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Explaining choices in energy infrastructure development as a network of adjacent action situations: The case of LNG in the Baltic Sea region

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ABSTRACT

This paper contributes to the development of a polycentric perspective on energy infrastructure governance by developing the concept of network of adjacent actions situations (NAAS). Examining the case of LNG infrastructure development in the Baltic Sea region, it clarifies how choices made in interlinked policy areas may affect infrastructural policy output in a regional context. It is argued that LNG is expanding as a new major energy technology around the Baltic due to its capacity to fulfill policy expectations in three issue-areas: enhancing energy security, providing low-sulphur bunker fuel, and balancing renewables in the power sector. The analysis of linkages between these actions situations emphasizes the spatial, temporal, and discursive aspects of energy infrastructure governance at the regional level. The application of NAAS as an analytical tool to map out the unintended consequences of infrastructural choices is relevant in policymaking.

1. Introduction

Until 1980s, energy infrastructure provision was typically in the hands of the governments and state-owned businesses. Shifts in the political economy towards privatization have not only changed infrastructure ownership, but also management, operations, and decision-making models (Solomon, 2009). While the energy policy objectives, conditions and instruments of financial procurement are defined at the highest political level, infrastructure planning has become a deliberative landscape – and sometimes a battlefield - for a broad array of stakeholders (Wolsink, 2007; Hindmarsh and Matthews, 2008; Ottinger et al., 2014). The role of multiple actors acting at different levels was highlighted in energy governance literature (for example, Smith, 2007; Goldthau and Sovacool, 2012; Goldthau, 2014), particularly articulated in energy transition studies (Verbong and Geels, 2007). Empirical case-studies indicated that temporal and contextual contingencies pertaining to the variety of decision-making contexts have an effect upon infrastructural policy choices (Hill and Gaddy, 2003; Collier, 2011). Nevertheless, most previous studies of energy infrastructure development focused on a single-country policy context (Irwin, 1997; Priemus, 2007; Flyvbjerg et al., 2009; Marshall, 2012).

The aim of this paper is to clarify how policy choices made in interlinked policy areas may affect infrastructural policy output in a transboundary regional context. Goldthau (2014) presented theoretical considerations for polycentric energy infrastructure governance, acknowledging a lack of empirical studies on this topic. This paper contributes to the development of a polycentric perspective on energy infrastructure governance by investigating the case of liquefied natural gas (LNG) infrastructure 'boom' in the Baltic Sea region (BSR)[1] through the lens of network of adjacent action situations (NAAS) concept. NAAS was introduced as a part of the institutional analysis and development (IAD) framework (Ostrom, 2005) to investigate "how simultaneously occurring decision processes interact with each other to shape governance and policy implementation" (McGinnis, 2011, p. 51).

The Baltic Sea region presents a curious case of energy infrastructure development. In 2011, the first Baltic LNG terminal was opened in Swedish Nynäshamn, providing capacity of 20,000 m^3 per annum, most of which was sourced from the natural gas liquefaction plant in Stavanger (Norway). In 2014–2016, another four LNG import terminals with cumulative storage capacity of 550 000 m^3 were deployed in Finland, Lithuania, Poland, and Sweden. Moreover, the GIE LNG database projected that by 2020 there will be up to seventeen import facilities with a total capacity 1,305,400 m^3 and an export terminal with a capacity of 10 mln m^3 per year in Ust Luga, Russia (GIE, 2016). This is not a case of technological innovation uptake: LNG technology has been in regular use in other European regions since 1960s. Moreover, since the negative environmental and health effects of fossil fuels are well-established and globally alternative energy technology investments outplace gas (Randall, 2016), large-scale LNG investments at this point in time are puzzling. Given the circumstances,

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[1] For the purpose of this paper, the Baltic Sea region is defined as nine Baltic Sea littoral countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden).

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how can we explain why actors around the Baltic Sea commit to development of LNG infrastructure as a new major energy technology?

This paper argues that growing interest in LNG infrastructure development in the BSR is explained by the capability of LNG technology to fulfill policy expectations in addressing three diverse, yet interlinked policy problems: increase energy security, mitigate air emissions from shipping, and assist sustainable energy transition. In this way, the article makes a contribution to understanding the complexity of energy infrastructure governance by highlighting that policy outcomes are influenced not only by actors within a focal action situation (one policy area and/or one country), but by a combination of functional interdependencies between different decision-making contexts. The practical contribution of this research is in showing the relevance of functional interdependencies between adjacent action situation for planning and governance of energy infrastructure at the regional level.

This paper proceeds as follows. Section 2 outlines the analytical framework. Section 3 discusses methodological choices. Section 4 proceeds to mapping of individual action situation, as well as analyzing the network interdependencies. Section 5 identifies the contributions of the NAAS framework to the energy infrastructure analysis. Section 6 points out policy implications and concludes.

2. Analyzing a network of adjacent action situations

Polycentric governance, a concept denoting the co-existence of many decision-making centers within a common overarching framework (Ostrom et al., 1961), has significant analytical value in energy research (Smith, 2007; Sovacool, 2011; Cherp et al., 2011), with a relevance in the context of energy infrastructure (Goldthau, 2014). While polycentric governance has been successfully used as both descriptive and normative concept (Thiel, 2016), empirical studies have remained limited and largely concentrated on cases of resource governance. Partially, this can be explained by the lack of frameworks that operationalize polycentric governance and translate this theoretical construct into a number of variables accessible for empirical work. To bridge this gap McGinnis (2011) suggested to 'zoom out' from action situations to a network of adjacent action situations.

Action situations are settings where two or more actors make choices out of a set of potential actions that jointly produce outcomes, whereas exogenous variables are assumed constant (Ostrom, 2005). An action situation is composed of seven components: (1) actors, (2) their positions, (3) set of actions, (4) the potential outcomes, (5) control, (6) information, and (7) costs and benefits associated with the outcomes (Ostrom, 2011). Since complex institutional systems exhibit a property of polycentricity, analysis of one analytically separated action situation is unable to grasp the dynamics of policy-making and implementation. As noted by Ostrom, "in field settings, it is hard to tell where one action situation starts and another stops" (2011, p. 15). Linking action situations appears to be crucial for understanding the dynamics of outcomes in complex policy settings and operationalizing polycentric governance.

The basic assumption in NAAS analysis is that while each action situation is a decision-making center in its own right, rules governing an action situation are determined not only endogenously, but also exogenously – within other (adjacent) action situations. McGinnis proposed two procedures for identifying adjacent action situations in a complex policy setting: first, on the basis of rules that define the seven components of an action situation, and second, drawing upon the generic governance tasks (provision, production, consumption, coordination, dispute resolution, rule-making) (McGinnis, 2011, p.51). In his 2011 article, McGinnis used the second procedure (generic governance tasks) to illustrate how networks of adjacent action situations can be analyzed.

Kimmich (2013) extended NAAS application by integrating the ecology of games approach and proposed a method to empirically capture the adjacency and its effects on the policy process. Villamayor-Tomas et al. (2015) combined NAAS and the value chain framework to

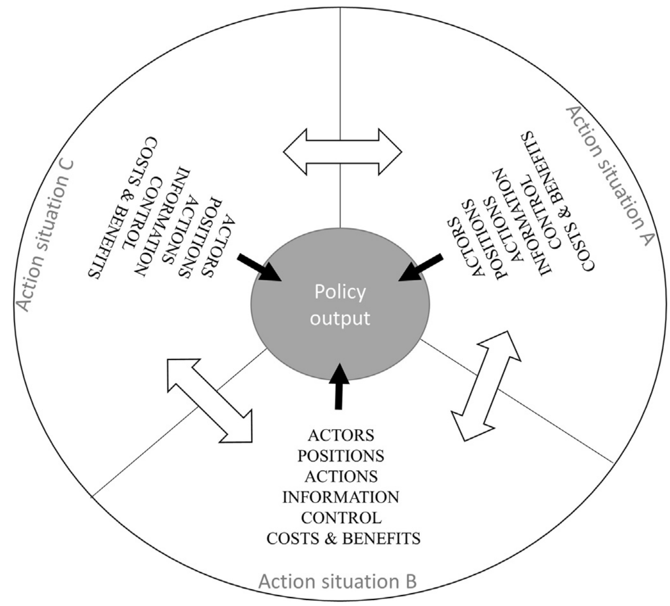

Fig. 1. Linking action situations: Adjacency on the basis of a shared outcome.
Source: Author.

conceptualise interrelations between action situations as a production chain where outputs from one situation affect the other. Jones et al. (2017) applied NAAS to understand how processes that occur in parallel across scales and levels affect the future policy outcomes. However, neither the original nor the subsequent studies explicitly using the NAAS framework illustrated the first procedure suggested by McGinnis – defining networks of adjacent situations based on the seven components of the actions situation (McGinnis, 2011, p.51). This paper aims to fill in this gap by suggesting how NAAS analysis can be conducted on the basis of functional interrelations between the components of action situations.

McGinnis advocated a broad definition of adjacency: action situations are adjacent if "outcomes generated in one action situation help determine the rules under which interactions occur within the other action situation" (McGinnis, 2011, p. 52). Fig. 1 illustrates a network of adjacent action situations A, B and C linked on the basis of a shared outcome. Outcomes can vary from immaterial (e.g., shared understanding, legal provisions) to physical (e.g., harvest results, industrial output) (Ostrom, 2011). If two or more action situations share outcomes, they have common scope rules, that is, rules that identify required, desired or prohibited outcomes, thus, can be considered adjacent. The network of linked action situations reveals the complexity of policy settings that condition each other.

3. Methodology

The analysis of energy infrastructure development as a network of adjacent action situations requires identifying the actions situations and their adjacency, collecting data pertaining to each of the action situations, and making explicit the functional interrelations in the network. In this analysis, NAAS is based on the measurable outcomes of the policy process, meaning, the LNG terminals as shared physical output of infrastructural policy choices in the BSR. The use of LNG is considered as a viable policy option in three actions situations: enhancing energy security, promoting sustainable energy transitions, and curbing air pollution from shipping. These action situations correspond to the three major use cases for LNG: as a form of natural gas transportation, as a form of natural gas storage, and as an alternative fuel (EU, 2016, MEMO/16/310). In gas-exporting countries, competitiveness and penetration of new markets is another action situation where LNG is expected to play a role, for instance, in Russia. Yet, as most BSR countries do not produce and export gas, this action situation has been considered within the energy security (of demand) issue-area.

Policies aimed at improved energy security, resilience and sustainability of energy systems (e.g., *European Strategy for the Baltic Sea Region* 2009) and minimized shipping pollution (e.g., HELCOM *Baltic Sea Action Plan* 2007) were on the Baltic regional agenda for over a decade. It was after 2013, that LNG emerged as a policy option in the BSR stemming from a combination of factors that were previously absent. First, the deterioration of EU-Russia political relations since 2014, including the suspension of EU-Russia Energy Dialogue, created increased interest towards LNG in the Baltic region, where dependence on Russian gas import was strong (Judge et al., 2016). LNG transport provides an alternative to pipeline gas transport, thereby allowing importers to diversify the suppliers and play a role in emerging competitive gas market. Second, the new environmental legislation on shipping sulphur emissions in the Baltic Sea coming into force on 1.1.2015 raised LNG to the top of agenda in the maritime industry, where its capability to serve as alternative bunker fuels were evaluated (Gritsenko and Yliskylä-Peuralahti, 2013). Third, the 2030 EU Energy Strategy adopted in 2014 created new impetus for Europe-wide energy transition. The use of LNG as natural gas storage that offers flexibility and proximity to individual and industrial consumers on and off the grid, offers an alternative to other more polluting fossil fuels by contributing to more sustainable heat and energy production. This property of LNG came in the forefront in the *Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy* in 2015 (COM, 2015). Such non-binding strategies, as well as upcoming binding regulations, contribute to policy change already at the time of initiation as they have a ‘framing effect’ on the policy agenda (López-Santana, 2006). In addition, as global oil price fell in late 2014, traditionally oil-linked gas prices also declined, making an outlook for LNG-related investment more attractive.

For the purpose of empirical investigation, the components of the action situations were operationalised in the following way. An actor is defined as “a single individual or a group functioning as a corporate actor” (Ostrom, 2011, p.12). A rather seamless web of actors and events in each actions situation can be regarded at three different levels – constitutional, collective (institutional) or operational (Ostrom, 2005). This study concentrates on the operational level, that is, day-to-day actors interactions and physical policy outputs. Position is defined as actor's role in governance interaction, distinguishing between rule-demanders (beneficiaries), rule-suppliers (regulators), targets of rules (adopters), and rule intermediaries (e.g., experts, international organizations and agencies) (Büthe, 2010; Abbott et al., 2017). This framework allows for a systematic approach to identification of positions actors occupy in the action situation and highlights that positions may change over time and depending on the situation. Actions are choices available to actors who act in regard to the policy problem – what they may, must, or cannot do in given circumstances. Key question for analysis is which actions are pursued, announced, desired, rejected, and intended by whom? The outcome, which is the development of LNG infrastructure, is shared by the three action situations under scrutiny. The level of control the participants have over choices and the information available to them (as well as uncertainties) were assumed in accordance with formal rules and public information. Costs and benefits assigned to the shared outcome were outlined on the basis of estimations provided in the secondary literature.

The assumptions made in this study with regard to information about and control over the potential outcomes impose limitations on our analysis. First, while incomplete information and imperfect information-processing capabilities are built into the model (Ostrom, 2011), information asymmetries cannot be made explicit. While we assume that incomplete knowledge affects all actors in a similar way, some actors may exploit information advantages and act opportunistically. To compensate for these shortcoming, the study pays special attention to the larger policy context in the BSR using media and observations at a number of policy events during 2013-16 (Annex I). Second, actors are assumed to take actions either on their own initiative or in result of compliance with existing laws and regulations. Yet, much of the interaction is governed by informal rules that are not written anywhere. These shared meanings emerging within organizations and issue networks (e.g., expert groups) are difficult to ascertain in empirical research, thus, our focus is on the locus of formal aggregation (including permissions, agreements, and laws).

Desktop research, field observations and personal communications were used to derive rich data for reconstructing the individual action situations and ascertaining the interrelationships between the functional components of the action situations at hand. The data included energy, maritime and sustainability policy documents from the EU and the Baltic Sea countries, statistical data, media communications from energy companies, observations and personal communication with stakeholders at key events (Annex I). The qualitative data was used to extract information about existing and planned LNG terminals (GIE, 2016), particularly on the actors, their interrelations, and the policy context. Methodologically, the outlined analytical procedure is in line with methods of qualitative analysis, specifically information extraction based on topics of interest, pattern recognition, event tracing (Miles and Huberman, 1994).

After mapping out the individual action situations, overlapping and interdependent components were identified to reveal functional connections between the action situations and explore how functional connections between the other components of these adjacent action situations prompted LNG infrastructure 'boom' in the BSR. In this way, NAAS analysis is different from network analysis of governance, since network analysis seeks to establish connections between the actors across different levels of governance (in energy research, for example, Parag et al., 2013; Maggetti, 2014), whereas NAAS identifies a wide array of functional connections not limiting the analysis to interpersonal or interorganizational connections. The results focus on the material and/or institutional parameters that structure one situation and influence components of the adjacent action situations.

4. Results: LNG infrastructure development in the Baltic Sea region

4.1. Focus on energy security

The first action situation where LNG is considered a viable policy option is energy security. In the definition of the World Bank, energy security encompasses three aspects: diversification of supply, minimization of price volatility, and energy efficiency (World Bank Group, 2005). Security of supply usually denotes uninterrupted supply of energy critical for the functioning of an economy (Kruyt et al., 2009). From the producers’ perspective, energy security is related to stable demand for their products, as well as access to primary resources (Sovacool and Brown, 2010). Energy efficiency, in its turn, adds to a holistic perspective on energy security, in particular in the context of developing economies (Selvakkumaran and Limmeechokchai, 2013). As a result, the matter of energy security is among the top priorities on the national energy policy agendas of most countries.

Gas trade governance is a subject of constant tensions between importing and exporting countries. As EU-Russia attempts to define comprehensive energy trade rules has not been successful, the positions of the EU member states and Russia are defined broadly by the WTO rules (Prontera, 2017). Hence, the level of decision making is national or even supranational, which gives actors a high level of control over their choices. For the European Union (EU), that imports more than half of its energy, in particular oil and gas, the issues of energy security are pressing. Until recently, four Baltic countries were net gas importers fully dependent on Russian gas supplies (Table 1).

The recurrent EU-Russia energy crises made the issue of energy dependency particular relevant and the desire for supply diversification

Table 1
Natural gas in the economy of the Baltic Sea EU countries and EU 28.
Source: Eurogas statistical report 2014. *(NB: 1 TWh = 0,0923 bcm)*

Country	Own production	Norway	Russia	Total net	% in energy mix	Companies
Denmark	56.0	4.2	0.0	35.8	17	DONG (purchase and transmission)
Estonia	0.0	0.0	7.0	7.0	9	Elering (transmission), import demonopolized 2013 (Eesti gaas, LITGAS)
Finland	0.0	0.0	36.8	36.8	8	Gasum (import and transmission)
Germany	115.8	225.0	436.0	956.0	22	Multiple transmission and import companies
Latvia	0.0	0.0	15.0	15.0	28	Latvijas Gāze (import and transmission)
Lithuania	0.0	0.0	28.0	28.0	31	AB Amber Grid (transmission), import demonopolized 2010 (eight operators)
Poland	49.4	0.0	102.3	178.5	14	Polish petroleum and gas mining (PGNiG) (import and transmission)
Sweden	0.0	1.1	0.0	12.4	2	Swedegas (transmission), import demonopolized 2007
EU 28	*1699.7*	*1046.1*	*1332.3*	*4996.0*	*23*	

particularly strong (Liuhto, 2013; Judge et al., 2016). In 2014, the EU released its Energy Security Strategy and prompted all the Member States to carry out energy security stress tests (COM(2014) 654 final). The short-term resilience of the European gas system has proven to be particularly weak in the BSR. The low resilience of the EU gas supply is due to the logistics of natural gas in Europe that is largely dependent on gas pipelines: 86% of natural gas is imported in the EU through pipelines and only 14% in form of LNG (Eurogas, 2014). Though gas pipelines remain the most cost efficient way of gas transportation, they are spatially bound and do not allow flexibility in supply choices. It has been long recognized that LNG has a potential to revolutionize the future gas logistics (Hayes, 2007), as it allows a greater volume to be stored at smaller facilities with greater flexibility.

The gas market in the BSR is characterized by a large share of state-owned gas companies. In Finland Latvia, and Poland gas is still operated as a natural monopoly, while Sweden, Lithuania and Estonia demonopolized their gas markets within the last few years. Gas market liberalization in the Baltic States came hand in hand with introducing the LNG technology (Pakalkaitė, 2016). LNG import terminal development seems favorable for the eastern Baltic Sea countries, as it allows decreasing energy dependency on single supplier (Russia) by increasing gas supply diversification. By building capability to import LNG, the gas importing countries will have an opportunity to create complex multi-supplier portfolios (Rozmarynowska, 2010), including gas import from Qatar, Malaysia, Algeria and the neighboring LNG producer – Norway (IGU, 2017) (Table 2).

Russia also seeks benefits from LNG technology that allows shipping gas overseas bypassing the transit countries. LNG terminal in Kaliningrad aims at avoiding pipeline transit to the Russian enclave currently running through Belarus and Lithuania, in line with the overall Russian strategy to favor sea transport to land-based transit (Gritsenko, 2015). Russian gas export that has been controlled by the state monopoly Gazprom for two decades has been liberalized from 1.1.2014, contributing to stimulation of LNG exports. According to Russia's *Energy Strategy up to 2030*, LNG shall not only boost gas export to new markets both geographically (e.g., in Asia) and functionally (transportation fuel business).

Table 2
TOP-10 LNG producers in 2016.
Sources: IGU (2017) and Eurogas, 2015. *(NB: 1 TWh = 0,0923 bcm)*

Country	Supply to market	Market share	% of EU LNG supply, 2014
Qatar	77.2	29.9%	47%
Australia	44.3	17.2%	< 0,1%
Malaysia	25	9.7%	< 0,1%
Nigeria	18.6	7.2%	10%
Indonesia	16.6	6.4%	< 0,1%
Algeria	11.5	4.5%	7%
Russia	10.8	4.2%	26%
Trinidad	10.6	4.1%	< 0,1%
Oman	8.1	3.2%	0.4%
Papua New Guinea	7.4	2.9%	< 0,1%

The dominant narrative of energy security lends an explanation why construction of LNG import terminals and floating storage and (re)gasification units (FSGUs) in Baltic Sea countries is being prioritized by national governments that secure significant funds to co-finance this infrastructure, in particular by applying for EU funds (EU, 2016). Lithuania offers an example of how the idea of LNG as a way of leveraging the Russian 'energopower' (Tynkkynen, 2016) by commissioning LNG FSGU under the symbolic name *Independence* that eventually did not yield commercial viability.

There is strong evidence that oil prices present an important dimension of energy security concerns and can affect the speed of energy infrastructure deployment (Csereklyei et al., 2016). Oil prices are particularly important for the LNG market due to a large share of oil-linked contracts. The sharp decrease in oil prices in late 2014 enhanced actors' expectation of lower priced LNG (IGU, 2017). Coupled with plans to increase LNG liquefaction capacity in producing countries, and consequently lower prices, this added incentives for developing new receiving and storage terminals as a measure to diversify the supply portfolio. Yet, diversification of suppliers does not equate with diversification of energy supply. Renewable energy sources have been highlighted as a potential source of enhanced energy security by switching from extensive import to more localized and decentralized production of energy (Valentine, 2011).

Whereas benefits of constructing LNG import infrastructure as a tool for diversification of gas supply are largely political, costs are both financial and environmental. Financially, LNG may not be the best way to enhance energy security given the volatility of gas market and steady decrease in price of renewables. Moreover, environmentally LNG is inferior to alternative energy solutions, thus, in the long run the benefits offered by LNG proliferation may be significantly reduced, in particular, when carbon taxation instruments are fully implemented.

4.2. Focus on reduction of shipping air emissions

The second action situation where LNG has gained a status of one of the preferred policy options is reduction of air pollution from seagoing vessels. In 1997, the International Maritime Organization (IMO) adopted the Annex VI to the International Convention on Prevention of Marine Pollution from ships (MARPOL1973/78). In accordance with this regulation, progressive reduction of air emissions from ships, including sulphur (SOx), nitrogen (NOx), particle matter (PM) and measures to improve energy efficiency were introduced. Five geographic areas, which with regard to European waters are currently limited to the Baltic Sea, the English Channel and the North Sea, have been designated as Sulphur Emission Control Areas (SECA), which set a maximum 0.1% sulphur for all ship operations in SECAs from 2015, comparing to the global cap of 3.0%.

The EU has also expressed its concerns about the impact of transport on air quality and adopted the EU sulphur directive (2012/33/EU) that enforced the IMO regulation, aiming at ensuring a substantial reduction of SOx in ship exhaust to the benefit of coastal communities and the marine environment. Apart from public regulators, an important role in the process of sulphur emission reduction in the BSR is played by ports, equipment manufacturers and other parties that are directly involved in creating conditions that enable the adoption of new technologies (Gritsenko and Yliskylä-Peuralahti, 2013). Baltic Ports Organization has played a crucial role by initiating two *LNG in Baltic Ports* projects co-financed by the EU in the TEN-T framework, which produced design, planning, and technical knowledge through assessment and feasibility studies. Finally, some of the companies operating in the Baltic Sea decided to take a first move: *Viking Grace*, the world's first passenger ferry running on LNG, has had its maiden voyage in January 2013.

Ship-owners operating in the SECA areas were offered several compliance options in order to meet the SECA regulation, including use of low-sulphur fuel (MDO/MGO); use of exhaust gas cleaning systems (scrubber); and use of LNG (EMSA, 2010). The benefit of LNG as a bunker fuel is a significant reduction of sulphur (SOx), nitrogen (NOx) and particle matter (PM) emissions in ship exhaust it allows in comparison to other options (Table 3). In addition, the promise of LNG bunkering was instigated by projections of a future global average LNG base price of $10–15/mmBTU in 2015. The expectation of reduced compliance cost (in comparison to oil-derived fuels) and the interest of suppliers to create new markets for natural gas are strong drivers for LNG penetration in shipping (IGU, 2017).

Yet, LNG is not the only available alternative to oil-based marine fuels. Methanol, which allows emission reduction at the rate of LNG (almost complete elimination of SOx and PM, 60% less NOx and humble 25% reduction of CO_2), is especially attractive in the light of carbon capture and storage (CCS) technology adoption that enables conversion of CO_2 into methanol, as well as easier storage and distribution (Winnes et al., 2015). In the BSR, methanol bunkering has been tested by Swedish shop owner *Stena Line*. Another option is the use of non-fossil shipping biofuels, which are also biodegradable and thus less harmful for marine environment. They can be produced from local materials, including waste, thereby contributing to circular economy and reducing lifecycle emissions (Yliskylä-Peuralahti, 2016). Biogas can be converted into liquefied biogas and used as a marine fuel, i.a. in combination with fossil fuels, but the deployment of this technology is at the trial stage. Wind, solar, and nuclear propulsion, though technically possible options, are not currently considered as viable alternatives in shipping. After all, it is LNG bunkering that has eventually taken hold in the BSR as LNG infrastructure is being set up.

Unlike in the case of developing LNG infrastructure as means to diversify the security of supply, where control over the decision-making process is at the highest political level, uptake of LNG as an alternative marine fuel is often referred to as a ‘chicken-and-egg’ problem. Ship owners are not willing to retrofit their vessels as long as the bunkering infrastructure is absent, whereas ports and energy companies are reluctant to invest large capital into building up the LNG infrastructure as long as there are no users. Initially, LNG did not have an infrastructural advantage in comparison to methanol or biofuels - all of them required setting up extensive new infrastructure. That is why interventions of public actors have been important: the European Commission called for development of LNG bunkering facilities in European ports by 2025, prioritizing 139 EU seaports by 2020 as part of the TEN-T projects (COM(2013) 17, Faber et al., 2010). Support has been granted by committing funding to ensure availability of LNG for maritime use on a core network of European ports as a part of 5.85 bln EUR *Connecting Europe Facility* plan available for trans-European energy infrastructure projects (EU, n/d).

In addition to the ‘chicken-and-egg’ problem, ship owners are acting under the informational uncertainties related to the cost of infrastructure development and vessel retrofitting, safety perception, and economic and regulatory aspects of LNG bunkering. Though the LNG industry enjoys a better safety record than many other segments of the energy sector (Licari and Weimer, 2011), confidence in LNG as a bunker fuel has not yet been developed due to a lack of precedent. Large ports are often located in proximity of densely populated areas and construction of LNG terminals may provoke skeptical and rejecting attitudes within local population (Licari and Weimer, 2011).[2]

Table 3
Comparison of shipping emission reduction options.
Source: own compilation from Corbett and Winebrake (2008); Wik and Niemi (2016).

	NOx	SOx	CO_2	PM
Scrubber	± 0	− 97%	± 0	− 40 … 65%
LNG	− 85%	− 99%	− 20%	− 95%
MDO/MGO	± 0	− 70… 85%	± 0	− 55 … 70%

When it comes to cost projections, LNG ‘naked commodity’ price as a benchmark for LNG bunker can be somewhat misleading as intermediaries are required between large LNG import terminals and bunkering vessels/stations (Bourgeois, 2014). The price of LNG that ‘enters’ a terminal and of that ‘entering’ an LNG-fueled vessel differs due to logistical cost. The regulatory uncertainties are expected to improve with the recent adoption by the IMO of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) that provides mandatory provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using low-flashpoint fuels, among others LNG.

While LNG has often been proclaimed the ‘marine bunker of the future’ in various BSR stakeholder events, the uptake has been slow. The early adopters, however, may gain significant advantage and positive image effects over the latecomers. Even though to date the effect of LNG facilities development on port competition in the Baltic Sea ports cannot be empirically proven, changes may be expected once a critical amount of vessels have switched to LNG. Baltic ports may need to adopt a more proactive position and try to acquire LNG infrastructure at an early stage of LNG maritime applications development as the absence or presence of bunkering facilities may affect their competitiveness in the near future (Gritsenko and Serry, 2015). Finally, it should be kept in mind that LNG is still a fossil fuel and does not represent a sustainable long-term solution. In addition, slow transition to LNG bunkering may provoke modal shift from sea to land (Holmgren et al., 2014), which would result in reduced pollution from ships, but increased pollution and congestion on the roads. In sum, the major benefit stemming from adoption of LNG is the reduction of air pollution from ships and competitive advantage for early adopters. Yet, we may ask whether the costly long-term infrastructural investment into another fossil fuel is the best available option to reduce air emissions from shipping in the long run (Yliskylä-Peuralahti, 2016).

4.3. Focus on energy transition

The third action situation is energy transition, defined as a shift from a system dominated by fossil-based energy towards a system using a majority of renewable energy sources, also increasing energy efficiency and improving energy demand management (Geels, 2002). In the BSR, energy transition is among the key topics discussed in regional policy events. All countries, including Russia, have in place public finance schemes that support adoption of renewable energy, have adopted national energy efficiency strategies, and in some countries such plans are also available at the regional level. Much of these efforts are directed towards public sector, building, and improved efficiency of energy infrastructure. In the private sector, energy-intensive industries seek ways of improving their energy balance as means of cost-saving. For example in Scandinavia, LNG has replaced oil products in a variety

[2] Licari and Weimer (2011) demonstrated that density of population and fear of negative impacts can give rise to a NIMBY (“Not in my back yard”) or even a BANANA (“Build absolutely nothing anywhere near anything”) response within local population.

Table 4
Gross inland energy consumption in the Baltic Sea region (2013).
Source: Eurostat, IEA IRENA database and EIA report 2014.

	Total, ktoe	**Growth**[a]	**Renewables** (% total consumption)	**Renewables** (% total consumption by 2020)	**Gas,** ktoe	**Growth**[a]	**Renewables** ktoe	**Growth**[a]
Denmark	18101	− 0,96	24,2	30	3 331	− 3,46	4378	5,56
Estonia	6703	2,24	12,7	25	555	− 4,46	851	4,72
Finland	33926	− 0,22	29,2	38	2 860	− 2,83	9919	2,58
Germany	324272	− 0,66	10,3	18	72 885	− 0,81	33397	8,64
Latvia	4466	− 0,35	36,1	40	1 205	− 1,49	1611	1,1
Lithuania	6687	− 3,25	18,1	23	2 165	− 1,67	1212	4,07
Poland	98159	0,78	8,7	15	13 727	1,45	8559	8,41
Sweden	49134	− 0,46	34,8	49	963	1,05	17083	1,79
Russia[b]	747400	20	3	4,5	4134600	0,5	2800	2,6

Gross inland consumption is calculated as follows: primary production + recovered products + total imports + variations of stocks - total exports - bunkers.
[a] Average annual growth rate during 2006–2013.
[b] For Russia, data is for 2012, growth notifies % in 2012 to 2002. RES 2020 goal includes only electricity generation. Gas = 459.4 bln m^3.

of industries and is used for combined heat and power production (heating, drying, or cooking of products), and as a raw material in the manufacture of hydrogen (Skangas, 2017). Finally, energy transition is a business opportunity for equipment manufacturers and energy providers in the renewable and bioenergy segments. Thus, the policy arena of energy transition is populated with a variety of stakeholders who have interest in LNG technology.

The frameworks for energy transition in the BSR were taken to the highest political level. The EU does not have exclusive competence in the field of energy, so Member States have the right to determine their own energy mix within the framework of the EU's sustainability and climate policy. Non-EU states have full control over their means of meeting the climate commitments of their national strategies and the Paris Climate agreement 2015, to which all BSR countries are signatories. Currently, the use of renewables and the future strategies vary among the countries in the Baltic Sea region. Table 4 indicates, that in all countries of the BSR, gross inland energy consumption of renewable energy has been increasing, and for some EU countries it even exceeds inland renewables production (Table 5). Apart from Germany that pursued policies aimed at increase in solar and wind power generation (*Energiewende*), the BSR countries do not benefit from solar energy, while wind energy occupies a significant share only in Denmark.

Whereas a need for change towards a more sustainable energy system has been acknowledged in all BSR countries and at the regional level by the Baltic Sea Energy Co-operation (BASREC), the set of potential actions is widely debated. Renewable sources of energy, such as solar, wind, hydropower, and alternative fuels, ultimate the picture. Among the questions that remain unsolved are the extent of and timescale when the use of fossil fuels shall remain acceptable. Moreover, the position of nuclear energy remains ambiguous. As a result, most of contemporary conversations on energy transition in the BSR are speculations about what will constitute a sustainable future energy mix, with LNG as an inherent part thereof.

LNG has been branded as the 'cleanest fossil fuel' (IGU, 2016). The idea of LNG as an intermediary step to enable energy transition is promoted by think-tanks and consultancies (see, for example, Alhashemi, 2016). The International Energy Agency estimated that LNG will play a key role in helping the shift towards a lower carbon economy and meeting world's energy needs during the transition to renewable energy. Some scientific studies also argued for the uptake of LNG as a ‘bridging’ technology (Van Foreest, 2010; Weijermars et al., 2011; Park et al., 2013). Germany, where the policy strategy of nuclear exit called *Energiewende* presupposes reduction of GHG by 80% and increase of renewables share in energy mix by 60% by 2050 (Matschoss, 2013), provides an example. The German Energy Agency (DENA) promotes LNG as a clean transport fuel to support the ambitions *Energiewende* program (Siegemund et al., 2014). The increased pressure to phase out coal in Europe through the broader adoption of a carbon price creates favorable conditions for the gas-fired power sector (IGU, 2017). In addition, LNG is considered as a way of dealing with renewable energy's intermittency and storage challenges.

The main role for the public actors in this process is securing conditions in which LNG infrastructure (transport, storage, (re)gasification) can be developed. Backed by the EU funds and other public finance, plans for LNG infrastructure in the BSR assume construction of large import terminals, as well as smaller terminals for local LNG distribution. A growing number of medium- and small-scale LNG facilities is driven by expansion of LNG end-use markets (Jankowski et al., 2014). The use of LNG as a marine fuel of the future discussed in the Section 4.2 fits within this larger trend. Demand by a large number of users (including road/inland navigation, local industries, power generation) is seen as a crucial incentive to supply LNG to ships for any large import terminal. Moss et al. (2015) conducted a study of ‘ownership’ of the German energy transition and observed a mixture of top-down and bottom-up initiatives, as well as demonstrated how shift to renewables informed the idea of regaining control of energy at the local level. Similarly in the BSR, despite the push for energy transition coming from the highest political level, the policies related to energy transition affect

Table 5
Primary production of renewable energy in the BSR (EU) (2013).
Source: Eurostat, IEA IRENA database, and IEA report 2014.

	Total,ktoe	**Solar, %**	**Biomass & waste, %**	**Geothermal, %**	**Hydropower, %**	**Wind, %**	**Main support scheme**
Denmark	3240	2,1	68,1	0,2	0	29,5	feed-in tariff
Estonia	1222	0	95,7	0	0,2	4,1	feed-in premium
Finland	9934	0	88,2	0	11,1	0,7	feed-in premium
Germany	33680	9,6	70,8	0,4	5,9	13,2	feed-in tariff & auction
Latvia	2137	0	87,8	0	11,7	0,5	feed-in tariff
Lithuania	1288	0,3	92,1	0,1	3,5	4	feed-in tariff
Poland	8512	0,2	91,1	0,2	2,5	6,1	power auctions
Sweden	16770	0,1	63,4	0	31,5	5	green certificate scheme
Russia[a]	1331800	0	0,6	0,1	1,1	0	capacity auction

[a] Data for Russia for 2012.

Table 6
Network of adjacent action situation in uptake and proliferation of LNG infrastructure in the Baltic Sea region.
Source: Author.

Rule type	Component	Energy security	Clean shipping	Energy transition
Boundary	Actors	Nation states, EU, energy companies.	IMO, EU, ship owners, ports, energy companies.	Nation states, EU, local industries, energy companies.
Position	Positions	Energy-importer Net energy-exporter Bi/multilateral	Regulators Adopters Experts	Regulators Adopters Experts
Choice	Actions	LNG suppliers' diversification Increase renewables Diversify customers	MDO/MGO Scrubber LNG Other 'new fuels'	Energy efficiency Increase renewables LNG "bridging fuel" Nuclear
Aggregation	Control	Highest political level	"Chicken-and-egg"	Mixture of top-down and bottom-up initiatives
Information	Information	Assessment studies Energy diplomacy	Assessment & feasibility studies Pilot projects	Assessment studies Pilot projects German example
Scope	**Outcome**	**LNG infrastructure**	**LNG infrastructure**	**LNG infrastructure**
Payoff	Cost/benefit	Investment/Supply diversification, 'energopower' leverage	Long-term costly investment, persistent GHG/compliance, New business opportunities	Investment, persistent GHG/intermittency & storage solution, New business opportunities

and challenge local actors, necessitating their involvement and response.

Investment into building up a comprehensive LNG infrastructure is costly, but it may pay off in the mid-term for the early adopters as they will have a competitive advantage once LNG use will become a common place in local industries (Acciaro et al., 2014; Songhurst, 2014). Besides emission reduction, among the benefits of including LNG into the future energy mix they name diversifying and adding resilience to the energy system. Yet, a comprehensive assessment of cost and benefits stemming from uptake of LNG as a 'bridging' energy technology shall take an account of lifecycle emissions of LNG, which include up-, mid-, downstream and fugitive emissions. No studies proposing assessment models have been identified. Moreover, the optimal future energy mix is an open question as it depends not only on the current, but also on the new technologies and their comparative cost-efficiency.

4.4. Analyzing network configuration

Table 6 aggregates information about the components of the three adjacent action situations where LNG is presented as a policy option that can alternate the status quo. LNG infrastructure is the shared physical outcome – and a solution to a policy problem - in three action situations: energy security, clean shipping, and energy transition. Also other components of the action situations overlap and these linkages realize in form of synergies that affect the pay-off calculations.

In terms of actors, we observe that the nation states are the core decision-making actors when it comes to energy policy and choices regarding the future energy mix, while in the shipping action situation international organizations (the IMO and the EU) are central actors to prompt LNG as a bunker fuel through regulatory measures. The EU also secured significant funds for Baltic EU ports development, including LNG infrastructure. Local industry actors, including ship owners, are dependent in their choice of energy/fuel options on availability of infrastructure and cost comparison of different options. The nation states, within the EU and independently, are dependent in their capacity to implement energy transition initiatives, as actors at the local level, both public and private, have a significant control over technological developments. This is very different in the energy security situation, where states are not mere regulators of private activity, but rather active promoters of LNG infrastructure that is seen as a way to diversify both suppliers and customers, and a bargaining chip in the regional energy politics. Energy companies are involved in all action situation, as they are strategically pursuing the development, construction and operation of LNG terminals acting as the primary investors into the new infrastructure, often at transnational level.

There are different actions available in each action situation that could solve the core problem of the situation. In order to ensure energy security, energy importing countries can reduce their dependency on a single supplier by diversifying their energy portfolio through uptake of LNG or by increasing the share of inland renewable energy production. In order to address air emission from shipping, ship owners can use different types of fuels, including low-sulphur fuels, LNG, methanol, biofuels, or install a scrubber. In order to enable transition of the energy system to low-carbon, energy users can increase energy efficiency, increase the use of renewable energy sources, accept nuclear energy or use LNG as a 'bridging' solution to substitute other more polluting fossil fuels. In fact, the options in the three action situations are not completely mutually exclusive; future energy mix will most probably be based on a combination of LNG and renewable energy sources. Yet, LNG appears to be the option that can fulfill policy expectations in all three action situations in the immediate future. Thus, while LNG may be considered inferior to other options within a single action situation, the outcome can be better understood when considered within a network of adjacent situations.

The role of expert assessments and feasibility studies can be highlighted in all three situations. Future assessments play an important role in structuring the field of possible actions and legitimizing policy choices (Anderson, 2010), also in relation to natural gas, where private consultants "become partly responsible for new energy development on a local and global scale" (Mason, 2007, p. 368). The flow of information from one policy situation to another becomes apparent from the policy documents: for instance, Finnish and Estonian energy strategies make explicit linkages between multiple use options of LNG. While the individual action situations are prone to incomplete information, network membership allows actors easier access to information and lowers the efforts necessary for persuasion, consequently lowering transaction costs. The government-funded pilot projects and sustainability experiments in facilitating the diffusion of uptake of new energy and environmentally-related technologies, highlighted in the literature on technological innovation (see for example Raven, 2007 and Hendry et al., 2010), complement and illustrate expert assessments.

Finally, it appears that the cost/benefit component has shared cost (infrastructure investment), while offering different benefits in different situations. The fact that a number of problems can be addressed through one investment seems attractive to the investors, since the development of energy infrastructure is costly, and LNG is no exception. The cost of an LNG terminal construction ranges from 45 to 55 mln USD for a small-scale facility to up to 10 bln USD for a large-scale multifunctional plant and an LNG-carrier vessel costs about 200 mln USD. In the BSR, the EU has been the major investor into infrastructural projects since the EU Eastern Enlargement, state contributions through guaranteed loans have also been typical (Kuznetsov and Olenchenko, 2013). The initial push is coming from the EU and its member states willing to diversify their energy supplies, and by choosing LNG technology this goal aligns with the growing pressure to decarbonize energy systems. LNG is now seen as a 'bridging' technology to increase adoption of renewables, which, in its turn, will also contribute to energy security. Eventually, as LNG facilities start to appear along the Baltic coast, it becomes more viable for ship owners to consider LNG as a viable option for complying with tightening environmental regulation for shipping.

5. Discussion

Network of adjacent action situation concept was proposed by McGinnis (2011) to advance the diagnostic capacity of scholarly investigations relying on IAD framework. NAAS recognizes the dynamic and networked nature of action situations and suggests that in order to understand an outcome in a certain action situation we often need to take into consideration adjacent actions situations that may influence this outcome. The relations captured by NAAS concept are simultaneously multi-level, as two-level games explaining the vertical entanglements between national and international policy-making (Putnam, 1988), and polycentric, highlighting horizontal connections between policy arenas, similar also to ecology of games framework (Long, 1958; later adapted by Lubell, 2013). NAAS analysis allows us not only to recognize the linkages between action situations, but also to assess the factors that affect the development of linkages and outcomes. In what follows, I will highlight the contributions of a polycentric approach to the analysis infrastructure governance that emerged from the empirical analysis, with relevance beyond the BSR case, specifically, the scalar, discursive, and temporal aspects of infrastructure policy choices.

Scale is a persistent topic of infrastructure policy research (see for example, Priemus et al., 2008). Energy infrastructure has a strong local component, including embeddedness of physical installations into concrete landscape, while individual installations "easily scale up to complex regional infra-structure systems" (Goldthau, 2014, p. 136). In case of LNG infrastructure, one single terminal can have an impact on the local actors, but a system of terminals has a potential to enhance the overall resilience of the regional energy systems, thereby contributing to public policy goals of energy security and short-term CO_2 reduction. The case of shipping emissions reduction illustrates the benefits of looking at infrastructure policy from a larger scale particularly well. A ship owner would want to be able to bunker their ship at any port, thus, fuel availability is paramount to propulsion technology choice and port choice. NAAS framework makes us sensitive to the question of scale: examining one policy arena in a single country provides a different idea of what is going on than examining three policy arenas at the regional scale.

Secondly, the flow of information between the action situations emphasizes the role of both expert assessments and pilot projects in policy framing (for an overview on framing in energy policy see Scrase and Ockwell, 2010). NAAS emphasizes that not only actors, but also other elements of action situations may be overlapping and interdependent, so that resources, information and rules transcend the given action situation, and affect the outcomes in adjacent situations. The framing of LNG as a 'bridging' solution and 'the cleanest fossil fuel' makes it seem as a silver bullet in all analyzed action situations, thereby creating a stronger case for developing LNG infrastructure. At the same time, expanding use of LNG is at odds with the strategy to decarbonize the economy through increased use of renewable energy adopted by all the EU countries. Stephenson et al. (2012) argue that the transition fuel argument for natural gas is unsubstantiated by the best available evidence and amounts to 'greenwashing'. The availability of alternative options in all action situations (such as, renewable and alternative sources of energy) shall be evaluated, instead, the possibility to use LNG for multiple purposes is advertised as one of its key benefits.

Finally, the temporal aspect of infrastructure highlights how path dependency is preserved (for instance, as a 'technological lock in', see Unruh, 2000). As return on investment for large infrastructure projects, such as LNG terminals, is estimated at around 20–30 years, the actors within existing energy power structures possess strong interest in keeping them operational for a longer term even in the presence of alternative, more environmental-friendly technologies. The 'bridging' technology argument strongly used in maritime and energy transition contexts reinforces the energy independence argument used in energy security context, even though it had initially no importance in that context. Even though the rapidly decreasing price of renewables may yield gas as a 'bridging' technology obsolete, extensive LNG infrastructure can legitimize the use of natural gas and prolong the use of fossil fuels, by committing actors to technical lock-in of energy infrastructure that is incompatible with the long-term climate change mitigation strategies.

6. Conclusions and policy implications

It was suggested in the introduction to this article that two contributions would be made. One has been to apply network of adjacent action situations (NAAS) as a conceptual approach that helps to explain the readiness of states and energy companies to invest in building up significant LNG infrastructure in the BSR within a relatively short period of time. The evidence here suggests that a possibility to fulfill policy expectations simultaneously within three issue-areas (energy security, mitigation of air emissions from shipping and energy transition) reinforced the optimism with regard to constructing LNG infrastructure. Consideration of the multiple overlapping elements and actors' ability to draw upon resources and information that transcends the boundaries of a single action situation has been important to understand the functioning of adjacent action situations as a network.

The second contribution to energy policy research is rather practical and concerns with the policy implications. The analysis demonstrates how LNG being an attractive cross-sectoral solution can affect actors' capacity to respond to future policy challenges by bringing inertia and draining the available resources. While at the national level, an LNG terminal can indeed diversify the energy mix and enhance supply security, a system of terminals emerging at the regional scale bears potential for creating a 'technological lock-in' that will commit the region to continued use of fossil fuels due to the existence of path dependent infrastructure. The 'stubborn' nature of costly LNG infrastructure may delay, rather than accelerate, decarbonisation of the regional economy. Moreover, it may be burdening the state budgets in case an overcapacity will be created at the regional level. The EU and energy companies are the key promoters – and key investors – into the Baltic LNG infrastructure development. The perception of spreading the cost of technology uptake among all the future potential beneficiaries is complemented by safeguarding the demand for LNG technology in the future in order to prolong the acceptable payback time. Yet, in case of future supply-demand imbalance, which is not something unheard of in volatile hydrocarbon markets, heavily co-financed through public investment LNG projects may become unprofitable and weigh on state budgets due to sheer scope of the physical infrastructure.

Summing up, NAAS provides a diagnostic tool to identify the relevance of interdependencies between adjacent action situations for planning and governance of energy systems. The observation that actions occurring in one action situation may influence adjacent situations poses questions regarding the 'points of policy intervention' (McGinnis, 2011, p. 73). The procedure of identifying and specifying which elements of the adjacent action situations overlap, which actors and in which positions dominate these situations, as well as how rules, resources, and information transcend the boundaries of action situations to blend arguments endogenous to a policy setting with new arguments that initially were outside its scope. The use of this procedure for decision support can help identifying the unintended consequences of infrastructural choices that are made within a network of adjacent action situations.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.enpol.2017.10.014.

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