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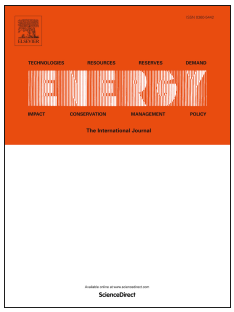

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Flow-based nodal cost allocation in a heterogeneous highly renewable European electricity network

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Abstract

For a cost efficient design of a future renewable European electricity system, the placement of renewable generation capacity will seek to exploit locations with good resource quality, that is for instance onshore wind in countries bordering the North Sea and solar PV in South European countries. Regions with less favorable renewable generation conditions benefit from this remote capacity by importing the respective electricity as power flows through the transmission grid. The resulting intricate pattern of imports and exports represents a challenge for the analysis of system costs on the level of individual countries. Using a tracing technique, we introduce flow-based nodal levelized costs of electricity (LCOE) which allow to incorporate capital and operational costs associated with the usage of generation capacity located outside the respective country under consideration. This concept and a complementary allocation of transmission infrastructure costs is applied to a simplified model of an interconnected highly renewable European electricity system. We observe that cooperation between the European countries in a heterogeneous system layout does not only reduce the system-wide LCOE, but also the flow-based nodal LCOEs for every country individually.

Keywords: large-scale integration of renewables, system design, renewable energy networks, wind power generation, solar power generation, levelized system cost of electricity, Europe

1. Introduction

A future sustainable electricity system will strongly depend on the efficient integration of high shares of renewable power generation (see for instance the Energy Roadmap 2050 from the European Commission [1]). In particular, wind and solar technologies have become increasingly cost competitive [2] and show considerable expansion potential for large-scale deployment [3, 4]. The weather-dependent resource quality and thus cost efficiency of these variable renewable energy sources (VRES) is unevenly distributed across the European continent. An efficient placement of generation capacity will result in a heterogeneous

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