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Benefits and costs of renewable electricity in Europe☆

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ABSTRACT

The European Union (EU) is committed to the deployment of electricity from renewable energy sources (RES-E). However, the large and recent increase in the RES-E penetration has raised the concern of policy makers in the EU Member States (MS) about the costs of public promotion of RES-E. Nevertheless, an economic analysis of the RES-E contribution should include the policy costs of RES-E deployment, but also its benefits. This would contribute to support the debate on renewable energy policy targets in the EU and its MS. The aim of this paper is to close this gap in the literature with a novel methodology and put those policy costs into perspective by evaluating some of the most relevant benefits of RES-E deployment in the EU and its MS. The results show that RES deployment due to RES-E support has led to two main benefits (lower CO_2 emissions and fossil fuel savings), which are slightly below those costs. Behind this broader picture, significant country and technology differences emerge. The benefits are above policy costs for hydro and wind, and below those costs for bioenergy, solar photovolatics and other RES-E.

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Abbreviations: BM, Build margin; CDM, Clean Development Mechanism; CEER, Council of European Energy Regulators; CM, Combined margin; EU ETS, European Union Emission Trading System; FI, Financial Incentive; FIP, Feed-in-premium system; FIT, Feed-in-tariff system; GHG, Greenhouse Gases; II, Investment Incentive; IPCC, Intergovernmental Panel of Climate Change; MS, Member States; NM, Net Metering; OM, Operating margin; PV, Solar photovoltaic; QO, Quota Obligations; RES-E, Renewable energy sources; SCC, Social Cost of Carbon; TE, Tax Exemption; TGC, Tradable Green Certificates; TN, Tendering Schemes; TSO, Transmission System Operator; UNFCCC, United Nations Framework Convention on Climate Change

☆Member States abbreviations: AT: Austria; BE: Belgium; BG: Bulgaria; CZ: Czech Republic; CY: Cyprus; DE: Germany; DK: Denmark; EE: Estonia; EL: Greece; ES: Spain; FI: Finland; FR: France; HR: Croatia; HU: Hungary; IE: Ireland; IT: Italy; LT: Lithuania; LU: Luxembourg; LV: Latvia; MT: Malta; NL: Netherlands; PL: Poland; PT: Portugal; RO Romania; SE: Sweden; SI: Slovenia; SK: Slovakia; UK: United Kingdom; NO: Norway; EU-28: European Union (28 Member States).

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1. Introduction

The European Union (EU) has been and is committed to the deployment of electricity from renewable energy sources (RES-E). In 2001, a Renewable Electricity Directive set indicative targets for the penetration of RES-E in the EU Member States (MS) in 2010 [1]. The current Directive on the promotion of renewable energy sources, Directive 28/2009/EC [2] has set a target that renewables should contribute to 20% of energy consumption in 2020. The recent 2030 policy framework aims to make the EU's economy and energy system more competitive, secure and sustainable and also sets a target of at least 27% for renewable energy by 2030 [3].

It has been well-established that generating electricity, especially from fossil fuels, creates environmental and socio-economic impacts on third parties, which are not included in the electricity price. These impacts are referred to as externalities. Although, in general, private generation costs are higher for RES-E than for conventional electricity, the former provides benefits that are not valued by the market. Those benefits translate into a generally lower social cost (inclusive of private costs plus negative external costs minus positive externalities) for RES-E, but market operators (investors, generators, suppliers and consumers) are guided by the incentives provided by the market, where decisions are taken on the basis of private and not social costs (unless, of course, policy measures internalise those externalities). Public support to RES-E levels the playing field with respect to conventional electricity, internalises the positive externalities of renewable energy in the decisions taken by economic actors and allows renewable energy to penetrate the electricity market [4]. Almost all EU MS have enacted support schemes in order to promote the use of RES-E, correct market failures and achieve the desired level of RES-E.

Notwithstanding, the penetration of RES-E in the EU has raised the concern about the costs of public promotion for RES-E. These support costs have increased significantly in recent years, i.e., by 144% between 2009 and 2012 [6] and [7].

As a result of such increase, headlines such as "renewables are too costly" have been relatively common in the press. More importantly, it has triggered a reaction by the national authorities in the MS and by the European Commission itself.

On the one hand, governments in EU MS implemented cost-containment measures, including capacity caps, generation caps, periodic revisions, traditional degression, flexible degression and budget caps (see [8] for a review).

On the other hand, the European Commission has stressed the need to have cost-effective and market-based instruments, suggesting that feed-in tariffs (FITs) have been too expensive and not suitable to integrate an increasing volume of RES-E in electricity markets. While it is true that RES-E support costs have increased significantly in the last decade and that it is certainly desirable to deploy RES-E at the lowest possible support costs, an analysis of the social contribution of RES-E should put those costs into perspective and also take into account the benefits of RES-E deployment. Indeed, the debate has centred too much on the costs of support and much less on the benefits. The neglect of those benefits is most striking given that they have generally been recognized by the EU and its MS in European policy documents. For example, in the analysis of [9], sustainable energy supply and environmental benefits represent the two primary goals in Germany's energy policy. The benefits of RES-E deployment in terms of greenhouse gases (GHG) emissions reductions are undisputed in the literature, and have particularly been stressed by the Intergovernmental Panel on Climate Change (IPCC) [10] and [11] and the EU [12,13] and [14].

Notwithstanding their relevance, a quantification of the costs and benefits for different technologies and EU MS has been absent in the literature, as noted by [5]. Three notable exceptions are [15,16] and [17]. Redondo et al. [15] compares the benefits associated to the CO_2 emissions avoided with the costs of the Spanish FIT system and [16] analyses the avoided costs of imported fuels in Europe. Marcantonini et al. [17] compares the policy costs of RES-E deployment with the social benefits in terms of CO_2 emissions reduction and fossil fuel savings in Germany, leading to the conclusion that the former outweigh the later.

The costs and benefits of RES-E deployment support usually fall on different actors. According to Breistschopf et al. [5], support for renewables is a distributional effect (Fig. 1) whose costs are ultimately borne by end-users, through higher electricity prices, taxes or directly added to electricity bills.

The aim of this paper is to close this gap, i.e., to quantify in monetary terms the policy costs and some of the most relevant benefits of RES-E deployment in the EU MS, including climate change mitigation and fossil fuel savings in 2012. Three perspectives are combined: system related effects, broader macroeconomic effects and distributional effects (Fig. 1). In strictly economic terms, benefits and costs cannot be compared between each other because the respective impacts fall on different types of actors [5]. Therefore, a cost-benefit analysis is not carried out.

The paper is structured as follows. The following section provides a brief background on RES-E generation and support policies in the EU. The methodology to calculate the benefits and costs of RES-E support is developed in Section 3. Section 4 is devoted to the application of this methodology to the EU MS. The results are provided and discussed in that section. Section 5 concludes.

2. Renewable electricity in Europe

2.1. The current energy situation in Europe

In 2012, the base year for this analysis, net electricity production in the EU amounted to 3124 TWh [18] and was concentrated in a few countries. Germany, France, United Kingdom, Spain and Italy accounted for 65% of electricity generation.

The EU has a relatively diversified electricity generation mix. Several energy sources have significant shares in this mix in 2012, including coal (28.4%), nuclear (26.8%), natural gas (17.7%) and renewable energy sources (24.7%). Only oil (2.8%) has a negligible share in electricity generation, although it is the dominant fuel in Malta and Cyprus (in 2012, fuel-oil represented 99.0% and 94.6% of electricity generation, respectively). Within RES, hydro (11.1%) dominates, followed by wind (6.3%), which has grown considerably in the last years. Biomass, biogas and waste (4.5%), solar (2.2%) and geothermal (0.2%) have smaller shares [18] (Table 1).

RES-E significantly increased in the 2002–2012 period in the EU, with an average annual growth rate (excluding large hydro) of 18%. Hydropower still represents the dominant RES-E, but it is relatively less important than it was a decade ago (Fig. 2). This is due to the substantial increase of the deployment of other RES-E technologies, such as on-shore wind and biomass. In turn, this increase has been triggered by national support schemes, in