THE EFFECT OF LIMITED RENEWABLE RESOURCES ON THE ELECTRICITY GENERATION IN A LOW-CARBON EUROPE

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Overview

Renewable-based electricity generation technologies are recognized to be a major-prerequisite to reach a sustainable and secure energy system by 2050 (European Commission, 2011). From an energy-systems analysis perspective, a significant increase in the relevance of renewable electricity generation technologies is foreseen (European Commission, 2013) both in current policies scenarios and in those targeting over 80% CO_2 emission reductions in 2050. Usually the impact of current and future technology cost on their competitiveness is analysed (European Commission, 2013), while less attention has been given to investigate the total amount of renewable resources available. Work has been already conducted to evaluate these renewable potentials (Resch et al., 2008), but still substantial uncertainties remain due to methodological challenges or due to coarse measuring resolution (Badger & Ejsing Jørgensen, 2011). In this paper we will assess the sensitivity of the electricity mix evolution to the available renewable energy sources potentials by analysing the response of the partial equilibrium energy model JRC-EU-TIMES (Simoes et al., 2013) in the 2020-2050 time frame.

Preliminary results unveil the relation between the renewable potential available for a certain technology and its window of opportunity against competing technologies. Wind onshore is less responsive to potential variations in the midterm than wind offshore that almost translates all the variations in potential to installed capacity in the long term. This research will help to prioritize which resource potentials may require more precise quantification, or to quantify the economic impact in the future energy system that persisting uncertainties in such potentials may have.

Methods

The JRC-EU-TIMES is a linear optimization, partial equilibrium, bottom-up technology-rich energy system model generated with the TIMES model generator from ETSAP of the International Energy Agency.(Loulou, Remme, Kanudia, Lehtila, & Goldstein, 2005a). It covers the energy systems of EU28 plus Switzerland, Iceland and Norway from 2005 to 2050. Detailed description of the model and its validation process can be found at (Simoes, et al., 2013), where also modelling of Renewable Energy Technologies (RET) and Renewable Energy Sources (RES) potentials is described in detail.The techno economic parameters for RET were developed by experts from the JRC-IET and used for the 2013 SET-Plan Technology Map (JRC-IET, 2011). The capacity factors for wind and solar implemented follow the approach shown in (Martínez-Anido et al., 2012). We consider country-specific values that are modelled as maximum upper bounds on the amount of electricity that can be generated from each RET, as documented in (Simoes, et al., 2013).Our analysis is conducted by individually varying the reference RES potentials for solar, onshore and offshore wind, biomass, geothermal and hydro, from -50% to +50% in 10% steps. The time frame of this analysis is the period 2020-2050. Resulting energy mix shifts, total system cost, and main energy system drivers are therefore analysed. A comparison of two policy scenarios is conducted, to analyse the possible economic impact due to RES potentials availability when moving from a Current Policies Initiatives (CPI) –including from RES 2020 targets to (European Commission, 2014)- to an 80% Decarbonisation in 2050 (CAP) scenario.

Results

Preliminary results show differentiated response patterns to variation in available RES potentials for each technology. Wind onshore does not fully translated additional potential available in the the midterm as it later loses its competitiveness in front of other options. Under CAP Scenario, the relevancy of the RES potential variations is increased, especially for wind offshore. Variations registered in the installed capacity compared with the GW registered under the reference renewable potential base line for wind onshore and offshore is shown in Table 1. Absolute values can be checked at (Simoes, et al., 2013).

Table 1. Variation in Installed GW (%) for solar PV (PV), Wind Onshore (WON) and Offshore (WOF)

RET		WON				WOF			
SCENARIO		CPI			CAP80	CPI			CAP80
YEAR		2020	2035	2050	2050	2020	2035	2050	2050
VARIATION IN RES PONTENCIAL	+50%	101	134	132	148	100	89	82	145
	+40%	101	126	123	139	100	89	79	138
	+30	101	119	115	129	100	88	77	129
	+20%	101	112	106	119	100	83	76	119
	+10%	101	104	97	109	100	77	71	109
	BASE LINE	101	97	88	100	100	71	67	100
	-10%	101	89	79	91	100	71	64	92
	-20%	101	82	70	82	100	69	61	91
	-30%	101	74	61	71	100	64	58	79
	-40%	100	67	53	60	100	55	51	68
	-50%	100	59	44	50	100	47	42	57

In a CPI scenario, increased available RES potential for wind onshore is not proportionally translated into additional capacity installed. Wind offshore increasing available potential base line, will not have all additional potential available installed from a cost optimization point of view by 2050. Under CAP scenario, mainly all the variations in the available RES potential are proportionally translated to variations in the installed capacity. The sensitivities tested do not express relevant variations in the total system cost for the whole period, neither for fix or variable cost. We are analysing how this behaviour impacts the different electricity price metrics that can be established in an energy system model and comparing them along the different scenarios (CPI and CAP) considered.

Conclusions

Our ongoing research targets to quantify the relevance of RES potentials available on the deployment of low carbon technologies, both in current policies and 2050 CO2 cap scenarios. The obtained results must be explained from an energy system perspective; the amount of additional potential which may be installed for a given technology is greatly influenced not only by its own cost assumptions but also by its competitors and the resulting "window of opportunity" in the 2020-2050 time spam. Under CPI Scenario wind offshore is almost fully deployed in 2050 due to its higher capacity factor, while the developed wind onshore depends on the potential available along its 2020-2035 opportunity window. The CAP Scenario exacerbates the used renewable potential whenever new capacity is available.The suitability of several metrics to analyse the link between RES potential availability and electricity prices is being researched, which will also help to quantify increased RES potential availability impact on prices in a CAP Europe.

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