Atlantic Council
GLOBAL ENERGY CENTER

October 2025

Enhancing NATO's operational readiness through energy interoperability

Written by Jason Knapp, Christopher Olson, and Chamai Shahim

NATO faces significant new gaps in energy interoperability, but allies' commitment to increase defense spending presents a pivotal opportunity for the Alliance to fix these deficits and ensure operational success.

Introduction

At the recent summit in The Hague, NATO allies committed to increase defense spending to 5 percent of gross domestic product (GDP) by 2035, including a dedicated 1.5-percent allocation to protect critical infrastructure. This provides a unique and pivotal opportunity to address two of the most pressing issues facing NATO: energy security and interoperability. Russia's war in Ukraine and its ongoing systematic attacks on Ukraine's energy infrastructure exposed energy systems as viable targets and strategic vulnerabilities, which, if damaged, can paralyze civilian, commercial, and military operations.[1]

NATO's challenge is to guide Alliance-wide energy interoperability without dictating national energy choices. It must strike a balance between supporting flexibility and driving convergence where mission assurance depends on it. To facilitate this, NATO must consider developing standards at an operational level that national leaders can address and that can help drive civilian and military infrastructure development, as well as weapons and equipment development and procurement.

Energy interoperability is a critical operational imperative for NATO forces in an era of hybrid warfare and contested environments. NATO forces face significant energy-related operational constraints: Military transport and host-nation support often rely on civilian contracts and commercial energy systems.[2] The transition from fossil fuel standardization under the Single Fuel Concept to a fragmented landscape of electric vehicles (EVs), hydrogen systems, and hybrid technologies has created new interoperability gaps.[3]

National energy transitions are contributing to this fragmentation, proceeding in parallel

1. Vytautas Butrimas, et al., "Hybrid Warfare against Critical Energy Infrastructure: The Case of Ukraine," NATO Energy Security Centre of Excellence, 2023, https://www.enseccoe.org/publications/hybrid-warfare-against-critical-energy-infrastructure-the-case-of-ukraine/.
2. Leonid I. Polyakov, *U.S.-Ukraine Military Relations and the Value of Interoperability* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 2004), https://press.armywarcollege.edu/monographs/760/.
3. Paul J. Kern, et al., "An Albatross around the US Military's Neck: The Single Fuel Concept and the Future of Expeditionary Energy," Modern War Institute, June 29, 2021,https://mwi.westpoint.edu/an-albatross-around-the-us-militarys-neck-the-single-fuel-concept-and-the-future-of-expeditionary-energy/.

NATO commits to an allocation of 1.5 percent GDP to protect critical infrastructure at The Hague Summit.

Source: NATO, www.act.nato.int/article/nato-summit-2025.

rather than in coordination, with the US military pursuing hybrid-electric vehicles while European forces emphasize hydrogen fuel cells.[4] This divergence, combined with the proliferation of proprietary defense technologies, might ultimately undermine NATO's collective operational effectiveness. The 2025 Hague Summit Declaration's commitment to allocate 1.5 percent of GDP to resilience and infrastructure offers a potential opportunity to address these challenges.[5]

This paper explores NATO's energy interoperability challenge as both an operational requirement and a strategic imperative. It argues that without harmonized energy systems—including fuel standards, power interoperability, and common infrastructure guidance—NATO cannot fully execute Article 5 operations. With forces such as the Allied Reaction Force (ARF) expected to deploy rapidly into contested and energy-degraded environments, energy resilience is no longer just about supply—it is about interoperability, survivability, and flexibility across the battlespace.

In this paper, the authors recommend several actions: elevating and centralizing energy planning within NATO; embedding energy interoperability into the NATO defense planning process; supporting coordination among governments to develop national policies on energy security that support energy interoperability; supporting and operationalizing Article 3 to build increased energy security and interoperability based on the 2025 Hague Declaration; and building increased focus on military energy system interoperability both within the defense sector and between the defense and civilian sectors.

4. Joshua D. Simulcik, Fabian E. Villalobos, and Morgan D. Bazilian, "Electrification of the Joint Force: Challenges and Opportunities for Competition in the Pacific and Arctic Theaters," *Electricity Journal* 38, 1 (2025), https://www.sciencedirect.com/science/article/pii/S104061902500003X.

5. "The Hague Summit Declaration," NATO, June 25, 2025, https://www.nato.int/cps/en/natohq/official_texts_236705.htm.

Refocusing on the energy interoperability challenge

The ability of NATO forces to sustain prolonged operations, defend strategic assets, and maintain mission readiness is increasingly reliant on secure, resilient, and interoperable energy systems. This need has become more urgent as modern warfare grows more electrified and data driven, encompassing everything from drones and ISR (intelligence, surveillance, and reconnaissance) to digital communications, mobile command units, and, increasingly, military vehicles. Historically, NATO's energy security focus was rooted in national infrastructure and liquid fuel logistics. However, in the context of evolving threats—including hybrid warfare, cyberattacks, and attacks on critical energy infrastructure—energy security has become not only a national security priority but a key enabler of joint operational capability.

While NATO has long identified energy security as a critical element of national security, the resilience of Europe's energy sector was called into deep question after Russia's full-scale invasion of Ukraine. The disruption to, and sanctions on, Russia's energy supplies to Europe—which accounted for 40 percent of the natural gas for European electricity and 29 percent of Europe's crude oil imports—showed the weakness in the European energy system and forced rapid development of alternatives.[6] The near-constant attacks on Ukraine's energy infrastructure have further highlighted the importance of, and risk to, NATO's energy infrastructure and the massive impact this disruption has on deployed combat forces.

The recent Hague Summit Declaration to increase defense spending partially reflects recognition of this new energy reality. Importantly, Article 3 of the NATO Charter—which requires nations to "maintain and develop their individual and collective capacity to resist attack"—has emerged as an operational linchpin. In practice, Article 3 means that civil and commercial infrastructure must be interoperable with military needs across the Alliance.[7]

Maintaining interoperability, however, is increasingly challenging as countries address their national energy concerns. The branching of national energy infrastructure development, when viewed through the lens of current and active targeting of energy infrastructure in hybrid warfare, threatens NATO's ability to conduct sustained joint operations. Without coordinated and compatible energy systems, NATO nations' forces risk deployment with discordant power solutions in contested environments.

Strategic and operational context

Since the adoption of the 2022 NATO Strategic Concept, the Euro-Atlantic security environment has deteriorated significantly. The war in Ukraine has demonstrated the scale and brutality of modern high-intensity conflict. Infrastructure attacks, including deliberate strikes on Ukraine's power grid and fuel depots, have underscored how energy systems are now primary targets of hybrid and kinetic warfare. NATO has recognized that protecting energy assets is not only a matter of national resilience but critical to joint warfighting readiness.[8]

Simultaneously, NATO's dependency on civilian infrastructure remains striking. Ninety percent of military transport during operations is sourced from civilian contracts, while 75 percent of host-nation support—including fuel and utilities—comes from local commercial systems.[9] This makes interoperability dependent on civilian infrastructure and essential to any sustained NATO operation.[10]

This heavy dependence on national civilian systems is also a strategic concern, complicating the ability to protect energy infrastructure. Unlike Article 5, which mandates collective defense, Article 3 requires each state to maintain individual resilience. NATO cannot dictate national energy systems but, as the 2025 Hague Declaration suggests, it can shape standards and interoperability guidelines that influence infrastructure design and investment choices across the Alliance.

Additionally, while historically military- and government-driven innovation led military technology development, the speed of innovation and the private sector's degree of influence in driving the equipment and technology used in modern warfare have become pivotal. Especially in the areas in which the mi-

6. "Energy Highlights No. 17," NATO Energy Security Centre of Excellence, June 16, 2022, https://www.enseccoe.org/publications/energy-highlights-no-17/.
7. "The Hague Summit Declaration."
8. "NATO 2022 Strategic Concept," NATO, last updated March 3, 2023, https://www.nato.int/cps/en/natohq/topics_210907.htm.
9. "Resilience, Civil Preparedness and Article 3," NATO, November 13, 2024, https://www.nato.int/cps/en/natohq/topics_132722.htm.
10. "Energy Highlights No. 20," NATO Energy Security Centre of Excellence, last updated August 25, 2025, https://www.enseccoe.org/publications/energy-highlights-20.

litary relies on civilian infrastructure, private-sector investment has become a factor driving military decision-making.[11]

This is also reflected in some of the changes in warfare seen in the Ukraine conflict. The use of massive waves of inexpensive drones has shown that large numbers of inexpensive weapons can overpower and destroy a smaller number of expensive and high-tech equipment. This makes defending against these kinds of attacks more challenging, especially when it comes to protecting large and disparate infrastructure such as energy grids, power plants, pipelines, and refineries.

The new NATO force model highlights the need for a flexible structure that can more rapidly scale a deployable force capable of meeting a range of challenges beyond defense and deterrence, including cooperative security and crisis prevention and management.[12] NATO's ARF—formerly the NRF—has been redesigned to reflect the demands of modern conflict but is even more reliant on existing national energy infrastructure. Structured for high readiness and rapid deployment, the ARF draws on multinational, multi-domain assets, but must be prepared to operate in energy-constrained and infrastructure-degraded conditions.[13] These forces are expected to be forward deployed into areas of potential conflict to provide deterrence and defense, and to execute on all of NATO's core tasks, which requires larger energy requirements.[14]

The result is a new operational landscape in which the distinction between civil and military energy systems is increasingly blurred. As NATO forces electrify—from ISR platforms to command nodes and even tactical vehicles—the need for plug-and-play, modular, and multi-fuel capable systems becomes mission critical.[15] Without common energy design, shared protocols, and joint energy planning, the Alliance's ability to project and sustain power together is fundamentally compromised.

Modern adversaries increasingly target energy infrastructure as part of hybrid warfare strategies. The war in Ukraine is the most salient example, as Russia has executed sustained attacks on electrical grids, oil depots, and fuel logistics nodes. These attacks aim to paralyze both civil society and military operations. According to NATO's Energy Security Centre of Excellence (ENSEC COE), energy systems are now seen as primary targets in modern conflicts because of their dual-use nature and their critical importance to both operational and strategic continuity.[16]

Hybrid threats often blend cyber, kinetic, and psychological tactics. Russia has both launched missile strikes on Ukraine's grid and disabled critical energy infrastructure with cyberattacks in countries such as Poland and the Baltic states. These are not isolated incidents. NATO member states increasingly recognize that energy is both a strategic vulnerability and a deterrence factor—its disruption can delay troop deployments, disable communication systems, and force mission abortion.[17]

11. Dominik P. Jankowski and Julian Wieczorkiewicz, "Energy Transition: How NATO Can Get It Right," Council on Geostrategy, March 23, 2023, https://www.geostrategy.org.uk/britains-world/energy-transition-how-nato-can-get-it-right/.

12. "NATO Force Model," NATO, April 2, 2025, https://www.nato.int/cps/en/natohq/topics_234075.htm.

13. John R. Deni, "The New NATO Force Model: Ready for Launch?" NATO Defense College, last updated March 28, 2025, https://www.ndc.nato.int/the-new-nato-force-model-ready-for-launch/.

14. Ibid.

15. Simulcik, et al., "Electrification of the Joint Force."

16. Arnold C. Dupuy, et al., "Energy Security in the Era of Hybrid Warfare," NATO Review, January 13, 2021,https://www.nato.int/docu/review/articles/2021/01/13/energy-security-in-the-era-of-hybrid-warfare/index.html.

17. Ibid.

Case study: Russian attacks on Ukraine's energy infrastructure

When Russia launched its full-scale invasion of Ukraine in February 2022, Ukraine possessed one of Europe's most robust energy infrastructures. By 2023, Ukraine's electricity generation totaled about 103 terawatt-hours (TWh), with nuclear power providing 51 percent, coal and other thermal generation 21 percent, natural gas 12 percent, hydroelectricity 10 percent, and renewables (primarily wind and solar) making up roughly 6 percent. Despite wartime disruptions, this generation mix was generally sufficient for Ukraine's civilian needs and positioned the country as a critical node in Europe's energy security architecture, with multiple interconnections to neighboring states and a historically significant role as a natural gas transit and storage hub for European markets.[18]

Ukraine's military forces, like those of NATO, depend largely on civilian energy networks and distribution systems. Fixed military infrastructure is typically wholly reliant on a national electricity distribution system. Furthermore, military operations depend on fuel distribution networks and require stable energy supplies in order to maintain continued capabilities and production schedules.[19] Ukraine maintained six major oil refineries along with an extensive pipeline network and strategically positioned petroleum reserves.[20] While this powered Ukraine during peacetime, the centralized infrastructure created what military planners recognized as a target-rich environment for attacks designed to degrade both Ukraine's military capabilities and the military-industrial base to continue operations.[21]

Russia's attack on Ukraine's energy infrastructure unfolded through three distinct phases that demonstrated both strategic patience and tactical precision. The initial phase, running from February through August 2022, concentrated primarily on fuel infrastructure within proximity of the forward line of troops, with the goal of hindering heavy transport and military equipment. Russian forces systematically degraded fuel depots and refineries, reducing Ukraine's fuel processing capacity by about 30 percent within the first six months.[22]

The second phase represented a significant escalation in both targeting scope and operational tempo. In October 2022, Russia initiated coordinated missile and drone swarm attacks specifically engineered to collapse Ukraine's electrical generation and transmission infrastructure.[23] Critical nodes that included substations, step-up transformers, and power plants faced repeated strikes, with follow-on attacks specifically designed to kill repair technicians and destroy stockpiled replacement equipment. By November 2022, this systematic campaign had induced rolling blackouts affecting as many as 10 million residents, while simultaneously degrading military C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) capabilities.[24]

The third phase, extending through 2024, evolved into a sustained campaign of systematic attrition targeting Ukraine's power infrastructure. Russian forces adopted an attrition-based strategy focused on repeated strikes against previously repaired infrastructure. Ukraine struggled to source replacement equipment, with lead times for critical equipment extended up to two years and the challenge compounded by compatibility issues between Western equipment and Ukraine's Soviet-era hardware.[25] During peak demand periods, the country experienced acute generation capacity loss, as capacity fell 2.3 GW below its peak demand of 12 GW, despite receiving energy imports. Over the course of 2022–2023, about half of Ukraine's power generation capacity was either occupied by Russian forces, destroyed, or damaged, with the wave of at-

18. "Country Analysis Brief: Ukraine," US Energy Information Administration, June 3, 2025, https://www.eia.gov/international/content/analysis/countries_short/Ukraine/Ukraine.pdf.
19. Dupuy, et al., "Energy Security in the Era of Hybrid Warfare."
20. "Country Analysis Brief: Ukraine," US Energy Information Administration, June 3, 2025, https://www.eia.gov/international/content/analysis/countries_short/Ukraine/Ukraine.pdf.
21. John Fasching, "Strategic Mobility: The Essential Enabler of Military Operations in Great-Power Competition," Heritage Foundation, November 17, 2020, https://www.heritage.org/military-strength-topical-essays/2021-essays/strategic-mobility-the-essential-enabler-military.
22. Kateryna Stepanenko, et al., "Russian Offensive Campaign Assessment, September 11," Critical Threats, September 11, 2022, https://www.criticalthreats.org/analysis/russian-offensive-campaign-assessment-september-11.
23. Justin Bronk, Nick Reynolds, and Jack Watling, "The Russian Air War and Ukrainian Requirements for Air Defence," Royal United Services Institute, November 7, 2022, https://static.rusi.org/SR-Russian-Air-War-Ukraine-web-final.pdf.
24. "Blackouts Hit 10 Million in Ukraine after Russian Strikes," Al Jazeera, November 18, 2022, https://www.aljazeera.com/news/2022/11/18/10-million-ukrainians-without-power-after-russian-attacks.
25. Suriya Evans-Pritchard Jayanti, "Ukraine Struggles to Repair Power Grid as Russian Airstrikes Continue," Atlantic Council, January 13, 2023, https://www.atlanticcouncil.org/blogs/ukrainealert/ukraine-struggles-to-repair-power-grid-as-russian-airstrikes-continue/.

tacks between March and May 2024 causing Ukraine to lose another 9 GW of generation capacity, leaving only about one-third of its pre-war capacity.[26]

Russian attacks on Ukraine's energy infrastructure had initial, but limited, impacts on military operations. Russian attacks on Ukraine's gas infrastructure resulted in a 40-percent reduction in gas output in February and March 2025, forcing Ukraine to increase gas imports nearly tenfold to meet immediate demand.[27] Industrial power consumption halved, drastically changing Ukraine's electricity consumption patterns. In the two years following the full-scale invasion, Russia's attacks damaged eighteen large-scale CHP plants, 815 boiler houses, 152 central heating points, and 354 kilometers of district heating pipes. Direct damage was estimated at $2.4 billion.[28]

Faced with this existential threat to its energy infrastructure, Ukraine demonstrated remarkable adaptability and innovation. The most dramatic achievement came in March 2022 with the emergency synchronization of Ukraine's power grid and the European Network of Transmission System Operators for Electricity (ENTSO-E) network. What had been planned as a two-year technical project was completed in less than three weeks under combat conditions, a testament to both Ukrainian determination and European solidarity.[29] This connection provided access to 1.7 GW of emergency power imports, which proved crucial for maintaining critical defense production and essential services.[30]

Ukraine's distributed resilience strategy also fundamentally reimagined energy security. Rather than attempting to harden centralized infrastructure against precision strikes, Ukrainian authorities embraced energy decentralization as a strategy for survival, deploying thousands of backup generators and developing a comprehensive distributed generation framework. This included receiving more than 5,500 generators through international aid programs and implementing a national Strategy for the Development of Distributed Generation until 2035, which focused on small distributed power units ranging from 5 to 100 megawatts (MW) each to prevent future blackouts.[31] This decentralized approach meant that no single strike could cripple large areas, forcing Russian targeters to expend more munitions for diminishing returns.

International support also proved essential to Ukraine's energy survival. Through coordinated efforts that included the EU Civil Protection Mechanism, NATO's Comprehensive Assistance Package, and bilateral aid programs, allies and partners provided the 5,500 generators mentioned above, along with specialized repair equipment and technical expertise.[32]

Through diversified energy imports, Ukraine also deployed distributed renewable energy systems—such as photovoltaic (PV) solar and wind—that are more resilient to targeted attacks than traditional centralized infrastructure.[33]

At a more tactical level, units needed to develop new tactics for operating in energy-degraded environments, including manual backup procedures for digitized systems and increased reliance on passive sensors to conserve power. Logistics planning became increasingly complex as fuel convoy routes required constant adjustment based on infrastructure damage and enemy targeting patterns. The need to allocate air-defense assets to protect critical energy infrastructure meant fewer systems available for traditional military targets, creating painful tradeoffs for commanders.

26. "Ukraine's Energy System under Attack," International Energy Agency, last visited September 15, 2025, https://www.iea.org/reports/ukraines-energy-security-and-the-coming-winter/ukraines-energy-system-under-attack.
27. Slawomir Matuszak, "Ukraine: A Difficult Situation on the Gas Front," OSW Centre for Eastern Studies, April 2, 2025, https://www.osw.waw.pl/en/publikacje/analyses/2025-04-02/ukraine-a-difficult-situation-gas-front.
28. "Ukraine's Energy System under Attack."
29. "Continental Europe Successful Synchronisation with Ukraine and Moldova Power Systems," European Network of Transmission System Operators for Electricity, March 16, 2022, https://www.entsoe.eu/news/2022/03/16/continental-europe-successful-synchronisation-with-ukraine-and-moldova-power-systems/.
30. "The Ukrainian Energy System Is Synchronized with the European Network," US Agency for International Development Energy Security Project, December 5, 2023, https://energysecurityua.org/news/the-ukrainian-energy-system-finalized-synchronization-with-the-european-network/.
31. Romina Bandura and Alexander Romanishyn, "Striving for Access, Security, and Sustainability: Ukraine's Transition to a Modern and Decentralized Energy System," Center for Strategic and International Studies, July 2, 2025, https://www.csis.org/analysis/striving-access-security-and-sustainability.
32. "EU Sends Additional 500 Power Generators to Ukraine," European Commission, press release, December 22, 2023, https://enlargement.ec.europa.eu/news/eu-sends-additional-500-power-generators-ukraine-2023-12-22_en.
33. Dan De Luce and Daryna Mayer, "Ukraine Appeals to the World for Help Keeping the Lights On," NBC News, January 20, 2023, https://www.nbcnews.com/news/world/ukraine-asks-world-electrical-equipment-keep-lights-on-rcna66292.

NATO's operational energy challenges

NATO countries across the Alliance are in a similar position to Ukraine at the time of the Russia invasion. The interdependence between civilian and military energy systems emerged as both a vulnerability and an opportunity. While military dependence on civilian infrastructure created targeting opportunities for Russian forces, the dual-use nature of many energy systems also enabled flexible response options. Commercial generators could support military operations, civilian repair crews could restore defense critical infrastructure, and industrial facilities could shift between civilian and military production based on power availability.

Moreover, NATO's strategic dependency on civilian infrastructure underscores the need for dual-use and interoperable energy architecture. This is particularly relevant in the increasingly electrified and network-connected battle space, in which reliance on national power and infrastructure provides not only energy for deployed units but also a host of potential attack vectors that can be exploited and degraded.[34] This includes liquid fuels and electricity used to power deployed forces. Military units might need to plug into local grids or rapidly deploy modular systems to sustain mission readiness. Without standardized interfaces and compatible energy systems, ARF forces risk deploying into spaces where they are unable to power critical systems.[35]

Ukraine's experience demonstrates that energy interoperability can provide strategic resilience in ways that pure military capabilities cannot. The ability to rapidly connect to neighboring grids, share power across borders, and leverage allied energy resources proved decisive in preventing Russian energy warfare from achieving its strategic objectives. For NATO, this underscores that common energy standards, interoperable systems, and integrated planning are not administrative concerns but operational necessities for twenty-first-century collective defense.

Divergent national energy policies and the interoperability challenge

The 2022 NATO Strategic Concept noted that the organization will seek to "enhance [its] energy security and invest in a stable and reliable energy supply, suppliers, and sources," mitigating vulnerabilities and dependencies.[36] As NATO allies pursue building energy security, however, national-level divergence in fuel types, propulsion technologies, and energy infrastructure is becoming an interoperability barrier. National governments that have embraced, or have been pressured to accelerate, the energy transition are being pressured to adopt often-competing technologies that are designed to power deployable military forces (for example, electric-drive engines versus hydrogen fuel cells for land mobility).[37] In an attempt to standardize fuel for aircraft, land-based vehicles, and equipment to simplify logistics and improve interoperability on the battlefield, NATO developed the Single Fuel Concept (SFC). Centered around F-34 (JP-8/Jet A-1), which historically provided a unifying framework for liquid fuels, the rapidly evolving post-oil battlefield is more complex and fragmented.

For example, the United States military aims to field hybrid-drive tactical vehicles by 2035 and fully electric vehicles by 2050, whereas European militaries, especially Germany and France, have emphasized hydrogen fuel cells as a decarbonization pathway for heavy-duty ground transport.[38] Meanwhile, multiple NATO air forces are piloting sustainable aviation fuels, introducing further diversity in fuel logistics, sourcing, and supply chain requirements.[39] These energy technology trajectories—driven by national energy policy and commercial-sector innovation—are accelerating in parallel rather than in coordination, leading to fractured planning and siloed capabilities across NATO member states.

The role of the commercial sector further complicates matters. Private-industry innovation has outpaced the defense sector around electric vehicles, smart grids, and hydrogen logistics, which defense contractors still need to develop systems optimized for military and Department of Defense (DOD) requirements—often using proprietary technologies and further reinforcing energy fragmentation.[40]

34. Dupuy, et al., "Energy Security in the Era of Hybrid Warfare."
35. Simulcik, et al., "Electrification of the Joint Force."
36. "NATO 2022 Strategic Concept."
37. Jankowski and Wieczorkiewicz, "Energy Transition."
38. Simulcik, et al., "Electrification of the Joint Force."
39. Jankowski and Wieczorkiewicz, "Energy Transition."
40. Simulcik, et al., "Electrification of the Joint Force."

This divergence creates significant logistical and operational dilemmas. Multinational task forces deploying into forward theaters might arrive with incompatible refueling systems, grid voltages, energy storage technologies, or battery management requirements. In effect, national energy transition strategies—absent coordination—are creating energy silos that erode NATO's operational cohesion.

NATO's evolving force structure—especially with the transition from the NRF to the ARF—reflects a growing emphasis on flexibility, high-readiness deployment, and multi-domain coordination.[41] However, the ability of ARF elements to deploy rapidly and sustain operations is increasingly shaped by the energy environment they enter.[42] This was a concern noted in exercise Steadfast Defender, as concerns were raised about the integration of technology negatively impacting interoperability.[43] Many NATO operations will take place in energy-degraded or infrastructure-denied spaces, either due to hybrid attacks—as seen in Ukraine—or due to the fragility of host-nation infrastructure.[44] In this context, energy becomes a rate limiter for everything from command and control to mobility, sustainment, and survivability.

The shift toward an electrified and sensor-saturated battlefield—including ISR platforms, command nodes, and potentially autonomous systems—places growing demand on electrical power in the field. Yet this transformation has not been matched by commensurate interoperability in power delivery or energy logistics. While fossil fuels such as F-34 (under the Single Fuel Concept) remain standardized, electricity remains fragmented. Differences in voltages, connectors, storage systems, and recharging protocols create friction points during joint operations.[45]

NATO's opportunity to achieve energy interoperability

NATO's energy interoperability challenge requires an unprecedented level of coordination between the Alliance's institutional structures and the sovereign energy policies of thirty-two member nations—plus increasingly critical partners such as Ukraine, Georgia, and others that routinely operate alongside NATO forces in real-world contingencies.[46] Effective security cooperation requires moving beyond parallel efforts and toward coordinated action, with Brussels headquarters and national capitals working through shared processes and cross-participation mechanisms, while maintaining explicit respect for national competences and sovereign decision-making that member states guard zealously.[47] This is particularly critical to support ARF and other rapid-reaction forces, and to ensure deployed NATO forces have the energy required to support these missions.

The limiting factor in this process is that NATO has no formal authority over national energy infrastructure decisions. This places the burden on soft-power tools: common standards, shared planning processes, and joint exercises. The 2025 Hague Summit Declaration offers a new policy lever. By linking defense spending targets with resilience and innovation, NATO can incentivize energy modernization that also serves operational ends.[48] This can be viewed through three levels of consideration,

- NATO-developed guidelines and recommendations;
- national-level policy and investment recommendations driven by NATO guidelines; and
- military equipment interoperability standards (driven by NATO guidelines and national policy).

NATO leadership and guidelines

Multiple institutions affect energy resilience in NATO operations—national energy ministries, defense procurement agencies, NATO headquarters, Supreme Headquarters Allied Powers Europe (SHAPE), the European Union, and private contractors. Yet coordination between these actors is inconsistent at best, and nonexistent at worst. A dedicated EU-NATO Energy Interoperability Working Group—comprising military planners, energy-sector experts, and industrial base repre-

41. Deni, "The New NATO Force Model."
42. "NATO Force Model."
43. Mahad Butt, "Evaluating NATO's Strategic Posture: An Analysis through Steadfast Defender 2024," *Atlantica,* Atlantic Forum, May 6, 2024, https://www.atlantic-forum.com/atlantica/evaluating-natos-strategic-posture-an-analysis-through-steadfast-defender-2024.
44. Butrimas, et al., "Hybrid Warfare against Critical Energy Infrastructure."
45. Kern, et al., "An Albatross around the US Military's Neck."
46. Thierry Tardy, "NATO 2030. United for a New Era: A Digest," NATO Defense College, December 2020, https://www.ndc.nato.int/download/nato-2030-united-for-a-new-era-a-digest/.
47. "Brussels Summit Communiqué," NATO, June 14, 2021, https://www.nato.int/cps/en/natohq/news_185000.htm.
48. Butrimas, et al., "Hybrid Warfare against Critical Energy Infrastructure."

sentatives—could bridge these gaps in planning and procurement and directly support dialogue among individual member countries on national-level energy policy that impacts NATO interoperability.

Achieving energy interoperability across NATO is not solely a technological challenge, but a concern that expands beyond the already complex issues of traditional military standardization. Unlike ammunition or liquid fuels, which have been standardized through multiple NATO standardization agreements (STANAGs), "energy" encompasses a remarkably complex web of technical parameters required across operational domains and competing technologies, and can potentially undermine interoperability if allies adopt divergent solutions without coordinated standards.[49] Electrical systems interoperability across NATO presents complex standardization challenges spanning frequency standards—50 hertz (Hz) throughout Europe versus 60 Hz in North American systems. Power quality requirements are increasingly stringent, with military electronic systems requiring total harmonic distortion below 5 percent to prevent malfunctions in sensitive equipment like communications systems and electronic controls. Even minor variations can cause erratic equipment behavior with potentially serious operational consequences.[50]

These issues are further magnified in an increasingly electrified military. The US Army has committed to fielding an all-electric light-duty non-tactical vehicle by 2027. A US military vehicle equipped with SAE J1772 connectors simply cannot draw power from German infrastructure utilizing IEC Type 2 connectors without appropriate adapters. This is reminiscent of the Tesla Supercharger compatibility issues seen in the US commercial market.[51] While this presents a challenge during peacetime operations and exercises, these issues become critical for the ARF or other rapidly deploying forces that must operate with limited access to existing NATO infrastructure. The resulting technical interoperability requirements transform what were once straightforward deployments into complex systems engineering challenges requiring extensive testing and de-risking of deployable systems, each carrying downstream implications for mission readiness and combat effectiveness.[52] While energy supply remains a national prerogative, NATO's collective defense obligations require not just a coherent Alliance-wide framework for energy planning, procurement, and crisis response, but a detailed technical architecture that addresses these multifaceted compatibility requirements at every level from strategic infrastructure to tactical connectors.

Recommendations

1. **Elevate and centralize energy planning.**

   NATO should look to create a position of assistant secretary-general for energy and resilience at headquarters, with budget authority and directive power. This position should have direct reporting lines to the secretary-general to ensure there is significant authority to bring together SHAPE, Allied Command Transformation (ACT), and others to ensure action and acceptance of responsibility on energy standards. The position should maintain direct liaison relationships with national energy coordinators to allow for bypassing of the usual diplomatic channels that turn urgent operational requirements into years-long staffing exercises. The systematic oversight that is demonstrated in NATO's most current Energy Highlights publication, produced by the NATO Energy Security Center of Excellence (ENSEC COE), illustrates the kind of coordinated analysis needed, focused at the strategic and operational levels.[53]

2. **Embed energy interoperability into NATO defense planning.**

   The NDPP should formally incorporate energy interoperability as a capability requirement. Future force packages—especially ARF components—should be evaluated not only on operational readiness and firepower but also on energy compatibility with allied systems and civilian infrastructure. NATO exercises (e.g., Steadfast Defender and Steadfast

49. Jankowski and Wieczorkiewicz, "Energy Transition."

50. "519-2014: IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems," Institute of Electrical and Electronics Engineers, 2014, https://ieeexplore.ieee.org/document/6826459; "STANAG 2601: Standardization of Electrical Systems in Tactical Land Vehicles," NATO, September 14, 2017, https://standards.globalspec.com/std/10266893/stanag-2601.

51. Reed Blakemore and Tate Nurkin, "Power Projection: Accelerating the Electrification of US Military Ground Vehicles," Atlantic Council, November 3, 2022, https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/power-projection-accelerating-the-electrification-of-us-military-ground-vehicles/.

52. "Defence Capabilities Initiative Approved by the Heads of State and Government," NATO, press release, April 25, 1999, https://www.nato.int/cps/en/natohq/official_texts_27443.htm; James Derleth, "Enhancing Interoperability: The Foundation for Effective NATO Operations," NATO Review, June 16, 2015, https://www.nato.int/docu/review/articles/2015/06/16/enhancing-interoperability-the-foundation-for-effective-nato-operations/.

53. "Energy Security Highlights No. 20."

Dart) should include energy-denied scenarios to stress test logistics, validate smart grid resilience, and improve interoperability under degraded conditions. NATO should consider the following.

- One of the primary needs is establishing a structure to ensure cohesion among military equipment, hardware, and infrastructure so that NATO countries have an interoperable fuel that can be used among deployed forces. To support this, NATO can require each nation to designate a national energy interoperability coordinator reporting to both national defense leadership and NATO Supreme Allied Commander. This role will help ensure dialogue on the range of energy issues relevant for deployed forces. Additionally, establishing bilateral Energy Interoperability Agreements between NATO and each partner, modeled on existing defense cooperation agreements, can help create necessary protocols.

3. **Establish formal energy interoperability frameworks with partner nations.**

NATO cannot achieve energy security in isolation from partners that share geography, threats, and operational space. This framework recognizes that Ukraine's current grid integration with Europe occurred under fire. The forced and rapid nature of such planning under distress can and does lead to inefficiencies and real-time fixes that might not be sustainable over the long term. For these reasons, future crises demand such interoperability be established in peacetime. NATO can create programs like the Partnership Energy Interoperability Programs (PEIP), offering technical assistance and standards alignment to partner nations, and can establish Energy Security Consultation Mechanisms within existing partnership frameworks (Partnership for Peace, Mediterranean Dialogue, etc.) to build a common-use energy infrastructure.

National policy on energy interoperability

While technical and policy standards from NATO can help, a fundamental challenge remains in the disparate energy policies among the thirty-two national capitals, as allies follow their own separate paths toward energy security, creating risks to interoperability. Greater alignment among member nations on such a joint vision is essential. Energy security is largely and normally considered a national economic issue, yet NATO provides the ideal platform for allies to coordinate efforts through shared benchmarks and standards.[54] The increase in defense spending per The Hague Summit Declaration provides an opportunity for NATO and member countries to coordinate some of this funding to allow for increased interoperability.

The Russian invasion of Ukraine cracked the European understanding of energy security and has set off a range of reactions regarding how to move forward. The dismantling of nuclear power plants, build out of renewable power, questions about the future of transport fuel, and prior over-reliance on Russian oil and gas have created a new wave of disparate energy projects, including liquefied natural gas (LNG) import facilities, new gas-fired power plants, and an increase in coal for power. As individual nations redefine energy security to power national economies and infrastructure, a lack of common vision on the future of transport fuels, especially between the United States and Europe, makes a common framework even more important and more challenging.

One of the greatest challenges is the fragmentation of energy policy among most member states across the governmental and commercial sectors. The commercial sector drives energy development in many countries, based on policy guidelines of the individual member states.[55] Additionally, energy policy is usually viewed through the lens of domestic civil and economic infrastructure priorities, and not through those of national security.[56]

Recommendations

1. **Improve national energy security coordination.**

   To help address the fragmentation of national energy policies, each NATO member state would benefit from the establishment of an Inter-Ministry Energy Defense Committee, modeled after Singapore's Inter-Ministerial Committee on Climate Change or the United States' whole-of-government approach. Each national committee

54. Kathleen McInnis, "No Strategy without Society: Rethinking NATO's Coordination Mechanisms," Center for Strategic and International Studies, June 24, 2025, https://www.csis.org/analysis/no-strategy-without-society-rethinking-natos-coordination-mechanisms.
55. Jankowski and Wieczorkiewicz, "Energy Transition."
56. "Energy Highlights No. 17."

should be anchored under the Ministry (Department) of Defense to ensure alignment with national security priorities, while including senior representatives from energy, foreign affairs, and economic ministries (or departments). To reinforce cross-ministerial authority, each committee should be convened by the National Security Council or the Prime Minister's Office, as appropriate, providing the political weight necessary to cut across bureaucratic silos. Meetings should occur at the deputy minister level, giving sufficient authority to drive action. NATO's Energy Security Centre of Excellence should provide the standardized frameworks and best practices to help national delegations convert Alliance standards into procurement-ready documents, ensuring that contracting officers can operationalize requirements. Finally, each national committee's mandate should formally extend to structured consultation with private-sector critical infrastructure operators, enabling governments to anticipate and mediate conflicts should and when civilian renewable mandates risk undermining military readiness.

2. **Spotlight energy reporting.**

   The NATO Energy Center for Excellence was established in 2012 with the stated mission of supporting NATO nations and partners to meet the challenges of a dynamic energy security environment. The center produces a range of reporting on energy issues, much of which is exceptionally relevant to the interoperability concerns addressed here as well as the need to increase civilian-defense collaboration. But the items are not widely read or discussed. Establishing an annual National Energy Interoperability Report, in partnership with the energy center but elevated to the assistant general secretary for energy level, would help create accountability and a rhythm that synchronizes with NATO's existing four-year NDPP cycles and annual reporting mechanisms.[57] This will also put into writing each member state's plan to enable NATO to better understand the potential influence of the process, especially when national-level leaders are committing to their reports.[58]

3. **Support The Hague Declaration.**

   NATO has an opportunity to not only encourage member states to allocate a portion of funding announced at The Hague Summit toward energy for interoperability projects as part of their increased defense spending to 3.5 percent, but also to help influence the direction of both the 3.5 percent and the 1.5 percent infrastructure funding based on clear guidelines and expectations as earlier discussed. While there must be alignment with other national and EU priorities, NATO has a stronger role to play than ever before and setting these guidelines will require new mechanisms for collaboration:

   - As one example, NATO can foster dialogue across the member countries on building national-level infrastructure and logistics systems capable of supporting common future transport fuels. A discussion on the mix of electrification, fossil fuels, and hydrogen is needed to ensure the infrastructure is in place to meet needed crisis demand. This dialogue is equally important in countries such as the United States, the United Kingdom and Germany—some of the leading producers of heavy military equipment—and in countries such as the Baltics, Poland, and Romania, which are closer to the front lines of a potential future conflict.
   - This government-led dialogue must include the commercial sector to ensure there is a clear signal on the direction. Government funding via public-private partnerships on energy infrastructure and interoperability will ensure common and dual-use energy systems that support both national infrastructure resilience and military interoperability. This could include
     - military-grade EV charging networks that serve both public and tactical vehicles;
     - hydrogen refueling corridors with defense-use prioritization; and
     - civilian smart grids with military microgrid compatibility.

To avoid national divergence, NATO can publish design guidance documents—not prescriptive, but directional—to shape how infrastructure is built going forward.

Military system interoperability

A core barrier to interoperability is the fragmented nature of defense acquisition across member states. As of 2025, the United States operates thirty-three major weapons systems

57. Angus Lapsley and Pierre Vandier, "Why NATO's Defence Planning Process Will Transform the Alliance for Decades to Come," Atlantic Council, March 31, 2025, https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/why-natos-defence-planning-process-will-transform-the-alliance-for-decades-to-come/.
58. "Membership Action Plan (MAP)," NATO, press release, April 24, 1999, https://www.nato.int/cps/en/natohq/official_texts_27444.htm.

while Europe manages more than 170, complicating both logistics and energy support. Likewise, eight European nations produce tanks and fifteen produce other kinds of armored vehicles, leading to interoperability challenges.[59]

While there is some identified progress on the 2023 NATO Defense Production Action Plan and 2024 NATO Industrial Capacity Expansion Pledge to align the military industrial base across the Alliance, these initiatives should be extended to energy platforms, including logistics vehicles, deployable infrastructure, and battlefield generators.[60] Without unified technical specifications, energy systems—from microgrids to vehicle propulsion—risk becoming siloed by national prerogative, priorities, and decisions, not by function.

NATO can play a stronger role in energy systems standardization by expanding the NATO Codification System to cover modular power technologies, publishing Alliance-wide interoperability guides for energy infrastructure, and encouraging cross-national procurement consortia to reduce duplication.

Recommendations

1. **Increase the visibility of energy interoperability within NATO.**

   Similar to the need to create a focal point within the NATO civilian secretariat, NATO needs to create a position focused on energy and interoperability within the military construct. This position must be at a senior level to ensure it has not only the responsibility but the authority to create action across the command structure.[61] Regular Energy Implementation Board meetings will help ensure these requirements receive the visibility needed, especially at this critical juncture, and ensure there is systematic oversight when addressing these urgent needs. Monthly Energy Implementation Board meetings will help ensure these requirements receive the visibility needed, especially at this critical juncture, and ensure there is no "drift" when addressing these urgent needs.[62]

2. **Ensure accountability.**

   Holding NATO members to account will be critical to achieving energy interoperability. Every member that stalls on harmonizing voltage standards or upgrading connectors creates vulnerabilities that Russian targeting cells are already mapping. NATO has the opportunity to implement multiple mechanisms to reduce these weaknesses.

   - Creating deadlines for National Implementation Roadmaps is a proven tool for NATO to ensure national militaries and NATO members maintain momentum in their planning process. This approach also aligns with NATO's established NDPP, which apportions capability targets to each ally and facilitates their implementation through regular assessment of progress within structured four-year cycles. The systematic monitoring and deadline-driven approach has demonstrated effectiveness in translating Alliance objectives into concrete actions.[63] NATO and member countries need a conceptional change on these kinds of roadmaps as well, especially on energy interoperability, away from "studying the issue" or "coordinating with stakeholders" and toward more measured actions, together with the private sector, to ensure alignment on national budget processes, industry contracts, and procurement schedules.
   - Hosting an annual NATO Energy Summit might also provide additional opportunity for collaboration between military and industry leaders to help ensure commitments are being followed and member states can ensure continued contact.[64] While energy was a topic discussed at the 2024 NATO Resilience Summit, it is too critical to be reduced to a single panel during a larger event.[65] Bringing together defense, energy, and finance ministers can promote the necessary cross-ministry coordination, which rarely happens naturally. A rotation of the summit among nations could create a healthy

59. Deni, "The New NATO Force Model."
60. Mark Kennedy and Jeremy "Maestro" Renken, "Preparing for the Next Conflict: How NATO Is Fortifying Its Defenses," Wilson Center, January 28, 2025, https://www.wilsoncenter.org/article/preparing-next-conflict-how-nato-fortifying-its-defenses.
61. David Julazadeh, "NATO's Capability Development: A Call for Urgent Reform," Atlantic Council, March 13, 2025, https://www.atlanticcouncil.org/blogs/new-atlanticist/natos-capability-development-a-call-for-urgent-reform/.
62. "Brussels Summit Communiqué."
63. "NATO Defence Planning Process," NATO, last updated April 16, 2025, https://www.nato.int/cps/en/natohq/topics_49202.htm.
64. "Innovation and Critical Infrastructure in Focus as Energy Security Experts Meet at NATO Headquarters," NATO, December 9, 2024, https://www.nato.int/cps/en/natohq/news_231363.htm.
65. "2024 NATO Resilience Symposium Report," NATO, last visited September 29, 2025, https://www.act.nato.int/wp-content/ploads/2025/09/NATO-Resilience-Symposium-2024-Report.pdf

competition, as each member country wants to put its mark on moving the discussion forward.[66]

- Additionally, linking these actions to the defense procurement process helps create accountability and compliance. With the agreed-upon increase in defense spending, national leaders will face increasing public scrutiny on meeting these commitments. Adding energy interoperability as a formal readiness metric, with specific capability targets for noncompliant nations, can help transform these commitments into a more actionable direction.[67]

3. **Create a NATO-Industry Energy Advisory Board.**

   As noted, NATO forces rely on civilian energy infrastructure for power, and the military industrial sector increasingly directs the kinds of development, especially with energy, that deployed forces utilize. The NATO-Industry Energy Advisory Board recognizes a simple truth: Governments set requirements, but industry delivers capabilities.[68] Bringing together the chief executive officers from major energy-sector companies and defense industry representatives together with NATO leadership could unlock innovations that government coordination never would. Semi-annual meetings keep the pressure on without overwhelming executive calendars, while mixing traditional defense contractors with commercial energy firms prevents the usual suspects from dominating the conversation.[69]

4. **Establish NATO energy interoperability standards.**

   To understand the many issues related to energy interoperability at the strategic and tactical levels, NATO should convene a task force to define technical and operational energy interoperability standards; establish a NATO-National Energy Coordination Council with permanent representatives from each member's energy and defense ministries that provide guidance to and collaboration with the NAC and Political Committee. This should be both operational and strategic, and the technical interoperability is directly tied to the broader issues of national infrastructure development and defense procurement. This should also include Partner Nation Observer Status for Ukraine, Georgia, Sweden, and others to ensure standards compatibility beyond formal membership; and mandate that national defense procurement offices have NATO energy standards experts embedded by 2026. While this structure would be difficult to achieve given the time constraints of these leaders, energy interoperability is a core warfighting function that needs to be further elevated beyond NAC and Political Committee discussions to be addressed. Examples of the issues this body would discuss include the following:

   - voltage and connector compatibility for expeditionary and mobile energy systems;
   - plug-and-play standards for modular generators, energy storage, and EV charging;
   - interoperable smart grid protocols for base operations and mobile networks; and
   - multi-fuel flexibility requirements (SAF, diesel, hydrogen, etc.).

5. **Update the framework regularly.**

   Coordinating bodies must update the framework periodically to reflect commercial innovation and evolving military needs. The framework should be embedded into acquisition guidance and training.

66. "NATO Summit Defence Industry Forum 2025—Time to 'Unite, Innovate & Deliver,'" NATO, June 24, 2025, https://www.nato.int/cps/en/natohq/news_236641.htm.
67. "NATO Defence Planning Process"; Julazadeh, "NATO's Capability Development."
68. Ben Cook, "Securing Allied Power Demand," Planetary Security Initiative, July 9, 2025, https://www.planetarysecurityinitiative.org/news/securing-allied-power-demand.
69. Raluca Csernatoni, "How to Future-Proof NATO's Defence Innovation and EDT Strategy," Centre for European Policy Studies, July 17, 2024, https://www.ceps.eu/how-to-future-proof-natos-defence-innovation-and-edt-strategy/.

Conclusion

NATO's credibility in the twenty-first century will be defined not only by its combat power, but by its ability to operate as a cohesive, interoperable force under contested and energy-constrained conditions. The war in Ukraine has demonstrated that modern conflicts begin not just on the battlefield, but with strikes on infrastructure, energy systems, and information networks. As the battlespace grows more electrified, data driven, and modular, energy interoperability is no longer a peripheral concern—it is a core determinant of mission success.

Energy resilience and adaptability must now be understood as operational imperatives, not mere logistical preferences. The increasing use of EVs, drones, ISR platforms, and digital communications demands a reliable, flexible, and interoperable energy backbone—one that must function across national lines and civilian-military boundaries. If left unaddressed, fragmentation in voltage standards, refueling systems, and energy storage designs will paralyze otherwise capable joint forces.

To mitigate this, NATO must prioritize a future-ready energy strategy rooted in Article 3 resilience, guided by joint standards, and aligned with the 1.5-percent resilience and infrastructure commitment from the 2025 Hague Summit Declaration. This includes integrating energy planning into the NDPP, updating the Single Fuel Concept to reflect post-oil realities, and building shared dual-use infrastructure that can sustain both military and civilian response in times of crisis.

The Alliance must also lead—not follow—commercial innovation in modular energy systems, field-deployable grids, and smart logistics. Civilian technology will shape the energy tools available in any future theater of war. Without NATO-guided interoperability frameworks, commercial divergence will become a battlefield liability.

Ultimately, energy interoperability is foundational to NATO's strategic interoperability.[70] It touches every layer of NATO's mission: deterrence, crisis response, and cooperative security. By aligning technologies, harmonizing doctrine, and investing in resilient infrastructure, NATO can transform a looming vulnerability into a defining advantage. The ability to move, fight, and sustain power—together—is what will distinguish NATO from its adversaries in the decades ahead.

The approach must extend beyond formal NATO members to include partners who share operational space. As recent conflicts have demonstrated, energy interoperability cannot stop at Alliance borders or those of NATO partners. Ukraine's emergency grid synchronization with the European ENTSO-E network under combat conditions proved that rapid interoperability measures are possible when strategic necessity demands it.

The path forward demands that NATO transcend the traditional divide between Alliance coordination and national implementation. Energy interoperability requires a new model in which Brussels, Mons, and capitals work as integrated partners, not separate actors. This extends beyond formal members—Ukraine, Georgia, and other partners have proven through combat that interoperability cannot stop at Alliance borders. The modern battlefield offers no forgiveness for incompatible plugs, mismatched voltages, lack of civilian energy supply, or policy silos between ministries. Energy interoperability must become as fundamental to NATO identity as Article 5 itself—a technical embodiment of the political commitment that an attack on one is an attack on all, and that all must be able to fight as one.

70. "Parameters Spring 2024," *US Army War College Quarterly* 54, 1 (2024), https://press.armywarcollege.edu/parameters/vol54/iss1/1/.

About the authors

Jason Knapp is a 2024-2025 Veterans Advanced Energy fellow with the Atlantic Council's Global Energy Center. Knapp is the founder and managing director of Capitol Energy Advocacy, where he works to advance clean energy technologies, strengthen critical mineral supply chains, and promote US manufacturing through strategic government relations. He also serves as an adjunct professor at American University's School of Public Affairs.

Knapp served in the US Navy for more than twenty years, during which he held senior legislative and political positions at NATO and US European Command. He has expertise in the National Defense Authorization Act, Infrastructure Investment and Jobs Act, and Department of Energy grant and loan programs, and has experience securing legislative language and funding for clean energy initiatives.

Prior to founding Capitol Energy Advocacy, Knapp was vice president in government relations at KORE Power and Unity Aluminum, where he developed strategies to secure government support for domestic manufacturing.

Based in Washington, DC, Knapp's work focuses on energy policy and fostering collaboration between government, industry, and academia. Knapp holds a BS in aerospace engineering from the University of Virginia and an MBA from Florida State University. He has also studied at the Naval War College, Georgetown University, and the NATO Defense College in Rome.

Christopher Olson is a 2024-2025 Veterans Advanced Energy fellow with the Atlantic Council's Global Energy Center.

Olson serves as the vice president for government relations for Weatherford, a global energy services company. In this role, Olson provides leadership in global government relations, energy trade associations, and community affairs. Before joining Weatherford, Olson served as the director of trade and international affairs in the Houston Mayor's Office, where he advised city leaders on global strategy and market positioning to increase economic development. Olson also serves as the executive director for the World Energy Cities Partnership, where he developed strategies for the energy transition and advised global business and government leaders on ESG strategies.

At the US Department of State, Olson had diplomatic postings in the Balkans and South and Central Asia; supervised programs in Africa, the Middle East, and Eastern Europe; and advised US and international business executives. As a business consultant, Olson advised on corporate market strategy, organizational structure, and business processes. Olson also served in the US Navy, leading large, diverse, cross-functional teams through shipboard tours. As a staff officer for the chief of naval operations in the Pentagon, he supported special warfare operations and led antiterrorism and continuity of operations programs.

Olson holds a bachelor's degree in history and political science from Northwestern University and a master's degree from the Edmund A. Walsh School of Foreign Service at Georgetown University. Olson also earned an MBA with a focus on strategy and innovation from Rice University Business School, where he was recognized as a Jones scholar for academic and leadership excellence.

Chamai Shahim is a 2024-2025 Veterans Advanced Energy fellow with the Atlantic Council's Global Energy Center. Shahim is the vice president of strategy and execution at Gambek, where she leads strategic initiatives aimed at driving sustainable growth. Her work focuses on integrating emerging technologies—such as semiconductors, automated mobility, and lithium batteries—into actionable strategies that support economic development and technological advancement.

Previously, as the strategic futures innovation manager for the Arizona Commerce Authority, Shahim helped shape long-term strategies that have influenced national policies, including the CHIPS Act and the Inflation Reduction Act. In this role, she focused on advancing high-tech industries such as renewable energy, zero-emission vehicles, and advanced manufacturing.

Shahim served in Oregon Army National Guard for seven years. She holds a global executive MBA from the Thunderbird School of Global Management and a bachelor's degree in mechanical engineering from the Colorado School of Mines.

About the center

The Atlantic Council Global Energy Center develops and promotes pragmatic and nonpartisan policy solutions designed to advance global energy security, drive economic opportunity, and foster a sustainable energy future.

Atlantic Council

The Atlantic Council is a nonpartisan organization that promotes constructive US leadership and engagement in international affairs based on the central role of the Atlantic community in meeting today's global challenges.

Atlantic Council
1400 L Street NW, 11th Floor
Washington, DC 20005
(202) 778-4952
www.AtlanticCouncil.org