the Plan for the Promotion of Efficiency in Electricity Consumption, mechanisms that are available for a short-term horizon but which may come to be replicated in the future if they are found to be necessary and cost-effective in promoting decarbonisation of the Portuguese economy.

PRIVATE SECTOR FINANCIAL INSTRUMENTS

Financing for decarbonisation and the circular economy has given rise to the development of financial products by the private financial sector, which thus manage to capture investment to be used in business activities that promote decarbonisation and the more efficient use of resources. Some of these products:

- Corporate green bonds: these are any type of bond instrument where the amount of the debt contracted will be applied exclusively to finance or refinance, in whole or in part, new projects and/or eligible green projects. The definition of project eligibility is normally given by the International Capital Market Association (ICMA) Green Bond Principles and the European Commission is currently working on the definition of a European Standard for Green Bonds.

- Sovereign green bonds: these are sovereign bonds very similar to the bonds usually issued, with the important difference that the funds obtained are exclusively dedicated to covering public expenditure on environmental benefits. As such, there is a need for detailed information on the destination of the funding raised, and there is also a need for annual reporting to investors on the use of the capital and the impact of the investments.

- Green loans: These are any type of lending instrument made available exclusively to finance or refinance all or part of new projects and/or existing eligible green projects. These green loans consist of assigning a loan to an entity, for which the interest rate payable will depend on the company's ability to meet the environmental objectives set and agreed between the lender and the borrower. For a loan to be considered green, there are several procedures outlined in the Principles for Green Loans produced by the Loan Market Association.

- Sustainable investment funds: these are funds that have environmental, social and governance criteria for choosing their assets. That is, they are funds that seek to acquire shares and/or bonds of companies that have demonstrated sustainability practices. These funds are growing fast, and 53% of European funds have some kind of environmental, social and governance criterion in structuring their portfolio.

- Blended Finance: this uses a combination of public and private (or philanthropic) financing to finance projects with a high impact on development and to improve the project's risk-return profile, that is, to improve its commercial viability for the private investor. The existence of blended finance means that it is possible to combine several types of financing for the same project, such as, for example, grants for training and technical assistance, investment in the company's capital, secured loans, among others.

These financial products are increasingly being used and are essential market tools for promoting effective decarbonisation in the economy.

Tax policy should also be aligned with the defined neutrality objective, giving the right signals to the economy, internalising externalities, influencing behaviour change and at the same time allowing the generation of public revenues that can be applied in decarbonisation measures and to ensure a fair transition. Green taxation should therefore be pursued with the aim of obtaining a triple dividend, economic, social and environmental.

The investment dynamics associated with decarbonisation of the economy and energy transition also provide an opportunity for innovation in the financial sector with the creation of new products and services linked to this new green economy, especially green bonds, green loans, sustainable investment funds and impact funds.

On the other hand, the financial sector should progressively incorporate environmental, social and governance factors into risk analysis, in order to minimise the risks arising from the exposure of its portfolios to projects and assets that, in the transition to neutrality paradigm, may become obsolete. These approaches contribute to reducing the risks associated with an investment and attracting new kinds of clients.

It is also important to mention the carbon price instruments that aim to internalise the carbon price in companies' strategic and operational decisions and promote the adoption by operators of lower cost measures that aim to reduce emissions. Setting a carbon price is one of the most cost-effective measures and a real incentive to reducing GHG emissions. A carbon price can be applied through a carbon tax or through an emissions trading systems, such as CELE. Portugal has participated in CELE since 2005 and adopted a carbon tax in 2015, in the form of an addition to the Petroleum and Energy Products Tax, subsequent to the 'Green Tax Law'.

Carbon pricing policies should be fostered, particularly through effective implementation of the CELE regime, promoting actions that lead to reinforcement of the carbon price, encouraging widespread application of the carbon tax to sectors not covered by CELE, eliminating existing exemptions. It is therefore important to ensure that these funds are recycled in the decarbonisation of society, by setting the right signals for economic operators on the one hand and, on the other, channelling the proceeds towards investment in decarbonisation and development of the necessary sustainable infrastructures for the country and so that the private sector can leverage its activity.

Achieving the established carbon neutral objective should therefore exploit a variety of financial instruments, and it is necessary to:

- Align funding cycles and national public funds with the key decarbonisation drivers and energy transition, and discontinue investments that are not in line with this objective;

- Leverage and guide direct investment (national and foreign) for a future economy, aligned with the areas and objectives of decarbonisation and national energy transition, enhancing the creation of new clusters in the country;

- Make taxation a key instrument for the transition to a carbon neutral society, by benefiting clean technologies and removing perverse incentives for fossil fuels or investments that increase emissions;

- Align the financial system with the decarbonisation objectives.

In this context, it will be essential to guarantee the existence of a stable and competitive regulatory framework that ensures the mobilisation of public and private financial flows for implementation of the measures necessary to achieve the stated objectives, thereby providing investors with stability in the various sectors.

In this context, it will still be necessary to establish mechanisms to monitor the mobilisation of financial flows to achieve the objectives of this RNC2050, notably through their integration into existing reporting mechanisms for climate policy monitoring matters.

7.4. IMPACT ON EMPLOYMENT AND GDP

Carbon neutrality, like any other profound transformation of society, presents both opportunities and challenges for the economy and employment.

In terms of opportunities, it is undeniable that there will be a positive effect on GDP and employment caused by investments for stimulating new sectors. Examples include investment in industrial modernisation, the circular economy, sustainable mobility and centralised and decentralised photovoltaic energy production. This investment with high potential for creating new business models, products and services, will generate wealth and employment in all the associated value chains - whether related to production, assembly, distribution and sale, financing, insurance, operation and maintenance, decommissioning, recycling.

However, the national total of this amount and employment will depend on the country's ability to attract and generate investment in the production of such equipment and the ability to develop the supply chain of services and related activities. This refers to the early identification of the new activity clusters that will be created by carbon neutrality and the need for the State to create a regulatory, fiscal and incentive framework that fulfils two main functions: eliminate any perverse barriers and subsidies that prevent the new technologies from expanding or that perpetuate technologies that impede decarbonisation; and maximise and promote information and adoption of technologies that foster decarbonisation.

The role of the State will also be fundamental for the development of the infrastructures that will be necessary for certain technologies to be a reality. Examples include the challenges posed by a mostly battery-based and/or hydrogen-based mobility, especially the need to greatly expand the battery charging network or to design and implement new networks, such as a network for hydrogen supply or of overhead electric contact lines on the main roads.

Another positive aspect of carbon neutrality lies in increased investment and employment in research, innovation and development activities, which should cover the development or refinement of technologies that enable decarbonisation, and also the development of new business models and the mobilisation of families and companies to work towards the decarbonisation objectives. In the field of training, it is possible to anticipate new training needs for staff and workers at many levels, that are able to produce, install and operate these technologies.

However, and in terms of challenges, there will be sectors that could potentially be affected by the energy transition. It is therefore necessary to identify in advance which sectors will be most affected and to start designing policies that create alternative opportunities for the affected workers and/or regions. For example, the changes in the automotive value chain due to the expansion of electric mobility, which must be reconverted in order to take advantage of the opportunities arising from this transition.

The economic and employment balance of carbon neutrality will therefore depend on: the wealth and employment generated by the opportunities of carbon neutrality; the wealth and employment that will be affected by this same neutrality; and the ability of Portuguese society to create new clusters.

The impact on GDP may be around 8%, compared to a scenario of stagnation of the current energy system, and an energy efficiency growth of only 0.1%/year, a very conservative scenario (BAU scenario).

Neutrality trajectories induce in the long term an additional positive impact in the economy, estimated at 0,5-0,9%, compared to an energy system that evolves to support a competitive and efficient economy, but which has not achieved neutrality (scenario without neutrality).

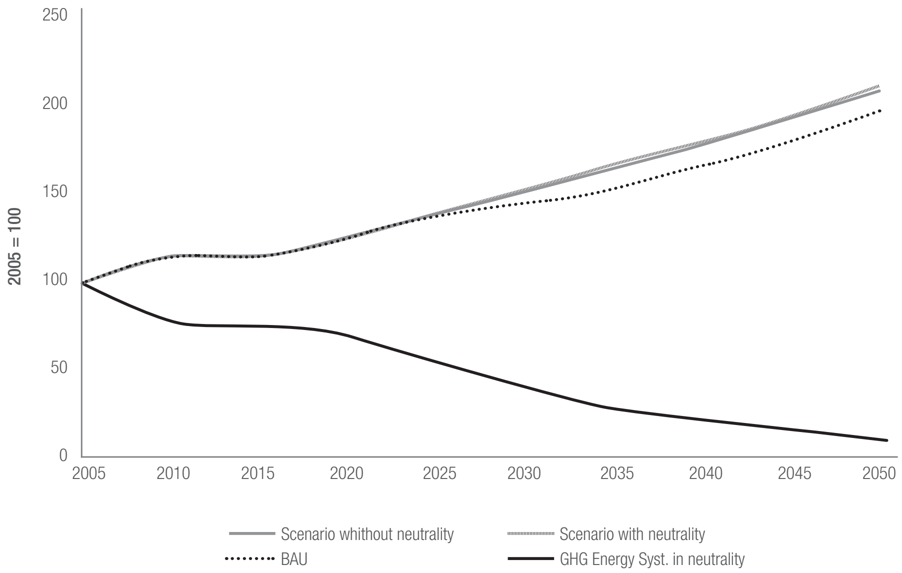


FIGURE 33

Evolution of GDP and GHG emissions in the period 2005-2050

TABLE 20: Macroeconomic impact of decarbonisation and carbon neutrality scenarios in 2050

IMPACT SCENARIO WTHIOUT NEUTRALITY (2050)		ADDITIONAL IMPACT OF NEUTRALITY (2050)	
GDP	8.1% I 9.2%	GDP	0.5% I 0.9%
PRIVATE CONSUMPTION	21.1% I 29.0%	PRIVATE CONSUMPTION	2.0% I 3.4%
INVESTEMENT	41.7% I 43.9%	INVESTEMENT	3.1% I 7.2%
EMPLOYMENT	0.8% I 0.8%	EMPLOYMENT	0.1% I 0.1%

In summary, the economic modelling of these changes suggests a broadly positive impact on GDP resulting from almost total decarbonisation of the national energy system, leveraged by a significant growth in investment and private consumption and net marginal job creation. That is, carbon neutrality will be positive for Portugal overall. It should be noted that these estimates do not include the benefits of the climate change damage avoided and the related costs of adaptation.

In addition, it should be acknowledged that the macroeconomic modelling is based on a structure of the economy and sectoral relationships maintained in the long term, so using these models over extended time horizons is always a challenge and a very uncertain exercise. In the context of RNC2050, the uncertainty related to the 35 years of modelling is exacerbated by the profound change in society and relations between economic agents that will be dictated by carbon neutrality itself. This means that macroeconomic models capture better the losses of the sectors affected by carbon neutrality than the opportunities brought about by new sectors or technologies. In other words, the economic and employment impacts are probably underestimated, and the benefits of carbon neutrality are probably far greater than those reported.

GEM-E3_PT MODEL

The GEM-E3_PT model is the national version of the European GEM-E3 model used several times by the European Commission to assess the macroeconomic impact of various European energy-climate policies. GEM-E3_PT is a dynamic, general equilibrium recursive model that encompasses all sectors of the national economy aggregated into 18 productive sectors (e.g. agriculture, forestry and fisheries; ferrous and non-ferrous metals; chemicals; other energy-intensive industries; transportation equipment; land transport; credit and insurance services) and 13 household consumer goods (e.g. clothing and footwear; housing; fuels and electricity; heating and kitchen appliances; medical and health care; transport equipment; communications).

The main objective of the model is to maximise profit in the productive sectors and the economic well-being of households by calculating the equilibrium between market prices for goods and services, labour and capital.

In addition, the model also has a technological breakdown of the power generation sector into 13 distinct technologies, which have different production factors, including materials from numerous sectors, as well as a sectoral investment matrix.

The GEM-E3_PT model is based on a calibrated social accounting matrix for 2005, which represents the economic transactions of national accounts between the various economic agents, determining the different revenues and expenses of the productive sectors, households, government and the rest of the world, i.e. exports and imports, as well as production, employment, investment and others.

8.
ENSURE A FAIR AND COHESIVE TRANSITION

Climate change and the responses to this global challenge have an impact on employment and economic activities, and the Paris Agreement takes into account the need to safeguard a fair transition for the workforce and the creation of decent and quality jobs, according to each country's development priorities.

The transition to carbon neutrality implies a systemic transformation of the structure and operation of the current economic system which, at a national level, may represent more opportunities than risks. Indeed, this transformation will bring opportunities for new business models and the creation of new clusters with network generation, for example in the sectors related to renewable energy production, automation engineering or services and logistics associated with shared and autonomous mobility. Thus, the macroeconomic analysis developed points to marginal net job creation, in an extremely conservative scenario.

However, job losses are also expected to occur in traditional sectors of goods and services, especially those based on energy-intensive production and fossil-based consumption. At a national level, for example, following the commitment to abandon coal-fired power generation by 2030, direct impacts of energy transformation on the two coal-fired power plants can be anticipated. Proper management involving all the relevant actors will be critical in planning the transition and identifying specific measures to ensure a fair transition for the workers and communities concerned.

If, on the one hand, the large combustion plants will necessarily lose importance, it is now relatively consensual that job creation in renewable energy production can more than compensate for this loss of local employment. Therefore, a series of actions will have to be programmed to anticipate creation of the conditions and skills necessary for a fair transition, focused on professional retraining and requalification that will ensure the income of the populations most directly linked to the sectors in decline.

Carbon neutrality will drive the acquisition of new skills, as well as the creation of new business models. Currently in Portugal there are about 10,000 direct jobs linked to the renewable energy cluster, including about 3,000 in the wind cluster. The nature of the transition to a less concentrated system will mean greater demand for skilled, though necessarily more dispersed, labour.

It is therefore crucial to ensure that national and European support frameworks are oriented towards research and technological development alongside comprehensive investment in education, professional and vocational training in line with the new paradigms of national business sectors that aim to (re)qualify the workforce to ensure a fair transition.

9.
GUARANTEE EFFECTIVE CONDITIONS FOR GOVERNANCE AND ENSURE THE INTEGRATION OF CARBON NEUTRAL OBJECTIVES IN SECTORAL AREAS

In order to ensure monitoring of the transition to carbon neutrality, it will be necessary to adopt a governance model that will guarantee policy articulation, climate policy implementation and the coherence of national sectoral policies and strategies with the aim of achieving carbon neutrality by 2050.

To this end, there is already a series of governance structures at a national, either at a political level, such as the Interministerial Commission on Air, Climate Change and the Circular Economy (CA)[13] , or at a technical level with sectoral articulation, in which the SPeM[14] and the National System of Inventory of Emissions and Removal of Atmospheric Pollutants (SNIERPA) take on particular relevance.

CA2 provides guidance of a political nature and promotes the articulation and integration of climate change policies into sectoral policies and monitoring of the implementation of the relevant sectoral measures, programs and actions that are adopted.

In addition to monitoring compliance with Portugal's commitments at national, Community and United Nations levels, this Commission should also ensure the promotion, supervision and monitoring of the implementation of policies and measures for effective implementation of the guidelines and compliance with the emission reduction targets established by the Integrated National Energy and Climate Plan (PNEC), and future periodic reviews, pursuant to Regulation (EU) 2018/1999 of the European Parliament and the Council of 11 December 2018.

In this way, monitoring progress towards the carbon neutral target will also fall to this Commission.

The National System of Policies and Measures (SPeM) aims to involve and strengthen sectoral accountability in integrating the climate dimension into sectoral policies; ensure monitoring, follow-up and reporting of implementation of the policies and measures and their effects, and reporting of the projections of greenhouse gas emissions and other air pollutants; assess compliance with national obligations, including sectoral targets, under the EU package of climate and energy and of air policies for the 2020, 2025 and 2030 time horizons, as set out respectively in PNAC 2020 - 2030 and the National Strategy for the Air 2020.

Charting a course for carbon neutrality entails aligning sectoral policies with this long-term objective, and therefore the decarbonisation guidelines and vectors will need to be integrated into the various relevant sectoral policy plans and instruments, notably in the areas of energy, transport, trade, services, waste, agriculture and forests. Sectoral policies should thus focus on solutions that contribute to carbon neutrality and avoid options that limit the achievement of decarbonisation objectives in the future.

13 Created by Council of Ministers Resolution no. 56/2015, of 30 July, and its specific CA2 responsibilities are set out in Order no. 2873/2017, of 6 April

14 Created by Council of Ministers Resolution no. 45/2016, of 26 August

In this context, it will be essential to establish an impact assessment procedure to be incorporated into the legislative process, in order to make it possible to measure the contribution of these sectoral policy instruments and plans to carbon neutrality.

Achieving this goal implies changes in our economy, our territorial model and our society, and therefore strengthening territorial cohesion in the transition process is crucial. Thus, this transition must be made in a planned way, involving the different sectors of our society and the different regions.

Promoting the development of carbon neutrality roadmaps, at a regional and/or inter-municipal level, consistent with and linked to RNC2050, will enable a cohesive transition that is closer to the citizen, involving the active participation of regional actors and entities from different levels of territorial organisation.

10.
ENGAGE SOCIETY, FOCUS ON EDUCATION, INFORMATION AND AWARENESS AND CONTRIBUTE TO INCREASING INDIVIDUAL AND COLLECTIVE ACTION

Understanding the problem of climate change and mobilising citizens, economic actors and policy makers to reduce GHG emissions and promoting society's adaptation to a world with a changing climate are prerequisites for the success of any climate policy.

According to the Special Climate Change Eurobarometer of 2017, the Portuguese expressed the following opinions:

- 83% consider climate change a 'serious or very serious problem';
- they consider that national governments (50%), businesses and industry (48%), the EU (38%), local and regional authorities (36%) should take action to combat climate change;
- they believe that the impact on the economy and employment will be positive when combating climate change and promoting energy efficiency (87%) and reducing fossil fuel imports (79%);
- they consider it important for the government to set national targets for increasing the use of renewable energy (94%);
- they consider that the transition to clean energy should be supported financially and that fossil fuel subsidies should be reduced (82%) and that the government should support energy efficiency, particularly in the residential sector (93%)
- 20% consider themselves personally responsible for taking action;
- 60% say they have recently taken actions in the sense of combating climate change. However, when asked about concrete actions (such as adopting energy efficiency measures at home, acquiring efficient household appliances, behavioural change and mobility investments, etc.) the positive answers are not very significant.

These results suggest that the Portuguese, as consumers and citizens, acknowledge climate change as a problem but expect the government, businesses and local and regional authorities to act. It is therefore necessary to reinforce the notion of the importance of the contribution of individual action, through changes in behaviour and lifestyle.

In the business world, there is also a growing number of companies that have been integrating climate change as a critical factor in their business strategies and external communication, thus adopting a series of concrete actions that reduce their GHG emissions and/or call for changes in the behaviour of their consumers.

The installations with bigger emissions at a national level have, since 2005, been covered by the CELE regime, whereby they are required to monitor, report and reduce their annual emissions. This coverage has internalised in these companies the environmental cost of greenhouse gas emissions, since such emissions have an associated cost. The existence of a robust carbon price is a key factor in driving investment in energy efficiency and low carbon technologies, resulting in reduced emissions, but also in reduced production costs and increased competitiveness.

Aware of the paradigm shift, the various industrial sectors have been developing their own low carbon roadmaps, in which they identify the options for adapting their activity to the new reality; by anticipating the risk of disruption of their business model and strategic positioning focused on climate action as a competitive advantage.

There is also increasing adherence to systems that calculate their carbon footprint; auditing and reporting systems; eco-labelling systems; or environmental certification systems. Many companies are already using this information in their communication with consumers, their suppliers and other stakeholders, suggesting that many are aware of and interested in the social transformation associated with decarbonisation.

To generalise these trends, it is necessary to focus on raising awareness and training of corporate decision makers and employees to adopt sustainable production and service delivery methods that contribute to the fight against climate change, in particular by exploiting strategic themes such as the potential for GHG emissions reduction that their companies can achieve; the importance of integrating and safeguarding decarbonisation in their supply chains; the dissemination of good practices in terms of communication with consumers and enhancing transparency through tools such as the carbon footprint; the diffusion of new technologies and promotion of an environment for dialogue between research, innovation and development and the business world; the importance of eco-design, of energy efficiency; the circularity of production processes and materials, encouraging the use of by-products from other industries and the reduction or disposal of waste.

The financial system should be encouraged to differentiate positively and redirect investment towards sustainable, resilient and low carbon technologies and projects. Training of the staff of these institutions will be crucial for their decision trees to start to include criteria related to the contribution of proposed investments to decarbonisation and to assess the tolerance and resilience of these investments with regard to the consequences of climate change itself. It is also important to mobilise the demand side to increase its interest in more sustainable financial products and to publicise the importance of decarbonisation issues to businesses and consumers.

Portuguese non-governmental organisations active in the most diverse thematic areas, such as the environment, cooperation for development, human rights and local development, have also given increasing importance to the theme of climate change, contributing to citizens' greater awareness and information and monitoring the actions of businesses, public bodies and policy decisions in this field.

Finally, and at the level of public authorities, there has also been significant progress. Examples of concrete measures for decarbonisation in the public sector include the Energy Efficiency in Public Administration Program 'ECO.AP', which has the aim of enabling the State to reduce energy consumption in services and agencies and to achieve a level of energy efficiency of 30% in Public Administration bodies and services; the Support Program for Electric Mobility in Public Administration, which aims to promote decarbonisation and improve the environmental performance of the State's vehicle fleet; and the National Strategy for Green Public Procurement 2020 (ENCPE 2020), which aims to stimulate the adoption of a green public procurement policy.

Employees and decision makers of the State and its central, sectoral, regional and local institutions will also need to be continually trained in order to integrate a climate change dimension into various sectoral policies and local planning. Also at a local level, there is an increasing number of municipalities involved in projects for reducing emissions of greenhouse gases and/or planning adaptation to climate change, which can be seen, for example, in the Adap.PT Program[15] and the national participation in the Covenant of Mayors[16] .

In the context of defining climate change policies, plans and programs, the involvement of the relevant actors and society at large is already an acquired practice that contributes to the adjustment essential to ensure their successful implementation. The preparation of RNC2050 was a participatory process with different formats and in different phases that allowed, from the beginning, the involvement of different points of view, the sharing of experiences and the co-creation of knowledge, which contributed to the development of a more informed Roadmap.

The need for vast climate literacy at all levels of Portuguese society demonstrates the fundamental role of the education system, universities, vocational training and research laboratories. The decision makers in these areas should be mobilised and made aware of the importance of introducing these subjects into the curricula at various education levels, but also of the development of specific programs for training company employees for the new technologies and practices that will help the occupational retraining of workers in the sectors affected by decarbonisation.

These subjects should also be included in the National Financial Education Plan.

It therefore seems reasonable to assume that, as far as Portuguese society in general is concerned, there is a favourable starting point in Portugal for taking ambitious decisions on climate action. However, as RNC2050 shows, climate action will have to be sustained over decades and support for these policies cannot be taken for granted, so it is important that interest in and acceptance of these policies be continually promoted.

This task will always have a special focus on the citizen and, in this regard, it will be necessary to continue:

- Communicating what climate change is, how it manifests itself and how it evolves;
- Educating about the climate impact of consumption choices and individual behaviours on emissions and ways to reduce these impacts;
- Reinforcing the role of agents of change among the economic actors as consumers of goods and services;
- Facilitating access to information on the impact of goods and services consumed; and
- Creating a culture that demands that policy makers and economic and financial actors at all levels make decisions that lead to effective climate action.

15 https://apambiente.wixsite.com/adapt/sobre-adapt

16 https://www.pactodeautarcas.eu/pt/

11.
FINAL CONSIDERATIONS

The path to carbon neutrality poses a significant series of challenges and opportunities for society. The transition to a carbon neutral economy requires timely long-term planning to take advantage of the opportunities associated with the transformation of the existing economy and to establish the basis of trust with the citizens and economic agents that this change is possible, advantageous and timely.

Carbon neutrality by 2050 is economically and technologically feasible and is based on a reduction in emissions of between 85% and 90% by 2050, compared with 2005, and offsetting the remaining emissions through a carbon sink provided by land use and forests. The trajectory to neutrality allows the anticipation of greenhouse gas emission reductions of between -45% and -55% by 2030 and between -65% and -75% by 2040, compared to 2005.

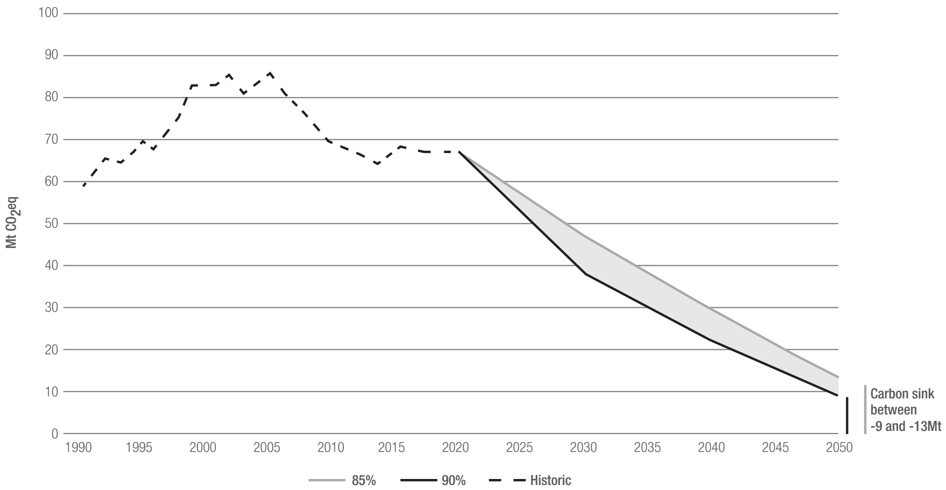


FIGURE 34

Emissions reduction trajectory from 85% to 90% by 2050, compared to 2005

TABLE 21: Trajectories for carbon neutrality in 2050

RNC2050 TRAJECTORIES	2015	2030	2040	2050
Emissions reduction vs 2005	-	45%I55%	65%I75%	85%I90%
Emissions (Mt CO_2eq)	68	39I48	22I30	9I13
Carbon sequestration (Mt CO_2)	9			9I13

RNC2050 identifies key future trends and the social and economic transformations that will be needed, involving all sectors of the economy and society, and preparing a socially fair and cost-effective transition, enhancing the competitiveness of the national economy, promoting job creation and boosting co-benefits, particularly associated with air quality and human health.

In this regard, the following decarbonisation vectors and action lines for a carbon neutral society are identified:

a) Decarbonising power generation by eliminating coal-based power generation by 2030 and proceeding with full decarbonisation of the power generation system by 2050, counting on renewable endogenous resources;

b) Achieving energy transition by significantly increasing energy efficiency in all sectors of the economy, focusing on incorporating endogenous renewable energy sources into final energy consumption, promoting electrification and adjusting the role of natural gas in the national energy system;

c) Progressively decentralising and democratising energy production and highlighting the role of the consumer as an active part of the energy system;

d) Promoting decarbonisation in the residential sector, favouring urban regeneration and increased energy efficiency in buildings, fostering progressive electrification of the sector and the use of more efficient equipment, and combating energy poverty;

e) Decarbonising mobility by favouring a public transport mobility system, by strengthening it and decarbonising fleets, supporting innovative and intelligent solutions for multimodal, active, shared and sustainable mobility, as well as electric mobility and other zero emission technologies, in addition to reducing the carbon intensity of sea and air transport, focusing on innovation, efficiency and cleaner, renewable fuels, as well as, by decarbonisation of short and long distance freight transport, promoting a logistic chain with a modal split that minimises the carbon and energy intensity of the transport system, reaffirming the role of maritime and inland waterway transport combined with rail freight transport.

f) Promoting energy transition in industry, the incorporation of low carbon production processes and industrial symbioses, promoting innovation and competitiveness;

g) Committing to sustainable agriculture, through a significant expansion of conservation agriculture and precision agriculture, substantially reducing emissions associated with livestock and fertiliser use and promoting innovation;

h) Encouraging carbon sequestration through active agricultural and forest management, promoting valorisation of the country;

i) Changing the paradigm of resource use, moving away from the linear economic model and moving towards a circular and low carbon economic model;

j) Preventing waste generation, increasing recycling rates and reducing waste disposal in landfills very significantly;

k) Boosting the participation of cities and local governments in decarbonisation by encouraging an integrated approach to its different vectors, in particular mobility, buildings, services and waste management, and enhancing the role they have played in mitigating climate change;

l) Encouraging research, innovation and the production of knowledge in favour of neutrality in the various sectors of activity;

m) Making taxation an instrument of the transition to neutrality, continuing to eliminate environmentally harmful subsidies, reinforcing application of the carbon tax and promoting greater taxation of resource use, reducing the tax burden on labour, recycling revenues for decarbonisation and a fair transition;

n) Aligning financial flows for carbon neutrality, notably by fostering the development of a favourable environment for sustainable financing and greater involvement of the financial system;

o) Promoting the involvement of society in the transition, contributing to increase individual and collective action, the adoption of sustainable behaviours and a change in patterns of production and consumption in favour of sustainability, particularly through environmental education and awareness;

p) Promoting skills development and (re)qualification directed towards the new opportunities for economic development;

q) Encouraging the development of the new economy linked to energy transition and decarbonisation, supporting the development of new industrial clusters and the generation of new business opportunities;

r) Promoting a fair and cohesive transition that enhances the country, creates wealth, promotes employment and contributes to raising the standards of quality of life in Portugal.

The practical realisation of the path to carbon neutrality and of these vectors should be initiated now within the PNEC framework, in order to achieve by 2030 the ambitious GHG reductions needed to align the national economy with a carbon neutral trajectory.

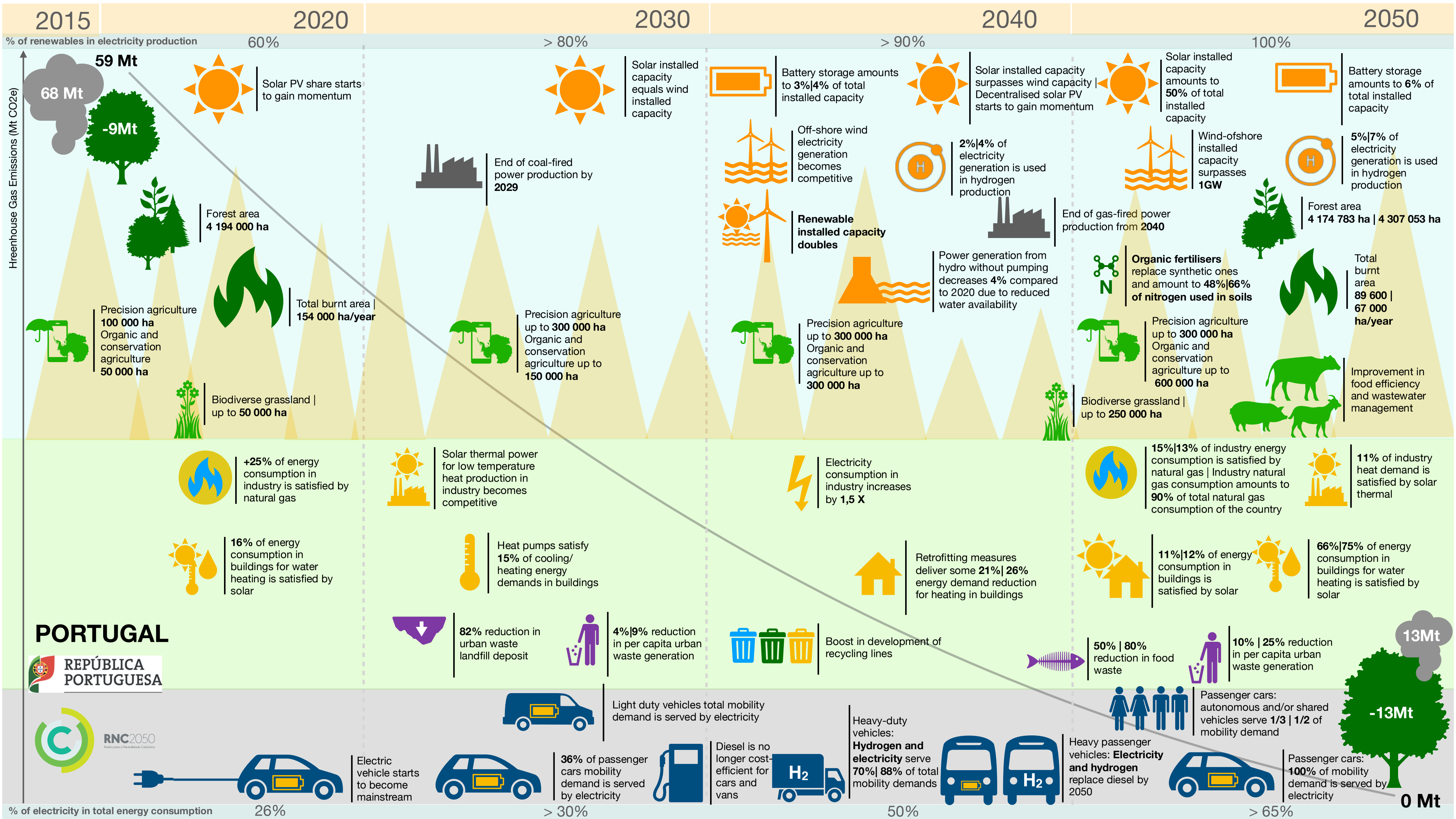
The decarbonisation vectors should be integrated into the development and review of relevant sectoral policies, in conjunction with existing instruments such as SPeM and SNIERPA, creating a culture of assessing the impact on national emissions of legislative proposals and all relevant sectoral instruments.

The achievement of a cohesive transition with the active participation of entities at different levels of territorial organisation, of regional agents and those closest to the citizen can be better ensured by a deeper understanding of RNC2050 at a sectoral, regional and/or inter-municipal level.

Given the normal development of society and the evolution of technologies at the disposal of the country over a broad time horizon, it is important to ensure that RNC2050 is periodically updated with a view to incorporating, inter alia, monitoring of the evolution of climate change and the relevant international and European policies.

Articulation and coordination of the different actors would benefit from a climate change law, which would be a fundamental instrument for combating climate change, in terms of mitigation and adaptation, enshrining their integration across society as a whole and establishing a governance structure for this purpose.

Ensuring compliance with the Paris Agreement implies continuing to support the mobilisation of efforts to increase global ambition and climate action, strengthening international cooperation on climate action, in particular with the Portuguese-speaking countries; continuing to defend Europe's leading position in combating climate change; and continuing to participate in initiatives aimed at promoting and disseminating good climate action practices.



OVERALL NARRATIVE OF CARBON NEUTRALITY BY 2050

RESOLUTION OF THE COUNCIL
OF MINISTERS

RESOLUTION OF THE COUNCIL OF MINISTERS

The Paris Agreement reached in 2015 set long-term objectives to contain the increase of the global average temperature to a maximum of 2 °C above pre-industrial levels, with the commitment of the international community to make all possible efforts to ensure that this increase would not exceed 1.5 °C, figures that science defines as maximums to ensure the continuation of life on the planet without overly serious changes. It also set objectives to increase the ability to adapt to the adverse impacts of climate change and for mobilisation of financial flows consistent with low emission paths and resilient development, emphasising the need to strengthen international cooperation among states to achieve these objectives.

The Paris Agreement thus represents a paradigm shift in the implementation of the United Nations Framework Convention on Climate Change, with the explicit acknowledgement that only with everyone's contribution can the challenge of climate change be overcome, and its main commitments are to achieve a global balance between anthropogenic emissions and removals - carbon neutrality - in the second half of the century.

Limiting global warming to 1.5 °C, in line with the more ambitious objectives of the Paris Agreement and the International Panel on Climate Change (IPCC) Special Report on global warming of 1.5 °C, requires the unprecedented transformation of societies and the urgent and profound reduction of greenhouse gas (GHG) emissions in all sectors of activity, as well as behavioural changes and the involvement of all the actors. It is also an unprecedented economic opportunity for an open economy that is still heavily dependent on fossil fuel imports like the Portuguese economy.

The Paris Agreement acknowledges that achieving carbon neutrality in the second half of this century will require strong leadership from developed countries and urges all Parties to present their long-term low-GHG development strategy by 2020.

The European Union (EU) is preparing to adopt its long-term strategy, based on the European Commission Communication "A Clean Planet for All", presented on 28 November 2018. The Commission's proposal sets a long-term strategic vision for a prosperous, modern, competitive and climate-neutral economy. Under this strategy, projections indicate that the policies and objectives already established for the EU as a whole will allow GHG emissions to be reduced by around 45% by 2030 and around 60% by 2050.

However, in order to contribute adequately to the Paris Agreement objectives, the EU should achieve carbon neutrality by 2050, corresponding to reductions of 80-95% in GHG emissions. Thus, it is essential to outline the best way to achieve this goal by aligning action in key areas, investing in realistic and cost-effective technological solutions, promoting active citizen participation and ensuring a fair transition.

Portugal has shown excellent results in climate policy matters over the past decades, having exceeded the targets set in the Kyoto Protocol and being on course to meet the goals set for 2020 of GHG emission reduction, energy efficiency and promotion of renewable energy sources. Since 2005, the national economy has tended to decouple economic growth from GHG emissions.

In 2016, the government made a commitment to achieve carbon neutrality by 2050, outlining a clear vision on decarbonisation of the national economy and contributing to the most ambitious objectives under the Paris Agreement.

To support this commitment, the government decided to draw up a 2050 Carbon Neutrality Roadmap (RNC2050) with the aim of exploring the feasibility of trajectories that lead to carbon neutrality, identifying the main decarbonisation vectors and estimating the carbon reduction potential of various sectors of the national economy, such as energy and industry, mobility and transport, agriculture, forests and other land uses, and waste and wastewater.

Decarbonisation of the economy is an ambitious goal that demands the broad involvement and participation of society as a whole, which is why RNC2050 motivated an unprecedented participatory process of involvement of the main sectors and mobilisation of Portuguese society.

RNC2050 shows that there are technologically feasible and economically viable cost-effective means for achieving carbon neutrality. Achieving carbon neutrality will have a positive impact on the economy and job creation, boosts investment and creates greater economic dynamism, while allowing significant savings that lead to equilibrium of the balance of payments. Additionally, it is associated with several positive impacts, such as improved air quality that inevitably translates into health gains.

Achieving carbon neutrality by 2050 implies, along with strengthening the carbon sequestration capacity of forests and other land uses, the near-total decarbonisation especially of the power generation system and of urban mobility, as well as profound changes in the way we use energy and resources, focusing on an economy that is based on renewable resources, that uses the resources efficiently and that relies on circular economy models, with special attention to logistic chains, with a modal split that minimises the carbon and energy intensity of short and long-distance freight transport, enhancing the country and promoting national cohesion.

The proposal is a process that will be truly transformational regarding how one faces some of the most crucial aspects of life in society, in particular as regards production and consumption patterns, the relationship with energy production and use, the way cities and housing, work and leisure spaces are thought of, or the way mobility needs are addressed.

Achieving carbon neutrality by 2050 represents an opportunity for the country to consolidate an inclusive and people-centred model of sustainable development based on innovation, knowledge and competitiveness, while contributing to improving the health and well-being of people and of ecosystems. Achieving carbon neutrality is indeed probably the *only way* for Portugal to leverage its gains and position itself in a highly competitive international economic environment.

This vision will necessarily have to be translated into various sectoral policy plans and instruments in the areas of energy, transport, industry, trade, services, waste, agriculture and forests. Although greater investment in GHG reduction and energy transition is required over the next decade, this investment will have a high return and the co-benefits will be advantageous to society as a whole.

The Portuguese strategy for the transition to a carbon neutral economy is based on a combination of several options of policies and measures, as well as cost-effective technological options, seeking to find synergies between the various options. Decarbonisation is feasible with current technologies, and the development of new technologies will make it possible to achieve this goal more quickly and effectively than is currently estimated.

The development of new technologies and the refinement of existing low carbon technologies requires a significant impetus in innovation and research, which shall be achieved by adopting an ambitious and broad agenda covering all stages of the technology development cycle through to marketing.

For this, a large contribution will come from national and European support frameworks for research, innovation and development, which should be geared towards research into new technologies, new business models and the promotion of behavioural changes that will permit further increases in decarbonisation, creating innovative, efficient and "green" solutions with near zero emissions.

Achieving the objective of carbon neutrality will entail allocating different financial flows to this objective, notably the next financing cycle under the Multiannual Financial Framework, national funds and directing foreign direct investment towards decarbonisation of the economy and of society and the energy transition, avoiding financing investments that are not in line with this objective and boosting the creation of new clusters in the national territory.

It is also necessary to examine the economic and social aspects of carbon neutrality, including new clusters and the affected sectors, and to develop policies to, respectively, create conditions for their development and anticipate appropriate territorial or social responses, at the level of education, training and professional retraining, to ensure a fair transition.

Therefore:

Under the terms of paragraph g) of article 199 of the Constitution, the Council of Ministers resolves:

1. To approve the Roadmap for Carbon Neutrality 2050 (RNC2050), which is in the annex to this resolution and which forms an integral part thereof, adopting the commitment to achieve carbon neutrality in Portugal by 2050, which translates into a neutral balance between greenhouse gas (GHG) emissions and carbon sequestration by land use and forests.

2. To establish the objective, for the purposes of the preceding paragraph, of reducing GHG emissions in Portugal by 85% to 90% by 2050, compared to 2005, and to offset the remaining emissions through land use and forests, to be achieved through a trajectory of emissions reduction between 45% and 55% by 2030, and between 65% and 75% by 2040, compared to 2005.

3. To establish as the main decarbonisation vectors and lines of action for a carbon neutral society, for the purposes of paragraph 1, the following:

    a) Decarbonising power generation by eliminating coal-based generation by 2030 and proceeding with full decarbonisation of the power generation system by 2050, counting on renewable endogenous resources;

    b) Achieving the energy transition by significantly increasing energy efficiency in all sectors of the economy, focusing on incorporating endogenous renewable energy sources into final energy consumption, promoting electrification and adjusting the role of natural gas in the national energy system;

    c) Progressively decentralising and democratising energy production and highlighting the role of the consumer as an active stakeholder in the energy system;

    d) Promoting decarbonisation in the residential sector, favouring urban rehabilitation and increased energy efficiency in buildings, fostering progressive electrification of the sector and the use of more efficient equipment, and combating energy poverty;

    e) Decarbonising mobility, favouring the system of mobility in public transport, through its reinforcement and decarbonisation of fleets, supporting innovative and intelligent solutions for multimodal, active, shared and sustainable mobility, as well as electric mobility and other zero emissions technologies, in addition to reducing the carbon intensity of maritime and air transport, focusing on innovation, efficiency and cleaner and renewable fuels, as well as decarbonisation of short and long-distance freight transport, promoting a logistics chain with a modal split that minimises the carbon and energy intensity of the transport system, reaffirming the role of maritime and inland waterway transport combined with rail freight;

f) Promoting the energy transition in industry, the incorporation of low carbon production processes and industrial symbioses, promoting innovation and competitiveness;

g) Committing to sustainable agriculture, through a significant expansion of conservation and precision agriculture, substantially reducing emissions associated with livestock and fertiliser use and promoting innovation;

h) Encouraging carbon sequestration through active agricultural and forest management, promoting valorisation of the territory;

i) Changing the paradigm of resource use in production and consumption, moving away from the linear economic model and moving towards a circular and low carbon economic model;

j) Preventing waste generation, increasing recycling rates and reducing waste disposal in landfills very significantly;

k) Boosting the participation of cities and local governments in decarbonisation by stimulating an integrated approach to its different vectors, in particular mobility, buildings, services and waste management, and enhancing the role they are beginning to play in mitigating climate change;

l) Encouraging research, innovation and the production of knowledge in favour of neutrality in the various sectors of activity;

m) Making taxation an instrument of the transition to neutrality by continuing to eliminate environmentally harmful subsidies, reinforcing the application of carbon taxation and promoting higher taxation on resource use, recycling revenues for decarbonisation and fair transition;

n) Redirecting financial flows to promote carbon neutrality, in particular by fostering the development of a framework that favours sustainable financing and greater involvement of the financial system, and monitoring it;

o) Promoting the involvement of society in the transition, contributing to increased individual and collective action, the adoption of sustainable behaviours and a change in patterns of production and consumption in favour of sustainability, particularly through environmental education and awareness;

p) Promoting skills development and (re)qualification directed towards the new opportunities for economic development;

q) Encouraging development of the new economy linked to energy transition and decarbonisation, supporting the development of new industrial and service clusters and the generation of new business opportunities;

r) Promoting a fair and cohesive transition that valorises the territory, creates wealth, promotes employment and contributes to raising the standards of quality of life in Portugal.

4. To determine that RNC2050 is the long-term low-GHG development strategy to be submitted to the United Nations Framework Convention on Climate Change, in accordance with UNFCCC Decision 1/CP.21, and to the European Commission, in accordance with article 15 of Regulation (EU) 2018/1999 of the European Parliament and the Council, dated 11 December 2018.

5. To establish that the realisation of the policies and measures for effective implementation of the guidelines contained in this resolution and achievement of the emission reduction targets established are carried out within the framework of the Integrated National Energy and Climate Plan, which is reviewed in accordance with Regulation (EU) 2018/1999 of the European Parliament and the Council, dated 11 December 2018.

6. To determine that the neutrality objective and decarbonisation vectors identified by RNC2050 shall be included and specified in the development and review of relevant sectoral policies, in liaison with the National System of Policies and Measures, established by Council of Ministers Resolution no. 56/2015 of 30 July, and the National Inventory System of Emissions and Removal of Air Pollutants, as defined by the Resolution of the Council of Ministers no. 20/2015, of 14 April.

7. To promote the elaboration of regional or inter-municipal carbon neutral roadmaps, consistent with and linked to RNC2050 and also between themselves, that enable a cohesive transition and involve the active participation of entities from different levels of territorial organisation, of regional agents and closer to the citizen.

8. To establish that monitoring progress towards the goal of carbon neutrality is carried out by the Interministerial Commission for Air, Climate Change and Circular Economy, created by Council of Ministers Resolution no. 56/2015 of 30 July.

9. To determine that RNC2050 is updated every 10 years with a view to incorporate, inter alia, monitoring of the evolution of climate change and important international and European policies, the normal development of society and of the technologies available to the country and the evolution of the cost structure of the technologies considered.

10. To determine that this resolution shall enter into force on the day following its publication.

Presidency of the Council of Ministers, 6 June 2019

The Prime Minister

NOTE: The annex referred to is the Roadmap for Carbon Neutrality presented in the first part of this document.

REPÚBLICA PORTUGUESA
AMBIENTE E TRANSIÇÃO ENERGÉTICA

FUNDO AMBIENTAL
Environment Portugal

apa
portuguese environment agency

ENGLISH VERSION | 2019