

Review

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Credible transition plans for coal power sector: current disclosure framework and considerations for transition finance

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How to cite this article: Liu Y, Gao C, Yang X, Yuan J, Ren Y. Credible transition plans for coal power sector: current disclosure framework and considerations for transition finance. *Carbon Footprints* 2024;3:1. <https://dx.doi.org/10.20517/cf.2023.41>

Received: 27 Jul 2023 **First Decision:** 4 Sep 2023 **Revised:** 18 Sep 2023 **Accepted:** 20 Oct 2023 **Published:** 26 Oct 2023

Academic Editor: Feng Dong **Copy Editor:** Fangyuan Liu **Production Editor:** Fangyuan Liu

Abstract

The zero-carbon transition of the coal power industry comes with substantial economic costs, both in terms of the cost of stranded assets and the innovation and application of carbon reduction, zero-carbon, and decarbonization technologies. Mobilizing social capital through transition finance is crucial to support companies in their efforts to reduce carbon emissions. The lack of high-quality data and consistent, comparable disclosure frameworks hinders proper due diligence and strategic planning, presenting a major obstacle to financing the transition. To identify the mismatches between existing disclosure frameworks for transition plans and the needs of transition finance, we conducted a systematic review of various transition disclosure frameworks, such as TCFD (Task Force on Climate-Related Financial Disclosures), CA100+ (Climate Action 100+) and TPT (Transition Plan Taskforce), and compared them with the information requirements of financial institutions for assessing coal phase-out plans of production entities. The results indicate that the ex-ante assessment of transition finance requires disclosure frameworks to be further expanded and aligned in areas such as technological distinctions and data quality to meet the demands of pricing, risk management, new product innovation, and disclosure of financial institutions' carbon footprints in their asset portfolios. Moreover, the implementation of the current disclosure standards by coal power enterprises may encounter dual constraints from soft regulatory practices and the external business environment, resulting in the emergence of the "green silence" phenomenon. The inconsistency between disclosure frameworks may also give rise to regulatory arbitrage, leading to a distorted evaluation of the transition process of coal power enterprises by the capital market, resulting in potential price distortions and credit risks.

Keywords: Coal power sector, zero-carbon transition, transition finance, information disclosure



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INTRODUCTION

From a global perspective, coal remains the primary source of electricity generation, accounting for approximately 36% of the total global electricity generation^[1]. In 2022, the total CO₂ emissions from the power sector amounted to 14.8 Gt, with coal-fired power generation contributing 10.9 Gt, accounting for approximately 73.6% of the total^[2]. A global zero-carbon transition of coal power is therefore needed to achieve the goal of net zero CO₂ emissions by 2050 and limiting global warming to well below 2 °C. Major economies such as China^[3], the United States^[4], and India^[5] are progressively formulating ambitious decarbonization targets, especially in the power sector^[6]. In this context, there are two main pathways for power sector transition. The first involves a complete phase-out of coal-fired power, relying heavily on renewable energy sources to meet the whole society's energy demands. The second pathway relies on a combination of low-carbon technologies, such as CCS (Carbon Capture and Storage), to achieve the decarbonization of fossil energy.

It is estimated that energy supply and infrastructure investments will total \$92 trillion to \$173 trillion over the next 30 years^[7]. Some studies suggest that the early closure of operating coal mines will impact all major power coal-producing regions globally, with stranded assets in operating coal mines totaling \$120 billion to \$150 billion by 2050^[8]. Annual global investment in CCUS (Carbon Capture, Utilization, and Storage) is projected to surpass \$160 billion by 2050^[9]. Moreover, based on multiple estimations and existing practices, many regions with traditional energy industries are facing significant funding gaps for decarbonization and transition^[10]. One of our previous studies, focusing on China, highlights the substantial losses experienced by the coal power sector in 2021. This resulted in 55% of coal power companies facing a gearing ratio (the gearing ratio, also known as the debt-to-business ratio, is the percentage of total liabilities divided by total assets at the end of the period, and is used to measure the ability of an enterprise to utilize funds provided by creditors to carry out its business activities, as well as to reflect the degree of security of creditors in granting loans) of over 80%, and 25% of enterprises dealing with insolvency and credit crises. The low-carbon transition requires significant capital investment, estimated at 5-12 trillion yuan. Additionally, the continuous operating pressure may lead to a loan default rate exceeding 20% within the next decade^[11]. Therefore, regardless of the chosen pathway to achieve net-zero emissions, the transition of coal power requires capital-intensive technologies, necessitating increased financial support for the successful net-zero transition.

Although green finance has been developing rapidly in recent years, in a financial system oriented towards green development, high-carbon emitting industries do not belong to the category of green financial support, and it is difficult to obtain financing in the financial market. The climate transition of the entire economy requires broader investment support, including investments in transformational activities and GHG-intensive sectors and enterprises, that align with the Sustainable Development Goals (SDGs) and support the entire economy in transitioning towards low-emission, net-zero emissions, and climate-resilient goals in accordance with the objectives of the Paris Agreement^[12].

The definition, criteria, and industry scope of transformative finance remain subjects of early-stage discussions, lacking a consensus on which sectors, entities, or activities should fall within the purview of transformative finance support. Regarding the electric power industry, the types of activities covered by transformative finance standards in different regions are highly contingent on the transformation pathways of local electricity sectors. In nations and regions where coal-fired electricity remains a predominant energy source, such as China, published regional transformative finance catalogs and financial institution transformation directories often include activities related to the flexible retrofitting of coal-fired power

plants, the adoption of CCS technologies, as well as worker training and placement initiatives associated with coal-fired plant closures within the transformative finance support scope. Conversely, the European Union, where the proportion of renewable energy sources is higher, generally omits such activities from its purview.

The lack of high-quality data and a consistent, comparable information disclosure framework is a significant obstacle to conducting proper due diligence and strategic planning in the context of transition financing and investment^[13]. This deficiency may also lead to the possibility of funds from the transition finance instrument being utilized to support activities that neither contribute to decarbonization nor reduce the duration of carbon-polluting activities but instead extend their lifespan, which will be elaborated upon in detail later in the text. On the one hand, some key information including expected GHG emission reductions, supply chain structures, exposure to risks in other markets (e.g., policy changes), and climate-related (e.g., physical) risks is critical in assessing whether a project meets the requirements of transition finance instruments (currently mainly fixed income instruments linked to key performance indicators, such as an SLB (sustainability-linked bond), sustainability-linked loan revolving credit facility, *etc.*) and thus successfully embedding incentive mechanisms into the transition process^[14]. On the other hand, for the financial sector, investing in coal-fired power plant projects is often controversial, and even if these projects claim to aim at a cleaner, more flexible transition, their credibility is often questioned due to the imperfections of the global transition plan disclosure frameworks. In the case of coal power projects, the impact of such controversies quickly propagates through the supply chain, from the project's developers to the suppliers to the financial institutions and investors that provide the financing - all parties involved in a controversial project can be exposed to reputational risk. Therefore, the improvement of information disclosure systems related to zero-carbon transitions is crucial for the development of transition finance^[15].

At present, from a worldwide perspective, the practice of transition finance and related research is far less in-depth and comprehensive than green finance, limited by difficulties such as insufficient disclosure of carbon information, imperfect frameworks, and information fragmentation. To address this, it is essential to develop corresponding assessment criteria, gather and organize foundational data for key transition projects, and enhance relevant information disclosure^[16]. The existing disclosure frameworks are mainly based on the TCFD of the FSB (Financial Stability Board), which was initially launched to enhance the market and society's understanding of the potential financial impacts of climate change.

Our review makes two core contributions. Firstly, it comprehensively examines the prevailing disclosure frameworks for transition plans and identifies the consistency that exists between these frameworks through comparative analysis. Additionally, it highlights the urgent need for disclosure in transition finance and related practices. Secondly, while literature studies on disclosure frameworks exist, most of them focus on individual frameworks and pay less attention to critical issues, such as the gaps between current frameworks and the requirements of transition finance, the potential regulatory arbitrage by large multinational corporations, and the challenges faced by coal power companies in implementing these standards. Consequently, this review will summarize the key components of the existing mainstream transition plan disclosure frameworks, compare them from the perspective of information requirements for financial institutions issuing transition finance products, and provide valuable insights to further enhance the usability of transition information from coal and power enterprises in the financial sector.

The rest of the paper is organized as follows: In the section of "CURRENT DISCLOSURE FRAMEWORKS RELATED TO TRANSITION PLANS", we will identify several existing transition disclosure frameworks and summarize their consistency. Section of "REQUIREMENTS OF FINANCIAL INSTITUTIONS ON

DISCLOSURE RELATED TO TRANSITION PLANS” describes the urgency and practice of disclosure in transition finance. The section of “DISCUSSION” elaborates on the gaps between current frameworks and the requirements of transition finance, the potential regulatory arbitrage by large multinational corporations, and the challenges faced by coal power companies in implementing the standards. In the section of “CONCLUSION”, the conclusion provides a comprehensive summary of the entire paper and offers valuable insights and outlook.

CURRENT DISCLOSURE FRAMEWORKS RELATED TO TRANSITION PLANS

Achieving the goals of the Paris Agreement will require companies to reduce power coal production and/or transition away from unabated coal-fired power generation. This viewpoint was recognized and reaffirmed at COP26 by the Glasgow Climate Pact^[17]. Relevant coal-production and coal-fired power generation companies should disclose their transition plans and implementation methods, including clear and comprehensive disclosure of timelines and associated plans for phasing out coal-fired units. Transparent and compelling disclosure of relevant information will enable financial markets to accurately price securities and will provide investors with consistent, comparable, and reliable (and therefore decision-useful) information that will enable them to make informed decisions about climate-related risks on current and potential investments^[18,19].

The current transition disclosure frameworks have been set up primarily by a wide range of third-party organizations, the more influential of which include the GRI (Global Reporting Initiative), formerly the CDP (Carbon Disclosure Project), CDSB (Climate Disclosure Standards Board), Value Reporting Foundation (formed through a merger of the SASB (Sustainability Accounting Standards Board) and the IIRC (International Integrated Reporting Council)), CA100+ and the TCFD, *etc.*

TCFD is the most globally influential and widely supported climate disclosure standard. It not only fosters institutional consistency among G20 member countries but also provides a common framework for information disclosure in carbon-intensive industries and enterprises. Many of the current low-carbon transition disclosure frameworks are built upon the development of TCFD. CA100+ is the world's largest investor-led climate engagement initiative, enjoying substantial support from numerous financial institutions. While the TPT standard is an evolution of TCFD, it offers a more detailed set of recommendations, particularly concerning the electricity industry. It is one of the most comprehensive standards in existence. Consequently, the following sections will provide a detailed introduction to these three standards, which hold significant importance in both the electric power and financial sectors.

TCFD framework

On December 4, 2015, the FSB established the industry-led TCFD (Task Force on Climate-Related Financial Disclosures). TCFD extracted the most financially relevant metrics from various disclosure systems and incorporated the scenario analysis requirements from CDP, to develop a recommended disclosure framework that provides concrete recommendations for industry-wide disclosure practices while allowing flexibility for further development. TCFD has rapidly become the global best practice of climate-related risk and opportunity disclosure, with governments worldwide starting to incorporate aspects of the TCFD recommendations into policies and regulations. The TCFD framework recommendations have four pillars - governance, strategy, risk management, and metrics and targets - and based on the four pillars, eleven recommended disclosures are proposed, as shown in [Table 1](#).

For the energy sector, TCFD highlights key elements that should be emphasized in disclosure: describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial

Table 1. TCFD disclosure framework^[20]

Four pillars	Recommended disclosures
Governance	<ul style="list-style-type: none"> Board's oversight of climate-related risks and opportunities Management's role in assessing and managing climate-related risks and opportunities
Strategy	<ul style="list-style-type: none"> Climate-related risks and opportunities the organization has identified over the short, medium, and long term Impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning The resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2 °C or lower scenario
Risk management	<ul style="list-style-type: none"> Organization's processes for identifying and assessing climate-related risks Organization's processes for managing climate-related risks Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management
Metrics and targets	<ul style="list-style-type: none"> Metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks Targets used by the organization to manage climate-related risks and opportunities and performance against targets

planning; describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2 °C or lower scenario; and disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process. And since the energy sector is among the organizations with greater exposure to climate-related issues, consideration should also be given to disclosing key aspects of their scenario analysis, such as the scenarios used, including 2 °C or lower scenario; time frames used for scenarios, including short-, medium-, and long-term milestones; and information about the resiliency of the organization's strategy, such as strategic performance implications under the various scenarios considered, potential material financial implications for the organization's operating results and/or financial position, *etc.*

The main contents of the current zero carbon disclosure system formulated by the EU, the U.S., the U.K., Hong Kong, China, Singapore, and other regions mainly refer to the TCFD^[21]. However, due to different development strategies, economic and legal environments, degrees of market development, regulatory directions, *etc.*, different regions have chosen diverse regulatory policies. For example, the European Union, the United States, and the United Kingdom adopt categorized regulation, i.e., dividing the scope of the application according to the categories of companies, while Hong Kong, China, and Singapore adopt phased regulation, i.e., the gradual transition from voluntary disclosure of information to mandatory disclosure of information. Therefore, each country or region should tailor their regulatory approach based on policy objectives and the policy environment. A context-specific approach allows for a gradual progression in promoting zero-carbon disclosure in alignment with policy goals.

In terms of its content, TCFD places a strong emphasis on commitments and disclosure-related metrics. In contrast, the "alignment" section is comparatively less robust. It does not encompass all sectors and does not consistently provide actionable aggregated results. For countries heavily reliant on coal-fired power generation, such as China, where coal power plays a critical role in ensuring energy security, lobbying alignment is of particular significance in the context of the transformation of coal enterprises.

CA100+

CA100+ represents the world's largest investor climate engagement initiative, dedicated to fostering collaboration between investors and companies to enhance climate change governance, reduce emissions, and enhance climate-related financial disclosure. In March 2023, CA100+ launched version 2.0 of the Net Zero Emissions Company Benchmark, which draws on publicly and self-disclosed company data and is organized into two indicators: a disclosure framework indicator, which evaluates the adequacy of corporate

disclosure; and alignment assessments, which evaluate the alignment of company actions with the Paris Agreement goals. The disclosure framework encompasses 11 essential elements^[22].

Based on the 2022 CA100+ Progress Update^[23], it is reported that 75% of the focus companies have made net-zero emission commitments and 91% have made disclosures in line with the recommendations of the TCFD. However, the Carbon Tracker Initiative's consistency assessment of power sector focus companies reveals that 59% have announced partial coal phase-outs or provided insufficient information, 16% have announced full coal phase-out plans that are inconsistent with the Beyond 2 °C Scenario (B2DS), and only 25% have announced full coal phase-out plans that are consistent with the B2DS. Furthermore, the results of RMI's Capital Consistency Assessment for the power sector also indicate a significant gap from the 1.5 °C scenario requirements. Consequently, many companies currently still have inadequate disclosure or lack consistency with the B2DS, warranting greater efforts to promote comprehensive and aligned company disclosure.

CA100+ has also put forth the following recommendations in its global industry strategy for the electricity sector regarding the phased elimination of high-emission assets, such as coal-fired power plants. Investors should understand the actions required for decarbonization within the electricity industry and utilize the CA100+ framework to assist companies in developing comprehensive transition plans. These plans should encompass emission targets, decarbonization strategies, alignment with CAPEX (Capital Expenditure), fair transition plans, and disclosure of information. For companies that have not yet participated in or are planning to construct new coal-fired power plants, it is recommended to develop upgrading strategies. These strategies may include joint investor statements, shareholder resolutions, board resolutions, and more. The establishment of transition financing mechanisms is encouraged to support the development of the necessary infrastructure for achieving a low-carbon society.

In the application within coal enterprises, CA100+ faces several challenges. Firstly, the disclosure metrics are overly complex, inundating investors with excessive information, thereby diminishing the significance of certain ideal transformation progress indicators, such as climate governance and reporting, compared to more generic metrics like greenhouse gas emissions. Secondly, some metrics may employ methods that are not necessarily aligned with industry best practices. For instance, greenhouse gas emission reduction targets are based on carbon intensity rather than absolute emissions. Consequently, this allows companies, under certain conditions, to increase their absolute emissions to meet the standards. For coal-fired power companies that are in the process of phasing out their operations, the introduction of such a target as a Key Performance Indicator (KPI) in transition finance instruments may potentially pose additional greenwashing risks^[24].

TPT framework

In April 2022, to develop a robust disclosure standard for corporate climate transition plans in the private sector in the UK and elsewhere, aiding financial institutions and listed companies in formulating effective net-zero transition planning, the UK Treasury established the TPT. The TPT Framework builds upon the existing recommendations and supplementary guidance from TCFD, and accompanying guidance, as well as transition plan disclosure recommendations in the ISSB's (International Sustainability Standards Board) proposed standards. The TPT is also aligning with recommendations for information needs of financial institutions on transition plans from the GFANZ (Glasgow Financial Alliance for Net Zero), with members of GFANZ participating in all levels of TPT governance. TPT Framework will provide specificity and granularity for the UK context and is exemplary for other regions to establish national initiatives based on the ISSB and TCFD^[25].

The TPT disclosure framework contains five dimensions involving 19 sub-elements, which are based on the three principles of ambition, action, and accountability and are organized around five elements - foundation, implementation strategy, engagement strategy, metrics & targets, and governance - which are aligned with the GFANZ recommendations for financial institutions. Ten of the most critical and mandatory disclosures for the power sector are objectives and priorities, business model implications, business planning and operations, financial planning, governance, business and operational metrics and targets, financial metrics and targets, GHG emissions metrics and targets, board oversight and reporting, roles, responsibilities and accountability, and incentives and remuneration^[26]. TPT is also working on the development of an international standard for net-zero transition in the power sector based on the ISSB's "Power and Utilities" ^[27].

Table 2 provides a comparative analysis of the core similarities and differences in the expectations for financial institution disclosure presented by TCFD, CA100+, TPT, and GFANZ. GFANZ, being an information disclosure framework tailored for the financial sector, is a crucial reference in discussing the variance between disclosure requirements for transitioning finance and the existing disclosure frameworks. Notably, we include GFANZ within our comparative scope. Our analysis reveals that as a principled framework, TCFD does not specify detailed disclosure requirements pertaining to coal phase-out plans. In contrast, the latter three frameworks all contain comprehensive provisions for disclosing plans related to coal transition or the support for coal phase-out or transition by financial institutions. None of the four schemes, however, consider an evaluation and differentiation of prospects for applying coal transition technologies.

Other frameworks and their alignment

Transition plan disclosure (sustainability disclosure) has evolved from a period of diverse standards to a new phase characterized by more aligned guidelines. Most of the existing frameworks for transition plan disclosure, including CA100+ and TPT, have made significant efforts to harmonize with the recommendations of the TCFD in key aspects.

The CA100+ framework does not operate as a standalone reporting mechanism but rather utilizes existing disclosure platforms (e.g., CDP) and other public information, such as company annual reports, sustainability reports, press releases, *etc.* One of the indicators in CA100+ is directly linked to the TCFD framework, i.e., that the company has made a public commitment to implement the recommendations of the TCFD. The year of the long-term target for electric utilities in CA100+ is 2040, which corresponds to a 1.5 °C pathway P1 or net-zero emissions by 2050 in the IPCC Special Report^[22].

The EU Corporate Sustainability Reporting Directive's (CSRD) text on climate disclosures broadly aligns with the four pillars (governance, strategy, risk management, indicators, and targets) of the TCFD. Both are intended to standardize climate- and sustainability-related disclosures, as well as to promote transparency and accountability in capital markets. However, the CSRD goes beyond the TCFD in several ways; for example, the CSRD regulation adopts a double materiality approach (i.e., companies must disclose how sustainability-related risks and opportunities affect their operations and businesses, as well as how their businesses affect various ESG concerns), while the TCFD uses a single materiality approach (i.e., the TCFD solely focuses on how climate risks and opportunities affect organizations' operations and financial bottom lines); the CSRD regulation requires organizations to report their compatibility with a 1.5 °C temperature rise, the TCFD only requires companies to test their resilience against a 2 °C warming scenario.

Table 2. Key differences between the disclosure standards for different transformation plans

	TCFD	CA100+	TPT	GFANZ
Availability of detailed information disclosure proposals for (supporting) coal power decommissioning	No	Yes	Yes	Yes
Current main application areas	Global	Global	UK	Mainly Asia-Pacific (coal power)
Assessment of the significance of coal power conversion technology	Not yet	Not yet	Not yet	Not yet
Emphasis on including scope 3 emissions	If appropriate	If appropriate	Obligatory	Obligatory
Inclusion of policy conditions for local transformation	Yes	Yes	Yes	Yes

This table has been compiled and created by the author.

The ISSB and TCFD disclosure recommendations are also broadly similar, but the ISSB goes further in certain areas by requiring additional and more detailed information to be disclosed. For example, for strategy, the ISSB requires some additional information regarding resiliency. Additionally, in terms of risk management, the ISSB makes some additions across the processes used to identify and prioritize opportunities, input parameters used to identify risks, and whether processes have changed. Furthermore, for metrics and targets, alongside disclosing the same categories of cross-industry metrics as in the TCFD guidance, the ISSB introduces requirements relating to new disclosure of industry-based metrics relevant to an entity's industry and activities.

REQUIREMENTS OF FINANCIAL INSTITUTIONS ON DISCLOSURE RELATED TO TRANSITION PLANS

The urgent need for information disclosure in transition finance

From a theoretical standpoint, “carbon information” as a form of environmental information profoundly impacts enterprise financing costs. An enhanced information disclosure system can mitigate information asymmetry, ensuring equitable market operations. Long-term environmental information disclosure will foster a trust mechanism, positively influencing external financing for enterprises and easing financing constraints^[28]. From the investor's perspective, investment and financing decisions are significantly influenced by the enterprise's environmental information disclosure. Robust environmental information disclosure instills confidence in investors, leading to more efficient and appropriately relaxed financing scales, costs, and efficiency for creditors^[29,30]. Financial institutions also benefit from reduced information asymmetry, which translates to lower uncertainty regarding counterparty credit risk. Particularly during the transitional phase for high-pollution and high-energy-consumption enterprises, non-financial information disclosure aids financial institutions in mitigating default risks^[31]. Thus, the quality of environmental information disclosure exhibits a positive correlation with the magnitude of loans or bond financing granted by banks and a negative relationship with interest rates^[32-34].

At present, the international financial landscape includes several transition financial instruments, such as sustainable development-linked loans, sustainable development-linked bonds, *etc.* To effectively incentivize financing entities (enterprises or projects) to meet or surpass agreed-upon transition targets, these instruments necessitate the design of reward and punishment mechanisms linked to their transition performance^[16]. SLLP (Sustainability Linked Loan Principles)^[35], jointly published by the Loan Market Association and others, and the Sustainability-Linked Bond Principles^[36], introduced by ICMA (International Capital Market Association), both state that the issuance of sustainability financial products should be linked to corporate ESG objectives, in particular KPIs. As the main body of information disclosure on transition finance continues to be clarified and improved, and the regulators are becoming more stringent in reviewing the carbon footprint of the issuers themselves who issue transition finance

products, financial institutions need to be more rigorous and prudent in their investigations of the financiers' transition plans before the issuance of the products. The ICMA issued the SLLP, which clarifies that the borrower of a sustainability-linked loan is the subject of disclosure^[37]. In March 2020, the EU Taxonomy (EUT), published by the EU's Technical Expert Group on Sustainable Finance, clarified that the main subjects of transition financial disclosure are financial institutions (funds, insurance, investment banks) and non-financial institutions required to submit non-financial reports^[38].

However, compared to green finance, the entities and projects supported by transition finance, its compliance, i.e., the color of the entities or activities, is more difficult to define. Transition finance does not simply involve a shift from brown to green, but rather represents a transition from brown to light brown. Determining whether a project qualifies for financial support or how to reduce the cost of support requires more detailed and complex information and professional judgment^[39-41]. In addition, the risk of greenwashing is a major issue for financial support for the transition of high-carbon enterprises. It is increasingly difficult for high-carbon enterprises to obtain financing, so they may resort to greenwashing tactics to secure bank funds. This could involve packaging non-green projects as environmentally friendly endeavors or seeking bank funds under the pretense of equipment modifications aimed at reducing carbon emissions^[10]. Compared with green finance, companies receiving financing for transition projects have more discretion in how they use the funds, and the information disclosure system and related transition finance policies are still not perfect, which means that transition finance lacks supervision from the acquisition to the use of funds, and there is a risk that the funds will be used for non-transition activities^[42]. Therefore, enterprises need to disclose information honestly and accurately in their ESG or social responsibility reports to prove that their transition activities or projects are indeed light brown. Simultaneously, disclosure is also essential for transition financial instruments issued by relevant institutions to prove that the funds raised are indeed directed to light brown projects. In addition, in the case of voluntary disclosure, the source and authenticity of the data are largely unreliable, and it is difficult to control the risk of greenwashing in the absence of third-party audits.

Transition finance disclosure-related practices

Financial institutions are also subject to low-carbon transition requirements. For asset-light service industries that have minimal direct carbon emissions from operations and energy use, it is more important to manage the risks associated with GHG emissions in their portfolios to meet stakeholders' needs and prevent ESG-related reputational risks. Currently, various financial industry associations, regulators, and financial institutions are proactively exploring carbon footprint disclosure for investment and financing portfolios, particularly for transition financial products in high-carbon industries^[43].

Firstly, there are national or regional disclosure requirements in place. The EU Taxonomy and its annexes describe in detail the principles of classification of economic activities and also clarify the climate criteria and transition finance criteria for economic activities^[38]. The Hong Kong Monetary Authority of China has issued a Guide to Climate Transition Finance, which refines ICMA's transition finance principles^[44]. The Financial Services Agency, the Ministry of Economy, Trade and Industry, and the Ministry of the Environment of Japan published Basic Guidelines on Transition Finance, which guides financial assistance for decarbonization and low-carbon transition^[45].

The second aspect pertains to the disclosure requirements set by international organizations. The Climate Bond Initiative (CBI) released Financing Credible Transitions, which put forward an initial framework and five principles for transition finance^[46]. The ICMA released the Climate Transition Finance Handbook, highlighting the issue of information disclosure in climate transition finance activities, and its four

principles of information disclosure for transition bonds have become the main reference framework for the management of similar products internationally^[47]. The G20 Bali Summit adopted the G20 Framework for Transition Finance, which, for the first time, formed an international consensus on the development of transition finance.

The third aspect is the disclosure requirements of some financial institutions. DBS Bank released the Sustainable and Transition Finance Framework and Taxonomy, which points out the four conditions and disclosure requirements that transition finance programs must meet^[48]. Among the Chinese financial institutions, the Construction Bank, Bank of China, and other financial institutions have issued transition finance bonds overseas and disclosed information related to bond raising, investment, and management in accordance with the ICMA framework^[49].

As shown in Table 3, various stakeholders such as the International Financial Industry Association, regulatory bodies, and financial institutions have actively explored aspects related to transformative finance standards, development strategies, and management principles. The core components of these explorations primarily encompass transformative financial goals and pathways aligned with global climate objectives, corporate governance systems for transformative finance, policy frameworks for transformative finance, identification and management of transformative financial risks, innovative development of transformative business activities, and environmental and climate benefits of transformation. Subsequently, this article will draw upon these elements to compare the information requirements of transformative finance with existing transformative disclosure frameworks, particularly with regard to disclosure obligations in the coal-fired power industry.

DISCUSSION

The gap between the requirements of transition finance and existing frameworks

In the area of transition finance, there has also been much discussion on exactly what aspects and granularity of information financial institutions need to assess the credibility of a transition plan. In this regard, steps and recommendations for financial institutions to assess coal phase-out plans for producing entities were mentioned in a public consultation on coal management phase-out in the Asia Pacific conducted by the Asia-Pacific Network of GFANZ. Based on it, the Monetary Authority of Singapore in June 2023 conducted a consultation on coal phase-out criteria under the Asian Taxonomy^[53]. First, to evaluate the credibility of relevant energy transition and coal phase-out commitments and plans at the national level, financial institutions should assess the nature, strength, and stability of the energy sector transition commitments of the government of the country in which the Coal Fired Power Plant (CFPP) is located, as well as the completeness of energy transition planning. At the entity level, attention should be paid to the transition plan as a counterparty as a whole (not only including CFPPs). At the asset level, financial institutions should assess whether financing is needed to accelerate the closure of the CFPP. For the potential climate and economic impacts of the conversion program, financial institutions should be able to assess as accurately as possible the availability and affordability of emission reductions and clean energy alternatives to coal. For financial impacts, financial institutions are required to conduct a comprehensive financial viability analysis of the coal phase-out program. In addition, transparency and accountability of coal phase-out programs should be achieved in accordance with the GFANZ NZTP (Net Zero Transition Plan) framework^[54]. These steps and recommendations comprehensively reflect the core information needs of financial institutions to assess transition projects, subsequently disclosing pertinent information related to transition financial products.

Table 3. Selected principles for financial disclosure in transition

Implementing entity & documentation	Disclosure principles
Subject type: polities EU & transition finance report ^[50]	Transition financial instruments: <ul style="list-style-type: none"> • Should include transition metrics, transition-related (plans and actions) disclosures, and how these (plans and actions) meet the requirements of the EU taxonomy • Should include the use of financial instruments
Hong Kong & navigating climate transition finance ^[24]	Bond issuers: <ul style="list-style-type: none"> • Medium and long-term plans aligned with the Paris Agreement • Constraint(s) on engaging in low-carbon activities with evidence • Technologies and activities for climate transition financing • Measures in place to “do no significant harm” and propose a “do least harm” strategy
Japan & basic guidelines on transition finance ^[49]	Transition bonds: <ul style="list-style-type: none"> • It needs to be throughout the company’s periodic reports, statutory instruments, and other documents, etc. • It should be consistent with the TCFD reporting framework • The sponsor’s explanation of how the climate change strategy contributes to the achievement of the SDGs • The organizational structure overseeing the implementation of the transition strategy, as well as its management process
Subject type: international organization CBI & transition finance for transforming companies ^[45]	Bond issuers: <ul style="list-style-type: none"> • Goals that are aligned with the Paris Agreement • Robust transition plans • Implementation actions • Internal monitoring • External reporting
ICMA & climate transition finance handbook ^[47]	Transition bond issuers: <ul style="list-style-type: none"> • Issuers’ climate transition strategy and corporate governance • Considering environmental elements in the business model • The climate transition strategy should be informed by scientifically based goals and pathways • Transparency of information relating to implementation
G20 & G20 transition finance framework ^[49]	<ul style="list-style-type: none"> • Scientifically based transition plans • Progress towards transition goals at regular and appropriate intervals • Changes in climate data • Corporate governance arrangements • Methods used to measure transition progress and achievement • The KPI performance of the beneficiaries of the transition financing
Subject type: financial institution DBS Bank & sustainable and transition finance framework and taxonomy ^[48]	Transition financial products: <ul style="list-style-type: none"> • Total GHG emissions reduced • Amount of loans committed under the product • Sectoral breakdown of the asset portfolio • Breakdown of financial instruments • Annual third-party certified sustainability report issued
Bank of China, China Construction Bank & transition bond management statement, transition bond framework ^[51,52]	Transition bonds: <ul style="list-style-type: none"> • Climate transition strategy and corporate governance • Scientific and policy consistency of transition objectives • Classification of projects that meet the criteria for transition bond support • Transition bond fund and account management requirements • Transparency arrangements related to transition bonds

For financial services firms, the comprehensiveness and comparability of disclosure frameworks assume heightened significance, given that the initiatives of banks, insurance companies, and asset managers necessitate meticulous scrutiny of all financing and investment portfolios, intricately connected to wider market transition endeavors. Although SLBs (Sustainability-Linked Bonds), Transition Bonds, and other transition finance products already have relatively separate, more stringent and specific requirements for key KPIs during the life of the product, the ex-ante needs of transition finance still require the disclosure framework to be further compatible in terms of technical differentiation, data quality and other aspects.

Financial institutions need to assess and manage issuer credit risk, which calls for the differentiation of transition technologies based on their development stages. However, the current frameworks have limited provisions in this regard. Technologies such as solar photovoltaic (PV) systems, onshore wind turbines and mature hydroelectric power generation, which have been proven in practice to offer good emission reductions and economic returns at stable costs, are less likely to pose additional financial risks during their application, as opposed to technologies that are still in the early stages of application, such as CCUS and hydrogen fuel cells.

Secondly, in terms of data quality, the current disclosure framework predominantly relies on companies' annual disclosures, and there is a greater emphasis on qualitative data rather than quantitative data. Products such as SLBs have shorter durations, a significant portion of which are 2-3 years in duration, and the use of annual disclosure data may have a serious lag in terms of the overall financial assessment of financial institutions before the issuance of the product, and the lack of accuracy of the qualitative data is not conducive to the development of equity and insurance products in the future. Moreover, for the power sector, the current framework focuses more on electricity generation and less on grid expansion, electricity sales and other indirect emissions (Scope 3 emissions) from the companies' value chain. This limitation could result in overlooking significant sources of carbon emissions that are vital to a comprehensive assessment of the sector's environmental impact. For example, the French companies Engie, Electricite de France, E. ON, Exelon, and Enel are significant contributors to the country's Scope 3 GHG emissions from the electricity and utilities sectors^[55].

Third, in addition to entity-level data, financial instruments have an unmet need for specific projects, even asset-level data. For example, if financial institutions need to examine whether an enterprise needs financing to accelerate the closure of a CFPP, they need to estimate the fair value of the coal power plant at the time of the transition through an appropriate methodology. In this context, disclosure of asset-level data, such as the plant's production capacity, ownership structure, sources of financing, and operating costs, would be beneficial to financial institutions and investors as well as to the various stakeholders and even to the enterprise itself. While the KPIs set for coal power companies by transition finance instruments such as SLBs and Sustainability-Linked Loans (SLLs) are generally the average coal consumption of coal supplied for thermal power generation and the amount of electricity substitution (e.g., Datang Power's First Medium-Term Notes for FY2021, sustainability-linked), the verification of qualification for the issuance of the bonds and the loans will involve the calculation of the fair value of the assets, including even the valuation of the stranded assets.

Regulatory arbitrage

As noted earlier, while certain disclosure frameworks clearly defined the scope of their mandatory application, such as the TCFD, which is now part of the regulatory frameworks of many jurisdictions, including the EU, Singapore, Canada, Japan, and South Africa, New Zealand and the UK have set requirements for climate risk disclosure under the TCFD by 2023 and 2025, respectively. The UK's Financial Conduct Authority (FCA) plans to use the TPT to strengthen its transition plan disclosure expectations for listed companies, asset management firms, and regulated asset owners. However, review provisions for multinationals are still missing in the current frameworks, primarily due to inconsistencies in framework requirements across jurisdictions. As regulatory authorities strengthen disclosure standards, large multinational companies might opt to relocate their non-compliant local operations to regions with less stringent requirements (e.g., the UK's TPT framework being more specified and rigorous than the TCFD). This could potentially result in regulatory arbitrage.

For example, Huaneng Hong Kong applies the Climate Disclosure Guidelines issued by the Hong Kong Stock Exchange, but its investment in the 300,000 kW OCGT (open cycle gas turbine with black start) project in Spalding, UK, which is operating in the UK, should also be subject to the more stringent TPT standard, and Huaneng Hong Kong may not choose to parallel the two sets of standards under the premise of non-mandatory disclosure standards. Table 4 summarizes the current disclosure standards adopted by the four large multinationals, and it can be seen that none of them has chosen to apply the TPT standard, even though all of them are involved in local operations in the UK. In addition, many of the large firms that have declared several sets of standards to be in parallel have inconsistencies between the different standards in terms of the units they report using. For example, the four large multinationals in the table above have all adopted the GRI standard, and Wal-Mart has also applied the SASB standard, which expects energy use information to be in GJ, whereas GRI is in MWh.

Such regulatory arbitrage can also occur within the administrative scope of the application of a given disclosure framework. For example, the United States Securities and Exchange Commission (SEC) regulation will only target listed companies, the EU CSRD covers large unlisted companies in addition to listed companies, and disclosure requirements for unlisted subsidiaries are still absent from most existing disclosure frameworks, which leads to an incentive for many coal power companies to sell their high-polluting projects to non-transparent private companies, i.e., to conduct a company-level greenwashing and even use it to obtain inflated ratings in the capital markets. These private companies have an advantage over their public competitors in engaging in environmentally unsustainable activities, thanks to the more lenient regulatory standards to which they are subject.

Given the inconsistencies between different disclosure frameworks and the potential for regulatory arbitrage resulting from the regulatory vacuum for transnational corporations and complex ownership enterprises, it may be necessary to add this component to the TCFD, which serves as the blueprint for most of the new standards, and which will be an inevitable part of a just transition.

Challenges for coal power companies

Short-term concerns of coal power companies are inconsistent with the long-term phase-out requirement under voluntary disclosure mechanisms. Many enterprises, while recognizing net-zero emissions as an opportunity, are suffering from operational problems that make short-term transition more difficult, such as supply chain disruptions, rising interest rates, high energy prices and inflation, and there is a lack of constraints on such short-term choices under some non-mandatory disclosure frameworks.

Businesses exhibit insufficient awareness of climate action. According to the annual corporate assessment report of Carbon Tracker, an independent non-profit organization, none of the 134 high-emission companies surveyed had conducted a climate risk impact assessment^[60]. A survey of 1,200 companies by global climate consultancy South Pole found that a phenomenon known as “green hush” is spreading, with more and more companies choosing not to publicize the details of their climate goals to avoid scrutiny and accusations of greenwashing^[61]. For example, Adaro, Indonesia’s largest coal miner, has been criticized for plans to build a coal-fired power plant for a new aluminum smelter, contradicting the company’s claims of a green transition.

The regulatory frameworks are not sufficiently robust. Compared to Europe and the US, relevant regulations in Asia are mainly incentive-based, e.g., ESG disclosure by companies in Japan is still governed by piecemeal soft laws, and Singapore is also dominated by incentives, with companies’ adoption of TCFD recommendations remaining voluntary. For emerging market countries, especially those with a high

Table 4. Reference framework for disclosure by selected transnational corporations

Transnational corporation	Reference framework
PetroChina ^[56]	Compliance with the Shanghai Stock Exchange Guidelines on Self-Regulation for Listed Companies and the ESG Reporting Guide issued by HKEX. Information disclosure is made with reference to the Recommendations of the TCFD, the Sustainability Reporting Guidance for the Oil and Gas Industry (2020), the GRI Sustainability Reporting Standards (2021), and the Ten Principles of the United Nations Global Compact (UNGC) together with other guidelines
Sinopec ^[57]	In accordance with the Guideline for the Self-Regulatory Supervision of Listed Companies of Shanghai Stock Exchange (SSE) No. 1 - Standardized Operation, the Environmental, Social and Governance Reporting Guide issued by Hong Kong Stock Exchange (HKEX), Ten Principles of the United Nations Global Compact (UNGC), and the criteria of the Global Compact Advanced Communication on Progress, and with reference to the recommendations of the TCFD, the 2021 GRI Universal Standards (GRI Standards) and GRI 11: Oil and Gas Sector 2021
Walmart ^[58]	The GRI standards, SASB, TCFD and the United Nations (U.N.) SDGs
Volkswagen ^[59]	The GRI, the German CSR Directive Implementation Act (CSR-Richtlinie-Umsetzungsgesetz – CSR-RUG), ESG sustainability ratings and stakeholder expectations

This table has been compiled and created by the author.

dependence on coal power, practicing transition program disclosure is particularly challenging due to financial constraints, existing energy infrastructure, and the lack of a clear and consistent policy and regulatory framework^[62].

CONCLUSION

Coal-fired power generation generates a large amount of greenhouse gas emissions, and to achieve the Paris Agreement targets, a net-zero transition of coal power is crucial. Currently, there are two main technological pathways for this transition: complete coal phase-out with a high share of renewable energy as a replacement, or coal power with CCS. However, both pathways involve substantial costs, including stranded costs from retiring coal power plants, costs for flexibility improvements, investments in renewable energy infrastructure, *etc.* To facilitate this transition, social capital and support from the financial market are necessary. However, due to the difficulties of insufficient carbon information disclosure, imperfect frameworks, and dispersed information, the practice of transition finance and related research is lagging behind green finance. Existing transition information disclosure frameworks, such as TCFD, TPT, CA100+, *etc.*, still have gaps in meeting the needs of financial institutions.

Coal power companies should disclose their transition strategies, plans, actions and progress based on the best practices of disclosure frameworks like TCFD. By doing so, investors, regulators, financial product issuers, and other stakeholders are able to assess their transition progress, thereby facilitating the fair pricing of transition finance products and promoting market development. This review has summarized the key components of the main contents of the existing mainstream transition plans disclosure frameworks, compared them from the perspective of information requirements for financial institutions issuing transition finance products, and has provided several insights to further enhance the usability of coal and power enterprises' transition information in the financial sector. (1) Distinguishing the stages of development of transition technologies for coal power companies can assist investors and financial institutions in guarding against the financial risks that may be associated with CCUS, hydrogen fuel cells, and other technologies that are at an early stage of application; (2) Enhance the frequency of data disclosure and increase quantitative disclosure data, which should also emphasize indirect emission projects in the value chain of power sector companies, including grid expansion, electricity sales, and other related emissions; and (3) Strengthening asset-level data disclosure, including the disclosure of specific coal power plant funding sources, capacity, operating costs, *etc.* can help strengthen the credibility of the transition plans, and help investors and financial institutions to enhance their risk control capabilities and prevent greenwashing risks, *etc.* In addition, there are some challenges for coal power enterprises to practice the

existing disclosure framework, including the possible confusion in choosing disclosure standards for enterprises with complex regulatory ownership, the lack of constraints and confidence of enterprises to disclose transition plans under the voluntary disclosure mechanism, and the still limited strength of the regulatory mechanism.

Higher quality disclosure of the transition plan can not only facilitate a credible and fair transition of the coal power sector but also enable the financial sector to develop transition financial products that are deeply integrated with net-zero transition, including financial instruments linked to carbon footprint, sustainable equity, and insurance products that have higher requirements for information transparency. This approach will help establish robust long-term supervisory mechanisms for information disclosure, effectively preventing greenwashing, low-cost capital misuse, and fraudulent information disclosure, thereby addressing various ethical risks. By fully leveraging transition financial tools to attract funds, it can accelerate the low-carbon transformation process for coal-fired power companies.

This review briefly touches upon certain aspects that merit further investigation, such as a more comprehensive examination of the development trajectory of zero-carbon transition information disclosure frameworks and a more in-depth exploration of their consistency. Additionally, it hints at the need to explore the impact of information disclosure on the assessment and development of transition financial products. Future research should be directed towards delving deeper into these areas, focusing on enhancing the comparability of different disclosure standards, and investigating the influence of high-quality information disclosure on risk assessment, pricing, and design of transition financial products. Such future investigations will yield more specific and comprehensive insights.

DECLARATIONS

Authors' contributions

Contributed the central idea, analyzed most of the data, and wrote the initial draft of the paper: Ren Y, Liu Y
Contributed to refining the ideas, carrying out additional analyses, and finalizing this paper: Gao C, Yang X, Yuan J

Availability of data and materials

Not applicable.

Financial support and sponsorship

This work was supported by the National Natural Science Foundation of China (72173043) and the Rockefeller Brothers Fund (21-200).

Conflicts of interest

Yuan J is a Editorial Board Member of the journal *Carbon Footprints*, while the other authors have declared that they have no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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