**Electricity grids and geopolitics: A game-theoretic analysis of the synchronization of the Baltic States' electricity networks with Continental Europe**

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## Abstract

Can supply of electricity be used as an energy weapon? This question rises in importance as more countries trade electricity across borders to smooth out grid stability issues and improve cost-efficient dispatching across large geographic areas. In the context of the Baltics' disentanglement from the BRELL (Belarus, Russia, Estonia, Latvia, and Lithuania) electricity grid and synchronization with Europe, we develop a game-theoretic model and examine the strategies of the involved parties in light of the potential for electricity trade to be used as a geopolitical weapon. We conceptualize the process of the synchronization project as a sequential-move game between three actors (Russia, the Baltic states, and the EU-U.S.). Our findings suggest that, in large part due to reputational concerns, Russia is unlikely to cooperate in the synchronization process. Instead, our model predicts that Russia will not wait for the Baltic states to complete their synchronization with the European grid before disconnecting them from the BRELL system. Direct Russian cyberattacks against Baltic grids are not implemented and the Baltics do not have to make concessions, provided that Western allies signal a strong likelihood of deterrent retaliation. We offer policy recommendations for Europe, Russia and the Baltic states.

**Keywords**: electricity; geopolitical coercion; Russia; Baltic States; game theory.

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# 1. Introduction

Fossil fuels have been the foundation of the global energy system, shaping the geopolitical map over the last two centuries (Maugeri, 2006; Victor et al., 2006; Yergin, 2011; Grigas, 2017; Yergin, 2020). However, the growing deployment of low-carbon energy technologies involves a deep transformation of the global energy landscape that will have profound geopolitical implications, altering relations between states, affecting the global distribution of power, and creating new vulnerabilities (Scholten, 2018; Hafner and Tagliapietra, 2020; Scholten et al., 2020; Jaffe, 2021). In particular, as the green energy transition gains momentum, the share of electricity in satisfying global electricity demand is expected to more than double, rising from about 20% of final energy consumption today to over 40% by 2050 (International Energy Agency, 2023). In the U.S., the Net-Zero America report by Princeton University projects that electrification of transportation and heating will also increase electricity demand, which is expected to more than double by 2050 across all pathways to net zero (Larson et al., 2021).

As increased electrification and rising use of renewable energy take hold, as supported by policy mechanisms like renewable portfolio standards and feed-in tariffs (Hao et al., 2020), cross-border electricity grids will gain in importance. Cross-border electricity trade is already on the rise, as more countries seek to smooth out grid stability issues caused by increasing amounts of intermittent power and to improve cost-efficient dispatching of electricity across large geographic areas.

Despite the growing importance of cross-border electricity flows, the geopolitical relevance of electricity trade has traditionally been underestimated. Scholten et al. (2020) introduce the idea that "grid politics will be the order of the day" in the increasingly global electrified energy system and note that a "struggle between the use of supergrids as tools of power projection" within regional cross-border electricity networks could emerge. The article suggests energy geopolitics might become more regional as a result. Cornell (2020) also argues that evolving international electricity grids will have "regional political implications in a world where critical infrastructure informs trade and national security." To date, studies at the intersection of energy and geopolitics have mainly centered around the commerce of fossil fuels, which differ from electricity in several important ways. Unlike primary energy sources like coal, oil, and natural gas, electricity cannot be directed along a specific route because laws of physics dictate that power flows along the path of least resistance. Further, because large amounts of electricity cannot be stored economically yet, demand and supply need to be balanced at all times at all locations on a synchronized grid, and interruptions have immediate cascading effects. Even with limited electricity trading between countries in the same interconnected electricity grid, control over grid frequency gives the central dispatching center the ability to affect the operations of the electric power system in a connected country.[1] Lastly, governments need to confront a new set of sophisticated threats (including hybrid threats such as cyberattacks) to protect their grid infrastructure. In turn, this requires different equipment and tools than those being used to defend primary energy supplies.

There are several reasons why "the impact of electricity interconnection on international relations and geopolitics deserves the closest possible scrutiny" (Westphal et al., 2022). First, electricity is essential to modern society, and many different types of energy infrastructure (from pipelines to refineries, natural gas wells and pipeline compressors), as well as other vital infrastructures (e.g., banking, communications, and water systems), depend on it to function. Second, as noted above, greater use of renewable energy will further increase electricity's role going forward. As a result, initiatives driving greater international electricity interconnection are gaining importance and

[1] "Synchronisation with Continental Europe." 2023. https://elering.ee/en/synchronization-continental-europe.

momentum, as highlighted by China's recent plans for a global grid in the Belt and Road Initiative (BRI) (Freeman, 2018). Cornell (2019) notes that such international linkages can create technological dependencies and susceptibility of networks to backdoor access that can become national security problems for connected countries. Security concerns to integrated electricity networks are not without precedent. Russian hackers, for example, were able to briefly disconnect three Ukrainian electricity distribution companies in December 2015 in an event allegedly linked to Moscow decision-makers.[2] More recently, the Russia-Ukraine war highlights that striking the electrical infrastructure of a country is an effective means of warfare (Popik, 2023). Russia's November 23, 2022 attacks on Ukraine left parts of Kyiv, Lviv, Zaporizhzhia, and Odessa disconnected from electricity services, as reported by the United Nations Office for the Coordination of Humanitarian Affairs. DTEK, Ukraine's largest private sector energy company, also reported 13 attacks on its facilities in October and November 2022. Human Rights Watch identified 22 separate Russian attacks damaging power plants and hydroelectric power stations in 10 regions around Ukraine in October 2022.[3]

Can electricity supply be used as an energy weapon? Some researchers have argued that future electricity trade will involve more symmetrical relationships between prosumer countries that are mutually dependent on each other and have an equal stake in the well-functioning of the grid (Overland, 2019). Therefore, physical interconnection and re-routing possibilities in electricity grids would leave little room for direct geopolitical pressure. We argue that this logic cannot fully exclude the possibility that power asymmetry does exist in specific grids and could proliferate, as

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[2] Park, Donghui, and Michael Walstrom. "Cyberattack on Critical Infrastructure: Russia and the Ukrainian Power Grid Attacks." *The Henry M. Jackson School of International Studies at the University of Washington*. October 11, 2017. https://jsis.washington.edu/news/cyberattack-critical-infrastructure-russia-ukrainian-power-grid-attacks/.

[3] "Ukraine: Russian Attacks on Energy Grid Threaten Civilians." *Human Rights Watch*, December 6, 2022, https://www.hrw.org/news/2022/12/06/ukraine-russian-attacks-energy-grid-threaten-civilians.

more nations link grids in an effort to lower carbon emissions and tap into different kinds of resources. Electricity cut-offs may pose more serious risks than fossil fuel disruptions, given the present inability to economically store electricity in large quantities. Electricity sabotage represents a distinct but related concern. Russia's attacks on Ukraine's electricity grid in 2015, 2016 and 2022 were considered a wake-up call to the possibility of large cyber and sabotage risks.[4] Cyber threats in the region are not new. Estonia suffered cyberattacks across several public web-based services during tensions with Moscow in 2007. Concerns about security for subsea electricity cables in European waters have also been raised in studies on the topic (Cornell, 2019). Earlier this year, with U.S. input, NATO launched a new center for protecting undersea cables and has boosted its presence in the Baltic and North Sea areas, adding dozens of ships, supported by maritime patrol aircraft and undersea monitoring equipment like drones. The stakes are high since cross-border electricity cut-offs or sabotage may result in blackouts and failures that could cascade across infrastructures, with significant and possibly catastrophic effects. Despite these risks, the potential use of electricity as a foreign policy weapon has not been the object of thorough scholarly analysis.

In this paper, we investigate the potential for exploiting asymmetric power in electricity grids for geopolitical goals. Specifically, we apply a game-theoretic model to developments surrounding the Baltics' disentanglement from Russia's electricity grid and synchronization with the

[4] Howell O'Neill, Patrick. "Russian Hackers Tried to Bring down Ukraine's Power Grid to Help the Invasion." *MIT Technology Review*. April 12, 2022. https://www.technologyreview.com/2022/04/12/1049586/russian-hackers-tried-to-bring-down-ukraines-power-grid-to-help-the-invasion/; Lyngaas, Sean. "This pizza box-sized equipment could be key to Ukraine keeping the lights on this winter." *CNN*. November 21, 2023. https://www.cnn.com/2023/11/21/politics/ukraine-power-grid-equipment-cisco?cid=ios_app; Pearson, James. "Russian spies behind cyber attack on Ukrainian power grid in 2022 - researchers." *Reuters*, November 9, 2023. https://www.reuters.com/technology/cybersecurity/russian-spies-behind-cyberattack-ukrainian-power-grid-2022-researchers-2023-11-09/#:~:text=LONDON%2C%20Nov%209%20(Reuters),opens%20new%20tab%20on%20Thursday.

Continental European Network (CEN). We construct this framework to examine the strategies of the involved parties during the transition process, in light of the potential for electricity trade to be used as a geopolitical weapon. Scholten et al. (2020) suggest that Baltic desynchronization from Russia is “first evidence” of what could become a “fragmented multipolar electric world” where geographically large grid communities might revolve around great powers or economic blocks, but the authors do not extend their observations through a systematic study. We build on their work and contribute to the literature by conceptualizing the process of the Europe-Baltic state synchronization project as a sequential-move non-cooperative game among three actors: Russia, the Baltic states, and the transatlantic alliance (the EU-U.S.). The U.S. is considered as an interested party in the game both because it is a dominant global power that has interests in the Baltics, and because it has long been a security guarantor of Europe through the North Atlantic Treaty Organization (NATO) security alliance (Mix, 2022). A core consideration to this non-cooperative game is the fact that NATO members Estonia, Latvia, and Lithuania currently participate in a transmission system including Russia and Belarus set up under a treaty (the BRELL agreement) that was signed back in February 2001. The Baltic states’ agreement with Moscow regarding BRELL membership is automatically renewed every year, absent a notice of withdrawal from one of the parties six months prior to the agreement’s expiration. Notably, Russia has the ability to affect the operations of the electric power system in the Baltic states through its control over grid frequency in the BRELL power ring.

Our analysis considers both economic and geopolitical payoffs for the actors. Economic payoffs are based on the direct costs associated with Baltic desynchronization from the Russian grid and synchronization with the EU grid, as well as commercial benefits associated with the possibility of maintaining electricity trade with Russia in the future. On the other hand, in our setup geopolitical payoffs include gains or losses of an actor's reputation and political influence.[5] Maintaining Russia's geopolitical status and influence as a great power (so-called "derzhavnost", referring to a preoccupation with stature despite economic or military limitations) is a principal foreign policy priority steeped in history and emphasized repeatedly in public speeches by Russian leader Vladimir Putin (Svarin, 2016; Tsygankov, 2012). Maintaining his credibility to intimidate is also viewed as a key element to Putin's strategic focus both in international relations and military conflicts and in preserving his power base at home (Hill and Gaddy, 2017). In addition, we consider the possibility that Russia might threaten or employ coercive actions, such as cyberattacks, to gain geopolitical leverage or to delay or disrupt the synchronization project.

Our findings suggest that, in large part due to reputational concerns, Russia is unlikely to cooperate with the Baltics' withdrawal from the BRELL agreement. Moscow would prefer to maintain its coercive leverage and geopolitical status during the desynchronization period, if possible. In the subgame perfect equilibrium of our game, the EU-US assists the synchronization process of the Baltics, and direct Russian cyberattacks are not implemented provided that the U.S. and its allies signal a strong likelihood of deterrent retaliation. The Baltics states terminate their electricity trade with Russia because geopolitical considerations outweigh any economic payoffs that buying electricity from Russia might provide. Anticipating such an outcome, our model predicts that Russia will not wait for the Baltic states to complete their synchronization with the European grid before disconnecting them from the BRELL system. In light of the findings, we recommend that the Baltic states and Europe prepare in advance to respond to this contingency, including steps already being taken to map out emergency back-up plans to speed up synchronization with Europe.

[5] There is a large literature in game theory emphasizing the role of reputation; see, for example, Fudenberg and Tirole (1991), Mailath and Samuelson (2006) and references therein.

On the other hand, Russia will want to ensure that the Baltic desynchronization process does not dent its international reputation. This means Russia will want to demonstrate it is receiving a gain from desynchronization such as a financial payment or geopolitical concession from the Baltic states or NATO.

The rest of the paper proceeds as follows: Section 2 reviews the literature that is most closely related to our study, Section 3 provides background on the Baltic synchronization with the Continental European Network, Section 4 describes the synchronization game, Section 5 discusses the equilibrium of our game, and Section 6 concludes.

## 2. Literature Review

Few studies have examined the geopolitical benefits and risks associated with greater electricity interconnection. Some existing literature contends that electricity trade will be characterized by more symmetric interstate import-export relationships because power flows in both directions, unlike unidirectional oil and gas pipeline trade. For example, Overland (2019) argues that future electricity trade will involve more symmetrical relationships between prosumer (producer-consumer) countries that are mutually dependent on each other and have an equal stake in the well-functioning of the grid. Under such conditions, physical interconnection and re-routing possibilities in an electricity grid would leave little room for direct geopolitical pressure. Additionally, cross-border electricity trade may foster regional cooperation, creating "grid communities" centered around economic blocks or great powers. Although grid communities have existed for decades,[6] their development is on the rise, and several renewable "super grids" have been proposed, including China's proposal for a global grid network (Freeman, 2018). Cross-

[6] For example, Nord Pool, the world's first multinational exchange for electricity trading, was established in 1993 as a Norwegian electricity exchange, and extended its trade to Norway and Sweden in 1996.

border electricity interconnections can be used to smooth out short-term grid stability issues caused by increasing amounts of intermittent power and improve cost-efficient dispatching of electricity across large geographic areas. Because electricity is costly to store and electricity exports are not easily redirected in the short term, replicating strategic stockpiling behavior that characterizes petroleum and natural gas politics would be more difficult in practice.

Although these studies generally argue that the benefits of increased electricity interconnection outweigh its risks, there is some evidence that geopolitics may hinder cross-border electricity interconnections. In fact, several transnational interconnection projects have been subject to substantial delays and not advanced beyond the conceptual level for geopolitical reasons. Further, aversion to cross-border electricity hookups has persisted where countries fear an asymmetry of related dependence could create a means for the electricity provider to extract political concessions on matters unrelated to electricity trade. A case in point is found in an examination of historical efforts to establish cross-border integration of electricity grids between Israel and its Arab neighbors. Fischhendler et al. (2016) examine Israeli negotiation protocols to analyze ten attempts to connect these grids between 1991 and 2015, finding a direct relationship between the success (or failure) of these interconnections and geopolitical factors. Their analysis shows that two bottlenecks, in particular, discouraged cooperative grid connections in the region in the 1990s and 2000s: lack of trust due to ongoing or past political relations, and Israel's perception that cross-border electricity interconnection could create asymmetric dependencies whereby its Arab neighbors could use electricity exports for coercive foreign policy objectives.

The Middle East is not the only region of the globe where geopolitical bottlenecks slowed down or prevented electricity cooperation historically. Different domestic paradigms of energy security and the deterioration of bilateral relations and trust between Germany and Poland after the construction of Nord Stream 1 (connecting Russian gas to the German market bypassing Poland) played an important role in explaining the "grid-lock" in a third German-Polish interconnector (Puka and Szulecki, 2014). Further, energy security concerns over sourcing renewable electricity imports in MENA countries with higher geopolitical risks led to the failure of the Desertec project and the Mediterranean Solar Plan, in the aftermath of the wave of political and social upheaval that unleashed in the Middle East and North Africa in 2010-2011 (Escribano, 2019).

Another pressing example of the importance of geopolitics for electricity grids is currently given by the developments surrounding the desynchronization of Estonia, Latvia and Lithuania from the post-Soviet electricity grid (the IPS/UPS) and synchronization with the continental European network. In this case, the deterioration of political relations after the Baltic accession to the EU and NATO in 2004, coupled with increasing concerns about the use of energy dependence as political and economic leverage by Russia, tipped the scale in favor of the decision to end reliance on Russian electricity (Westphal et al., 2022). In contrast, Moscow operates within the geopolitical context of "derzhavnost" and its desire to maintain the Soviet Union's historical stature within the region including political influence and infrastructure connections (Svarin, 2016). As such, intimidation remains an operative strategic tool (Hill and Gaddy, 2017). Section 3 describes these developments, which motivated our game-theoretic model, in more detail.

## 3. Background on the Baltic synchronization with the Continental European Network

The Baltic states joined NATO and the European Union in 2004, but their electric power systems remain connected and synchronized with those of Russia and Belarus within the Integrated/Unified Power System (IPS/UPS), which was created during the Soviet times and is centrally managed by Moscow (Juozaitis, 2021a). The five countries form a circular transmission system that is part of the IPS/UPS and is commonly referred to as the BRELL (Belarus, Russia, Estonia, Latvia, and Lithuania) power ring (Figure 1). The technical rules defining the participation in the transmission system are set up under a treaty (the BRELL agreement) that was signed in February 2001 and is automatically renewed every year absent a notice of withdrawal from one of the parties by August, six months before expiration.


Figure 1: The BRELL power ring. Source: Karčiauskas, 2023.

Baltic desynchronization from the IPS/UPS system and synchronization with the CEN have been considered a strategic priority for EU energy policy since 2013, leading to the inclusion of some of the necessary grid infrastructure reinforcements into the list of Projects of Common Interest (PCIs) eligible for EU funding.[7] Prior to 2016, the Baltic states were connected to the EU electricity markets via just two transmission lines between Estonia and Finland (Estlink 1 and 2). Two projects built with EU support (the 500 MW LitPol HVDC line connecting Lithuania to Poland, and the 700 MW NordBalt undersea cable between Lithuania and Sweden) were inaugurated in December 2015 and became operational in early 2016, laying the technical foundations for synchronizing the Baltic states' power grids with the rest of the EU.[8] In June 2018, the governments of Estonia, Latvia, and Lithuania signed an agreement with Poland and the European Commission on the Political Roadmap for synchronization with the CEN by 2025. While several scenarios for Baltic desynchronization were proposed,[9] the Roadmap outlined a technical plan for synchronization with the CEN via Poland through the existing LitPol link (whose capacity would be doubled from 500 MW to 1 GW), complemented by a new submarine cable between Lithuania and Poland (the Harmony Link) and other reinforcements (including internal transmission network reinforcements in the Baltic states) to support grid stability, such as the installation of synchronous condensers for inertia.[10] In March 2019, a CEF grant agreement was

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[7] PCI status is a precondition for grants under the Connecting Europe Facility (CEF) ("European solidarity on Energy: Synchronisation of the Baltic States' electricity network with the European system strengthens security of supply", June 28, 2018, https://ec.europa.eu/commission/presscorner/detail/de/MEMO_18_4285; "Commission Delegated Regulation (EU) No 1391/2013 of 14 October 2013 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council on guidelines for trans-European energy infrastructure as regards the Union list of projects of common interest", https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R1391).

[8] "Completion of NordBalt and LitPol closes the Baltic Ring." March 23, 2016, https://www.modernpowersystems.com/features/featurecompletion-of-nordbalt-and-litpol-closes-the-baltic-ring-4847289/. The LitPol HVDC line was listed on the first EU list of PCIs adopted by the Commission in 2013.

[9] Options under consideration included the synchronous operation of the Baltic states and the Nordic countries, the autonomous synchronous operation of the Baltic states, and the synchronous operation of the Baltic states and the Continental European Network. Technical studies indicated that the latter option would minimize de-synchronization costs (Purvins et al., 2017).

[10] "Questions and answers on the synchronization of the Baltic States' electricity networks with the continental European network (CEN)." June 28, 2018. https://ec.europa.eu/commission/presscorner/detail/de/MEMO_18_4285.

signed to fund the first phase of the synchronization process.[11] Further, in May 2019, the European Network of Transmission System Operators (ENTSO-E) and the High-Level Group for Baltic Energy Market Interconnection Plan (BEMIP), a working group overseeing the integration of electricity markets between EU countries in the Baltic sea region, formally approved the conditions for the interconnection project.[12] Lastly, the political roadmap for implementing the synchronization was signed by the EU, the Baltics and Poland in June 2019.[13]

Transmission network reconstruction and reinforcements to complete the synchronization project have proceeded at a steady pace, receiving over 1.2 billion euros in EU support so far,[14] as well as U.S. funding.[15] For example, preparations for construction of the Harmony link have been underway since 2019, with expected completion in the first quarter of 2028,[16] and a new high-voltage electricity line connecting Estonia and Latvia was completed in June 2023.[17]

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[11] Hyndle-Hussein, Joanna. "EU Support for Synchronising the Baltic States' Power Grids." *OSW Centre for Eastern Studies*. January 30, 2019. https://www.osw.waw.pl/en/publikacje/analyses/2019-01-30/eu-support-synchronising-baltic-states-power-grids.

[12] "Conclusions of the Baltic Energy Market Interconnection High-Level Group on the synchronisation of the Baltic States network with the continental European Network (Senior Officials' level)." May 28, 2019. https://energy.ec.europa.eu/system/files/2019-06/conclusions_bemip_hlg_28.05_0.pdf; "First Milestone of Future Synchronous Connection of the Baltic Power System with Continental Europe." May 29, 2019. https://www.entsoe.eu/news/2019/05/29/first-milestone-of-future-synchronous-connection-of-the-baltic-power-system-with-continental-europe/.

[13] "Political Roadmap on implementing the synchronization of the Baltic States' electricity networks with the Continental European Network via Poland." https://energy.ec.europa.eu/system/files/2019-10/20190620_signed_political_roadmap_0.pdf; "Energy security: The synchronisation of the Baltic States' electricity networks - European solidarity in action." June 20, 2019. https://ec.europa.eu/commission/presscorner/detail/en/IP_19_3337.

[14] "Lithuania completes electricity grid test, 'giant step towards energy independence'." April 24, 2023. https://www.lrt.lt/en/news-in-english/19/1969404/lithuania-completes-electricity-grid-test-giant-step-towards-energy-independence.

[15] "Why the Baltic States Are Reconfiguring Their Electric Grids." August 13, 2020. https://www.economist.com/europe/2020/08/13/why-the-baltic-states-are-reconfiguring-their-electric-grids.

[16] "Harmony link." https://www.enlit.world/projects/harmony-link/.

[17] Rats, Liisbeth. "Updated Estonian-Latvian electricity connection launches." June 9, 2023. https://news.err.ee/1609003223/updated-estonian-latvian-electricity-connection-launches.

Synchronization with the Continental European Network has been elevated in importance following Russia's 2022 cyberattacks on Estonia (Mix, 2022) and physical attacks on Ukraine's grid (Popik, 2023), out of concern that the Baltic states' infrastructure could be targeted by Russia, given the ongoing war in Ukraine. It is important to note that the Baltic states do not currently buy electricity from or sell electricity to Russia/Belarus.[18] Market data from Nord Pool show that imports into Latvia and Lithuania from Russia/Belarus and exports from Estonia to Russia/Belarus have fallen since 2021 (Figure 2). However, some flows remain because the five countries still operate as part of a single synchronous transmission system, and that makes it technically difficult to halt power flows within their interconnected grid.

[18] "Baltics agree to move up European power grid synchronization target." July 25, 2023. https://news.err.ee/1609043660/baltics-agree-to-move-up-european-power-grid-synchronization-target; "Synchronisation with Continental Europe." 2023. https://elering.ee/en/synchronization-continental-europe; Lazarczyk and Le Coq (2023) also note that "commercial trading in the Nord Pool DA market does not exist, as in the case of Estonia, or is limited, as in the case of the other two Baltic states" (p. 16).

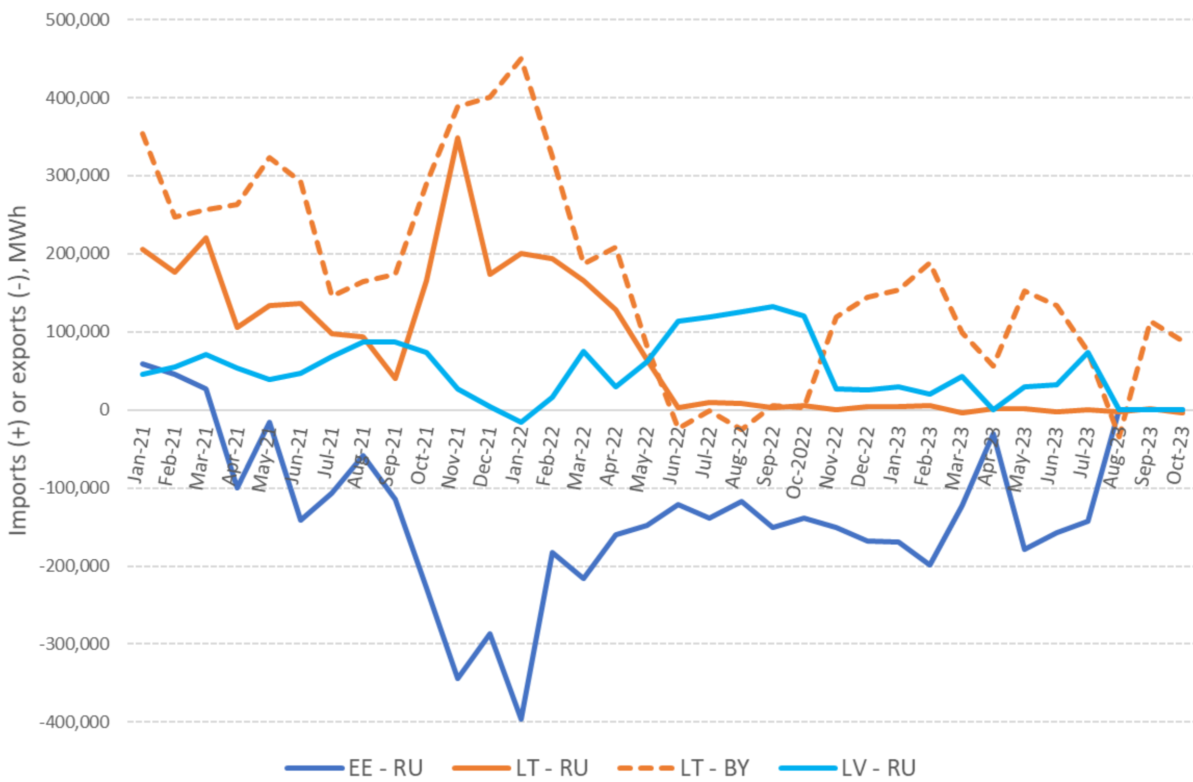


Figure 2: Imports and exports between the Baltic states and Russia/Belarus. Source: Own elaboration based on Nord Pool data.

Even with limited power flows between Russia and the Baltics, Russia plays an important role for frequency stabilization of the IPS/UPS, and can thus influence the functioning of the electricity grids in the Baltic states. In the early stages of the synchronization project, Russia was unable to cut off energy supply to the Baltics without affecting its semi-exclave Kaliningrad. However, recent completion of infrastructural upgrades may allow Russia now to threaten to prematurely disconnect the Baltic states from the BRELL system before the Baltic states are ready to completely synchronize with Europe and not affect Kaliningrad's grid (Tuohy et al., 2018; Juozaitis, 2021a, 2021b; Westphal et al., 2022). This development means that Russia has the means to potentially create severe blackouts in one or more of the Baltic states by disconnecting some of the lines connecting the Baltics to the rest of the BRELL ring before a full synchronization with Europe is completed (Lazarczyk and Le Coq, 2023). As a result, the region has developed contingency plans, should Russia take steps to abruptly detach Lithuania, Latvia or Estonia from the IPS/UPS. However, Russia could still possibly benefit from the element of surprise in timing of such a disconnection to try to stimulate the greatest cost and difficulty to ameliorate its actions.[19]

While the Baltics are in agreement about the need to move as quickly as feasible on a technical level to complete synchronization with the European CEN system, their viewpoints and preparations on the specific timeline for synchronization have not been perfectly aligned. Lithuania's state-owned energy firm EPSO-G has initiated a special purpose company, called Energy Cells, which is now operating four battery storage projects connected to substations throughout the country. The batteries will facilitate the country's ability to run in "energy island" mode.[20] In April 2023, Lithuania's transmission system operator successfully tested the ability of its individual electricity system to disconnect from the IPS/UPS system and operate in island mode for ten hours.[21] Lithuanian officials had previously noted that, if the test was successful, the country could consider unilateral withdrawal from the BRELL agreement from February 2024. Lithuania has argued for a decoupling date of early 2024, which was deemed feasible by a technical study by the University of Gdańsk.[22] In contrast, Estonia and Latvia believe it is preferable to

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[19] Expediting synchronization is feasible, as shown by the case of Ukraine, which completed an emergency synchronization with the European grid in March 2022.

[20] Murray, Cameron. "Testing starts on Fluence 200 MWh battery storage projects in Lithuania for spring 2023 activation." *Energy Storage News*. February 13, 2023. https://www.energy-storage.news/testing-starts-on-fluence-200mwh-battery-storage-projects-in-lithuania-for-spring-2023-activation/.

[21] "Lithuania completes electricity grid test, 'giant step towards energy independence'." April 24, 2023. https://www.lrt.lt/en/news-in-english/19/1969404/lithuania-completes-electricity-grid-test-giant-step-towards-energy-independence.

[22] Patricolo, Claudia. "An Early Power Synchronisation in 2024 Is Feasible, New Study Finds - CEENERGYNEWS." June 30, 2023. https://ceenergynews.com/electricity/an-early-power-synchronisation-in-2024-is-feasible-new-study-finds/; Zylm, Wojciech. "Baltic Countries Ready to Synchronize with European Power Grids in 2024, Confirms Study." June 15, 2023. https://bnn.network/tech/innovations/baltic-countries-ready-to-synchronize-with-european-power-grids-in-2024-confirms-study/.

speed up the target date to the beginning of 2025.[23] Estonia, in particular, is opposed to decoupling in 2024 because it would bear most of the associated costs and power outage risks.[24] A compromise was reached in July 2023, when Lithuania confirmed that it had no plans to separate independently from the BRELL system,[19] and the Baltic states agreed to bring the new target date for desynchronization from BRELL up to February 2025 (instead of the end of 2025). This target date means the Baltic states will need to give a formal notification to Russia in August 2024, as required under the BRELL agreement to withdraw from that system. After the technical details of the synchronization process are finalized based on the results of ongoing technical feasibility studies, the Baltic states are expected to make a final political announcement.[16]

## 4. The Synchronization Game

To analyze the strategies of various actors involved in the decision-making process, we conceptualize the process of the Baltic States' synchronizing with the Continental European Network as an extensive-form game among three actors: Russia, the Baltics (a unitary actor representing Lithuania, Latvia, and Estonia), and the transatlantic alliance denoted as EU-U.S. Our model assumes that the U.S. and the EU have formed a largely unified decision-making body, as the two allies are already closely consulting with each other.[25] A coordinated policy response to the Baltic electricity situation, along with plans for financial and technical assistance, has already been announced by Brussels and Washington. It seems unlikely at this juncture that Russia could

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[23] "Baltic states look into expediting synchronization with continental grid." July 14, 2023. https://news.err.ee/1609034591/baltic-states-look-into-expediting-synchronization-with-continental-grid.

[24] "Baltics unable to decouple from Russian power grid sooner, official says." July 17, 2023. https://www.lrt.lt/en/news-in-english/19/2036031/baltics-unable-to-decouple-from-russian-power-grid-sooner-official-says.

[25] "US and Baltic States reaffirm commitment to the power synchronisation project." March 7, 2023. https://ceenergynews.com/electricity/us-and-baltic-states-reaffirm-commitment-to-the-power-synchronisation-project/.

drive a wedge between the two parties. In addition, NATO provides credible deterrence against a direct Russian military attack on the last infrastructure connection still under construction—the Harmony Link between Lithuania and Poland—because that would be considered an act of war against NATO members, and thereby trigger Article 5 of the NATO alliance system.[26] Therefore, Russia's less costly coercive choice of action might be to cyberattack the related European synchronization infrastructure. In such a cloudier, less clarified situation, we envision that the U.S. would still provide security guarantees including a credible threat of cyber counterattack, a form of counter response that might not necessarily lead to military escalation. Through existing actions and staged planning, the United States is poised to provide necessary assistance in the event that the CEN was attacked and destabilized post synchronization with the Baltics. The United States already provides cyber assistance to Europe and the Baltic states, and NATO has added a new special effort in June 2023 to guard undersea cables throughout Northern Europe.[27] In the autumn of 2023, a U.S. Air Force plane delivered custom-built equipment designed to withstand Russian electronic warfare attacks on Ukraine's power grid.[28] The Biden administration has also expanded its cyber deterrence efforts and procedures and issued warnings to Moscow (Lonergan and Schneider, 2023). This background information informs our modeling which we describe in detail below.

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[26] Article 5 provides that if a NATO ally is subject to an armed attack, it will be considered an attack on all alliance members and each member of the alliance will respond with actions it deems necessary to assist the allied nation that was attacked.

[27] "NATO establishes new centre to safeguard undersea pipelines, cables as concern mounts over Russian sabotage threat." June 17, 2023. https://www.firstpost.com/world/nato-establishes-new-centre-to-safeguard-undersea-pipelines-cables-as-concern-mounts-over-russian-sabotage-threat-12750222.html; "NATO Moves to Protect Undersea Pipelines, Cables Amid Concern Over Russian Sabotage Threat." June 16, 2023. https://www.voanews.com/a/nato-moves-to-protect-undersea-pipelines-cables-amid-concern-over-russian-sabotage-threat/7140442.html.

[28] Lyngaas, Sean. "This pizza box-sized equipment could be key to Ukraine keeping the lights on this winter." *CNN*. November 21, 2023. https://www.cnn.com/2023/11/21/politics/ukraine-power-grid-equipment-cisco?cid=ios_app.

### 4.1. Sequence of moves

Based on the real-world events described in Section 3, we present the sequence of a game that we believe most closely aligns with the actual timeline. The baseline game is depicted in Figure 3. In the Appendix, we analyze variations of the baseline game, demonstrating the robustness of our model's predictions across different orders of moves.

In the baseline game, Russia is faced with the first choice. As noted in Section 3, Baltic desynchronization from the IPS/UPS system and synchronization with the CEN has become a strategic priority for EU energy policy since 2013. Therefore, Russia has known that the Baltics intend to synchronize their grids with the CEN at least since 2013. Accordingly, Russia faces the decision between cutting off the Baltics prematurely from the BRELL power grid before synchronization with Europe is completed, or acting cooperatively during the transition by continuing to engage with the Baltic states during the interim process.

By "early termination" in Figure 3, we refer to the scenario where Russia breaks the terms of its BRELL contract with the Baltics and notifies them to prepare for an early disconnect. We distinguish this case from a sudden cut-off by Russia leaving no time for the Baltics and Europe to make advance preparations for the shutoff. The latter case, in our view, would be considered a hostile act rising above the level of a simple contract violation. Such a hostile act has happened before. For example, Russia abruptly shut off natural gas supplies to Poland and Bulgaria prematurely in April 2022 despite their valid contracts due to end later that year, amid the context of Russia's attacks on Ukraine earlier that year.[29] The Baltic states should certainly be prepared

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[29] Poland had indicated it did not plan to renew its existing natural gas supply contract with Russia as early as 2019. "UPDATE 1-Poland's PGNiG tells Gazprom it plans to end the gas supply deal in 2022." November 15, 2019. https://www.reuters.com/article/pgnig-gazprom-idUSL8N27V469. As a second example of sudden move, Russia reduced natural gas supplies to Poland, Slovakia, and Germany in the autumn of 2014 ahead of implementation of a new round of European sanctions against Moscow.

for this worst-case scenario; however, in our model, such a sudden cut-off would imply the end of the strategic interaction between Russia and the Western actors. In this case, the EU-U.S. and the Baltics would likely activate an emergency plan, which is not the focus of our modeling. We discuss further the policy implications of this immediate cut-off scenario in the conclusion.

The EU-U.S. moves next, deciding whether to assist the Baltics financially during the transition. As previously noted, the EU expressed full support for the Baltics' synchronization project in 2013; however, it was not until early 2019 that the details of the financial support were crystalized. After the EU financial plan was announced, the synchronization process gained momentum. Therefore, it makes intuitive sense to model in the baseline game the EU-U.S. as contemplating their appropriate actions in view of Russia's behavior since 2013, taking into account the Russian occupation of Crimea and the alleged 2015 Russian cyberattack on Ukrainian electricity companies. In our baseline game sequence, Russia is then presented with the choice of whether to engage in cyberattacks, which can be harder to attribute and raises a more complex set of response alternatives.

At the final stage of our baseline game, we assume that the Baltics must decide whether to discontinue electricity trading with Russia entirely or to consider trading electricity with Russia once synchronization is complete. It is worth pointing out that, although the Baltics have expressed their desire to fully disconnect from BRELL, it will be much harder and possibly prohibitively expensive to do so by themselves without EU-U.S. support. Thus, the Baltics need to carefully weigh the choices of the other more powerful actors before making their own decisions.

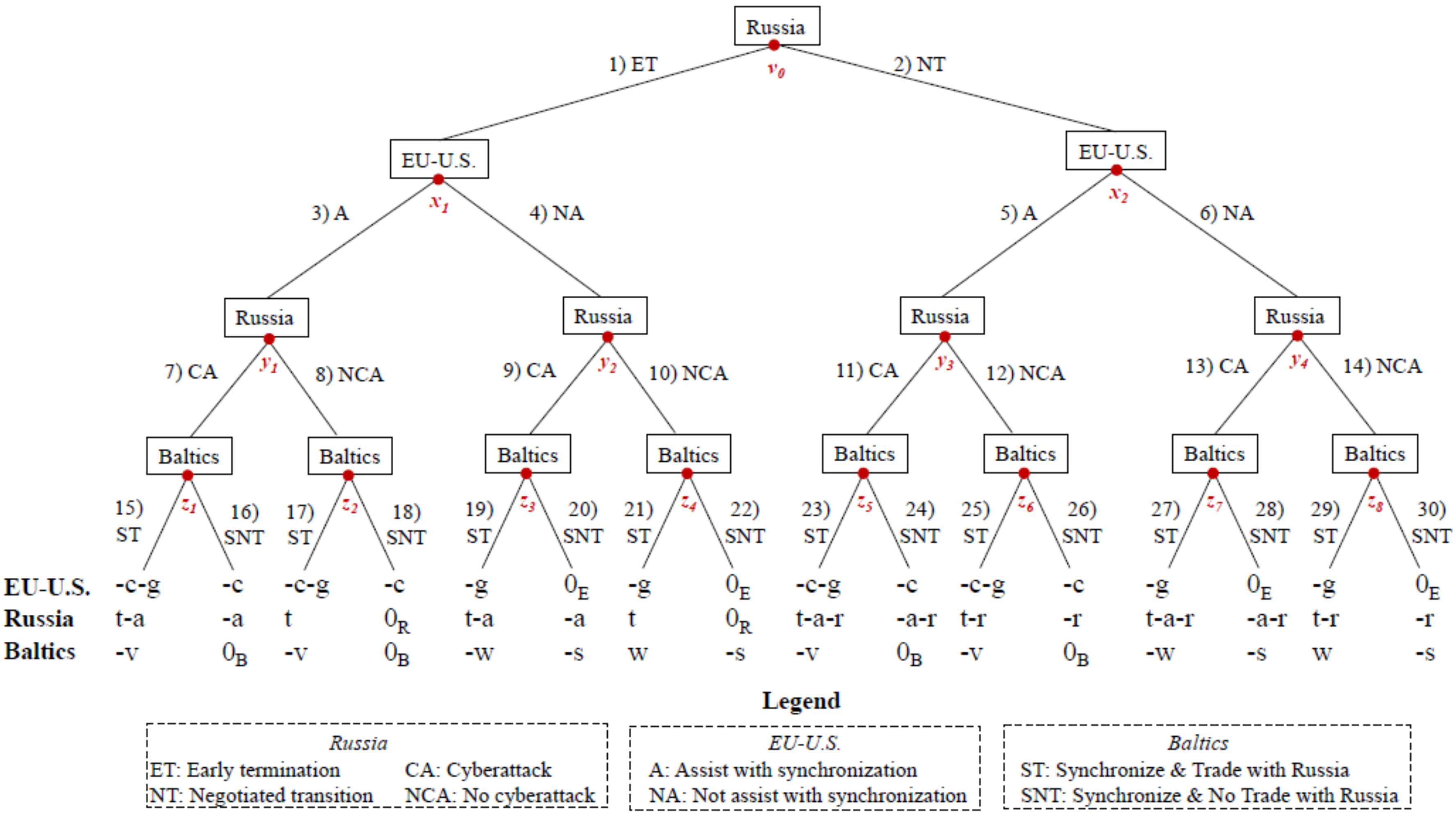


Figure 3: Sequence of the game and payoffs.

### 4.2. Payoffs

We consider both economic and geopolitical payoffs for the respective actors. Economic payoffs include the direct costs of synchronization and the respective financial benefits from electricity trading between the Baltics and Russia. The geopolitical payoffs include the gains or losses to each individual actor's reputation and geopolitical influence. Below we describe these payoffs in more detail.

As shown in Figure 3, the game considers two types of outcomes for the Baltic states: "synchronization with no trade" with Russia and "synchronization with trade" with Russia. In principle, electricity trade between the Baltics and Russia could theoretically continue after the synchronization, and be subject to Nord Pool Spot procedures for trade with countries outside the EU market (Tuohy et al., 2017).[30]

In the case of synchronization with no trade, when the EU-U.S. assists with synchronization, we normalize the Baltics' payoff to be "$0_B$." EU-U.S. engagement signals commitment to prevent electricity shortages during the process, while also offering deterrence from Russian attacks.[31] If

[30] As discussed in Section 3, electricity trade between the Baltics and Russia has substantially reduced or stopped since 2021, and current power flows mainly ensure grid stability (Lazarczyk and Le Coq, 2023). Existing electricity connections between the Baltics and Russia/Belarus could only continue to be used if substantial investments in converter substations were made in the future ("FAQ on synchronization". 2023. https://elering.ee/en/faq-synchronization).

[31] European Union. "Commission, Baltic States and Poland commit to accelerated Baltic grid synchronisation with Continental Europe." December 19, 2023. https://energy.ec.europa.eu/news/commission-baltic-states-and-poland-commit-accelerated-baltic-grid-synchronisation-continental-2023-12-19_en#:~:text=Today%2C%20the%20European%20Commission%20and,via%20Poland%2C%20by%20February%202025; CEENERGYNEWS. "US and Baltic States reaffirm commitment to the power synchronisation project." March 7, 2023. https://ceenergynews.com/electricity/us-and-baltic-states-reaffirm-commitment-to-the-power-synchronisation-project/; U.S. European Command Public Affairs. "U.S. and Baltic States Strengthen Information Interoperability at Baltic Sea C5I Synchronization Board." April 22, 2022. https://www.eucom.mil/pressrelease/42024/us-and-baltic-states-strengthen-information-interoperability-at-baltic-sea-c5i-synchroniza

the EU-U.S. chooses not to assist, we assume the resulting payoff to the Baltics would be lower, -s (s > 0): if supplemental electricity was not readily available from Europe, then not trading with Russia at all could theoretically result in an electricity supply shortfall for the Baltics, if the Baltic countries failed to generate all the electricity that is needed to meet demand in their domestic markets.

Next, we consider synchronization options involving electricity trade with Russia. It is important to note that, regardless of whether the EU-U.S. provides assistance, maintaining electricity trade with Russia can help maintain energy balance during times of shortfalls, but also subjects the Baltics to a geopolitical cost of continued dependence on Russia via physical electricity connections. Hence, we consider *net* payoffs in this case. When the EU-U.S. provides assistance, we assume that the net payoff to the Baltics is -v (v > 0). This is because the EU-U.S. assistance signifies their commitment to shielding the Baltics from Russian threats and taking necessary retaliatory actions. The continued connectivity between the Baltics' grids and the Russian grid could impose additional costs to the Western allies in fulfilling a continuous protective role (Tuohy et al., 2017). The Baltic states will want to ensure that the EU-U.S. maintain security guarantees for their electrical grids and that the alliance will pose a strong retaliatory response to any Russian attack or coercion. Maintaining a connection to the Russian grid could potentially cause frictions within the NATO alliance and weaken the willingness of the EU-U.S. to provide continued protection to the Baltic states' electricity system. Thus, the geopolitical considerations would outweigh the economic considerations in this case and result in a negative net payoff for the Baltics if they chose to maintain electricity trade with Russia. On the other hand, under a case where the EU-U.S. was not assisting in synchronizing the Baltics to the European electricity grid, such a hypothetical situation would be a signal to the Baltic states of a lack of commitment by Western allies. In this case, the Baltic states could leave them to manage electricity shortfalls on their own in the event of Russian energy coercion. In such a case, the Baltic states would be more inclined to kowtow to Moscow, hoping to derive some benefits from the possibility of continued electricity trade with Russia in the hopes to avoid electricity shortfalls. However, the possibility of Russia conducting cyberattacks or other threats during the transition period could make a difference in risk assessment for the Baltics in this case. To distinguish between these two scenarios, we assume that the Baltics' net payoff is given by $w > 0$ if Russia does not conduct cyberattacks, and by $-w$ if Russia conducts cyberattacks. The idea is that cyberattacks by Russia during the transition would imply that Russia signals hostile intentions and that concessions to Moscow are unlikely to provide reprieves. In this case, any remaining trade relations will likely carry a higher risk and thereby a negative net payoff for the Baltic states. On the other hand, if Russia signals an intention to be cooperative by not sabotaging the Baltic grid transition, then the Baltic states might find it economically beneficial to maintain electricity trade with Russia for times of shortfalls in the hypothetical case where the EU-U.S. has not made a commitment of support. Such a case might imply less explicit mutual obligation between the Western allies and the Baltic states in the sphere of electricity grids' policy overall.

We now turn our attention to Russia's payoffs. We assume that maintaining electricity trade with the Baltics implies a positive payoff $t > 0$ as it generates revenues, while a complete absence of trade results in a payoff of $0$ for Russia. Furthermore, we assume that if Russia were to conduct cyberattacks during the synchronization process, such attacks would be met by a strong response, possibly including counterattacks by the EU-U.S. alliance that could result in non-trivial damages to Russia's own energy operations.[32] Thus, we normalize Russia's payoff for any outcome in which it does not conduct cyberattacks to "$0_R$," and we assign a negative payoff of $-a$ $(a > 0)$ to the case where cyberattacks are conducted. Lastly, we assume that Russia would suffer from a reputational cost, $-r$ $(r > 0)$, if it chose to be cooperative in the first stage of the game. As previously discussed, the Kremlin has cultivated a perception of Putin as a resolute leader, willing to persevere in a conflict even when at a disadvantage. The Ukraine War has placed Russia in a military and economic standoff with the entire Western world, and making concession to the EU-NATO in the Baltic synchronization process could signal Russia's vulnerability despite the Kremlin's triumphant rhetoric, considering that there is virtually no remaining goodwill for Russia to cultivate in Europe and the United States (Hill and Gaddy, 2017). Therefore, all payoffs for Russia on the path where it chooses a negotiated transition represent a negative geopolitical/reputational value.

For the EU-U.S., assisting synchronization would involve economic costs $c > 0$ (mostly borne by the EU[33]). In addition, we assume that allowing for some Russian influence over the Baltic states through electricity trade would result in a negative payoff of $-g$ $(g > 0)$ for the EU-U.S, where $g$ represents the geopolitical costs of synchronization associated with potential imbalances of electricity demand/supply in the Baltic states that could come as a result of Russian cut-offs.[34] We assume that $c < g$ because, while the expenses linked to synchronization (encompassing financial aid, technical adjustments, and grid modifications in neighboring countries like Poland) are

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[32] Lonergan and Schneider (2023) provide a survey of the U.S. Department of Defense's evolving strategic response to deterrence, norms, and escalation across cyber space and ongoing policy linkages between defensive and offensive cyber deterrence.

[33] "Lithuania completes electricity grid test, 'giant step towards energy independence'." April 24, 2023. https://www.lrt.lt/en/news-in-english/19/1969404/lithuania-completes-electricity-grid-test-giant-step-towards-energy-independence.

[34] Tuohy et al. (2017) note that "reliance on the power system of a potentially hostile power like Russia raises the importance of Baltic energy issues inside NATO and the EU - while also raising the possibility that energy will be used as part of a hybrid warfare campaign."

substantial, from the EU-U.S. perspective, the geopolitical consequences of continuing electricity trade with Russia are even greater, affecting the energy security of the Baltic states and across Europe.[35] [36] More specifically, continuing to trade electricity with Russia would give Russia leverage to threaten to cut off electricity connections to the Baltic states abruptly at an inopportune time, potentially causing debilitating disruptions in service or full blackouts. Europe is spending considerable resources to minimize such risks, and discontinuing the Baltics' physical integration with the IPS/UPS synchronous electricity grid would minimize physical and geopolitical risks from connectivity to Russia's grid management. That geopolitical risk of coercion likely outweighs any cost savings that could be achieved from limited electricity trade between the Baltics and Russia. Finally, the payoff for the EU-U.S. from not assisting synchronization absent trade between Russia and the Baltics is given by "$0_E$".

In the next section we use backward induction to solve for the Subgame Perfect Nash Equilibrium (SPE) of the game. The SPE constitutes our theoretical model's prediction of the likely outcome for the above specified game.

## 5. Equilibrium: Unilateral Termination by Russia

To predict likely outcomes in sequential-move games like ours, it is customary to restrict attention to those that are consistent with the concept of a SPE. This rules out any outcomes that rely on non-credible threats by any of the participants in the game. Thus, a SPE gives the most likely prediction about how play will evolve when the game is played by rational actors. Technically,

[35] "Lithuania external relations briefing: Synchronization of the Baltic Electricity Network and Breaking Dependence on Russian Energy Market." October 10, 2023. https://china-cee.eu/2023/10/10/lithuania-external-relations-briefing-synchronization-of-the-baltic-electricity-network-and-breaking-dependence-on-russian-energy-market/#_ftn4.

[36] We discuss the case where $c>g$ in the next section.

SPE accomplishes this by requiring that actions by all participants are consistent with a Nash equilibrium in every possible subgame, including those branches that will not be reached in equilibrium. Backward induction provides a powerful technique for solving for the SPE. The process involves starting at the last stage of the game and considering the possible actions of the final mover in every possible node. Assuming that the last mover will choose their payoff-maximizing action, one then considers the best response of the one but last mover, and so on, until we reach the choices of the first mover. Ruling out all the strategies that will not be followed by the players, this results in the SPE of the sequential game.

We solve the game by backward induction, examining all possible strategy configurations in turn. In the Appendix, we provide a more formal description of the backward induction process, referring to the players' decisions (in reverse chronological order) in all decision nodes in Figure 3 above. Here we provide some highlights of the argument involved.

As shown in Figure 3, the first stage of the game (node $v_0$) involves Russia deciding whether to disconnect early (ET) or negotiate a transition (NT). We first consider the case in which Russia disconnects early, i.e., the left branch of the game tree (node $x_1$). In this case, if the EU-U.S. chooses to assist in the transition (A), the Baltics' optimal strategy is to pursue synchronization without trade with Russia (SNT). Given the Baltics' strategy, Russia's optimal strategy is not to carry out a cyberattack (NCA) to avoid a possible U.S.-NATO retaliation.

If the EU-U.S. chooses not to assist the transition (NA), however, then the Baltics' optimal strategy would depend on Russia's behavior during the transition. Our assumptions on payoffs imply that the Baltics would choose "synchronization with trade" (ST) in node $z_4$, where there is no coercive threat or cyberattack by Russia (NCA), and would choose "synchronization with no trade" (SNT) in node $z_3$, where there is a cyberattack by Russia, provided that $s \leq w$.[37] For Russia, the optimal strategy in this case would be not to engage in a cyberattack.[38] Finally, given the equilibrium strategies of the Baltics and Russia, the best strategy for the EU-U.S. is to assist in the transition (A) in node $x_1$ (recall that $c < g$).

Next, we consider the scenario in which Russia chooses to negotiate during the transition, i.e., the right branch of the game tree (node $x_2$). Applying a similar reasoning, the same equilibrium strategies emerge. To summarize, in both cases the equilibrium strategies of the three actors are: (1) the EU-U.S. assists the Baltics during the synchronization; (2) Russia does not engage in cyberattacks regardless of whether the EU-U.S. assists or not; (3) the Baltics choose synchronization with Europe and terminates permanently the electricity connection with Russia if they receive assistance from the EU-U.S., regardless of what Russia does. Alternatively, the Baltics would choose European synchronization and consider not permanently terminating the electricity connection with Moscow if the EU-U.S. does not assist and Russia does not engage in cyberattack or coercive threats. In contrast, the Baltics would choose synchronization and permanently terminating the electricity connection with Moscow if the EU-U.S. does not assist, but Russia signals hostile intent by carrying out cyberattacks or posing other kinds of threatening behaviors.

Finally, we consider the equilibrium for the entire game by comparing Russia's equilibrium payoffs in the two cases discussed above. Russia receives $0_R$ if it chooses to threaten or implement an early termination to its contractual BRELL agreement terms (ET) in node $v_0$, while it earns *-r*

[37] If Russia cyberattacks and $s>w$, then the Baltics' choice will be "synchronization with trade" with Russia. The equilibrium outcome is the same for both cases. From here we assume $s \leq w$.

[38] We remark that a cyber-attack is a dominated action for Russia and thus would not be followed in any Nash equilibrium of the game.

if it chooses a negotiated transition (NT). As a result, Russia's best strategy is to choose early termination (ET) in node $v_0$ in order to protect its stature as a geopolitical power. The logic behind Russia's best strategy is that the equilibrium outcome will be no different for Russia regardless of what path it chooses. More specifically, the geopolitical risk of having continued electricity connections with Russia is likely to be deemed extremely high by the West, no matter what exact posture Moscow takes on the wind-down of the BRELL agreement. That is because all possible actions will be contextualized by the ongoing tense relationship between Russia and the West since the Ukraine war, and the still unfolding negative consequences for Europe from its energy dependency on Russia. In the context of our game, this implies that regardless of Russia's decisions, all subsequent paths are likely to lead to Baltic synchronization with Europe under conditions of a permanent termination of the Baltic electricity grid connection with Russia, regardless of whether Russia offers to negotiate favorable terms for desynchronization of the Baltics or takes a more coercive posture. Consequently, assuming that there is some reputational cost for Moscow, either domestically or internationally, from appearing conciliatory with the West, our analysis implies that Russia is unlikely to remain cooperative over the course of the synchronization process.

While the above analysis of the predicted equilibrium in our game hinges on the assumption that $c < g$, which we believe to be the more realistic scenario, Russia's equilibrium strategy of early termination (ET) would remain the same if $c > g$. In this alternative case, the equilibrium of the game would predict that: (1) the EU-U.S. does not assist the Baltics during the synchronization because the cost of assistance is higher than the geopolitical costs; (2) Russia chooses early termination and does not engage in cyberattacks; (3) the Baltics choose synchronization but maintain electricity trade with Russia, as there could be an electricity supply shortfall for the Baltics without supplemental electricity readily available from Europe.

## 6. Conclusion and Policy Implications

Using a game-theoretic framework, this paper explores the possible outcomes of the implementation of synchronization of the Baltics' electricity grid with Europe and the simultaneous desynchronization with Russia's BRELL network as a means to improve energy security for Estonia, Latvia, and Lithuania. We argue that economic savings in terms of electricity costs for the Baltic countries of maintaining the possibility of electricity trade with Russia are likely to be insufficient to motivate continuation of any electricity imports by the Baltic countries from Russia. We believe ongoing hostilities of the Ukraine war, combined with historical and ongoing enmities between the Baltics and Russia as well as the West and Russia, will leave little appetite in Western or Baltic capitals for outcomes that maintain Moscow's continued influence over vital electricity supply. Our exercise projects that the Baltic countries will opt to fully desynchronize from the Russian BRELL system and cut off all electricity connectivity with Russia, regardless of the negotiating stance of Moscow. It is expected that the U.S. and EU will continue to fully support the synchronization process of the Baltic countries with Europe's electricity grid via economic and technological assistance.

Given this likely strategy and attitude from the West, Russia will have no real incentive to offer concessions or pursue a smooth negotiated transition. The more cooperative a stance taken by Russia, the more likely it would be to suffer reputational costs in appearing weak or ineffective in the eyes of its key domestic or international audiences. As a result, our model predicts that Russia will take a non-cooperative approach as desynchronization approaches. At a minimum, one can expect Russia to try and exploit the geopolitical capital already expended by the U.S. and Europe regarding Baltic grids to gain something for itself, either reputationally or financially. Russia's previous actions in the natural gas market could be construed as an informative precedent that Moscow will not feel constrained by contractual obligations and processes. We believe that a strong risk exists that Moscow will be inclined to take unilateral actions, including a possible premature unilateral termination of electricity connections between the Baltics and the Russian network, depending on its view of potential retaliatory actions that would be taken by the U.S.-Europe. In effect, there are no reputational gains for Russia to reap from cooperative activity because such offers would be unlikely to be reciprocated by the Baltic countries, who as members of the NATO coalition receive continued support from Europe and the United States. In this way, it must be recognized that negotiated outcomes have limited scope. Geopolitically, Russia would not want Europe to achieve a clear win with a smooth transition for Baltic synchronization to the CEN.

For our equilibrium result to hold, however, it will be necessary for the United States and Europe to provide a credible threat of retaliation to ensure Russia will find the costs too high to engage in cyberattacks or overt sabotage of Baltic electricity grids or connector infrastructure to Europe. That is, the U.S. deterrence element is a key driver of ultimate outcomes. U.S. defense and retaliatory readiness must be positioned to leave Russia with no costless actions that it can take to undermine synchronization, including hybrid or direct attacks or early unilateral disconnection. The policy implications of this outcome are multifold. First and foremost, the United States and Europe must maintain a credible deterrent to prevent electricity coercion by Russia against the Baltic states. This means that the United States and NATO must maintain superiority in offensive cyber capabilities related to electricity networks. But offensive capabilities are just part of the story. The United States and other NATO member countries must also be able to credibly stand in a premiere position in cyber protection of their own domestic grids from cyber counterattack. That will require a sharper focus on upgrading and maintaining American electricity assets and networks than is currently taking place.

The Baltic states must have an emergency backup plan to reduce the leverage that Russia reaps from its current ability to interfere with Baltic electricity frequency. The United States and Europe can support the Baltic states by providing state-of-the-art technical assistance. Ukraine offers a useful precedent. In the early days after Russia's February 2022 military attack on Ukraine, Kyiv quickly shifted its grid to island mode and then hastened to activate connections to Europe. Ukraine is in the process of installing static synchronous compensators to enhance power stability, but risks remain and the path to full synchronization to Europe is likely to be influenced by ongoing outcomes of the war with Russia.[39] It should be pointed out that Ukraine's two-week synchronization was predated by nearly two decades of planning. This foundation allowed the nation to successfully operate in island mode, thereby meeting the minimum requirements to safely transition to the centralized European grid. Part of this success may also be due to the country's energy mix which is dominated by nuclear, coal, and gas. These conventional fuel sources provide higher levels of rotational inertia, which in turn safeguards against grid instability enabling a smoother transition.

[39] Baustein, Anna. "How Ukraine Unplugged from Russia and Joined Europe's Power Grid with Unprecedented Speed." *Scientific American*. March 23, 2022. https://www.scientificamerican.com/article/how-ukraine-unplugged-from-russia-and-joined-europes-power-grid-with-unprecedented-speed/.

The Baltic States, in contrast to Ukraine, have all worked to diversify their grids with renewables, which now account for 24%,[40] 32%[41] and 42%[42] of energy production in Lithuania, Estonia, and Latvia, respectively. Additional complexity could arise from the difficulty that the Baltics would have to synchronize to the European grid in unison. For its part, Lithuania has taken the most aggressive stance in decoupling from the BRELL grid: as noted above, the country has successfully operated an island mode test[43] and invested in preparation for synchronization with 200 MWh of battery storage.[44] Cumulatively, these actions have enabled Lithuania to call for an expedited transition. Estonia has cited technical feasibility and other hurdles to rapid transition,[45] but recently announced its first grid-scale battery storage project would be undertaken in 2024.[46] The country is also constructing a 550 MW pumped hydro storage facility. Latvia has not yet announced plans to build storage assets as a means to enhance grid stability.

The U.S. and its allies have had to consider how much electricity equipment and technical assistance can be provided to Ukraine without leaving other regions in Europe vulnerable to any additional disruptions and repair requirements, including Finland, Poland, Sweden, and the Baltic

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40 International Renewable Energy Agency. 2022. "Lithuania Energy Profile." https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Europe/Lithuania_Europe_RE_SP.pdf.

41 International Renewable Energy Agency. 2022. "Estonia Energy Profile." https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Europe/Estonia_Europe_RE_SP.pdf.

42 International Renewable Energy Agency. 2022. "Latvia Energy Profile." https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Europe/Latvia_Europe_RE_SP.pdf.

43 "Lithuania completes electricity grid test, 'giant step towards energy independence'." April 24, 2023. https://www.lrt.lt/en/news-in-english/19/1969404/lithuania-completes-electricity-grid-test-giant-step-towards-energy-independence.

44 Murray, Cameron. "Testing starts on Fluence 200 MWh battery storage projects in Lithuania for spring 2023 activation." *Energy Storage News*. February 13, 2023. https://www.energy-storage.news/testing-starts-on-fluence-200mwh-battery-storage-projects-in-lithuania-for-spring-2023-activation/.

45 Ots, Mait. "Lithuania Speeding Up Desynchronization Process Breaches Agreement." June 16, 2023. https://news.err.ee/1609009895/elering-lithuania-speeding-up-desynchronization-process-breaches-agreement.

46 Colthorpe, Andy. "Estonia's first grid-scale battery storage project to 'launch next year' though tender." June 1, 2023. https://www.energy-storage.news/estonias-first-grid-scale-battery-storage-project-to-launch-next-year-through-tender/.

states who are all involved in the plans to disconnect the Baltic states permanently from the Russian-run BRELL grid system. Moscow targeted electricity transformer manufacturing facilities in Ukraine as well as its power plants and substations during the first phase of the 2022 war. The United States has provided $53 million in equipment for the repair of Ukraine's electrical system, including small transformers, circuit breakers, disconnectors, and backup generators. But any ongoing bombing of Ukraine's electricity system creates a challenge as there exists a shortage of large transformers globally, and therefore the United States and European allies need to keep spare equipment in reserve at home. Attempts in the U.S. Congress to fund expansion of U.S. domestic production of large transformers and special input steel got cut from 2022 bills and remain a pressing area for increased U.S. congressional attention.

From Moscow's perspective, it is not in its interests to trigger significant retaliatory actions against its own grid or economy. But Russia will want to ensure that the Baltic desynchronization process does not dent its international standing nor set a precedent for other countries in its near abroad to try to reduce energy dependence. Thus, it will need to impose visible costs on the Baltic desynchronization process and receive some kind of payoff to itself, either geopolitical or financial. Extracting financial compensation for "going quietly" would be a win in both categories.

Going forward, the ability to rapidly launch and manage electricity smart grid assets and install backup systems will play a critical role in alliance networks such as NATO. The United States and Europe need to boost capacity to be able to provide equipment for the repair of Ukraine's electrical system, including small transformers, circuit breakers, disconnectors, backup generators, and other kinds of distributed energy systems (DERs) such as solar panel systems with battery storage. However, they also need to consider how to bolster the speed at which such DER systems could be deployed within the Baltic states, should undersea infrastructure get damaged or a sudden cut-off by Russia take place. Manufacturing of DER solution technologies is prioritized in the U.S. Inflation Reduction Act, but the U.S. Department of Defense will need a coherent strategy on how to utilize DERs and other technologies related to resilience and restoration of services as part of its deterrence posture and projection of power.

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## Appendix

Here we provide a more formal treatment of the backward induction analysis of the game in Figure 3. Let $I = \{R,U,B\}$ stand for the set of players in the game (Russia, the EU-U.S., and the Baltics), and let

$$N = \left\{ v_0, x_j, y_k, z_l \right\}, j = 1, 2;\ k = 1, 2, 3, 4;\ l = 1, 2, 3, 4, 5, 6, 7, 8$$

stand for the set of nodes where the respective players take an action. We denote by $u_i(a,n)$ the von Neumann-Morgenstern expected payoff to player *i* from choosing action *a* in node *n*, when the respective player is assigned and the action is available at the respective node. Starting with the Baltics choosing their actions during the terminal nodes, we have, for example, the following:

$$-v = u_B\left( ST, z_2 \right) < u_B\left( SNT, z_2 \right) = 0_B$$

In words, as argued in the text, in the contingency where play leads to node $z_2$, the Baltics will choose to synchronize and not trade with Russia (SNT), as this strategy provides a higher payoff ($0_B$ versus -*v*). A similar calculation leads to the respective optimal choices for the Baltics in all other terminal nodes.

Moving one step up in the decision tree, we have Russia choosing whether to cyber-attack (CA) or not. For example, note the following:

$$-a = u_R\left( CA, y_1 \right) < u_R\left( NCA, y_1 \right) = 0_R$$

In words, if Russia finds itself in node $y_1$, it will refrain from cyberattacking, as this strategy leads to a higher payoff for Russia, given the subsequent best responses we computed above for the Baltics. Again, similar calculations lead to the respective optimal choices for Russia in all other $y$-nodes.

Moving one more step up in the decision tree, we have the EU-U.S. choosing whether to assist (A) or not. For example, note the following:

$$-g = u_U(NA, x_1) < u_U(A, x_1) = -c$$

In words, if the EU-U.S. finds itself in node $x_1$, it will assist, as this strategy leads to a higher payoff, given the subsequent best responses we computed above for Russia and for the Baltics. Again, similar calculations lead to the respective optimal choices for the EU-U.S. in all other $x$-nodes.

Finally, we have thus reached the top of the decision tree, where Russia (the first mover) chooses early termination (ET), or a negotiated transition. Note that

$$-r = u_R(NT, v_0) < u_R(ET, v_0) = 0_R$$

In words, anticipating the best responses by the other players down the tree, Russia will choose early termination, as this strategy will lead to a higher payoff than a negotiated transition.

**Robustness to changing the order of moves**

The extensive form game in Figure 3 in the text assumes a particular sequence of events. Russia moves first, followed by the EU-U.S., then followed by a second move by Russia and, finally, by the Baltics. The underlying assumption is that the previous choices are observed by the players when they make a choice at a lower node in the game tree. A natural question to ask is whether the resulting subgame perfect equilibrium outcome is robust to the assumed ordering of the sequence of the players' choices. To answer this question, here we consider two realistic variations of the sequence assumed in the text. We demonstrate that our prediction is robust, as the same equilibrium choice emerges even when we perturb the sequence of moves. In the first variation, we assume that, in contrast to the assumption in the text, the EU-U.S. moves first, while Russia decides whether to unilaterally disconnect last. In the second variation, we assume instead that the Baltics move before Russia decides whether to engage in a cyberattack. The two corresponding extensive games are given in Figures A1 and A2 below. In both cases, backward induction results in a unique subgame perfect equilibrium, which coincides with the one we focus on in the main text.[47]

[47] An additional variation suggested by an anonymous referee involves the EU-U.S. decision to aid or not, taking place after the Russian decision on whether to cyberattack. The equilibrium prediction remains intact under this alternative sequence of events.

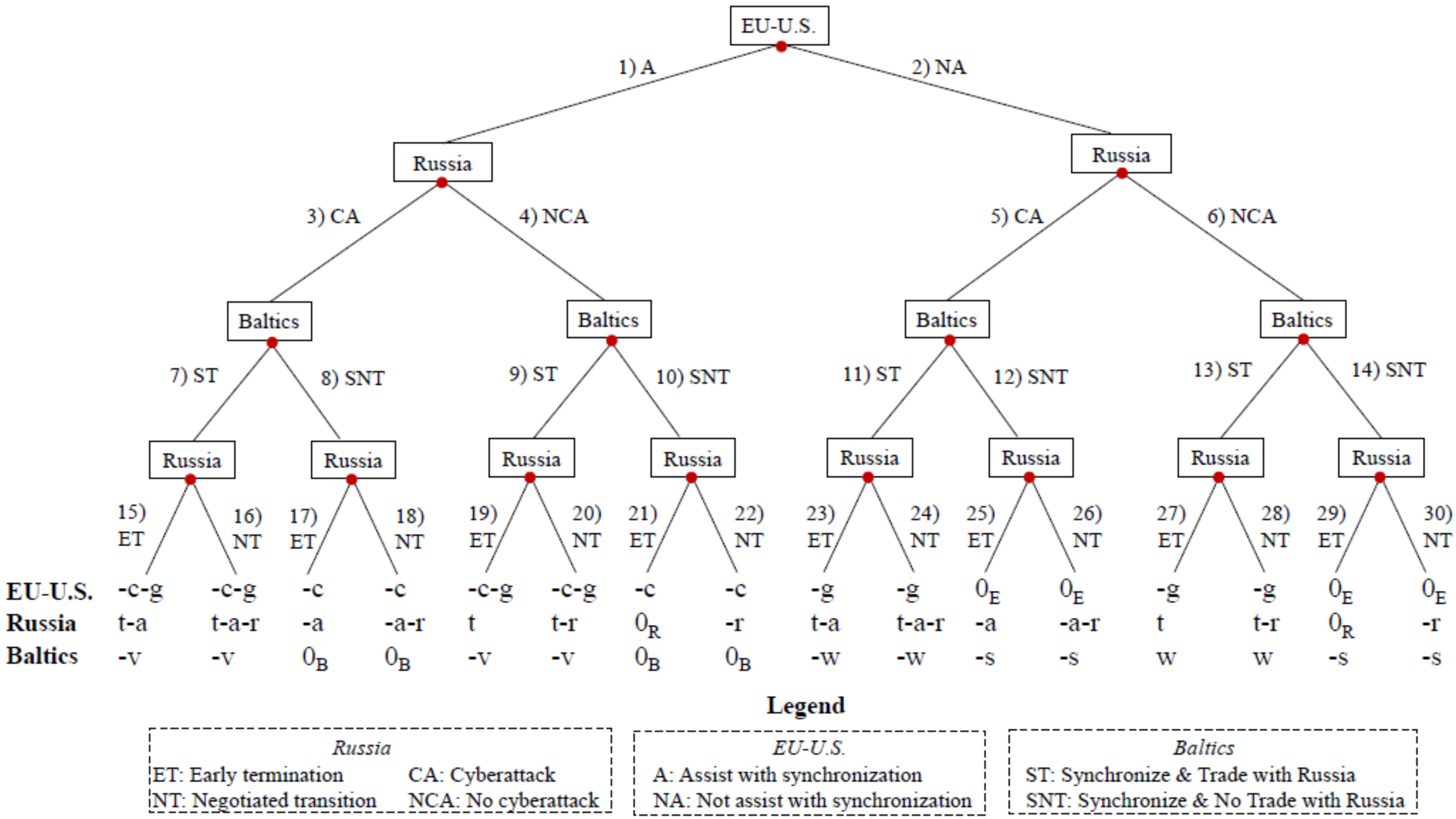


Figure A1: Sequence of the game and payoffs when the EU-U.S. moves first, Russia chooses to disconnect last.

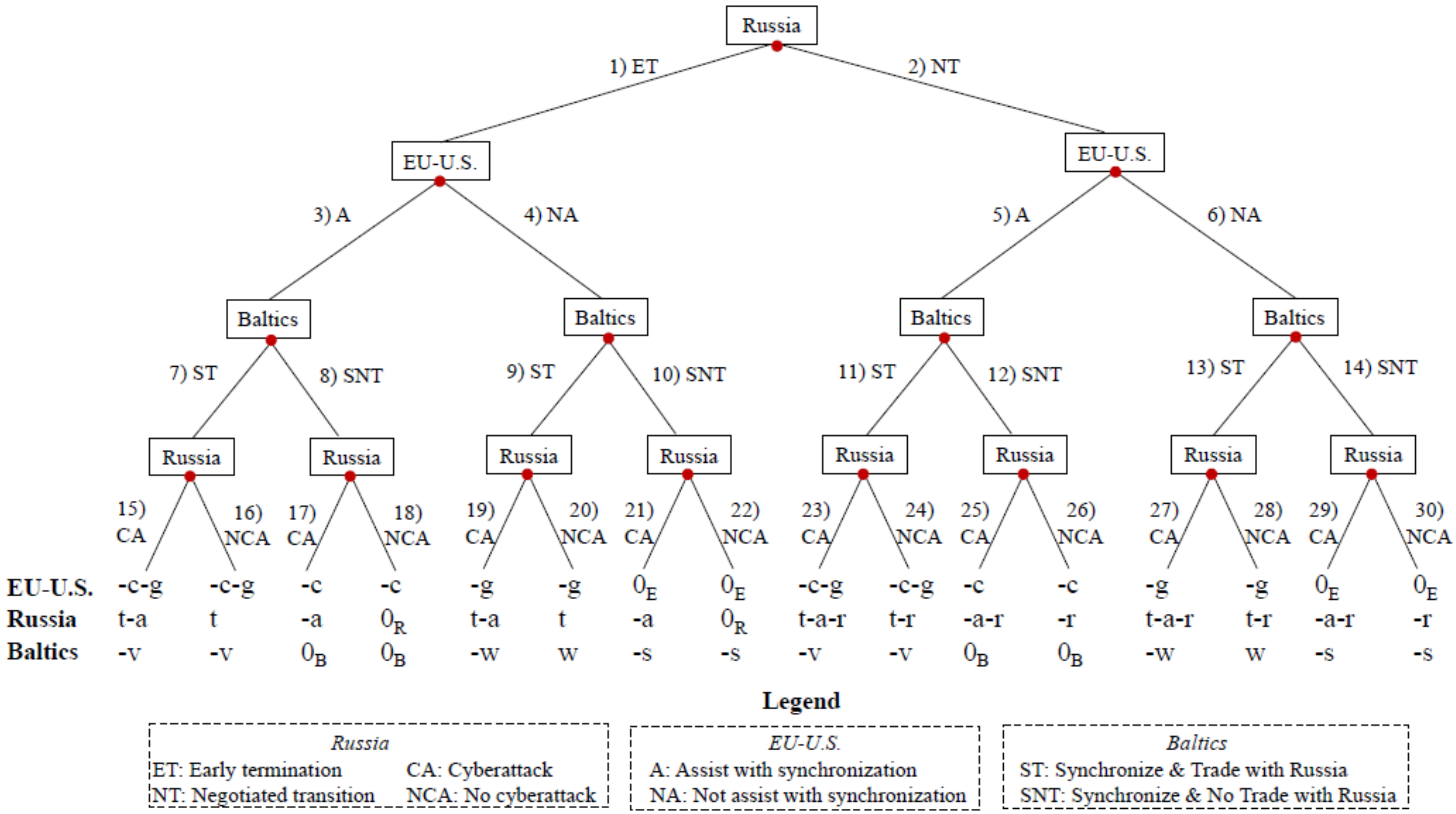


Figure A2: Sequence of the game and payoffs when the Baltics move before Russia decides to cyberattack.