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Energy System Transformation for a 1.5°C Future

The Accelerating Capital Transition

Adjusting to the Reality of Climate Accountability

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Businesses, governments, and other institutions are facing increasing pressure to mitigate the worst impacts of climate change by dramatically reducing emissions in line with the Paris Agreement. However, the strategists, analysts, and decision makers whose actions will shape the necessary market and policy transformations may be challenged to see past legacy modeling approaches and assumptions. These approaches and assumptions capture neither the massive economic opportunities for early movers nor the compounding risks of being left behind.

To strengthen this interface, RMI is releasing a series of insight briefs to help demystify the available tools for 1.5°C alignment, identify critical gaps that require complementary approaches, and highlight emerging opportunities to reinvent the future. **These insights are bound by our assessment that a rapid transition to a low-carbon energy system is not only achievable, but also a source of growth, prosperity, and benefit for all.**

This insight brief explores corporate efforts to transform their long-term business strategies as financial institutions increasingly focus on the risks of a rapid transition to a net-zero economy. Companies that want to survive these capital shifts must plan ahead and begin acting now, as investors and underwriters increasingly look toward a best-case global climate scenario of 1.5°C of temperature rise. This includes engaging with collaborative initiatives that seek to inform the finance and policy instruments that will shape the transition.

Companies should also understand how the deflationary impact of renewable energy will fundamentally change the nature of energy markets and society. By understanding the drivers of a 1.5°C-aligned economy, companies can work with financial institutions to identify and test strategies to mitigate stranded asset risk while simultaneously identifying new ways to create and capture value in a low-carbon world.

The Coal Sector's Dramatic Decline

Global coal demand peaked in 2013, one year after the International Energy Agency (IEA) projected continued growth until 2035.[1] No model is perfect, but signs of coal's decline had already appeared in earlier-moving markets, many of which were beginning to set more ambitious climate policies. Coal demand peaked in OECD markets in 2010, as cheaper renewables and natural gas captured the majority of new investment.[2] The inevitability of continued decline became evident as investors sent equity prices tumbling and banks updated lending guidelines.[i] Peak coal was the canary in the proverbial mine, highlighting the need to better prepare for climate-related transition risks in other carbon-intensive sectors.[ii]

As the coal industry has shown us, the confluence of policy action, technological change, and the response from capital markets can catalyze the cascading decline of an industry. Peaking demand and rapidly growing challengers signal this dynamic shift from legacy technologies and businesses to disruptive ones. If not managed proactively, such a decline can leave in its wake stranded assets and communities struggling to adapt. To facilitate a smooth and rapid transition, companies must work in partnership with their key stakeholders to carve out their place in a 1.5°C future.

[i] For example, the Dow Jones U.S. Coal Index lost 95% of its value over five years, while actual US demand decreased by 25%.

[ii] Climate-related transition risks are those that arise from adjustments to a low-carbon economy, such as substantial shifts in policy or regulation (e.g., carbon pricing, consumption limits) in a market or increasing competition from lower-carbon technologies and solutions.

THE FINANCIAL SECTOR'S GROWING CLIMATE FOCUS

Capital markets are influenced by forces that react to and are reinforced by climate change: the search for growth, the need to manage risk, and the preservation of value. Unmitigated climate change threatens all of these, with scientists telling us that 1.5°C of temperature rise is the most ambitious goal still physically possible for humanity. Projections show that just one-half degree more warming (i.e., 2°C) would cause at least twice the magnitude of impacts on many metrics such as fisheries loss, number of people subjected to extreme heat, and reductions in crop yields.[4]

Many of the world's largest financial institutions, invested in every corner of the global economy, are realizing that such a future is untenable. A recent study by Moody's credit rating agency found that $7.2 trillion of rated debt qualified as having high credit risk from the physical risks of climate change.[iii] This underscores the notion that a smooth and rapid path to a 1.5°C limit on warming would greatly benefit humanity—and therefore our underlying institutions.[5]

Investors Have Assigned Trillions of Dollars in Climate-Related Transition Risks

Financial institutions are also becoming more sophisticated at quantifying the transition risks posed by efforts to mitigate climate change. The same Moody's study found that almost $4.9 trillion of rated debt was at either high or very high risk from the energy transition (Exhibit 1).[6] The industry's emerging capabilities to measure these risks are revealing significant exposure for certain high-risk sectors,[iv] including coal mining and terminals ($10 billion), automotive ($674 billion), and oil and gas ($1.8 trillion).[v]

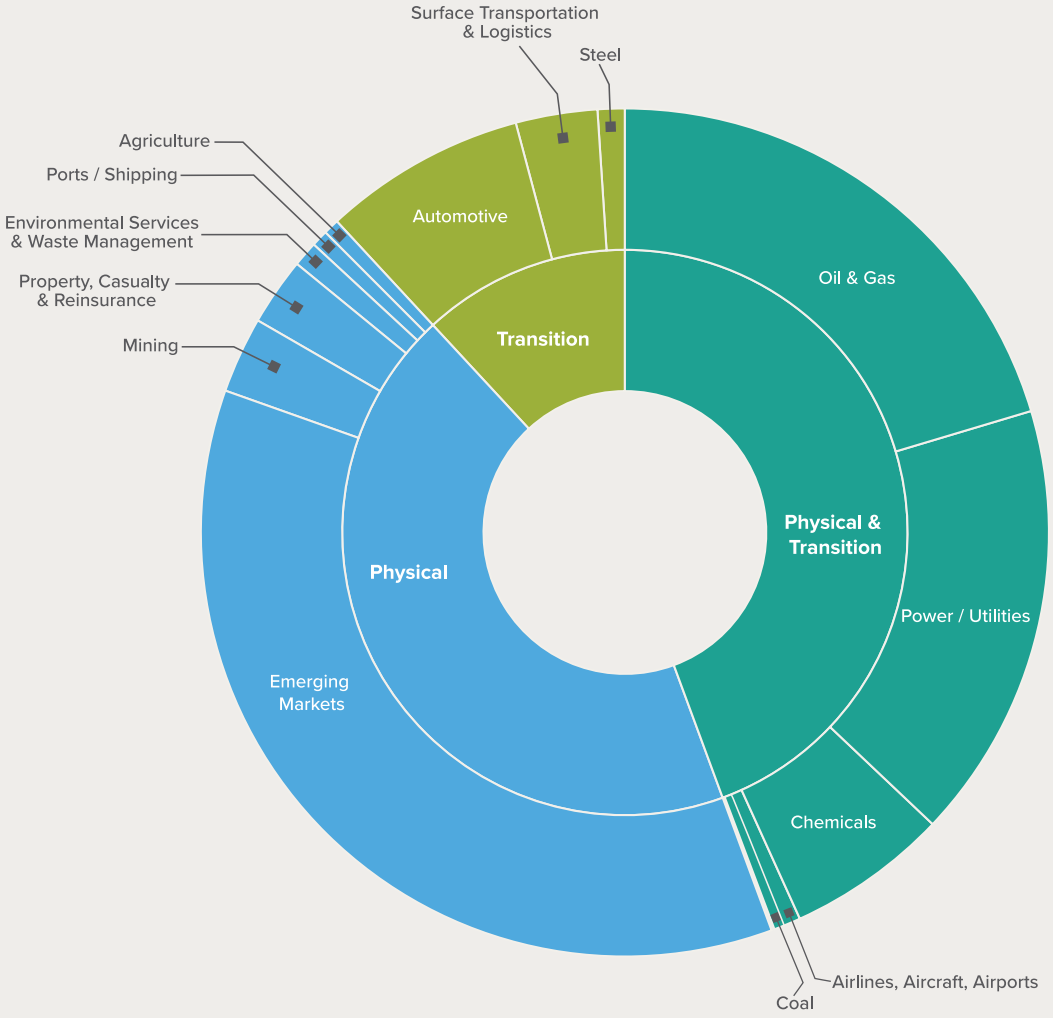
[iii] Physical risks stem from the acute or long-term impacts of climate change, such as increased frequency of severe weather events, flooding, or drought, that can disrupt supply chains or damage physical assets.

[iv] Overall environmental risk scores are a composite of carbon transition, physical risk, water management, waste and pollution, and natural capital risk scores.

[v] Aggregated categories have larger cumulative debt than the highest-rated categories in the original analysis: coal mining and coal terminals ($10 billion), oil and gas—integrated oil companies ($799 billion), and automobile manufacturers ($555 billion).

EXHIBIT 1

Rated debt in sectors categorized as high or very high physical and/or transition risk



Risk Type	Industry	Rated Debt (Billions)
Physical	Emerging Markets	$3,139
	Mining	$253
	Property, Casualty and Reinsurance	$225
	Environmental Services and Waste Management	$84
	Ports / Shipping	$55
	Agriculture	$52
Transition	Automotive	$674
	Surface Transportation & Logistics	$271
	Steel	$90
Physical & Transition	Oil & Gas	$1,774
	Power / Utilities	$1,454
	Chemicals	$536
	Airlines, Aircraft, Airports	$90
	Coal	$10
	Total	$8,707

Source: Moody's Investors Service

These more sophisticated climate risk analyses now emerging, coupled with rapidly expanded transparency and reporting requirements and institutional changes in the financial sector, create the potential for a catalytic shift.[7] Capital providers (e.g., investors, banks) and insurers can wield incredible influence across the economy, through access to capital and pricing of risk, as well as through their relationships to key decision makers (e.g., shareholder engagement, advocacy).[8] As the financial sector increasingly incorporates climate into decision-making, lending, and investment practices, the actions of one institution may reinforce those of others, causing cascading effects across the economy.[9]

Disruptive Solutions Provide Growth-Focused Opportunities

Alongside physical and transition risks, the response to climate change will create new opportunities in emerging growth markets seeded by a changing economy. Decades of government policies, including technology innovation programs, pollution policies and investments, carbon markets, and industry and market regulations, are creating the conditions for new low-carbon technologies to move rapidly from niche to mainstream-market growth sectors. Solar PV and energy storage have both crossed critical tipping points,[10] each providing a classic example of industry disruption that carries both new financing and investment opportunities and increased risk.

As new and disruptive technologies emerge, often reinforced by technology learning curves, digitalization, and dematerialization trends, companies and their capital providers need to quickly understand the magnitude, speed, and direction of such changes in order to manage risks and capitalize on opportunities.[11]

Coordinated Financial Sector Initiatives Are Turning the Tide

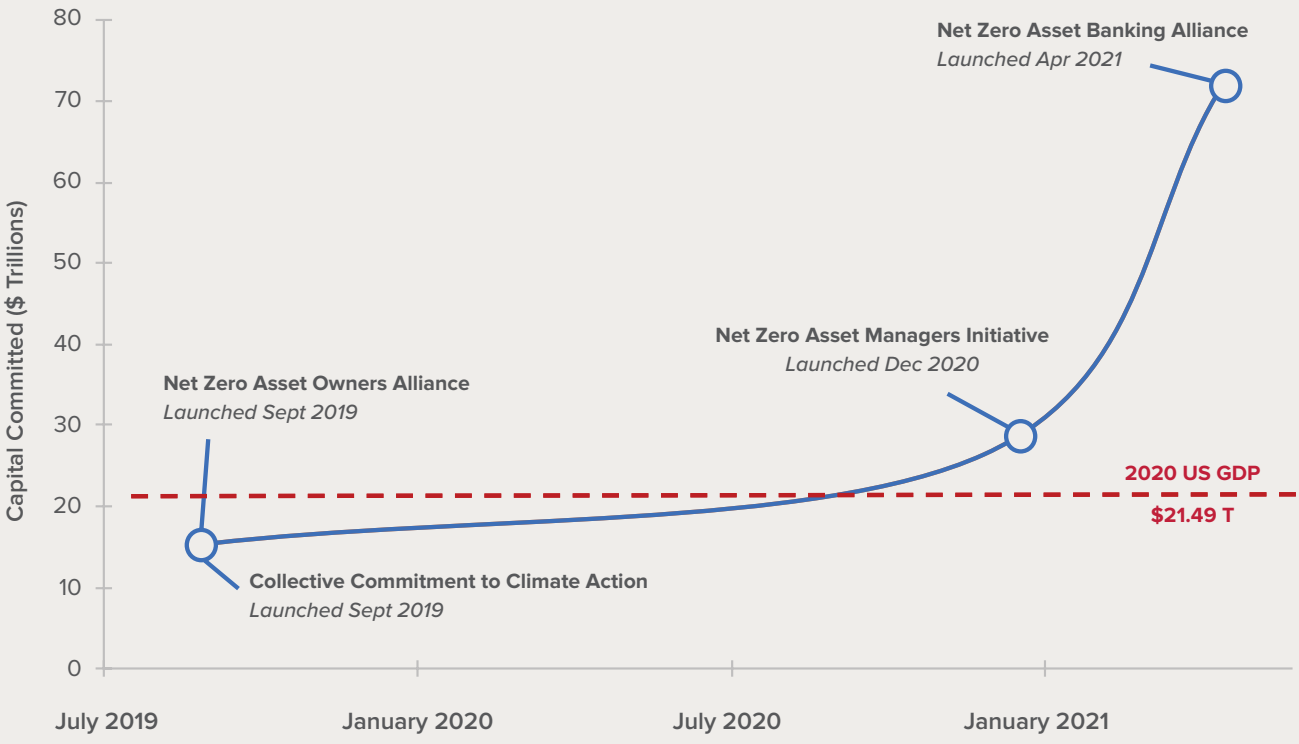
A shared desire within the financial sector to move decisively on climate-related transition risks and opportunities has led to a proliferation of collaborations and commitments to make a net-zero future a reality.[12] The doubling of net-zero commitments in 2020 by companies, cities, regions, and countries reflects this momentum and signals exponential growth in ambition to achieve net-zero goals.[13] As shown in Exhibit 2, coordinated multistakeholder efforts and networks are rapidly developing shared infrastructure to align company strategies and asset portfolios with a net-zero future. These efforts include working around structural challenges to influence the real economy, overcoming competitive disadvantages, selecting methodologies to assess alignment, understanding decarbonization pathways, and sourcing adequate data.[14]

The expansion of institutional engagement has been dramatic. The four initiatives shown in Exhibit 2 illustrate the rapidly increasing scale of financial institutions' efforts to align their portfolios with the net-zero transition. Almost 150 private financial institutions, representing over $70 trillion in assets under management, have committed to transitioning their portfolios to support the goal of net-zero greenhouse gas emissions by 2050 or sooner, in line with global efforts to limit warming to 1.5°C. By comparison, the 500 largest asset managers had $104 trillion in assets under management globally at the end of 2019.[15]

The expansion of these efforts is promising. Continuing to increase the amount of capital committed to decarbonization will be an important ingredient in creating and sustaining the type of virtuous loop between business and policy that is necessary to accelerate net-zero outcomes. This dynamic is critical; initiatives are not a replacement for strong government policy, which provides the incentives, infrastructure, predictable regulation, and long-term market signals that fuel greater commitments and growth opportunities.[16] Conversely, these networks of commitments and collaboratively developed sector decarbonization strategies give confidence to and inform the strategies of government policymakers as they commit to passing more ambitious climate-related policies—and of companies as they invest in their own transitions.

EXHIBIT 2

Capital committed to aligning with a 1.5°C climate trajectory by three leading financial sector initiatives



Note: Some organizations participate in more than one initiative simultaneously. Data shown is scrubbed to avoid double counting. Participation and cumulative asset values reflect the most recently reported figures by each initiative as of April 22, 2021.

Source: RMI, initiative websites

HOW TO RECOGNIZE DISRUPTIVE CAPITAL TRANSITIONS

Despite the financial sector's emerging frameworks and collaborative efforts, many companies have yet to explicitly recognize the transition risks associated with a 1.5°C-aligned transformation. This dismisses a net-zero future that foretells countless business model disruptions as demand for higher-emitting legacy technologies and services gives way to lower-carbon alternatives. Underlying this climate-aligned focus of capital providers are two key market dynamics—the role of peak demand and the deflationary nature of renewable energy—that companies must acknowledge and integrate into their strategic planning.

Peak Demand and the Transition Risk Continuum

Peak demand is a critical milestone for any industry, and one that signals a shift away from growth thinking toward risk minimization thinking.[17] Although this milestone is often driven by new technology or business model innovations, it is also influenced by exposure to new policies such as carbon pricing, internal combustion engine (ICE) vehicle bans, or renewable portfolio standards. Many carbon-intensive industries are currently grappling with potential decreases in demand and the value of their output (e.g., oil and gas, ICE vehicle manufacturing) or will be soon (e.g., gas turbines, conventional steel plants).

As shown in Exhibit 3, the relative timing and role of peak demand and other phases of industry decline can be thought of as hours on a "transition risk" clock. In this illustration, each hand on the clock represents an industry at its respective stage of the transition, with its size reflecting the magnitude of stranded asset risk. The industries included in this illustration represent at least $10 trillion in potentially stranded assets. Understanding the stages of this clock can help investors and companies to identify policies and strategies to proactively manage transition risk. Although many sources of instability can trigger this dynamic, the risks and opportunities presented by climate change generate a pattern of identifiable dynamics for incumbent industries.

EXHIBIT 3

Stages of the "transition risk clock" with description of industries at various phases

Coal Exploration and Production ($1.2 Trillion)

Sell Assets

Annual coal mining and infrastructure investments have been about $100 billion over the past decade, but write-downs, bankruptcies, and insurance woes continue, such that the total book value of these assets as of May 2020 was less than $200 billion.

Oil and Gas Extraction ($5.9 Trillion)

Cut Costs

Around $500 billion annually was invested in more than 2 million oil wells over the past decade. Increasing market share of electric vehicles, however, is slowing demand, and many capital investment and cost reductions may be permanent. Demand reductions cause capital goods (e.g., drilling equipment) to decline before actual extraction assets.

ICE Vehicle Manufacturing & Equipment ($0.3 Trillion–$1.5 Trillion)

Dividends Falling

It is yet unclear to what extent ICE vehicle manufacturers can repurpose equipment, factories, processes, and parts, but it could implicate the book value for both automotive manufacturer and supplier assets.

Oil and Gas Refining and Transportation ($2.5 Trillion)

Peak Demand

Approximately $250 billion has been invested annually into more than 1,000 refining and gas processing facilities, 2 million km of pipeline, and shipping transport capacity. As oil demand peaks and low-cost clean energy portfolios undercut the need for flexible gas electricity generation, the plastics market is unlikely to provide significant demand to mitigate declines.

Conventional Steel Plants ($0.5 Trillion)

New Technology Competing

Although steel is early in the transition process, there is significant transition risk at play for the 2,200 million metric tons of global steel production capacity. Companies that don't commit early to developing a strategy around carbon capture, utilization, and storage and/or hydrogen are likely to be left behind by more innovative companies.

Note: Estimates of potential stranded asset base shown in parentheses.

Source: RMI; Kingsmill Bond, Ed Vaughan, and Harry Benham, Decline and Fall: *The Size and Vulnerability of the Fossil Fuel System,* Carbon Tracker, June 2020; data via Bloomberg LP

In the energy space, decline of a dominant technology is often presaged by a lack of innovation and stagnant thinking about how a company can provide value. As disruptive technologies or business models emerge, even at low percentages of market share, investors begin to take notice and adjust their expectations about lifetime returns on investment for legacy assets. The energy industry is especially prone to stranded asset risk given the long operating lifetimes assumed for energy infrastructure. As technologies and market dynamics shift, what may have seemed like reasonable assumptions about expected returns increasingly fall short.

New growth opportunities for legacy solutions quickly erode, leaving incumbents with difficult choices about how to invest shrinking profits. These reduced profits logically lead to a reconsideration of new capital expenditures, a decrease that can foretell a larger industry challenge. As demand volume and prices continue to fall and asset operating times are reduced, investor profits, fixed costs, and interest payments are all at stake, opening the door to mergers and acquisitions or asset sales. Eventually, continuing to operate even a fully depreciated asset may become uneconomic if its marginal cost exceeds that of new entrants, resulting in fully stranded assets.

Oil Following in Coal's Footsteps?

Although the coal industry had been struggling for years against lower-cost renewable energy and increasing social and political pressure, few people expected before COVID-19 that global peak oil might occur in the next few years. Now, some oil majors are considering the possibility that global demand peaked in 2019.[18] COVID-19 may have accelerated the arrival of the peak, but the signs have been growing for years, including the IEA's acknowledgment that demand has already peaked in advanced economies.

Further, electric vehicle (EV) sales, especially in China and the EU, had been steadily growing, constituting most of the growth in an otherwise stagnating light-duty vehicle market. Learning effects, especially for batteries, were increasingly making EVs cheaper, with capital cost parity for entry-level models now predicted to occur before 2025.[vi] New and larger models were being revealed to meet customer preferences and delivery and supply companies were signing deals for all-EV delivery fleets.

Because road transport constitutes around 50% of global oil end use, these trends will have a significant impact on demand.[19] Negative oil prices in April 2020 hinted that the industry was unprepared for such rapid change and foretold of the more than $170 billion in write-downs and credit downgrades that have followed.[20] Of course, the oil and gas industry is integrated into the economy in deeper and more diverse ways than was coal, but nonetheless it faces growing risks as the energy transition accelerates overall.

[vi] Parity in terms of total cost of vehicle ownership has already been achieved for many models.

Renewable Energy's Deflationary Economics

The energy industry has historically been characterized by a foundational economic relationship: lower-cost resources are exploited first, followed by progressively higher-cost resources as supply diminishes and demand increases. In general, higher demand leads to higher costs. Periodic technology improvements may contribute to temporary cost declines, but inevitably the lowest-cost supply will again be used up. This relationship has been the basis for business and national security strategies and regulatory frameworks, and it lies at the heart of our dependence on nonrenewable energy sources.

With renewable energy, this equation is fundamentally different: the demand-cost relationship curves downward instead of up.[21] The more we install it, the cheaper it gets as a result of both learning effects and its near-zero variable costs.[22] When more equates to cheaper, businesses must shift their focus to providing competitive value through quality rather than low-cost quantity alone. This has significant implications for the speed of the capital transition and the potential for stranded assets, as this self-catalyzing change could overtake additional sectors at an accelerating pace. This dynamic likely contributed to renewable energy defying expectations by adding 50% more capacity during COVID-19 than in previous years, while fossil fuel demand plummeted.[23]

Consider natural gas, an industry that in many ways appears quite healthy. Although the US shale gas industry has struggled with profitability,[24] historical sales and outlooks are increasing. Some coal-fired power plants are being converted to natural gas,[25] with the aim of providing cleaner grid balancing.[vii] But just like for oil, there are warning signs for rapid nonlinear disruption, suggesting that investments being made today will be stranded earlier than companies expect. Clean energy portfolios of renewables, storage, efficiency, and demand-side management are rapidly closing the cost gap in many markets.[26] Continued cost reductions in renewables and storage are causing many energy planners to recognize that they are a safer bet than gas over multiyear time horizons.

[vii] The degree to which natural gas provides for cleaner balancing depends on the amount of methane leakage. High methane leakage is a major problem that erases the relative climate benefit of gas over coal.

HOW COMPANIES CAN ADAPT

As the largest finance institutions increasingly engage on the growing risks and requirements of the climate transition, companies with high greenhouse gas footprints must work proactively with their investors and lenders to communicate and enable their transition. The World Economic Forum recently proposed seven key steps any company should take to engage in the transition.[27] Below we explore three of them: using climate science and analysis to understand transition risk and inform low-carbon strategies, engaging with ongoing finance and sectoral decarbonization initiatives, and identifying and developing new approaches to value creation in a net-zero world.

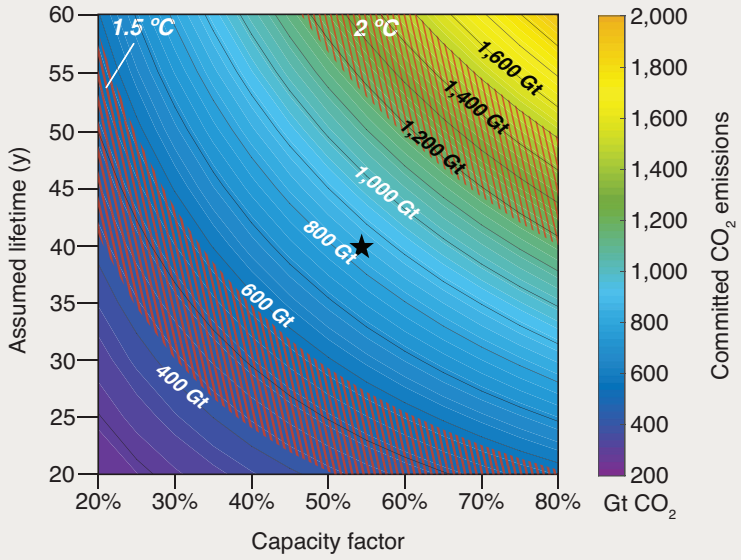
Use 1.5°C Scenarios and Analysis to Inform Strategy

Financial institutions and net-zero initiatives are adapting energy-economic models to inform their climate change mitigation strategies. By adopting similar approaches to planning for the changes that a 1.5°C future requires, companies will be better positioned to manage transition risks and benefit from the inexorable march of innovation and policy targeting climate mitigation and adaptation. In particular, those in carbon-intensive industries can use 1.5°C-focused scenarios and models to qualify the right levels of capital expenditure investments and plan for how to operate and retire existing assets in line with emissions reduction targets.

In a 2019 paper, Dan Tong of the University of California, Irvine, and her coauthors demonstrated that most existing energy assets do not have a pathway to a typical lifetime of returns in a world focused on carbon mitigation.[28] The researchers conceptualized that *existing* energy infrastructure (primarily electricity, industry, transport, and buildings) would emit about 658 gigatons of carbon over its working life if operated as it has been historically, while *proposed* infrastructure would emit another 188 gigatons, for a total of 846 gigatons (see Exhibit 4). This is almost double the 2019 estimated carbon budget for 1.5°C, which ranged between 420 gigatons and 580 gigatons of CO_2 equivalents. Under these operating assumptions, a 1.5°C pathway requires abating or mitigating more than 50% of these emissions.

EXHIBIT 4

Committed CO_2 emissions from existing and proposed infrastructure



Source: Dan Tong et al., "Committed Emissions from Existing Energy Infrastructure Jeopardize 1.5°C Climate Target," *Nature 572 (2019): 373–377*

Meeting this emissions reduction trajectory implies substantial decreases in both the average capacity factor (53%) and plant lifetimes (40 years) for these assets. Even generously allocating the entire remaining 1.5°C carbon budget to existing and proposed energy infrastructure (and ignoring all other emissions sources) would require either 40% capacity factors with 30-year lifetimes or 60% capacity factors with 20-year lifetimes. Absent an improbable scale-up of costly carbon capture technology, owners and financiers of many of these assets will lose out on a 1.5°C-aligned pathway.

Engage in Reporting, Target Setting, and Shared Pathway Development Initiatives

Companies should work with target-setting initiatives (e.g., SBTi, Race to Zero) and financial institutions to develop both targets and pathways for industry transitions to net zero. This can help all parties to reduce uncertainty, ensure common understanding of what 1.5°C requires, and identify and organize around the necessary transition support structures. Collaborative engagement can also help industries and value chain partners more quickly align on and influence government policies and regulations that will shape the transition.

Collaborative disclosure standards (e.g., CDP, TCFD) and subsequent climate pathway development efforts (e.g., the Poseidon Principles, Mission Possible Partnership) demonstrate how catalytic coordinated action can move an industry beyond reactivity to proactive risk reduction. The 24 financial institutions that signed on to the Poseidon Principles actively report on their alignment to the climate targets set by the UN International Maritime Organization. This approach has created new opportunities to identify leverage points and engage with shipping companies. It has also helped to crowd in additional support through sustainability-linked loans (which reward emissions performance and compliance with beneficial finance terms) and the launching of the Shipping Criteria for the International Climate Bonds Standard.[29]

Envision Your Company's Role in a Net-Zero Future

Increasingly, investors and banks will work to measure and reduce the carbon footprint of their portfolios.[30] Companies need to work proactively to understand how they fit into those calculations, develop individual transition strategies, and leverage their industry knowledge to educate financial institutions on the transition. Many will not be able to afford short-term, "bridge-to-nowhere" solutions that will soon be outcompeted by lower-carbon alternatives and result in larger stranded asset costs.

Despite the warning signs and financial and political momentum, some companies will opt to manage the transition by sticking to their current model, trying to slow climate policies, and squeezing whatever value is possible out of their assets. Others will instead pursue emerging growth opportunities, either as integrated energy players or low-carbon pure plays.[31] These companies can identify which of their current (or planned) assets and solutions can be repositioned to provide value in a net-zero future that, in addition to mostly running on low-cost clean energy, will look very different than today.

The Low Energy Demand (LED) scenario provides a useful framework for envisioning this future and developing rapidly scalable strategies whereby emerging solutions can provide greater value than incumbent technologies.[32] LED, developed by the International Institute for Applied Systems Analysis (IIASA), recognizes five drivers of long-term change in energy end use, which interact to create five "additional elements" that can be thought of as scaling vectors.Exhibit 5 summarizes each of these factors, which investors and companies can use to begin exploring net-zero solutions. Strategies that aim to hedge industry decline should have a strong hypothesis about what would both support novel value creation in a low-carbon world and have the ability to scale rapidly in line with 1.5°C emissions reduction trajectories.

EXHIBIT 5

The LED 1.5°C scenario's framework for end-user-driven value creation

DRIVERS OF LONG-TERM CHANGE	
Quality of Life	Continued push for higher living standards, clean local environments, widely accessible services, and end-use technologies
Urbanization	Continued rapid urbanization, particularly in midsize cities in developing countries
Novel Energy Services	End-users demanding novel, more accessible, more convenient, cleaner, and higher-quality energy services
End-User Roles	Continued diversification of end-user roles in the energy system, from consumer to producer, trader, citizen, designer, and community member
Information Innovation	Rapid improvements in cost and performance of information and communication technologies

ADDITIONAL ELEMENTS	
Granularity	Proliferation of small-scale, low-unit-cost technologies that enable experimentation, rapid learning, and equitable access
Decentralized Energy Provision	Provision of energy generation, distribution, and end use
Value from Service	Move away from ownership of single-purpose goods to "usership" with flexible multipurpose services delivered through digital platforms or sharing economies
Digitization	Integration of sensors, processors, wireless communication, and control functionality into energy-using technologies and daily routines
Rapid Transformation	Accelerated improvement demanded by end-user in the changing form and quality of energy-service provision as incomes and aspirations rise

Source: Adapted from IIASA

These attributes are likely only a starting point, but they can provide a framework for companies to strategize and pilot approaches for how their existing physical, informational, and human assets can reduce the likelihood of becoming stranded in a deflationary energy future. Exhibit 6 highlights a few examples of this type of strategic foresight that are already emerging across several sectors.

EXHIBIT 6

Illustrative examples of transitional net-zero strategies leveraging the LED 1.5°C value creation and scaling strategies

Company	Historical Assets	Future Assets	Quality of Life	Urbanization	Novel Energy Services	End-User Roles	Information Innovation	Granularity	Decentralized Services	Value from Service	Digitization	Rapid Transformation
Aral	2,400 gas filling stations in Germany	Microgrid Mobility Hub: Ultrafast charging of EVs where grid does not meet technical requirements	●	●	●			●	●			
Origin Energy	Coal power generation plant and transmission interconnection	700 MW/2,400 MWh battery located at Eraring coal plant	●					●				
Fortescue Metals	Iron ore mining operations	235 GW of renewable energy projects to support green hydrogen and ammonia for industrial and fuel use			●							●
Toyota	Connected vehicles and mobility data	Smart, autonomous vehicle dispatch for on-demand mobility services for Japanese and public agencies		●			●			●	●	●
E.On	Natural gas pipeline	Converting natural gas pipelines to transport hydrogen	●		●			●				
Ørsted	Coal- and gas-fired power stations	Offshore wind power and biomass power generation with carbon capture, utilization, and storage	●		●							
Schneider Electric	Large-scale, fossil fuel-based microgrids	Solar and battery backup microgrids-as-a-service for C&I customers	●		●			●	●	●	●	

Source: RMI

There are countless frameworks and approaches to corporate innovation, and most can be adapted to exploring new, lower-carbon approaches to value creation. Whatever the approach, it is essential to our collective prosperity that companies begin this journey now. Competitive advantage and future growth await those who forge the path, while those who delay action risk potentially spiraling costs and diminishing opportunities to play a role in a net-zero economy.

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