STEPS centre

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Destabilisation of Sustainable Energy Transformations: Analysing Natural Gas Lock-in in the case of Germany

Louise Michelle Fitzgerald, Isabell Braunger and Hanna Brauers

STEPS centre

About the STEPS Centre

The ESRC STEPS (Social, Technological and Environmental Pathways to Sustainability) Centre carries out interdisciplinary global research uniting development studies with science and technology studies.

Our pathways approach links theory, research methods and practice to highlight and open up the politics of sustainability. We focus on complex challenges like climate change, food systems, urbanisation and technology in which society and ecologies are entangled. Our work explores how to better understand these challenges and appreciate the range of potential responses to them.

The STEPS Centre is hosted in the UK by the Institute of Development Studies and the Science Policy Research Unit (SPRU) at the University of Sussex. Our main funding is from the UK's Economic and Social Research Council.

We work as part of a Global Consortium with hubs in Africa, China, Europe, Latin America, North America and South Asia. Our research projects, in many countries, engage with local problems and link them to wider concerns.

Website: **steps-centre.org**

Twitter: **@stepscentre**

For more STEPS publications visit:
steps-centre.org/publications

This is one of a series of Working Papers from the STEPS Centre

ISBN: 978-1-78118-547-6

IDS Institute of Development Studies

US UNIVERSITY OF SUSSEX | BUSINESS SCHOOL | SCIENCE POLICY RESEARCH UNIT

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Destabilisation of Sustainable Energy Transformations: Analysing Natural Gas Lock-in in the case of Germany

Louise Michelle Fitzgerald, Isabell Braunger and Hanna Brauers

STEPS Working Paper 106

Correct citation: Fitzgerald *et al.* (2019) *Destabilisation of Sustainable Energy Transformations: Analysing Natural Gas Lock-in in the case of Germany*, STEPS Working Paper 106, Brighton: STEPS Centre

ISBN: 978-1-78118-547-6

Funding: Isabell Braunger and Hanna Brauers gratefully acknowledge support granted from the German Ministry of Education and Research (BMBF) by financing the research group “CoalExit” [grant number 01LN1704A] as part of the “Global Change” funding priority and the project “Future of Fossil Fuels in the Wake of Greenhouse Gas Neutrality” [grant number 01LA1810A] being part of the “Economics of Climate Change” funding priority.

For further information please contact: STEPS Centre, University of Sussex, Brighton BN1 9RE

Tel: +44 (0) 1273915673; Email: steps-centre@ids.ac.uk; web: www.steps-centre.org

Contents

Abstract

In recent years, natural gas has seen increased support in the context of climate change mitigation. Described as a 'bridge fuel' it is seen as aiding in the low-carbon energy transformation process. This is puzzling, given the high global warming potential of natural gas, which is composed almost entirely of the greenhouse gas methane. In this paper, we seek to explain the factors underpinning the political processes surrounding natural gas support, despite its unsuitability for climate mitigation. Drawing guidance from the pathways approach, and drawing on the broader institutional and regime literature, we analyse the role of actors and their networks, interests and politics as well as discourses and narratives. Our central claim is that support for natural gas is a result of institutional and incumbency lock-in, and has resulted from strategies that incumbent fossil fuel actors have deployed to secure their interests in the context of decarbonisation. We focus on liquefied natural gas (LNG) infrastructure in Germany, a representative case study for understanding the dynamics of natural gas support. The paper concludes by highlighting further avenues of research. In particular, we note specific misperceptions that need to be more openly contested in the discourse surrounding natural gas, in order to address the issue of natural gas lock-in.

Keywords: Lock-in mechanisms, pathways approach, politics of knowledge, discourses, actor networks, energy transitions, LNG, fossil gas, climate mitigation

1 Introduction

Natural gas is being discussed as a 'bridge fuel' and 'transition fuel' in the light of increasing moves to restrict greenhouse gas (GHG) emissions to mitigate climate change (Mac Kinnon *et al.* 2018; Neumann and Hirschhausen 2015), promoted especially by the natural gas industry (Goldthau *et al.* 2018). Natural gas is used across the globe in the energy sector, including in electricity, heating, transport and directly in industry. In Germany, the home of the historic *Energiewende* (low-carbon energy transformation) (Hirschhausen *et al.* 2018), increased political support can be observed for natural gas projects, including in technologies such as liquefied natural gas (LNG). This is puzzling, as across its full life cycle[1], natural gas still emits substantial amounts of GHG and also other pollutants, with a significant degree of uncertainty about the exact extent (Alvarez *et al.* 2018) and there is evidence that methane concentration in the atmosphere has increased rapidly since 2007 (Nisbet *et al.* 2019).

Natural gas is composed almost entirely of methane. Methane is a GHG with a global warming potential 84 times more potent than CO_2 over a 20-year time period and 28 times over a 100-year period (IPCC 2014: 87). Analyses show that the potential of natural gas for absolute GHG emission reductions is at best small in the short-term and at worst actually increasing emissions (McGlade *et al.* 2018; Howarth 2015; Howarth 2014; Anderson and Broderick 2017; Mac Kinnon *et al.* 2018; Alvarez *et al.* 2018; Davis and Shearer 2014). Nevertheless, significant new natural gas investments in pipelines, LNG terminals, power plants or for the transport sector are planned worldwide, leading to a further lock-in of fossil fuels. Discussions about extending gas consumption, in particular, centre on switching from coal to natural gas in the power sector. However, even this can lead to additional greenhouse gas emissions (Howarth 2014; Howarth 2015) and carbon infrastructure lock-in effects (Wilson and Staffell 2018). An additional issue in related discussions and analyses is the assumption of future availability of carbon capture, transport and storage technology (CCTS, also known as CCS).

This latter systematic tendency to assume a technology that does not yet exist, strengthens the policy bias in favour of natural (fossil) gas. Much modelling of the costs for CCTS in decarbonisation scenarios for the European Union (EU) and globally are set erroneously low, such that models show this technology to begin use in 2020 on economic grounds alone (Mendelevitch *et al.* 2018). But this is not plausible either in any EU member state, nor worldwide. In the absence of additional climate policies regulating GHG emissions, many analyses show that this kind of reliance on natural gas could delay rather than accelerate decarbonisation efforts (Davis and Shearer 2014; Zhang *et al.* 2014). These studies have already shown that natural gas expansion plans would exacerbate negative climate impacts instead of mitigating climate change. Nevertheless, the trend towards natural gas is becoming ever more entrenched in many countries, with increasingly positive appraisals of and investments in new natural gas infrastructure.

Our contribution is to analytically unpack the emerging dominant pathway of natural gas being framed as a decarbonisation approach. We show that the narratives surrounding natural gas in Germany are a politically and socially constructed outcome representing particular interests, not a physical reality necessary to combat climate change. Drawing on institutionalist approaches, and in particular work on lock-in mechanisms, we argue that support for gas has resulted from lock-in dynamics, and in particular strategies of incumbent energy players to protect their vested interests.

Drawing conceptual guidance from the pathways approach (Leach *et al.* 2007), our theoretical approach also appreciates actors and networks, politics and interests as well as discourses and narratives, in

[1] Life cycle stages and related infrastructures that need to be included in an assessment are pre-production, natural gas production, transmission, distribution, storage, and well production end-of-life (Mac Kinnon *et al.* 2018).

explaining the policy processes surrounding natural gas in Germany. In particular, it focuses attention on investments in LNG terminals, which provide a useful example for analysing the dynamics underpinning expansion of gas dependency within the German case. The surrounding narrative of natural gas as a 'bridge' or 'transition' fuel can limit wider debates about other possible roles that it might actually play (Stephenson *et al.* 2012). This is especially relevant in considering carbon budget constraints under the Paris Agreement.

As it currently stands, there is little attention on issues of natural gas lock-in and expansion, either within social science research or in commentaries from civil society.[2] With this paper, we aim to contribute to addressing this gap. Given that this paper is the first of its kind in focusing on natural gas support in Germany, its central contribution lies in providing an overview of the key dynamics underpinning the policy processes of natural gas in Germany. The policy relevance is high due to the potential long-term impacts of a lock-in to natural gas and related negative climate impacts (Anderson and Broderick 2017). In particular, we focus on the mismatch between the implications of climate science on natural gas and the scale of German infrastructural developments in this sector. By interrogating the vested interests involved in this case and further processes of lock-in around the industrial fossil fuel complex, we hope to provide critical data for understanding and contesting this emerging energy pathway.

As for academic relevance, we hope to contribute to the broader literature concerning the factors that support and inhibit energy transitions (Araújo 2014; Geels *et al.* 2016*;* Turnheim *et al.* 2015*;* Markard *et al.* 2012; Grubler 2012). In particular, we note that as coalitions and relations between state institutions and incumbents inhibit radical transitions they deserve special attention (Johnstone and Newell 2018; see also Stirling (2018) for an approach to analyse incumbency). As such, we focus on the lock-in effects of incumbent regimes, the material and political dimensions of this, and what this can mean for renewable energy transitions. In this regard, Germany, given its progress in transitioning to renewables and away from fossil and nuclear sources of energy, provides an interesting case for examining dynamics of incumbent energy corporations, their relationships with the state, and strategies they employ to stabilise existing regimes and protect their interests. With this paper, we look at the incumbency of natural gas, related actors and their relationship with policymakers and how this influences natural gas investments.

To understand the discussion of natural gas in Germany, some background on the specifics of natural gas markets is necessary. Important for energy questions is especially the 'nexus' between markets, security and climate change (Kuzemko *et al.* 2018). As natural gas trade often takes place outside of the public sphere, discrepancies occur between statements of public officials and market realities. Germany, and in fact most of the European Union, is increasingly dependent on imported pipeline gas as well as LNG. Germany's natural gas supply comes mostly from Russia, Norway and the Netherlands, but also Algeria and the Caspian region (IEA 2018).

The rest of the paper is structured as follows: Section 2 outlines the theoretical framework employed, and notes the central factors posited to underpin policy processes. Section 3 is the case study, with the analysis of the proposed locations for the construction of LNG terminals in Germany, and the actors involved in each instance. The paper then turns to the discussion of these cases in Section 4, with reference to our theoretical claims, finding evidence that the support for natural gas results from lock-in dynamics. Finally, the paper concludes by noting further avenues of research.

[2] For exceptions, please see: Anderson and Broderick (2017), Oil Change International (2016), Trout *et al*. (2017), Stockman *et al.* (2018), Physicians for social responsibility (2017), initiatives by the German Nature Conservation Ring (DNR 2018), CAN Europe or Friends of the Earth (Friends of the Earth Europe 2017), and Food and Water Europe (food&water europe 2016).

2 Theoretical Background and Methodology

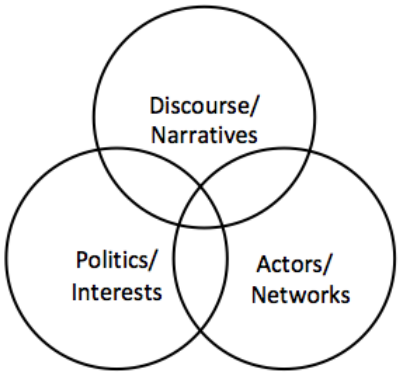
Our theoretical framework takes guidance from Keeley and Scoones' (2003) synthesis, pointing out in contrast with conventional views, that policy processes are not linear, but rather messy and contested. In the following, the four central elements of the framework are discussed.

2.1 The Institutional and Regime Dimension

Broader institutionalist theories highlight how institutional dynamics lead to particular outcomes. In particular, the framework by Keeley and Scoones (2003) notes that given path dependency, there are strong incentives to stay on the existing trajectory. In this case, solutions that favour the status quo of the existing fossil fuel regime will be preferred. Existing regimes can provide formidable barriers for low-carbon transitions, and in particular incumbent actors can resist, delay or derail low-carbon transitions (Geels 2018). It is argued that the different elements of such a complex system – the material, organisational and conceptual dimensions of the system (Sandén and Hillman 2011) – are aligned with each other and as such the existing sociotechnical system has a stabilising influence on innovation dynamics and technological change and prevents the introduction of radically new technological trajectories (Klitkou *et al*. 2015). The central mechanism of this is lock-in effects, conceptualised as mechanisms which reinforce a certain pathway of economic, technological, industrial and institutional development and can lead to path-dependency (*ibid*.). Lock-in refers to infrastructures, but also more generally to the integration into the economy and, hence, the prevention of deeper social change away from fossil fuels (Castán Broto 2018).

Keeley and Scoones argue that policy processes can be explained by looking at discourses and narratives, politics and interests, as well as actors and the networks within which they are located. To a greater or lesser extent, understanding policy processes therefore comes as a result of looking at all three together – at the intersection of the three overlapping perspectives ((IDS 2006), see Figure 2.1).

Figure 2.1: Main Factors Influencing Policy Processes



Source: Keeley and Scoones 2003

Noting however that this framework is best understood as a selection of prompts to ask useful questions of policy (IDS 2006), we also draw on broader and complementary interdisciplinary perspectives such as insights from neo-institutional theories – in particular the concept of path dependency, including infrastructural path dependency. These perspectives are weaved through the discussions of each of the three lenses, and are addressed in a concluding section. In this way, we can further the understanding of the interplay of very material politics, but also a politics of knowledge (Scoones *et al.* 2015: 5).

2.2 Discourses and Narratives

Policy discourse can be considered causally significant in shaping policy change. Discourse can be defined as 'a specific ensemble of ideas, concepts, and categorisations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities' (Hajer 1995 as cited in Keeley and Scoones 2003: 37). The concepts that are part of environmental discourse (the 'knowledge') are intertwined with practices, institutional capacities and technologies, or form part of this (Feindt and Oels 2005: 163). Important to understand is that fundamentally, discourses are frames that define the world in certain ways; in the process, they exclude alternative interpretations (Schram 1993; Apthorpe and Gasper 1996; and Grillo and Stirrat 1997 as cited in Keeley and Scoones 2003: 37). These combine to form 'policy narratives,' which provide both a diagnosis and a set of measures and interventions (IDS 2006: 10). They define a problem, explain how it comes about and show what needs to be done to avert disaster or bring about a happy ending (Leach *et al.* 2010: 130).

Often particularly simple narratives gain traction, due to the way in which they simplify complex issues in a way appealing to politicians (IDS 2006: 10). Most fundamentally, we focus on how such narratives become adopted as 'truth' because of social processes, rather than because of a realist belief that such narratives reflect biophysical reality as uncovered by science (Forsyth 2003: 96). This then is about politics around knowledge production in debates about green transformations, turning both on what we think we know (consensus and uncertainties) and on who knows it (whose knowledge counts) (Scoones *et al.* 2015: 4). The narratives become embedded in particular institutional structures, bureaucracies or actor-network groups (IDS 2006: 11). This then, takes on its own path dependency, in which norms of behaviour and understandings are locked-in.

2.3 Actors and Networks

Actors and the networks within which they organise are significant in accounting for policy change and development. Actors are characterised by specific capabilities, specific perceptions and specific preferences (Scharpf 1997). Networks, coalitions and alliances of actors (individuals or institutions) with a shared vision – similar belief systems, codes of conduct and established patterns of behaviour – are important in spreading and maintaining narratives through chains of persuasion and influence such as journals, conferences, education or informal introductions (IDS 2006: 11). We must ask which scientists or other stakeholders, which forms of expertise, from the official to the informal, which disciplines and which regions have most voice in the construction of knowledge about the predicaments that underpin calls for green transformations (Scoones *et al.* 2015: 4).

The actor networks that coalesce around such large-scale, technology-led solutions revolve around scientists-engineers and associated research funders whose commitment to technological solutions is paramount (Schmitz and Scoones 2015: 19). Through these networks 'norms of good and bad practice are reinforced, research agendas are set, and orthodoxies or conventional wisdoms are reiterated and, very often, dissenting opinions or unconventional views are suppressed' (IDS 2006: 11). Actor networks are not exclusively confined to state institutions, rather they link up parts of the bureaucracy and government with the private sector, donors and actors in civil society – such as journalists, researchers and non-governmental organisations (NGOs) (Leach *et al*. 2010: 131). The strategies that such actors pursue, and how stakeholder groups interact and behave within the constraints of a particular institutional design, are of particular interest.

2.4 Politics and Interests

In understanding policy process, it is also important to note that the political context is moulded by the interests of particular regime authorities to remain in power (IDS 2006). In the case of decarbonisation, this can be seen in fossil fuel players as seeking to stabilise the fossil fuel regime. Within all policymaking there exist power dynamics and inequalities. Politics and power are important to how pathways are

shaped, which pathways win out and why, and who benefits from them (Scoones *et al.* 2015: 3). Understanding the impact of this politics of interests involves analysing how such positions are asserted, commercial-political interests are deployed, and alliances for or against change are formed (Scoones 2016: 295). In the case of the shift to support gas infrastructure in Germany, the key factor to analyse then is the vested interests at play: who stands to gain, and how and in what ways they sought to influence policy in line with their interests – and to what extent this is then reflected in policy decisions – are crucial lines of inquiry. In the case of fossil fuels, which also have a material structure, the dynamics of the built environmental are also significant. When infrastructures, incentives and interests combine they can be difficult to shift (Schmitz and Scoones 2015). Powerful, incumbent forces and historical lock-ins of political, commercial or technical interests mean that in some settings transformations are especially challenging (Scoones 2016: 301). These cumulative influences affect each stage of the process, from agenda setting, to the identification of alternatives, weighing up the options, choosing the most favourable and implementing it (IDS 2006: 13).

The frames of Keeley and Scoones help give guidance on what elements mediate the impacts of lock-in dynamics. They enable us to analyse the development of dominant pathways and the processes by which technologies that are incompatible with the dominant technological regime are locked out (Klitkou *et al.* 2015). As such we focus on the role of lock-in, not only how incumbent regimes block, but also the strategies they employ towards solutions that favour regime stabilisation.

Centrally we argue that the shift of support for natural gas is a case of lock-in, explained by strategising of traditional incumbents in reaction to destabilisation of their related dominant market position in the context of climate mitigation. Drawing on the pathways approach and the conceptual guidance provided, we examine actors and their networks, narratives and discourses, as well as politics and interests. We conducted a first basic literature review mostly based on primary data in German and English provided by corporations, network operators, politicians and so on, as well as on secondary literature consisting of peer reviewed journals. In the following step we identified the relevant actors involved. Subsequently, we clustered them in consistent actor groups and researched in a more in-depth analysis the most relevant stakeholders of these groups. In that step we identified their interests, narratives used and their linkages.

3 Case Study: LNG Terminals in Germany

LNG terminals mainly enable imports to countries where pipeline deliveries are not feasible.[3] The utilisation of LNG has increased strongly since the first delivery between Algeria and the United Kingdom in 1964 (Rüster 2010). Despite the availability for more than 50 years and first discussions about an import terminal in Germany in the 1970s, no investment decision for an LNG import terminal was ever taken. LNG itself can either be used directly, or regasified and used in pipelines. On an EU-wide level, the utilisation rate of existing LNG infrastructure was less than 25 per cent in 2017 (ACER and CEER 2018).

Despite these large overcapacities, a shift in political support for LNG terminals can be observed, with regional, federal and state governments pledging both political and financial support to the projects (see section 3.2.3). As of January 2019, there were three potential locations for large-scale LNG terminals in Germany, all in the north of the country: Brunsbüttel, (Schleswig-Holstein) Wilhelmshaven and Stade (both located in Lower Saxony). The three cities are now in a race to secure themselves as the location of the first terminal in Germany (Wieschemeyer 2018).

[3] Natural gas is liquefied and then transported on a ship to an import terminal.

With our choice of the LNG terminals as a case study, we focus this analysis on the pro-gas pathway, as it is currently dominant in public and political discourse. We ground this paper in the fact that this dominance cannot be attributed to a need to expand gas infrastructure. Studies show that the phase-out of coal and gas in Germany in combination with further expansion of renewable energy infrastructure and storage capacity is possible until 2030 (Oei *et al.* 2019).

3.1 LNG Terminal Investments

3.1.1 Wilhelmshaven

Since the 1970s, Wilhelmshaven has been under consideration as a potential location for an LNG terminal in Germany. Although there was repeated interest in the project, it has not been realised so far. In 2018, the leading partners in Wilhelmshaven were still having difficulties finding potential investors, despite the support of the regional government.

Since 1972, Deutsche Flüssiggas Terminal GmbH has been planning the construction and operation of an LNG terminal in Wilhelmshaven. The company owns suitable land as well as the needed rights of use for an existing jetty (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr 2017). The corporation is 90 per cent owned by Uniper. The company sees itself more as a purchaser and reseller of LNG in Wilhelmshaven than as an investor. The leading partners of the project are: Nord-West Ölleitung GmbH (NWO), HES Wilhelmshaven GmbH, Deutsche Flüssigerdgas Terminal, and Uniper (BMWi 2018). NWO is a service provider for oil transit and aims to diversify and secure its core business, which is mainly the import of crude oil for the refinement plants owned by their shareholders (Abeldt 2018). HES Wilhelmshaven is Germany's largest independent liquid bulk terminal, for products such as crude oil and liquefied petroleum gas.

Wilhemshaven is already connected to the gas transmission grid as well as to storage capacities, and approval procedures for the construction of an LNG terminal have already been completed (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr 2015). The deep-water port allows the landing of large LNG tankers. The potential size of the terminal ranges between 10 and 14 billion cubic metres (bcm) and could go into operation in 2022 (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr 2018; Wadewitz 2018).

The latest construction cost estimate for a shore-side supply-strategic LNG import terminal is, according to Deutsche Flüssiggas Terminal, approximately €1.5bn; whereas the construction of a Floating Storage and Regasification Unit (FSRU) would be less expensive according to NWO, i.e. around €130m.[4] Additional to this is the cost of providing the FSRU, which can cost tens of millions of euros (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr 2015). For the FSRU option, Wilhelmshaven attracted the Japanese shipping company Mitsui O.S.K. Lines as an investor (Wadewitz 2018). The shipping company is one of the largest worldwide. Additionally, the location hopes for investments from Qatar, the world's largest producer of LNG (Maksimenko 2018b).

3.1.2 Stade

Since the beginning of 2018, Stade has been under consideration for building an LNG terminal. Dow Germany and LNG Stade GmbH are the two project partners involved. Dow Germany is part of the American company The Dow Chemical Company and claims to consume with its chemical parks about 1 per cent of total German electricity production, making it one of the country's largest energy consumers.

The Australian investor Macquarie has already signed a letter of intent to finance the terminal. Macquarie is part of the Macquarie Group, a financial services company and one of the world's largest

[4] €100m for the docking station and €30m for the gas grid connection.

asset managers and investors for infrastructure projects. The Chinese group China Harbour Engineering Construction is also part of the shareholder group and is examining the takeover of construction work. However, the final investment decision requires outstanding internal and external audits (Maksimenko 2018a).

The LNG terminal is planned with an annual capacity of approximately 4 bcm, which can be expanded to up to 12 bcm. For the first stage, €400m to €500m in costs are estimated (Handelsblatt 2018). Dow already has the necessary pipelines to feed natural gas into the German grid and could supply waste heat for regasification (NDR1 Niedersachsen 2018a). The proximity to Hamburg is also seen as a location advantage. According to the project partners, they already have two customers for the LNG: The resident company Aluminium Oxide Stade GmbH (AOS) and Uniper (NDR1 Niedersachsen 2018b). The Dow Group receives political support from the Trump administration (NDR1 Niedersachsen 2018a) for the project.[5]

3.1.3 Brunsbüttel

In the case of Brunsbüttel, the project coordinator German LNG Terminal GmbH is responsible for the project. Shareholders of German LNG Terminal are the two Dutch firms, Gasunie LNG Holding B.V. and Vopak LNG holding B.V., as well as Oiltanking GmbH, which belongs to the Mabanaft Group. Mabanaft Group is the trading division of Hamburg-based Marquard & Bahls AG and specialises in oil trading, but the company is also involved in liquid gas trading. Gasunie is a gas infrastructure company working in the Netherlands and northern Germany. Vopak is a liquid fuel terminal operator, which also owns LNG regasification terminals in the Netherlands and Mexico.

According to German LNG Terminal, the terminal in Brunsbüttel should be completed in 2023 and have an annual capacity of 5 bcm. Seven bcm of feed-in capacity have already been registered (Lycklama à Nijeholt 2018). RWE AG signed an agreement guarantying the corporation access to a 'substantial share of the prospective terminal's annual capacity' (RWE Supply & Trading GmbH 2018). RWE is one of the biggest energy utilities in Germany.

An application for exemption from network access and charges regulation pursuant to Section 28a Energiewirtschaftsgesetz (energy industry law)has already been submitted for Brunsbüttel (Bundesnetzagentur 2018).[6] In addition, Brunsbüttel is the only one of the three locations which has been included in the Network Development Plan Gas 2018-2028 of the Federal Network Agency (FNA), Germany's energy regulator. In 2018, an application was submitted to the Federal Ministry of Transport under the Mobility and Fuels Strategy (MFS) of the Federal Government. An application for GRW[7] funding is yet to be made (Lycklama à Nijeholt 2018).

3.1.4 Small-scale Terminals

Additionally, there are several smaller-scale LNG terminals planned: one in Rostock, also as an import terminal, and two pilot inland LNG terminals to be constructed by June 2021 (ten are planned in total so far). The EU funds the inland projects under the Connecting Europe Facility (CEF) with '[t]he overall objective […] to promote the use of Liquefied Natural Gas (LNG) as fuel for inland navigation and road

[5] At the official handover of a funding application for the project to the Federal Ministry of Economics, the US Ambassador Richard A. Grenell was present (Penz 2018).

[6] New infrastructure investments can, subject to defined conditions, be exempted from existing regulatory provisions for a limited period of time.

[7] The GWR (community task to improve the regional economic structure) funding pool serves to improve the economy in structurally weak regions. 'Business enterprises and the tourism industry are entitled to apply for investment projects that are particularly worthy of economic support, as well as municipalities, municipal associations and other entities that pursue tax-privileged purposes or are not geared to generating profit, in the case of economic infrastructure measures' (BMWi. 2018b; GRW 2018).

freight transport'. The construction in Duisburg (on the Rhine) started in August 2017. The company responsible, LIQUIND 24/7 GmbH, received €3.3m to build ten LNG fuelling stations. LIQUIND wants to start an LNG distribution network, consisting of distribution terminals and gas stations for heavy-duty trucks and inland waterway vessels (LIQUIND 2018). While this infrastructure is already advanced in other EU countries, it is new for Germany.

3.2 Findings

In the following sections, we analyse actors related to the above-mentioned LNG projects and natural gas infrastructure more generally, not claiming that the following illustration of actors is complete. However, it is a broad overview to gain an understanding of the complexities, and also of the joint underlying interests and discourses. We structure the following section by actor groups and discuss in each subsection their related discourses and interests.

One can see science as an additional actor group in the context of fossil gas. However, the scientific community cannot be considered as a homogenous actor group, with consistent interests and narratives, and for that reason cannot be grasped in our analytical framework. In general, an increase in publications on fossil gas can be observed which range from phase-out to an increase in natural gas support, varying across institutions and also countries.

3.2.1 Suppliers

The main supplier for natural gas in Germany is Russia. According to estimates by the International Energy Agency (IEA), in 2017 Germany imported 72 bcm (60 per cent) from Russia, 13 bcm (11 per cent) from Norway and 34 bcm (29 per cent) from other countries (IEA 2018).[8] The historic dependence on Russia for natural gas deliveries, and especially conflicts over supply disruptions since 2006, have led to aims to reduce import dependence on Russia, to increase supply diversification and, in general, energy security debates (Richter and Holz 2015; Neumann *et al.* 2018).

Dutch natural gas supply reductions further increased fears of a dependency on Russian gas (Holz *et al.* 2017). While natural gas has until now been delivered entirely via pipelines, an import LNG terminal would open the German market for new suppliers, especially from Australia and Qatar, the USA, but also Africa and South America (Office of the Chief Economist 2018).

Most visible in the debate has been the USA, openly pushing the EU, but also Germany (as a major consumer and transit country) more specifically, to commit to buying US natural gas (European Commission 2018b). The USA is increasing its efforts to enter the European gas market (Goldthau *et al.* 2018), as Europe would be one of the important markets for the USA's intention to become one of the largest LNG exporters. Conflicts have arisen especially regarding the plan to build a new pipeline between Russia and Germany (Nord Stream 2), giving Russia even greater access to the EU natural gas market (Neumann *et al.* 2018). Geopolitical tensions between the USA and Russia also play an important role in decisions on natural gas contracts and new infrastructure projects.

Australian and Qatari investors and supplier firms (Australian Macquarie Group and Qatar Petroleum) are involved in the proposals for German LNG terminals. Relevant in this context is that Qatar exited the Organisation of the Petroleum Exporting Countries (OPEC) in November 2018, enabling the country to increase natural gas and oil production. It is already the biggest LNG supplier to the EU. The main contributing factor to the growth in Australian emissions has been LNG dedicated for exports, with an expected growth of 200 per cent between 2015 and 2020 (Climate Analytics 2018).

These suppliers consist of complex networks of different private and state actors, with diverse interests and power. For this analysis, however, it is sufficient to note that there are a range of LNG suppliers

[8] 35 bcm were re-exported to other countries.

with an interest in entering the German (and EU) market, and on the other hand pipeline gas suppliers which have an interest in keeping their market share and high natural gas prices. Especially in the case of the USA and Russia, conflicts run a lot deeper than just natural gas contracts and related revenues. Related discourses repeated in media articles are mainly about *supply security, cheaper gas prices* and *supply diversification*.

3.2.2 Demand for Natural Gas

The current demand for natural gas is dominated by the residential and commercial sector for direct natural gas consumption (especially for heating), the electricity sector and industry (especially the chemical industry but also, for example, for steel production) (IEA 2018). Another sector that is currently being discussed as a potential major consumer is the transport sector, mainly for shipping (inland and overseas) and heavy-duty trucks (BMVI 2016).

Related relevant actors with an interest in LNG are therefore energy utilities, energy-intensive corporations and chemical industry producers, the shipping industry, harbours, as well as heavy-duty trucks and related logistic companies.

Utilities need to contract natural gas for electricity generation with their gas-fired power plants. RWE and Uniper, for example, have announced they are going to buy capacity at LNG terminals. Dow is the equivalent example of a chemical company trying to secure favourable natural gas contracts, but also being directly involved in the construction of the LNG terminal.

The first LNG gas station used for trucks was opened in September 2018 in Hamburg, operated by Shell (German Foreign Policy 2018). It is supported by the LNG Task Force founded by, amongst others, the German Energy Agency (DENA) under the patronage of the Federal Ministry of Transport (BMVI) as a 'cross-sectoral initiative for low-emission mobility' (DENA 2018). The potential demand growth of the transportation sector, especially due to tighter emission regulations, is used as an argument for LNG investments for the shipping and road industry (see, for example, the International Maritime Organization (IMO) or the German Energy Agency). For shipping, tighter emission regulations on sulphur by the IMO will restrict the use of current fuels, mainly heavy oil, from 2020 onwards (Parkin and Shiryaevskaya 2018).

The transport industry is well connected with other energy-intensive industries, fuel sellers and gas station operators, and related lobby institutions (for more on these networks and their influence see Section 3.2.6). For trucks and personal vehicles, there is also a push for natural-gas-powered automobiles, with the narrative of gas being the environmentally friendly alternative (Zukunft Erdgas e.V. 2018a).

The discourse pushed for by the corporations and associations involved in natural gas circles is again around LNG being 'environmentally friendly' and 'green'. The underlying interests lie in the potential monetary gains or losses in new investments and the competitiveness of the affected industries. LNG-fuelled ships are much costlier than conventional ships today (Saul and Chestney 2018). If LNG ships are to advance not only will shipping companies need to invest in new ships or reconstruction, but a fuel station system will also need to be developed again leading to substantial lock-in effects once the investments have been made. However, LNG is the option for emission reductions that is most aligned to the old system and configurations, and therefore includes most players of the existing networks (gas stations, turbines, suppliers (which trade with both oil and gas) and so on).

3.2.3 State Actors

Germany's energy policy must be viewed in the light of the European Union. Since the 1980s, there has been a growing effort to create a joint European energy market. The integration of the gas market and the encouragement of private investments play an important role. Gas is seen as a key energy source for the EU in the coming decades. The narratives for the use of LNG are based in particular on energy security as well as competitiveness, and compliance with the EU's sustainability objectives (European Commission 2016a). LNG infrastructure expansion is portrayed as necessary to ensure that all Member States have access to gas markets (*ibid.*). In particular, regions in South East Europe, Central Eastern Europe and the Baltic States are considered for financial support in order to expand their infrastructure.

According to the EU, these countries do not have access to LNG and/or are heavily dependent on a single gas supplier and would therefore be hit the hardest in case of a supply crisis. The EU, however, already has a considerable LNG import capacity – sufficient to cover around 43 per cent of its current gas demand (as of 2015) (European Commission 2016b). The Commission's narrative, to justify the expansion and, in particular, the subsidisation of infrastructure, is that LNG terminals are not optimally distributed across the EU. According to the Commission, this is one of the contributing factors to the vulnerability of certain Member States' energy security.

In total, subsidies amounting to €638m were paid or committed for LNG infrastructure projects between 2013 and 2018 (European Commission 2018a). Geopolitical interests also play an important role at EU and national level for the political and financial support of the construction of a German LNG terminal.

With regard to the need for an LNG terminal in Germany, federal and state governments have changed their position considerably in recent months. Still in 2017, according to the Federal Ministry of Economic Affairs and Energy, an own LNG terminal was not considered to be in Germany's interest. Access to LNG via neighbouring states such as Belgium (Zeebrugge), the Netherlands (Rotterdam), and Poland (Świnoujście), or other European countries, was seen as sufficient (BMWi 2017). Then in 2018, Peter Altmaier, Federal Minister of Economic Affairs and Energy welcomed the construction of several terminals and the construction of an LNG terminal was included in the latest party coalition agreement (CDU, CSU und SPD 2018).

In 2015, Lower Saxony's government argued that the installed pipeline infrastructure was sufficient and that LNG was not economically viable (Niedersächsischer Landtag 2015). However, in 2017, the construction of an LNG terminal on the North Sea coast was part of the coalition agreement of the state government. Here, the narrative was that LNG could take over a systemic function within the German gas supply. In addition, positive economic and labour market relevant effects were expected. Lower Saxony aims to encourage the federal government to participate in the financing for strategic reasons (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr 2017). In Schleswig-Holstein, the state government is also strongly committed to the construction of a terminal and considers the project 'top priority'.[9] The coalition agreement of the Conservative, Liberal and Green government also states that it will ensure that the LNG terminal in Brunsbüttel is promoted.

According to the law on electricity and gas supply (EnWG §15a Abs.1), the Transmission System Operators (TSOs) have to draw up a joint Germany-wide Network Development Plan (NDP) every two years. The NDP is based on a scenario framework which the private operators of transmission networks submit to the Federal Network Agency in the previous year and which the latter needs to confirm. The scenario framework for the Network Development Plan for Gas 2018-2028 is based on two scenarios. In both scenarios, German gas demand will not decrease enough by 2028 compared to 2015 to meet German greenhouse gas reduction targets of 55 per cent by 2030. The first scenario assumes a reduction

[9] The prime minister himself has invited representatives from politics and business to visit the Rotterdam LNG terminal.

of 43 per cent, while the second scenario assumes 50 per cent (Prognos 2017). The Federal Network Agency has nevertheless confirmed the scenario framework (Bundesnetzagentur 2017).

Decision-makers at all political levels favour the construction and subsidisation of an LNG terminal in Germany. This position is justified in particular by the narratives of security of supply and a presumably higher demand for LNG in the mobility sector – contrary to compliance with the national climate targets, which are not respected in any scenario of the Federal Network Agency's NDP. At the state level, a positive effect on the regional economy is anticipated.

At both EU and federal level, network operators have a major impact on the design of NDPs, being given privileged access to decision-makers (see Section 3.2.4). This puts them in a position to enforce their interests at the political level. These networks can be further strengthened at EU and national level through well-organised stakeholder associations and intervention in the national discourse through well-financed campaigns (see Section 3.2.6).

3.2.4 Network Operators

In Germany, there are over 700 network operators – most of them Distribution Network Operators. These are partly private service companies or municipal actors (for example, municipal utilities). There are 16 Transmission System Operators (TSOs). As already described in Section 3.2.3, the TSOs draw up the NDP and are obliged to base 'reasonable' assumptions on the development of extraction, supply and consumption of gas and its exchange with other countries (EnWG 2018).

The association of German gas TSOs promotes natural gas as a 'safe and environmentally friendly' alternative to other fossil fuels and as the strongest growing energy source in Germany and Europe (FNB Gas 2018).

The planning of grid expansion at the EU level is organised similarly to Germany. ENTSOG, an association of European gas transmission system operators, many of which are private service companies, is responsible for the modelling of future EU gas consumption and sources, and every two years for the development of an unbinding community-wide Ten-Year Network Development Plan (TYNDP). This plan lists all infrastructure projects which the network operators themselves consider relevant from a commercial or security of supply point of view.

The TYNDP 2018 includes 29 LNG-terminal-related projects, among them the LNG terminal in Brunsbüttel. All projects that are included in the TYNDP can apply to become a Project of Common Interest (PCI) (Official Journal of the European Union2013: 347). Projects that are on the PCI list benefit from accelerated approval procedures, faster and better streamlined environmental impact assessment and, under certain conditions, are subsidised with EU funds (European Commission 2017).

Transmission system operators recently commissioned a study that analyses the potential contribution from gas grids to the energy transition. The study argues that gas grids retain their importance in providing consumers with 'green gas' (Frontier Economics 2017). However, the use of so-called synthetic gas to the extent of the current use of natural gas is unlikely due to the high conversion costs. Synthetic gas is more likely to be used in areas where electrification is difficult to achieve (for example, in air traffic) (DIW Berlin, Wuppertal Institut and Ecologic Institut 2018).

Gas network operators are keen to ensure that the gas network continues to be perceived as an important infrastructure and is sufficiently used in order not to jeopardise its existing investments. At both the EU and national level, the profiteers of high gas consumption play a key role in the gas infrastructure development process. Network operators are also involved in numerous stakeholder associations with other major players in the gas sector to promote the narrative of gas as a sustainable energy carrier in public discourse at both EU and federal level (see Section 3.2.6).

3.2.5 Civil Society

Civil society and in particular environmental NGOs have had few negative responses to natural gas, and have even responded positively. To understand this behaviour, it is necessary to appreciate the historical context in Germany. In recent decades, in the context of the *Energiewende*, the main aim of environmental groups has been to, first, work towards a nuclear phase-out whilst increasing support for renewable energies and, later, to achieve a coal phase-out (Lauber and Jacobsson 2016; Brauers 2017; Leipprand and Flachsland 2018). Especially in the context of promoting the technical and social feasibility of a coal phase-out, several environmental NGOs promoted natural gas as a cleaner alternative.

Since information about the real climate impacts of natural gas (for example, Shindell *et al.* 2009), and the environmental justice implications along the supply chain emerged, many German-based NGOs have been rather silent on the issue of gas and its related lock-in. Although most environmental NGOs promote the phase-out of fossil fuels and mention natural gas, campaigns against natural gas in particular are rare. Another reason could be that during a time period when the public focus and debate is on a coal phase-out plan, issues of capacity have simply prohibited organisations from meaningfully addressing the issue of gas lock-in as an additional factor. There are a number of smaller organisations contesting natural gas (for example, Food & Water Europe as well as Gastivists Berlin).

3.2.6 Networks of Actor Groups: Official Lobbying Organisations

At a German level, initiatives like Future Natural Gas (*Zukunft Erdgas*), consisting of more than 140 corporations of the entire German natural gas industry value chain, plus representatives from politics and science, link actors with a vested interest in natural gas consumption and influence the related discourse. Since 2010, they have created several nationwide advertising campaigns, conducted studies and developed the website www.klima2020.de (climate2020) around their narrative that natural gas is climate friendly. They founded the official brand *ERDGAS* (natural gas), with the intention of creating an image for natural gas, engaging with 'millions of contacts (…) end users, opinion builders and market partners'.[10] The aim is to create a 'positive image' of natural gas, related to it being economic, environmentally protective, modern and future oriented (Zukunft Erdgas e.V. 2018b).

Also at the German level, the 'initiative Natural Gas Mobility' (*Initiative Erdgasmobilität*), which includes automobile producers, gas stations, and gas industry and gas technology corporations, builds a close network of all actors interested in natural gas as a fuel for road transportation. They are party funded by the Federal Ministry of Transport and coordinated by the German Energy Agency (DENA 2018).

At a European level, the association Eurogas represents the interests of the gas wholesale, retail and distribution sectors of different EU countries towards the EU institutions. It links actors along the value chain, giving them greater negotiating power, for example by promoting demand growth in natural gas for the transport sector in Europe. There is also the lobby group Natural & bio Gas Vehicle Association (NGVA) with members from national associations, energy companies, gas infrastructure corporations and vehicle manufacturers, which is partly funded by Gazprom (Transport & Environment 2018).

Another EU-wide association Gas Infrastructure Europe (GIE) represents operators of transmission pipelines, storage facilities and LNG terminals across the EU towards EU institutions, including the Commission and the Parliament but also the regulators, Agency for the Cooperation of Energy Regulators (ACER) and Council of Europe Energy Regulators (CEER).

[10] Translated from German.

A comparably new group (since 2017) in lobbying for natural gas is the Gas for Climate: a path to 2050 coalition, representing gas infrastructure companies of six[11] EU Member States. It is coordinated by the environmental consultancy Ecofys (now Navigant), which provides Gas for Climate with more credibility and also lobbying access, having repeated direct meetings with members of the European Commission, Parliament and Council.

Manifold bilateral connections exist between firms, for example between the Russian natural gas producer and LNG operator Novatec and the German engineering corporation Siemens AG, including cooperation on LNG liquefaction plants, gas deliveries and gas power generation (LNG World News 2018).

By building a strong network, with members representing the entire gas value chain, *Zukunft Erdgas* has substantial negotiating and discourse-building power. Financially strong and with personnel in leading business, industry association and science institutions, they have good access to decision-makers and 'opinion builders', as advertised on their own webpage.

Constructing, owning, supplying and operating much of the gas infrastructure, it is highly relevant for these companies that current gas consumption levels remain or even grow, so that the infrastructure is needed instead of being decommissioned and rendered stranded assets (Wachsmuth *et al*. 2019; Stern 2019). Further interests are to obtain more state subsidies for gas infrastructure projects from governments and to influence political decisions in general which favour natural gas in the power, industry and transport sectors. So far, the lobbying organisations have managed to keep up the illusion that a fossil fuel can be clean, and compatible with climate protection.

3.2.7 Investors and Financial Support

There are already some potential investors for the planned LNG terminals in Germany. Some of them are LNG producers, while others are operators of large fossil infrastructure facilities, such as Nord-West Ölleitung or Oiltanking, whose main interest is to expand their portfolio and thereby hedge their core business (Abeldt 2018). In addition, major investment companies, such as the Australian investor Macquarie, have signalled strong interest in the business.

In the Brunsbüttel project, the only location for which additional pipeline network expansion would be necessary, the Dutch network operator Gasunie has expressed interest. Gasunie has a subsidiary in Germany, which as a TSO, is partly responsible for the German Network Development Plan. Both companies are members of ENTSOG, influencing which infrastructure projects are included in the TYNDP. Final investment decisions have not yet been made as many of the investors speculate on direct or indirect subsidies for construction as well as operation.

At provincial, federal, and EU level, negotiations about possible funding sources are ongoing. At EU level, LNG projects have so far been funded by the European Energy Programme for Recovery (EEPR), the Connecting Europe Facility (CEF) and the European Regional Development Fund (ERDF). At the federal level, funds from the Federal Ministry of Transport, which are intended for the implementation of the Mobility and Fuels Strategy (MFS), are being considered. In addition, Brunsbüttel and Wilhelmshaven have the opportunity to apply for a GRW grant. This would then have to be co-financed by the federal states of Lower Saxony and Schleswig-Holstein. The operators may also request indirect subsidies, such as derogations.

In addition, the German state-owned development bank (KfW) also provides discounted loans as LNG appears in the bank's Environment Programme. KfW has already advised a Canadian company about

[11] Germany, Italy, Belgium, France, the Netherlands and Spain, collectively responsible for around 75 per cent of total natural gas consumption in Europe.

obtaining a loan guarantee for the Goldboro LNG terminal from the German federal government (KfW 2018).

A press release from Oiltanking illustrates the narrative of the investors: 'The terminal offers the opportunity to further diversify Germany's sources of gas supply and access to LNG as an alternative to low-emission fuel for ships and trucks' (Oiltanking 2018). At all three potential German LNG sites, companies are involved which have a significant interest in a continued use of fossil fuels in the long-term based on their existing portfolio. Part of their communication strategy is to represent gas as a "bridge fuel" for a transformation process towards renewable energies. One narrative is, for example, that fossil gas can be replaced by "green gas" or "synthetic gas" in the long run. However, they do not provide technical details on how and when this switch will take place.

4 Discussion

Our analysis reveals that the emergence of the dominant natural gas pathway has broadly resulted from climate protection urgency being co-opted by (multinational) business interests. As fossil fuel production and consumption are increasingly under threat by decarbonisation efforts, the presentation of natural gas as more climate friendly than coal and oil is used to protect conventional business models.

What we find is regime stabilisation, resulting from strategies that incumbent fossil fuel actors have deployed to secure their interests in the context of decarbonisation. Actors along the value and supply chain actively promote natural gas as a sustainable solution in the context of increased environmental policy stringency, which represents a threat to their interests. We find strong evidence for our central claim that support for LNG in Germany is a result of institutional and incumbency lock-in.

Interesting in this context is the long time period during which German LNG terminals were in a planning stage but never completed. In the 1970s, at the beginning of the planning process, investors were unable to attract exporters for long-term supply contracts, as was the case in the gas market that time. In the following years the project could not be realised due to low gas prices. Germany has been a transit hub in the EU with large gas storage capacities, giving it a favourable position in negotiating prices and gas trading with other EU countries. Germany is well connected via gas pipelines to its neighbouring countries, especially other natural gas producing countries like the Netherlands, and, importantly, Russia. Import prices for pipeline gas in Germany are relatively low compared to other EU countries (Holz *et al.* 2017). Due to less favourable long-term contracts with Russia and less well interconnected gas grids, LNG terminals made more economic sense in countries like Spain or the UK. The diversification of natural gas supplies is used as an argument for the construction of LNG terminals, despite Russia being both the largest pipeline and LNG supplier of Europe (LNG World News 2019).

We find the actors involved in both LNG infrastructure investments plans, and natural gas more broadly, to be existing fossil fuel players. Relevant actors related to LNG include corporations in the power sector (for example, RWE), the chemical industry (for example, Dow), gas station operators (for example, Shell), the transport sector (especially shipping and trucks; for example, WESSELS or AIDA cruise ships), network operators (for example, Gasunie), natural gas producers (for example, Qatar), investors and banks (for example, the Macquarie Group), harbours (for example, Hamburg), NGOs (for example, Greenpeace) as well as regulators (for example, FNA or ACER) and various governments (for example, Lower Saxony). A push for natural gas consumption is especially visible in sectors where it was previously underrepresented: shipping and heavy-duty trucks. The power sector and industries also encourage an increase in natural gas infrastructure. Attention can be focused on the actions of single corporations such as RWE increasing their natural gas business and booking capacities at LNG terminals. However,

the trends are much wider: a cross-company, cross-sector multinational expansion of old and development of new natural gas investments.

Domestic and European actors along the entire value and supply chain are extremely well connected. Despite competition between corporations who want to enter the same markets, they are involved in associations lobbying for an increase in natural gas consumption in various sectors, such as GIE, Gas for Climate or Future Natural Gas. These well-managed and highly funded institutions can influence the public discourse and political decisions more effectively than single actors along the value and supply chain could on their own. Furthermore, these associations have partnered to launch the GasNaturally campaign (representing gas exploration, production, transmission, distribution, wholesale, retail and transport companies)[12] to portray their vision for the future of natural gas. Additionally, manifold bilateral connections between firms exist.[13] These connections reveal the actor networks expected by the framework's approach, involving government and private sector actors as well as researchers and other actors.

Our analysis reveals the employed strategies seeking to protect vested interests, and reveals a significant level of access to and support of political actors. The LNG terminals are considered for state support at a regional and federal level. The support for gas was contained within the federal government coalition contract for 2017-2022. At the federal state level, Lower Saxony is especially supportive of this. As a key supplier of natural gas in Germany (90 per cent of German natural gas production comes from Lower Saxony), gas generates significant revenues and forms a large part of the state's economy. The LNG terminals thus represent a further extension of this established regime.

At the European level, policies which directly support natural gas have been implemented. Politics and business interests intermingle, with gas industry events being attended by high-level EU politicians. At an event in September 2018, with the EU Climate Action & Energy Commissioner, Miguel Arias Cañete, attendees were assured that the gas infrastructure would not become stranded and would remain a key sector (CEO 2018).

There are a number of discourses and framings surrounding natural gas and LNG technology in Germany, for example, as more flexible and, compared to other fossil fuels, as a climate-friendly source for power generation, suitable for storing energy, and as an energy source for mobility.

LNG is implicitly or explicitly defined as a solution to the issues of diversification, decarbonisation and air pollution, providing an ostensibly simple solution in all cases. Simple in the sense that it requires little to no deviance from the existing status quo of business models and modes of production. Underlying the diversification narrative are geopolitical concerns especially regarding overdependence on Russian gas, traced back more recently to Ukrainian gas crises prompting renewed concerns of dependency on Russia (Neumann *et al.* 2018).

How issues are framed, and what is prioritised within the discourses, is also revealing; 'The strategic relevance of diversifying our gas supplies via LNG is, I hope, by now a given', Oliver Grundmann, Stade constituency lawmaker Christian Democratic Union (CDU), said (Parkin and Shiryaevskaya 2018). 'The big question is who can build it fast and run it cost-effectively' (*ibid*.). The necessity of LNG is, thus,

[12] Consisting of Eurogas, the European Gas Research Group (GERG), Gas Infrastructure Europe (GIE), the International Association of Oil and Gas Producers (IOGP), Marcogaz, and the Natural & bio Gas Vehicle Association (NGVA Europe).

[13] For example, between the Russian natural gas producer and LNG operator Novatec and the German engineering corporation Siemens, including cooperation on LNG liquefaction plants, gas deliveries and gas power generation (LNG World News 2018)

portrayed as a given fact, steering the discussion away from a general debate to a focus on details such as cost competitiveness.

LNG is being promoted as environmentally friendly, both in climate and air protection terms. This narrative reveals the conception of 'technology-led' transitions, with related innovation of LNG cruise ships and trucks portrayed as providing environmental solutions. A conversation on other mitigation options, which are not technology based, is omitted.

GasNaturally recently presented at the International Climate Conference in Katowice in December 2018, using narratives including how 'clean fuel' natural gas can 'hand in hand with renewables' play an important role in energy transformations. They even 'welcomed' the EU's aim of climate neutrality by 2050, despite the fact that natural gas as a fossil fuel can simply not be a part of such a system (GasNaturally 2018). However, they promote the role natural gas can play in the medium-term and suggest that renewable gas and hydrogen could replace it thereafter. With this, they manage to convince stakeholders of the wrongly portrayed information, avoiding mentioning the related negative social and environmental consequences. For a discussion on the feasibility of an increase in biomass use for energy, see: Popp *et al.* (2014), Creutzig *et al*. (2015), Robledo-Abad *et al*. (2017) and Transport & Environment (2018).

5 Concluding Remarks

This paper has provided an analysis of the emerging dominant emergent pathway of liquefied natural gas infrastructure investments in Germany. The aim was to provide the grounding for future examinations, including data regarding the central factors underpinning the policy process of increasing support for LNG. Of central relevance, we have explored the impact of diverse lock-in mechanisms allowing for an enhanced understanding of the risks of energy transitions being derailed due to strategies employed by incumbent energy players.

The analysis has shown how well entrenched the connections and networks between all relevant actors along the value and supply chain, regulators and policy makers are. It is not just one or several alliances, but nested and interlaced associations and initiatives, all interested in increasing (or at least maintaining) natural gas production and consumption, with large financial resources and power through their connections and positions in influential corporations and politics in general.

Fostering support and demand for LNG can be seen as a strategy of the petrochemical regime to stabilise itself within the threatening context of climate mitigation efforts. The construction of LNG terminals or other fossil infrastructure holds the risk for lock-in effects, thus undermining climate mitigation efforts. Announcements of investment in LNG infrastructure such as import terminals, and also shipping, trucks and gas distribution, create further lock-in effects, which make it harder to withdraw political support afterwards.

The paper has sought to raise awareness about developments concerning natural gas in Germany more generally, which is currently receiving little attention, particularly in mainstream discourses. We have contrasted the dominant policy process with the climate science regarding greenhouse gas emissions of natural gas. As many analyses have shown, natural gas emits substantial amounts of GHGs, which is not compatible with meeting emission reduction goals by 2030 and the carbon neutrality goal by 2050. It is important to note that the current pathway, which strengthens the position of fossil fuel natural gas, is not the only option. It has been shown that an energy and transport system without (or with negligible amounts of) natural gas by 2050 is feasible (Ram *et al.* 2017; Löffler *et al.* 2017; Greenpeace, GWEC and SPE 2015). Developments need to be seen in the context of drastically falling solar and wind energy costs as well as first storage solutions being cost competitive with new gas-fired power plants.

The dominant discourses around natural gas being environmentally and climate friendly, the only way to provide safe and affordable energy, and the need to diversify an increasing gas supply, illustrate the successful influence of the natural gas regime on public opinion and decision-makers. If climate mitigation is to be successful enough to stay within either the 1.5°C or 2°C targets, it is imperative to challenge the assumptions about the necessity of natural gas and to focus instead on actual climate and environmentally friendly solutions.

This paper provides a solid starting base for further research, and we would like to propose possible avenues of further inquiry. The lock-in of natural gas is not limited to Germany and given that social science research on natural gas lock-in remains scarce, we advocate for further examination of moves by several countries to increase natural gas production, especially via fracking. Further avenues of research would be to point out alternative pathways without natural gas expansion plans. Importantly, a deeper process of tracing the causal links for natural gas support and strategies of the key actors can help to understand current policy decisions and to ultimately challenge them. Further useful research questions might be how the 'gas as a climate-friendly fuel' discourse enables political and financial support for projects. What could challenge the current discourse to reflect the true climate impact of natural gas?

Building on our preliminary results it would be useful to analyse the relevant actors and especially their networks and coalitions in more depth. It could be important to include actors that are not yet that visible, but most likely play an important role (which might be, for example, investors or asset management agencies, or the "revolving door" of people between business and the political and public sectors). As a systematic lack of available information can itself be revealing, it could be helpful to look for missing data, for example on subsidies and meetings closed to the public. When researching this paper, for example, it was difficult to find data on the cost of projects, spending of banks or concrete subsidy commitments.

For a more quantitative analysis it might be interesting to explore how much natural gas can still be consumed in Germany under emission reduction and carbon neutrality targets in 2050, and what that means for the different sectors (energy, industry and transport in particular) and grid infrastructure. What would it mean for gas market regulators and network planers/investors, if they took GHG emission constraints seriously? The focus should be on the short- to medium-term, and to put that into context with current infrastructure investment plans. Another interesting avenue could be to analyse what can be learned from coal phase-out processes to prevent similar mistakes, and to implement successful measures for the upcoming natural gas phase-out.

Lastly, our research is a call to act upon the findings of natural science regarding the urgency of climate change mitigation and the related need to reduce and not to increase natural gas consumption. From an environmental justice perspective, the impacts of natural gas along the supply chain need to be more thoroughly articulated. History has shown that the entrenched vested interests of corporations will not be overcome without a strong opposition by civil society and effective policies restricting and regulating their dominance.

Following previous calls by STEPS to challenge dominant pathways and for pragmatic, clear and simple alternative policy storylines, the natural gas narrative needs to be somewhere close to this: natural gas is a dirty, GHG-intensive fossil fuel that cannot play a role beyond 2050 and needs to be drastically reduced in the upcoming years. Otherwise, sufficient climate mitigation is simply not possible. This is feasible due to other readily available technologies to create competitive, more equitable, carbon-neutral and secure energy, transportation and industry sectors. In revealing the constructed nature of the dominant gas pathway, we hope the way has been paved for it to be meaningfully contested and emancipatory alternatives to be articulated and realised.

References

Abeldt, G. (2018) 'NWO setzt auf Flüssiggas-Terminal', *Nordwest Zeitung*, 14 March 2018, https://www.nwzonline.de/wirtschaft/wilhelmshaven-bilanz-nwo-setzt-auf_a_50,1,415477667.html

ACER and CEER (2018) *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017: Gas Wholesale Markets Volume*, Ljubljana and Brussels: Agency for the Cooperation of Energy Regulators and Council of European Energy Regulators, https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202017%20-%20Gas%20Wholesale%20Markets%20Volume.pdf

Alvarez, R. A., Zavala-Araiza, D., Lyon, D. R., Allen, D. T., Barkley, Z. R., Brandt, A. R., ... Hamburg, S. P. (2018) 'Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain', *Science* 361 (6398): 186–88, https://doi.org/10.1126/science.aar7204

Anderson, K. and Broderick, J. (2017) *Natural Gas and Climate Change*, Tyndall Manchester Climate Change Research, CEMUS, Teeside University, https://www.research.manchester.ac.uk/portal/files/60994617/Natural_Gas_and_Climate_Change_Anderson_Broderick_FOR_DISTRIBUTION.pdf

Araújo, K. (2014) 'The Emerging Field of Energy Transitions: Progress, Challenges, and Opportunities', *Energy Research & Social Science* 1: 112–21, https://doi.org/10.1016/j.erss.2014.03.002

Brauers, H. (2017) 'Diverging Coal Phase-out Strategies and Their Implications for EU Climate & Energy Policies', Master Thesis, Berlin: Berlin University of Technology (TU Berlin)

BMVI (2016) 'Nationaler Strategierahmen über den Aufbau der Infrastruktur für alternative Kraftstoffe', Berlin: Bundesministerium für Verkehr und digitale Infrastruktur, https://www.bmvi.de/SharedDocs/DE/Anlage/MKS/mks-nationaler-strategierahmen-afid.pdf?__blob=publicationFile

BMWi (2018) 'Schriftlicher Bericht des Bundesministeriums für Wirtschaft und Energie (BMWi) zu den Planungen der Bundesregierung in Bezug auf LNG-Infrastruktur in Deutschland', Deutscher Bundestag

—— (2017) 'Versorgungssicherheit bei Erdgas', Monitoring-Bericht nach § 51 EnWG, Berlin: Bundesministerium für Wirtschaft und Energie, https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/monitoringbericht-versorgungssicherheit-2017.pdf?__blob=publicationFile&v=20

Bundesnetzagentur (2018) 'BK7-18-063', 10 August 2018, https://www.bundesnetzagentur.de/DE/Service-Funktionen/Beschlusskammern/1BK-Geschaeftszeichen-Datenbank/BK7-GZ/2018/2018-0001bis0999/2018_0001bis0099/BK7-18-0063/BK7-18-0063_Verfahrenseinleitung.html

—— (2017) 'Az. 8615-NEP Gas 2018-2028 – Bestätigung Szenariorahmen', Bonn, https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/NetzentwicklungUndSmartGrid/Gas/NEP_2018/Szenariorahmen/NEP_Gas2018_Bestaetigung_BNetzA.pdf?__blob=publicationFile&v=4

Castán Broto, V. (2018) 'Natural Gas and Climate Finance', *Climate Policy* 18 (2): 170–83, https://doi.org/10.1080/14693062.2016.1264357

CDU, CSU und SPD (2018) 'Koalitionsvertrag zwischen CDU, CSU und SPD', https://www.cdu.de/system/tdf/media/dokumente/koalitionsvertrag_2018.pdf?file=1

Climate Analytics (2018) *Western Australia's Gas Gamble: Implications of Exploiting Canning Basin and Other Unconventional Gas Resources for Achieving Climate Targets*, https://climateanalytics.org/media/climateanalytics-report-westernaustraliasgasgamble-2018.pdf

Corporate Europe Observatory (2018) *A Dangerous Distraction: 'Renewable' Gas Keeps Us on the Fossil Fuel Path. Part 2: The Industry Lobby Behind So-Called Renewable Gas*, Corporate Europe, https://corporateeurope.org/sites/default/files/attachments/pt2_renewable_gas_-_lobbying.pdf

Creutzig, F., Ravindranath, N.H., Berndes, G., Bolwig, S., Bright, R., Cherubini, F., … Masera, O. (2015) 'Bioenergy and Climate Change Mitigation: An Assessment', *GCB Bioenergy* 7 (5): 916–44, https://doi.org/10.1111/gcbb.12205

Davis, S. J. and Shearer, C. (2014) 'A Crack in the Natural-Gas Bridge: Climate Change', *Nature* 514 (7523): 436–37, https://doi.org/10.1038/nature13927

DENA (2018) 'Initiative for Natural-Gas-Based Mobility', German Energy Agency, https://www.dena.de/en/topics-projects/projects/mobility/initiative-for-natural-gas-based-mobility/

DIW Berlin, Wuppertal Institut, and Ecologic Institut (2018) 'Phasing out Coal in the German Energy Sector', Berlin, https://epub.wupperinst.org/frontdoor/deliver/index/docId/7265/file/7265_Phasing_Out_Coal.pdf

DNR (2018) 'Erdgas - Eine gesunde Alternative?', https://www.dnr.de/rohstoffpolitik-20/blog/erdgas-eine-gesunde-alternative/?L=0

EnWG (2018) *Gesetz über die Elektrizitäts- und Gasversorgung (Energiewirtschaftsgesetz – EnWG)*, https://www.gesetze-im-internet.de/enwg_2005/__11.html

European Commission (2018a) 'EU-U.S. Joint Statement of 25 July: European Union Imports of U.S. Liquified Natural Gas (LNG) Are on the Rise', European Commission Press Release, Brussels: European Commission

http://europa.eu/rapid/press-release_IP-18-4920_en.htm[Please confirm whether the reference inserted above in English is the correct one. That's correct!]

—— (2018b) 'Joint EU-U.S. Statement Following President Juncker's Visit to the White House', 25 June 2018, http://trade.ec.europa.eu/doclib/press/index.cfm?id=1898; [This second link is to a different article which is not cited.]

—— (2017) 'Questions and Answers on the Projects of Common Interest (PCIs) in Energy and the Electricity Interconnection Target', European Commission Fact Sheet, Brussels: European Commission

—— (2016a) 'EU Strategy for Liquefied Natural Gas and Gas Storage', Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels: European Commission https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v10-1.pdf

—— (2016b) 'Liquified Natural Gas and Gas Storage Will Boost EU's Energy Security', European Commission Fact Sheet, 16 February 2016, Brussels: European Commission

http://europa.eu/rapid/press-release_MEMO-16-310_en.htm[Please confirm whether the reference inserted above in English is the correct one.] That's correct!

[Is this from the Official Journal of the European Union/ EUR-lex? If so, is the publishing organisation the European Union rather than the European Commission? Yes you are right, I would suggest to cite it like that: Official Journal of the European Union (2013) ´Regulation (EU) 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009´, L 115/39, Brussels

Feindt, P. H. and Oels, A. (2005) 'Does Discourse Matter? Discourse Analysis in Environmental Policy Making', *Journal of Environmental Policy & Planning* 7 (3): 161–73, https://doi.org/10.1080/15239080500339638

FNB Gas (2018) 'Zahlen und Fakten', https://www.fnb-gas.de/de/fernleitungsnetze-/zahlen-und-fakten/zahlen-und-fakten.html

food&water europe (2016) 'Facts about LNG: Dismantling Misleading Rhetoric', https://www.foodandwatereurope.org/factsheet/facts-about-lng-dismantling-misleading-rhetoric/

Forsyth, T. (2003) *Critical Political Ecology: The Politics of Environmental Science*, London: Routledge

Friends of the Earth Europe (2017) *Can the Climate Afford Europe's Gas Addiction?*, Friends of the Earth Europe and Fossil Free Europe, http://www.foeeurope.org/sites/default/files/extractive_industries/2017/can_the_climate_afford_europes_gas_addiction_report_november2017.pdf

Frontier Economics (2017) 'Der Wert der Gasinfrastruktur für die Energiewende in Deutschland - eine modellbasierte Analyse', https://www.fnb-gas.de/files/fnb_gas_wert_von_gasinfrastruktur-endbericht.pdf

GasNaturally (2018) 'Press Release: Joint Statement – Response to the European Commission Vision for a Climate Neutral Economy', https://gasnaturally.eu/wp-content/uploads/2018/12/Long-Term-Vision-Energy-associations-joint-press-release-1.pdf

Geels, F. W. (2018) 'Disruption and Low-Carbon System Transformation: Progress and New Challenges in Socio-Technical Transitions Research and the Multi-Level Perspective', *Energy Research & Social Science* 37 (March): 224–31, https://doi.org/10.1016/j.erss.2017.10.010

Geels, F. W., Berkhout, F. and van Vuuren, D. P. (2016) 'Bridging Analytical Approaches for Low-Carbon Transitions', *Nature Climate Change* 6 (6): 576–83, https://doi.org/10.1038/nclimate2980

Gemeinschaftsaufgabe 'Verbesserung der regionalen Wirtschaftsstruktur' (GRW), 16 December 2018, http://www.foerderdatenbank.de/FoerderDB/Navigation/Foerderrecherche/suche.html?get=views;document&doc=373

German Foreign Policy (2018) 'The Transatlantic Liquefied Gas Dispute', 28 September 2018, https://www.german-foreign-policy.com/en/news/detail/7739/

Goldthau, A., Keating, M. and Kuzemko, C. (2018) *Handbook of the International Political Economy of Energy and Natural Resources*, Cheltenham: Edward Elgar Publishing, https://doi.org/10.4337/9781783475636

Greenpeace International, Global Wind Energy Council and SolarPowerEurope (2015) *Energy [R]Evolution - a Sustainable World Energy Outlook*, Hamburg: Greenpeace International, Global Wind Energy Council, SolarPowerEurope, https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/greenpeace_energy-revolution_erneuerbare_2050_20150921.pdf

Grubler, A. (2012) 'Energy Transitions Research: Insights and Cautionary Tales', *Energy Policy*, Special Section: Past and Prospective Energy Transitions - Insights from History, 50 (November): 8–16, https://doi.org/10.1016/j.enpol.2012.02.070

Handelsblatt (2018) 'Offenes Rennen um Deutschlands erstes Flüssiggas-Terminal', 18 September 2018, https://www.handelsblatt.com/politik/deutschland/gasnetz-offenes-rennen-um-deutschlands-erstes-fluessiggas-terminal/23079402.html?ticket=ST-955168-ypkb1KbuV3IWGekPSXy0-ap4

Hirschhausen, C. von, Gerbaulet, C., Kemfert, C., Lorenz, C. and Oei, P-Y. (eds) (2018) *Energiewende 'Made in Germany': Low Carbon Electricity Sector Reform in the European Context*, Berlin: Springer International Publishing, //www.springer.com/de/book/9783319951256

Holz, F., Brauers, H., Richter, P. M. and Roobeek, T. (2017) 'Shaking Dutch Grounds Won't Shatter the European Gas Market', *Energy Economics* 64 (May): 520-29, https://doi.org/10.1016/j.eneco.2016.03.028

Howarth, R. (2015) 'Methane Emissions and Climatic Warming Risk from Hydraulic Fracturing and Shale Gas Development: Implications for Policy', *Energy and Emission Control Technologies* 2015 (3): 45–54, https://doi.org/10.2147/EECT.S61539

Howarth, R. (2014) 'A Bridge to Nowhere: Methane Emissions and the Greenhouse Gas Footprint of Natural Gas', *Energy Science and Engineering* 2 (2): 47-60, https://doi.org/10.1002/ese3.35

IDS (2006) 'Understanding Policy Processes: A Review of IDS Research on the Environment', Brighton: Institute of Development Studies

Intergovernmental Panel on Climate Change (2014) 'Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change', Geneva: IPCC

International Energy Agency (2018) 'Natural Gas Information 2018', Paris: OECD/IEA

Johnstone, P. and Newell, P. (2018) 'Sustainability Transitions and the State', *Environmental Innovation and Societal Transitions* 27 (June): 72–82, https://doi.org/10.1016/j.eist.2017.10.006

Keeley, J. and Scoones, I. (2003) *Understanding Environmental Policy Processes: Cases from Africa*, London: Routledge

KfW (2018) 'KfW-Umweltprogramm', 240/241. Merkblatt - Umweltschutz in Unternehmen, Kreditanstalt für Wiederaufbau, https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-(Inlandsf%C3%B6rderung)/PDF-Dokumente/6000002220-Merkblatt-240-241.pdf

Klitkou, A., Bolwig, S., Hansen, T. and Wessberg, N. (2015) 'The Role of Lock-in Mechanisms in Transition Processes: The Case of Energy for Road Transport', *Environmental Innovation and Societal Transitions* 16 (September): 22–37, https://doi.org/10.1016/j.eist.2015.07.005

Kuzemko, C., Keating, M. and Goldthau, A. (2018) 'Nexus-Thinking in International Political Economy: What Energy and Natural Resource Scholarship Can Offer International Political Economy' in A. Goldthau, M. F. Keating and C. Kuzemko (eds) *Handbook of the International Political Economy of Energy and Natural Resources*, Handbooks of Research on International Political Economy, Cheltenham: Edward Elgar Publishing Limited

Lauber, V., and Jacobsson, S. (2016) 'The Politics and Economics of Constructing, Contesting and Restricting Socio-Political Space for Renewables – The German Renewable Energy Act', *Environmental Innovation and Societal Transitions* 18: 147–63. https://doi.org/10.1016/j.eist.2015.06.005

Leach, M., Scoones, I. and Stirling, A. (2010) *Dynamic Sustainabilities: Technology, Environment, Social Justice*. Pathways to Sustainability, Abingdon: Earthscan

—— (2007) 'Pathways to Sustainability: An Overview of the STEPS Centre Approach', STEPS Approach Paper, Brighton: STEPS Centre, https://steps-centre.org/wp-content/uploads/final_steps_overview.pdf

Leipprand, A. and Flachsland, C. (2018) Regime destabilization in energy transitions: The German debate on the future of coal, *Energy Research & Social Science* 40 (June): 190–204. https://doi.org/10.1016/j.erss.2018.02.004.

LIQUIND (2018) 'Liquind Standorte', http://www.liquind.com/Liquind-Standorte.php

LNG World News (2019) 'Russia Becomes Europe's Top LNG Supplier in February, https://www.lngworldnews.com/russia-becomes-europes-top-lng-supplier-in-february/?utm_source=emark&utm_medium=email&utm_campaign=daily-update-lng-world-news-2019-03-04&uid=53990

LNG World News (2018) 'Russian LNG Player Novatek Ties up with Germany's Siemens', 3 October 2018, https://www.lngworldnews.com/russian-lng-player-novatek-ties-up-with-germanys-siemens/?utm_source=emark&utm_medium=email&utm_campaign=daily-update-lng-world-news-2018-10-03&uid=53990

Löffler, K., Hainsch, K., Burandt, T., Oei, P-Y., Kemfert, C. and Hirschhausen, C. von (2017) 'Designing a Model for the Global Energy System—GENeSYS-MOD: An Application of the Open-Source Energy Modeling System (OSeMOSYS)', *Energies* 10 (10): 1468, https://doi.org/10.3390/en10101468

Lycklama à Nijeholt, E. (2018) 'German LNG Terminal: Projektvorstellung', Hamburg, June 3, https://germanlng.com/wp-content/uploads/2018/07/German_LNG_Terminal-Projektpr%C3%A4sentation.pdf

Mac Kinnon, M. A., Brouwer, J. and Samuelsen, S. (2018) 'The Role of Natural Gas and Its Infrastructure in Mitigating Greenhouse Gas Emissions, Improving Regional Air Quality, and Renewable Resource Integration', *Progress in Energy and Combustion Science* 64 (January): 62–92, https://doi.org/10.1016/j.pecs.2017.10.002

Maksimenko, A. (2018a) 'Stade will LNG-Standort werden', Energate, 30 May 2018, https://www.energate-messenger.de/news/183461/stade-will-lng-standort-werden

Maksimenko, A. (2018b) 'LNG-Lieferungen: Katar hat Wilhelmshaven im Blick', Energate, 23 November 2018, https://www.energate-messenger.de/news/187771/lng-lieferungen-katar-hat-wilhelmshaven-im-blick

Markard, J., Raven, R. and Truffer, B. (2012) 'Sustainability Transitions: An Emerging Field of Research and Its Prospects', *Research Policy* 41: 995–967, https://doi.org/10.1016/j.respol.2012.02.013

McGlade, C., Pye, S., Ekins, P., Bradshaw, M. and Watson, J. (2018) 'The Future Role of Natural Gas in the UK: A Bridge to Nowhere?', *Energy Policy* 113 (February): 454–65, https://doi.org/10.1016/j.enpol.2017.11.022

Mendelevitch, R., Kemfert, C., Oei, P-Y. and Hirschhausen, C. von (2018) 'The Electricity Mix in the European Low-Carbon Transformation: Coal, Nuclear, and Renewables' in C. von Hirschhausen, C. Gerbaulet, C. Kemfert, C. Lorenz, and P-Y. Oei (eds) *Energiewende 'Made in Germany' Low Carbon Electricity Sector Reform in the European Context*, Berlin: Springer International Publishing AG

NDR1 Niedersachsen (2018a) 'Rennen um LNG-Terminal geht auf die Zielgerade', 18 September 2018, https://www.ndr.de/nachrichten/niedersachsen/lueneburg_heide_unterelbe/Rennen-um-LNG-Terminal-geht-auf-die-Zielgerade,lng128.html

NDR1 Niedersachsen (2018b) 'Erdgas-Terminal: Stade denkt schon an Baustart', 9 November 2018, https://www.ndr.de/nachrichten/niedersachsen/lueneburg_heide_unterelbe/Erdgas-Terminal-Stade-denkt-schon-an-Baustart,lng142.html

Neumann, A. and Hirschhausen, C. von (2015) 'Natural Gas: An Overview of a Lower-Carbon Transformation Fuel', *Review of Environmental Economics and Policy* 9 (1): 64–84, https://doi.org/10.1093/reep/reu022

Neumann, A., Göke, L., Holz, F., Kemfert, C. and Hirschhausen, C. von (2018) 'Natural Gas Supply: Another Baltic Sea Pipeline Is Not Necessary', *DIW Berlin Weekly Report*, no. 27–2018: 241–48

Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr (2018) 'Niedersächsischer Landtag – 18. Wahlperiode Drucksache 18/1319 Kleine Anfrage zur schriftlichen Beantwortung mit Antwort der Landesregierung: Quo Vadis LNG-Importterminal in Niedersachsen?'

Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr (2017) 'Niedersächsischer Landtag – 17. Wahlperiode Drucksache 18/75: Welche Bedeutung misst die Landesregierung der Errichtung eines LNG-Importterminals bei?'

Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr (2015) 'Niedersächsischer Landtag - 17, Wahlperiode Drucksache 17/4873 LNG-Terminal in Wilhelmshaven: Wie unterstützt Niedersachsen den „Neustart"?'

Niedersächsischer Landtag (2015) 'Niedersächsischer Landtag - 17. Wahlperiode: Drucksache 17/3930', Hannover

Nisbet, E. G., Manning, M. R., Dlugokencky, E. J., Fisher, R. E., Lowry, D., Michel, S.E. … White, J. W. C. (2019) 'Very Strong Atmospheric Methane Growth in the Four Years 2014-2017: Implications for the Paris Agreement', *Global Biogeochemical Cycles*, February, https://doi.org/10.1029/2018GB006009

Oei, P-Y., Göke, L., Kemfert, C., Kendziorski, M. and Hirschhausen, C. von (2019) 'Erneuerbare Energien als Schlüssel für das Erreichen der Klima-Schutzziele im Stromsektor', 133, Politikberatung Kompakt,

Berlin: DIW Berlin,
https://www.diw.de/documents/publikationen/73/diw_01.c.616181.de/diwkompakt_2019-133.pdf

Office of the Chief Economist (2018) 'Resources and Energy Quarterly', Australian Government Department of Industry, Innovation and Science,
https://publications.industry.gov.au/publications/resourcesandenergyquarterlyseptember2018/documents/Resources-and-Energy-Quarterly-September-2018.pdf

Muttitt, G., McKinnon, H., Stockman, L., Kretzmann, S., Scott, A., and Turnbull, D. (2016) *The Sky's Limit: Why the Paris Climate Goals Require a Managed Decline of Fossil Fuel Production*, Washington, D.C.: Oil Change International,
http://priceofoil.org/content/uploads/2016/09/OCI_the_skys_limit_2016_FINAL_2.pdf

Oiltanking (2018) 'German LNG Terminal Launches Open Season', 2018,
https://www.vopak.com/newsroom/news/news-german-lng-terminal-launches-open-season

Parkin, B. and Shiryaevskaya, A. (2018) 'Two Small Towns in Germany Seek to Realize Trump's LNG Dream', Bloomberg, 23 October 2018, https://www.bloomberg.com/news/articles/2018-10-22/two-small-towns-in-germany-vie-to-make-trump-s-lng-dream-reality

Penz, T. (2018) 'Förderantrag für Deutschlands erstes Flüssiggas-Terminal in Stade', Kreiszeitung Wochenblatt, 19 October 2018, https://www.kreiszeitung-wochenblatt.de/stade/politik/foerderantrag-fuer-deutschlands-erstes-fluessiggas-terminal-in-stade-d124684.html

Physicians for Social Responsibility (2017) 'Too Dirty, Too Dangerous: Why Health Professionals Reject Natural Gas', Washington DC, https://www.psr.org/wp-content/uploads/2018/05/too-dirty-too-dangerous.pdf

Popp, J., Lakner, Z., Harangi-Rákos, M. and Fári, M. (2014) 'The Effect of Bioenergy Expansion: Food, Energy, and Environment', *Renewable and Sustainable Energy Reviews* 32 (April): 559–78, https://doi.org/10.1016/j.rser.2014.01.056

Prognos (2017) 'Szenariorahmen für den Netzentwicklungsplan Gas 2018-2028 der Fernleitungsnetzbetreiber', Berlin,
https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/NetzentwicklungUndSmartGrid/Gas/NEP_2018/Szenariorahmen/SzenariorahmenNEPGas2018_final.pdf?__blob=publicationFile&v=2

Ram, M., Bogdanov, D., Aghahosseini, A., Oyewo, S., Gulagi, A., Child, M. and Breyer, C. (2017) 'Global Energy System Based on 100% Renewable Energy - Power Sector', Lappeenranta and Berlin: Lappeenranta University of Technology (LUT) and Energy Watch Group

Richter, P. M. and Holz, F. (2015) 'All Quiet on the Eastern Front? Disruption Scenarios of Russian Natural Gas Supply to Europe', *Energy Policy* 80 (May): 177–89,
https://doi.org/10.1016/j.enpol.2015.01.024

Robledo-Abad, C., Althaus, H-J., Berndes, G., Bolwig, S., Corbera, E., Creutzig, F. ... Smith, P. (2017) 'Bioenergy Production and Sustainable Development: Science Base for Policymaking Remains Limited', *GCB Bioenergy* 9 (3): 541–56, https://doi.org/10.1111/gcbb.12338

Rüster, S. (2010) 'Vertical Structures in the Global Liquefied Natural Gas Market: Empirical Analyses Based on Recent Developments in Transaction Cost Economics', Dresden: Technische Universität Dresden

RWE Supply & Trading GmbH (2018) 'RWE und German LNG Terminal vereinbaren Kapazitätsvertrag für erstes Deutsches LNG-Terminal', 6 September 2018, https://news.rwe.com/rwe-und-german-lng-terminal-vereinbaren-kapazitatsvertrag-fur-erstes-deutsches-lng-terminal/

Sandén, B. A., and Hillman, K. M. (2011) 'A Framework for Analysis of Multi-Mode Interaction among Technologies with Examples from the History of Alternative Transport Fuels in Sweden', *Research Policy* 40 (3): 403–14, https://doi.org/10.1016/j.respol.2010.12.005

Saul, J., and Chestney, N. (2018) 'New Fuel Rules Push Shipowners to Go Green with LNG', Reuters, 15 August 2018, https://www.reuters.com/article/us-shipping-fuel-lng-analysis/new-fuel-rules-push-shipowners-to-go-green-with-lng-idUSKBN1L01I8

Scharpf, F. W. (1997) *Games Real Actors Play: Actor-Centered Institutionalism in Policy Research*, New York: Routledge

Schmitz, H. and Scoones, I. (2015) 'Accelerating Sustainability: Why Political Economy Matters', IDS Evidence Report 152, Brighton: IDS, https://opendocs.ids.ac.uk/opendocs/handle/123456789/7077

Schram, S. F. (1993) 'Postmodern Policy Analysis: Discourse and Identity in Welfare Policy', *Democracy and the Policy Sciences* 26 (3): 249–70

Scoones, I. (2016) 'The Politics of Sustainability and Development', *Annual Review of Environment and Resources* 41 (1): 293–319, https://doi.org/10.1146/annurev-environ-110615-090039

Scoones, I., Leach, M. and Newell, P. (eds) (2015) *The Politics of Green Transformations*, Pathways to Sustainability, Abingdon: Routledge

Shindell, D. T., Faluvegi, G., Koch, D. M., Schmidt, G. A., Unger, N. and Bauer, S. E. (2009) 'Improved Attribution of Climate Forcing to Emissions', *Science* 326 (5953): 716–18, https://doi.org/10.1126/science.1174760

Stephenson, E., Doukas, A. and Shaw, K. (2012) 'Greenwashing Gas: Might a "Transition Fuel" Label Legitimize Carbon-Intensive Natural Gas Development?', *Energy Policy* 46 (July): 452–59, https://doi.org/10.1016/j.enpol.2012.04.010

Stern, J. (2019) 'Narratives for Natural Gas in Decarbonising European Energy Markets', Oxford Institute for Energy Studies (OIES) Paper NG141, Oxford, UK: Oxford Institute for Energy Studies (OIES), https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/02/Narratives-for-Natural-Gas-in-a-Decarbonisinf-European-Energy-Market-NG141.pdf

Stirling, A. (2018) 'How Deep Is Incumbency? Introducing a "Configuring Fields" Approach to the Distribution and Orientation of Power in Socio-Material Change', SPRU Working Paper Series 2018-23 (November), https://www.sussex.ac.uk/webteam/gateway/file.php?name=2018-23-swps-stirling.pdf&site=25.

Stockman, L., Muttitt, G., Doukas, A. and Rees, C. (2018) *Debunked: The G20 Clean Gas Myth*, Washington DC: Oil Change International, http://priceofoil.org/content/uploads/2018/06/debunked_g20_eng_07_web.pdf

Transport & Environment (2018) ‘CNG and LNG for Vehicles and Ships - the Facts’, Brussels, https://www.transportenvironment.org/sites/te/files/publications/2018_10_TE_CNG_and_LNG_for_vehicles_and_ships_the_facts_EN.pdf

Trout, K., McKinnon, H., Doukas, A., Muttitt, G. and Lee, A. (2017) *Time to Stop Digging: Why German Climate Leadership Requires a Rapid Phaseout of Fossil Fuel Production and Finance*, Washington DC: Oil Change International, http://priceofoil.org/content/uploads/2017/11/skys_limit_germany_final.pdf

Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B. and van Vuuren, D. (2015) ‘Evaluating Sustainability Transitions Pathways: Bridging Analytical Approaches to Address Governance Challenges’, *Global Environmental Change* 35 (November): 239–53, https://doi.org/10.1016/j.gloenvcha.2015.08.010

Wachsmuth, J., Michaelis, J., Neumann, F., Wietschel, M., Duscha, V., Degünther, C., Köppel, W., and Zubair, A. (2019) 'Roadmap Gas für die Energiewende - Nachhaltiger Klimabeitrag des Gassektors', Dessau - Roßlau: Umweltbundesamt.

Wadewitz, F. (2018) ‘LNG-Importeure wetten auf Wilhelmshaven’, Tagesspiegel Energie Und Klima Background, 18 December 2018

Wieschemeyer, K. (2018) ‘Altmaier Kann sich mehrere LNG-Terminals im norden vorstellen: Wilhelmshaven aus Netzplan gestrichen’, Osnabrücker Zeitung, 30 August 2018, https://www.noz.de/deutschland-welt/niedersachsen/artikel/1511855/altmaier-kann-sich-mehrere-lng-terminals-im-norden-vorstellen

Wilson, I. A. G. and Staffell, I. (2018) ‘Rapid Fuel Switching from Coal to Natural Gas through Effective Carbon Pricing’, *Nature Energy* 3 (5): 365–72, https://doi.org/10.1038/s41560-018-0109-0

Zhang, X., Myhrvold, N. P. and Caldeira, K. (2014) ‘Key Factors for Assessing Climate Benefits of Natural Gas versus Coal Electricity Generation’, *Environmental Research Letters* 9 (11): 114022, https://doi.org/10.1088/1748-9326/9/11/114022

Zukunft Erdgas e.V. (2018a) ‘ERDGAS als Kraftstoff – Sicher, sauber, günstig’, 2018a, https://zukunft.erdgas.info/markt/absatzmaerkte/mobilitaet

Zukunft Erdgas e.V. (2018b) ‘Eine Marke – ein Produkt – ein Markt', 2018b, https://zukunft.erdgas.info/ueber-zukunft-erdgas/experten-leistungen/kommunikation/marke

About the authors

Louise Michelle Fitzgerald is a doctoral researcher at the School of Politics and International Relations, University College Dublin, Ireland. Her research interests include environmental and climate policy, political ecology, political pathways to sustainability, alternative sustainabilities, climate and environmental justice, system-thinking and holistic perspectives; solutions to current socio-ecological crises. She has been awarded an Irish Research Council Government of Ireland Postgraduate Research Scholarship to conduct her doctoral research, which focuses on what factors facilitate successful climate policy, drawing lessons from the case of the German Energy Transition.

Isabell Braunger is a research associate and doctoral student at the Technical University of Berlin (TU Berlin) and a guest researcher at the German Institute for Economic Research (DIW Berlin). She is a political scientist and sociologist. As part of the CoalExit research group, she works in an interdisciplinary team on energy transformations. In her research, she combines social, political and economic perspectives.

Hanna Brauers is a research associate and doctoral student at the Technical University of Berlin (TU Berlin) and a guest researcher at the German Institute for Economic Research (DIW Berlin). Being an industrial engineer with a focus on energy and resource management, her research focuses on coal and gas markets as well as energy transformations. She combines economics and political science approaches with modelling exercises to enable the inclusion of stakeholders interests, power and inequality, as well as technological constraints.

Acknowledgements

We want to express our sincere thanks to Dr Andy Stirling who, despite being very busy, kindly reviewed and thereby provided us great support in improving this paper. We are also grateful to Prof. Dr Franziska Holz for reviewing this paper and for sharing her profound knowledge on natural gas markets with us. We appreciate useful feedback and support from members of the junior research group 'CoalExit' and the Workgroup for Infrastructure Policy at TU Berlin, in particular Dr Pao Yu Oei and Prof. Dr Christian von Hirschhausen. Our thanks also go to Ian Scoones, Nathan Oxley and Becky Ayre for providing sustained support for this paper from the very beginning, making this publication possible. All remaining errors remain ours.

Destabilisation of Sustainable Energy Transformations: Analysing Natural Gas Lock-in in the case of Germany

STEPS Working Paper 106

In recent years, natural gas has seen increased support in the context of climate change mitigation. Described as a 'bridge fuel' it is seen as aiding in the low-carbon energy transformation process. This is puzzling, given the high global warming potential of natural gas, which is composed almost entirely of the greenhouse gas methane. In this paper, we seek to explain the factors underpinning the political processes surrounding natural gas support, despite its unsuitability for climate mitigation.

Drawing guidance from the pathways approach, and drawing on the broader institutional and regime literature, we analyse the role of actors and their networks, interests and politics as well as discourses and narratives. Our central claim is that support for natural gas is a result of institutional and incumbency lock-in, which has resulted from strategies that incumbent fossil fuel actors have deployed to secure their interests in the context of decarbonisation. We focus on liquefied natural gas (LNG) infrastructure in Germany, a representative case study for understanding the dynamics of natural gas support. The paper concludes by highlighting further avenues of research. In particular, we note specific misperceptions that need to be more openly contested in the discourse surrounding natural gas, in order to address the issue of natural gas lock-in.