Technical Report on GHG Projections

Under Article 18.º of Regulation (EU) 2018/1999 of the European Parliament and of the Council and Article 38.º of the Commission Implementing Regulation (EU) 2020/1208

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Contents

Acronyms

GHG	Greenhouse Gas
INERPA	National Emissions Inventory
NECP 2030	National Energy and Climate Plan 2030
RNC2050	2050 Carbon Neutrality Roadmap
SNIERPA	National System of Inventories of Emissions and Remotions of Atmospheric Pollutants
SPeM	National System for Policies and Measures and for Projections
UNFCCC	United Nations Framework Convention on Climate Change
WAM	With Additional Measures
WEM	With Existing Measures
WOM	Without Measures

Introduction

This report aims to respond to the provisions of Article 18 of the Regulation (EU) n.º 2018/1999 of 11st of December, concerning integrated reporting on greenhouse gas (GHG) policies and measures and projections, and it concerns the reporting on projections.

In 2016, the Portuguese government committed to achieve carbon neutrality by 2050, outlining a clear vision of 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 waste water.

This new roadmap was approved through the Council of Ministers Resolution n.º 107/2019 of 1st of July and is also the national strategy for long-term low-GHG development submitted to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement and to the European Commission under the Regulation on the governance of the energy union and climate action (EU/2018/1999).

It is a forward-looking document of where to go, contributing to the definition of trajectories, not being a policy and measures planning document. The targets previously set for 2030 were revised in light of the conclusions of the IPCC Special Report on 1.5°C and sustained by the path that Portugal has taken in the past and new national targets for 2040 and 2050 were also defined, aligned with a carbon neutrality trajectory until 2050.

Based on these new projections exercice, a more ambitious target for 2030 was stablished of 45% to 55% emission reduction, compared to 2005 levels and it was also stabliched a trajectory of emission reduction of 65% to 75% by 2040 and 85% to 90% by 2050, compared to 2005 levels.

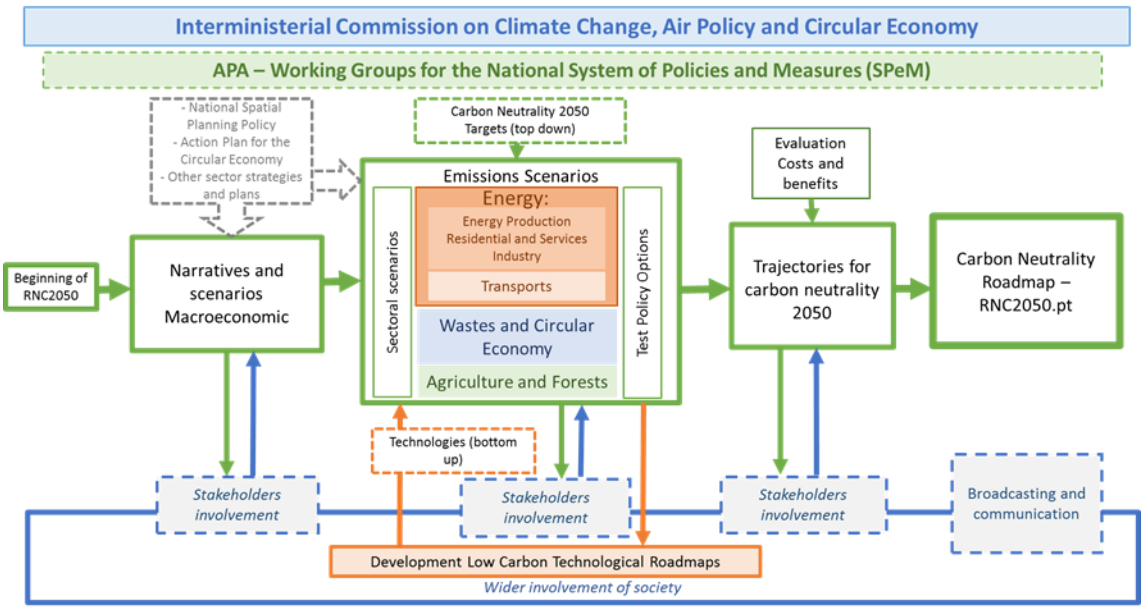
In line with this vision and developed in conjunction with the RNC2050, Portugal's 2030 integrated National Energy and Climate Plan (NECP 2030) was also developed and is the main energy and climate policy instrument for the period 2021-2030.

The National Energy and Climate Plan, appoved throught the Council of Ministers Resolution n.º, 53/2020, of 10th of July, is also based in the same emission projections elaborated under the RNC2050 exercice, ensuring the full alignemnt of the two planing perspectives (medium and long term).

Projection results for total greenhouse gas emissions

As mentioned, the projections presented in this report were prepared during the elaboration of the 2030 National Energy and Climate Plan and of the 2050 Carbon Neutrality Roadmap. Hence, they are an updated comparing to the projections reported in 2019 report under Monitoring Mechanism Regulation (that were the preliminary results of those exercices). This new modelling exercise, with the 2050 horizon, aimed to identify cost-effective trajectories and the main decarbonisation drivers consistent with the carbon neutrality objective.

Figure 1
Workflow of the 2050 Carbon Neutrality Roadmap



The Roadmap work had as its starting point for the development of greenhouse gas emission trajectories, the development of coherent socioeconomic scenarios, based on common narratives of possible evolutions of the Portuguese society until 2050, based on the evolution of macroeconomic parameters and demographic trends.

The proposed scenarios were subject to an external consultation and validation process, in particular with entities with responsibilities in the field of economic forecasting in Portugal (such as Portugal Central Bank, GPEARI – Finance Ministry Office of Planning, Strategy, Evaluation and International Relations; INE – Portuguese National Statistics Institute; GEE – Economy Ministry Office for Strategy and Studies; Foresight and Planning Department of the Environment Ministry, among others).

The narratives and their macroeconomic and demographic variables developed allowed, in the later modelling phase, to establish and characterize evolution scenarios for the different activity sectors - energy and industry, transport and mobility, agriculture, forests, and waste and wastewater, namely by the estimation and characterization of demand for energy and services.

In this context tree scenarios were developed:

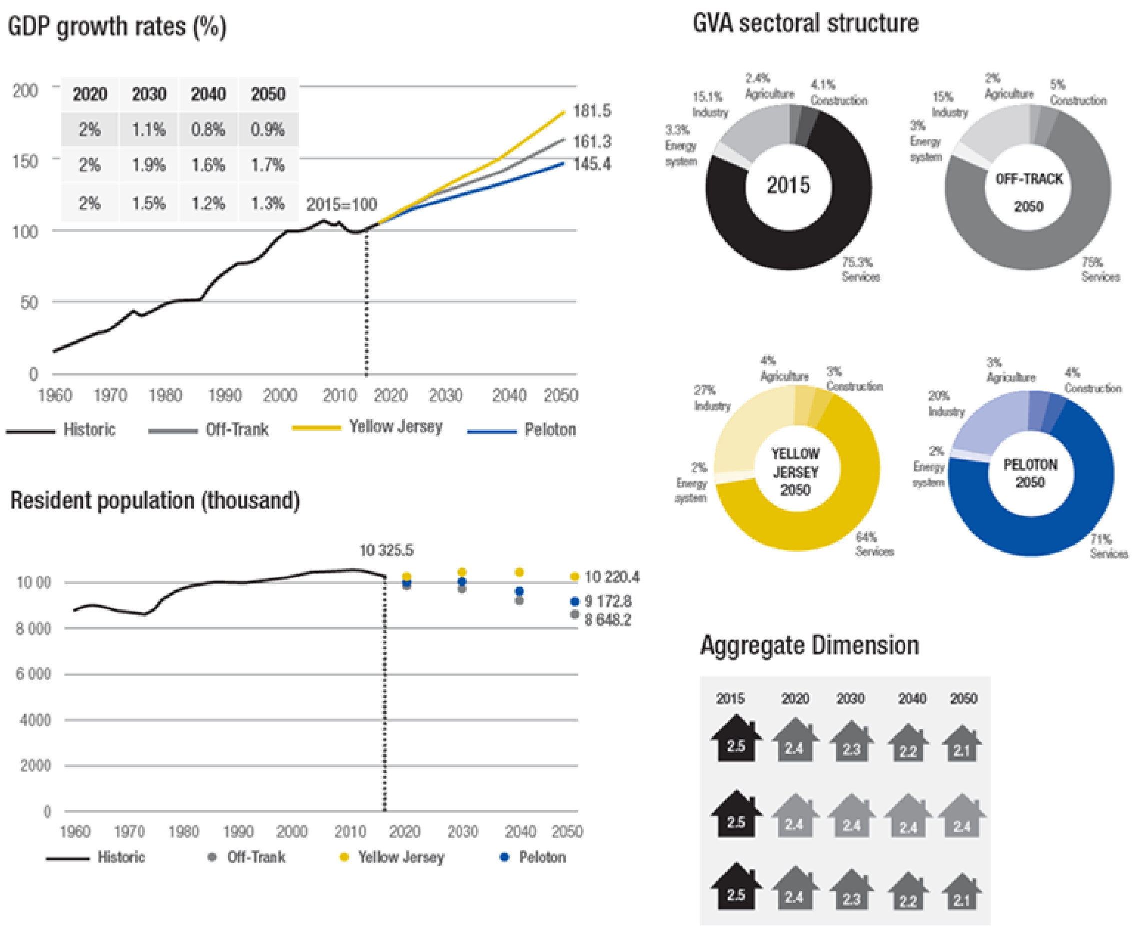
- a scenario that retains the essentials of the economic structure and current trends as well as decarbonisation policies already adopted or in force, but does not include the adoption of additional policies, called the Off-track Scenario (FP);

- two scenarios of socioeconomic evolution compatible with carbon neutrality, however achieved in different contexts, called Platoon Scenario (PL) and Yellow Jersey Scenario (CA).

The Platoon scenario is characterized by 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, while the Yellow Jersey Scenario is characterised by a structural and transverse change in production chains, made possible by the combination of a series of technologies of the 4^{th} Industrial Revolution. It foresees a more effective incorporation of circular economy models and greater growth of the importance of medium-sized cities. In the Platoon 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").

Thus, for the purposes of this projection report and to fill in Table 3 regarding the parameters used for the projections, the macroeconomic scenario associated with the Platoon (PL) scenario was considered (scenario "without neutrality" – corresponding to a WEM scenario and scenario "with neutrality" – corresponding to a WAM scenario), which translates into a more conservative evolution of GDP, the structure of the economy and the population over the period 2020-2050 (compared to the CA scenario).

Figure 2
Macroeconomic assumptions considered in the different scenarios of the 2050 Carbon Neutrality Roadmap



The development of the national projections also took into consideration the policies and measures adopted at Union level, namely, the Renewable Energy Directive (Directive 2009/28/EC and Directive (EU) 2018/2001), the Energy Efficiency Directive (Directive 2012/27/EU), EU ETS Directive 2003/87/EC as amended by Directive 2008/101/EC, Effort Sharing Regulation, among others.

More details about the different scenarios, assumptions, sectorial drivers and results can be found in the 2050 Carbon Neutrality Roadmap, available at: https://unfccc.int/process/the-paris-agreement/long-term-strategies.

In complement to that reference, socioeconomic details and assumption of the different scenarios can also be found in a specific report that perspectives the country's evolution until 2050, available at:
https://descarbonizar2050.pt/uploads/181220_Cenarios_RNC2050.pdf (PT version only).

1.Main results

The results of this exercise allowed a review of the potential for national emission reductions, confirming the technical and economic feasibility of pursuing a low carbon pathway to achieve carbon neutrality by 2050.

The sectorial analysis of emissions trajectories confirms that all sectors have significant GHG emission reduction potential in the different analysed scenarios, although the rates of reduction are different.

It is also noted that, for the purposes of the projections presented in the existing policies scenario, account was taken of the policy instruments and measures approved and published by 31st of December 2017, as well as some commitments made by Portugal, such as the end of the production of electricity from coal.

The difference between WAM and WEM scenarios for a given year can be taken as an estimate of the emission reductions from additional measures necessary. For 2030 the most significant policies and measures are already identified in the NECP 2030.

1.1 With Existing Measures scenario (WEM)

Even in an existing policy scenario, it is already foreseen a sharp reduction in GHG emissions in the coming decades and there is a cost-effective potential for Portugal to achieve total emission reductions of around 51% in 2030 compared to 2005, up to 60% by 2040 and around 64% by 2050 (without LULUCF).

In 2030 this reduction is largely due to the decommissioning of coal-fired power stations and the commitment to strengthening the role of renewable energies in the national energy mix, with boost to solar energy, with the electricity generation sector representing in 2030 a potential GHG emission reduction of about 93% compared to 2005 (and about 97% reduction in 2040).

In the transport and mobility sector, profound changes are foreseen, with large penetration of the electric vehicle, which leads to an emission reduction of about 41% in 2030 compared to 2005, and about 60% in 2040.

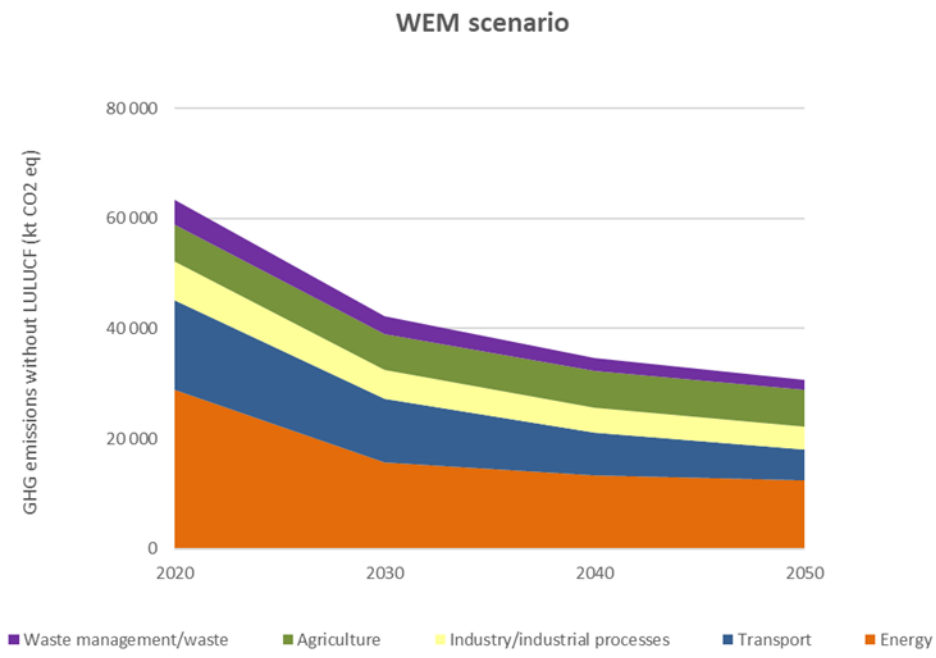
The waste sector also have a strong potential to reduce GHG emissions, contributing with reductions of 49% in 2030 and around 64% in 2040, as a result of the increase energy efficiency and the necessary compliance with the Landfill Directive which restricts disposal to only 10% by 2035. Thus, the existing policy scenario already presupposes the achievement of the target set in the Landfill Directive. The projections of this sector are identical in both the existing policy scenario and the additional policy scenario.

The agricultural sector have a lower decarbonisation potential over this time horizon. The figures are around 3% reduction in 2030 and aroud 2% in 2040.

In terms of F-gases, whose relevance in terms of emissions has been increasing in recent years. As with the waste sector, in the F-gases sector, it is assumed that the targets set in the Kigali Amendment are met, and the projections of this sector are identical both in the existing policy scenario and in the additional policy scenario.

However, for most sectors there is a need to consider a set of additional policy measures in order to pursue a more ambitious low carbon path and achieve carbon neutrality by 2050.

Figure 3
Sectorial projections with existing measures scenario (kt CO_{2eq})



1.2 With Additional Measures scenario (WAM)

With regards to the additional policy scenario (or neutrality scenario), unlike the previous one, emission restrictions consistent with carbon neutrality were imposed in 2050. This scenario thus allows to assess the additional effort required for each sector so that overall achieve neutrality, not accurately translating a typical scenario of policy impact assessment and planned measures.

There is still a cost-effective potential to reduce GHG emissions more sharply compared to the existing policy scenario, around 55% compared to 2005, rising to 73% by 2040 and around 82% by 2050 (without LULUCF), decarbonizing almost entirely electricity production, and strongly reducing emissions from mobility and transport and buildings, over the next decades.

Thus, the electricity generation sector in an additional policy scenario has in 2030 a GHG emission reduction potential of around 95% compared to 2005, the transport sector by 46% and the building sector by 48%, rising to 98%, 84% and 82% respectively by 2040.

As for the industrial processes sector, reductions of around 39% in 2030 to 48% in 2040 are expected, due to the expected improvements in process efficiency and the use of less polluting fuels, with the incorporation of more Fuels Derived from Waste / RDF (refused derived fuel), biomass and electrification of some subsectors.

The agricultural sector, in this scenario of additional policies could contribute to emission reductions of about 6% in 2030 to 7% in 2040.

Within the waste and F-gas sectors, and given the assumption, respectively, of meeting the targets set in the Landfill Directive and the Kigali Amendment, the evolution is similar to the scenario with existing policies.

In this context, it is still necessary to reinforce the role of forest sink and other land uses, and effective agroforestry management is a determining factor in achieving the goal of neutrality in 2050.

Figure 4
Sectorial projections with additional measures scenario (kt CO_{2eq})

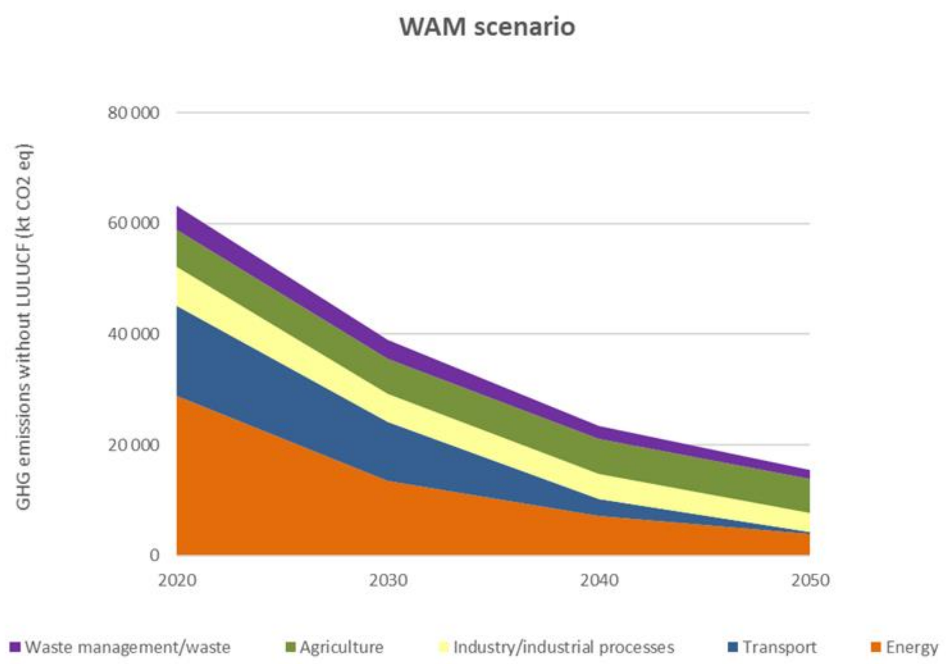


Table 1
Potential for GHG emission reductions compared to 2005 (%)

	Potential for GHG emission reductions compared to 2005 (%)					
	Scenario With Existing Measures			Scenario With Additional Measures		
Sector	2030	2040	2050	2030	2040	2050
Energy	-65%	-70%	-72%	-70%	-84%	-91%
Transport	-41%	-60%	-72%	-46%	-84%	-98%
Industry/industrial processes	-39%	-48%	-50%	-39%	-48%	-61%
Agriculture	-3%	-2%	-1%	-6%	-7%	-9%
Waste management/waste	-49%	-64%	-73%	-49%	-64%	-73%
Total without LULUCF	-51%	-60%	-64%	-55%	-73%	-82%

This scenario of neutrality served to inform the new greenhouse gas emission reduction targets set for the 2030, 2040 and 2050 horizon, from -45% to -55% by 2030, -65 % to -75% by 2040, and from -85% to -90% by 2050 compared to 2005, as mentioned above.

The results also indicate that a trajectory that achieves emission reductions of -85% to -90% in 2050 compared to 2005 levels, will induce significant effects on renewables and energy efficiency, very significant final consumption of final energy consumption reaching 85-90% by 2050, in particular in electricity generation and transport which could reach full electrification by 2050 (road and rail) and a significant increase in economy efficiency.

Emissions projections for all sectors of activity and gases are provided for in reporting Table 1a.

1.3 Other atmospheric pollutants

In the scope of the RNC2050 exercice, projections of other atmospheric pollutants were also performed. They are based on the projection of activity variables that are associated with their origin. These, in turn, result from scenarios of demand for energy and materials services. For the purpose of these projections, the macroeconomic scenario associated with the Platoon Scenario "with neutrality" – corresponding to a WAM scenario in Climate Policy - was selected as the scenario With Existing Measures (WEM) in the context of the new NEC Directive, since it was assumed that the respective measures will be implemented under Climate framework. So the scenario WAM for Air Pollution Policy will be considered and adopted under the NAPCP (National Air Pollution Control Programme) for further reductions taking into account the national emission reduction commitments applicable from 2020 to 2029 and from 2030 onwards. The Table 2 below is a summary of the main results obtained.

Table 2

Atmospheric emissions (kt), projections and percentage reductions compared to 2005 by sector

Pollutant	Sector	Historical			Projection				
		2005	2010	2015	2020	2030	2040	2050	Δ2030-2005(%)
NOx (as NO2)	Energy	60	18	15	14	7	3	1	-89%
	Industry	46	41	38	32	29	26	26	-38%
	Buildings	45	30	26	18	18	15	12	-60%
	Transport	103	90	69	67	27	9	6	-73%
	Agriculture	6	6	6	3	3	3	3	-49%
	Waste	0	0	0	0	0	0	0	-70%
	TOTAL	**260**	**184**	**154**	**134**	**84**	**56**	**48**	**-68%**
VOC	Energy	12	11	11	11	9	3	1	-24%
	Industry	114	102	104	100	95	93	96	-16%
	Buildings	19	15	16	14	9	8	2	-51%
	Transport	37	24	16	15	8	1	0	-78%
	Agriculture	2	3	3	13	13	13	13	447%
	Waste	3	2	2	2	2	1	1	-43%
	TOTAL	**187**	**157**	**152**	**156**	**136**	**119**	**114**	**-27%**
SOx (as SO2)	Energy	124	16	8	7	6	2	1	-95%
	Industry	45	31	22	19	18	20	20	-60%
	Buildings	6	4	3	1	1	1	1	-83%
	Transport	2	1	1	1	2	1	1	-30%
	Agriculture	0	0	0	0	0	0	0	31%
	Waste	0	0	0	0	0	0	0	-65%
	TOTAL	**176**	**51**	**35**	**29**	**26**	**24**	**23**	**-85%**
NH_3	Energy	0	1	1	1	1	1	0	156%
	Industry	9	7	6	5	6	7	7	-33%
	Buildings	3	2	2	2	3	0	0	1%
	Transport	2	1	1	1	1	0	0	-69%
	Agriculture	42	39	39	37	36	36	36	-14%
	Waste	2	2	1	1	1	1	1	-36%
	TOTAL	**57**	**51**	**50**	**48**	**47**	**44**	**43**	**-17%**
$PM_{2,5}$	Energy	2	1	1	1	1	0	0	-66%
	Industry	31	25	22	22	23	24	25	-25%
	Buildings	19	16	17	15	10	8	1	-47%
	Transport	8	7	5	5	3	2	2	-61%
	Agriculture	1	2	2	1	1	1	1	1%
	Waste	1	0	0	0	0	0	0	-38%
	TOTAL	**61**	**50**	**47**	**44**	**38**	**36**	**29**	**-37%**

Changes in reported projections between submissions

Since the previous report, Portugal has completed the two related and extensive planning processes – the 2050 Carbon Neutrality Roadmap and the 2030 National Energy and Climate Plan, which were under preparation at the time of submission of the 2019 report, and whose preliminary results were already used for the purpose of GHG emissions projections of that time.

Although the main model is the same as before, TIMES_PT, the different technology available and its costs were also updated during the past years, following technological and price developments of the last decade.

The scenarios analysed and the modelling performed, confirm the existence of cost-effective trajectories and infer a set of guidelines and action lines for sectoral policies that contribute to the established GHG emission reduction, renewable energy and energy efficiency objectives.

The results allowed a review of the potential for national emission reductions presented in the earlies reports and confirmed the technical and economic feasibility of pursuing a low carbon pathway to achieve carbon neutrality by 2050.

The impact of policies and measures identified

The conclusion of the work done over the preparation of the RNC2050 and the NECP2030 also allowed the identification of additional measures to be deployed.

One of the measures that will deliver a significant emission reduction will be the end of coal-fired electricity production. This objective was firstly defined for 2030 and after revised for 2023 and will result in a significant reduction in emissions.

Taking into account the existence of factors that strongly discourage coal-fired power generation, such as the increase in the price of CO2 emission allowances, the end of the Tax on Oil Products (ISP) exemption and the increase in the price of coal, as well as security of supply studies already carried out, Portugal was even able to anticipate the closure of the two remaining coal fired power plants - Pego and Sines. So, at the beginning of 2021 one of the plants decided to cease its operation (Sines) and the other one started to prepare for its reconversion to biomass use. These recent developments will be reflected in future projections and reports.

In order to promote the production and consumption of renewable gases, some innovative measures are foreseen (in the additional measures scenario), such as green hydrogen, through its production, storage and use by the various sectors where electrification is not so viable and cost-effective. This is also estimated to be a strong ally in reducing emissions.

The efficient storage of energy is a fundamental pillar of the energy transition, as it allows flexibility in the production of renewable energy and ensures its integration in the system, and for that purpose the promotion and development of new storage solutions, namely batteries and hydrogen, are fundamental. The new storage solutions will allow mitigating the challenges in terms of dispatchability and security of supply that the daily and inter annual variability of renewable energy sources bring to the system.

The progressive replacement of fossil fuels and the promotion of an increasing incorporation of renewable sources in energy consumption is essential for an effective reduction of GHG emissions. In this sense the promotion of electric vehicles in transport and the strengthening of charging infrastructures are measures that are expected to accelerate the reduction of emissions in this sector.

Promoting eco-innovation projects and low carbon technologies and supporting the development of innovative and low carbon products and services will contribute to the decarbonisation of industry. To support the energy transition of the sector, the promotion and reinforcement of the use of renewable fuels, such as biomass, waste-derived fuels and renewable gases like green hydrogen, are essential for the reduction of emissions and the decarbonisation of the industrial processes.

With the aim of promoting sustainable agriculture and forestry and enhancing carbon sequestration, the promotion of biodiverse pastures and the promotion of ecosystem services stand out as essential measures to promote the future of forestry and the country's decarbonisation objectives. Although the agriculture sector is one of the sectors that contributes less to the reduction of emissions, we believe that a focus on more sustainable agriculture, namely through the promotion of biodiverse pastures, will allow us to reduce emissions and increase the efficiency of water use. The promotion of ecosystem services through the promotion of biodiversity in the territories and a greater enhancement of its value and resilience will contribute to erosion control, to an increase in carbon sequestration, to the regulation of the hydrological cycle, to biodiversity conservation and to the reduction of susceptibility to fire.

Overall, these are the policies and measures that we consider to have the greatest impact on the economy's emission reductions and thus in the projections reported.

The results of the sensitivity analysis performed

In the context of the 2050 Carbon Neutrality Roadmap modelling exercise, a series of sensitivity analysis and variants were carried out, which allowed to better understand the impact of specific aspects on the final emission trajectory established. Some examples are the variation on the technology costs, such as hydrogen (for transports and energy sectors), variation on the use of public transport and soft mobility, greater incorporation of renewable gases, balance of electricity imports, etc.

The uncertainty associated with the impact of climate change on water availability also justified the analysis of an alternative scenario that considered the inherent impacts of a RCP8.5 climate scenario.

Additional sensitivity analyses were also carried out, varying some aspects of Circular Economy in the different sectors, in order to increase or decrease its impact, to see what the impact in terms of emissions would be.

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.

The sensitivity analysis performed did not generate global results compatible and possible to transcribe to the structure requested in reporting tables 6 and 7, for this reason no data is reported in those tables at this point.

The methodologies used for the projections

For the development of projections, a methodologically separate approach was adopted for each of the four main sectors, since there is no single model that makes it possible to project emissions for all sectors and gases in an integrated manner. Thus, for the:

- 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 (including industrial processes), transport, residential, services and agriculture (only energy use) in their multiple uses (heating, cooling, lighting, electrical equipment, passenger and freight mobility, among others).
- 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.
- 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.
- 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.

In reporting tables 1a and 5a the projected GHG emissions have 2018 as base year and the data related to that year is consistent with the data reported for 2018 in the 2020 inventory report.

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.

1.1 Sectoral Methodology

- **Energy system** that includes also the industry/industrial processes, the transport and the housing, service and agriculture (only energy use) sectors:

TIMES_PT is a technological model of linear optimization which results from the implementation of a generation of economy – energy – environment optimized models, with a TIMES technology base, in Portugal.

The generic structure of TIMES can be adapted by each user, to simulate a specific energy system, at local system national or multi-regional.

TIMES_PT was initially developed under the European Project NEEDS, integrating a Pan European TIMES model used to estimate total European costs (including externalities) of energy production and consumption. The ultimate goal of any TIMES is to satisfy the demand for energy services at the minor cost. In order to do that, investment options and the operation of some technologies, as well as the primary energy sources and energy exportations and importations, according to the following equation:

$$NPV = \sum_{r=1}^{R} \sum_{y \in YEARS} (1+d_{r,y})^{REFYR-y} \bullet ANNCOST(r,y)$$

NPV: actualizes net value of total costs; ANNCOST: annual total cost; d: actualization rate; r: region; y: years; REFYR: reference year for the actualization; YEARS: years in which costs exist (all costs for the modelling period + past years when costs where defined for past investments + the number of years after technology life time, in case there are decommissioning costs).

For each year, the TIMES models calculate the current sum of the total costs, expect the income. In the case of TIMES_PT model, the costs taken into account are the investment, operation and maintenance costs (fixed and variable) of the various production technologies and energy consumption. The Income usually considered in TIMES models include subsidies and materials recovery, which are not considered in the TIMES_PT model.

TIMES_PT model represents the Portuguese energy system from 2000 to 2050, including the following sectors:

1. Primary energy supply (refining and synthetic fuels production, import and local resources);

2. Electricity production;

3. Industry (cement, glass, ceramics, steel, chemical, paper and pulp, lime and other industrials);

4. Residential;

5. Commercial and Services;

6. Agriculture, forestry and fisheries (only the energy consumption);

7. Transport.

In each sector, the monetary, energy and materials fluxes are modelled according to the various production technologies and energy consumption, including mass balances for some industry sectors.

The simplified structure of the TIMES_PT model is shown in the figure below, as well as its main inputs and outputs.

The implementation of TIMES_PT requires a set of exogenous inputs, namely:

1. Demand for energy services;

2. Technologies' technical and economic characteristics for the base year and the future (e.g. efficiency, input/output ratio, availability, investment, operation and maintenance costs and actualization rate);

3. Availability of primary energy sources in the present and in the future, especially the potential for the use of endogenous energy resources;

4. Policy restrictions (e.g. energy production targets or reduction of emissions).

Based on these elements, it is possible to obtain from the TIMES_PT model a series of outputs, such as:

1. Inherent costs to the energy system;

2. Energy flows inherent to each sector;

3. Technological options, including the installed capacity in the electricity production sector;

4. Energy imports and exports;

5. Use of indigenous resources;

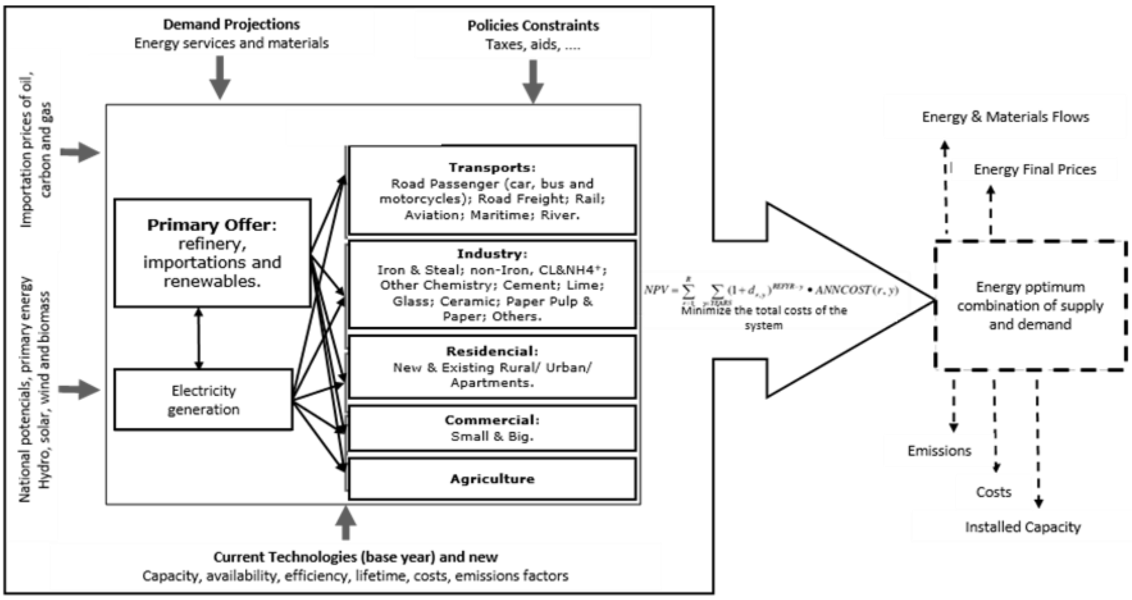
6. Emissions by sector.

Presently emissions considered by the model include the GHG emissions generated by combustion and industrial processes, and do not include fugitive emissions associated with the production, storage and distribution of fossil fuels and emissions of F-gases.

It should be noted that TIMES, being a partial equilibrium model, does not consider the economic interactions outside the energy sector, as for instance the implications in the activity of other economy sectors (e.g. impact of wind energy in the metal sector) or the implications in the activity of national sectors dictated by changes in international demand for their goods or services.

Furthermore, TIMES model does not take into account irrational aspects that influence investment in new and more efficient technologies, e.g. motivated by aesthetic preferences or social status which mainly occurs in the acquisition of end-use technologies. Thus, the model assumes that agents have perfect knowledge of the market, present and future. Finally, it should be emphasized that the based technology models such as the TIMES_PT do not accommodate market decisions based on price, instead they make choices based whether technologies or energy resources costs. For this reason, the solutions found show the best options in terms of cost - effectiveness and hence competitiveness, lato sensu.

Figure 5 - TIMES_PT model simplified structure



Economic policy instruments, such as VAT and the ISP (tax on petroleum products and energy products), have not been considered, since the aim is to identify cost-effective technological solutions, and therefore the whole exercise is based on technology costs. The electricity exchange with Spain is also not included in the modelling exercise, since it is mainly based on market decisions, and TIMES_PT model is not an appropriate tool to account for it. According to the expectations of REN (concession holder of the national network), a zero balance with Spain is assumed as from 2025.

New in relation to similar exercises in the past is the fact that some of the expected impacts of climate change on the horizon of 2050 have been internalized within the framework of the modelling exercise, in particular by considering changes in technology efficiency and in service demand and resource availability (such as reduced water availability or increased cooling needs).

It should be noted that the TIMES_PT model, provided an important contribution to the setting of national goals and targets by the 2030 horizon and pointing clear guidelines for the horizon 2050.

The information about TIMES_PT model is included in Table 4.

- **Agriculture, forests and other land uses, Waste and wastewater and Fluorinated gases**:

For Agriculture, forests and other land uses and for Waste and wastewater and Fluorinated gases, Excel spread sheets based on inventory methodologies were used, and so all categories and different gases were covered.

An advantage of using these models is the fact that a similar approach was already used in previous projections exercises like, for example, in the National Program for Climate Change (PNAC 2020/2030) and the National Low-Carbon Roadmap (RNBC 2050), so the methodologies are well known and the specific data bases for Portugal are fed in regularly. On the other hand, these more simplified models are not based in a cost-benefit analyses, which can be considered as a disadvantage, however they are based in expert judgments.

The impact of the covid-19 on projections

In the scope of the projections presented in this report the impact of the COVID 19 pandemic was not considered.

To analyse the impact of the COVID-19 pandemic on national GHG emissions, a follow-up of emissions from the energy sector is being carried out on a monthly based since March 2020, based on the information provided in the Rapid Estimates of Fossil Fuel Consumption published monthly by the Directorate General for Energy and Geology. These are first estimates and represent only emissions from "fuel combustion", which is the main source of emissions in Portugal, and which accounted for 72% of emissions in the 2016/2019 period.

This monitoring of emissions from the energy sector, allows us to verify that during the confinement period there was a slight reduction of emissions related to the transport sector and that there was no decrease in the production and consumption of electricity or renewables.

This monitoring also allowed us to verify that in periods without confinement or with reduced confinement, the verified changes tend to return to pre-Covid levels.

For this reason, we have not yet seen the need to change the projections up to 2050, as we consider that the impact of COVID-19 may induce temporary changes, that can have limite impact in the medium or long term.

More detailed information on the preliminary analysis of the Effect of Pandemic Covid-19 on National Greenhouse Gas Emissions during 2020 can be found at: https://apambiente.pt/index.php?ref=16&subref=81&sub2ref=1230&sub3ref=1684

Table 1a

- Portugal does not have processes leading to NF3 emissions, thus no projections are presented for this GHG.
- No data is provided for the intermediate years as these have not been estimated in the projections made.
- No emissions are reported for "Unspecified mix of HFCs and PFCs" since it is not estimated or occurred (NO,NE).
- A without measures scenario (WOM) analysis was not performed.

1.A.3.c. Railways	WEM; WAM	CO_2;CH_4; N_2O	Given the electrification of the sector and the growing incorporation of renewable gases, it is not expected that emissions of these gases will occur after 2035, so the projections after this year are presented as zero.
1A5. (Other)	WEM; WAM	CO_2; CH_4; N_2O	No emissions are reported for the years 2020 onward so the projections after this year are presented as zero.
1.B. Fugitive emissions from fuels	WEM; WAM	N_2O	No emissions were reported for the years 2020 onwards, as they were not estimated by the modeling tool used: TIMES_PT. Notation keys NO, NE were used in these cells.
1.B.1. Solid fuels	WEM; WAM	CH_4	No emissions are reported for the years 2020 onward so the projections after this year are presented as zero.
1.B.2. Oil and natural gas and other emissions from energy production	WEM; WAM	N_2O	No emissions are reported for the years 2020 onwards since they were not estimated (NE) by the modelling tool used: TIMES_PT.
2.E. Electronics industry	WEM; WAM	SF_6; HFC; PFC	No emissions are reported since they were not estimated (NE) or not occurred (NO).
2.G. Other product manufacture and use	WEM; WAM	N_2O	No emissions are reported for the years 2020 onward so the projections after this year are presented as zero.
4. LULUCF	WEM, WAM	N_2O	Emissions from N_2O in historical years include Table 4.(III) and Tables 4.(IV). However, Projections do not include Table 4.(III). Emissions from TABLE 4(IV) are only included in the "total including LULUCF" for the historical years, but not in projections.
4.A Forest Land	WEM, WAM	CO_2, CH_4, N_2O	Projection values for land converted to forest land are available in aggregate only and do not allow separation into CL-FL, GL-FL, ST-FL,

			WT-FL and OL-FL. All values are reported under CL-FL and the remaining categories are reported as IE
4.B Cropland	WEM, WAM	CO_2, CH_4, N_2O	Projection values for land converted to cropland are available in aggregate only and do not allow separation into FL-CL, GL-CL, ST-CL, WT-CL and OL-CL. All values are reported under FL-CL and the remaining categories are reported as IE
4.G Harvested Wood Products	WEM, WAM	CO_2	Only total HWP are calculated. Total values are reported under "Harvested wood products from managed forest land". HWP from afforested land are assumed to be included in HWP from managed forest land and are reported as IE. Other HWP are assumed to not occurred and are reported as NO.
4.(V) Fire Emissions	WEM, WAM	CO_2, CH_4, N_2O	Fire emissions are only available in CRF Tables and in the Projections for total "land converted to XXX". The disaggregation per subcategories is made on the basis of share of area of that subcategory in total area of "land converted to XXX"
5.E. Other (please specify)	WEM; WAM	N_2O	No emissions are reported for the years 2020 onward so the projections after this year are presented as zero.
Memo items: International bunkers	WEM; WAM	CO_2;CH_4; N_2O	No emissions are reported for the years 2020 onwards since they were not estimated. For this reason, historical data will also not be reported, being replaced by the NE notation key.
Memo items: IB.Aviation	WEM; WAM	CO_2;CH_4; N_2O	No emissions are reported for the years 2020 onwards since they were not estimated. For this reason, historical data will also not be reported, being replaced by the NE notation key.
Memo items: IB.Navigation	WEM; WAM	CO_2;CH_4; N_2O	No emissions are reported for the years 2020 onwards since they were not estimated. For this reason, historical data will also not be reported, being replaced by the NE notation key.
Memo items: CO_2 emissions from biomass	WEM; WAM	CO_2	No emissions are reported for the years 2020 onwards since they were not estimated. For this reason, historical data will also not be reported, being replaced by the NE notation key.
Memo items: Indirect CO_2	WEM; WAM	CO_2	No emissions are reported because they were not estimated (NE).

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