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Current state of renewable energies performances in the European Union: A new reference framework

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ABSTRACT

Initially pushed by the European Union (EU) through the Europe 2020 strategy, the development of renewable energies is a strategic action aiming to limit climate changes and cut greenhouse gas emissions. National subsidies favored the diffusion of this new kind of energy sources, even if there are interesting economic opportunities also in non-subsidized markets. Renewable energy (RE) is a sustainable choice, but its management requires a proper analysis, both from political and operational levels. The aim of this paper is the assessment of European renewable energy source (RES) trajectory towards 2020, starting from historical values and through common scientific methods. In addition, a new reference framework is proposed, in order to evaluate RESs performances in Europe. The framework is based on three indicators: (i) share of energy from RESs in gross final energy consumption, (ii) REs primary production per capita and (iii) gross final consumption of REs per capita. Results could have practical implications for the decision makers involved in the management of energy sources throughout Europe and could be used for the comparison on a global scale.

1. Introduction

The Renewables Directive, officially coded as 2009/28/EC, defines an overall policy for the energy production from RESs within Europe. This guideline forces European nations to gather at least the 20% of their total energy needs by renewables within 2020, with specific targets for each Member State (MS). Furthermore, European countries agreed recently on a new 2030 Framework on climate and energy, imposing at least a 27% in share of RE consumption [1]. This transformation of the European energy system aims to reach the following goals: (i) guarantee the energy supply, (ii) reduce greenhouse-gas (GHG) emissions, (iii) lower energy costs and (iv) lead industrial development, growth and occupation [2,3].

Initially, the development of RESs was considered as an alternative to the depletion of fossil fuels in industrialized and developing areas. However, now it represents an opportunity to improve the sustainability of energy systems [4–6]. In fact, policy-supporting mechanisms favored the development of RESs and the improvement of technical efficiency, viability and competitiveness of RES through a costs reduction strategy [7]. However, when these financial incentives end, a shock effect ensues [8].

The ongoing transition from centralized to distributed energy generation systems was pushed by RESs [9,10]. Their management was analysed in a dynamic context, by evaluating the bi-directional interaction with external energy networks and coupling it with conventional fossil fuel-based energy systems [11]. Smart grids aimed to integrate RESs with already existing distribution and transmission systems, in order to solve power unbalances issues and other technical problems in real time [12]. The harmonization between consumption and production of energy, even if representing a key-element in decision-making processes, is not always possible [13]. Consequently, the balance can be obtained into two ways: Demand Side Management (DSM) and Energy Storage Systems (ESSs). DSM is the customers' ability to take more informed decisions about its energy consumption, by adjusting both timing and quantity of electricity use [14]. ESSs are equipments able to solve the intermittency of solar and wind energy, by providing stability to applications when applied [15].

From one side, this topic is widely analysed in literature. Someone defines EU 20-20-20 targets as not ambitious enough, but others judge them as excessive [16]. These targets can be achieved only through strong investments in the European energy sector, especially in research and innovation [17]. However, the interaction between internal energy markets and climate change

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packages can be improved and different national energy policies represent a weakness point [18]. From another side, the European Commission continuously checks the trend towards 2020 targets. In 2014, the share of energy from RESs in gross final consumption of energy terms reached a 16.0% in the EU 28, doubling the 2005 data (9%). Only nine MSs already achieved their 2020 targets [19].

This paper aims to reach two goals: (i) the definition of a 2015–2020 RES trajectory based on average values obtained in the 2008–2014 period and (ii) the comparison of twenty-eight European countries. For these reasons, REs primary production per capita and gross final consumption of REs per capita will be proposed as reference indexes. This methodology does not criticizes the current one (represented by an indicative trajectory and the share of energy from RESs in gross final energy consumption), but tries to offer additional information in order to support governmental actors during the definition of corrective measures.

2. Materials and methods

The Renewable Energy Directive (2009/28/EC) defines the levels of REs use within Europe. Given the initial level of REs (taken 2005 as reference period (S_{2005})), an indicative trajectory is proposed, in order to reach the final level of REs (taken 2020 as reference period (S_{2020})). A growing steps structure is taken into account: $S_{2005} + 0.20 * (S_{2020}–S_{2005})$ is the average for 2011–2012 period, $S_{2005} + 0.30 * (S_{2020}–S_{2005})$ is the one for 2013–2014 period, $S_{2005} + 0.45 * (S_{2020}–S_{2005})$ is the one for 2015–2016 period and $S_{2005} + 0.65 * (S_{2020}–S_{2005})$ is the one for 2017–2018 period [2]. For example, by setting S_{2005} equal to 2.2% and S_{2020} to 13% for Belgium, indicative values are equal to 4.36% in 2011–2012, 5.44% in 2013–2014, 7.06% in 2015–2016 and 9.22% in 2017–2018. Half of European nations must increase at least of 10% their share of energy from REs in gross final energy consumption terms – Table 1.

2.1. Share of energy from renewables in gross final energy consumption terms

Eurostat is a General Directorate of the European Commission with the main responsibility to give statistical information to European institutions, by favoring the harmonization of statistical methods across member states. Latest available data (released the 10th of February, 2016) highlight that the share of RESs in gross final energy consumption terms grew significantly in many MSs [19]. Among the twenty-eight European countries, one third of them already reached their 2020 target (Sweden, Finland, Croatia, Estonia, Romania, Lithuania, Bulgaria, Italy and Czech Republic). However, it does not means that these countries have a greater value in share of RESs terms (see Latvia, Austria and Denmark) – Table 2.

Table 2
Share of energy from renewables in gross final energy consumption terms (%) [19].

Geo/time	2008	2009	2010	2011	2012	2013	2014	Target 2020
EU 28	11.0	12.4	12.8	13.1	14.3	15.0	16.0	*20*
Belgium	3.8	5.1	5.5	6.2	7.2	7.5	8.0	*13*
Bulgaria	10.5	12.1	14.1	14.3	**16.0**	19.0	18.0	***16***
Czech Republic	7.6	8.5	9.5	9.5	11.4	12.4	**13.4**	***13***
Denmark	18.6	20.0	22.1	23.5	25.6	27.3	29.2	*30*
Germany	8.6	9.9	10.5	11.4	12.1	12.4	13.8	*18*
Estonia	18.9	23.0	24.6	**25.5**	25.8	25.6	26.5	***25***
Ireland	4.1	5.1	5.6	6.6	7.1	7.7	8.6	*16*
Greece	8.0	8.5	9.8	10.9	13.4	15.0	15.3	*18*
Spain	10.8	13.0	13.8	13.2	14.3	15.3	16.2	*20*
France	11.1	12.1	12.6	11.1	13.4	14.0	14.3	*23*
Croatia	**22.0**	23.6	25.1	25.4	26.8	28.1	27.9	***20***
Italy	11.5	12.8	13.0	12.9	15.4	16.7	**17.1**	***17***
Cyprus	5.1	5.6	6.0	6.0	6.8	8.1	9.0	*13*
Latvia	29.8	34.3	30.4	33.5	35.7	37.1	38.7	*40*
Lithuania	18.0	20.0	19.8	20.2	21.7	**23.0**	23.9	***23***
Luxembourg	2.8	2.9	2.9	2.9	3.1	3.6	4.5	*11*
Hungary	6.5	8.0	8.6	9.1	9.6	9.5	9.5	*13*
Malta	0.2	0.2	1.1	1.9	2.9	3.7	4.7	*10*
Netherlands	3.6	4.3	3.9	4.5	4.7	4.8	5.5	*14*
Austria	28.2	30.2	30.6	30.8	31.6	32.3	33.1	*34*
Poland	7.7	8.7	9.2	10.3	10.9	11.3	11.4	*15*
Portugal	23.0	24.4	24.2	24.7	25.0	25.7	27.0	*31*
Romania	20.5	22.7	23.4	21.4	22.8	23.9	**24.9**	***24***
Slovenia	15.0	20.0	20.5	20.2	20.9	22.5	21.9	*25*
Slovakia	7.7	9.4	9.1	10.3	10.4	10.1	11.6	*14*
Finland	31.4	31.4	32.4	32.8	34.4	36.7	**38.7**	***38***
Sweden	45.3	48.2	47.2	**49.0**	51.1	52.0	52.6	***49***
United Kingdom	2.7	3.3	3.7	4.2	4.6	5.6	7.0	*15*

National target 2020 denotes in bold.

A description of models used to assess European decarbonisation pathways was proposed by [20,21]. These authors classified several types of models:

- Partial equilibrium energy system models (e.g. PRIMES and TIMES-PanEu),
- Energy models dedicated to specific sectors (e.g. GAINS and Green-X),
- General equilibrium models (e.g. GEM-E3 and WorldScan),
- Macro-econometric models (e.g. NEMESIS).

Advantages coming from the adoption of a strong climate migration action were proposed by [22]. They use the GEME3-RD model basing on learning curves for clean energy technologies.

Table 1
Share of energy from RESs in gross final energy consumption terms in 2005–2020 (%) [2].

Geo/time	2005	2020	Δ2020–2005	Geo/time	2005	2020	Δ2020–2005
United Kingdom	1.3	15	*13.7*	Malta	0	10	*10*
Denmark	17	30	*13.0*	Finland	28.5	38	*9.5*
Ireland	3.1	16	*12.9*	Sweden	39.8	49	*9.2*
France	10.3	23	*12.7*	Slovenia	16	25	*9*
Germany	5.8	18	*12.2*	Hungary	4.3	13	*8.7*
Italy	5.2	17	*11.8*	Lithuania	15	23	*8*
Netherlands	2.4	14	*11.6*	Poland	7.2	15	*7.8*
Spain	8.7	20	*11.3*	Latvia	32.6	40	*7.4*
Greece	6.9	18	*11.1*	Slovakia	6.7	14	*7.3*
Belgium	2.2	13	*10.8*	Estonia	18	25	*7*
Austria	23.3	34	*10.7*	Czech Republic	6.1	13	*6.9*
Portugal	20.5	31	*10.5*	Bulgaria	9.4	16	*6.6*
Luxembourg	0.9	11	*10.1*	Romania	17.8	24	*6.2*
Cyprus	2.9	13	*10.1*	Croatia	23.8	20	*−3.8*