

# International Power Systems and Energy Security

## —The Connection of Ukraine and the Baltic States to the European Power Grid

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### Introduction

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One of the characteristics of Russia's invasion of Ukraine, which began in February 2022, is Russia's series of violations of international law.<sup>1</sup> Although Additional Protocol I to the Geneva Conventions stipulates the prohibition of indiscriminate attacks, the protection of civilian objects, and the minimization of civilian casualties, it is highly likely that the Russian military is intentionally establishing these as targets. Critical infrastructure that has suffered particularly severe damage includes power generation facilities and the power transmission grid. As of the end of May 2024, approximately 70% of Ukraine's thermal power generation capacity was either under Russian occupation or lost due to damage.<sup>2</sup> Zaporizhzhia Nuclear Power Plant, which was responsible for approximately one-quarter of Ukraine's electricity supply, had been placed under Russian control and approximately half of its high voltage substations had been damaged, as well as many distribution substations.

As a result, electricity shortages are occurring frequently in Ukraine. Nonetheless, the electricity supply has not been decisively destroyed, and the country's social and economic activities have been maintained despite the constant exposure to danger. Ukraine separated its power systems from Russia and connected them to the European Network of Transmission System Operators for Electricity (ENTSO-E) the month after the invasion began (March 2022). Thirty-six countries and 40 transmission system operators in Europe are members of ENTSO-E, and this measure enabled Ukraine to build a structure for importing electricity from Europe. This has become a major factor enabling Ukraine's electricity supply to be maintained (naturally, there are factors other than this, including rapid restoration in the event of damage, the dispersed locations of power generation facilities, and the construction of an air defense network).

While an emergency connection was made in response to the Russian invasion, such actions cannot be implemented overnight. Ukraine was no exception, with the project based on a contract concluded in June 2017 and originally scheduled for completion in 2023.<sup>3</sup> The emergency connection, which brought forward the original schedule, synchronized Ukraine's transmission system operator Ukrenergo and Moldova's Moldelectrica with ENTSO-E, securing their electricity

supplies. As of March 2024, Ukraine's total electricity imports were 935 GWh, and that figure represents a significant increase compared with the 415 GWh of imports before the invasion commenced (in 2021).<sup>4</sup>

Furthermore, the Baltic states completed their connection to ENTSO-E in February 2025. This project is older than that of Ukraine and Moldova, having been underway since the 2000s. Although the Baltic states are not under direct attack, the connection to Russia's power systems was regarded as questionable in terms of energy security. Note that Lithuania's withdrawal from Russia's power systems has isolated the strategically important Kaliningrad Oblast from mainland Russia.

In this paper, we will discuss the importance of power systems, particularly power grids, from the perspective of energy security, using the examples of Ukraine and the Baltic states.

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## **Russia's Power Systems (IPS/UPS)**

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The Integrated Power System/Unified Power System (IPS/UPS), a power transmission grid in the former Soviet bloc that includes Ukraine, Moldova, and the Baltic states, still connects Russia to its neighboring countries today. UPS refers to the network inside Russia and IPS refers to the network connecting neighboring countries to the UPS. In the Soviet era, power systems mutually connecting central and eastern European countries to the Soviet Union existed in the Comecon (Council for Mutual Economic Assistance) framework, but they were split up as a consequence of the collapse of the Soviet Union. A characteristic of IPS/UPS is that the frequency is centrally controlled in Moscow, so artificial frequency destabilization is possible.<sup>5</sup> This is a major concern for the Baltic states, in addition to the electricity supply being influenced by political impacts.

The necessity of frequency management arises from the fact that current alternating current (AC) power sources are the mainstream electricity transmission method. With AC power sources, it is necessary for the amount of power generation and the amount of electricity consumption (load) to match at all times. Frequency is an indicator of this balance; when the amount of power generation exceeds load the frequency rises and when the opposite occurs frequency declines. A sustained imbalance can destabilize the grid, causing equipment failures, malfunctions, and power outages. The frequency deviation tolerance is typically  $\pm 0.1\text{Hz}$  to  $0.3\text{Hz}$ . In the 21st century, the introduction of high voltage direct current (HVDC) has increased around the world. While HVDC has a major advantage over the AC method, namely frequency management not being necessary because electricity transmission loss is low, it faces issues such as high initial costs and the

difficulty of maintenance and management.<sup>6</sup>

For some time after the collapse of the Soviet Union, Russia's electricity business had a structure centered on the state-owned electricity holding company Rossiyskoye Aktsionernoye Obshchestvo Unified Energy System (RAO UES), which was established in 1992.<sup>7</sup> However, business reforms were commenced in 2001 and as a result RAO UES was dissolved and separated into different sectors in July 2008. Operating companies were established for the sectors of power transmission and distribution/grid operation, hydroelectric power generation, thermal power generation, and retail supply, and the grid operating company (SO EES), which serves as the nationwide load dispatching center; the federal electricity transmission company (FSK EES), which owns, maintains, and manages the core power grid; and MRSK Holdings, the electricity distribution holding company, were established in the power transmission and distribution/grid operation sector. The Russian government owns 100% of the shares of SO EES and the streamlining of operations is required in the electricity distribution sector where capital investment demand is high, so it was integrated with the electricity transmission sector. Finally, MRSK Holdings was renamed Rosseti and placed FSK EES under its umbrella. The situation is that Russian government owns 88% of Rosseti's shares and the operation of the power systems and frequency and supply and demand adjustments are completely under the management of the Russian government. Similarly, a government-linked company is responsible for maintenance and management of the power grid.

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## The Situation in Ukraine

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At the April 2008 NATO Summit in Bucharest, it was declared that Ukraine and Georgia would become members in the future, but the South Ossetia conflict in August the same year extinguished that momentum. Subsequently, after the Crimean crisis and start of the Donbas conflict in 2014, Ukraine and Russia were plunged into conflict and Ukraine's sense of crisis during this period led to its contract with the ENTSO-E in 2017.<sup>8</sup> Note that in February 2025 the Trump administration announced the suspension of the functions of the United States Agency for International Development (USAID) and its integration into the Department of State, and after that it was de facto in a dismantled state, but USAID also provided support concerning the connection of Ukrenergo to ENTSO-E.<sup>9</sup>

As if to corroborate Ukraine's concerns, a large-scale cyberattack was launched on its power systems, primarily in western Ukraine, on December 23, 2015. A cyber firm in the United States

identified the perpetrator of this attack as a Russian hacking group known as "Sandworm"<sup>10</sup> and power outages were caused over a wide area due to cyberattacks on three regional electricity distribution companies. In the cyberattacks on each company, remote administration tools or industrial control systems via virtual private network (VPN) connections were used maliciously, so there is a possibility that the actors acquired legitimate credentials prior to the cyber-attack to facilitate remote access.<sup>11</sup> A similar cyberattack was carried out in December 2016, but this caused less damage than the attack in the previous year.

This attack attracted attention as the world's first successful cyberattack on a power network, but it also demonstrated Russia's willingness to target critical infrastructure. The main targets of the attack were step-down substations and electricity distribution networks on the periphery of the power network, but parts of the power transmission grid including high-voltage electricity transmission lines, intermediate substations, etc. were also attacked, raising the alarm about the security of the power network as a whole. Even though the method of frequency manipulation was not used, for the Baltic states as well this attack represented the emergence of a long-standing potential threat.<sup>12</sup>

Furthermore, in regions under Russian control, Russia has the responsibility to maintain and develop infrastructure functions, regardless of the legitimacy of its control. In the case of the Crimean Peninsula, originally approximately 85% of its electricity depended on the Ukrenergopower grid, but as a consequence of its annexation by Russia in 2014 the Ukrainian government decided to take the measure of restricting its electricity supply in stages. Even after that, Ukrenergopower continued to supply the majority of Crimea's electricity demand, but in November 2015 an incident occurred in which the electricity transmission lines were blown up, and therefore the electricity supply from Ukraine completely stopped.<sup>13</sup> The attack was allegedly carried out by a Ukrainian nationalist group. Russia was prepared for this kind of situation and had prepared a submarine power cable in the Kerch Strait immediately after the annexation, so it connected Crimea to IPS/UPS using this cable.<sup>14</sup> This submarine cable was augmented in stages until 2016. In post-annexation Crimea, military facilities were revamped, and radar was installed facing in the direction of Türkiye, Bulgaria, and Romania,<sup>15</sup> so securing electricity became an extremely critical problem. Furthermore, in the "Donetsk People's Republic" and "Lugansk People's Republic," electricity transmission from Ukrenergopower was stopped in 2017 in connection with the lack of payment for electricity supplied and consumed.<sup>16</sup> It is thought that since then both regions have likely relied on existing thermal power plants to cover their electricity needs as a temporary solution. In October 2022, President Putin declared their annexation and the annexation procedure was completed under Russian domestic law, and it is highly likely the connection to IPS/UPS has been completed.

The handling of the Zaporizhzhia Nuclear Power Plant is a particular problem in the Russian-controlled regions. Currently, it is under Russian occupation, but for its power systems it is connected to Ukrenergo rather than IPS/UPS. The external electricity supply is frequently lost due to damage to the electricity transmission lines and other factors, and this kind of situation most recently occurred on July 5, 2025.<sup>17</sup> When external power sources are lost, on-site diesel power generators are used to maintain the cooling system, etc., but they shut down if the fuel runs out and may malfunction, increasing the risk of accidents. In the case of July 5, power was restored after three and a half hours, but the International Atomic Energy Agency (IAEA) warned about safety that the situation is “extremely unstable.” Construction of electricity transmission lines between Zaporizhzhia Nuclear Power Plant and IPS/UPS is under way, so it appears that Russia is planning to restart the nuclear power plant,<sup>18</sup> but safety concerns have been raised about this.

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## **The Situation in the Baltic States**

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On February 9, 2025, the Baltic states disconnected from IPS/UPS and completed their connection to the ENTSO-E.<sup>19</sup> This marked a major turning point in energy security in the Baltic region. The Baltic states were connected to IPS/UPS due to the need for a stable electricity supply and the power shortage which resulted following the decommissioning of the Ignalina Nuclear Power Plant which was formerly located in eastern Lithuania. Constructed during the Soviet era, the Ignalina Nuclear Power Plant boasted high power output, and 42% of its power generation was exported outside Lithuania as of 1989.<sup>20</sup> However, this Ignalina Nuclear Power Plant was a graphite-moderated boiling light water pressure tube reactor (known as an RBMK reactor), the same as the Chernobyl Nuclear Power Plant, which became a problem in the later EU accession negotiations. The direct cause of the explosion in the Chernobyl Nuclear Power Plant accident is believed to have been the insertion of control rods during an accident response exercise due to reactor instability, which conversely led to a sudden power surge.<sup>21</sup> The first reported case of a power surge phenomenon (positive scram phenomenon) caused by control rod insertion was an event at the Ignalina Nuclear Power Plant in 1983.<sup>22</sup> Furthermore, structural problems were identified at Chernobyl, such as inadequate reactor containment vessels, and these were also shared in common with the Ignalina Nuclear Power Plant. The decision to decommission the Ignalina Nuclear Power Plant was ultimately made in 2000 (Unit 1 was actually decommissioned in 2004 and Unit 2 in 2009), raising concerns about future electricity shortages. The total cost of completing the connection with ENTSO-E by 2025 reached approximately 1.6 billion euros, approximately 75% of which was covered by EU subsidies.<sup>23</sup> At the time, it was impossible for the

Baltic states to contribute this amount.

Given these circumstances, IPS/UPS was necessary infrastructure for the Baltic states. However, the connection was only maintained lackadaisically after the collapse of the Soviet Union, leaving it in a state of limbo. For this reason, it was necessary to build a formal framework for future maintenance and management. Furthermore, for Russia, an electricity transmission line through Belarus and Lithuania was important for the stable supply of electricity to Kaliningrad Oblast, a strategically important exclave. Because these interests coincided, the BRELL Agreement was concluded in 2001, formally clarifying maintenance and management responsibilities and other matters, and allowing the connection to continue (BRELL stands for “Belarus, Russia, Estonia, Latvia, and Lithuania”).

However, the Baltic states did not abandon their desire to connect to the European power systems, BALTSO (Baltic Transmission System Operators) was established in 2006 as a cooperative organization of transmission system operators in the Baltic states,<sup>24</sup> and six regional power system operator associations in Europe, including BALTSO, integrated to form ENTSO-E in 2008. In 2009, BALTSO transferred its operations to ENTSO-E and was developmentally dissolved. Furthermore, the EU sought to diversify energy supply sources to ensure a safe and affordable energy supply throughout the region. In order to utilize renewable energy effectively, it is necessary to develop an appropriate power system that can compensate for the weaknesses of renewable energy, such as its dependence on the weather. For this reason, connecting the power systems of the Baltic region and Europe was viewed as important and the connection between the Baltic states and Europe was included in the Projects of Common Interest (PCI), an important cross-border infrastructure development program. Consequently, this project was positioned as a project with political priority and became eligible for EU funding,<sup>25</sup> and due to this subsea electricity transmission cables in the Baltic Sea and electricity transmission lines between Lithuania and Poland have been installed.<sup>26</sup>

Furthermore, in order to diversify energy sources and escape from dependence on Russia, a liquefied natural gas (LNG) terminal was installed in the Port of Klaipėda, Lithuania, in 2014. Due to the opening of this terminal, the gas market in the Baltic region was opened up to global LNG suppliers, including the United States.<sup>27</sup> With an alternative gas supply route now secured, the Baltic states embarked on completely banning the import of Russian LNG as of April 2022.

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## The Response from Russia

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During Russia's invasion of Ukraine in February 2022, no attacks on power systems were carried out through IPS/UPS. Regarding the situation at the beginning of the war, there is a high likelihood that the Russian military was aiming for a quick resolution of the conflict, given the airborne attack on Hostomel Airport near the capital and the lack of a unified commander overseeing the entire combat theater. It is thought that it was for this reason that Russia refrained from attacks on infrastructure, considering the possibility that they might raise the alarm on the Ukrainian side. Subsequently, IPS/UPS was promptly shut down and the ENTSO-E connection was quickly established, so these concerns were largely eliminated.

Meanwhile, the Baltic states notified Russia of their decision to withdraw from the BRELL Agreement in August 2024, but immediately after that an unidentified individual launched a negative social media campaign alleging supply disruptions and rising electricity prices as a result of the withdrawal.<sup>28</sup> Furthermore, in December 2024, an incident occurred in which the Finnish Coast Guard seized a ship carrying Russian oil on suspicion of damaging or cutting a subsea electricity cable connecting Finland and Estonia and four Internet lines. The Finnish customs service expressed the view that the vessel in question was part of a "shadow fleet" used by Russia to evade sanctions in order to trade oil.<sup>29</sup>

The withdrawal of the Baltic states from the BRELL Agreement will reduce Russia's influence on those countries. However, a bigger problem is the stable supply of electricity to Kaliningrad Oblast. The withdrawal was formally notified in 2024, but construction of a power grid and various other preparations had already been under way, so Russia also had perceived the intentions of the Baltic states accurately. Anticipating Kaliningrad Oblast's electrical isolation, four new power plants were built in the oblast between 2016 and 2019.<sup>30</sup> Three natural gas-powered power plants and one coal-powered power plant were constructed, and total power generation capacity reached approximately 1 GW.

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## Comparison with Japan

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Compared with these power systems of Europe, we can see that Japan is in a very different situation. The distinctive features of Japan's power systems are the following three points: (i) no connections with other countries, (ii) differing frequencies within the country, and (iii) the independence of the Nansei Islands (Okinawa Electric Power Company). The first point concerning connections with other countries arises from Japan's geographical characteristic as an island nation surrounded by sea. The United Kingdom, another island nation near to a continent, is



connected to ENTSO-E. While the concept of Japan also connecting to the continent through an Asian Super Grid has been floated, it is unlikely to be realized because of the overwhelming disadvantages from an energy security perspective. The problem of frequency, the second point, is the well-known coexistence of 50 Hz regions and 60 Hz regions. This problem dates back to the introduction of German-made power generators (50 Hz) and American-made power generators (60 Hz) during the Meiji era. Once built, infrastructure is extremely difficult to modify, and electricity interchange between the two regions was previously impossible. Currently, electricity interchange is possible through three frequency converter facilities in Shizuoka and Nagano, but during the Great East Japan Earthquake electricity shortages occurred because there was not enough conversion capacity, and in response to this the frequency converter stations were upgraded. They were upgraded from the former 1.2 GW to 2.1 GW in 2021, and they are scheduled to reach 3 GW in 2027.<sup>31</sup> Regarding the third point, the ten power companies in Japan each have their own power systems, and the power systems of the nine companies from Hokkaido to Shikoku are mutually connected. However, Okinawa Electric Power Company only has an isolated power system, so it is a similar situation to Kaliningrad Oblast. Okinawa Electric Power Company has to prepare power generation facilities with surplus capacity and take actions such as storing extra fuel for thermal power generation, so power generation costs are higher than in Honshu. Concerning the outlying islands other than the main island of Okinawa, while there are cases in which neighboring islands are connected to each other by submarine cables or overhead lines, each island is basically independent.

Given Japan's situation, although there is a possibility that fuel imports may be affected by the international situation, there is basically no concern that Japan's electricity supply will be affected by the political motivations of other countries. Furthermore, there is no possibility of attacks through frequency manipulation (apart from cyberattacks). On the other hand, it should be recognized that in the event of an emergency, frequency conversion facilities, as nodes, could become targets and, in the Nansei Islands, protecting the power systems will become even more important.

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## Conclusion

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Energy security refers to stably and sustainably ensuring the energy necessary for a country or region, and it specifically includes elements such as supply stability, economic performance, diversity of energy sources, environmental impact, and reliability of technology and infrastructure. Concerning the stable supply of electricity, unlike oil and gas, electricity has the characteristic that



it basically cannot be stored (storage batteries cannot satisfy the demand of the entire society). Therefore, the general practice is for countries with land connections to connect their own power networks to those of other countries to prepare for contingencies. The following three lessons can be learned from the series of events related to the disconnection of IPS/UPS and connection to ENTSO-E in Ukraine and the Baltic states.

The first lesson is the importance of trust in the maintenance and management of international infrastructure. It was an already known fact from the start that Russia could manipulate frequencies through IPS/UPS, and if it were to actually harm another country's power system, trust in Russia would plummet. There seemed to be no advantage to be gained from such an act, and it was not that big a concern for some time after the collapse of the Soviet Union. However, a series of outrageous acts by Russia since 2014 made the possibility of attacks through IPS/UPS seem like a real possibility. Ukraine prepared to connect with ENTSO-E due to this concern, and it was a silver lining in the tragic situation that Ukraine was able to make an emergency connection immediately after the Russian invasion. Of all the losses Russia has suffered as a result of the invasion of Ukraine, trust related to infrastructure will be particularly difficult to restore. Furthermore, Kaliningrad Oblast became a "solitary island" due to Lithuania's withdrawal from IPS/UPS. Russia has responded to this situation by upgrading the oblast's power plants, but the redundancy is inferior to the situation when the power systems were connected. This has led to a vicious cycle in which loss of trust leads to a worsening strategic situation.

The second lesson is the difficulty of withdrawing from embedded power systems. Ukraine could not withdraw from IPS/UPS immediately even after 2014 when it fell into a conflict with Russia. Supposing it had withdrawn from IPS/UPS without connecting to ENTSO-E, there would have been the possibility of large-scale power outages and grid failures due to destabilization of frequency control or even electricity supply shortages, which would have had a bigger impact than Russia's malicious actions. The Baltic states, wary of Russia, faced a similar situation, with their national direction constrained by their infrastructure. Both Ukraine and the Baltic states were unable to avoid the events which led to them being embedded into Russia's power systems, but this was a real-life example of how international power systems can be forced into dangerous situations at the whim of another party.

The third lesson is the function as strategic communication. Strategic communication refers to the implementation of foreign and security policies that use words, actions (or inactions), images, and symbols with the purpose of changing the behavior and attitudes of others in order to assist with the achievement of policy goals.<sup>32</sup> The Baltic states have constantly communicated their wariness of Russia, and during the war in Ukraine they have strengthened their own defenses while condemning Russia and calling for support for Ukraine. Strategic communication is not

simply the communication of information; actions that can make that information communication more persuasive are also necessary. Following the Crimean crisis in 2014, Ukraine prepared to withdraw from IPS/UPS and connect to ENTSO-E, clearly presenting where it stood to Russia and Europe through those actions. The Baltic states are similar. While this is a message to Russia in one respect, it is an even stronger message to the European countries. The Baltic states have completely parted ways with Russia and clearly identified as belonging to Europe. A stable supply of electricity is directly linked to a country's economic and social activities, so power systems in some sense resemble an alliance. Globally, Japan's electricity situation is unusual, so it can be concluded that its peculiarities should also be recognized.

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<sup>2</sup> International Energy Agency, "Ukraine's energy system under attack – Ukraine's Energy Security and the Coming Winter – Analysis," IEA Publications, September 2024, p.13.

<sup>3</sup> ENTSO-E, "Continental Europe successful synchronisation with Ukraine and Moldova power systems," March 16, 2022, <https://www.entsoe.eu/news/2022/03/16/continental-europe-successful-synchronisation-with-ukraine-and-moldova-power-systems/>.

<sup>4</sup> European Commission, "2 years since Ukraine and Moldova synchronised electricity grids with EU - European Commission," March 15, 2024, [https://energy.ec.europa.eu/news/2-years-ukraine-and-moldova-synchronised-electricity-grids-eu-2024-03-15\\_en](https://energy.ec.europa.eu/news/2-years-ukraine-and-moldova-synchronised-electricity-grids-eu-2024-03-15_en).

<sup>5</sup> Justina Budginaite-Froehly, "Baltic states unplug from Russia's power grid—but Moscow still looms over critical infrastructure," Atlantic Council, February 5, 2025, <https://www.atlanticcouncil.org/blogs/new-atlanticist/baltic-states-unplug-from-russias-power-grid-but-moscow-still-looms-over-critical-infrastructure/>.

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<sup>7</sup> Japan Electric Power Information Center, Inc., "The Electric Power Industries in Foreign Countries (2019 Edition) | Russia," February 2019, <https://www.jepic.or.jp/data/w2019/w08rusa.html>.

<sup>8</sup> Marta Golonka, IMANISHI Haruka, "ウクライナとモルドバ、欧州の電力網に接続(Ukuraina to Morudoba, Oshu no Denryokumo ni Setsuzoku) [Ukraine and Moldova Connect to Europe's Power Network]," JETRO Biz News, March 25, 2022, <https://www.jetro.go.jp/biznews/2022/03/1d7ddbe200789faa.html>.

<sup>9</sup> USAID, "The Ukrainian energy system is synchronized with the European network," December 5, 2023, <https://energysecurityua.org/news/the-ukrainian-energy-system-finalized-synchronization-with-the-european-network/>.

<sup>10</sup> Reuters, "Ukraine hit by 6,500 hack attacks, sees Russian 'cyberwar'," December 30, 2016, <https://www.reuters.com/article/us-ukraine-crisis-cyber-idUSKBN1411QC/>.

<sup>11</sup> CISA, "Cyber-Attack Against Ukrainian Critical Infrastructure," July 20, 2021 (Last Updated), <https://www.cisa.gov/news-events/ics-alerts/ir-alert-h-16-056-01>.

<sup>12</sup> Tom Bennett, "Baltic states begin historic switch away from Russian power grid," BBC News, February 8, 2025, <https://www.bbc.com/news/articles/c627d55v07go>.

<sup>13</sup> AFPBB News, "クリミアで送電ケーブル爆破、大規模停電で非常事態宣言(Kurimia de Soden Keburu Bakuha, Okibo Teiden de Hijo Jitai Sengen) [Crimea Declares State of Emergency after Power Cable Explosion Leads to Large-Scale Power Cuts]," November 22, 2015, <https://www.afpbb.com/articles/-/3067670>.

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<sup>15</sup> Reuters, "In Crimea, Russia signals military resolve with new and revamped bases," November 1, 2016, <https://www.reuters.com/investigates/special-report/russia-crimea/>.

<sup>16</sup> UAWire, "Ukraine has stopped the electricity supply to LPR," April 25, 2017, <https://www.uawire.org/news/ukraine-has-stopped-the-electricity-supply-to-the-lpr>.

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<sup>21</sup> Japan Atomic Energy Agency, "チェルノブイリ原子力発電所事故の概要(Cherunobuiri Genshiryoku Hatsudensho Jiko no Gaiyo) [Overview of the Chernobyl Nuclear Power Plant Accident]," January 2007, [https://atomica.jaea.go.jp/data/detail/dat\\_detail\\_02-07-04-11.html](https://atomica.jaea.go.jp/data/detail/dat_detail_02-07-04-11.html).

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