Harnessing AI in Transition Finance: A Critical Pathway to Mitigating Rising CO2 Emissions

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This opinion piece explores the critical role of AI in enhancing transition finance to address the rising global CO2 emissions. It examines the potential of AI to improve risk assessment, optimize investment strategies, and drive efficiency in carbon-intensive industries. The paper highlights how AI and transition finance can work synergistically to accelerate the global shift towards a low-carbon economy, while also addressing the challenges of AI's energy consumption and the need for collaboration among diverse stakeholders.

BACKGROUND

In 2023, the International Energy Agency (IEA) reported a concerning uptick [1] in global energy-related CO2 emissions, registering a 1.1% increase equating to 410 million tonnes (Mt), pushing emissions to a record high of 37.4 billion tonnes (Gt). This surge marked a continuation from the previous year's rise of 490 Mt in 2022 (1.3%). The primary driver behind this escalation was attributed to emissions from coal, which contributed significantly, constituting more than 65% of the overall increase observed in 2023. Consequently, the intensified release of carbon dioxide has magnified the natural greenhouse effect, culminating in a historic breach of the critical 1.5°C threshold outlined in the Paris Agreement [2]. This unprecedented warming trend, compounded by record CO2 levels and the climatic phenomenon El Niño, has exacerbated extreme weather events such as heatwaves, floods, and wildfires, posing severe risks to ecosystems and human well-being globally (Figure 1). Therefore, urgent and concerted efforts are imperative to address climate change and accelerate the transition towards sustainable, low-carbon alternatives.

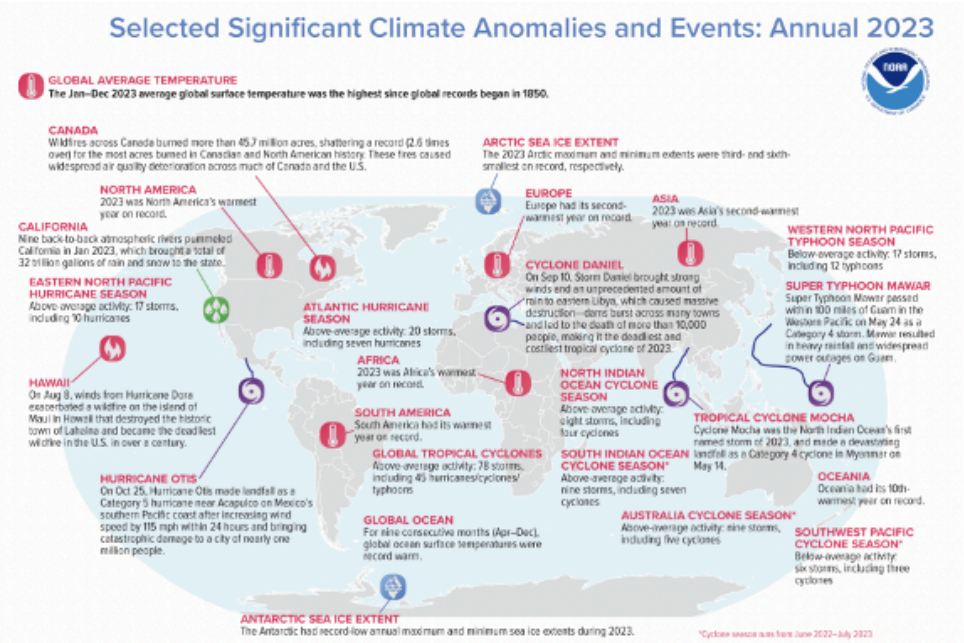

Figure 1. Selected Significant Climate Anomalies and Events in 2023
Source: National Oceanic and Atmospheric Administration. U.S. Department of Commerce

Transition finance emerges as a crucial component for achieving the global net-zero carbon emissions target by 2050, with energy transition requiring an estimated 4$ trillion annually by the mid-2030s [3]. It plays a crucial role in facilitating the transition to net-zero carbon emissions by 2050, offering a range of financial instruments and institutional arrangements to support economic activities and enterprises in high carbon-emitting sectors. By allocating financial resources, mitigating transition risks, and pricing associated costs, transition finance enables organized transformations within industries and regions, making a significant contribution to addressing climate change on a global scale. Since its introduction by the OECD in 2019, transition finance has rapidly become a key tool in global decarbonization efforts, offering targeted financial instruments like transition bonds, sustainability-linked bonds (SLBs), and loans (SLLs) to support emission reduction goals. Despite the steady growth of the transition bond market, reaching nearly $15 billion by 2023 [4], its issuance remains relatively low compared to green and social bonds (see Table 1). Notably, over half of the capital raised through SLBs between 2018 and 2023 was directed toward high-carbon sectors, underscoring the importance of transition finance in facilitating industry decarbonization [5]. Addressing these gaps is vital for facilitating a just and effective transition to a low-carbon economy.

Artificial intelligence (AI) refers to technology that empowers machines to emulate human cognitive functions, including learning, problem-solving, and decision-making. It encompasses disciplines such as machine learning and deep learning, which involve the development of algorithms capable of refining their performance through data analysis. AI is now pervasive in various applications, including digital assistants, autonomous vehicles, and generative tools, increasingly becoming an essential component of contemporary life [6].

AI holds the potential to play a transformative role in bridging the existing gaps within transition finance. By improving **risk assessment accuracy**, AI can help financial institutions better understand and manage the risks associated with transition projects. Advanced data analytics and predictive modeling enable AI to **identify potential investment opportunities in green projects**, ensuring that capital is allocated efficiently. Furthermore, AI can **optimize financial portfolios** by integrating sustainability metrics, allowing institutions to balance returns with environmental impact, thus accelerating the shift towards sustainable, low-carbon economies.

TABLE 1. ISSUANCE OF GREEN, SOCIAL, AND TRANSITION BONDS (2019-2023)

(Bil.US$)	Green bonds	Social bonds	Transition bonds
2019	265	19	1
2020	308	170	3
2021	570	221	4
2022	523	175	4
2023	575	181	3

THE RISE OF AI IN THE FIGHT AGAINST CLIMATE CHANGE

The increasing significance of AI impacts both the transition process and the evolution of transition finance. AI applications extend to various aspects of decarbonization efforts and ESG reporting, providing crucial data on carbon liabilities and supporting sectors in adopting greener practices.

The use of AI for environmental purposes, as reported by PwC and Microsoft, is projected to decrease carbon intensity by 8% by 2030, aiding in addressing climate change impacts and fulfilling Paris Agreement objectives [7]. With over 50 different uses identified in the energy system alone, the AI market in this sector is expected to reach USD 13 billion, while the global AI in renewable energy market is forecasted to surpass USD 114.87 billion by 2032, with a significant CAGR of 27.70% [8].

However, the development of AI presents a paradox: its deployment demands significant electricity, potentially exacerbating the very issues it aims to address. To resolve this contradiction, unprecedented collaboration between technology and energy sectors is essential, ensuring that AI's advantages outweigh its environmental impact. One potential solution involves developing AI-driven methods to optimize energy use, including "smart" monitoring and optimization systems [9], [10]. Accurate measurements of energy consumption across various AI workloads will further aid in understanding and reducing energy use.

Despite that, there is considerable reason for optimism. AI is already contributing to energy efficiency improvements in carbon-intensive sectors (Figure 2) [11]. For example, in buildings, AI integrated with IoT analyzes vast data sets to identify hidden energy costs and improve systems like HVAC, potentially cutting electricity use by up to 30% [12].

In manufacturing, AI enables predictive maintenance to prevent breakdowns and reduces energy waste, while also automating quality checks to minimize material waste. Additionally, AI-driven design innovations lead to more energy-efficient products, further contributing to reduced energy consumption and improved sustainability [13].

Numerous examples exist where AI is already boosting efficiency across different industries, lowering emissions, and advancing sustainability efforts. For instance, Abu Dhabi National Oil Company (ADNOC), through its technology joint venture AIQ with G42 and Presight, has successfully used AI-driven predictive maintenance and machine-learning tools to cut carbon dioxide emissions by up to a million tons in just one year. By deploying AI tools such as SMARTi and Robowell, ADNOC has enhanced its ability to monitor and manage operational equipment remotely, optimize drilling and production activities, and improve resource management. This approach not only streamlined processes but also significantly reduced carbon emissions through advanced predictive analytics and efficient resource utilization [14].

In summary, Large Language Models (LLMs) enhance computational efficiency through deep learning techniques that process and interpret vast and complex data sets, far surpassing traditional methods. These models break down intricate data patterns, enabling industries to make faster and more informed decisions. In energy production, LLMs can simultaneously analyze multiple variables—such as weather patterns, historical data, and market trends—allowing for precise forecasting and optimal use of energy resources. This results in significant reductions in energy waste and carbon emissions. Additionally, LLMs streamline operations by automating routine tasks and delivering real-time insights, freeing human resources to focus on higher-level strategic initiatives. By integrating these models, organizations can achieve greater efficiency and sustainability, transforming industry operations and contributing to environmental conservation efforts.

In the field of material sciences, AI is being used to identify molecular structures that are most effective for carbon capture, a crucial technology in the fight against climate change.

In agriculture, another energy-intensive sector, AI is transforming farming practices by analyzing soil micronutrients, enhancing crop yields, and reducing water usage by up to 40%.

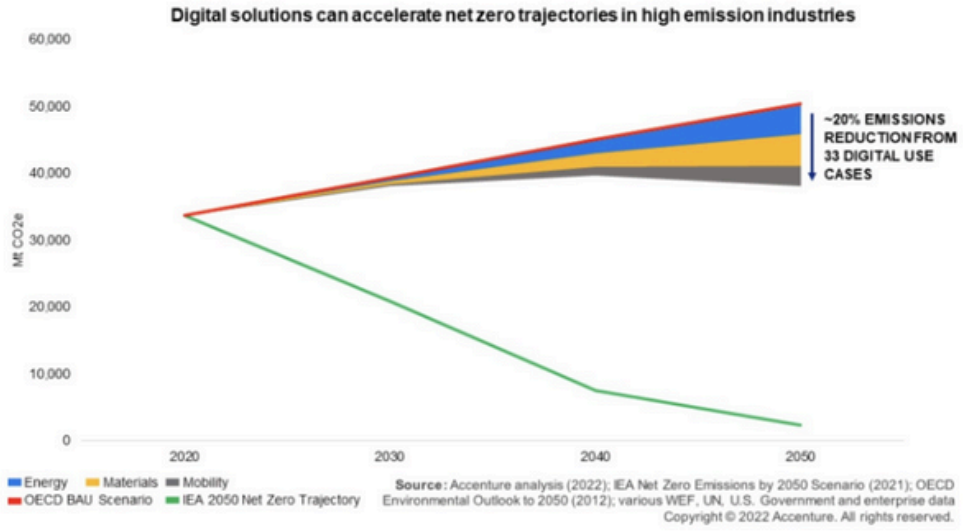

Figure 2. Digital technology including AI could make a significant contribution to helping sectors including energy reach net zero
Source: World Economic Forum, https://www.weforum.org/agenda/2024/07/generative-ai-energy-emissions/

These advances not only lower the environmental impact of agriculture but also contribute to the overall reduction of greenhouse gas emissions.[14]

Over the next five to ten years, AI is expected to drive breakthroughs in fusion, hydrogen, modular nuclear power, and long-term battery storage, as well as other climate solutions that are currently unimaginable. These innovations will be critical in meeting the global goal of affordable and clean energy for all by 2030, as outlined in the United Nations Sustainable Development Goals (SDGs).

Moreover, AI is revolutionizing the manufacturing sector, particularly in the decarbonization of steelmaking. Electric arc furnaces (EAFs), which melt scrap metal using electricity instead of coal, can significantly reduce emissions. However, managing the variability of recycled feedstock presents a novel challenge. AI addresses this issue by recommending optimal production settings that adapt to each batch of scrap, minimizing the need for costly and carbon-intensive additives (Figure 3). For example, a Brazilian steel manufacturer recently used AI to achieve an 8% reduction in alloy additive consumption, resulting in both cost savings and a 7.5% reduction in CO2 emissions per metric ton of steel produced [15].

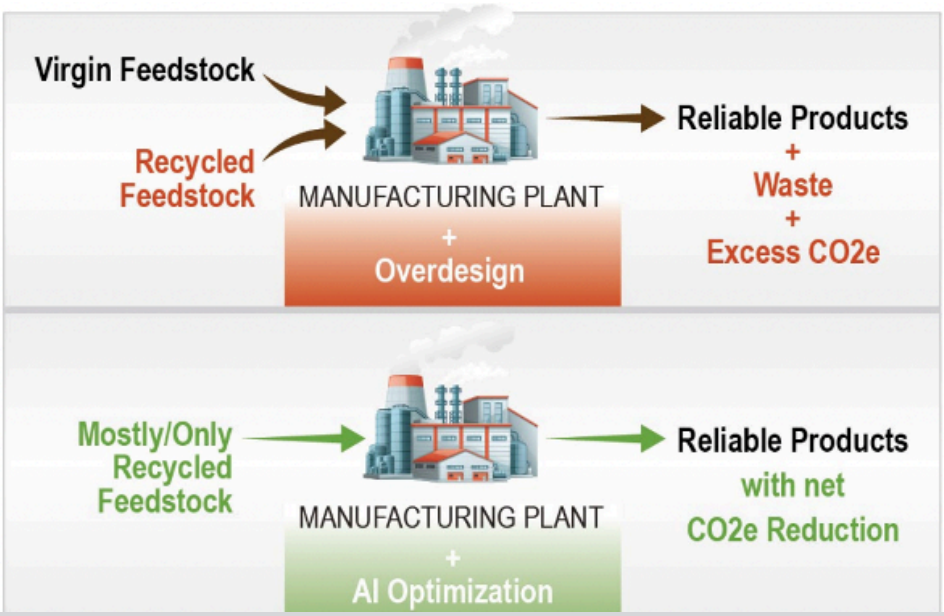

Figure 3. AI enables manufacturers to adapt to recycled feedstock.
Source: https://www.icef.go.jp/wp-content/uploads/2024/02/AI-Climate-Roadmap-ICEF-Dec-1-2023.pdf

AI is also making a significant impact in vulnerable communities by enhancing their ability to cope with climate change. In regions like Burundi, Chad, and Sudan, AI-driven initiatives are crucial for predicting climate change patterns and shaping effective adaptation strategies. The IKI Project, funded by Germany's Federal Ministry for the Environment under the International Climate Initiative, aims to advance clean energy access, improve waste management, and promote reforestation. Additionally, it empowers local communities to tackle climate impacts directly.

By leveraging AI to assess climate vulnerability in humanitarian hotspots and implement targeted adaptation solutions in water, sanitation, and energy, the project supports the integration of climate and environmental considerations into humanitarian planning processes [16]. The MyAnga app, which provides Kenyan pastoralists with data on drought conditions, is another example of how AI can empower communities to better manage resources and mitigate the impacts of climate change. Additionally, AI is enhancing urban resilience by improving air quality monitoring, traffic management, and waste disposal, thereby making cities more sustainable and livable. [17]

AI's role in combating climate change extends to global initiatives as well. The United Nations, through its World Meteorological Organization (WMO), is leveraging AI to improve weather forecasting and disaster risk reduction. The UN Secretary-General's Early Warnings for All initiative aims to ensure that everyone on Earth is protected from hazardous weather events by 2027, with AI playing a central role in achieving this goal [17].

AI has the potential to revolutionize the fight against climate change by enabling more efficient and sustainable practices across a wide range of industries. From reducing emissions in energy production and manufacturing to enhancing resilience in vulnerable communities, AI is poised to become a critical tool in the global effort to achieve carbon neutrality and mitigate the impacts of climate change. However, realizing this potential will require careful management of AI's own energy demands and a commitment to collaboration between technology and energy sectors to ensure that the benefits of AI-driven innovation far outweigh its environmental costs.

SYNERGY BETWEEN AI AND TRANSITION FINANCE: LEVERAGING AI FOR FINANCIAL REGULATION

AI plays a significant role in transition finance by leveraging data analytics to assess climate-related risks and opportunities, optimize investment strategies for sustainable projects, enhance decision-making processes, and automate tasks such as carbon accounting and reporting.

At the Global Ethical Finance Conference 2023, WWF introduced a new AI-backed tool to assist financial stakeholders in evaluating companies' net-zero transition plans for credibility, science-based targets, and potential 'greenwashing'.

Developed in collaboration with the University of Zürich and the University of Oxford, the tool aims to automate and scale up the analysis of transition plans, emphasizing the importance of careful assessment from a financial supervisory risk perspective. [18] Another example, the project Gaia, an AI application developed by the Bank for International Settlements (BIS) in collaboration with partners such as the Bank of Spain, the Deutsche Bundesbank, and the European Central Bank, facilitates the analysis of climate-related risks within the financial system, and aims to simplify data extraction from corporate climate disclosures.

AI is increasingly applied in global carbon accounting pilot projects, analyzing Scope 3 emissions data to address measurement challenges, aiding companies in formulating realistic transition plans and devising emission mitigation strategies across their value chains.

AI drives value in the global energy transition, with BNEF's net zero scenario modeling indicating that every 1% increase in demand efficiency could generate $1.3 trillion in value between 2020 and 2050 through reduced investment needs.

As AI integration in sector transition activities expands globally, it's vital to acknowledge its broader implications beyond mere technology. Addressing risks like cybersecurity, data biases, and energy usage is essential before widespread AI adoption, emphasizing the necessity for international collaboration to navigate challenges and promote its integration into transition finance initiatives.

CASE STUDY: CHINA'S DUAL CARBON GOALS AND AI-DRIVEN TRANSITION

China's dual carbon objectives—reaching peak emissions by 2030 and attaining carbon neutrality by 2060—are catalyzing substantial industrial transformation efforts. The People's Bank of China is spearheading the development of a transition finance framework to support critical sectors such as thermal power, iron and steel, construction, and agriculture.

At the local level, cities like Huzhou and Quzhou in Zhejiang Province, and Pingxiang and Jiujiang in Jiangxi Province, have pioneered initiatives in transition finance. Huzhou, in particular, has made significant progress by integrating the G20 Transition Finance Framework and developing a comprehensive "Transition Finance Support Activities Catalog" that focuses on high-carbon industries. This catalog delineates 106 transition technologies and sets guidelines for enterprise transition plans, fairness in the transformation process, and carbon accounting standards. These efforts reflect a concerted push to advance transition finance and address the challenges related to carbon emissions and industrial transformation at the local level.

AI is playing a crucial role in driving China's transition towards its dual carbon goals. AI technologies are being integrated across various sectors to enhance efficiency, reduce carbon emissions, and promote sustainable development.

AI in Financial Sector

China has been widely developing the application of AI in the financial sector thought the application of intelligent customer service, intelligent investment research, intelligent operation, digital staff, and AI assistants. These developments highlight the financial industry's potential as an early adopter of AI large models, given its extensive data resources and advanced digitalization. The application of these models is expected to enhance efficiency and reduce costs across various sectors, including banking, insurance, and asset management.

Industrial and Commercial Bank of China (ICBC) has pioneered the integration of AI large models into its banking operations, marking a significant milestone in the financial industry's digital transformation. Leveraging a self-developed technology stack, ICBC built a robust AI model with over 100 billion parameters, enabling full-process innovation across key business areas such as remote banking, credit risk management, and financial markets. This AI-driven approach has resulted in substantial improvements, including enhanced service efficiency, intelligent risk assessment, and automated operational management, establishing ICBC as a benchmark for smart banking and setting a new standard for the industry's transition to comprehensive digitalization [19].

The Agricultural Bank of China (ABC) has introduced its AI-powered large model, ChatABC, marking a significant step in the financial industry's AI-driven innovation. Built on ABC's comprehensive AI service infrastructure, ChatABC enhances financial knowledge comprehension, content generation, and secure Q&A capabilities. With over 10 billion parameters, the model is used internally for tasks like multi-turn Q&A and automated responses, while also providing decision-support services through a Model as a Service (MaaS) platform. ABC continues to expand ChatABC's applications across marketing, risk control, and customer service, driving digital transformation and enhancing its service capabilities [20].

The Postal Savings Bank of China (PSBC) has integrated Baidu's "Wenxin Yiyan," a generative AI dialogue model, into its "PSBC Brain" platform to enhance its smart financial services, marking a significant step in the bank's digital transformation. This collaboration enables PSBC to offer more personalized and intelligent financial products, particularly in customer service, digital employees, and virtual branches. Leveraging "Wenxin Yiyan's" deep understanding of Chinese language, cross-modal semantic capabilities, and advanced AI technologies, PSBC has improved customer interactions, automated routine tasks, and provided

24/7 support, significantly enhancing operational efficiency. The AI model is fine-tuned with PSBC's industry-specific knowledge to deliver tailored financial services to its diverse customer base, including rural populations, SMEs, and green finance clients. Additionally, the AI supports internal operations and risk management by analyzing data to predict issues and optimize decision-making processes. As part of PSBC's broader "PSBC Brain" innovation platform, this integration not only boosts the bank's service capabilities but also sets a new standard for AI-driven financial innovation, contributing to the development of inclusive, efficient, and sustainable banking services in China [21].

While AI innovations are progressing in the financial sector, parallel advancements are underway in the power sector, where AI is enhancing efficiency, sustainability, and operational excellence.

AI in the Power Industry

In the power industry, AI is being leveraged across multiple scenarios, including power generation, grid management, and consumption. For example, the Southern Power Grid's AI Data Analysis Platform for pumped storage power stations has revolutionized equipment maintenance, shifting from manual inspections to online intelligent management (Figure 4). This platform has significantly reduced costs and improved efficiency, enabling the identification of potential equipment defects and enhancing power generation during peak demand periods [22].

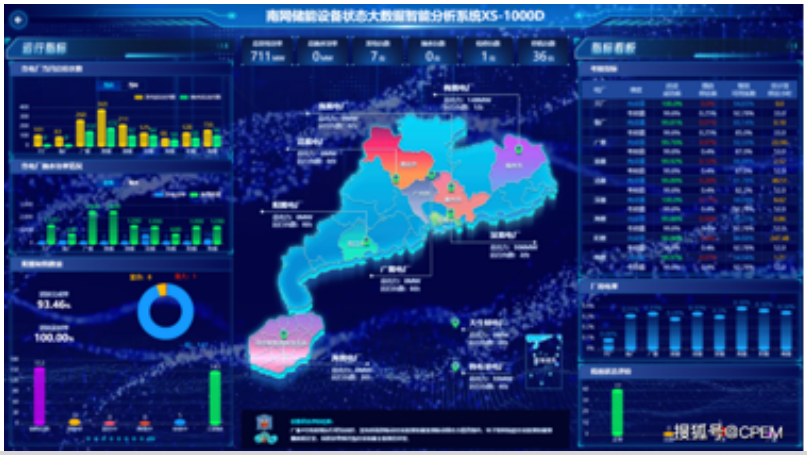

Figure 4. The Southern Power Grid's AI Data Analysis Platform
Source: https://www.icef.go.jp/wp-content/uploads/2024/02/AI-Climate-Roadmap-ICEF-Dec-1-2023.pdf

In the field of renewable energy, the State Grid Xinjiang's latest power forecasting system employs over ten algorithms, including artificial intelligence, to deeply analyze data and continuously monitor renewable energy generation. This system enhances the integration of renewable energy into the grid. By creating refined forecasting models based on different weather conditions, the system improves forecasting accuracy. It can receive data from nearly a thousand renewable energy plants to predict the renewable energy output of the Xinjiang power grid, aiding the dispatch department in scheduling generation plans and controlling power dispatch. The system's renewable energy power forecasting accuracy exceeds 93%, significantly increasing the utilization rate of renewable energy. Additionally, AI can be applied in coal-fired power plants for decision support and fault resolution. In substations and transmission lines, AI technology is also used for equipment monitoring and maintenance [22].

AI's impact extends beyond the energy sector. The Ningde Nuclear Power Company has developed a proprietary large language model, "Jinshu," designed specifically for the nuclear industry. This model enhances work efficiency, promotes knowledge sharing, and supports innovative functions like text-to-image and text-to-PPT generation. Additionally, the National Energy Group has created the first AI assistant for coal-fired power plants, leveraging comprehensive data analysis to support scientific decision-making in production and management [22].

AI is also driving innovation in distribution and microgrids, with projects like Shanghai Electric Power's AI-assisted decision-making system and Beijing Power Equipment Company's integrated green microgrid. Furthermore, Shenzhen's Virtual Power Plant Management Center represents one of China's most comprehensive and largest virtual power plants, integrating AI to optimize power supply and demand.

Synergy of AI Application in Both Sectors

China's dual carbon goals and transition finance efforts are being bolstered by the strategic integration of AI technologies across various sectors. While the progress of transition finance instruments like transition bonds has been slower compared to green bonds, the combination of financial frameworks and AI-driven innovations is creating new opportunities for sustainable industrial transformation. These efforts not only contribute to China's carbon reduction targets but also position the country as a leader in AI-driven sustainability practices.

The application of AI in both the financial and power sectors in China is creating significant opportunities to foster energy transition and facilitate the development of transition finance. In the financial sector, AI-driven innovations in intelligent customer service, risk management, and operational efficiency are setting new standards for digital transformation and support the enhancement of financial institutions' ability to support green finance initiatives, efficiently manage large datasets, and provide personalized financial services that cater to sustainable development goals.

Simultaneously, in the power sector, AI is revolutionizing energy management through advanced data analysis, predictive maintenance, and optimized power generation, as demonstrated by the case studies above. By improving the accuracy of power predictions and enhancing equipment efficiency, AI is contributing to the stability and sustainability of energy systems.

The integration of AI technologies across both sectors presents a unique opportunity to align financial mechanisms with energy transition goals. AI can be used to analyze vast amounts of data from the energy sector to inform better investment decisions in the financial sector, particularly in green and transition finance. For example, AI-driven financial models can be fine-tuned with real-time data from power grids and renewable energy projects to create innovative financial products that support the development of sustainable energy infrastructure.

Moreover, AI's role in automating and optimizing operations in both sectors can reduce costs and improve the efficiency of energy and financial services, making them more accessible and scalable. This convergence of AI applications not only accelerates the energy transition but also enhances the effectiveness of transition finance, enabling China to progress toward its dual carbon goals while positioning itself as a leader in AI-driven sustainable development.

CLOSING INSIGHTS AND PATH FORWARD

The integration of AI into transition finance presents substantial opportunities, yet it also encounters significant challenges that need to be addressed to ensure its effective and responsible application. In China, as in many other countries, a critical issue is the absence of a unified national definition of transition finance. This lack of clarity can lead to risks such as the emergence of "fake environmental protection" projects and insufficient data support for accurate project identification and supervision. Additionally, the path to net-zero for the industrial sector remains unclear, further complicating the role of transition finance.

To address these challenges and unlock the full potential of AI in transition finance, it is imperative for China to establish a clear national definition of transition finance, refine standard frameworks, and develop comprehensive information disclosure systems. AI can significantly contribute to these solutions by providing advanced data analytics and predictive modeling to enhance project identification and monitoring. By leveraging AI to analyze large datasets, identify credible transition projects, and ensure transparency, the risk of greenwashing can be minimized.

AI also offers solutions for improving the clarity and effectiveness of transition finance frameworks. Machine learning algorithms can help refine and standardize definitions and criteria for transition finance, while AI-driven tools can enhance the accuracy of data reporting and project evaluation. Additionally, AI can support innovation in financial products and tools by providing insights into emerging trends and optimizing financial strategies for transition finance.

During the 2024 Multi-stakeholder Forum on Science, Technology, and Innovation for the Sustainable Development Goals, Daniela Braga, Founder and CEO of Defined.ai, highlighted the significant underfunding and lack of resources dedicated to AI-driven sustainability initiatives [23].

This article seeks to emphasize the importance of AI technology in advancing sustainability, particularly in the energy transition sector, through its integration with the financial sector via transition finance. International collaboration is vital for fostering the synergy between these two sectors by promoting the exchange of best practices, knowledge sharing, and the establishment of global standards. Additionally, AI can enhance this process by enabling real-time data sharing and facilitating cross-border analysis. As global CO2 emissions continue to rise, leveraging AI within transition finance provides a critical mechanism for accelerating the transition to a low-carbon economy. The synergy between AI and transition finance not only offers a path to mitigating climate change but also strengthens the resilience of the global economy, presenting a transformative opportunity to build a sustainable future for all.

Link to the Chinese Version:
https://mp.weixin.qq.com/s/POJ1jz8JGgAZlY0sK7_dCQ

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