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Transforming the electricity generation of the Berlin–Brandenburg region, Germany

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ABSTRACT

We present possible steps for Germany's capital region for a pathway towards high-level renewable energy contributions. To this end, we give an overview of the current energy policy and status of electricity generation and demand of two federal states: the capital city Berlin and the surrounding state of Brandenburg. In a second step we present alternative, feasible scenarios with focus on the years 2020 and 2030. All scenarios were numerically evaluated in hourly time steps using a cost optimisation approach. The required installed capacities in an 80% renewables scenario in the year 2020 consist of 8.8 GW wind energy, 4.8 GW photovoltaics, 0.4 GW_{el} bioenergy, 0.6 GW_{el} methanation and a gas storage capacity of 180 GWh_{th}. In order to meet a renewable electricity share of 100% in 2030, approximately 9.5 GW wind energy, 10.2 GW photovoltaics and 0.4 GW_{el} bioenergy will be needed, complemented by a methanation capacity of about 1.5 GW_{el} and gas storage of about 530 GWh_{th}. In 2030, an additional 11 GWh_{el} of battery storage capacity will be required. Approximately 3 GW of thermal gas power plants will be necessary to cover the residual load in both scenarios. Furthermore, we studied the transmission capacities of extra-high voltage transmission lines in a second simulation and found them to be sufficient for the energy distribution within the investigated region.

1. Introduction

Germany aims for a reduction of CO_2 output by 80–95% in the year 2050 compared to 1990. A first step is the reduction of CO_2 emissions by 40% by 2020, concurrent with a share of 35% renewable energy in electricity generation [6].

This target seems easy to realise since the renewable energy share was at 25% in the first half of 2012 [2]. However, the installation of additional renewable energy capacities will lead to an increasing need for energy storage. To ensure that the costs for electricity generation will not rise significantly during the transition towards sustainable energy generation, nationwide research on the distribution of different power plants and storage solutions is essential.

The region Berlin–Brandenburg is of particular interest in the context of Germany's ambitious aims of the *Energiewende*, i.e., the transformation towards sustainable energy generation in the next decades. The region encompasses a unique combination of Germany's capital city Berlin with 3.5 million inhabitants in 892 km^2 (population density of approx. 3900 people per km^2), surrounded by the structurally weak federal state of Brandenburg which has a population of 2.5 million in 29,500 km^2 (density of only 85 people per km^2). The properties of this region lead to specific challenges that must be met for a successful *Energiewende*, since Berlin has little open spaces for the use of renewable energy sources (RES), while Brandenburg features significant lignite capacities for energy generation. The countrywide unique feature of Brandenburg is the massive net energy generation from fossil fuels [29]. At the same time, the federal state already meets approximately 60–70% of its annual energy demand from renewable energy if fluctuations are neglected [16].

A major question not only for Berlin–Brandenburg but also for many other similar regions is how these issues can be overcome, what possible pathways may facilitate a transition towards RES within the next decades, which technologies will be required, and which steps have to be undertaken. We expect these challenges to arise whenever there is a combination of a major population centre with rural surroundings.

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The purpose of our studies is to present possible steps on the path for the Berlin–Brandenburg region to a "100% region". For context, we give an overview of the current energy supply and political objectives of the federal state governments of both, Berlin and Brandenburg. In a second step we present alternative, feasible scenarios. Our simulations focus on the electricity supply in the years 2020 and 2030. We show that a far higher increase in the use of RES for electricity generation than currently planned in both regions is indeed possible.

For the design of alternative scenarios we applied an economic optimisation tool with hourly time-steps. We performed numerical simulations to find cost-optimised energy scenarios within a single-node approach, resulting in energy generation system compositions with lowest total system costs for the years 2020 and 2030. The computations yielded optimised systems, consisting of photovoltaics (PV), wind turbines, energy storage and combined cycle gas turbines (CCGT) for 0–100% electricity generation from RES (RES-E). Biomass usage was set to currently installed capacities.

Moreover, the optimised configuration for an 80% renewable energy share in 2020 was used as input for a multi-node model to study the geographical distribution of RES-E plants, storages, and the feasibility of transmission capacities of extra-high voltage (EHV) transmission lines.

The results of the present study document that the *Energiewende* for the Berlin–Brandenburg region is possible within the next two decades. They display a possible pathway towards realising 100% RES-E, calling for strengthened cooperation of both political entities.

2. Status quo

2.1. Transmission network

The current 380/220 kV grid is depicted in Fig. 1. It shows a strong interconnection of Berlin and Brandenburg, as well as additional interconnections of Brandenburg and the surrounding German federal states. This is mainly due to large generation capacities in the Lusatia region, which has traditionally been a major lignite power generation site since 1894.

There are several interconnections between Brandenburg and Berlin. One 380 kV underground transmission line in Berlin connects its western and eastern parts. In addition, Berlin is connected

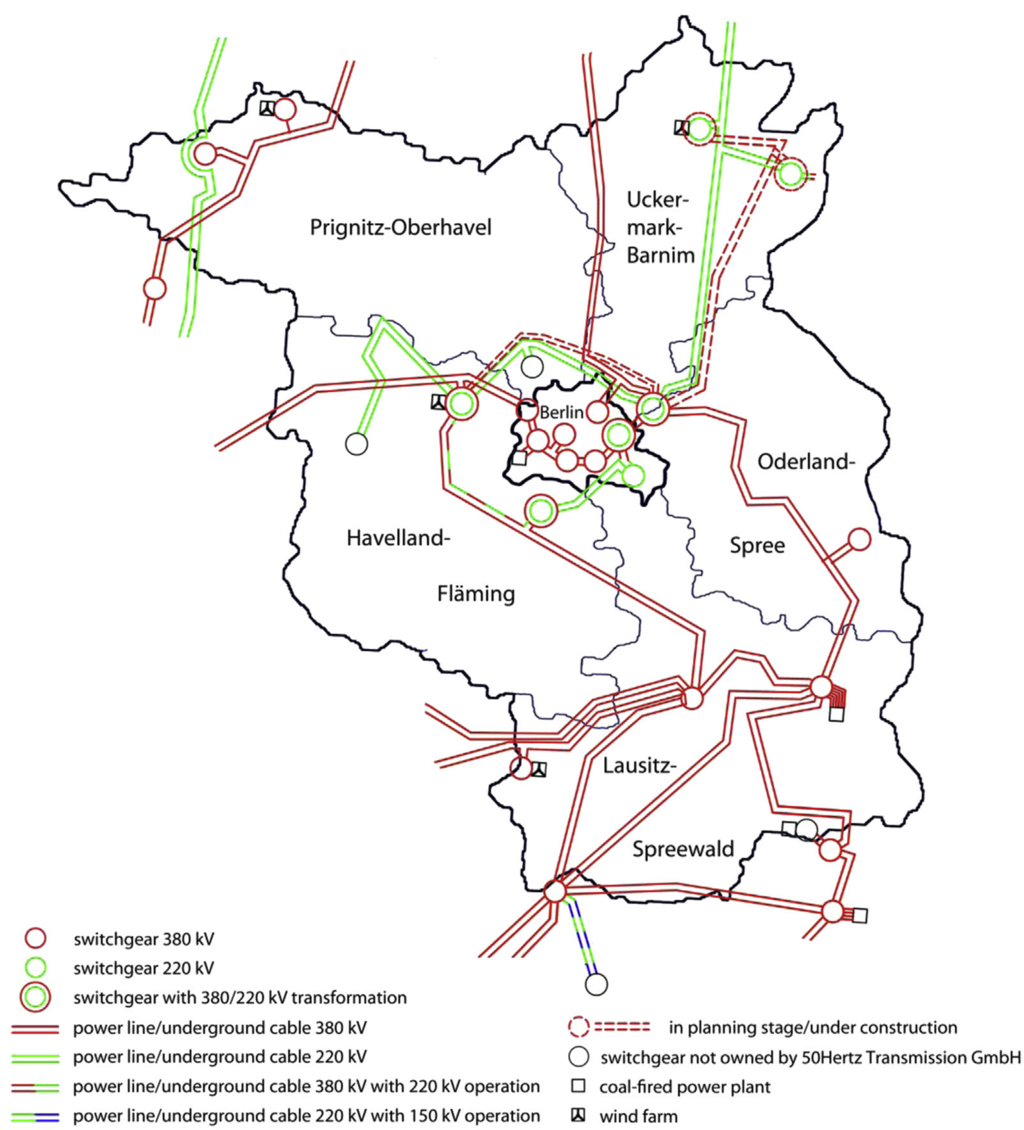

Fig. 1. Transmission network in the Berlin–Brandenburg region and local authorities in Brandenburg [1].