

IMPACT OF THE CONFLICT IN THE SOUTH-EAST OF UKRAINE ON THE SECURITY OF THE UKRAINIAN GAS TRANSPORTATION SYSTEM

Aliaksandr Autushka-Sikorski

Summary

The Ukrainian gas transportation system (GTS) is a crucial component of the European gas infrastructure, which accounts for supplies of up to a quarter of the total amount of natural gas consumed in Europe on an annual basis. A substantial portion of Ukraine's south-eastern regions has found itself in an instability zone caused by a conflict between the Russian Federation and the new Kyiv authorities. This instability zone threatens the integrity of Ukrainian GTS, as some of its structural elements might be damaged as a result of military activities, or the Ukrainian government might eventually lose control over some of its parts.

However, various parts of the Ukrainian GTS do not have the same significance for the sustainability of natural gas transit within Ukraine and towards the EU. Which components of Ukrainian GTS have the most significance for gas transportation? Do the combat operations in the south-east of the country have potential for threatening the security of natural gas transit through Ukraine?¹

The *network analysis* method offers answers to all of these questions. A simulation of the Ukrainian GTS and analysis of its structure show that nodes most important for the stable operation of the network are the gas compressor stations located in the vicinity of the village of Shebelinka, in the Balakliia Raion of the Kharkiv Oblast, and the urban village of Dashava, in the Stryi Raion of the Lviv Oblast. Any suspension or damage of these stations may either seriously hinder the intake of Russian gas into the Ukrainian GTS (the Shebelinka station) or virtually completely halt natural gas transit to European consumers (the Dashava station).

As of today, the area controlled by separatists and sites of clashes between separatists and the Ukrainian regular army are more than 300 kilometers away from Shebelinka and more than 1,000 kilometers away from Dashava; therefore, there is no direct threat to the integrity of the Ukrainian GTS. However, the very fact that there is an instability zone in relative proximity to a point that is crucial for the operation of the Ukrainian GTS makes the creation of a special unit responsible for the protection of the Ukrainian gas transport infrastructure increasingly relevant. Such a unit can be established on the basis of "Scorpion", an operational guards unit of the Ukrainian Special Forces that is responsible for the protection of the nuclear facilities located in Ukraine.

At the same time, given the organizational challenges that the Ukrainian army has faced recently, additional support in the creation of such a specialized unit can be provided by foreign specialists experienced in the protection of energy infrastructure. Experts at the United States Department

¹ Admittedly, the hostilities in the south-east of Ukraine are not the only threat to the transit of natural gas through its territory and the energy safety of Ukraine. A whole new challenge is the construction of the South Stream project to transport natural gas from Russia to Western Europe bypassing Ukraine. The current situation and potential risks will be addressed in one of BISS's upcoming research papers.

of Defense could offer such support, since the U.S. Army has a wealth of experience in the protection of the Iraqi oil infrastructure. Further, peacemaking troops could also be involved in the protection of gas transport facilities, provided they are sent to Ukraine and given a relevant mandate.

Introduction

The infrastructure of the Ukrainian GTS is capable of transiting 142 billion cubic meters of Russian natural gas to Europe on an annual basis, which accounts for 55% of the total transit capacity that supplies Russian natural gas to European consumers and exceeds the combined capacity of the other transit routes — Yamal–Europe and Nord Stream (EEGas, 2014). The Ukrainian GTS accounts for 20% of Europe’s annual gas consumption, and the stability of the GTS is critical for uninterrupted supplies of energy resources to European consumers.

As of today, Russian gas transit is using approximately 50% of the combined capacity of the Ukrainian GTS (which became possible after the launch of Nord Stream, see transit statistics in Naftogaz, 2014). However, even given these limitations, gas transit through Ukraine is almost equal to the combined peak transit capacity of the Nord Stream and Yamal–Europe pipelines.

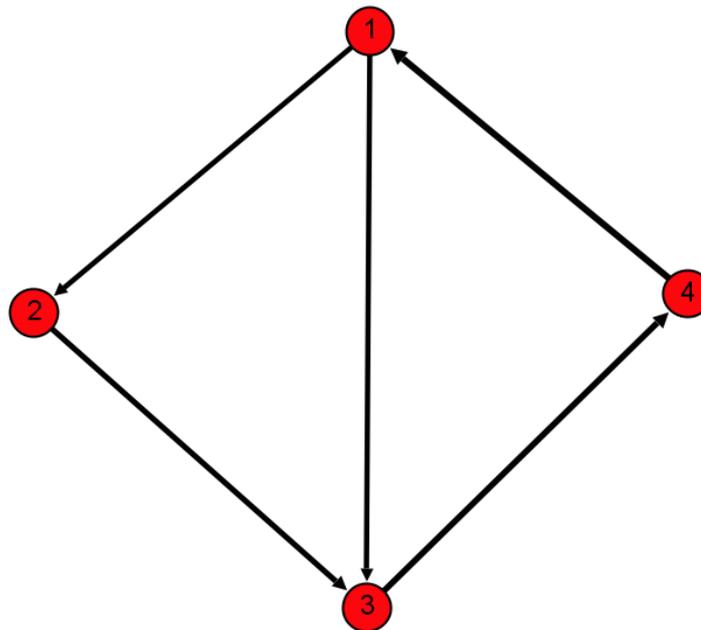
The Ukrainian GTS is not a single transit pipeline, but an extensive *network* of gas pipelines that provides natural gas transport not only all over Ukraine, but also to several European countries — Slovakia, the Czech Republic, Austria, Poland, Moldova, Romania, etc. A logical question would be, is any portion of the Ukrainian GTS more important for gas transit and the operation of the entire GTS than the other portions? If the answer is yes, what is the location of these critical GTS portions, and what would be the consequences of their shutdown? These questions become increasingly relevant because of the armed conflict in the south-east of Ukraine. Any damage to separate parts of the Ukrainian GTS may affect its performance and stability of gas deliveries, whereas if separatists manage to take the GTS under their control, the system may be used as a “bargaining chip” in their negotiations with Kyiv, as well as in talks over the terms and conditions of Russian natural gas supplies to Ukrainian and European consumers.

Methodology and data

Any network is characterized by the existence of *nodes* and *links* between these nodes. Nodes are the basic components of a network, which ensure its operation and determine its characteristics. For instance, in a terrorist network, terrorists themselves will serve as nodes, whereas in a power grid network, nodes are the facilities that generate electricity and the transformer plants that ensure the distribution of electricity throughout the network.

Nodes in a network are connected by links, which provide exchange between nodes and distribution of content across the network. In a terrorist network, content is represented by information, whereas in a power grid network, electricity serves as content. Links in a network can have various importance depending upon the amount of content that they transfer from one node to another. Furthermore, links can be either directed or undirected. A directed link is characterized by the transfer of content exclusively in one direction from one node to another (see Barabási, 2012). See Figure 1 for a visualization of an elementary network.

Figure 1. A visualization of a network having four nodes and five links (the nodes are in red, the links are in black, and the arrows show the direction of the links)



We will use the same pattern to simulate the Ukrainian GTS as a network with directed links. Compressor stations, connections and junctions of pipelines represent the nodes, and the links that connect the nodes are the pipelines itself that transport natural gas across the GTS. The map of the Ukrainian gas transportation system will be used as a source of data to encode the network (Naftogaz, 2009).

In order to decide which of the nodes appear to be critical for gas transportation across the GTS and for the stability of the entire GTS, we will calculate the parameter of so-called *flow betweenness*.

This term is borrowed from financial market analysis, where free and fast capital flow is critically important. Flow betweenness determines the extent to which any given node within a network is significant for free passage of any flows through the network — information, money, or, as in our case, flows of natural gas. If we remove the nodes with the highest level of flow betweenness or disrupt their operation, we will seriously slow or halt the passage of natural gas flows through the network as a whole or its parts. Flow betweenness is measured on a scale zero to infinity — the higher the level, the higher the importance of the node in question for free passage of flows through the network (White, Smith, 1988; Freeman, Borgatti, White, 1991). The significance of a specific node for free passage of flows through a network is determined by a set of factors, including the number of links connected to the node, their direction, and the configuration of the entire network.

Network analysis

The low detailed map of the Ukrainian GTS is presented schematically in Figure 2. The area that is controlled by separatists, to a greater or lesser degree, is presented in red.

Figure 2. The Ukrainian GTS with a low detailed map of the gas pipeline network (see the legend for the explanation of the signs)

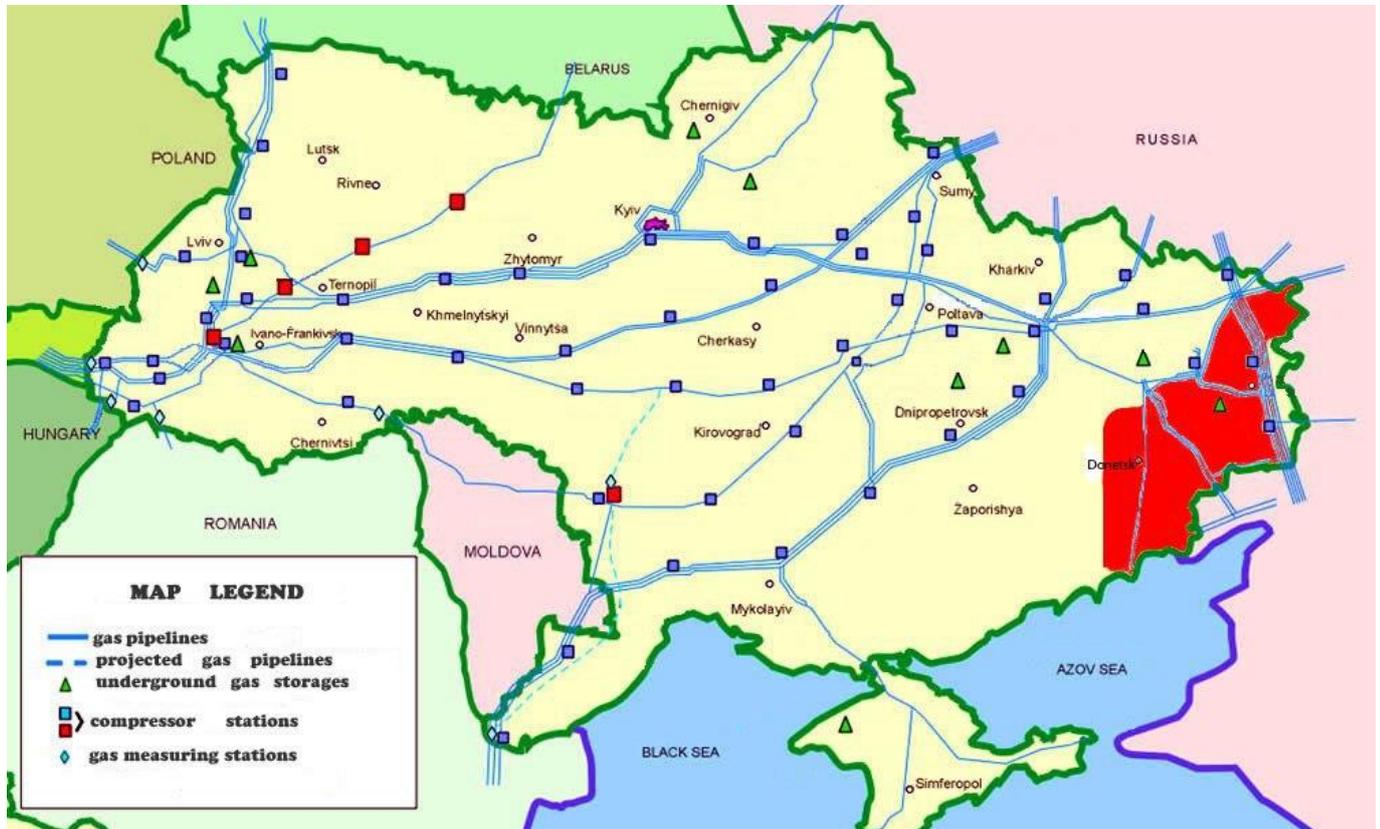
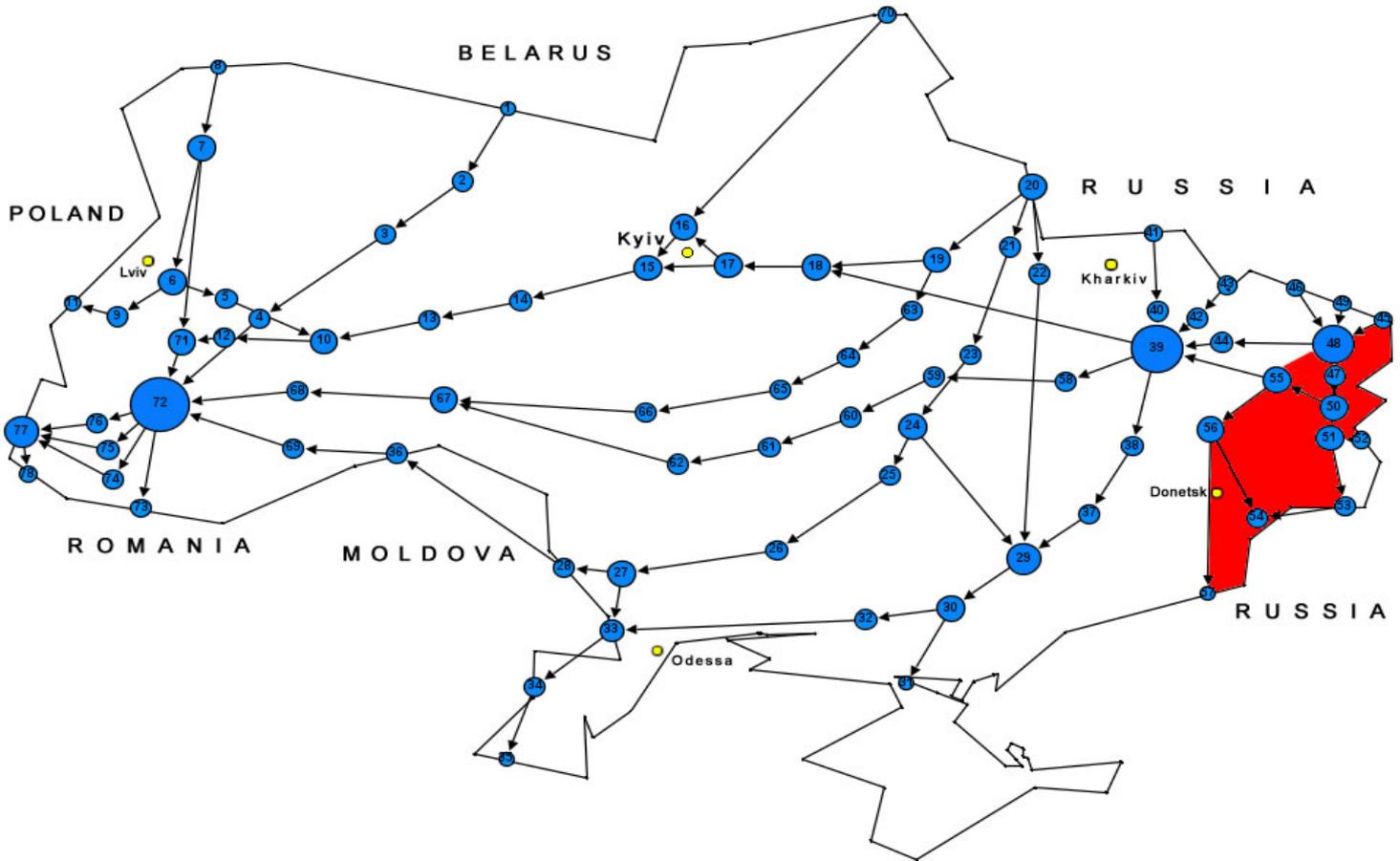


Figure 3 presents a visualization of the Ukrainian GTS as a network. The diameter of a specific node depends upon the number of links that connect that node to other nodes. Arrows show the direction of the links. The area controlled by separatists is marked in red. The portion of the GTS located in Crimea is not included in the visualization and further analysis, because it is de-facto beyond the control of the Ukrainian government. The numbers of the nodes in the network are put randomly; for the correspondence to geographical locations, see the map used to encode the network (Naftogaz, 2009).

Figure 3. A visualization of the Ukrainian GTS as a network² (with approximate geographical scales)



Network analysis shows that nodes 39 and 72 are *hubs* — the nodes that connect most of the other nodes. These nodes appear to have the highest level of flow betweenness (see Table 1).

Table 1. Nodes with the highest level of flow betweenness (the table includes nodes with flow betweenness above 10)

Node	Flow betweenness ³
39 (Shebelinka) ⁴	42.824
72 (Dashava)	40.416
71 (Bobrka)	19.354
67 (Berdychiv)	17.600
48 (Novopskov)	16.718
10 (Ternopil)	14.596
44 (Borovaya)	13.470
29 (Krasnopillya)	12.935
68 (Husiatyn)	10.647
13 (Krasyliv)	10.181

² Gephi application (version 0.8.2) is used for network visualization (Gephi, 2014).

³ Flow betweenness has been calculated using the UCInet 6.0 software package (Borgatti, Everett, 2002). UCInet is the most frequently used package for the visualization and parametric analysis of various types of networks. See (Vedres, Scotti, 2012) for alternative uses of the package.

⁴ In the brackets are the names of the settlements closest to the indicated nodes.

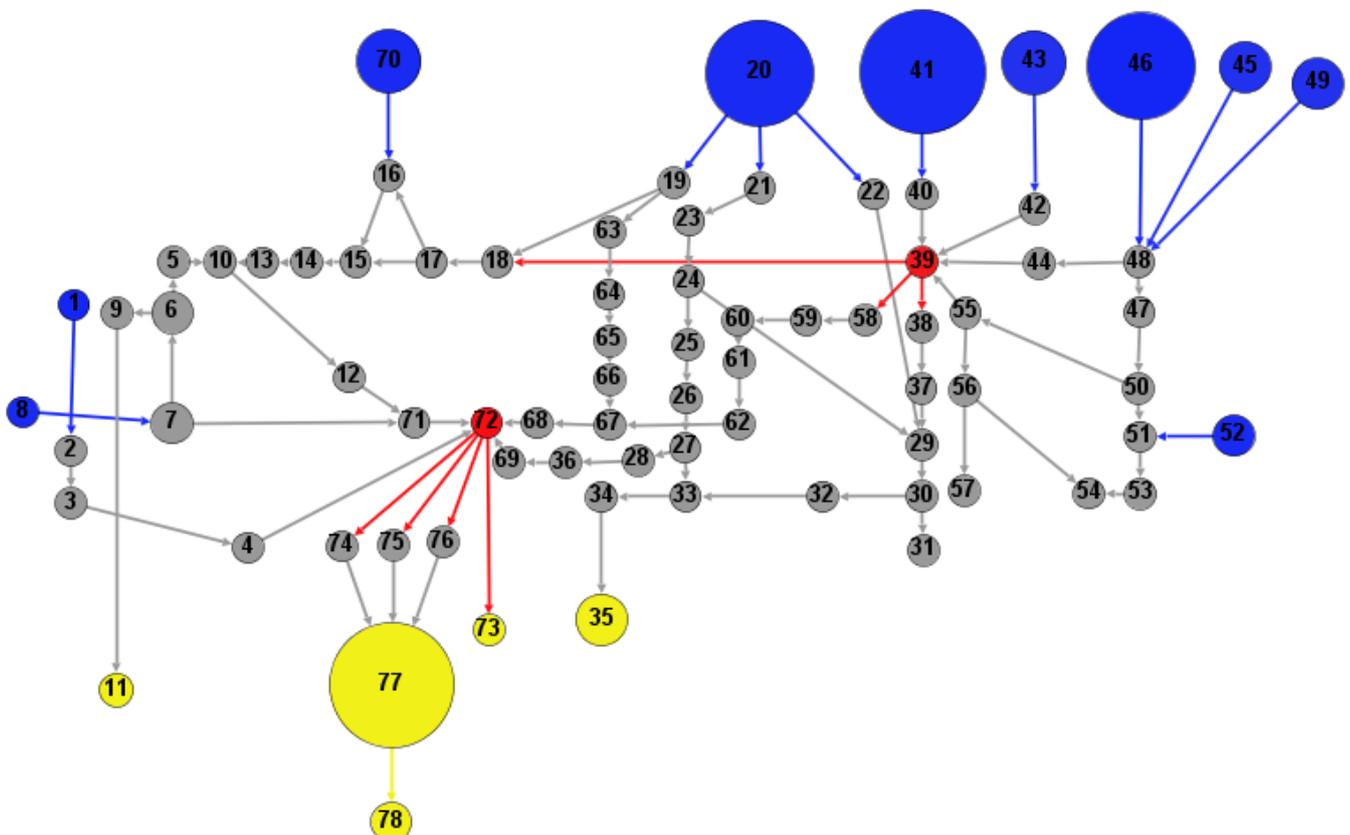
Thus, the most significant nodes for natural gas transit within and beyond the Ukrainian GTS are the compressor stations in the vicinity of the village of Shebelinka, in the Balakliia Raion of the Kharkiv Oblast (node 39), and the urban village of Dashava, in the Stryi Raion of the Lviv Oblast (node 72). Importantly, these two nodes show very high level of flow betweenness in comparison with other nodes: the level of flow betweenness of node 72 is more than twice as high as that of node 71, which is the third one by flow betweenness level in the whole network (see Table 1).

The said nodes therefore play the most important roles in ensuring the stability of natural gas transit both inside Ukraine and beyond it. Two factors determine the importance of these nodes – network configuration and geographical location.

Hubs are not always represented by nodes with the highest levels of flow betweenness; everything depends upon the direction of connecting links and location of hubs in a network. In the case of the Ukrainian GTS, nodes 39 and 72 are located quite close to the state border. Node 39 is responsible for distributing large volumes of natural gas coming from Russia *inside* Ukraine, i.e. it serves as a “mediator” between sources of natural gas and the rest of the network. Node 72, for its part, is a “mediator” between pipelines within the GTS and those going *beyond* Ukraine. In other words, it is crucial for Russian natural gas to reach European consumers.

Figure 4 features a visualization of the Ukrainian GTS with an indication of nodes responsible for the intake of natural gas into the Ukrainian GTS and transfer of natural gas from the Ukrainian GTS further to Europe. The nodes responsible for the delivery of natural gas to Ukraine are highlighted in blue, and those responsible for natural gas supplies to Europe are marked in yellow. Nodes 39 and 72 are shown in red. The size of the nodes responsible for natural gas intake depends upon the volume of natural gas coming through them.

Figure 4. A visualization of the Ukrainian GTS as a network with a highlight of the nodes responsible for the intake of natural gas into the GTS and its delivery to European consumers (geographical scale is inaccurate)



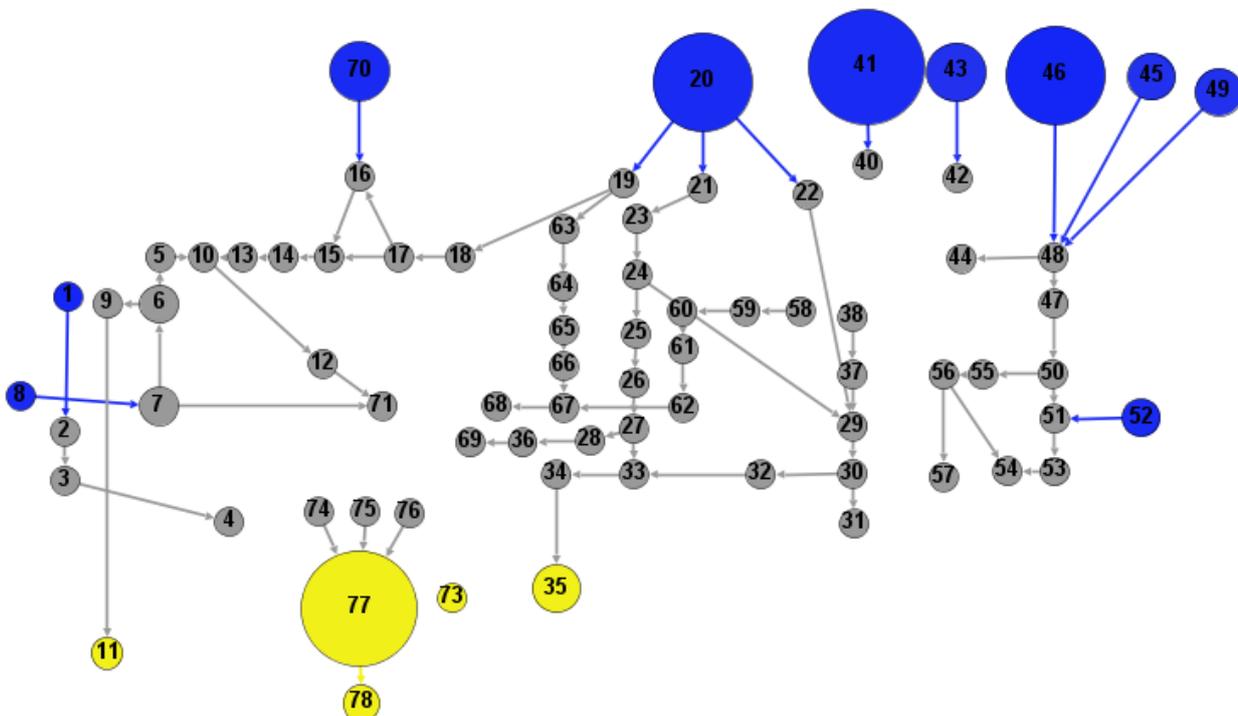
As is seen from the figure, node 39 is responsible, one way or another, for the distribution of natural gas from Russia along the Petrovsk–Novopskov, Orenburg–Novopskov, Urengoy–Novopskov, Ostrogozhsk–Sheblinka, Yelets–Kremenchuk–Kryvyi Rih lines (see the map Naftogaz, 2009 for details). Node 39 de facto provides, to a greater or lesser degree, natural gas supply to the parts of the Ukrainian GTS located beyond Donetsk and Luhansk Oblasts. Henceforth, natural gas is distributed across the network in different ways, but overall, node 39 ensures the connection of major nodes, which serve as natural gas sources, with the western and southern portions of the Ukrainian GTS. These “source nodes” are capable of supplying up to 177 billion cubic meters of natural gas annually.

For its part, node 72 is responsible for providing natural gas to the nodes that deliver natural gas to the EU. These nodes are the end points of the Khust–Satu Mare, Uzhhorod–Beregovo, Sokhranovka–Uzhgorod, and Sudzha–Uzhgorod lines, with a combined annual capacity of 155 billion cubic meters of natural gas.

Disconnection of nodes and consequences for natural gas transit

What are the consequences of hypothetical disconnections of nodes 72 and 39 for natural gas transit within the Ukrainian GTS and transit to the EU? To answer this question, we should *simulate an attack* on these nodes presuming that the functionality of the nodes has been compromised or that they have been destroyed. Network configuration after the exclusion of these two nodes is visualized in Figure 5.

Figure 5. Network visualization after a simulated attack on nodes 72 and 39



As is seen from Figure 5, the result of the “disconnection” of node 39 from the network is the lack of access of six nodes — 41, 43, 46, 45, 49, and 52 — to the western part of the Ukrainian GTS. Formally this means a sharp reduction in natural gas supplies to the west of Ukraine and preservation of natural gas supplies only to the Luhansk and Donetsk Oblasts. A disconnection of node 39 would additionally make it impossible to supply to the EU more than 80% of natural gas annually delivered to European consumers through Ukraine.

Whereas node 39 is important for providing access of natural gas to the Ukrainian GTS network, node 72 is critical for the supply of natural gas to the nodes responsible for the transportation of natural gas to the EU. If node 72 would be disconnected, access of the entire network to nodes 73, 78, and 77 will become unavailable, i.e. the annual transport of up to 80% of natural gas coming through Ukraine to European consumer will be disrupted.

Potential impact of the conflict on the stability of the Ukrainian GTS

Apparently, there is no way the conflict in the south-east of Ukraine can impact the operation of the compressor station encoded as "node 72" in the Lviv Oblast, which is very far from the combat zone.

However, the distance from the positions of separatists to Shebelinka — node 39 — was approximately 300 kilometers as of 1 November 2014. This distance is well outside the range of the artillery available to separatists, and the only real threat to the operation of the compressor station would be a considerable advancement of their troops, or gaining access to long-range rocket complexes, such as the "Tochka-U" (NATO reporting name – SS-21 Scarab A) missile, or a sabotage attack.

Therefore, given the ceasefire regime between the Ukrainian regular army and separatist troops, the instability in the south-east of Ukraine does not threaten the operation of the most significant nodes of the Ukrainian GTS. However, in the foreseeable future, the instability zone in Ukraine will remain, which means there will still be a potential threat to the security of natural gas transit through the country, given the relative proximity of the compressor stations in the vicinity of Shebelinka to the positions of separatists.

Ukrainian energy infrastructure facilities have already been damaged as a result of combat operations. On 31 August 2014, spokespeople for Russian oil major Rosneft reported shelling of Lisichansk Oil Refinery, which resulted in a fire at the refinery and called for its temporary shutdown. The positions of separatists were approximately 60 kilometers from Lisichansk back then.

The persistent instability zone in relative proximity to structurally important components of the Ukrainian GTS one way or another questions the security of natural gas transit through Ukraine. The likelihood of subversive actions, sabotage, and rekindling of the conflict increases the relevance of the creation of a law-enforcement agency that would have the same functions as the so-called Chechen "oil regiment" — a special unit at the Ministry of the Interior that ensures the security of oil infrastructure facilities.

Conclusions and brief recommendations

The use of the network analysis method to identify the most significant nodes for the operation of the Ukrainian GTS shows the high importance of the compressor stations in the vicinity of Shebelinka and Dashava. If the operability of these two compressor stations would be disrupted, considerable amounts of Russian natural gas will be unable to enter the Ukrainian gas transport system or be transferred to European consumers.

As of today, the location of the conflict zone in the south-east of Ukraine does not pose a direct threat to the integrity of the Ukrainian GTS. However, the very fact of the existence of that instability zone in a relative proximity to structurally important components of the GTS bears risks to the security of natural gas transit through Ukraine⁵.

⁵ Some European officials already have concerns over risks to the integrity of the Ukrainian GTS and security of natural gas transit to the European Union caused by combat operations. See the statement by Václav Bartuška, Ambassador-at-Large for Energy Security of the Czech Republic in the EU (Reuters, 2014).

Ukraine could curb risks if it created a special law-enforcement unit to protect the GTS for the entire period of the armed conflict or reinforce the combat units of the regular army deployed in neighboring regions. As of today, Ukraine has a “basis” to create such a unit — it could make use of “Scorpion”, an operational guards unit of the Ukrainian Special Forces that is responsible for the protection of the nuclear facilities located in Ukraine. When necessary, additional resources to train specialists could be provided by experts at the United States Department of Defense, since the U.S. Army has a rich experience in the protection of the Iraqi oil infrastructure. Further, should the military conflict aggravate, peacemaking troops having a relevant mandate could also be involved to ensure the protection of the Ukrainian gas transport system.

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