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Gas pipelines critical infrastructure network

Keywords

critical infrastructure, gas pipeline, North Stream, Baltic Gas Pipeline Critical Infrastructure Network (BGPIN), Global Baltic Network of Critical Infrastructure Networks (GBNCIN)

Abstract

The liquid natural gas (LNG) will be commonly used by shipping and industry in the future. In this paper we present existing and planned natural gas networks in the Baltic Sea region, installed through the Baltic Sea. These gas pipeline installations create the Baltic Gas Pipeline Critical Infrastructure Network (BGPIN) that is one of eight critical infrastructure network of the Global Baltic Network of Critical Infrastructure Networks (GBNCIN).

1. Gas pipeline installations in the Baltic Sea region

One of the biggest infrastructure in the Baltic Sea region is the system of North Stream pipelines. *Figure 1* shows North Stream pipeline across the Baltic Sea with other shore based interconnection pipelines.

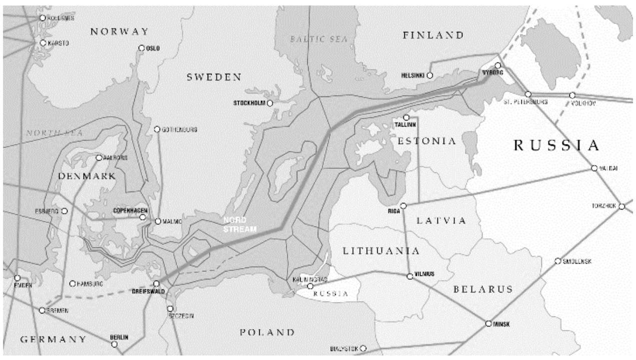

Figure 1. Gas pipelines across Baltic Sea and basic land connections (source: http://www.gazprom.com)

The Nord Stream twin pipeline system through the Baltic Sea runs from Vyborg, Russia to Lubmin near Greifswald in Germany. The pipelines were built and are operated by Nord Stream AG. The Nord Stream route crosses the Exclusive Economic Zones of Russia, Finland, Sweden, Denmark and Germany, as well as the territorial waters of Russia, Denmark and Germany [11].

The Nord Stream offshore pipeline is ordered and operated by Nord Stream AG. It runs from Vyborg compressor station at Portovaya Bay along the bottom of the Baltic Sea to Greifswald in Germany. The project includes two parallel lines. The construction of Line 1 of the twin pipeline system began in April 2010, and was completed in June 2011. The transportation of gas through Line 1 began in mid-November 2011. Construction of Line 2, which runs parallel to Line 1, began in May 2011 and it was completed in April 2012. The gas transport through the second line began in October 2012. Each line has a transport capacity of roughly 27.5 billion cubic metres of natural gas per annum [11]. The length of the subsea pipeline is 1.222 kilometres of which:

– 1.5 kilometres in Russian inland,
– 121.8 kilometres in Russian territorial waters,
– 1.4 kilometres in the Russian economic zone,
– 375.3 kilometres in the Finnish economic zone,
– 506.4 kilometres in the Swedish economic zone,
– 87.7 kilometres in the Danish territorial waters,

– 49.4 kilometres in the Danish economic zone,
– 31.2 kilometres in the German economic zone,
– 49.9 kilometres in German territorial waters and
– 0.5 kilometres in German inland.

Each of two parallel lines has capacity of 27.5 billion cubic metres of natural gas per year. Pipes have a diameter of 1.220 millimetres, the wall thickness of 38 millimetres and a working pressure of 220 bars. It has an annual capacity of 55 billion cubic metres. However, due to EU restrictions on Gazprom, only 22.5 billion cubic metres of its capacity is actually used. The two 1.224 kilometres offshore pipelines are the most direct connection between the vast gas reserves in Russia and energy markets in the European Union. Combined, the twin pipelines have the capacity to transport a combined total of 55 billion cubic metres of gas a year to businesses and households in the EU for at least 50 years. As the project strengthens the EU energy market and reinforces security of supply, the project has been designated as being of "European interest" by the European Parliament and Council. Both lines of the Nord Stream Pipeline system were laid in three sections. The three sections have different wall thicknesses following the direction of the gas flow. Gas pressure reduces as it makes its way through the pipelines. Therefore, the walls are thickest at the start of the pipelines at Portovaya Bay, Russia, and thinnest at the landing point at Greifswald, Germany. Each of the pipelines is made up of about 100,000 pipes. Along the pipeline route, five harbour sites supplied concrete-coated pipes on a continuous basis to the lay barges [10]. A 917-kilometre onshore pipeline in Russian territory built by Gazprom connects Nord Stream to the Russian gas transmission system. Two onshore connections from Greifswald to the south and west of Germany, with a total length of more than 900 kilometres, built by W&G and E.ON SE, connect the pipeline with the European gas transmission system [11].

The Baltic Pipe is a 230 km long planned submarine pipeline that would connect Redvig in Denmark and Niechorze in Poland with the capacity of 3 billion cubic metres a year [13]. The aim of the project is the construction of the subsea gas pipeline connecting the natural gas transmission systems of Denmark and Poland, which would bring the following potential benefits [4]:
– possibility for transmission of natural gas from the Norwegian Continental Shelf to Poland,
– connecting the Baltic Pipe to the LNG terminal under construction in Świnoujście (just started to work in December 2015) could in the future guarantee Scandinavian countries access to the global liquefied natural gas (LNG) market,
– direct impact on the diversification of gas sources for Poland as well as for Denmark and for the entire European Union in the future.

The project is currently in pre-investment phase [4].

The Energobaltic Sp. z o. o. is a unique plant in Poland or even Europe. It uses the natural gas coming from the oil explored from the bottom of the Baltic Sea in "Baltic Beta" Sea Oil Mine owned by LOTOS Petrobaltic S.A. After the process of drying and compressing, the so called dense phase gas, which is a suspension of hydrocarbons in dry gas, is transferred by the underwater pipeline to the gas separation station in the heat power plant in Władysławowo (*Figures 2, 3*). The gas pipeline is 82.5 km long and its diameter is 115 mm. The pressure of the gas transferred by it reaches 13 MPa [7], [8].

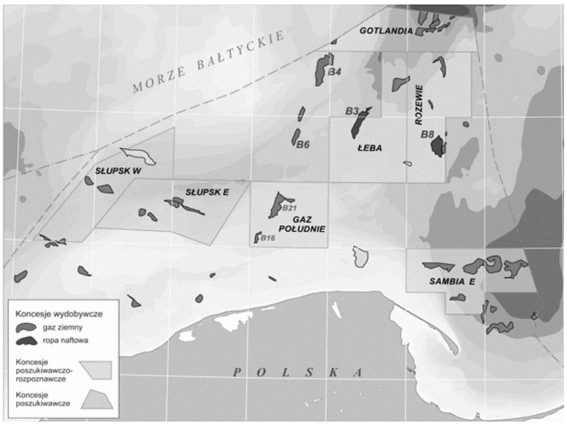

Figure 2. Gas pipeline delivers product from B3 field to the northernmost part of Poland

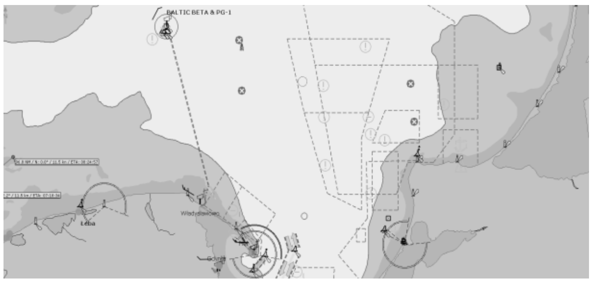

Figure 3. The location of "LOTOS Petrobaltic" oil rigs and the gas pipeline at the southern Baltic Sea (source: MarSSIES – Maritime Office in Gdynia)

The Balticconnector natural gas pipeline will connect the gas transmission pipeline networks of Finland and Estonia. Connecting national gas transmission networks would significantly improve the regional availability and security of supply of gas and thus enhance the reliability of energy transmission in various circumstances in Finland and the Baltic countries. The Balticconnector is categorised as a priority project and has therefore been granted Community financial assistance. Previously, the

Balticconnector offshore pipeline project became part of the EU founding Trans-European Energy Network (TEN-E) programme. Connecting Finland and Estonia gas infrastructures it will guarantee a more coherent and diversified natural gas grid within the Baltic Sea Region, and there by improve the security of supply of natural gas to the north-easterly EU member states. The offshore pipeline would enable the exchange of natural gas between Finland and Estonia, and at the same time offer the possibility for making use of the underground natural gas storage facilities in Latvia. The pipeline would be able to operate in both directions – as a true "interconnector" pipeline – making it also possible to transfer natural gas through Finland to Estonia. If the Baltic Sea regional LNG terminal location will be decided to be in Inkoo, the Balticconnector pipeline will be connected to existing gas network in Finland and to the planned Finngulf LNG terminal in Inkoo. Linked to large-scale LNG terminal, Balticconnector would create a coherent natural gas network in the Baltic States and Finland. However, the offshore pipeline will be equipped with a compressor station at both ends to allow bidirectional flow also without the operation of the LNG terminal. The developer of the Balticconnector gas pipeline project is Gasum Oy. According to the developer's schedule it would be possible to start the Balticconnector construction works in the beginning of 2016 and to commission the pipeline during 2017. Injection capacity to the Balticconnector pipeline will be about 7.2 million m^3/day i.e. about 300.000 Nm^3/h. The annual throughput from the terminal to Balticconnector is estimated to be 5 TWh/a. The planned annual gas transfer capacity of Balticconnector will be two billion cubic meters. In the preliminary plans, the offshore pipeline is of size 20 inches (= 508 mm). The length of the offshore pipeline is about 81 kilometres. The optimisation of the route will take place in connection with the detailed route planning based on geotechnical and geophysical surveys [3].

2. Gas pipeline critical infrastructure network interactions with the Baltic Sea environment and other critical infrastructures

Those all described in previous Section 1 gas pipeline installations create the Baltic Gas Pipeline Critical Infrastructure Network (BGPIN).

The natural disasters and hazards, threats coming from other installations, hazards from dumped munitions and terrorism-related hazards are the main threats for gas pipelines. Fortunately, there are no known successful terrorism attacks on underwater pipelines.

Generally, seismic events, tsunamis, rough sea with strong swells, onshore winds, and storms could affect a subsea pipeline. Problems are also created by buried subsea pipelines becoming exposed, particularly after violent wave action associated with storms. The landfall pipelines are exposed to the risk of rockfall impacts and the ice cover of coastal area [10]-[11]. The experience from the Gulf of Mexico shows that pipelines on the seabed suffered only minor damage after major hurricanes; most damage affected platforms and risers leading from bottom pipelines to the surface and for pipelines up to a depth of 60 meters [1]. For NEGP, sea storms, rockfall and ice cover come into question, since seismic events or tsunamis are unlikely in the Baltic Sea region [11].

Before the construction of Nord Stream number of environmental aspects arose. Among others there were concerns that during construction the sea bed would be disturbed, dislodging World War II-era naval mines and toxic materials including mines, chemical waste, chemical munitions and other items dumped in the Baltic Sea in the past decades, and thereby toxic substances could surface from the seabed damaging the Baltic's particularly sensitive ecosystem. It is estimated that at least 40,000 tonnes of chemical warfare materials have been dumped in the Baltic Sea. The southern Baltic coast and the Gulf of Finland are the main dumped munition zones (*Figure 4*) [5].

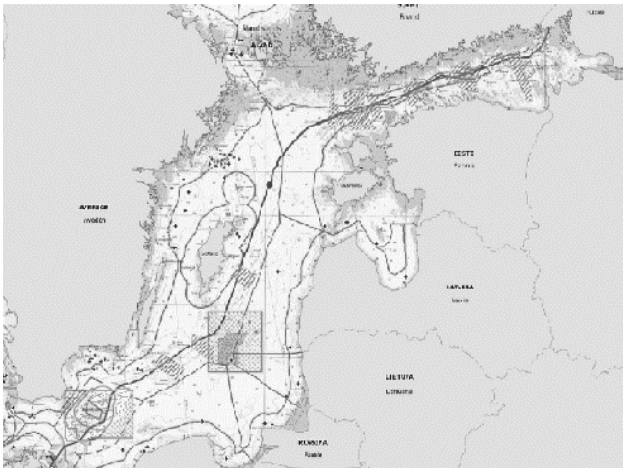

Figure 4. Dumped munitions in the Baltic Sea and Nord Stream pipeline

Swedish Environment Minister Andreas Carlgren demanded that the environmental analysis should include alternative ways of taking the pipeline across the Baltic, as the pipeline is projected to be passing through areas considered environmentally problematic and risky. Sweden's three opposition parties called for an examination of the possibility of rerouting the pipeline onto dry land. Finnish environmental groups campaigned to consider the more southern route, claiming that the sea bed is flatter and so construction would be more straightforward, and therefore potentially less disruptive to waste, including dioxins and dioxin-like compounds, littered on the sea bed. Latvian president Valdis Zatlers said that Nord Stream was environmentally hazardous as, unlike the North Sea, there is no such water circulation in the Baltic Sea. Ene Ergma, Speaker of the Riigikogu (Parliament of Estonia), warned that the pipeline work rips a canal in the seabed which will demand leveling the sand that lies along the way, atomizing volcanic formations and disposing of fill along the bottom of the sea, altering sea currents.

The impact on bird and marine life in the Baltic Sea is also a concern, as the Baltic Sea is recognized by the International Maritime Organization as a particularly sensitive sea area. The World Wide Fund for Nature requested that countries party to the Baltic Marine Environment Protection Commission of Helsinki Commision (HELCOM) safeguard the Baltic marine habitats, which could be altered by the implementation of the Nord Stream project. Its Finnish branch said it might file a court case against Nord Stream AG if the company did not properly assess a potential alternative route on the southern side of Hogland. According to Nord Stream AG, this was not a suitable route for the pipeline because of the planned conservation area near Hogland, subsea cables, and a main shipping route. Russian environmental organizations warned that the ecosystem in the Eastern part of the Gulf of Finland is the most vulnerable part of the Baltic Sea and assumed damage to the island territory of the planned Ingermanland nature preserve as a result of laying the pipeline. Swedish environmental groups are concerned that the pipeline is planned to pass too closely to the border of the marine reserve near Gotland. Also Greenpeace is concerned that the pipeline would pass through several sites designated marine protection areas.

The anchoring, trawling and fishing are the additional threats to subsea pipelines. Trawling or the anchors of drifting ships may cause damage, e.g. moving the pipelines or disrupting them. However, the probability of damage to pipelines caused by vessels (anchoring, running to the bottom) has been estimated to be once per 237 years [9].

5. Conclusion

The Baltic Gas Pipeline Critical Infrastructure Network (BGPIN) is an element of the Global Baltic Network of Critical Infrastructure Networks (GBNCIN). Moreover, GBNCIN is consisted of:

- the Baltic Port Critical Infrastructure Network (BPCIN),
- the Baltic Shipping Critical Infrastructure Network (BSCIN),
- the Baltic Oil Rig Critical Infrastructure Network (BORCIN),
- the Baltic Wind Farm Critical Infrastructure Network (BWFCIN)
- the Baltic Electric Cable Critical Infrastructure Network (BECCIN)
- the Baltic Oil Pipeline Critical Infrastructure Network (BOPCIN)
- the Baltic Ship Traffic and Port Operation Information Critical Infrastructure Network (BSTPOICIN).

Modelling of GBNCIN operation process is described in [2]. Next, parameters' identification, characterictics' prediction of the process and its characteristics optimization with respect to the GBNCIN safety and its resilience to climate/weather change are going to be done in the next steps of the EU-CIRCLE GMU researches described in [7].

Acknowledgments

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