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Distribution of costs induced by the integration of RES-E power

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ABSTRACT

This article focuses on the distribution of costs induced by the integration of electricity generation from renewable energy sources (RES-E). The treatment to distribute these costs on different market actors is crucial for its development. For this purpose, individual actors of electricity markets and several cost categories are identified. According to the defined cost structure, possible treatments to distribute the individual cost categories on different relevant actors are described. Finally, an evaluation of the cost distribution treatments based on an economic analysis is given. Economic efficiency recommends that clearly attributable (shallow) grid connection as well as (deep) grid costs are charged to the corresponding RES-E producer and that the RES-E producers are also charged the regulating power costs. However, deep grid integration costs should be updated to reflect evolving scarcities. Also regulating power costs should reflect actual scarcity and thus be symmetric and based on real-time prices, taking into account the overall system imbalance. Moreover, the time span between the closure of the spot market and actual delivery should be chosen as short as possible to enable accurate RES-E production forecasts.

1. Introduction

An increased share of total power production covered by intermitting, i.e. variable and not perfectly predictable, electricity generation from renewable energy sources (RES-E) influences the costs of existing power systems. Present literature offers various studies estimating the magnitude of integration costs due to the integration of RES-E power by applying different methodologies, compare e.g. Dale et al. (2004), DeCarolis and Keith (2006), Grubb (1991), Hirst and Hild (2004), Strbac (2002). A detailed discussion of qualified methods to derive such integration costs and the corresponding determination of integration cost figures for selected European countries can for example be found in Swider et al. (2006a). But beside the magnitude of the integration costs, the approach how these cost changes are distributed on individual actors taking part in different electricity markets has considerable impacts on profitability, investor behavior and finally on the integration of new RES-E capacity. In Auer et al. (2006), the impact of individual cost allocation schemes on future installed RES-E capacity and generation is estimated. They find that the pattern of RES-E deployment significantly varies depending on the allocation of RES-E grid integration costs and that an allocation of grid connection, extension and reinforcement costs to the RES-E developer may hamper the deployment of additional RES-E significantly. In Swider et al. (2007), results of selected country-specific case studies on conditions and cost for RES-E grid connection under different regulatory regimes are presented and analyzed for best practice. They show that, especially for wind off-shore, the allocation of grid connection costs can form a significant barrier for the installation of new RES-E generation if the developer has to bear all such costs. The conclusion is that if energy policy makers want to reduce the barriers for new large-scale RES-E deployment, then the grid connection costs should be covered by the respective grid operator.

Following this brief literature review, the focus has been on political goals to reach defined shares of RES-E in the future, the efficiency of system-wide RES-E deployment has not been discussed and individual cost distribution methods and their variants are not reviewed in detail. Yet for a comprehensive analysis of the impacts of individual methods to distribute integration costs, a survey that takes different market structures into account has to be considered.

With this paper, an investigation of possible models for distributing additional costs of introducing large amounts of RES-E capacity with a subsequent economic analysis is given. The discussion is based on the subdivision of individual groups of actors participating in a liberalized electricity market environment. Furthermore, a subdivision of the total integration costs into reasonable cost categories is applied.

This paper is organized as follows: relevant actors of electricity markets and categories of costs and benefits induced by the integration of RES-E are discussed in Section 2. Individual treatments for the distribution of the integration costs on the individual market actors are presented in Section 3. A discussion of

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these cost distribution treatments based on an economic analysis follows in Section 4. Finally, conclusions are given in Section 5.

2. Relevant groups of actors and integration cost categories

This Section begins with a definition of groups of actors participating in electricity markets that are relevant concerning the distribution of costs induced by the integration of RES-E power. Subsequently, categories of integration costs are distinguished according to their origin.

2.1. Relevant groups of actors in electricity markets

For the description and analysis of the individual distribution models the following actors in the electricity systems have to be considered explicitly:

- RES-E power producers;
- Transmission and distribution system operators (TSO and DSO);
- Consumers.

RES-E can be one production form in the portfolio of power producers, however, in this report RES-E power is treated separately in order to identify possible impacts of RES-E power production on the operation of conventional power plants. For the transmission or distribution of the generated electrical power to the consumers within a certain area, a transmission or distribution system operator is responsible, respectively. Possible metering companies are presumed to be part of these system operators. For the individual electricity consumers no subdivision between purchasers of electricity connected to a TSO or a DSO is considered.

2.2. Relevant categories of integration costs and benefits of RES-E

The integration of fluctuating and not perfectly predictable RES-E into the electricity system may induce both additional costs and benefits (especially with wind energy).[1] A detailed discussion on methods to derive figures evaluating these additional costs and benefits can be found in Söder (2005) and Weber (2006). In general, the cost impacts can be separated into capital expenditures (investments) and operational costs or benefits, compare Auer et al. (2004). Integration costs or benefits related to capital expenditures can further be separated into:

- Grid connection costs;
- Grid reinforcement costs;
- Power plant investment costs.

The latter occur due to additional need of flexible generation technologies able to provide regulating power caused by intermittent RES-E power.

Operational integration costs are mainly due to a change of operational costs of conventional power plants, i.e. more frequent start-ups and more need for part-load operation. The various subcategories are discussed in more detail in the following.

2.2.1. Grid connection costs

The connection of a RES-E power plant to the existing transmission or distribution grid requires the installation of an additional underground cable or overhead line from the RES-E power plant to the existing transmission or distribution grid and the modification of the existing busbar. It has to be further ensured that common requirements defined on EU and national level concerning power quality measures and short circuit levels are met. Additional requirements are defined by the corresponding grid operator.

The grid connection costs can be principally subdivided into the costs of the local electrical installation (the internal grid) and the connection to the existing power grid. The latter part is the most interesting factor considering cost distribution and mainly depends on the following factors, compare Auer et al. (2004):

- The distance of the RES-E power plant to the point of coupling with the grid.[2]
- The voltage level of the connection line and the connected grid.
- The possibility to apply standardised equipment (cables, busbars, etc.).

Grid connection costs are an important economic constraint for the development of RES-E in many cases where good energy resources are found in remote locations far from load centers. Hence, it is often the case that a compromise between locations with good renewable energy conditions with potentially higher RES-E power production and locations without extremely high grid connection costs has to be found.

The costs of grid connection are often included into the total costs during the evaluation process of projected RES-E power plants. Based on selected country-specific case studies average grid connection costs are estimated by Swider et al. (2007) as 9% of the total investment costs for on-shore and 18% for off-shore wind farms.

2.2.2. Grid reinforcement costs

The integration of large-scale RES-E power plants can require additional network capacities in the distribution and transmission grid, depending on the location of the RES-E power plant relative to the load centers and the existing grid structure. For example, in Germany, the highest concentration of installed wind power can be found in the North whereas the main consumption area is in the midland. Thus, there are periods with high electricity transits from North to South and from East to West especially at weekends with high wind speeds and low demand, compare e.g. Dena (2005). As the grid was originally planned to supply the relatively low local demand of these regions, it has to be extended to meet power stability and quality requirements. On the other hand, in the case that RES-E power plants in terms of distributed generation are located near to the load, the RES-E production can reduce the occurrence of bottlenecks and defer the need of grid reinforcements, compare Méndez et al. (2006).

The intermittent feed-in from RES-E must be balanced with regulating conventional power plants that can be located elsewhere in the grid. Also larger control areas that can make use of regulating capacity from outside a country require sufficient transmission capacities. Basically, RES-E will change the power flows in the transmission system and new bottlenecks in the existing transmission or distribution grid may occur.

The more frequent operation of the grid at full capacity due to the transmission of RES-E power to the consumer leads to a higher demand for reactive power in the grid. For example in Germany, additional reactive power sources are already required for the wind power capacity of the year 2007, compare Dena (2005). Hence, further additional investments into devices for the compensation of reactive power like capacitors, inductors and

[1] In fact, also the integration of conventional power plants induces integration costs and benefits.

[2] This cost factor is essential for off-shore wind power farms.