Environmental, economic and socio-economic life cycle assessment of the Spanish electricity system

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Abstract

This paper investigates the sustainability of the Spanish electricity system under four different scenarios for 2030 and 2050 published by a reputable think tank assessing the Spanish Government. The analysis was performed using a life cycle approach and evaluates five sustainability indicators: overall carbon footprint, carbon footprint per MWh, overall economic costs, LCOE and job creation. The results evidence that the most ambitious scenarios (100 % share of renewables) produced the best results in terms of environmental and socio-economic performance (10-fold reduction of GHG emissions and 15-fold increment in employment compared to 2015) but involved higher costs (15 €/ MWh more expensive).

Keywords: LCA, electricity, sustainability, carbon footprint, employment, LCOE.

1. Introduction

The recently approved *2030 Framework for climate and energy* has set ambitious targets aimed at improving the sustainability of energy systems across the EU. The 40 % cut in GHG gas emissions and the 32 % share of renewables projected for 2030 will have profound effects on the configuration of the Spanish electricity system. This transformation will influence not only the environmental performance of the system but also its socio-economic and economic functioning (CETE, 2018, Linares and Declercq, 2017; Stamford and Azapagic, 2014). This paper analyzes the sustainability of four electricity scenarios projected for 2030 and 2050.

2. Methods

The scenarios investigated were presented by *Economics for Energy*, a reputable think tank assessing the Spanish Government on energy matters (Linares and Declercq, 2017). They describe power demand, installed capacity and technology mix in four projections cited as follows: decarbonization (DC), current policies (CP), accelerated technical advance (AT) and stagnation (ST). Carbon footprint was calculated using inventory data from Ecoinvent 3.1 and ILCD 2011 Midpoint+ for impact assessment. Economic sustainability was estimated in terms of generation costs and LCOE following procedures published by IEA-NEA (IEA-NEA, 2015). Socio-economic performance was based on employment generation and calculated according to methodology published by ISF-UTS (Rutovitz et al., 2015).

3. Results and Discussion

The results show notable improvements in terms of environmental performance compared to 2015 in all cases. Despite the 70.6 % rise in power demand and 129 % increase in installed capacity (compared to 2015 values), the most ambitious scenario (DC - 100 % renewables) shows a 10-fold carbon footprint reduction by 2050 (figure 1) due coal and oil being displaced with wind and PV power. Regarding the economic dimension, the lowest production costs occurred in the least ambitious scenario (ST - 44 % renewables) (figure 2) due to fewer changes in the structure of the electricity system and reduced power demand compared to other scenarios. Despite the fact that the LCOE of renewables is decreasing fast with time, wind and PV appear as the technologies contributing the most to the total cost of the power system in all scenarios. This is due to their high share, increasing contribution and relatively high capital costs. Concerning the socio-economic dimension, the results show higher employment generation in the CP and AT scenarios (share of renewables above 90% by 2050), with a 5-fold and a 15-fold increase by 2030 and 2050, respectively, compared to 2015 (figure 3). The life cycle stages contributing the most to this are construction and manufacturing, since the 2030 and 2050 scenarios imply a large deployment of new renewable installations.

4. Conclusions

The results show that none of the scenarios performed best in all the sustainability categories. The most pro-renewable scenarios (DC, CP and AT) produced better results in the environmental and socio-economic categories. In contrast, the ST scenario performed better in economic terms.

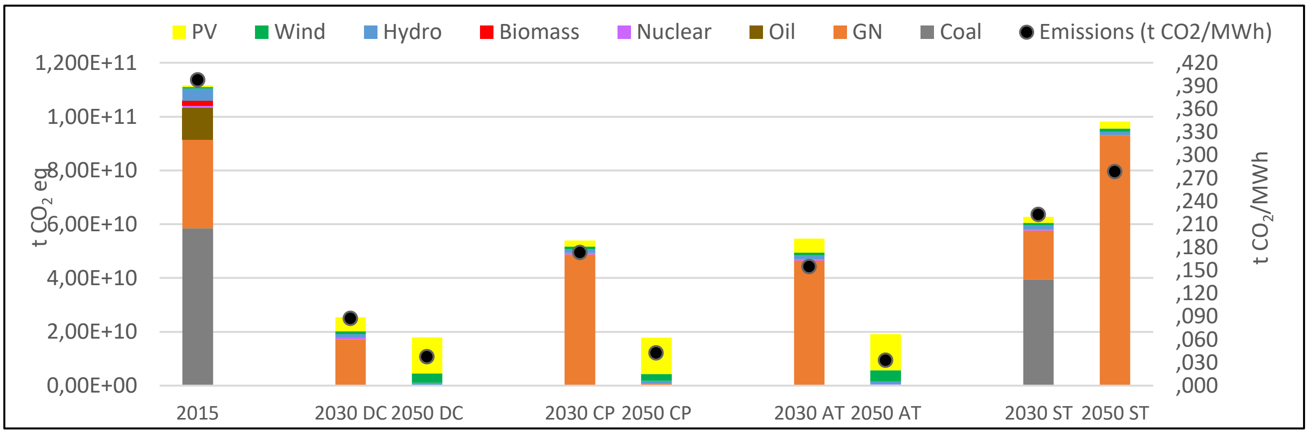

Figure 1. Carbon footprint by scenarios and technologies for 2015, 2030 and 2050.

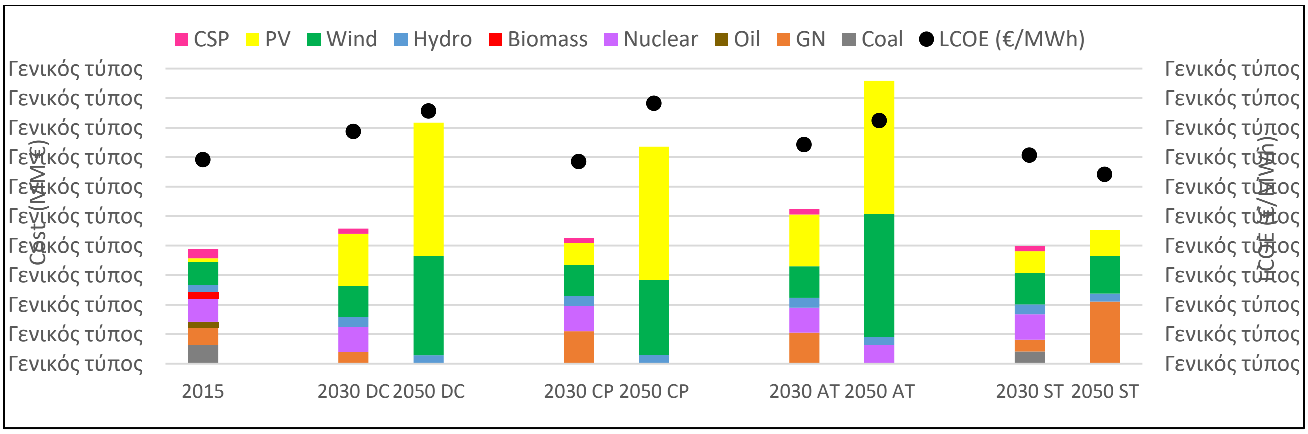

Figure 2. Generation cost by scenarios and technologies for 2015, 2030 and 2050.

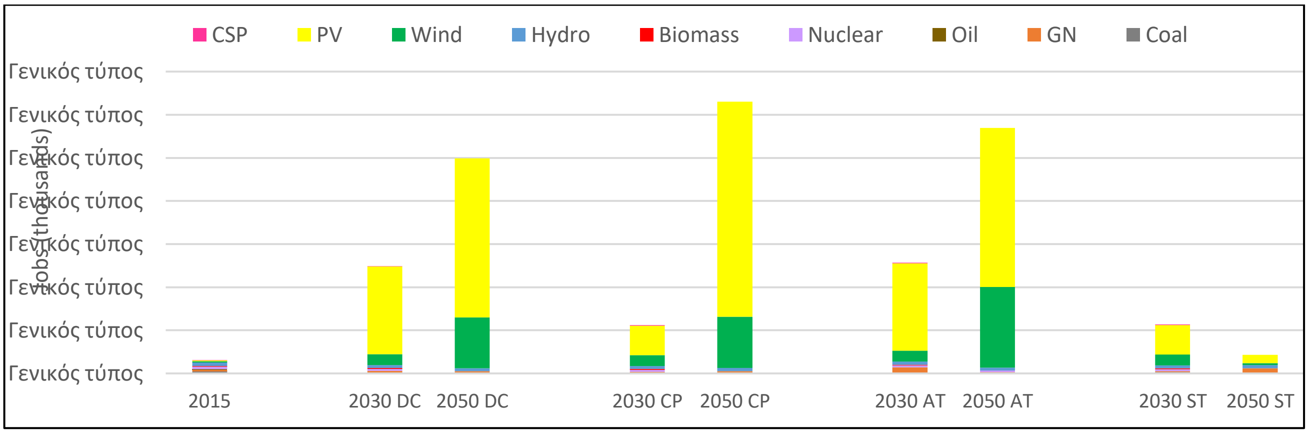

Figure 3. Thousands of jobs generated by scenarios and technologies for 2015, 2030 and 2050.

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