



ORIGINAL ARTICLE

The Role of AI in Predictive Geopolitical Risk Modelling for Energy SecurityApala Ghosh^{1,*}¹PhD Research Scholar, Department of International Relations, Jadavpur University, Kolkata, 700032, West Bengal, India

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ABSTRACT

Geopolitical risks pose evolving threats to global energy security, shaping supply chains, market stability, and national energy strategies. While AI has already enhanced predictive modelling, the future holds transformative potential in leveraging AI for more advanced risk mitigation. This paper explores the prospects of AI in predictive geopolitical risk modelling, focusing on future applications, challenges, and possibilities. The discussion also incorporates potential drawbacks, ethical considerations, and the integration of AI into proactive decision-making frameworks. Real-life geopolitical crises, such as tensions in the Taiwan Strait, shifts in Arctic energy routes, and growing cyber threats, are analysed through the lens of AI's future capabilities. It examines emerging AI methodologies, advanced risk indicators, novel data sources, and future case scenarios that illustrate AI's expanding role. The research underscores the need for international cooperation, continuous AI development, and ethical AI governance to harness AI's full potential in securing energy futures.

Keywords: Artificial Intelligence; Geopolitical Risk; Energy Security; Predictive Modelling; AI Governance; Cybersecurity in Energy

INTRODUCTION

Energy security is one of the most pressing global challenges in the 21st century, defined by a rapidly evolving geopolitical landscape, technological advancements, and shifting economic power centres. The increasing dependence on energy resources for industrial, economic, and social development makes the uninterrupted availability of affordable and sustainable energy a critical concern for nations. Traditionally, geopolitical risk assessment relied on historical patterns, expert analysis, and real-time intelligence, but these conventional methods often struggle to keep pace with the unpredictability of global conflicts, cyber threats, trade disputes, and climate-related disruptions. In response, AI has emerged as a powerful tool capable of transforming predictive geopolitical risk modelling, offering new opportunities for real-time, data-driven decision-making in energy security. Real-world geopolitical events demonstrate the

urgent need for enhanced AI-driven predictive capabilities. The 2022 Russian invasion of Ukraine severely disrupted global energy markets, causing significant fluctuations in oil and gas prices. If AI-driven predictive modelling had been more advanced, energy stakeholders might have been able to anticipate and mitigate the supply chain shocks resulting from the crisis. In the future, AI could provide early warnings of geopolitical conflicts by analysing military movements, supply chain disruptions, and shifts in energy trade patterns. By leveraging satellite imagery and AI-powered geopolitical simulations, energy analysts could assess the likelihood of military interventions affecting global energy supplies and develop contingency plans accordingly.



DEFINING ENERGY SECURITY AND THE ROLE OF AI IN ITS FUTURE

'Energy security' – the continuous availability of energy sources at a price that is affordable – is a central pillar of global security, economic prosperity, and national sovereignty. In the existing multipolar geopolitical context, energy security goes beyond the physical availability of energy resources, and includes the reliability of supply chains, resilience to cyber risks, and readiness to cope with climate-fuelled disruptions. In the past, the current age depended for energy security on diversified sources of supply, strategic reserves, and geopolitical alliances. Whereas these approaches have proved adequate enough in a world driven by change but also in complexity and unpredictability¹. With increasing decentralised energy production, changing centres of global power and climatic volatility these traditional risk assessment models have lost some of their efficacy. This shift is driving the demand for a new architectural approach: one that can handle multi-dimensional data in real time and adapts automatically to evolving threats. At the forefront of this paradigm shift is artificial intelligence (AI), which offers an unsurpassed ability to collate data, identify patterns, and predict trends. AI presents not only an opportunity to improve existing risk analysis approaches, but also to transform the way in which energy security is framed and addressed.

Unlike traditional analytical tools, heavily based on static historical data and subjective expert opinion, AI-enabled models continually learn from large and divergent sets of data. With machine and deep learning architectures, AI can pick up subtle anomalies or correlations which human analysts would miss and provide an early warning of potential geopolitical events (that would affect the supply or demand of energy). For example, an AI model that has been educated with transport logistics, port activity and diplomatic signals could foretell tensions in a major oil-producing region several days or weeks before they harden into overt conflict. In a global energy network, where blockages or shocks in one part of the network can spread quickly across continents, this capacity to act proactively is particularly important.

Furthermore, the use of AI in the field of energy security frameworks leads to real-time scenario simulations and policy testing that would allow the stakeholders to ascertain the implications of various decisions in different configurations of the geopolitical landscape. This use case in AI does not only improve strategic planning, but also decreases the time of response in crises. If, for instance, the Strait of Hormuz is blockaded, or if a pipeline in Eastern Europe is cyber-sabotaged, AI-powered systems will model new trade routes, every supply chain adjustment and market forecast in minutes. The ability to be more agile is inestimable in a world where minutes could equal billions of dollars in economic losses or cause irreparable

harm to an energy asset. It is imperative to leverage AI to protect our energy system, and as energy systems become more digital and interconnected, the role of AI is invaluable in protecting against cyber threats. It facilitates predictive cybersecurity, where it detects breaches before they occur through behavioural analysis and thwarts them, and thus protects the digital backbone of nowadays' energy systems².

ADVANCED AI TECHNOLOGIES SHAPING THE FUTURE

AI has evolved from rule-based systems to highly complex models capable of mimicking human cognition. Machine learning, deep learning, and reinforcement learning have significantly enhanced AI's ability to process large datasets, recognize patterns, and make autonomous decisions. As AI technologies continue to advance, they are becoming indispensable in solving global challenges, optimizing efficiency, and driving economic growth. With rising cyber threats, AI-driven security systems are crucial for detecting and mitigating cyberattacks. AI can analyse network behaviour, predict security breaches, and enhance encryption methods to safeguard sensitive data. The future of AI in cybersecurity will focus on proactive threat detection, leveraging real-time data analytics to anticipate and neutralize cyber threats before they manifest³. AI-driven security frameworks will integrate self-learning capabilities, allowing them to continuously adapt to emerging threats. Additionally, AI will play a significant role in securing Internet of Things (IoT) ecosystems, ensuring that interconnected devices remain resilient against potential cyber vulnerabilities.

The evolution of AI is set to redefine the way energy security is managed in the coming decades. Advanced AI technologies, including quantum computing, AI-driven cybersecurity, and autonomous energy systems, are expected to improve risk analysis and decision-making in the energy sector. Future AI-driven cybersecurity solutions will employ self-learning algorithms that can detect and neutralize cyber threats in real-time. As cyber warfare targeting energy grids and oil pipelines intensifies, AI will be instrumental in securing national energy infrastructure. Countries such as the U.S. and China are already developing AI-enhanced cybersecurity measures for protecting power networks, but the future holds even more advanced solutions like AI-driven countermeasures that can autonomously mitigate threats before human intervention is needed.

AI-powered digital twins will become more sophisticated, allowing energy providers to simulate geopolitical risks in real-time and implement pre-emptive measures. Future digital twins will integrate AI-driven climate models, social-political simulations, and even cyber threat intelligence to provide a comprehensive risk mitigation strategy. For example, oil and gas companies could use AI-generated virtual models of energy supply chains to simulate disruptions and optimize responses before crises occur, ensuring resilience



against geopolitical instabilities. Future AI-powered energy trading platforms will operate without human intervention, automatically adjusting trade routes, production levels, and pricing based on real-time geopolitical data. AI will enable fully autonomous oil and gas trading, where algorithms factor in global tensions, transportation bottlenecks, and diplomatic developments to dynamically optimize market strategies⁴. Companies like Trafigura and Glencore are already integrating AI into their trading models, but the future promises even more seamless automation and predictive adaptability.

As climate change continues to reshape global geopolitics, AI-driven models will play a pivotal role in predicting and adapting to energy-related risks. Advanced AI models will not only forecast extreme weather events but also predict long-term geopolitical consequences of resource scarcity, rising sea levels, and climate-induced migration. Future developments in AI-driven climate security may involve AI-powered regional stability models that help policymakers anticipate political upheavals in resource-rich but climate-vulnerable areas like Sub-Saharan Africa and the Arctic. Quantum computing will improve AI-driven risk analysis by processing massive geopolitical datasets at unprecedented speeds. This will allow energy analysts to simulate thousands of geopolitical scenarios simultaneously, improving the accuracy of long-term energy security strategies. Companies like IBM and Google are already investing in quantum AI research, with future applications including hyper-accurate energy demand forecasting and AI-driven scenario planning for potential energy crises.

EMERGING RISK INDICATORS AND DATA SOURCES

As AI technologies advance, the ability to monitor and respond to emerging risks in energy security is becoming increasingly sophisticated. AI-driven risk analysis relies on a range of emerging indicators and new data sources to identify geopolitical threats more accurately and in real time. The integration of the Internet of Things (IoT) with AI enables real-time monitoring of critical energy infrastructure. Smart sensors placed on pipelines, power grids, and refineries can detect anomalies such as leaks, sabotage attempts, or cyber intrusions⁵. For example, in 2021, AI-enhanced IoT systems helped detect cyberattacks on U.S. Colonial Pipeline operations, allowing for a rapid response to mitigate supply disruptions⁶.

AI-driven sentiment analysis and OSINT methodologies are becoming essential in detecting early warning signals of geopolitical crises. Social media platforms, news feeds, and localized online discussions provide immediate insights into potential threats. For example, during the 2022 Russia-Ukraine conflict, AI-based OSINT tools helped energy analysts predict disruptions in natural gas supplies to Europe, allowing policymakers to devise contingency plans.

As climate change increasingly affects energy security, AI models are incorporating environmental indicators such as drought patterns, hurricane forecasts, and temperature anomalies to assess risks. AI-driven climate analytics help predict extreme weather events that could disrupt energy supply chains. A notable example is the Texas winter storm of 2021, where energy analysts could have used AI-driven weather models to foresee infrastructure failures and prevent widespread power outages.

FUTURE CASE SCENARIOS: AI'S ROLE IN PREDICTING ENERGY CRISES

Energy security is a fundamental component of economic stability and national security. The geopolitical landscape surrounding energy resources is complex, with factors such as resource scarcity, supply chain vulnerabilities, political instability, and climate change influencing global energy markets^{7,8}. AI has the potential to transform how governments and corporations assess and mitigate these risks by providing real-time analysis, predictive modelling, and automated decision-making capabilities. As AI technologies advance, their role in energy security will become more critical, helping stakeholders navigate geopolitical uncertainties with greater precision.

- **Taiwan Strait Tensions:** AI models will assess the likelihood of a geopolitical crisis disrupting energy trade flows in East Asia, recommending contingency strategies for global markets. AI will map military manoeuvres against supply chain vulnerabilities in real time.
- **Arctic Energy Expansion:** AI will predict how climate-driven Arctic accessibility will reshape global energy transport routes, assessing geopolitical contestation over new resources. AI-driven risk maps will forecast the impact of territorial disputes over Arctic reserves.
- **Middle Eastern Energy Shifts:** AI will simulate the geopolitical impact of the Middle East's transition to renewable energy, forecasting shifts in regional power structures. Predictive AI will assess how decreased oil reliance in the West will reshape Middle Eastern geopolitical influence.
- **Russia-Ukraine Energy Disruptions:** AI will model potential outcomes of ongoing conflicts, predicting shifts in energy alliances and the geopolitical consequences of supply chain disruptions.

CHALLENGES AND ETHICAL CONSIDERATIONS

The integration of artificial intelligence (AI) into predictive geopolitical risk modelling for energy security aims to improve risk assessment and strategic decision-making. However, its deployment presents significant challenges and ethical concerns. It is necessary to examine the primary obstacles and moral implications associated with AI-driven



geopolitical risk analysis, including biases in AI models, data privacy concerns, cybersecurity vulnerabilities, regulatory compliance, and the ethical ramifications of AI-based decision-making in energy security. As AI technologies advance, they are increasingly utilized to assess geopolitical risks affecting global energy security. AI models analyse vast datasets to predict potential disruptions, optimize energy supply chains, and enhance national security strategies. Despite their potential, these models face technical and ethical challenges that must be addressed to ensure their reliability and responsible use.

- **Key Challenges :**

AI systems rely on historical data to make predictions, which can introduce biases into their analyses. If training datasets are incomplete, outdated, or reflect geopolitical biases, AI predictions may reinforce existing prejudices rather than provide objective insights. For example, if an AI model is trained primarily on Western political sources, it may overemphasize risks associated with non-Western energy markets while underestimating threats in Western regions. Ensuring diverse and representative training data is critical to minimizing biases in AI-driven risk assessments.

AI models require access to extensive geopolitical, economic, and social data, raising concerns about data privacy and security⁹. Governments and corporations must balance the need for data-driven insights with the protection of sensitive information. Unauthorized data access or cyber breaches could expose critical energy infrastructure vulnerabilities, making them targets for cyberattacks. Establishing robust data governance frameworks and encryption protocols is essential to safeguarding geopolitical risk analysis systems.

AI systems used for geopolitical risk modelling are susceptible to cyber threats, including adversarial attacks that manipulate AI outputs. Hackers could exploit vulnerabilities in machine learning algorithms to generate misleading geopolitical forecasts, potentially influencing energy policy decisions. For example, a cyberattack on an AI-driven risk model could falsely predict stability in an unstable energy-producing region, leading to flawed strategic investments. Enhancing AI resilience through continuous security updates, anomaly detection, and threat mitigation strategies is crucial.

The rapid advancement of AI technologies has outpaced the development of regulatory and ethical frameworks. Without standardized guidelines, AI-driven risk models may operate with insufficient oversight, raising concerns about accountability and transparency. Governments must establish policies that ensure AI applications in geopolitical risk analysis adhere to ethical standards, such as human oversight, explainability, and fairness in decision-making.

- **Ethical Considerations :**

As AI assumes a more significant role in geopolitical risk analysis, questions arise about the ethical responsibility of its decision-making processes¹⁰. If AI models predict an imminent geopolitical crisis, should governments act solely based on AI-driven recommendations? The lack of human intuition in AI decisions can lead to ethical dilemmas, particularly when energy security strategies impact vulnerable populations. Ensuring human oversight in AI-driven risk assessment is necessary to address ethical concerns and avoid unintended consequences.

AI-powered risk models have the potential to influence global energy markets by predicting price fluctuations and supply chain disruptions. However, unethical use of AI predictions could lead to market manipulation, benefiting specific entities at the expense of others. Ensuring that AI applications in energy security operate within ethical boundaries is essential to maintaining fair and transparent global energy markets.

THE WAY FORWARD: MAXIMIZING AI'S POTENTIAL

As artificial intelligence (AI) continues to evolve, its role in predictive geopolitical risk modelling for energy security is becoming increasingly critical. With global energy markets facing heightened volatility due to geopolitical conflicts, economic shifts, and climate change, AI offers a powerful tool for forecasting risks and optimizing energy strategies. However, unlocking AI's full potential requires addressing challenges such as data integrity, regulatory oversight, ethical AI deployment, and international cooperation. AI-driven predictive modelling has transformed how governments and corporations assess energy security risks. By analysing vast datasets, AI can detect emerging threats, predict supply chain disruptions, and inform policy decisions.

Enhancing Data Quality and Integration: AI's predictive accuracy depends on the quality and diversity of data sources. To improve energy security modelling, stakeholders must develop standardized data-sharing mechanisms across nations and industries. Governments and private entities should collaborate to create open-source energy databases, incorporating data from IoT sensors, satellite imagery, and financial markets. For instance, the European Union's Copernicus program already utilizes AI-powered satellite monitoring to track energy infrastructure vulnerabilities, setting a precedent for global data integration¹¹.

Advanced AI and Quantum Computing for Energy Forecasting: Quantum computing is poised to improve AI-driven energy risk analysis by processing complex geopolitical variables at unprecedented speeds. Future quantum-enhanced AI models will simulate multiple geopolitical scenarios simultaneously, allowing policymakers to develop proactive strategies for energy crises. Companies like IBM and Google are pioneering quantum AI applications, and in the future, these technologies could be leveraged to anticipate energy



market fluctuations with extreme precision^{12,13}.

Establishing Global AI Governance Standards: To prevent AI misuse in energy geopolitics, international regulatory bodies must establish standardized ethical guidelines. The International Energy Agency (IEA) and the United Nations (UN) should collaborate on AI governance frameworks, ensuring transparency and accountability in AI-driven energy risk assessments. These frameworks must mandate human oversight, ethical AI development, and cross-border cooperation to prevent AI from being weaponized for economic or political gain^{14,15}.

Ensuring AI Transparency and Explainability: One of the biggest challenges in AI-driven risk modelling is the "black box" nature of AI decisions. Future AI models should incorporate Explainable AI (XAI) techniques to clarify how predictions are made. Governments and corporations must mandate AI transparency laws similar to the European Union's AI Act, which promotes fairness and accountability in AI-driven decision-making¹⁶.

AI-Powered Early Warning Systems: Future AI applications will feature real-time early warning systems capable of predicting and mitigating energy crises before they occur. AI-driven systems could analyse geopolitical events, market trends, and environmental risks to provide governments with pre-emptive action plans. For example, AI could have foreseen the 2021 Texas power grid failure by integrating climate modelling with energy consumption data, enabling timely intervention.

AI in Energy Supply Chain Resilience: AI will play a crucial role in building resilient energy supply chains. By utilizing digital twins—virtual replicas of physical infrastructure—energy companies can simulate disruptions and test contingency plans. Shell and ExxonMobil are already experimenting with AI-powered digital twins to optimize refinery operations and mitigate geopolitical risks.

AI-Driven Geopolitical Simulations for Energy Policy: In the coming decades, AI-driven simulations will assist governments in shaping energy policies based on predictive geopolitical models. By modelling potential conflicts and economic sanctions, AI can help nations navigate energy diplomacy more effectively. For instance, AI-driven trade simulations could have helped predict the global energy impact of Russia's invasion of Ukraine, allowing nations to develop contingency strategies in advance.

AI-Powered Climate Risk Analysis in Energy Planning: As climate change increasingly influences energy security, AI will be instrumental in forecasting environmental risks. Future AI models will integrate climate data with geopolitical risk assessments to identify vulnerabilities in global energy supply chains. AI-driven climate simulations could help predict extreme weather events that threaten energy infrastructure, ensuring proactive energy resilience strategies.

CONCLUSION

The future of AI in predictive geopolitical risk modelling for energy security lies in technological advancements, ethical governance, and international cooperation. By enhancing data quality, leveraging quantum computing, establishing regulatory frameworks, and deploying AI-powered early warning systems, stakeholders can maximize AI's potential while ensuring transparency and accountability. However, the path forward requires proactive engagement from policymakers, industry leaders, and researchers to continuously refine AI methodologies and address emerging challenges. Collaboration across borders will be crucial, as energy security is a global concern that transcends national interests. AI-driven solutions must be developed with inclusivity and adaptability in mind, ensuring that both developed and developing nations can leverage these advancements to enhance their energy resilience. Additionally, the role of AI in mitigating cyber threats to energy infrastructure must be further explored, as digital vulnerabilities pose significant risks to the reliability of energy supply chains. In the long term, AI could become the cornerstone of a decentralized, intelligent energy grid capable of self-optimization and rapid response to geopolitical disruptions. By integrating AI with blockchain for secure energy transactions, leveraging advanced machine learning models for scenario planning, and fostering international regulatory harmonization, the global energy landscape can move towards a future that is not only more secure but also more sustainable. As AI continues to evolve, its responsible deployment will be crucial in securing global energy stability amidst an increasingly volatile geopolitical landscape.

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REFERENCES

1. Shell. AI-Powered Predictive Analytics for Energy Supply Chains. 2023. Available from: <https://www.shell.com/>.
2. World Economic Forum. AI and the Future of Global Energy Diplomacy. 2023. Available from: <https://www.weforum.org/>.
3. Van Soest H, Rueda IA, Park HM, Spurling B, Wyatt A, Fine H, et al. The use of AI for improving energy security: Exploring the risks and opportunities of the deployment of AI applications in the electricity system. *RAND Corporation*. 2024. Available from: https://www.rand.org/pubs/research_reports/RRA2907-1.html.
4. Rueda IA, Park HM, Steier J, van Soest H, Fine H, Lebet M. *RAND Corporation*. The Use of AI for Improving Energy Security. 2024. Available from: https://www.rand.org/pubs/research_reports/RRA2907-2.html.
5. Shell Global. The 2025 Energy Security Scenarios. 2025. Available from: <https://www.shell.com/news-and-insights/scenarios/the-2025-energy-security-scenarios.html>.
6. McNabb D. MarketWatch. New Energy Sources for AI, Data Centres Are Vital to U.S. National Security. 2024. Available



- from: <https://www.marketwatch.com/story/ai-and-data-centers-are-devouring-energy-resources-threatening-u-s-security-d2316452>.
7. Wang Q, Ren F, Li R. Geopolitics and energy security: a comprehensive exploration of evolution, collaborations, and future directions. *Nature Humanities and Social Sciences Communications*. 2024;11:1–26. Available from: <https://doi.org/10.1057/s41599-024-03507-2>.
 8. Wang Q, Wang X, Li R. Geopolitical Risks and Energy Transition: The Impact of Environmental Regulations and Green Innovation. *Nature Humanities and Social Sciences Communications*. 2024;11:1–22. Available from: <https://doi.org/10.1057/s41599-024-03770-3>.
 9. International Energy Agency (IEA). AI and Energy Security. 2024. Available from: <https://www.iea.org/reports/energy-and-ai/ai-and-energy-security>.
 10. Iqbal A, Zhang W, Jahangir S. Building a Sustainable Future: The Nexus Between Artificial Intelligence, Renewable Energy, Green Human Capital, Geopolitical Risk, and Carbon Emissions Through the Moderating Role of Institutional Quality. *Sustainability*. 2025;17(3):990. Available from: <https://dx.doi.org/10.3390/su17030990>.
 11. European Union. Copernicus Programme: AI-Driven Satellite Monitoring for Energy Security. 2023. Available from: <https://www.copernicus.eu/en>.
 12. IBM Quantum. Quantum Computing and AI for Geopolitical Risk Modelling. 2023. Available from: <https://quantum.ibm.com/>.
 13. Google DeepMind. AI for Climate Risk Prediction in Energy Planning. 2023. Available from: <https://deepmind.google/>.
 14. International Energy Agency (IEA). AI in Energy Security: Strategies for a Resilient Future. 2023. Available from: <https://www.iea.org/search?q=AI%20in%20Energy%20Security%203A%20Strategies%20for%20a%20Resilient%20Future>.
 15. United Nations (UN). AI Governance and Ethical Frameworks for Global Security. 2023. Available from: <https://www.un.org/site-search/?query=AI+Governance+and+Ethical+Frameworks+for+Global+Security>.
 16. European Union AI Act. Ensuring Transparency and Accountability in AI Decision-Making. 2023. Available from: <https://artificialintelligenceact.eu/>.

