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PHYSICAL AND TECHNICAL ENERGY PROBLEMS

RISK TREATMENT AND SYSTEM RECOVERY ANALYSIS OF GAS SYSTEM OF GAS AND ELECTRICITY NETWORK OF LATVIA

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The Latvian natural gas system is interconnected with transmission networks located in Lithuania, Estonia and Russia. Natural gas commercial metering is provided by GMS "Karksi" (Estonia) and by GMS "Kiemenai" (Lithuania). Natural gas is supplied to all larger urban areas in Latvia. Natural gas is supplied to Latvia along the Latvian–Russian pipeline only during the warm period of the year (April–September), and it is accumulated in the underground gas storage facility in Incukalns. During winter, gas from the underground facility is delivered to Latvian customers, as well as transmitted to Estonia and back to Russia. There is also a connection to Lithuania. Out of the gas supply disruption risks that are assessed at different levels, the essential one with a trans-border impact potential consists in the insufficient technical capacity of Incukalns UGS. Given the current technical possibilities, IUGS cannot pass the gas volume required for the Baltic States to compensate the gas supply deficit. The paper performs system recovery analysis after selected critical events. The paper provides a report describing the steps to be followed in order to restore the gas transmission system to normal operation after selected critical events. A very significant region of the power system of Latvia is the central part of Latvia and Riga region, where both of Riga CHPs, as well as Riga HPP, is located. The restoration time of the gas system of Latvia depends on the gravity of the situation and damage in the gas system and may range from several hours to several days.

Keywords: critical infrastructure, gas system, risk assessment

1. INTRODUCTION

The Latvian natural gas system is interconnected with transmission networks located in Lithuania, Estonia, and Russia. Natural gas commercial metering is provided on the Latvian–Estonian border by GMS "Karksi" (Estonia), on the Latvian–Lithuanian border GMS "Kiemenai" (Lithuania). Natural gas is supplied to all larger urban areas in Latvia.

Natural gas is supplied to Latvia along with the Latvian–Russian pipeline only during the warm period of the year (April–September), and it is accumulated in the underground gas storage facility in Incukalns. During winter, gas from the underground facility is delivered to Latvian customers, as well as transmitted to Estonia and back to Russia. There is also a connection to Lithuania. Incukalns UGS started its operation in 1968. Incukalns UGS is used not only for customers in Latvia but also for the needs of consumers in Estonia, Lithuania, and Northwest Russia, thus securing reliable gas supply for the whole region [1].

2. POSSIBLE EVENTS THAT COULD CAUSE GAS SYSTEM ISOLATION

In case of an incident on any of the gas transmission pipelines leading to a situation when the supply of natural gas to consumers is limited or disrupted, the impact of the situation depends on such conditions as:

- Natural gas supply season and direction (summer/winter; pumping in/out of Incukalns underground gas storage);
- The possible places of gas pipeline damage (presence/absence of parallel gas pipeline; blind-end gas pipeline; presence/absence of trans-border connection);
- The current operating mode of the natural gas supply system (natural gas working pressure and distribution of natural gas reserve in the gas pipeline system);
- The actual natural gas demand in Latvia, its neighboring countries and in the Baltic region as a whole [2], [3].

The average natural gas consumption on a cold winter day is 10...13 million m^3. Since the amount of working (active) gas in Incukalns underground gas storage is 2.35 billion m^3 and the maximum pumping-out amount reaches 30 million m^3 per day, the storage has a sufficient additional amount of natural gas, which is used in emergency situations. Latvia's main gas pipelines constitute part of the natural gas supply system of the Baltic countries. For the case if the supply of natural gas from Incukalns underground gas storage is disrupted, Latvia has the possibility to receive alternative natural gas supplies from Russia: in winter, up to 2 million m^3 per day (directly); in summer, up to 20 million m^3 per day (directly); 6.48 million m^3 per day by way of transit via Lithuania. Alternative supplies of natural gas are also possible from Klaipeda liquefied natural gas terminal in Lithuania, which started its operation on 1 January 2015 [3], [4].

A more detailed description of the main risks related to gas pipelines is presented in Task 1.2. The following three scenarios of consequences are analysed:

- Natural gas flow disruption from Incukalns UGS in winter;
- Natural gas flow disruption from Russia in winter (GMS “Kotlovka”);
- Natural gas flow disruption from Russia in winter (GMS “Kotlovka” and CS Izborsk) [3], [4].

Latvia has regulations regarding gas supply limitation. Depending on supply limitation, three stages of limitation are defined: I–7…12 %, II–12…17 %, III–above 17 %. There are 3 groups of customers and depending on the stage, the limitations for each group of customers are determined as percentage [5].

2.1. Disruption of Gas Supply from Incukalns UGS

During the winter season, natural gas supply to Latvia, Estonia and the Western part of Pskov Region of the Russian Federation is ensured from Incukalns UGS. The daily natural gas withdrawal capacity from Incukalns UGS is 24 million m^3, half of which is allocated to consumers in Latvia, while Russia and Estonia each get 6 million m^3 daily. For the case if gas supply from Incukalns UGS is lost, alternative gas supplies are available (Fig. 1):

- The maximum available supply from Russia to Latvia through GMS “Korneti” – 4.0 million $m^{3/}$day;
- The maximum available supply from Lithuania to Latvia through GMS “Kiemenai” – 6.5 million $m^{3/}$day;
- From Russia, there are no other gas supply routes.

Gas flow rearrangement:

- Disruption of the gas flow from Latvia to Russia;
- Disruption of the gas flow from Latvia to Estonia;
- Rearrangement of the gas flow from Russia to Estonia;
- Rearrangement of the gas flow from Russia to Latvia;
- Rearrangement of the gas flow from Latvia to Lithuania.

Short-term gas supply limitations for users in Latvia during the winter season in case of Incukalns UGS failure are analysed for 3 user groups depending on the scale of gas supply disruption [4], [6].

Taking into account the technical limits of natural gas supply, in case of disruption of natural gas supply from Incukalns UGS, rearrangement of the natural gas flow will not result in the daily demand for natural gas being met – the natural gas shortage in Latvia will make 6 million cubic meters per day.

As regards the operation of the compressor stations, the present paper contains those units of process equipment situated in the base territory, defects or incidents on which may lead to a natural gas leak and, consequently, a gas explosion or fire in case of ignition. The amount and spread of the incident consequences are influenced by the nature of the incident and the amount of leaked gas, which in turn depends on the possibilities of timely leak detection and disruption of gas supply to the damaged equipment unit or assembly. In the simulation of the incident consequences, the worst-case situation has been presented, i.e., a case when the safety system fails to come into action, which means that, according to the Dutch guidelines for the assessment of quantitative risk, a 30-minute leak is considered, or a leak that lasts until complete emptying of the tank [2], [4], [7].

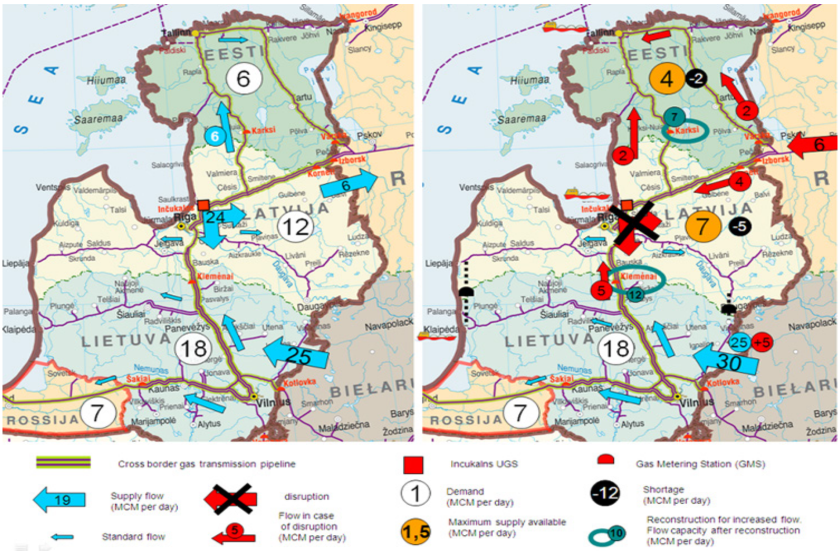

Fig. 1. Gas supply of the Baltic States in case of the scenario of gas supply disruption from Incukalns UGS.

In a gas compressor, there may be a leak from the compressor through a damaged place with a diameter equal to the diameter of the largest pipeline connected to the equipment unit; also a leak is considered from the compressor through a damaged place with a diameter equal to 10 % of the diameter of the largest pipeline connected to the equipment unit.

As regards the gas pipelines, two gas leak scenarios are analysed: (1) a leakage from a pipeline through a damaged place with a diameter equal to 1/3 of the nominal diameter of the pipeline; (2) a complete disruption of the pipeline. For pipeline incidents, both instantaneous ignition and delayed ignition of the gas are considered; hence, the incident consequences have been described both for a jet-type fire and a gas cloud explosion/fire [3], [5], [8].

Separately, as part of pressure tanks, dust catchers and dividing filters are considered, evaluating incident consequences according to the Dutch recommendations for assessing quantitative risk: (1) in case of tank emptying within ten minutes; (2) in case of instantaneous emptying of the tank. In case of a gas leak, both instantaneous ignition and delayed ignition of the leaked gas are possible.

For the gas collection stations (GCSs), incident scenarios related to the operation of gas pipelines as well as separators are considered. In connection with the GCSs, scenarios related to the operation of the methanol facilities have also been analysed. For the gas pipelines, two leak scenarios have been analysed: (1) a leak from the pipeline through a damaged place with a diameter equal to 1/3 of the nominal diameter of the pipeline; (2) a complete disruption of the pipeline. Calculations show that further spread of the adverse influence in the case of an incident involving the pressure tanks of a GCS might be expected in case of instantaneous emptying of gas and delayed ignition; yet, considering the properties of the gas and its amount in the considered tanks, the possibility of such an incident is to be deemed only hypothetical. A much more typical incident could be tank damage accompanied by gas leakage, the worst type of incident consequence being a jet fire. Calculations show that the adverse influence of a jet fire in case of tank emptying over ten minutes might extend up to 20 meters from the damaged place.

The risk assessment includes gas-pumping pipelines between compressor stations and GCSs as well as between GCSs and the wells of the gas storage. As regards the transport pipelines, two scenarios have been considered according to the Dutch guidelines for the assessment of quantitative risk [1]: (1) a leak from the pipeline through a damaged place with a size equal to 10 % of the nominal diameter of the pipeline, (2) complete disruption of the pipeline. Likewise other natural gas leak scenarios, also regarding the pipelines, the paper considers a gas leak with instantaneous ignition and subsequent development of a jet fire as well as a delayed ignition of the leaked gas with a potential development of gas cloud explosions/fire [9], [10].

For Incukalns UGS, the document considers spread of the influence of gas cloud explosion and jet fire in the following emergency cases: (1) a large-scale leak from a well (a leak from a damaged place with a size equal to the diameter of the extraction column) – vertical leakage; (2) a leak from a well (a leak from a well through a damaged place with a diameter equal to 10% of the diameter of the extraction column) –vertical leakage; (3) a leak from a well (a leak from a well through a damaged place with a diameter equal to 10% of the diameter of the extraction column) – horizontal leakage. The worst-case course of development, both for the old wells and the reconstructed ones, is an incident when the safety system fails to come into action and the leakage of gas from the well lasts for thirty minutes and longer [11]–[13].

3. RESTORATION OF THE GAS SYSTEM OF LATVIA

Readiness for an emergency situation is planned on the basis of the following:

- The results of the identification and assessment of industrial incidents (Safety Report, other documents (including inspections, monitoring, equipment checks)),
- Preventive risk-diminishing measures;
- Emergency action plans for emergency cases checked in theoretical and practical training and reviewed.

The *emergency communications plan* indicates the co-operation services that are involved in the case of emergency situations and incidents in the Republic of Latvia and determines the co-operation partners outside Latvia in cases of emergency situations and incidents [14]–[16].

The most important actions in case of fire are calling the rescue service and performing fire containment works. If the incident has taken place, the most important thing to do is timely stopping of the technological process so as to diminish the scale of the incident (catastrophe) and its potential consequences. Mass notification is to be done immediately [16], [17].

Below follow the possible solutions for the case of an incident involving the gas transmission pipelines, along with their influence on the neighbouring member countries (Estonia, Lithuania):

- For the gas pipelines with interconnections to Russia (Valday–Pskov–Riga) and Lithuania (Riga–Vilnius) it is possible to change the natural gas supply directions for reverse supply/reception of natural gas (in the Viresi–Tallinn interconnection with Estonia); it will be possible to use the reverse supply possibilities after the completion of the European project of common interest "Enhancement of Estonia-Latvia Interconnection (PCI project 8.2.2)" in 2021). Taking into account that the natural gas supply systems of the neighbouring countries have their own interconnections with Russia and that there is a liquefied natural gas terminal in Lithuania, the potential change of the gas supply direction to ensure reverse supply of natural gas would have minimum impact on the natural gas supply reliability in the neighbouring member states;
- In summer, there is a possibility to interrupt the supply of natural gas from Russia via the Valday–Pskov–Riga gas pipeline and to rearrange Incukalns underground gas storage to pumping-out mode and ensure the supply of natural gas to the consumers in Latvia without significant influence on the natural gas supply reliability in the neighbouring member states;
- Regarding the blind-end gas pipelines (Riga–Daugavpils, and Iecava–Liepaja), the situation depends on the possible location of the damage; the influence is mainly determined by the actual natural gas demand, the gas pressure in the disconnected gas pipeline section and the total remaining natural gas reserve amount. This solution leads to the risk of an increased influence on the natural gas supply systems of the neighbouring member countries;
- Depending on the extent of damage, the T.D.Williamson gas pipeline blocking system can be used, building a local bypass line around the damaged place to ensure natural gas supply as a temporary arrangement, with minimum influence on the natural gas supply reliability of the neighbouring member countries;
- Within approximately 24 hours, it is possible to ensure supply of liquefied natural gas tanks from Poland and other producers of liquefied natural gas [8], [16], [17].

3.1. Emergency Containment and Elimination Plan

The report should include a hypothetical scenario of a complete loss of gas in the transmission network. Losses of gas are possible only in some places and territories. Automatic shut-off valves are set up in all GRS. Valves are working the case of losses of gas and/or power supply. Therefore, it is possible to evaluate gas loss in separate cases or territories. Firstly, personnel has to check whether the gas leaks and the system phase are emptied. The next step is to restore the damaged site. Then it is necessary to open the closures and check the system for leakage and pressure resistance. Hypothetically, if the pressure in the transmission system drops to 1 bar, then it is possible to restore the pressure throughout the transmission system within one day [1].

3.1.1. Fires and Explosions

The possible causes of the emergency are ignition or an explosion at a gasified facility, etc. The sequence of actions is as follows:

1.1. Accept the emergency call and inform the caller about the required safety measures to be taken before the arrival of the emergency service team.

1.2. Register the emergency call and create an emergency call registering the card.

1.3. Inform the emergency service team about the nature of the emergency situation and prepare the required documentation. Depart for the emergency location within five minutes.

1.4. Discontinue gas supply to the affected facility.

1.5. Fence off a safety area by means of barrier belts and warning signs and provide it with surveillance, prohibiting smoking, the use of open fire, switching on and off of electrical switches, the use of bells and other electrical appliances, in co-operation with the State Fire and Rescue Service.

1.6. By using a gas concentration meter (further referred to as "analyser"), check the gas concentration within a radius of 50 meters in cellars, staircases, living accommodations and underground utility wells.

1.7. Create an emergency call registering the card and draw up a technical protocol, along with other required documentation [18].

3.1.2. Gas Odor from the Underground Gas Pipeline

The possible causes of the emergency are as follows: a gas leak from a disrupted underground gas pipeline; a gas leak at a corroded or welded place, from an underground well-less shutoff device, etc. The sequence of actions is as follows:

1.1. Accept the emergency call and inform the caller about the required safety measures to be taken before the arrival of the emergency service team.

1.2. Register the emergency call and create an emergency call registering the card.

1.3. Inform the emergency service team about the nature of the emergency situation and prepare the required documentation. Depart for the emergency location within five minutes.

1.4. Determine the safety area based on the gas odor or measured gas concentration; delimit it by means of barrier belts and warning signs. Ensure surveillance for the safety area, prohibiting smoking and the use of open fire and electrical appliances.

1.5. By using a gas concentration meter (further referred to as "analyser"), check the gas concentration within a radius of 50 meters in cellars, staircases, underground utility wells. Determine the safety area more precisely and make changes according to the situation.

1.6. By using the gas analyser, determine the gas leakage location on the underground gas pipeline; if required, the leak is sought for by means of check boring.

1.7. If possible, disconnect the damaged pipeline section or perform pressure lowering.

1.8. If it is required to start uncovering the damaged pipeline section (excavation), representatives from the other organisations operating the underground utilities are summoned to the emergency site.

1.9. The damaged section is uncovered and the leak is contained or eliminated. The gas consumers are notified about the prospective gas supply disruption or pressure lowering.

1.10. Draw up the required documents about the handing over of the facility to a repair team for reconstruction [18].

3.1.3. Changes in Gas Pressure or Disrupted Gas Supply

The possible causes of the emergency are as follows: damage to the gas pressure regulator; clogging caused by condensate, snow, or ice; mechanical clogging of the gas pipelines; a closed shutoff device on the gas pipeline; etc. The sequence of actions is as follows:

1.1. Accept the emergency call and inform the caller about the required safety measures to be taken before the arrival of the emergency service team.

1.2. Register the emergency call and create an emergency call registering the card.

1.3. Inform the emergency service team about the nature of the emergency situation and prepare the required documentation. Depart for the emergency location within five minutes.

1.4. Determine the actual cause of the changes in the gas pressure conditions by performing monitoring of the exit pressure related to the emergency location as well as monitoring of the pressure before the gas equipment of the caller.

1.5. Restore the gas pressure in the pipelines according to the prescribed pressure conditions.

1.6. If it is impossible to restore the gas pressure according to the prescribed pressure conditions:

  1.6.1. Discontinue gas supply and warn the consumers about the discontinuation of gas supply during the repair period.

  1.6.2. Summon to the emergency location an additional repair team with the required equipment.

1.7. Draw up the required documents [16].

3.2. Starting to Use the Pipelines

A pipeline may only be commissioned after a pressure check. If a pipeline section is commissioned or decommissioned, gas pipeline flow-out may be used. The flow-out procedure has been completed if the results of the measurements made at the flow-out place show a safe and acceptable gas concentration. Before the check, it is necessary to check the cleanliness and (if required) quality of the pipeline section. The pipeline section has to be cleaned by means of a piston. In order to clean the pipe and (if required) check its quality, it is necessary to pass the piston through each of the blocked pipeline sections a number of times. The piston moving speed has to be monitored by means of a manometer.

The pressure test has to be used to make sure about the strength and leakproofness of the pipeline. Testing the pressure, water can be used as the fluid; it has to be clean and (if required) with a corrosion inhibitor added. In order to prevent the formation of air pockets, the pipe has to be filled by using pistons. After the filling has been completed, it is necessary to allow the water in the pipeline sections to settle. Before starting the test, it is necessary to determine the water pressure to be applied as well as the locations of the metering devices and their characteristic quantities. At the places where the manometers are located, sheds have to be installed.

The minimum duration of the strength test is fifteen minutes. The pipe strength test has to be conducted, starting from an actual maximum pressure that exceeds the maximum working pressure 1.15 times in the lowest pipeline section to be tested.

The pressure used in the strength test must not exceed the pressure that causes permanent deformations. During the test, the monitored pressure must not form considerable pressure drops. The test may be conducted during the stabilization period before the leakproofness test. A hydrostatic test can be conducted. Air or an inert gas is acceptable as the testing medium if adequate safety measures are taken and the pressure-volume product is kept within certain limits. The leakproofness test may be conducted together with the strength test. The pressure used in the leakproofness test must not be higher than the pressure used in the strength test. At the beginning of the leakproofness test, the pressure must not be lower than the working pressure. The duration of the test may not be shorter than 24 hours.

A hydrostatic test may be conducted. Air or an inert gas is acceptable as the testing medium if adequate safety measures are taken and the pressure-volume product is kept within certain limits. Before the leak proneness test, it is necessary to make sure that the amount of air in the pipe is so small that it will not influence the testing results. The pipe is to be considered leak proof if the temperature and pressure measurements show that the volume of the testing medium has remained unchanged during the testing.

If the test has yielded satisfactory results, the pipeline has to be cleaned from the water. The piston devices have to be passed through the pipeline as many times as is necessary to clean it from the water.

The putting into operation has to be conducted in such manner as to ensure elimination of all the gas/air mixtures that have been formed and to prevent any air from remaining in the pipeline. After that, the pressure under the checking pipeline has to be increased to reach a normal working pressure.

Before repeated commissioning, it is necessary to make sure that the work has been performed and checked in a proper way. Special attention has to be paid to welding works, leak proneness, coating integrity and cathodic protection. During the repeated filling, the pressure must not exceed the permissible limit values [19].

4. CONCLUSIONS

Out of the gas supply disruption risks that are assessed at different levels, the essential one with a trans-border impact potential consists in the insufficient technical capacity of Incukalns UGS. Given the current technical possibilities, IUGS cannot pass the gas volume required for the Baltic States to compensate the gas supply deficit.

From the point of view of Latvian gas supply system security, the highest priority should probably be attributed to the necessity to renew the technical resources of the gas transmission pipeline Iecava–Liepaja, as well as to construct the Latvian and Lithuanian gas supply system gas transmission pipeline junctions Liepaja–Klaipeda, and Daugavpils–Visaginas. As GMS “Kiemenai” is considered the bottleneck of the region’s gas supply, in order to avoid useless investments, it would be required to make a survey regarding the increase of optional interconnection capacity. Estonia, in case of maximum gas demand, is not able to meet its gas needs only from Russia via pipelines; rather, it also has to receive gas from Latvia. Besides, the pressure in Estonia’s gas system depends on external sources and pressure limitations in separate parts of the system limit the options in crisis situations.

A very significant region of the power system of Latvia is the central part of Latvia and Riga region, where both of Riga CHPs, as well as Riga HPP, is located.

The restoration time of the gas system of Latvia depends on the gravity of the situation and damage in the gas system and may range from several hours to several days.

As GMS Kiemenai is considered the narrowest place of region gas supply, in order to avoid useless investments, it would be required to make a survey on the increase of optional inter-connection capacity. Estonia, in case of maximal gas demand, is not able to provide the necessity for gas only from Russia by pipelines, but it has to receive gas also from Latvia. Besides, the pressure in Estonian gas system depends on the external sources and pressure limitations in separate system parts limit the options in crisis situations.

From the perspective of Latvian gas supply system security, it is necessary to renew the technical resources of the transmission gas pipeline Iecava – Liepaja, as well as the construction of Latvian and Lithuanian gas supply system transmission gas pipeline junction Liepaja – Klaipeda and Daugavpils – Visagina.

REFERENCES

1. Latvijas dabasgāzes apgādes drošība (2015). *PSI “Risks un audits” SIA*. Rīga.
2. Republic of Latvia Cabinet Regulation No. 496. (2010). *Procedures for the Identification of Critical Infrastructures, Including European Critical Infrastructures and Planning and mplementation of Security Measures.* [Online]. [Acessed: 9 March 2017] https://likumi.lv/doc.php?id=212031.

3. JSC Latvijas Gāze, & JSC Conexus Baltic Grid. Unpublished materials.
4. Niedrite, I., Kreslins, A., Davis, A., & Zeltins, N. (2013). Security of gas supply risk assessment alternatives. In *Proceedings of 22nd World Energy Congress*, (No. 820, pp. 14), 17 October 2013. Daegu, Korea.
5. Committee for the Prevention of Disasters. (1999). *Guidelines for Quantitative Risk Assessment*, "Purple Book" CPR 18E, Hague.
6. Umbach, F. (2010). Global Energy Security and the Implications for the EU. *Energy Policy, 38*(3), 1229–1240.
7. Jansons, L., Zeltins, N., & Savickis J. (2016). The Latvian UGS potential and alternative use of underground geological structures. e-Proceedings of 23rd World Energy Congress, 9–13 October 2016, Lütfi Kırdar Congress Center, Istanbul. ISBN: 978-605-89548-9-2.
8. Regulation of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing regulation (EU) No 994/2010, {SWD(2016) 26 final}. [Accessed: 9 March2017]
9. Ivanova, P., Sauhats, A., & Linkevičs, O. (2016). Towards optimization of combined cycle power plants' start-ups and shut-down. In *57 International Scientific Conference on Power and Electrical Engineering of Riga Technical University (TUCSON)*, Latvija, Riga.
10. Ivanova, P., Sauhats, A., Linkevičs, O., & Balodis, M. (2016). Combined heat and power plants towards efficient and flexible operation. In *IEEE 16th International Conference on Environmental and Electrical Engineering (EEEIC),* 7–10 June 2016, Florence, Italy.
11. The Role of Underground Gas Storage for Security of Supply and Gas Market. (2010). Occasional Paper. Energy Charter Secretariat.
12. Szikszai, A., & Monforti, F. (2011). GEMFLOW: A time-dependent model to assess responses to natural gas supply crises. *Energy Policy, 39*(9), 5129-5136.
13. Parks, P., Kopustinskas, V., & Masera, M. (2015). Probabilistic modeling of security of supply in gas networks and evaluation of new infrastructure. *Reliab. Eng. and Syst. Saf. 144*, 254–264.
14. Zemite, L., Gorobecs, M., Smats, A., Jasevics, A., & Shevchenko's, A. (2017). Genetic algorithm for optimization of power switch allocation in distribution network. In *17th IEEE International Conference on Environment and Electrical Engineering and 1st IEEE Industrial and Commercial Power Systems Europe*, *EEEIC / I and CPS Europe 2017.*
15. Zemite, L., Gerhard, J., Gorobetz, M., & Levchenkov, A. (2016). Optimization of distribution system reliability. In *the International Conference on Environment and Electrical Engineering*.
16. Zemite, L., Bode, I., Zeltins, N., Kutjuns, A., & Zbanovs, A. (2018). Analysis of the power system damage hazard from the point of view of the gas supply system. In *International Conference on Environment and Electrical Engineering*.
17. Moshkin, I., & Sauhats, A. (2016). Solving district heating problems by using cooperative game theory methods. In *Proceedings of 16th International Conference on Environment and Electrical Engineering.*
18. Zemite, L., Kutjuns, A., Bode, I., Kunickis, M., & Zeltins, N. (2018). Consistency analysis and data consultation of gas system of gas-electricity network in Latvia. *Latvian Journal of Physics and Technical Sciences*, *55*(1)., 22–34.
19. Zemite, L., Gerhard, J., Gorobetz, M., & Levchenkov, A. (2015). Optimization of distribution systems reliability with the stochastic behavior. In 56th International Scientific Conference on Power and Electrical Engineering of Riga Technical University, RTUCON 2015.

LATVIJAS GĀZES – ELEKTROENERĢIJAS TĪKLU GĀZES SISTĒMAS RISKU NOVĒRTĒJUMS UN SISTĒMAS ATJAUNOŠANAS ANALĪZE

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K o p s a v i l k u m s

Latvijas dabasgāzes sistēma ir savstarpēji savienota ar Lietuvas, Igaunijas un Krievijas pārvades tīkliem. GMS "Karksi" (Igaunija), GMS "Kiemenai" (Lietuva) tiek nodrošināta dabasgāzes mērīšana. Dabasgāze tiek piegādāta visām lielākajām Latvijas pilsētām. Dabasgāze tiek piegādāta uz Latviju pa Latvijas un Krievijas cauruļvadiem tikai vasaras sezonā (aprīlis-septembris), un tā tiek uzkrāta Inčukalna pazemes gāzes krātuvē. Ziemas laikā gāze no pazemes gāzes krātuves tiek piegādāta Latvijas klientiem, kā arī piegādāta uz Igauniju un atpakaļ uz Krieviju. Ir arī savienojums ar Lietuvu. No gāzes piegādes traucējumu riskiem, kurus novērtē dažādos līmeņos, būtiskākais ar pārrobežu ietekmes potenciālu ir Inčukalna PGK nepieciekamā tehniskā kapacitāte. Ņemot vērā pašreizējās tehniskās iespējas, IPGK nevar nodrošināt gāzes apjomu, kas nepieciešams Baltijas valstīm, lai kompensētu gāzes piegādes deficītu. Rakstā tiek veikta sistēmas atjaunošanas analīze pēc izvēlētiem kritiskiem notikumiem. Šajā rakstā ir sniegts pārskats par pasākumiem, kas jāievēro, lai pēc izvēlētiem kritiskiem notikumiem atjaunotu gāzes pārvades sistēmas normālu darbību. Ļoti nozīmīgs Latvijas energosistēmas reģions ir Latvijas centrālā daļa un Rīgas reģions, kur atrodas gan Rīgas TEC, gan Rīgas HES. Latvijas gāzes sistēmas atjaunošanas laiks ir atkarīgs no situācijas nopietnības un bojājumiem gāzes sistēmā un var būt no vairākām stundām līdz vairākām dienām.

24.04.2018.