E-ISSN : 2790-2404
P- ISSN 2070-9250
Qadaya siyasiyyat

Ministry of Higher Education
& Scientific Research
Al-Nahrain University
College of Political Science

وزارة التعليم العالي والبحث العلمي
جامعة النهرين
كلية العلوم السياسية

قضايا سياسية
Political Issues

مجلة فصلية محكمة

العدد ٨٤
Issue 84

كانون الثاني - شباط - اذار / ٢٠٢٦
Jan. - Feb. - Mar. / 2026

قضايا سياسية
العدد ٨٤
٢٠٢٦

جامعة النهرين
كلية العلوم السياسية

قضايا سياسية
Political Issues

E-ISSN 2790-2404
P- ISSN 2070-9250
DOI prefix: 10.58298

مجلة فصلية محكمة تعنى بنشر الأبحاث والدراسات السياسية العراقية والعربية والدولية
http://pissue.iq

البحوث المنشورة تعبر عن آراء أصحابها وليس بالضرورة عن رأي المجلة

العدد 84 كانون الثاني_ شباط_ اذار 2026

مجلة قضايا سياسية

pissue.iq

قواعد النشر

- لغة المجلة هي اللغة العربية والانكليزية على أن يراعى الوضوح وسلامة النص.
- ترحب المجلة بنشر البحوث والدراسات السياسية النظرية والتطبيقية ولا سيما التي تجعل من قضايا المنطقة والعالم محط اهتمامها، ماضياً وحاضراً ومستقبلاً، وعلى وفق الآتي:

1. أن لا يزيد عدد صفحات البحث أو الدراسة عن (15) صفحة مطبوعة بحجم خط (14) والتباعد (1,15) ونوع الخط Simplified Arabic تقدم عبر المنصة الاليكترونية للمجلة على الرابط : https://pissue.iq/index.php/pissue/about/submissions
2. أن تتصف البحوث والدراسات بالموضوعية والدقة العلمية.
3. أن تعتمد الترقيم العشري للعناوين الأساسية والفرعية او التنصيف المعياري العام.
4. يرفق مع كل بحث او دراسة ملخصين (احدهما باللغة العربية والآخر باللغة الانكليزية/ يتضمن اهداف البحث ، المنهج والمعالجة ، ابرز النتائج واهم الاستنتاجات والمقترحات) مع ضرورة مراعاة ان الملخص مختلف اختلافا جذريا عن المقدمة وليس تكرارا لها .
5. تخضع جميع البحوث المقبولة للنشر الى نظام الاستلال الالكتروني في كلية العلوم السياسية –جامعة النهرين.
6. يرفق مع كل بحث ودراسة سيرة ذاتية مختصرة للباحث وتعهد .

- تقوم المجلة بإخطار الباحثين بإجازة بحوثهم أو دراساتهم من عدمها بعد عرضها على محكمين تختارهم على نحو سري من بين أصحاب الاختصاص.

مجلة قضايا سياسية

pissue.iq

- يجوز للمجلة أن تطلب إجراء تعديلات شكلية أو شاملة على البحث أو الدراسة قبل إجازتها للنشر بما يتماشى مع أهدافها.
- البحوث المنشورة تعبر عن آراء أصحابها ، ولاتعبر عن راي المجلة .
- ترحب المجلة بالمناقشات الموضوعية لما ينشر فيها أو في غيرها من الدوريات وبأية ردود فكرية أو تصويب، وكذلك ترحب بنشر التقارير عن المؤتمرات والندوات ذات العلاقة ومراجعات الكتب وملخصات الرسائل الجامعية التي تتم إجازتها على أن تكون من إعداد أصحابها.

توجه جميع المراسلات إلى هيأة التحرير على العنوان الآتي
مجلة قضايا سياسية، كلية العلوم السياسية، جامعة النهرين-بغداد – الجادرية.
E.mail: pirj@nahrainuniv.edu.iq

الموقع الاليكتروني
https://pissue.iq/index.php/pissue

E-ISSN 2790-2404
P- ISSN 2070-9250
DOI prefix: 10.58298

Table of Contents

Energy Security, Geopolitical Competition and The Reshaping Role of Renewables[▽]

Prof. Dr.Nisreen Riad Shanshul*

Abstract

Global economic security has been built on the foundation of stable and prosperous nations and societies. The rising complexities of an increasingly interdependent world have demonstrated that secure sources of energy are essential for achieving economic safety. In particular, several recent international events, such as the COVID-19 pandemic and Russia's war on Ukraine, have highlighted the fragile nature of global supply chains, their potential to create inflationary pressures, and their considerable impact on the geopolitical stability of nations. As such, the present study will examine the relationship between energy security and geopolitical rivalry through the lens of renewable energy technologies as they apply to each of these dimensions. Using international energy databases and comparative analysis of energy policy in order to support this exploration, the study will explore the areas that will serve as the battlegrounds of future geopolitical competition—traditional oil and natural gas supply chains; liquefied natural gas (LNG) trade; and supply chains for critical minerals—and will demonstrate how these competing interests among global powers will be actualized in the European Union's experience of relocating toward lower-carbon energy sources. Conclusion: The analysis indicates a transition to renewable energy; thus, it is not only an environmental necessity and obligation but also a basic economic and geopolitical strategy for building national resilience against external shocks. This transition is progressively restructuring such power dynamics globally; thus, creating a shift from dominion over fossil fuel "molecules" to dominion over minerals critical for their supply chain as well as clean technology value chain for purposes of establishing a strategic advantage.

Keywords: Energy Security, Geopolitical Competition, International Economic Security, Renewable Energy, Green Transition, Critical Minerals, Strategic Resilience

تاريخ التقديم : 2026/ 2/14 تاريخ القبول: 15 /3 /2026 تاريخ النشر: 31/ 3/ 2026▽

* كلية العلوم السياسية – جامعة النهرين dr.nisren@nahrainuniv.edu.iq
Al- Nahrain University / College of Political Science.

1. Introduction

Energy is at the centre of a profound global transformation. Up to this point in the history of the global system, the security of energy supply has been the cornerstone of national strategies focused on providing security and stability for economic and political purposes. Recent turmoil in international affairs—most notably the conflict between Russia and Ukraine—has brought energy security back to the forefront of international policy agendas in a way that has exposed the fragility of historical dependencies on various forms of energy.

This transformation will not only affect technical and environmental issues; it will also re-arrange the coordinates of global competition in geographic and economic ways.

The implications of this research will be threefold. At the theoretical level, this research will expand on the existing literature on energy security theory to include national resilience, technological sovereignty, and control over strategic value chains; policy frameworks that can effectively integrate economic and geostrategic considerations into climate policy based on analysis of the EU's experience with the green transition; and, policy makers will have tools for analyzing the new geostrategic risks associated with emerging trends in energy supply.

When the 21st century began, the value of oil was known as the most important global commodity and was also known as the most valuable; thus, considerably increasing in value; but was also less predictable (see Figure 2). The annual average price of a barrel of crude oil set by OPEC was \$2.70 in 1973, and it increased dramatically to over \$10 by 1978, though fluctuated between approximately \$30 to \$30 until approximately 1985. It fell under approximately \$20 per barrel through 1999 before rising dramatically to an all-time high of \$94.10 in 2008, which shocked the global economy. The price of oil fell back to just over \$60 and rose to reach a new high of \$109.45 in 2012; the price then fell to approximately \$40 per barrel before rebounding to a value of \$69.52 in 2018. As of the time of this writing, the preliminary average annual price of a barrel of oil for the year 2019 is \$64.05.(Paravantis & Kontoulis,2023).

The price volatility after 2008 displayed the world's transition into a longtime state of global peak oil, no matter that shale oil and natural gas are expected to contribute to international markets for many years to come.

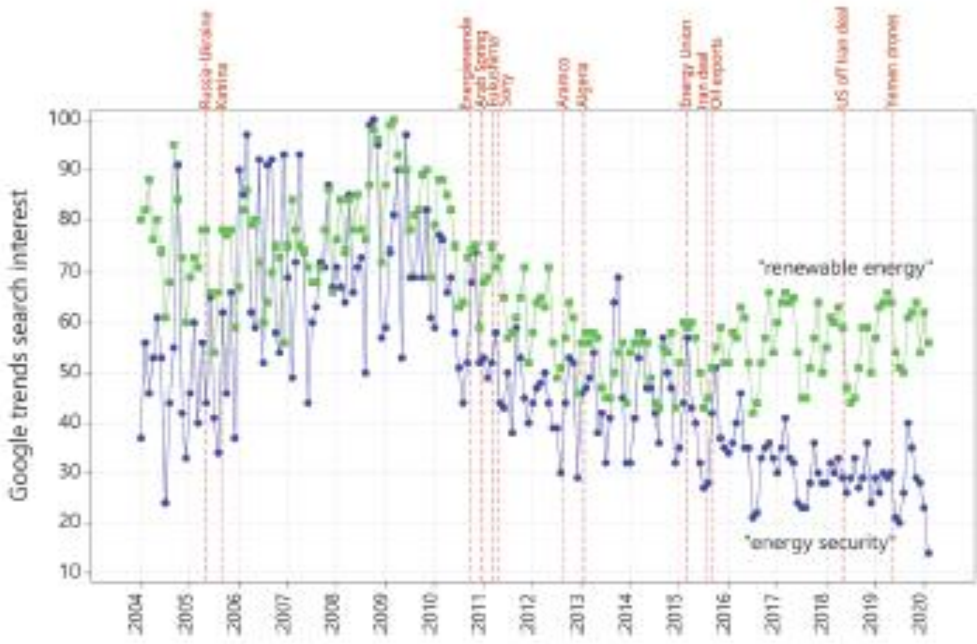

Figure1: ***Google trends (https://trends.google.com/trends/?geo=US) search interest of energy security and renewableenergy compared to global geopolitical events .***

1.1 Key Questions and Hypothesis:

The hypothesis of this research is that the global transition to renewable energy is causing a major change in where countries compete on geopolitical grounds, moving from control over fossil fuel resources to control over the production of critical minerals (for example, lithium) and the manufacturing of clean technology products; these changes will provide some economic security for countries that can successfully diversify their suppliers of both mineral and clean technology supply chains.

This research is being done to answer five important questions on different aspects of what energy security is, how geopolitical crises affect energy security, where do countries compete for energy security, how is the distribution of power across the globe changing, and how effective is the EU Green Transition strategy.

2. Conceptual Framework and Quantitative Metrics

2.1 Energy Security: An Evolving Definition

The United Nations Economic and Social Commission for Western Asia (UN-ESCWA, n.d.) defines energy security as (1) the ever-present ability to obtain energy in a variety of forms, (2) with enough available energy to meet any and all PM2.5 increacses, (3) at a price that is reasonable to the economy as a whole or to each individual with respect to their monthly budget. According to the Organization for Security and Co-operation in Europe (OSCE, n.d.), energy security includes the assurance of (a) reliable, uninterrupted access to energy resources in a timely manner, (b) energy resources in an environmentally sustainable manner, and (c) access to energy resources in an economically viable manner. The International Energy Agency (IEA, n.d.-a) has a much simpler definition: "a reliable and reasonably priced supply of energy sources on a consistent basis" (IEA, 2022).

In addition to the definitions put forth by organizations such as UN-ESCWA, OSCE, and IEA, academic literature has identified and developed many different frameworks to explore the idea of energy security from various angles and with varying degrees of complexity. One example of this is the "Four As" framework developed by Jones and Dodds (2017), which explored energy security from four broad dimensions: (1) Availability (adequate amounts of energy), (2) Affordability (energy prices in a range reasonable to the purchasing power of consumers), (3) Accessibility (electricity access provided across geographical areas via necessary infrastructure), and (4) Acceptability (mitigation of negative environmental effects from use of energy). Other authors have explored energy security within alternative conceptual frameworks, including the Vulnerability-Based Approach that explores energy security based on diminished vulnerability of different sectors of the energy system and the System Properties Approach that examines energy security as an inherent quality of the energy infrastructure with its four fundamental components (i.e., stability, resilience, durability, and robustness) (Jones & Dodds, 2017, pp. 23–24).

Table 1: Energy Security Conceptual Frameworks

Framework	Key Dimensions	Practical Application
Four As Framework	Availability, Affordability, Accessibility, Acceptability	Assessing national energy system performance across supply, cost, access, and environmental dimensions
Vulnerability-Based Approach	Protection targets, values at risk, threat sources	Identifying vulnerable sectors in renewable transition and cyber-physical systems
System Properties Approach	Stability, Resilience, Durability, Robustness	Evaluating grid capacity to handle renewable variability and external shocks

Source: Compiled from Jones & Dodds (2017)

2.2 The Link Between Energy and Economic Security – Effects of Energy Security on the Overall Economy

The World Economic Forum's Energy Transition Index for 2025 has shown an increase in the number of countries improving their index score. 65% of countries improved overall, and 28% improved across the three core dimensions of the energy transition (security, sustainability, and equity). The index has shown a 1.1% improvement from the prior year, the largest increase since before the COVID-19 pandemic. In 2024, global investments into renewables were over $2 trillion; however, carbon emissions increased to record levels of 37.8 billion tons as a result of increased demand for energy due to the increased usage of artificial intelligence, data centers, cooling, and electric vehicles (World Economic Forum, 2025a; Yahoo Finance, 2025).

Table 2: Global Energy Investment and Emissions Indicators (2024-2025)

Indicator	Value	Source
Global energy investment (2025)	$3.3 trillion	IEA (2025b); Sina Finance (2025)
Clean energy investment (2025)	$2.2 trillion	IEA (2025b); Sina Finance (2025)
Fossil fuel investment (2025)	$1.1 trillion	IEA (2025b); Sina Finance (2025)
Solar PV investment (2025)	$450 billion	IEA (2025b); Szgfa (2025)
Battery storage investment (2025)	$66+ billion	IEA (2025b); Sina Finance (2025)
Grid investment (2025)	$400 billion	IEA (2025b); Szgfa (2025)
Nuclear investment (2025)	$70+ billion	IEA (2025b); Sina Finance (2025)
Global emissions (2024)	37.8 billion tons	World Economic Forum (2025a)
Energy demand growth (2024)	2.2%	World Economic Forum (2025a)

Energy security is the point at which national and economic security meet; it is also where both environmental and security concerns intersect. Global energy markets have been rocked by events occurring around the world: war, pandemic and inflation have all mounted risks for both imported and exported energy (Group of Researchers, 2023). Countries that export energy often find themselves caught in the crossfire of global politics while countries that import face a high level of concern about their supply chain and the cost of their energy. Developing nations are especially vulnerable because they depend on imported technology and infrastructure that could be destroyed by conflict (Group of Researchers, 2023).

2.3 Comparing Energy Security Systems

The 2025 edition of The World Economic Forum's Energy Transition Index provides data from the Energy Transition Index, which tracks over 118 countries. Sweden, Finland and Denmark hold the 1st, 2nd and 3rd positions respectively on the index due to their established commitment to policy, strong and diverse infrastructure, and a strong low-carbon energy system. China is in the 12th position, an indication of the country's size and its leading role in innovation and investment in clean energy. Brazil ranks 15th and is the highest ranked country in Latin America due to its high level of energy diversity and usage of renewable combinations of energy sources. The United States is ranked overall at 17th but remains ranked first in Energy Security, due to its diverse supply and innovation capabilities (World Economic Forum, 2025b).

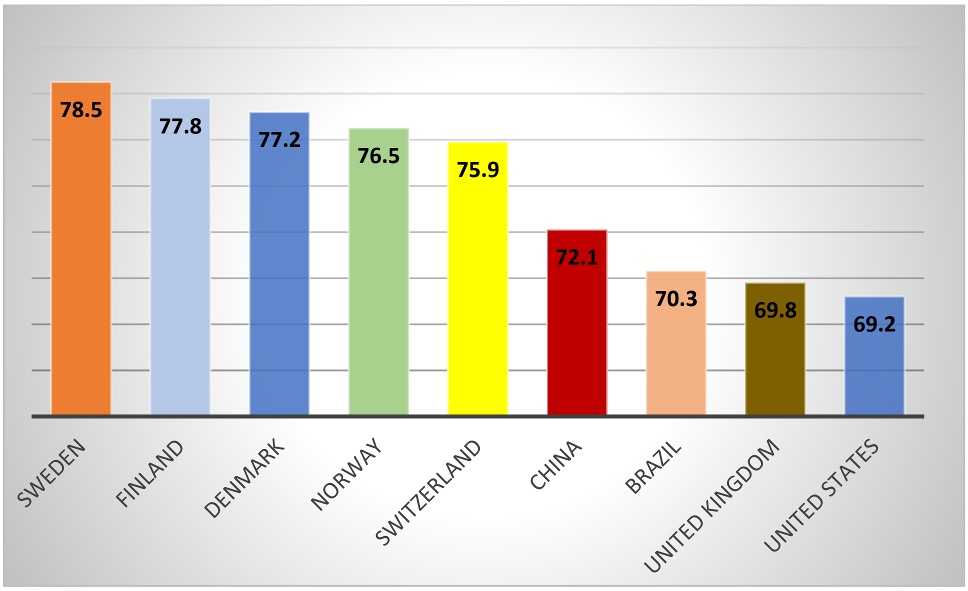

Figure1: Energy Transition Index 2025(Prepared by the researcher)

Table 3: Energy Transition Index 2025 - Top Performers

Rank	Country	Score	Key Characteristics
1	Sweden	78.5	Long-standing policy commitment, robust infrastructure, diversified low-car)bon energy systems
2	Finland	77.8	Strong policy commitment, robust infrastructure, clean energy diversification
3	Denmark	77.2	Strong policy commitment, renewable energy leadership
4	Norway	76.5	Renewed momentum, hydropower resources, energy security
5	Switzerland	75.9	Renewed momentum, policy stability
12	China	72.1	Record high, fueled by innovation and clean energy investment scale
15	Brazil	70.3	Leading Latin America, greater energy diversification, lower prices
16	United Kingdom	69.8	Strong performance across dimensions
17	United States	69.2	Ranked 1st in energy security, diversified energy system, strong innovation

Source: World Economic Forum (2025b)

With an increase in both infrastructure (+8.3%) and equity (+5.8%), Emerging Europe demonstrated regional increase of the largest amount. Emerging Asia has made strides in regulatory improvements (2.6%) and an increase in clean energy investment (18.7%) with China leading followed by Malaysia. Sub-Saharan Africa also saw progress being made through an increase in political commitment and improved financial flows; Nigeria moved up from being 109th in 2016 to 61st in 2025 (World Economic Forum, 2025b). The comparative indicators illustrate that there is a disparity between different regions regarding their level of energy security based on their policy structures, infrastructure investment and diversification strategies.

3. Quantitative Analysis of Key Areas in Geopolitical Competition

3.1 Fossil Fuel Competition

Fossil fuels, despite the accelerating energy transitions, still exist as significant venues for geopolitical competition. The four main core Middle Eastern producers—Saudi Arabia, UAE, Kuwait and Iraq—continue to be the main contributors to the supply of oil in OPEC+, and the regional capacity management of these countries will continue to be important for stability in oil prices worldwide (IEA, 2025a). With the lower amounts of oil being used to generate power in the Middle East as a result of the reduction of use of crude by gas and renewable energy in place of crude, some more crude oil will be available to be exported, strengthening the Middle East's role as the balance in the market (Energy Connects, 2025).

The Russian-European Energy Relationship Has Undergone a Complete Change

With Russia's military invasion of Ukraine in 2022, the amount of natural gas being transported via pipelines from Russia to the EU dropped to almost zero (Gross & Stelzenmuller, 2024). By the year of 2025, the amount of oil being supplied by Russia to the EU will have fallen to less than 2% and the amount of natural gas supplied by Russia to the EU will have been reduced to 12%, primarily taking the form of what little remains to be delivered through the TurkStream pipeline; at this point, the US will have become the main LNG supplier to Europe ahead of Russia (Reuters, 2025a). The latest State of the Energy Union Report issued by the European Commission for the year 2025, confirms that the total amount of natural gas imported from Russia by the EU has fallen from 45% in 2021 to 12% as of August 2025, while>Total of Russian Oil Imported by the EU will fall from 27% at the Start of 2022 to 3% at the Start of 2025 (European Commission, 2025a; AICEP Portugal, 2025).

The United States surpassed Australia and Qatar to become the top exporter of liquefied natural gas (LNG) in early 2024, with Europe being the main market for LNG to substitute Russian pipeline gas (IEA, 2024). The growth of new LNG supply continues into 2025 as global LNG trade increased by 4% in the first half of 2025, creating further competition between the U.S., Qatar, and Russia (LNG Prime, 2025). In terms of project approvals, the Middle East led final investment decisions for LNG in 2024 (Qatar, UAE, and Oman), while the United States has paused permitting decisions for exporting LNG to non-Free Trade Agreement countries (IEA, 2024a).

3.2 Concentration of Critical Minerals Supply Chains

The ongoing construction of clean energy sources has created increased competition for nickel, lithium, graphite, cobalt, and rare earth elements. According to the IEA's Global Outlook on Critical Minerals, 2025, China is the primary refiner of 19 of 20 critical minerals and holds on average a market share of 70% for these minerals, and this trend has continued to accelerate in recent years (IEA, 2025c; World Resources Institute, 2025). China alone has approximately 90% of the rare earth processing capacity, 70% of cobalt refining globally, and over 60% of lithium refining (Deccan Herald, 2025).

Table 4: Critical Minerals Supply Chain Concentration Indicators (2025)

Mineral/Product	China's Market Share	Stage	Source
Strategic minerals (19 of 20)	70% average	Refining	IEA (2025c); WRI (2025)
Rare earth elements	60%	Mining output	Deccan Herald (2025)
Rare earth elements	90%	Processing	Deccan Herald (2025); Energy Intelligence (2025)
Rare earth separation	91%	Refining	IEA (2025c)
Rare earth magnets	94%	Manufacturing	IEA (2025c)
Cobalt	70%	Refining	Deccan Herald (2025)
Lithium	60%+	Refining	Deccan Herald (2025)
Copper	47-87%	Refining range	Energy Intelligence (2025)
Graphite	47-87%	Refining range	Energy Intelligence (2025)
Precursor cathode materials	95%+	Manufacturing	IEA (2025c)
LFP cathode materials	95%+	Manufacturing	IEA (2025c)
Battery midstream/downstream	80%+	Multiple segments	IEA (2025c)

In 2025, the concentration of rare earth elements shifted from being just a theoretical issue to an actual problem. In April of that year, China imposed restrictions on exporting various rare earth elements, tightening regulations on the entire lithium-ion battery supply chain (Deccan Herald, 2025). Following the imposition of export restraints in April, import volumes into Europe plummeted, causing European prices to rise to as much as six times those in China (IEA, 2025c). Then, on October 9, 2025, China announced even more stringent export restrictions on rare earth materials and related goods, including many additional rare earth materials. Additionally, any foreign businesses importing any items made with material sourced from China required a special permit (IEA, 2025c; Energy Intelligence, 2025). On the same day, China also implemented new export controls over the lithium-ion battery manufacturing sector, which included all battery cells/packs used in high-performance applications, as well as the major components used in the manufacture of batteries (i.e., cathode precursor materials, anode materials, and battery manufacturing equipment) (IEA, 2025c).

The Western World has ramped up their efforts to diversify their sources of critical minerals. For instance, the US and Australia signed an $8.5 billion agreement to work together on critical minerals, the G7 nations have announced a critical minerals production alliance, and the US Department of Defense has invested billions into US-based miners with long-term purchasing agreements (Energy Intelligence, 2025). Unfortunately, these efforts on their own are not likely to obviate reliance on Chinese sources in the near term as China's decades-long development of processing knowledge and integrated supply chain clusters makes their refining operations less costly than competitors (Energy Intelligence 2025).

Latin America is centre stage with respect to lithium and copper supply chains. For example, India recently announced an investment in lithium exploration in Argentina of nearly $2 billion and signed a significant agreement (between Khanij Bidesh India Ltd.) to explore five lithium brine blocks in Argentina's Catamarca Province (CSEP 2026). Additionally, India is pursuing discussions surrounding trade agreements with Peru and Chile where minerals are the primary focus.

Cyber Threats to Electrical Infrastructure as Non-Standard Global Adversarial Competition – New Cyber Threats to Energy Infrastructure Are Also the Target of New Non-Conventional Global Adversarial Competition (Emerging Forms of Non-Conventional Global Adversarial Competition – An Increase in Potential Attack Surfaces Associated with the Ongoing Global Energy Transition from

Fossil Fuels to Smart Grids and Digital Technologies is Transforming the Understanding of Energy Security by Creating Large Portions of Potential Attack Surfaces From Which Cyber Threats Have Evolved into One of the Most Quantitatively Significant Forms of Non-Conventional Global Adversarial Competition in the Last 5 Years; COMMENTARIO- Cyber Threats – State and Non-State Actors Conducting Cyber Attacks on Utilities to Obtain Geopolitical Advantage or to Destabilize an Opponent) (EFTIT Report, DNR, 2026) (400-1900-1000 US Dollars in Damages for 1 Data Breached at an Energy Firm) (CERT-CH).

In addition to being expended against the aforementioned energy infrastructure systems, November 3, 2026, saw coordinated attacks against 30 separate wind- and solar-powered energy-generating facilities, the productions of an unnamed private manufacturer in Poland's eastern region, and Poland's electrically-driven combined heat-and-power manufacturing facility, which provide heating to nearly half of the country's population (CERT-CH-ATTACKS).

The intent of each of the coordinated attacks against the respective energy infrastructure systems was solely to cause destruction similar; (i.e., Premeditated Arson) <<<--- What Are You Trying To Create As A "Standard" In Current Energy Infrastructure Systems? (a premeditated attempt to destroy both IT systems and all physical production equipment; Certainly something we have not previously witnessed before) (CERT-CH-ATTACKS) —(500.jpg).

Table 5: December 2025 Polish Energy Sector Cyberattack - Key Facts

Element	Description
Targets	30+ wind and photovoltaic farms; large combined heat and power plant (500,000+ customers); manufacturing sector company
Timing	December 29, 2025, during cold weather and snowstorms
Objective	Pure destruction (sabotage), comparable to deliberate arson
Methods	Firmware damage, system file deletion, custom wiper malware; simultaneous targeting of IT and industrial devices
Impact	Stations lost communication with DSO; remote control prevented; energy production unaffected
Attribution	Activity cluster "Static Tundra" (Cisco), "Berserk Bear" (CrowdStrike), "Ghost Blizzard" (Microsoft), "Dragonfly" (Symantec)—first publicly described destructive activity from this cluster

Source: CERT Polska (2026)

The attackers disrupted the distribution systems and caused communication loss via destruction of firmware and deletion of system files, as well as implementation of custom devastation software (wiper malware). The above events resulted in the inability of distribution systems to communicate with their respective Distribution System Operator; however, the attacks have no impact on energy production. In conclusion, analysis indicated that an extremely high overlap exists between the infrastructure utilized by these actors and those infrastructure elements associated with activity clusters whose members have demonstrated an increased interest in launching attacks against energy facilities and have the capability to successfully attack industrial control systems. Thus far, this represents the first publicly attributed act of destruction associated with this particular group of actors.

In order to enhance the overall resilience of the energy sector against cyberattacks, the U.S. Department of Energy's Office of Cybersecurity, Energy Security and Emergency Response (CESER) has partnered with the National Association of Regulatory Utility Commissioners to establish Cybersecurity Baselines for distribution systems and distributed energy resources (U.S. Department of Energy, 2025); the 2021 Colonial Pipeline Ransomware Attack illustrates the real-time and systemic risk posed by ransomware attacks on U.S. critical infrastructures by disrupting (i.e., halting) U.S. East Coast fuel flows and resulting in implementation of emergency measures (CISA, n.d.); Europe's cyber security agency (ENISA - European Union Agency for Cyber Security) has indicated that it assesses critical cyber threats to energy operations throughout Europe as being at substantial levels (National Security Archive, n.d.).

4. The European Union's Green Transition: A Quantitative Approach.

4.1 General Description and Objectives.

The European Green Transition is part of a multi-faceted EU approach that aims to reduce greenhouse gases by at least 55% by 2030 and achieve net-zero greenhouse gas emissions by 2050 (Council of the European Union, n.d.). The Fit for 55 policy package, Electricity Market Reform in 2024, the Net-Zero Industry Act and the Critical Raw Materials Act are all legislative and industrial efforts to advance the renewable energy transition on the continent, improve infrastructure supporting the use of renewable energy, and create conditions necessary for the manufacture of clean technology in Europe. The Carbon Border Adjustment Mechanism will begin transitional operations in 2023 and is to be fully implemented by 2026 (European Commission, n.d.-a).

As part of the Green Transition, the European Union's Renewable Energy Directive (RED III) was adopted on 20 November 2023 and sets a legally-binding target of at least 42.5% of all final energy to be derived from renewable energy sources by 2030, with an aspirational target of 45% (European Commission, 2023; European Commission, n.d.-e). As of the time of this writing, the transposition of RED III into national law in the EU's 27 member states has been made, with differing contributions from the EU's National Regulatory Authorities affecting the EU's collective ability to meet the 2030 renewable energy targets as established by RED III (ACER, 2025).

The European Commission's 2025 report measures EU progress through quantitative assessments. The reports show that the EU will achieve its 2030 climate target; therefore, emissions are 37.2% below 1990 levels while GDP has grown 71% in 2024 compared to 2023 (AICEP Portugal, 2025). In addition, there has been a 2.5% reduction (or decrease) in global GHG emissions compared to 2023 emissions; therefore, this continuing trend of emission reduction has demonstrated the EU's decoupled economic growth and emissions (European Commission, 2025a).

Table 6: EU Energy Security Transformation Indicators (2021-2025)

Indicator	2021	2024	2025	Change	Source
Russian gas import share	45%	19%	12% (Aug)	-33 pp	European Commission (2025a)
Russian oil import share	27% (early 2022)	-	3% (H1 2025)	-24 pp	European Commission (2025a)
Renewables in electricity mix	~37%	47%	-	+10 pp	European Commission (2025a)
New renewable capacity installed	~50 GW	77 GW	-	+54%	European Commission (2025a)
GHG emissions vs 1990	~34% reduction	37.2% reduction	-	-3.2 pp	European Commission (2025a)
Final energy consumption vs 2022	-	-3%	-	-3%	European Commission (2025a)

Table 7: EU Economic and Investment Indicators

Indicator	Value	Source
Consumer savings from solar PV and wind (2021-2023)	€100 billion	European Commission (2025a)
Fossil fuel import cost (2024)	~€375 billion	European Commission (2025b)
Energy efficiency impact on gas imports	1% improvement → 2.6% reduction	European Commission (2025a)
Required annual energy investment (2031-2040)	€695 billion	European Commission (2025a)
Required annual investment (2026-2030)	€660 billion	European Commission (2025b)
REPowerEU estimated investment	€65.3 billion	European Commission (2025b)
Baltic synchronization EU grants	€1.23 billion (CEF) + €60 million (RRF)	European Commission (2025b)

Between 2021 and 2023, consumers of electricity across the EU were able to save €100 billion as a result of the new generation of both solar and wind power (European Commission, 2025a). For every 1% increase in energy efficiency, gas imports have been reduced by an estimated 2.6% (European Commission, 2025a). The amount of new renewable power capacity installed during the year 2024 is estimated to be approximately 77 GW. Of this total, approximately 12.9 GW was generated by wind power and approximately 65.5 GW from solar energy; this amount is a 17% increase over the previous year's capacity (European Commission, 2025b). By receiving approximately 47% of total electricity generated by renewable resources in the European Union, renewable energy secured its leadership position in the total electricity produced across the EU for the first time with solar energy (European Commission, 2025b).

Policy Impact Assessment

The Action Plan for Affordable Energy (2025), which launched in February 2025 with the Clean Industrial Deal, contains multiple components to facilitate the rollout of alternative sources of energy, such as: financially mobilizing investment; increasing flexibility; streamlining permitting; making energy efficiency investments; and strengthening the existing electricity grid (European Commission, 2025a). In support of its implementation of the plan above, the Commission adopted guidance pertaining to anticipatory investment in electric grids, innovative alternative energy technology, and revised network tariff methodologies.

The first two Tripartite Agreements (TA) to achieve Affordable Energy were made in September 2025 with respect to Offshore Wind & Grids and Energy Storage, involving three different groups – Producers, Industrial Consumers and Public Sector representatives who have agreed to collaborate in order to unlock the investments needed for the rapidly developing Affordable Energy from Domestic Sources (as per the European Commission, 2025b). Furthermore, Estonia, Latvia and Lithuania successfully synchronized their respective Electricity Grids with the Continental Europe Synchronous Area on 9th February 2025, which is a major project that contributes to the long-term energy security of the European Union, with funding for this project from the EU's Connecting Europe Facility amounting to €1.23bn and from the Recovery and Resilience Facility amounting to €60m (as per the European Commission, 2025b).

In addition, the EU's gas storage filling plan is on track, at 83.0% by early October 2025, which is consistent with the average filling rate between 2016 and 2021 and a projected filling rate of 90% on or before 1st November (as per the European Commission, 2025b). The recent changes to the Gas Storage Regulation will allow Member States to optimise their storage operations by providing them with increased flexibility.

On the downside, the European Climate Neutrality Observatory (ECNO) 2025 Flagship Report identified an investment gap in the context of climate change of €344 billion in 2023. The lack of Renovation of existing Buildings, decreasing installation rates for Heat Pumps and insufficiently Rapid expansion of Onshore Wind capacity are examples of the manifestation of such an Investment gap (as per ECNO, 2025). Furthermore, according to ECNO (2025), Climate change has caused €160 billion in economic losses in EU countries between 2021 and 2023.

There are still many hurdles for Europe to overcome to achieve its goal of energy independence. The EU is also struggling to address its dependence on critical minerals, the supply of which have been heavily concentrated in one area: China. If Europe cannot diversify its supply lines or other sourcing options then it runs the risk of replacing its reliance on Russian natural gas with dependence on Chinese supply chains for clean energy technologies. The good news is that there are options for Europe based on the development of assets that can provide critical minerals within its borders. Significant investments have been made to increase France's ability to refine silicon; Sweden is ramping up production of copper and zinc and supplies roughly 90% of iron ore produced in the EU from domestic sources; Portugal is developing considerable lithium reserves; and Finland has two large nickel refineries, as well as a large zinc refinery (Zhang, 2026).

Infrastructure for the grid is another important issue that must be addressed. It is expected that global total grid investments will amount to around $400 billion annually; however, investments in generation assets are estimated to be approximately $1 trillion annually (IEA, 2025b; Szgfa, 2025). The World Energy Outlook report (2025) suggests that in order to maintain electricity security within the grid electricity security will be based largely on the rate at which new grid, energy storage, and other sources of power system flexibility are installed, but many of these important components are lagging behind schedule (IEA, 2025a). An example of how vulnerable the electricity system can be occurred in April 2025 during a blackout across the Iberian Peninsula, where the sudden loss of about 15 GW of solar power overwhelmed networks and systems that were primarily based on inverter-based generation without adequate back-up support to time (Reuters, 2025b).

5.Results and Conclusions

5.1 Key Findings

In 2025 global energy investment was $3.3 trillion, of which $2.2 trillion (twice what was invested in fossil fuels) was spent on clean energy technologies (IEA, 2025b; Sina Finance, 2025). China has become the largest global investor in energy (equal to the combined investment of the United States and European Union) (IEA, 2025b; Sina Finance, 2025). Although China invested in clean energy, in 2024, there were record high emissions (37.8 billion metric tons) for the second consecutive year as energy demand grew by 2.2% because of growth in AI, data centers, cooling, and electrification (World Economic Forum, 2025a).

Geopolitical competition is no longer tied to either fossil fuel resources or control over global oil prices; instead, it is focused on geopolitical competition for mineral resources and digital infrastructure. China dominates the refining of strategic minerals (70% share), rare earth mineral processing (90% share), and manufacturing of permanent magnets (94% share) (IEA, 2025c; Deccan Herald, 2025; Energy Intelligence, 2025). The introduction of export restrictions on rare earth elements and the lithium-ion battery supply chain illustrates that these geopolitical vulnerabilities have immediate real-world effects on the global automotive and industrial manufacturing sectors (IEA, 2025c). Cyber threats emerged as new forms of non-conventional warfare; for instance, in December 2025, coordinated cyberattacks targeted renewable energy infrastructure in Poland (CERT Polska, 2026).

Finding Three: Green Transition Case Study - The EU's Renewable Energy Transition demonstrates increased Energy Independence (reduced dependence on Russian gas from 45% to 12% of supply) while also creating new dependencies that require active management (critical mineral supply chains, grid resilience, and relying on Chinese components for Clean Technologies). The EU generated 47% of its electricity using Renewable Energies in 2024, and the amount of money that consumers saved from new Solar PV and Wind Power between 2021-2023 was €100 billion. There are still many challenges to address, e.g. very High and Volatile Energy Prices, limited Grid Capacity, and Critical Mineral Supply Vulnerabilities; as a result, the Investment Requirement from 2031-2040 is €695 Billion per Year.

Finding Four: Redefinition of Energy Security - Energy Security in the 21st Century extends beyond supply route security to include National Resilience through Technological Sovereignty (designing, manufacturing, and producing locally), Diversified Supply Chains (not relying on one supplier or region for a product), Robust Cyber Defense Capabilities (cyber-attacks on critical infrastructure), and Institutional Quality (the capacity of the institution to buffer against Energy Related Shocks). Quantitative analysis has confirmed that improvements in Regulatory Quality and Rule of Law offset approximately 20% to 30% of the negative impact of Import Concentration and Price Volatility. The World Economic Forum Energy Transition Index 2025 - Benchmarking shows that 65% of Countries improved their score; Sweden, Finland, and Denmark are at the top of the world.

Observation Five: Quantifiable Economic Impacts of Energy Supply and Demand Imbalances: Energy supply-demand imbalances significantly affect economic growth, and it has been established that an energy supply-demand imbalance increases economic growth, meaning that larger gaps between the quantity and level of energy imported and exported decrease real GDP by per capita (ScienceDirect, 2023). The European Commission found that for every one percent increase in energy efficiency there would be a reduction of two percent in the amount of natural gas imported into the EU, which helps to quantify the relationship between energy efficiency and GDP growth (European Commission, 2025a). Also, climate changes will be responsible for over €160 Billion of economic losses in the EU from 2021-2023 (ECNO, 2025).

Observation Six: The Geopolitical Fragmentation Affecting Energy Demand: Increased geopolitical fragmentation is expected to decrease international trade and the growth of GDP, thus declining the overall demand for energy worldwide as Countries become self-sufficient rather than relying on imports (Dale, cited in ET EnergyWorld, 2025). The fragmented world creates very different adjustment paths for energy-importing and exporting countries, as well as for countries at different levels of technological advancement.

By broadening its analytics from simply analysing supply security, this study develops a new integrated view of energy security that captures:

Mineral Security - The reliance on a concentrated critical mineral supply chain for the world's energy system produces vulnerabilities similar to those of dependence on fossil fuel imports as will be shown by the export control measures in place in 2025.

Technology Security - The strategic advantages associated with being a dominant manufacturer of clean technologies impact the cost and time it takes for energies to be deployed.

Cyber Resilience - Kinetic and digitalised energy infrastructures are developing new vulnerabilities requiring the establishment of integration security plans.

Institutional Buffering - The quality of governance is an important moderating factor of the impact of energy insecurity on national economies.

Geopolitical Fragmentation - The growing trend towards self-sufficiency in international energy systems is changing the way global markets will demand and consume all forms and types of energy (i.e., oil, natural gas, electricity).

5.3 Recommendations for Action

Supply Chain Diversification of Critical Minerals: The global market of critical minerals is highly concentrated; 70% of strategic minerals are refined in China, and 90% of rare earth mineral processing occurs in China. Countries will need to prioritize diversifying sources of supply and processing. This will require strategic stockpiling of critical minerals, engaging diplomatically with countries rich in mineral resources, investing in domestic processing capacity, and coordinating with other countries through multilateral mechanisms such as the Minerals Security Partnership (IEA, 2025c; Energy Intelligence, 2025).

Increased Resilience Against Cyberattacks: There is an urgent need for investment towards cybersecurity for renewable energy and smart grid infrastructure. Cybersecurity baselines should be established for renewable energy derived distributed resource systems, in accordance with Department of Energy (U.S. Department of Energy, 2025) developed system-level cybersecurity frameworks and implemented throughout the U.S. energy infrastructure. The recent December 2025 cyberattack on Polish renewable energies during the power and energy crisis shows that renewable energy facilities are high-profile targets for malicious cyberattacks and need to be protected (CERT Polska, 2026).

Policy Integration: To effectively address complex geopolitical risks, policymakers must completely integrate strategies for energy, climate, and national security. In order to achieve this, there must be cross-ministerial coordination, consistent methodology for risk assessment, and alignment of trade, investment, and climate policies. The 2025 State of the Energy Union Report from the European Commission shows the progress that has been made in linking energy security, competitiveness, and climate objectives (European Commission, 2025a).

Grid Modernization and Flexibility: Currently, with an annual investment of $400 billion in grids, grid investments do not keep up with generation investment and will need to rise to be comparable to the generation investment by early 2030. The need for streamlined permitting and accelerated investment in energy storage and interconnection capacity are critical (IEA, 2025b; Szgfa, 2025).

Investment Imbalance in Africa: While Africa makes up 20% of the world's population, only 2% of global clean energy investment has gone to Africa. Therefore, the international investment community needs to provide large-scale public finance to address the issue. As an international community, there is also a need to provide significant climate financing to developing economies in order to achieve COP 28 renewable energy targets (IEA, 2025b; Sina Finance, 2025).

Closing EU Investment Gap: To close the €695 billion annual climate investment gap within the EU requires aligning public budgets, expediting the permitting process, and supporting lead markets for clean goods. A key priority for the proposed EU Multiannual Financial Framework from 2028-2034 is support for cross-border infrastructures and clean strategic energy technologies (European Commission, 2025a).

Addressing Geopolitical Fragmentation: Policymakers must prepare for a world of increased geopolitical fragmentation where self-reliance becomes prioritized over international trade. This requires developing robust contingency plans, maintaining strategic reserves, and building flexible energy systems capable of adapting to rapidly changing geopolitical circumstances.

Reference

1. ACER. (2025). Transposition of RED III in the EU - October 2025. EU Agency for the Cooperation of Energy Regulators.
2. AICEP Portugal. (2025, November 7). State of the Energy Union Report 2025 - EU is progressing towards its 2030 climate and energy goals while tackling high energy prices. https://portugalglobal.pt/en/news/2025/november/state-of-the-energy-union-report-2025/
3. Cambridge Dictionary. (n.d.). Geopolitics. https://dictionary.cambridge.org
4. CERT Polska. (2026). Energy Sector Incident Report - 29 December 2025. https://cert.pl/en/posts/2026/01/incident-report-energy-sector-2025/
5. CISA. (n.d.). Attack on Colonial Pipeline: What we've learned, what we've done over past two years. https://www.cisa.gov/news-events/news/attack-colonial-pipeline-what-weve-learned-what-weve-done-over-past-two-years
6. CNBC. (2018, June 21). OPEC agrees to increase oil production. https://www.cnbc.com/2018/06/21/oil-markets-opec-meeting-in-vienna-in-focus.html
7. Council of the European Union. (n.d.). European Green Deal. https://www.consilium.europa.eu/en/policies/fit-for-55
8. CSEP (Centre for Social and Economic Progress). (2026). Latin America: A New Geography for India's Emerging Critical Minerals Partnerships.
9. Cyber Defense Magazine. (2025). Energy Sector Cyber Threats.
10. Deccan Herald. (2025, November 8). At COP30, a case for mineral diplomacy. https://www.deccanherald.com/opinion/at-cop30-a-case-for-mineral-diplomacy-3790592
11. Energy Connects. (2025, September). IEA sees lower oil use in Mideast power, boosting crude exports. https://www.energyconnects.com/news/utilities/2025/september/iea-sees-lower-oil-use-in-mideast-power-boosting-crude-exports
12. Energy Intelligence. (2025, December 30). The West's New Critical Minerals Playbook. https://www.energyintel.com/0000019a-9c49-d672-a9be-9f5f0fd50001

13. ET EnergyWorld. (2025, October). Geopolitical fragmentation to slow energy demand: BP Chief Economist.
14. European Climate Neutrality Observatory (ECNO). (2025). State of EU progress to climate neutrality – 2025 Flagship Report. I4CE - Institut de l'économie pour le climat.
15. European Commission. (2023). Renewable Energy Directive (RED III). Official Journal of the European Union.
16. European Commission. (2025a). State of the Energy Union Report 2025. Brussels: European Commission. https://energy.ec.europa.eu/publications/state-energy-union-report-2025_en
17. European Commission. (2025b). REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: State of the Energy Union Report 2025. COM(2025) 667 final. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52025DC0667
18. European Commission. (n.d.-a). Carbon Border Adjustment Mechanism. https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en
19. European Commission. (n.d.-b). Climate strategies & targets. https://climate.ec.europa.eu/eu-action/climate-strategies-targets_en
20. European Commission. (n.d.-c). Electricity market design. https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en
21. European Commission. (n.d.-d). RePower EU. https://enlargement.ec.europa.eu/news/repowereu-plan-rapidly-reduce-dependence-russian-fossil-fuels-and-fast-forward-green-transition-2022-05-18_en
22. European Commission. (n.d.-e). Renewable Energy Directive. https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en
23. European Environment Agency (EEA). (n.d.). Energy Security Glossary. https://www.eea.europa.eu/help/glossary/eea-glossary/security-of-supply
24. German Council on Foreign Relations (DGAP). (n.d.). Energy security. https://dgap.org/en/research/glossary/climate-foreign-policy/energy-security
25. Green Switch Capital. (n.d.). Renewable vs Traditional Energy Comparison.
26. Group of Researchers. (2023). Energy Security and Developing Economies. International Journal of Energy Economics.
27. Guevara, P. (2024, June). What is energy security. https://safetyculture.com/topics/energy-security/
28. Halina, Y., Ziankova, I., & Said, R. (2020). Global energy security and international economic development. University of Novopolotsk, Belarus.
29. International Energy Agency (IEA). (2024). World Energy Investment 2024. Paris: OECD/IEA.
30. International Energy Agency (IEA). (2024a). World Energy Outlook 2024. Paris: OECD/IEA.
31. International Energy Agency (IEA). (2024b). Critical Minerals Market Review 2024. Paris: OECD/IEA.

32. International Energy Agency (IEA). (2025a). World Energy Outlook 2025. Paris: OECD/IEA.
33. International Energy Agency (IEA). (2025b). World Energy Investment 2025. Paris: OECD/IEA.
34. International Energy Agency (IEA). (2025c). Global Critical Minerals Outlook 2025. Paris: OECD/IEA.
35. International Energy Agency (IEA). (n.d.-a). Energy Security Definition. https://www.iea.org/glossary#E
36. International Energy Agency (IEA). (n.d.-b). Hydrogen production. https://www.iea.org/reports/global-hydrogen-review-2024/hydrogen-production
37. International Energy Agency (IEA). (n.d.-c). Latin America's opportunity in critical minerals for the clean energy transition. https://www.iea.org/commentaries/latin-america-s-opportunity-in-critical-minerals-for-the-clean-energy-transition
38. ISS Governance. (n.d.). Cyber Threats to Critical Infrastructure.
39. Jones, C., & Dodds, P. E. (2017). The Four As of Energy Security: A Framework for Analysis. Energy Policy. (Chapter 2, 2.2.1 Early definitions, pp. 23–24)
40. Lawrence Livermore National Laboratory (LLNL). (n.d.). Achieving fusion ignition. https://lasers.llnl.gov/science/achieving-fusion-ignition
41. LNG Prime. (2025). Global LNG Trade Analysis.
42. Merriam-Webster. (n.d.). Geopolitics. https://www.merriam-webster.com/dictionary/geopolitics
43. National Security Archive. (n.d.). Energy Infrastructure Cyber Threats. https://nsarchive.gwu.edu/media/29543/ocr
44. Organization for Security and Co-operation in Europe (OSCE). (n.d.). Energy Security Definition. https://www.osce.org/oceea/446236
45. Oxford Reference. (n.d.). Geopolitics. Oxford University Press.
46. John A. Paravantis and Nikoletta Kontoulis.(2023), Energy Security and Renewable Energy: A Geopolitical Perspective, https://www.researchgate.net/publication/344733640_Energy_Security_and_Renewable_Energy_A_Geopolitical_Perspective
47. Reuters. (2025a, September 15). US and Europe do billions in trade with Russia despite sanctions. https://www.reuters.com/business/autos-transportation/us-and-europe-do-billions-trade-with-russia-despite-sanctions-2025-09-15
48. Reuters. (2025b, September 16). Europe's next big challenge is closing its energy security divide.
49. ScienceDirect. (2023, October). Energy security and economic stability: The role of inflation and war. Energy Policy, 208, 114918. https://www.sciencedirect.com/science/article/pii/S0140988323004474
50. Sina Finance. (2025, June 16). Renewable energy remains global investment focus. https://finance.sina.com.cn/jjxw/2025-06-16/doc-infafiet7967367.shtml
51. Spectra MHI. (n.d.). Energy Sector Cybersecurity Report.
52. Szgfa. (2025, July 8). IEA releases World Energy Investment 2025 report. https://www.szgfa.com/news_view.aspx?nid=2&typeid=4&id=2251

53. United Nations Economic and Social Commission for Western Asia (UN-ESCWA). (n.d.). Energy Security Definition. https://www.unescwa.org
54. U.S. Department of Energy, Office of Cybersecurity, Energy Security, and Emergency Response (CESER). (2025). Cybersecurity Baselines for Distribution Systems and Distributed Energy Resources: Interim Implementation Guidance. Washington, DC: DOE.
55. U.S. Energy Information Administration. (2024). Natural Gas Monthly.
56. World Economic Forum. (2025a). Fostering Effective Energy Transition 2025. Geneva: WEF. https://www.weforum.org/publications/fostering-effective-energy-transition-2025/
57. World Economic Forum. (2025b, June 18). Global Energy Transition Gains Ground, but Security and Capital Challenges Persist. https://www.weforum.org/press/2025/06/global-energy-transition-gains-ground-but-security-and-capital-challenges-persist/
58. World Resources Institute. (2025, May 20). WRI Statement on the IEA Global Critical Minerals Outlook 2025. https://www.wri.org/news/statement-wri-statement-iea-global-critical-minerals-outlook-2025
59. Yahoo Finance. (2025, June 18). Global energy transition picks up pace amid rising challenges: WEF report. https://finance.yahoo.com/news/global-energy-transition-picks-pace-142756737.html
60. Zhang, H. (2026). Resilience of critical transition minerals supply chain in the context of strategic rivalry. Journal of World Energy Law & Business, 67-93.