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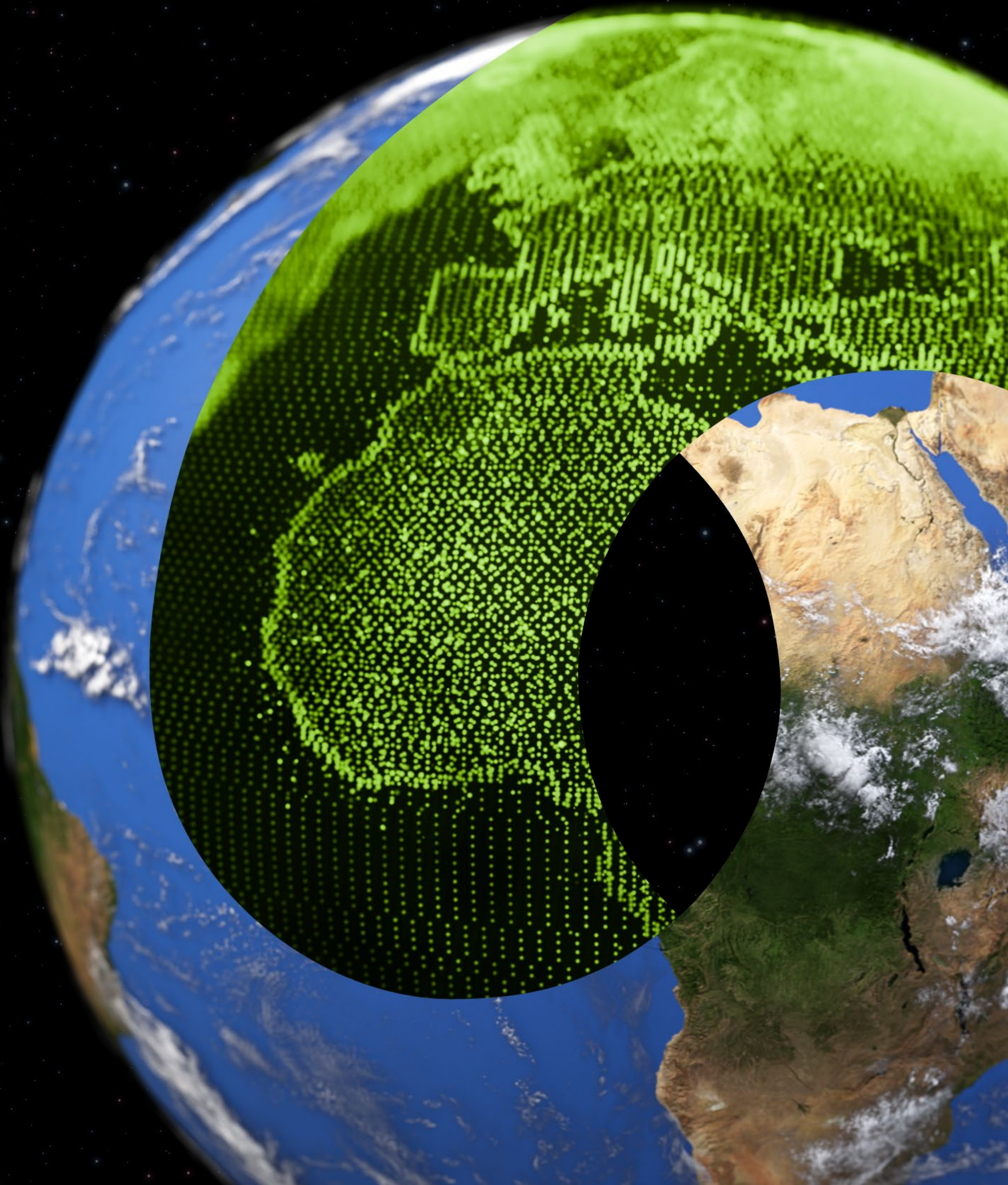
Financing the Green Energy Transition
A US$50 trillion catch

November 2023



Foreword

The global community has been on a journey from skepticism and fear of climate change to now one of ambition to seize the opportunities for growth and development. But the transition pathway is neither costless nor easy. The energy and climate transition represents one of the biggest modernization projects of the production system of economies, worldwide, since the Industrial Revolution; and the perils of climate change mandate that this takes place in just a fraction of the time.

This report on Financing the Green Energy Transition, is the latest in Deloitte's series of insights from the macro analysis around the global economic imperative to get to net zero in *The Turning Point*, to the criticality of skills in *Work toward net zero: the rise of the Green Collar workforce in a just transition*, and the potential of new energy in *Green hydrogen: energizing the path to net zero*. This report is a practical contribution to the global effort in recognizing, at its foundation, that finance is critical to economic growth and a key driver of this economic modernization effort.

Critical to this report is not some simplistic articulation of rates of return, but a detailed study in the factors to help unlock finance in service of building new markets with new rules, and, consequently, new risks and strategic outlooks. Importantly, this report places focus on a less recognized understanding of this transition—that the optimal path to net zero requires us to collectively manage the debt and equity aspects of global investment flows in this transition upfront.

Why? Because the energy transition requires developing economies as much as, if not more than, the developed economies, for global growth consistent with net zero by 2050. And as the finance community knows well, de-risking projects, or making them bankable, is key for both developed and developing economies. The essence of a just transition sits at the heart of this report.

The report highlights the magnitude of the global task ahead of us to achieve net zero by 2050—an investment ask of above US$7 trillion per annum under current financing conditions. But enabling optimal, low-cost finance, by making projects bankable, could help optimize the global investment initiative and reduce the investment ask by around US$2 trillion per annum—a US$50 trillion benefit to the global economy over the period to 2050.

This global transition proceeds having learned the lesson of the last 80 years—that growth and the equitable distribution of that growth are critical for a sustainable future. The geopolitical imperative for this cannot be ignored or not embedded into our collective thinking going forward. This is a report to help make the economic transition real—bankable—in the service of global economic growth and prosperity.

Each day, the global community, and Deloitte's clients, stakeholders, and people confront the risks and realities of the structural economic change ahead of us. Our objective is to generate greater conversation and debate on the best means of achieving our global imperative of building a net-zero economy by 2050. To this end, Deloitte welcomes you to engage with us and each other, as we help build an ecosystem for action, on the least-cost, optimal and equitable path to reach our common ambitions.

Jennifer Steinmann
Global Sustainability & Climate Practice Leader
Deloitte Global

Glossary

Term	Definition
ASEAN	Association of Southeast Asian Nations
BAU	Business-as-usual
CAPEX	Capital expenditure
CBI	Climate Bonds Initiative
CST	Climate stress test
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization and storage
(C)CfD	(Carbon) Contract for difference
CO_2	Carbon dioxide
COP	Conferences of the Parties
DBSA	Development Bank of Southern Africa
DFI	Development finance institution
DRI	Direct reduction of iron
EAF	Electric arc furnace
ECB	European Central Bank
EIB	European Investment Bank
EMDEs	Emerging markets and developing economies
EPC	Energy performance certificate
ESG	Environmental, social and governance
EU	European Union
EV	Electric vehicle
FiP	Feed-in premium
FiT	Feed-in tariff
GBP	Green bonds principle
GDP	Gross domestic product
GHG	Greenhouse gas
ICE	Internal combustion engine
IEA	International Energy Agency
IMF	International Monetary Fund

Term	Definition
IPP	Independent power producer
LCOE/H	Levelized cost of electricity/hydrogen
LICs	Low-income countries
MDB	Multilateral development bank
MICs	Middle-income countries
NDC	Nationally determined contribution
NZE	Net-zero emissions
OECD	Organization for Economic Co-operation and Development
OPEX	Operational expenditure
PPA	Power purchase agreement
PV	Photovoltaic
R&D	Research and development
RoR	Rate of return
UK	United Kingdom
UN	United Nations
US	United States

Executive summary

Reaching net-zero greenhouse gas (GHG) emissions globally by 2050 requires a fundamental transformation of society from the current fossil fuel-centric model to a highly renewable and electrified energy system.

This transformation entails significant investments, on the order of US$5 trillion/year to more than US$7 trillion/year through 2050. However, currently, less than US$2 trillion are invested each year to drive this transition. If investments do not scale up rapidly, the world will fail to meet its climate objectives.

A direct result of poor investment opportunities and risk-return profiles for green projects is the lack of private money financing the required transformation. Most of the identified technological solutions for climate neutrality (renewable energy, electrification, green hydrogen, etc.) are highly capital-intensive and often new and immature with significant development uncertainties. A highly capital-intensive energy transition means that the cost of capital is a key cost driver. This reflects an immutable law of finance: the riskier the project the higher the cost of capital. In fact, financing costs, stemming from the cost of capital, can account for as much as half of the investment expenditure.

Green projects currently suffer from underinvestment and high required return rates because private investors see green technologies as riskier than alternative investments. A key contributor to this risk perception is the political and regulatory risks that stem from governments' failure to establish the necessary mechanisms and instruments that can guarantee attractive returns on investment.

Developing economies, where about three-quarters of green investments should occur, often face greater risks and stricter public budget constraints for energy transition projects. Therefore, green projects, especially when they are in the Global South, are often not bankable, i.e., their risk-return profiles do not meet the investors' criteria to mobilize sufficient capital.

Deloitte's *Financing the Green Energy Transition* project aims to raise awareness of the need for governments, financial institutions, lenders and investors and project developers to jointly develop and agree on mechanisms to foster bankability. The current paper, as the first of its series, addresses this bankability challenge and assesses the financial instruments that can foster investments in the green transition, notably in developing economies, focusing on the energy-industry nexus, responsible for 80% of global greenhouse gas (GHG) emissions. In writing this report, Deloitte calls on its readers to engage in the conversation on the future of green finance and on the resolution of key investment barriers to accelerate the energy transition today.

Governments of countries across the full spectrum of economic development should work with financial institutions to develop mechanisms and instruments that can reduce risks and unlock private finance at attractive costs. These risks are associated with political, market and transformation barriers.

The key action levers to overcome them can be grouped in three main categories: reducing the risks of green projects, bridging the cost gap between fossil-based GHG-intensive products and their green counterparts and cutting the use of fossil fuels.

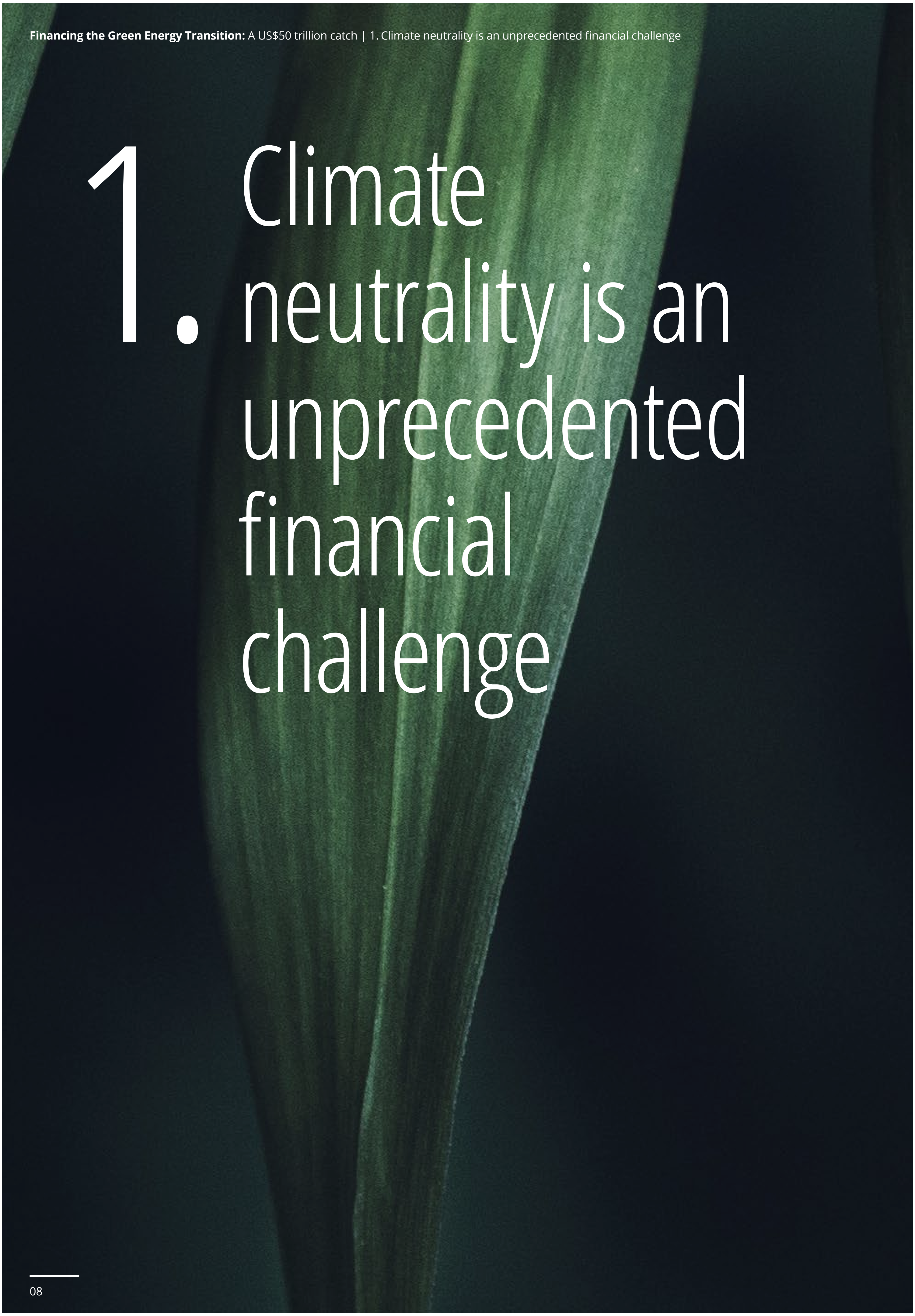
- Clear climate policies, guarantee mechanisms, offtake reliability and the development of domestic capital markets can significantly reduce the risks associated with these projects. Notably, blended finance mechanisms can reduce both project risks and facilitate commercial capital flows to green projects by virtue of the mobilization power of concessional capital. US$1 of concessional public finance can mobilize more than US$4 commercial capital, more than half of which can come directly from private capital.
- R&D and upfront investment support schemes, the addition of operating premiums to green assets and the penalization of GHG-intensive assets are some of the key tools to bridge the cost gap between green and GHG-intensive assets. They are often used in combination to facilitate market integration of green products (e.g., carbon tax and feed-in premiums).
- Ending fossil subsidies, compensating for the early phase-out of some of the fossil assets and facilitating the job transition of people employed in GHG-intensive industries to clean ones can facilitate the transition both socially and economically, preparing the groundwork for cutting fossil assets.

Developing countries often face higher political and regulatory, offtaker, market liquidity, currency and inflation risks. These are all factors impacting projects' financing costs, making capital-intensive energy transition projects disproportionately expensive. While developing regions generally have better renewable endowments, higher cost of capital entails higher product costs in these regions. Financing costs account for about one-quarter of the levelized cost of electricity (LCOE) from solar power plants in advanced economies, but they account for about half of it in developing economies. Moreover, the governments of developing countries tend to run on tighter budgets. Therefore, two key efforts chiefly aimed at emerging economies will be to de-risk projects to lower the cost of capital, and to remove barriers constricting the flow of private capital toward green projects.

In the absence of concessional finance in developing economies, a net-zero scenario would cost more than US$7 trillion/year on average through 2050 (almost US$200 trillion cumulatively). About 70% of those investments would take place in low- and middle-income economies. Reducing capital costs can both facilitate private capital flows toward the transition and reduce their cost. Achieving bankability can unleash private finance and bring investment spending down by US$2 trillion every year (US$50 trillion cumulatively, about half of global yearly GDP today) in the period to 2050.

Achieving climate goals is a formidable challenge. Decisive and coordinated policy support, and collective action from investors and policymakers are paramount to guide investments toward green and sustainable projects.

- **Governments should reduce the risks that threaten the bankability of green investments.** All underlying risks, from unreliable offtake to unstable macroeconomics, raise financing costs. De-risking the investment landscape can help unlock the low-cost capital that will make the costly and capital-intensive energy transition more affordable. Overall, governments will be pivotal in making more green projects bankable.
- **Under current financing conditions, reaching net zero by 2050 can cost more than US$7 trillion/year.** Concessional finance via innovative financing structures can reduce the cost of the transition by nearly 40% for developing countries, lowering global investment needs to US$5.5 trillion/year.
- **Societies and investors should deal with significant upfront investments today and reap the benefits later.** The cost of inaction is higher than the burden of a smooth, planned transition initiated today. The green transition can increase the world economy by US$43 trillion between 2021 and 2070. Required investment levels remain below 6% of global GDP annually, whereas a current policy pathway (aligned with +3°C of global warming) would entail almost 8% of global GDP loss by 2070.
- **Investors should channel green funds to developing economies.** Currently, less than half of green investments take place in developing countries. Excluding China, which accounts for one-third of green investments, that number shrinks to 16%. To reach climate goals, some 70% of green investments would need to happen in the Global South by 2030. This can only be possible with international cooperation and the active participation of development finance institutions and multilateral development banks.



1. Climate neutrality is an unprecedented financial challenge

1.1. Limiting global warming to 1.5°C

Anthropogenic greenhouse gas (GHG) emissions like carbon dioxide (CO_2), methane and nitrous oxide (N_2O) have caused much of the observed global warming over the past 150 years.[1]

Climate change caused by the rise of temperatures over the earth's surface seriously threatens to endanger biodiversity, make fresh water scarcer, and cause frequent devastating events such as droughts, floods and wildfires.[2] According to the Intergovernmental Panel on Climate Change (IPCC), limiting global warming to 1.5°C could "reduce the probability of extreme drought, precipitation deficits, and risks associated with water availability in some regions". This requires very rapid global GHG emission reductions and reaching climate neutrality by no later than 2050.[3]

Energy and industrial activities are responsible for more than 80% of global GHG emissions.[4] Therefore, the profound transformation of both energy supply and industrial processes is an unavoidable step on the path to climate neutrality. The key decarbonization levers of these activities consist of large-scale renewable deployment,[5] electrification of end-uses (buildings, industrial processes and transport sector),[6] direct and indirect use of green hydrogen in hard-to-abate sectors (e.g., steelmaking, e-fuels for aviation and maritime transport)[7] and energy efficiency improvements.[6] Moreover, carbon capture, utilization and storage (CCUS) will be required to decarbonize industrial activities that use fossil fuels as feedstock, and to produce e-fuels for maritime and aerial transport.[8] Such a transformation of the energy-industry nexus from a highly fossil-based system (above 80% of primary energy and feedstock supply)[9] to a nearly fossil-free world amounts to a true societal, cultural, economic and political revolution which will require unprecedented efforts and investments.[10]

1.2. The struggle to finance the energy transition

Both the International Energy Agency[11] and International Renewable Energy Agency[12] estimate that about US$4 trillion/year of global investments will be needed until 2050 to achieve net-zero GHG emissions and limit global warming to 1.5°C. This requires a shift from the historical value of US$1.8 trillion/year in 2019 and current policy trajectory of US$ 3.3 trillion/year.[12]

Thus, despite strong efforts from each side of the economy, the world has been struggling to keep up with the investment needs of the transition. Financing the energy transition has proven particularly challenging in developing countries, which face even higher investment hurdles than advanced economies where the transition is also slow.[10,13]

Moreover, the developing world will be more severely affected by climate change than advanced economies and will also be the home of most humans throughout the 21st century.[14,15] This is why financing the transition in developing regions is arguably the crux of the global race to net zero. The silver lining lies in the immense natural resource endowment of the developing world, from precious raw minerals to make batteries to sunbaked plains where solar panels thrive. With its young and increasingly educated workforce, the developing world has what it takes to leverage its natural resources for the transition. The question now is how to resolve the funding deadlock.

Governments, and especially developing countries, cannot single-handedly fund the required investments to get to net-zero GHG emissions by 2050. The private sector must be mobilized. As much of the required transformation consists of highly capital-intensive technological changes, project developers, especially in developing countries, are limited by financial constraints. Indeed, funding may not always be readily available for green transition projects, particularly in places where investments face higher risks or for new technologies without a proven track record. Consequently, unlocking abundant and affordable funding for the transition will require policy and market actors to work together to overcome key investment barriers.

1.3. Objective

The *Financing the Green Energy Transition – A US$50-trillion catch* study aims to understand the key bottlenecks that hinder the investments required to reach net zero.

The project consists of an identification of the key financial facilitating instruments to help accelerate the transition, a mapping of the gaps regarding the practical implementation of these facilitating instruments, a technology- and geography-differentiated assessment of these financial instruments based on modeling, and a stakeholder return on experience and depiction of a future project finance ecosystem in service of sustainability and climate targets. More precisely, the overarching goal of this project is to find and list out tools for increasing the bankability of green projects, especially in developing countries, to facilitate private capital flows toward the energy transition by answering the following questions:

- What are the existing financial tools to increase the bankability of sustainable projects and make them more attractive from an investor perspective, and how effective are they?
- What is missing from the existing spectrum of solutions and why are the investments not taking place at the required scale or pace?
- How does a green project financing environment look and how do different actors interact in such an environment? What are the practical and institutional inefficiencies in financing such projects and how can they be overcome?
- What are the potential new innovative financial instruments to promote globally, and what are the region-specific requirements for helping to accelerate the transition toward net-zero?
- What can public and international organizations do as catalyzers of project finance? What can policymakers do to help ease the transition and guide private funds toward climate targets?

To answer to these questions, Deloitte's *Financing the Green Energy Transition* study assesses:

01. the state of play of financial facilitating instruments and their regional and technological specificities, and

02. the project finance environment and some of its complexities and suggestion of a practical comprehensive sustainable finance ecosystem.

The first step is therefore to understand the state of play and the existing financial instruments in service of climate. Given that the energy-industry nexus is the key contributor to global warming (80% of global anthropogenic GHG emissions), this report aims to create such knowledge and introduce regional and technological considerations to this analysis of the state of play along with missing pieces of the green energy transition finance puzzle.

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2. Toward a climate-neutral world

2.1. A dynamic but insufficient policy environment

The year 2015 marked a turning point for global climate policy with 195 parties signing the Paris Agreement and the UN adopting its 17 Sustainable Development Goals (SDGs).[16] However, the follow-up on these landmark agreements has been disparate around the globe, with some countries doubling on green energy policies and others stagnating since.[17] The measure of this progress are the nationally determined contributions (NDCs), which Paris Agreement signatories should update every five years.

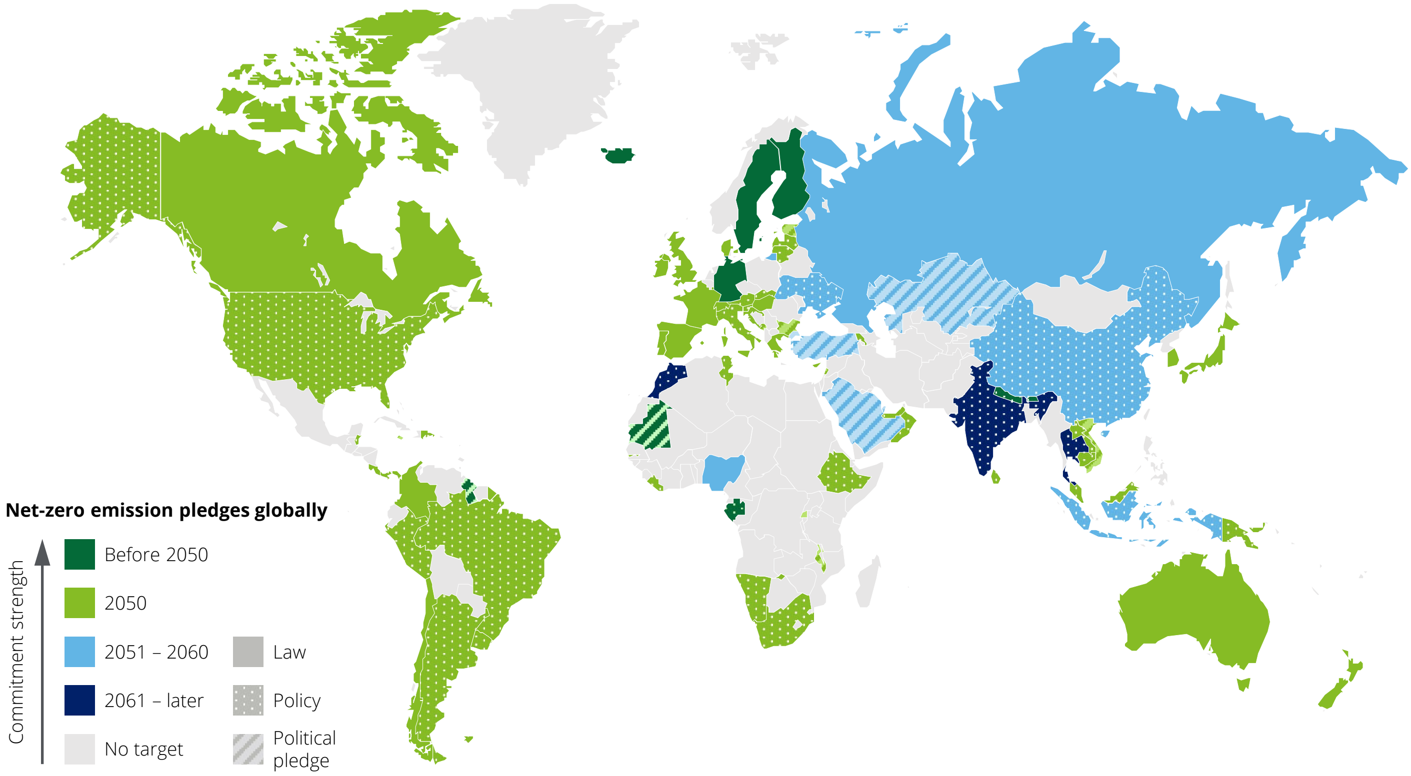
As of October 2023, 177 countries have updated their NDCs.[18] Of those, 107 countries representing over 80% of global GHG emissions have opted for more ambitious emissions reduction targets. These include historical emitters (advanced economies) and potential future emitters (emerging countries). Although the reporting procedures of the Paris Agreement are mandatory for signatories, the achievement of its objectives is not.[19] Hence, the Paris Agreement is effectively non-binding. This is why NDCs, as well as binding net-zero GHG emission targets are key to securing climate objectives against the tides of growth and crises, particularly when fossil fuel subsidies become politically attractive. For instance, the recent energy price crisis forced governments to deploy vast subsidy plans[20] to protect consumers who were trapped[21] in their dependency on increasingly expensive fossil fuels.

Besides temporarily boosting fossil fuel subsidies, the energy price crisis has also induced a paradigm shift, placing energy security and strategic dependencies at the top of policymakers' agenda.[22] This, along with a sharp rise in fossil fuel prices, has reduced the gap in economic attractiveness between fossil fuels and green technologies. Before the energy crisis, economic growth was largely planned around the expansion of fossil fuel consumption. The historical reality of developed countries having built their economies on the back of fossil fuels made it particularly challenging to ask developing countries not to. However, today, clean energies are entering the fray as a viable alternative growth model. Even if GHG emissions and economic development were deeply correlated in the past,[23] some developed economies managed over the past few decades to decouple their economic growth and GHG emissions.[24] The main reasons for this observation are a decrease in carbon intensity of the energy mix of these economies as well as a decoupling of energy use and economic growth.[25] Explaining this decoupling only by the offshoring of production overseas would have been primarily true in the early years following this observation. However, as consumption-based methodology is showing now, since mid-2000s, it is not the main driver of this decoupling anymore for most advanced economies such as the UK, Europe and North American countries.[26] Clean energies, notably renewable energies, have already managed to change the story as they become increasingly attractive. Not only are they catching up with fossil fuels in terms of costs, but they also offer a greater degree of strategic autonomy. This is especially relevant for countries that have historically been hit hard by fossil fuel supply shocks.

Global tides shifting in favor of climate neutrality transitions can be measured by the progress made on national net-zero targets. As of August 2023, 93 economies (92 countries and the EU) have net-zero targets, including 19 in pledges, 51 in policy documents and 22 in law (Figure 1). Advanced economies, Latin America and Asia-Pacific nations are largely leading the race to net-zero by 2050. By contrast, emerging and developing regions, particularly Africa, China, the Middle East, Russia and South Asia show weaker pledges, later deadlines or missing targets. If left unchecked, the climate footprint of these booming economies could escalate. India for instance targets net-zero emissions by 2070, by which point it could host 16% of the world's population[27] and be close to overtaking the US economy.[28] Therefore, despite considerable political progress, more pledges must be made to help secure the achievability of climate targets.

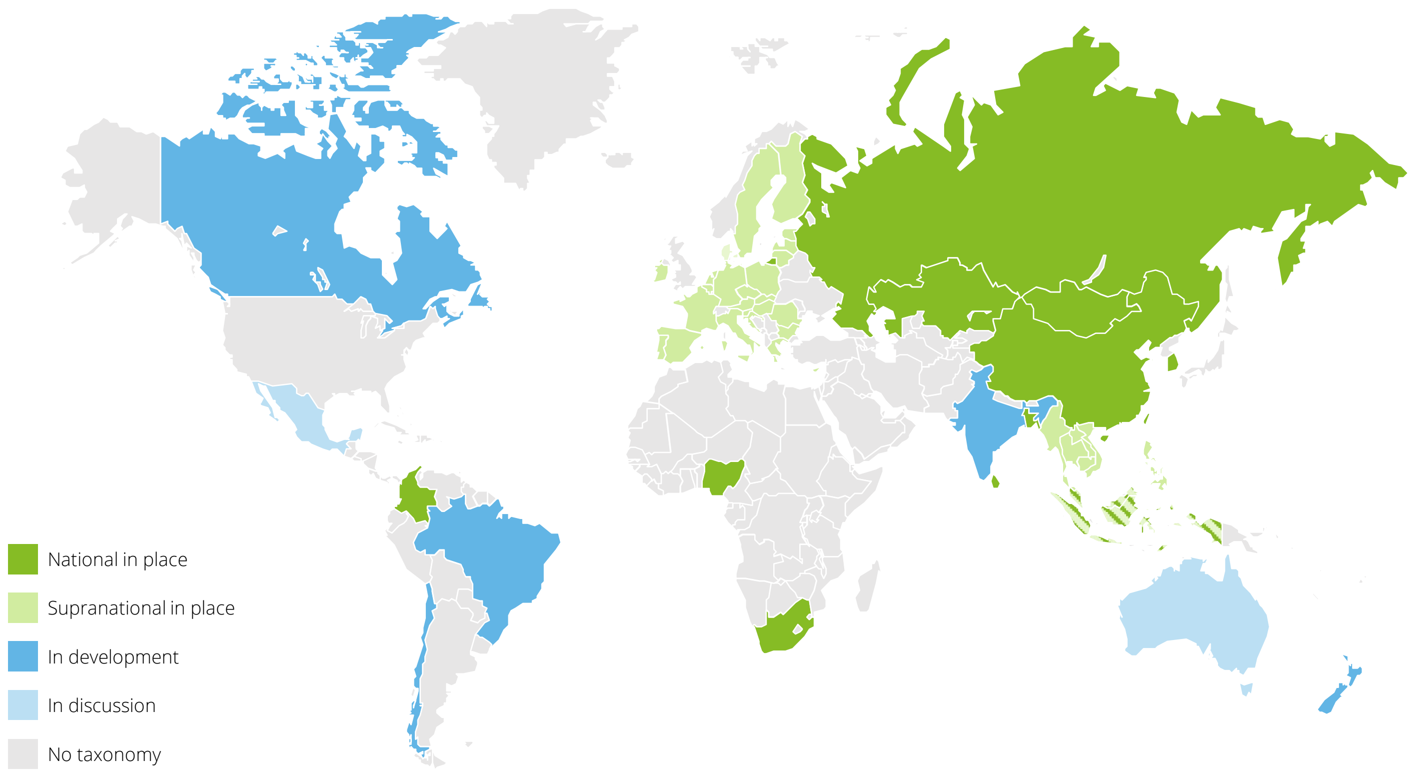
Rising green technologies and big climate promises provide the backdrop for the ongoing construction of a global network of climate policies and transitions. Governments and companies are releasing strategies with targets, pathways and investment outlines. Emissions pricing measures are also gradually being implemented globally to incentivize the switch to clean energies. According to the World Bank, such measures would only cover about 23% of global GHG emissions in 2023 but are ramping up rapidly.[29] Indeed, total revenues from emission pricing increased sixfold from 2016 to 2022, both due to higher CO_2 prices and to expansion into new jurisdictions.[30] Clean energy strategies and support schemes are also being shaped around the globe. For instance, there are now around 60 countries with national hydrogen strategies and roadmaps, up from less than five before 2020.[31] The US Inflation Reduction Act's (IRA) section 45V[32] deployed up to US$100 billion in massive tax credits for hydrogen, raising the stakes globally.[33] However, green subsidies of this scale are still largely lacking in the parts of the world where challenging economic and financing conditions make them most impactful.

Figure 1. Global map of net-zero targets



Source: Deloitte analysis based on data from Climate Watch[34,35]

Figure 2. Global map of green taxonomies



Source: Deloitte analysis based on data from Institute for Energy Economics and Financial Analysis and from Climate Bonds Initiative[36,37]

Furthermore, the ramp-up of financial regulations in service of climate mitigation has been slower than more direct energy and climate policies and is already showing strong geographical disparities. These disparities are already salient with green taxonomies–classification systems that set criteria to label some economic activities as sustainable. Defining green taxonomies can create a common understanding of which activities are considered "green". It can also help increase security for investors and reduce greenwashing opportunities. Green taxonomies appear to be largely absent from official discussions (Figure 2) in key geographies including the United States, Japan, Africa (except South Africa) and the Middle East. Despite their individual benefits, the development of many different green taxonomies around the globe can reduce their credibility and effectiveness. For example, a less climate-ambitious country with a high share of coal in its electricity mix could see natural gas power plants as green investments, whereas a more ambitious country would not.

Moreover, under the right circumstances, green taxonomies can help reduce financing costs. For instance, all other things equal, if equity investors become averse to environmental risks, a firm with a poor environmental track record could face higher equity costs than a demonstrably greener company.[38] These green equity cost reductions via green taxonomies are not clearly mirrored in the debt market, where the issuance of so-called green bonds currently lacks adequate international standardization.[39] Green bonds are another key green finance instrument and consists of debt that is traceably linked to green investments. The key to unlocking debt cost reductions with green bonds is to bolster their green credibility, i.e., to make them more transparent and uniform via, for instance, taxonomies. Green bonds and other sustainable debt instruments could thus help debt-constrained entities raise funds for energy infrastructure projects. As of 2022, advanced economies concentrated about 80% of sustainable debt issuances.[40] Further work is therefore needed to help standardize green finance instruments and to expand their use in and beyond advanced economies.

2.2. Key technical characteristics of a net-zero world

Green transition policy frameworks are considered insufficient today in part because green technologies remain misunderstood. Coordinating and financing the green transition requires a deep understanding of the green products that need funding.

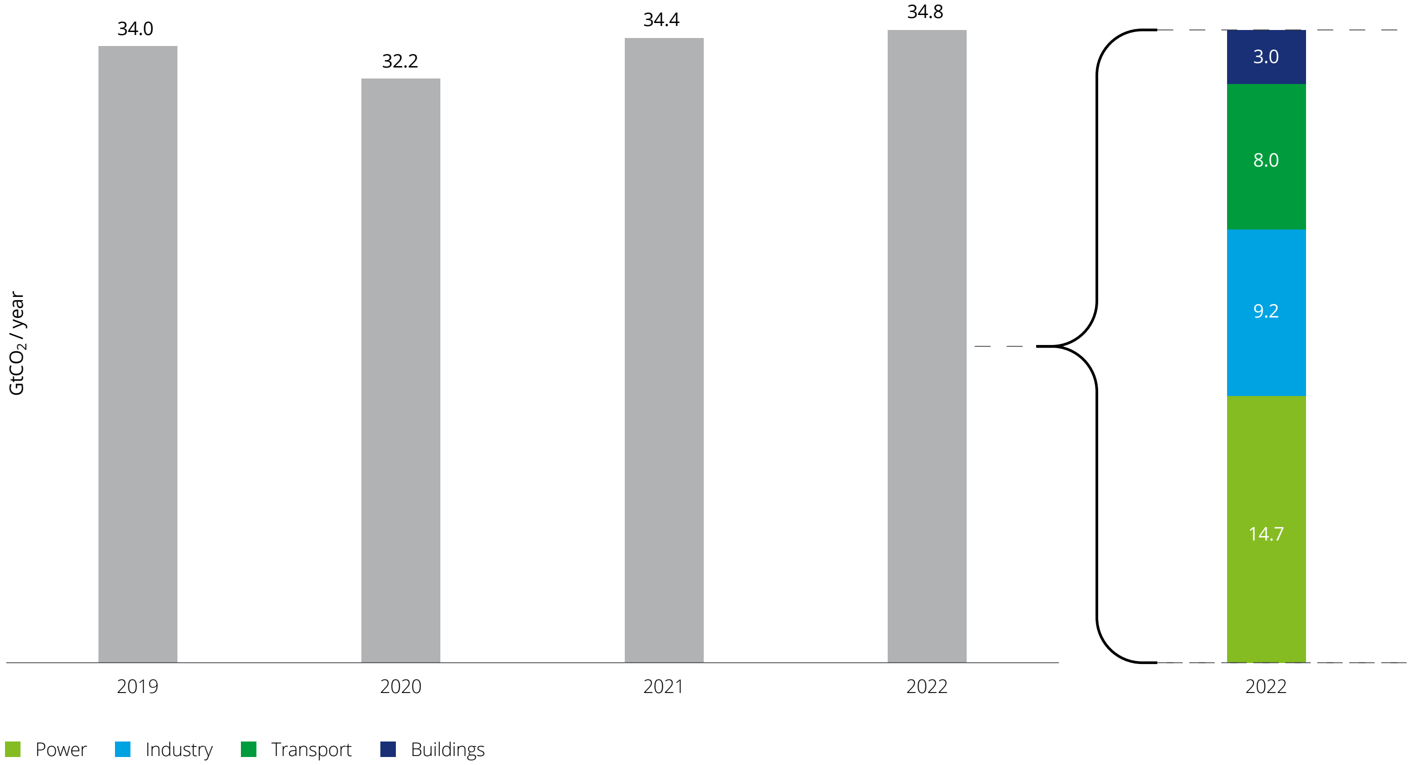
Global energy-related CO_2 emissions are distributed across power generation, industry, transport and buildings (Figure 3). Each of those sectors has its own characteristics, complexities and potential solutions, nullifying the prospects of a one-size-fits-all decarbonization solution.

- Power generation accounted for 42% of global energy-related CO_2 emissions in 2022,[41] making it one of the highest-emitting sector of the global economy. Fossil fuel-fired power plants produced 61% of global electricity in 2022, and coal alone accounted for over 35% of electricity production.[42] The development of clean electricity can bring the dual benefit of cutting emissions and helping enable electrification in end-use sectors like industries, transport and buildings.[43]
- Industries are responsible for around 9.2 $GtCO_2$ emissions each year (26% of global CO_2 emissions).[41] Cement, chemicals and steel are the largest industrial emitters, accounting for around 60% of energy consumption and 70% of CO_2 emissions[44] in the global industry sector. Global demand for chemicals and steel is expected to increase by 30% and 12% respectively by 2050, while cement demand is expected to remain flat thanks to efficiency measures in construction.[11] Long investment cycles are coming to an end within the next decade for a number of industrial sites, making decarbonization a now-or-never decision for a large share of the sector.[11] Due to the low maturity and significant infrastructure transformation requirements of high-temperature electric heating technologies, decarbonizing industrial sectors, particularly the heavy ones like cement, chemicals and steel, has proven challenging.[45]
- Transport added up to 23% of global energy-related CO_2 emissions in 2022,[41] split across a diverse array of sectors spanning aviation, road, rail and maritime transport. Some sub-sectors such as passenger cars have clearly identified decarbonization solutions like electric vehicles.[46,47,48] Others like aviation are struggling to find a viable alternative to conventional technology, often due to techno-economic constraints on the use of electricity or hydrogen and low-maturity of biofuels and synthetic fuels to replace fossil fuels in large scale.
- Finally, the buildings sector emitted 3 $GtCO_2$ in 2022 or just under 10% of global emissions. Today, buildings around the globe are largely dependent on the use of fossil fuels,

particularly natural gas, for cooking and space and water heating. Electrification and efficiency measures (such as the thermal insulation of buildings) are increasingly seen as viable decarbonization options in the building sector.[49]

Figure 4 shows the main technological options to reach net-zero GHG emissions from the perspective of individual sites, buildings or vehicles. As such, it displays, at a glance, some of the key characteristics, barriers, uncertainties, and thereby opportunities of each solution in each sector. The purpose of this information is to enable the reader to make informed decisions about the products they want to regulate or invest in. In particular, the figure reveals the high capital-intensiveness and relatively low technological readiness of many of the solutions that stand out with regards to overall costs, system disruptiveness, and skilled labor requirements. As explored throughout the rest of the report, the capital intensiveness and riskiness of green technologies make reducing financing costs a high-priority action lever to help unlock the transition.

Figure 3. Global energy-related CO_2 emissions over time and breakdown by sector between 2019 and 2022



Source: Illustration based on data from the IEA[41]

Figure 4. Global decarbonization hinges on highly capital-intensive technologies[50]

Sector	Category	Main solutions	Additional requirements: Skilled workers	Additional requirements: Disruptiveness	Additional requirements: Cost	Cost structure (Upfront / Lifetime / Both)	TRL (1)	NZP (2)	Potential limitations of the solution
Power **42%** of global energy-related CO_2 emissions	Renewables	Wind	High	Medium	Low	Upfront	High	High	Land use, mineral needs
	Renewables	Solar (PV)	High	Medium	Low	Upfront	High	High	Land use, concentrated market
	Renewables	Geothermal	High	High	Medium	Upfront	Medium	High	Geographical constraint
	Renewables	Hydro	High	Medium	Low	Upfront	High	High	Geographical constraint
	Fossil fuels	Retrofitting (bio/H_2)	Low	High	Medium	Lifetime	High	Medium	Fuel cost, limited biomass
	Fossil fuels	CCUS	Medium	Medium	Medium	Upfront	Medium	High	Missing CO_2 infrastructure
	Nuclear	Gen III+ / SMR	High	Medium	High	Upfront	High	Medium	Safety, waste management
Industry **26%** of global energy-related CO_2 emissions	Chemicals	Electrification	Low	Low	High	Both	Medium	High	Power price and supply stability
	Chemicals	Hydrogen	High	Medium	High	Both	Medium	High	Infra., hydrogen availability
	Chemicals	Bioenergies	Low	Low	Medium	Lifetime	High	Medium	Limited sustainable biomass
	Chemicals	Recycling	Low	Low	Medium	Lifetime	High	Medium	Plastic collection rates
	Chemicals	CCUS	Medium	Medium	Medium	Both	High	Medium	Missing CO_2 infrastructure
	Steel	Electrification (EAF)	Low	Low	Medium	Lifetime	High	High	Power price, scrap availability
	Steel	Hydrogen (DRI)	High	High	High	Both	Medium	High	Infrastructure, technical limitations
	Steel	CCUS	Medium	Medium	High	Both	Medium	High	Missing CO_2 infrastructure
	Cement	Alternative input materials	Medium	Low	Medium	Lifetime	High	High	Availability of good clay deposits
	Cement	CCUS	Medium	Medium	Medium	Lifetime	High	High	Safety, end-of-life
	Cement	Hydrogen (heat)	High	Medium	High	Lifetime	Low	Medium	Infrastructure requirements
	Cement	Electrification	Low	High	High	Lifetime	Medium	Medium	Maturity/infrastructure/cost issues
	Light industry	Electrification	High	Low	Medium	Lifetime	High	High	Power price and supply stability
	Light industry	Hydrogen	High	Medium	High	Lifetime	High	Medium	Infrastructure requirements
	Light industry	Bioenergies	Low	Low	Medium	Both	High	Medium	Limited sustainable biomass
Transport **23%** of global energy-related CO_2 emissions	Road	Electricity (battery)	Low	High	Medium	Upfront	High	High	Infrastructure, clean electricity
	Road	Hydrogen (fuel cell)	Low	High	High	Both	Medium	High	Infrastructure, fuel cost
	Road	Biofuels (ICE)	Low	Low	Medium	Lifetime	High	High	Fuel cost, limited biomass
	Road	E-Fuels (ICE)	Low	Low	High	Lifetime	Medium	High	Fuel cost, limited CO_2
	Maritime	Biofuels (ICE)	Low	Low	Medium	Lifetime	High	Medium	Fuel cost, limited biomass, safety
	Maritime	E-Fuels (ICE)	Low	Low	High	Lifetime	Medium	Medium	Fuel cost, limited CO_2, safety
	Maritime	H_2 - pure (fuel cell)	Medium	High	High	Lifetime	Medium	High	Fuel cost, low range
	Maritime	Electricity (battery)	Medium	High	High	Upfront	Low	Medium	Safety, very low range
	Aviation	Biofuels (ICE)	Low	Low	Medium	Lifetime	High	Medium	Fuel cost, limited biomass
	Aviation	E-Fuels (ICE)	Low	Low	High	Lifetime	Medium	Medium	Fuel cost, limited CO_2
	Aviation	Hydrogen (fuel cell)	Medium	High	High	Lifetime	Medium	Medium	Safety, low range, fuel cost
	Rail	Electricity (cable)	Low	Low	Low	Upfront	High	High	Infrastructure cost & feasibility
	Rail	Hydrogen (fuel cell)	Medium	High	High	Lifetime	Medium	Medium	Fuel cost, low range
Buildings **9%** of global energy-related CO_2 emissions	Heating & cooling	Heat pumps	High	Medium	Medium	Upfront	High	High	Concentrated market, cooling gases
	Heating & cooling	Solar thermal	High	Low	High	Upfront	High	High	Space footprint
	Heating & cooling	District heating	Medium	High	Medium	Upfront	High	High	Infrastructure, non-renewable
	Heating & cooling	Bio/H_2 gas boilers	Medium	Low	High	Lifetime	Medium	High	Limited clean gases
	Heating & cooling	Solid biomass	High	Medium	High	Lifetime	High	Medium	Limited biomass, low efficiency
	Heating & cooling	Thermal storage	High	High	High	Upfront	Medium	High	Wear and tear (corrosiveness)
	Construction	Sustainable materials	High	Medium	High	Upfront	Medium	Medium	Long lifespan of building stock
	Construction	Recycling	High	High	Medium	Lifetime	Medium	Medium	Limited net-zero potential

High (green) / Medium (yellow) / Low (red)

Source: Deloitte analysis based on the IEA's Energy Technology Perspective and various other sources mentioned in the text.
(1): TRL = Technological Readiness Level; (2): NZP = Net-Zero Potential

The decarbonization of electricity rests on the development of three strands of technologies.

- First, renewable power generation capacity, particularly solar photovoltaic (PV) and onshore and offshore wind, will by all benchmarks need to increase massively around the world.[51] Hydroelectric power plants and geothermal power plants can provide power systems with flexible power generation capacity, but their overall availability is scarce around the globe. Renewables, including geothermal energy and hydro-electricity, are by nature highly capital intensive but incur zero fuel costs. Both wind and solar PV have low capacity-to-land use ratios compared to fossil plants, and face highly concentrated upstream supply chains. However, wind and solar power plants do not require any fuel to run. Therefore, while they might face upfront import dependence challenges, over their lifetime, they require no fuel imports, boosting the resilience of the local energy systems. Due to their low overall costs, gains in strategic autonomy and instant environmental benefits upon installation, renewables will form the backbone of the global electricity transition.[52]
- Second, the retrofitting of existing fossil assets to clean gas (co-) combustion or to power plants with carbon capture and storage (CCS) extensions can reduce emissions, particularly in regions with poor renewable endowments. These solutions are deemed somewhat disruptive because they require the development of capital-intensive hydrogen or CO_2 infrastructure networks. While clean gas combustion is limited by the availability and cost of the fuel, CCS can be limited by the absence of CO_2 networks.
- Third, the development of nuclear energy can bring significant emission reductions in suitable locations that have the means to fund such projects. Indeed, nuclear power plants come at significant upfront costs and very long construction times.[53] Moreover, the costs of nuclear power plant decommissioning and waste disposal remain highly uncertain.[54] While high upfront costs can get redeemed over enormous power production volumes thanks to high utilization factors over long periods, mechanical failures and changes in nuclear safety standards can entail significant costs. Concerning small modular reactors (SMR), they have yet to gain more technological maturity to start challenging existing fossil power plants.

Overall, clean electricity generation pathways are technologically mature but highly capital intensive, making the cost of developing clean projects highly sensitive to financing costs in this sector. Both renewable and nuclear value chains are maintained by highly skilled workforce, which emphasizes the importance of formal training.

The global industrial sector should not be viewed as a single block to decarbonize, but as an array of industries with varying constraints that dictate different responses to the same solutions.

- Electrification is a key emission reduction solution across a number of industrial subsectors whose processes only require low-to medium-temperature heating (below 400°C). As a rule of thumb, the effectiveness of electrification dwindles as temperatures approach 1000°C under current technological levels.[55] This leaves less space for electricity in heavy industries, where processes usually operate above 500°C. In the chemical sector, electrification can be used for steam cracking, a process in which long-chain hydrocarbons are broken into simpler ones. In the cement sector, electricity can be used to power units that produce clinker for cement production, although that technology is still at the demonstration stage. In the steel sector, electric arc furnaces (EAF) are an already proven technology.
- With a wide variety of highly energy-intensive processes and many carbon-based products, the chemical industry is a hard-to-abate sector with no one-size-fits-all abatement solution. Recycling and especially the reuse of plastics is a technologically mature decarbonization solution for chemicals production. However, it will require higher plastic collection rates and lower recycling costs to become viable.[56] Carbon capture and utilization (CCU) is another mature solution, but its current energy intensiveness can offset the benefits of CO_2 capture and make it less economically attractive.[57,58] Also, integrating capture technologies into existing chemical processes can be complex and require costly CO_2 transport and storage infrastructure. Lastly, hydrogen and bioenergy feedstocks have been used in the industry, but their consumption is slated to surge massively. The scale of the required implementation will therefore call for new costly infrastructure, putting more capital-intensive pressure on such decarbonization projects.
- Today, blast furnaces are one of the most common and highest CO_2-emitting steelmaking pathway.[59] Hydrogen-based direct-reduced steelmaking is seen as one of the primary approaches to help the industry achieve its decarbonization goals. Many firms are also exploring opportunities to lower emissions through the increased use of recycled scrap steel, melted via the electric arc furnace (EAF) steelmaking process, which can cut 85% of the emissions of blast furnaces.[59] The widespread adoption of these solutions faces barriers such as unfavorable investment cycles and scarce skilled workforce. Adding to that, hydrogen-based green steel currently suffers from the lack of infrastructure and high cost of green hydrogen. Finally, the limited availability of high-quality scrap can hurt the viability of both recycled steel production and hydrogen-based green steel production.
- Unlike other energy-intensive industries, only one-third of emissions from cement production comes from fuel consumption, while two-thirds come from the use of raw materials.[60] Using cleaner input materials can offer significant emission reduction potentials, but this may be limited by the availability of cleaner inputs. Carbon capture and storage can be another solution to help decarbonize cement. Like in other industrial sectors, CCS faces barriers which also include the practical challenges of CO_2 leakage and socio-political acceptability. Finally, hydrogen can also be used as a chemical input to reduce raw material needs and thereby emissions. However, the economic viability of hydrogen use in cement remains low for now.[61]

Physical constraints vary across transport sectors, but three technological choices stand out:

- Electrification is the clear winner in cars, light- and medium-duty road vehicles and trains, where vehicle range or weight are relatively low or where cable electricity can be dispensed. Technological improvements could push electrification further into more hard-to-electrify segments such as long-haul road transport,[62] but commercial aviation and large ships remain out of reach for now.[63] Electrification is capital intensive because it requires the purchase of batteries and the installation of charging networks. However, electric engines are also twice as energy efficient as internal combustion engines depending on the transport segment, making them save energy and thereby emissions.
- While hydrogen fuel cells could decarbonize the hard-to-electrify transport sectors, they are costly, requiring high expenses in fuel cells, clean hydrogen supply and supporting infrastructure networks. However, they offer longer range and faster fueling times than battery-electric vehicles, making them more operationally versatile.[64] A key physical limitation of hydrogen vehicles is the low volumetric energy density of hydrogen under ambient conditions, which makes it technologically infeasible today to fly a commercial high-capacity aircraft on hydrogen.[65]
- Drop-in clean fuels could provide an interim option while battery and fuel cell vehicles ramp-up, or a long-term solution where electricity and hydrogen cannot penetrate. Synthetic fuels (e-fuels) that have the same properties as fossil fuels but are made from clean hydrogen and climate neutral CO_2[66] are limited by their high cost and low availability. While biofuels (produced from biological feedstock rather than fossil sources) have lower production costs than e-fuels, they are limited by the availability of sustainable biological feedstock.[67] Despite being net-zero, their combustion still produces harmful pollution in the form of particulate matter. Nonetheless, current technological levels fail to elect another alternative than bio or e-jet fuel to reduce emissions from aviation.[68]

Overall, transport will have a multi-fuel future. Electricity is likely to take the lion's share of passenger car, light-duty and other electrifiable segments while hydrogen in its pure form, hydrogen-based synthetic fuels and biofuels share the rest based on operational capabilities. Technological maturity remains low for many of the true net-zero solutions, implying a need for further research and development (R&D) expenditure.

Emissions from buildings come from heating and cooling food, water and space, and construction.[69] As heating and especially cooling demands are expected to rise with global warming,[70] their decarbonization is vital. Heating, cooling and construction all see clear solutions emerge from Figure 4.

- The key solutions to help decarbonize heating and cooling are heat pumps, followed by district heating and, marginally, clean gas boilers. Heat pumps are two to four times more expensive upfront than gas boilers but are three to five times more energy efficient, making them potentially cost saving over their lifetime.[71] They are a proven and moderately disruptive technology that could become the first heating technology by 2050.[72]
- District heating can be another option, but it needs a clean heat source and highly capital-intensive infrastructure. Finally, the benefits of clean gas boilers are limited by their low energy efficiency and the availability of low-cost hydrogen or biogas. Hydrogen boilers would also require the creation of costly distribution networks, and their use in buildings presents safety challenges.[73,74]

Overall, the decarbonization of buildings will require high upfront investments into heat pumps and district heating but also into clean electricity supply in the upstream. These improvements can help mobilize many skilled workers, on the order of, for example, around 30,000 heat pump engineers in the UK alone.[75] Grants and funding schemes will be key for adoption, as homeowners tend to have limited borrowing power.

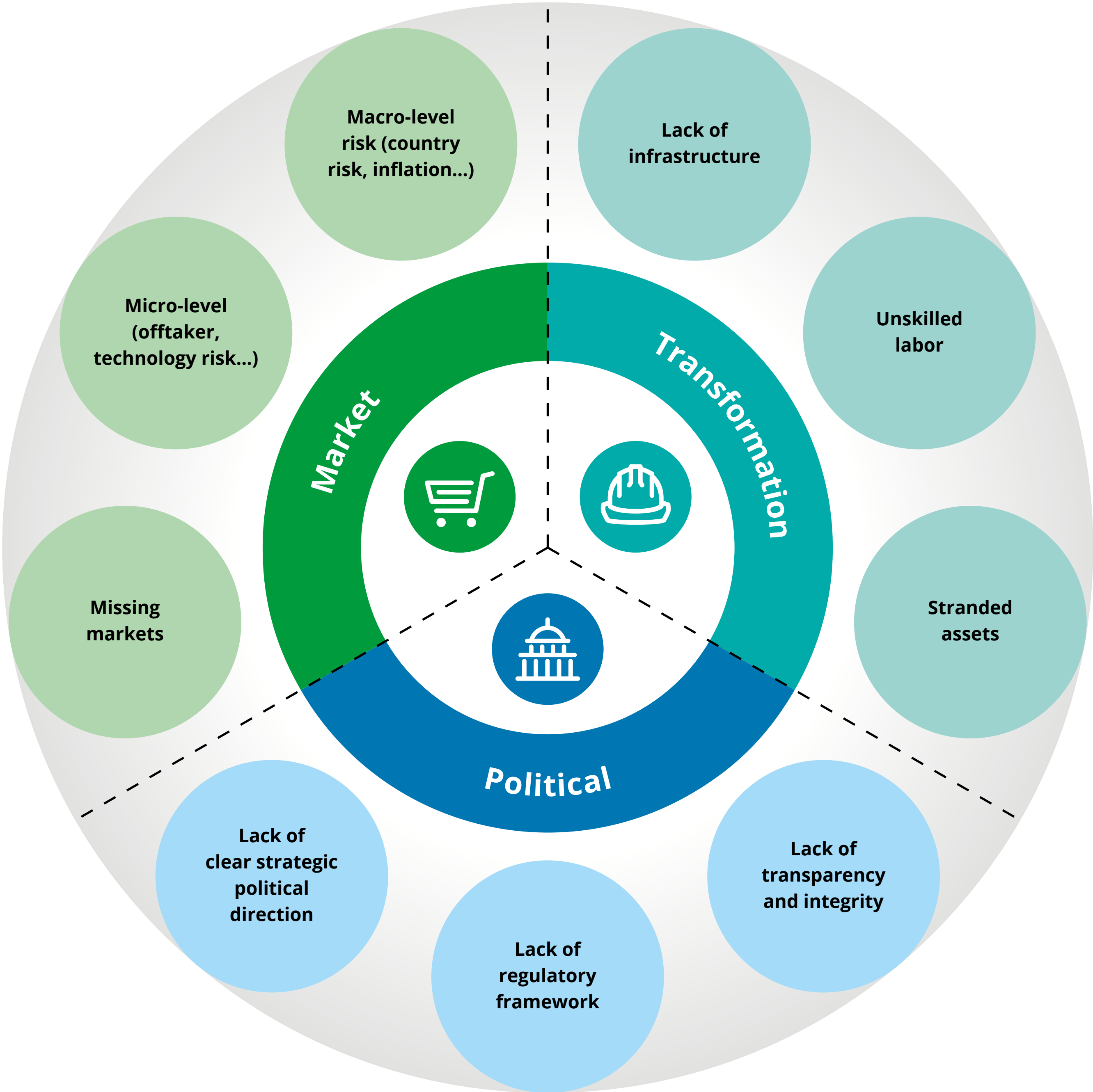
Regardless of their respective pros and cons, clean (especially green) technologies are on average more capital-intensive than their fossil counterparts. Financially constrained entities can therefore be trapped into a costlier fossil fuel pathway simply because the green alternative may be too expensive upfront. This can happen for instance with natural gas-fired power generation, which is cheaper upfront but far more expensive down the line than solar electricity.[76] In a perfect world, this situation does not arise as the cheaper option prevails. However, countries, firms and individuals face an intricacy of constraints that may bar investments from flowing into the energy transition.

3. What is holding back sustainable investments?

As shown previously, the energy transition will largely depend on the replacement of fossil-based means of production by costlier green technologies.

The tremendous amount of needed clean energy investments will call for both private and public capital providers. However, to help attract private funding, deciders should first overcome an array of structural investment hurdles that can be categorized into political, market and transformation barriers (Figure 5). Each geography faces a different mix of those barriers. This means there will be no one-size-fits-all solution.

Figure 5. Main barriers to investment in clean technologies



Source: Deloitte analysis

3.1. Political barriers

Politics and the social acceptability of the energy transition can make or break green investments. Good leadership will be critical in removing political hurdles, from the high level where strategies are made down to local administrations that deliver permits. Removing political barriers can allow policymakers to both help bridge the green-fossil cost gap and de-risk green projects.

The first barrier to overcome is a lack of clear strategic political direction. Unstable governments or ambiguous priorities can send negative signals to prospective local energy transition investors. Looking at North Africa, Libya and Morocco offer two radically different political perspectives despite comparable solar irradiations.[72] Morocco has ratified the Paris Agreement, issued an ambitious nationally determined contribution and issued a comprehensive regulatory transition framework.[72,77,78,79,80] The ruling Moroccan government is also expected to stably remain in power and to keep expanding green energy, including green hydrogen export projects with Europe.[81] By contrast, the Libyan political leadership can be seen as less stable, and the country has neither ratified the Paris Agreement nor published new energy transition policies since 2012.[77,82,83] Despite roughly equal solar power potential, a solar PV investor would choose Morocco over Libya due to lower political risks impacting projects' risk profiles.

The second obstacle is the lack of clear and transparent regulatory frameworks. This can trickle down from missing strategic guidance or political instability, but it can also frequently occur in advanced economies. For instance, until recently, the EU regulatory framework for green hydrogen was largely unclear and thus seen as a major barrier to investments in this industry.[84] Zooming into local regulation, inefficient administrations pose another risk for green projects, especially as new or disruptive technologies often require special construction permits.[85] In 2022, the EU had about four times more wind capacity in permitting than in construction, with lead times of often 5 years from the start of permitting procedures.[86] Yet, the factor that can turn slow administration, unclear regulation and unpredictable governance into rigged project tenders is corruption.[87,88] Eliminating corruption, particularly in developing countries where it may be more prevalent,[89] can help decrease political risks and facilitate green investments.

3.2. Market barriers

Market forces working against the green transition consist of missing green markets, and macro- and micro-level risks that interfere with the bankability of green projects.

At the macro level, global inflationary shocks like the 2022 energy crisis triggered by the Russia-Ukraine war, can constrict capital flows, raising the cost of financing green projects. Inflation can compound with depreciation of local currencies against the US dollar to make debt repayment extremely difficult for green projects in developing countries. This was the case in Sierra Leone, whose currency lost 40% of its value against the US dollar in 2022-23 as inflation soared by 40%.[90] Green projects often have long lifetimes of over 25 years,[91] over which foreign exchange quotes can fluctuate widely. The cost of hedging increases with the risk to hedge.[92] This can make foreign green investments overly expensive in tense macroeconomic contexts. Finally, local risk premium, the aggregated market metric for the political barriers described earlier, increases the cost of capital. Zooming into markets, the key risks are related to offtakers, project management and technologies. Offtake risk depicts the risk of a project not finding reliable buyers for their product. This can happen with new green technologies like clean hydrogen, which can struggle to break through due to missing demand.[93] In the same vein, liquidity can be a key risk for new green technologies, which might not be able to generate enough revenue to cover their due payments on time. For instance, an offshore wind farm that took longer than anticipated to be built may face liquidity challenges if creditors ask for repayment before it starts operating. Lastly, technology risk encompasses all the complexities described in section 2.2, plus uncertainties on cost reductions and actual performance in harsh conditions. For example, battery-electric vehicles can underperform in extreme temperatures,[94] making them less attractive in many developing countries.

Above all, green projects are risky because they often lack a market. Green hydrogen, for example, does not yet have a global and often local market. This means that prospective investors do not have reliable prices or quantity benchmarks, lack visibility on technology and delivery specificities, and will have limited predictability as to future demand and supply patterns. For instance, the IEA projects EU electrolyzer capacity to reach 39 GW in 2030, less than half of the EU's political objective of 80 GW.[95] Therefore, despite green hydrogen being a viable option to, for example, decarbonize steel (Figure 4), demand-side investors have little supply-side certainty besides political pledges. Supply-side investors experience the opposite with high offtake uncertainty, creating a "chicken and egg" problem that can be solved by government intervention. By contrast, other capital-intensive markets like real estate tend to have far more predictable patterns and have long moved past the "chicken and egg" problem. Thus, green finance may be riskier than conventional finance, at least until green product markets are operational.

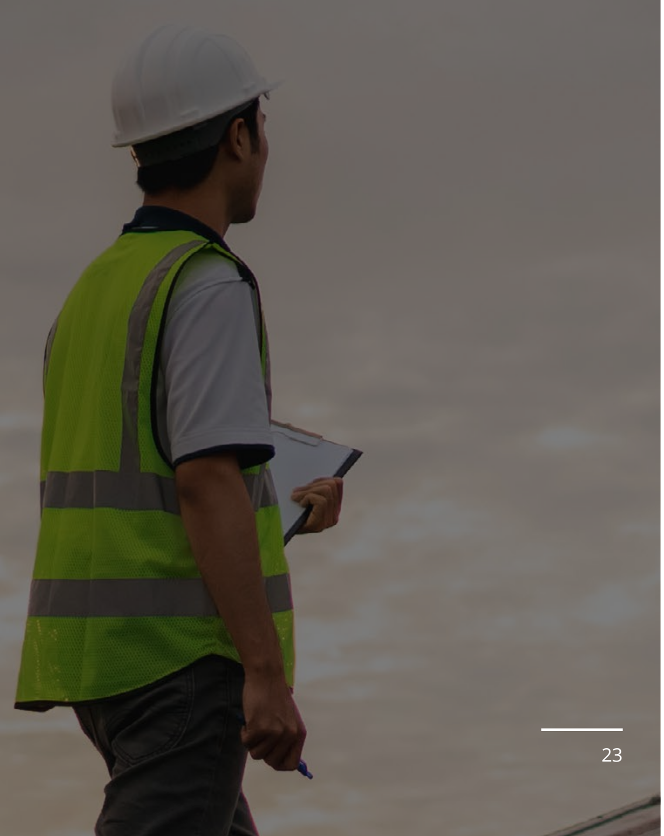
3.3. Transformation barriers

As green projects gradually come online, fossil-based projects will inevitably be discarded, leaving fossil industry assets and workers stranded.

Today, the fossil fuel industry is vital to most countries. In Kazakhstan, fossil fuels account for around half of all exports by monetary value.[96] Abruptly closing fossil fuel plants without an immediate sustainable replacement could therefore hurt jobs, industries and financial systems that are overexposed to stranded asset risks, like in wealthy countries.[97] This incentivizes being slow to cut fossil fuel investments, which in turn can make potential green investors unsure of whether they lose money by not investing in fossil assets. However, the clean energy sector already employs more people worldwide than the fossil industry and is slated to be a key job creation source throughout the transition.[98] The shift to clean economies can create new opportunities and lower the costs of green energy for industries. The gains in strategic autonomy from renewable energy will also cushion financial markets against the volatility of global fossil fuel prices. The true risk of phasing out the fossil fuel industry therefore lies more in the cost of political inaction than in the closure of plants.

Decarbonizing the global economy will entail unprecedented transformation that some countries might not have the capacity to accommodate. Upstream from green projects, infrastructure and education are often priority areas where crucial investments could remove bottlenecks down the line. This argument is paramount when it comes to energy infrastructure, particularly electricity. Developing countries lose an estimated US$120 billion/year from frequent power outages.[99] One of the worst-hit countries is Nigeria, with 4,600 hours of outages in 2018,[100] mostly due to poor infrastructure and grid management.[99,101] However, Nigerian electricity is overwhelmingly made from oil, gas and hydropower, whose production is far more predictable than that of solar or wind power plants.[102] This casts doubts on Nigeria's ability to handle variable renewable power production without first investing into a profound overhaul of its electricity infrastructure. Yet, solar and wind power could also alleviate power problems in countries like Bangladesh where most power outages are caused by fossil fuel shortages.[103] Skilled labor is another capacity barrier to green investments, particularly in the developing world. Boots on the ground are always needed to install, maintain and replace equipment. This requires skilled labor, which is scarcer in developing countries than in advanced economies.[104]

The clean energy sector already employs more people worldwide than the fossil industry and is slated to be a key job creation source throughout the transition.[98]



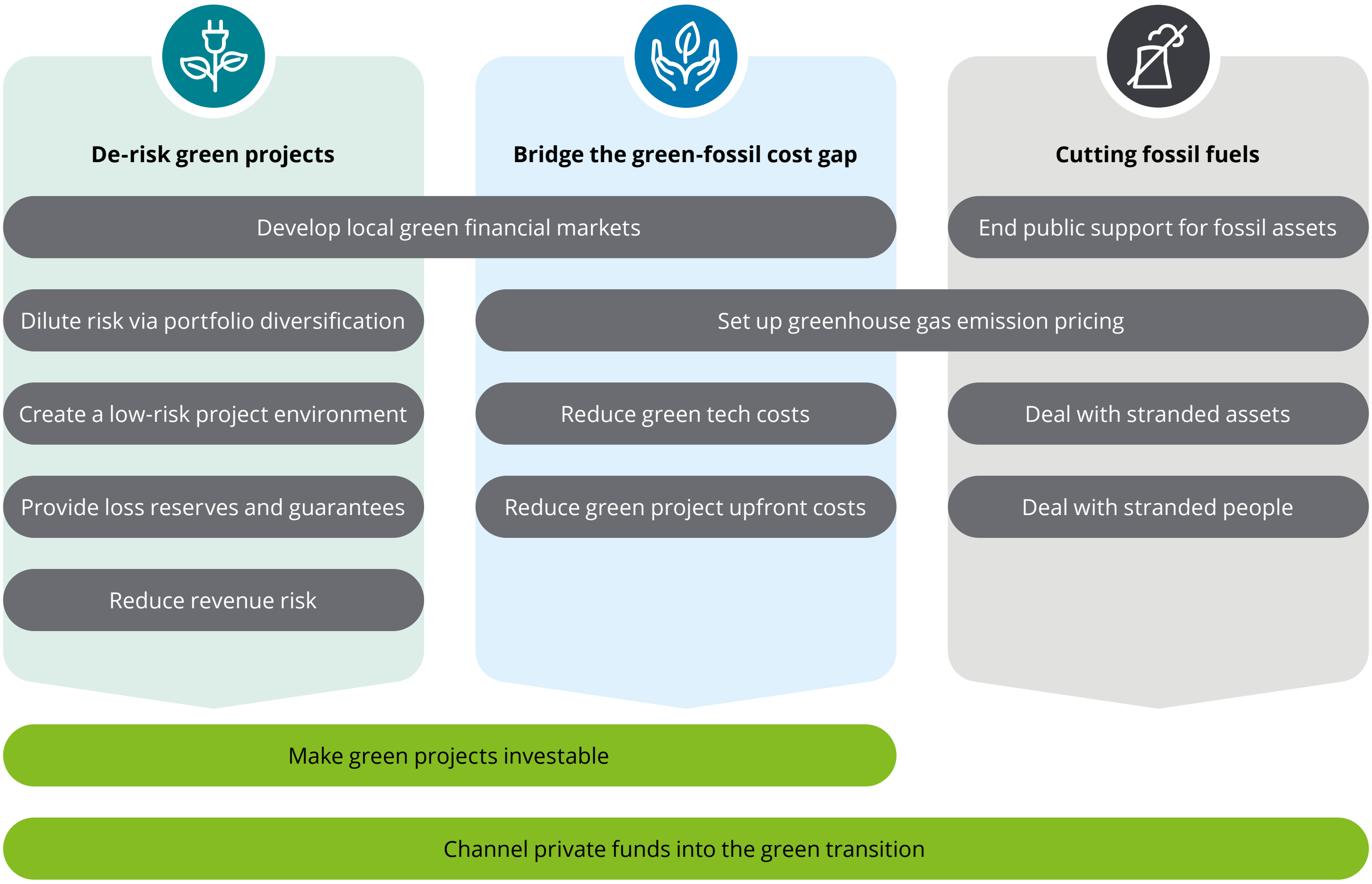
4. Fostering investments in the green transition

4.1. A toolkit to foster sustainable investments

Guiding investments toward sustainable projects calls for three types of actions: de-risking green projects, bridging the cost gap between green and fossil projects and cutting fossil fuels.

The key action levers highlighted in the existing literature on the financing issues of energy transition such as the work of IEA,[10] IRENA,[12] the World Bank[13] and the World Economic Forum[105] are summarized in Figure 6. De-risking green projects entails lowering financing costs to help enable critical investments in sustainable infrastructure. Bridging the green-fossil cost gap means increasing the cost competitiveness of green assets to help attract investors and offtakers. Inversely, bridging the cost gap also implies reducing the attractiveness of fossil assets. These actions can steer the economy toward reducing the use of fossil fuels, whose economic burden on countries, firms and people, particularly in emerging markets, should be managed throughout the transition.

Figure 6. Overview of key solutions to turn green projects more bankable



Source: Deloitte analysis based on IEA,[10] IRENA,[12] the World Bank[13] and World Economic Forum[105]

De-risking sustainable and green projects

Developing low-risk project environments

Section 3 outlines how regulatory, political, market and currency risks drive financing costs. Implementing and coordinating holistic energy transition policy frameworks at the regional and international levels can somewhat mitigate these risks to reduce financing costs. Concretely, this amounts to fostering market transparency and regulatory clarity, developing infrastructure plans, publishing long-term targets and strategies and assisting project developers. National energy and climate strategies are often the starting point for setting a low-risk environment for green projects. South Africa's Just Energy Transition Investment Plan (published in November 2022) is a case in point, which created a solid and transparent base for the development of green projects (Box 1).

Loss reserves and guarantee mechanisms

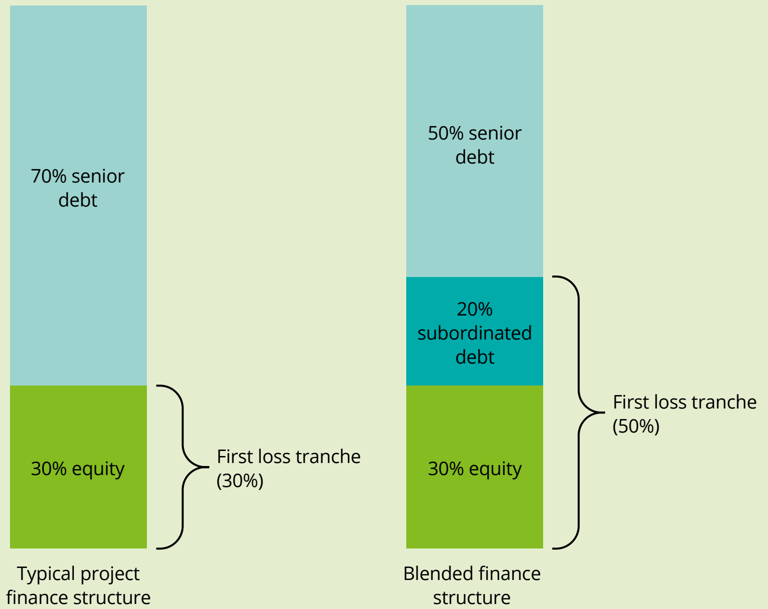
Financial support mechanisms such as guarantees or first-loss tranches can help to reduce project risk and thus financing costs, making green projects more bankable. The first-loss tranche refers to the tranche with the lowest priority in terms of repayment. Therefore, in case of default, it will first absorb the losses. Such reserves and guarantee products insure investors against losses if, for example, the project meets bottlenecks, underperforms or faces financial difficulties. This risk reduction makes the project more appealing to risk-averse investors, especially in emerging or risky markets. Subordination of capital can provide additional security to help attract investors. A project's debt structure may have different layers of repayment priority (Box 2), whereby senior debt is repaid before subordinated debt and thus has a lower default risk. The same subordination mechanism exists for equity. These mechanisms, commonly used in blended finance frameworks, are essential to the toolkit of development banks.

Box 1. The Just Energy Transition Investment Plan in South Africa

Like many countries,[106] South Africa's nationally determined contribution (NDC) to mitigating climate change initially lacked a detailed energy transition and investment plan for the country. However, after COP27, the South African government filled this gap by issuing its Just Energy Transition Investment Plan (JET IP).[107] This plan outlined the US$100 billion of investments needed to achieve the nation's decarbonization commitments set in its NDC for 2023-2027. To help reach US$100 billion, South Africa and other contributing countries hope to leverage around US$4 of private money for every US$1 of public investment. It is uncertain whether South Africa can achieve such leverage, but the high level of detail and clarity of JET IP seems to provide a solid base for attracting private investors. The plan lays out targets, budgets, policy tools and infrastructure and skill requirements to help build a convincing case that green projects can take place in a low-risk regulatory environment.

Box 2. Climate Investment Funds

To date, the Climate Investment Funds (CIF) has committed US$7.5 billion of blended finance products to developing countries to unlock investments in low-carbon technologies, clean energy storage and industrial decarbonization.[108] The CIF expects to mobilize US$62.1 billion of co-financing, or US$8 for each US$1 of blended finance.[109] The instruments CIF deploys to attract investments are diverse and include[110] senior concessional loans, subordinated loans and mezzanine instruments,[111] which help reduce senior debt default risk. The following figure illustrates the benefits of debt subordination. Compared to traditional finance structures, the first-loss tranche is greater in subordinated debt mechanisms, which decreases default risks for senior debt.



Source: Illustrative example based on Deloitte analysis

Market creation

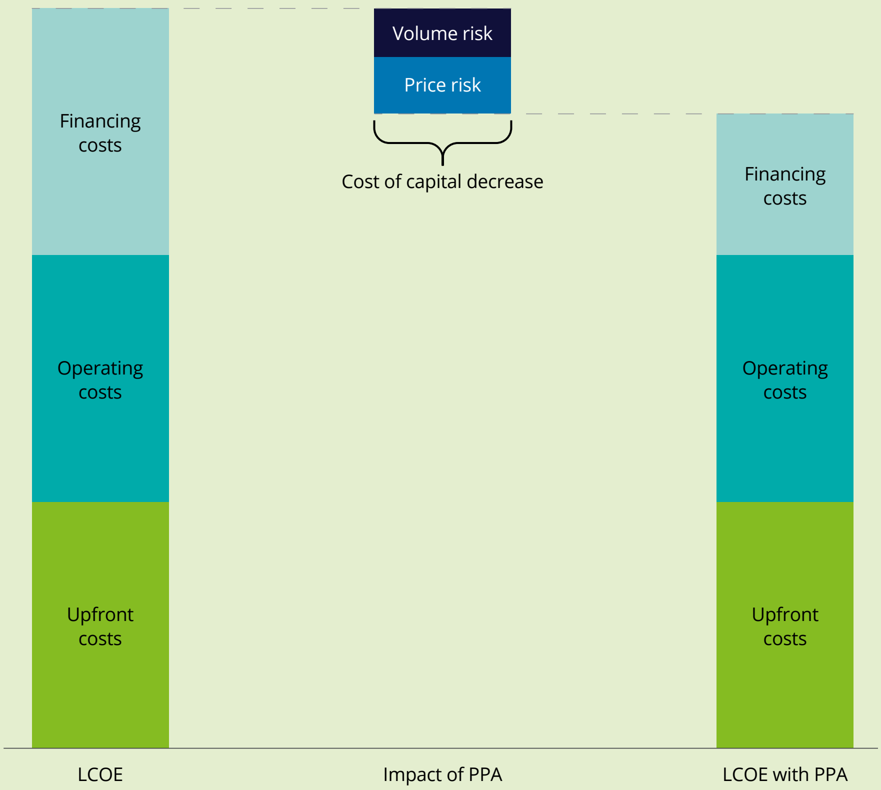
Creating or facilitating access to an exchange platform for non-existing markets can reduce revenue risks, lowering the financing cost of clean energy projects. Despite being key to decarbonizing hard-to-abate sectors,[112] green hydrogen lacks its own market and remains too expensive to compete with GHG-intensive gray hydrogen.[95] For instance, in July 2023, US gray hydrogen prices were below US$1/kg$H_2$, while the cheapest US green hydrogen was priced at US$2.7/kg$H_2$.[113] Offtake contracts can solve this challenge by enabling buyers to find green products, and sellers to secure buyers. Power Purchase Agreements (PPAs) are a type of offtake contracts whereby the parties fix an exchange price for electricity, usually based on its levelized cost of production. Thus, PPAs can create green product markets and help bridge the green-fossil cost gap by reducing green product revenue risk. Other PPA types include feed-in tariffs (i.e., PPAs where the government is the buyer), and contracts for difference (see Box 8 for more information). PPA variants help to reduce price and volume risks, which lowers revenue uncertainty and, in turn, reduces financing costs (Box 3).

Developing capital markets

Developing local financial ecosystems can incentivize sustainable investments in four broad ways. First, an adequate local financial market instills confidence in long-term investments.[115] Second, well-functioning markets can provide information through price discovery and financial reporting. This can help reduce information asymmetries for prospective investors.[116,117] Third, developing financial markets can increase competition between capital suppliers, which potentially reduces financing costs. Finally, mature financial ecosystems can offer a wide range of hedging and financing options, including solutions that are better suited for green projects, like green bonds. Growing demand for climate-conscious finance has fueled the rise of green bonds and sustainability bonds, whose global volume exceeded US$650 billion in 2022.[118] These work like conventional bonds except they aim to raise funds for environmentally beneficial projects. However, ensuring that green bonds actually fund green projects is impossible without also developing global green bond standards to shore up transparency, comparability and thus credibility.

Box 3. Impact of PPAs in de-risking projects

Revenue risk is a key component of financing costs, as investors aim to ensure projects generate returns. PPAs can reduce financing costs for renewables projects by dampening revenue risk. Securing long-term contracts with reliable offtakers like governments stabilizes project revenues throughout the PPA's lifetime. As such, global contracted PPA volumes rose from 0.3 GW in 2012 to 36.7 GW in 2022, with an 18% leap in 2021-2022, partly due to the Russia-Ukraine war raising demand for revenue certainty.[114] The following figure illustrates the impact of a PPA on the levelized cost of electricity (LCOE – the average net present cost of electricity production over a project's lifetime). Stabilizing project revenue decreases risk, lowering investors' required returns and thereby reducing financing costs.

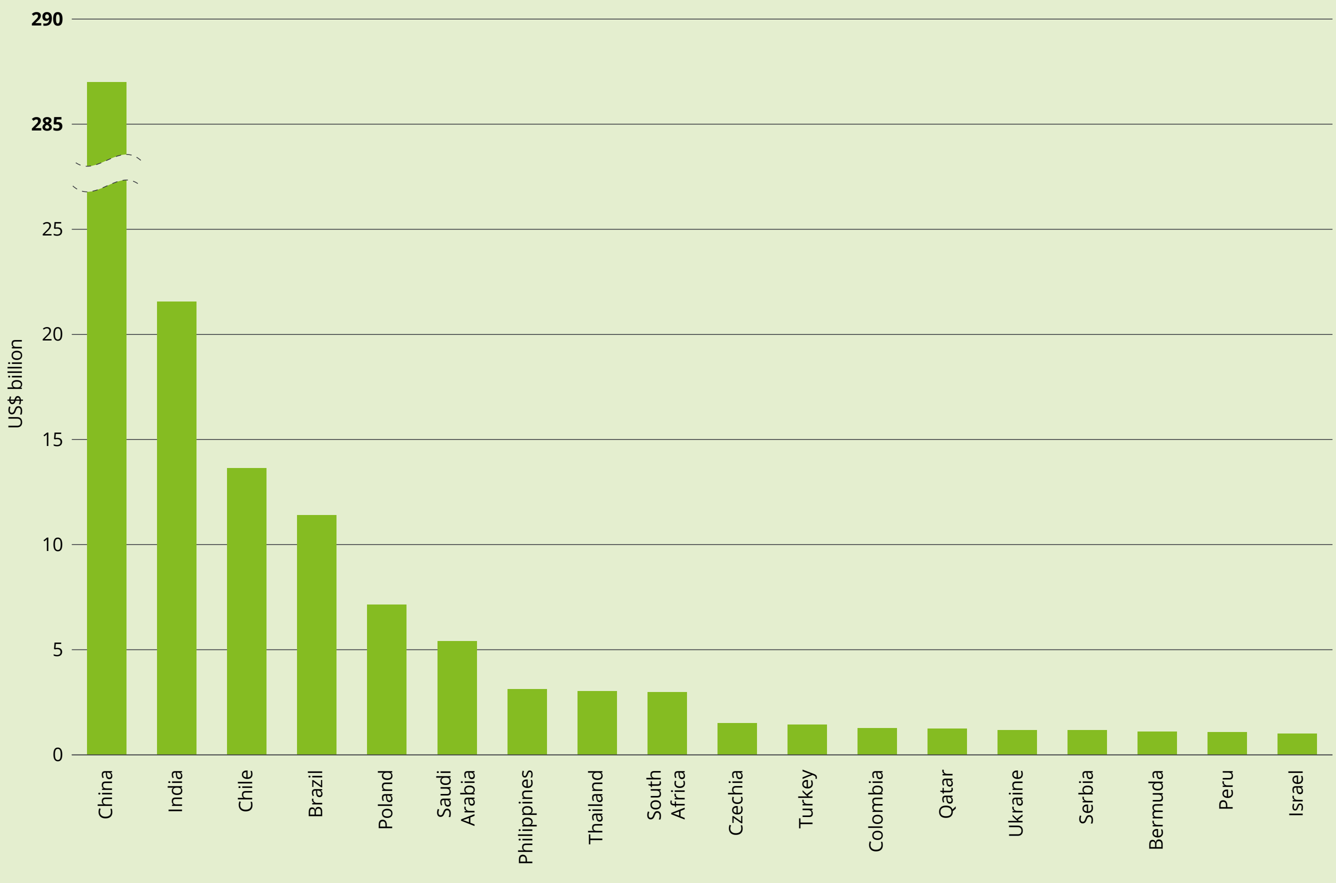


Source: Illustrative example based on Deloitte analysis

Many such standards exist around the world,[119] but, ideally, issuers should work toward international convergence. A measure of this lack of convergence today is the dispersion of green bond issuance by currency across euros (45%), US dollars (26%) and other currencies (29%).[118,120] Moreover, to lower default risk, the risks of green bonds are tied to the issuer, not the green project. This incidentally makes the credibility of the issuer central to risk assessments. Thus, politico-economic instability can hamper the growth of green bonds in developing countries.[121] To overcome this, nascent green bond markets will rely on the maturing of green transition frameworks and capital markets, and on overall improvements in political stability. Experience has shown that green and other sustainable bonds can be effective capital mobilization tools when growth and transition objectives align (Box 4).

Box 4. Green bonds in South Africa

South Africa is one of the leading emerging economies on the green bond front thanks to its well-developed financial markets which sees frequent bond issuance. The country pioneered green bonds among emerging economies with a first issuance in 2014 of US$143 million to help fund clean infrastructure projects in Johannesburg. Cumulative South African green bond issuance has grown to US$3 billion in 2022, but still trails behind that of other countries with less developed financial markets like Brazil or the Philippines[122] (see the following figure). This gap in the volume of green and sustainability-linked bonds called for a certification scheme aligned with international environmental criteria. Hence, in April 2022, South Africa released its own green taxonomy in alignment with the EU taxonomy.[123] Development banks also have a key role to play in increasing the volume of green bonds in South Africa. Indeed, the cost of green bonds largely depends on the issuer's credibility (and not the project's)[124] and development banks have strong credit ratings. Finally, the majority of issuance in emerging countries, and especially in South Africa (with 84% share), is in local currency.[121] This can create currency risks for international investors who then face hedging costs. Overall, South Africa can overcome barriers to green bond growth by shoring up its macroeconomic stability and unleashing the potential of its already well-functioning financial market.



Source: Climate Bonds Initiative.[118]

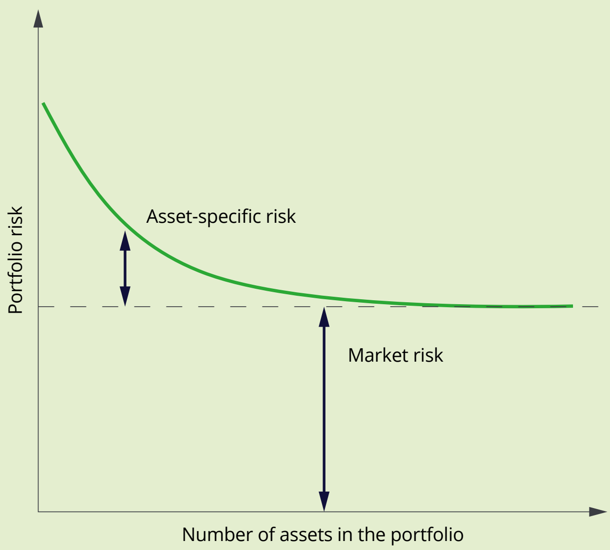
Portfolio diversification

Portfolio diversification is a risk management strategy that involves spreading investments across various assets to mitigate the impact of each specific asset on overall portfolio performance (Box 5). However, portfolio diversification only works if the returns of the assets are effectively uncorrelated. This bears two implications. First, optimal diversification means investing in various sectors or technology[125] and conversely, investing heavily in green projects can increase assets correlations and make diversification less effective. Second, during crises or major events like the 2022 energy price crisis, asset correlations rise, which can dull the effect of diversification.[126] Knowing these limitations, portfolio diversification can still be successfully applied to reduce risks for green transition investors. As shown previously, the green transition will be the sum of multiple simultaneous changes across different sectors of the economy. A healthy, low-risk green transition strategy should thus encourage investments across the full spectrum of the economy instead of focusing on a specific part of the value chain, or a specific technology, such as solar power plants.

A healthy, low-risk green transition strategy should encourage investments across the full spectrum of the economy instead of focusing on a specific part of the value chain, or a specific technology.

Box 5. Project risk reduction thanks to portfolio diversification

Crucially, portfolio diversification can reduce risk exposure, but cannot eliminate it fully (see the following figure). All assets are subject to systematic risks relating to broad economic or geopolitical risks that can affect the performance of the assets in the market. A well-diversified portfolio sheds specific risks linked to a project, industry, or sector, but will always be exposed to systematic risk.[125] To reduce this risk implies working toward political and market security, notably to overcome the barriers outlined in section 3 previously.



Source: Illustrative example based on 2 degrees investing initiative.[125]

Bridging the cost gap between green and fossil technologies

Reducing the upfront cost of sustainable assets

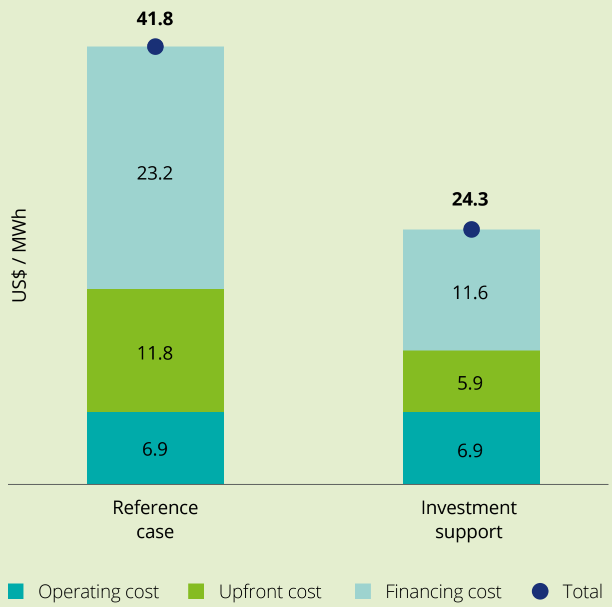
Two strands of direct measures to reduce upfront costs for green projects are relevant: upfront cost reductions through R&D (cost reductions via innovation) and investment subsidies. These measures can reduce project development costs in the short run, and trigger system-wide cost reductions in the long run. R&D support can bring down costs to help scale up emerging technologies, eases investments by making new-technology projects more bankable and helps build up a skilled workforce.[127] Additionally, investment support mechanisms can play a key role in making projects bankable by taking on some of the upfront costs. As explained in section 3, this can be especially relevant in emerging markets where potential investors are financially constrained. There are many funds that support clean-energy projects by financing a part of their capital expenditures, which ultimately helps some green projects bridge the cost gap with fossil technologies (Box 6).

Penalizing GHG-intensive assets

Carbon pricing is an umbrella term for various policy schemes that put a price on GHG emissions to internalize their cost to society and incentivize their reduction. The two main strands of carbon pricing schemes are carbon taxes, which set a fixed price on GHG emissions, and cap-and-trade systems, which set a fixed quantity of GHG emission permits and let participants trade permits. In both cases, GHG emissions are assigned a cost, encouraging participants to invest in cleaner technologies and practices to cut expenses or, with cap-and-trade, to sell excess permits (Box 7). Additionally, public revenue from carbon pricing can be redirected to climate-related initiatives. Doing so would transfer revenues from fossil assets to their green counterparts[128] and could also serve to ease the impact of fossil job or asset closure (stranded assets and people). This is one of the goals of the 'EU Emissions Trading System' (EU ETS), whose revenues go in part to the 'Modernisation Fund' which supports the transition in poorer or fossil-dependent EU regions.[129] Today, most of the developing world and some rich economies like the United States lack a comprehensive nationwide carbon pricing scheme.[130] A degree of regional harmonization in emerging green policies will be required to help avoid economically harmful industrial relocations. For example, if Mexico taxes GHG emissions at US$100/t$CO_{2eq}$ but Guatemala does not, a South Mexican industrial could relocate just a few kilometers into Guatemala and avoid taxation. In summary, carbon pricing serves to bridge the green-fossil cost gap by increasing the cost of fossil assets and potentially by transferring fossil taxation to green support.

Box 6. Case study: Impact of grant support on the levelized cost of electricity (LCOE)

The EU Innovation Fund[131] aims to bring new low-carbon technologies to commercial maturity by providing grants that cover up to 60% of the capital costs of eligible projects. To a large extent, the fund focuses on aiding clean hydrogen projects across their entire value chain. This fund uses CO_2 quota auction revenues from the EU Emissions Trading System (EU ETS), expected to recycle up to US$21.6 billion (€20 billion, depending on the CO_2 price) of CO_2 quotas into clean technology support during the period from 2020 to 2030. Grant supports like the Innovation Fund can help reduce the average cost of supply (for instance LCOE for electricity production) by lowering investment costs, but also financing costs, as less capital must be raised. The following figure shows how such a support can reduce the levelized cost of a project, both by reducing the overnight costs (the investment cost of a project, assuming it was done in overnight, meaning with no interest) directly and the financing costs indirectly. This type of financial support can be effective in emerging economies, where financing costs can be high.[132,133]



Source: Deloitte analysis of solar production in Southern Africa based on the renewable endowments from the reanalysis of Copernicus-ERA 5 hourly solar PV capacity factors database,[134] current technology costs for renewables and electrolyzers from IRENA[135] and IEA[136] cost data respectively and country-specific costs of capital aligned with IRENA's lower and upper bound estimations.[135] Grant support is assumed to account for a 50% reduction in upfront costs.

Box 7. Carbon tax in Sweden

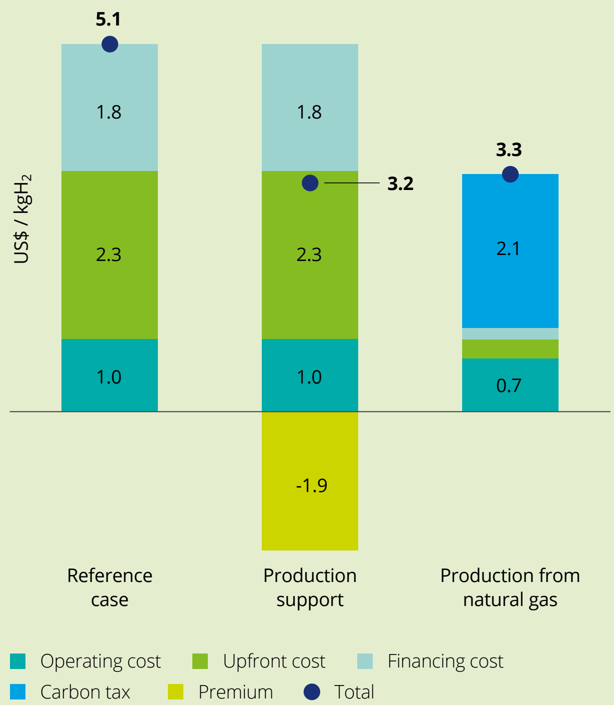
Sweden pioneered carbon taxation globally by introducing an about US$26/t$CO_2$ tax in 1991. The tax has since increased to exceed US$130/t$CO_2$ and grown to cover 95% of Swedish GHG emissions jointly with the EU ETS.[137,138] The Swedish carbon tax has brought important CO_2 emission reductions.[139,140] However, its overlap with the EU ETS also encouraged industrials to increase their emissions to cross the minimum emission threshold to fall under the EU ETS, where the price in €/tCO_2 was for a long time lower than the Swedish carbon tax. The Swedish carbon tax also affected industrial sectors that competed internationally with firms that did not face carbon pricing, prompting exemptions and tax rebates for, as an example, Swedish steelmakers. Lastly, the Swedish carbon tax disproportionately affects poorer households, who tend to spend a larger share of their budgets on fuel. Concerns of international competitiveness[141] and social justice[142] can discredit carbon pricing despite its benefits. Therefore, carbon pricing measures should not be introduced as standalone policies, especially in developing countries where a fuel tax increase would hit small businesses and poor households hardest. Instead, carbon pricing should be set up together with redistributive measures,[142] and a plan for helping the local industry against unfair international competition.[143] In the EU, this plan has taken the form of the Carbon Border Adjustment Mechanism,[144] which puts a carbon price on products entering the trade block.

Operational premiums to guarantee breakeven

The previous sub-section (De-risking sustainable and green projects) presented operating support schemes as a way to reduce revenue risk in order to help clean-energy projects break even. An increasingly common solution to improve the bankability of green projects is (carbon) contracts for difference, or (C)CfD. The parties of a (C)CfD agree on a strike price, and the seller pays the difference between the market and strike price if the market price is higher and receives the difference if the market price is lower. The strike price of a CfD is often determined through auctions where developers bid a strike price for their projects, and CfDs are allocated in ascending order of bids until the auction's target is reached.[145] As the technology supported by the CfD matures over time, eligibility criteria can evolve to trigger cost reductions via increased competition.[145] A (C)CfD works like a CfD, except prices are measured per ton of avoided CO_2, to help incentivize decarbonized solutions. Box 8 discusses the economic effect of (C)CfDs on green hydrogen projects and how they differ from the more orthodox feed-in tariffs (FiTs).

Box 8. Case study: CfDs for energy supply

Contracts for difference were introduced to the power sector in the UK in 2014 and have been successful in reducing power producers' market risk exposure by keeping the sale price of electricity constant.[146] Likewise, FiTs have proven their effectiveness in helping to foster renewable development in Europe and China.[147] However, the "reversible" aspect of CfDs makes them just as effective as FiTs when market prices are too low, but also brings tax revenue when market prices are high. Thus, CfDs can be easier for governments to balance out on a budget, making them an attractive option to subsidize clean energy deployment. In this vein, Germany is starting a new billion Carbon CfD (CCfD) program to compensate developers for the extra costs of low-carbon technologies.[148] This new scheme plans to award 15-year contracts via an auction where projects will bid a strike price in € per avoided ton of CO_2 (€/tCO_2 avoided). The following figure shows how (C)CfDs (working as operational support) and carbon pricing can tilt the scales for the levelized costs of green hydrogen production in southern Europe. Crucially, CfDs also have downsides: they do not hedge volume risk, they mobilize administrative capacity and their incentives for producers to reduce costs are not reinforced throughout the contract's lifetime.



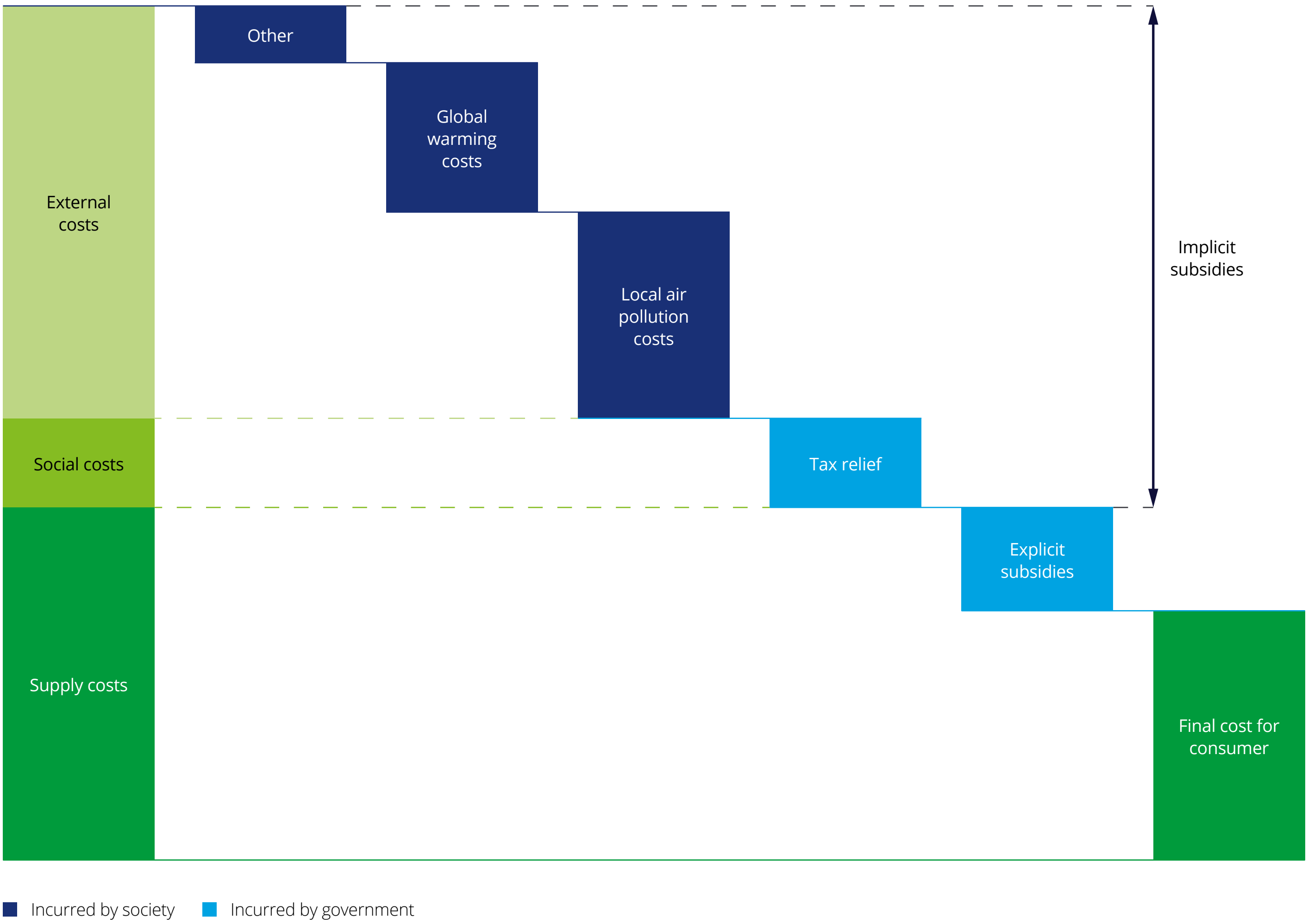
Source: Deloitte analysis based on the data used in Box 6. A carbon price of US$220/t$CO_2$ is chosen based on Shirizadeh and Quirion (2021)[149] that conclude that reaching climate neutrality would require a carbon price of at least €200/tCO_2. The premium is based on IRA 45V[32] and accounts for US$3/kg$H_2$ over 10 years.

Cutting fossil fuels

Ending public support for fossil assets

Despite their incompatibility with a net-zero by 2050 trajectory, fossil fuel subsidies accounted for US$7 trillion in 2022, 7.1% of global GDP in 2022,[150] up from US$5.9 billion or 6.8% of global GDP in 2020.[151] Fossil fuel subsidies can be explicit (direct cashflows) or implicit (tax rebates, etc.). Economists explain that the full social cost of carbon consists of direct subsidies paid by the state, and environmental damage that is incurred by society as implicit subsidies when not taxed by the state (Figure 7).[152] This makes implicit subsidies often monetarily larger than explicit subsidies,[153] as most countries' fossil fuel prices do not fully reflect pollution or climate change costs.[151] Incorporating the full social cost of fossil fuels into their price can therefore effectively lower the attractiveness of GHG-intensive activities like coal power generation by reducing the implicit subsidies that they receive.[151] In practice, this would require vast, costly and time-consuming fiscal reforms. However, it could also unlock public revenues of around US$4.2 trillion globally and US$3 trillion in emerging economies in 2025[151]—numbers close to the US$5 trillion of investments needed to reach net-zero in the IRENA's scenario.[12] Implementation remains a key problem, and compounded by the controversiality of fossil fuel taxes. Fossil investments are still attractive in developing countries, where fossil asset debt issuance has more than doubled since 2015.[154] The picture appears to be the same in G20 countries, where fossil fuel subsidies have hovered around US$160 billion despite phase-out promises.[155] Nonetheless, the upside here is a recent spread of new carbon pricing and green taxonomies measures around the globe.[154]

Figure 7. Decomposition of the full social cost of a fossil fuel



Source: International Monetary Fund[154]

Dealing with stranded assets

In the context of the global energy transition, stranded assets are fossil assets (infrastructure, resources) that lose (potentially all) value prematurely, i.e., before the end of their asset lifetime. This could be due to unforeseen changes in regulation (e.g., a new carbon tax), markets (e.g., EVs become cheaper than ICEs), social norms (e.g., less air travel), available technologies, financial context, or due to physical exposition to climate change.[156,157] Stranded assets are a liability, and a key challenge is to decide who will bear it. Managing stranding assets thus entails identifying stranded assets, as banks do via climate stress tests (see Box 9) and choosing who should bear the losses. In that regard, government can choose to fully, partially, or not compensate for stranded assets losses.[158] However, unplanned stranding could hurt the economy due to the value of fossil assets.[159] The World Bank estimates that unplanned stranding could cost 30% of global GDP.[160] As explained in section 3.3 the main risk with stranded assets comes from the cost of inaction. Delaying stranded asset management until after stranding occurs only makes the cost go up.[161] Governments can thus preventively cushion the budgetary impact of assets at risk of stranding, as is the case in, e.g., Indonesia via the Climate Investment Funds Accelerating Coal Transition.[162] Germany's coal exit plan also includes a precise coal power plant shutdown schedule and more than US$4.5 billion (€4.35billion) package to help compensate coal plant operators for their losses.[163]

Box 9. 2022 climate risk stress test of the ECB

In 2022, the European Central Bank carried out a climate risk stress test (CST)[164] as part of its new strategic priorities for 2023 to 2025.[165] The risks analyzed included physical risks, i.e., the risks related to climate events like wildfires and floods, and transition risks, i.e., the risks associated with stranding fossil assets amidst the green transition.[166] The Central Bank's CST assesses European banks' physical and transition risks as well as progress on their own CST framework. This CST found that around 60% of banks did not have their own well-functioning CST, even though 60% of non-financial corporate interest income came from high-emitting industries.[164] In other words, the European banking sector is highly exposed to transition risks and ill-prepared to manage them. The Central Bank's CST also found that losses are higher in scenarios of disorderly fossil fuel cuts. This means that banks have a strong economic incentive to proactively implement long-term green investment plans.[167]

Dealing with stranded people

The energy sector accounted for over 65 million jobs in 2019.[98] The IEA estimates that the energy transition will create more jobs than it will destroy.[168] However, cutting fossil assets will likely change the employment landscape, as can already be seen in the coal sector. For instance, in the US, the number of jobs in the coal sector decreased by 57% between 2011 and 2021, impacting more than 50,000 workers.[169] While coal workers will be the first ones hit by the transition, other sectors can expect to be impacted in the coming years, like oil and gas and some heavy industries. This makes job transformation and retraining strategies paramount. South Africa's JET IP[170] includes a nationwide strategy to anticipate and coordinate the change in employment needs for a just transition. This plan emphasizes the creation of a job market platform for coal, renewable energy, electric vehicles and hydrogen sectors, to map the skill supply in relation to current and future demand. The JET IP plan aims to unlock around US$140 million to develop the required skills from 2023 to 2027. Furthermore, the imperative to foster new skills and job opportunities presents a chance to promote inclusivity. In Chile, the *Energía más Mujer* initiative was implemented to include 5,000 more women in the energy sector by 2030,[171] as they only make up 23% of the sector's workforce.[172] Finally, in Germany, the coal exit plan contains a more than US$5 billion (€5 billion) payment plan until 2048 for older lignite and coal miners and power plant workers who lose their jobs.[163]

4.2. Focus on developing economies

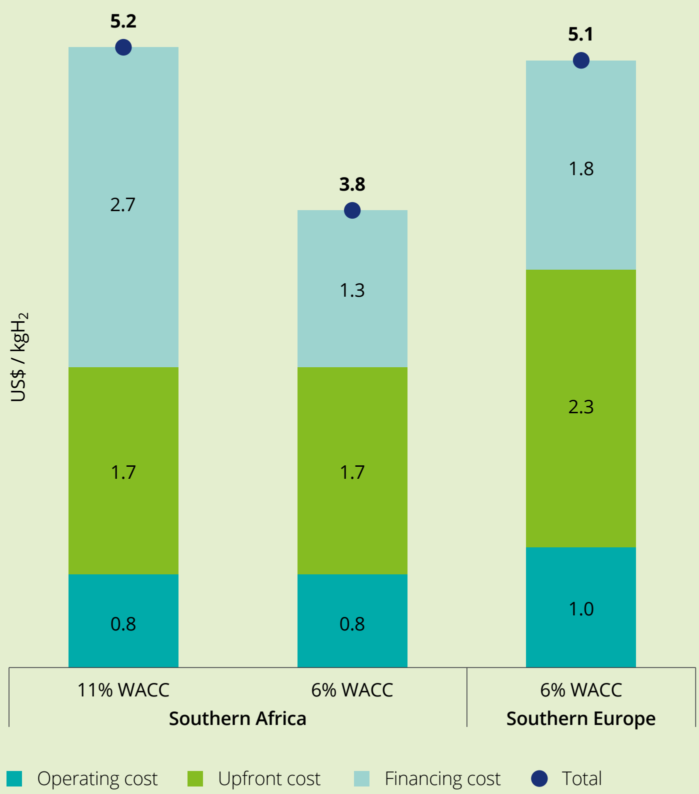
Green and sustainable technologies are often more capital-intensive than their conventional counterparts (section 2.2), therefore financing costs and conditions bear considerable weight in green project investment decisions.

For instance, producing green hydrogen implies building renewable power plants, installing electrolyzers and setting up electricity supply. As such, developing green hydrogen means incurring vast investment costs, i.e., raising large sums of debt and equity. This makes the availability of liquidity crucial when developing green hydrogen. Illiquid markets raise financing costs, which damages the economic prospects of capital-intensive green hydrogen. A key driver of financing costs is the risks associated with the local political environment and legal frameworks,[132] which can offset the productivity advantage of some of the world's best locations for renewables. Private capital providers expect higher returns to compensate for greater risk. This translates into a higher weighted average cost of capital (WACC), raising overall project costs by increasing their financing components. Thus, not only access to investments, but also access to affordable finance are the key enablers for green and sustainable projects, especially for those located in developing markets with high political risks.

Developing countries often face higher offtaker, market liquidity, currency and inflation risks.[112] These are all factors impacting projects' financing costs, making capital-intensive energy transition projects disproportionately expensive. While developing regions often have better renewable endowments, they also face higher capital costs, leading to higher overall production costs (Box 10).[112] Thus, making green projects bankable and attracting investments is more challenging in developing economies. Furthermore, as developing countries often operate on tighter state budgets,[10] bringing in multilateral development banks (MDBs) and development finance institutions (DFIs) could markedly facilitate investments. Therefore, two key challenges are attracting investments and accessing concessional finance (low cost of capital). Developing local capital markets and working with facilitators like MDBs and DFIs can be a key enabler of private capital mobilization and of cost of capital reductions.

Box 10. Case study: Impact of the cost of capital on the levelized cost of green hydrogen production in Southern Europe (developed economies) and Southern Africa (developing economies)

Solar irradiation in Southern Africa can be twice as high as in the sunniest parts of Southern Europe.[173] Therefore, the cost of green hydrogen production is expected to be lower as the same solar PV-to-hydrogen system produces more hydrogen in Southern Africa than in Southern Europe. Nevertheless, in current financing conditions, green hydrogen made in Southern Africa is slightly costlier than the one produced in Southern Europe (see the following figure). This is due to the higher cost of capital in Southern Africa. While financing costs represent 35% of the LCOH in Southern Europe, they add up to almost 50% of the LCOH in Southern Africa. This applies to other energy products in other developing regions: a 2023 IEA report finds that financing costs add up to 50% of the LCOE of solar power in developing countries, but only 25%-30% in advanced economies and China.[91] In this example, lowering the Southern African cost of capital to 6% (its current levels in Europe) reduces LCOH by 26%, enough to make Southern African green hydrogen 25% cheaper than its Southern Europe-made equivalent. Hence, improving financing conditions and thereby reducing the cost of capital is an effective way to encourage green investments in developing countries.

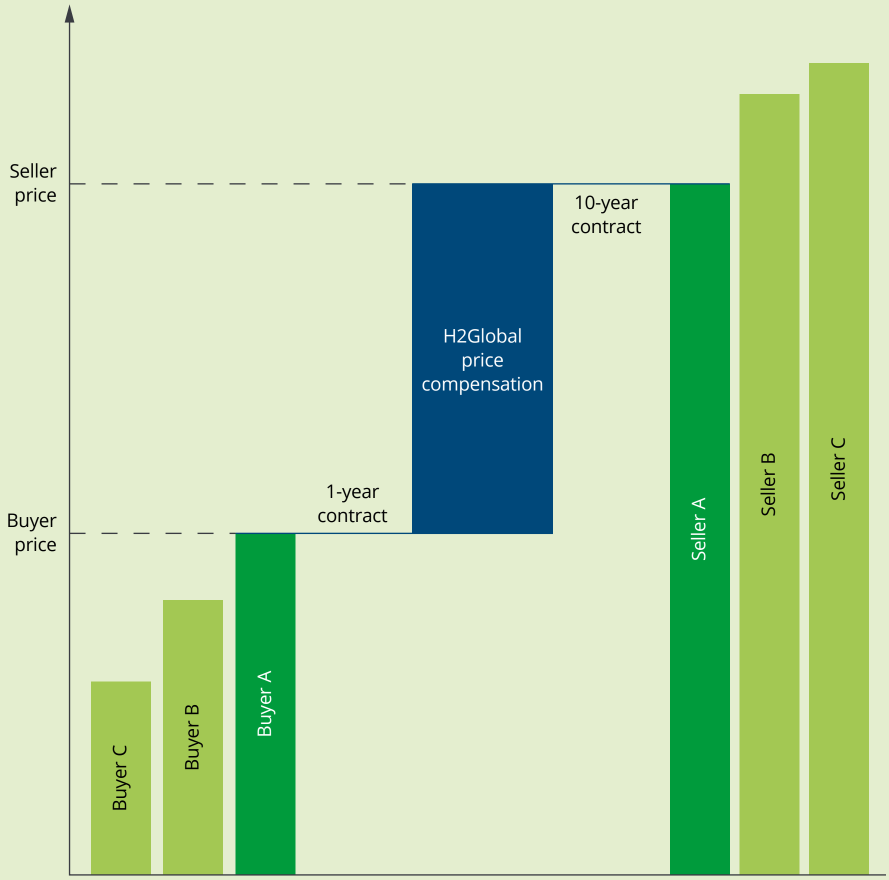


Source: Deloitte analysis based on the renewable endowments from the reanalysis of Copernicus-ERA 5 hourly solar PV capacity factors database,[134] current technology costs for renewables and electrolyzers from IRENA[135] and IEA[136] cost data respectively and country-specific costs of capital aligned with IRENA's lower and upper bound estimations.[135]

After the adoption of the Addis Ababa Action Agenda[174] in 2015, the focus pivoted to mobilizing private capital to make the jump from "billions to trillions" in development finance investments. Blended finance could guide this leap, but a 2023 G20 study found that its current private capital mobilization ratio was 0.6 private US$ invested for each US$ lent by MDBs.[175] Another study found that, of the US$4.1 of commercial capital raised for each US$1 of concessional capital, only US$1.8 came from private capital providers.[176] Thus, because blended finance seems to attract more DFI capital than private capital,[177] it is often perceived as "all talk and little action" today.[178] The lack of bankable projects, especially in lower income countries (LICs), is another cause of the under-mobilization of private capital. This is where initiatives like the H2Global hydrogen auction platform (Box 11) and subsidy scheme are needed. H2Global reduces offtake risks on the supply side with long-term contracts, and transition risks on the demand side with short-term contracts. Furthermore, growing pleas[175,179] to initiate the shift from "originate to hold" to "originate to share or sell"[180] models can be observed. Finally, standardizing DFI assets could ease their pooling, allowing DFIs with different risk preferences to work together.[179] Overall, making more green projects bankable, initiating the shift to "originate to share or sell" business model and enabling DFI asset standardization can help maximize private capital mobilization.

Box 11. Focus on H2Global

H2Global is a facilitating platform for green hydrogen imports to Germany. It is a two-sided auction system which acts as a buffer, match-maker and cost-bridger between supply and demand sides. To do so, it establishes a physical intermediary, the Hydrogen Intermediary Company (Hintco). On the supply side, it allocates long-term contracts through a competitive bidding process to lower the purchase price. On the demand side, H2Global issues short-term sales contracts to the highest bidder. Then, German government funds the gap between sellers' production costs and buyers' willingness to pay for green hydrogen. H2Global launched its first auction for green ammonia, methanol and e-fuel imports in December 2022. The results were not made public but encouraged the EU to gradually incorporate H2Global at the EU-level.[181]



Source: Deloitte illustration based on H2Global Stiftung[181]

4.3. Investment implications

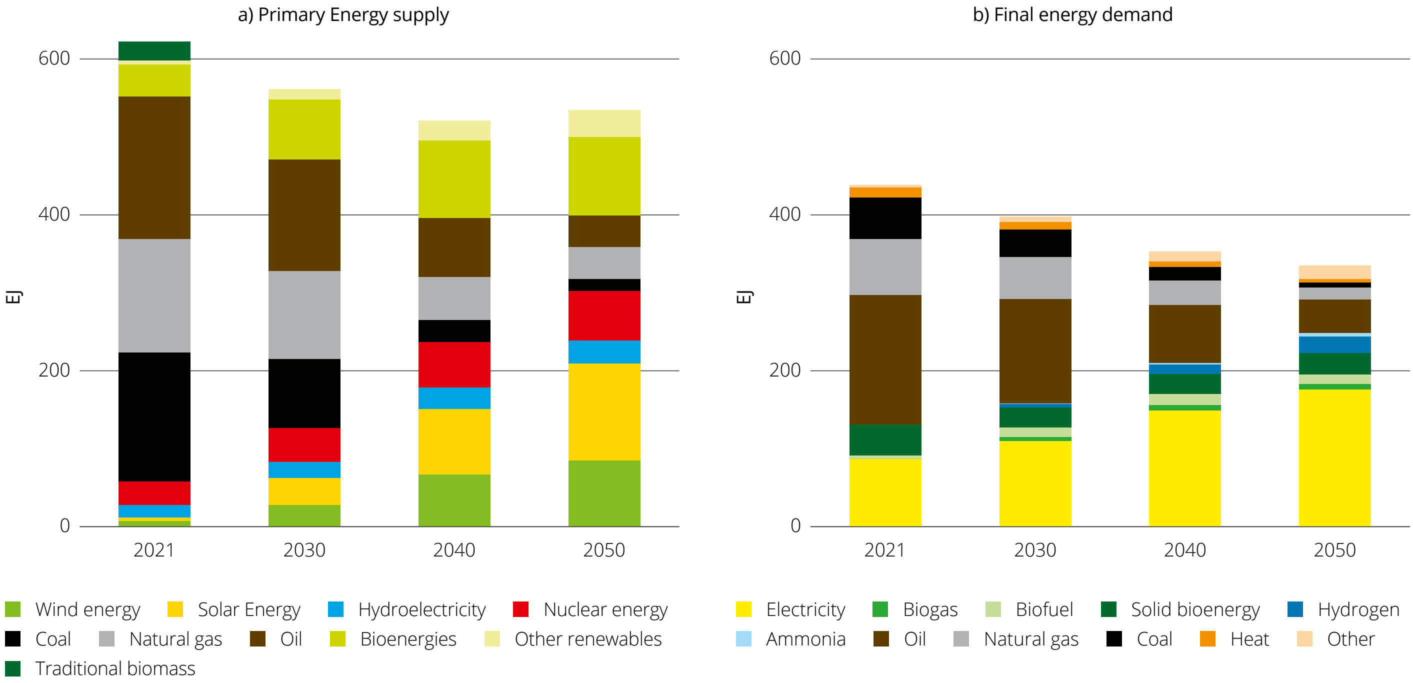
The IEA's net-zero pathway[44] is the chosen energy transition scenario that covers covering both the entire energy-industry nexus and the use of energy commodities as feedstock in industries and transport.

This scenario also depicts the profound transition of our global economies from the fossil fuel-centric model to a new energy system largely based on renewables and electrification. Global primary energy supply in this scenario falls from current levels of 620 EJ to about 530 EJ by 2050 (Figure 8.a). The share of renewables in primary energy supply increases from 12% in 2021 to 70% by 2050. Wind and solar power are the drivers of the energy transition, together representing 40% of the primary energy supply by 2050. On the consumption side, global final energy demand falls by more than 100 EJ in less than 30 years, reaching 337 EJ, thanks to efficiency improvements, consumer-side efforts and shift to more efficient electric end-use appliances (Figure 8.b). In fact, electricity represents 52% of final energy demand, becoming the key end-use energy carrier (vs. 20% in 2021). The share of oil, natural gas and coal in final energy consumption experiences a steep decline from about two-thirds in 2021 to less than one-fifth in 2050. Hydrogen and hydrogen-based molecules represent almost 10% of final energy consumption by 2050, partially replacing fossil commodities.

In the absence of concessional finance in developing economies, such a transition scenario would require nearly US$200 trillion through 2050 (about US$7 trillion/year on average) considering clean energy, feedstock, end-use technologies and efficiency measures. The investment requirements amount to 5.7% of global GDP in 2030 and 3% of it in 2050. The lion's share of investments through 2050 goes to electricity production and efficiency measures and end-use technology expenditures (43% each). Of these investments, about 70% should take place in low- and middle-income economies. Reducing the cost of capital can significantly enhance the ability of developing countries to keep the track of the transition.

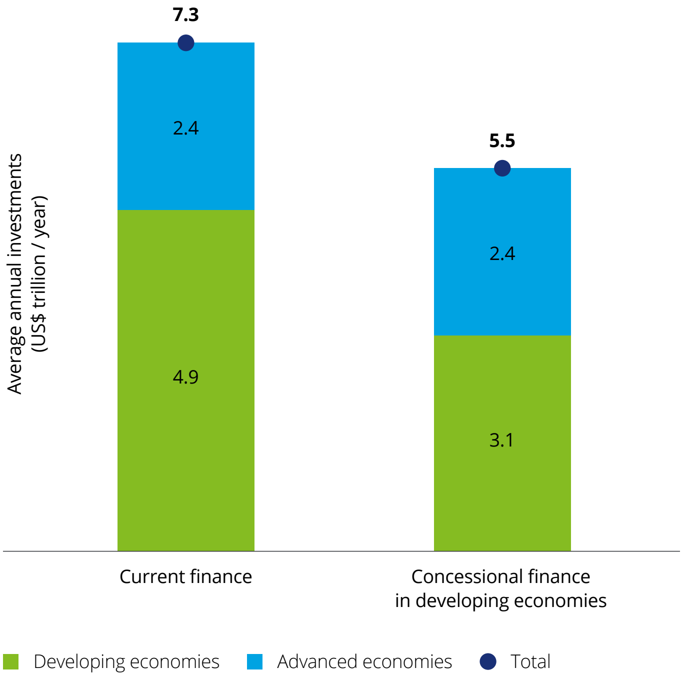
Reducing the cost of capital can both facilitate the flow of private capital toward the transition and reduce its cost. In case of similar financial conditions in developing and developed countries, the transition cost could fall by more than 25%, reaching about US$5.5 trillion/year (Figure 9). Accessing such levels of low-cost finance would require the help of concessional finance enablers. Active involvement of DFIs, international standardization, increased debt to equity ratio (via notably subordinated loans and mezzanine instruments) and innovative guarantee mechanisms (such as first-loss tranches) can reduce investor risks significantly and reduce the cost of both equity and debt. On top of clear-cut reduction of financing costs directly, these tools could also facilitate investments into green projects in developing economies, improving the access of these regions to capital which would also in turn reduce project risks.

Figure 8. Global primary and final energy mix aligned with net-zero through 2050



Source: Deloitte analysis based on International Energy Agency's net-zero emission pathway[44]

Figure 9. Average annual investments in advanced and developing economies through the period to 2050 with and without enabling concessional finance in developing countries

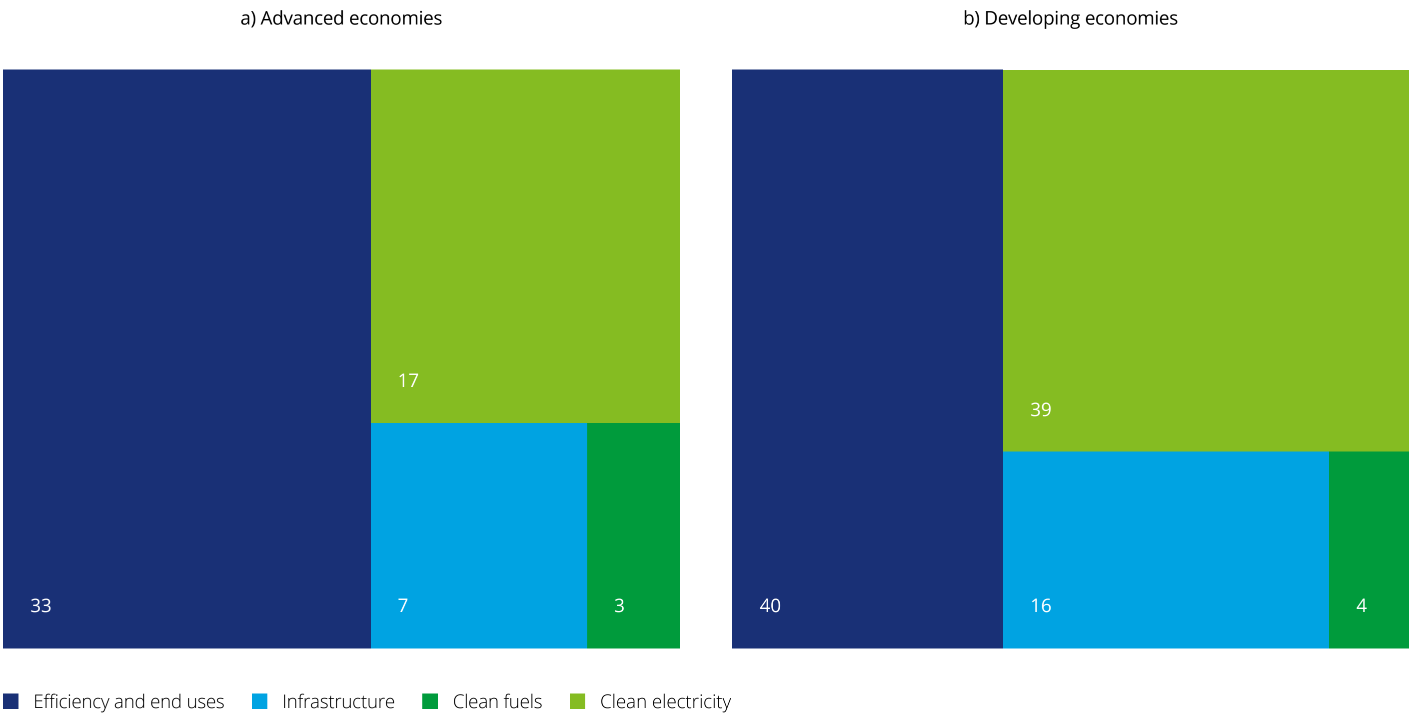


Source: Deloitte analysis[182]

Electrification implies a significant shift in an important proportion of end uses in all sectors. This leads to an important technological shift in the end-use technologies (shift to electric vehicles, heating pumps, industrial processes, etc.) and increase in the share of electricity in the final energy consumption. Therefore, investments in end-use technologies (including efficiency measures) and clean electricity production make up the largest shares of all investments—together accounting for about 80% of all investments both in advanced and developing economies. Production of clean fuels such as hydrogen and synthetic fuels captures the smallest part in the investment needs, accounting for about 4% of the investment needs.

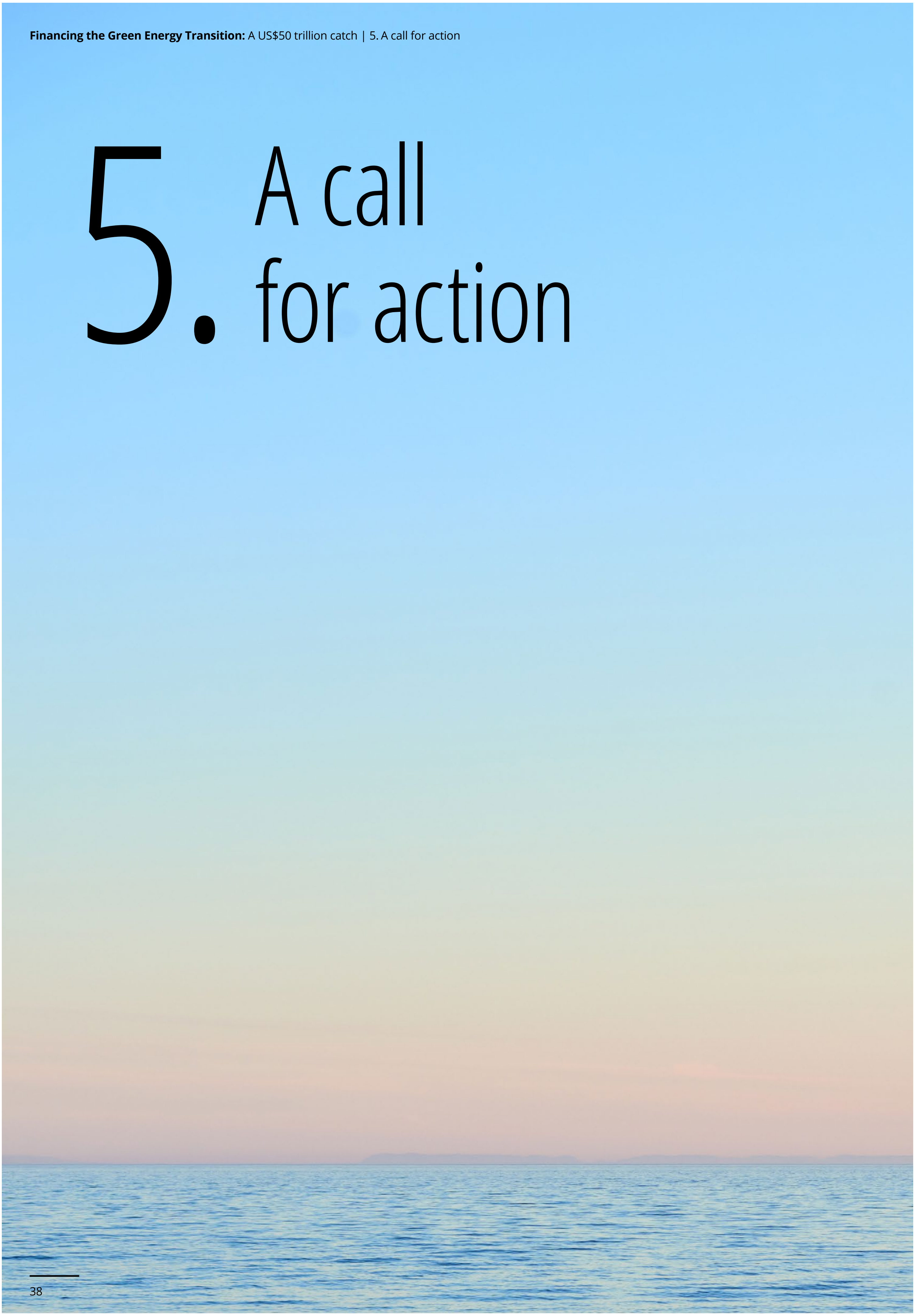
The needed investments are huge, and the financing costs can more than double the needed funds. For a real overnight cost level of about US$100 trillion with no financing costs, the current costs of equity and debt, with the current ratios between them[183] would almost double the needed funds for clean energy investments. Blended finance is the tool designed to help reduce these financing costs. Currently, US$1 of concessional capital can mobilize over US$4 of commercial capital (leverage ratio), including nearly US$2 from private investors (private capital mobilization ratio).[177] Moreover, private capital mobilization ratios also seem to increase with investment valuation.[177] Larger projects therefore may need less subsidization. This confirms that blended finance can be an appropriate tool for funding large-scale energy infrastructure projects. Pooling subsidized and commercial capital together can help fight high financing costs in developing regions to enable the growth of a global net-zero-compatible economy.

Figure 10. Total cumulative investments through the period to 2050 in the net-zero pathway in advanced and developed economies by investment category, in US$ trillion



Source: Deloitte analysis[182]

5. A call for action



Currently, green projects still lack bankability, and investments (including planned ones) are far from the required levels. More precisely, projects suffer from high investment costs, missing financial incentives, uncertain returns on investment, lack of skilled workforce, significant market, political and technological risks, lack of data and metrics and limited access to the required fundings. In developing economies, access to funding is even more challenging and political risks tend to be greater, putting even more upward pressure on the cost of capital. Section 4 identifies and details the financial instruments to improve the bankability of green and sustainable projects, grouping them into three key action levers: de-risking green projects, bridging the cost gap between green and fossil technologies and cutting fossil fuels. Figure 11 summarizes these instruments and their impact levers, as well as their geographical and technological comprehensiveness.

Figure 11. Financial tools to foster investments in green and sustainable projects

	Tools and Instruments	How does it work	Parameter influenced	Effectiveness: Technology – Green	Effectiveness: Technology – Conv.	Effectiveness: Regional – LICs	Effectiveness: Regional – MICs	Effectiveness: Regional – HICs
De-risking sustainable and green projects	Implement policy frameworks; Set climate strategies	Provides market transparency and regulatory clarity	Reduce political risks	●	●	●	●	●
De-risking sustainable and green projects	Guarantee mechanism; Loss reserves	Protect the investors against losses	Reduce the risk of default	●		●	●	
De-risking sustainable and green projects	Market creation	Facilitate access to an exchange market	Reduce revenue risk	●		●	●	●
De-risking sustainable and green projects	Offtake contracts (PPA, CfD, FiT...)	Guarantee a sell price for the producer	Reduce revenue risk	●		●	●	●
De-risking sustainable and green projects	Develop a domestic financial market	Increase confidence, information transparency	Lower borrowing costs	●	●	●	●	
De-risking sustainable and green projects	Bonds (green, blue, sustainability-linked)	Categorize the end-use of bonds	Lower borrowing costs, gives transparency	●			●	●
De-risking sustainable and green projects	Portfolio approach	Diversify investments	Reduce portfolio risk	●	●	●	●	●
Bridging the cost gap	Upfront cost reduction; R&D support	Activate the experience curve; Financial support	Reduce investment costs and financing costs	●			●	●
Bridging the cost gap	Carbon pricing	Put a price on GHG emissions	Make fossil alternative more expensive		●	●	●	●
Bridging the cost gap	Operational premiums (CfD, tax reduction)	Increase the revenue linked to the sale of the product	Make clean energy technologies more profitable	●			●	●
Reducing the use of fossil fuels*	Ending public support for fossil assets	Stop direct socially untargeted support to fossil fuels	Make fossil alternative more expensive		●		●	●
Reducing the use of fossil fuels*	Compensate for stranded assets	Compensate the unanticipated devaluation of fossil assets	Ease the economic impact on the society		●		●	
Reducing the use of fossil fuels*	Do Climate stress test	Assess the exposure of portfolio to transition risk	Avoid unanticipated losses and allow devaluation management	●	●		●	●
Reducing the use of fossil fuels*	Support job transformation	Implement training programs and job reallocation	Provide skill labor for the transition and social benefit	●	●		●	●

Source: Deloitte analysis.

* This section provides instruments to facilitate transition from a fossil-intensive energy system to a clean energy system. For LICs, most of the development of the energy system has not already occurred and they have the opportunity to develop their energy system directly using clean technologies without developing fossil fuel dependency. In other words, they can "leapfrog directly into a greener future", as Werner Hoyer, EIB President said.[184]

Achieving climate goals is a formidable challenge. Decisive and coordinated policy support, and collective action from investors and policymakers are paramount to guide investments toward green and sustainable projects.

The energy transition must commence throughout the globe today, but it will cost unfathomable sums of money, requiring private capital which is largely deterred by the risks of investing in green projects.

The solutions are here, now is the time to implement them. Research and field work have clearly identified technological solutions to decarbonize each sector of our global economy. Those solutions, i.e., renewables, clean electricity, and green hydrogen, are highly-capital intensive and face many investment barriers. Now is the time to articulate effective implementation strategies to support the growth of green economies.

However, the energy transition will cost too much for governments to afford it alone; private capital should also be mobilized. The quests for economic growth and climate neutrality converge in aiming to make green investments economically viable. This alignment will forge the path of a just, cost-efficient and successful transition. Governments and especially developing countries cannot single-handedly fund the required several trillion US$ per year of required investments. Private capital providers must be mobilized.

Currently, private capital providers are deterred from investing in the green transition because it is riskier than alternative investments. The lack of clear regulation, transparency and general certainty on the viability of green markets is making private capital providers think twice about investing in green projects. Their contribution will however be pivotal to achieve net zero by 2050.

Therefore, our global institutions must prioritize two simultaneous actions:

First, governments and regulators should reduce the risks that threaten the bankability of green and sustainable investments. All underlying risks, from unreliable off-take to unstable macroeconomics, raise financing costs. De-risking the investment landscape will unlock the low-cost capital that can make the costly and capital-intensive energy transition more affordable. Overall, governments will be pivotal in making more green projects bankable.

Second, concessional capital providers must maximize the potential of blended finance to mobilize private capital. Under today's rates, reaching net zero by 2050 will cost over US$7 trillion/year. Concessional finance via innovative financing structures can reduce the cost of the transition by nearly 40% for developing countries, lowering global investment needs to US$5.5 trillion/year.

On this journey, policymakers will need to balance local constraints with global green policy trends:

At the micro-level, the tools to reach net-zero must be adapted to their local setting. Experience has shown that frameworks should be tailored to specific geographies and technologies. There is no one-size-fits-all solution, and the transition needs to be multi-solution, or it will fail to take off.

At the macro-level, green policy guidelines and frameworks must be harmonized globally. The global transition to net zero should be more than the sum of individual national contributions. Its achievement will take unprecedented levels of international cooperation. This calls for the development and global harmonization of standards for green policies, technologies and financial instruments. Dissonant frameworks can create unaffordable inefficiencies.

Investors and lenders should be ready to face the challenge ahead:

Societies and capital providers should deal with huge upfront investments today, reaping the benefits later. The transition is an unprecedented financing challenge, but the cost of inaction is higher than the burden of a smooth, planned transition initiated today. The green transition can increase the world economy by US$43 trillion between 2021 and 2070.[185] Required investment levels remain below 6% of global GDP annually, however, a current policy pathway (aligned with +3°C of global warming) would entail almost 8% of global GDP loss by 2070. Delaying the start of the transition will only make the rise of green and fall of fossil more challenging and costly.

More than ever, investors should channel green funds to developing economies. Currently, less than half of green investments take place in developing countries. Excluding China, which accounts for one-third of green investments, the figure shrinks to 16%.[40] To reach climate goals, some 70% of the green investments need to happen in developing countries by 2030. This can be possible through active participation of DFI/MDBs and international cooperation.

The struggle to foster sustainable investments is a pressing challenge to remedy and the findings of this study suggest that there is a need for all actors of the project finance environment to mutualize their key learnings from years of experience in the field. This report's findings call for pooling practical knowledge on green finance and the creation of new finance ecosystem models to help lay the foundations for a global sustainable green finance environment aligned with climate ambitions.

Appendices

Appendix 1. Calculation of levelized cost of electricity and hydrogen

Electricity generation is calculated using yearly wind speed and solar irradiation time series from the Copernicus-ERA5 dataset.[134] Fixed ground-mounted PV systems with optimized tilt angles were considered to represent solar power plants in the model to compute their annual average yields in the considered cells. In the case of hydrogen production, the output is calculated with a Python script to get the optimal electrolyzer capacity over PV capacity ratio and annual green hydrogen production per unit installed electrolyzer capacity. Figure 12 summarizes the key techno-economic parameters considered in the calculation of the cost of hydrogen production via electrolyzers and steam reformation of natural gas.

Figure 12. Techno-economic parameters of hydrogen production technologies

Technology	Efficiency	Lifetime	Overnight cost	Variable O&M costs	Fixed O&M cost
Solar PV	100%	25	649 US$/$MW_e$	0 US$/$MWh_e$	14 US$/$MWh_e$
Alkaline electrolyzers	62.50%	20	793 US$/$MW_e$	0.53 US$/$MWh_e$	11.9 US$/$MWh_e$
Steam methane reformers	90%	20	869 US$/$kW_{H2}$	0.08 US$/GJ	40.8 US$/$kW_{H2}$

Source: Own calculations, based on IEA (2019),[186] Bolat and Thiel (2014),[187] Hydrogen 4EU (2022),[188] IRENA (2022)[135]

The levelized cost of hydrogen (LCOH) and the levelized cost of electricity (LCOE) can be calculated as in Eq. 1:

$$LCO(H\ or\ E) = \frac{CAPEX + \sum_{t=1}^{lt} \frac{OPEX_{fixed,t} + OPEX_{var,t} \times E_t}{(1+WACC_t)^t}}{\sum_{t=1}^{lt} \frac{E_t}{(1+WACC_t)^t}} \quad \textbf{(Eq. 1)}$$

Where $CAPEX$ is the overnight costs (investments at the beginning of the project), $OPEX_{fixed,t}$ is the fixed operation and maintenance cost (in annual basis) in year t, $OPEX_{var,t}$ is the variable operation and maintenance cost that depends on the production level, E_t is the annual hydrogen production output in the calculation of LCOH and the annual electricity production for LCOE, $WACC$ is the weighted average cost of capital in year t and lt is the lifetime of the production facility.

A premium on the production is normally constant over time, without any indexation to inflation or discounting effect. The premium is included in LCOH calculation to show its direct effect on the overall LCOH reduction (Eq. 2).

$$LCOH = \frac{CAPEX + \sum_{t=1}^{lt} \frac{OPEX_{fixed,t} + OPEX_{var,t} \times E_t - H_2 premium \times E_t}{(1+WACC_t)^t}}{\sum_{t=1}^{lt} \frac{E_t}{(1+WACC_t)^t}} \quad \textbf{(Eq. 2)}$$

On the contrary, the investment support is given at year 0, which has no depreciation impact because of the interest rates. The inclusion of this support in the LCOH is represented by Eq. 3.

$$LCOH = \frac{CAPEX - Investment\_support + \sum_{t=1}^{lt} \frac{OPEX_{fixed,t} + OPEX_{var,t} \times E_t}{(1+WACC_t)^t}}{\sum_{t=1}^{lt} \frac{E_t}{(1+WACC_t)^t}} \quad \textbf{(Eq. 3)}$$

The cost of capital used as the discount rate depends on regulatory risks, political risks, offtaker risks, currency risks and other land, resource and technical risks. Among these elements, the most important ones are regulatory and political risks, that can account for up to half of the weight of the risk elements.[132] The considered weighted average cost of capital values for Southern Europe and Southern Africa are 6% and 11% respectively. These cost of capital values are aligned with IRENA's lower and upper bound estimations.[135]

Appendix 2. Deloitte's Energy Transition Investment Calculator

Deloitte's Energy Transition Investment Calculator quantifies the cost of the green energy transition. It uses the IEA's Net-Zero Emissions (NZE) pathway[44] as a key energy, feedstock and industrial activities' transition scenario to compute the total investment needed annually until 2050. Both energy demand and feedstock uses of energy commodities are considered to calculate required investments in physical assets. Total energy demand is divided by sector (industry, buildings and transport) and subsector (steelmaking, cement, aviation, etc.) and IEA's future demand estimations for 2030, 2040 and 2050 are used. Deloitte's Energy Transition Investment Calculator computes the total investment costs using the following methodology:

01. First, additional capacities in each subsector are retrieved based on the evolution of annual energy demand in the NZE pathway. Additional capacities in physical assets are divided into categories: end-use, electricity generation, energy infrastructure and low-emission fuels. Each of these categories includes the means of decarbonization and thus the investments needed in buildings (e.g., retrofits, heat pumps, renewable heating), transport (e.g., electric vehicles and fuel-cell vehicles, aviation, shipping), carbon removals (i.e., carbon capture and utilization or storage), industry (i.e., steel, cement, chemicals and light industry), power generation (i.e., renewables, nuclear and other low-carbon generation) and infrastructure development (i.e., networks, storages assets and vehicle charging infrastructures).

02. Then, an investment cost (or overnight cost) is associated to the additional capacity. Cost data of Deloitte's Energy Transition Investment Calculator are based on IEA's "World Energy Outlook 2022" NZE scenario,[44] the European Commission's "Joint Research Centre (JRC) Data Catalogue",[189] IEA's "Global Hydrogen Review: Assumptions annex"[190] and Argonne National Laboratory's database.[191] The overnight costs evolve during the considered period based on technical maturity expected or change in material costs. All cost data are converted in US$$_{2021}$.

03. Finally, the investment cost is assigned to the year when it is incurred using an annuity formula. The total investment cost includes capital spent and financing costs. The financing costs depend on the technology cost, the capacity installed and the cost of capital. Investments are translated into annuities including their lifetimes, construction periods, cost of equity, cost of debt and equity-debt ratio. The annuity is computed with the following equation:

$$annuity = \frac{discount\_rate \times CAPEX \times (discount\_rate \times construction\_time + 1)}{1 - (1 + discount\_rate)^{-lifetime}} \quad \textbf{(Eq. 4)}$$

Where $CAPEX$ is the total overnight cost and $discount\_rate$ is the weighted average cost of capital given by Eq. 5:

$$discount\_rate = cost\_of\_debt \times share\_of\_debt + cost\_of\_equity \times share\_of\_equity \quad \textbf{(Eq. 5)}$$

The costs of debt and equity, as well as the equity-debt ratio are technology specific and differ between emerging economies and developed economies to reflect difference in risk premia. The lower and upper bound of WACC levels are derived from IEA's World Energy Outlook 2022[44] and are considered constant until 2050.

Deloitte's Energy Investment Calculator also allows to access to the distribution of investment between advanced and developing economies. This is the key requirement to assess the efficiency of concessional finance (notably through blended finance structures) in lowering the cost of the global green transition. When only global data are available for capacities, a weighting correction factor is applied to represent a realistic distribution of investment between the two categories of economies previously mentioned. A standard ponderation factor based on GDP is used for aviation, maritime shipping and industries except steel and cement production. For cement and steel production, a custom ratio is applied to consider the geographic peculiarity of these two industry sectors, which are not correlated with GDP. Moreover, for the coal industry, this correction follows the geographic distribution of this industry given by the IEA. Finally, the ponderation for heating is based on the geographic distribution of the energy consumed in space heating, based on the same database.

Deloitte's Energy Transition Investment Calculator allows to study the impact of changing the financing structure on the total cost of the energy transition. The cost of capital drives annual investments by impacting annuities, which decrease when the cost of capital deflates. The cost of capital is affected by the origin (i.e., public, private, MDBs) and form (i.e., equity, debt, concessional, grant) of a project's funding. The model allows to assess the direct impact of the cost of financing on total investments.

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