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THE NET-ZERO TRANSITIONAL COST FOR MULTIPLE SECTORS IN THE ECONOMY AND THE ASSOCIATED CHALLENGES TO ACHIEVE THIS TARGET

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ABSTRACT

Persistent development in technology by mankind has directed the human race to the point of jeopardizing the unique scenario that has brought in this progression; the equilibrium of our planet's climate. Global warming which is a consequence of greenhouse gas emissions and these emissions not being offset by reductions is now an international concern. To prevent the hazardous outcomes of global warming and to conserve our planet to support life, the International Treaty on Climate Change, the Paris Agreement in 2016 targeted to preserve the average long-term surge in global temperature to 1.5℃ above pre-industrial levels. Acknowledging these implications would require reducing global carbon emissions by 50% nearing 2030 and a further contraction to net-zero by 2050.

Hence, it is crucial to attain net-zero would and this would imply an absolute adaptation of the global economy, as it would mandate substantial transformations in the major energy and land-use scenarios that generate a majority of the earth's emissions, namely power generation, industrial processes, mobility and transportation, residential and commercial buildings, agriculture, forestry and additional land-use, and waste generation and accumulation, that generate approximately 85% of overall hazardous emissions. Furthermore, this transition would encompass the economic consequences on market demand, capital distribution, expenses on physical assets and direct and indirect employment opportunities in various economic sectors. This research highlights the need for such a transition and the social and economic costs related to this evolution.

The study elaborates on the expenditure for modifying physical assets for energy and land usage procedures and their relevant percentage share of GDP for developed and developing economies, the average delivered cost of electricity using clean energy resources and how nations with lower

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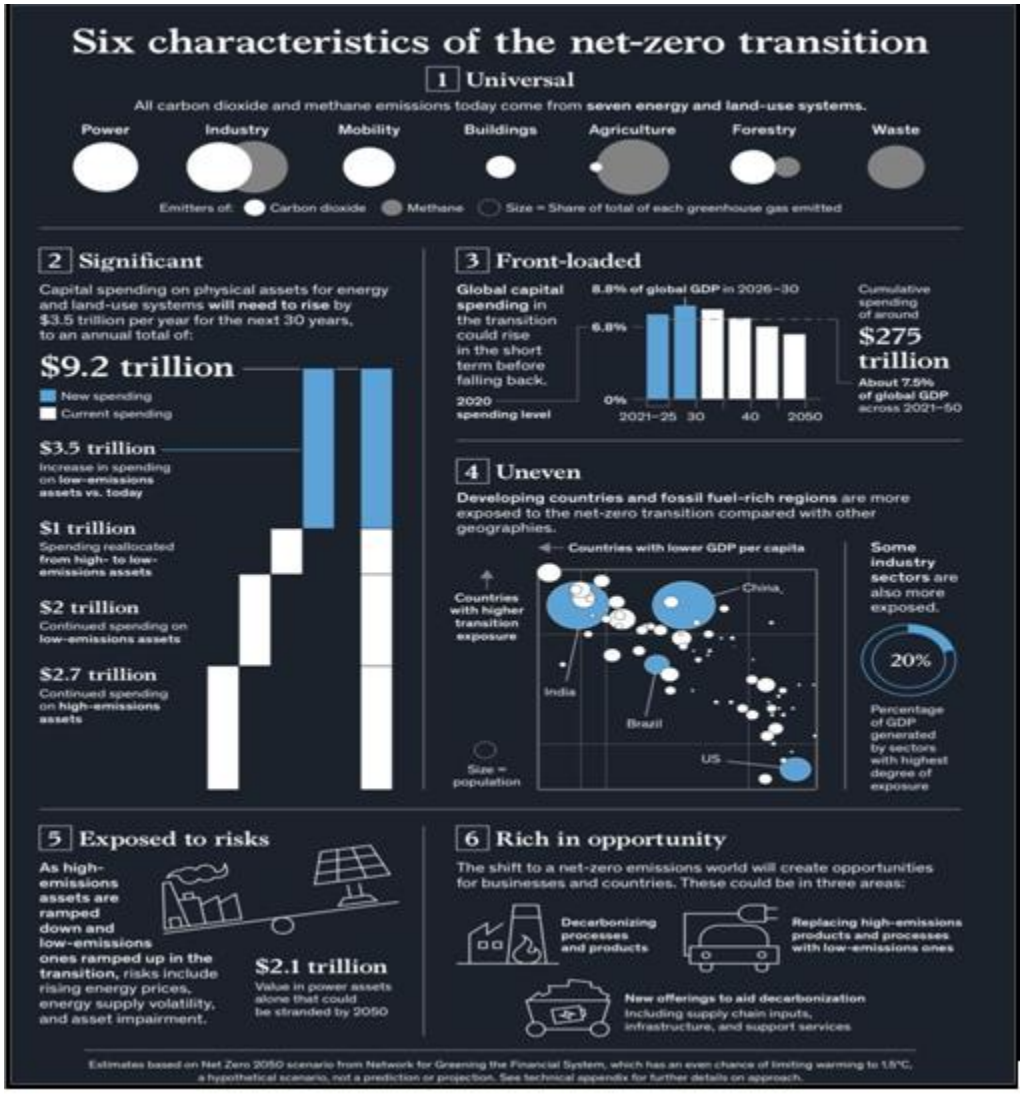
GDP per capita and fossil fuel-producing nations are likely to have greater transition exposure. It also brings to light the significant archetypes of nations founded on the typical essence of their transition exposure and the cumulative investments for the future as per the Network for Greening the Financial System (NGFS) net-zero scenario. This paper concludes with solutions on how to unravel this net-zero balance through essential and interrelated system-level prerequisites that are crucial for this evolution and modifications.



Source: The net-zero transition: What it would cost, what it could bring, McKinsey Global Institute analysis

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Introduction

Constant advancement in technology and revving development has led human ethnicity to the juncture of threatening the extraordinary scenario that brought in this progression: the equilibrium of our planet's climate. The indications of an altering climate, global warming and their socio-economic consequences are evidently visual across the world and are likely to rise in a nonlinear manner unless the earth evolves to a net-zero economy. As greenhouse gas emissions persist and are not offset by reductions, the net-zero equation remains unsolved. Hence, this matter is of tremendous concern to public administrations and corporations worldwide who are currently engaging to speed up climate action.

To prevent hazardous outcomes of global warming and to conserve our planet to support life, the International Treaty on Climate Change, the Paris Agreement in 2016 targeted to preserve the average long-term surge in global temperature to 1.5℃ above pre-industrial levels. Acknowledging these implications would require reducing global carbon emissions by 50% nearing 2030 and a further contraction to net-zero by 2050.[1] This would mandate the adoption of economic and social transformations, as net-zero implies diminishing greenhouse gas emissions to roughly zero and the remaining emissions to be reabsorbed from the atmosphere. Nonetheless, the majority of these targets have yet to be supported by careful strategies and agendas and the implementation of these undertakings will not be an easy process, as unraveling the net-zero equation cannot be separated from seeking economic growth and development.

Attaining net-zero would imply an absolute adaptation of the global economy, as it would mandate substantial transformations in the major energy and land-use scenarios that generate a majority of the earth’s emissions, namely power generation, industrial processes, mobility and transportation, residential and commercial buildings, agriculture, forestry and additional land-use, and waste generation and accumulation. Furthermore, this transition would encompass the economic consequences on market demand, capital distribution, expenses and employment possibilities in the above-mentioned economic sectors. Exhibit 1 depicts the anticipated reduction in carbon dioxide and methane emissions according to the Network for Greening the Financial System, due to usage of clean energy resources and net offsets in these sectors from 2020 to 2050.

[1] “ Nationally Determined Contributions (NDCs) The Paris Agreement .” *Unfccc.Int*, United Nations Climate Change (UNFCCC), unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs.

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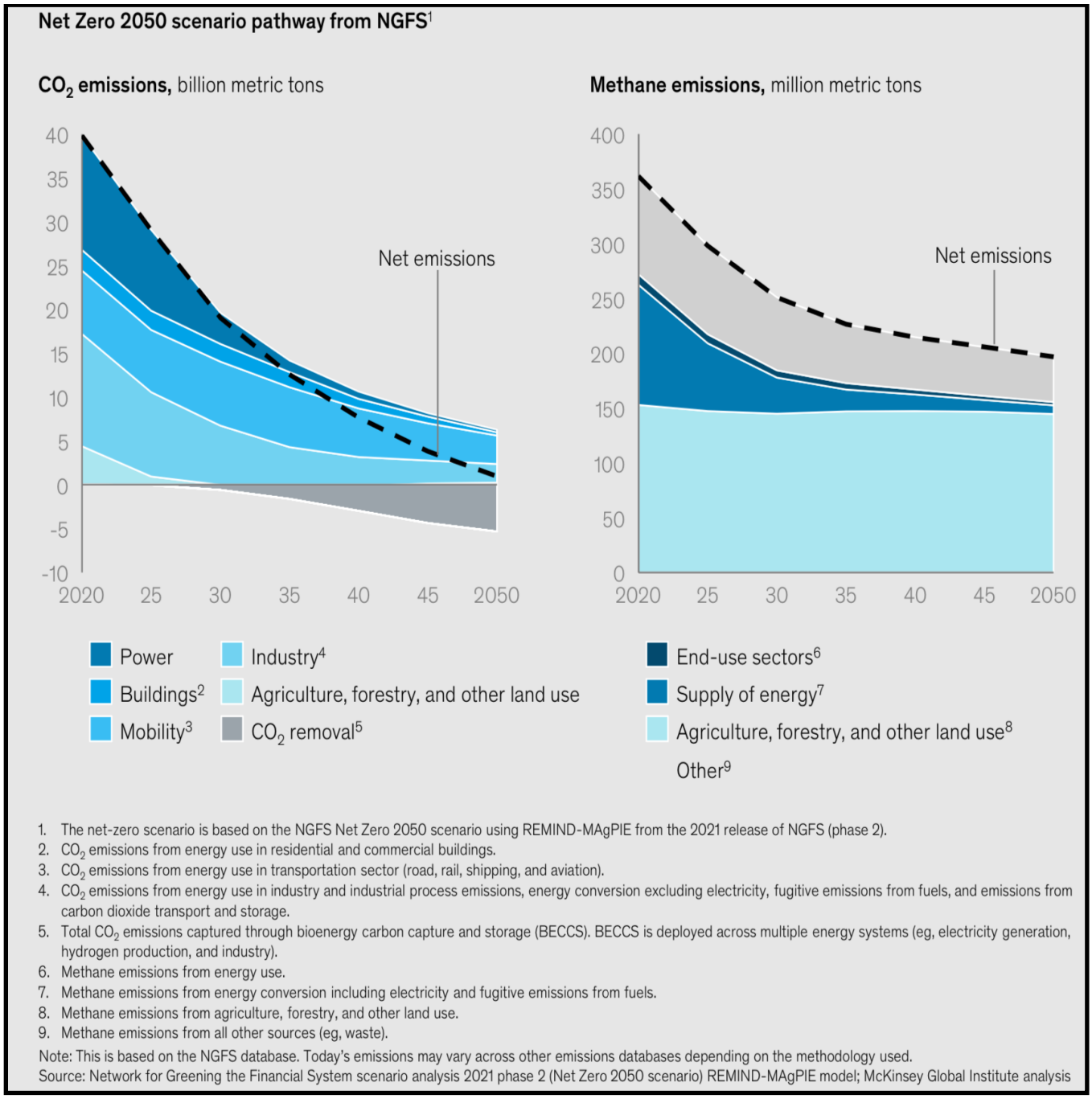
Exhibit 1: The net-zero 2050 scenario from the Network for Greening the Financial System (NGFS) for various sectors of the economy



Source: Network for Greening the Financial System scenario analysis 2021 phase 2 (Net Zero 2050 scenario) REMIND-MAgPIE model; McKinsey Global Institute analysis

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This would mandate a prudent balancing of the short-term threats of inaccurately set or uncoordinated efforts with the long-term threats of inadequate or postponed productive activity. Indeed, a disorganized metamorphosis could harm the energy supply and affect energy access and economics, particularly for lesser-income households and territories and could have knock-on effects on the economy developing a backlash which would impede the evolution.

Achieving the net-zero target implies dealing with multiple complexities such as the following: what would be the ideal blend of technology that would be required to be used to attain emissions deductions while remaining within a carbon budget, restricting expenses, as well as attaining the necessary criteria of performance? How would this transition budget be funded and how would this transition impact businesses and different market conditions? What blockages are probable to arise in manufacturing capability, supply chains, availability of natural resources and infrastructure facilities restricting the swiftness of the net-zero transition? What would be the likely impact on employees and customers and furthermore what prospects and hazards would this transition likely to form for corporations and nations? Also, how would customers be motivated to bring in modifications to consumption and expense behavior, which would be required to ensure the net-zero transition?

Additionally, the net-zero scenario could be attained exclusively if all energy and land-use techniques that cause these hazardous emissions would be decarbonized and all economic sectors across all nations globally would be required to take part. Despite the obstacles faced while assembling financial and society adaptations, this transition would give birth to expansion prospects across multiple sectors across multiple nations and would assist to evade the buildup of related physical threats.

This research highlights forecasts related to the net-zero transition and also provides explanations for some of these queries, specifically those connected to monetary and social adjustments. The assessments based on the report consider the economic modifications that are likely to occur in a net-zero evolution consistent with 1.5℃ of global warming.

The Need For Universal Transformation In The Energy And Land Usage Procedures

In order to stabilize climate change and restrict global warming, it is crucial to diminish the accumulation of greenhouse gasses into the environment and attain net-zero emissions in the energy and land-use systems. Listed here are rough estimates of toxic emission footprints from these sectors.

- The power sector which comprises electricity and heat generation, causes 30% of carbon dioxide emissions and 3% of nitrous oxide emissions

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- The industry sector has myriad industrial procedures comprising manufacturing of steel, cement and chemicals, and extraction and refining processes of oil, gas and coal which generate 30% of carbon dioxide emissions, 33% of methane emissions and 8% of nitrous oxide emissions
- The mobility sector which comprises land, air and water transport causes 19% of carbon dioxide emissions and 2% of nitrous oxide emissions
- The building industry comprising residential and commercial buildings, also incorporating heating and cooking causes 6% of carbon dioxide emissions
- The agriculture sector comprising direct on-farm energy usage and emissions from agrarian procedures and fishing processes leads to 1% of carbon dioxide emissions, 38% of methane emissions and 79% of nitrous oxide emissions
- Forestry, additional ground usage and predominantly terrain cover modification leads to 14% of carbon dioxide emissions, 5% of methane emissions and 5% of nitrous oxide emissions
- Waste accumulation comprising of solid scrap dumping as well as garbage treatment, incineration and wastewater treatment, leads to 23% of methane emissions and 3% of nitrous oxide emissions

Each of these energy and land-usage procedures adds significantly to ejected emissions. Hence, every one of these procedures will be required to go through modification if the net-zero objectives is to be attained. Nonetheless, these procedures are extremely connected and efforts to decrease ejected emissions must happen across the entire value chain in all economic components globally. Energy usage estimates for 83% of the carbon dioxide footprints ejected from energy and land-usage procedures. Power and industry sectors are primary energy users and jointly emit roughly 60% of carbon dioxide emissions.[2] Exhibit 2 depicts this information graphically. Refer to Exhibit 3 which highlights the breakdown of carbon dioxide emissions from each of the energy and land-usage procedures using different inputs.

[2] Krishnan, Mekala, et al. "The Net-Zero Transition: What It Would Cost, What It Could Bring." *McKinsey & Company*, 2022, www.mckinsey.com/business-functions/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring.

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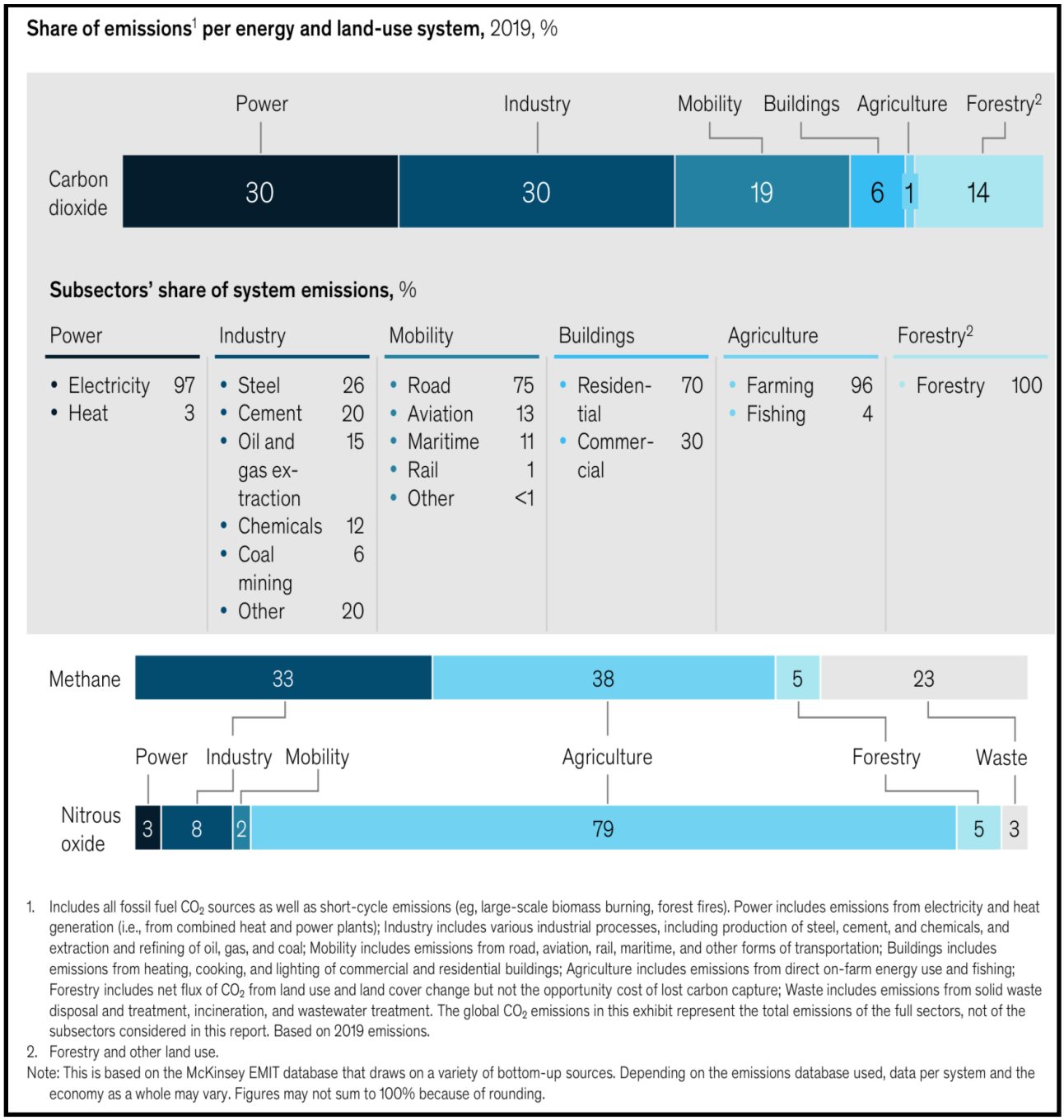
Exhibit 2: Power and industry sectors jointly consume major energy inputs and eject 60% of carbon dioxide emissions



Source: EMIT database by McKinsey Sustainability Insights (September 2021, data for 2019); McKinsey Global Institute analysis

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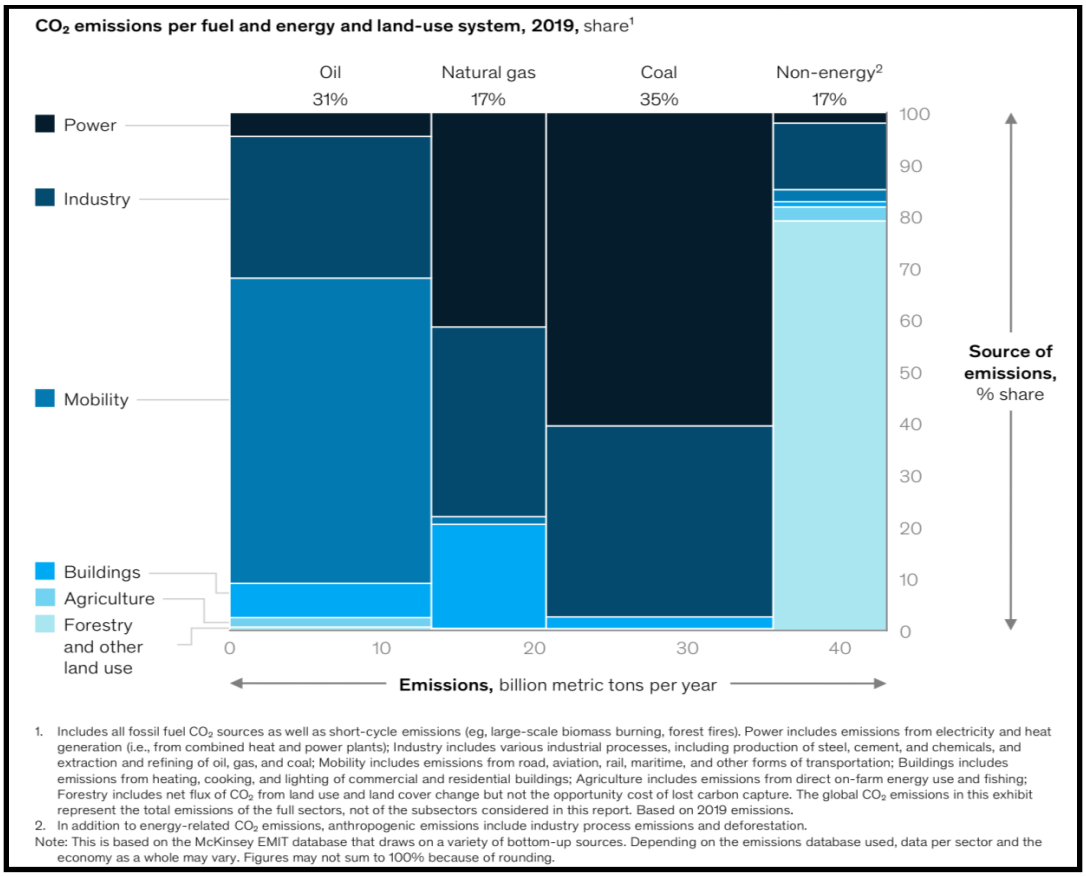
Exhibit 3: Energy usage and related emissions of carbon dioxide ejected across from energy and land-usage procedures



Source: EMIT database by McKinsey Sustainability Insights (September 2021, data for 2019); International Energy Agency; McKinsey Global Energy Perspectives; McKinsey Global Institute analysis

Hence, efficient decarbonization efforts should comprise veering around the energy mix away from fossil fuels and move towards zero-emissions electricity and additional low-emissions energy carriers namely hydrogen. Furthermore, modifying industrial and agrarian procedures, using lesser emissions-intensive products, improving energy efficiency technology and supervising the demand for energy effectively, would develop a circular economy. Also, deploying carbon capture, utilization, and storage (CCS) technology, reducing deforestation and stimulating afforestation is extremely significant for recharging and improving greenhouse gas reductions. Exhibits 4 and 5 explain how according to the Network for Greening the Financial System (NGFS) achieving the targets of the net-zero transmission utilizing clean energy and power resources and green changes in multiple energy and land usage systems would assist in bringing down the hazardous carbon dioxide emissions for multiple sectors of the economy.

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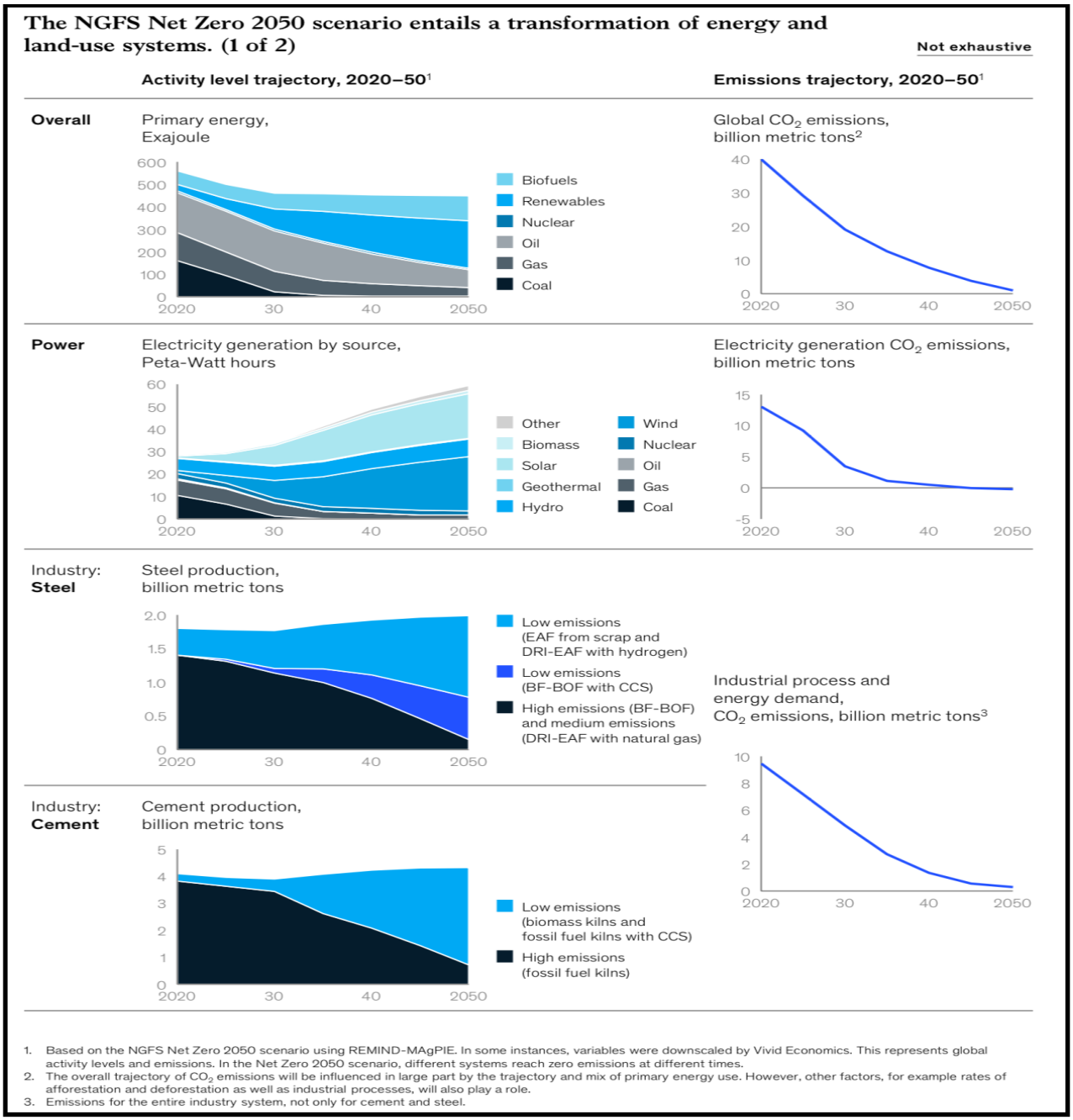
Exhibit 4: Network for Greening the Financial System (NGFS) achieving the targets of net-zero transmission in energy and land usage systems utilizing clean fuels



Source: NGFS Net Zero 2050 scenario using REMIND-MAgPIE (phase 2); Vivid Economics; McKinsey Sustainability Insights; McKinsey Global Institute analysis

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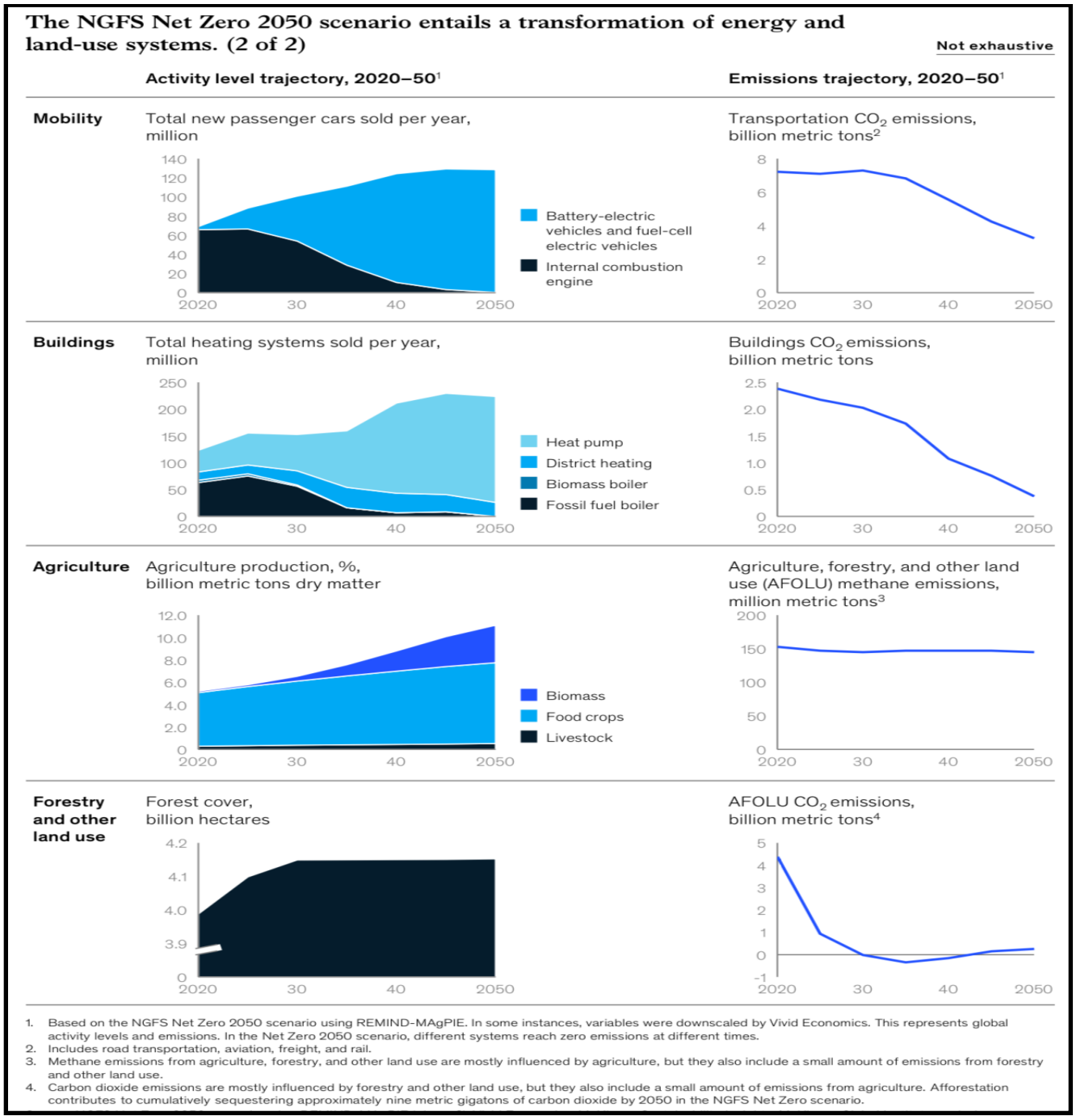
Exhibit 5: Network for Greening the Financial System (NGFS) achieving the targets of net-zero transmission in energy and land usage systems utilizing clean fuels



Source: NGFS Net Zero 2050 scenario using REMIND-MAgPIE (phase 2); Vivid Economics; McKinsey Sustainability Insights; McKinsey Global Institute analysis

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The Net-Zero Transition Cost

This research paper studies McKinsey & Company's study which assesses the net-zero transition financial impacts on market demand, capital allotment, expenses, and employment opportunities up to 2050 worldwide across multiple energy and land-use systems that generate approximately 85% of overall emissions and evaluates economic transformations for 69 nations.

The study takes into account the attainment of the hypothetical theory to restrict the rise in global temperatures to 1.5℃ above pre-industrialization levels using the net-zero 2050 scenario from the Network for Greening the Financial System (NGFS), to deliver an assessment of the financial modifications and society adaptations related to this net-zero evolution. The study anticipates that the net-zero transition would be versatile and meaningful, however, there is likelihood to have erratic impacts on different sectors of the economy, nations and societies, even though it is proposed to develop development prospects.

The estimated capital expenditure on physical assets for energy and land-use systems in the net-zero transition between 2021 and 2050 would be approximately US$275 trillion, or a mean estimate of US$9.2 trillion per annum, with a yearly growth of about US$3.5 trillion from the current date. In relative terms, this US$3.5 trillion is roughly equal to 50% of worldwide corporate gains in 2020, 25% of aggregate tax earnings and 7% of household spending. Furthermore, an additional US$1 trillion of the current yearly expenditure would be required to transit from increased-emissions to lower-emissions assets. The expenditure would increase the current average GDP from 6.8% to 8.8% between 2026 and 2030, and then it's likely to decrease.[3] Refer to Exhibit 6 for further details.

Also, keeping in mind the expense prerequisites are tremendous and financing is yet to be selected, and multiple investments are expected to have favorable recovery results and should not be viewed as simply expenses. In fact, technical invention could decrease capital expenses for net-zero technologies quicker than anticipated. Also, all nations have growth opportunities from endowments of natural capital like sunlight and forests and can utilize their technical and human resources.

The net-zero transition would lead to a rise in the worldwide average delivered expense of electricity in the short term due to building renewable sources and then a decrease from the peak, an increase of approximately 25% from 2020 to 2040 and 20% in 2050. Refer to Exhibit 7 for further graphical details.

[3] Krishnan, Mekala, et al. "Insights on the Net-Zero Transition." *McKinsey & Company*, 2022, www.mckinsey.com/capabilities/sustainability/our-insights/insights-on-the-net-zero-transition.

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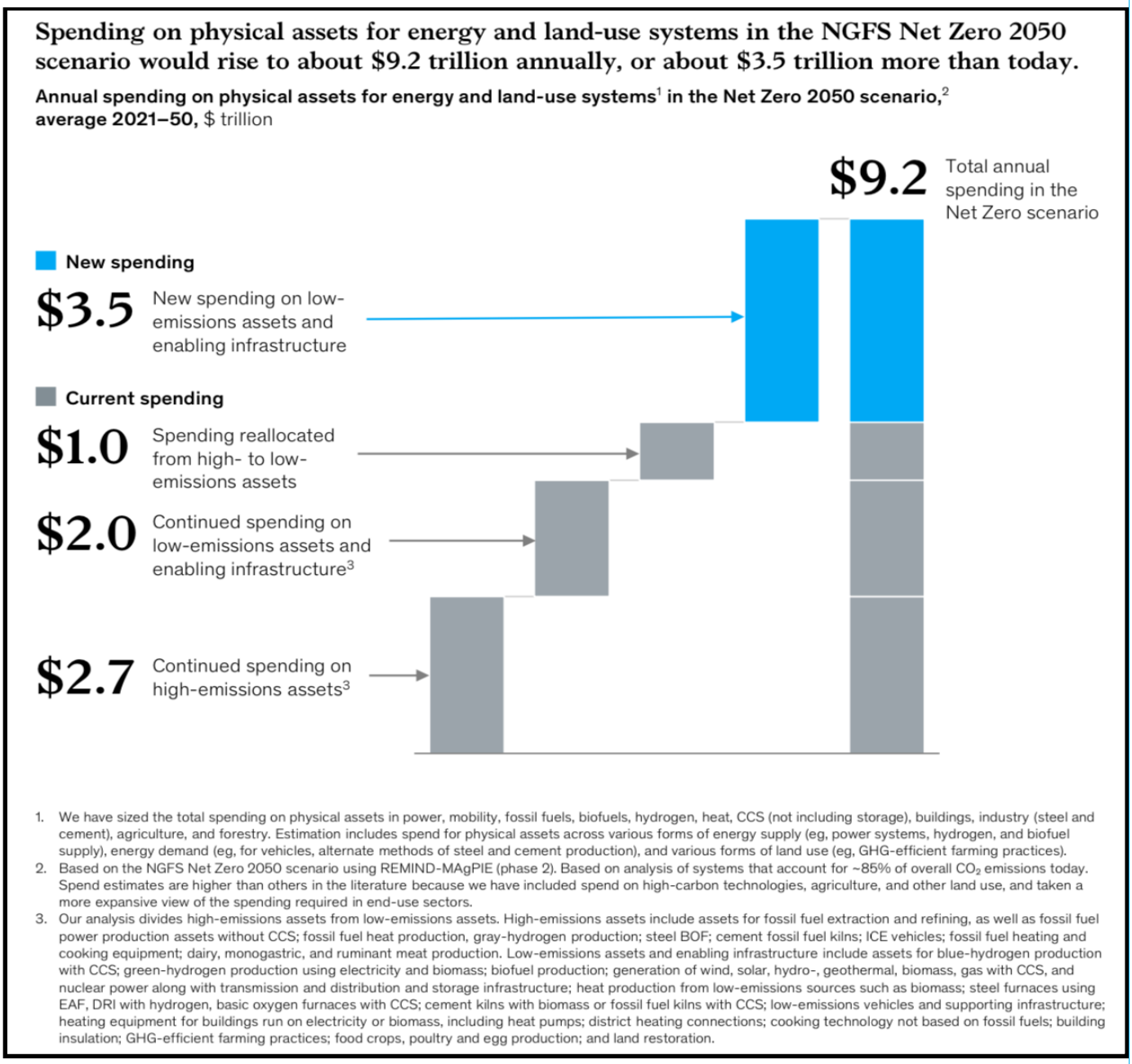
Exhibit 6: Expenditure on physical assets for energy and land usage procedures according to the Network for Greening the Financial System (NGFS) net-zero scenario



Source: McKinsey Center for Future Mobility Electrification Model (2020); McKinsey Hydrogen Insights; McKinsey Power Solutions; McKinsey–Mission Possible Partnership collaboration; McKinsey Sustainability Insights; McKinsey Agriculture Practice; McKinsey Nature Analytics; McKinsey Global Institute analysis

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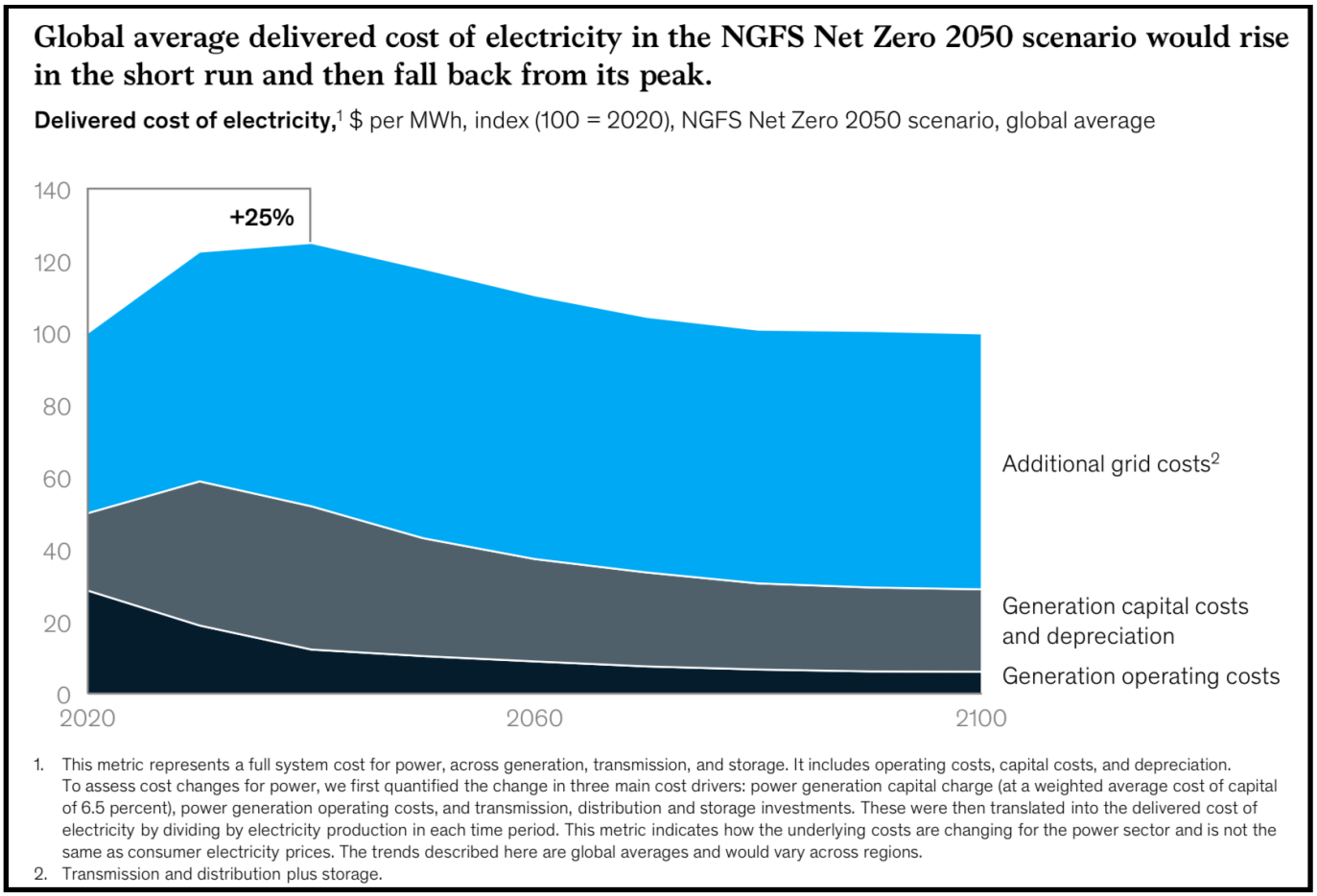
Exhibit 7: The average delivered cost of electricity as per the Network for Greening the Financial System (NGFS) net-zero scenarios



Source: Network for Greening the Financial System scenario analysis 2021 phase 2 (Net Zero 2050 scenario) REMIND-MAgPIE (phase 2) model; Vivid Economics; World Resources Institute Power Plant Database; McKinsey Power Solutions; McKinsey Global Institute analysis

Furthermore, this net-zero evolution could result in an increase of nearly 200 million and a decrease of approximately 185 million direct and indirect employment opportunities worldwide by 2050. The demand for employment opportunities in the fossil fuel extraction, manufacturing and fossil-based power sectors could decrease by nearly 9 million and 4 million direct employment opportunities, respectively, while the demand for nearly 8 million direct employment opportunities are likely to be made in renewable power, hydrogen, and biofuels by 2050. Nonetheless, the displaced workers would require support, apprenticeship and reskilling through the transition. Refer to Exhibit 8 for further details.

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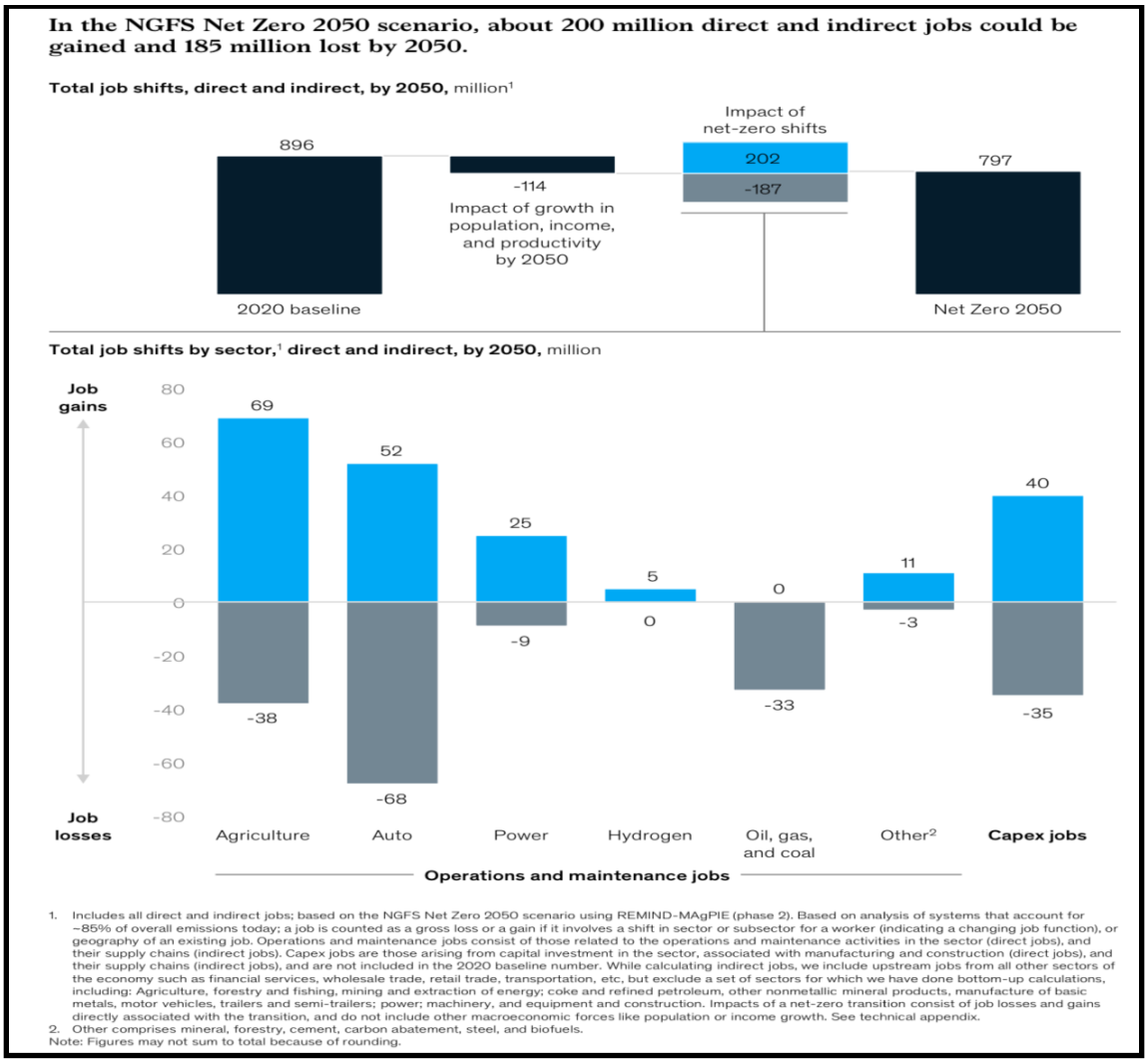
Exhibit 8: Impact on direct and indirect employment opportunities as per the Network for Greening the Financial System (NGFS) net-zero scenarios



Source: Network for Greening the Financial System 2021 (Net Zero 2050 scenarios) REMIND-MAgPIE model; Vivid Economics; McKinsey Center for Future Mobility Electrification Model (2020); McKinsey Hydrogen Insights; McKinsey Power Solutions; McKinsey Sustainability Insights; McKinsey Agriculture Practice; McKinsey Nature Analytics; Jobs baseline (ILO, OECD, MinSTAT, INDSTAT, IHS, WIOD, IEA, US BLS, India NSS-Employment Survey, China-NBS, IRENA); Jobs multipliers (McKinsey Economics Analytics Platform, GTAP, Asian Development Bank, US BEA, OECD, Oxford Economics); McKinsey Global Institute analysis

Certain markets for lower-carbon products and support services are likely to develop. Less developed nations, those who are heavily dependent on fossil fuels are likely to be impacted the most in a net-zero transition, although they are likely to have greater development prospects and

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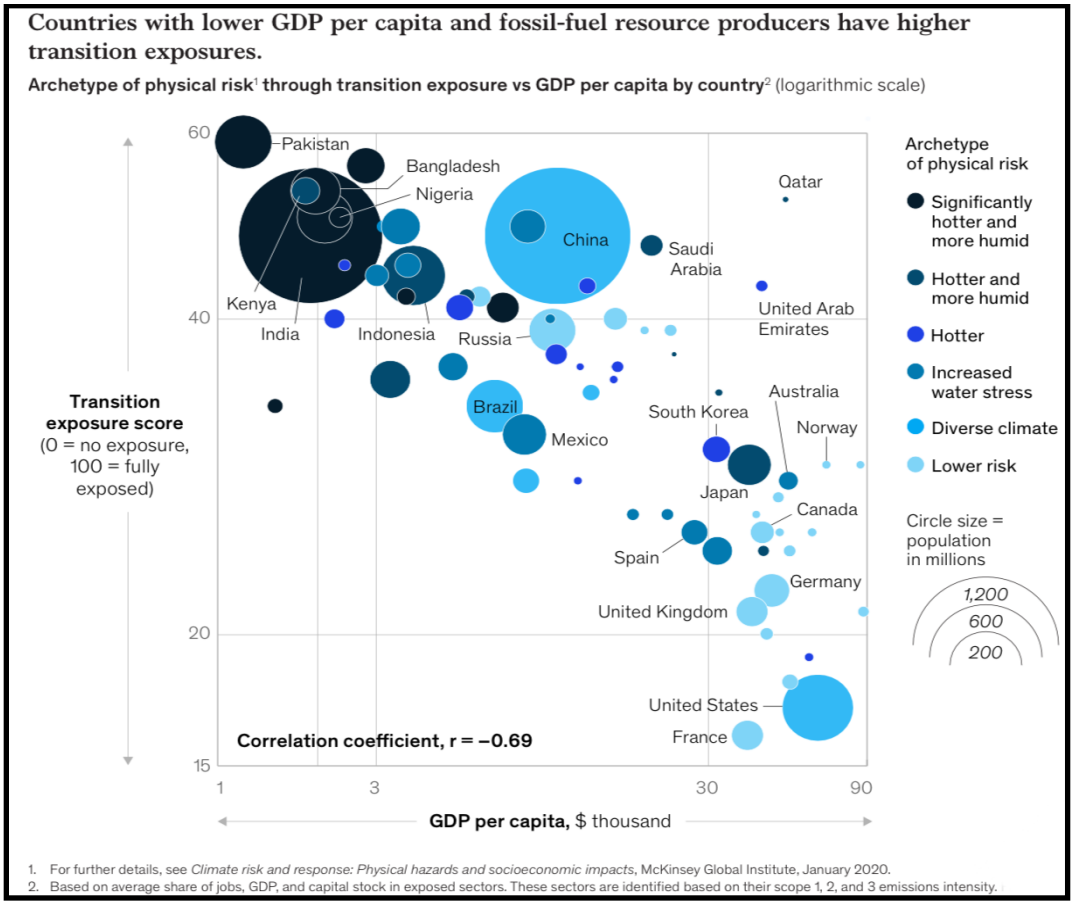
are more sensitive to modifications in output, capital stock and employment as their exposed sectors comprise fairly considerable aspects of their economies. It is anticipated that there is likely to be increased grades of exposure in nations with lesser GDP per capita, like Pakistan, Bangladesh, India, Indonesia, Nigeria and Kenya, as these nations tend to have moderately elevated share of employment, GDP, and capital stock in economic sectors that have emissions-intensive processes and their production processes and supply chains are likely to face greater levels of transition. Furthermore, higher fossil fuel resource manufacturing produces an elevated exposure for nations involved in this process, namely the UAE, Qatar, Russia, and Saudi Arabia. Refer to Exhibit 9 for further graphical inputs related to the subject.

Exhibit 9: Countries with lower GDP per capita and fossil fuel-producing nations are likely to have greater transition exposure



Source: Oxford Economics; OECD; ILO; World Input-Output Database; IHS Connect; World Bank; International Energy Agency; US Bureau of Labor Statistics; India NSS-Employment survey; China National Bureau of Statistics; UN; International Renewable Energy Agency (IRENA); MINSTAT; INDSTAT; Global Solar Atlas; Global Wind Atlas; US Geological Survey; WEF; McKinsey Nature Analytics; McKinsey Global Institute analysis

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For example, sub-Saharan Africa and India would be required to invest 1.5 more than developed economies as a percentage of their GDP to sustain economic expansion and construct low-carbon infrastructure. Furthermore, these net-zero modifications would raise production expenses in certain sectors, with steel and cement encountering boosts by 2050 of almost 30% to 45%, respectively.[4] By 2050, it is anticipated that oil and gas production quantity will fall by 55% and 70% respectively, as compared to 2020, and coal production for energy usage is likely to come to an end by 2050.

The global most developed economies such as the United States, China, Australia, New Zealand, Canada, the European Union, Japan, and the United Kingdom account for nearly 50% of the international spending on physical assets and this can be estimated at nearly 6% of their combined GDP from 2021 to 2050. However, in developing nations, the expenditure on energy and land usage would constitute a substantially bigger percentage of their GDP, nearly 10%. Exhibit 10 depicts the names of such nations whose economy is based on fossil fuel production as well as developing countries which would require spending a higher percentage of their GDP as compared to other nations to modify and develop physical assets for energy and land usage procedures.

Globally lesser-income households spending patterns may also be influenced by decarbonization endeavors, as they would be required to substitute products that consume fossil fuel, namely, automobiles and home heating systems. The economic and social expenses of a late or harsh transition would inflate the risk of asset stranding, employee dislocations and a backlash that pause the transition. Furthermore, supply may not be competent enough to scale up satisfactorily, leading to deficits and price upsurges. Hence, a lot consequently relies on how the transformation is administered. Nonetheless, it is extensively notable that attaining net-zero emissions and restricting global warming to 1.5℃ would lessen the probability of creating the most disastrous consequences of global temperature rise, restricting the hazard of biotic feedback loops and preserving our environment.

Therefore, corporations would need to modify their business prototypes incorporating climate-related aspects into decision-making procedures for planning, finance, and capital allotment. They would be required to determine, enforce and evolve decarbonization and counteracting strategies for scope 1 emissions (direct emissions by an individual or organization) and scope 2 emissions (indirect emissions by an individual or organization) emissions and potentially extend

[4] "Net Zero Coalition." *United Nations*, United Nations, www.un.org/en/climatechange/net-zero-coalition.

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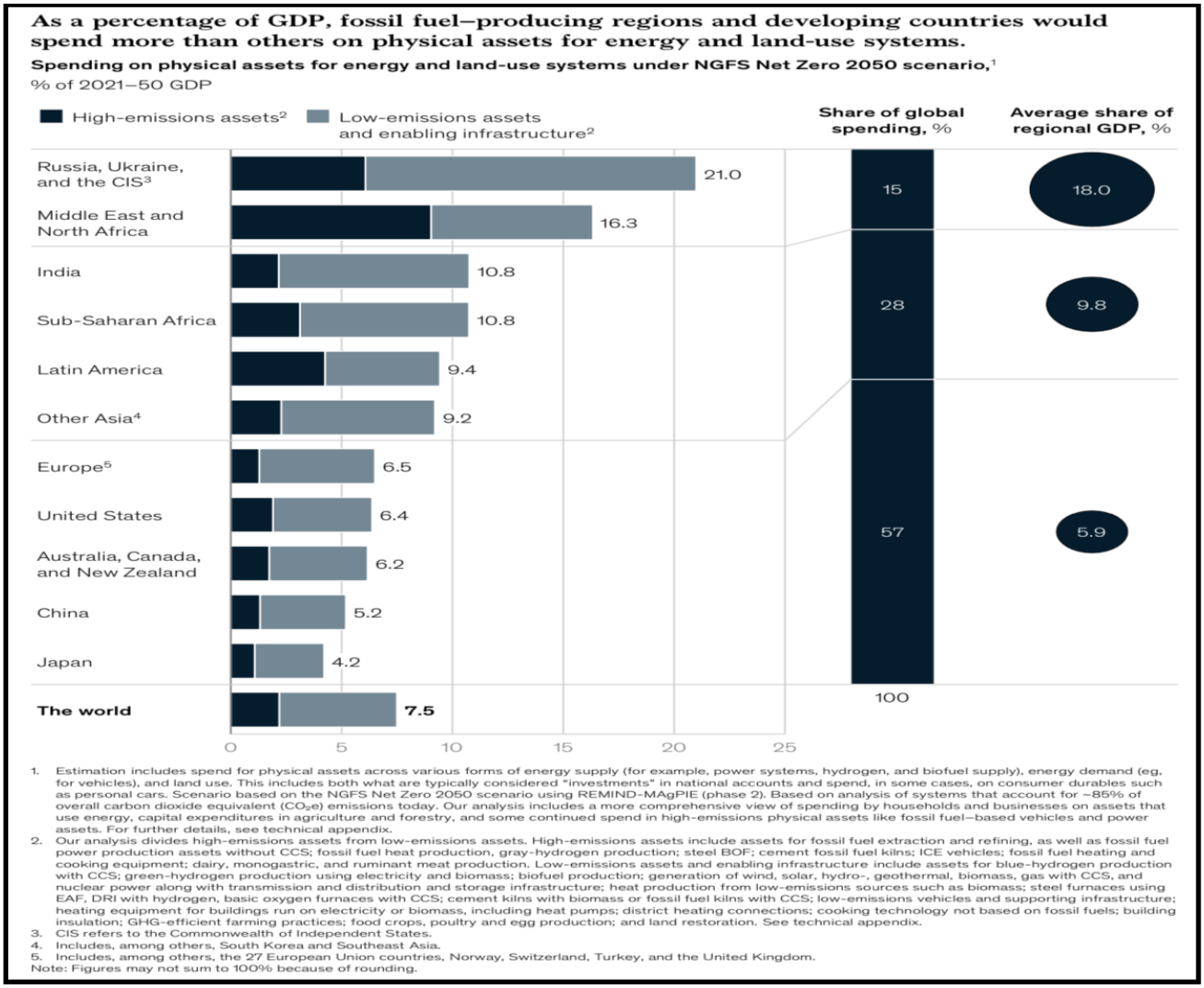
those strategies to incorporate scope 3 emissions (emissions caused down the value chain), depending on the character of their functions, applicability and feasibility.

Exhibit 10: List of nations whose economy is based on fossil fuel production as well as developing countries which would require spending a higher percentage of their GDP as compared to other nations to modify and develop physical assets for energy and land usage procedures



Source: Network for Greening the Financial System 2021 (Net Zero 2050 scenarios) REMIND-MAgPIE model; Vivid Economics; McKinsey Center for Future Mobility Electrification Model (2020); McKinsey Hydrogen Insights; McKinsey Power Solutions; McKinsey–Mission Possible Partnership collaboration; McKinsey Sustainability Insights; McKinsey Agriculture Practice; McKinsey Nature Analytics; McKinsey Global Institute analysis

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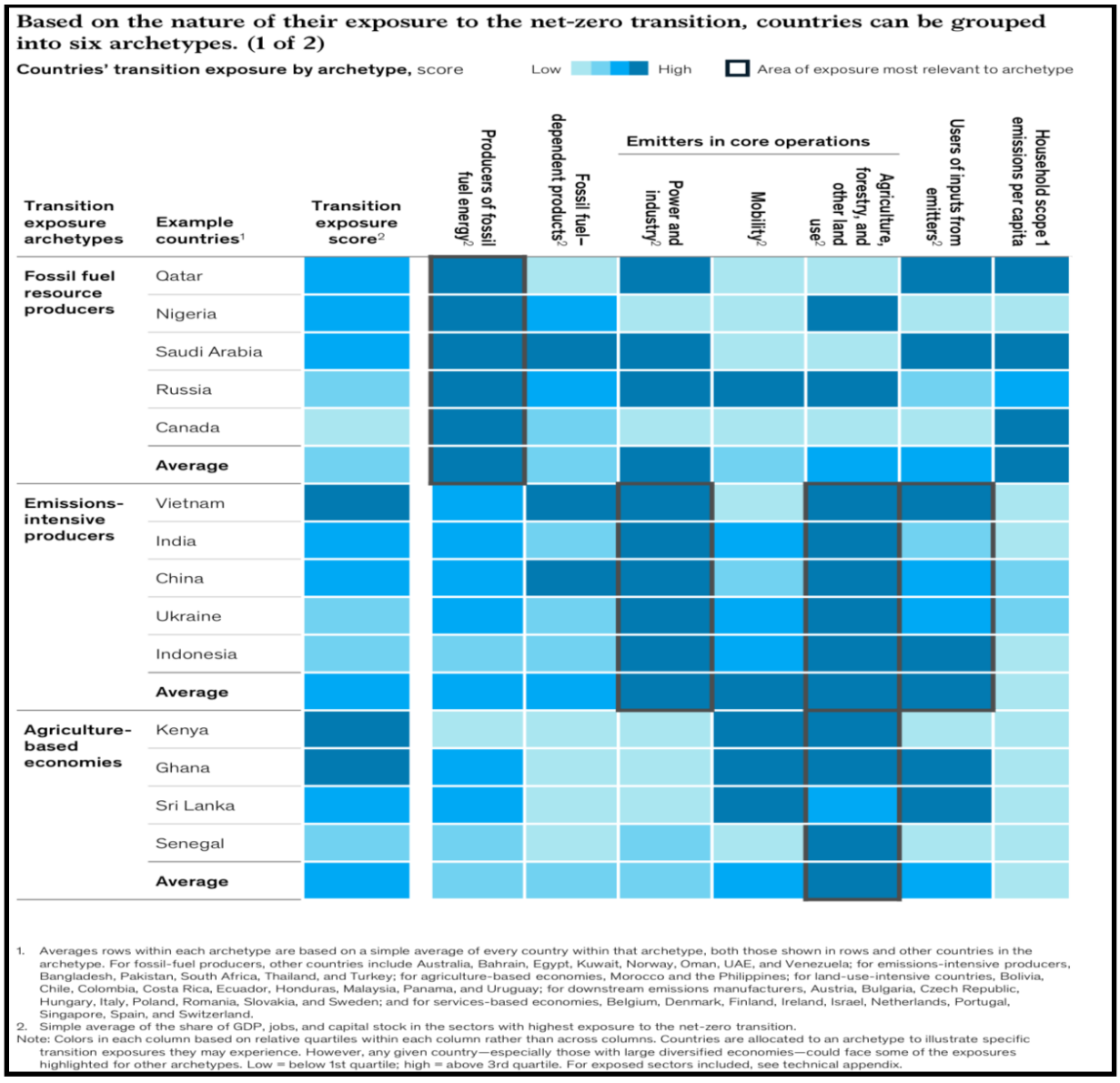
Furthermore, six central archetypes of nations are founded on the typical essence of their transition exposure based on the character and volume of their exposure across sectors and households which is explained in Exhibits 11 and 12.

Exhibit 11: Significant archetypes of nations founded on the typical essence of their transition exposure



Source: Oxford Economics; OECD; ILO; World Input-Output Database; IHS Connect; World Bank; International Energy Agency; US Bureau of Labor Statistics; India NSS- Employment survey; China National Bureau of Statistics; MINSTAT; INDSTAT; McKinsey Global Institute analysis

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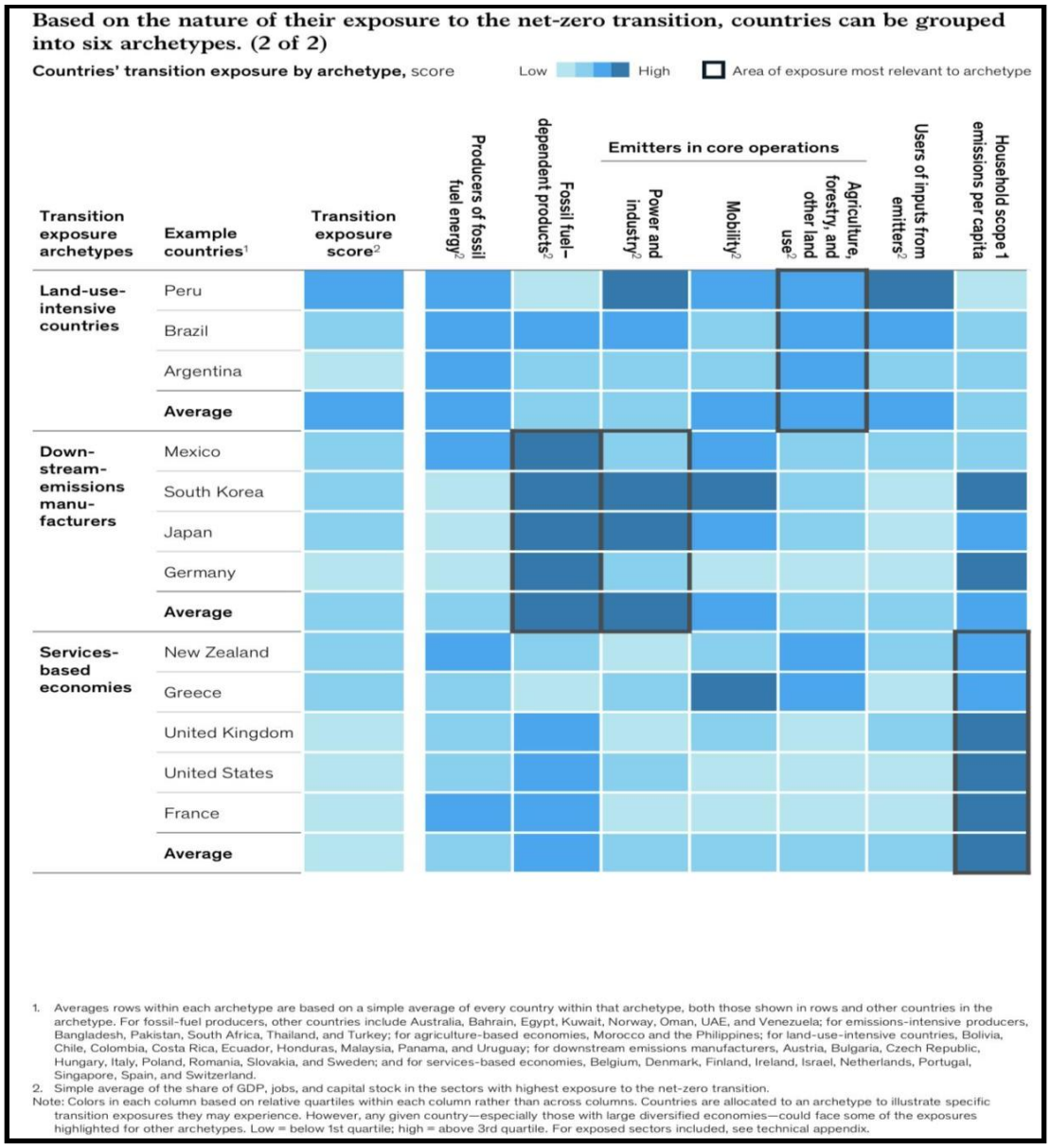
Exhibit 12: Significant archetypes of nations founded on the typical essence of their transition exposure



Source: Oxford Economics; OECD; ILO; World Input-Output Database; IHS Connect; World Bank; International Energy Agency; US Bureau of Labor Statistics; India NSS- Employment survey; China National Bureau of Statistics; MINSTAT; INDSTAT; McKinsey Global Institute analysis

Monetary organizations especially have a key function to play in funding large-scale capital reallocation and administering threats and opportunities. Public bodies and other organizations

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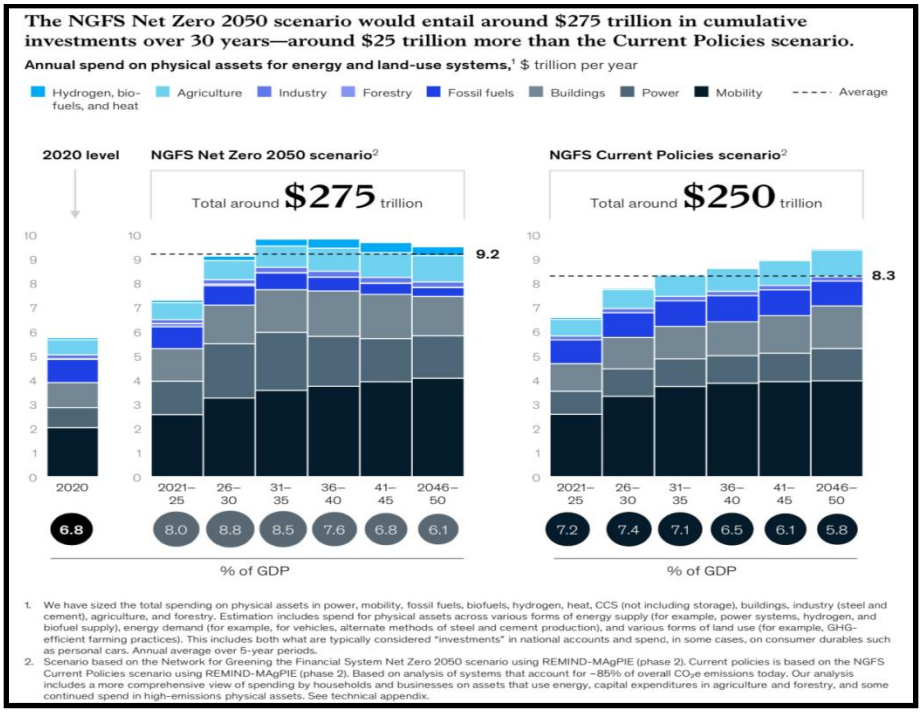
should employ fresh policies and regulatory and fiscal mechanisms to find incentives, aiding stakeholders and nurturing joint efforts to supervise inconsistent effects. As per the Network for Greening the Financial System (NGFS) net-zero scenario current investments need to be made in physical assets for energy and land usage techniques. Exhibit 13 depicts that an additional US$25 trillion would be required from 2020 to 2050 to attain the targets of the Network for Greening the Financial System (NGFS) net-zero scenario. Additionally, this expenditure projection is assessed to be from 6.8% of GDP in 2020 to 8.8% of GDP between 2026 and 2030 before decreasing in the future. The share of incremental spending is evaluated to be approximately 7.5% of GDP from 2021 to 2050.[5]

Exhibit 13: Cumulative investments for the future as per the Network for Greening the Financial System (NGFS) net-zero scenario



Source: Network for Greening the Financial System 2021 (Net Zero 2050 scenarios) REMIND-MAgPIE model; Vivid Economics; McKinsey Center for Future Mobility Electrification Model (2020); McKinsey Hydrogen Insights; McKinsey Power Solutions; McKinsey–Mission Possible Partnership collaboration; McKinsey

[5] Krishnan, Mekala, et al. "The Net-Zero Transition: What It Would Cost, What It Could Bring." *McKinsey & Company*, 2022, www.mckinsey.com/business-functions/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring.

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Sustainability Insights; McKinsey Agriculture Practice; McKinsey Nature Analytics; McKinsey Global Institute analysis

Procedural Requirements To Solve The Net-Zero Equation

To unravel this net-zero balance essential, interrelated system-level prerequisites are crucial for this evolution and modifications. These are listed here:

- Physical development requirements include technical invention, the capability to formulate at-scale supply chains and related infrastructure support systems and the availability of critical natural resources and inputs.
- Economic and societal adaptations include useful and efficient capital reallocation and financing organizations, managing demand changes and short-run price rises and offsetting tools to deal with socioeconomic effects.
- Effective governments and public organizations for completing societal responsibilities which include overseeing norms, tracking and market instruments, teamwork among public, private, and social-sector authorities worldwide along with backing from residents and customers.

Furthermore, all nations have possibilities to tap into the transition's probable growth opportunities and gain from benefits by utilizing their endowments of natural capital like sunlight, water resources and wind energy and employing the availability of technical, human, and physical capital resources. Exhibit 14 highlights the global potential to harness solar and wind energy.

The transition to net-zero emissions is likely to develop international opportunities for decarbonizing techniques, procedures, services and products, replacing high emissions with low emissions to support supply chain intakes and infrastructure. Thus, cooperative efforts of industries, corporations and public administrations must merge global warming problems into their decision-making schemes, apprehending the impacts of changing the global economy and thoughtfully advising international efforts to determine the transformation procedure, particularly as the hindrances of the decarbonization transition would not be the same globally.[6] Nonetheless, the rewards associated with net-zero transition in the long run, would significantly outperform

[6] "Global Climate Agreements: Successes and Failures." *Council on Foreign Relations*, Council on Foreign Relations, 2022, www.cfr.org/backgrounder/paris-global-climate-change-agreements.

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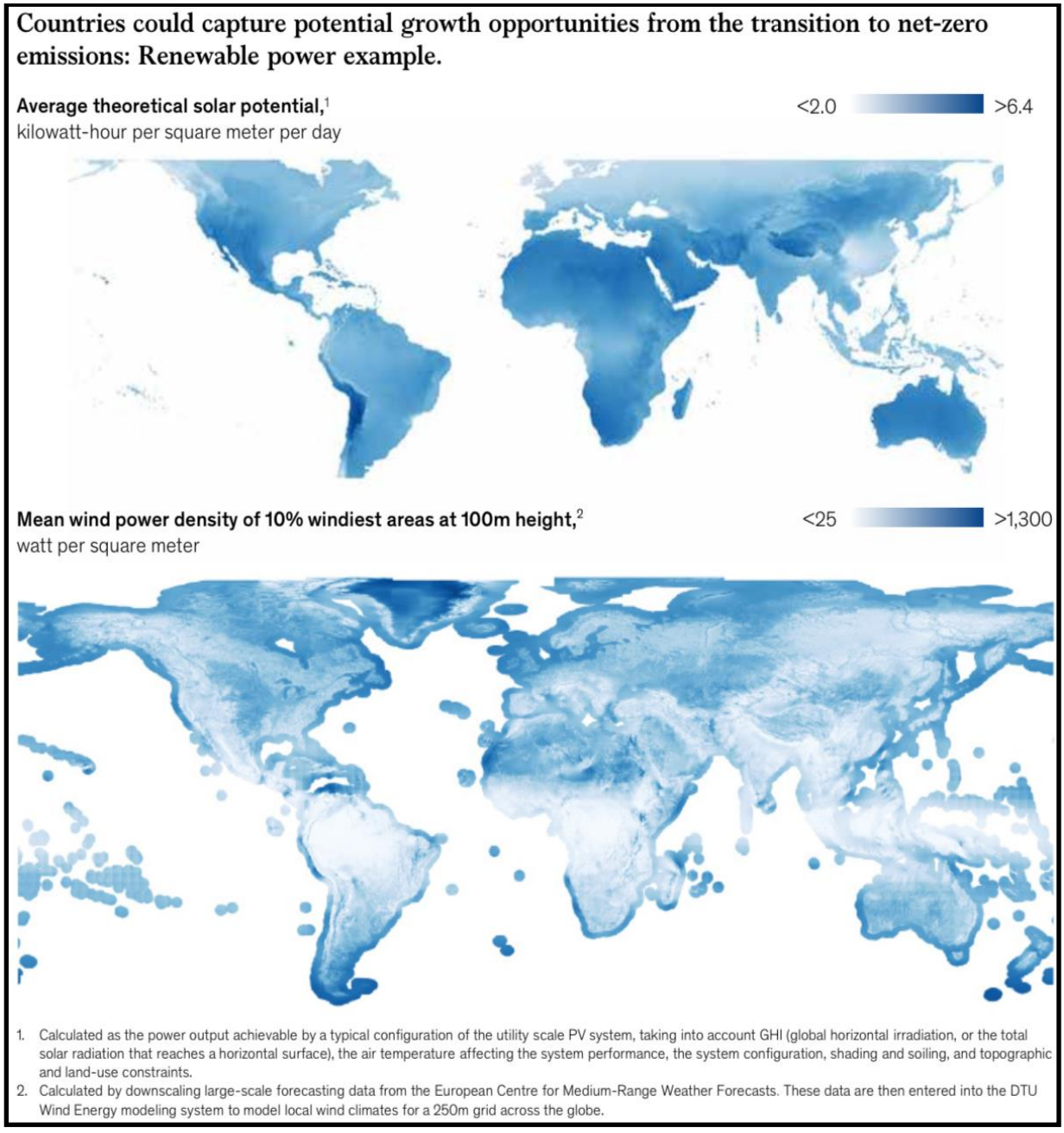
the economic and social problems associated with this evolution and possibly eradicate the dangerous outcomes of global warming, encompassing natural capital conservation.

Exhibit 14: Worldwide potential to harness solar and wind energy



Source: Global Solar Atlas; Global Wind Atlas; McKinsey Global Institute analysis

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