2030 emissions in the context of the 2050 carbon neutrality roadmap for Portugal

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Context

2015 | 2016 | 2017 | 2018 | 2019

Paris Agreement

Article 2

"Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and **to pursue efforts to limit the temperature increase to 1.5 °C**"

Portugal Mitigation Goal

"Portugal reaffirms its firm commitment to be neutral in GHG emissions by the end of the first half of the century"

António Costa
Portugal Prime Minister
@COP22, dez-2016

Portugal Carbon Neutrality Roadmap

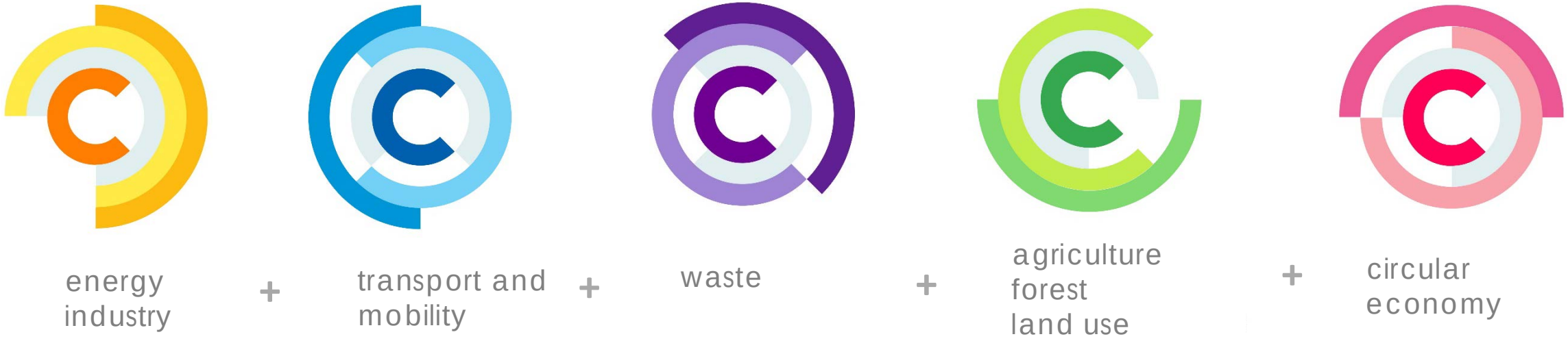
RNC2050
Carbon Neutrality Roadmap

Alternative pathways for all sectors of economy that allow the achievement of net carbon emissions up to 2050

Context & Objective

- Outdoor air pollution can be harmful to the environment and human health
- Most air pollutants and greenhouse gases have common sources, which mainly arise from fuel combustion and industrial processes
- What are the ‘net zero GHG pathways’ effects on Air Pollutants Emissions, for Portugal, until 2050?

Carbon Neutrality Roadmap



GHG (CO_2, CH_4, N_2O, F-gases) EMISSIONS AND CAPTURE IN 2050

= **0 tCO_2e**

Which is the most cost-effective pathway to achieve net zero GHG by 2050?

Storylines and Socioeconomic Scenarios

- Structural changes in production chains associated with the knowledge and creative industry
- More decentralized economic growth
- Deep environment conscience and severe mitigation policies
- Circular Economy leads to higher levels of efficiency

GDP: ↗ 1.7%/year | Pop: → 0.0%/year

- Economic growth led by greater integration of Portugal in international circuits
- The production structure and population living standards do not change significantly
- Deep environment conscience and severe mitigation policies
- Circularity levels increase (<YJ scenario)

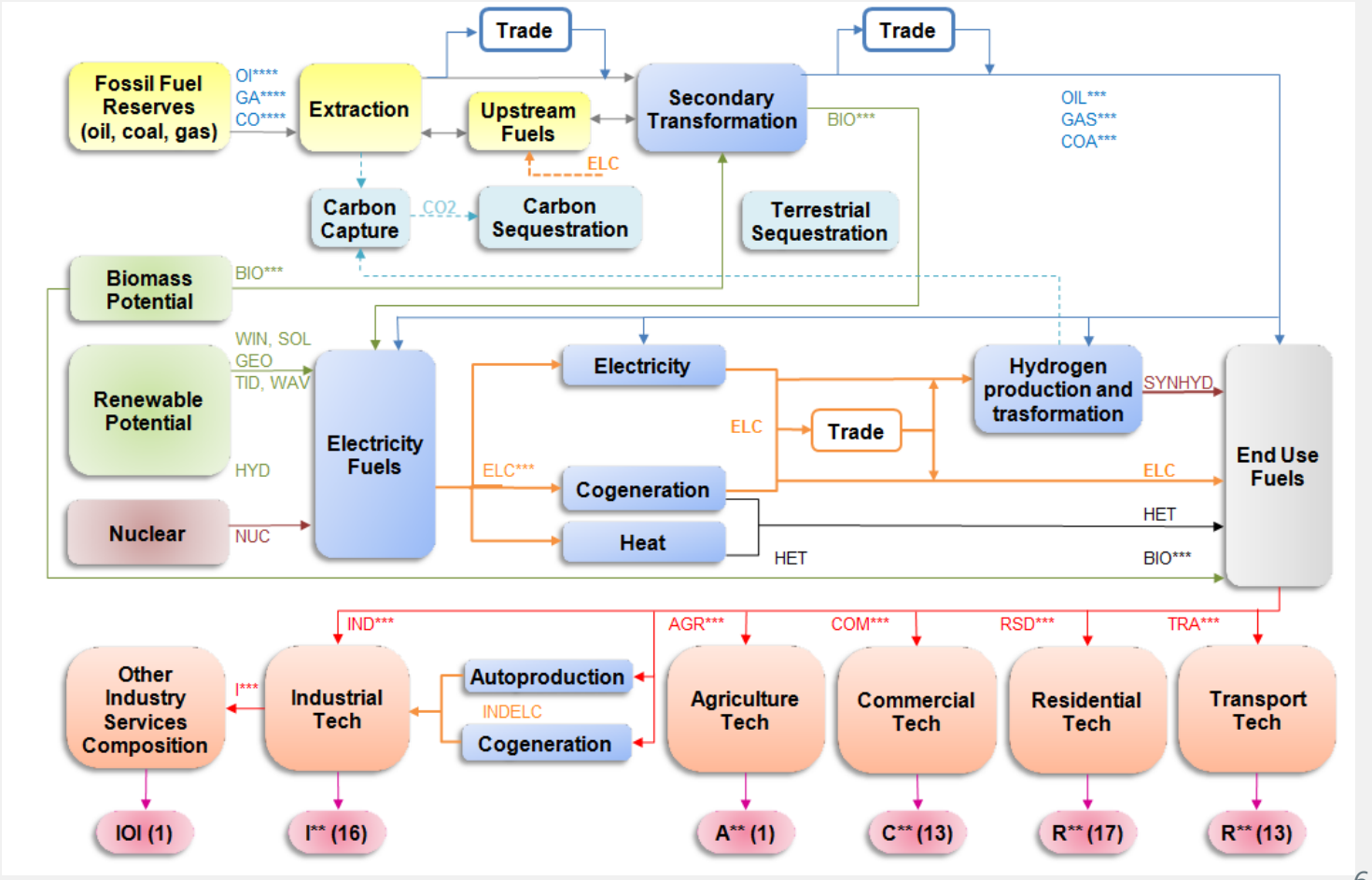
GDP: ↗ 1.3%/year | Pop: ↘ -0.4%/year

- Maintenance of society and economy structure and continuity of current energy / climate policies.

GDP: ↗ 0.9%/year | Pop: ↘ -0.6%/year

TIMES_PT modelling tool

- Bottom-up, linear **optimization energy system model**
- Represents the entire net structure of the Portuguese energy system up to 2050 with a very detailed technology description:
  - Investment, operation & maintenance costs;
  - Life time, starting year, efficiency, availability;
  - Emission factors



Results: decarbonisation transition by sector

Energy transition
↓
+electrification
+renewables
-consumption

- Reduction of final **energy consumption** by 2050 between 25% and 22% compared to 2015 (although higher energy services demand)
- Increasing **electrification** of the economy, with increased integration of **renewable** energy sources into final energy consumption by 2050

Transports transition
↓
+electrification
+sharing

- Fast decarbonisation of the sector, even with higher demand for mobility in all modes (-98% in 2050 compared to 2005 GHG emissions)
- Traditional fossil fuels are progressively replaced by **electricity, biofuels and H2** (93% of the energy consumption in 2050)
- Electricity is preponderant in most of the means of transport (70% of the energy consumption in 2050)

Industry transition
↓
+electrification
+biomass

- **Electrification** and the use of **biomass** contribute to sector decarbonisation
- Emissions **reduction** occurs at a **lower** rate than in other sectors → industry will increase its share of national emissions by 39% in 2050

From storylines to TIMES_PT inputs

Buildings
↓
+electrification
+solar

- Extensive **electrification** of services (85% of energy consumption), accompanied by **solar thermal** (11%) for water heating and predominance of heat pumps for space heating
- **Biomass** remains the option for housing in the 2020-2040 horizon, disappearing practically in the decade 2040-2050 in *Pack* (1% of final energy consumption), but maintaining in *Yellow Jersey* scenario (> decentralized, accounting for 3% of energy consumption)

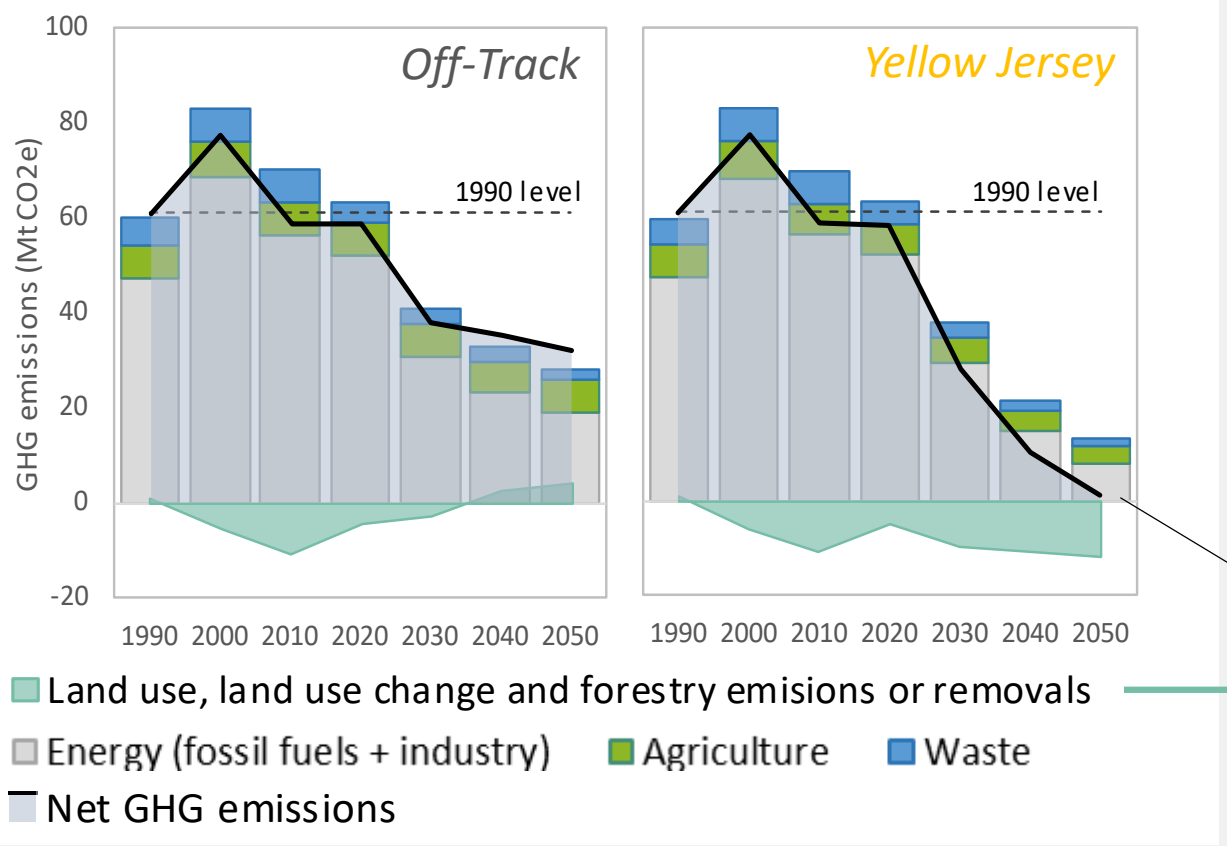
Agriculture and Forests
↓
+organic/precision farming

- Increase of **cereal** cultivated areas
- Changes of cattle composition (-cows, +pigs), with changes in effluent treatment systems
- Increase of **organic farming**, conservation and precision agriculture → less use of animal effluents and fertilizers
- Better forest management and less fire losses

Waste
↓
-waste

- Significant **reduction** in the production of urban **waste** per capita (-82%)
- Reduction of organic waste production by 2050 of 60% to 85%
- Wastewater sector with little evolution in relation to the starting point already very favourable

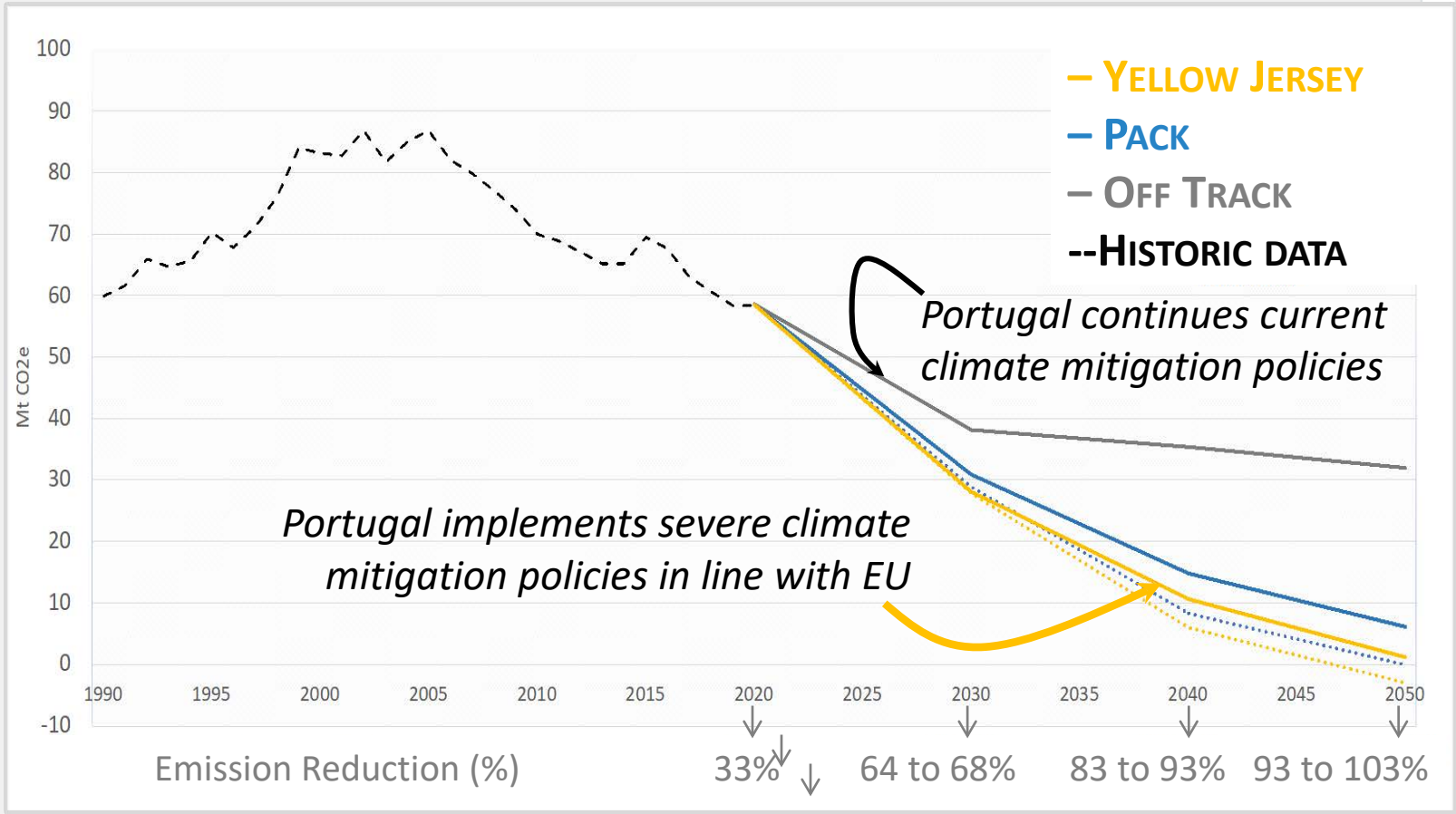
Reaching net zero GHG emissions



LULUCF offsets GHG emissions – carbon neutrality

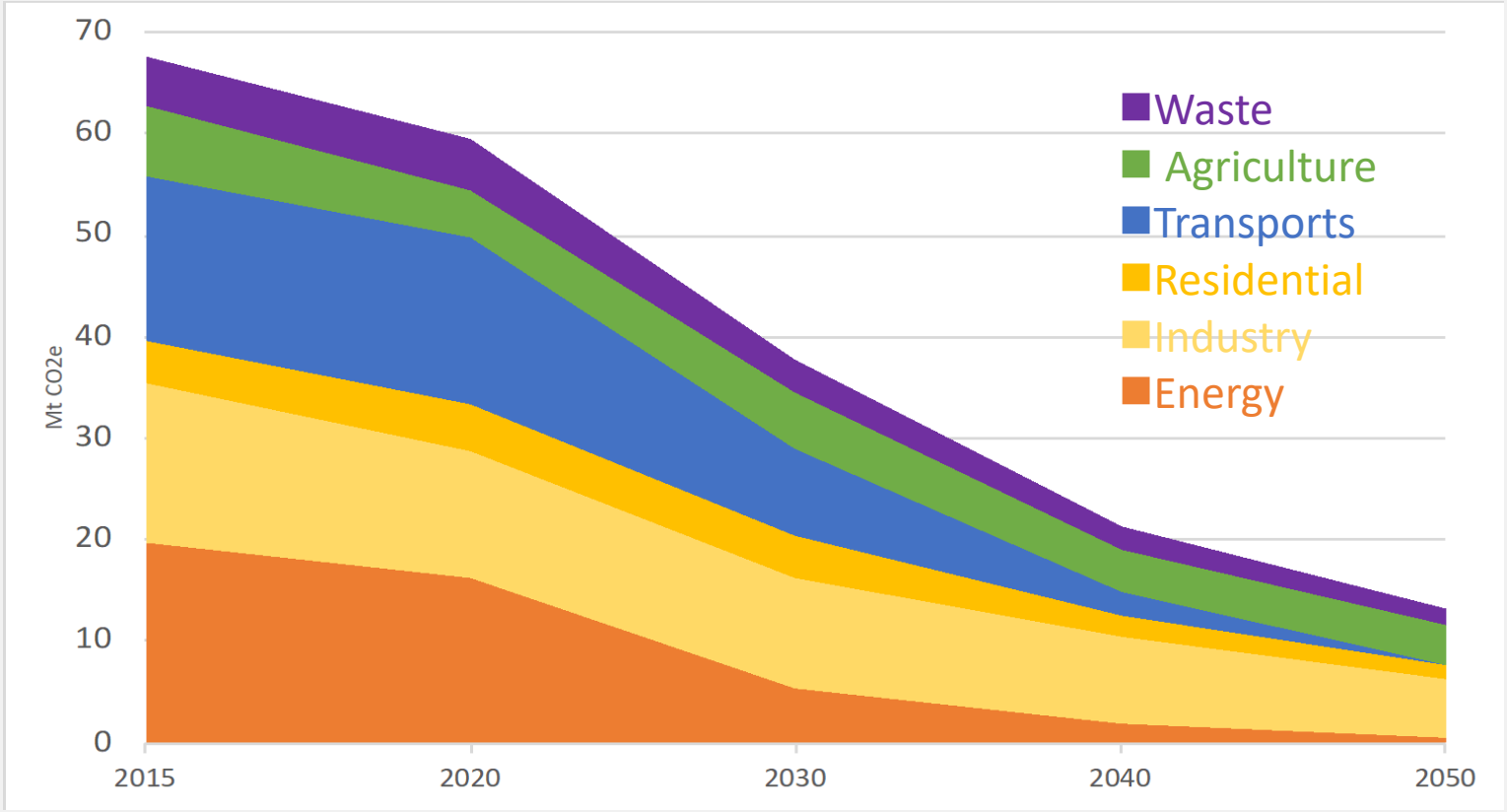
Carbon neutrality is possible in Portugal by 2050

- A significant mitigation of GHG emissions is needed in the 2020-2030 decade
- It is technological feasible to achieve carbon neutrality in Portugal by 2050
- It is possible to operate this profound decarbonisation using technologies and processes known today (with varying degree of maturity)
- All sectors of the economy contribute to the trajectories of carbon neutrality, although with different intensities



CO2e Emissions reduction by sector

- A strong decarbonisation of **energy production**, **mobility** and **transport**, and **buildings** is needed over the next two decades (2020-2040)
- **Industry** and **Agriculture** sectors have a lower decarbonisation potential, but still contribute to significant reductions specially on 2040-2050 decade
- Effective **agroforestry** management is a determining factor for the objective of carbon neutrality in 2050



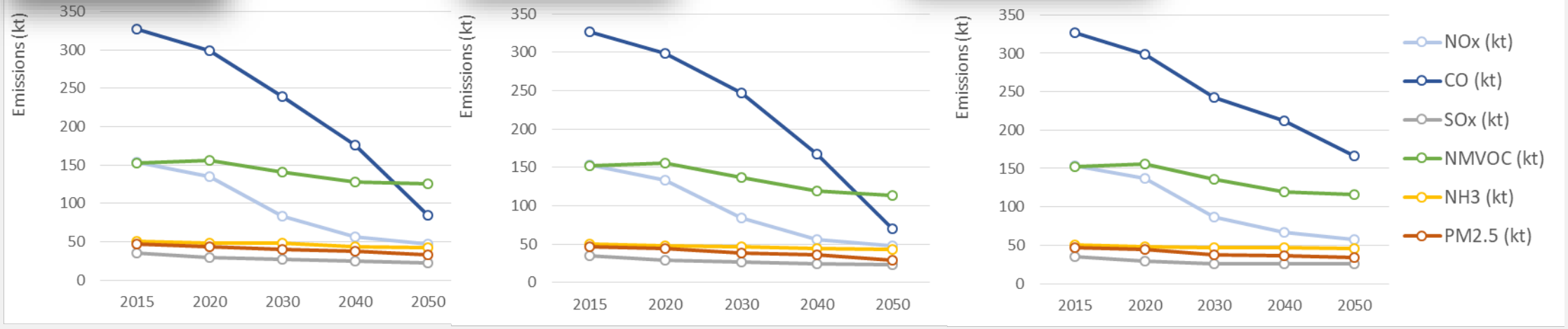
CNR2050 | GHG Emissions reductions by sector

Air pollutant emissions

Yellow Jersey

Pack

Off Track



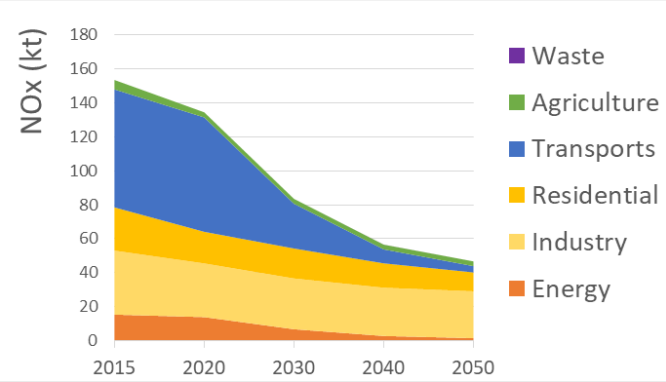
Emissions reduction by 2050 (regarding 2015) (%)

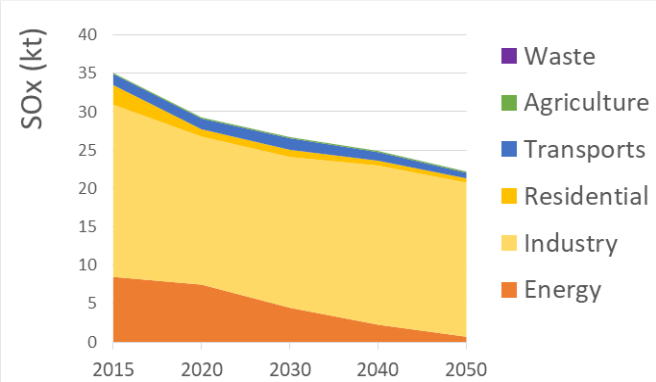
Pollutant	Yellow Jersey	Pack	Off Track
NOx	70	69	62
CO	74	79	49
SOx	37	35	26
NMVOC	17	25	24
NH3	17	14	8
PM2.5	30	38	27

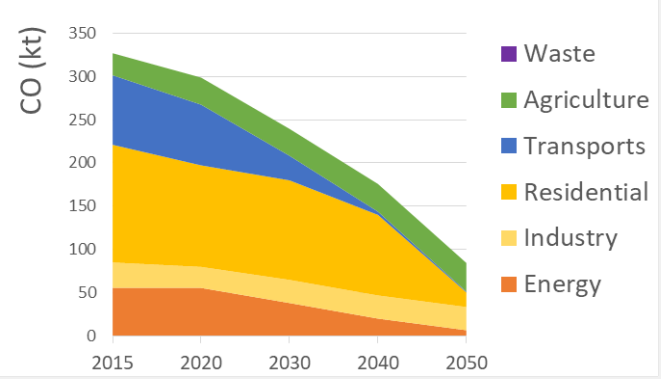
reduction intensity + -

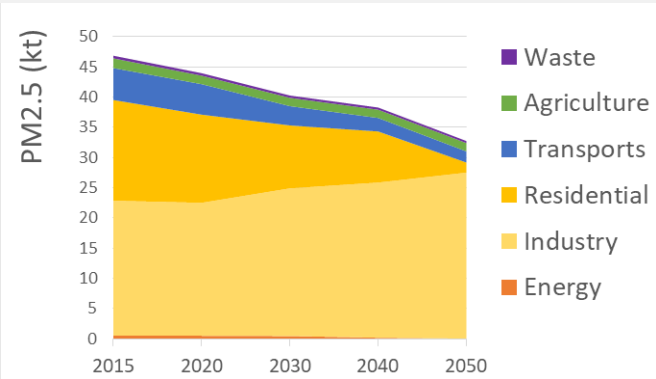
- Decarbonisation also leads to air pollutant emission reductions, in all tested scenarios
- Reductions are higher for NOx and CO, due to lower fossil fuels consumption and a shift to renewable energy sources

Air pollutant emissions by sector (i)









- **Transports** (mainly road transport):

  →will reduce 95% of NOx and 99% of CO emissions in 2050

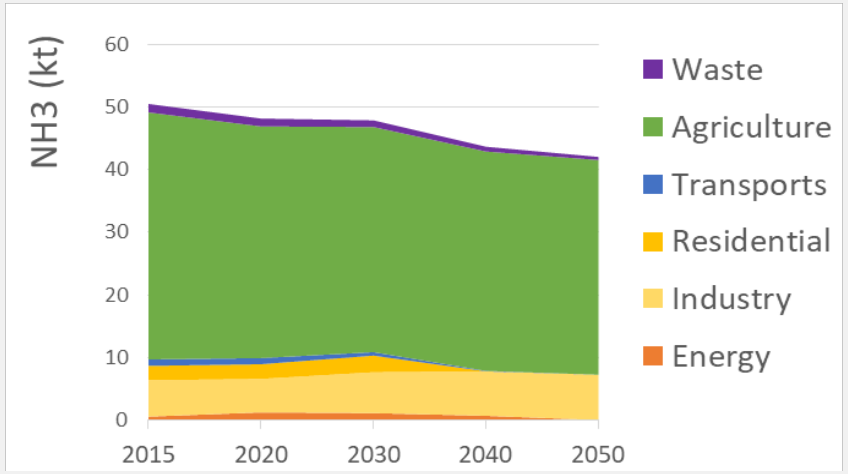
  → 2030 air emission targets (NECD) are highly dependent on the fulfilment of expected electric vehicle penetration

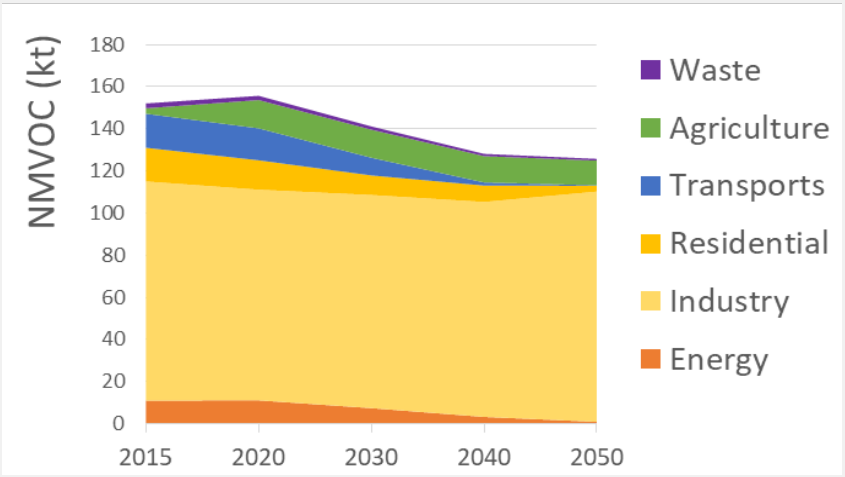
- **Industry** is one of the least cost-effective sector to reduce GHG emissions

  → also verified for air pollutants

  → for PM2.5, there is an increase of 23% in 2050, due to the shift to biomass fuels use and to the weight of process emissions

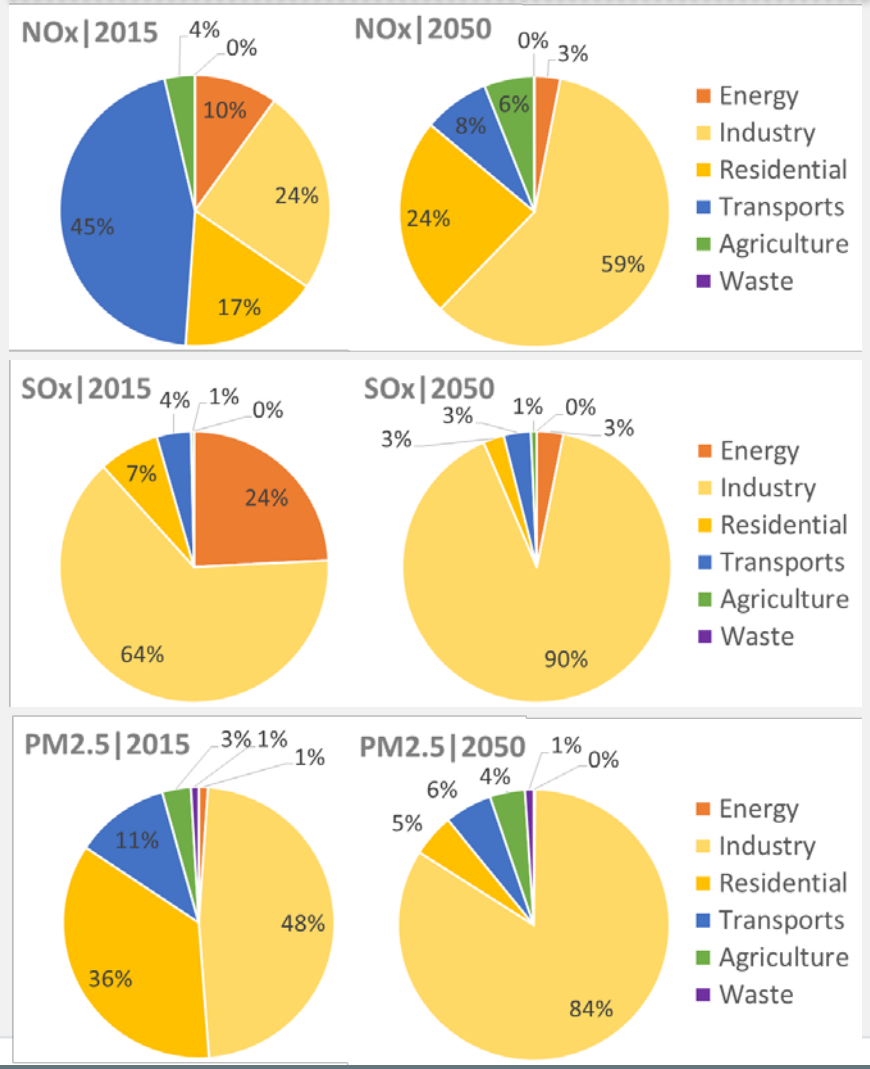
Air pollutant emissions by sector (ii)





- **Agriculture** is major source of **NH3** (78% in 2015, 82% in 2050)
- **NMVOC** emitted mainly by **Industrial sector** (68% in 2015, 87% in 2050)
- Global reduction by 2050 of **17%** for NH3 and NMVOC

Air pollutant emissions by sector (iii)



- Main sectors contributing to atmospheric emissions will change:
  - **NOx**: less Transports weight in emissions (8% in 2050). Industry is major sector in 2050 (59% in 2050)
  - **SOx**: less weight of Power generation (from 24% to 3%). Industry is major source in 2050 (90%)
  - **PM2.5**: less Residential contribution (from 36% to 5%). Industry gains relevance

Industry appears to be a relevant sector to tackle air pollution in the future, when designing strategies to control emissions

Conclusions

- In both scenarios '**Yellow Jersey**' and '**Pack**' Portugal reaches carbon neutrality goal, in 2050, with strong benefits to air pollutant emissions
- These levels of emission reductions imply:

  →significant levels of **renewable sources** on final energy consumption, reaching 85-90% by 2050, in particular in the production of electricity, and consequently on road transport, which reaches full **electrification** by 2050

  →a significant increase in the **economy efficiency**, resulting in a reduction in primary energy consumption of around 40% and a significant reduction in the **energy intensity** of the economy

Conclusions

- **Transports and Power generation** are the sectors with the greatest potential to reduce **GHG emissions**
- Transports and Power generation can also provide the most significant reductions of **air pollutant emissions** → win-win situation
- **Energy efficiency** measures benefit both GHG and air pollutant emissions

Conclusions

- **Industry**:

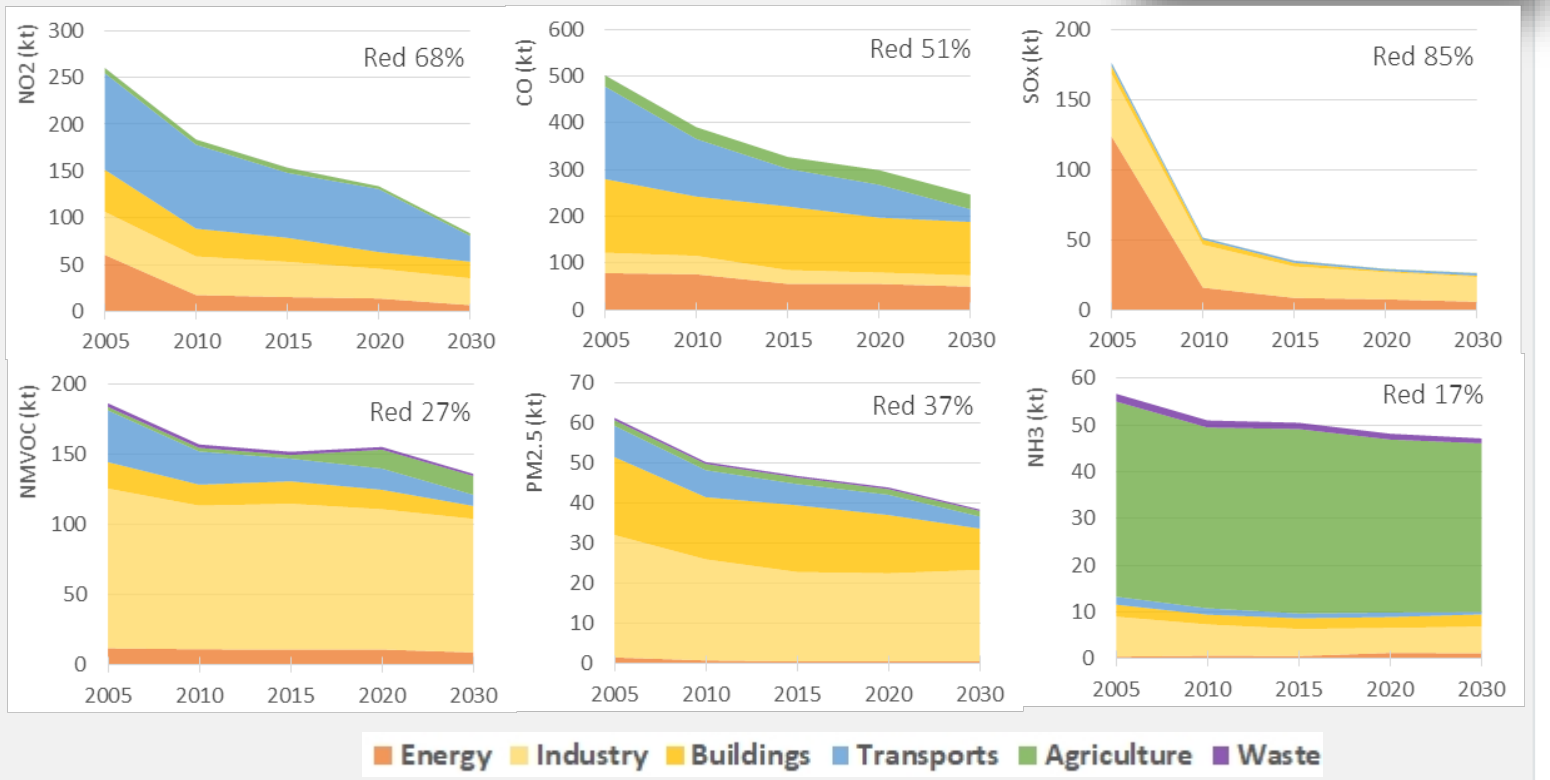
  →is one of the least cost-effective sectors to reduce GHG emissions due to limited range of technological options to reduce process emissions

  →this is also valid for air pollutant emissions: strong reductions in other sectors highlight industry contribution to emissions by 2050

- **PM2.5** emissions in 2030 are associated with biomass combustion in Industry and Residential sectors, showing a negative trade off from climate change solutions

Air pollutant emissions – projections for 2030

Sector	Δ2030-2005 (%)					
	NO2	CO	SOx	NMVOC	PM2.5	NH3
Energy	-89	-37	-95	-24	-66	156
Industry	-38	-45	-60	-16	-25	-33
Buildings	-60	-27	-83	-51	-47	1
Transports	-73	-86	-30	-78	-61	-69
Agriculture	-49	31	31	447	1	-14
Waste	-70	-87	-65	-43	-38	-36
TOTAL	**-68**	**-51**	**-85**	**-27**	**-37**	**-17**



- power sector, buildings, and transports account for the largest emissions reduction due to: trajectories of renewable electricity production, ensured by endogenous resources, as well as final consumption massive electrification

NEC DIRECTIVE 2016/2284

- emission reductions, obtained under the scope of CNR2050 (Pack scenario), are **not sufficient** to achieve the Portuguese reduction commitment for **$PM_{2.5}$** and of **NMVOC**, in 2030
- additional measures to reduce these pollutant emissions must be mainly oriented to industrial and agriculture sector

Projections		NO_x			NMVOC			SO_2			NH_3			$PM_{2,5}$		
		2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030	2005	[2020; 2029]	≥2030
Historical (2005) and NEC	Emissions (kt)	245	157	91	190	156	118	172	64	29	56	52	48	65	56	31
	Δ 2005 (%)		-36%	-63%		-18%	-38%		-63%	-83%		-7%	-15%		-15%	-53%
Projection	Emissions (kt)		132	82		144	124		29	26		48	47		44	38
	Δ 2005 (%)		-46%	-67%		-25%	-35%		-83%	-85%		-15%	-16%		-33%	-41%
Attainment			✓	✓		✓	✘		✓	✓		✓	✓		✓	✘
Emission Gap	Emissions (kt)		-25	-9		-12	6		-34	-3		-4	-1		-12	8
	(%)		-10%	-4%		-7%	3%		-20%	-2%		-8%	-1%		-18%	12%

* According to Article 4, point 3 d), of Directive 2016/2284, activities covered by the nomenclature NFR 3B (manure management) and NFR 3D (agricultural soils) are not included in the national total emissions reduction comitments for NOx and NMVOC.

Compliant | Compliant (by a margin <2%) | Non-compliant

NEC DIRECTIVE 2016/2284

- **$PM_{2.5}$**: emitted essentially by the **industrial** sector, also having a significant contribution from the **residential/commercial** sector, due to **biomass** use for heating

- **NMVOC**: emission reduction commitment exceeded in 2030, with a gap of 3% to compliance. This pollutant is emitted essentially by the **industrial** sector

- In the **industrial** sector it was not possible to achieve a significant reduction in process emissions (contrary to combustion), particularly in the subsectors responsible for the largest emissions, such as cement, paper and glass

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- In the **long term**, **industry** acquires the highest weight in national emissions, due to the current technological limitations, which does not allow significant reductions, especially in the fraction related to process emissions

- **NH_3**: compliance with NEC, but with no margin for deviation. The agricultural sector is the dominant source of NH_3 (accounts for 78% emissions in 2030)

Thank you

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