LOW CARBON ROADMAP FOR PORTUGAL: TECHNOLOGY ANALYSIS

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Overview

There is a growing consensus on the need to reduce significantly global greenhouse gases emission (GHG) to keep global warming below 2ºC of pre-industrial levels and limit the negative impacts of climate change. In line with to this goal the EU has established the objective of reducing its emissions by 80 to 95% in 2050 face to 1990 values. The *Roadmap for moving to a competitive low carbon economy in 2050* [1] outlines the EU strategy and the sectoral reductions to achieve this target, prompting member states to develop similar exercises. This paper aims to present an exploratory analysis of the cost-effective opportunities for Portugal to achieve such a GHG abatement target. Since technology is a key driver to achieve a low carbon pathway, its role will be evaluated, taking into account the uncertainty associated with technology development, namely on its cost curves.

Method

To design a low carbon technological roadmap for Portugal up to 2050, we used TIMES_PT model [2] to generate six scenarios (Table 1). TIMES_PT is a linear optimization technological model that maps the Portuguese energy system, peer-reviewed for 2005. Its ultimate goal is to satisfy a given energy services demand at a minimum total system costs, supported by its technological database. All the scenarios assume the same initial energy service demand from a high socio-economic scenario ([3]), that represents an optimist economic forecast (GDP growth of around 2.9%/a after 2020) when compared to the current Portuguese situation.

Table 1 – Studied scenarios

Scenarios	80% GHG emission target (compared to 1990)	Technology assumption	Energy price elasticities
Base_TE*	No	Evolution	No
Base_TF*	No	Frozen	No
CAP_TE	Yes	Evolution	No
CAP_TF	Yes	Frozen	No
CAP_TE_ELAS	Yes	Evolution	Yes
CAP_TF_ELAS	Yes	Frozen	Yes

*Use as baseline scenarios

Due to the uncertainty associated with the development of end use and supply energy technologies, we establish two scenarios: i) Technology frozen scenario (**TF**), assuming that the prospects about technical and economic data will be frozen 2015-2020 onwards (conservative technological development). Technologies that are expected to be in a commercial phase after this period will not be available, such as carbon capture and storage (CCS); ii) technology evolution scenario (**TE**), assuming that emerging technologies will appear in the future and existing ones will become more efficient and cheaper. Two additional scenarios assuming energy price elasticities were also modeled (**ELAS**) to assess the importance of energy services demand reduction (induced by energy price increase) in technology choices.

Results

Regarding all scenarios and selected years, power sector has the biggest GHG emission abatement potential, reducing its emissions from 14 Mt CO_2eq in 1990 up to 1.7 and 2.0 Mt CO_2eq in 2050 for CAP_TE and CAP_TF, respectively (Table 2).
As shown in Fig 1, the production of electricity is continuously increasing in both scenarios mainly supported by the growth of renewable energy (RES), reaching 75% and 96% of the power production mix technologies in 2030 and 2050 respectively. In this mitigation scenario, hydro, win onshore and solar PV are the most cost efficient technologies for Portugal, achieving its maximum potential in both scenarios. Although CCS is available in CAP_TE scenario, the technology does not have a relevant role in electricity generation (applied in only 4% of the total production). The main difference between the scenarios is associated with wave and wind offshore technologies. Wave technology only appears in CAP_TE in 2035, while in CAP_TF, wind offshore becomes an option in the same year. Despite currently the investment cost of wave technology is nearly three times higher than wind offshore, experts [4] envisage for the long term, a reduction of the gap costs between the two technologies, and an increase of wave efficiency, factors that are not captured by CAP_TF scenario.
Industry has the second highest mitigation potential in 2050 (comparing to 1990 emissions), more than 10 Mt CO_2eq. CCS is a selected technology in industry after 2040 in CAP_TE, reducing 66% of industrial emissions in 2050, while in CAP_TF solar heating and more efficient technologies (e.g more efficient kilns) are preferred.
CCS plays an important role in energy use, being responsible for a high percentage of fossil consumption in total final energy, 14% in CAP_TE in 2050 vis-à-vis 3% in CAP_TF, while the proportion of RES is higher in CAP_TF (45%) than in CAP_TE (33%).
Even though in 2030 transport sector increases its emissions comparing to 1990, in 2050 this sector suffers significant reduction (above 8 Mt CO_2eq), being the use of biofuels and the increase of energy efficiency due to electric vehicles the main drivers. In 2050, hybrid-plug in and electric vehicles satisfy 57% to 41% of the road mobility (including passengers and freight transport) in CAP_TE and CAP_TF respectively, and biofuels are responsible for 23% to 12% of the road mobility in the same period and scenarios.

In 2050, buildings have the lowest emissions, (less than 1 Mt CO_2eq.). Its decarbonization is supported, in both scenarios, by an increase of its energy performance (highly efficient heat pumps and insulation measures), and a shift to zero carbon emission technologies (solar heating and electricity). In 2050, fossil energy consumption will be below 1% of the total sector energy
Additional scenarios with energy prices elasticities (CAP_TE_ELAS and CAP_TF_ELAS) do not change these results significantly, still final energy consumption is reduced about 7 to 11% comparing to CAP_TE and CAP_TF, respectively.

Table 2- GHG emissions (Mt CO2eq) from energy system for CAP_TF and CAP_TE scenarios ([% of reduction face to 1990])

	1990	2010	CAP_TF		CAP_TE	
			2030	2050	2030	2050
Power & Heat Production	14.0	17.5 [25%]	7.2 [-49%]	2.0 [-86%]	5.9 [-58%]	1.7 [-88%]
Industry	16.0	15.6 [-2%]	14.6 [-8%]	5.1 [-68%]	16.6 [4%]	4.9 [-69%]
Transport	10.1	19.4 [93%]	18.2 [81%]	1.4 [-86%]	17.0 [68%]	1.3 [-87%]
Buildings	2.8	4.9 [76%]	2.7 [-3%]	0.8 [-71%]	2.1 [-24%]	0.1 [-97%]
Agriculture	1.8	0.9 [-50%]	0.9 [-48%]	1.1 [-42%]	0.8 [-53%]	0.8 [-56%]
Total	***44.7***	***58.4 [31%]***	***43.0 [-4%]***	***9.6 [-80%]***	***43.0 [-4%]***	***9.6 [-80%]***

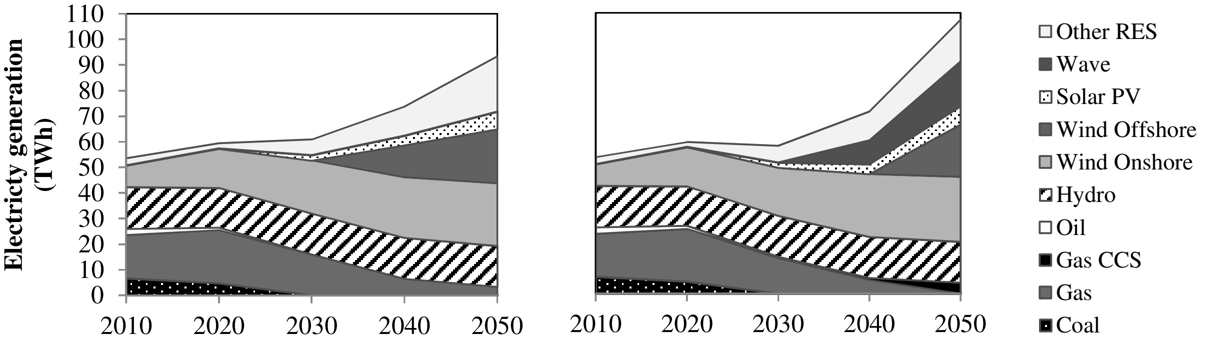

Figure 1 – Electricity generation (left side: CAP_TF; right side: CAP_TE)

The total cost needed to achieve an 80% reduction by 2050 in Portugal is around 25 to 69 bn$€_{2011}$ for CAP_TE and CAP_TF respectively, associated with an additional investment costs of 17 and 55 bn$€_{2011}$. The significant differences between the scenarios costs reflect the importance of technology development in a low carbon scenario, although R&D expenses are not included in this analysis. Scenarios considering energy price elasticities induce a 7% (CAP_TF_ELAS) and 4% (CAP_TE_ELAS) decrease of energy service demand, reproducing a minor reduction in the total mitigation costs comparing to CAP_TEP/TEF scenarios: (-4% and -1% in CAP_TF_ELAS and CAP_TE_ELAS, respectively).

Conclusions

This paper identifies the role of low-carbon technologies to achieve an 80% reduction of GHG emissions by 2050. Even in a conservative technological development scenario, it is feasible to achieve this aggressive target, although the additional costs, when compared with a technology evolution scenario, are substantially higher (more 44 bn$€_{2011}$). Depending on technology development, the low-carbon technology roadmap for Portugal can present some differences, namely in industry due to CCS development. However, regarding power sector, RES are always the most cost-effective option.

References

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