

On the verge of blackout: Ukraine facing attacks on its electricity generation system

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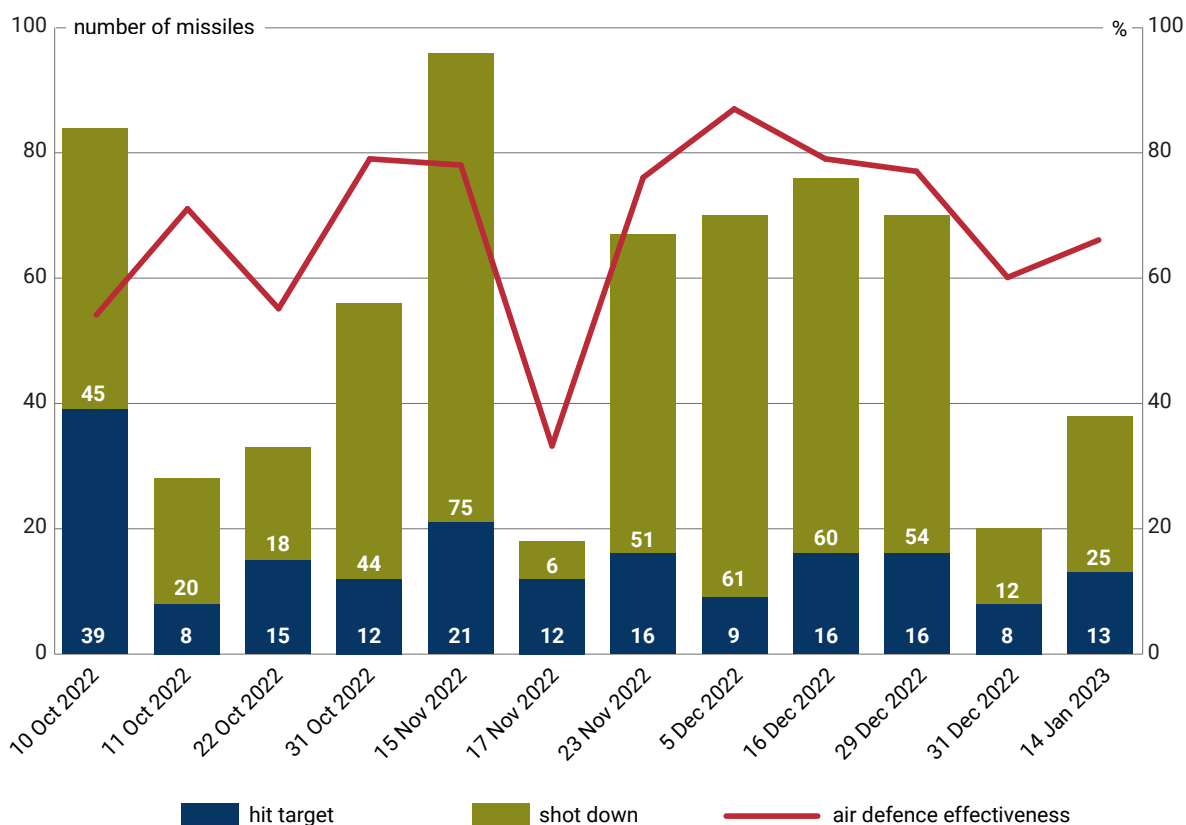
Ukraine's power plants and electricity grid have been subjected to regular, massive shelling campaigns using ballistic missiles and kamikaze drones for the past three months. Although they have not so far brought about a permanent nationwide blackout, on several occasions they resulted in significant destabilisation of the grid's operation. Increasingly frequent power outages (both planned and unplanned, usually lasting many hours) have become daily occurrences in almost all regions of Ukraine. In response to this, Kyiv has prepared measures to secure the state's continued operation in situations of prolonged power outages. At the end of December 2022, a network of nearly 1500 banking outlets was established to provide banking services regardless of the situation. To ensure that other sectors of the economy can continue operating uninterrupted, filling station and mobile network operators have also taken similar measures. While it is impossible to predict whether Russia will attain its goal, namely to cause a complete and prolonged blackout of Ukraine, the attacks carried out so far have already had a very negative impact on the country's economy. At the same time, there are no indications that the problems with electricity supplies will break the resistance of Ukrainian society or significantly boost migration.

Attacks on critical infrastructure

Although Russia had been carrying out strikes on Ukrainian energy facilities since the first days of the war, especially in localities close to the front line, it was only on 10 October 2022 that these attacks were expanded onto a mass scale. On that day, 84 rockets were launched, nearly 40 of which hit their planned targets and seriously destabilised the electricity grid over half of Ukraine for the first time. Since that day, Russia has carried out more than ten mass-scale missile attacks, half of them using at least 60 cruise missiles. In addition, these missile attacks were combined with strikes carried out using kamikaze drones, which the Russians began to use increasingly frequently at the turn of 2023. Kyiv claims that the Ukrainian air defence shoots down most of the missiles Russian forces launch (see Chart 1 for details), and the necessary repairs of the electricity grid are carried out promptly; however the scale of the damage is mounting, and the continuous attacks generate problems for the electricity grid and extend the duration of the necessary power cuts, even if the devastation they cause is smaller.



Chart 1. Missile attacks on energy infrastructure carried out since 10 October 2022 and the effectiveness of the Ukrainian air defence



Source: General Staff of the Ukrainian Armed Forces.

It seems that most of the Russian missile attacks (especially the initial ones) targeted high-voltage distribution substations. Although the Ukrainian authorities did have a certain stock of spare parts and transformers, they were unable to stockpile enough of them, and most of the repairs to the damaged substations were only provisional. The situation has been further complicated by the fact it takes several months to manufacture the large custom-built transformers which are needed for specific locations. The shelling carried out on 23 November 2022, the seventh in the series of recent attacks, temporarily split the power generation system into several smaller systems operating separately, which forced the national power company Ukrenergo to suspend the operation of all units running in the country’s nuclear power plants for the first time in the history of independent Ukraine. This deprived two-thirds of Ukrainian consumers of access to electricity, and it took a week to restore power to 80% of them.¹ For comparison, it took between several hours and less than a day to resolve the consequences of the 10 October 2022 attack. In contrast, due to the shelling carried out on 16 December 2022, energy consumption in Ukraine as a whole decreased by more than 50%, and four days after these attacks 80% of Kyiv oblast still had no access to electricity. It is worth noting that the last two attacks launched in 2022 (on 29 and 31 December) caused fewer problems with electricity supply than those mentioned above.

The scale of damage and the consequences for the economy...

The Russian aggression launched on 24 February 2022 has caused a reduction in Ukraine’s electricity consumption of around 30%. This was due to military activity, decreased industrial production, and the fact that several million Ukrainians have left the country. Despite the fact that Ukraine lost

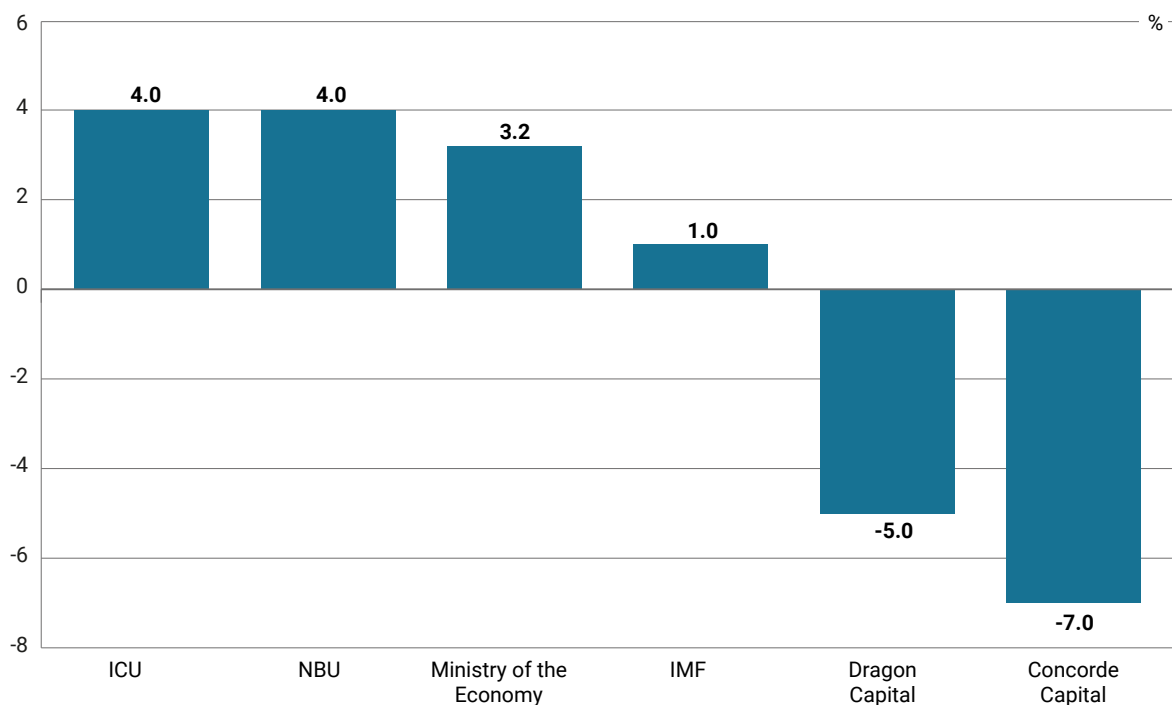
¹ I. Маскалевич, ‘Новий удар по енергосистемі. Чого чекати?’, 30 November 2022, zn.ua.

control of a portion of its territory, including the region which hosts the Zaporizhzhia Nuclear Power Plant, Europe’s largest such plant (which has 6 GW of installed capacity), it was initially still capable of meeting its electricity demand. The mass shelling campaign seems to have changed this situation. Although it is difficult to assess precisely whether the current power deficit results from damage to the power transmission lines or from the destruction of power generation facilities, Ukrenergo has been issuing regular announcements of power shortages for several weeks now.

The scale of the damage is difficult to estimate because the government only provides partial information. In December 2022, it announced that all thermal and hydroelectric power plants in Ukraine had suffered damage as a result of the attacks. However, it provided no information regarding the scale or nature of the damage. 35% of ‘critical facilities of the high-voltage grid’ (no details were provided regarding which ones) had come under fire, 70% of them having been attacked more than once. In January 2023, the government estimated that nearly 50% of the country’s electricity infrastructure had been damaged.

The damage to the energy infrastructure has had a negative impact on Ukraine’s economic standing. According to calculations by the Ministry of the Economy, in October 2022 the country’s GDP shrank by 39% compared to October 2021, whereas the figure for November 2022 was 41%. Taking the figures recorded for August and September 2022 (-35%) into account, this indicates a significant and steady drop in the value of Ukraine’s GDP. The Ministry has also revised its GDP growth forecast for 2023 downwards by 1.4 p.p., from 4.6% to 3.2%, on the assumption that the war will end in mid-2023 and Ukraine will win. The National Bank of Ukraine has announced that it will publish a similar revised forecast soon. It is worth noting that the IMF is less optimistic, and predicts that in 2023 Ukraine’s GDP growth rate will be 1%, while investment funds expect that economic recession will continue (see Chart 2).

Chart 2. Ukraine’s GDP growth forecasts for 2023

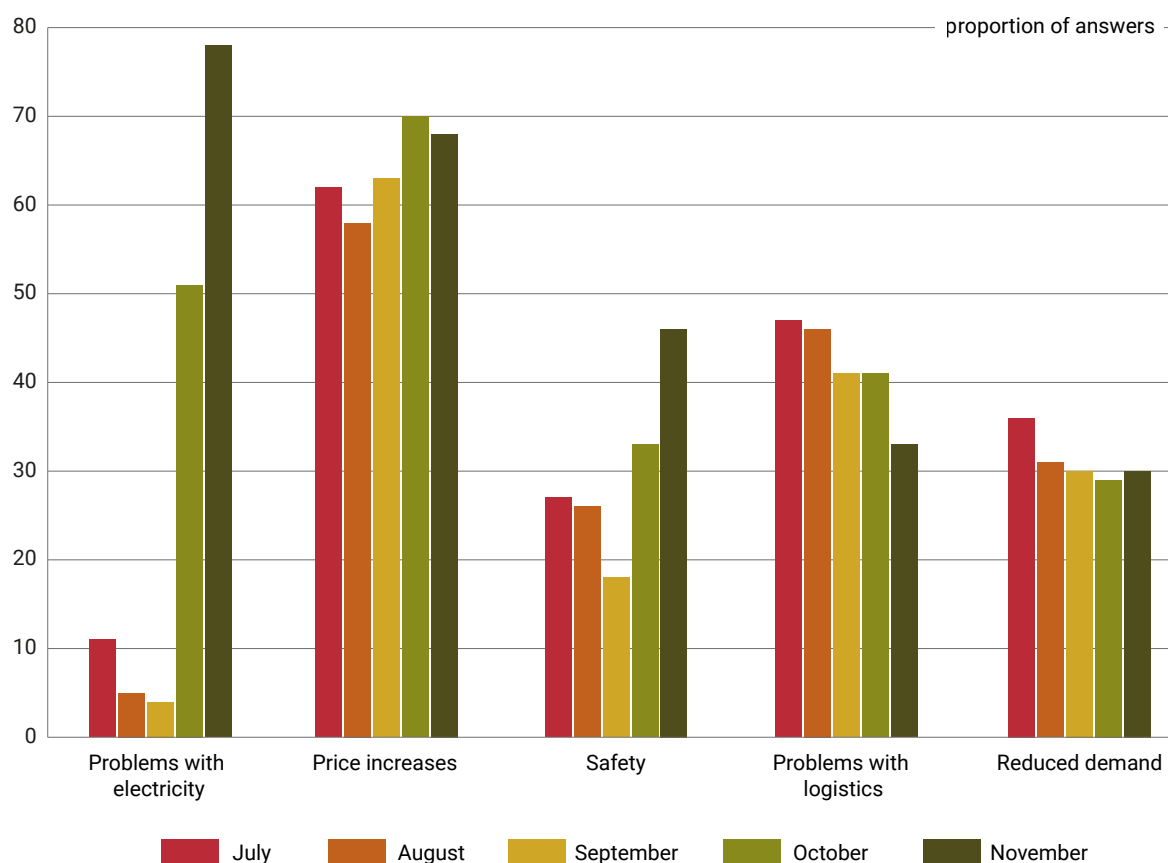


Source: *Ekonomichna Pravda*, epravda.com.ua.

...and for business

The power cuts are strongly affecting the business sector. Although their impact had been marginal until September 2022 (a mere 5% of businesses viewed them as an inconvenience), in November 2022 they began to be perceived as the biggest challenge business is facing, as reported by 78% of Ukrainian companies (see Chart 3), much bigger than the challenges posed by the rising prices of components and raw materials, or by logistical problems. A major increase in concerns about workplace safety in the situation of repeated rocket attacks has also been recorded.

Chart 3. The five most important challenges faced by Ukrainian business owners



Source: Institute for Economic Research and Policy Consulting.

A poll conducted in December 2022 by the European Business Association (EBA) showed that a mere 18% of Ukrainian companies claimed that the power outages did not have any significant impact on their daily operations.² 40% of Ukrainian companies have reduced their production, and 9% have suspended their business activity. At the same time, business is adapting to the new circumstances: 86% of the companies surveyed by the EBA have purchased power generators, and 66% of them have modified their daily work schedule.

The severity of the power supply problems varies in degree for each sector of the economy. In the energy-intensive heavy industry, especially the metallurgical sector, the level of inconvenience is particularly high. As a result of the power cuts, some steelworks have reduced their production significantly; for example in November 2022, ArcelorMittal in Kryvyi Rih was using less than 20% of its production capacity. The Zaporizhzhstal steelworks, which is controlled by the Metinvest Group, produced 79% less

² 'Вплив атак на українську енергосистему на роботу бізнесу', Європейська Бізнес Асоціація, December 2022, eba.com.ua.

steel in December 2022 than in December 2021. In both cases the decrease in production was due to limited export capacity, which in turn resulted from problems with logistics. Although the degree to which the electricity deficit is affecting the agricultural sector is smaller, livestock farming is one exception. In large industrial farms, electricity is needed for ventilation, heating and so on. Although electricity can be produced using generators, the cost of the current they produce is several times higher. Power generators are also used in retail stores and in the service sector. However, businesses (especially small ones) are facing another major challenge posed by the insufficient availability of these devices, as well as the costs of their purchase and maintenance.

Preparations for blackouts

The relatively high level to which public services have been digitised was one of the factors that helped the Ukrainian people to get through the first weeks of the war, as it enabled them to take care of various formalities online without the need to visit a specific institution in person.³ The situation was similar in the case of online banking: the popularity of cashless transactions, which the authorities continued to promote, helped to avoid queues forming at banks and ATMs (with the exception of the very first days of the war). However, in the situation of increasingly frequent and prolonged power cuts in many regions of the country, the previously positive aspects of the high popularity of digital services soon turned into a nuisance.

The mobile telephony infrastructure includes 32,000 antennas, 93% of which are equipped with batteries and 7% with power generators, and is one of the key elements enabling online connectivity in Ukraine.⁴ Those which run on batteries can operate without power for relatively short periods (up to four hours), and it takes about a day to recharge them, which is difficult to achieve when there are regular power outages. In addition, during power cuts affecting households (which also disable their wi-fi networks) many users switch to mobile internet access, which often exhausts antenna capacity. This problem affects residents of big cities in particular. As early as March 2022, the Ukrainian government took action to ensure undisturbed connectivity and introduced so-called internal roaming, initially on the territory of those oblasts where fighting was ongoing, and then throughout the country. This was done on the basis of an agreement between Ukraine's three largest mobile operators (Kyivstar, Vodafone and Lifecell) and the Ministry of Digitisation and other public institutions, and it enabled the subscribers to use the signal provided by any of these companies at no extra charge. In addition, the operators decided to purchase power generators on their own, and to launch partnerships with local authorities and private companies, in order to share the electricity generated for the purpose of powering the antennas with them. Despite this, Russian shelling continues to severely disrupt internet access in Ukraine: for example, on 29 December 2022, 79% of users in Sumy, 75% in Odesa and 57% in Lviv oblast had problems with internet access which lasted several hours.⁵

As a consequence, Starlink terminals are increasingly important for the provision of online connectivity in Ukraine. While at the beginning of the war they were crucial for undisturbed communication by the military on and around the front line, at present, due to regular internet access disruptions, they are becoming increasingly important for the smooth operation of public institutions, businesses, and the daily life of ordinary citizens. Although the government has not revealed how many Starlink terminals operate in Ukraine, in mid-October 2022 SpaceX's owner Elon Musk estimated their

³ S. Matuszak, 'The digitisation of Ukraine: anatomy of a success story', *OSW Commentary*, no. 403, 23 August 2021, osw.waw.pl.

⁴ М. Максимчук, '„Мережі працюють, але їх ресурс не може всіх задовольнити“. Мінцифри про мобільний зв'язок та інтернет в блекаут', *Економічна правда*, 27 December 2022, epravda.com.ua.

⁵ Ю. Тарасовський, 'Російські обстріли призвели до перебоїв з інтернетом. Найгірше було у Сумах, Одесі та Львівській області', *Forbes*, 29 December 2022, forbes.ua.

number at more than 25,000. On 30 December 2022, Prime Minister Denys Shmyhal announced that Ukraine had received another batch of Starlink terminals from Poland. According to media reports, this shipment contained 13,000 units, which suggests that Warsaw has already provided around 20,000 terminals to Ukraine.⁶

Other sectors of the economy which are crucial to its normal operation also have to prepare for potential blackouts. In order to maintain the stability of the banking system in such situations, on 26 December 2022 the National Bank of Ukraine (NBU) launched its Power Banking project. It covers nearly 1500 branches of Ukraine's fourteen largest banks operating in all of the country's oblasts. Each of these outlets has been equipped with a power generator, an alternative channel of communication and additional cash. In addition to normal banking operations, clients can withdraw cash from ATMs at these outlets free of charge, even if they are not customers of the specific bank.

The fuel industry, in particular filling stations, is also making preparations for potential blackouts. By the end of December 2022, the largest chains had installed alternative sources of electricity at the vast majority of their outlets (90% of OKKO and WOG's stations, 100% of SOCAR's, and 75% of Prime's).⁷ Moreover, numerous filling stations owned by Naftogaz (which has nearly 580 stations in 20 Ukrainian oblasts) have been equipped with power generators. This means that even in a situation of prolonged power cuts, there should be no problems with the availability of petrol and diesel.

Remedial measures: power generators, reduced consumption, imports

To reduce the severity of the problems resulting from power cuts, the government has taken steps to facilitate the supply of foreign-made electricity generation equipment. On 9 November 2022, it adopted a decree suspending tariffs and VAT in relation to generators, transformers and their components, as well as heating devices and Starlink terminals; the suspension will remain in effect until May 2023. In addition, the limit on the volume of fuel which can be stored without having to obtain the relevant permit was raised to 2000 litres, making it easier for businesses to increase their stockpiles. These amendments have resulted in a major increase in the import of power generators: between January and October 2022 fewer than 200,000 generators were imported, while in November and December 2022 the figure reached up to 470,000 (see Chart 4).

Local authorities are also taking steps to facilitate the acquisition of alternative sources of electricity. In many cities (including Kyiv and Lviv), residents of apartment blocks have been offered subsidies to purchase generators at between 50 and 75% of their list price.⁸ Another type of assistance provided by the authorities involves the creation of the so-called 'points of invincibility'; these are fixed or mobile rooms capable of holding up to 500 people, which are equipped with access to heating, water, electricity, the internet and mobile telephone networks. They have been built all over Ukraine since November 2022: according to figures compiled at the end of 2022 there were 11,500 such points nationwide.

Moreover, the authorities are also planning to purchase portable gas-fired power stations with capacities of 30–50 MW each. They will be used to provide electricity to critical infrastructure (such as water supply systems and boiler houses) during blackouts. According to various sources, the government plans to buy 10–14 such stations, although the demand reported by Ukraine's major cities is much

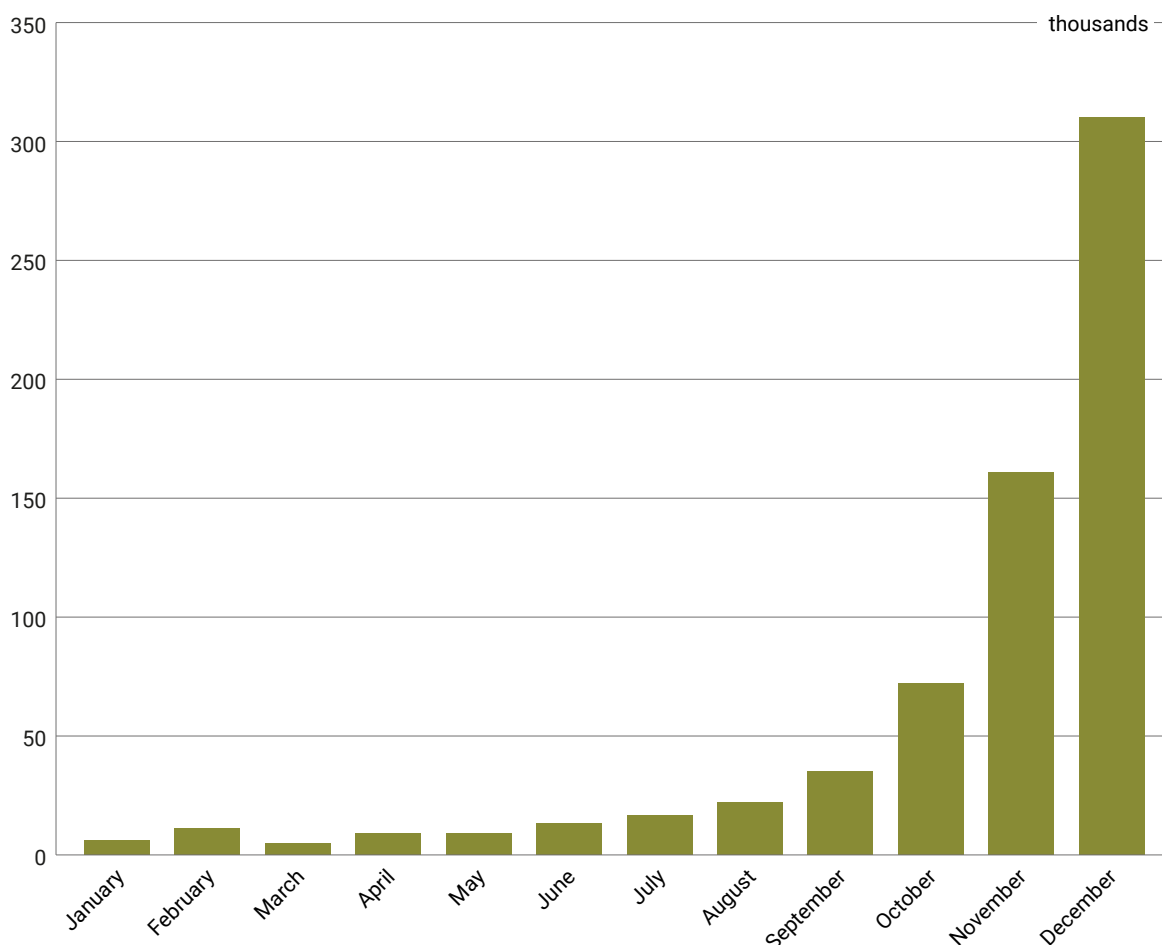
⁶ А. Прасад, 'Україна отримала нову велику партію Starlink від Польщі. Ймовірно, йдеться про понад 13 000 терміналів', *Forbes*, 30 December 2022, forbes.ua.

⁷ М. Топалов, 'На деяких заправках зникло пальне. Що відбувається та чи загрожує Україні чергова паливна криза?', *Економічна правда*, 28 December 2022, pravda.com.ua.

⁸ А. Дячкіна, 'Українці можуть отримати компенсацію за придбані генератори: як це зробити', *Економічна правда*, 9 December 2022, pravda.com.ua.

larger, up to 800–900 MW. Their estimated cost is \$225–540 million, and talks with the US and other countries to purchase more are underway; these will most likely be financed by the World Bank and the EBRD. Ukraine expects to receive the first batch of these power stations at the end of January 2023.⁹

Chart 4. Ukraine’s monthly power generator imports in 2022



Source: information shared on social media by Yaroslav Zheleznyak, deputy chair of the Ukrainian parliament’s committee on finance, tax and customs policy.

Furthermore, initiatives to reduce electricity consumption have been launched. Under a special government programme, between January and March 2023 every Ukrainian citizen will be authorised to exchange up to five standard light bulbs for LED light bulbs free of charge. The government estimates that replacing 50 million standard light bulbs will help Ukraine to save up to 1.5 GW of energy at peak hours, accounting for around 10% of Ukraine’s electricity consumption. To achieve this, Kyiv is counting on help from foreign partners: on 13 December 2022 the President of the European Commission Ursula von der Leyen announced the intention to fund 30 million energy-efficient light bulbs, while France will purchase another 5 million such bulbs, and other sponsors another 15 million.

Importing electricity from neighbouring countries is viewed as another possible solution to the electricity deficit problem. Until 11 October 2022, Ukraine had been an electricity exporter. However, in order to stabilise the voltage on its grid following Russia’s first mass-scale missile attack, it had to cease selling it to foreign customers. The government estimates that it will need emergency electricity

⁹ О. Чайка, ‘Україна знайшла 14 мобільних електростанцій, щоб швидше оговтуватись від блекаутів. Потрібно \$225 млн і мінімум місяць. Як це може працювати?’, *Forbes*, 26 December 2022, forbes.ua.

supplies from EU countries of up to 2 GW (worth €800 million) at least until the end of the heating season. Test imports of a small amount of power (1 MW) from Slovakia and Romania were carried out in October and November 2022. On 3 January 2023, the government announced that arrangements had been made regarding commercial electricity supplies from the EU to Ukraine and Moldova (0.7 GW at night and 0.6 GW in the daytime). However, the main drawback of this solution is that the price of electricity is much higher in EU member states than in Ukraine and Moldova. In order to encourage Ukrainian energy companies to import electricity and reduce the load on the Ukrainian grid, on the same day the government adopted a decree stating that companies which import electricity will be exempt from emergency power shutdowns until the end of April 2023. On 11 January 2023, the Energy Ministry announced that Ukraine had started to import small amounts of electricity from the EU, and is hoping to increase these deliveries in the near future. However, even if this does happen, this initiative will be limited to those oblasts which border EU member states, due to problems with transmitting electricity further into Ukraine.

Prospects

Since 10 October 2022, the main goal of the Russian shelling campaign has been to cause a permanent blackout in Ukraine as a whole, which in turn would trigger an economic collapse, a humanitarian catastrophe and a wave of migration to neighbouring countries, consequently undermining Ukraine's resistance and forcing Kyiv's capitulation. However, it is very difficult to assess whether in such circumstances any such power outage would actually last longer than a few days. Some industry experts argue that such a scenario cannot be ruled out. Ukraine's energy minister Herman Halushchenko believes that Russia would be unable to cause such a situation,¹⁰ and the CEO of Ukrenergo has said that a nationwide permanent blackout is unlikely. Although the last two attacks carried out in 2022 were not as devastating as some of the previous ones, they did cause power cuts in such large cities as Kyiv and Lviv.

It is an open question as to whether Russia will continue to be capable of launching indiscriminate cruise missile attacks on territories located far from the front line. According to the head of Ukrainian military intelligence Kyrylo Budanov, Russia's missile stockpile could still enable it to carry out two or three such attacks (while its new missile production capacity is limited).¹¹ However, it is difficult to assess whether this statement contains true information or whether it is an attempt to boost the Ukrainian public's morale. In the event of its stock of long-range missiles becoming significantly depleted, Moscow is likely to continue attacking the infrastructure of frontline cities using shorter-range missiles such as the S-300. It is worth noting that the shelling is continuing, even though Ukrainian government representatives have been reporting the alleged imminent exhaustion of the Russian missile stockpile for several months now.

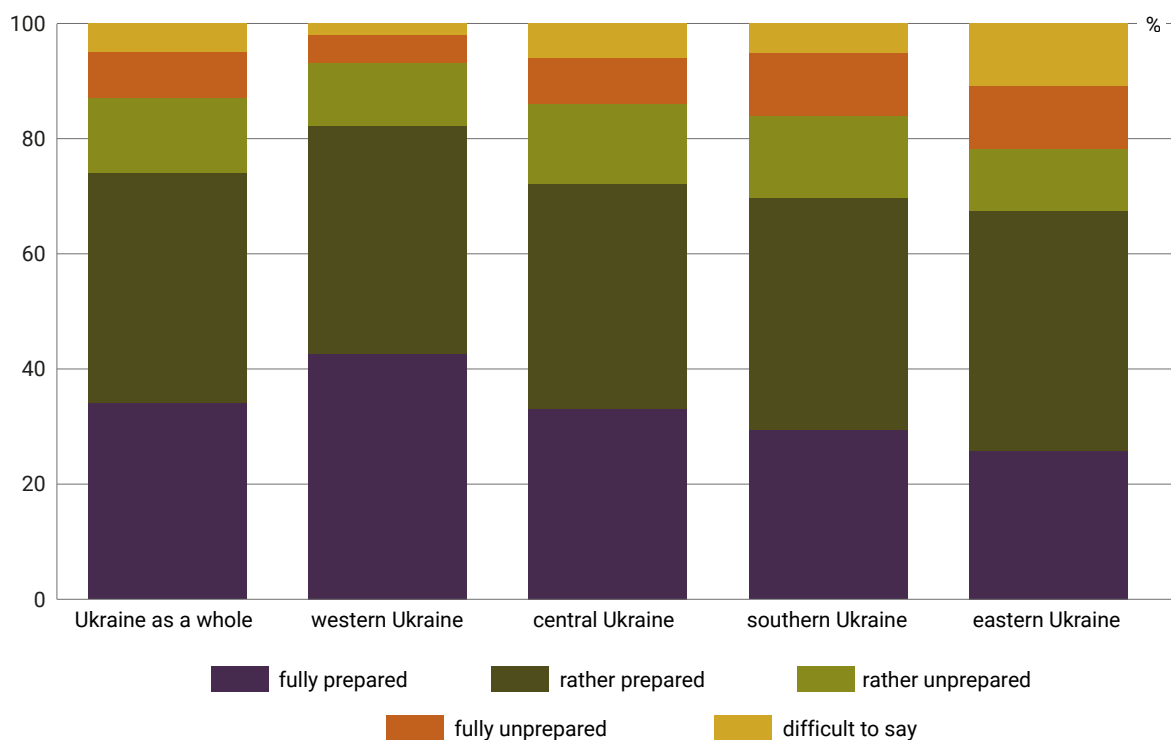
After three months of Russian attacks on the critical infrastructure of Ukraine, it is evident that its damage and the related inconvenience caused to citizens in their daily life have not translated into increased public discontent, nor have they undermined Ukrainian citizens' readiness to continue to resist. According to a poll conducted by the Kyiv International Institute of Sociology (KIIS), in December 2022 85% of those surveyed were in favour of continuing the fight until the whole of Ukraine's territory is liberated (in September 2022 the proportion was 87%), and no major differences were recorded for specific regions (even in eastern Ukraine, which is most affected by the war's

¹⁰ І. Орел, О. Чайка, «Чи можливий блекаут всієї України? Думаю, у них не вийде». Міністр енергетики Герман Галушенко про відновлення енергосистеми України. Інтерв'ю', *Forbes*, 22 December 2022, forbes.ua.

¹¹ Ю. Смірнов, В. Кондратова, «Кирило Буданов: Наші підрозділи зайдуть до Криму зі зброєю в руках», *ЛІГА.net*, 26 December 2022, liga.net.

consequences, the proportion was 80%)¹². Moreover, it was found that Ukrainians assess the level of their households' preparedness for heating cuts as relatively high. Another poll conducted by the KIIS in December 2022 showed that 74% of respondents said that they were prepared or moderately prepared for such situations, while the proportion of the respondents who consider themselves as fully prepared has risen by 10 p.p. compared to September 2022, from 24 to 34%. Certain differences were recorded in answers provided by residents of specific parts of the country (see Chart 5), although these are relatively insignificant.

Chart 5. Assessment of the level of households' preparedness for heating problems



Source: Kyiv International Institute of Sociology.

¹² 'Динаміка готовності до територіальних поступок для якнайшвидшого завершення війни', Київський міжнародний інститут соціології, 2 January 2023, kiis.com.ua.