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Infrastructure Standard - an Indicator of Sufficient Level of Infrastructure for Security of Gas Supply

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***Abstract* – In the setting of increasing European concern over gas supply security, this article provides an empirical assessment of the gas supply security level of one the most gas dependant countries in Europe: Latvia. The analysis challenges the existing infrastructure standard (N-1 indicator) and places an emphasis on developing a detailed understanding of a country's specific gas supply set up, the structure of its gas consumption.**

Keywords – security of gas supply, infrastructure standard

I. Introduction

The completion of the gas internal market, increase of security of supply and fostering of competition are the main priorities outlined in the European Union's (thereafter – the EU) energy policy. One of the crucial issues in Europe at the moment is security of gas supply. This subject became even more important after gas supply interruptions and limitations took place in January of 2009 in some countries of the EU.

In light of the increasing European concern over the security of gas supply, the investments in infrastructures to increase the resilience and robustness of the gas system in the event of a supply disruption are required. The actions aimed at achieving the objectives in the gas sector have been largely intensified over the last two years. The most important risk-reducing measures of gas supply are related to the development of gas supply infrastructure including gas pipelines and gas storage facilities. Therefore, the main emphasis is put on the increase of the security by creating the incentives to invest in necessary interconnections to meet a common minimum level of preparedness – the so-called infrastructure standard (*N* – 1 indicator).The objective of the infrastructure standard is to describe the ability of a country to satisfy total gas demand in the event of disruption of the single largest gas infrastructure, i.e. to define the level of security of gas supply in the short term.

II. Security of Supply and Infrastructure Standard

A discussion on security of supply requires a common understanding of the concept. There are several competing definitions of supply security. They all include the idea of avoiding sudden changes in the availability of energy relative to demand. However, the definitions show strong differences with respect to the impact measure that is used for the benefits of increased continuity and the level of discontinuity that is defined as insecure.

The concept of the continuity of services can be found in the study on gas supply security by Noel and Findlater. According to them, "security of gas supply (or gas supply security) refers to the ability of a country's energy supply system to meet final contracted energy demand in the event of a gas supply disruption" [1].

Definitions of energy security often emphasise the economic cost and physical availability of energy. Thus, the International Energy Agency defines energy security as "the uninterrupted physical availability at a price which is affordable, while respecting environmental concerns" [2].

Following Findlater and Noël and for the purpose of this article the definition of short-term energy security that emphases the ability of the energy system to react promptly to sudden changes within the supply-demand balance will be used.

Measures to safeguard security of gas supply require continuous operation of the natural gas infrastructure in the case of disruption of the single largest element of the system. Estimation of the level of security of supply for a separate country or region can be performed using the indicator that characterizes quantitatively the existing security threat and its degree.

The infrastructure standard – *N* – 1 indicator, means assessment of the situation in the event of disruption of the single largest gas infrastructure delivery connection. For the calculation of *N* – 1 indicator, the following formula is used [3]:

$$N-1=\frac{EP_m+P_m+S_m+LNG_m-\mathrm{I}_m}{D_{\max}}\cdot 100,\quad N-1\geq 100\% \qquad (1)$$

where:

EP_m – technical capacity of entry points (in MCM/d), other than production, liquefied natural gas (hereafter – LNG) and storage facilities covered by P_m, S_m and LNG_m, means the sum of the technical capacity of all border entry points capable of supplying gas to the calculated area;

P_m – maximal technical production capability (in MCM/d) means the sum of the maximal technical daily production capability of all gas production facilities, which can be delivered to the entry points in the calculated area;

S_m – maximal technical storage deliverability (in MCM/d) means the sum of the maximal technical daily withdrawal capacity of all storage facilities, which can be delivered to the entry points of the calculated area, taking into account their respective physical characteristics;

LNG_m – maximal technical LNG facility capacity (in MCM/d) means the sum of the maximal technical daily send-out capacities at all LNG facilities in the calculated area, taking into account critical elements like offloading, ancillary services, temporary storage and re-gasification of LNG as well as technical send-out capacity to the system;

I_m – means the technical capacity of the single largest gas infrastructure (in MCM/d) with the highest capacity to supply the calculated area. When several gas infrastructures are connected to a common upstream or downstream gas infrastructure and cannot be separately operated, they shall be considered as one single gas infrastructure;

D_{max} – means the total daily gas demand (in MCM/d) of the calculated area during a day of exceptionally high gas demand occurring with a statistical probability of once in twenty years.

The technical capacity of all remaining available gas infrastructure in the event of disruption of the single largest gas infrastructure should be at least equal to the sum of the total daily gas demand of the calculated area during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years. If in the event of interruption it is possible to rearrange deliveries without any supply disruption, the *N*-1 criterion is met (infrastructure standard is at least equal to 100 %). Infrastructure standard can be used as minimum acceptable risk criteria.

III. Gas Supply Set Up of Latvia and Associated Risk

At present, JSC "Latvijas Gaze" is the only enterprise in the natural gas market of Latvia. JSC "Latvijas Gaze" according to conditions of share purchase agreement has exclusive rights on transmission, storage, and distribution until 2017 and the license for the sale of natural gas as well as unlimited and exclusive right to use Incukalns Underground Gas Storage (UGS) for the period of twenty years in Latvia.

Natural gas is supplied to Latvia via two parallel pipelines (DN700) from Russia only during the warm period of the year (April-September), and it is accumulated in the underground gas storage facility in Incukalns.

The total volume of Incukalns UGS is 4.45 BCM, including working gas volume of 2.30 BCM. Currently, the maximum Incukalns UGS capacity during gas injection is 18 MCM/d. Maximum storage operation pressure is equal to 105 bar. After putting into operation of second gas dehydration unit in 2012, maximum Incukalns UGS capacity in the initial gas withdrawal period (October) can reach 30 MCM/d. The performance of UGS is reduced to 10 mcm/d at the end of the gas withdrawal period (March / early April), when the pressure in the storage drops to 30 bar. Incukalns UGS is the largest gas infrastructure in Latvia.

The JSC "Latvijas Gaze" ensures the supply of natural gas to 442,370 customers in Latvia. Daily natural gas consumption in Latvia in winter is 12.14 MCM/d; and it is provided only from Incukalns UGS. Incukalns UGS is used not only for customers in Latvia, thus securing reliable gas supply for the whole region. During the heating season, JSC "Latvijas Gaze" also supplies natural gas from the Incukalns UGS to Estonia and North-Western Russia as presented in Fig. 1.

There is also a connection to Lithuania, but currently it is only used as an emergency backup system for the supply emergency cases and when repairs of pipelines are carried out.

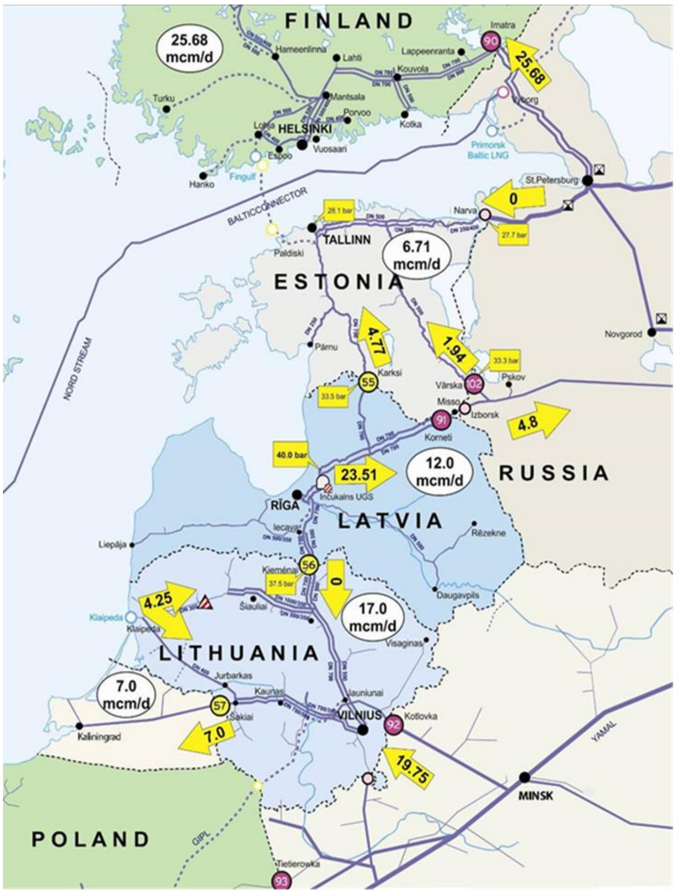

Fig.1. Maximal natural gas flow in Latvia.

Given its gas supply infrastructure set-up, Latvia is at risk of gas supply disruption due to either pipeline failure during the summer months or to the failure of Incukalns UGS on which it is totally reliant during the winter months.

Taking into consideration the following technical capacities of entry points - from Russia 20 MCM/d and form Lithuania 6.48 MCM/d as well as the mentioned withdrawal capacity of Incukalns UGS - 30 MCM/d and maximal daily consumption of 12.00 MCM/d, the infrastructure standard for Latvia calculated according to formula (1) is 220.66 %. As infrastructure standard N-1 for Latvia is bigger than 100 % i.e. 218.18 %, it means that in the event of a disruption of supply from Incukalns UGS, the capacity of the remaining infrastructure should be able to satisfy total gas demand of the country during a day of exceptionally high gas demand statistically occurring once every twenty years.

In order to verify and confirm the assessment of the level of the security of supply based on the infrastructure standard N-1, response scenario method of risk assessment was applied. Response scenarios, for their part, reveal the capability of the system to react properly in the cases of a variety of unwelcome events.

In case of gas supply disruption from Incukalns UGS, the supply to Latvia can be organized from Russia through gas metering station Korneti and from Lithuania trough gas metering station Kiemenai. Gas supply to Estonia would be provided from Russia trough gas metering station Värska and entry point Narva. According to the modelling of gas supply flows in the Baltic States and Finland made by transmission system operators of the mentioned countries, in this case the system has the following limits [4]:

- maximum available flow from Russia to Latvia trough gas metering station Korneti – 4.0 MCM/d;
- maximum available flow from Lithuania to Latvia trough gas metering station Kiemenai – 2.0 MCM/d;
- maximum available flow from Russia to Estonia trough gas metering station Värska – 2.0 MCM/d;
- maximum available flow from Russia to Estonia trough entry point Narva – 2.0 MCM/d;
- there are no more available volumes of gas in Russia, to supply the region.

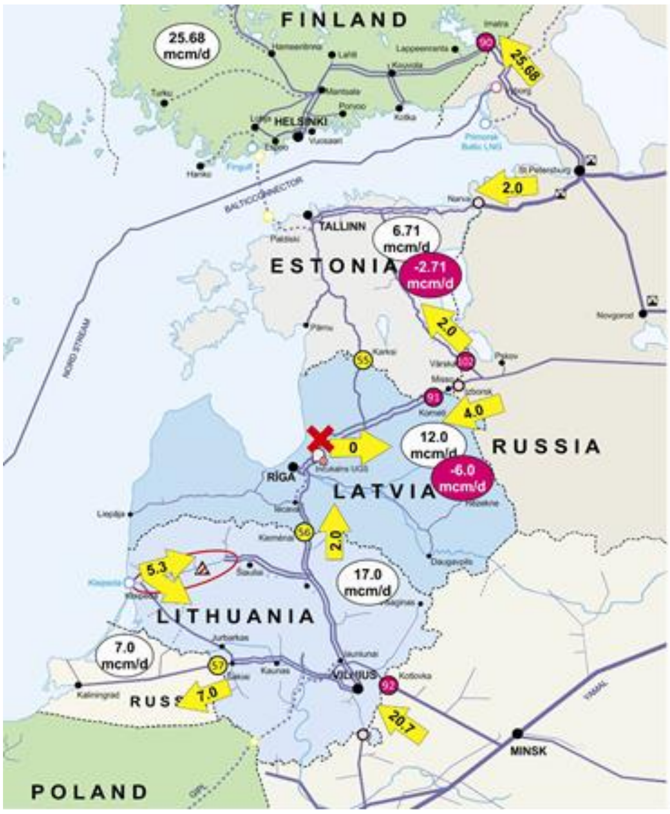

Fig.2. Natural gas flow during the gas disruption from Inčukalns UGS.

As a result of gas flows rearrangement during the gas disruption from Inčukalns UGS (see Fig.2.):

- gas deficit in Latvia – 6.0 MCM/d;
- gas deficit in Estonia – 2.71 MCM/d;
- Lithuanian gas markets are fully supplied.

The empirical analysis shows that the actual level of security of gas supply for Latvia is much lower than the result shown by N-1 calculation.

IV. MODIFIED FORMULA OF INFRASTRUCTURE STANDARD

The existing formula on N-1 criteria calculation does not reflect the real situation because it does not take into consideration technical availability of gas system at the moment of high gas consumption, but is based only on technical maximum capacity of the entry points. Therefore, it is proposed to modify the formula as follows:

$$N-1=\frac{EP_e+P_e+LNG_e+I_e}{D_{\max}}\cdot 100, \qquad (2)$$

where:

EP_e – technical capacity of entry points (in MCM/d), other than production, LNG and storage facilities covered by Pm, Sm and LNGm, means the sum of the available technical capacity of all border entry points capable of supplying gas to the calculated area;

P_e – available technical production capability (in MCM/d) means the sum of the maximal technical daily production capability of all gas production facilities, which can be delivered to the entry points in the calculated area;

S_e – available technical storage deliverability (in MCM/d) means the sum of the maximal technical daily withdrawal capacity of all storage facilities, which can be delivered to the entry points of the calculated area, taking into account their respective physical characteristics;

LNG_e – available technical LNG facility capacity (in MCM/d) means the sum of the maximal technical daily send-out capacities at all LNG facilities in the calculated area, taking into account critical elements like offloading, ancillary services, temporary storage and re-gasification of LNG as well as technical send-out capacity to the system;

I_e – means the available technical capacity of the single largest gas infrastructure (in MCM/d) with the highest capacity to supply the calculated area. When several gas infrastructures are connected to a common upstream or downstream gas infrastructure and cannot be separately operated, they shall be considered as one single gas infrastructure;

D_{max} – means the total daily gas demand (in MCM/d) of the calculated area during a day of exceptionally high gas demand occurring with a statistical probability of once in twenty years.

In the modified infrastructure standard formula, the maximal capacities of gas system elements are preplaced with the available during high gas demand.

Taking into the consideration the following available technical capacities of entry points at the moment of maximal gas consumption in Latvia - from Russia 4 MCM/d and form Lithuania 2 MCM/d as well as withdrawal capacity of Incukalns UGS – 23.15 MCM/d and maximal daily consumption of 12.00 MCM/d, the infrastructure standard for Latvia calculated according to formula (2) is 50%. The result of infrastructure standard calculation corresponds to the findings of response scenario analysis.

V. CONCLUSIONS

Infrastructure indicators can provide insights into the state of an energy system, therefore, they can be used to track a country’s resilience to short-term gas supply disruptions.

The relatively high infrastructure standard (N-1 indicator) for Latvia wrongly suggests that Latvia could access alternative gas if the Inčukalns UGS failed in the middle of a cold winter (which, however, is highly uncertain at best).

A meaningful indicator would have to reflect precisely, for each country, to what extent would gas supply be effectively replaced or demand effectively suppressed in the face of a disruption. Modified formula for the infrastructure standard calculation, which takes into consideration the available capacity of the gas supply system during the period of maximal gas demand, provides the result approximating to the results of empirical analysis.

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