

The impact of electrification on the gas sector

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Abstract—The Electrification of fossil fueled applications is considered a promising decarbonization measure. To investigate the impact of increased demand-side electrification in Germany on the European gas market, the gas market model MINGA is extended. First, aggregated load profiles are adjusted to distributed load profiles per sector. Second, a regionalization methodology is determined for each sector, resulting in a gas consumption which is distributed to 38 regions in Germany. In a scenario analysis an electrification scenario and a base scenario for 2030 are compared to show that long-range gas transports significantly increase despite a much lower gas demand in Germany. In particular, the East-West transits from Russia to Western and Southwest Europe are affected. Regarding the resulting gas prices, only minor changes in the marginal costs of gas procurement are visible.

Index Terms—Electrification, Gas sector, Linear gas market modelling, Regionalized gas consumption, sector coupling

I. INTRODUCTION

The gas market is facing challenges under the impact of the energy transition. It is uncertain to what extent the gas infrastructure will be used in the future and whether more renewable gases or hydrogen will be fed into the grid. Regarding the energy system in 2030 a reduction of greenhouse gases of 40 % below 1990 levels is targeted [1].

Substituting fossil fueled applications through electrical end-use application is considered a promising CO₂-emissions reduction possibility. Considering the gas sector on the one hand it could lead to an increase of gas consumption as a consequence of an increased use of gas power stations. On the other hand it may decrease the gas consumption as gas based appliances are exchanged by electrical end-use technologies. The impact of electrification on the electricity sector, in contrast to the gas sector, is widely analyzed [2]. However, the effects of electrification on the gas price and European gas flows using a gas market model is still under-researched and consequently the focus of this research paper.

To analyze the effects of electrification in Germany on the European gas market, the gas market model MINGA (“Market- and Infrastructure model of the Gas sector”) is used (II). In order to divide and regionalize the sector-divided load adaptation, the model is adapted on the

consumer side (III). The impact of an electrification scenario in 2030 with regard to European gas transits and the change in marginal costs are evaluated in IV.

II. GAS MARKET MODEL MINGA

MINGA formulates a mathematical description of the European gas market using linear optimization. In this context, the whole gas sector including all European producers, Liquefied Natural Gas terminals (LNG terminals), storages and consumers are modeled. Furthermore, the coupling between the European balance areas is taken into account as MINGA uses the maximum transmission capacities [3].

The optimization which is executed in MINGA targets the minimization of all arising costs C . The target function (1) therefore includes the costs of natural gas purchased by the main producers, LNG imports, Non-European pipeline imports, as well as transmission and storage fees.

$$\min C = \sum_{r,t,e} x_{r,t,e} * c_{r,t,e} \quad (1)$$

C [€]: Overall system costs
 x [MWh]: Usage of element e in region r for time step t
 c [€/MWh]: Costs of element e in region r for time step t

The gas production costs result from the amount of drilled gas and the corresponding drilling costs. The arising costs concerning the LNG imports and Non-European pipeline imports depend on the amount of imported gas as well as the import costs. Depending on the amount of transported gas and the involved balance areas, entry and exit fees for gas transmissions are charged. Moreover, costs for storage are included in the overall arising costs, with respect to the amount of injections and withdrawals of gas and the given costs for gas storage facilities.

As the target of this research paper is to examine the effects of a German electrification in 2030, future developments of the European gas market need to be implemented in MINGA. Therefore, the extension of the European LNG terminals as well as the extension of the European gas storages up to the current state are included [4], [5]. Moreover, the development of the European gas