Chapter 2. Carbon neutrality

Portugal has overachieved its 2020 climate mitigation goals thanks to a significant decrease in greenhouse gas (GHG) emissions over the past decade. It has stepped up its efforts to adapt to climate change. The country can be commended for its leading role in climate action under its Presidency of the Council of the European Union in 2021. This chapter reviews progress and identifies remaining challenges regarding climate change mitigation and adaptation. It also examines the effectiveness of sectoral and horizontal policies towards Portugal's 2050 carbon neutrality goal.

2.1. Trends and performance on climate change mitigation

2.1.1. GHG emissions profile, intensity and trends

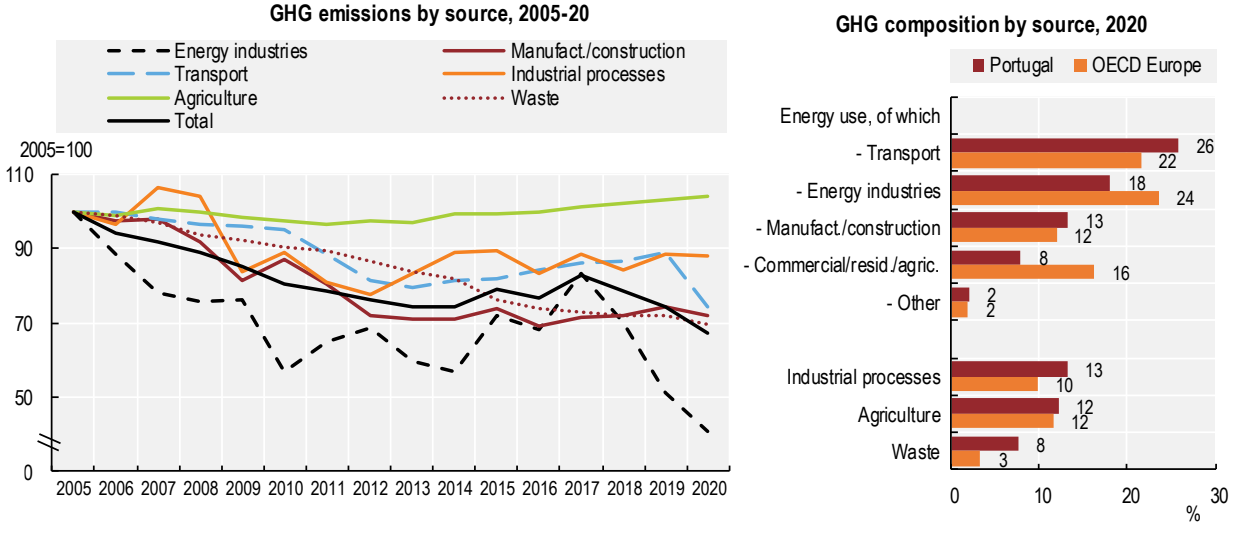
Portugal is a small GHG emitter, accounting for less than 2% of total EU emissions in 2020. Two-thirds of its emissions come from energy use, especially in transport and energy production (Figure 2.1). Compared to the OECD Europe average, Portugal's emissions structure has a higher share of transport, industrial processes and waste and a lower share of energy industries, and residential and commercial sectors. The land use, land use change and forestry (LULUCF) sector is a net sink.

Carbon dioxide (CO_2) emissions account for the largest share of GHG emissions in Portugal, although this share is lower than in OECD Europe (73% vs. 80%). Emissions of methane (mainly from agriculture and waste) and fluorinated gases (hydrofluorocarbons from refrigeration and air conditioning equipment) are more important (16% vs. 11% and 6% vs. 2%, respectively). The share of nitrous oxide emissions (N_2O, mainly from agricultural soils) is the same as the average of European OECD countries (6%).

Portugal's economy is slightly less energy intensive than the OECD Europe average due to the high share of services. The carbon intensity of its energy mix is also lower thanks to renewable energy. Emissions of methane and fluorinated gas make the country's economy more GHG emission intensive than the OECD Europe average.

Considering the impacts of the COVID-19 crisis, GHG emissions have been reduced by one third over 2005-20. Portugal is in the top third of European OECD countries in terms of emission reductions over this period. Since 2005, emissions have decreased in all sectors but agriculture (Figure 2.1). Following the 2008 economic crisis, GHG emissions declined driven by a reduction in energy demand. As renewable electricity production increased, emissions from energy industries fell, with annual variations depending on hydropower generation (IEA, 2021a). The decline in activity, particularly in the construction sector, also pushed down industrial emissions related to energy use and processes. With the economic recovery, emissions rebounded in 2014-17, particularly in the transport sector. They have since fallen, driven by a strong shift away from coal-fired power generation. The last two coal power plants were closed in 2021.

Figure 2.1. Since 2005, GHG emissions have decreased in all sectors but agriculture



Note: Excluding land use, land-use change and forestry.
Source: APA (2022), National Inventory Report 2022, April; OECD (2022), Environment Statistics (database).

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2.1.2. Progress towards climate targets

EU targets and legislation shape Portugal's climate and energy policy. In 2019, the country approved a Roadmap for Carbon Neutrality (RNC 2050) (Government of Portugal, 2019a) (Table 2.1). In 2020, it adopted the National Energy and Climate Plan 2021-30 (NECP 2030) setting the main priorities for the coming decade (Government of Portugal, 2019b). The NECP focuses on increasing the share of electricity generation from renewables, expanding electrification, and reducing energy demand. Portugal can be commended for its active role in the approval of the European Climate Law under its Presidency of the Council of the European Union in 2021, and for enshrining carbon neutrality in the 2021 Framework Climate Law.

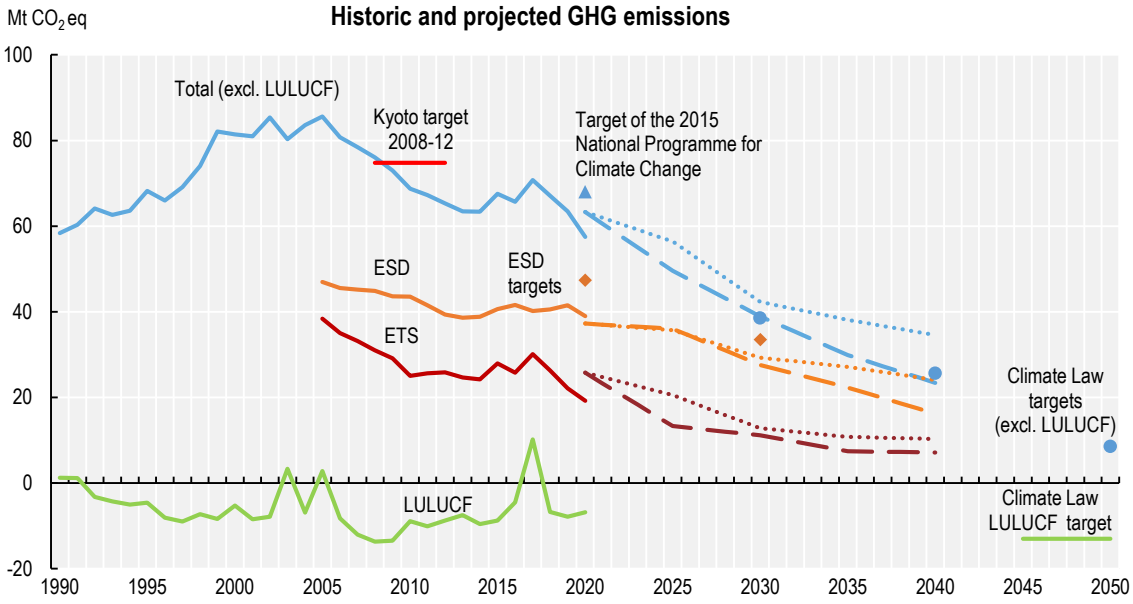
Table 2.1. National climate objectives of Portugal

Law or regulation	Objective variable	Objective	Base year	Objective year
Effort Sharing Regulation	GHG emissions from non-EU ETS sectors	-17%	2005	2030
Roadmap for Carbon Neutrality (RNC 2050)	GHG emissions excluding LULUCF	-85%-90%	2005	2050
		-65%-75%	2005	2040
		-45%-55%	2005	2030
	Carbon sequestration	9-13 Mt CO_2	-	2050
National Energy and Climate Plan (NECP 2030)	GHG emissions excluding LULUCF	-45%-55%	2005	2030
	Energy efficiency (primary energy consumption)	- 35%	2005	2030
	Renewable energy (as a share of final consumption)	47% (20% in transport)	-	2030
	Electricity interconnexion (as a share of energy capacity)	15%	-	2030
	Energy dependence on energy sources (dependency ratio)	65%	-	2030
Climate Law 2021	GHG emissions excluding LULUCF	-55%	2005	2030
	GHG emissions excluding LULUCF	-65-75%	2005	2040
	GHG emissions excluding LULUCF	-90%	2005	2050
	CO_2e sink of the land use and forestry sector	-13 $MtCO_2e$	-	2045-50

Source: Government of Portugal (2019), Roadmap for Carbon Neutrality 2050; Government of Portugal (2019), National Energy and Climate Plan 2021-30; Government of Portugal (2021), Framework Climate Law no 98/2021.

Portugal met its commitments under the first period of the Kyoto Protocol (2008-12), limiting the increase in GHG emissions to 19% compared to 1990 levels (vs a commitment of +27%) (Figure 2.2). It reached the 2020 economy-wide objective of the 2015 National Programme for Climate Change (-18% to -23% from 2005 levels). The country overachieved its 2020 target under the EU Effort Sharing Regulation (ESR). It has already met its ESR target for 2030 and seems on track to meet a more stringent one (-28.7%) proposed by the European Commission to meet commitments under the Paris Agreement (EC, 2021a). National projections show that, with existing measures, total emissions will fall by 51% over 2005-30 (Figure 2.2,Table 2.2).

Figure 2.2. Portugal seems on track to meet its 2030 climate targets



Note: LULUCF: land use, land-use change and forestry. Dotted lines refer to projections of the 2020 National Energy and Climate Plan (NECP) with existing measures. Dashed lines refer to projections with additional measures. ESD 2020 target: under the EU Effort Sharing legislation; 2030 target: European Commission's proposal for the revision of the Effort Sharing Regulation COM (2021) 555 final.
Source: APA (2022), National Inventory Report 2022, April; EEA (2021), Greenhouse Gas Projections Data Viewer – December; Eurostat (2022), Greenhouse gas emissions in ESD sectors; Government of Portugal (2021), Framework Climate Law no 98/2021.

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However, additional efforts will be needed to reduce emissions by 55% by 2030. The country will need to tap the decarbonisation potential of all sectors. So far, most of the emission abatement has taken place in energy production (Table 2.2). The NECP projects that the residential, service and agricultural sectors will not meet the 2030 targets in the scenario with additional measures. In addition, the assumptions underlying the projections for waste and transport could be questioned given the high level of landfilling and the low rate of renewal of the vehicle fleet (Chapter 1).

Emissions of fluorinated gases from industrial processes has increased significantly (Table 2.2). Although they represent a small share of emissions, they need to decline to comply with climate objectives and the 2016 Kigali Amendment of the Montreal Protocol. The Kigali Amendment plans the phasing out of the use of these gases as other options are made available.

The NECP provides limited details on the policies to be implemented. The impact of existing and planned measures is not quantified, and their financing is not specified. Therefore, it is not yet clear how Portugal will deliver on its 2030 targets.

Meeting 2050 targets calls for increased efforts for research and development (R&D). A substantial part of the abatements to be achieved between 2030 and 2050 depends on technologies at demonstration or prototype stage. The share is even higher in hard-to-abate sectors such as heavy industry and long-distance transport (IEA, 2021b). Stepping up R&D efforts (for energy storage, green fuels or carbon capture) will be key to reduce the cost of measures and expand electrification in all sectors. It is also an opportunity to become more competitive in the international market of environmental goods.

Table 2.2. Cutting emissions by 55% in 2030 calls for additional measures

Past and projected GHG emissions compared to 2030 targets

	GHG emission reduction achieved		NECP scenario with existing measures	NECP scenario with additional measures	NECP sectoral targets
	GHG evolution 2005-2020 (in $MtCO_2e$)	GHG evolution 2005-2020 (in %)	2005-2030	2005-2030	2030
1. Energy	-25.5	-40%	-57%	-62%	-
Production of electricity	-15.1	-59%	-93%	-95%	..
Industry	-3.0	-28%	-41%	-51%	..
Transport	-5.1	-26%	-41%	-46%	-40%
Residential	-0.6	-20%	-23%	-26%	-35%
Services	-2.1	-68%	-62%	-66%	-70%
2. Industrial Processes and Use of Products	-1.0	-12%	-39%	-39%	
Product uses as ODS substitutes (F gases)	+2.3	+217%	-20%	-20%	..
3. Agriculture	+0.3	+4%	-3%	-6%	-11%
5. Waste and Wastewater	-1.9	-31%	-49%	-49%	-30%
Total without LULUCF	**-28.1**	**-33%**	**-51%**	**-55%**	**-45% to-55%**
LULUCF*	-9.6		-9.6$MtCO_2e$	-10.7$MtCO_2e$	..

Note: LULUCF = land use, land-use change and forestry. Negative evolution in the LULUCF sector shows an increase in carbon capture. The LULUCF was a net emitter in 2005 following big fires.
Source: APA (2022), National Inventory Report 2022, April; APA (2021), Emission projections under the EU Greenhouse Gas Monitoring Mechanism Regulation (art. 14); Government of Portugal (2019), National Energy and Climate Plan.

2.2. Governance of climate action

The Ministry of Environment and Climate Action oversees Portugal's climate policy. Its mandate covers environment, energy, natural conservation, forests, territorial planning and mobility. It also houses the Directorate General for Energy and Geology, which oversees the energy policy and compliance to EU directives in the field of energy, including on energy efficiency and renewable energy. The Portuguese Environment Agency (APA), under the responsibility of the ministry, provides guidance for environmental and climate policies with recommendations, policy assessments and policy monitoring.

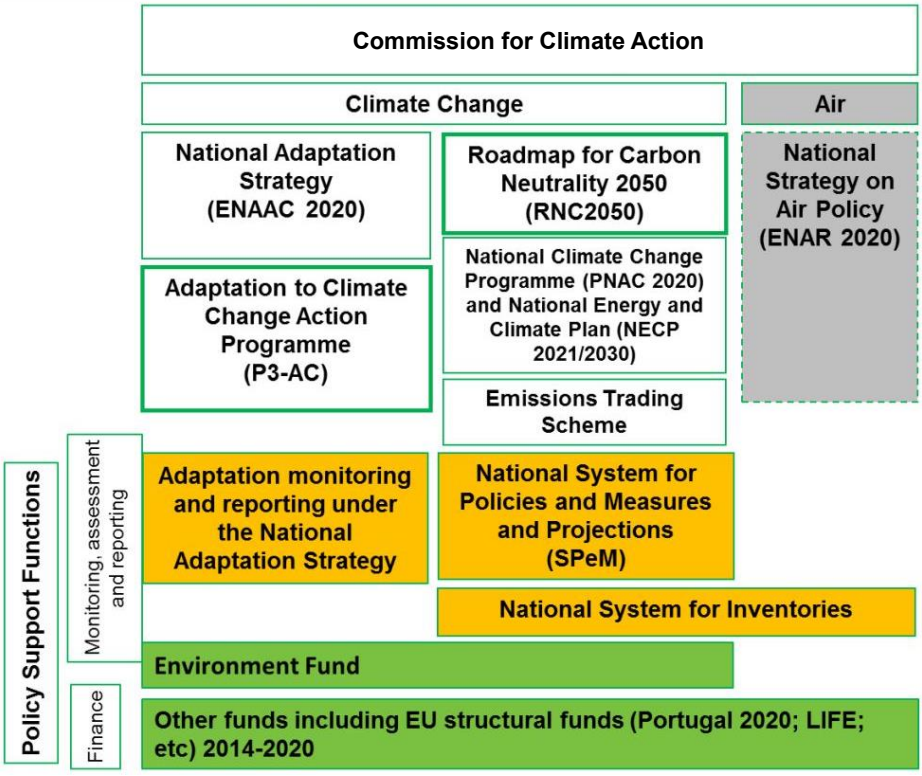
The competent authority for implementation of the climate strategy, both for mitigation and adaptation, is the Commission for Climate Action (CAC), created in 2015 by the Portuguese government (Figure 2.3). The commission is chaired by the minister responsible for climate action and includes government members in charge of key sectors such as energy, tourism, transport, health, agriculture and forest. Representatives of regional governments of Azores and Madeira are also part of the commission. The CAC ensures that Portugal's climate strategy complies with commitments at the national and international level. It provides policy advice and promotes the integration of climate objectives into sectoral measures. It also ensures that regional plans of Azores and Madeira are aligned with national targets. Finally, it supervises the monitoring and reporting of policies and emissions.

The CAC conceived the RNC 2050 and the NECP 2030 as the basis for the climate change mitigation strategy for the coming decades. It also monitors the activity of the National System for Policies and Measures and Projections (SPeM). This system was established in 2015 to streamline the monitoring and assessment of sectoral policies and mitigation measures in light of national climate objectives. For each sector, progress assessment should integrate the results of policies, a cost-benefit analysis and the reporting of synergies and trade-offs (UNFCCC, 2019).

In line with international good practices, the 2021 Climate Framework Law requires five-year climate budgets, sectoral mitigation plans, municipal climate action plans and an annual government progress report to Parliament. It sets out green budgeting principles requiring the government to specify the resources allocated to climate policy in the state budget. The law also creates an independent body, the Council for Climate Action, to assess climate action and provide recommendations. It plans a web portal to inform the public. Although promising, the law remains to be implemented through specific regulations.

The government consulted sectoral experts and segments of society to shape climate mitigation and adaptation policies. Experts took part in working groups as technical support and consultation to define macroeconomic and sectoral scenarios. The groups' work also informed the definition of the RNC 2050 and the NECP 2030 before their publication. The climate strategy was subject to public consultations that lasted several weeks (3 months for the RNC and 30 days for the NECP), with the participation of the public sector, private sector, associations representing sectors of the economy and civil society. Notably, a primary version of RNC 2050 was presented throughout the country in public sessions in Coimbra, Porto, Évora and Faro in continental Portugal and in Funchal in the Autonomous Region of Madeira. Suggestions from the public were integrated into the final draft, mainly through sensitivity analysis (UNFCCC, 2019). Specific stakeholders contribute to the sectoral working groups of the National Adaptation Strategy (NAS) and a scientific panel advises the coordination group (Section 2.4.2).

Figure 2.3. Governance of climate action in Portugal



Source: APA (2020), 4th Biennial Report to the United Nations Framework Convention for Climate Change.

2.3. Policy measures for climate mitigation

2.3.1. Policy tools for decarbonisation

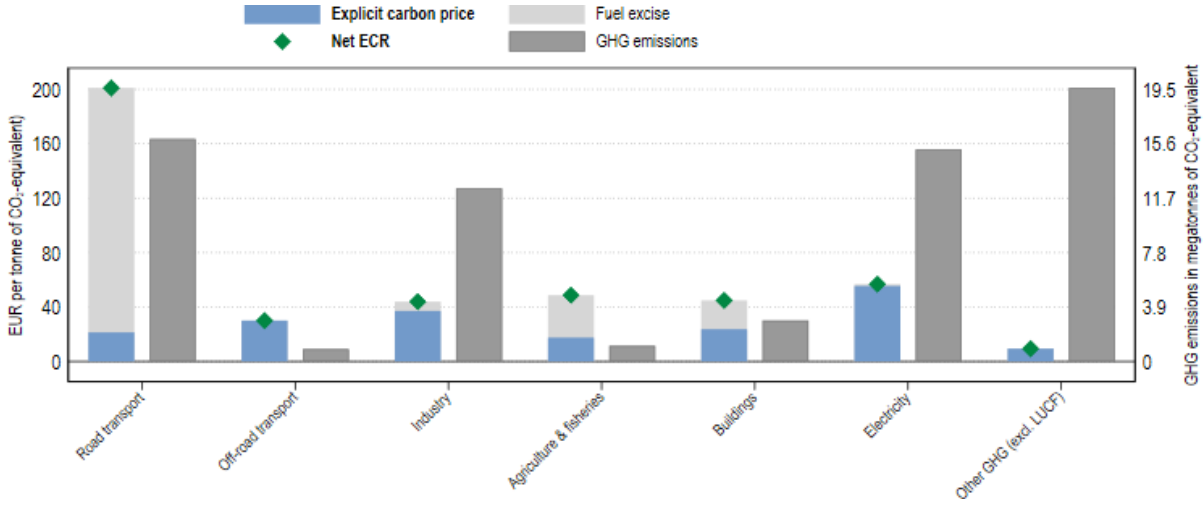
Carbon pricing covers most of carbon dioxide emissions

Pricing instruments make emitters pay in proportion of the damages and compensate for carbon sequestration in proportion of the benefits. Relative to regulation, they have the advantage of encouraging the most cost-effective measures, leaving the possibility to actors to adapt to specific contexts in a decentralised way. Pricing instruments are key levers in the Portuguese decarbonisation strategy. The country prices carbon emissions in three ways: i) energy taxes levied in the framework of the EU Energy Tax Directive, ii) the EU ETS and iii) the carbon tax introduced in 2014, as part of Portugal's green tax reform (Chapter 1).

In 2021, effective carbon rates (ECR) consisted of fuel excise taxes and to a smaller extent of permit prices from the EU-ETS and of carbon taxes (Figure 2.4). Portugal priced about 74% of its GHG emissions, of which 28% at an ECR above EUR 60 per tonne of CO_2, the midpoint benchmark for carbon costs in 2020. Emissions priced at this level originated primarily from the road transport sector. Most unpriced emissions were non-CO_2 emissions. Portugal's average effective carbon rate increased by a third over 2018-21, mainly due to higher EU ETS allowance prices. With an average rate of EUR 74 per tonne of CO_2, in 2021, it ranked in the middle of other OECD European countries (OECD, 2022a). However, as they varied by sector and fuels, effective carbon rates did not provide a consistent carbon price across the economy.

Figure 2.4. Carbon prices vary by sector and fuel

Average effective carbon rates by sector in 2021



Note: Excludes emissions from the combustion of biomass. The explicit carbon price covers the carbon tax and EU ETS permits.
Source: OECD (2022), Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action.

In addition, effective carbon rates are reduced by preferential tax treatments such as reduced rate for diesel used in agriculture, partial refund to freight companies, tax exemptions on energy products used for electricity production or by industrial installations under the EU ETS or an energy-efficiency agreement (Chapter 1). In 2018, Portugal started to gradually phase out some fuel and carbon tax exemptions which helped to phase out coal power in 2021. However, responding to rising energy prices the government froze

the carbon tax at the end of 2021, alongside new support measures for energy and fuel consumption sending different signals (Box 2.1).

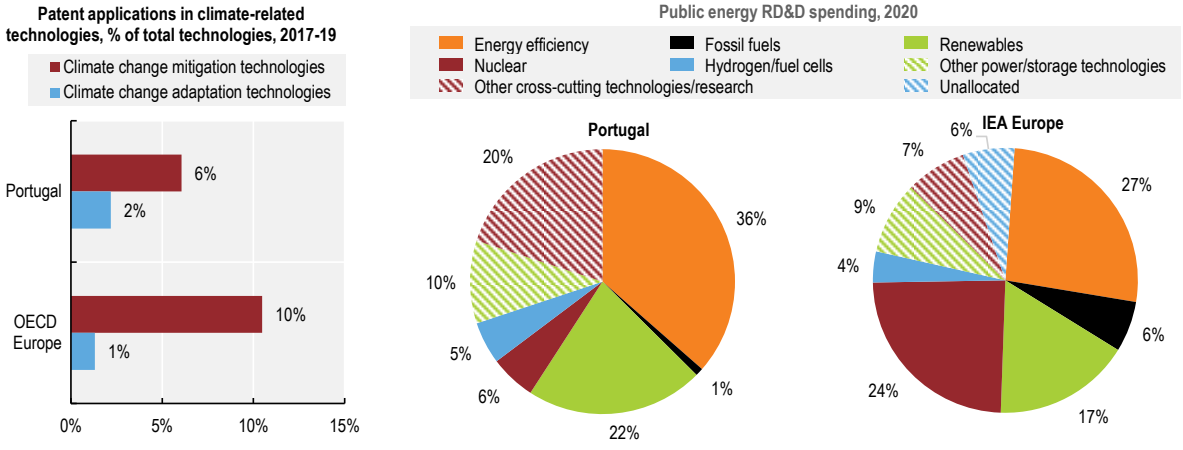
Developing a national innovation strategy for climate

A large part of Portugal's decarbonisation and adaptation strategies relies on technological development, especially for pursuing emission abatement after 2030. Innovation in the sector of transport and energy could accelerate the decarbonisation of the economy in the short term and will be key to reach climate neutrality (IEA, 2021b). Major stakes include, for instance, development of renewable gases, more efficient batteries or the implementation of carbon capture and sequestration at a large scale. Accordingly, the NECP 2030 plans to allocate 0.2% of gross domestic product (GDP) to R&D in the energy sector and 0.2% to R&D for water and climate in 2030.

Portugal has increased its effort for developing green technologies and innovations. It has been a pioneer in experiencing cutting-edge technologies for large-scale projects of renewable energy, co-funded with EU and private funds. It has approved floating offshore farms, renewable gas power stations (Section 2.3.2), as well as research projects to make the most of its solar and hydropower resources (IEA, 2021a). Portugal encourages R&D generally through generous tax credits for businesses, which covered 27% of the business expenditure on R&D in 2019 (as compared to 7% in the European Union) (OECD, 2021a).

However, there is no strategy guiding energy research, development and demonstration (RD&D) (IEA, 2021a). Increased policy co-ordination on energy RD&D is needed to ensure that the numerous RD&D entities, strategies and support measures are aligned with Portugal's decarbonisation goals. The country is considered as a "moderate innovator" in the European Eco-Innovation Scoreboard (EC, 2022a). This is due to low government spending on R&D in environmental and energy fields and limited patenting activity (Figure 2.5), although Portugal holds a relative advantage in terms of technologies for climate adaptation. Public and private spending on energy R&D increased from 0.06% of GDP in 2014 to 0.08% in 2020, remaining well below the NECP target (DGEEC, 2022). Public budget on energy R&D is mostly allocated to energy efficiency, renewable energy and cross-cutting technologies (Figure 2.5).

Figure 2.5. Portugal's climate innovation is modest



Note: Patent applications for higher-value inventions that have sought protection in at least two jurisdictions.
Source: IEA (2022), Energy Technology RD&D Budgets (database); OECD (2022), Environment Statistics (database).

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Financing the decarbonisation: Mobilising the private sector

Accelerating the transition to a low-carbon economy will require substantial investments to develop renewable energies, enhance energy efficiency, electrify the energy sector, reduce the demand for energy, encourage carbon capture and sequestration, and facilitate transitions for workers, consumers and firms. Estimates made in the NECP 2030 show that reducing emissions by 45-55% by 2030 would require EUR 407-431 billion in 2020-30, adding EUR 11-15 billion to current trends (Chapter 1).

A large part of these investments is embedded in specific plans such as the National Hydrogen Strategy. It provides for EUR 7 billion investment for the installation of 2 GW of electrolysis capacity to increase the share of hydrogen in final energy consumption to 5% by 2030. Most of available funds for the decarbonisation of Portugal are from the European Union. Following the downturn of the global economy and restrictions due to the pandemic, the European Union has raised unprecedented amounts of liquidity for the recovery of member states. Climate-related measures account for 38% of Portugal's Recovery and Resilience Plan for 2021-26. They cover substantial efforts to decarbonise the industry, foster energy efficiency in buildings and develop public transport (Chapter 1).

In 2021, the European Investment Bank (EIB) agreed to a Memorandum of Understanding on hydrogen, including financial and advisory support to foster investments in eligible projects. Moreover, a partnership with the Netherlands on green hydrogen will allow the installation of a 1 GW capacity of electrolysis in Sines (Government of Portugal, 2019b).

Domestic funds are much smaller. The Environmental Fund had a budget of EUR 648 million in 2020, mostly coming from the revenues of the auctioning of allowances under the EU ETS. This fund is notably used for the development of low-emission vehicle, public transport, the More Sustainable Buildings Program or the Ecosystem Services Remuneration Program (Government of Portugal, 2021a).

To cover the needs for green investment without digging further into scarce public resources, the Portuguese government also needs to mobilise private capital for green investments. A first step is to ensure visibility to investors through a clear and detailed pathway for carbon pricing and network access for the different technologies. The government uses feed-in tariffs to develop renewable energy in small-scale projects for private consumption. Since 2021, auctions have also supported development of large-scale photovoltaic (PV) projects. However, there is no concrete agenda to develop other energy sources (IEA, 2021a) (Section 2.3.2).

Direct support for financing can also be an option when liquidity is scarce, or the liquidity market is strained. The new Portuguese Bank of Development is required to promote, among other objectives, sustainable infrastructures, transport and climate neutrality. It does this through loans and guarantees to firms, and more particularly small and medium-sized enterprises. It is crucial that these instruments are tailored for the specific needs and difficulties of investors. For instance, take-up for the large programs supporting households' investment in house energy efficiency is still low due to poor targeting of supports (Sections 2.3.1 and 2.3.2).

Labelling public and private investments can help steer funds from carbon-intensive to greener activities. The 2021 Climate Law (article 36) stipulates that the EU green taxonomy should be integrated into public investment and procurement. This implies a disinvestment from activities not considered sustainable before. Moreover, private institutions are required to factor in climate risk and climate impact in their financing decisions, more particularly through risk analysis for finance and insurance actors (article 35).

Aiming for a just transition

The economy's general equilibrium is not expected to be strongly affected by decarbonisation, although sectoral impacts may arise. Portugal does not have a major fossil fuel industry at risk and its energy production is made from renewable sources, mainly bioenergy, wind and hydro (IEA, 2021a). However,

industries that are energy-intensive or related to fossil fuels (refineries) are vulnerable to more stringent climate policies affecting energy prices, like increased carbon pricing, which can slightly hinder GDP growth. For instance, estimates show replacing the Tax on Petroleum and Energy Products (ISP) by a EUR 114 carbon tax would reduce Portugal's GDP by 1.2% relative to the baseline in 2030 (Pereira and Pereira, 2019). Conversely, the ramping up of renewable energy has not boosted the economy so far.

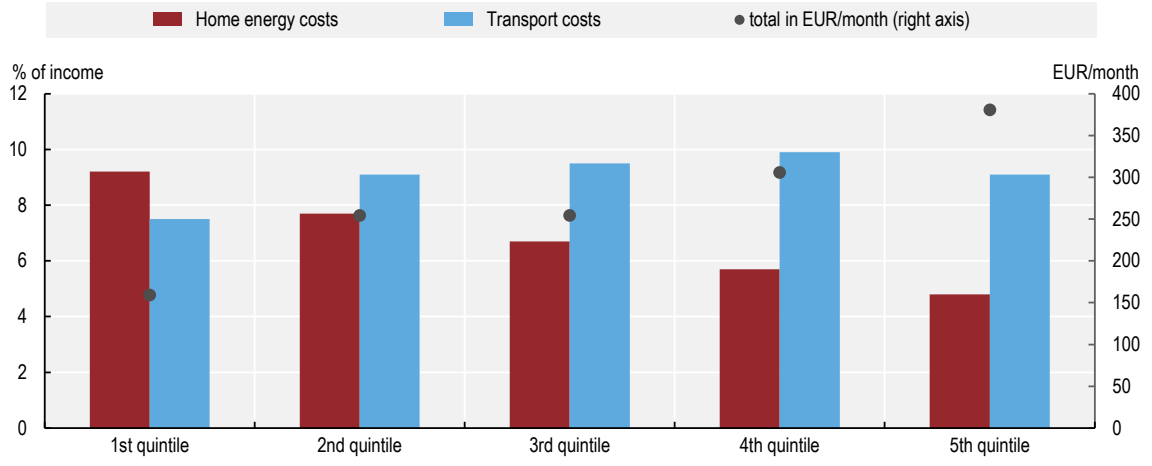
As a result, the impact of the transition on aggregate employment in Portugal is likely to be weak. However, changes in the labour market between sectors should be anticipated to maintain people and skills. Only 2.5% of the Portuguese workforce is employed in energy-intensive sectors and 2.2% in the provision of environmental goods and services (EC, 2022b). This is in line with most countries where both green and emission-intensive jobs only cover a marginal range of the labour market. However, transitions from emission-intensive to green sectors on the labour market might not be straightforward. Key sectors like construction, transport or energy already suffer from labour shortages in Portugal (Eurofound, 2021). Moreover, experience globally shows that skills between different sectors do not automatically match and incoming workers in green jobs from emission-intensive sectors are under-represented (IMF, 2022a).

The accompanying and upskilling of workers from decaying industries will be a challenge, especially in a country where adult education is not yet streamlined (OECD, 2021b). The plan to phase-out coal in power-generation in Portugal comprises an assessment of reskilling needs for workers from coal-fired power plants. The EU Just Transition Fund is also expected to provide EUR 224 million to regions in Portugal affected by the transition (EC, 2022b). However, this will mostly take the form of direct income support; the development of specific training is so far uncertain (Almeida, 2021).

Another issue arises from the price impact of the transition. Without offsetting measures, the transition might amplify purchasing-power inequalities, with lower-income households carrying a heavier weight than one with higher incomes. This is particularly the case for home energy costs (Figure 2.6). In the case of a transport fuel price increase, middle-income households will be the most affected. This is because poor households are less likely to own a car and those with higher incomes spend a smaller share of their income on transport.

Figure 2.6. Low-income households will be the hardest hit by higher home energy prices

Energy costs as a share of income by income quintile (left axis) and as monthly expenses (right axis), 2016



Note: Transport costs include all operational costs for running a car except equipment.
Source: INE (2016), Household Budget Survey.

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While the government has to encourage cuts in energy consumption, it must not worsen energy poverty, which is a major issue in Portugal. Although temperatures in Portugal are relatively mild compared to other countries, many households have difficulties insulating their home against hot or cold weather. Portugal stands out among EU countries with the highest energy poverty share: in 2019, 19% of people in Portugal were unable to keep their home adequately warm vs. 7% of people in the European Union. This share reached 38% among people below the poverty line (MAAC, 2021). In parallel, 36% of people are unable to keep their home adequately cool during the summer.

Portugal has carried out ambitious measures to address energy poverty through price support and, more structurally, energy efficiency work. However, it needs to better target the former measures and strengthen the latter. Social energy tariffs seek to protect vulnerable consumers, guaranteeing access to this essential service at affordable prices and under conditions of greater tariff stability. Vulnerable households benefit from social tariffs for electricity and gas, under social and income criteria. In 2016, the automation of eligibility and broader criteria led to a more than eightfold increase in the number of beneficiaries. In 2020, 787 665 households benefitted from social tariffs (of which only 34 709 benefitting from the natural gas social tariff). They received an average yearly benefit of about EUR 146 for electricity and EUR 51 for gas[1] (i.e. 15.6% and 11.7% of yearly expenses, respectively).[2]

However, these social tariffs fail to cover all dimensions of energy poverty. No dwelling-related criterion for energy poverty is considered and the structural issue of the bad housing conditions is overlooked (Section 2.3.2); they also do not encourage efficient use of energy, particularly since they can be accumulated (but most benefitting households are not concerned). Vouchers for supporting efficiency works by low-income households have also been implemented since 2020 under the More Sustainable Buildings Support Programme (PAE+S) for a total of EUR 135 million. However, average amounts cover a small share of renovation costs. As a result, the energy efficiency work still requires a level of liquidity rarely available for the eligible households. Uptake for this tool is particularly low. As in October 2022, 106 131 households had applied; of which 67 188 were eligible, covering 1.6% of households and 1.9% of those living in buildings with poor performance; unallocated fund amounted to EUR 18 million at this date (CNADS, 2022; Government of Portugal, 2022a). Since mid-2021, beneficiaries of the social electricity tariff who own their home are eligible for the energy efficiency voucher programme (*Vale Eficiência).* The aim is to allocate 100 000 vouchers by 2025. However, the programme covers a small share of the renovation costs (EUR 1 300 plus VAT). By the end of 2022, only 11 000 vouchers had been allocated.

The government needs a comprehensive strategy to encourage energy consumption cuts while improving poor households' well-being, tailored to the needs of households in energy poverty. Promoting energy efficiency in rented dwellings, for instance, is challenging, as owners are not encouraged to undertake the work. New Zealand addressed this issue by allocating specific funds (NZD 18 million) to deliver insulation to low-income rental households with high health needs, including children ("Warm up New Zealand Healthy Homes Extension for Rentals Programme"). Portugal's National Strategy against energy poverty submitted to public consultation in April 2021 includes a broad set of measures that could address many deadlocks such as households' education or liquidity issues. However, the strategy has not been adopted yet. Moreover, itis not entirely funded, including for key measures such as those regarding financial institutions, or professional training.

Box 2.1. Cushioning the impact of higher energy prices

Despite being relatively sheltered from soaring energy prices, the government has launched measures to prevent a purchasing power downturn, with the risk of subsidising fossil fuels

Like most countries, Portugal must cope with an inflation rate at a level unseen for decades as consumer price is to increase by 6.3% in 2022. This inflation is fuelled by the rebound in demand following the COVID-19 pandemic and the recent attack on Ukraine that hampered global markets, and particularly the distribution of energy.

The increase in energy price in Portugal has been milder than in most EU countries so far. This is due notably to Portugal's smaller dependence of energy resources from the Russian Federation or Ukraine. In September 2022, for example, the yearly increase of home energy prices reached 31% in Portugal, compared to 53% in the whole European Union, diesel by 23% and gasoline by 2% (respectively +30% and + 12% in the EU).

The government carried out strong action to compensate households and firms from higher energy prices. These measures include price support like the partial reimbursement of fuel consumption or the refund of bottled gas for beneficiaries of social tariffs. Notably the carbon tax increase is suspended until further notice, along with an extraordinary reduction ISP. These measures will cost the government EUR 1.5 billion in 2022. Other measures support the fuel consumption of specific sectors like public transport (buses, taxis, etc.), the road transport, agriculture or gas-intensive industries. In September 2022, the government approved a EUR 1.4 billion package for companies and the social sector, including grants, credits and tax cuts, along with supports for the energy transition, as well as training for new skills.

To curb the wholesale electricity price rise resulting from higher gas prices, Portugal and Spain agreed with the European Commission to insulate the Iberian peninsula's electricity market from Continental Europe and to cap electricity producers' gas costs. This measure will take the form of a subsidy amounting to the differential between gas market prices and the agreed cap, which is expected to increase. This measure should be phased out on 31 May 2023. It will cost EUR 8.4 billion (EUR 6.3 billion from Spain, EUR 2.1 billion from Portugal). It will be fully funded, notably by a charge on buyers benefitting from the measure.

Source: Bruegel (2022), National policies to shield consumers from rising energy prices; EC (2022), State aid: Commission approves Spanish and Portuguese measure to lower electricity prices amid energy crisis; Government of Portugal (2022), *Familias Primeiro;* Government of Portugal (2022), *Pacote Energia para Avançar mobiliza 1400 milhões para apoiar empresas e setor social*.

2.3.2 Sectoral mitigation measures

Energy production and use

Portugal has made commendable progress in the decarbonisation of the energy generation sector, which is a main driver of recent progress for mitigation. However, energy production and use still accounts for two-thirds of all GHG emissions, and energy production alone for 18% (against 30% in 2005). Portugal's strategy to reduce these emissions relies on development of renewables in energy generation, more particularly in electricity generation; electrification of sectors dominated by fossil fuels; and energy efficiency.

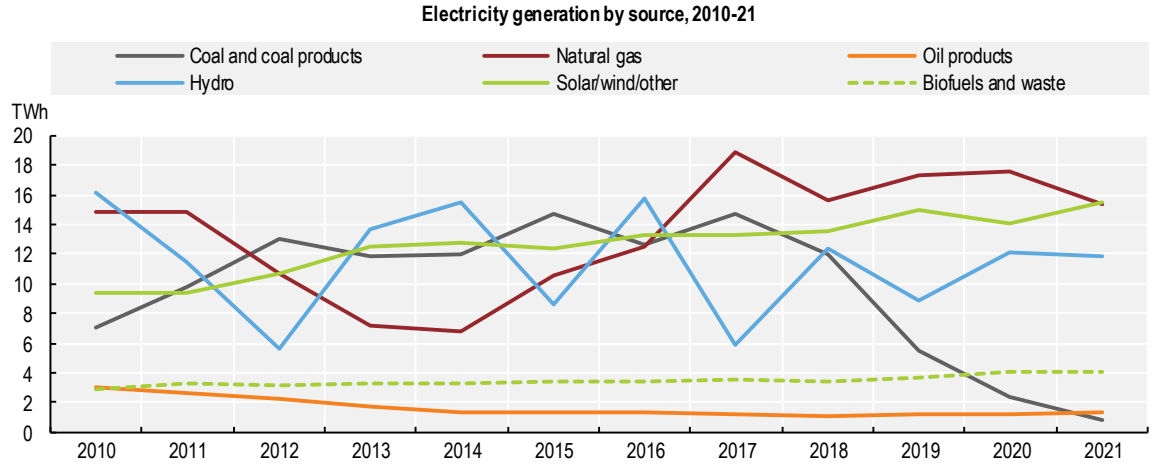
Decarbonising energy generation

Portugal plans to reduce its emissions from energy generation by 93% with existing measures, and by 95% with additional measures by 2030 and 99% by 2050. This trajectory is even more challenging in that it comes with the electrification of the economy and the need to increase generation capacity by 47-54% in a decade according to the NECP (Figure 2.8).

With 34% of renewable energy in gross final energy consumption in 2020, Portugal overachieved its binding target of 31% set by the EU Renewable Energy Directive (Eurostat, 2022). The country has set an ambitious target of 47% by 2030. This is above the 42% required for Portugal by the EU Regulation on Governance of the Energy Union and Climate Action and above the 45% proposed for the European Union in the revised Renewable Energy Directive. This objective translates differently between different sectors:

- Portugal plans to produce 80% of its electricity from renewable sources by 2030. With a rate of 58% in 2020, it was just below its objective of 60%. With the increased taxation of coal (Section 2.3.1), its share in electricity generation fell from 28% to 4% between 2015 and 2020, as renewable energy and natural gas became relatively more competitive (Figure 2.7).
- Portugal successfully developed renewable energy for heating and cooling, meeting its 2020 target under the Renewable Energy Directive. In 2020, renewables made up 41% of energy consumption for heating and cooling, well above the EU average (Eurostat, 2022). This comes mostly from biomass and heat pumps (IEA, 2021a). The deployment of energy efficiency plans and new technologies should allow reaching 49%, as required by EU commitments.
- Renewable energy makes up 9.7% of transport energy consumption, which is below the EU objective of 10% for 2020 and below the EU average (Eurostat, 2022). Almost all renewable energy in the transport sector now comes from biodiesel with sustainability criteria as defined in the Renewable Energy Directive (2018).

Figure 2.7. Electricity generation from coal is declining to the profit of natural gas and renewables



Note: 2021: provisional data.
Source: IEA (2022), IEA World Energy Statistics and Balances (database).

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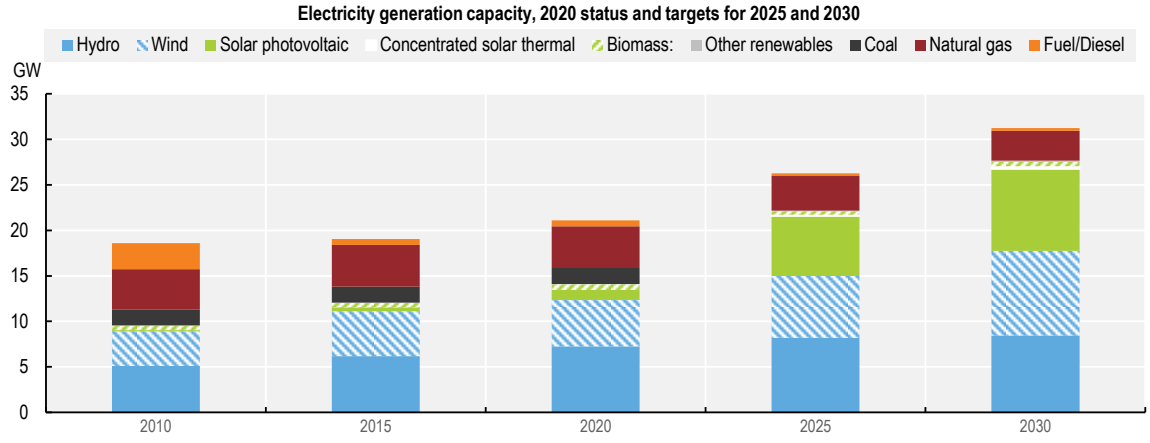
The deployment and diversification of renewable sources is the key pillar of Portugal's energy strategy. All types of renewables are expected to develop. In particular, solar photovoltaic capacity is expected to increase tenfold by 2030 (Government of Portugal, 2019a).

The government does not plan to reduce Portugal's installed capacity of natural gas for electricity generation before 2025, although it is far from carbon neutral. Natural gas supply has so far buffered the variation of hydropower generation. It will be used as a transitionary energy source in the way to decarbonisation. Natural gas still benefits from tax exemptions, due to a decline of 40% by 2023 but with an unclear 2030 horizon. The RNC plans to reduce the natural gas share in electricity generation by 2 by 2040 and by 20 by 2050 (Figure 2.8). Portugal is completely dependent on imports for natural gas, mainly from Algeria (*via* pipeline) and Nigeria (liquified natural gas). The cut of gas supply from the Russian Federation to the European Union did not threaten the security of supply. However, it caused a surge in prices that prompted a EUR 2.1 billion emergency plan to lower input costs for power generation (Box 2.1).

Figure 2.8. Portugal needs to double its renewable capacity by the next decade to meet its target



Note: Projections from the NECP with existing measures.
Source: IEA (2022), IEA World Energy Statistics and Balances (database), Government of Portugal (2019), National Energy and Climate Plan 2021-30.

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Monetary incentives prompted development of renewable energies as early as the beginning of the century, making Portugal a pioneer in green energy. From 2004 to 2012, a feed-in-tariff programme fuelled the development of wind, which became the first renewable source for electricity generation. The financial crisis led to the end of this subsidy; the development of wind energy has been stalled ever since. Since 2014, small-scale installations (below 250 kW) benefit from feed-in-tariffs of EUR 95 per MWh for hydro and PV and EUR 85.5 per MWh for biomass and biogas. Energy communities and self-consumption are also encouraged by partial exemptions of grid access tariffs (IEA, 2021a).

Electricity prices from producers benefitting from feed-in tariffs are heterogeneous according to the energy source. They range from around EUR 90/MWh for onshore wind, waste and hydropower to EUR 147/MWh for offshore wind EUR 290/MWh for PV. In 2019, guaranteed remuneration accounted for 63% of the total installed capacity of renewable energy, 36% of PV and nearly all wind.[3]

The government also provides a general framework for development of renewable energy sources and their integration into the electricity grid, putting a strong focus on solar energy. To adapt to the network's limitation and provide visibility to investors, projects with a capacity greater than 1MW must be granted a network capacity reserve. The access can be subject to an auction where the network capacity is tight, so that investors pay to strengthen it. From June 2019 to March 2020, only 27 projects corresponding to 4.5 GV were granted access to the network, out of 1 472 requests (IEA, 2021a). An auction was held in 2019 for the installation of 1.4 GW of PV dispatched in 24 lots on the network. Winning bids that offered the cheapest final electricity price were allocated to the projects. The government plans to continue holding

auctions twice a year for a total capacity of 1.0 GW and favour projects that will not put further strain on the network.

Decarbonising electricity generation while increasing its capacity calls for massive investment from both the public and the private sector to build the infrastructures and ensure their connection to the grid. The additional investment needs to achieve carbon neutrality of the electricity sector is estimated at EUR 1.2 to 2.2 billion in 2016-30 and EUR 9 to 11.3 billion in 2031-40 (Chapter 1). Solar energy (either centralised or decentralised) will get more than half.

Large infrastructure projects with innovative technologies have been launched to meet needed renewable capacity. Notably, the Tâmega Hydro Complex, made of three hydropower plants with total capacity of 1 158 GW, was launched with a EUR 1.5 billion investment costs. Of this amount, the EIB funded EUR 650 million. Substantial investments were leveraged by EU and national grants and a EUR 60 million loan from the EIB to Windplus SA. These allowed building of a viable cutting-edge floating offshore wind power station near Viana do Castello with a 25 MW capacity. The NECP indicates that floating offshore wind capacity should reach 300 MW by 2030.

No strong policy measure has been carried out for further development of wind generation. The deployment of onshore wind energy stalled by the end of feed-in-tariffs. Government policy is focused on repowering of existing onshore wind farms. The NECP notes that Portugal has significant generation potential to be explored but does not specify which policies or measures will support increasing onshore wind capacity in line with the target for 9 GW in 2030 (IEA, 2021a).

Decree-Law No 162/2019 provides a framework of self-consumption and energy communities, that offer multiple co-benefits to households and communities (highlighted in the NECP). However, it did not prompt the expected ramp up of small-scale generation. This calls for further education for households and municipalities, together with a simplified process and strong monetary incentives (IEA, 2021a).

Electrification and the development of hydrogen

The electrification of energy use in Portugal is the second pillar of the country's decarbonisation strategy. It should be achieved through sectoral policies (e.g. mainstreaming of electric vehicles – EVs). Electricity accounts for 50 TWh and 52.4% of final consumptions. This level has been stable for nearly 15 years but will need to accelerate to comply with climate commitments. This, in turn, entails the replacement of a large part of fossil fuels by electricity from renewable sources, particularly in the transport sector. The NECP projects that the installed capacity from renewable should be increased by about 50% from 2020 to 2025 and by 87% to 2030. To do so, Portugal notably aims to increase the number of international interconnections from the present 10% of total capacity to 15% in 2030.

Fiscal incentives and price signals should be aligned with the objective of a broad electrification of all sectors. The Green Taxation Law, passed in 2014, consistently planned the gradual suppression of tax exemptions for fossil fuels in energy generation. The introduction of a progressive value-added tax on gas and electricity for households also encourages energy savings and the installation of small capacities. However, non-carbon taxation accounts for most of the retail prices. It does not particularly encourage electricity use over gas in households' energy consumption: tariffs and taxes constitute 62% of natural gas final price and 67% of electricity retail price. This level of taxation can be reviewed while electricity is decarbonised to encourage low-carbon energy sources (IEA, 2021a).

Price incentives could encourage off-peak consumption by households and industries and then help manage the risk related to the intermittence of renewable energy. Electricity prices include peak-hour tariffs. By the end of 2021, 4 million smart meters were installed covering two-thirds of customers in mainland Portugal. Peak-hour tariffs for big consumers are only in a pilot phase (IEA, 2021a).

The development of hydrogen by electrolysis will allow decarbonisation of sectors that are hard to electrify (air and maritime transport) and development of carbon storage. Portugal estimates that it can cover 7%

of renewable energy for transport by 2030 and replace 10- 15% of natural gas in the gas network. Portugal launched a National Hydrogen Strategy to ramp up the integration of an untapped energy source and make it cover up to 2% of energy demand by 2030. This would ensure deployment of 2.0-2.5 GW of electrolysis capacity and the required regulation reforms. Investments have been initiated for a first project of 1 GW of green hydrogen from wind and solar power in the industrial area of Sines.

Energy efficiency

Portugal has successfully reduced the energy intensity of its economy, even while it was recovering from the 2008 economic crisis. It has largely met its 2020 target under the EU Energy Efficiency Directive. The country stands among the most energy-efficient in Europe, in terms of energy consumption per capita or GDP unit. Most of this progress has been achieved *via* energy savings in the industrial sector, notably in the non-metallic minerals and in the chemical and petrochemical industry. In contrast, energy consumption rebounded in the transport sector over 2013-19.

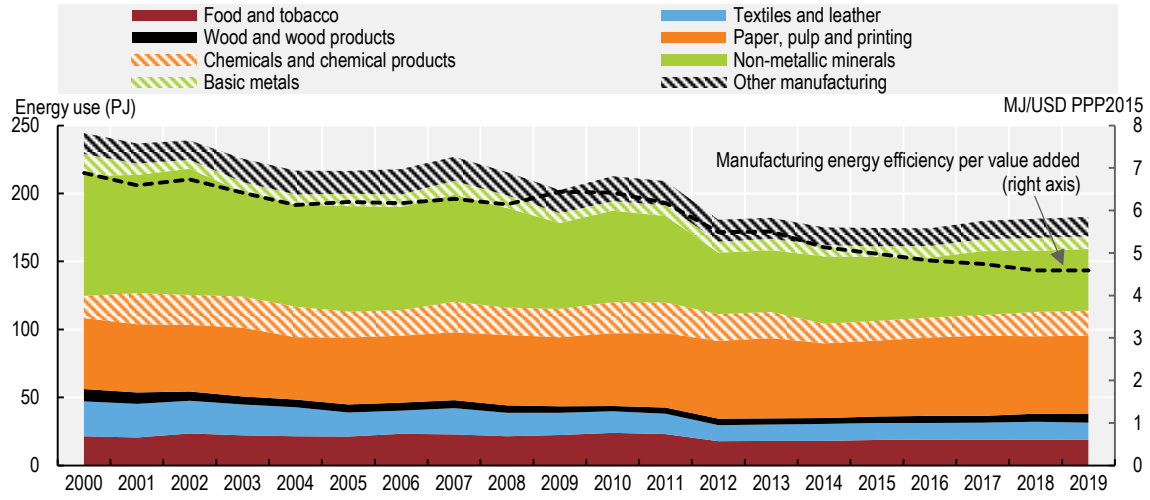
Further efforts will be required to meet 2030 targets, as Portugal committed to reduce its final consumption to 14.9 Mtoe (from 17.1 Mtoe in 2019 and 15.0 Mtoe in 2020), which the European Commission deems modest. Without information on how individual measures will affect energy consumption, it is impossible to assess whether they will suffice to put the country on track to meet its targets (EC, 2020a). The new EU objectives for 2030 calls for more ambitious commitments and accelerated action, particularly for building insulation.

General energy efficiency programmes have been launched to finance projects, mainly in the energy sector. The Portuguese government also created an Energy Efficiency Fund to promote behavioural changes in diverse areas. Between 2012 and 2018, this fund contributed to 20 calls for project by EUR 14 million. It is now integrated into the Environmental Fund.

The industry sector has reduced its energy consumption by 17.5% over 2010-2020, notably driven by strong policy incentives. Energy intensive industries (with an energy consumption exceeding 500 toe per year) are subject to the EU ETS. They must also conduct an energy audit every eight years followed by a plan for optimising energy use. Industries validating an agreement to rationalise their energy consumption are notably exempt from ISP.

Still, they are two reasons why industry uses less energy. Apart from energy efficiency progress, notably in the chemical industry, some sectors like textile and construction have a reduced value added following the 2008 financial crisis. The value added of the cement industry fell due to the 2008 crisis and its production volume has more than halved in less than a decade. In 2019, aggregate manufacturing production far outreached its pre-recession crisis level, while reducing its energy use by 19.4% compared to 2007 (Figure 2.9).

Figure 2.9. Manufacturing sectors have improved their energy efficiency



Source: OECD (2022), Industry Sector Detailed Data and Indicators (database).

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Energy consumption from the residential sector, which made up 16% of final energy consumption in 2019, has not been substantially reduced; it is at the same level of energy consumption as in the late 20th century. Two-thirds of the building stock was built before any energy efficiency requirement existed (IEA, 2021a). Dwellings appear more degraded than in the rest of the Union. A larger share of people lives in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floors (25.1% of people in Portugal and 14.8% in the European Union in 2020). More generally, 23% of dwellings that have undergone an energy performance review suffer from low energy efficiency (classification E or F);12.3% are very efficient (MAAC, 2021).

Portugal has taken measures to fight energy poverty (Section 2.3.1) and to ramp up energy efficiency. Following EU legislation, the performance of every building is audited when it is constructed, bought or leased. New buildings must comply with minimum energy performance standards. Furthermore, with funding from the EU, the European Investment Bank and the Council of Europe Development Bank, the Financial Instrument for Urban Renovation and Revitalisation provides co-financing for loans supporting deep renovation of buildings that are older than 30 years (EUR 1.4 billion budget over 2015-2025) (IEA, 2021a). The Recovery and Resilience Plan also notably aims to double the rate of renovation in buildings by 2025. It dedicates EUR 300 million to the improvement of energy efficiency in residential buildings with a programme that refunds part of household works (EUR 135 million) and offers efficiency vouchers (Section 2.3.1) and support to collective self-consumption and energy communities (EUR 35 million).

However, these programmes fail to substantially improve the energy efficiency of either dwellings or buildings, which calls for more resources. Generally, allocated funds fall short of the estimated EUR 110 billion of investment needed (EUR 3.7 billion per year on average), even with the lower estimate of a 15% coverage by public entities. Remaining costs for households are high (CNADS, 2022). It is also crucial that allocated funds are well-distributed for energy efficiency work. Public education, decentralised information available in local communities and training of workers, as planned in the project of a strategy against energy poverty will be key to avoid deadlocks.

Mitigating GHG emissions in transport

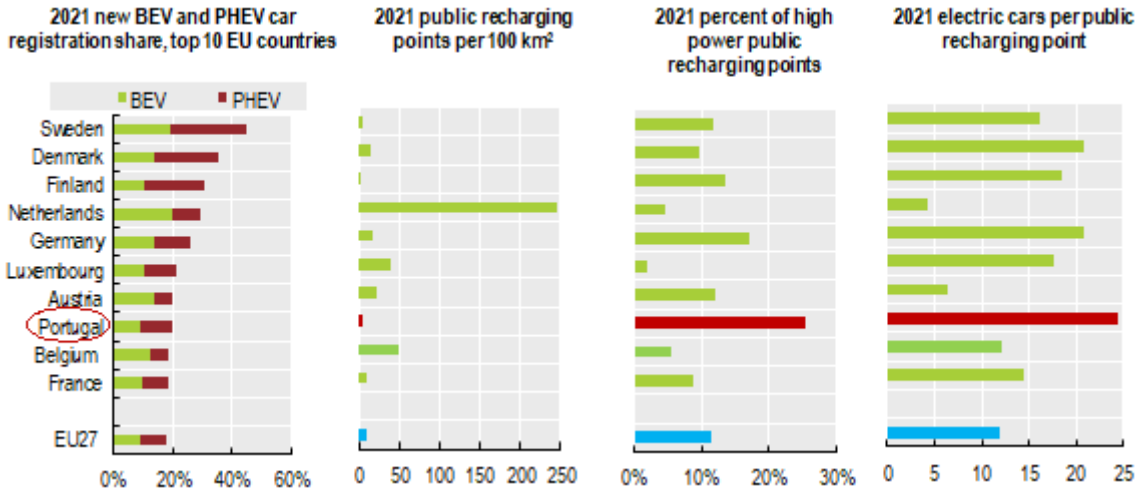
Emissions from the transport sector are at odds with Portugal's climate objectives. They grew steadily from 2013, together with the number of vehicles, until the COVID 19 pandemics halted the trend in 2020. The emission intensity of the sector (in tCO2 per unit of GDP) is high compared to other EU countries, even to south European countries such as Spain, Italy or Greece.

The vast majority (95%) of these emissions come from the road transport, which has been at the centre of the government's strategy to decarbonise the sector. Taxation is a main lever to green the vehicle fleet and discourage the use of emitting fuels. However, fuel and vehicle taxation did not reverse the growth in GHG emissions from road transport (Chapter 1). Closing the tax gap between diesel and petrol, and removing the preferential circulation tax treatment for older vehicle would help to rejuvenate the fleet and steer towards cleaner vehicles.

Since the mid-2010s, new car registrations have shifted to petrol and, in recent years, EVs and plug-in hybrid electric vehicles (PHEVs). The NECP estimates that electricity should cover more than 30% of transport demand in 2030 and 100% in 2050. Portugal promotes EVs through subsidies (EUR 4 000 in 2022 for light passenger vehicles up to EUR 62 500) and vehicle tax exemptions as well as investment in charging infrastructure. In 2021, the shares of EVs and PHEVs in new car registrations (9% and 11% respectively) were above the EU average (Figure 2.10).

However, EVs and PHEVs only make up 1.7% of the car fleet, far below the objectives for 2030 (EAFO, 2022). Direct support for the purchase of an electric passenger car (EUR 5.2 million planned from the environmental fund in 2022) is low compared to the needs. Portugal is also among the countries with the lowest number of charging stations per square kilometre. It should avoid deadlock by promptly stepping up deployment of charging equipment across the country. Large investments for the deployment of charging stations across the countries are included in the NECP. Portugal expects 15 000 public recharging points to be available by the end of 2025, compared to more than 5 000 in September 2022 (EC, 2021b; MOBI.E, 2022).

Figure 2.10. EV registrations are increasing but lack of charging stations risks creating deadlock



Note: BEV: battery electric vehicles; PHEV: plug-in hybrid electric vehicles. New car registrations fell by 35% in 2020 due to the COVID-19 and increased only slightly in 2021. High power recharging point: with power output higher than 22 kW.
Source: EAFO (2022), European Alternative Fuels Observatory.

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The Portuguese government must anticipate the potential impact on public finance of ramping up of EV among the national car fleet. The case of Norway (OECD, 2022b) shows the simultaneous increase of tax exemptions for low-carbon vehicles and decrease of tax revenue from excise duties on oil products can deter public finance. It can also lead to unwanted consequences such as increased congestion. In Portugal, fuel and vehicle taxes made up 4.7% and 1.6% of total tax revenues in 2020. Shifting to distance-based taxation would help to address the loss of fuel tax revenue (Chapter 1).

Portugal needs to reverse the trend towards increasing energy consumption in the transport sector, in parallel of emissions. To that end, it should reduce use of individual vehicles that rebounded after the 2008 crisis. Encouraging a greater use of public transit is a major lever, even more as it makes up a relatively small share of inland transport: trains covered only 5% of land passenger transport in 2019 compared to 8% in the European Union (Eurostat). Public transport also covered 13% of freight compared to 18% in the European Union. Efforts to ramp up public transport should include major infrastructure investment to improve coverage of the territory and the quality of these transport (Chapter 1). The Recovery and Resilience Plan includes EUR 967 million for their development, particularly expansion of Lisbon and Porto metros, and decarbonisation of public transport.

Land management could reduce car dependency and decrease the carbon impact of cities. The NECP embraces sustainability criteria and measures to contain expansion of urban areas and to limit soil sealing or revitalise urban centres. Local climate plans, mandatory under the Climate Law, are opportunities for municipalities and local governments to encourage use of active mobility and reduce urban sprawl that might increase car dependency. The National Strategy for Active Cycling Mobility aims to increase bike lanes by fivefold by 2030 (from 2 000 km in 2018 to 10 000 km in 2030).

International navigation and aviation represent 3% and 4% of Portugal's GHG emissions, respectively. Although they are not included in the national inventory total, these emissions increased by 51% over 2013-19. Flights within the European Economic Area are covered by the EU ETS but incentives to reduce emissions are not sufficient and the European Commission has proposed to remove fuel tax exemptions for the aviation and maritime sectors. In 2021, Portugal introduced a EUR 2 ticket tax on passengers travelling by air and sea. However, its rate is low by EU standards and it could better reflect the climate effects of the flights taxed (Chapter 1). The development of alternative fuels, and more particularly hydrogen, will be key to reduce emissions from international aviation and navigation at the EU level. Meanwhile, international shipping firms like Maersk have been developing new vessels to use biomethane as soon as 2024-2025. This calls for a quick adaptation of ports and infrastructure.

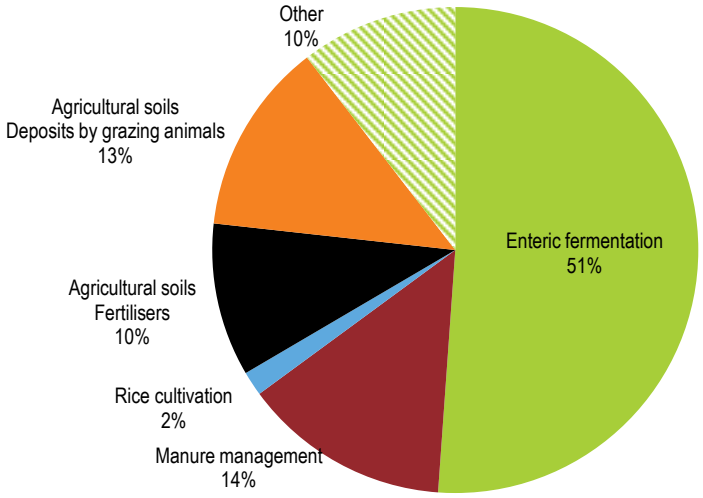
Mitigating GHG emissions in agriculture and promoting carbon sequestration in agriculture lands

Agriculture accounts for 12% of emissions, 2.3% of the country's gross added value and 3.2% of employment. Most of these emissions come from animal breeding, either from enteric fermentation, mainly from bovine livestock, or, from deposits of grazing animals on pastureland (Figure 2.11). Agriculture and agriculture land have the potential to abate emissions and capture carbon and are therefore key components of Portugal's strategy to net zero.

However, Portugal is not on track to meet its objective for 2030 (Table 2.2). GHG emissions from agriculture have increased since 2005, notably driven by the increasing number of animal heads (Figure 2.1). Major efforts are needed to reduce emissions related to the livestock sector and agriculture soils. In parallel, the NECP projects a strong use of grasslands as a carbon sink as early as 2030 (Table 2.3).

Figure 2.11. Most emissions from agriculture in Portugal come from the livestock sector

Breakdown of GHG emissions by the agricultural sector, 2020



Source: APA (2022), National Inventory Report 2022, April.

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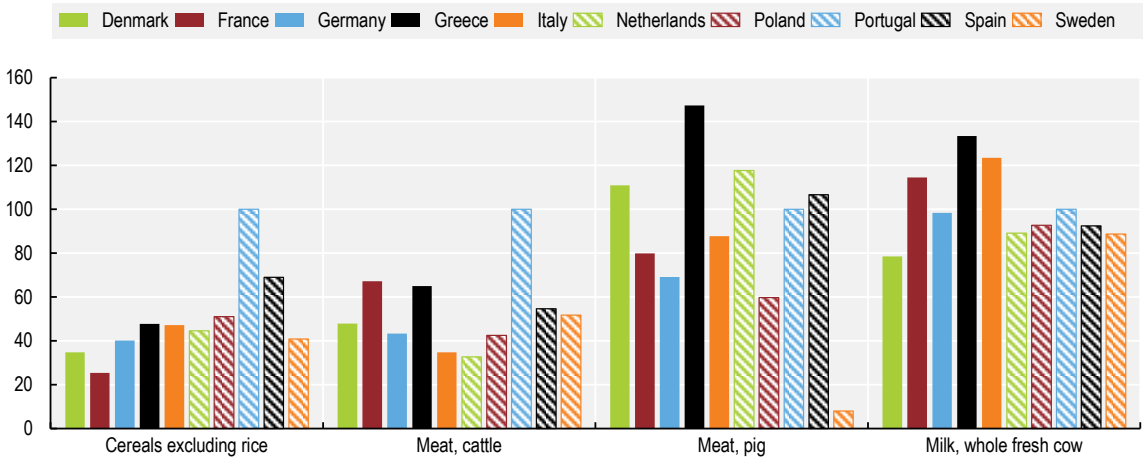
Portugal's agriculture products are more emission intensive than in most countries (Figure 2.12). This is especially the case for grains (excluding rice) and meat cattle, the largest source of GHG emissions from agriculture in the country. In this latter sector, emissions have grown since 2013. This is, driven by the small rebound in the number of heads and the constant increase of emissions per meat produced since the late 1980s. Meanwhile, organic farming has been gaining momentum in Portugal, as dedicated supports (for conversion and maintenance) cover 18% of the agricultural surface in 2021-2022. This represents a significant jump from 7% in 2020. It also puts the country on track for its domestic objective of 19% by 2030 (as the EU-wide objective European Green Deal is 25%).

Portugal's agriculture policy, including for climate change mitigation, is embedded in the EU's Common Agriculture Policy (CAP), of which the next programming period will cover 2023 to 2027. The country's CAP Strategic Plan, approved by the European Commission, has a EUR 6.6 billion budget (of which 9% is national co-financing). EUR 1.1 billion is reserved for environmental and climate objectives under rural development (EC, 2022c).

So far, agricultural policies have not been up to the climate change mitigation challenge. Compared to the EU average, a larger share of Portugal's support to agriculture is dedicated to climate and the environment. Few actions support the mitigation of agriculture emissions and specifically target livestock. In addition, the country has among the highest share of coupled supports (i.e. proportionate to production or the number of animal heads), targeting mainly ruminants and incentivising livestock-intensive farming. The proportion of land used for climate purpose (e.g. carbon sequestration) is low and the budget dedicated to land restoration is below the average on the continent. Finally, the clauses on the reduction of food waste and promotion of healthy diets in the 2021 Climate Law (article 56) could reduce the environmental footprint of agriculture. Theycall for concerted efforts to build a detailed and broad strategy with stakeholders belonging to all parts of the supply chain.

Figure 2.12. Portugal has margins to reduce the emission intensity of its main agriculture products

GHG intensity of agriculture products (CO_2e/kg) relative to Portugal (Portugal=100), 2017



Source: FAO (2022), FAOSTAT (database).

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Table 2.3. Projected emissions from agriculture and lands induce a reverse in current trends

Inventoried and projected emissions from AFOLU in $MtCO_{2e}$

	Level of emissions (in $MtC0_2e$)	Evolution in $MtCO_2e$				
		Observed 2010/2020	With existing measures		With additional measures	
	2020		Projected 2020/2030	Projected 2020/2050	Projected 2020/2030	Projected 2020/2050
Agriculture	**7.0**	**0.4**	**-0.2**	**-0.1**	**-0.4**	**-0.6**
Enteric fermentation	3.6	0.2	-0.1	0.0	-0.2	-0.1
Manure management	1.0	0.1	0.0	0.1	0.0	-0.1
Rice cultivation	0.1	0.0	0.0	0.0	0.0	0.0
Agricultural soils*	2.2	0.2	-0.1	-0.2	-0.2	-0.3
Other	0.1	0.0	0.0	0.0	0.0	0.0
LULUCF	**-6.8**	**2.1**	**-3.9**	**-6.2**	**-5.1**	**-7.5**
Forest land	-9.2	1.8	-4.0	-6.7	-4.0	-6.7
Cropland	0.6	-0.1	-0.2	-0.2	-0.2	-0.2
Grassland	0.1	-0.6	0.3	0.5	-0.9	-0.8
Other	1.7	0.9	0.0	0.2	0.0	0.2

* Nitrous oxide from agriculture soils notably resulting from nitrate fertiliser use.
Note: LULUCF = land use, land-use change and forestry. AFOLU = Agriculture, forestry and other land use.
A negative level of emissions means that additional carbon was sequestrated.
Source: APA (2022), National Inventory Report 2022, April; APA (2021), Emission projections.

Climate plans for 2030 do not include impactful measures for agriculture and even less so for livestock. Despite ambitious targets for the climate performance of agriculture in the RNC 2050 and the NECP 2030, details on implementation are lagging. A strong and legitimate focus is put on carbon capture and on-farm energy generation, but the country lags in emissions abatement measures in agriculture. The national plan for the future CAP has small ambitions for supporting on-farm practices and investments to abate GHG emissions (EC, 2022d).

Only strong and prompt action would help Portugal achieve its climate targets and revert the increasing trends of agricultural emissions. More particularly, there is a strong potential to reduce methane emissions from livestock breeding. Measures could include improved management of manure and cattle housing or culture change. These might require substantial on-farm investment from a population with a smaller income than average and exposed to climate risk (EC, 2020b). In many cases, these investments should be supported by a public fund, taking care to avoid credit-related risk. These supports can take the form of credit support, subsidies or guaranteed payment related to the benefits of the investment for the public. In the longer term, Portugal could promote result-oriented subsidies for ecosystem services in the CAP instead of payments based on land area. This would enhance ecosystem services, and particularly carbon sequestration, in agriculture lands.

Portugal has the potential to improve farmers' livelihoods and decrease GHG emissions by developing in-farm renewable energy (sustainable biofuels, cogeneration or biogas). A broad strategy, such as mentioned in the 2021 Climate Law, should ensure the environmental sustainability of projects by avoiding unwanted pollution, and avoid the use of food crops. In parallel, the market should ensure a profitable environment for developing the market for sustainable biogas, notably through adapted legislation and grid connexions. Dialogue with stakeholders will be key.

Demand-side measures that promote low-carbon diets could help achieve targets by reducing the need for livestock production, but also enhance public health and food security. The 2021 Climate Law enshrines the principle of aligning food taxes and incentives to their social costs. However, it does not provide details on the considered tax or implementation of such a tax system (article 56). Reducing food waste is also a major lever for lowering the impact of agriculture production. In 2018, Portugal launched a comprehensive

strategy for combatting food waste, covering all segments of the supply chain. However, results are so far lagging, notably due to lack of agreements of stakeholders on guidelines (CNCDA, 2021).

Mitigating GHG emissions from waste and wastewater

Portugal has the highest share of waste emissions in the OECD (Figure 2.1). More than three-quarters of these emissions came from solid waste disposal. This is due to the high volume of municipal waste generated per capita and the high share of waste sent to landfill (Chapter 1).

The NECP projects that the sector will meet its 2030 target (Table 2.2). It assumes that Portugal will comply with the EU Landfill Directive, which limits the share of municipal waste landfilled to 10% by 2035 (from 53% in 2020). However, this requires much faster progress than has been made in the last decade. Instruments to reach this objective are still unclear.

New circular economy strategies and projects could reduce emissions from the waste sector and should be accelerated. The strategy for a circular economy aims to drastically reduce the amount of waste produced by the Portuguese economy, from producers to consumers. This will cut both their direct emissions, particularly with the strategy for reduced food waste, and the indirect emissions generated by their management. Revision of the Urban Waste Water Treatment Directive will probably support measures reducing GHG emissions from treatment plants. It is expected to implement stricter rules to smaller agglomerations (now not affected by the directive), promote energy efficiency and prevent leaks.

The potential of bioenergy from waste is still to be harnessed. It amounts for 0.6% of the capacity of renewable energy but could be ramped up to produce biofuels (biomethane) and help decarbonise the transport or residential sectors.

2.4. Policy framework and measures for climate change adaptation

2.4.1. Risks related to climate change have increased in Portugal

Climate change will strongly affect Portugal's environment

Mainland Portugal's position alongside the Atlantic Ocean and close to the Mediterranean Sea puts it amongst the most exposed territories to climate change in Europe. The mainland territory has an overall Mediterranean climate, with rainy winters and dry summers, while the south has the hottest summers. The inland's climate has drier winters than the rest of the country, due to the influence of the Iberian climate.

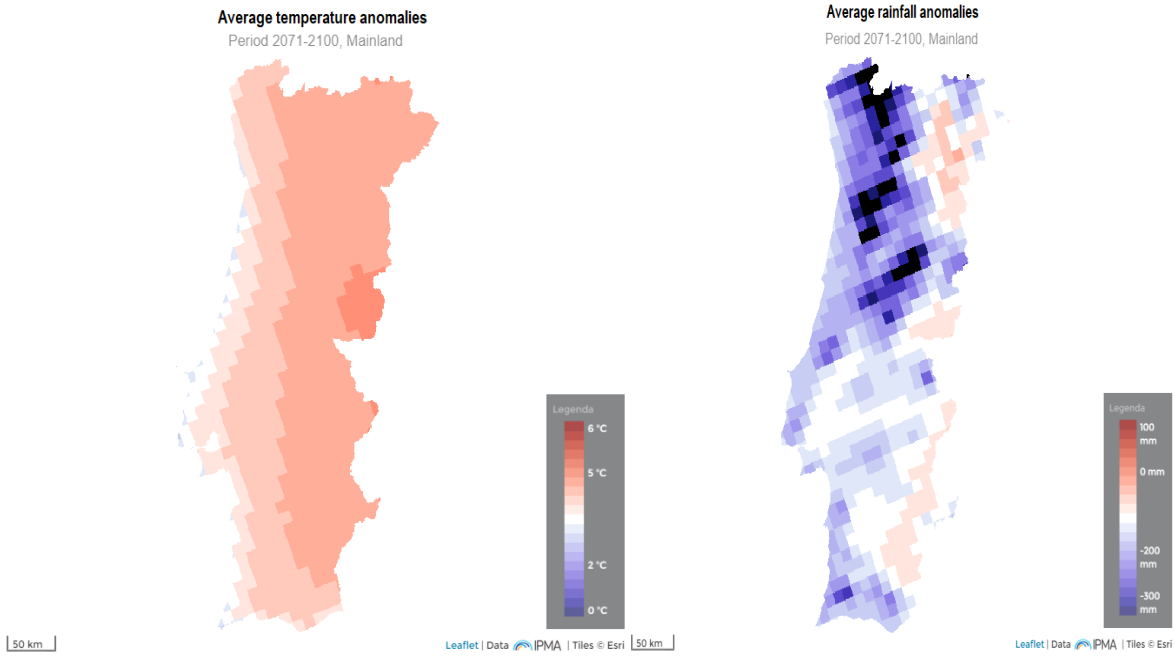
Portugal will likely experience increased average and maximum temperatures, rising sea and more frequent extreme events. Indeed, these impacts are already apparent (Table 2.4). The Intergovernmental Panel on Climate Change projects that if the world succeeds in limiting global warming to 2°C by 2100, temperatures in Portugal would increase by 2-3°C beyond pre-industrial levels by then, with an increased number of very hot days, especially in the southern inlands. More intense and longer heatwave will hit the country more often (Government of Portugal, 2021b), as the number of hot days is expected to double by 2030 (IPMA, 2016). Temperatures have already increased and regularly exceeded the maximum temperatures of the fourth quarter the 20th century (Figure 2.13).

Precipitation is expected to become more erratic and less frequent. Average annual precipitation has already decreased by approximately 15 mm per decade since the 1970s (World Bank Group, 2022). Over the last two decades, rainfall has been particularly low in mainland Portugal. It can be reduced by up to 10-50% by the end of the century, following current emission trends. Periods of drought are to be expected, as well as extreme precipitation and an extended dry season (Government of Portugal, 2021b).

These hazards are expected to be severe but heterogeneous across the territory depending on latitudes and according to proximity to the ocean (Figure 2.13). Notably, the southern inlands will suffer the most

from very hot days. The temperature rise in the Autonomous Regions of the Azores and Madeira is expected to be more subdued than in mainland Portugal (Government of Portugal, 2021b). Regions alongside the Atlantic Ocean will be relatively less affected by increasing temperatures. However, they will have to cope with coastal erosion of which climate change is a major driver. Sea-level rise is expected to reach 0.5 m by the end of the century (even exceeding 1 m above 1990 levels in some estimates). This will increase the risk of salinisation of coastal areas and coastal erosion (Government of Portugal, 2021b). The disruption of wave directions and storm regime, drought and the reduced provision of sediments from rivers to the coast further contribute to the shoreline retreat.

Figure 2.13. Climate change impacts differ across the Portuguese territory



Note: Anomalies compared to observed data in 1971-2000 for 2071-2100, RCP8.5 scenario (high GHG emission scenario by the IPCC). Regional and global model Ensemble.
Source: Climate Change in Portugal Portal, http://portaldoclima.pt/.

Table 2.4. Current and projected impacts of climate change in Portugal

Observed and projected changes relative to 1995-2014 observed data

	Observed change 2014-21	Projected change 2028-32	Projected change 2048-52	Projected change 2090-2100
Mean temperatures	+0.4°C	+0.6°C	+1.2°C	+2.0°C
Maximum temperature	+0.8°C	+0.7°C	+1.3°C	+2.3°C
Nb of hot days (>35°C)	-	+6.1	-	+19.1
Precipitation	-128.1mm	-179.9 mm	-215.5 mm	-257.8 mm
Number of consecutive dry days	-	+5.8	-	+17.5

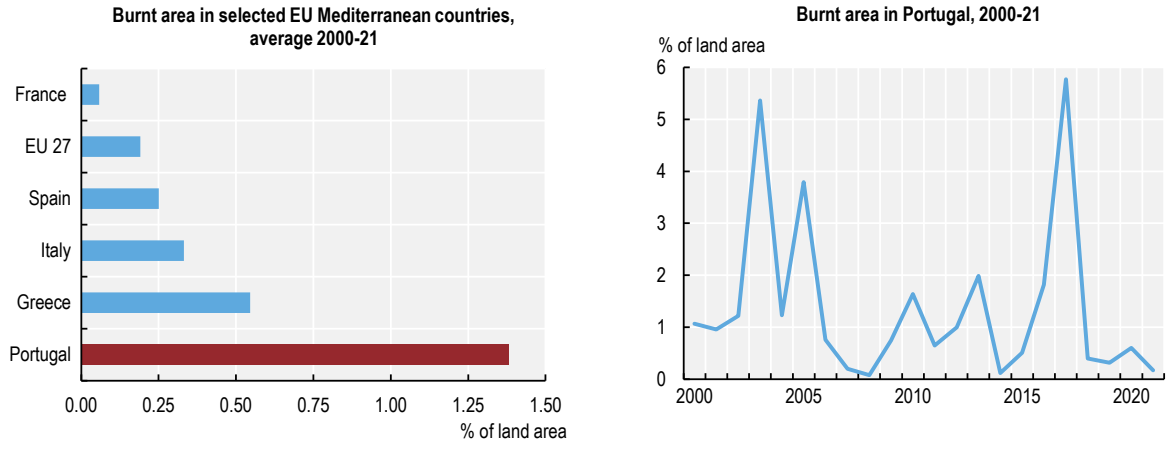
Note: Projections are based on a SSP2-4.5 scenario as defined by the IPCC ("middle-of-the-road" scenario).
Source: World Bank Group (2022), Climate Change Knowledge Portal.

These new climate conditions negatively impact Portugal's natural environment. As precipitation is reduced with a higher variability, water resources have become increasingly scarce, threatening the recharging of aquifers and weakening water flows. In future, major rivers of the Iberian Peninsula could run dry. This could accelerate biodiversity loss and desertification (i.e. land degradation in drylands) in Portugal. Between 2016 and 2020, soil moisture in croplands was 3.3% below the average of 1981-2010 (Maes et al., 2022). The year 2022 has been particularly dry. Volumes stored in reservoirs and groundwater could not be replaced, calling for extensive measures, including abstraction quotas for hydropower generation and irrigation (Government of Portugal, 2022b).

Heat and drought are accelerating soil desertification particularly in southern regions. Such phenomena induce soil degradation, salinization, loss of organic carbon and biodiversity loss. In Portugal, desertification intensified and spread in the last decade. In the future, the risk of aridity might affect most of the country's land in case of an extreme 4.3°C warming scenario[4] (ECA, 2018).

These environmental conditions also increase wildfire hazard. Intense heat and strong winds facilitate the spread of the wildfires, affecting biodiversity and accelerating land erosion, particularly in the northern and central parts of the country. Mainland Portugal experienced its most extreme forest fires in recent decades (Figure 2.14). The areas burnt reached unprecedented levels, even compared to other south European countries, in 2003, 2005 and 2017 (in which year at least 66 people were killed). Between 2017 and 2021, nearly 1.5% of the country's area burnt. This makes Portugal the country most affected by wildfires in Europe and sixth-affected globally (behind Australia, South Africa, Brazil, India and Colombia). Nearly three-quarters of its tree-covered area is exposed to very high or extreme fire danger (Maes et al., 2022). The country also went through intense wildfires in the summer of 2022, although less intense than those experienced by neighbouring countries like Spain or France.

Figure 2.14. Portugal has been the EU country with the highest share of burnt area in the last decades



Source: Maes et al. (2022), Monitoring exposure to climate-related hazards: Indicator methodology and key results.

StatLink https://stat.link/ta2kin

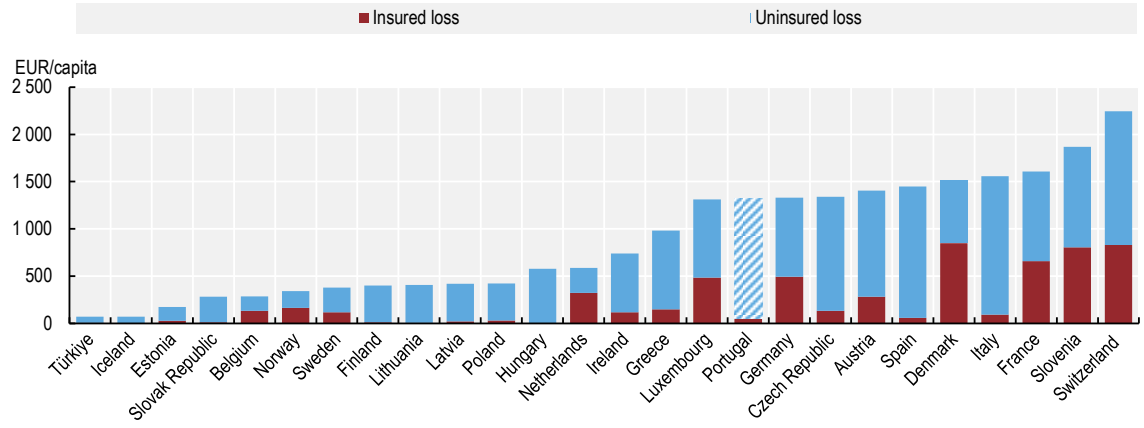
All these factors combined to disrupt environmental balance, putting biodiversity at risk due to climate change. Changes in precipitation, temperatures and soil quality lead to fragmentation of species' habitat and the spreading of invasive species as biodiversity is already in poor condition in Portugal (Chapter 1).

A drop in Portuguese well-being is expected if the country does not adapt to the new context

Without adaptation measures, climate change will strongly undermine the well-being of the Portuguese population. Southern European countries will face a large range of these impacts and are the most affected within the European Union: if no adaptation or mitigation measures are taken, the welfare cost would amount to 2.9% of the region's GDP by the end of the century (compared to 1.8% for the whole European Union). This is mainly related to additional energy costs and health issues (Ciscar et al., 2014).

A precise estimate of the overall economic loss related to climate change in Portugal is challenging; figures are scarce and largely uncertain. This is related to the difficulty of attributing damages to climate change, but also to the scattered consequences of climate events, which makes gathering all information a challenge. Using insurance data and local experts, the European Environment Agency estimated that extreme weather or climate events caused the loss of EUR 13.5 billion to the Portuguese economy and 9 267 deaths (EEA, 2022a). Only 3.6% of damages are insured (Figure 2.15). Portugal also estimated that costs induced by forest fires amounted to EUR 60-140 million yearly and those induced by severe drought to EUR 290 million in 2005 and EUR 200 million in 2012.

Figure 2.15. Few economic losses related to extreme weather and climate events in Portugal are covered by insurance



Note: 1980-2020.
Source: EEA (2022), Economic losses from climate-related extremes in Europe.

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Key elements of Portugal's economy and welfare are exposed to climate change impacts

Large parts of the population and the economy are exposed to the impacts of climate change. Notably, infrastructures and people are exposed to heavy rainfall in the coastline regions where three quarter of the population and 85% of the economy concentrates.

The tourism industry, a major economic driver, may need a thorough overhaul to adapt to new conditions. Portugal is among the European economies most reliant on tourism that is threatened by climate change. The acceleration of tourism from 2010 helped the country recover from the 2008 crisis, as the number of tourists nearly doubled in the following decade. It directly and indirectly accounted for 15% of the GDP and 18% of employment in 2019 (including 9% of direct employment) (IMF, 2022b). As a large majority of tourists stay in coastal areas, rising sea levels and coastline erosion will be a challenge for the industry and a threat for the overall economy. Biodiversity loss and water scarcity damaging the landscape can also undermine inland tourism.

Changes in the natural environment already strongly affects agriculture, forestry and fisheries with lasting effects. Agriculture (2.2% of GDP) will also have to adjust to less precipitation, weather variability, extreme events, desertification, emerging disease and the change in overall climate conditions that can severely impact some cultures. Portugal's cropland productivity will suffer the most from drought among EU countries with 61% of cropland affected (EEA, 2022b). A large part of Portuguese crops is also dependent on irrigation. Estimates from the third River Basin Management Plans show an increase of about 25% in agricultural water abstractions since the mid-2010s, particularly in the southern regions. Irrigated areas increased by 21% over 2009-19 (Chapter 1).

Finally, the increasing number of fires and the spreading of exotic species and plague endangers the forestry economy, which accounts for 10% of total exports (ICNF, 2020). Timber harvesting is also made difficult with forest fires and the induced age variability between trees within the same parcels, as younger trees in burnt areas mix with older vegetation that survived (APA, 2020).

People's health will be affected, and Portugal's ageing population is particularly vulnerable. Increased heat, biodiversity changes and floods worsen both morbidity and mortality. The impact on health is aggravated

by an ageing population, due to increased life expectancy (from 78.4 years in 2004 to 81.8 years in 2019[5]), lower birth rates and emigration. Notably, extreme temperatures kill and generate new pathologies (respiratory, cardiovascular, renal failure). The number of deaths related to climate change might double in the European Union by the end of the century if emission trends persist (+100 000 deaths per year on the continent), with most deaths occurring in central and southern EU (Ciscar et al., 2014). As an illustration, the 2003 heatwave that stroke all Europe caused an excess of mortality of 38% during the summer relative to other years in the same period (which translates into 1 316 excessive deaths) (Nogueira et al., 2005).

Climate change puts at risk the country's energy system and its capacity to reach net zero emissions by 2050.

New climate conditions undermine the country's capacity to meet its objectives for the deployment of renewables. Energy demand is expected to increase in all countries of the southern European Union (+8% in average) by the end of the century. This calls for further renewable generation (Ciscar et al., 2014), but the potential of some renewables is at risk. Indeed, water scarcity weakens the capacity of hydropower, which covers 5% of Portugal's total energy supply. In the case of a 2°C warming, the hydropower potential would be reduced between 10% to 20% (Hoegh-Guldberg et al., 2018; Fortes et al., 2022). In 2022, drought caused officials to close five hydropower power stations. However, details on how the government considers the reduction of water availability in its climate change mitigation are unclear.

Forest fires are directly responsible for CO_2 emissions while compromising forests and soils' capacity to sequestrate carbon. The net-zero objective described in the RNC 2050 entails that carbon sequestration in forest land is doubled from 2020 to 2050. However, the rate has not substantially increased for three decades and, in fact, has been slowly decreasing. In 2017, the massive forest fires made forestry a net carbon emitter by a nearly similar amount of carbon that it usually sequestrates (7 Mt CO_2).

Climate change can also affect the relative cost-effectiveness of different renewable sources like photovoltaic and offshore wind (Fortes et al., 2022). This calls for the integration of thorough climate scenarios into strategic energy plans. Finally, the difficulties faced by the wood industry because of climate change (fires, pests), can undermine the potential contribution of biomass in the decarbonisation of the energy sector (Casau et al., 2021) (Section 2.3.2).

Table 2.5. Portugal's exposure and vulnerabilities to climate change

	Portugal	OECD average	Year
Tourism as a share of direct employment in total employment	9.8%	7.1%	2016
Share of the primary sector in the economy	2.2%	2.5%	2018
Share of agriculture in employment	3.2%	4%*	2020
Population exposed to one or more hot days [Tmax > 35°C]	37.5%	45.2%	2020
Built-up areas exposed to coastal flooding 2010-20	0.2%	1.4%	2020
Population exposed to at least one storm event	56.2%	34.8%	2020
Tree-covered land exposed to wildfire	74.1%	15. 8%	2020
Population over 65 years old	22.7%	17.8%	2021
Projected population over 65 years old	26.5%	20. 9%	2030
Hydroelectricity in the total energy supply	5.3%	3.2%	2020
Renewable energy in electricity production	58.2%	46.4%	2020
Irrigated land as a share of agriculture land	14.5%	..	2019
Land equipped for irrigation as a share of agriculture land	14.6%	11.4%*	2020

*EU 27 average.

Source: Maes et al. (2022), Monitoring exposure to climate-related hazards: Indicator methodology and key results; OECD (2021), OECD Economic Surveys: Portugal 2021; EC (2021), Portugal: Agriculture statistical factsheet; FAO (2022), FAOSTAT (database).

2.4.2. Portugal has ramped up its strategy to adapt to climate change

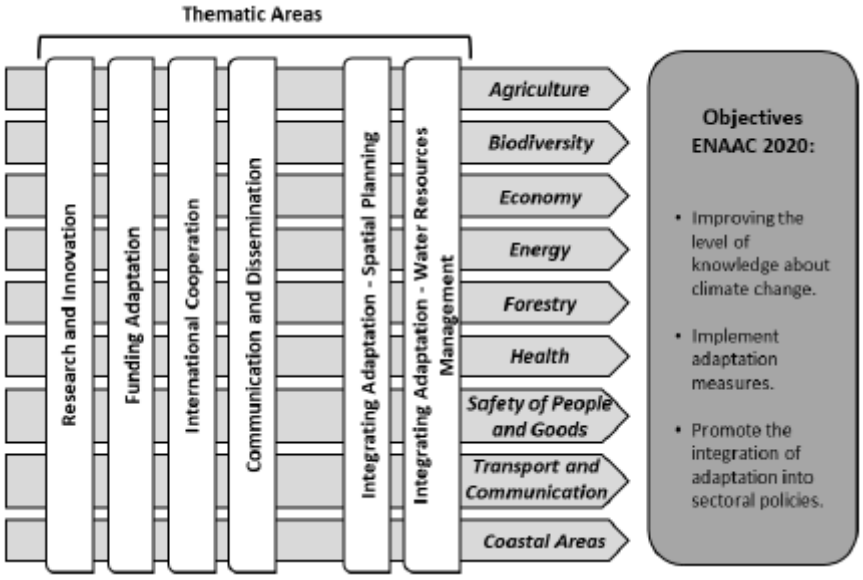
The Ministry of Environment and Climate Action is at the centre of the institutional framework for adaptation

The CAC, headed by the minister, is responsible for Portugal's overall climate strategy, including for adaptation. The APA oversees monitoring action and assessing risks, and manages the working groups (Section 2.2).

Portugal's strategy for adaptation to climate change relies mainly on two structural documents:

The National Climate Change Adaptation Strategy (ENAAC 2020), adopted in 2015, is the update of the 2010 NAS. It establishes governance and responsibilities of Portugal for climate change adaptation and determines the main impacts and vulnerabilities. Its major goals are to improve knowledge on climate change; implement adaptation measures; and promote integration of adaptation into sectoral policies. The foundation of ENAAC for adaptation policies rests on working groups (Figure 2.16). They provide reports and recommend adaptation policies to the coordination group managed by the APA. A scientific panel also advises the co-ordination group.

Figure 2.16. Representative diagram of ENAAC's thematic areas and priority sectors



Source: Government of Portugal (2021), Portugal's Adaptation Communication to the United Nations Framework Convention on Climate Change.

The Action Programme for Adaptation to Climate Change (P-3AC), adopted in 2019, aims to implement the adaptation strategy on the territory. It defines nine priority areas and comprises the actions and budget for the short term. It also provides outcome indicators to monitor the action for climate change adaptation (Government of Portugal, 2021b). P-3AC ensured the funding of public actions for adaptation until 2020 with EUR 372 million. Most of its fundings (96%) came from the Rural Development Programme (PDR) and the Sustainability and Resource Efficiency (POSEUR). Remaining funding came from the Environmental Fund (EUR 14 million).

Portugal will benefit from massive EU funds to scale up its action for climate change adaptation, but not all the P-3AC action lines will benefit. Portugal's Recovery and Resilience Plan includes more than

EUR 1 billion of grants and loans for the preservation of forests or water management. However, it fails to cover other P-3AC areas such as coastal protection or soil conservation. Addressing all priorities in the adaptation strategies will require sound and predictable funding for ambitious action.

Municipal and intermunicipal Climate Action plans are major elements of the country's strategy for adaptation to climate change. They are made mandatory under the 2021 Climate Law and to be delivered within two years. Regional development and coordination commissions, as well as metropolitan areas, must also build their own plans. In 2020, adaptation plans covered a vast majority of municipalities, including in Azores and Madeira. The first phase assesses local risks and needs for adaptation, while the second phase implements adaptation measures, for the coastline, water resources and nature conservation, among other areas.

Portugal's government must adjust to the induced devolution of adaptation measures by both empowering local governments and ensuring overall consistency. Local governments still have minor responsibilities, and the strategy does not have bottom-up processes that could ensure the effectiveness of the strategy. Municipalities are not required to monitor or assess their adaptation plans, although this would contribute to good practices. Furthermore, there is no statutory requirement for policy alignment between the municipalities, inter-municipalities, or sectors, although action in one area can impact vulnerability to climate change risk in others. In the case of coastal management, dozens of entities, local governments and administration share responsibility (Oliveira, Moura and Boski, 2020). Such co-ordination of local action could help enhance synergies, implement measures on a large scale and avoid conflicts of interest, notably regarding land or water use. Sectoral and inter-sectoral co-ordinations also seem to lag behind, although they are crucial for effective action (EC/EEA, 2022).

Box 2.2. Loulé: A pioneer municipality in local climate action

Loulé, a city of 70 620 inhabitants in Algarve region near Faro, has led ambitious climate action, illustrating the role municipalities can play for climate and the environment. Due to its location, Loulé is exposed to rising temperature, increasing sea level, water scarcity and periods of drought.

Loulé was among 26 cities to commit to AdaptLocal, a network of Portuguese municipalities working together for adaptation to climate change as early as 2016. Following the Climate Law, Loulé has defined the priorities of its Municipal Climate Action Plan and built governance to ensure the plan was operational. Notably, it created a council incorporating key stakeholders from civil society and public institutions like APA to monitor and discuss actions for climate. It also works in close co-operation with neighbouring municipalities. This collaboration is either direct for specific measures, or within the framework of the Inter-municipal Community of the Algarve for an intermunicipal plan for adaptation to climate change.

Loulé has been closely monitoring the impacts of climate change to address the challenge of adaptation. It launched a study on the future of sea levels and tides and the associated risks, with a focus on socio-economic vulnerabilities. A municipal observatory on the environment and climate also allows the gathering of information as open data for public and private decision-makers.

The city has taken strong actions to address the numerous challenges of climate change: mitigating the municipality's GHG emissions, adapting to climate change and protecting the environment. Water availability is a particular challenge in this region. The municipality has built a contingency plan for drought period to minimise the impact of scarce water and engaged for a more efficient water use. It encourages the production of renewable energy in public building and places, and allowed a school to be nearly self-sufficient for its energy. To protect its territory and biodiversity, it aims to create a UNESCO Global Geopark together with two neighbouring municipalities. The municipality notably suspended a tourist development plan in wetlands. Following this decision, it approved classification of the area as a local natural reserve in early 2022.

Source: Lemos (2021), Loulé approves the creation of the Foz do Almargem and Trafal Local Nature Reserve; Loulé City Council (2022), Notice of 7 February; www.louleadapta.pt/en.

The ambitious objectives for monitoring of adaptation measures calls for further resources

Monitoring adaptation measures is crucial for good implementation. The P-3AC defines indicators and result targets based on both coverage of measures (e.g. the share of municipalities with an adaptation plan) and the impact of climate change on human activities (e.g. reduction of cases of human diseases caused by vectors related to climate change). These indicators are used as a basis for the annual monitoring report on the P-3AC and gathered by the NAS co-ordination group together with the APA.

Monitoring of action shows good implementation of adaptation measures. Most municipalities have released their adaptation plan (271 of 308 in early 2022). The tracing of EU support shows large disbursements for Portugal's adaptation (notably EUR 1 745 million from the Rural Development Programme to agriculture and forestry) (EC/EEA, 2022).

However, monitoring and evaluation of measures and strategies is challenging. Municipalities do not report on their implemented action in a centralised way. The biannual report of ENAAC provides only qualitative information on progress tracking and P- 3AC indicators have not yet been updated due to lack of stable funding. The first evaluation of the P-3AC is due in 2022, three years after release of the plan. As a

comparison, the United Kingdom's adaptation plans have a five-year cycle, including several steps of monitoring and reforms based on quantitative indicators (OECD, forthcoming). The National Roadmap for Adaptation 2100, expected by the end of 2023, will update the projection of the physical and economic impacts of climate change and assess the impact of adaptation measures, using several climate and policy scenarios.

2.4.3. Actions for adaptation have gained momentum in Portugal

Public information on climate change risks has been substantially improved

Portugal has focused on dissemination of knowledge, fully integrating scientists in the governance system of the ENAAC (EEA, 2020). Information systems have been developed for people, companies and public entities to anticipate climate change. The Portuguese Institute for Sea and Atmosphere (IPMA) used regional climate models to assess the precise geophysical outcome of climate change in the country. Websites like Portal do Clima help disseminate information on vulnerabilities across the country. The IPMA presented 40 indicators on climate vulnerabilities on a single portal (portaldoclimat.pt), as well as real-time detailed information on wildfire risks. Extreme risk scenarios are also assessed to anticipate and protect infrastructure, notably for electricity or transport.

Risk assessment has been increasingly mainstreamed in public work projects, notably for infrastructure. Environmental Impact Assessment, implemented upstream of the decision of launching a project, includes a risk assessment related to climate change scenarios, as well as critical risk thresholds. Climate change is also increasingly factored into spatial planning as a factor of risk and opportunities. Meanwhile, the national programme for Spatial Planning Policies includes a guideline to promote adaptation. A specific ENAAC working group also focuses on the mapping of climate-related risk. The Portuguese Insurers Association and the Faculty of Science of the University of Lisbon, for instance, have developed a high-resolution mapping of flood risks and vulnerabilities in mainland Portugal (Garrett et al., 2014).

Integrating adaptation measures into sectoral strategies: Coastal management and agriculture

The government helps sectors to anticipate and cope with the impact of climate change. This is especially true of agriculture, tourism, buildings, energy and water management. Support measures include sectoral strategies for sharing knowledge and good practices to monitor and mitigate risk.

Coastal areas protection relies on efficient land use planning. Increasing the resilience of coastal zones against the risk of flooding and erosion is a major objective of Portugal's climate strategy and has been mobilising many national and local actors. So far, protection measures have been implemented, together with the rehabilitation of coastal system, the natural restoration of sedimentary transport, or even planned retreat of population an infrastructure. Nature-based solutions have been increasingly used. In Cascais (in the Metropolitan Region of Lisbon), for example, a waterbed restoration and greenway trail help reduce risks related to flooding, increasing temperatures and biodiversity loss.

Governance has also evolved to integrate coastal risks. Portugal has long implemented Integrated Coastal Zone Management in its planning process and complied with EU requirements (Oliveira, Moura and Boski, 2020). The National Planning Strategy includes development of a detailed mapping of hazards that would support local land use decisions and aims to align coastal plans to regional and municipal plans. However, coastal management must respond to multiple challenges (erosion, flooding, increasing sea level) with multiple authorities from municipalities to public administration such as the APA and the central state. The overlapping of authorities on coastal management adds complexity to processes and can stall risk-alleviating measures (e.g. vegetation cleaning processes or destruction of endangered onshore building) (Oliveira, Moura and Boski, 2020; Dal Cin et al., 2020).

The mainstreaming of adaptation measures in agriculture strategies and policies is vital for the sector, which is on the front line of climate change impact. It has been fighting land degradation and managing water scarcity for years to keep productivity high. These threats will amplify in the coming years, including the potential emergence of diseases or pests related to new climate conditions (Government of Portugal, 2021b). Addressing such turmoil will require strong on-farm actions, changes in long-standing practices (e.g. transitioning to mixed farming, agro-forestry or organic agriculture) and substantial investments (e.g. for precision agriculture) (UNDP, 2020). It will be even more challenging for an ageing and relatively poor sector.

The CAP, and more specifically, the Rural Development Plan (RDP), provides the main support for climate change adaptation practices and investment. Portugal has among the highest share of agro-environmental and climate measures (20%) in its RDP budget in 2020. It further plans to dedicate more than EUR 1 billion to such measures in 2023-27 (covering both adaptation and mitigation) (EC, 2022c). This will fund cultural system changes, water management and soil rehabilitation. In parallel, the sector has been developing R&D and notably supported the dissemination of risk information in rural areas.

Getting the private sector on board

Public and private entities have been working together on R&D projects to improve sectors' resilience to climate change, notably in agriculture. Private organisations also build their own instruments such as the Sustainable Tourism Plan 2020-23 for implementation of sustainable practices in tourism.

However, risk-sharing between public and private entities could be rebalanced. The role of private insurance regarding climate change risk is minor. The government and public authorities carry a large part of the risks related to climate change, despite strained public finance. Few losses and damages caused by extreme climate events are insured in Portugal (Figure 2.15). On the other hand, the government and the European Union provide public funds to compensate victims of disasters, notably through the EU Solidarity Fund. Between 2002 and 2017, Portugal received EUR 134 million from the EU Solidarity Fund (with grants amounting from EUR 3.9-50.7 million) to cope with flood and forest fires (EC, 2019). Such unconditional support to affected firms and households can prevent the take-up of private insurance or preventive measures, further weakening the role of the private sector in risk coverage.

2.4.4. Addressing the key challenge of wildfires

Portugal's forest is prone to catching fire because of a dry and hot climate in the summer and early fall. This caused land desertification and biodiversity loss, while undermining the potential of forests as carbon sink. The 2017 wildfires were unprecedented and prompted a strong response of public authorities and the overhaul of rural fire management in the country.

Human activity and poor land management partly explain the intensity of wildfires in Portugal. Most fire ignitions are due to human activity (Meira Castro et al., 2020). They are also more prone to occurring in mixed areas, where forests are close to urban areas or industries (Nunes, Lourenço and Meira, 2016).

Portugal's specific land pattern in rural areas amplifies the intensity of wildfires. Large parts of rural landscapes are poorly managed, if at all, because of unclear ownership. The ageing population in rural areas leads to agriculture land abandonment, specifically in northern regions, to the benefit of forest, grasslands and woody crops in the past decades. This enables the spreading of natural vegetation in sensitive areas and exacerbates the risk of rural fire (Nunes, 2012).

Moreover, the structure of forest land ownership deters consistent forest management that could reduce rural fire risks. A large part of forest land does not have any official owners: only 46% of forest properties have a cadastral delimitation, with 3% being publicly owned (compared to 40% in the European Union) (APA, 2020). Registered parcels are small and divided between 11.7 million different properties inscribed in tax registries. As a result, investment for land management is rarely profitable and large-scale action,

with possible economies of scale, is difficult. Scattered ownership also hampers the building of firefighting infrastructure or access to water. The number of owners associations aiming to make their land profitable with land management rules has been growing, only 27% of forests were covered by a long-term forest management plan in 2016 (compared to 96% in Europe).

The government has carried out a comprehensive strategy to address the multiple factors related to wildfire risk. It first dedicated substantial amounts to address the threat (34% of available funds in the P-3AC). Land management solutions (e.g. discontinuity bands or planting of fire-resistant species) have also been put in place to reduce the risk of spreading (Government of Portugal, 2021b). Furthermore, regulation to avoid fire ignition and reduce their impact has been increasingly stringent, putting rules on activities and built areas to limit fire ignition (Law N°114/2017- article 153). The government has improved its information system, documenting risk of fire and sharing daily monitoring reports with the public.

Portugal has also been implementing a prevention strategy to cope with the structural drivers of wildfire risk. Most additional funding for the fight against wildfire went to preventive measures, which now make up 45% of allocated funds (compared to 20% in 2017). Until 2017, short-term emergencies prevailed at the expense of prevention measures as public authorities dealt with immediate disasters (Collins et al., 2013). In 2021, the Recovery and Resilience Plan of Portugal included a EUR 615 million budget for forest management to prevent rural fires, including establishment of a cadastre and a land-use use monitoring system.

Recommendations on carbon neutrality

Improving the governance of climate policy

- Swiftly implement the Framework Climate Law. Clarify the measures envisaged to achieve the 2030 goals, quantify their mitigation impact and specify how they will be financed.
- Enhance public participation in climate policies by informing the public in advance of upcoming consultations and allowing sufficient time.

Aligning the economy with climate ambitions

- Align economic incentives to climate targets. Set clear milestones to phase out all fossil fuel subsidies by 2030, as committed in the Climate Law. Continue to protect vulnerable groups by shifting from energy price control to targeted income support measures uncorrelated to energy consumption, and by increasing investment in decarbonising buildings.
- Anticipate the labour market needs for green jobs, notably to address an increasing demand for energy renovation, by developing skills and facilitating immigration for workers with requisite skill sets.
- Support private investment for climate by providing long-term visibility to investors on future regulations and carbon prices, developing tailored sector-specific tools (e.g. auctions or third-party payment organisations in sectors where liquidity is strained).

Develop renewable energy sources on a cost-efficient basis

- Increase the use of auctions for renewable energy projects, with a technology-neutral approach. Consider requiring environmental indicators in public tenders to rule out projects with strong detrimental impact on natural capital.
- Encourage private renewable energy producers to sell their production on the grid by reducing the administrative and price barriers.
- Assess and monitor climate impacts on security of supply, including the volatility of hydro generation, as part of the annual security of supply monitoring report for the national electricity system.

Step up action for energy efficiency in buildings

- Accelerate and mainstream retrofitting works with a package of measures adapted to all households' configurations and specific instruments for households unable to contribute to the work such as direct grants or tax cuts. Facilitate access to existing supports, including with information, technical support and a dedicated platform putting actors together.
- Encourage deep retrofits by correlating supports to the energy consumption cut generated, adding premiums for packages of works, more efficient than dispersed measures.

Reduce emissions from vehicles and car dependency

- Continue supporting the purchase of low-carbon vehicles and phase out supports to older vehicles. Accelerate the deployment of charging stations for electric vehicles across the country, supporting their installation in remote areas as planned.
- Reduce private car use. Shift investment from new road building to improving the rail network. Integrate the reduction of private car dependency as a requirement for land and road management in municipal climate plans. Facilitate the access to services and activities by active mobility and public transport in cities.

Accelerate action for reducing GHG emissions from agriculture production

- Increase use of monetary incentives to enhance GHG emission mitigation and sequestration in agriculture. Consider introducing taxes based on the number and type of animals, and on fertiliser use. Mainstream payments for ecosystem services under the new common agricultural policy. Divert public support from emission-intensive activities in the agriculture sector (e.g. energy tax break or support coupled to animal heads).
- Develop a national food strategy encouraging sustainable diets through education campaigns and developing alternatives to meat-intensive diets in public catering, with the co-operation of local stakeholders. Make the fight against food waste a key pillar in this strategy.

Sharpen the country's adaptation strategy

- Improve the information system related to climate change adaptation policies to track their implementation and impacts on risks and exposure. Ensure stable funding to track the progress of the adaptation strategy on a yearly basis; assess the impact of policies on climate change risk.
- Enhance the value of rural lands for the mitigation and the adaptation to climate change. Accelerate development of the land cadastre in rural lands. Encourage the sustainable creation of value from rural land by extending payments for ecosystem services to all rural land, including non-agricultural lands, and setting the rule of a sustainable management of forestry resources by the energy sector and the industry.

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Notes

[1] In 2019, the measure cost EUR 112 million, with EUR 110 million to electricity tariffs and EUR 1.8 million to natural gas tariffs (MAAC, 2021[79]).

[2] This calculation was made using 2015 household budget survey, inflated by the 2015-20 evolution of energy prices (HCIP in Eurostat).

[3] Calculation from ERSE and IEA data.

[4] This global climate scenario, built by the IPCC, corresponds to the case where economic development in the 21st century is based on fossil fuels.

[5] OECD population data.