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Integration of renewable energy sources in southeast Europe: A review of incentive mechanisms and feasibility of investments

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ABSTRACT

Incentivizing development and deployment of renewable energy sources (RES), but also other low carbon technologies (LCT), has been a successful way of promoting new technologies by creating a feasible investment case and making them competitive with traditional energy sources. Although different incentive mechanisms exist, feed-in tariffs have shown to be the best model for accelerating LCT development guaranteeing producers preferential prices for the produced electricity over a period of time and enabling them access to the power network to sell/inject produced electricity. Due to these benefits, feed-in tariff models are the most common model for stimulating RES integration in southeast Europe.

The paper reviews the current state of preferential tariffs for RES in countries of southeast Europe. While some countries already have significant installed RES capacity, others are still in the planning stage. The review shows that the amount of installed capacity of a specific technology has a strong impact on the support for the future projects for same technology. This comprehensive review of legislative development supporting RES, as well as technologies preferred in different countries of the region, is supported with feasibility assessment of investing in RES using the example of two different technology projects, wind and photovoltaic, analysing the impact of the current tariffs on the return on investment for each country of the region.

1. Introduction

1.1. Technical aspects of RES

In times of constant fluctuations of fossil fuel prices, increase of energy demand and awareness of reducing CO_2 emissions, there is a need for new sources of electricity. Supported by regulatory decisions and goals for reducing the environmental impact of the electricity generation [1], RES are the fastest growing technologies in the previous years [2,3]. The characteristics of RES, such as spatial distribution, low or zero CO_2 emissions, are also characterized by, in lesser or greater extent, volatility and variability in production and lower power density than those of conventional power plants. The basic operational principle of the energy sector is stable and secure supply of a specific energy vector (electricity, heat, gas etc.) procured through various market services and delivered at different time horizons. In order to provide these services, energy systems need to be flexible to maintain the supply-demand balance, responding to uncertainties and variability in both production and consumption. The increasing share of RES in the generation mix redefines requirements on the flexibility of energy systems. Although the uncertainty and variability have always been present in these systems, the integration of RES has increased them, setting new technical and economical requirements. The share of RES in most countries of the world is still relatively small and these systems have sufficient flexibility to cope with them. However, several systems have already experienced problems with large share of RES in overall electricity production [4]. These problems resulted in an increased awareness of advanced planning tools and strategies to avoid potential problems. To address the challenge, multiple studies have been conducted analysing different aspects, issues and challenges ranging from low and high voltage ride-through capabilities, active and reactive power responses during and after faults, extended range of voltage–frequency variations, active power (frequency) control facility, and reactive power (voltage) regulation support [5]. In [6], the authors provide an insight into grid code requirements for power factor in large scale wind power plants connected to the system, discussing the increased voltage regulation issues as a consequence of RES integration [7]. Summarizing many RES integration studies, the authors of [8] emphasize that “Grid codes help to ensure that the needs of all connected parties to the grid can be met in the most efficient and optimal way”. In line with that, they discuss experiences of several European countries with respect to the RES integration, ranging from

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dynamic stability issues, short-circuits, electromagnetic transients, to transmission network expansion and operational reserve requirements. While some countries, such as Germany and Spain, have been constantly upgrading the technical requirements for newly installed generation to cope with the changes [9], others, such as Ireland, introduced additional new services (negative reserve) to maintain the stability of the system. Special focus in the report is put on the RES output forecasting challenges, as these have a crucial role in successful transition to a sustainable electric system. Due to lack of experience in developing tools, as well as practical knowledge, the errors in forecasting could be high for a single unit (up to 40% daily in terms of the forecasted electricity produced), while the error significantly reduces with shortening the forecast period or for spatially dispersed RES production [10]. These inputs lead to new concepts in power system dispatch, through different unit commitment models, recognizing benefits of stochastic and rolling unit commitment approaches, emphasizing the value of load and RES forecasting [11], as well as interconnecting multiple balancing areas [12]. Multiple studies show that, with the increase of RES penetration, the need for balancing services increases in order to mitigate the stochastic nature of wind and solar production [13]. The authors of [14,15] conclude that the balancing requirements increase by 2–9%, similar to the conclusions of a Germany market study in [16], estimating the increasing needs to 4%. It is interesting to note that the type of service to be increased, due to RES, differs depending on the source, especially when discussing the increasing needs for the fastest contingency reserve (or primary response) [17]. Several papers have proposed solutions to new operational practices to cope with higher primary response requirements, either by adjusting the existing operational principles [18] or by engaging the providers of flexibility services [19,20]. As the share of the RES in power systems increases, it will be necessary to adjust the current market rules [21,22] enabling them to become balancing service providers [23]. In addition to balancing services, RES integration can have an impact on technical grid constraints [24] (voltage, congestion etc) both at the transmission level [25,26] and at the distribution level [27].

Prospects and integration issues in South Eastern Europe have been addressed in multiple studies. In the following sections, multiple technical aspects are elaborated for each country individually. A summary of barriers and potentials for wind integration in Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Macedonia, Montenegro, Romania and Serbia is given in [28]. While all these European countries have common issues and challenges in order to integrate the desired levels of RES, e.g. available reserve levels, specifics, such as low spatial distribution of wind projects in Croatia, require customized approaches and solutions.

The solution to technical aspects of RES integration is rather complex and requires significant changes both in operational and planning approaches as well as technical grid code requirements. As the market rules are changing [29], it is important to understand what financial instruments were and are implemented and how they encouraged or hindered integration of a specific RES technology.

1.2. Financial aspects of RES

Uncertain and variable characteristics of RES also impact risk assessment of making an investment [30]. These obstacles can be overcome in two ways: the first is through political measures and the second by introducing financial incentives. The main initiative for promoting renewable energy at the European Union level was set back in 1997 when the European Council and the European Parliament adopted the “White Paper for a Community Strategy and Action Plan”, aiming to increase the share of renewable energy which was at the time only 6% of gross energy consumption [31]. The Directive of the European Parliament and of the Council of 23 April 2009, sets the targets for final energy consumption and CO_2 emission reductions by 20%. It also defines national targets for the share of RES in total energy production for every member state for target year 2020 [32]. The RES group comprises of wind power plants, solar power plants, plants using biomass and biofuel, cogeneration plants, geothermal and small hydro power plants. Political measures do not directly affect investors and RES producers; this is the assignment of member states and regional governments who independently establish support mechanisms for stimulating investors and producers [33].

There are several different classifications of incentive models. One of those is the object of the research by Del Rio and Mir-Artigues [34], who differentiate primary and secondary models. Primary, or main incentive models, are the basis of the RES integration. They shift the costs of purchasing the electricity from RES producers to end consumers. Almost every country in Europe, has implemented one of the models [35–37]. Mainly, it is either a feed-in tariff model or Renewable Portfolio Standard model (RPS) [38–41]. Jenner et al. in [42] divide incentive models in two categories. One criterion is the object of the regulation, and the other is the object of the support. The incentive model can regulate either price of the energy from RES or the amount of the produced energy. On the other side, the object of the support can be the RES investment or the production itself. In that respect, primary incentive models are those which support the production, and by the object of regulation they are divided into feed-in tariffs, which regulate the price of electricity, and RPS which regulates the amount of produced energy [43]. Models that support the investment are characterized in [34] as secondary incentive models. These are capital incentives, tax incentives, credit enhancement, soft loans and public funds.

Feed-in tariffs are an incentive model defined by Feed-in laws, usually on a national level. Its primary goal is to reduce the investor's risk by contracting three key elements between a producer and the market operator: fixed long-term period of support, preferential price for purchased electricity and prioritized access to the grid. RPS or incentive model through green certificates is a form of a market in which eligible producers sell certificates to retailers. Green certificates are a guarantee that a certain amount of electricity, usually 1 MW h, sold by retailers is produced by RES. Depending on the technology, 1 MW h can generate more than one certificate, and thus different RES technologies can get different support levels. Retailers then shift the cost of electricity produced by RES to the end consumers. The principle is the same as in the tariff system, with the exception that in the tariff system the regulatory body determines the cost to be transferred to the end consumers, not the retailers [44].

Strengths and weaknesses of feed-in tariffs and RPS are the topic of many papers [43,45–47]. Sun et al. [43] and Couture et al. [45] came to conclusion that feed-in tariffs are more effective in the promotion of RES development. Their research has shown that with the rise of subsidy, the amount of energy delivered from RES increases more than when applying certificates. Another result was that feed-in tariffs perform better at decreasing market prices [43,48–51]. In the case of RPS, after a certain amount of subsidy, further increase of subsidy starts increasing market price [52,53].

As the most common incentive policy in the European market, feed-in tariffs are also studied with an objective to define the optimal model, not only from the perspective of the RES share in total production portfolio, but also considering economic sustainability of such system and the impact on market prices and on end consumers [54–57]. Couture et al. [45] define seven different types of feed-in tariff models, divided into two groups with respect to their market dependency. Market-independent models offer a fixed price for the whole duration of the contract. Beside the basic model, market-independent models are also *fixed price with inflation adjustment tariff model*, *front-end loaded tariff model* and *spot market gap model*. Front-end loaded model is especially interesting since, in the case of equal total cash flow during the lifetime of the project, it provides investors a shorter payback period. This is achieved by setting a higher feed-in tariff at