Analisis of the technical solutions that have been applied to the LNG terminals in Świnoujście and Klaipėda

Introduction

Poland is a country that has its own natural gas reserves. Its largest part is in 66% of the Polish Lowlands, 29.5% in the foothills of the Carpathians, and a small amount in the zone of the Baltic Sea. In recent years, mining of domestic resources accounted for about one third of the national demand for energy and gas was over 4 billion m$^3$. The ability to meet the demand forces upon us the need to import the raw materials from other countries. In recent years we have seen an increase in the gas coming from the Russian Federation, which is at the level of 7 billion m$^3$. The annual demand for gas in Poland is constantly increasing, and the Word import has become increasingly important. The situation that has led Poland to take steps to diversify gas supplies took place in 2009 due to the Russian-Ukrainian crisis. The impasse of a lack of agreement between the parties on the issue price per 1000 cubic meters of gas. Countries affected by this dispute were divided into three groups:

- The most affected countries: Bulgaria, Slovakia, Serbia, Bosnia and Herzegovina, Macedonia
- Countries seriously affected: Poland, Hungary, Greece, Croatia, Austria, Czech Republic, Slovenia, Romania
- The countries least affected: Germany, Italy, France [2].

The first effects of the conflict Poland suffered of 2 January 2009. In point of handover showed a decrease in the amount of transmitted natural gas from Ukraine by 6%. As a result of these circumstances, there was an increase offtake of gas from Russia. From day to day delivery from Ukraine decreased, which resulted in a disruption in the Polish economy and industries [2].

LNG Terminal in Świnoujście is a strategic point which will ensure energy security of the country by varied lines of gas import. The European Union generally apply this method of securing the country against the lack of energy supply in the XXI century. Over the next few years the Member States of the European Union will slow the extraction of their own raw materials, and will invest more capital in the import. The predicted the biggest LNG exporters for EU countries are Russia, Norway and Algeria. It is estimated that in the next few years the sector transport much liquefied natural gas develops [2].

Historical data show that in 2005, imports of LNG to Europe ranged from 37 billion cubic meters. It is expected that by 2015 its level rises and reaches the level of 225 billion cubic meters. Polish terminal in the first stage of its operation will allow reception of 2.5 billion cubic meters of gas, and sometimes these opportunities will increase from 5–7.5 bcm [2].

Rating adopted technical and organizational solutions manual terminal for maritime transport

Poland is not the only country who has decided to take action in order to diversify gas supplies from Russia. A similar solution has decided to Lithuania, which close the port of Klaipeda on construction investment.

In both cases, the aim is the same. However in Lithuania, it was decided to other technical and organizational solutions. Differences in technical solutions between terminal in Świnoujście and Klaipeda, are presented in Table 1.

Before making a definitive decision on the location of investment both in Lithuania and Poland considered several contingency location of the object. Poland has taken into account: the western part of Świnoujście coast and the eastern part located near Gdansk [4].

Eventually it was decided to initiate the construction of the terminal in Świnoujście (Figure 1), because of the distance from the Danish port, which will reduce the distance, which will have to overcome methane transporting LNG. The advantage of the currently selected location is also reducing transport congestion on the route navigable, located to the north of the island of Bornholm – this could reduce the number of collisions occurring in the fairway. Due to its location in an area less populated, the choice of this location will be beneficial from the point of view of industrial and safety [7].
Tab.1. Differences between terminals technology in Świnoujście and Klaipeda [1]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>LNG terminal in Świnoujście</th>
<th>LNG terminal in Lithuania</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Port of Świnoujście</td>
<td>Port of Klaipeda</td>
</tr>
<tr>
<td><strong>The technology used</strong></td>
<td>Terminal land-sea</td>
<td>Vessel for storage and regasification FSRU&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>The ability of a terminal</strong></td>
<td>In the I stage: 2.5 bcm/year *</td>
<td>2–3 bcm/ year</td>
</tr>
<tr>
<td></td>
<td>In the II stage of 5 bcm/year *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the III stage of 7.5 bcm/year *</td>
<td></td>
</tr>
<tr>
<td><strong>Terminal area</strong></td>
<td>48 acres of land part of</td>
<td>Depending on the parameters of FSRU</td>
</tr>
<tr>
<td></td>
<td>and 130 hectares of marine parts</td>
<td></td>
</tr>
<tr>
<td><strong>Expandability terminal</strong></td>
<td>Increasing export capacity to 7.5 bcm/year</td>
<td>Ability to expand business to the regional activist</td>
</tr>
</tbody>
</table>

<sup>1</sup> FSRU – Floating Storage and Regasification Unit

* Shipping capacity depends on the amount of used tanks. Assumed that in the first phase will be used which would allow LNG storage tank at a level of 2.5 bcm/year. Currently, the LNG Terminal formed two tanks, which increased its capacity to 5 bcm/year. Land-use plans for LNG terminal also provide place for a third tank, whose construction will create the possibility of storing a total of 7.5 bcm/year, which gives half of the gas demand in Poland.

In Lithuania, were taken into account such contingencies as the southern part of the port of Klaipeda and Butinge Melnragė. Diagnosed with the most appropriate position will be the southern part of the sea port of Klaipeda. Qualities such locations are favorable meteorological conditions, which allows the safe operation of the terminal, a safe distance from the residential area, the existing essential infrastructure at the port closest possible connection to the pipeline, and short construction time [3].

![Fig. 1. Location of the terminal LNG in Świnoujście](image-url)
In terms of technology both terminals are very different. Terminal in Świnoujście is divided into two parts. The first of these is part of the sea, which has been marked in Figure 1 in blue and the land highlighted in yellow. The Terminal is equipped with two above-ground tanks, which will be able to store a total of about 5 bcm of gas per year. LNG gasification plants liquefied gas and unloading arms mounted on the pier formed part of the Maritime Terminal. Their role will be unloading of liquefied natural gas from an oil tanker.

In Klaipeda was made a decision to use a modern methods, which is the vessel to storage and re-gasification gas FSRU. FSRU is a solution that is mainly used by collecting smaller quantities of LNG cargo. On the platform, moored near the waterfront is turning and storage of gas. Then the gas is unloaded by using underground pipelines and transferred to the main transmission network [3].

The use of technology is the solution, cheaper faster FSRU in construction than the terminal overland and flexible, because it allows you to change the location of the unit when necessary.

Figure 3 shows a diagram of the FSRU technology [3].
Sea-going vessel intended for the carriage of gas, otherwise known as a tanker, it flows into port loaded on board LNG gas. Then the vessel is parallel to the FSRU. When connected to the loading Bay of the arms, that is placed on the unit to the regasification and storage, followed by the transfer of liquefied gas. Transported LNG goes to re-gasification area, in which it is subjected to changing the character of the liquid gas. Then the gas is stored on this unit [5].

For the gas to be able to go on the national circuit is unloaded using salaried arms, and then gas unloading line is passed to a pipeline.

Despite the fact that in both cases, the two different technology solutions are used, shipping capacity is on the same level. Terminal in Klaipeda gives ability to receive gas at a level of 2 to 3 bcm of gas per year. The terminal in Świnoujście gives the ability to receive 2.5 bcm/year, assuming that the stage will be used only one tank [5].

The area used for the construction of the terminal to a significant extent is dependent on the technology used. The port of Klaipeda is using vessel, so it has an area of coastal water in the vicinity. Dimensions magazine floating FSRU, fall within the limits of: length – approx. 288 m, width – about 48 m. For the remaining part of the surface of terminal run pipelines for gas unloading platform of FSRU [9]. In Świnoujście investment has been torn apart by including approximately 48 hectares.

The possibility of extending the range of services provided by the LNG terminal in Świnoujście

Both terminals offer opportunities for growth and expansion over the next few years. The terminal in Świnoujście due to the adopted technological solutions, allows for multiple solutions. One of them is the extension works of the third tank, and thus increase export capacity to 7,5 bcm/year, equivalent to half the annual demand for gas in Poland.

In Klaipeda is dependent on the increase in the diameter of the pipeline. When the diameter of the pipeline will be increased from 300 mm to 700 mm, the LNG terminal capacity will reach up to 4 billion cubic meters per year.

In November 2012, the company conducted a survey LNG Polish market under the name Market Screening, whose task was to obtain information about market demand for the expansion of the terminal in Świnoujście and the ability to provide additional services.

Market research related to the demand for the expansion of the terminal in the area:
- increases regasification capacity – this service will allow to provide higher power regasification of the LNG terminal. This should be understood as the amount of fuel gas (LNG), which can be picked up at the starting point for 1 hour
- trans-shipment of LNG on Tank Car – this service will allow the distribution of gas by means of road transport. At the time of putting the terminal into operation, it will be equipped with two positions for the transshipment of LNG tank trucks with a total handling capacity equal to 95 000 tonnes per year
- trans-shipment of LNG on tanker rail-offering this service would require expansion of terminal infrastructure in order to gain space serving as a railway siding, which will be possible to make the fuel reloading LNG to its further distribution. Figure 4 shows a simulation of the sample position for loading rail tankers [11]
- bunkering of sea-going vessels with LNG fuel. In Świnoujście was built unloading platform, which can also function as a terminal for bunkering ships. Bunkering is a process is a process which involves refueling tankers using LNG fuel [4].

![Fig. 4. Position for loading rail tankers](Fig. 4. Position for loading rail tankers [10])
For the terminal in the future, it may be a profitable business, because in the next few years, the market will be introduced LNG fueled vessels. The reason for this is Directive 1999/32/EC relating to the sulfur content of certain liquid fuels and further reduce emissions from maritime transport. The so-called Sulphur Directive. Directive tightens rules on emissions of sulfur dioxide into the atmosphere. Under the new arrangements, which will come into force on 1 January 2015, requires a ten-fold reduction in sulfur oxide emissions to the environment. This means lower emissions of sulfur compounds from 4.5% to 0.5%, and sulfur emission control area (called Sulphur Emission Control Area) SECA, to which the Baltic Sea, North Sea and English Channel Mache from 1.5% to 0.1%. These rules may cause problems for many maritime companies that cannot afford to install desulphurization plant for fuel.

Market research conducted by the investors of the LNG terminal in Świnoujście, showed that the greatest interest was accompanied by the construction of the third tank. Bunkering Terminal in Świnoujście it plans for the future do not yet have the form of the project. However, preliminary observations can be concluded that in the future a terminal in Świnoujście can offer bunkering of both large passenger ships and smaller vessels at sea [10].

Bunkering LNG can be done in three ways, which are shown in Figure 5:

1. Ship-to-ship called (ship-to-ship – STS) on the waterfront or at sea
2. Tank-to-ship (called tank truck-to-ship – TTS)
3. Terminal-to-ship through the pipeline (called terminal-to-ship via pipeline – TPS).

When designing the right solution for bunkering vessels LNG terminal to be taken into account many factors, such as distance, traffic volume, capacity, frequency, security, proximity to other ports of bunkering and demand [6].

The first method of ship-to-ship, gives the possibility of bunkering parallel to the waterfront as well as at sea. The possibilities of using the latter option is very limited due to weather conditions such as strong winds, waves, visibility, ice, currents.

The first solution is the best and most realistic, when the vessel nears the other vessel docked at the wharf. To execute such bunkering LNG terminal in Świnoujście must be equipped with reflectors and durable mooring ropes, which are necessary when using the STS method [5].

In practice, this method is flexible, and the LNG transfer by this method is reduced by defining a minimum quantity of gas at the level of the transferred 100 m³. The standard amount of gas transferred marine vessels is from 1000 m³ to 10000 m³.

Bunkering by tank truck-to-ship, this solution does not require very high costs compared with other bunkering which consists of small units in an amount of from 100 m³ to 200 m³ of gas. The service delivery time is relatively long, as it requires the involvement of three to four tankers. One tank car is able to provide from 40 m³ to 80 m³ of LNG, depending on the design of the container [4]
The third method of bunkering is to connect a vessel to the pipeline from the LNG terminal. This simplifies the realization of bunkering operations of large amounts of gas in a short time. It applies to liner shipping, as a key element of this type of transport is fast delivery of port operations. Depending on the needs of the size tank, the LNG fuel is taken, ranging from 20 to 100,000 m³. A very important role in the solution play space conditions prevailing at the terminal. Most effective methods of TPS can be observed when the distance between the terminal and the waterfront are small. When the distance is larger marine vessels, this creates a difficulty in supplying the fuel, which bind to expand the infrastructure and the need to position the additional pipelines. This method is not flexible, because fueling can take place only in the designated location on the waterfront, which may interfere with other activities performed in the harbor [4].

To increase the flexibility of the TPS method, we can use the barge as a terminal intermediary in bunkering operations. This solution will also reduce interference from other activities carried out in the port [4]. The above discussed methods of bunkering LNG marine vessels are shown in Table 2.

<table>
<thead>
<tr>
<th>Type of ship / technology bunkering</th>
<th>STS</th>
<th>TTS</th>
<th>TPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship Ro-Pax/Ro-Ro</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Tugs</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bulk</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Container</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>LNG tankers</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>LNG bunker vessels</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>LNG tankers (140,000 bcm)</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Offshore</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Smaller passenger ships</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Larger vessels</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VLCC</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

1 – The most appropriate solution of ships bunkering of LNG fuel
2 – The right solution of ships bunkering of LNG fuel
3 – Inadequate solution of ships bunkering of LNG fuel

Considering the logistical and operational aspects, in each method, we can distinguish the following advantages and disadvantages. This is represented in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>STS</th>
<th>TTS</th>
<th>TPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>High performance load</td>
<td>Low investment costs and operating</td>
<td>The ability to download large amounts of fuel</td>
</tr>
<tr>
<td></td>
<td>The ability to download large amounts of fuel</td>
<td>–</td>
<td>The ability to quickly bunkering</td>
</tr>
<tr>
<td></td>
<td>The possibility of refueling at sea (expansion of the market)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>The need for maneuvering in port by ships approaching the bunkering</td>
<td>The ability to use only a small naval units</td>
<td>The need for bunkering vessels dedicated to this place</td>
</tr>
<tr>
<td></td>
<td>High investment costs</td>
<td>Low efficiency of loading</td>
<td>It takes place at the terminal</td>
</tr>
</tbody>
</table>

In summary, the method of bunkering STS is a flexible solution investment and operating costs of this method are high, because the application requires equipment berth with suitable facilities and unit for bunkering, so this method can be used both on the waterfront and in the open sea. It may be difficult for ports with a small area of the port basin.

TPS method, allows the execution of bunkering vessels individuals with high demand for large quantities of LNG fuel in a relatively short time of implementation. It requires the use of fixed installations and requires a large surface area [4].

The third method bunkering TTS, it’s an affordable and flexible solution. The disadvantage of this method is limiting the amount of fuel LNG bunkering which we carry out bunkering seagoing vessels.

The most preferred option due to its location and proximity to the ferry terminal, it would choose the TPS method, due to the fact that in the future LNG terminal in Świnoujście creates opportunities for bunkering small and large units. This method will allow refuel cruise liners in a short period of time. In order to bunkering small vessels TPS method should be supported by the TTS solution [1].
Further opportunities to extend the scope of services offered by the LNG terminal in Świnoujście are:

- Reloading for smaller LNG vessels – these are the expectations of the market related to the provision of transshipment in Świnoujście LNG supplied to smaller vessels for further distribution
- Services of storage LNG Terminal – this involves ensuring the possibility of gas storage tanks, which are located at the terminal in Świnoujście, without having to start the process of regasification [7].

The directions of development of the LNG terminal in Świnoujście

Poland is a country on the European continent midwives. Its area is 312.683 thousand km². In terms of volume takes 9th place in Europe and 63 in the world.

Among the most important natural resources at its disposal, there is also a gas.

At the end of 2012, the state of natural gas resources in Poland amounted to 89 billion cubic meters, and the ratio remained at a level of 23 units, as shown in Fig. 6.

![Coefficient reserve / production in 2005-2012](image)

In the above figure, we can notice a sudden decrease in the reserves of natural gas resources in Poland. From 2008 to 2012 it fell by about 4 units.

Due to the high drop in their gas resources, and the problems arising from the supply of gas from Russia, Poland decided to ensuring energy security of the country. To this end, a project of the LNG terminal in Świnoujście.

The LNG terminal is a complex of facilities for the reception, regasification and storage of gas. Świnoujście terminal to its surface and the location offers opportunities to develop and expand their services.

The first stage involves the supply of gas from Qatar, at a level ensuring the ability of mailing of 2.5 bcm/year. To ensure that such capacity is needed one overland tank. The LNG terminal has land reserves for the construction of three ground tanks, each of them can provide the ability mailing about 2.5 billion cubic meters/year.

During the construction of the terminal in the first stage it was decided to build two reservoirs, which make the export capacity will reach 5 bcm/year. Figure 7 shows the locations of the two above-ground tanks to be produced in the first stage of construction of the LNG terminal in Świnoujście.
Figure 7 shows the arrangement of the terminal facilities. The tanks area is located between the area of the blow-out, process and part of the sea LNG terminal. In the first phase, will be created the tanks indicated by symbols I and II.

Poland annually consumes about 14 billion cubic meters of gas per year. This is a much larger amount than that that terminal is able to satisfy the first stage of use.

Based on market research, the decision was taken to increase the power of re-gasification terminal and is therefore built a third LNG storage tank, whose location is shown in Fig 8.
A third LNG storage tank was placed in the same row, where there are tanks I and II. Ranked third tank is marked in red.

After the construction of another reservoir and increase export capacity to 7.5 billion cubic meters per year LNG terminal in Świnoujście will provide security for the country at half the demand for gas in Poland.

Conclusions

The construction of a terminal for receiving and regasification of LNG in Świnoujście covers a large part of the area. The total area used for the construction of the terminal, is 48 acres in section 130 hectares of land and sea in part, on which was built semi-open body of water known as the external port.

Lithuania compared to Polish, decided on a different solution technologies. Due to the use of technology FSRU, significantly reduced the area occupied by the terminal (it depends on the parameters of the vessel).

Regasification capacity of technology in Klaipeda estimated 2-3 bcm per year. The terminal in Świnoujście offers the sent-out capacity of 2.5 bcm per year, taking into account the use of a single LNG tank. At present, Polish terminal is equipped with two tanks and a place to build a third tank without expending the area devoted to the construction of the terminal.

These terminals create opportunities for increased capacity. The terminal in Świnoujście has been able to increase that capacity to 7.5 bcm per year. This value corresponds to half of the annual gas demand in Poland. The gas Terminal in Klaipeda, can increase its ability to slip to 4 bcm per year. This is dependent on increasing the diameter of the pipeline of 300 mm to 700 mm.

The LNG terminal will give you the opportunity to extension of services provided. These include: bunkering ships, LNG storage, handling LNG tanker railroad, handling LNG tankers, increasing the power regasification of LNG transshipment to smaller vessels. Based on the results of market research called Market Screening was decided that the most favorable future possibility of expanding services is the ability to expand the terminal of infrastructure and equipment for bunkering vessels. This argument is based on the “Directive sulfur” which will come into force on 1 January 2015, which in sulfur emission control area (SECA – called Sulphur Oxide Emission Control Area) to which the Baltic Sea, North Sea and English Channel. The Directive will exacerbate requirements for sulfur oxide emissions from marine fuels from 0.5% to 0.1%.This process will cause the change the propulsion of watercraft for LNG.

Abstract

The energy balances of individual economies growing importance of natural gas LNG as an energy source. Individual countries are seeking to diversify its natural gas supplies from a variety of reasons: economic, strategic and energy security. It is one of the most important investments in the Polish sea ports, which requires cooperation with suppliers of raw materials, as well as the creation of the necessary infrastructure and provide the technology needed for the handling and transmission of natural gas. It is understood that the construction of transshipment Terminal in Świnoujście, gas is a complex and technically advanced venture, to ensure efficient handling of LNG to be supplied by sea through the specialized vessels called tankers. The main purpose of the article is to analyze developments support the LNG terminal in Świnoujście by maritime transport, as well as to assess the technical solutions adopted by terminal handling maritime transport compared with LNG terminal in Klaipeda. Indicated on the possibility of extending the services provided by the terminal, shows a project development services for bunkering vessels with LNG-powered, enabling business expansion in the future, LNG terminal in Świnoujście. Assessment were also subjected to the directions of development of the LNG terminal in Świnoujście.
LITERATURA / BIBLIOGRAPHY


