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ANALYSIS

The impact of Polish unconventional production on the regional distribution of natural gas supply and transit: A scenario analysis

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ABSTRACT

We use the MEOS model to assess the possible impact of Polish unconventional gas (UNG) production on natural gas flows through the Czech Republic, Hungary, Poland and Slovakia. MEOS is a network flow optimization model designed to solve the minimum-cost flow problem in a network that consists of nodes (production areas, consumption areas, transshipment junctions) and arcs (pipelines). The article postulates and analyzes five distinct scenarios combining various levels of UNG production with different settings of regional infrastructure. The MEOS simulations reveal the critical importance of currently missing cross-border links between the countries. Polish UNG production is therefore likely to trigger new infrastructure projects and foster the ones that are currently under consideration. The biggest changes in natural gas supply can be expected in Slovakia and Hungary, as these markets do not have direct access to German hubs. Similarly, it is reasonable to expect Polish UNG to be traded at the Austrian CEGH hub, which will further catalyze the transformation of the regional market. It is further argued that in addition to sufficient infrastructure, UNG production will require liberalization of the Polish domestic market and a certain degree of integration of regional markets, effectively changing the nature of natural gas trading in the region, which is still dominated by Russian long-term, take-or-pay contracts.

1. Introduction

The advent of unconventional gas (UNG) is nowadays recognized as one of the most important events in the global energy industry of the last decade. The question whether an unconventional gas industry can be formed also outside the North American market first appeared after 2009 when unconventional resources started to influence other continental markets, pushing down prices of natural gas and coal. This article focuses on Poland, a country that has due to her estimated UNG reserves been considered as a future energy superpower, and its fellow Visegrad Four (V4) countries: the Czech Republic, Hungary, and Slovakia. The article does not strive to predict whether the Polish unconventional gas will be produced, instead, it outlines the changes in the regional natural gas flow patterns that the eventual Polish unconventional success might trigger.

In the next chapter we provide a brief overview of the existing research of the natural gas infrastructure, in which we focus on literature that combines the methods of scenario analysis and network flow modeling. In Chapter 3 we introduce our theoretical assumptions. We outline how the natural gas flows are related to the regional market structure and furthermore to the energy security of the respective countries. Building on that, we use the techniques of scenario analysis method (see Chapter 4) to introduce five alternative paths of development (scenarios) of the Polish UNG production and regional market interconnection (Chapter 5). In Chapter 6 we further analyze these scenarios using the MEOS network optimization model. Chapters 7 and 8

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are then dedicated to interpretation of the simulations and conclusions. We further add a Methodology Appendix that contains detailed description of the MEOS model including all data used in the simulations.

2. Literature review

As of 2014, two main streams of literature on unconventional gas can be identified. The first focuses on natural gas market(s) and includes studies that tend to elaborate on the impact of unconventional gas on North American, European, and Asian markets [1—3], the likely development of a robust global LNG market under the new circumstances [4—6], or on Russia, whose market power in Europe has been jeopardized by the unconventional revolution [7—9]. The second stream analyzes the likelihood of replicating the U.S. unconventional gas success outside the North American milieu, building its argumentation mostly on a comparison of geological, legal, technological, or social characteristics of the U.S. and the respective country or region [10—13].

Given the fact that in a network industry, the network topology may greatly influence the way that market is organized and market power is exerted [14—16], it is noteworthy that with the exception of Mariusz Ruszel's brief chapter on possible Polish natural gas exports (Ruszel, 2011, pp. 161—164 [17]), the issue of cross-border infrastructure and its impact on the market structure is largely absent in the debate. In this article we endeavor to fill this gap and interconnect the above-mentioned streams of contemporary unconventional gas-related literature. We argue that infrastructure is of crucial importance for UNG development in Poland as well as for the role it may play in the V4 gas market transformation. (For details, see Chapter 3.)

To achieve that, we combine scenario analysis, a method suitable for highly uncertain environments, with formal modeling techniques. Scenario analysis has been extensively used in energy research carried by universities and think tanks [18,19], international organizations [20—22], national or supranational institutions [23], as well as energy companies [24,25]. Formal modeling is a well-established technique in the research of international transactions involving network-bound transactions such as natural gas trade. Holz (2009, pp. 15—16 [16]) argues that models serve a twofold purpose: first, they are helpful for a company to simulate future demand situations and market outcomes to evaluate its needs for infrastructure in the long run and for supplies in the short, medium, and long run. In a different context, academia and regulators may get a better understanding of the market structure by using numerical models with different market structure assumptions. Gas market models such as the GASTALE model family [26—28], NATGAS [29], or GASMOD [30] have been used extensively in the past decade to evaluate market actors' behavior under the constraints of oligopolistic competition and network interaction (For a brief overview, see Holz 2009, pp 15—35 [16]).

So far, the work closest to what we intend to do is that done by Lochner and Bothe [31], Lochner [32,33], Lochner and Dieckhöner [34], and Dieckhöner et al [35], who use the TIGER model to localize bottlenecks in the European gas grid or simulate supply cut-offs. However, as a high granularity model, TIGER is especially useful in situations where only a few factors vary (as is the case of Lochner and Bothe [31]). In a high-uncertainty environment, low-granularity models such as MEOS is more suitable due to their lower sensitivity to variations of the input factors. This especially holds in the case of our research as we are interested in general trends rather than concrete predictions (For more details see Chapter 4 and the Methodology Appendix.).

3. Theoretical assumptions

The research is meta-theoretically grounded in rational choice theory. Rationality is defined as a choice of action that results into the most preferred outcome [36]. An agent is defined as an entity capable of choice that abstracts from normative considerations and faces a fixed and known set of choices. These conditions are given and are not subjected to rational calculation (Kydd 2008 [37], pp. 425—426, Simon 1955, p. 100 [38]).

With regards to the policies pursued by the agents, we argue in accordance with Adelman [39], Yergin [40], Noël [41], De Jong and van der Linde [42], and Nordhaus [43,44], that the very basis of international energy transactions is trade, i.e. mutually beneficial exchange that can be expressed in money. However, operating in a network industry such as the natural gas trade, the actor's business strategy may differ from strategies pursued in network-free markets [14—16]. In Černoch et al. [45] we used this line of reasoning to provide an alternative explanation of the Russian foreign energy policy vis-à-vis Central and Eastern Europe to the currently prevailing geopolitical ones. We argue that the current setting of the regional gas market (i.e. limited interconnection, limited sources of supply, netback pricing system, long-term rigid take-or-pay contracts, and destination clauses) primarily serves Russia in achieving the highest possible margins. Conveniently enough, the dominant market position that results from this setting also enables Russia to exert the highest amount of political influence on the respective countries. Hence, we do not see natural gas purely as a political tool and, contrary to the geopolitical explanations, we argue that the Russian foreign energy policy towards the region is largely determined by the pursuit of market power that is followed by both extraordinary margins (monopoly profit) and political influence. Importantly, there is an inherent positive feedback mechanism in such policy as the dominant market power amplifies the political influence that is in turn used to maintain or increase the market power.

Having in mind the most frequent definition of energy security, which is "availability of sufficient supplies at affordable prices" (for example Ref. [40]), we see that such market setting neither enhances the availability of supply nor the affordability of the commodity. We therefore assume that this vicious circle can only be broken by a combination of market liberalization, interconnection, and elimination of the netback pricing in favor of gas-to-gas competition, i.e. by supporting the availability of (alternative) supplies and pushing the prices down at the same time. In this context, Polish UNG can indeed become a major factor in such market transformation.

4. Methodology

4.1. Research background

The research is exploratory-oriented. Since our focus is on the V4 countries, the level of analysis is regional; the unit of analysis is the supply network as defined below and in the Methodology Appendix. Our aim is to describe actors' plausible actions depending on different future levels of UNG production and different infrastructural settings. This brings us to the central research question:

How can the development of UNG in Poland affect regional natural gas flows?

The core of the research design therefore consists of the following: the driving factors of the UNG production and the development of the regional infrastructure, and the response factor of natural gas flows distribution in the network.

Clearly, at this point it is not possible to estimate either the future UNG production levels or the shape of the infrastructure, as both will be determined by a myriad of largely unpredictable variables. In such situations, scenario analysis is an appropriate tool to be applied (Dermawan et al., 2012, p. 763 [46]). In accordance with Kahn [47] and Peterson et al. [48], we perceive a sharp distinction between prediction, projection, forecast, and scenario. Although a scenario may encompass features of the others, it is not a mere prediction or projection. Not using (only) probabilistic tools is one of the key features of