Are there interactions between a coal phase-out and the new battery capacities created by electric vehicles?

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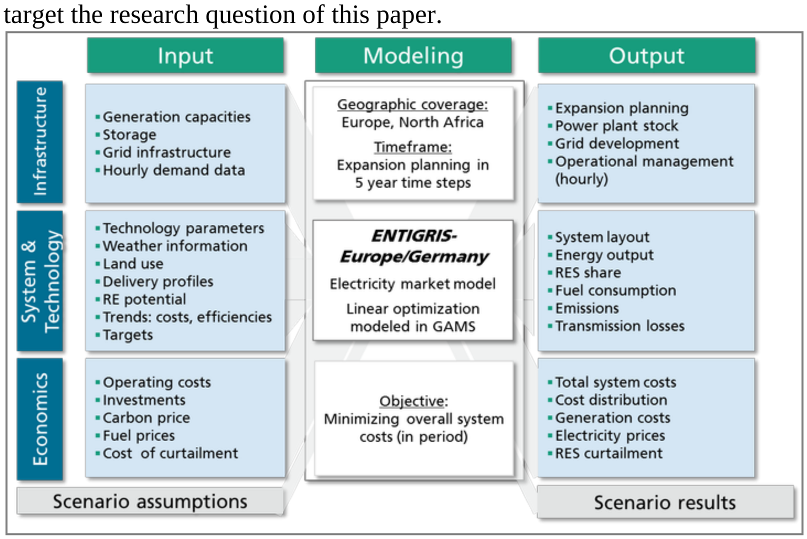
Overview

Within the framework of the Paris agreement, 195 Countries adopted the first ever legally binding global climate agreement. The goal is to keep the global average temperature well below 2 degree Celsius (European Commission, 2016). One of the predominant CO2 emitters in most countries is the electricity sector, and coal fired power plants in particular (Gutmann et al. 2014). Mobility is another sector with high emissions caused by the wide use of internal-combustion engines fired with petrol in all kinds of vehicles today. To sharply reduce CO2 emissions of the electricity and mobility sector, the phase-out of coal-fired power plants and combustion engines is discussed as a key activity to reach the CO2 emission targets (Quaschning 2016). But what are the interactions in the electricity sector of this double phase-out process, starting probably in the timeframe between 2030 and 2040? Does the energy system profit from both activities or are there many specific concerns and constraints?
By using the ENTIGRIS energy model, this paper shows different scenarios of potential interactions in a study of the German electricity system within the European electricity system. The paper concludes that the increase in electricity demand due to electric vehicles requires a larger supply side (which can also be filled with coal-fired power plants), but if deployment of renewable energy is extended this demand can also be supplied by green electricity. Furthermore, batteries of electric vehicles extend the short-term back-up capacity, increase flexibility and reduce short-term dependencies from conventional power plants. However, only green electricity reduces CO2 emissions in the mobility sector and therefore both activities have to be strongly linked with an increase of renewables in the electricity sector, on a European level.

Methods

The electricity model ENTIGRIS – Europe is an expansion planning model for the European and North African electricity system (Kost et al. 2014, Fraunhofer ISE 2016). The model results can be used to analyze the long-term portfolio of power plants, regional specific expansion of renewables and conventional power plants, required grid capacities and the development of total system costs. Scenarios for the long-term development are calculated by considering cost projections and long-term climate policies, such as framework conditions of limited CO_2 emissions in the electricity system. The detailed coverage of the generation from renewables and energy storages enables to target the research question of this paper.



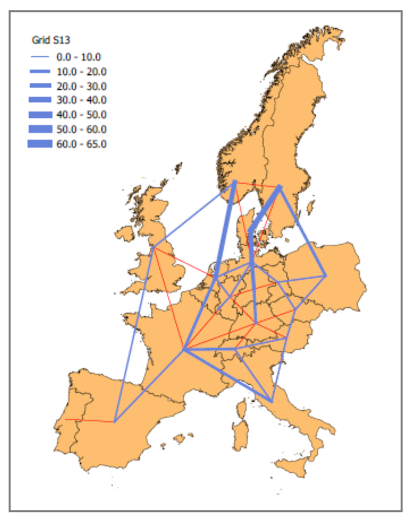


Figure 1 and 2: Energy system model ENTIGIRS with its input and output, grid capacities between region in an extended case

Germany (6 regions) with its neighboring countries plus Norway, Sweden, Great Britain, Spain and Italy are included in the area modelled. Energy is exchanged via the NTC capacities between the countries. Conventional electricity demand is assumed to be stable. The electricity demand for electric vehicles is added as flexible and inflexible load. The load for electric vehicles increases over the years up to 25% of the conventional electricity demand. While flexible charging should be possible for most electric vehicles depending on the access to an electric outlet, other grid services like grid feed in are considered less likely, because of the higher cost compared to other grid storage. The hourly demand for the electric vehicles is based on the vehicle usage pattern. The geographic distribution of electric vehicles is based on the distribution of today's vehicle inventory. Power plants and grid capacities will increase according to existing planned power plants plus optimally added plants by the model. RES potentials are included by using a GIS approach to obtain highly distributed resources of solar and wind (Kost et al. 2016).

Results

To analyze the research question, a base case is modelled in which coal-fired power plants are accepted (under CO2 emission constraint) and no electric vehicles are added. Then scenarios are assumed in which coal-fired power plants are forbidden in Germany or the EU. These scenarios are then extended with the additional electricity demand and additional flexibility of the batteries from the electric cars connected to the grid. Additionally the difference between flexible and inflexible load demand of electric cars and their influence on the electric sector is also a part of the analysis.

Scenario Setup

(1) Base case — No restriction for coal, no e-mobility
(2) GER_Coexit — No Lignite by 2030, no coal by 2040 (in GER)
(3) GER_MoCoexit — Similar to (2) plus E-Mobility : Strong increase after 2030 (in GER)
(4) EU_Coexit — No Lignite by 2030, no coal by 2040 (in EU)
(5) EU_ MoCoexit — Similar to (4) plus E-Mobility : Strong increase after 2030 (in EU)

The analysis of this paper is carried out by using ten year time steps for the years 2020, 2030, 2040 and 2050.

Results

The CO2 emission targets are preferred to be met by a decrease of coal-fired power plants and their operating hours (=reduced CO2 emissions). This is coupled in all cases with a strong increase of renewables. However, the results show an interesting output regarding the interactions between coal-fired power plants and available batteries in the electricity system due to an increasing amount of electric vehicles in the mobility sector. Lower capacities of coal-fired plants and a higher demand require sufficient and long-term planning for other capacities in the system. The model runs will show a detailed quantitative analysis of each technology. Furthermore, the operation of each technology, especially the load and use of batteries, is exploited in the paper. To some extend the spacial resolution of the German energy system is able to highlight some regional effects of energy flows caused by an unequal distribution of new renewable energy capacity in the system. The analysis of this paper is then able to provide recommendations on how and when these phase-outs can be conducted on a German but also on a European level.

Conclusions

The accelerated deployment rate of renewables, but also gas power plants, is quantified to define the needs of the coal-fired phase-out. The flexibility of batteries is a huge advantage which will be added to the system, but comes also along with additional cost.

References

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