THE NATURAL GAS SUPPLY OF THE LATVIAN MUNICIPALITY DURING THE LOCAL ENERGY CRISIS

L. Zemite*, E. Nevercika, L. Jansons, I. Bode, A. Koposovs,
N. Kondrahins, A. Jasevics

Riga Technical University,
Faculty of Electrical and Environmental Engineering,
Institute of Power Engineering
12-1 Azenes Str., Riga, LV-1048, LATVIA
*e-mail: laila.zemite@rtu.lv

Natural gas is an essential element of the Latvian and the Baltic energy portfolio, so its supply disruption can seriously affect the national economy and energy security of our country.

The article focuses on a basic case study of the natural gas supply to one of the Latvian municipalities, when the energy crisis is announced. It also marks potential vulnerabilities factors that may cause the natural gas supply shortages or disruption periods of different length for a wide spectrum of the Latvian natural gas consumers – starting with households and finishing with large industrial consumers and energy producers.

A legal framework analysis along with an emergency natural gas supply review has been proposed as well, taking into account the actual distribution of the natural gas consumption among the urban energy users, which can be compared with references included into the Cabinet of Ministers Regulation No. 312 “Procedures for the Supply of Energy Users and Sale of Heating Fuel during Declared Energy Crisis and in Case of Endangerment to the State” (hereinafter – Regulation 312).

Keywords: *Definition, energy crisis, Latvian municipality, natural gas, user groups.*

1. INTRODUCTION

Natural gas is regarded not only as one of the most notable energy resources worldwide – the cleanest of conventional fossil fuels, but also as an essential element of the Latvian and the Baltic energy portfolio. Since the mid-twentieth century, it has always played an important role in the energy supply of the Baltic region, including Latvia. Its disruption can seriously affect the national economy and energy security of our country. The Latvian natural gas market comprises approximately 35 % of the natural gas market in the Baltic States [1], and in a midterm perspective natural gas is considered to be an important low carbon energy resource to ensure smooth transition to carbon neutrality both on the national and regional scale [2], [3].

Natural gas as transitional fuel might benefit significantly to more active introduction of both the renewable gases and “green” hydrogen to the EU primary energy sector [4]. The natural gas consumption has been rather stable in the EU, with import amount equalling 300–400 billion cubic meters (hereinafter – BCM) a year. However, the EU natural gas consumption in 2020 fell by 3 % in comparison with 2019 to 394 BCM due to the COVID-19 pandemic, but the imports throughout 2020 reached 326 BCM, down from 358 BCM in 2019 [5].

The stability of positions of natural gas as a future transitional fuel is a reason why awareness in the European Union (herein-

after – the EU) must be risen on the natural gas security of supply issues in order to prevent situations, when access to natural gas resources is limited, disrupted or terminated. The concept of energy crisis normally applies to the whole energy sector or one or several neighbouring countries, when all the energy supply chain is affected, but practically the cause of such a crisis almost always lies in problems related to one particular segment of energy sector, which can have a stronger or weaker impact on functionality of others. The energy crisis inevitably brings the disruption to the rest of the national economy as well [6].

In order to minimise the predictable national economy impact of the natural gas related energy crisis, models should be developed and studies initiated in order to understand, whether existing legislation frameworks for the natural gas supply reductions to different groups of users are set up correctly, or need some improvements. The current research presents calculations based on real natural gas consumption data of one Latvian municipality – dubbed “town A”, in high and low natural gas consumption points of 2018 – months of February and July. The calculations are done in order to verify, whether the national regulation on limitation of the natural gas supply in Latvia correlates with real consumption fluctuation date of the “virtual” local energy crisis.

2. THE CONCEPT OF ENERGY CRISIS AND ITS DEFINITION IN LATVIA

An energy crisis is a reduction of the amount of available energy at national or local level that adversely affects the nor-

mal functioning of consumers and can have social, political and economic consequences [7]. The energy crisis might affect

the whole energy sector, or only part of it. Serious and continues natural gas supply disruptions, shortages or terminations also directly relate to appearance of energy crisis or situations, when one or several groups of the natural gas consumers (users) might be limited in their actual access to the said energy resource. In all, the security of the natural gas supply currently plays one of the crucial roles in the EU energy sector, and is one of the pillars of its stability and sustainability [8]. In addition, it is regarded as one of the bridging fuels that will ensure and support smooth energy transition in the EU Member States, with predictable reaching of continental-scale carbon neutrality by the mid-21st century [9]–[11].

Regulation 2017/1938 of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010 [12] clarifies the established levels of the energy crisis, which are divided into three categories:

- early warning category (early warning): if specific, serious and credible information is available that a situation is likely to arise which could lead to a significant deterioration of the natural gas supply and is likely to lead to an alert or emergency; the early warning level can be activated by an early warning mechanism;
- alert level category (alert) occurs in the event of the natural gas supply disruption or extreme demand for natural gas that significantly worsens the natural gas supply situation, but the market is still able to cope with the disruption or demand without the need for non-market measures;
- emergency level category (emergency) is declared when there is an exceptional demand for natural gas or there is a

major natural gas supply disruption or a significant deterioration in the natural gas supply situation, and if all relevant market measures have already been implemented, but the natural gas supply is insufficient to meet the remaining demand for the gas resources. Therefore, additional non-market measures should be introduced to ensure the supply of natural gas to protect the customers [12].

At the same time, the Latvian legislation, in accordance with Chapter II, Section 4 of the Civil Protection and Disaster Management Law, identifies several scale-related variations of the energy crisis:

- local disasters – the scale of damage caused by a disaster does not exceed the borders of the administrative territory of one local government;
- regional disasters – the scale of damage caused by a disaster exceeds the borders of the administrative territory of one local government;
- state disasters – the scale of damage caused by a disaster affects the entire territory of the state or a significant part thereof [13].

Regulation 312 prescribes how supply of the users should be carried out during an announced state or local energy crisis. It also sets up procedures, by which energy supply merchants, as well as merchants who provide security reserve services, and merchants to whom licenses for fuel business have been issued in accordance with the procedures specified in regulatory enactments, sell the fuel at the request of the state or local government's energy crisis centre.

In accordance with Clause 9 of Regulation 312, the Latvian natural gas distribution system operator (hereinafter – DSO)

JSC “Gaso” is authorised to put restrictions on the amount of supplied natural gas, when the energy crisis is declared in the country.

During the energy crisis, if the supply of natural gas is disrupted, all the natural gas users should be divided into four groups: the priority users, the first group energy users, the second group energy users and the third group energy users.

The priority group consists of households, schools, pre-school educational institutions, hospitals, state and municipal long-term social care and social rehabilitation institutions, crisis centres, social rehabilitation institutions for persons addicted to narcotic, toxic or other intoxicating substances, emergency services, telecommunications units, emergency medical service, state fire and rescue service, the national armed forces, police, state border guard, state security institutions, water supply and sewerage works, penitentiaries, mobilized civil defence formations.

The first group of energy users is made of administrative institutions, energy generation objects (power plants), railways, airports, bus stations (if distance of bus routes (trips) in one direction exceeds 50 km), ports, the Latvian Environment, Geology and Meteorology Centre, responsible state custodians of the material reserves (in the places of storage of state material reserve resources).

The second group comprises ambulatory health care facilities, food and agricultural production plants, local public transport (all types of public transport in cities and municipal territories, if the distance of the transport route (trip) in one direction does not exceed 50 km), food supply transport, industrial facilities, state and local government institutions not included in the first group.

The third group, however, is much less defined, and it includes those not included in the first three groups [14].

If the energy crisis is declared, Clause 2 of Regulation 312 stipulates that the following restriction to the natural gas supply can be applied by the DSO to its users in Latvia:

- in case of the first level energy crisis – the possibility to ensure energy supply decreases by 7]–12% of daily (average) energy consumption;
- in case of the second level energy crisis – the possibility to ensure energy supply decreases by 12–17 % of daily (average) energy consumption;
- in case of the third level energy crisis – the possibility to ensure energy supply decreases by more than 17 % of daily (average) energy consumption [14].

On 8 May 2018, the Cabinet of Ministers of the Republic of Latvia approved amendments to Chapter IV, Paragraph 12¹ of Regulation 312, by adding this information: “In order to ensure the daily capacity of the natural gas withdrawal from Incukalna underground gas storage (hereinafter – UGS) facility during the energy crisis, the unified natural gas storage and transmission system operator must guarantee that in the period from the end of the natural gas injection season of the specific storage cycle to March 1 of the following year the amount of active gas intended to ensure the supply of natural gas to Latvia does not fall below 3160 thousand MWh (300 million m³) [15]. It means that the strategic reserve of natural gas is formed to be kept in Incuklans UGS facility, so the Latvian consumers must be guaranteed to receive less severe impact of the possible natural gas related energy crisis, at least for a certain period of time.

3. MODELLING FRAMEWORK FOR THREE LEVELS OF ENERGY CRISIS

Regulation 312 clearly states that a certain percentual energy supply restriction is

set for each consumer group depending on the level of the energy crisis (Table 1).

Table 1. Energy Cuts Required According to Regulation 312 (%)

Distribution of the users*	Priority group	The first group	The second group	The third group
The natural gas delivery cuts (%), the 1st level energy crisis	0	0	20	20
The natural gas delivery cuts (%), the 2nd level energy crisis	0	20	40	100
The natural gas delivery cuts (%), the 3rd level energy crisis	0	40	80	100

Formulas (3.1) and (3.2) were developed and applied to calculate the energy reduction (cuts) in the “town A”, where energy crisis was announced. Using For-

mula (3.1), the total energy cuts in “town A” (m^3/day) are calculated depending on the level of the declared energy crisis:

$$Q_{\text{nodr}} + Q_{\text{pirm}} + Q_{\text{otr}} + Q_{\text{tr}} = Q_{\text{n.lim}}, \quad (3.1)$$

where

Q_{nodr} – energy cuts to the priority users, m^3/day ;

Q_{pirm} – energy cuts to the first group users, m^3/day ;

Q_{otr} – energy cuts to the second group users, m^3/day ;

Q_{tr} – energy cuts to the third group users, m^3/day ;

$Q_{\text{n.lim}}$ – total energy cuts depending on the declared energy crisis level, m^3/day .

Formula (3.2) calculates the above-mentioned total energy cuts in the “town A” depending on the level of the announced

energy crisis percentwise in order to compare the obtained results with those specified by Regulation 312.

$$\frac{Q_{\text{n.lim}}}{Q} * 100 = Y_{\text{n.lim}}, \quad (3.2)$$

where

Q – the total amount of the energy consumed in the “town A”, m^3/day ;

$Y_{\text{n.lim}}$ – the energy reduction during the energy crisis, $\%/ \text{day}$.

By modelling the energy crisis scenarios for the “town A”, energy consumption throughout the reference year 2018 was taken into account. Depending on the weather, the amount of natural gas used

can fluctuate significantly during the winter and summer seasons, so the calculations are based on the natural gas consumption results of two reference months – February, when maximal amount of the natural

gas is most frequently consumed in Latvia due to long-term low outdoor temperatures,

and July, when the natural gas consumption drops to a minimum.

3.1. Level 1 Energy Crisis Modelling

The priority group users:

$X_{nl} = 0$ – in accordance with 0 % of the natural gas consumption cuts for this group of users;

February 2018:

$$\begin{aligned} Q_{nodr} &= 67912.74 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{nodr.min} &= 50\,709.38 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{nodr.max} &= 90\,837.06 * 0 = 0 \text{ m}^3/\text{day}; \end{aligned}$$

July 2018:

$$\begin{aligned} Q_{nodr} &= 5449.96 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{nodr.min} &= 4\,040.64 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{nodr.max} &= 6\,241.22 * 0 = 0 \text{ m}^3/\text{day}. \end{aligned}$$

The first group users:

$X_{pl} = 0$ – in accordance with 0 % of the natural gas consumption cuts for this group of users;

February 2018:

$$\begin{aligned} Q_{pirm} &= 293908.51 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{pirm.min} &= 219\,456.87 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{pirm.max} &= 393\,118.96 * 0 = 0 \text{ m}^3/\text{day}; \end{aligned}$$

July 2018:

$$\begin{aligned} Q_{pirm} &= 69005.68 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{pirm.min} &= 51\,161.37 * 0 = 0 \text{ m}^3/\text{day}; \\ Q_{pirm.max} &= 79\,024.45 * 0 = 0 \text{ m}^3/\text{day}. \end{aligned}$$

The second group users:

$X_{ol} = 0.2$ – in accordance with 20 % of the natural gas consumption cuts for this group of users;

February 2018:

$$\begin{aligned} Q_{otr} &= 30907.86 * 0.2 = 6181.57 \text{ m}^3/\text{day}; \\ Q_{otr.min} &= 23\,078.41 * 0.2 = 4\,615.68 \text{ m}^3/\text{day}; \\ Q_{otr.max} &= 41\,340.97 * 0.2 = 8\,268.19 \text{ m}^3/\text{day}; \end{aligned}$$

July 2018:

$$\begin{aligned} Q_{otr} &= 37517.45 * 0.2 = 7503.49 \text{ m}^3/\text{day}; \\ Q_{otr.min} &= 27\,815.74 * 0.2 = 5\,563.15 \text{ m}^3/\text{day}; \\ Q_{otr.max} &= 42\,964.51 * 0.2 = 8\,592.90 \text{ m}^3/\text{day}. \end{aligned}$$

The third group users:

$X_{tl} = 0.2$ – in accordance with 20 % of the natural gas consumption cuts for this group of users;

February 2018:

$$\begin{aligned} Q_{tr} &= 22911.35 * 0.2 = 4582.27 \text{ m}^3/\text{day}; \\ Q_{tr.min} &= 17\,107.54 * 0.2 = 3\,421.51 \text{ m}^3/\text{day}; \\ Q_{tr.max} &= 30\,645.20 * 0.2 = 6\,129.04 \text{ m}^3/\text{day}; \end{aligned}$$

July 2018:

$$\begin{aligned} Q_{tr} &= 5761.95 * 0.2 = 1152.39 \text{ m}^3/\text{day}; \\ Q_{tr.min} &= 4\,271.96 * 0.2 = 854.39 \text{ m}^3/\text{day}; \\ Q_{tr.max} &= 6\,598.52 * 0.2 = 1\,319.70 \text{ m}^3/\text{day}. \end{aligned}$$

The actual total energy cuts during the announcement of the 1st level energy crisis were as follows:

February 2018:

$$Q_{1.lim} = 0 + 0 + 6181.57 + 4582.27 = 10763.84 \text{ m}^3/\text{day};$$

$$Y_{1.lim} = \frac{10763.84}{415640.46} * 100 = 2.59 \%$$

$$Q_{1.lim.min} = 0 + 0 + 4\,615.68 + 3\,421.51 = 8\,037.19 \text{ m}^3/\text{day};$$

$$Y_{1.lim.min} = \frac{8037.19}{310352.2} * 100 = 2.59 \%$$

$$Q_{1.lim.max} = 0 + 0 + 8\,268.19 + 6\,129.04 = 14\,397.24 \text{ m}^3/\text{day};$$

$$Y_{1.lim.max} = \frac{14397.24}{555942.2} * 100 = 2.59 \%$$

July 2018:

$$Q_{1.\lim} = 0 + 0 + 7503.49 + 1152.39 = 8655.88 \text{ m}^3/\text{day};$$

$$Y_{1.\lim} = \frac{88655.88}{117735.04} * 100 = 7.35 \%$$

$$Q_{1.\lim.\min} = 0 + 0 + 5563.15 + 854.39 = 6417.54 \text{ m}^3/\text{day};$$

$$Y_{1.\lim} = \frac{88655.88}{117735.04} * 100 = 7.35 \%$$

3.2. Level 2 Energy Crisis Modelling

The priority users:

$X_{n2} = 0$ – in accordance with 0 % of the natural gas consumption cuts for this group of users;

February 2018:

$$Q_{\text{nodr}} = 67912.74 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.min}} = 50709.38 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.max}} = 90837.06 * 0 = 0 \text{ m}^3/\text{day};$$

July 2018:

$$Q_{\text{nodr}} = 5449.96 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.min}} = 4040.64 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.max}} = 6241.22 * 0 = 0 \text{ m}^3/\text{day}.$$

The first group users:

$X_{p2} = 0.2$ – in accordance with 20 % of the natural gas consumption cuts for this group of users;

February 2018:

$$Q_{\text{pirm}} = 293908.51 * 0.2 = 58781.70 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.min}} = 219456.87 * 0.2 = 43891.37 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.max}} = 393118.96 * 0.2 = 78637.79 \text{ m}^3/\text{day};$$

July 2018:

$$Q_{\text{pirm}} = 69005.68 * 0.2 = 13801.14 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.min}} = 51161.37 * 0.2 = 10232.27 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.max}} = 79024.45 * 0.2 = 15804.89 \text{ m}^3/\text{day}.$$

$$Q_{1.\lim.\max} = 0 + 0 + 8592.9 + 1319.7 = 9912.61 \text{ m}^3/\text{day};$$

$$Y_{1.\lim.\max} = \frac{9912.61}{134828.7} * 100 = 7.35 \%$$

Evaluating the obtained results, it has been established that according to the results of February 2018, $Y_{1.\lim}$ did not fit into the recommended percentual span from 7 % to 12 %, while in July the reduction of the natural gas did – it was satisfactory.

The second group users:

$X_{o2} = 0.4$ – in accordance with 40 % of the natural gas consumption cuts for this group of users;

February 2018:

$$Q_{\text{otr}} = 30907.86 * 0.4 = 12363.14 \text{ m}^3/\text{day};$$

$$Q_{\text{otr.min}} = 23078.41 * 0.4 = 9231.36 \text{ m}^3/\text{day};$$

$$Q_{\text{otr.max}} = 41340.97 * 0.4 = 16536.39 \text{ m}^3/\text{day};$$

July 2018:

$$Q_{\text{otr}} = 37517.45 * 0.4 = 15006.98 \text{ m}^3/\text{day};$$

$$Q_{\text{otr.min}} = 27815.74 * 0.4 = 11126.29 \text{ m}^3/\text{day};$$

$$Q_{\text{otr.max}} = 42964.51 * 0.4 = 17185.81 \text{ m}^3/\text{day}.$$

The third group users:

$X_{t2} = 1$ – in accordance with 100 % of the natural gas consumption cuts for this group of users;

February 2018:

$$Q_{\text{tr}} = 22911.35 * 1 = 22911.35 \text{ m}^3/\text{day};$$

$$Q_{\text{tr.min}} = 17107.54 * 1 = 17107.54 \text{ m}^3/\text{day};$$

$$Q_{\text{tr.max}} = 30645.20 * 1 = 30645.20 \text{ m}^3/\text{day};$$

July 2018:

$$Q_{\text{tr}} = 5761.95 * 1 = 5761.95 \text{ m}^3/\text{day};$$

$$Q_{\text{tr.min}} = 4271.96 * 1 = 4271.96 \text{ m}^3/\text{day};$$

$$Q_{\text{tr.max}} = 6598.52 * 1 = 6598.52 \text{ m}^3/\text{day}.$$

The actual total energy cuts during the announcement of the 2st level energy crisis were as follows:

February 2018:

$$Q_{2,\text{lim}} = 0 + 58781.70 + 12363.14 + 22911.35 = 94056.19 \text{ m}^3/\text{day};$$

$$Y_{2,\text{lim}} = \frac{94056.19}{415640.46} * 100 = 22.63 \%$$

$$Q_{2,\text{lim.min}} = 0 + 43891.37 + 9231.36 + 17107.54 = 70230.28 \text{ m}^3/\text{day};$$

$$Y_{2,\text{lim.min}} = \frac{70230.28}{310352.2} * 100 = 22.63 \%$$

$$Q_{2,\text{lim.max}} = 0 + 78623.79 + 16536.39 + 30645.2 = 125805.38 \text{ m}^3/\text{day};$$

$$Y_{2,\text{lim.max}} = \frac{125805.38}{555942.2} * 100 = 22.63 \%$$

3.3. Level 3 Energy Crisis Modelling

The priority group users:

$X_{n3} = 0$ – in accordance with 0 % of the natural gas consumption cuts for this group of users;

February 2018:

$$Q_{\text{nodr}} = 67912.74 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.min}} = 50709.38 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.max}} = 90837.06 * 0 = 0 \text{ m}^3/\text{day};$$

July 2018:

$$Q_{\text{nodr}} = 5449.96 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.min}} = 4040.64 * 0 = 0 \text{ m}^3/\text{day};$$

$$Q_{\text{nodr.max}} = 6241.22 * 0 = 0 \text{ m}^3/\text{day};$$

The first group users:

$X_{p3} = 0.4$ – in accordance with 40 % of the

July 2018:

$$Q_{2,\text{lim}} = 0 + 13801.14 + 15006.98 + 5761.95 = 34570.07 \text{ m}^3/\text{day};$$

$$Y_{2,\text{lim}} = \frac{34570.07}{117735.04} * 100 = 29.36 \%$$

$$Q_{2,\text{lim.min}} = 0 + 10232.27 + 11126.29 + 4271.96 = 25630.53 \text{ m}^3/\text{day};$$

$$Y_{2,\text{lim.min}} = \frac{25630.53}{87289.7} * 100 = 29.36 \%$$

$$Q_{2,\text{lim.max}} = 0 + 15804.89 + 17185.81 + 6598.52 = 39589.21 \text{ m}^3/\text{day};$$

$$Y_{2,\text{lim.max}} = \frac{39589.21}{134828.7} * 100 = 29.36 \%$$

Evaluating the obtained results, it has been established that according to the results of February and July 2018, $Y_{2,\text{lim}}$ was higher than the set level of energy reduction – from 12 % to 17 %.

natural gas consumption cuts for this group of users;

February 2018:

$$Q_{\text{pirm}} = 293908.51 * 0.4 = 117563.40 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.min}} = 219456.87 * 0.4 = 87782.75 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.max}} = 393118.96 * 0.4 = 157247.58 \text{ m}^3/\text{day};$$

July 2018:

$$Q_{\text{pirm}} = 69005.68 * 0.4 = 27602.27 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.min}} = 51161.37 * 0.4 = 20464.55 \text{ m}^3/\text{day};$$

$$Q_{\text{pirm.max}} = 79024.45 * 0.4 = 31609.78 \text{ m}^3/\text{day};$$

The second group users:

$X_{o3} = 0.8$ – in accordance with 80 % of the natural gas consumption cuts for this group of users;

February 2018:

$$\begin{aligned} Q_{otr} &= 30907.86 * 0.8 = 24726.29 \text{ m}^3/\text{day}; \\ Q_{otr.min} &= 23\ 078.41 * 0.8 = 18\ 462.75 \text{ m}^3/\text{day}; \\ Q_{otr.max} &= 41\ 340.97 * 0.8 = 33\ 072.78 \text{ m}^3/\text{day}; \end{aligned}$$

July 2018:

$$\begin{aligned} Q_{otr} &= 37517.45 * 0.8 = 30013.96 \text{ m}^3/\text{day}; \\ Q_{otr.min} &= 27\ 815.74 * 0.8 = 22\ 225.59 \text{ m}^3/\text{day}; \\ Q_{otr.max} &= 42\ 964.51 * 0.8 = 34\ 371.61 \text{ m}^3/\text{day}. \end{aligned}$$

The third group users:

$X_{i3} = 1$ – in accordance with 100 % of the natural gas consumption cuts for this group of users;

February 2018:

$$\begin{aligned} Q_{tr} &= 22\ 911.35 * 1 = 22\ 911.35 \text{ m}^3/\text{day}; \\ Q_{tr.min} &= 17\ 107.54 * 1 = 17\ 107.54 \text{ m}^3/\text{day}; \\ Q_{tr.max} &= 30\ 645.20 * 1 = 30\ 645.20 \text{ m}^3/\text{day}; \end{aligned}$$

July 2018:

$$\begin{aligned} Q_{tr} &= 5\ 761.95 * 1 = 5\ 761.95 \text{ m}^3/\text{day}; \\ Q_{tr.min} &= 4\ 271.96 * 1 = 4\ 271.96 \text{ m}^3/\text{day}; \\ Q_{tr.max} &= 6\ 598.52 * 1 = 6\ 598.52 \text{ m}^3/\text{day}. \end{aligned}$$

The actual total energy cuts during the announcement of the 3rd level energy crisis were as follows:

February 2018:

$$Q_{3.lim} = 0 + 117563.40 + 24726.29 + 22911.35 = 165\ 201.04 \text{ m}^3/\text{day};$$

$$Y_{3.lim} = \frac{165201.04}{415640.46} * 100 = 39.75 \%$$

$$Q_{3.level.min} = 0 + 87\ 782.75 + 18\ 462.73 + 17\ 107.54 = 123\ 353.02 \text{ m}^3/\text{day};$$

$$Y_{3.lim.min} = \frac{123353.02}{310352.20} * 100 = 39.75 \%$$

$$Q_{3.l.max} = 0 + 157\ 247.58 + 33\ 072.78 + 30\ 645.20 = 220\ 965.57 \text{ m}^3/\text{day};$$

$$Y_{3.lim.max} = \frac{220965.57}{555942.2} * 100 = 39.75 \%$$

July 2018:

$$Q_{3.lim} = 0 + 27602.27 + 30013.96 + 5\ 761.95 = 63\ 378.18 \text{ m}^3/\text{day};$$

$$Y_{3.lim} = \frac{63378.18}{117735.04} * 100 = 53.83 \%$$

$$Q_{3.level.min} = 0 + 20\ 464.55 + 22\ 252.59 + 4\ 271.96 = 46\ 989.09 \text{ m}^3/\text{day};$$

$$Y_{3.lim.min} = \frac{46989.09}{87289.7} * 100 = 53.83 \%$$

$$Q_{3.lim} = 0 + 31\ 609.78 + 34\ 371.61 + 6\ 598.52 = 72\ 579.91 \text{ m}^3/\text{day};$$

$$Y_{3.lim.max} = \frac{72579.91}{134828.70} * 100 = 53.83 \%$$

During level 3 energy crisis, the total natural gas cuts of all groups ultimately resulted in more than 39 % in February and almost 54 % in July despite the fact that the expected cut level should be within 17 %–18 % limit.

3. RESULTS AND DISCUSSION

The above-mentioned modelling provided data that helped track changes in the average consumption of natural gas in each of the four user groups. It was established that the natural gas consumption of the first group, during the announcement of the energy crisis,

many times exceeded the three other groups, which meant that also the main share in energy savings was taken by this group – state and municipal administration institutions, energy supply companies, railways, airports, long-distance bus terminals, ports etc.

Fig. 1. Average monthly natural gas consumption changes, 2018, in m³/day.

Examining the consumption figures by season, it was found that the energy consumption of the four groups differed a lot in winter and summer, which was related to the need to spend more natural gas for heating in winter, while demand for it sharply decreased in summer. Figure 2 shows that the decline in the demand for the natural gas

users of the priority group was 89 % in July. As it was stated above, this specific group consisted mainly of households, schools, hospitals, crisis centres, emergency services, telecommunications units etc. In case of all four groups, the year 2017 is shown in Fig. 2 along with the year 2018 for comparative purposes.

Fig. 2. Fluctuations of the natural gas consumption in the priority group (2017–2018, m³/day).

The results of the first group (see Fig. 3), which includes energy supply com-

panies, play an important role in overall energy security of supply. The amount of

natural gas consumed by this group during the heating season falls by 25 % in summer. Thus, the difference between winter

and summer consumption is much less pronounced than in case of the priority group.

Fig. 3. Fluctuations of the natural gas consumption in the 1st group (2017–2018, m³/day).

The results of the second group (see Fig. 4), however, show, that the amount of consumed energy during the heating season is by almost 25 % lower, if compared to the summer time. This can be explained by the fact that the second group users include

grain processing facilities, which consume the most of its energy – both in form of primary energy resources like natural gas and the secondary energy resources – electricity, during harvesting months in summer and early autumn.

Fig. 4. Fluctuations of natural gas consumption in the 2nd group (2017–2018, m³/day).

The consumption of natural gas in the 3rd group is shown in Fig. 5, which demonstrates the identical seasonally determined

trend as in the priority group and the 1st group.

Fig. 5. Fluctuations of the natural gas consumption in the 3rd group (2017–2018, m³/day).

Thus, it can be concluded that the consumption of natural gas in all groups may vary significantly during the heating and non-heating seasons, but it cannot be forgotten that natural gas is also used in electricity generation, demand of which is increasing every year.

During the generalized evaluation of the results of energy crisis modelling in the “town A”, shortcomings in the reduction

intervals offered by Regulation 312 were established. The results of the calculation are presented in Table 2, which shows that only in July $Y_{1.lim}$ falls into the necessary interval. In real life, the month of February plays the biggest role, because during the winter, consumption increases for all users, due to the fact that natural gas is used for both local and district heating purposes.

Table 2. Total Energy Reduction as Percentage by Energy Crisis Levels

	February 2018, %	July 2018, %
$Y_{1.lim}$	2.59*	7.35
$Y_{2.lim}$	22.63*	29.36*
$Y_{3.lim}$	39.75	53.83

* - does not meet the conditions of MK 312, because the obtained results do not fit into the energy reduction intervals offered in the regulations,

where:

$$7\% < Y_{1.lim} < 12\%$$

$$12\% < Y_{2.lim} < 17\%$$

$$17\% < Y_{3.lim}$$

According to the amendments of Regulation 312, the Incukalns UGS facility must have at least 3160 thousand MWh (300 million m³) of the active gas, which is intended to ensure the supply of natural gas in Latvia

during the energy crisis. However, if the energy crisis occurs both locally and nationally, the specified storage capacity might be exhausted rather quickly. The amendments of Regulation 312 show that after the open-

ing of the natural gas market in Latvia the risk of announcing the energy crisis has increased; therefore, it has been decided to ensure the minimum amount of the natural gas reserves in order to provide Latvian users at least for some period of time.

Results of $Y_{3.lim}$ in general agree with the energy reduction offered by Regulation 312, which must be greater than 17 %. In February, the estimated reduction of natural gas was 39.75 % per day and 53.83 % in July. However, such a decrease is unlikely to be beneficial and could have an adverse effect on local production, the economy and society as a whole.

To make the energy crisis provisions of the national scale, more calculations and the actual annual or semi-annual natural gas

consumption analysis of as many Latvian municipalities as possible should be performed in order to find out the average preferable percentage of the energy cuts that should be specified in Regulation 312. At the same time, the results obtained within the “town A” research could be critically compared with the results obtained in other Latvian municipalities, so the identification of deviation factor could also be possible. The deviation factor cannot be identified, if only one municipality case study is performed.

Percentual energy cuts according to the natural gas user groups and levels of the energy crisis as proposed in the amendments of Regulation 312, based on the results of the “town A” case study, are shown in Table 3.

Table 3. Energy Cuts as Proposed in the Amendments of Regulation 312, Based on the Results of the “Town A” Case Study (%)

Distribution of the users	Priority group	The first group	The second group	The third group
The natural gas delivery cuts (%), the 1st level energy crisis	0	10	15	20
The natural gas delivery cuts (%), the 2nd level energy crisis	0	15	20	30
The natural gas delivery cuts (%), the 3rd level energy crisis	0	20	35	40

4. CONCLUSION

Disruption of the natural gas supply in Latvia – both at the local and regional scale, can be detrimental to the economy, energy production and the society as a whole. For adequate provision and improvement of the security of the natural gas supply in a context of the energy crisis, the following proposals could me made:

- the comparative studies should be performed in several largest or all largest gasified municipalities in Latvia in order to determine variations of the natural gas consumption fluctuation during the local or/and state energy crisis;

- then, the results obtained during the “town A” case study can be critically compared with the results of other Latvian municipalities, and the identification of deviation factor could also be done;
- in regards to provisions of Regulation 312:
 - natural gas consumers’ distribution by energy user groups should be more carefully reviewed;
 - setting up more reality related natural gas consumption limits for certain energy user groups, based on

the actual distribution of the natural gas consumption among energy user groups;

- measures to restrict or interrupt the supply of natural gas shall be taken by the DSO in the area of operation of its license;
- currently the natural gas user during the energy crisis is not entitled

to consume more energy than DSO has decided. In case, if the natural gas user consumes more natural gas than that, the DSO is entitled to terminate natural gas supply to the user until the end of the energy crisis. This measure should be specified.

ACKNOWLEDGEMENTS

The research has been supported by the National Research Programme, project “Trends, Challenges and Solutions

of Latvian Gas Infrastructure Development” (LAGAS) (No. VPP-EM-INFRA-2018/1-0003).

REFERENCES

1. Grobblinghoff, S. (2019). *The Future of the Energy Sector – Challenges and Opportunities. Bull or Bear?* Outlook for natural gas demand in the Baltic region.
2. Bresciani, G., Heiligt, S., Lambert, P., & Rogers, M. (2020). *The Future of Liquefied Natural Gas: Opportunities for Growth.* Available at <https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-future-of-liquefied-natural-gas-opportunities-for-growth>
3. Krukowska, E. (2021). *Europe Kicks the Can on Defining Role for Natural Gas in a Clean Energy Transition.* Available at <https://www.worldoil.com/news/2021/4/15/europe-kicks-the-can-on-defining-role-for-natural-gas-in-a-clean-energy-transition>
4. S&P Global Ratings. (2020). *On How Hydrogen Can Fuel the Energy Transition.* Available at <https://www.spglobal.com/ratings/en/research/articles/210422-the-hydrogen-economy-can-natural-gas-and-h2-have-a-symbiotic-relationship-11911512>
5. Temizer, M. (2021). *EU's Gas Consumption, Imports, Production down in 2020.* Available at <https://www.aa.com.tr/en/energy/general/eus-gas-consumption-imports-production-down-in-2020/32422>
6. WEC. (2007). *Vulnerability of Europe and its Economy to Energy Crises* (Preliminary Executive Summary). Available at https://inis.iaea.org/collection/NCLCollectionStore/_Public/39/046/39046756.pdf?r=1&r=1
7. Vasiļevskis, K., & Mahņitko, A. (2018). *Latvijas energoneatkarības paaugstināšanas perspektīvas.* Rīga.
8. Brutschin, E. (2017). *EU Gas Security Architecture: The Role of the Commission's Entrepreneurship.* Palgrave Pilot.
9. European Commission. (n.d.). *2030 Climate Target Plan.* Available at https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en
10. Savickis, J., Zemite, L., Zeltins, N., Bode, I., & Jansons, L. (2020). The Natural Gas and Biomethane in the European Road Transport: The Latvian Perspective. *Latvian Journal of Physics and Technical Sciences*, 57 (3), 57–72. DOI: 10.2478/lpts-2020-0016
11. Savickis, J., Zemite, L., Zeltins, N., Bode, I., Jansons, L., Dzelzitis, E., & Ansone, A. (2020). The Biomethane Injection into the Natural Gas Networks: The EU's Gas Synergy Path. *Latvian Journal of Physics and Technical Sciences*, 57 (4), 34–50. DOI: 10.2478/lpts-2020-0020

12. Regulation (EU) 2017/1938 of the European Parliament and of the Council of 25 October 2017 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010. Available at <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32017R1938>
13. Saeima. (2016). Civil Protection and Disaster Management Law. Available at <https://likumi.lv/ta/en/en/id/282333>
14. Cabinet of Ministers. (2011). *Procedures for the Supply of Energy Users and Sale of Heating Fuel during Declared Energy Crisis and in Case of Endangerment to the State*. Available at <https://likumi.lv/ta/en/en/id/229557>
15. Cabinet of Ministers. (2018). *Amendments to Regulations No. 312 as of 19 April 2011 "Procedures for the Supply of Energy Users and Sale of Heating Fuel during Declared Energy Crisis and in Case of Endangerment to the State"*. Available at <https://likumi.lv/ta/id/299165-grozijumi-ministru-kabineta-2011-gada-19-aprila-noteikumos-nr-312-energijas-lietotaju-apgades-un-kurinama-pardosanas-kartiba-iz...>