Assessing the Credibility of Climate Transition Plans in the Power Sector

Discussion Paper

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Executive Summary

The urgency and importance of achieving a net zero transition in the power sector are paramount in limiting global warming to well below two °C above pre-industrial levels. The power sector is the most significant contributor to greenhouse gas emissions, accounting for approximately 36% of global energy-related CO2 emissions (International Energy Agency [IEA], 2021).

However, there is a lack of specific disclosure guidance, actionable and practical transition pathways, and actions that facilitate power firms in realising the net zero transition. This gap in guidance and support inhibits the ability of power companies to navigate the complexities and challenges associated with decarbonisation goals effectively.

As such, many utilities have decarbonisation targets, but only a small percentage are aligned with the necessary carbon budgets. The status of power decarbonisation varies globally, with progress observed in renewable energy generation and declining costs. While many power companies have set decarbonisation targets, progress has been uneven. More reliable commitments and credible actions are needed to achieve net zero.

This paper reviews the existing transition disclosure practices and guidelines for transforming global electricity generation. Moreover, it will explore feasible transition pathways, with a focus on key levers that can help achieve a net zero transition for the power sector. By analysing emission and technology pathways, as well as their credibility and feasibility, our objective is to contribute to the development of a practical and reliable transition framework. A credible transition plan will assist individual power firms and investors in assessing their progress and alignment with their transition plans.

Net zero transition disclosures: essential and beneficial elements

The evolution of the carbon disclosure framework has led to the need for comprehensive reporting standards and actionable efforts to mitigate climate risks. As an illustrative example, the UK's Transition Plan Taskforce (TPT) provides a net zero transition disclosure framework for the power sector.

TPT has identified 19 disclosure sub-elements, and we selected 10 essential elements for the power sector. These elements include setting decarbonisation targets, integrating transition plans into business models, and supporting technology, financial, and governance metrics and actions.

Establishing clear targets over time and understanding their implications can help organisations allocate resources efficiently and plan for the expenditure associated with transitioning to low-carbon technologies and business practices. Detailed emission reduction targets and plan disclosures hold organisations accountable for their part in reducing emissions.

Business operational, financial, and governance metrics and actions are reviewed as the direct actions that lead to tangible progress in achieving net zero transition. Direct actions are absolute requirements for successfully implementing a net zero transition plan and should be built by focusing on critical levers and milestones in transitioning to net zero. These disclosures help stakeholders understand the steps the firm is taking to meet its strategic objectives and assess the company's progress against its stated objectives and priorities.

Engaging with the government and communities, and possessing the necessary skills, competencies, and training throughout the organisation, are beneficial disclosure elements. They can be considered indirect actions required to facilitate the transition. These components can support the entity's strategic ambitions, objectives, priorities, and interim milestones. However, they are not strictly necessary for the core technical and operational changes the power generation company needs to implement to achieve its net zero goal.

Emission and technology transitions pathways

Power companies aiming for net zero emissions should adopt reliable transition pathways, adhere to credible assessment methods, and address challenges related to regional variations, reliability, and consistency. By following the TPT disclosure framework and embracing the necessary elements, power companies can demonstrate their commitment to decarbonisation and contribute to a sustainable future.

The emission transition pathway aligns a planned emission or emission intensity trajectory with a benchmark outlined in the Paris Agreement. It serves as a helpful tool for companies and investors to assess and manage transition risks. However, they are highly context-specific and complex to implement and influenced by the selection of benchmarks, emission scopes, and weighting on indicators. Moreover, incomplete or inconsistent data and disclosures can affect the validity of assessments, and the absence of standardised reporting practices across companies and sectors hampers the accuracy of evaluations.

The IEA NZE 2021 outlines a possible technology pathway for the global electricity sector to achieve net zero emissions by 2050. It identifies several key levers to facilitate this transition, including deployment of clean energy technologies and grid flexibility, phase out of unabated coal and usage of carbon capture, utilisation, and storage (CCUS). It allows power companies to adjust their strategies and alter their energy mix at the asset level and does not rely on the accuracy of carbon emission disclosures.

The emission transition pathway and technology transition pathway could potentially complement each other, delivering a credible analysis of a company's journey to net zero emissions. We encourage power firms to adopt the IEA NZE technology alignment pathway for short-term, medium-term, and long-term energy mix and asset-level fossil fuel retirement planning and to apply emission transition pathway analysis to conduct regular assessments on whether fossil fuel phase-out plant alignment aligns with the benchmark. This involves integrating renewable energy sources like solar, wind, hydroelectric, and geothermal power into their generation portfolios, upgrading existing infrastructure, investing in new power plants or facilities, implementing energy storage solutions, and incorporating smart grid technologies.

Key issues of transitioning to net zero emissions in the power sector

Regional variations highlight the need for tailored net zero transition pathways. While European countries have made significant progress in decarbonisation, many emerging markets face challenges due to their heavy reliance on fossil fuels. National variations in net zero transition commitments and environmental policies create unique challenges and opportunities, necessitating a regional or country-specific approach to net zero transition strategies. Customised strategies, robust policy frameworks, technological innovation, financial mechanisms, and international collaboration are essential for a just and inclusive transition in these regions.

Asset-level data is vital in understanding a company's transition dynamics and assessing its progress towards net zero emissions. This data provides insights into current technologies, capacities, and planned changes, enabling investors to determine the credibility of a company's transition plan and make informed decisions.

Nuclear power, despite contributing significantly to reducing CO2 emissions, faces challenges, including safety concerns, waste management, and a decline in usage in developed economies. Nevertheless, **its potential as a consistent, low-carbon energy source makes it a valuable part of the net zero transition.**

We also emphasise the importance of differentiating between mature and less mature technologies when evaluating power companies and their transition plans. Understanding this distinction helps evaluate the feasibility and challenges associated with their sustainability strategies.

Evaluating power companies' net zero transition requires comprehensive metrics that go beyond generation-related targets. Considering emissions from grid expansion, retail activities, and Scope 2 and 3 emissions provides a more holistic view of environmental impact and promotes transparency and accountability. Additionally, the critical role of investors in driving sustainable transitions is highlighted, with a call for active engagement to ensure alignment with sustainability objectives.

Addressing regional variations, accessing asset-level data, managing challenges associated with nuclear power, considering technology maturity, adopting comprehensive metrics, and fostering investor engagement are crucial for successful net zero transitions in the power sector. These factors contribute to transparency, accountability, and the development of customised strategies that align with sustainability objectives and promote a just and inclusive transition to a net zero future.

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1. Introduction

The urgency of the energy transition has been amplified by the Russian-Ukraine war, which has accelerated efforts to explore sustainable energy sources for long-term energy security. Among various efforts and practices, decarbonising the power sector is the most relevant and critical to achieving the climate goals agreed upon in the 2015 Paris Agreement, as the power sector represents the single largest source of greenhouse gas emissions, accounting for approximately 36% of global energy-related CO2 emissions (IEA, 2021). Additionally, it serves as a foundation for decarbonising other sectors, such as transportation, buildings, and industry. Practical electrification of these sectors requires the generation of electricity from clean sources.

While the global focus on addressing climate change and transitioning to a low-carbon economy drives increased action among nations, including international agreements, national decarbonisation targets, and policies, firm-level decarbonisation implementation makes the real difference in reaching net zero by 2050. The Glasgow Financial Alliance for Net Zero (GFANZ) 2022 defines a net zero transition plan as "a set of goals, actions, and accountability mechanisms to align an organisation's business activities with a pathway to net zero GHG emissions that delivers real-economy emissions reductions in line with achieving global net zero".

Is it possible for a power company to achieve net zero? And if so, what are the credible transition pathways for successful decarbonisation, and what could be credibility assessment methods? This discussion paper aims to address these questions by looking at the status of power decarbonisation, reviewing the current net zero transition assessment methods, discussing the reliable transition pathways and the alignment assessments and action, and identifying the challenges that arise, including regional variations and issues of reliability and consistency.

1.1 Current status of power decarbonisation

Decarbonising the power sector is one of the key strategies for mitigating climate change. While progress has been made in recent years, the current status of power decarbonisation varies significantly between countries and regions.

According to IEA (2021a), global electricity generation from renewable sources (i.e. solar, wind, hydro, and geothermal) increased by 7% in 2020, despite the COVID-19 pandemic. Renewables accounted for more than 28.7% of global electricity generation in 2021.

In addition, Oxford Sustainable Finance Group reports on the changing cost of capital in the energy sector (Zhou et al., 2021, 2023) found that the financing cost of renewable electricity is falling, making it increasingly competitive with fossil fuel-generated electricity.

At the country level, governments worldwide are taking steps to accelerate power decarbonisation. The European Union has been a leader in power decarbonisation, with renewable energy sources accounting for 39% of its electricity generation in Q3 2022 (European Commission, 2022), which is on track to achieve this target of reaching 40% renewable energy by 2030 (International Renewable Energy Agency [IRENA], 2021). In the United States, the picture is more complex. While renewable energy sources accounted for 23% of electricity generation in 2022 (World Economic Forum, 2023[1]), the country still relies heavily on fossil fuels such as coal and natural gas (US Energy Information Administration, 2021). However, there are encouraging signs that the US is moving towards greater decarbonisation, with a record number of coal-fired power plants closing in 2020 (Global Energy Monitor, 2021[2]). China, the world's largest emitter of greenhouse gases, has also made progress in power decarbonisation. The country generated 29% of its electricity from renewable sources in 2020, up from just 5% in 2005 (IEA, 2021). However, China is still building new coal-fired power plants, which could undermine its efforts to reduce greenhouse gas emissions (Carbon Brief, 2021).

At the firm level, many firms in the power sector have taken steps to decarbonise their operations, but the progress has been uneven. Watanabe & Panagiotopoulos (2021) find that 47% of over 400 utilities have a decarbonisation target as of May 2020, but only a small percentage aligned to a well below 2°C carbon budget. The Transition Pathway Initiative (TPI) assessment of the alignment with climate goals documents that 11 out of 80 companies aligned with 1.5°C in 2050 have set targets to reach net zero emissions by 2040 or earlier. In addition, Climate Action 100+ (CA100+) conducted an alignment assessment in 2022 and concluded that despite continued progress on some disclosure indicators, real-world activities do not yet demonstrate any meaningful shifts in business models to align with the Paris Agreement. Based on the current studies on the status of power decarbonisation suggest that we need more reliable commitments and credible actions to reach net zero.

1 World Economic Forum, 2023. A record share of US electricity comes from zero-carbon sources but more work is needed.

2 Global Energy Monitor, 05 April 2021. New Report: Record Coal Plant Retirements In U.S. and EU Offset By China Coal Plant Boom In 2020. https://globalenergymonitor.org/press-release/new-report-record-coal-plant-retirements-in-u-s-and-eu-offset-by-china-coal-plant-boom-in-2020/

1.2 Carbon disclosure framework

1.2.1 Evolution of disclosure framework

The practice of corporate carbon disclosure and net zero transition has evolved significantly over the past two decades as climate change concerns have moved to the forefront of global attention. This evolution began with the launch of Corporate Standards by the Greenhouse Gas Protocol (GHGP) in 2001, which provided the first standardised accounting and reporting framework for greenhouse gas emissions.[3] The publication of Task Force on Climate-related Financial Disclosures (TCFD) recommendations in 2017 has improved the consistency and comparability of climate-related financial disclosures across industries and regions and has brought climate risk and disclosure into the realm of financial risk.[4] The TCFD recommendations are structured around four thematic areas: governance, strategy, risk management and metrics and targets. The four recommendations are interconnected and supported by 11 recommended disclosure suggestions. This comprehensive framework allows companies to detail their approach to climate-related risks and opportunities.

More recently, the introduction of CA100+[5], the Science Based Target Initiative (SBTi)[6] and the UK Transition Plan Taskforce (TPT)[7] has signified a shift in focus from simple disclosure to actionable efforts and impacts to mitigate climate risks. CA100+ has developed ten disclosure benchmarks and aligning corporate actions, ensuring that sizeable corporate greenhouse gas emitters take necessary action on climate change. These actions encompass improving governance around climate change, reducing emissions, and strengthening climate-related financial disclosures, in line with the goals of the Paris Agreement. The goals of CA100+ are for investors engaging with firms to improve climate change governance, reduce emissions and strengthen climate-related financial disclosures, consistent with the goals of the Paris Agreement. The SBTi encourages companies to set targets and provides assessment measures for reducing carbon emissions. These are based on current scientific evidence specific to each sector, with the aim of limiting global warming

[3] https://ghgprotocol.org/about-us

[4] The Task Force on Climate-related Financial Disclosures (TCFD) was launched by the Financial Stability Board (FSB) in 2015, following a request from the G20. https://www.fsb-tcfd.org/about/

[5] https://www.climateaction100.org/

[6] https://sciencebasedtargets.org/how-it-works

[7] https://transitiontaskforce.net/

to well below 2°C. Specifically, it publishes quick guidance for setting science-based targets and highlights some decarbonisation options for electric utilities (SBTi, 2020). The TPT Disclosure Framework builds on the existing transition plan methodologies, guidance and frameworks. It covers climate-related risks and opportunities assessments, emission and target setting, decarbonisation actions, and governance and financial support. It aims to develop the gold standard for disclosing private sector climate transition plans in the UK and beyond.

1.2.2 UK Transition Plan Taskforce (TPT)

After a review of the carbon disclosure initiatives outlined above, we have chosen the TPT as the foundation for the net zero transition disclosure framework in the power sector. The reasons for this selection are as follows:

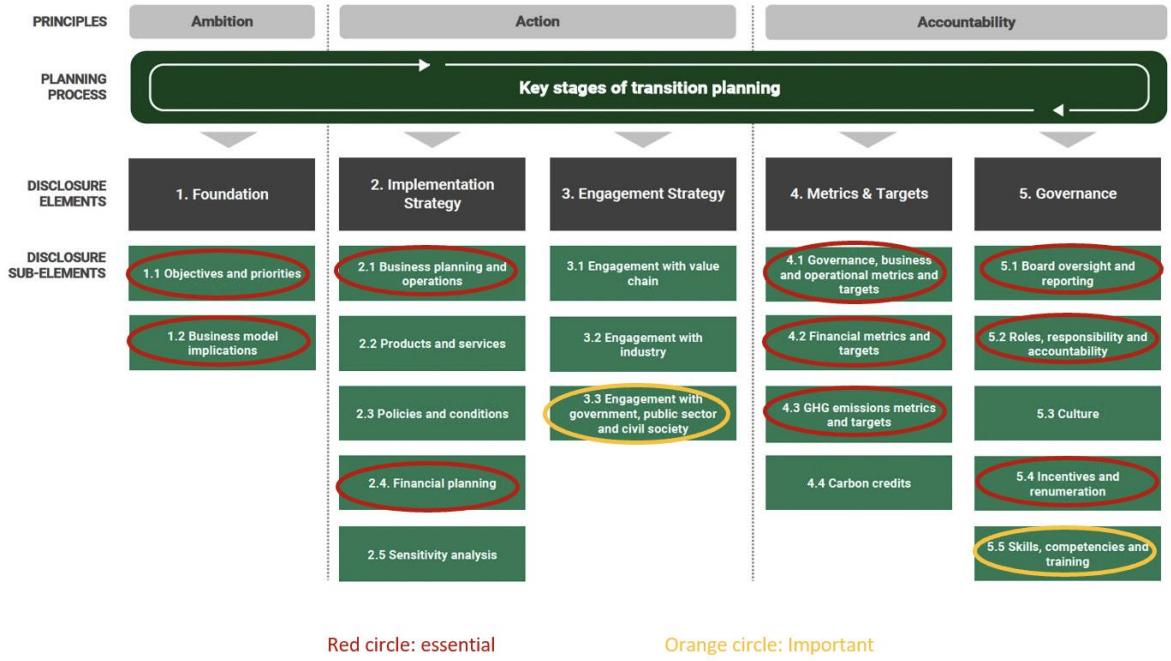
- The TPT framework builds upon international disclosure standards, including the TCFD recommendations and the International Sustainability Standards Board (ISSB) guidance, and provides greater granularity about what transition plans should encompass. It is developing international net zero transition disclosure standards specifically for the power sector, following the ISSB's guidelines for Electric Utilities & Power.
- The Financial Conduct Authority has been working closely with the TPT and is expected to integrate its vision into regulatory guidelines by the end of 2023 or the start of 2024.[8]
- The core indicators in CA100+ are also covered in the TPT framework.

TPT disclosure framework is structured around five key elements – Foundation, Implementation Strategy, Engagement Strategy, Metrics and Actions, and Governance – that reflect the main components of a transition plan as suggested by the GFANZ[9]. Expanding on this framework, the TPT recommends disclosures related to 19 Sub-Elements, which are concisely illustrated in Figure 1. We consider the elements highlighted in red as the most crucial and mandatory disclosures in the power sector. Meanwhile, the elements highlighted in orange are beneficial but not essential disclosures.

8 Financial Times, 18 July 2022. UK aims to set the pace for corporate net zero plans.

9 The components and themes are aligned with GFANZ recommendations for financial institutions. (GFANZ, June 2022 – updated November 2022. Recommendations and Guidance on Financial Institution Net-zero Transition Plans

Figure 1. TPT disclosure framework



Essential disclosure elements

1. Foundation

1.1 Ambitions/targets

- It is essential for power firms to set interim and long-term decarbonisation objectives/targets over time across emissions Scopes 1, 2 and 3 and the priorities and milestones used to measure progress.

By integrating carbon reduction targets and a priority plan, organisations can develop a comprehensive and focused approach to their net zero transition.

- Defining clear targets provides a specific goal for companies, governments, and organisations to aim for, fostering a shared vision for carbon reduction.
- Setting targets holds organisations accountable for their part in reducing emissions. They can also promote transparency, as stakeholders can see whether entities meet their commitments.

- Establishing clear targets can help organisations allocate resources efficiently and plan for the costs associated with transitioning to low-carbon technologies and practices, thus ensuring long-term financial viability.

1.2 Business models implications

It is essential for power firms to summarise how they will integrate the strategic ambitions of their transition plan into the business model, highlighting the key implications for increasing renewables capacities, technology upgrades, fossil fuel retrofitting, and phase-out.

Implementing a net zero transition plan can have profound implications on the business model of power firms. By considering and disclosing these business implications, power firms can better manage the transition to a net zero emissions model while maintaining stakeholder trust and meeting their broader corporate responsibilities.

- Transitioning to a net zero carbon business model may require significant changes in power production, distribution, and consumption processes. It may involve adopting new technologies such as renewable energy sources, improving energy efficiency, or implementing carbon capture and storage. These changes can significantly affect the company's operations, workforce, supply chain, and communities.
- The transition to net zero can involve substantial capital expenditures for new infrastructure, technology, and equipment, along with changes in operational costs. These financial factors should be incorporated into the business model to ensure the company remains profitable during and after the transition.

2. Implementation strategy

2.1 Business planning and operation

Disclose the roadmap of short-, medium- and long-term actions the entity will take to deliver on the strategic ambition in its transition plan and achieve its stated objectives and priorities, such as details of key planned changes to its business strategy and resource allocations, plans for carbon energy-intensive assets, including:

- Plans and timelines for retrofitting fossil fuel assets before 2025
- Plans and timelines to phase out fossil fuels assets and site rehabilitation
- Plans and timelines to increase renewable capacities and related infrastructure constructions.

Disclosure of business planning and operations during a net zero transition is a key aspect of responsible corporate behaviours, aiding power firms in managing risks, complying with regulations, attracting investment, and earning the trust of stakeholders.

- By integrating net zero targets into business planning, companies can align their strategic decisions, operational processes, and investment priorities with these goals. This alignment helps ensure consistency and effectiveness in achieving these targets.
- Climate change and the global transition towards a low-carbon economy present substantial risks to the power sector, including physical, transition, and regulatory risks. By integrating net zero targets into their business planning and operation, power companies can better manage these risks.
- Transitioning to net zero emissions often involves significant capital expenditure, for example, investing in renewable power generation or carbon capture and storage technologies. By integrating these investments into their business planning, power companies can better manage their financial performance and investor relations.

2.4 Financial planning

Disclose the financial implications of the planned changes to the entity's business strategy and resource allocations, including financial plans and investments.

- Disclose information on how a power firm expects its financial position and performance to change over time to meet the emission targets and enable entity-level decarbonisation.
- CAPEX planning to support the investment in renewable power generation and storage.
- R&D planning for climate solutions and technology innovations.

Decarbonisation within a power company requires detailed financial planning. This ensures that a power firm's transition to net zero is strategically sound, financially viable, and attractive to investors.

- Power firms may need to invest in renewable energy sources, energy-efficient equipment, and carbon capture technologies. Financial planning is essential to budgeting these expenses and securing the necessary funding.
- Transitioning to net zero can lead to changes in operational costs and affect a power firm's profitability. Financial planning assists firms in managing these cost fluctuations, assessing the financial viability of their transition plan, and making necessary adjustments to ensure long-term profitability.

- Various financing opportunities are available for firms transitioning to net zero, such as green bonds and climate finance. Financial planning can help firms identify and take advantage of these opportunities.

4. Metrics and targets

4.1 Governance, business operational metrics and targets

Disclose business, operational, and governance metrics and targets used by the entity and report the progress of their transition plan.

- Ownership of fossil fuel power plants
- Retrofitting coal-fired power plants to co-fire with ammonia by 2030
- Retrofitting gas turbines to co-fire with hydrogen by 2030
- Actions required to phase out all subcritical coal-fired power plants by 2030 (870 GW existing plants and 14 GW under construction)
- Actions required to phase out all unabated coal-fired plants by 2040
- Actions required to phase out sizeable oil-fired power plants in the 2030s
- The metric used to assess progress towards reaching the above targets

4.2 Financial metrics and targets

Disclose the financial metrics and support to enable the transition plan

- CAPEX in expanding low carbon capacity in line with emission reduction targets
- CAPEX in retrofitting existing coal-fired plants in line with emission reduction targets
- R&D Investment in renewables capacity in line with emission reduction targets
- R&D Investment and CAPEX in the set of energy storage technologies in line with emission reduction targets

4.3 GHG emissions metrics and targets

Disclose the GHG emission metrics and targets and how these reflect the objectives and implementing strategies

- Absolute gross GHG generated during report time, including Scope 1, 2 and 3 emissions
- GHG emission intensity for each scope and per unit power generation (kWh)
- Asset-level emission disclosure
- Total emission reduction target for Scopes 1 and 2 and by unit power generation
- Emission intensity reduction target for Scopes 1 and 2 and by unit power generation

Disclosing governance, business, financial and emission metrics, and targets by power firms is essential for increasing transparency, accountability and investor confidence.

- Disclosing governance, business, and operational metrics and targets help stakeholders understand the steps the firm is taking to meet its strategic ambitions and objectives. This transparency can help build trust with these groups.
- Disclosing financial metrics related to climate objectives provides an indication of a company's risk exposure related to climate change. This information can help investors and other stakeholders assess and mitigate the potential financial and operational risks associated with climate-related impacts on the company.
- Disclosing GHG emissions metrics and targets can show how the company translates these ambitions and objectives into measurable outcomes. This can reinforce stakeholders' confidence in the company's ability to achieve its strategic goals and contribute to broader societal objectives like mitigating climate change.
- Disclosing these metrics and targets can help create a sense of accountability, as stakeholders can track the company's progress against its stated objectives and priorities. It puts pressure on the firm to follow through with its commitments and facilitate progress.
- Disclosures enable comparison across the sector. They allow stakeholders to benchmark the performance of different power firms against each other, promoting a culture of best practices and continuous improvement.

5. Governance

5.1 Board oversight and reporting

Disclose the arrangements for board-level governance of the transition plan, board-level review, approval of the plan, and oversight of monitoring and reporting progress.

5.2 Executives' role, responsibility and accountability

Disclose senior management roles and responsibilities for the execution of the transition plan, as well as the entity's broader control, review and accountability mechanisms.

5.4 Inventive and remuneration

Disclose the arrangement to align executive remuneration and incentive structures with the transition plan.

Proper governance mechanisms, including clear responsibilities and accountabilities at the executive level, board oversight, and incentives and remuneration, play a crucial role in the process of net zero transition.

- A transition to net zero emissions requires a substantial shift in business operations, strategic planning, and investment decisions. Having top executives and board members commit to this goal sends a powerful message to the rest of the organisation and its stakeholders about the company's seriousness in tackling climate change.
- Clearly defined roles and responsibilities help ensure accountability.
- Aligning executive incentives and remuneration with climate goals can motivate management to work towards achieving these targets.

Beneficial disclosure elements

3. **Engagement strategy**

3.3 Government, public sector and civil society

Engagement with the government, public sector and civil society is an important component to support the entity's strategic ambition and objectives, priorities and interim milestones.

While engagement with the government and the public sector ensures alignment with policy trends, regulations, and incentives, which can facilitate the net zero transition, such engagement can be viewed as an 'important' rather than an 'essential' factor; this is because these engagements are not strictly necessary for the core technical and operational changes that the power generation company needs to make to achieve its net zero goal. Theoretically, the company could reach net zero emissions through internal changes alone, though the journey might be more challenging and receive less public support.

5.5 Skills, competencies and training

Power firms need to describe how they ensure that the firm has the appropriate skills, competencies and knowledge across the organisation to effectively design, develop and deliver the transition plan. The transition to net zero is complex and requires significant changes in technology, operations, and strategy. Having a workforce with the necessary skills and competencies can increase the likelihood of successful implementation. Thus, disclosing such information can demonstrate a power firm's commitment to the transition and allow stakeholders to understand and assess the firm's capacity to execute the transition effectively.

Although these benefits are substantial, the disclosure of skills, competencies, and training related to climate change might not be seen as essential because such disclosures are not yet a regulatory requirement in many jurisdictions and might not be material information for all firms in the power sector, depending on their specific context and strategy. Therefore, while it is beneficial for power firms to disclose this information, it is not an absolute requirement to successfully implement a net zero transition plan.

1.3 Net zero transition assessments

Transition pathway analyses provide scenarios and roadmaps for transitioning to a low-carbon and sustainable energy system. These analyses assess the potential pathways, policies, and technologies needed to achieve specific climate and energy goals at various levels. At the global level, the Intergovernmental Panel on Climate Change (IPCC) regularly publishes assessment reports that include transition pathway analyses. These reports provide scientific assessments of climate change and offer scenarios and pathways for achieving global climate targets, including the transition to renewable energy sources. The IEA outlines transition pathways to a sustainable energy future and provides insights into the required policy measures, investments, and technologies to achieve specific energy and climate goals. In addition, IRENA provides an in-depth analysis of renewable energy transition pathways at the global, regional, and national levels.

At the national level, many countries have developed their own energy transition plans, outlining pathways and strategies for transitioning to low-carbon energy systems (Appendix Table 1). These plans assess the current energy landscape, set goals for renewable energy deployment, and identify policy measures and investments required for the transition. These national analyses provide tailored transition pathways and strategies that align with regional energy needs and opportunities.

Industry-Specific Transition Pathways are also conducted for specific sectors, such as power generation and transportation and assess the potential technologies, policy interventions, and investment needs to transition to low-carbon alternatives within each sector. These analyses provide valuable insights and inform decision-making processes to support the transition to a sustainable energy future. This study focuses on the transition pathway analysis designed for individual firms.

1.3.1 Scenarios of net zero transition

A net zero transition scenarios refer to pathways through which an economy or entity reduces its greenhouse gas emissions to net zero. The scenario of net zero transition involves various assumptions, including 1) the assumed rate of technology development and cost of low-carbon technologies; 2) the introduction and enforcement of policies promoting decarbonisation is a common assumption; and 3) the changes in consumption patterns, lifestyle, economic growth, and societal choices towards more sustainable practices. These scenarios vary depending on the pace of the transition, the technologies employed, the level of international cooperation, and the sector-specific strategies and can be broken down broadly into three types: business-as-usual scenarios, moderate transition scenarios, and aggressive transition scenarios.

The business-as-usual scenarios typically assume that current policies and practices continue with little change. They often lead to a significant rise in global temperatures, exceeding the target set in the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels (IPCC, 2018). Aggressive transition scenarios envision a rapid and comprehensive transition to a net zero economy. They often involve extensive changes to energy systems, land use, transportation, and other sectors, with net zero emissions achieved well before 2050 (Rockström et al., 2017).

The most widely used scenarios are Moderate transition scenarios which assume some increase in the pace of transition, with greater emphasis on renewable energy, energy efficiency, and carbon capture. These scenarios likely lead to net zero emissions by the mid-to-late century. The IPCC and IEA outline several pathways to limit global warming well below 2°C, which require net zero CO2 emissions by around 2050 and concurrent deep reductions in emissions of non-CO2 forcers. These pathways vary in terms of reliance on energy demand reduction, the pace of energy transition, the extent of societal and systems changes, and dependency on Carbon Dioxide Removal (CDR) measures (IEA, 2020, 2021b; IPCC, 2018).

Using these scenarios as benchmarks involves comparing planned or actual emissions and energy mix to the trajectories outlined in these scenarios. This allows policymakers and businesses to identify areas where they are on track or falling behind and make necessary adjustments. For instance, a country or an entity might find that its renewable energy deployment is slower than outlined in the IEA scenario, indicating a need for more aggressive policies or incentives.

These scenarios provide a roadmap, but reaching the destination of a net zero power sector will require commitment, investment, and concerted action across many sectors of society. In the next section, we will look into details about how the scenarios have been used in net zero transition assessments.

1.3.2 Transition Pathway Initiative assessment of net zero transition

The Transition Pathway Initiative (TPI) is an investor-led initiative that assesses and encourages companies' transition to a low-carbon economy. The TPI Carbon Performance assessment is based on the Sectoral Decarbonization Approach (SDA). The SDA translates international greenhouse gas emissions targets, such as those outlined in the Paris Agreement, into benchmarks that compare individual companies' performance.

It evaluates the emissions performance of companies and their strategies, actions, and performance concerning the transition to a low-carbon future. TPI's transition pathways analysis focuses on two key elements:

- Management Quality: TPI evaluates the governance and management of climate-related risks and opportunities within a company. This includes examining the company's board oversight, executive incentives, and integration of climate-related factors into decision-making processes.
- Carbon Performance: TPI assesses the carbon performance of companies, analysing their greenhouse gas emissions trajectory and alignment with climate targets. This includes evaluating emissions intensity, progress in emissions reduction, and alignment with the goals of the Paris Agreement. In the electricity utilities sector, the specific measure of emissions intensity is greenhouse gas emissions per unit of electricity produced, in units of (metric) ton of CO2 equivalent per megawatt hour. This specifically covers emissions from the electricity generation process.
- TPI utilises various data sources, including company disclosures, public data, and third-party research, to assess companies' performance against these metrics. The analysis results in a rating that allows investors to compare companies' climate performance within their respective sectors. By highlighting leading and laggard companies, TPI encourages dialogue and collaboration between investors and businesses to accelerate the transition to a low-carbon economy. The transition pathways analysis provides investors with actionable information to make informed investment decisions and engage with companies to drive positive change.

Advantages

- Using the SDA and sector-specific benchmarks, the TPI's carbon performance assessment allows for evaluating individual companies' performance in relation to international emissions targets and the progress of an average company in their sector.
- TPI assess management quality and carbon performance separately. Management Quality assessment focuses on processes, while carbon performance focuses on decarbonisation ambition/commitment. Together they are intended to provide a comprehensive view of companies' progress on the low-carbon transition. In this way, firms with low-carbon performance could learn from their lead peers by improving their carbon management systems and processes.

Disadvantages

- TPI explicitly covers emissions from the electricity generation process. In most cases, these emissions constitute the firm's Scope 1 emission. While this measure covers most power-sector emissions, it may be a narrow measure for companies engaged in activities beyond electricity generation, such as distribution or retailing of electricity or other sectors like gas distribution/retail.
- TPI derives emissions intensity paths for companies using their self-reported emissions and activity data. This means that the accuracy of companies' paths depends on their disclosures' accuracy. Estimating emissions intensity involves making assumptions, so it is important to note that in some cases, the emissions path drawn by TPI is an estimate based on disclosed information rather than the companies' own estimate or target.

1.3.3 Assessing Low-Carbon transition approach of net zero transition

The Assessing Low-Carbon Transition (ACT) Initiative aims to develop methodologies and indicators to assess how ready an organisation is to transition to a low-carbon economy and whether they align with the Paris Agreement's goals. It is sector-specific and designed to evaluate a company's current and future ability to reduce its climate impact and assess companies' alignment with the low-carbon transition by considering quantitative and qualitative indicators. The initiative takes into account both direct emissions and indirect emissions linked to a company's products and services. It provides a transition pathway analysis to evaluate a company's current and future ability to reduce its climate impact and assess companies' alignment with the low-carbon transition by considering both quantitative and qualitative indicators. The ACT rating is based on performance (alignment measured with KPI), narrative and trend.

The ACT methodology for the Electric Utilities sector focuses on the following indicators:

- **Targets:** This metric gauge the extent to which a company's emissions reduction target aligns with its decarbonisation pathway. The indicator determines the discrepancy between the company's target and its decarbonisation trajectory as a percentage, termed as the company's commitment gap.
- **Material investments:** This metric assesses how well the company's recent trends in emissions intensity align with its decarbonisation pathway. The indicator will contrast the rate of this trend over the five years leading up to the reporting year with the expected trend of the decarbonisation pathway for the five years following the reporting year.
- **Intangible investments:** This metric measures the proportion of R&D investments allocated towards technologies relevant to emissions reduction.
- **Climate action management:** This step evaluates a company's strategy and management quality. It assesses whether a company has a forward-looking vision compatible with the goals of the Paris Agreement and whether it is backed by an operational management approach.
- **Policy engagement:** It assesses whether a company is working with its stakeholders, including suppliers and policymakers, to advance low-carbon objectives.
- **Business model alignment:** This examines the company's alignment with the low-carbon economy, including the development of low-carbon and energy-efficient products and services.

Advantages of the ACT approach

- ACT employs a dynamic emission intensity analysis approach. It takes into account the company's past, present, and future performance, ensuring that the firm's forward-looking low-carbon strategy is consistent with its past and present performance.
- It combines both quantitative and qualitative indicators to estimate a firm's climate performance score.

Disadvantages of the ACT approach

- The ACT methodology combines multiple dimensions from past carbon performance scores and forecasts of future emission intensity changes, to data collection and analysis and key narrative assessments. This complexity can make it challenging for power firms to understand and implement effectively.
- ACT also depends on self-reported and detailed emissions and activity data, which may not always be readily available or accurately tracked by all organisations. This could lead to gaps or inaccuracies in assessment results. For power sector companies, gathering

this data can be time-consuming and complex. This is particularly challenging for companies operating in multiple jurisdictions with different reporting standards.
- The weighting ratio ACT uses for different indicators may not accurately reflect their importance in facilitating the energy transition. Changes in these weights could result in different performance ratings.

2 Emission and technology transition pathways

2.1 Emission transition pathways

The emission intensity transition pathway analysis provides a standardised method to evaluate how companies are advancing towards achieving net zero emission status – a target that is widely recognised as critical in combating climate change (Rogelj et al., 2016). Companies that are lagging in the transition to a low-carbon economy could be exposed to various risks, including those associated with stranded assets and regulatory changes (Carney 2015). As such, emission transition pathway analysis serves as an essential tool for companies and investors to assess and manage transition risks.

2.1.1 Comparative analysis of existing creditability assessments solutions and applications

The TPI and ACT offer valuable insights and tools to companies, investors, and policymakers, guiding the shift towards a low-carbon economy. They do this by evaluating their greenhouse gas emissions and their strategies for reducing these emissions. Although the two frameworks have some commonalities, they also have some distinct aspects and concerns in their creditable assessments and implementation.

Commonalities

- Both ACT and TPI frameworks are underpinned by an understanding of the science-based targets, the 2° scenario of the Paris Agreement.
- Both frameworks have methodologies tailored for the power sector, recognising that this sector's decarbonisation is critical to achieving climate targets.
- Both initiatives employ quantitative and qualitative analyses to evaluate companies' transition plans for alignment with global climate targets. For quantitative analysis, they utilise the emission intensity transition pathway. The qualitative analysis focuses on

companies' governance and strategic approaches towards climate change, encompassing target setting and risk management.

Issues associated with their creditability assessments and implementation:

- The emission transition pathway is highly context-specific, subject to geographical location and national emission reduction strategies. Therefore, transition pathway analysis should correspond with national net zero transition targets and pathways. Where the national net zero transition pathway is absent, the companies can use scenario analysis to understand the potential impacts of various climate and policy outcomes. Meanwhile, they can develop new, low-carbon technologies and business models to prepare for alignment with industry and international benchmarks.
- The emission intensity analysis is influenced by the selection of benchmarks and the choice of emission scopes and weighting on indicators, which can result in divergent assessments of the same company. For instance, a power company with high current emissions might still score favourably under the ACT Initiative if it possesses a comprehensive transition plan towards low-carbon technologies, yet could receive a less favourable evaluation under the TPI's carbon performance assessment.
- Both initiatives are constrained by the availability and quality of companies' disclosures. Incomplete or inconsistent data can affect the validity of assessments. The absence of standardised reporting practices, along with data inconsistencies across companies and sectors, further hampers the accuracy of these evaluations.

What is still missing:

- Both frameworks largely rely on companies' self-disclosed information. There is a need for more robust third-party verification of companies' claims to ensure their accuracy.
- **There is a lack of analysis and explanations that link quantitative emission intensity transition milestones with their enabling actions (such as governance, financial, and business operations) that facilitate emission reduction and net zero transitions.** For instance, In the text analysis, TPI analysis indicates that 63 electricity firms meet the requirements of management quality levels 3 and 4. This suggests that these firms have integrated their transition plans into operational decision-making (level 3) and have strategic assessments in place (level 4). However, in the emission intensity analysis, only 43 firms align with the below 2°C scenario.

- These tools mainly focus on large corporations, often leaving out small and medium enterprises (SMEs) that also contribute to global emissions. There's a need for these frameworks also to include SMEs in their assessments.
  Both frameworks mostly focus on emissions from power generation. A comprehensive analysis of Scope1+2+ 3 emissions across the value chain is still lacking in the power-sector assessments.

2.1.2 Benchmark selections and their implications

This section compares the differences in emission intensity analysis between TPI and ACT, as outlined in Table 1. Notably, both analyses employ a sector-specific decarbonisation approach for carbon performance assessment and concentrate on the carbon intensity of electricity generation. However, the benchmarks they align with differ slightly. TPI employs benchmarks aligned with a 1.5° scenario, below a 2° pathway, and a national pledges scenario, thereby offering varying levels of ambition. In 2021, TPI found that 15% of electricity companies are aligned with 1.5°C in 2050, and 25% are aligned with 1.5°C in 2030[10].

In contrast, ACT utilises a single benchmark that aligns with the Paris Agreement's "well below 2 degrees" (IEA ETP 2DS) (ACT, 2019)[11]. This choice is made because it falls within a relatively narrow envelope compared to other scenarios in the power generation sector.

Choosing different benchmarks can lead to variations in how companies are rated and compared. Some benchmarks might be more stringent or lenient, yielding divergent outcomes. **The implications vary when companies use different benchmarks:**

- Different benchmarks can lead to different conclusions about a company's readiness for the low-carbon transition. This can impact investment decision-making, as investors may prioritise different aspects of a company's transition readiness.
- The benchmarks used can influence a company's business strategy for the low-carbon transition and what actions companies prioritise. For example, a benchmark emphasising current emissions might lead companies to focus on immediate reduction actions, while a benchmark focusing on future emissions could encourage

10 TPI, 2021. Management Quality and Carbon Performance of Energy Companies: November 2021 Update.

11 ACT benchmark selection of “well below 2 degrees” (IEA ETP 2DS) is referenced from its 2019 methodology report for Electricity (ACT, 2019). It is important to note that the benchmark may be updated by the time of publication of this report.

companies to prioritise long-term transition strategies. Companies need to align their strategies with the benchmarks that are most relevant to their sector or most recognised by their stakeholders.

- Using different benchmarks can make it more difficult to compare companies' performances. This could make it harder for stakeholders to hold companies accountable for their transition efforts.

In summary, the emission intensity pathway has its limitations and should be used in conjunction with other assessment tools. There is a clear necessity to connect emission intensity analysis with actionable strategies that facilitate a transition pathway. The technology transition pathway is ideally positioned to cater to this requirement, given that:

1. **It directly determines emission intensity within the realm of actual business operations and**
2. **It forms an integral component of low-carbon transition planning and strategy.**

Table 1. The emission intensity transition alignment assessments

	Carbon performance assessment method	Scope of emission	Carbon performance measure	Benchmarks
TPI	Sectoral Decarbonization Approach (SDA)	Scope 1	Carbon intensity of electricity generation	Update of benchmark in Nov 2021 • 1.5° scenario (IEA's Net Zero by 2050 scenario) • Below 2° scenario (IEA's 2020 Sustainable Development scenario) • New National Pledges scenario (IEA's 2020 Stated Policies scenario)
ACT		Scope 1+2		Emission intensity benchmark • IEA ETP 2DS R&D benchmark • Ecofys-WWF[12]

[12] Ecofys & WWF, 2010. The Energy Report: 100% renewable energy by 2050.

2.2 Technology transition pathways

Realising the transition from fossil fuels to renewable forms of energy requires credible, feasible and assessable net zero transition pathways. The IEA published a landmark report in 2021 titled "Net Zero by 2050: A Roadmap for the Global Energy Sector". This report provides a comprehensive plan to transition the global energy sector to net zero emissions by the middle of the century, in line with the Paris Agreement's goal to limit global warming to 1.5°C. It outlines a possible pathway for the global electricity sector to achieve net zero emissions by 2050 while ensuring stable and affordable energy supplies, providing universal energy access, and enabling robust economic growth.

In this section, we will use this report as the basis of the technology transition pathway analysis. We first explain the key levers in transforming global electricity generation and then discuss how firms could apply these transitional levers in their business strategies and portfolio investments to achieve the net zero target.

2.2.1 Key milestones in net zero transition in the power sector by 2050

Decarbonisation in the power sector hinges on the swift implementation of low-carbon electricity generation technologies, alongside advancements in storage, demand-control management, and investments in transmission. IEA (2021) identifies key levers to support the power sector's climate transition based on recognised science-based pathways that trace possible global and regional trajectories (Figure 2).

- **Expanding low-carbon power generation**

  The IEA's scenario requires a significant increase in renewable energy generation. Global generation from renewables is expected to nearly triple by 2030 and increase eightfold by 2050, raising their share in total output from 29% in 2020 to over 60% in 2030 and nearly 90% in 2050.

  - Solar photovoltaic (PV) and wind are set to become the leading sources of electricity globally before 2030, with each generating over 23,000 TWh by 2050, about 90% of all electricity produced in 2020. Pairing battery storage systems with solar PV and wind enhances power system flexibility and maintains electricity security.
  - These systems are complemented by demand response for short-term flexibility and hydropower or hydrogen for long-term flexibility. Hydropower, currently the largest low-carbon electricity source, is projected to double by 2050 in net zero emissions.

- Generation using bioenergy, whether in dedicated plants or as biomethane through gas networks, is expected to double by 2030 and increase almost fivefold by 2050.
- Nuclear power is another non-emitting energy source the IEA identifies as crucial to achieving net zero emissions. However, public acceptance and high costs are significant barriers to the expansion of nuclear power.

- **Phasing out coal and minimising natural gas**

In the IEA's pathway, the global use of unabated (not reduced or offset) fossil fuels in electricity generation need to be significantly reduced.

- Coal-fired generation without carbon capture is decreased by 70% by 2030, with a complete phase-out in advanced economies and in all other regions by 2040. Large-scale oil-fired generation will be phased out in the 2030s.
- Electricity generation using natural gas without carbon capture initially increases, replacing coal, but begins to decrease by 2030 and is 90% lower by 2040 compared to 2020. Natural gas use in electricity generation remains a part of the power sector mix due to its utility in balancing grids and supplying energy during periods of low renewable generation.

- **Retrofitting existing coal and gas-fired power plants' capacity with carbon capture, utilisation and storage (CCUS) or co-firing high with hydrogen-based fuels**
  Even with a massive ramp-up of renewables, the IEA recognises that some emissions will be unavoidable. According to IEA, fossil fuels generate 900 TWh of electricity in 2030 and 1,700 TWh in 2050.
  - CCS technology, which captures CO2 emissions and stores them underground, can help to offset these emissions.
  - In addition, future gas turbines will be capable of co-firing with high levels of hydrogen. Although the investment required to co-fire hydrogen-based fuels appears to be modest, the relatively high fuel costs suggest this approach is best suited for supporting power system stability and flexibility rather than bulk power generation.
- **Enhancing Infrastructure construction**
  - Power companies can modernise their grid infrastructure and incorporate smart grid technologies. This enables better integration of renewable energy sources, improved grid management, and enhanced flexibility. Grid modernisation

facilitates the integration of intermittent renewable sources and enables efficient demand response mechanisms.

- Companies should also increase investment in energy storage technologies, like batteries and grid enhancements, to accommodate a more decentralised and variable energy supply.

Figure 2. Key milestones in transforming global electricity generation identified by IEA

Category	
Decarbonisation of electricity sector	• Advanced economies in aggregate: 2035. • Emerging market and developing economies: 2040.
Hydrogen-based fuels	• Start retrofitting coal-fired power plants to co-fire with ammonia and gas turbines to co-fire with hydrogen by 2025.
Unabated fossil fuel	• Phase out all subcritical coal-fired power plants by 2030 (870 GW existing plants and 14 GW under construction). • Phase out all unabated coal-fired plants by 2040. • Phase out large oil-fired power plants in the 2030s. • Unabated natural gas-fired generation peaks by 2030 and is 90% lower by 2040.

Category	2020	2030	2050
Total electricity generation (TWh)	26 800	37 300	71 200
Renewables			
Installed capacity (GW)	2 990	10 300	26 600
Share in total generation	29%	61%	88%
Share of solar PV and wind in total generation	9%	40%	68%
Carbon capture, utilisation and storage (CCUS) generation (TWh)			
Coal and gas plants equipped with CCUS	4	460	1 330
Bioenergy plants with CCUS	0	130	840
Hydrogen and ammonia			
Average blending in global coal-fired generation (without CCUS)	0%	3%	100%
Average blending in global gas-fired generation (without CCUS)	0%	9%	85%
Unabated fossil fuels			
Share of unabated coal in total electricity generation	35%	8%	0.0%
Share of unabated natural gas in total electricity generation	23%	17%	0.4%
Nuclear power	*2016-20*	*2021-30*	*2031-50*
Average annual capacity additions (GW)	7	17	24
Infrastructure			
Electricity networks investment in USD billion (2019)	260	820	800
Substations capacity (GVA)	55 900	113 000	290 400
Battery storage (GW)	18	590	3 100
Public EV charging (GW)	46	1 780	12 400

Note: GW = gigawatts; GVA = gigavolt amperes.

2.2.2 Application of IEA transition pathway

A technology transition pathway for a power company typically signifies a shift from traditional, fossil fuel-based energy sources towards cleaner and more sustainable alternatives. Building on the IEA transition roadmap approaches and transition levers in the power sector, we encourage power firms to adopt the IEA technology alignment pathway for short-term, medium-term, and long-term energy mix and asset-level fossil fuel retirement planning. This transition involves integrating renewable energy sources like solar, wind, hydroelectric, and geothermal power into their generation portfolios, upgrading existing infrastructure, investing in new power plants or facilities, implementing energy storage solutions, and incorporating smart grid technologies.

Technology alignment pathway: firm-level energy mix assessment following IEA Net Zero by 2050 roadmap.

- The technology mix (60%): renewables vs fossil fuel – short-term target (2023–2030)
  - Reduce the share of unabated coal in total power generation to 8%
  - Reduce the share of unabated gas in total power generation to 17% by 2030
  - Oil & gas and coal plants retrofitting plan and CCS plan by 2025
  - Coal phase-out planning by 2030 in the developed markets
  - Capital expenditure/allocation in increasing renewables capacities to 61% by 2030
  - Regular emission intensity assessment on whether fossil fuel phase-out plant alignment aligns with 1.5°C benchmark
- The technology mix (80%): renewables vs fossil fuel – medium-term target (2031–2040)
  - Coal phase-out plan by 2040 in the developing markets
  - Reduce the share of unabated gas in total power generation to less than 10% by 2030
  - Capital expenditure/allocation in increasing renewables capacities to 75% by 2030
  - Regular emission intensity assessment on whether fossil fuel phase-out plant alignment aligns with 1.5°C benchmark
- The technology mix (88%): renewables vs fossil fuel – long-term target (2040–2050) for emerging markets firms
  - Oil & gas phase-out plan by 2050
  - Reduce the share of unabated gas in total power generation to 0.4% by 2050

- Capital expenditure/allocation in increasing renewables capacities to 88% by 2030
- Regular emission intensity assessment on whether fossil fuel phase-out plant alignment aligns with the 1.5°C benchmark

Power companies need to regularly assess their asset-level fossil fuel retirement plan to align with the IEA transition pathway.

- Summary of existing coal/gas power generation capacities
  - The number of operational coal power plants, ages, capacities
  - The number of operational gas power plants, ages, capacities
  - Any other coal/gas powers plants in planning/construction
  - Share of unabated coal/gas in total electricity generation
  - Calculate locked-in emissions of coal/gas assets
- Coal power plant retrofitting and retirements
  - Whether the coal plant that is feasible to equip with CCUS before 2030?
  - Whether the coal plant can retrofit to co-fire hydrogen-based fuels by 2025
  - If not, the plan and date to phase out the unabated coal power plants by 2030 and 2040
- Oil & gas power plant retrofitting and retirements
  - Whether the gas plant that is feasible to equip with CCUS?
  - Whether the gas plant can retrofit to co-fire hydrogen-based fuels by 2025
  - If not, the plan and date to phase out the unabated gas power plants by 2050
  - The plan to phase out large oil power plants by 2030

Advantages of the IEA technology pathway

- The IEA net zero pathways are one possible theoretical transition pathway and provide global guidance and benchmark in alignment with the Paris Agreement. It is feasible and possible to widely apply the IEA technology transition pathway due to the low costs, widespread policy support and maturity of an array of renewable energy technologies. The benefits of implementation of the IEA technology transition pathway include:
- It provides relative flexibility for power companies to adjust their strategies and alter their energy mix at the asset level due to changes in national or regional policies.
- The IEA technology transition alignment benchmark is clear and easily monitored and assessed by third parties.
- It serves as an effective strategy to avoid complications arising from the GHG emission intensity alignment pathway.

- It does not depend on the accuracy of carbon emission disclosures.

Disadvantages of the IEA technology pathway

The journey towards net zero emissions by 2050 is filled with uncertainties due to potential changes in economic conditions, policy effectiveness, societal responses, and technology advancements. The challenges of this scenario include:

- Assumptions made in this IEA net zero emission scenario might not be accurate, especially in areas of behavioural change and CCUS for fossil fuels. In the IEA Net Zero Emissions scenario, 7.6 Gt of CO2 is expected to be captured in 2050, with nearly half from fossil fuel combustion. However, the rapid scaling up of CCUS is uncertain due to economic, political, and technical reasons. Net zero emissions by 2050 would be natively affected if fossil fuel CCUS does not expand beyond current and planned projects, leading to the risk of stranded assets. IEA estimated that up to $90 billion worth of existing coal and gas capacity could become stranded by 2030, and this could rise to $400 billion by 2050.
- While the IEA net zero emission transition pathway provides a global benchmark for individual firms to align with, it does not consider regional differences and how firms should adjust in response to variations in national policies and resource limitations. The specific strategies and technologies a power company employs to achieve net zero targets can vary depending on factors such as regional context, available resources, and regulatory frameworks.

In summary, the emission transition pathway and technology transition pathway could potentially complement each other, providing a credible analysis of a company's transition to net zero emissions. This could be achieved by:

- **Utilising the emission transition pathway to monitor the disparity between firm-level emission intensity and the global benchmark.**
- **Employing the technology transition pathway to pinpoint required technology changes, business model adjustments, and supporting actions at various timelines to reduce emissions and align with the emission intensity benchmark.**

3. Alignment assessment and actions

This section provides the direct and indirect actions required by power firms to align carbon emission targets with the net zero transition pathway. The actions should be built by focusing on key levers and milestones in achieving a net zero transition for the power sector. Drawing on the IEA net zero transition roadmap and the TPT disclosure framework, we propose to consider alignment actions outlined in Table 2. The actions highlighted in red are essential actions that are required to be implemented in the power sector. Meanwhile, the elements highlighted in orange are indirect actions that would be beneficial to have in place.

Table 2. IEA net zero transition alignment assessment and actions

Disclosure framework	Alignment assessment and actions
Targets and planning	• Whether the company has set short-term (2023–2030), medium-term (2030–2040), and long-term (2040–2050) GHG reduction targets, clearly defined in terms of scope of emissions, at both the firm level and asset level? For example, achieve more than 60% of the decarbonisation of annual emissions from electricity generation by 2030. How will they achieve those goals? • Whether the company set fossil fuel phase-out targets by 2030/2040? • Whether the company set a target for increasing solar and wind capacities? • Does the company set any plans to develop or expand other low-carbon power generation, such as biomass, hydrogen, and nuclear?
Business planning and operational actions	• Whether the company disclose carbon emission, capacities, technology, financing, and ages of power generation by energy type at the asset level? • Whether the company has a business plan/strategy to increase the share of renewables. This could include identifying the main type of renewables they intend to expand. What are the actions required to support the deployment of renewables? • Whether the company has a business plan to phase out all subcritical coal-fired power plants by 2030 in developed countries and by 2040 in emerging markets? • Whether the company has a business planning to phase out sizeable oil-fired power plants in the 2030s?

	• Whether the company plans to retrofit coal-fired power plants to co-fire with ammonia by 2030. And what actions are required to implement this plan? • Does the company have a business plan to retrofit gas-fired power plants to co-fire with hydrogen by 2030 and specify the actions required to implement this plan? • What metrics will be used to assess progress towards the above business model adjustment?
Financial actions	• What are the financial metrics and support to enable the transition plan? • Does the company still have any investment plan for new fossil fuel power generation? Whether the company has any M&A expenditure for fossil fuel powers • How does the company commit to aligning future capital expenditures with its short-term, medium-term and long-term decarbonisation targets? • Whether the company discloses the methodology it uses to align its future capital expenditure with its portfolio changes toward low carbon power generations, including key assumptions and key performance indicators (KPIs)? • Whether the company disclose the amount of capital expenditure that will be used to expand renewables, grid infrastructure upgrade, and energy storage? What is the investment plan for renewable energy generation, grid update and storage? • Does the company disclose the amount of capital expenditure spent on CCUS and fossil fuel retrofitting? • Whether the company disclose its R&D investments in innovative technologies, including smart grid technologies, CCUS technologies, and battery storage technologies?
Governance actions and policies	• Whether the company's board is explicitly responsible for oversight on matters related to climate change? This could include: • The presence of an executive committee member specifically responsible for climate change, who reports to the board or a board-level committee. • The CEO takes responsibility for climate change issues and reports directly to the board. • A dedicated committee is responsible for climate change (beyond just sustainability performance), reporting to the board or a board-level committee. • Whether the company's executive remuneration scheme linked to climate performance?

	• Whether the board or a dedicated committee possesses the necessary experts, skills and competencies to manage risks and opportunities related to climate change? • For those nuclear power generations, does the company have a policy in place for nuclear safety and emergency preparedness to minimise the impact of nuclear disasters in and around nuclear plants?
Engagement actions and training	• Does the company's response to local climate change initiatives align with local/regional targets? • Whether the company demonstrates its commitment to mitigating climate change by participating in various domestic and international net zero emission disclosure initiatives? • Does the company regularly engage with peers for knowledge exchanges regarding the alignment actions stated above?

4. Deep dives and specific issues

4.1 Deep dives

4.1.1 Regional variations

While the IEA net zero transition roadmap as well as TPI and ACT transition analysis, provide global benchmarks for individual firms, national variations in net zero transition commitments and environmental policies need to be considered. We recognise that decarbonisation should be pursued with a relative equity principle and utilise more disaggregated scenarios. In this section, we will discuss regional variations and highlight the speed and progress of decarbonisation, considering the technological pathways that may differ by region.

To date, among 133 countries and regions that have proposed or prepared to propose their carbon neutrality goals (Net Zero Scorecard, 2023[13]), 24 countries have made their net zero targets legally binding by enshrining them in law. I have listed some of them in Table 3 to demonstrate the variation in net zero targets, time periods, progress made, and transition speed. For firms located in countries with strong net zero commitments and clear transition roadmaps, it is advisable to use the regional/country-specific net zero pathway whenever possible for greater accuracy. For instance, while the UK Net Zero Strategy outlines how the

[13] The Net Zero Scorecards for countries were prepared by the Net Zero Tracker. https://eciu.net/netzerotracker

UK aims to achieve net zero emissions by 2050, Sweden is committed to achieving net zero by 2045.

Regional variation can lead to confusion for multinational firms in setting carbon neutral targets when a country's pathway does not align with the international scenario. For example, Energetický a průmyslový holding (EPH Group), whose business is engaged in power production, heat production, electricity transmission and distribution, gas transmission, distribution, and storage, and mining, is a large European operator of coal and gas-fired power plants. They have a clear timeline for coal phase-out by 2030 (refer to pages 10–12 of their sustainability report). However, this transition plan does not apply in Germany, as the country plans to phase out coal by 2038, and the company intends to follow the German coal phase-out target[14].

Net zero transitions face different challenges in less-developed countries. It appears that achieving net zero transitions is not as urgent and relevant as it is for their European peers. Many companies do not have a good level of disclosure regarding specific emission reduction targets and strategies, primarily due to less stakeholder pressure and less stringent regulations or reporting requirements concerning climate-related disclosures. Power companies may choose not to prioritise or proactively disclose such data without clear guidelines or obligations to disclose climate-related information.

According to the IEA (2020), Africa has substantial renewable energy potential, particularly in solar and wind power. However, the region still heavily relies on fossil fuels for electricity generation, limiting progress towards net zero. Asian countries are major contributors to global greenhouse gas emissions. However, they are also investing heavily in renewable energy sources. For example, China is the world's largest investor in renewable energy, with significant capacity additions in solar and wind power (REN21, 2021). India has set a target of achieving 50% clean energy share, 500 GW of renewable energy capacity by 2030[15]. Challenges such as limited grid infrastructure and regulatory frameworks hinder the effective integration of renewable energy in South American countries (IRENA, 2020).

We understand that achieving net zero transitions is a complex task for emerging countries, particularly those heavily dependent on fossil fuels, such as coal, for power generation.

[14] EPH, Sustainability Report 2021, page 4. file:///Users/xyz/Downloads/eph_sr-2021-landscape_20220810.pdf

[15] The Economic Times, Nov 2021. *India to achieve 50% clean energy share, 500 GW RE capacity targets before 2030 deadline: RK Singh.*

Transitioning away from these fossil fuel-based energy systems requires significant investment in renewable energy infrastructure and technologies, which can be challenging due to financial constraints, existing energy infrastructure, and the absence of clear and consistent policies and regulatory frameworks (IRENA, 2020). In addition, limited technical expertise and institutional capacity pose challenges to effectively implementing and maintaining renewable energy projects. Addressing these challenges requires a multidimensional approach involving robust policy frameworks, technological innovation, financial mechanisms, and international collaboration. It is important for power companies in emerging markets to develop customised transition strategies that consider their unique socioeconomic contexts and ensure a just and inclusive transition to a sustainable, net zero future.

Table 3. National net zero commitments and transition roadmap

Country	**Net zero target and year**	**Decarbonising the power sector**		
		Fuel type	**Energy mix target and year**	**notes**
UK	Achieve carbon neutrality by 2050	**Power decarbonisation target**	**Fully decarbonise the electricity system by 2035**	
		Unabated coal phase-out	2024	UK's Coal Phase-Out Policy
		Unabated oil & gas		
		Renewables	70% in 2030	
		CCS/CCUS	10 in 2030	
		Nuclear		Established Great British Nuclear and will be producing a roadmap later in 2023
		Hydrogen	10 GW of low-carbon hydrogen by 2030	
Sweden	Achieve carbon neutrality by 2045	**Power decarbonisation target**	**100% renewable electricity generation by 2040 under the Swedish Climate Act**	
		Unabated coal phase-out	2020	
		Unabated oil & gas		
		Renewables	Increased by	

		CCS/CCUS		
		Nuclear	Phase out nuclear power by 2040.	
		Hydrogen		
Norway	Achieve carbon neutral by 2030	**Power decarbonisation target**	**100% renewable electricity generation by 2030**	
		Coal phase-out	2023	Source: Nordic Energy Research
		Oil & gas		
		Renewables		
		CCS/CCUS		
		Nuclear		
		Hydrogen		
France	Achieve carbon neutrality by 2050	**Power decarbonisation target**	40% of renewable energy in electricity production by 2030	France's National Low Carbon Strategy
		Coal phase-out	2022	
		Oil & gas	Less than 5% of the country's electricity mix by 2030	
		Renewables	40% by 2030	
		CCS/CCUS	not readily available	
		Nuclear	decrease the share of nuclear power from 70% to 50% by 2035	
		Hydrogen		
Germany	Achieve carbon neutrality by 2045	**Power decarbonisation target**	**100% renewable electricity generation by 2045**	
		Coal phase-out	2030	Update to the long-term strategy for climate action of the Federal Republic of Germany
		Oil & gas		

		Renewables	80% renewable electricity by 2030 and 80% to 95% by 2050	
		CCS/CCUS	30m tons of CO2 will have to be captured, transported, reused or disposed of by 2045	
		Nuclear	Phase out in 2022	
		Hydrogen		
Finland	Achieve carbon neutrality by 2035 and net negative by 2040	**Power decarbonisation target**	**Nearly emissions-free electricity and heat production by the end of the 2030s**	
		Unabated coal phase-out	2029	The new Climate Change Act 2022
		Unabated oil & gas		Carbon neutral Finland 2035
		Renewables		
		CCS/CCUS		
		Nuclear	33% in 2021 40% in 2023	
		Hydrogen		

4.1.2 Asset-level data

To effectively understand the dynamics of a company's transition towards net zero emissions, it is crucial to have access to asset-level data. Asset-level data should include the technology used, location, age, investment amount, financing sources, refinancing, operating cost, ownership structure, emission, capacities, and environmental and community impacts. These data provide insights into the current technology and capacities employed by the company and allow for an assessment of planned changes in technology and assets. Understanding the specific power plant emission and capacities in the transition is essential for applying the IEA net zero transition pathway. Asset-level data disclosure can also help improve investor relations, enhanced risk management, and increased market competitiveness.

From an investor's perspective, assessing an entire portfolio of companies at the individual asset level poses a significant challenge. Evaluating multiple companies and their respective assets requires access to detailed data, which is currently provided by only a small number of progressive companies. While it is essential to understand a company's commitments, it is equally crucial to assess the real actions and progress they have made towards their net zero targets. Consistent disclosure of asset-level data enables investors to determine if a company is on track to achieve its targets and assess the credibility of the underlying actions being taken. Expanding access to asset-level data not only provides investors with a clearer understanding of a company's net zero transition plans but also enhances transparency and accountability. It allows investors to make informed decisions and allocate resources based on comprehensive information about a company's sustainability performance. Furthermore, asset-level data disclosure fosters a sense of confidence and trust in the company's net zero commitments and progress, strengthening its credibility among stakeholders.

In summary, asset-level data disclosure plays a pivotal role in assessing a company's transition to net zero emissions. It enables investors to evaluate progress and determine if a company's targets are achievable. Consistent disclosure of asset-level data strengthens credibility and accountability, fostering trust in the company's sustainability efforts and supporting the transition towards a sustainable, net zero future.

4.1.3 Nuclear power

Nuclear power can play a significant role in the net zero transition in the power sector due to its potential to provide a substantial amount of low-carbon energy. Nuclear power was responsible for about 10% of the world's electricity supply and roughly one-third of all low-carbon electricity (World Nuclear Association, 2023)[16]. Unlike many renewable energy sources such as solar and wind, nuclear power can generate electricity consistently, regardless of weather conditions. This ability to provide stable baseload power is an essential complement to intermittent renewable energy sources (IEA, 2019). Moreover, future nuclear reactors can potentially support the production of green hydrogen through high-temperature steam electrolysis, which could be an integral part of a net zero emissions energy system (IEA, 2022). Canada, China, Russia, the UK, and the US have already explored using nuclear power for hydrogen production.

[16] World Nuclear Association, 2023. *Nuclear Power in the World Today*. https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx

According to the IEA, the use of nuclear power over the past 50 years has successfully mitigated CO2 emissions by an impressive 60 gigatonnes, equivalent to almost two years' worth of global energy-related emissions. Despite this significant contribution, a concerning trend is emerging in developed economies where nuclear power usage is declining. Existing nuclear plants are being decommissioned, and there's a noticeable lack of substantial new investments in this sector.

The main issues associated with nuclear power include safety concerns and waste management. Although nuclear power plants are designed with safety as a priority, accidents like those at Chernobyl and Fukushima have raised concerns about the potential risks associated with nuclear power, including the release of radioactive material and the long-term health effects of radiation exposure (WHO, 2017). In addition, managing nuclear waste, which remains hazardous for thousands of years, is a complex challenge. It requires highly secure, long-term storage solutions, which can be politically contentious and technologically challenging (Union of Concerned Scientists, 2021). There are also concerns about nuclear power proliferation, i.e. the potential for nuclear technology to be used to produce nuclear weapons. This adds a layer of political complexity to the global expansion of nuclear power (IAEA, 2021).

As such, while nuclear power offers substantial potential benefits in the transition to a net zero emissions future, these challenges need to be well managed. Policymakers should consider these factors carefully, as the net zero transition will require a diverse mix of low-carbon power sources, including solar, wind and nuclear power.

4.2 Other specific issues

4.2.1 Differentiating between mature and less mature technologies

Differentiating between mature and less mature technologies is a crucial aspect when evaluating power companies and their transition plans. It allows for a more nuanced understanding of the feasibility and challenges associated with their sustainability strategies.

Mature, clean energy technologies refer to those that have undergone significant development and are commercially viable. These technologies have been widely deployed and have demonstrated their effectiveness in generating clean energy with a reasonable level of cost-effectiveness and reliability. Examples include solar PV systems, onshore wind turbines, and established forms of hydroelectric power generation. On the other hand, less mature technologies are those that are still in the early stages of development or commercialisation.

They have great potential for decarbonising the power sector but may face high costs, limited scalability, or technological uncertainties. Some examples of less mature technologies include battery energy storage systems, hydrogen fuel cells, and CCUS technologies.

Understanding the maturity level of different technologies is vital for assessing a company's transition plan. Companies heavily reliant on mature technologies may have a more straightforward pathway to achieving their sustainability goals, as these technologies are well-established and readily available. Their transition plan may involve scaling up existing infrastructure, optimising operations, or integrating complementary technologies. However, for companies that rely on less mature technologies, additional complexities may exist. These technologies often require further research, development, and cost reductions to reach widespread commercialisation and deployment. Transition plans involving less mature technologies may involve pilot projects, collaboration with research institutions, partnerships with technology developers, and significant investments in research and development.

4.2.2 Comprehensive metrics and targets

While evaluating the sustainability of power companies, it is crucial to move beyond generation-related metrics and targets and adopt a holistic approach that considers various aspects of their business activities. This includes evaluating emissions from grid expansion and upgrade, retail activities, and Scope 2 and 3 emissions (indirect emissions from the company's value chain). Focusing solely on generation can overlook significant emissions sources and may not provide a complete picture of the company's environmental impact. Therefore, a comprehensive assessment considers a broader set of emissions sources and activities across the company's operations. This approach promotes transparency, accountability, and a more integrated approach to managing sustainability across the company's operations and value chain.

4.2.3 Investor engagement and alignment

Banks and other financial institutions continue to be major sources of financing for renewable energy projects, and they play a crucial role in driving sustainable transitions and aligning their investments with their own commitments and values. For example, the European Investment Bank (EIB) has been actively financing renewable energy projects in Europe. The EIB committed to providing €17 billion in financing for renewable energy, energy efficiency, and energy storage in 2022.[17]

[17] Edie, Feb 2023. *European Investment Bank provided record €17bn for energy transition in 2022.* https://www.edie.net/european-investment-bank-provided-record-e17bn-for-energy-transition-in-2022/

To assess the credibility of investee firms' transition plans, investors should engage in dialogue and collaboration with the companies. This engagement allows for a deeper understanding of the company's strategies, targets, and progress, providing insights into the feasibility and alignment of the transition plan with the investor's own sustainability objectives. Engaging with investee firms provides an opportunity to encourage transparency, promote best practices, and advocate for more comprehensive reporting and disclosure. It also enables investors to support and influence the transition strategies of companies in their portfolios.

4.2.4 Ownership structure

The net zero transition plan, disclosure framework, and implementations can vary between public and private firms due to differences in ownership structure, accountability mechanisms, and stakeholder expectations. According to the IEA (2020), about 70% of global electricity generation is carried out by publicly owned or controlled entities. However, the ownership structure of electricity companies varies widely across countries and regions. In some countries, the electricity sector predominantly comprises state-owned or public companies. For instance, in countries like China, India, and Brazil, state-owned enterprises play a dominant role in the electricity industry (IEA, 2020).

Public firms, mainly state-owned enterprises (SOEs), may be subject to government mandates and policies that guide their net zero transition plans. They are often required to adhere to stricter disclosure requirements, such as those related to financial reporting, environmental impact, and governance practices and face greater pressure from stakeholders, including citizens, NGOs, and civil society, to prioritise environmental and social goals.

Private firms have more flexibility in designing and disclosing their net zero transition plans based on market dynamics, shareholder expectations, and their own sustainability commitments. They may encounter difficulties aligning their business strategies and investment decisions with long-term sustainability goals, particularly if short-term financial performance takes precedence.

5.Conclusions

Achieving decarbonisation in the power sector is crucial to mitigate climate change and serves as a foundation for decarbonising other sectors. Evaluating the current status of power decarbonisation reveals varying progress across countries and regions, with renewable energy sources gaining momentum. However, many power companies still face challenges aligning their decarbonisation targets with well below 2°C pathways.

The transition to net zero requires power firms to adopt suitable emission and technology transition pathways that can be implemented and applied by firms, investors, and other stakeholders. These transition pathways will be facilitated by changes in the business model and energy mix, technology upgrades, and investment and governance support. Power firms are expected to disclose their decarbonisation strategy, planning, actions, and progress, enabling various stakeholders to assess their alignment with net zero transition goals, identify gaps, and learn from best practices.

This discussion paper provides several implications for financial institutions, particularly banks.

- Financial institutions with significant exposure to the power sector need to be aware of the climate-related risks associated with investments in power firms that are not aligned with net zero transition plans. Non-compliance with transition goals can lead to increased risks of stranded assets, regulatory interventions, and reputational risks. Investors should integrate these risks into decision-making and their overall risk assessment frameworks.
- Considering the importance of technology transition pathways in achieving net zero emissions, banks can play a role in supporting innovation and technological advancements in the power sector by providing financing for renewable energy projects, energy storage solutions, and smart grid technologies.
- Transitioning to net zero in the power sector is a complex and challenging journey that requires systematic cooperation between firms and various stakeholders, policy and financing support and behavioural and consumption changes. Banks operate in diverse regions with varying net zero transition commitments and policies, which necessitates the development of customised strategies. They will need to carefully consider the practicality of implementing our recommendations within their own operations and financing activities while aligning their financing practices with sustainable objectives. One effective approach to address these challenges is for banks to engage directly and actively with investee power firms regarding the progress of power companies towards their net zero transition targets. This

engagement can take various forms, including discussions, meetings, and reporting requirements. By sharing best practices, knowledge, and expertise on sustainable finance, renewable energy projects, and innovative technologies, banks can contribute to facilitating the power companies' transition to a low-carbon future.

In summary, we call for financial institutions to proactively address climate-related risks, align their investment strategies with net zero transition goals, and engage with investee companies to drive positive change in the power sector.

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