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Financing the Green Energy Transition

Innovative financing for a just transition

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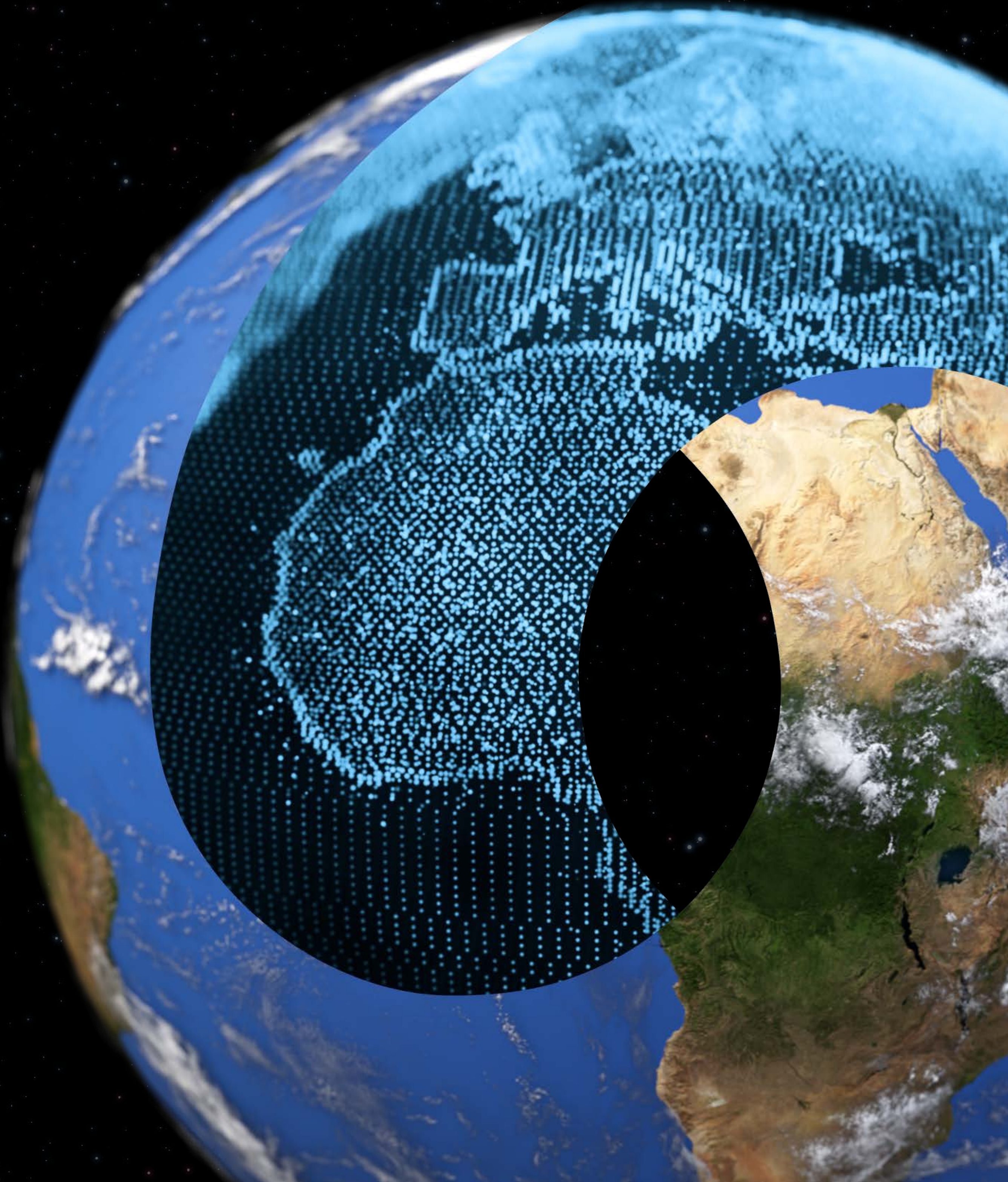

Foreword

Reaching collective goals of net-zero greenhouse gas (GHG) emissions globally requires a fundamental transformation of society to a highly renewable and electrified energy system. Enabling investments in green projects continues to be a central focus during major international gatherings, including the United Nations Conference of Parties (COP), further underscoring the global commitment to address climate challenges through mobilizing financing. Within this context, the findings of Deloitte's latest research report, Financing the Green Energy Transition—Innovative financing for a just transition, delves into the crucial role of financing in helping to drive the transition toward sustainable, green energy solutions.

As we collectively continue to observe significant changes to the global climate, the imperative for green investment has never been more pronounced. This new report builds on Deloitte's series of insights around the economic case to accelerate the energy transition, including earlier analysis, *Financing the Green Energy Transition – A US$50 trillion catch*, which outlines the state of play of the energy transition, and what's needed to help make green projects bankable.

This report provides theoretical foundations for a new concrete set of public-private solutions and approaches which can unlock the financing needed to help drive economic growth and development, consistent with the United Nations Sustainable Development Goals (SDGs). The analysis helps to demonstrate how we can collectively reduce the cost of capital by mobilizing innovative combinations of de-risking instruments and finance mechanisms, that could save US$50 trillion globally through 2050, making the green transition possible as well as affordable.

Financing green projects tends to be inherently complex given the relatively early stage of the global market for new green technologies and investment, including the array of differentiated products across unique markets, and the geoeconomic challenges of green resources in comparatively more risky jurisdictions. This complexity, along with the projections of where investments are needed to help reach global net-zero goals are core to addressing both the equitable aspects of a just transition, and to driving efficient and cost-effective investments for both developed and developing economies. The report provides practical solutions and recommendations to stakeholders and outlines a new ecosystem approach to financing green projects.

By fostering collaboration and adopting leading practices, Deloitte believes that together, we can accelerate the transition to a low-carbon economy. I am confident that the insights contained within this report can serve as a valuable resource for navigating the complex landscape of green energy financing to accelerate meaningful change towards a net- zero future.

Jennifer Steinmann
Deloitte Global Sustainability leader

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Glossary

Abbreviation	Meaning
BAU	Business as usual
bp	Base points (0.01%)
CAPEX	Capital expenditures (overnight cost)
CAPM	Capital asset pricing model
(C)CfD	(Carbon) contract for difference
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization, and storage
CDS	Country default spread
CO_2	Carbon dioxide
CO_{2eq}	Greenhouse gas emission equivalent to CO_2
CRP	Country risk premium
DAC	Development Assistance Committee (body of OECD)
DFI	Development finance institution
ECB	European Central Bank
ERP	Equity risk premium
EU	European Union
EV	Electric vehicles
FiP/T	Feed-in premium/tariff
GDP	Gross domestic product
GHG	Greenhouse gas
GW	Gigawatt

Abbreviation	Meaning
H_2	Hydrogen
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
IRR	Internal rate of return
LCOE/H	Levelized cost of electricity/hydrogen
MRP	Market risk premium
MWh	Megawatt-hour
NPV	Net present value
OECD	Organization for Economic Co-operation and Development
OPEX	Operational expenditures (operation and maintenance costs)
pp	Percentage points (difference between percentages in absolute terms)
PV	Photovoltaic
RE_{spread}	Renewable project spread (renewable debt margin)
SLB	Sustainability-linked bond
SP	Project-specific risk premium
US	United States
UK	United Kingdom
VaR	Value-at-risk
WACC	Weighted average cost of capital

Executive summary

The energy transition is an unprecedented investment challenge, which could cost up to US$200 trillion cumulatively through to 2050.

Reaching climate neutrality in the global energy sector will require investing in clean electricity (mainly renewables), electrolyzers for green hydrogen production, energy storage options (notably batteries), bioenergy, electrification of end uses (chiefly heating and transport), efficiency improvements, and carbon capture and storage. Some of these solutions are perceived as riskier than their conventional fossil-based counterparts because they are often highly capital-intensive, more disruptive, in some cases, costlier, or their respective markets are nascent.

The risks associated with investments directly increase their cost of capital, which in turn raises the cost of the energy transition. These risks can be categorized as macro (e.g., political and regulatory), technical (e.g., underperformance and delays), market (e.g., revenue and competitiveness) and financial risks. Macro risks are the sum of uncertainties stemming from a lack of political visibility, inadequate regulatory frameworks, ill-equipped administrations, and volatile currencies. They make up 45% to 90% of the cost of capital of current renewable electricity projects. Market risks are the second largest contributor to the cost of capital, adding up to 20% in developing economies. When these risks are combined, the cost of capital for renewable projects varies from 18% for solar PV to more than 21% for offshore wind power in Sub-Saharan Africa and from 7% for solar PV to 9% for offshore wind power in Western Europe.

De-risking instruments can partly or fully mitigate some of these risks, reducing the cost of capital and, thereby, investment needs. Systemic de-risking instruments include information, regulatory, institutional, and economic instruments, which can mitigate a large share of macro risks and some market and technical risks. Yet, even thorough systemic de-risking can leave some residual risks that require more tailored instruments, which essentially transfer residual risks onto (often public) entities that can take them. Indeed, the risks of nascent markets and technologies are too high for most private entities to bear due to a lack of experience and commercial track record. These financial instruments, based on a cooperation between public and private entities, fall under the umbrella of so-called blended finance mechanisms. Concessional loans, grants, mezzanine instruments, and securitization are some of the main blended finance tools that employ concessional capital and risk transfer to help reduce lenders and investors' risk perception of green projects.

Political risk guarantees can prove to be one of the most effective de-risking instruments in riskier countries, with up to 14 percentage points reduction in cost of capital. Among some of the most effective de-risking instruments are revenue guarantees and grants, which can reduce the cost of capital by up to 3 percentage points. This could reduce the levelized cost of a US$72/MWh onshore wind power project in South America by as much as US$12.5/MWh (17%). These instruments are followed by performance guarantees (0.2 to 2.5 percentage points), concessional loans (0.7 to 2.4 percentage points), and network planning and streamlined permitting processes (0.4 to 2.4 percentage points). To put this in perspective, a 0.2 to 2.5 percentage-point reduction in the cost of capital of a US\$7.1/kgH_2 renewable hydrogen project in Southern Africa could reduce its levelized cost by US\$0.05/kgH_2 to US\$0.75/kgH_2, though it will still likely remain more expensive than its fossil counterpart (US\$1/kgH_2 to US\$3/kgH_2). The establishment of transparent regulatory environments through climate and energy strategies and green or sustainable taxonomies can reduce the cost of capital by 1 to 1.8 percentage points.

Each of these instruments comes at a cost for society, implying the need for a comparative assessment of their economic efficiency, beyond their raw effectiveness. This is particularly important for developing economies, where tighter budgets demand a more efficient approach to maximize private capital leverage. Political risk guarantees can be one of the most or least effective de-risking instruments, while simultaneously representing the most or least cost-efficient options, depending on local macro risks. Moreover, tax incentives, grants and revenue guarantees are among some of the most efficient financial de-risking instruments with up to 2.3 US$/US$ efficiency. This means that US$1 of public spending on a project through each of these instruments can increase its net present value by more than US$2.

Each instrument tackles a different risk group that also depends on the market's maturity level, and different instruments are applicable and effective at different stages of market maturity. This means that the comparative effectiveness and economic efficiency assessments should contain this chronical dimension for a like-for-like comparison:

01. Climate and energy strategies and taxonomies are efficient starting-point instruments in a nascent market, but their effectiveness dwindles as markets mature. As pilot projects evolve into semi-functional markets, network planning can lay the foundations for the physical integration of green products into the energy system.
02. The need for economic instruments like grants, operational support mechanisms, and tax incentives comes as pilot projects are launched. These instruments come to bloom in a further market development stage with a clear policy and regulatory environment, and they can help green technologies gain in competitiveness. Achieving economic competitiveness paves the way for attracting large investors.
03. Consequently, widening the range of investors and lenders to more risk-averse actors will require financial de-risking instruments (blended finance mechanisms) and performance guarantees until the establishment of a mature market where the positive commercial track record is upgraded into a proper market scale up.

An efficient technology- and geography-specific combination of different de-risking instruments, applied at the right stage of market maturity, can save about US$40 trillion of the costs of the energy transition through 2050.

In a dynamic finance environment with timely investments, green project macro risks are set to decline, reducing the cost of capital. This so-called financial learning effect springs from an enhanced risk perception of investors and lenders regarding green projects as markets and regulatory environment mature. For instance, the costs of capital for onshore wind and solar PV installations in Germany have, on average, decreased by more than 4 percentage points between 2005 and 2017 in large part due to financial learning. The cost of capital of green projects are slated to keep decreasing as the underlying markets mature, especially in developing economies where clean energy and financial markets are less advanced. This financial learning effect, along with the continuous deployment of de-risking instruments, can reduce the cost of capital, not only for new projects, but also for past investments through refinancing: the cost of debt and equity can be reviewed during the project lifetime based on the market rates for new projects. Refinancing can bring up to US$10 trillion savings in capital through 2050.

Summing the savings from de-risking, financial learning and refinancing, a cost-efficient combination of different instruments with a flexible project finance environment can reduce the cumulative investments required in the energy transition by 25%, or US$50 trillion across the period to 2050. This could reduce the investment cost required to hit the net-zero by 2050 target from US$7.3 trillion/year to US$5.5 trillion/year, making the growth in expenditure from current rates of below US$2 trillion/year more attainable. This is due to the fact that the current project finance environment fails to include climate and environmental externalities, not only from an economic cost perspective, but also concerning risk-induced financial costs. Additionally, the current project finance ecosystem should facilitate the aggregation of investors and lenders and include ownership transfer mechanisms to leave no potential investor and lender behind, and to help enable a smooth and affordable energy transition. Given the need to make the most out of limited concessional capital, these elements reflect a missing piece in the project finance ecosystem which would manage the funds, centralize assessments and decision-making, and enhance the fluidity of investments in the green projects.

To conclude, the window to bring the world on course for net-zero targets for an affordable energy transition is closing fast. Policymakers, investors and lenders, development financial institutions, and international organizations should work together to help reshape the current project finance environment into a functional green finance ecosystem that incorporates the climate impact of investments and enables refinancing. More precisely:

- **Investors and lenders** should realign their priorities to incorporate decarbonization into their strategies and adapt their financial assessment methods to new demands. Institutional investors only accounted for less than 1% of global climate investments in 2021-22. There are profits to make on green technologies and losses to incur on fossil assets, but both are downplayed by the lack of internalization of the climate impacts of investments. Even today, 60% of European banks do not appropriately assess climate risks. Pension funds, banks, insurance companies, and other large-capacity investors can elevate green markets from today's billions to the required trillions. However, to do so, they should integrate climate risks and the (in)direct costs and benefits of green and fossil assets into their risk pricing methods.

- **Policymakers** are pivotal to help create the starting conditions, the required regulatory environment, and the sustained momentum required for an affordable transition to net-zero. This is a fourfold challenge to produce strategies and taxonomies, set up adequate de-risking instruments, create a differentiated and flexible green project finance ecosystem, and establish a first commercial track record to activate learning effects. At stake are US$40 trillion of costs saved thanks to the deployment of instruments like grants, tax credits and revenue guarantees, which add US$2.3 of value for each US$1 of public spending. Political risk guarantees will be pivotal in making green projects bankable in many developing countries, where they can slash the cost of capital by as much as 14 percentage points. For reference, such a drastic reduction would halve the cost of solar electricity made in Ghana.
- **Development finance institutions** (DFI) should calibrate their blended finance instrument mixes to make the most out of limited concessional capital and enable large-scale refinancing. The optimal deployment of blended finance can typically reduce the cost of green energy by up to 35%, and refinancing can cut investments needs by up to US$10 trillion through 2050. DFIs should foster refinancing to exploit financial learning, which has lowered the cost of capital of renewables by 4 percentage points since 2010 in developed renewable markets and is due to keep reducing it in the future. In essence, this is a call for DFIs to deepen their analysis of green project de-risking tools and to entrench their role as risk-absorbers to help facilitate the participation of large-capacity investors.
- **International organizations** should build and champion for a new energy world order in which the vital components of the transition are assessed and traded freely and in harmony. More concretely, there is immense value at stake in establishing the required diplomatic ties and aligned rulesets to allow for the facilitated global trade of green technologies and molecules. For instance, considering the future global green hydrogen economy, limited global trade can lead to a 25% (US$350 billion) increase in the cost of the future green hydrogen market, projected to grow into a US$1.4 trillion market by 2050.

The window to bring the world on course for net-zero targets for an affordable energy transition is closing fast. Policymakers, investors and lenders, development financial institutions, and international organizations should work together to help reshape the current project finance environment into a functional green finance ecosystem.

1. Low-cost green finance: a US$50 trillion catch

1.1. Low-cost finance to enable an affordable energy transition

The starting point of Deloitte's *Financing the Green Transition* project, as underlined in its first report of this series, *Financing the Green Energy Transition – A US$50 trillion catch*,[1] was the necessity to help reach net-zero greenhouse gas (GHG) emissions globally by 2050, and the colossal investments that decarbonization entails. The core of this global challenge will be the energy transition, as the energy and energy feedstock use in the key economic sectors (buildings, industry, transport, and agriculture) accounts for about 80% of global GHG emissions. The current analysis, as the second report of the series of Financing the Green Energy Transition, focuses on how to help unlock the investments required to fuel green energy transition around the world.

Abating GHG emissions in energy-consuming sectors will require investing in well-identified decarbonization solutions. In power generation, these solutions are clean electricity, chiefly coming from renewables like solar and wind farms. Industries, transport, and buildings will be decarbonized via a combination of electrification, hydrogen, bioenergy, carbon capture, utilization, and storage (CCUS), and energy efficiency improvements. These solutions tend to be perceived as riskier than their fossil counterparts because they are often highly capital-intensive, more disruptive, in some cases costlier or their respective markets are missing.

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Crucially, the elevated cost of capital, which reflects underlying investment risks, can discourage private capital investments in green energy projects, reducing their bankability. The key risks currently making the risk-return profiles of green projects unattractive to commercial investors include political, regulatory, offtake, revenue, technology, currency, inflation, and market-relevant commercial risks. De-risking green projects can thus enable the flow of private capital towards the transition, a necessary contribution given the scale of investments needed to reach net-zero.

Indeed, under current financing conditions, the energy transition will require more than US$7 trillion of investments per year or nearly US$200 trillion in total through 2050.[1] Unlocking low-cost finance through blended finance and other de-risking mechanisms for green investments has the potential to cut this bill by US$50 trillion in total, bringing it down to US$5.5 trillion per year through 2050.[1] The power of low-cost finance to reduce the cost of the transition is even greater in developing economies, where 70% of green investments must take place.[1] More than ever, decision-makers should guide large-scale, low-cost capital towards green projects in developing countries.

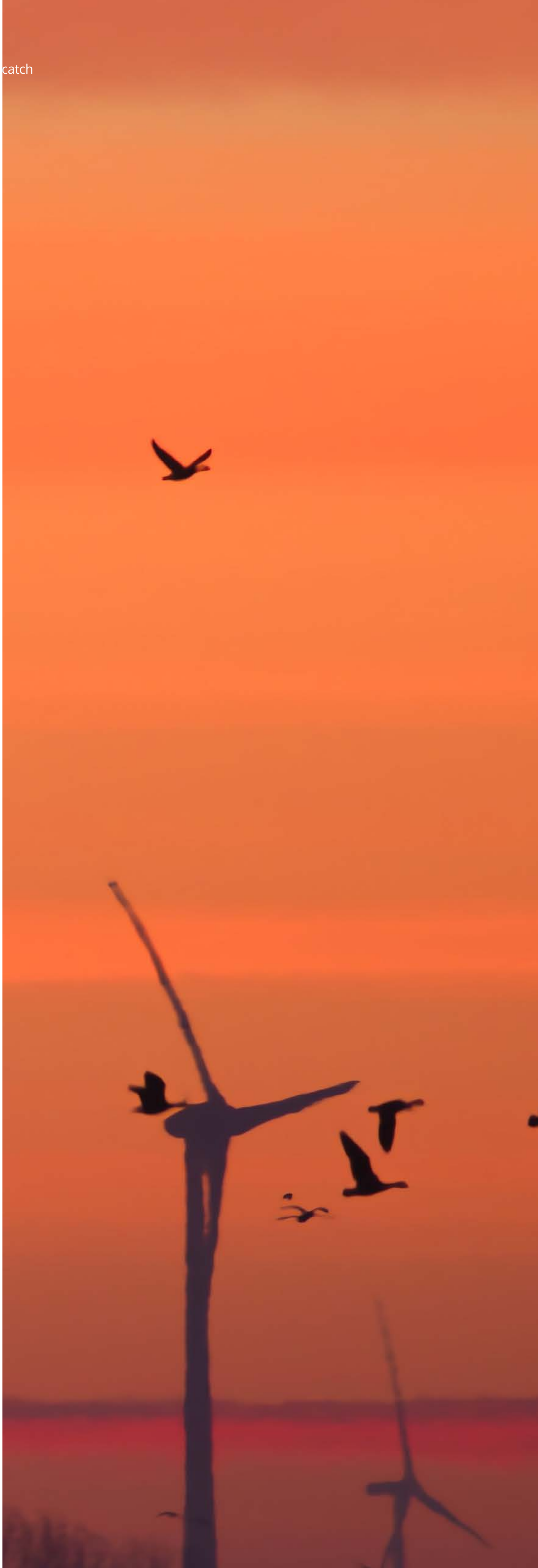
Setting off the green transition today can help limit global warming to well below 2°C and give time to ensure smooth transitions for people and assets at risk of being stranded. A growth-compatible green transition to global net-zero can increase global GDP by US$43 trillion through 2070. In comparison, current policy pathways, which lead to 3°C of global warming, would cause 8% of global GDP loss by 2070.[2] Therefore, the cost of inaction is higher than the burden of a smooth, planned transition initiated today.

Deloitte's *Financing the Green Energy Transition – A US$50 trillion catch*[1] report produced a toolkit to help foster green investments, including cost of capital reduction measures and private capital mobilization instruments. Those instruments work in three axes to help foster green investments: de-risking green projects, bridging the cost gap between green and fossil technologies, and transitioning away from fossil fuels. Green project de-risking measures look to create a low-risk project environment, reduce revenue risk, provide loss reserves and guarantees, develop local financial markets and dilute risk via portfolio diversification. There is a degree of overlap in de-risking and cost-bridging instruments, as the latter include local financial market development but also reductions in green technology and project upfront and operating costs as well as the implementation of carbon pricing. Carbon pricing is another cornerstone measure to help foster green investments. It helps transition away from fossil fuels, accelerate phaseout plans for fossil subsidies, while offering stranded asset or stranded people support. Overall, policymakers can choose between a wide range of solutions to help foster green investments.

However, this report also showed that, in many cases, those measures have failed to deliver. This is due to implementation barriers and possible design flaws stemming from misconceptions on the inner financial workings of green projects or their external environment. Implementation barriers were outlined in Deloitte's *Financing the Green Energy Transition – A US$50 trillion catch*[1] report as political, market and capacity barriers. Risks prosper in the absence of transparent policy frameworks, functional markets, and supporting infrastructure. These conditions vary across geographies and markets. Such disparities emphasize the need to account for local context when designing measures to help foster green investments.

To remove those implementation barriers, two major strands of uncertainties should be addressed:

- There remain misunderstandings on the **inner workings** of the cost of capital, and thereby how it can be reduced. In other words, the parameters influencing the costs of debt and equity of green projects and the relationships between those parameters and with other factors such as financial structures are often not fully understood. This is why decision-makers fail to design effective measures to help foster green investments today.
- Likewise, the **external environment** or financial ecosystem of projects is not always within the full grasp of decision-makers. Despite their potential to help mobilize private capital, blended finance mechanisms often fail to meaningfully scale up sustainable and green markets. This is partly because they are implemented on projects without a strategic vision for their insertion within the financial ecosystem. Understanding the external environment of green projects is thus a prerequisite to unleashing the full potential of blended green finance.



In helping to build the proposition for a new green project finance ecosystem, this report aims to provide the theoretical foundations for a new concrete set of public-private measures aimed at fostering green investments.

1.2. Objectives and scope

Consequently, the questions raised by Deloitte's first report in the *Financing the Green Energy Transition* series of reports can be summarized as following:

- How can different risk elements affect the cost of equity and the cost of debt of projects, and how can they be reduced?
- How could different de-risking instruments impact the risk return profile of projects and what combination of different instruments is needed to help scale up the nascent green markets in developing economies to progress toward self-functioning sustainable markets?
- How can the real potential of blended finance be unlocked? In other words: how can concessional capital help decarbonize economic activities and mobilize commercial capital in this direction as much as possible?
- How could the roles of government and public institutions evolve during the transition? How can financial and economic learning effects minimize public capital requirements in the transition?
- How can decision-makers help transform green pilot projects into sustainable markets?

The current report, *Financing the Green Energy Transition – Innovative financing for a just transition*, addresses these questions in three parts. First, the components of the cost of capital are explored and the individual and synergistic potentials of the main cost of capital reduction levers are assessed. Second, the current report analyzes how learning effects in financial markets and technologies can be leveraged to help lower the financial and economic burden of the green energy transition. Finally, the current report explains how decision-makers can guide the increase in scale from pilot projects to sustainable markets. This report concludes with a new financial ecosystem proposition, that is built around the central idea of transforming green pilot projects into sustainable markets.

In helping to build the proposition for a new green project finance ecosystem, this report aims to provide the theoretical foundations for a new concrete set of public-private measures aimed at fostering green investments. In essence, there is a need for an extra layer in the current project finance environment to help identify impactful climate projects, to assess how they can be bankable, to investigate their eligibility for existing grants and funds, to implement potential de-risking measures to them and to connect them to investors. Such a new layer can factor in the environmental benefits of the green projects, bringing a social cost approach (cost to the society) that can in turn internalize the environmental benefits to the cost-benefit assessments.

2. Matching de-risking instruments to investment barriers

The financial system is driven by a risk-return logic: investment returns on assets reward financiers who bear the associated risks. Therefore, when investors and lenders get involved in a transaction, one of the first steps of the process is the assessment of project risks, which helps determine the transaction price through the risk premium requested by financiers. Consequently, the costs of debt and equity asked by lenders and investors could become less attractive for projects that are perceived as riskier.[3] Higher perceived project risks thus mean higher financing costs,[3] but also a higher share of equity in the capital structure of the project, as investors are more risk-hungry than lenders, and consequently expect higher returns.[4] The capital intensity of clean energy assets makes their overall costs particularly sensitive to financing cost increases in comparison to fossil fuel assets,[5] making project risk assessment and capital pricing even more pivotal. However, since successful clean projects remain few and new, risk assessments often overestimate clean project risks, especially in developing economies.[6]
As a result, making a first wave of clean projects bankable and successful can help improve their risk perception, which in turn can trigger a downward repricing of risks.

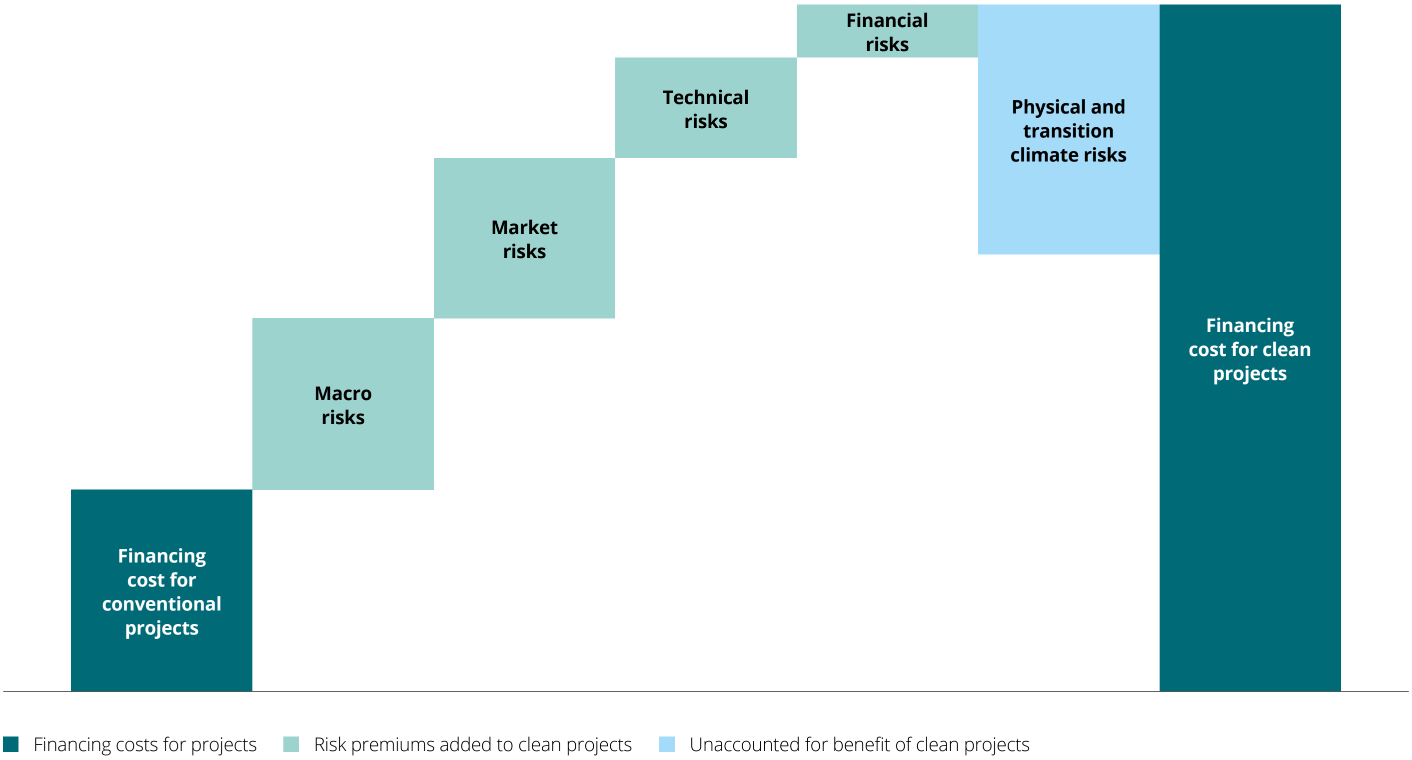
2.1. Risks stretching the cost of capital gap with fossil-based projects

Deloitte's *Financing the Green Energy Transition – A US$50 trillion catch* report[1] identified the various barriers preventing the green transition of the energy sector as falling into three groups. The first is political barriers relating to regulatory frameworks and political stability and transparency. The second is market barriers linked to the micro and macro business environment. The third group is transformation barriers, such as structural gaps in the skills, infrastructure, or other resources needed for a successful energy transition. These barriers generate risks for investors, lenders, and project developers. As Figure 1 shows, these risks can be categorized as macro, technical, market and financial risks:[7,8]

- **Macro risks** encompass political and regulatory risks and currency risks, i.e., volatility in currency valuation. Political and regulatory risks stem from a lack of political visibility, incomplete or inadequate regulatory frameworks, or poor administrative procedures such as lengthy permitting processes, which can disincentivize clean project development.[7,8,9] Macro risks can account for 45% to 90% of the total cost of capital for the existing renewable energy projects.[10] Compared to Europe, macro risks are 70% higher in South America and nearly twice as high in Africa. This discrepancy is due to higher political and currency risks, as well as a less stringent regulatory environment in developing regions.[10]
- **Technical risks** surround construction risk and different operational risks. They can essentially take the form of cost overrun and construction delays, and underperformance or higher operational and maintenance expenditures than expected. The effect of technical risks on the cost of capital project depends on the technology and the region considered. Renewable energy technologies are perceived less risky in developed economies compared to emerging economies because of their higher experience record.[11] Technical risks add a risk premium to the cost of equity of 1.4% for solar PV and 7.8% for onshore wind in developing economies.[10] In developed economies, these numbers fall to 0.9% for solar PV and 5.2% for onshore wind.[10] This risk premium results in an increase in the cost of capital of at least 0.3 percentage points for solar PV and 1.3 percentage points for onshore wind.[10]
- **Market risks** include credit and counterparty risk, liquidity risk, and offtake risk. Counterparty risk, i.e., the risk of default from borrowers, decreases with the credit worthiness of the borrower. Liquidity risk has two distinct components. The first is the lack of means of exit for investors and lenders when they are involved in a clean project. The second is the lack of project pipeline, i.e., the difficulty to develop investable projects or to make enough project concepts bankable.[12] Offtake risk accounts for the project's risk of insufficient demand levels at the required price to break even or general difficulties in securing offtake, in terms of sold volume or price. In developing economies, most green energy projects sign offtake agreements to reduce market risks.[13] Despite this, market risks still account for a risk premium of up to 13% in the cost of equity.[10]
- **Financial risks** incorporate risks that complicate access to capital. These can, for instance, include risks related to the information asymmetry stemming from underdeveloped capital markets.[14]

Besides macro, technical, market and financial risks, the underestimation of the environmental and health benefits of clean projects contributes to their overestimated risk perception, raising the cost of capital.[3] Climate-positive externalities and gains in resilience against transition risks are excluded from the pricing of risks even though they will bring net positive value to clean projects.[15]

Figure 1. Risk premium components associated with clean energy projects



Source: Deloitte analysis based on Glemarec (2023),[3] Blended Finance Taskforce (2018)[7] and United Nations Development Program (2013)[9]

Besides macro, technical, market and financial risks, the underestimation of the environmental and health benefits of clean projects contributes to their overestimated risk perception, raising the cost of capital.

2.2. Instruments to de-risk green projects

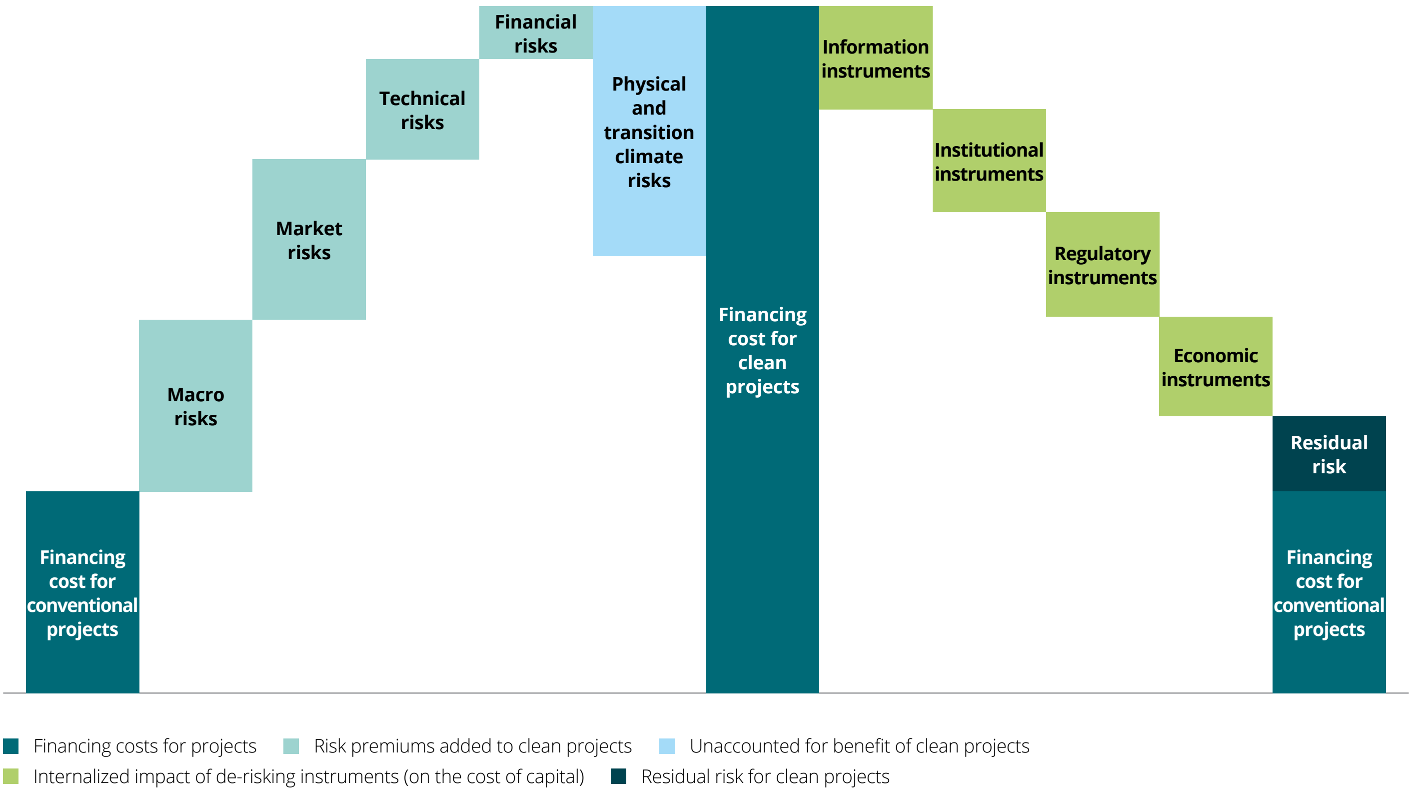
Policymakers and researchers have identified over 6,000 different instruments to deal with macro, technical, market, and financial risks and to make sustainable projects bankable.[16] A first-order classification can be made to distinguish instruments aiming to mitigate the risks of clean assets by addressing their sources, from instruments that seek to transfer risks onto entities capable of assuming higher risks than the project developer.[17] Risk-mitigating instruments generally take a systemic approach, since the risks faced by financiers tend to be more systemic than project-specific, and as such, cannot be solved at the project level.

A second-order classification of these instruments can be made based on their functionality and their impact areas: information, systemic, regulatory, and economic de-risking instruments (Figure 2).[17]

Information and empowerment instruments attempt to fix information asymmetries in markets. Their primary aim is to help empower industrial sectors, for example through training programs. **Systemic instruments** consist of institutional measures such as the establishment of environmental institutions or climate mandates for existing institutions, as well as restructuring organizational environment. These first two sub-categories of instruments have a wide-ranging ecosystem effect which is hard to quantify. Consequently, they often fall out of the quantification scope of studies, and their effects are often either completely ignored or qualitatively assessed.

Control and regulatory instruments refer to the establishment of a consistent regulatory framework with climate ambitions.[17] Concretely, this means establishing or empowering regulatory measures such as climate stress tests and norms and standards, but also streamlining permitting processes to help accelerate the commissioning of clean projects. Lastly, **economic and market instruments** aim to reshape markets by sending the right signals to players. These include the creation of consistent financial incentives through the design of effective subsidy policies and a coherent tax landscape.[17]

Figure 2. De-risking effect of systemic instruments on the financing cost of clean energy projects



Source: Deloitte analysis based on Glemarec (2023),[3] Blended Finance Taskforce (2018),[7] International Energy Agency (2023),[8] United Nations Development Program (2013)[9] and Green Climate Fund (2021)[17]

2.3. Residual risks: the need for project-level instruments

In most cases, systemic or risk-mitigating instruments cannot completely eliminate the risks of a clean asset, leaving a residual risk element that will require the help of risk-transferring instruments. These are mainly financial instruments relying on the cooperation between (often private) risk-averse capital providers and (often public) entities capable of assuming higher risks.[3] This type of cooperative interaction falls under the umbrella term of so-called "blended finance" mechanisms.

Blended finance is seen as a promising strategy to help address residual risk and thereby facilitate the flow of private capital into the clean transition. It is a structuring approach encompassing several strategies to reshuffle the risks of development finance investments.[17] To help achieve this goal, blended finance mechanisms deploy concessional capital to improve the risk-return profiles of impactful assets to make them compliant with capital market requirements.[18] This approach allows different players, especially development finance institutions (DFIs) and profit-seeking private entities, to invest in the same projects despite their different objectives.

Total residual risk after systemic enhancements is the sum of residual risks for each of the previously mentioned risk categories. De-risking tools, including financial instruments, have a certain level of risk-specificity (Figure 3). Therefore, the nature of the residual components should be considered on a project-level basis to help ensure the effectiveness of de-risking measures.[3]

Macro risks have the most significant impact on risk premium pricing.[8,9] Therefore, it is crucial to find instruments which can transfer these risks. Guarantees and insurance can cover a wide range of risks, making them the two most catalytic blended finance instruments.[7] They provide protection in case of underperformance, loss, or damage, and can significantly increase the creditworthiness of borrowers. Hence, guarantees and insurance have a wide coverage, especially against political risks. As the only reactive form of protection against governmental instability, political risk insurance is one of the most commonly used insurance types.[7]

Junior equity and subordinated debt (mezzanine instruments) serve to absorb the first tranche of monetary losses if they occur. Simply put, senior capital has priority in reimbursement or dividend payout over junior capital. Accordingly, financiers with senior capital are less exposed to under performance and default risk.[7] In addition to first-loss tranches, grants are also pivotal for private capital mobilization in nascent markets. Grants provide capital without return requirements, free up space for more debt funding and increase the returns on each dollar of equity invested.

Instruments that address specific risks include result-based mechanisms like sustainability-linked bonds (SLBs), securitization, and contractual mechanisms. SLBs aim to reward (or penalize) recipients depending on their environmental or social performance.[7,19] For instance, the coupon rate of an SLB could increase if the project fails to achieve a predetermined greenhouse gas footprint target. Securitization, commonly used by development and private banks, is a vital instrument to enhance liquidity. It is the process of bundling pools of individual–and thus often illiquid—assets into tradable assets called securities. Contractual mechanisms tackle residual offtake risk and can nullify market-related revenue risks (both price and volume).[7] This is especially relevant for markets with volatile prices, such as highly renewable power markets.[20] Since residual offtake risk is particularly salient in developing economies, offtake contracts and other contractual mechanisms which can address it are a focal point of this report.

Crucially, while de-risking instruments have a positive and intended impact on key project risks (Figure 3), they can also unintentionally increase exposure to other risks outside their scope. For instance, offtake contracts involving public authorities like Feed-in-Tariffs (FiT), Feed-in-Premiums (FiP) and Contracts for Difference (CfD) also increase projects' macro risk exposure. This spillover effect can apply to other subsidy policies as well.[21] Indeed, political priorities can change relatively quickly, inducing budget reshuffles and the potential de-prioritization of some green energy expenditures. In such a case, subsidies could increase political risk exposure while lowering target risk exposure. For example, in late 2023, the constitutional court of Germany ruled against the reallocation of about US$64 billion (€60 billion) of unused COVID-19 pandemic era debt to climate funds, jeopardizing the country's expected public investments in the green energy transition. This example illustrates how political constraints can affect the availability of public money for subsidies.[22]

Figure 3. De-risking tools and their risk effectiveness

		Macro risks		Market risks			Technical risks			Financial risks
		Political visibility	Regulatory	Missing markets	Revenue	Cost competitiveness	Under-performance	Construction delays and cost overruns	Missing infrastructures	Access to capital
Information instruments	Set climate and energy strategies	Full mitigation	Full mitigation	No impact	No impact	No impact	No impact	No impact	No impact	Full mitigation
	Taxonomies	Full mitigation	No impact	No impact	No impact	No impact	No impact	No impact	No impact	Full mitigation
Regulatory and control instruments	Streamlining licensing process	Partial mitigation	Full mitigation	Partial mitigation	No impact	No impact	No impact	Full mitigation	No impact	No impact
	Network planning	Partial mitigation	Partial mitigation	Partial mitigation	Partial mitigation	Partial mitigation	No impact	No impact	Full mitigation	No impact
Economic and market instruments	Demand aggregation	No impact	No impact	Full mitigation	Full mitigation	Partial mitigation	No impact	No impact	No impact	No impact
	Offtake contracts	No impact	No impact	Partial mitigation	Full mitigation	Full mitigation	No impact	No impact	No impact	No impact
	Tax incentives	No impact	No impact	No impact	Full mitigation	Full mitigation	No impact	No impact	No impact	No impact
	Consistent subsidy policies	No impact	No impact	Partial mitigation	Full mitigation	Full mitigation	No impact	No impact	No impact	Partial mitigation
Financial instruments	Guarantees and insurances	Full mitigation	Full mitigation	No impact	Full mitigation	No impact	Full mitigation	Full mitigation	No impact	Full mitigation
	Subordinated debt and junior equity	No impact	No impact	Partial mitigation	Full mitigation	No impact	Full mitigation	Full mitigation	No impact	Full mitigation
	Securitization	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	Full mitigation
	Concessional loans	Partial mitigation	No impact	Full mitigation	No impact	Full mitigation	No impact	No impact	No impact	Full mitigation
	Grants	Partial mitigation	No impact	Full mitigation	No impact	Full mitigation	No impact	No impact	No impact	Full mitigation

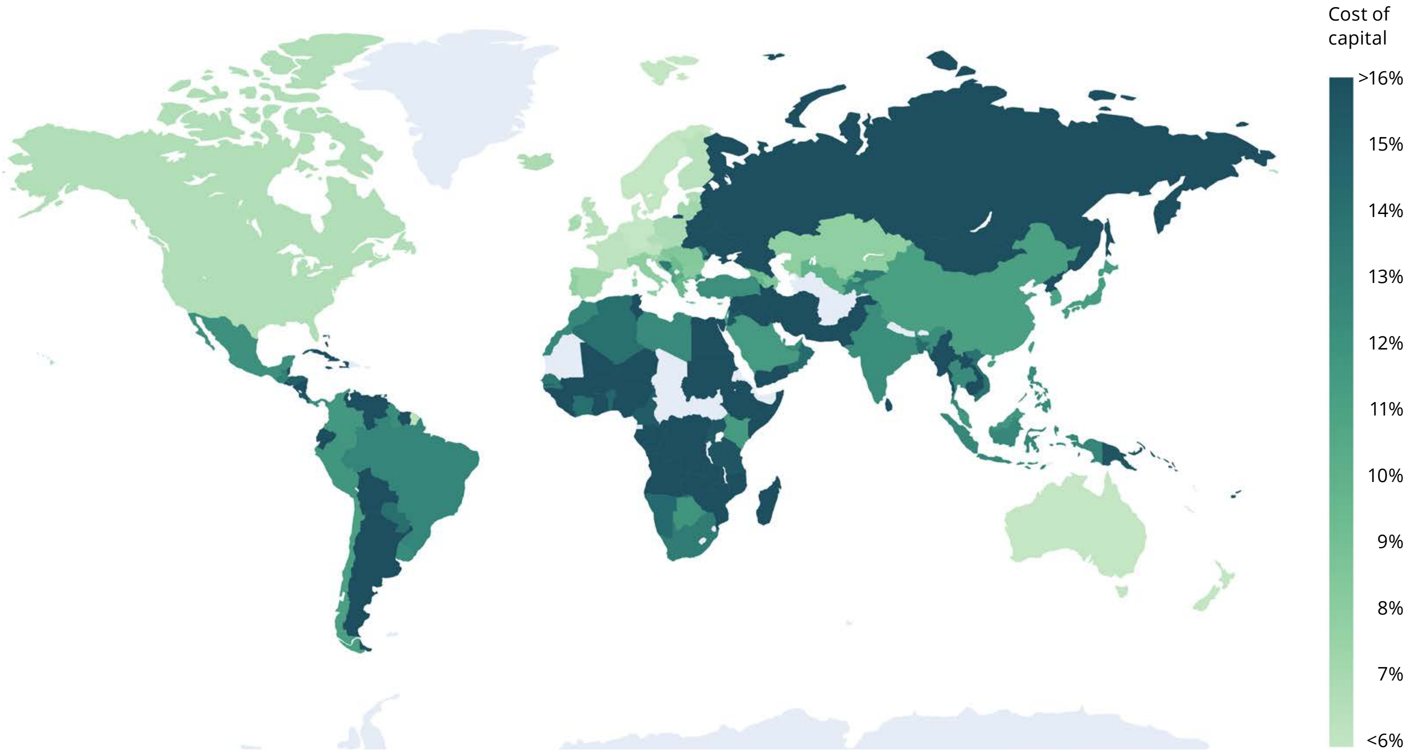
Full mitigation Partial mitigation No impact

Source: Deloitte analysis based on Deloitte (2023),[1] Blended Finance Taskforce (2018)[7] and Green Climate Fund (2021)[17]

3. Reducing the cost of capital through de-risking instruments

Clean energy projects face important macro, market, technical, and financial risks, especially in developing economies. Financiers compute these risks into project risk premiums that increase required returns on debt and equity, which in turn raise the cost of capital of the project.[1] Under current financing conditions and without de-risking instruments, the cost of capital for solar power plant projects varies across the globe from 7% in Western Europe to about 18% in Sub-Saharan Africa (Figure 4). For wind power, this increases to 8% in Western Europe and more than 19% in Sub-Saharan Africa (see the wind power cost of capital maps in Appendix 1).

Figure 4. The cost of capital of solar power plants around the world without de-risking measures



Source: Deloitte analysis[10]

As previously seen, reducing green energy project risks requires the deployment of information, regulatory, economic, and financial instruments. There are two layers of risk to remove: (1) systemic risks, which effective policymaking can address by reducing macro risks and some of the technical and market risks, and (2) residual risk, which calls for targeted economic and financial instruments. However, not all residual risk-reduction instruments are equal in their potential to lower the cost of capital across all regions of the world, as risks vary widely across geographies.[1] Moreover, different instruments have different costs for society.[9] Therefore, cost efficiency and effectiveness vary across both instruments and geographies. Finally, different instruments impact different risks, and thus, when combined, instruments can have mixed spillover or synergistic effects on the overall cost of capital. This mandates an assessment of not only the maximum individual contribution of each instrument but also of their combined synergistic potential and induced costs. Such a comprehensive assessment could paint a more holistic and vivid picture of how to set the transition in motion.

There are two layers of risk to remove: (1) systemic risks, which effective policymaking can address by reducing macro risks and some of the technical and market risks, and (2) residual risk, which calls for targeted economic and financial instruments.

3.1. Assessing the potential of de-risking instruments

Systemic de-risking via effective policymaking

Regulatory and information instruments are crucial to help build an ecosystem with low systemic risks for positive climate impact projects (see section 2.2). Effective policymaking in energy and climate can help provide transparency and visibility for investors and lenders and create an appropriate regulatory framework for facilitated project development and financing. These elements can contribute to eliminating key macro risks and help reduce market and technical risks.

Climate and energy strategies form the basis of a country's green energy development, providing a direction to aim toward, common targets to rally behind, and often a shared rulebook to refer to. Climate and energy strategies primarily work on macro and finance risks, providing political visibility, lowering regulatory uncertainty, and improving access to capital. They can also contribute to reducing micro risks at the project level by activating the "learning-by-doing" effect (see section 4.2). Their implementation takes time, resources, and political effort, especially in zones where the green energy transition is not a high sociopolitical priority. Additionally, there are levels of how good a strategy really is: this depends on the completeness, clarity, quantitative and detail richness, and the supporting strategy budget. Stability is needed to help ensure continuity and effectiveness. Green taxonomies establish a common language for investors, with standardized green energy definitions and environmental reporting methods. They are similar to climate and energy strategies as they can reduce macro and financial risks, but unlike these strategies, they intervene at the source of capital upstream rather than on the investment targets downstream.

Making green taxonomies effective entails promoting collaboration across countries to harmonize the many conflicting definitions of what should be considered "green" or "low carbon."[23] For instance, the European Union (EU) certifies hydrogen production as "low carbon" if the emission intensity is below about 3.38$kgCO_{2eq}/kgH_2$, while China Hydrogen Alliance sets the threshold for the same label at 14.5 $kgCO_{2eq}/kgH_2$.[24,25] The effectiveness of green taxonomies depends on the strength of their incentives and penalties and on their degree of environmental ambition. Like climate and energy strategies, green taxonomies affect political and regulatory risks. Current analyses estimate that putting in place such a standard green taxonomy could help to decrease the cost of capital by up to 1.8 percentage points.[10] Indirectly, this framework could reduce the cost of capital further by helping to create green energy markets and thereby decreasing market risks.

Streamlined permitting is a policy instrument to improve the regulatory environment by reducing administrative obstacles, which helps to shorten the commissioning time of projects. Doing so signals to investors that the government wants to accelerate positive climate impact projects. However, permitting processes still need to account for social acceptance and environmental standards. Streamlined permitting requires several factors working together, including procedural simplification, the provision of adequate resources to permit-granting entities, and the sharing of leading practices to identify suitable areas.[26] Lastly, policymakers should introduce streamlined permitting jointly with network planning to help facilitate the integration of new green energy into energy networks.

Network planning mainly addresses the risk of missing infrastructure to transport and deliver the energy produced. Robust infrastructure is not only crucial, but also indispensable for helping to foster investments. Even in an investor-friendly financial environment (i.e., very low cost of capital), the lack of adequate infrastructure remains a barrier to investments. The primary impact of these instruments revolves around ecosystem and systemic risks, both of which are necessary prerequisites for the successful implementation of a project. Furthermore, strong network planning minimizes additional risk perception. As an illustration, a delayed connection to the network means a delay in the start of operations, which raises perceived risk. The resulting cost of capital increase can be up to 2.40 percentage points for wind and 0.7 percentage points for solar in developing countries, but is much smaller in developed economies (below 0.4 percentage points).[10] The joint development of modeling capabilities, communication and climate and energy strategies should prevent delays and reduce such perceived risks.[27] Improved demand and production forecasting, global cooperation at the administration level, transparency on the status of the project application and resilience can strengthen the effectiveness of both streamlined permitting and network planning.[27]

Political visibility and regulatory frameworks are the foundations needed for the development of clean energy and feedstock production, and more generally, for the decarbonization of economic activities. Clear climate and energy strategies, green taxonomies, streamlined permitting processes, and network planning are key instruments to help address systemic risks and thereby reduce the cost of capital of green technologies significantly. Streamlined permitting and network planning remove crucial bottlenecks for renewable power capacity expansion and help ensure the timely launch of projects. However, residual risks require further technology- and location-based instruments, to improve the cost competitiveness, performance, or construction time of clean projects.[6]

Economic and financial instruments to help tackle residual risks

Economic and financial instruments are key for mitigating technology-specific, market-specific, and region-specific risks. These instruments are designed to ensure that green energy markets work, and that non-systemic bottlenecks do not stop projects from happening.[6] Therefore, these instruments aim to secure demand for green energies, to solve the chicken and egg dilemma between supply and demand, and to make green products and energy commodities (electricity, hydrogen, ammonia, etc.) cost-competitive against their fossil-based counterparts. Some of the most promising and impactful economic and financial instruments include:

- **Offtake contracts** serve to reduce market risks, by mitigating missing market risk, revenue risk and cost competitivity risk. These contracts instill investor confidence in the projects generating revenue by bringing certainty on sale price. This makes offtake contracts one of the most effective risk-reduction levers for green projects. The absence of market risk exposure reporting in almost all operational or in-construction green projects in developing economies proves how crucial the sale price certainty is.[13,28] In other words, green investments do not seem to happen without market risk mitigation. Thus, this analysis assumes that offtake contracts are already in place in the "business-as-usual" scenario. By this logic, revenue instruments that cover volume and price risks can help reduce the cost of capital by up to 3 percentage points in developing economies.[10] However, it should be noted that this assumption might undermine the importance of offtake contracts as integral prerequisites for project development. Offtake contracts can take many forms: government (e.g., CfDs) or business-to-business (e.g., power purchase agreement) contracts, fixed (e.g., FiT) or floating prices (e.g., FiP), or fixed or free delivery quantities and timings. Their effectiveness depends on two main factors: the reliability of the offtaker (including governments in countries with important political risks) and the volatility of markets, which can induce parties to seek to break out of unfit clauses.

- **Tax incentives** provide an effective carrot and stick approach to green investments. They are determined at the policymaking level and reduce threats to the cost competitivity of projects that fall in line with their criteria. Tax incentives in the energy sector serve to boost the internal rate of return by reducing overall tax burdens, to help mitigate relative revenue volatilities (by reducing its amplitude), and to encourage a higher proportion of debt financing (as enhanced revenues reduce the liquidity risk for debt repayment). Redistributive green taxation has a maximum cost of capital reduction potential of 1.6 percentage points for wind power wind and 1.4 percentage points for solar power in developing economies. In developed economies however, tax incentives can only reduce the cost of capital by 0.3 percentage points for both technologies.[10] Clearly defining eligible activities is crucial to aligning incentives with policy objectives.

Economic and financial instruments can secure demand for new green energy commodities and improve their cost competitivity and bankability.

Direct pay mechanisms[29] are necessary for tax-exempt organizations to receive cash payments for tax credits[30] that would work as operational support.[1]

- **Guarantees (and insurances)** are one of the most common ways to address risks across the board. Specific purpose guarantees can be put in place to help cushion against political insecurity, performance instability, or infrastructure-related uncertainties. Different guarantees exist and cover specific risks. Contractual agreements and legal protections can reduce risks by transferring them to the contracting stakeholder (governments, insurance companies, etc.). These guarantees can be risk-specific, such as performance guarantees[31] to cover low-energy generation, unanticipated additional costs, or political risk (political risk insurance).[32] Other guarantees such as the partial credit guarantee from the International Finance Corporation covers private lenders against debt service default on loans of a project regardless of the cause of the default.[33] The maximum cost of capital reduction potential of performance guarantees is 1.3 percentage points for onshore wind in developed economies (and up to 2 percentage points in developing economies). This potential reaches as high as 2.5 percentage points for offshore wind power in the same geographies. It is seen as a maturing technology with some remaining uncertainty concerning construction delays and cost overruns.[34] Political risk guarantee covering the country risk premium has the potential to decrease the cost of capital by up to 5.2 percentage points on average in developing economies. In very high-political risk countries, the reduction can be much greater. In Argentina, this guarantee can lead to a reduction of the cost of capital by 10 percentage points.[10,35] Guarantees and insurances can represent additional fees for the project, thus their implementation requires the right perception of risk.[36]
- **Grants** are the most direct forms of economic and financial support to the development of projects. They provide direct economic support that do not need to be paid back. They typically cover a part of the capital expenditure and increase the cost competitiveness of the projects by direct reduction of their overnight costs. Grants reduce not only the projects' physical costs, but also the needed capital and the related risks, and therefore financing costs. When 20% of initial capital needs are covered by a grant, the cost of capital is reduced by up to 3.3 percentage points on average in developing economies.[10] For developed economies, a maximum of 1.6 percentage points reduction in cost of capital is achieved when 20% of initial Capital cost (CAPEX) is provided as a grant.[10] Furthermore, grants allow an increase in the internal rate of return of the projects, making them more attractive to commercial lenders and investors. Thus, on top of the quantifiable overall investment and cost of capital reduction, grants also help facilitate the private capital flow towards the green projects by improving the risk perception of the potential investors and lenders.
- **Concessional loans** are loans offered at interest rates below the market rate provided by development banks or multilateral funds. They allow a reduction in the share of commercial debt, and consequently a reduced cost of capital. For instance, assuming an initial share of debt of 70% in developing economies, the maximal cost of capital reduction potential adds up to 2.4 percentage points (assuming 20% of initial capital is covered by a 1% interest concessional loan). For developed economies, a 0.7 percentage points reduction in cost of capital is achieved when 20% of initial CAPEX is provided by a concessional loan at 2%.[37] By the means of reduced cost of capital and enhanced return and liquidity, concessional loans can also reduce the project risks indirectly.
- **Debt and equity subordination** can reduce perceived risk by lowering senior default risk.[1] From the investor's perspective, capital subordination works as a guarantee on return, which helps to improve the risk-return profile. For example, junior equity protects senior equity and reduces the perceived risk. Equity subordination can reduce the cost of capital by up to 1 percentage point in emerging economies and 0.4 percentage points in advanced economies. Advocating for blended concessional finance necessitates a thorough evaluation of its developmental efficacy and the extent of its additional value.[38] The interest rate of the loan and its share on total costs should be closely aligned with risk perceptions and help create investment opportunities.

To sum up, guarantees tend to be effective de-risking tools. On top of mitigating an important part of macro risks, they can eliminate most market, technical and financial risks. Performance guarantees can help reduce the cost of capital in absolute terms by up to 1.3 percentage points for onshore wind and 2.5 percentage points for offshore wind, notably in developed economies. In countries with high political risks and unfavorable macroeconomic conditions, political risk guarantees can reduce the cost of capital on average by 5.2 percentage points. Grants, concessional loans, and subordinated debt can reduce liquidity risk and the share of commercial debt and equity, entailing up to 3.3 percentage points of reduction of the cost of capital in developing economies. Market instruments (notably offtake contracts, subsidy policies, tax incentives and demand aggregation) can mitigate a large share of the market risks related to revenues, cost competitiveness and access to/existence of markets, bringing the cost of capital down by 3 percentage points.

These instruments are to be deployed after policymaking and regulatory framework design. However, they also interact with macro risks, establishing the much needed commercial track record for market scale up. Their effect can be observed directly via reduced investment and/or operational costs and improved cost of capital, helping to reduce the cost of financing (see Box 1 for a green hydrogen example). Policy and market instruments help create functional green markets, which will be the backbone of the transition. However, these new markets will require the assistance of financial instruments to facilitate the flow of low-cost capital.[1] In summary, a targeted combination of different instruments is the lifeline of the green energy transition.

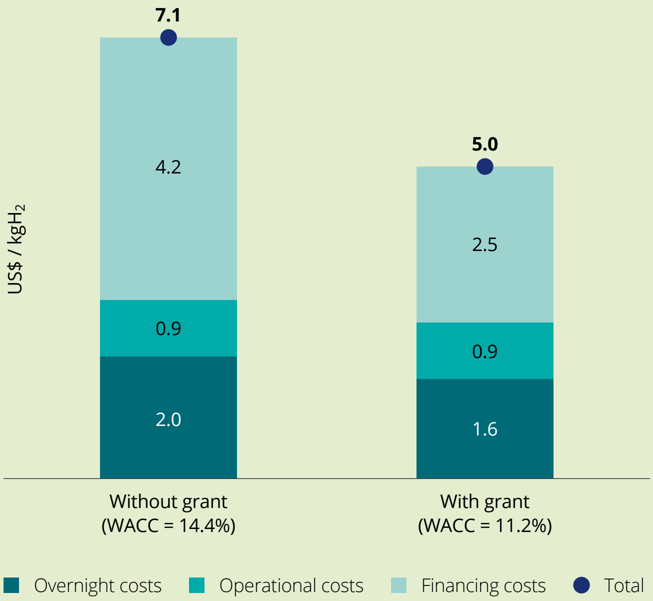
Box 1. The effect of financial instruments on the cost elements of green hydrogen

Green hydrogen is currently more expensive than its fossil counterparts (natural gas-based grey hydrogen or coal-based brown/black hydrogen).[39] As explained previously, it is also highly capital-intensive, hence financing conditions have a substantial impact on overall costs. For instance, while solar irradiation is higher in Southern Africa than in Southern Europe, high cost of capital induces significant financing costs, making solar PV-based green hydrogen more expensive in Southern Africa than in Southern Europe.[5]

Different mechanisms can reduce the cost of capital of solar PV-based green hydrogen production, and thereby lower the levelized cost of hydrogen production (LCOH) in Southern Africa. However, LCOH reduction is not the only effect. Some instruments can also decrease investment costs or increase revenue. This could in turn reduce revenue risks and enhance the cost competitiveness of Southern African green hydrogen, bringing down the cost of capital, which could lower financial costs as well.

As an example, an investment support mechanism (investment subsidy or grant) could reduce the overall needed initial capital and the need for equity (which is costlier than debt[1]), and therefore, lower the overall cost of capital. Moreover, by decreasing the overall required investments, such a mechanism could also reduce the overall financing costs of equity and debt provision.

The following figure illustrates the multiple effects of a grant worth 20% of initial upfront costs on the LCOH. First, the grant has a direct impact by decreasing the required initial investment to cover the overnight costs. This decreases the overnight costs (equal to the grant value, 20%). In addition, the grant leads to a decrease of the cost of capital by 3.20 percentage points due to lower initial capital requirement (assuming the same debt level as without grant). This cost of capital reduction and the lower required equity in the upfront expenditures result in a 40% decrease in the financing costs and a nearly 30% decrease in the LCOH in this example.



Source: Deloitte analysis based on cost of capital calculation in Appendix 2 and the LCOE calculation in Appendix 3

3.2. Exploring the synergies between the de-risking instruments

The previous sections have discussed the cost of capital reduction potential of each of the available instruments. Since no single instrument can fully de-risk a project, policymakers often deploy several instruments at once to help mitigate a combination of different risks. This makes it vital to look at the cost of capital reduction potential of a combined set of instruments.

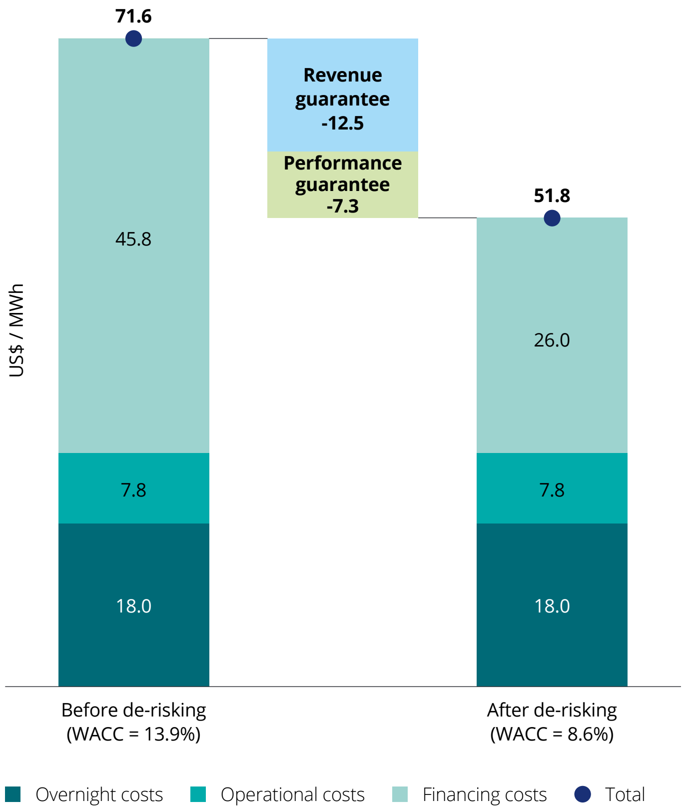
Instrument combinations vary with geographic, market, and technology specificities to help reduce the project's risk premiums, and ultimately its cost of capital. Reducing the cost of capital is crucial to making the project's risk-return profile attractive to investors. For illustration, the current analysis details four examples covering the key technologies and geographies: onshore wind power in South America, utility-scale solar power in Southeast Asia, offshore wind power in Northwest Europe, and solar PV-based green hydrogen in Southern Africa.

Onshore wind power in South America

Under current financing conditions, the cost of capital for an onshore wind power project in South America is on average 17% (with a maximum of nearly 26% and a minimum of 12.6%).[10] In Uruguay, the cost of capital is 13.9%, leading to a levelized cost of electricity (LCOE) value of around US$72/MWh for onshore wind production in the country.[40] Thus, onshore wind projects in Uruguay should secure a capture price of at least US$72/MWh to be bankable. An increase in the share of renewable electricity is expected and necessary to reach net-zero emissions.[41] However, this growth of renewables can induce a need for network expansion[42] and flexibility options.[43,44] Uncertainty in onshore wind projects affects both costs and revenues. The perceived risks of cost overruns and construction delays raise the cost of capital required by investors. Therefore, on top of the macro risks, which vary with geography and the local growth of renewables, an onshore wind project is subject to at a minimum revenue risks, performance risks, and missing infrastructure risks.

Figure 5 shows the evolution of the LCOE of the considered Uruguayan onshore wind project with and without de-risking measures. The activation of revenue guarantees can mitigate a large share of revenue risks that are unrelated to technical misestimations of production volume, bringing the cost of capital down by 3.3 percentage points, from 13.9% to 10.6%.[10] Performance guarantees covering uncertainties against overnight cost overrun, construction delays and operational costs' variation can reduce the cost of capital by almost 2 percentage points, down to 8.6%.[10] Altogether, these de-risking instruments reduce the LCOE of onshore wind power production in this example by around US$20/MWh, down to below US$52/MWh. It is worth noting that setting climate strategies and improving the regulatory environment have impact that goes beyond the cost of capital. They provide essential foundations to help guide investments, as well as developing infrastructures without which projects cannot take place, regardless of capital costs.

Figure 5. The impact of de-risking instruments on the levelized cost of onshore wind power production in Uruguay (Illustrative example)



Source: Deloitte analysis based on cost of capital calculated in Appendix 2 and the LCOE calculation in Appendix 3

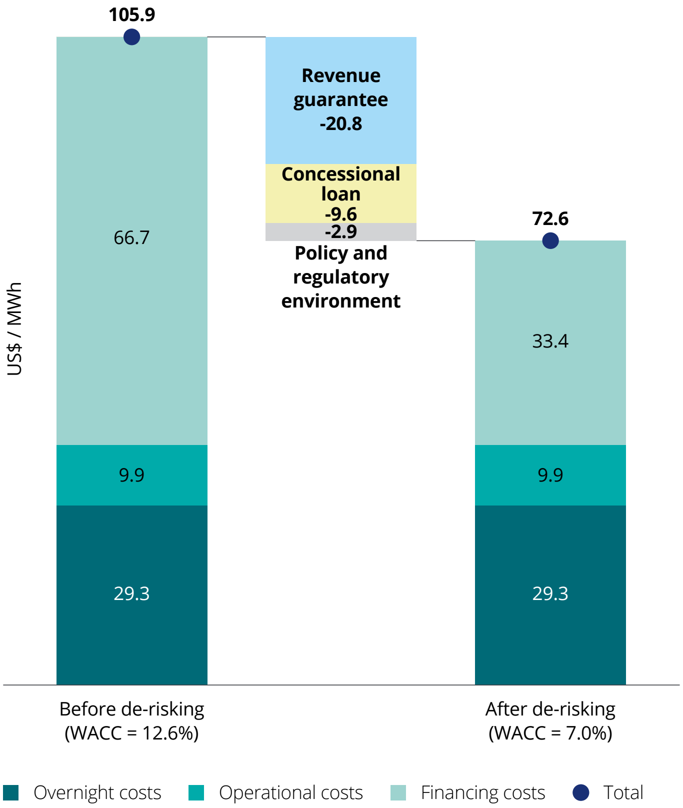
Utility-scale solar power in Southeast Asia

Utility-scale solar PV is considered the cheapest form of electricity production, especially in regions with high solar irradiation that are near the equatorial line, such as parts of Africa, the Middle East, South America and Southeast Asia.[45] Therefore, the LCOE of solar power supply in Southeast Asia is expected to be cost competitive compared to fossil power supply technologies. However, real-time solar PV power production sees variability because of cloud cover in this region, and because the power plant cannot produce electricity outside of sunlight hours. As sunset and sunrise times are predictable, this daily cycle does not induce revenue risks. Similar to onshore wind power, the real-time production variability combined with the need for network expansion results in revenue and missing infrastructure risks. These risks require both offtake contracts and network planning, in addition to macro risks' mitigation options like the creation of regulatory frameworks and climate strategies.

As an illustrative example, in Indonesia the cost of capital for a utility-scale solar PV project is estimated to be 12.6% on average.[10] This yields an LCOE of US$106/MWh.[46] Offtake contracts and adequate policy and regulatory frameworks can decrease the cost of capital by as much as 3.5 and 0.5 percentage points respectively. Concessional loans can reduce the cost of capital by an additional 1.7 percentage points, resulting in a final de-risked project cost of capital of 7%. This brings the LCOE of the project down to US$73/MWh (Figure 6).

Utility-scale solar PV is considered the cheapest form of electricity production, especially in regions with high solar irradiation that are near the equatorial line.

Figure 6. The impact of de-risking instruments on the levelized cost of solar power production in Indonesia (Illustrative example)



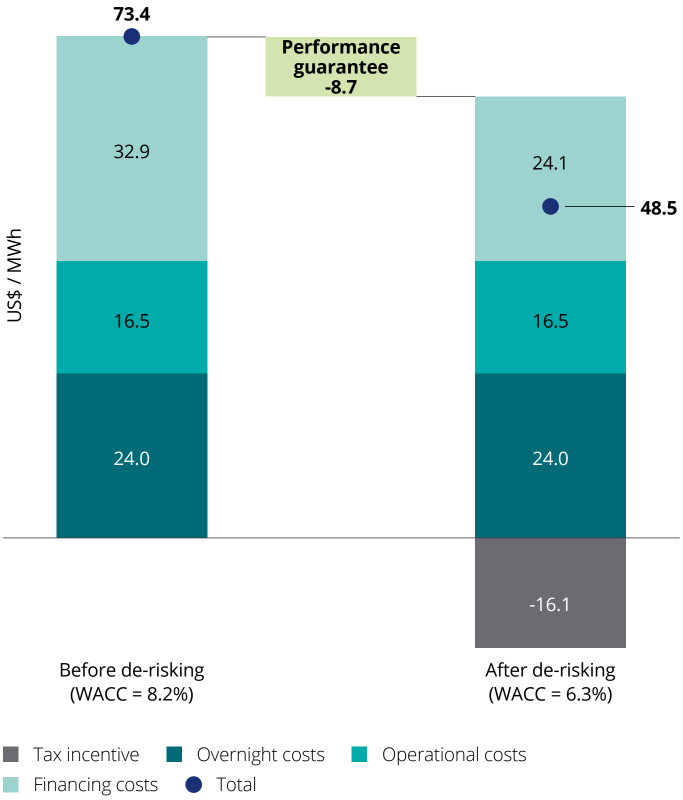
Source: Deloitte analysis based on cost of capital calculated in Appendix 2 and the LCOE calculation in Appendix 3

Offshore wind power in Northwestern Europe

Northwestern Europe has some of the world's least risky countries for renewable investments, as they have clear climate strategies, clear regulatory frameworks, well-developed and interconnected electricity transmission and distribution networks and low political risk premiums.[10] However, the local market for offshore wind is not as advanced as onshore wind and solar PV, and offshore wind power requires offshore network building and expansion. Due to the regularity of sea winds, this technology is associated with lower production variability than onshore wind (lower revenue risks), [20] however its LCOE is still relatively high, making it less cost competitive.[45] These risks are translated into an average cost of capital value of 9.3% in Western Europe. For the example, in Denmark, the cost of capital is equal to 8.2% leading to an LCOE of US$73.4/MWh.[47]

In most countries of Northwestern Europe, including Denmark, country risk premiums are negligible. The cost of capital for offshore wind is largely a product of the risks linked to project performance and complexity.[48] In particular, the risks of construction cost overruns and delays play a huge role as the offshore wind market and supply chain are less mature and developed than those of onshore wind or solar.[49] Offshore wind energy projects are capital-intensive, complex projects built in difficult marine construction environments. Therefore, these risks can be mitigated through the due diligence process for subcontractors and suppliers and performance guarantees or insurances. These instruments help protect the project developer against cost overruns and additional costs due to construction delays. As such, they reduce the cost of capital by 1.9 percentage points, bringing it down to 6.3%. This leads to a final de-risked offshore wind LCOE of about US$65/MWh in this illustrative Danish example. In addition, a tax exemption (working as an operational premium) over 10 years can lower the project's LCOE to under US$50/MWh (Figure 7).[30]

Figure 7. The impact of de-risking instruments on the levelized cost of offshore wind power production in Denmark (Illustrative example)



Source: Deloitte analysis based on cost of capital calculated in Appendix 2 and the LCOE calculation in Appendix 3

Solar PV-based green hydrogen in Southern Africa

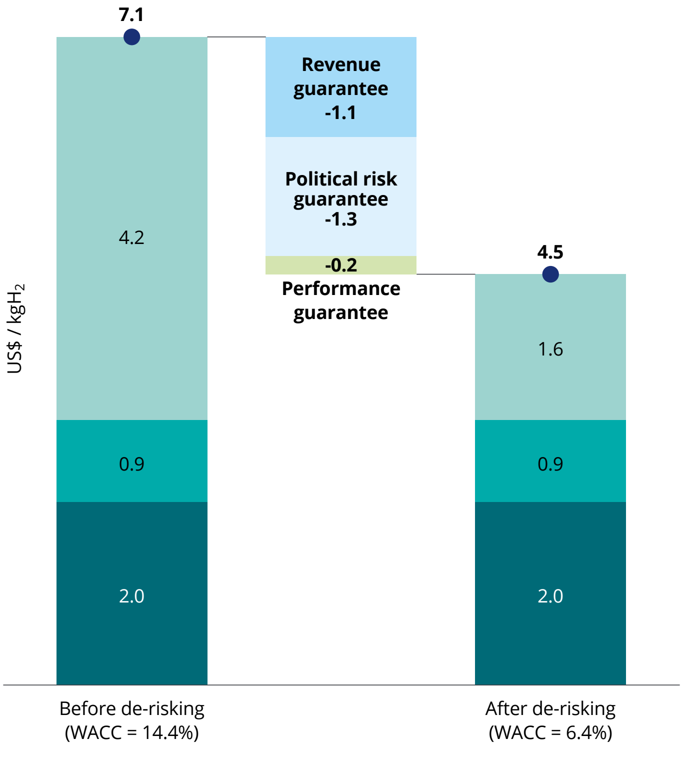
Currently, the cost of capital for green hydrogen production based on solar power plants and electrolyzers in Southern Africa is around 14.5%.[10] This yields a levelized cost of hydrogen (LCOH) in this region as high as US$7.1/kg$H_2$.[50] Of these costs, 28% are overnight costs (US$2/kg$H_2$), 13% are operation and maintenance costs (both fixed and variable) and the remaining 60% or US$4.2/kg$H_2$ are financing costs.

Such a project faces numerous risks: country-related macro risks, market risks (e.g., revenue, missing markets, and cost competitivity) and majority technical and financial risks. This is due to green hydrogen being new, meaning the product costs more than its fossil-based counterparts,[39] its demand is small or nonexistant,[5] and its transport and storage infrastructure is not yet available.

Uncertain demand translates into high revenue risks, entailing significant financial and capital availability risks. Moreover, the low technological readiness of electrolyzers and hydrogen transport and storage options, as well as potential delays in their construction make green hydrogen projects highly vulnerable to technical risks.

As a first step, revenue guarantee can reduce the cost of capital by about 4 percentage points, down to 11%, which would cut LCOH by 20%.[10] In conjunction with offtake contracts, a profound de-risking of such a project could require at least a performance guarantee or insurance to enhance permitting and network access. This can bring the cost of capital down to 10.5%, bringing the LCOH of the project down to US$6/kg$H_2$. The remaining risks stem from the macroeconomic environment. A political risk insurance can further decrease the cost of capital. By assuming a partial risk guarantee that covers lenders and investors against non-payment (loans or bonds) caused by political events, the cost of capital can be reduced to 6.4%, resulting in a final de-risked LCOH of US$4.5/kg$H_2$ (Figure 8).

Figure 8. The impact of de-risking instruments on the levelized cost of solar PV-based green hydrogen production in Namibia (Illustrative example)



Source: Deloitte analysis based on cost of capital calculated in Appendix 2 and the LCOH calculation in Appendix 3

In summary, the cost of capital comprises of many different risk elements and, as such, de-risking green projects, especially in developing countries, requires deploying combined sets of instruments rather than lone measures. The de-risking potential of these instruments is higher in developing countries than in advanced economies for four key reasons. First, developing countries tend to have higher political risks and less regulatory visibility. Second, green markets are generally smaller and less mature in developing economies. Third, advanced economies tend to have better and more widespread infrastructures, especially considering energy networks. Finally, financial and capital markets are more developed in advanced economies,[8,51,52,53] facilitating both due diligence and debt and equity allocation processes, especially in green markets.

While onshore wind and solar power technologies are currently cost-competitive, offshore wind power is still relatively more expensive than conventional power production technologies.[45] Moreover, the need for infrastructure expansion is particularly salient for offshore wind given its need for offshore power transmission network development. This situation is even more pronounced for more nascent clean energy commodities, like hydrogen, where neither the market nor the infrastructure exists.[39]

The combined deployment of de-risking instruments can both unlock the maximum cost reduction potential and help minimize institutional hurdles and complications indirectly. The latter means that different de-risking instruments have unquantifiable effects on other risks and showstoppers. For instance, if a grant reduces the overall required overnight costs and the cost of capital, it can also help the project obtain lower-cost debt. The more that de-risking instruments are utilized, the lower the cost of capital, and therefore the more bankable the project. The results of this report indicate that good policy instrument design can reduce the cost of renewable energy by up to 35%. Nevertheless, de-risking instruments are not free. They come with costs not only for project developers (as fees) but also for society through the use of public capital.[9] Therefore, these instrument combinations should be assessed not only on their effectiveness (cost of capital reduction potential), but also on their cost efficiency.

3.3. A cost-effective combination of de-risking instruments

Sections 3.1 and 3.2 showed the effectiveness of different de-risking instruments and the synergy of combining these instruments together to unlock multiple de-risking levers and enhance the risk-return profile of energy projects. However, these instruments come with costs, and assessing the relative efficiencies of these instruments requires a comparative assessment of their associated costs.[9] This cost-effectiveness issue is particularly pressing for developing economies, where states run on tight budgets, and the energy transition requires public participation, at least in the early and risky stage of market development.[8] This section focus quantifying the cost of the key instruments for private investors and public entities, and assessing their cost effectiveness.

Figure 9 summarizes the key quantifiable de-risking instruments assessed in this paper for the case study of onshore wind in Uruguay. Grants and tax incentives are some of the most effective instruments, bringing up to 3.3 percentage points and 1.6 percentage points of cost reductions respectively in developing economies. They are also among some of the most efficient instruments for onshore wind in Uruguay because they can enhance projects' profit and loss profiles. Despite their efficiency, they can be too expensive for a government or administration. Political risk guarantee can be a highly efficient tool in countries with high country risk premiums (but not a safer country like Uruguay). They can bring up to double digit reduction in the cost of capital for countries with higher levels of political and currency instability, well above the overall average reduction of 5.2 percentage points. In other words, political risk guarantees can be just as efficient as grants, while costing less public money.

Figure 9. Effectiveness and the cost efficiency of the key studied de-risking financial instruments for the case study of an onshore wind power project in Uruguay (Illustrative example)

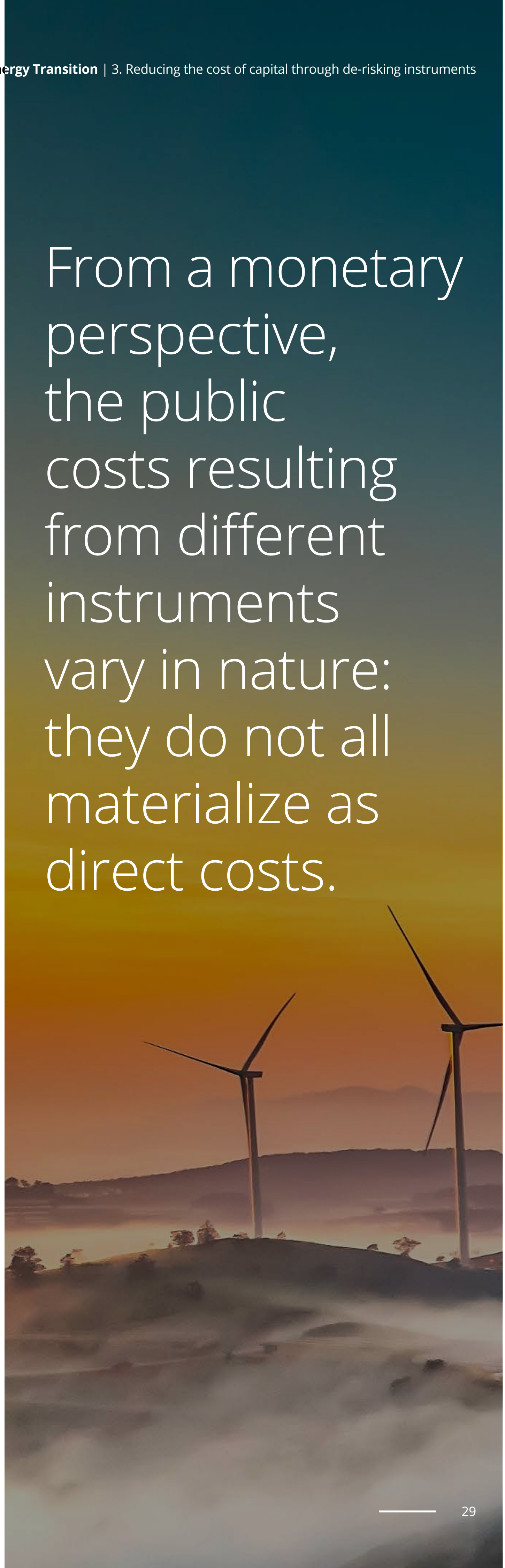
Instrument name	Maximum WACC reduction potential (in percentage points)	Efficiency (difference in NPV over public cost)	Who bears the main cost?
Revenue guarantee	3	1.76	Project
Tax incentive	1.6	2.30	Government
Performance guarantee	2	1.1	Project
Political risk guarantee(1)	1.94	0.96	Project
Grant	3.3	1.84	Public entity, development bank
Concessional loan	1.3	1.06 – 1.43(2)	Development bank
Equity subordination	0.9	1.12	Development bank

Source: Deloitte analysis for onshore wind in Uruguay. Methodology and data used can be found in Appendix 2.
Note: (1) Political risk guarantee can be more efficient and effective for countries with high political risk. In Argentina, the WACC reduction is of 11 percentage points and the efficiency of 11.8, (2) The lower bound is reached when a 10% loss is assumed on the capital covered and the upper bound when no loss is observed (see Appendix 4).

While the efficient use of limited capital is a key metric, it can also be misleading in the assessment of the optimal choice of de-risking instruments, as they differ in their nature, implementation, and features. In particular, two essential questions are how costs materialize and who bears the costs of the instrument. For instance, guarantee-based instruments represent additional costs for projects through fees. However, they require less public cost, and might be easier to implement. Guarantees and insurances can lead to a reduction of 200bp to more than 3 percentage points with an efficiency between 1.1 and 1.76, but are among the less costly in terms of public costs. In addition, the public cost assessment understates the societal advantages gained from projects' implementation. Numerous positive externalities spring from these projects, including economic growth, job creation, and a range of climate and health benefits. These impacts are challenging to quantify in economic terms, yet an optimal mix of de-risking instruments should also consider these factors and thus can vary depending on the use case.

Finally, from a monetary perspective, the public costs resulting from different instruments vary in nature: they do not all materialize as direct costs. While grants and premiums entail directly spending public money, guarantees and insurances are more hypothetical costs, only incurred if a risk physically materializes. Therefore, there is a difference between hard expenditures (direct spending) and soft expenditures (hypothetical costs). A third type of spending further complicates the picture: fully or partly foregone future income. This category chiefly includes tax incentives. If the existence of a project is conditional to the tax incentive, a full tax exemption could entail no real public cost, as in the absence of the project, no tax money can be collected. In case of partial tax exemption, a government could collect more tax revenue than the counterfactual case where the project does not see the light of the day. This unseen counterfactual scenario leads to the overestimation of public costs.

Policy instruments are used to help influence the behavior and decision-making of individuals, organizations, and societies. However, quantifying the impact of these instruments is inherently challenging. This difficulty arises because not all the consequences of policy actions are quantifiable, and they often reshape the entire framework and environment within which they operate. Policies can also have unintended consequences.[54] For instance, a policy aimed at reducing carbon emissions may lead to changes in industrial processes, consumer behavior, and even the broader economic landscape. Moreover, the influence of policy instruments on individual behavior tends to be complex and variable. Different individuals and organizations may respond differently to the same policy incentive, leading to a range of outcomes that can be difficult to predict and quantify.[55] Measuring a policy's success solely in monetary terms or immediate outcomes overlooks the multifaceted and sometimes delayed effects that policies can have. Also, quantifying the externalities of the energy transition can be challenging.



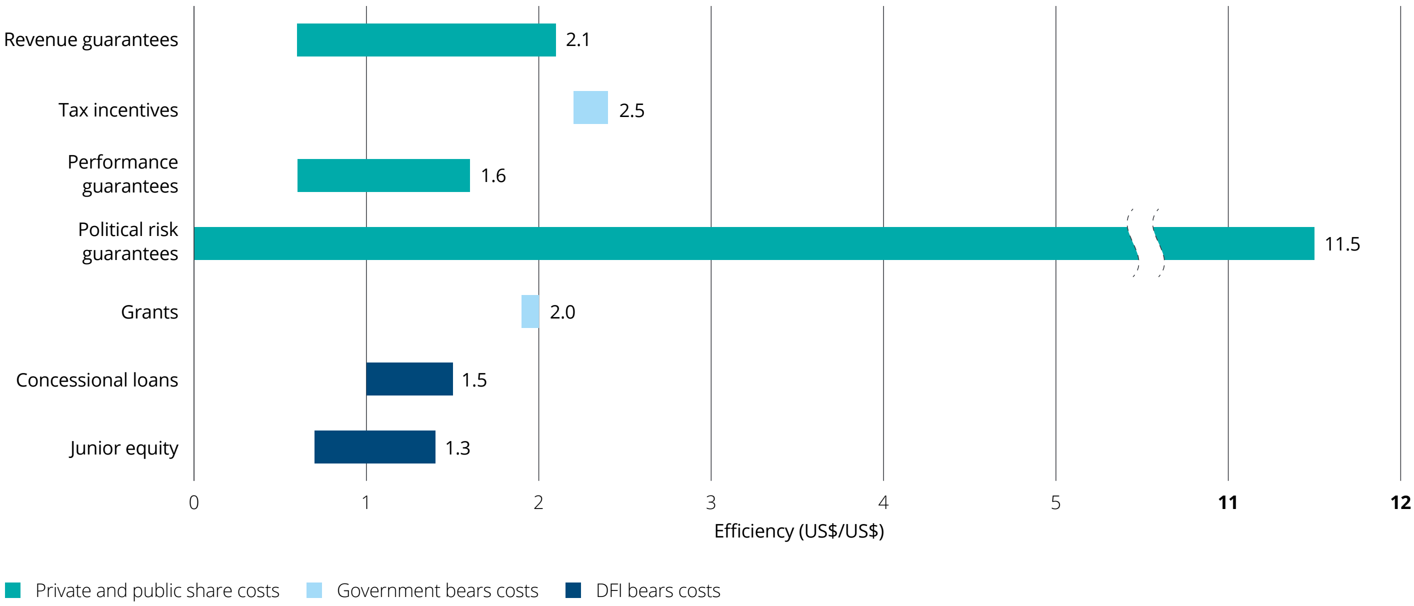
From a monetary perspective, the public costs resulting from different instruments vary in nature: they do not all materialize as direct costs.

For instance, the health effects of the energy transition are difficult to capture in economic impact assessments, considering both the value loss due to premature deaths, and the reduction in public health expenditures stemming from burning fossil fuels. There is often a significant time lapse between the implementation of a policy and the realization of its intended benefits. During this period, numerous external and internal factors can influence the outcome, making it even more challenging to isolate and measure the direct impact of the policy instrument.[56] This complexity necessitates a more nuanced approach to evaluating policy instruments, one that goes beyond simple quantitative measures and considers the broader, long-term impacts on society and the environment. For these reasons, policy instruments go further than pure financial considerations. They are essential tools for steering investments towards sustainable and efficient energy solutions, and as such, should be established first before other instruments.

Figure 10 shows the range of the efficiency of the instruments as a function of their associated public costs. Grants and tax incentives have an efficiency superior to 2 US$/US$ in each case (US$2 of gains over US$1 of expenditure). This means that for US$1 of public expenditures, they increase the net-present value of the project by at least US$2. Their efficiency does not vary widely depending on the considered countries. However, they are the costliest from a public perspective and thus can be difficult to implement in developing countries. About 60% of the world's lowest income countries were either associated with high political risks or in debt distress in 2022.[57] Additionally, they require tax administration capacity, labor skills as well as political stability to be effective.[58] On the one hand, as the examples of Uruguay and Argentina show, political risk guarantees can be very efficient or futile depending on the country considered. They are most efficient for countries with high political and economic risks. On the other hand, countries with low political risks will likely benefit more from revenue and performance guarantees. Indeed, their cost of capital mostly derives from micro- and project-level risks. Concessional finance instruments, like junior equity and concessional loans, can be offered in developing countries, reducing the risk for private capital providers. Their public costs are potential losses for DFIs. These public costs can be reduced through a so-called "portfolio approach" which DFIs commonly employ.[38] Despite their relatively lower efficiency, blended finance instruments can be useful tools that would not distort markets nor jeopardize market competition, but rather de-risk individual projects.[38]

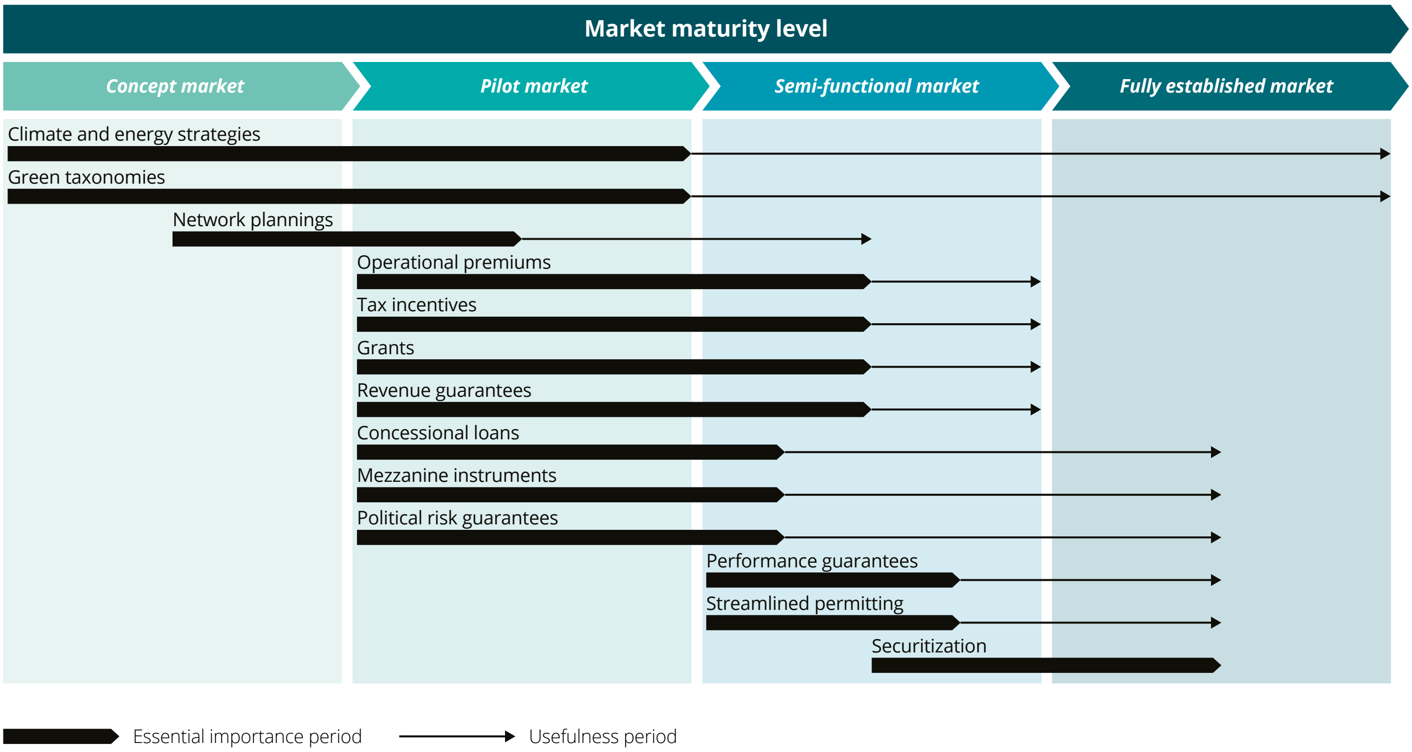
In addition to assessing the efficiency and effectiveness of the instruments, it is crucial to determine at which stage of market maturity these tools are most applicable. This can help select de-risking tools based on more than their cost-efficiency. Figure 11 shows the useful implementation spectrum of these instruments across the stages of market maturity. Climate and energy strategies and green taxonomies are investment prerequisites and should be prioritized in a nascent technology market. They are starting-point instruments for conceptual markets, but their effectiveness shrinks as the market gains in maturity. Network planning and facilitated infrastructure access instruments are necessary to lay the foundations for projects development and integration to the energy system.

Figure 10. Efficiency range of instruments



Source: Deloitte analysis based on Appendix 4 and the calculation of cost of capital in Appendix 2.
Note: An efficiency below 1 means that the instrument is not well suited for the specific case, meaning that the public cost of the project is more than the NPV gains of it. This can happen for instruments applied to mature markets (mostly in developed countries).

Figure 11. Illustrative timeline of use of instruments to support market scale-up



Source: Deloitte analysis based on the feature of each of the instruments defined in Section 3.1

From pilot through the beginning of an established market, economic instruments like grants, operational premiums, and tax incentives, bring support to improve the risk-return profile of investments and therefore attract private capital. These tools can operate alongside blended finance and become progressively less essential as markets develop. They pave the way to kick-start projects and help build the commercial track record needed to better assess risks and uncertainties. Blended finance through concessional loans, mezzanine instruments, and political risk guarantees can further de-risk projects to attract enough capital. Performance guarantees bolster investor confidence by addressing residual risks that experience cannot tackle alone. Securitization emerges at a more advanced market stage, enhancing project liquidity and accessing diverse investor pools. While certain instruments may align better with specific market phases, it is the synergy of these tools that can help enable market scaling and attract private capital.

The strategic combination of de-risking instruments plays a pivotal role in helping to reduce the cost of capital, thereby enhancing the appeal of investments. A key takeaway from this section is that the impact, effectiveness and efficiency of the tools are highly context dependent. Thus, tailoring the mix of de-risking strategies to specific market conditions, geographies, and technology maturity should help to maximize risk mitigation. A cost-efficient combination of different instruments can lead to a reduction of about US$30 trillion to US$50 trillion (in US$$_{2021}$) in the cost of the global energy transition, depending on the timing of their implementation.[59] While these instruments are effective, they entail costs, i.e., expenses for project developers and the use of public capital. Evaluating the cost efficiency of these instruments is crucial, especially in developing countries with limited public budgets. This involves a comparative assessment of the costs of each instrument. Additionally, de-risking instruments can have unquantifiable positive impacts on various risks and barriers. This section also shows how some financial instruments are necessary for some projects. Countries with high political risks and little experience with a given technology may require a combination of instruments to help make the risk return profile of projects attractive to investors.

This section showed how to help make green energy projects bankable and to initiate the momentum for the creation of a successful commercial track record. In a scaled and mature market, the cost of capital can be further reduced dynamically, during the lifetime of the project. This is thanks to the refinancing mechanism that can help reduce the cost of debt and equity during the lifetime of the projects, due in turn to the established track record that would lower market risks. Section 4 discusses this refinancing possibility and how it can entail cost reductions via financial learning.

4. Fostering dynamic cost reduction through learning

The success of the energy transition will rely on the continuous accumulation of improvements in the costs of technology and capital, and therefore, in the returns of green energy projects. Green technologies, particularly renewables and batteries, have experienced significant cost reductions in the last decades thanks to learning-by-doing and economies of scale effects.[60] The implementation of a new technology is associated with significant uncertainties and higher upfront costs, due to untrained workforce, immature supply chains, and regulatory delays and uncertainty. These historical trends imply a high probability of observing similar cost reduction patterns in the future for green technologies. Such patterns fall under the umbrella of techno-economic learning.

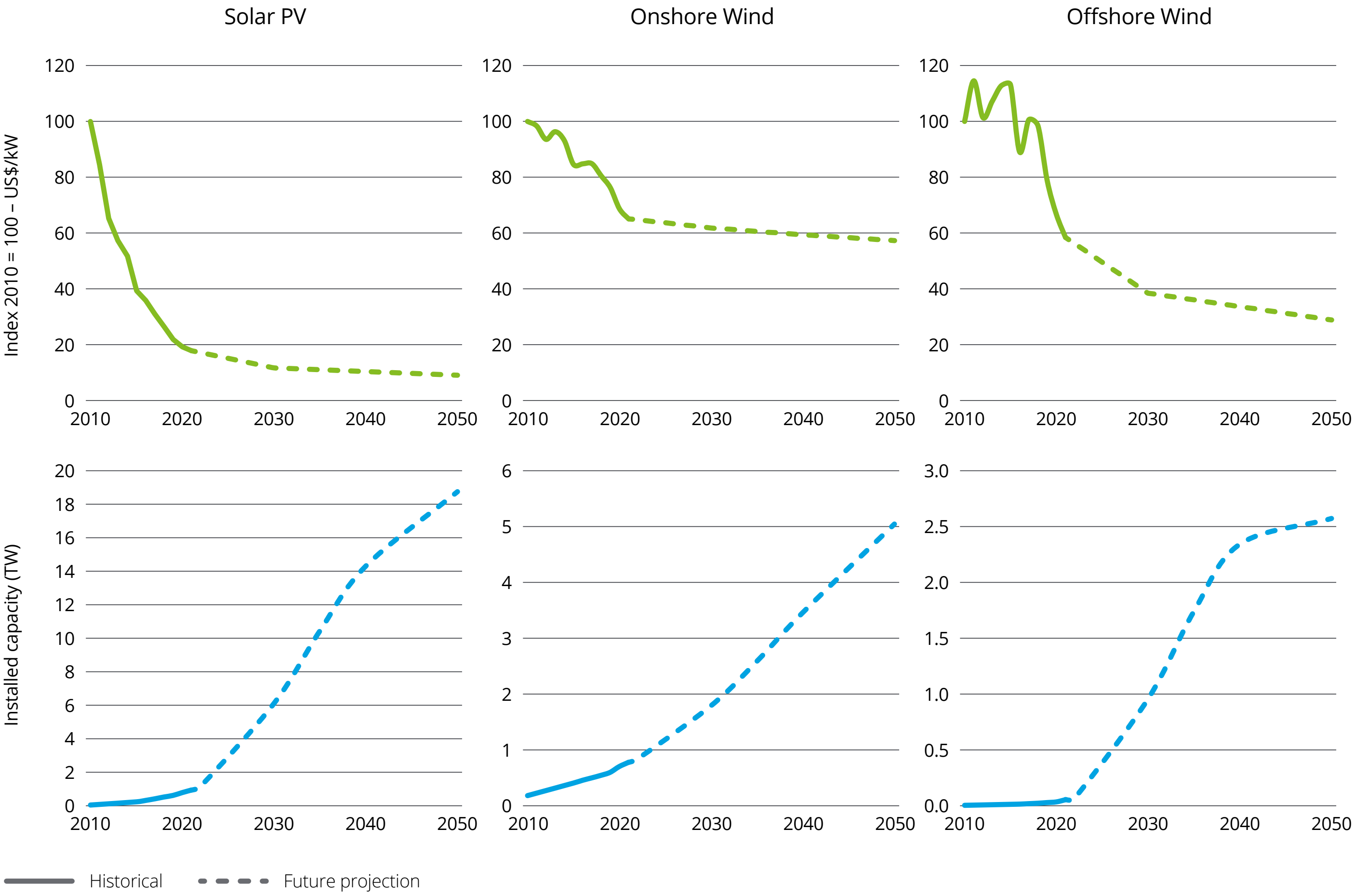
Additionally, as markets evolve and policy environment improves, the risks associated with green projects fall due to occurrence of "financial learning". These gains in maturity can help reduce technological, supply chain, market, and regulatory risks and improve the ability of financiers to assess risks. Consequently, like upfront costs with techno-economic learning, the cost of capital is also slated to experience learning effects (financial learning) since risks decrease or are at least better assessed and priced. Leveraging the cost of capital reduction through both de-risking instruments and financial learning, refinancing strategies can help project developers cut their financial costs over the lifetime of both debt and equity.

4.1. Techno-economic and financial learning: two distinct cost reduction effects

As seen in the first report of this series,[1] there is room for technological improvements in many of the green technologies that will be needed in the global energy transition.[60] The industry can thus expect that, by activating learning-by-doing, upfront costs for green energy technologies should decrease over time as knowledge is made and spread. Crucially, this also means that actual current costs are higher than expected future costs. However, triggering these techno-economic cost reductions also calls for making significant investments in the short term.

Looking at historical levels, the upfront cost of solar panels has been slashed by a factor of 5 globally since 2010, and 2050 upfront costs is expected to represent less than 10% of 2010 values (Figure 12). As illustrative examples of green technologies, wind and solar power technologies have entered a virtuous circle whereby techno-economic learning from adoption unlocks further adoption and so on. Despite a recent uptick in the upfront cost of some renewables due to heightened pressure on upstream markets, outlooks seem promising for most green products. Between 2020 and 2022, price hikes for transport and for key commodities such as steel, copper, aluminum, and polysilicon induced a more than 30% increase in LCOE for solar PV and a nearly 25% increase for onshore wind power.[61]

Figure 12. Evolution of upfront costs for utility-scale solar and wind farms



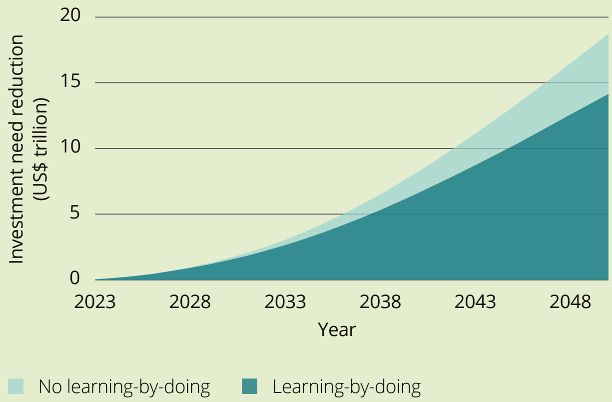
Source: Deloitte analysis based on International Renewable Energy Agency (2019),[62] (2023),[45] and International Energy Agency (2023)[63,64,65]

This high sensitivity of the cost of green products to input materials' price volatility is directly related to the capital intensiveness of green technologies. However, technology improvements are expected to compensate for such shocks in the medium to long run.[61] Indeed, the cut in upfront expenditures can generate significant savings (Box 2). Besides lowering capital expenditure, these upfront cost reductions help improve the bankability of green energy projects around the world. However, the viability of green investments will likely remain uncertain as long as capital is expensive.

If financial learning is activated, then green energy projects can expect to see their costs of debt and equity decrease over time. Similar to the reduction in upfront costs, the financing costs of different types of green projects have historically decreased over time and are projected to keep decreasing as their underlying markets mature. For instance, the costs of capital for onshore wind and solar PV installations in Germany have decreased by 4 percentage points and 4.4 percentage points between 2005 and 2017 on average (Figure 13). This reduction in cost of capital comes from decreases in the costs of both equity (4.2 percentage points for solar, 4 for onshore wind) and debt (4.4 percentage points for solar and 2.9 for onshore wind).

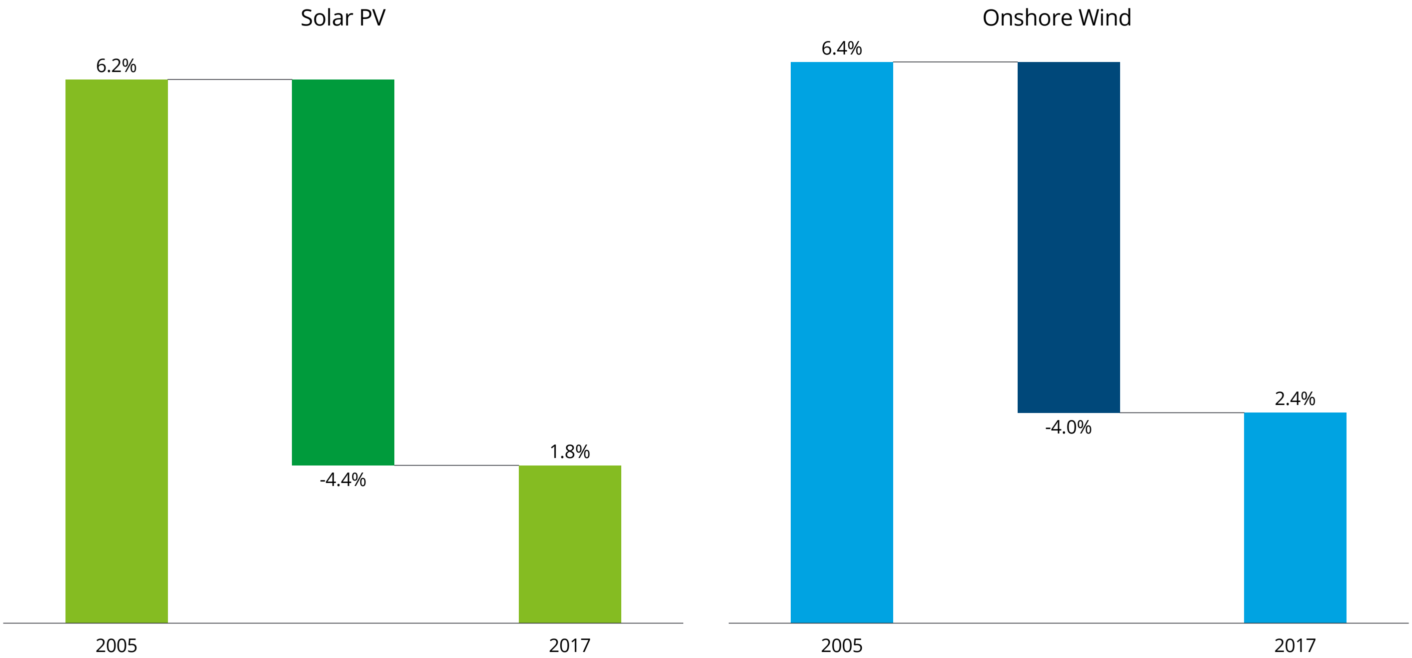
Box 2. Solar panel cost savings thanks to techno-economic learning

Techno-economic learning effect reduces the needed upfront costs. The IEA shows a need for about 18,750 GW of operational solar PV capacity in 2050 to reach net-zero greenhouse gas emissions by 2050.[63] This would require almost US$19 trillion of cumulative investments through 2050. Techno-economic learning can reduce this figure by about 25%, bringing cumulative investment needs down to around US$14 trillion (see the following figure).



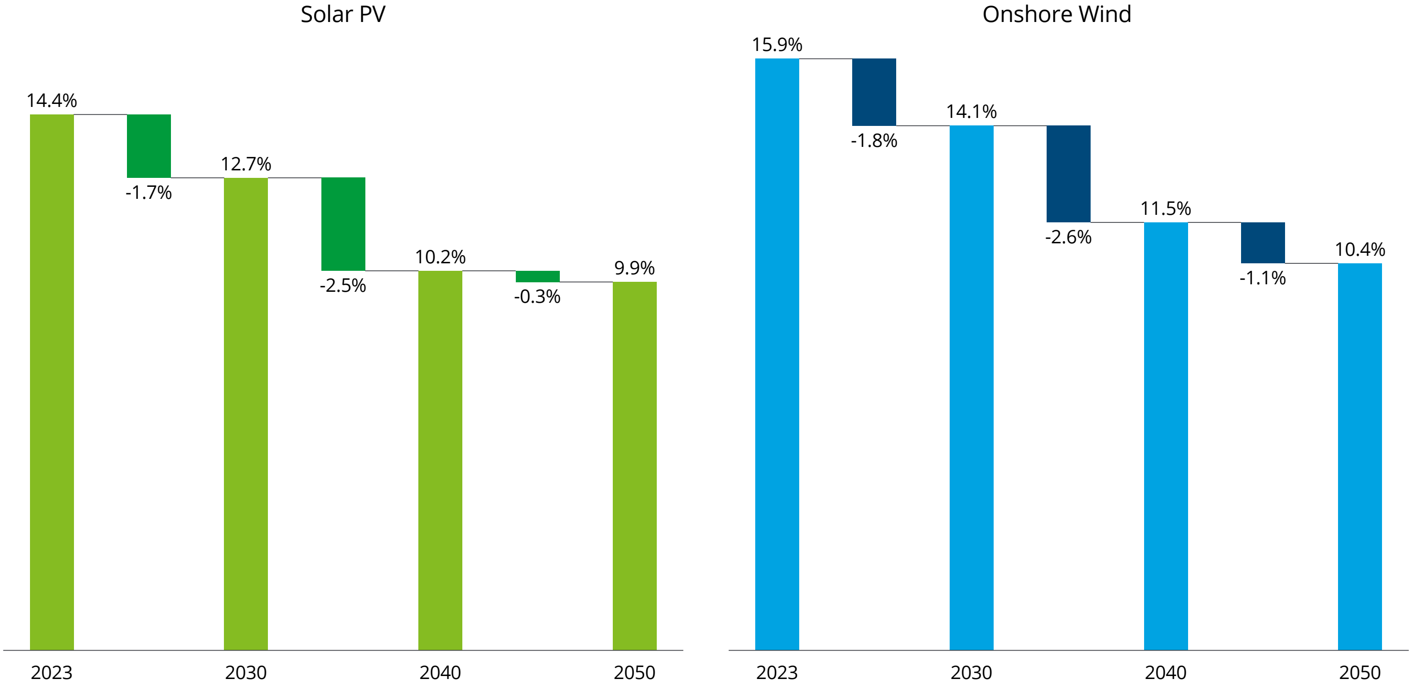
Source: Deloitte analysis based on data from Deloitte (2023)[1] and International Renewable Energy Agency (2023)[45]

Figure 13. Historical solar PV and onshore wind costs of capital evolution in Germany



Source: Deloitte analysis based on historical values from Egli et al. (2018)[66] and future cost of capital estimation method explained in Appendix 2

Figure 14. Projected evolution of the cost of capital for solar PV and onshore wind in Namibia



Source: Deloitte analysis based on Deloitte (2023)[1]

In developing economies, the costs of capital of solar and wind power are expected to decrease by around 4 to 5.5 percentage points by 2050 (Figure 14). This cost of capital reduction is notably due to a better risk perception improving risk pricing.[3] Uncertainties are generally the main cause of the overestimation of the cost of capital. Indeed, investors and lenders often struggle to deal with uncertainty, and it makes them overestimate risk premiums. Therefore, the emergence of a commercial track record drastically reduces the uncertainties associated with clean assets in nascent markets. This enables risk re-pricing, bringing about a reduction of the cost of capital.[3] In parallel to this better understanding coming from the finance ecosystem, the reduction of financing costs is also due to the evolution of regulatory framework, market maturity, and other systematic factors directly affecting the project.[67] In other words, the fall of financing costs is due to a less risky environment for clean projects. Moreover, the addition of previously understated risks associated with fossil fuel-based assets (climate change, reduced business opportunities, hostile policy environment) can narrow the gap in perceived risks with green projects (Box 3). This expected downward revision in the costs of financing is subject to the condition that refinancing or updating the cost of capital of a past investment (changing the cost of equity and debt in an ex-poste manner as the market rates change) is feasible.

The emergence of a commercial track record drastically reduces the uncertainties associated with clean assets in nascent markets.

Box 3. Risk-adjusted performance trajectory of fossil-based assets

Currently, fossil-based assets have more favorable risk-return profiles than green and sustainable assets.[3] This is due to the market not yet incorporating future uncertainty of fossil value chains.[17] In particular, the risks of stranded assets and high carbon pricing loom large on the future prospects of fossil assets. A slightly deeper risk-adjusted performance metric could help change the relative perceptions of risk-return profiles of green and fossil investments.

The inherent financial structure of fossil-based products makes them less sensitive to the risks perceived by financiers. Indeed, fossil projects typically show a smaller share of upfront costs and a larger share of lifetime (often mainly fuel) costs. Consequently, the financing cost has a limited impact on the overall cost of a fossil project in comparison with clean energy projects. In addition to this advantage, fossil-based assets benefit from an underestimation of their risk exposure. The recent climate risk stress test led by the European Central Bank (ECB) shows that financiers fail to properly assess how climate risks, both physical and transition risks, are threatening the value of their fossil-based assets. As a testament to this blind spot, 60% of European banks supervised by the ECB do not have well-integrated climate risk stress-testing framework.[68] This is why a substantial bias unfairly favors fossil-based assets' risk-return assessments. The theoretical framework to assess fossil-based risk exposure has been lacking, as historical literature has primarily focused on risks associated with emerging industries rather than declining carbon-intensive industries.[69]

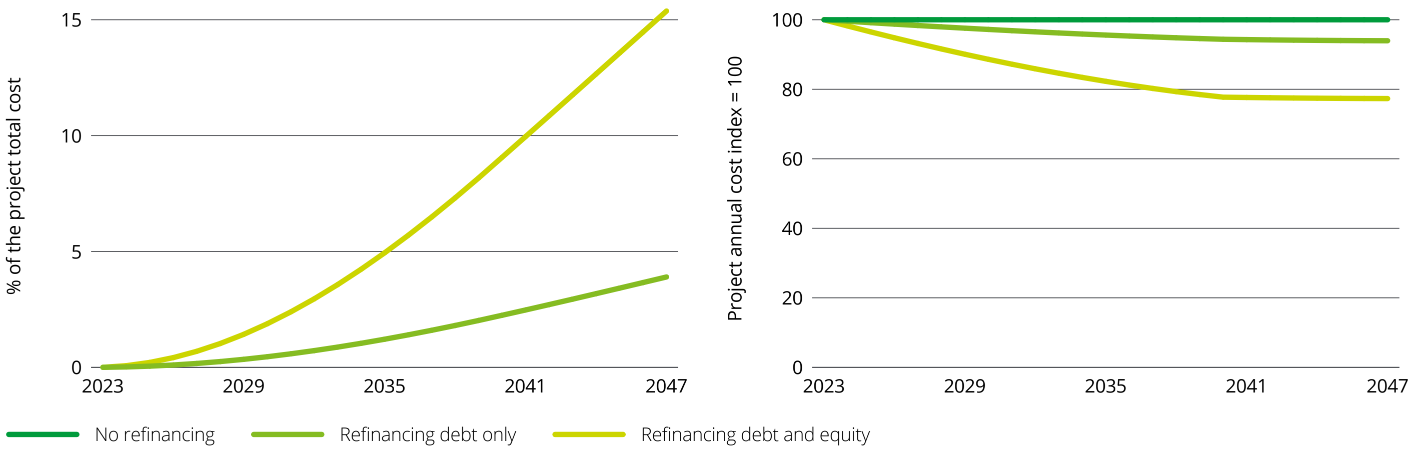
4.2. Unlocking learning effects through refinancing

From a modeling perspective, refinancing can unlock the potential of financial learning, i.e., it allows for the same capital provision to become cheaper over time as markets mature. This means that a project that had initial debt and equity interest rate agreements with lenders and investors can revise those rates each year following the evolution of market rates. Under the assumption of declining green interest rates, green project can thus benefit from constant cost reduction, even after construction is complete. Enabling the refinancing of long-term green projects can help make the transition more affordable by allowing projects to lower their financing costs as capital markets ease up. Crucially, learning effects introduce a dynamic vision of project costs: new projects will have lower financing costs, but ongoing projects can also reduce their financing costs as market conditions ease up and they refinance.

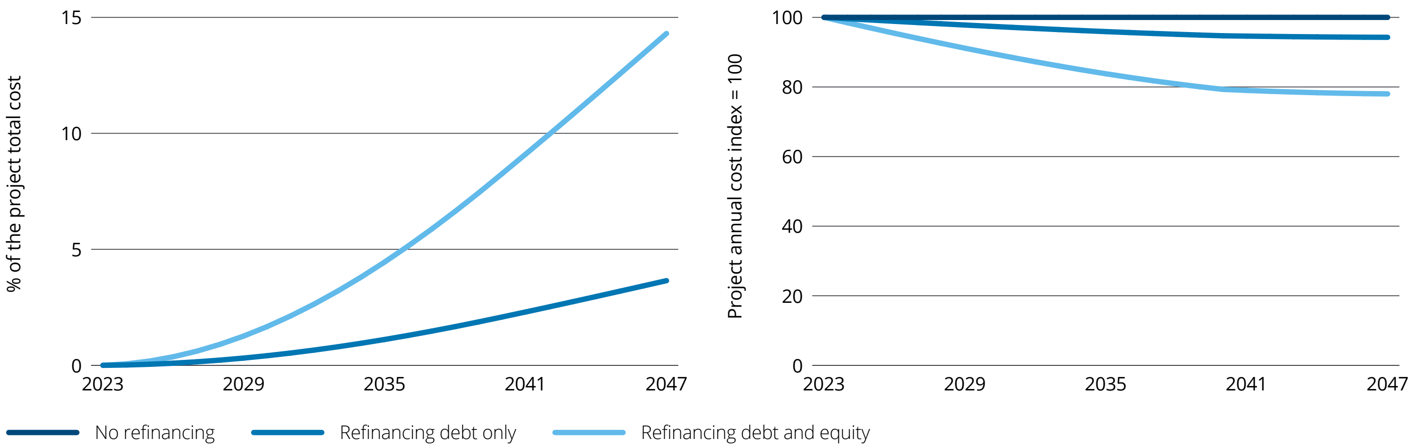
Figure 15 shows the effect of refinancing on financial costs. Three cases are shown, representing three key clean energy investment technologies in the years to come: a solar PV power plant, an onshore wind farm, and an offshore wind farm. Refinancing can save between 3% to 4% of the total project costs for renewable power generation if debt refinancing is unlocked, and between 14% and 15% if equity refinancing is also available. As seen in Figure 14, most of the cost of capital reduction through learning effects takes place before 2040 (see Appendix 5). This is due to both financial learning and to the leveling up of the regulatory, commercial, and technological environment.[3,67] In other words, the cost of capital falls because both the perception and magnitude of risk decrease. This also means that refinancing can harness these favorable dynamics, but its impact could be smaller once cost of capital bedrock is reached. From a project perspective, on the other hand, refinancing is one way out of the exceedingly high cost of capital incurred during the early widespread deployment of clean technologies.

Figure 15. Project-level view of the effect of refinancing on expenditures

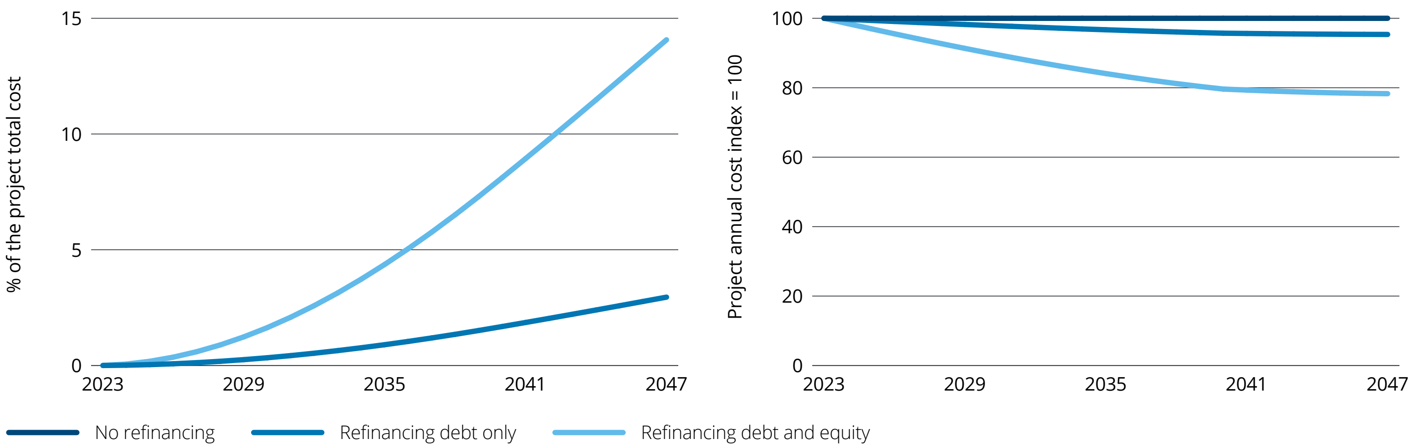
a) 100 MW solar PV farm in Chile



b) 100 MW onshore wind farm in Vietnam



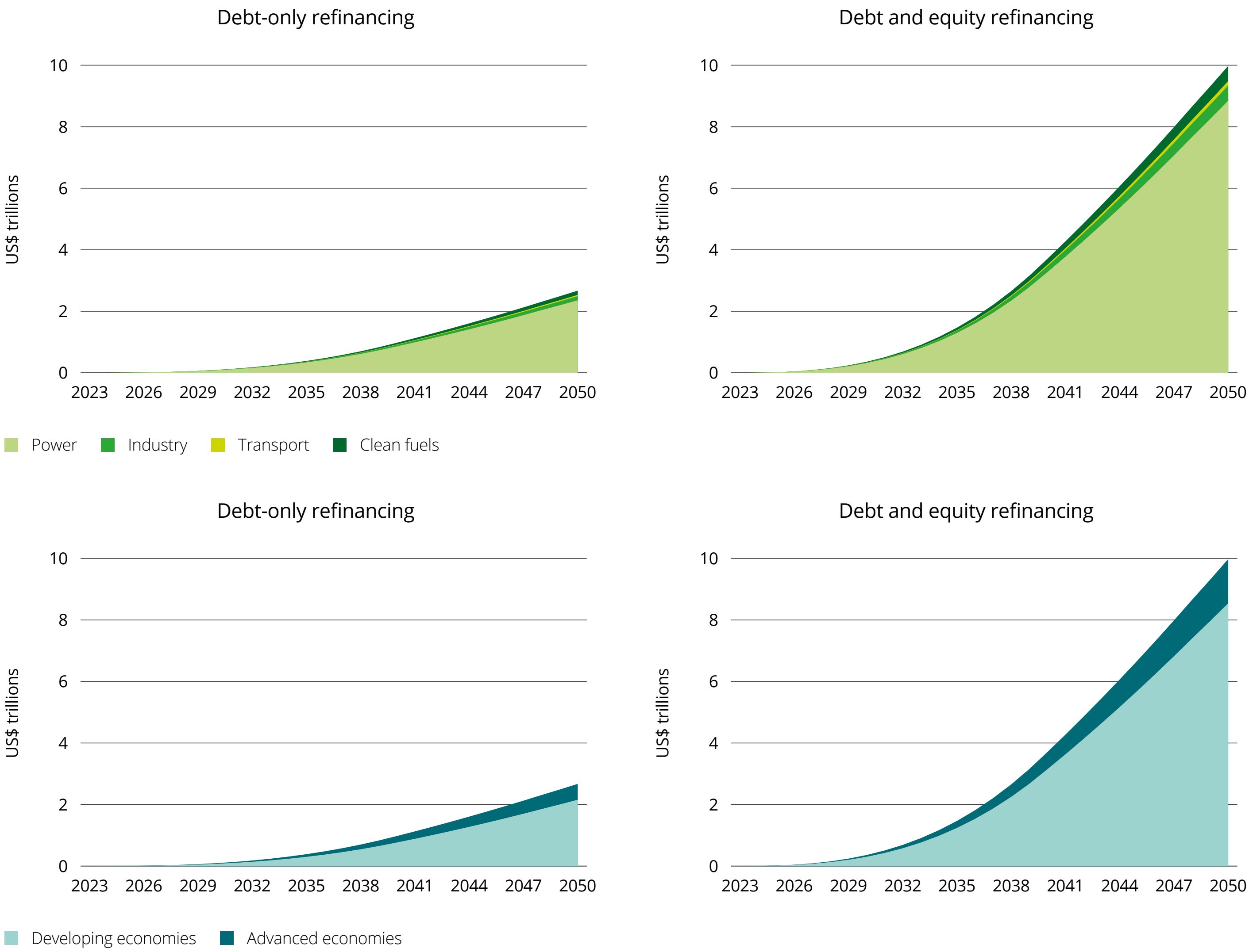
c) 1 GW offshore wind farm in Brazil



Source: Deloitte analysis based on the calculation methodology employed in Appendix 5

Considering the whole expenditures on the energy transition, refinancing can unlock as much as US$2.5 trillion of cumulative savings through 2050 with only debt refinancing and nearly US$10 trillion with both equity and debt refinancing (Figure 16). These values are derived from assuming the possibility of refinancing only for wholesale expenditures, and not for retail final consumers' expenditures (such as heat pumps and electric vehicles). In such a context, the total expenditures eligible for refinancing reach up to US$96 trillion through 2050 without refinancing. These eligible expenditures are then reducible by 3% with debt refinancing only and 10% with both debt and equity refinancing. Moreover, refinancing is often the marker of a transition from greenfield to brownfield investments, which only takes place after a successful initial transformation from pilot projects to functional markets.[70] Indeed, despite their considerable portfolio capacities, risk-averse financiers, especially institutional investors, are hardly involved in climate finance today.[71] In developing countries, where about 80% of savings via refinancing take place, the greenfield-to-brownfield transition often implies an increasing involvement of risk-averse capital providers, especially institutional investors like pension funds.[70] This is another key feature of refinancing: it frees up capital from financiers with high risk appetite by attracting more risk-averse investors and lenders into the arena, and as such it provides an exit opportunity for developers.[72] Summing up the impact of de-risking and re-financing, a cost-efficient implementation of de-risking instruments saves between $\text{US\$}_{2021}$30 trillion and $\text{US\$}_{2021}$50 trillion.[59] Unlocking the potential savings from refinancing (reducing the costs by almost $\text{US\$}_{2021}$10 trillion), an average of $\text{US\$}_{2021}$50 trillion overall cost reduction can be achieved through the period to 2050.

Figure 16. Cumulative cost saving potential of refinancing (debt refinancing only, and debt and equity refinancing)



Source: Deloitte analysis[73]

Both financial learning and techno-economic learning can help reduce the overall cost of the transition. Techno-economic learning can help reduce the upfront cost of capital-intensive green assets, by, for example, nearly 50% for solar power, adding up to more than US$4.5 trillion in cumulative savings through 2050. Financial learning can lower the cost of capital of green projects by around 2 percentage points in advanced economies and up to 5.5 percentage points in developing countries by 2050 (Appendix 2). On the one hand, a better understanding of the project environment is pivotal to enabling risk re-pricing by financiers by enhancing their risk perception. On the other hand, technological, regulatory, and market progress toward a more developed and mature stage contributes significantly to reducing the real risk magnitude. The joint forces of progress and refinancing can help to reduce the cost of capital of green projects, enlarging the scope of cutting the cost of the energy transition. Crucially, setting and keeping those dynamics in motion requires first, measures to make the first investments happen today, and second, enabling refinancing throughout projects' lifetimes. However, the current project finance environment has so far failed to enable learning and refinancing dynamics. Furthermore, the negative externalities of fossil fuels are still largely undervalued in current energy asset pricing, making it more difficult to create a low-risk environment for clean projects. Therefore, the current project finance environment should be rethought and enhanced to help facilitate the energy transition.

The joint forces of progress and refinancing can help to reduce the cost of capital of green projects, enlarging the scope of cutting the cost of the energy transition.

5. A new ecosystem to support the growth of green markets

The upfront cost and the cost of capital of green projects can decrease significantly over time through the combined effects of different financial instruments and financial and economic learning. This vision hinges on the assumption that these learning dynamics can be set in motion early enough to unlock significant savings. In other words, the transition should start today. However, this requires establishing mechanisms to make projects bankable, which means de-risking projects and improving economic and financial conditions.

This report and Deloitte's previous *Financing the Green Energy Transition – A US$50 trillion catch* report[1] have presented a wide array of measures that actors can take to help reduce the upfront costs and financial costs of the transition. Now the question is how those measures can be effectively implemented given the barriers that projects in the current markets face. Addressing this question requires a further deep dive in the existing green projects' finance ecosystem.

5.1. Toward new financial flows

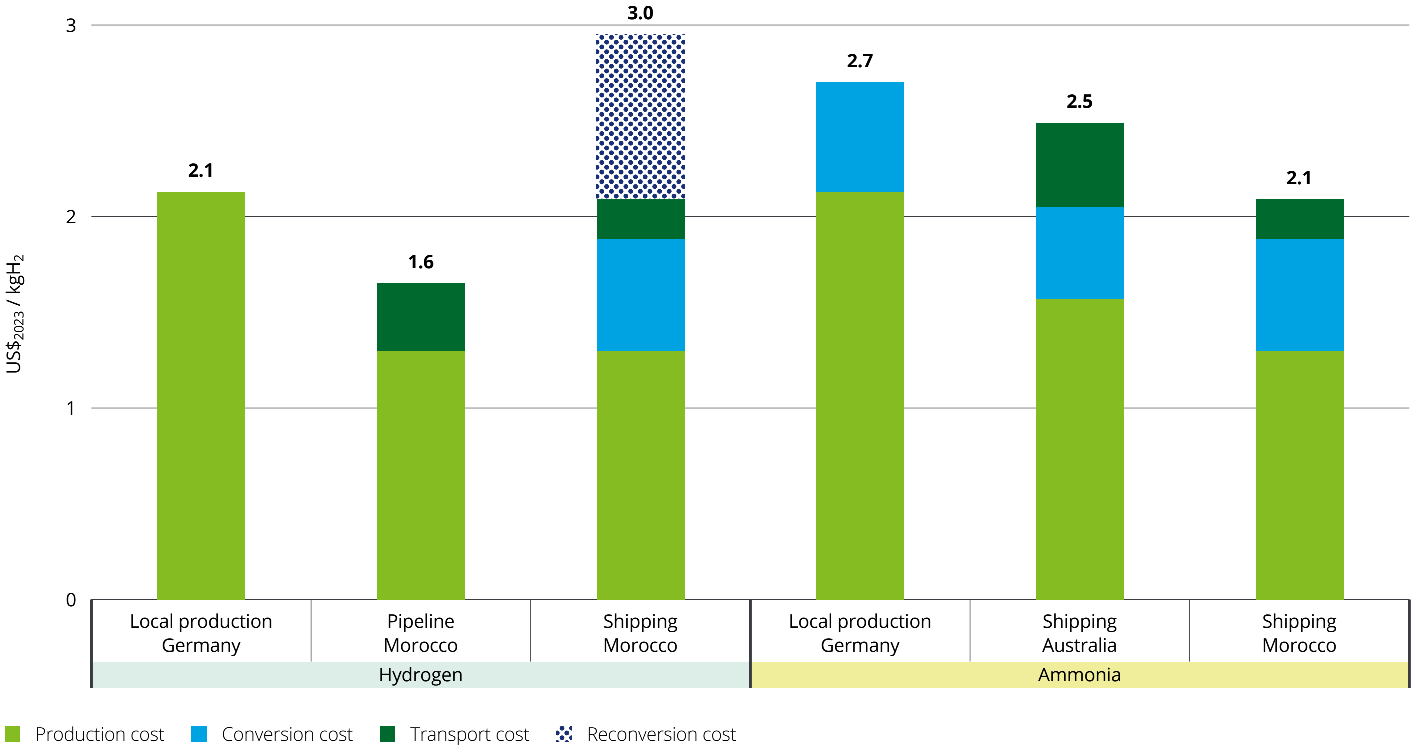
The developing world will carry a large share of the burden of the green energy transition. About 70% to 75% of the US$5-7 trillion/year of global green energy investments until 2050 needs to take place in emerging and developing economies.[1] This puts into question the ability of emerging, especially least developed economies to provide the required level of public investments to fuel the transition in developing countries. At the same time, climate change will on average cause the most damage in emerging and developing countries.[74] Africa for instance displays a high risk of negative changes in ecosystem structures and species and is exposed to droughts, famines, diseases and natural disasters.[74] As explained in Appendix 2, the results of the cost of capital calculation show that developing countries consistently have a higher cost of capital, in large parts driven by higher underlying country risks. As explored in detail in Deloitte's *Financing the Green Energy Transition – A US$50 trillion catch* report, developing countries on average face a taller set of political, market and transformation barriers to green energy investments.[1]

The removal of barriers to green investments will likely take a realignment of the financial flows that characterize the green finance ecosystem. In other words, who pays for what should be changed to better fit the strengths and weaknesses of different players but also different geographies. Although developing countries generally face the harshest odds with regards to climate change and barriers to green investments, they are also often the best-endowed in the key resources that can best support the transition. Africa as a whole is home to 60% of the world's best solar resources,[75] and African countries often have unique resources of their own. For instance, South Africa holds 90% of the world's reserves of platinum, an essential material to create proton exchange membrane electrolyzers to make clean hydrogen.[76] By contrast, many of the advanced economies like Europe or Japan have limited resources and renewable energy endowments.[39,77,78] In some cases like Japan, the availability of suitable land area is also a constraint preventing the development of renewables, which typically have a high area use-to-capacity ratio.[79]

This disparity creates win-win opportunities around the world, most notably with green hydrogen. European countries like Germany are betting on green hydrogen to help decarbonize their hard-to-abate sectors. However, due to resource constraints, it is more economically viable to relocate part of the required production outside of Germany, to places like Africa, Australia, the Middle East or South America. Relocating European hydrogen production to, for example, Sub-Saharan Africa means incurring additional conversion, transport, and infrastructure costs to bring the product to Europe, where it could instead be produced and consumed directly onsite. Despite these extra costs, the levelized cost of hydrogen made in other parts of the world with better renewable endowments and shipped to Europe can still be lower than that of hydrogen produced and consumed onsite in Europe. For instance, for the German case, hydrogen imports from North Africa, such as Morocco and ammonia imports from Australia and Morocco can be cheaper than local production (Figure 17). Exports of hydrogen from Africa, the Middle East, and South America could generate revenues of US$123 billion, US$20 billion and US$14 billion per year respectively in 2050.[39] These revenues could add up to over 10% of GDP in some countries like Egypt or Morocco, where they would fully offset today's trade deficits.[39] Lastly, green hydrogen provides an exit strategy for countries whose economies largely depend on the export of fossil fuels today, as global demand for fossil energy is set to diminish.[63] This makes green hydrogen trade doubly relevant for regions like North Africa and the Middle East, that are currently net exporters of fossil fuels such as oil and gas.

The developing world will carry a large share of the burden of the green energy transition. About 70% to 75% of the US$5-7 trillion/year of global green energy investments until 2050 needs to take place in emerging and developing economies.[1]

Figure 17. The cost of local production of green hydrogen and ammonia in Germany vs. imports from North Africa and Australia

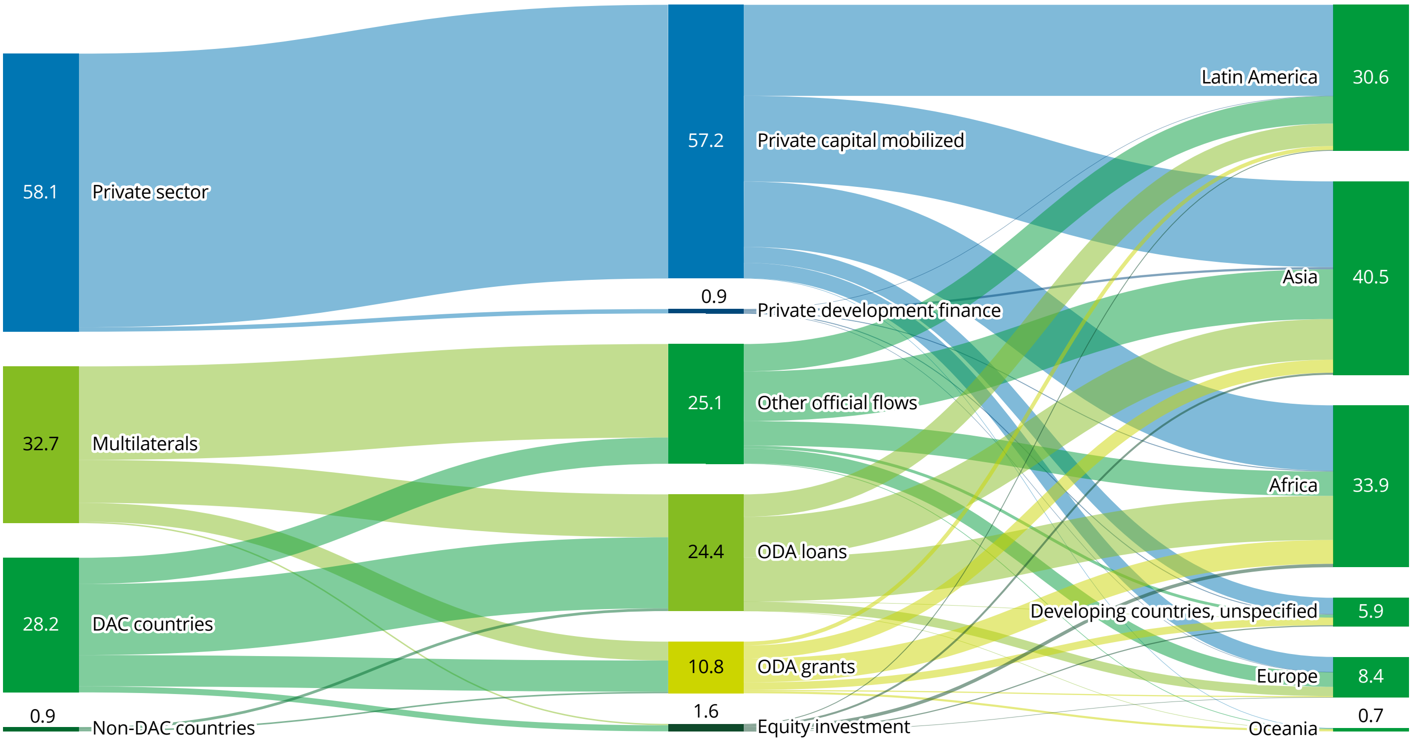


Source: Reproduction based on Deloitte's 2023 global green hydrogen outlook[39]

The economic potential of green hydrogen and its derivative molecules' (e.g., ammonia, methanol, and other synthetic fuels) trade for both developing and developed regions makes it a prime example of the benefits of reforging the financial flows of green finance across geographies. More generally, the green energy transition presents opportunities for developed regions to make use of their resources and young and increasingly educated workforce to fuel economic growth. For instance, developing solar and wind industries create jobs and lead to energy systems that are shielded from the whims of international fossil fuel markets.[80] Green energy transition technologies should create as many as 14 million jobs worldwide by 2030, and replace another 16 million jobs from the global fossil fuel industry, adding up to an overall 30 million jobs.[39,81] Green technologies also bring opportunities to indirectly reduce public expenditures–a unique selling point for fiscally-burdened governments. For instance, the deployment of electric vehicles leads to significant indirect benefits by reducing air pollution-induced mortality.[82] However, the current ecosystem is ill-suited to help build the new international links that enable such benefits. The primary challenges stem from the failure to recognize and account for the real health and climate costs of the fossil sources, inadequate information sharing across ecosystem players, and insufficient use of the potential of innovative finance mechanisms (such as blended finance) to transform markets.

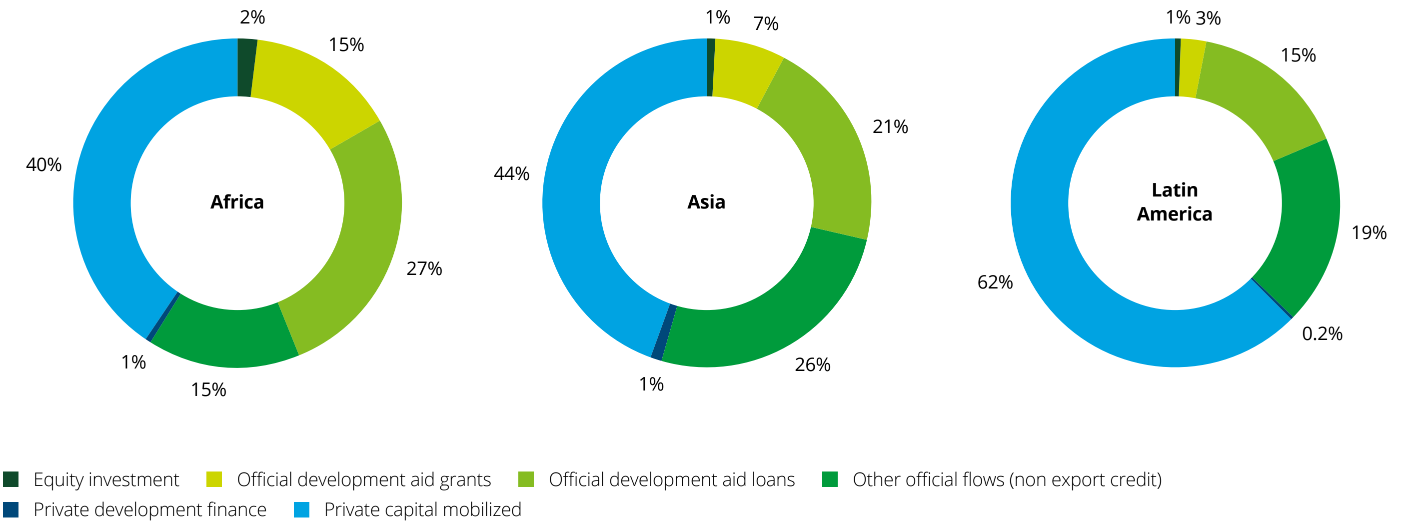
The potential of blended finance to create markets out of pilot projects has stagnated in recent years, and there is room for improvement. For instance, in the Middle East and North Africa, US$1 of concessional capital only attracts about US$1.8 of private capital, but this ratio increases to US$3.7 in Latin America and the Caribbean.[83] Overall, the private capital mobilization ratio of concessional finance is generally higher in regions with lower underlying risks, particularly those below the threshold at which institutional investors step in. This corroborates trends in financial flows observed across regions of the world (Figure 18). Private capital mobilization differs widely across developing economies. For instance, the share of private commercial capital in green energy projects is 40% in Africa, but 62% in Latin America (Figure 19). Grants display the inverse pattern: their share in total green energy investments is much higher in Africa than in Latin America. From a public cost perspective, these patterns underscore the necessity to de-risk projects until they are below large-capacity investors' risk-return threshold.

Figure 18. Current state of concessional green project finance for renewable power generation (cumulative 2013-2021 in US$ billion)



Source: Deloitte analysis based on OECD database[84]
Note: This landscape is not exhaustive, as it includes only the OECD project-level database. DAC stands for Development Assistance Committee, consisting of 24 countries in OECD, including European Union, Australia, Japan, South Korea, the United Kingdom and the United States. ODA stands for official development assistance.

Figure 19. State of play for green project finance in renewable power generation in three key emerging markets: Africa, Asia, and Latin America



Source: Deloitte analysis based on the OECD database[84]

De-risking and private capital mobilization are interconnected and mutually reinforce each other. Beyond mobilizing private capital, blended finance can also transform markets by attracting investors due to its de-risking effects. Historically, blended finance has enabled the creation of innovative financial products like weather insurance for agriculture or green bonds for green energy.[85] The market leverage potential of blended finance will be pivotal in helping to enable the scale up of significant capital flows.[86,87] However, a key concern with blended finance is its vulnerability to macroeconomic pressure, particularly inflation, debt, and geopolitics. High interest rates throughout the recent global crises hurt developing countries' currencies and constricted the flow of development capital under increasingly high debt pressure caused in large parts by COVID-related public expenses.[88] These macroeconomic shocks could seriously hinder the deployment of blended finance in countries without protective measures. Some of these protective measures are low-hanging fruits: the World Bank estimates that every US$1 invested in improving local credit worthiness can leverage US$100 of additional private sector financing, and yet only 20 percent of the 500 largest cities in developing countries are considered creditworthy.[89]

Furthermore, refinancing allows risk-averse private investors to partake in previously realized investments as they become less risky over time. Until recently, development finance in green energy had largely been about the "originate to hold" model, by which DFIs would finance an asset and hold it in their books for its entire lifetime. A new trend is likely to emerge towards "originate to sell/share" models, in which DFIs and public bodies finance the project in its earlier, riskier phase and then sell the asset to commercial capital providers once the risky phase (typically construction and early operation) is over.[90] This frees up the funds of DFIs and allows a faster recycling of their investment capacities onto new green energy projects. The originate to sell model also gives the project access to a larger potential pool of capital, especially in the case of multi-phase projects in which capacity is gradually expanded. Lastly, refinancing allows the integration of commercial capital providers with a low-risk appetite into the green energy ecosystem, fueling the learning dynamics. Moreover, although refinancing is usually thought of as from public to private, it can also happen horizontally among different public or private actors with varying risk appetites and investment capacities. For instance, a venture capital firm could finance the early stages of a hydropower project before selling it to a commercial bank. Overall, refinancing provides the de-risking opportunity for green energy projects by unlocking the dynamics of financial cost reductions that are expected for most green technologies and capital markets.

In summary, the financial mix of the future green energy transition will need to mobilize private capital towards positive climate impact projects.[1] To do so, market players will need to make the most out of limited public concessional finance, which will be key to setting cost reduction dynamics in motion. This largely depends on the ability of the ecosystem to attract large-capacity but risk-averse players, foster and mobilize de-risking practices and guide capital flows toward green projects. In the end, green technologies also present many opportunities to internalize and distribute the benefits of the transition more equitably across countries and within the society. These include creating new jobs while replacing fossil industry jobs, inverting the trade deficits of developing countries, or reducing public health expenditures.

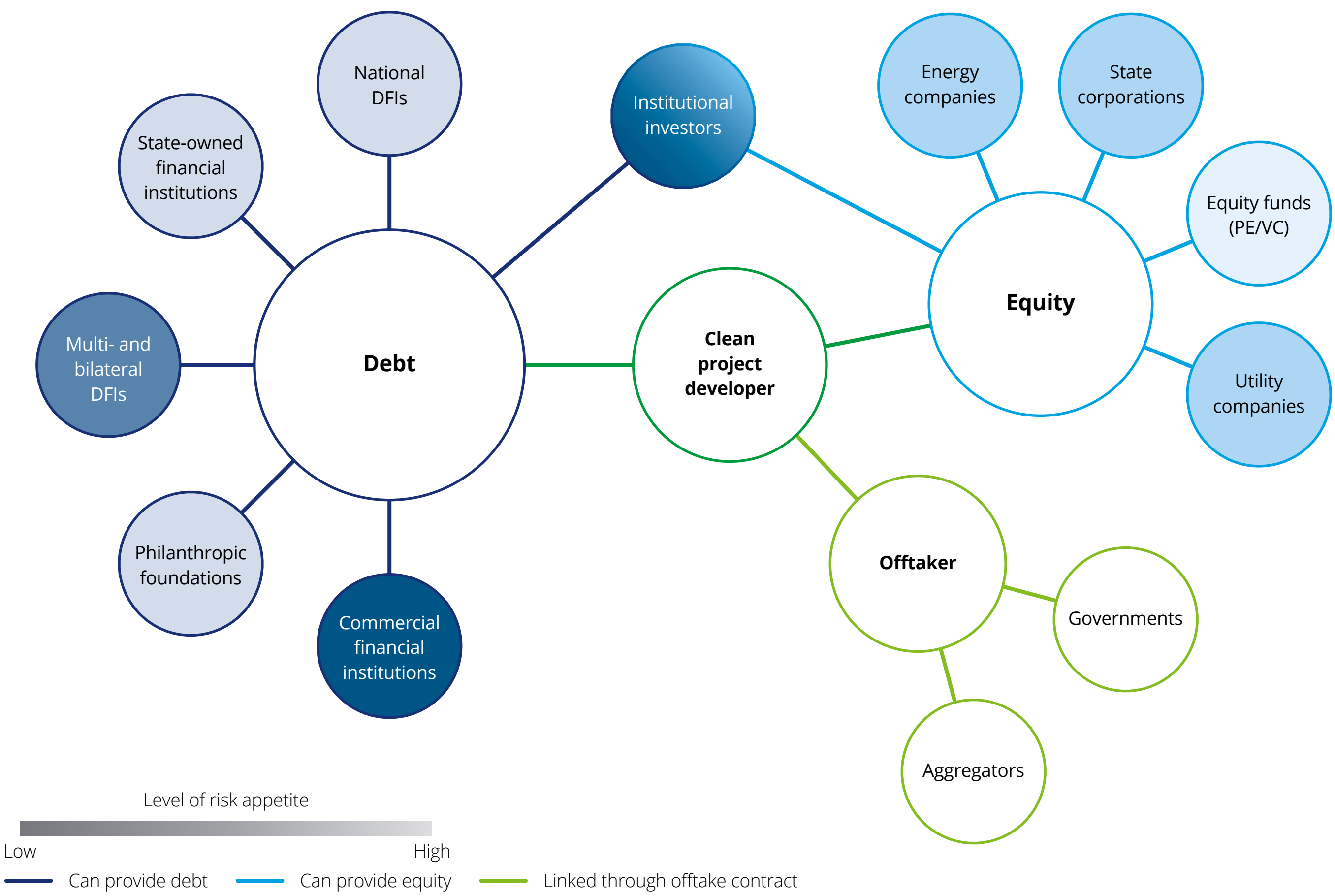
Refinancing provides the de-risking opportunity for green energy projects by unlocking the dynamics of financial cost reductions that are expected for most green technologies and capital markets.

5.2. Key aspects and missing pieces of the current ecosystem

The green finance ecosystem is made up of a constellation of different actors that interact together and face different objectives and constraints. These actors can be broadly categorized as project developers, offtakers, and debt and equity providers (Figure 20). Today, public institutions are a driving force of climate finance, accounting for about 50% of investments in green energy around the globe in 2021 and 2022.[71] In contrast, despite hopes that they would lead climate finance, institutional investors added less than 1% of global climate investments in 2021 and 2022.[71]

Equity and debt financing differ in many ways. Debt is owed capital that needs to be paid back to the lenders with a specific debt interest (debt rate of return) regardless of the project's success and before tax collectors and equity investors. Importantly, debt itself does not grant project ownership. Equity investors have a degree of ownership of the project and expect to receive dividends on the project's profits to pay back their investment.[91] From a project finance perspective, equity financing is generally more expensive than debt financing because the priority of debt payment over the equity profit sharing puts equity providers in riskier position, and therefore, lenders usually require lower rates than investors and unlike dividends, interest payments are tax-deductible.[92] Project developers will therefore seek to maximize the share of debt in their financial structures to minimize financing costs and maximize ownership.

Figure 20. A broad view of a clean project finance ecosystem with key actors and their action levers



Source: Deloitte analysis based on Climate Policy Initiative (2023)[71] and Mazzucato and Semienuk (2018)[93]

From most to least risk-averse, equity providers in the climate finance environment can be institutional investors, energy or utility companies, and national corporations. They can also be, equity funds such as private equity or venture capital firms (Figure 20). Equity funds tend to operate on high-risk projects such as unproven technologies or uncertain locations, but ask for a high reward to compensate, usually in the form of high required rates of return on equity.[94] The exit strategy of equity funds is usually to sell their shares in the project to another equity buyer such as energy or utility companies, or sell to the equity market in the case of an initial public offering. This transfer of ownership from risk-hungry to risk-averse equity providers allows the project to lower its cost of capital over time as fundamental risks decrease. More broadly, the transfer of ownership of green projects to local stakeholders (local firms, authorities or inhabitants) has already proven to be key in securing the sociopolitical acceptance of green energy projects like wind farms.[95] Moreover, crowdfunding provides an appealing way out of governmental liquidity challenges, but its relationship with social acceptance depends strongly on how it is done and on the political views of the community.[96] Like many other key success factors of the energy transition, the social acceptance of renewable energy strongly depends on political choices at each level (Box 4).

Box 4. Political choices and the energy transition

Policymaking and political messaging has set the course of green energy transitions around the world. Beyond country and regional borders, the choice of targets, regulatory frameworks, taxonomies, and fiscal policies provides an overall picture of the transition. For instance, the EU has clearly identified renewables, hydrogen, and electrification as the main pillars of its transition to net-zero emissions by 2050–a binding target for all EU Member States.[97] This detailed overarching framework has improved EU citizens' (risk) perceptions of the green energy transition.[98] Political decisions taken at the national level can also play a key role in the social acceptance of measures and technologies supporting the green energy transition. For instance, the Chinese government's extensive policy and political support for EVs caused a sharp rise in the acceptance of them and propelled the share of Chinese EV registrations in the global market to nearly 60% in 2022.[99,100] Lastly, local-level political messaging such as job creation perspectives has a strong impact on citizen support for the green energy transition.[101]

Important to note that debt providers have varying degrees of risk aversion. In descending order, they are commercial banks, institutional lenders, multilateral DFIs and state-owned financial institutions and philanthropic or national DFIs (Figure 20). As explained earlier, green projects will generally seek to maximize the share of debt in their capital mix to minimize financing costs and interest expenses, but also because the financial leverage effect increases with the share of debt. Different metrics can capture financial leverage, but at the core lies the debt-to-equity ratio. While it also leads to a lower expected cost of equity, a higher debt-to-equity ratio increases the profits or losses made on each dollar of equity invested. A high financial leverage, particularly in projects with a large share of concessional debt, can attract more return-maximizing equity investors who may see concessional debt as a strong de-risking factor.[102] DFIs often play this signaling role regardless of whether the loan itself is concessional or commercial: their reputation gives credibility to the assessment that borrowers are safe.[103] This is a clear opportunity for the energy transition: DFIs should focus on providing loans to green energy projects to help maximize both the financial leverage and signaling effects. However, DFIs and other risk-absorbing lenders can only spread so thin across the pipeline of green energy projects. Financing the transition will require the active participation of commercial banks and other high-capacity but risk-averse lenders. There are two broad ways to engage commercial banks. The first is to foster the gradual transfer of green debt from DFIs to commercial banks as projects mature over time.[104] This could require DFIs to incentivize both commercial banks by proposing viable risk-return contracts, and green projects by absorbing the added costs of refinancing. The second is to facilitate the securitization and aggregation of green debt, to unlock economies of scale and scope with wholesale green debt provision.[105] This can be made possible with the standardization of green debt.

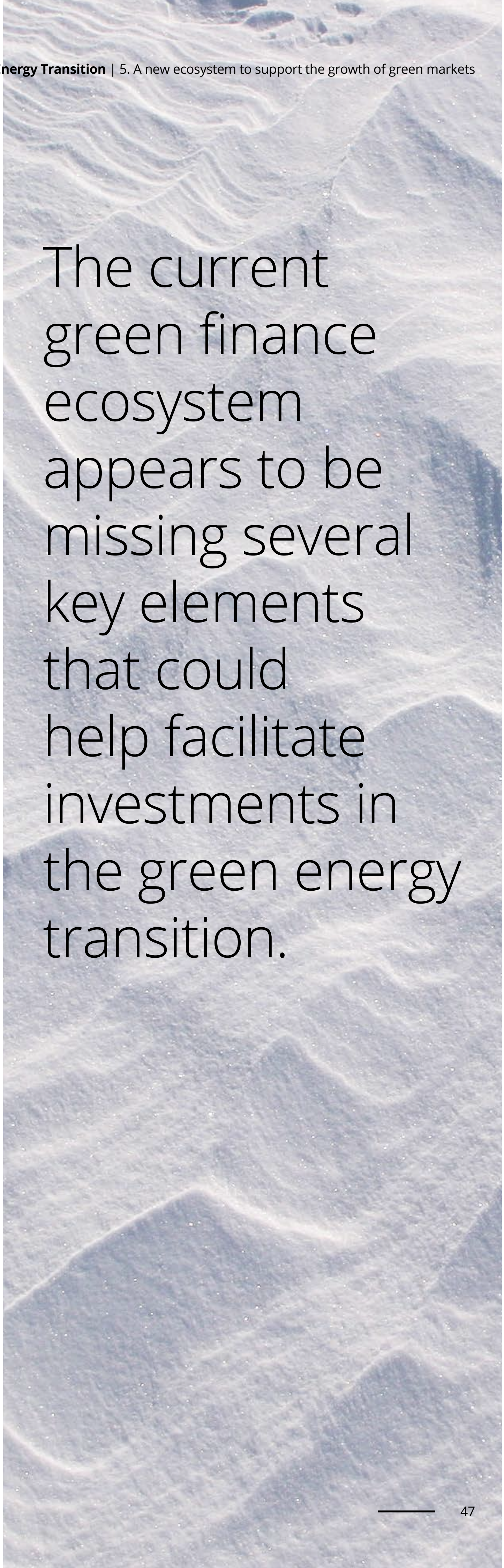
Downstream from capital provision, developers, governments, and consumers interact closely within the project environment (Figure 20). As explained in section 3.1, offtake contracts securing demand will be essential in making green investments bankable. However, their de-risking effect also strongly depends on the creditworthiness of the offtaker. The governments of fragile political systems or weak economies thus bring a risk of payment default on offtake contracts.[106] This risk is partly remedied in the offtake contract by adding financial covenants that protect the developer if breached. Like with green debt, the aggregation of demand can also help to reduce individual offtake default risks. Therefore, demand aggregators offer a vital source of risk hedging to both green energy projects and offtakers. This is especially relevant for commodities like renewable electricity whose consumption, supply and prices can fluctuate widely over time.[20,107] Ultimately, the choice of government over private aggregator or offtaker essentially depends on the creditworthiness of governmental offtake and on the desired degree of market privatization.

Cooperation and communication between project developers and offtakers will be crucial to help activate the effects of scale and scope of aggregators or large buyers like governments.

In summary, the current green finance ecosystem appears to be missing four elements that could help facilitate investments in the green energy transition:

- **Enhanced aggregation capabilities:** Facilitating the aggregation of investors can help overcome lending or investing constraints, particularly in the case of crowdfunding which also tends to boost social acceptance. Enabling the securitization of projects allows risk-averse investors to reduce risks through portfolio management and projects to lower financing costs via economies of scale. Lastly, empowering demand aggregation can help de-risk green energy projects, with a strong impact for volatile markets like electricity or new products like renewable hydrogen.
- **Transfer mechanisms:** A more fluid transfer of ownership maximizes the benefit of an ecosystem of players with different risk appetites. Moreover, easing the transfer of ownership of green projects to local stakeholders can help secure the social acceptance of the green energy transition.
- **Investment leadership:** Private capital providers' risk perception decreases when reputable institutions like multilateral DFIs make visible investments or loans to the project. Placing the green energy transition at the center of DFIs' capital provision strategies can amplify their signaling power for green investments.
- **Climate dimension:** Accounting for the environmental and social benefits (including health impacts of reduced pollution) of green projects and the social costs and climate risks of fossil fuels would help close the gap between the two strands of technologies. These effects may be difficult to quantify, but their integration into financial assessment would enable risk repricing and significantly improve the financing conditions of green technologies.[15]

These four elements would centralize assessments, decision-making, and information gathering in relation to existing concessional loans, funds and grants, thereby enhancing the fluidity of investments into the green transition.



The current green finance ecosystem appears to be missing several key elements that could help facilitate investments in the green energy transition.

6. The way forward to get the ball rolling

Fighting climate change means realizing unprecedented investments in sustainable and green projects that still lack bankability.[1] The low bankability of these projects is the direct cause of investors and lenders' high risk perception when macro, market, technical, or financial constraints loom large on the prospects of an investment. Macro risks, accounting for 45% to 90% of the total cost of capital of existing renewable energy projects, include political, regulatory and currency risks.[10] Technical risks, i.e., construction and operating risks, are generally higher in resource constrained regions and for newer technologies. Market risks encompass credit, liquidity, and offtake risks, and can generate a risk premium of up to 13 percentage points on the cost of equity. Lastly, financial risks stemming from dysfunctional or underdeveloped capital markets can restrict projects' access to capital. A wide spectrum of project de-risking tools can be envisaged, consisting of information, regulatory and control, economic and market, and financial instruments (Figure 21).

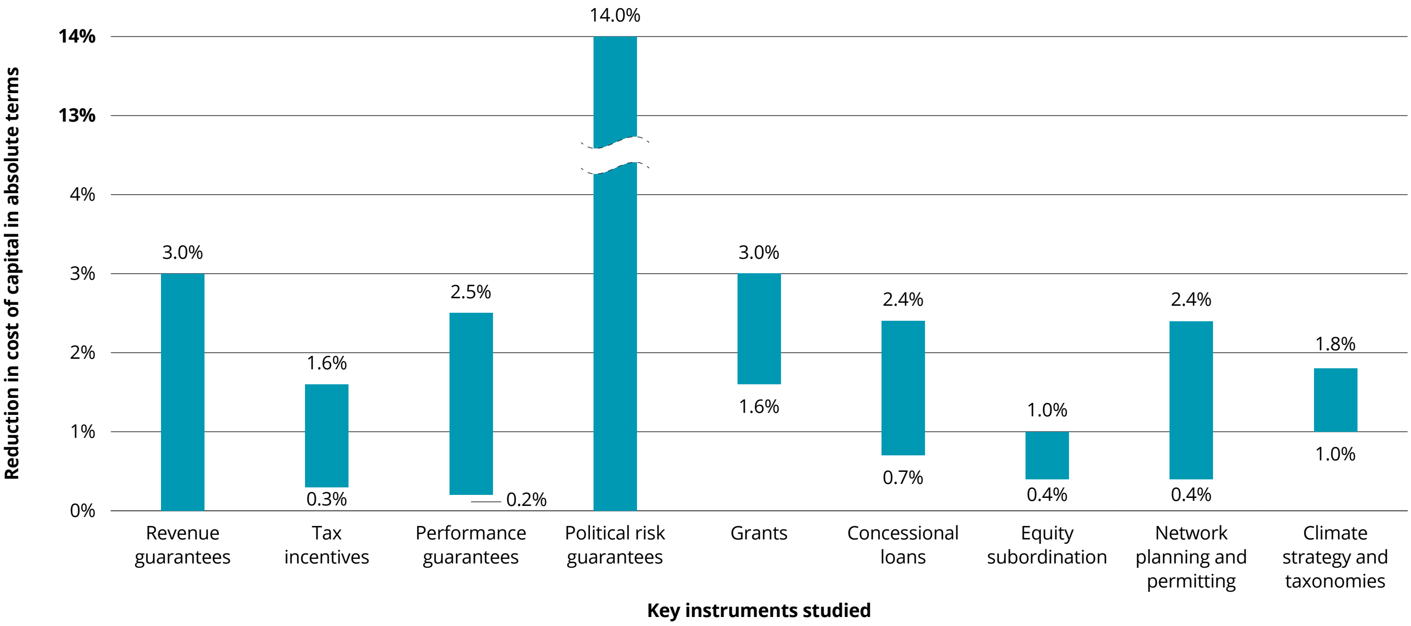
Figure 21. Tools to help de-risk the investments in green and sustainable energy projects

		Macro risks		Market risks			Technical risks			Financial risks
		Political visibility	Regulatory	Missing markets	Revenue	Cost competitiveness	Under-performance	Construction delays and cost overruns	Missing infrastructures	Access to capital
Information instruments	Set climate and energy strategies	●	●							●
	Taxonomies	●								●
Regulatory and control instruments	Streamlining licensing process	○	●	○				○		
	Network planning	○	○	○	○	○			●	
Economic and market instruments	Demand aggregation			●	●	○				
	Offtake contracts			●	●	●				
	Tax incentives				●	●				
	Consistent subsidy policies			○	●	●				○
Financial instruments	Guarantees and insurances	●	●		●		●	●		●
	Subordinated debt and junior equity			○	●		●	●		●
	Securitization									●
	Concessional loans	○		●		●				●
	Grants	○		●		●				●

● Full mitigation ○ Partial mitigation

Source: Deloitte analysis based on Deloitte (2023),[1] Blended Finance Taskforce (2018)[7] and Green Climate Fund (2021)[17]

Figure 22. Effectiveness range of key de-risking tools on the cost of capital



Source: Deloitte analysis based on Appendix 4 and the calculation of cost of capital in Appendix 2

Deconstructing the cost of capital allows to model the individual and synergistic cost of capital reduction potentials for each de-risking instruments. Macro risks are in many cases the pivotal target for risk-reduction strategies, because of their high weight in the cost of capital of green energy projects today. While not all of the de-risking instruments' impacts are quantifiable, key financial and economic instruments can cover a broad range of risks including macro, market, technical, and residual risks. Wide disparities in geographic, technological, and other technological characteristics can lead to a disparate effectiveness of available risk-reduction instruments (Figure 22).

Political risk guarantees have by far the highest potential in helping to reduce the cost of capital for green energy projects (zero to 14 percentage points) due to the impact of macro risks on project viability. Such measures are especially apt for green energy as some of the most volatile regions of the world also have immense renewable resources, like Sahara-adjacent countries.[77,108] For reference, a 14 percentage points decrease in the cost of capital would cut the cost of solar electricity in Ghana by over 50%.[109] Grants have a lower maximum but higher minimum potential to reduce the cost of capital than political risk guarantees (1.6 percentage points to 3 percentage points), as free capital always lowers the cost of capital regardless of project specificities. Revenue guarantees are one of the most effective instruments to help reduce the cost of capital of green energy projects (zero to 300bp).

There are cases where revenue guarantees are superfluous, for example, when a highly creditworthy government holds a fixed-price offtake contract. Performance guarantees can bring some degree of cost of capital improvement (0.2 percentage points to 2.5 percentage points), especially as renewable energy power production varies unpredictably from year to year.

Concessional loans will always decrease the cost of capital (0.7 percentage points to 2.4 percentage points) and are particularly effective in economically constrained regions or projects without affordable commercial debt. Network planning and permitting can reduce the cost of capital (0.4 percentage points to 2.4 percentage points) by dampening risks related to construction delays. In Europe, permit-granting for a wind farm can take up to nine years, leading to five times more wind capacity in permitting than in construction.[110,111] Climate strategies and taxonomies create the low-risk project environment needed to help lower the cost of capital (1 percentage points to 1.8 percentage points). Tax incentives offer a more modest reduction of the cost of capital (0.3 percentage points to 1.6 percentage points) by improving liquidity and increasing revenue and its certainty. Lastly, equity subordination slightly lowers the cost of capital (0.4 percentage points to 1 percentage points) by reducing risks of default on equity payment.

The comparison of different combinations of de-risking instruments is difficult for two major reasons. First, their effectiveness varies widely depending on context, such as, the maturity level of the project and the considered region and technology. Their effectiveness also changes depending on the developmental stage of the market as a whole. For instance, securitization is largely irrelevant until the market is fully formed, at which point support like revenue guarantees should be phased out. Second, effectiveness cannot be the sole comparator, especially as cost efficiency is often a pressing challenge in budget-constrained countries. Public budgets are not equally sensitive to actual spent dollars (subsidies and grants), hypothetically spent dollars (insurance and guarantees) and opportunity cost dollars (tax credits). The computation of public costs is made even more complex in cases where the project would not have taken place and thus generated public revenue without the subsidy, guarantee or tax credit. Furthermore, public cost calculations often fail to consider the benefits of green projects in terms of economic activity, employment, health, and climate.[112] If internalized, these benefits could strongly alter both the net added value of each instrument and comparisons of instrument combinations based on cost efficiency.

Key technologies of the energy transition, notably wind and solar power plants and batteries have experienced significant learning in the past. The cost of solar panels, onshore wind farms and batteries have fallen by 81%, 31%, and 88% between 2000 and 2020 respectively.[60] This trend is expected to continue in the period to 2050, as their deployment is set to grow.[63] The downward projected trajectories for the upfront costs of green technologies should be secured by an initial public investment giving enough momentum to activate innovative breakthroughs and learning-by-doing effects. Similar to techno-economic learning, as markets mature and investments scale up, green technologies will likely be subject to financial learning. The cost reduction potential of this type of learning can go beyond new investments, and include past investments, thanks to refinancing. Refinancing offers the dual benefit of reducing the cost of capital of previously realized investments for projects and allowing risk-averse private capital providers to partake in those projects once their risks have decreased sufficiently. It could unlock up to US$10 trillion of savings through 2050, if both lent debt and invested equity are subject to refinancing (see section 4.2). Adding up the US$40 trillion savings from de-risking projects, total potential savings reach US$50 trillion through the period to 2050.

Adding together the potential cost savings due to de-risking—US$40 trillion—and refinancing through a flexible project finance ecosystem—US$10 trillion—can unlock as much as US$50 trillion cumulatively through 2050.

Making the green energy transition affordable will require activation—obtained by the early de-risking of pioneer projects—and momentum—sustained by the reinforcement of learning potential. The first wave of large-scale green energy projects will need a degree of economic support to be economically and financially viable while the price and risk gaps with fossil alternatives close. Financial learning and the prospects of upfront or financing cost reductions will be key to gradually phase out the subsidies that initially made the first few projects viable. However, the current project finance environment fails to capture the negative externalities of fossil assets and the positive climate impact of green projects. This calls for the creation of a new green finance environment that could capitalize on each actor's constraints and abilities, internalize positive and negative climate impacts in financial systems, and make the most out of limited concessional capital.

The energy transition and its many challenges will entail unparalleled volumes of investment. However, the window to bring the world on course for net-zero targets for an affordable energy transition is closing fast. Policymakers should introduce adequate de-risking tools today to provide the necessary start of the first waves of large-scale projects. They should also work together with market players to help reshape the current project environment into a functional green finance ecosystem that incorporates the climate impact of investments and enables refinancing.

To help open and channel the flow of capital towards green projects and developing economies today, **investors and lenders** should:

- **Incorporate the green energy transition in their capital provision strategies.** Institutional investors made up less than 1% of global climate investments in 2021-2022.[71] More than ever, there are profits to make on green energy projects and losses to incur on fossil assets. The US$150 trillion to US$200 trillion of investments required to sustain the transition to net-zero call on capital providers to prioritize green finance in their investment strategies.
- **Adapt to the new ways of assessing and quantifying green energy and fossil-based projects.** The current misestimation of green and fossil projects' climate impact, costs, and risks blurs the overall picture of their real value. Indeed, the ECB has estimated that 60% of European banks currently fail to fully assess their exposure to climate risks.[68] In concrete terms, this is a call for investors and lenders to incorporate climate impact and risks into their assessment methodologies.

Policymakers will be pivotal in helping to ignite the transition and maintaining its momentum, specifically by:

- **Creating the low-risk environment necessary for large-scale green projects to come online.** A low-risk environment is vital to help reduce financial costs by lowering risks, and to secure many of the checklist items without which projects do not get approved. This essentially calls for a mix of carefully crafted energy and climate strategies, taxonomies, and vetting procedures.
- **Setting up adequate instruments to support the first waves of green energy projects.** These projects are currently not viable without a mix of de-risking and risk-transfer instruments to help reduce the cost of capital and other critical cost items. Some direct support instruments like grants or tax credits can increase project added value by more than US$2 for each US$1 of public money spent. The deployment of de-risking instruments can save up to US$40 trillion in the cost of the transition through 2050. Equally, the gradual phase out of instruments as projects evolve toward a self-sufficient market will help save crucial public funds.

For **development finance institutions** in particular, the challenge will be to make the most out of limited concessional finance, which will require:

- **Learning to tailor blended finance instruments to specific contexts and projects.** The cost-efficiency, effectiveness, and indirect effects of financial instrument combinations vary with the location, technology, and maturity level of the underlying markets. This implies increasing DFIs' analytical depth, going beyond single pilot project realization perspective, and synchronizing their actions with market maturity and growth. If successful, the optimal deployment of de-risking instruments can reduce the cost of green energy by up to 35% in many typical cases.
- **Enabling refinancing to help unlock additional cost savings and foster the shift to brownfield investments.** This would both reduce the cost of the transition and help accelerate it by making capital transfers across different investor profiles faster. To enable refinancing, DFIs should adapt their investment models from "originate to hold" toward "originate to sell or share."

Together, **policymakers** and **development finance institutions** should aim to reduce the cost of the transition by:

- **Activating and maintaining techno-economic learning to cut upfront costs.** Continuous support for and investments in green technologies can help reduce costs and exposure to supply chain risks, such as those linked to raw materials markets. Thanks to the learning-by-doing effect, the upfront cost of solar panels experienced a tenfold cost reduction in ten years (from 2009 to 2019),[113] and this trend is set to continue toward 2050. By setting a low-risk environment with adequate de-risking instruments, policymakers and DFIs can enable market players to build their first pilot projects and see subsequent waves of ever-larger projects reduce their costs as developers gain experience.
- **Unlocking the potential of financial learning to help reduce the cost of capital.** The capital intensiveness of green projects calls for the activation of financial learning. In practice, financial learning has already lowered the cost of capital of renewables by more than 4 percentage points since 2010 in advanced renewable markets. Unlocking further financial learning will require a flexible project finance environment where project ownership transfer and refinancing are enabled by default. This can accelerate the creation of a commercial track record for new green technologies and help bring in a larger spectrum of investors and lenders. By enabling refinancing, policymakers and DFIs can capitalize on financial learning effects to reduce the cost of the transition by another US$10 trillion through 2050.

Project finance environments should be redesigned to assess the climate impacts of green and fossil-based projects, to help facilitate the flow of capital towards green projects and to scale up green markets.

At the global level, **international organizations** should help secure the geopolitical foundations for the transition, which calls on them to:

- **Develop the diplomatic and economic ties needed to help create a global energy transition.** The transition will be built on electrification, technologies like electrolyzers and solar panels, molecules like hydrogen or biofuels, skilled labor, international commercial and capital flows, and global knowledge sharing. Geopolitical constraints will largely shape the movement of these vital resources around the globe through 2050 and international organizations should lay the foundations for a win-win global free trade environment to help reduce the cost of the energy transition and foster economic development everywhere on the planet.[39]
- **Harmonize climate and energy political and regulatory frameworks around the globe.** Common rulesets are necessary to help enable the global trade of future clean energy technologies, much-needed raw materials and molecules. In scope are taxonomies, definitions, carbon pricing practices, and other instruments that should be harmonized to avoid carbon leakage or arbitrage opportunities. For instance, the economic health of the future US$1.4 trillion global green hydrogen market largely depends on the establishment of common rules and open trade routes for clean molecules.[39] In a world where the trade of hydrogen is limited by tensions or legal disharmony, market costs for green hydrogen can increase by as much as 25% on average.[39]

After Deloitte's *Financing the Green Energy Transition – A US$50 trillion catch* report called on stakeholders to share knowledge, this report urges for profound change in the green finance ecosystem. Project finance environments should be redesigned to assess the climate impacts of green and fossil-based projects, to help facilitate the flow of capital towards green projects and to scale up green markets. This rehauled green finance ecosystem could centralize and standardize financial assessments and decision-making to make use of the latest data analysis tools to help foster an affordable transition.

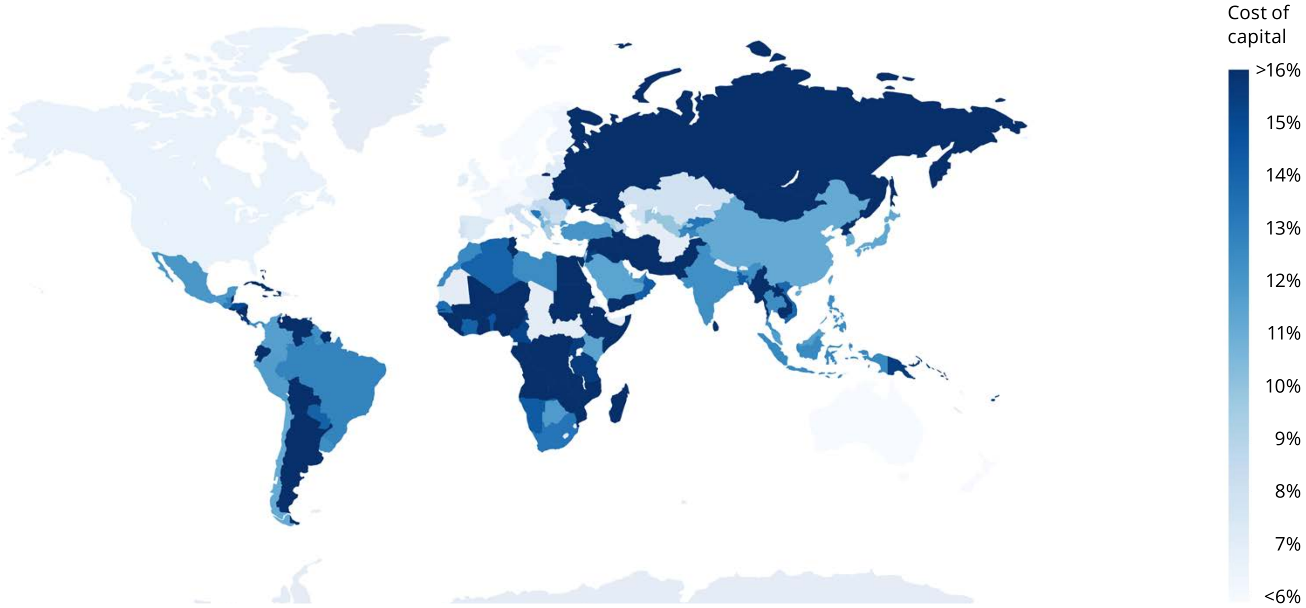
Appendices

Appendix 1. Cost of capital for wind technologies around the globe

Figures 23a and 23b show the current cost of capital values for onshore and offshore wind without de-risking measures around the globe. The cost of capital takes into account systemic risks (macro, political, currency, and regulatory risks) as well as micro risks (technical, performance, and market risks). Micro risks are higher for offshore wind compared to onshore wind, which explains the overall higher values for offshore wind.

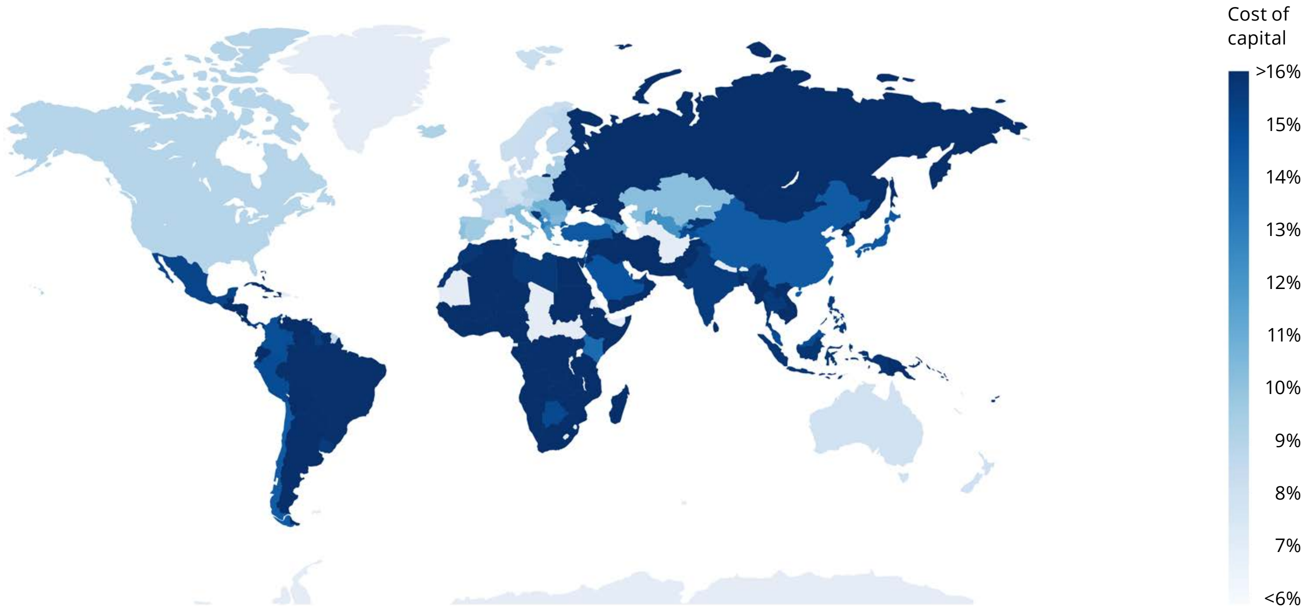
The de-risked cost of capital after implementation of de-risking measures for both offshore and onshore wind power projects can be observed in Figure 24. In an ideal future, these measures cover all the micro risks, eliminating the project-specific part of the cost of capital. Therefore, the remaining risks are linked to the macroeconomic conditions of the countries, that are the same for onshore and offshore wind. These maps highlight that the countries can be classified in three categories: (1) countries where projects already have relatively low cost of capital to unlock investments, (2) countries where micro de-risking instruments are sufficient to offer residual project risks that are low enough to attract investments, and (3) countries where both project and macro risks need to be de-risked.

Figure 23a. Cost of capital for onshore wind power plants



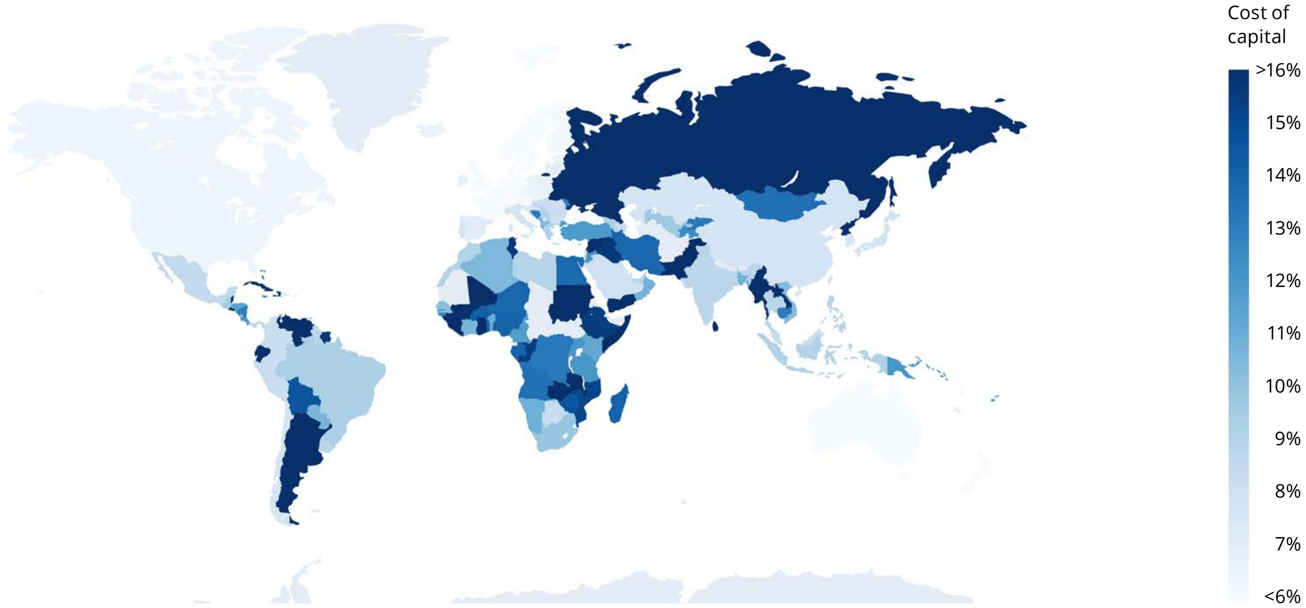
Source: Deloitte analysis[10]

Figure 23b. Cost of capital for offshore wind power plants



Source: Deloitte analysis[10]

Figure 24. Cost of capital for onshore and offshore wind after de-risking of project-level risks



Source: Deloitte analysis[10]

Appendix 2. Calculation of cost of capital

Cost of capital is a combination of the cost of debt and cost of equity. The average cost of capital is defined in Equation 1.

$$r = C_d * \delta + (1 - \delta) * C_e \quad \textbf{(Eq. 1)}$$

With C_d the cost of debt, C_e the cost of equity and δ the debt share (in % of total capital). Interest payments are often tax deductible.[114] The after-tax cost of capital (r_{at}) can be used to include the tax benefit on the debt in the cost of capital (Equation 2).

$$r_{at} = C_d * \delta * (1 - \tau) + (1 - \delta) * C_e \quad \textbf{(Eq. 2)}$$

With τ being the tax rate in the country.

The cost of capital translates the risk-return requirement by the lenders and shareholders; therefore, it depends on the risks of the project.

The literature widely uses financial market data to estimate the cost of debt and the cost of equity. To estimate the cost of equity, the capital asset pricing model (CAPM) has been used.[115] CAPM is one of the most widely used models to estimate the expected return on equity in the academic literature for renewable energy projects.[114] It is based on corporate financing structure, but it is one of the predominant ways to implement cost of capital values due to the complexity of retrieving project finance data for low-carbon assets. To estimate the cost of capital of a project, Equation 3 adapts the basic CAPM model to account for project risks:[116,117,118]

$$C_e = r_f + \beta * MRP + SP \quad \textbf{(Eq. 3)}$$

Where r_f is the risk-free premium, β is the elasticity of the asset return to the market return and it accounts for the volatility of the asset compared to the market returns as a whole, MRP is the market risk premium, and is calculated as $MRP = ERP + CRP$, with ERP the equity risk premium and CRP the country risk premium. SP is the "size premium" that accounts for a "company specific risk premium", which is a quantitative measure of the idiosyncratic risk.[119] In this application, represents the project-specific risk premium.

Using the CAPM methodology in emerging markets and in project finance means that the assessment is subject to the biases inherent to this type of modeling. Indeed, it relies heavily on public-listed companies, therefore not properly representing all companies. It can be hard to find the "best available proxy" for β and MRP data in emerging countries and finally, and as such, it is mostly used in corporate finance and not project finance.[120,121] The latter is the biggest drawback and limitation of this method since it uses financial data from listed companies rather than project data. The cost of capital can be different because other factors come into play: greater risks, higher debt costs, etc. However, it is still one of the most widely used and granular methods as it includes a big proportion of the identified risk premia in the cost of capital calculation. Adding the SP makes it suitable for estimation the cost of equity of the considered projects.

The cost of debt can be calculated using Equation 4.[114]

$$C_d = r_f + CDS + RE_{spread} \quad \textbf{(Eq. 4)}$$

Where CDS is the country default spread and RE_{spread} spread is the renewable energy project spread to include the risks linked to the renewable energy projects. The latter can be also considered as the additional margin required for renewable projects by the lenders.

Figure 25. Summary of assumptions to compute the cost of capital

Variable	Value	Source
r_f	4%	US 10-year treasury bonds[122]
ERP	5%	Computed using the implied ERP of the S&P 500 calculated against the 10Y US treasury bond from 1928 to today[123]
CRP and CDS	Country specific data	Damodaran dataset[124]
β	Levered beta of the "Green & Renewable Energy" sector: • Emerging economies: 1 • US: 1.6 • Europe and other developed economies: 0.91	Damodaran dataset[125]
RE_{spread}	4% in emerging economies 2% in developed economies	Scientific articles[66,126]

Source: Deloitte analysis based on the mentioned sources in the last column of the table

The SP is linked to the fact that the investments are considered at project level and not in a diversified portfolio. Therefore, computation of this value requires identification of the risks, quantification of them and measuring their impact on the required return expected by the investors. Company specific premium should account for any unsystematic risk that is not already captured in the other sentences of the CAPM equation. The main identified micro risks are offtaker risk, operational risks, production risk, construction cost overrun risk, and construction delay risk. Each of those risks are linked to the technology maturity level and their mitigation depends on the experience level.

To take into account the risks associated with renewable energy investments, the project-level risks can be calculated with Monte Carlo simulations, that is also the used method in the current analysis.[127,128,129,130] This method relies on a cash-flow modeling that incorporates the risk with uncertainty considering input data. The key metric used is the Internal Rate of Return (IRR).[131] The uncertainty is modeled with variable inputs that follow distribution functions. Each variable is assumed to have a normal uncertainty distribution and using relative standard deviation of them, the risk premia associated with the uncertainties are quantified. The uncertainty assumptions for the Monte Carlo simulation are summarized in Figure 26.

Figure 26. Summary of uncertainty assumptions for Monte Carlo simulation

	Standard deviation of construction delays (years)		Relative standard deviation of upfront cost overruns		Relative standard deviation of operation and maintenance cost		Relative standard deviation for uncertainty around energy production (capacity factor)	
Technology	*Advanced economies*	*Emerging economies*	*Advanced economies*	*Emerging economies*	*Advanced economies*	*Emerging economies*	*Advanced economies*	*Emerging economies**
Solar PV	0.08	0.13	1.3%	2%	2.2%	3.3%	2.5%	0.5%
Onshore wind	0.17	0.25	8%	12%	13%	20%	3%	1%
Offshore wind	2.60	3.9	10%	20%	17%	26%	5%	3%

Relative standard deviation on revenue from offtake contract	
Advanced economies	*Emerging economies*
0.1%	13%

Source: Deloitte analysis based on Callegari et al. (2018),[132] Sovacool et al. (2016),[133] Sovacool et al. (2014),[134] Kitzing (2014),[135] Rentschler et al. (2019),[136] Trabesinger[137].
(*): Include the reduced available produced energy to transport to an end consumer due to power outages.

To characterize the probabilities of occurrence, 2,000 scenarios are performed with random inputs adapted to their distribution function. Then, for each of the 2,000 scenarios, the IRR is retrieved. The value-at-risk (VaR) is a statistic that quantifies the extent of possible financial losses that could occur. Investor can require higher IRR to account for the potential losses induced by the materialization of risks and still meet their financial requirements. The considered VaR level in this assessment is VaR(80), which is the case where the 80th percentile of the risks are covered. It is defined by Equation 5.

$$VaR = IRR(P = 50\%) - IRR(P = 10\%) \quad \textbf{(Eq. 5)}$$

The calculated VaR level is then assumed to be equal to the project-specific micro risk (SP) as in Equation 6.

$$SP = VaR \quad \textbf{(Eq. 6)}$$

Applying this methodology allows to distinguish by technology and geography, and to study the learning curves of renewable energy and green hydrogen projects by adding a dynamic evolution to the volatility used. Additional assumptions regarding the quantitative impact of different de-risking instruments on the cost of capital of green projects are detailed in Figure 27.

Figure 27. Additional assumptions to assess the effectiveness of de-risking instruments on the cost of capital calculation

Instrument	Effect	Variable impact
Climate and energy strategies and green taxonomies	Decrease the correlation of the sector with the market	β is decreased to reach β of the power sector[125]
	RE_{spread} decreases because the environment is less risky	RE_{spread} is decreased by 1%[66]
Network planning and grid access	No additional risk linked to delay in start of operation	Construction delays is modeled with an additional 6-month delay
Offtake contracts	Decrease revenue risk and price volatility	Decrease revenue uncertainty to 0%
Tax incentives	Increase the revenue and improve the liquidity	Additional revenue of US$26/MWh without uncertainty[138] The share of debt is increased by 5%
	Reduce the relative volatility of revenue uncertainty	Revenue risk reduced by 30%
Political risk insurance	Reduce CRP and CDS	Decrease CRP and CDS to zero
Performance guarantee	Reduce uncertainties regarding construction delays, upfront cost overruns, energy production (capacity factor uncertainty), operation and maintenance cost uncertainty	Decrease micro risk (except for revenue risk) to zero
Grants	Cover 20% of the required capital	Reduce the cost of capital by decreasing the share of debt and the share of equity, while keeping the equity debt ratio constant
Concessional loans	Provide debt at below market rate	Decrease the share of commercial debt by the share of concessional loan
Junior equity	Act as a capped guarantee against all risk of default on equity	Reduce micro risks and country risk premium in the calculation of the cost of equity to zero for the share of equity that junior equity represents

Source: Deloitte analysis based on the sources mentioned in the explanation of each of the elements in Appendix 2

Financing conditions for renewable energy investments have evolved over time thanks to financial learning and the enhanced risk perception on the renewable investments.[66,126,139] Figure 28 summarizes the assumptions made to model the evolution of the cost of capital over time for both developed and developing economies.

The evolution of the whole macroeconomic environment (political risk, currency risk, etc.) are out of the scope of this analysis and it has been considered the same as 2023 values for the whole assessment period.

Figure 28. Assumptions regarding the financial learning of renewable and green projects

Geography	Assumption made
Developed economies	By 2040, the SP for solar PV in developed economies reaches an asymptote of 80% of its 2023 value.
	By 2040, the SP for onshore wind reaches the value of the SP of solar PV in 2023, based on the assumption that the technology will reach the same maturity. After 2040, the SP of onshore wind follows the same evolution as solar PV after 2023.
	By 2040, the SP for offshore wind reaches the value of the SP of onshore wind in 2023. After 2040, the SP of offshore wind follows the same evolution as onshore wind after 2023.
	By 2040, the renewable energy margin required by lenders (RE_{spread}) reaches an asymptote of 50% of the value of 2023 for all technologies.
Developing economies	By 2040, the SP reaches the value of developed economies in 2023. After 2040, the evolution is similar to the one for developed economies between 2023 and 2030.
	The RE_{spread} value decreases by 50% between 2023 and 2040 for all technologies, to reach the 2023 level of developed economies. After 2040, it follows the same evolution as in developed economies after 2023.

Source: Deloitte own assumptions based on the existing statistics of financial learning mentioned in Sections 4 and 5

Appendix 3. Calculation of levelized cost of electricity and hydrogen

Equation 7 shows the calculation of levelized cost of hydrogen (LCOH) and electricity (LCOE).

$$LCO(H \text{ or } E) = \frac{CAPEX + \sum_{t=1}^{lf} \frac{OPEX_{fixed,t} + OPEX_{var,t} \times E_t}{(1+WACC_t)^t}}{\sum_{t=1}^{lf} \frac{E_t}{(1+WACC_t)^t}} \qquad \textbf{(Eq. 7)}$$

Where $CAPEX$ is the overnight costs (investments at the beginning of the project), $OPEX_{fixed,t}$ is the fixed operation and maintenance cost 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 effect of on the overall reduction in LCOH is shown in Equation 8.

$$LCOH_{pr} = \frac{CAPEX + \sum_{t=1}^{lf} \frac{OPEX_{fixed,t} + OPEX_{var,t} \times E_t - H_2 pr \times E_t}{(1+WACC_t)^t}}{\sum_{t=1}^{lf} \frac{E_t}{(1+WACC_t)^t}} \qquad \textbf{(Eq. 8)}$$

On the contrary, the investment support ($Inv\_support$) is given at year 0, which has no depreciation impact because of the interest rates. Including this support in the LCOH leads to Equation 9.

$$LCOH_{inv} = \frac{CAPEX - Inv\_support + \sum_{t=1}^{lf} \frac{OPEX_{fixed,t} + OPEX_{var,t} \times E_t}{(1+WACC_t)^t}}{\sum_{t=1}^{lf} \frac{E_t}{(1+WACC_t)^t}} \quad \textbf{(Eq. 9)}$$

The key techno-economic parameters of hydrogen production and renewable power production technologies (geography-specific) are summarized in Figure 29 and Figure 30.

Figure 29. Techno-economic parameters of hydrogen production technologies

Technology	Efficiency	Lifetime	Overnight cost	Variable O&M costs	Fixed O&M cost
Solar PV	100%	25	740 US$/$MW_e$	0 US$/$MWh_e$	16 US$/$MW_e$
Alkaline electrolyzers	62.5%	20	904 US$/$MW_e$	0.53 US$/$MWh_e$	13.6 US$/$MW_e$

Source: Deloitte calculations (2023)[5]

Figure 30. Country specific techno-economic parameters of energy technologies

Technology	Lifetime	Overnight cost	O&M cost
Offshore wind in Europe	25	2,500 US$$_{2022}$/ MW_e	69 US$$_{2022}$/$MW_e$
Onshore wind in South America	25	1,418 US$$_{2022}$/ MW_e	25 US$$_{2022}$/$MW_e$
Solar PV in Indonesia	25	962 US$$_{2022}$/ MW_e	13.2 US$$_{2022}$/$MW_e$

Source: Based on IRENA (2022)[140]

Appendix 4. Calculation of economic efficiency of de-risking instruments

Assessing the efficiency of financial instruments requires a cost-benefit analysis on the cost of the instrument to the society (public cost) and the cost reduction it entails. To do so, an onshore wind project in Uruguay has been considered as a case study. While Uruguay is categorized as a developing economy, from a political environment perspective it is highly stable, and the renewables, especially onshore wind power, have experienced significant uptake in the last two decades there. Therefore, the onshore wind market in Uruguay can be considered in a relatively high development level. An extreme case study can overestimate (in case of underdeveloped economy and market) or underestimate (a highly developed economy with scaled of renewable market) the average gains from different de-risking instruments.

For each financial instrument, two scenarios are considered: one without the instrument and one with the instrument. Public and private costs as well as the net present value of the project is calculated based on the assumptions summarized in Figure 31. Equation 10 shows the calculation of the efficiency of each instrument, which is the difference between the NPV of the project in two scenarios, divided by the public cost of the instrument.

Figure 31. Assumptions for the calculation of the efficiency of financial instruments

Instrument name	Assumptions	Source
Revenue guarantee	***Private costs*** Upfront charges: 50 bp (processing) + 15 bp (initiation). Recurring charges per annum: 75 bp (guarantee). ***Public cost*** 10% loss reserve of the revenue stream.	The World Bank[141]
Tax incentive	***Public cost*** 100% of the tax incentive, that is assumed to be 2.6ct/kWh for 10 years.	Database of State Incentives for Renewables & Efficiency (DSIRE)[138]
Performance guarantee	***Private costs*** Upfront charges: 50 bp (processing) + 15 bp (initiation). Recurring charges per annum: 75bp (guarantee). ***Public cost*** 10% loss reserve of the debt and equity amount covered.	The World Bank[141]
Political risk guarantee	Assumes covering equity holders and debt tenors. ***Private cost*** 0.2% front end fee and 1% premium payment calculated annually. ***Public cost*** Assumes the public cost is 10% (loss reserve) of the equity and debt amounts covered.	United Nations Development Program[9]
Grant	***Public cost*** 100% of the grant.	Deloitte assumption based on the definition.
Concessional loan	***Public cost*** Upper bond: 20% of initial CAPEX is covered by a concessional loan at 1% of cost of debt. Lower bond: 20% of initial CAPEX is covered by a concessional loan at 1% but with a 10% loss reserve on the debt amount covered.	Abu Dhabi Fund for Development & International Renewable Energy Agency[142]
Junior equity	***Public cost*** Assumes the public cost is 30% (loss reserve) of the equity amount covered.	Deloitte assumption based on the definition.

Source: Adjustment based on the sources in the last column

$$\eta = \frac{NPV_{derisk} - NPV_{BAU}}{Public\_cost}$$ **(Eq. 10)**

Where η is the efficiency of the instrument, NPV_{BAU} is the net present value of the business-as-usual scenario, without any de-risking, NPV_{derisk} is the net present value of the project with the financial de-risking instruments, and $Public\_cost$ is the total public money spent for the implementation of the considered instrument. Private costs, if they exist, are additional costs to the project developer and they are included in the calculation of the NPV of the projects.

The NPV of each scenario of the case study is determined by calculating the costs (negative cash flows) and revenues (positive cash flows) for each year over the facility's lifetime. Equation 11 discounts the future cash flows of the considered project to represent the real time value of the considered currency (US$).

$$NPV = \sum_{t=0}^{lf} \frac{B_t}{(1+WACC)^t} - \sum_{t=0}^{lf} \frac{C_t}{(1+WACC)^t}$$ **(Eq. 11)**

Where B_t is the benefit or cash inflow at each year t, and C_t is the cost or cash outflow at the same year. The benefits are calculated by multiplying the sold quantity by the reference market price, while the costs are the sum of capital and fixed and variable operational and maintenance costs, the loan reimbursements, and the taxes.

Appendix 5. Calculation of cost reduction due to refinancing

Refinancing is the process by which new investors and lenders can get involved in the financing structure of a clean project, after the initial financing allocation. More precisely, new funders provide new capital that can replace initially allocated equity and debt, at lower costs. Practically, the project developer pays back its initial (and more expensive) debt and (potentially) equity earlier and "replaces" it with cheaper capital, and thus lower the associated financing costs.

Cost of capital r can be calculated as in Equation 12:

$$r_{k,l} = (1 - \delta) * C_{e,k} + \delta * C_{d,l}$$ **(Eq. 12)**

where δ is the share of debt, $C_{d,l}$ is the cost of debt after tax associated to a debt instrument contracted in the year l and $C_{e,k}$ is the cost of equity for an equity instrument contracted in the year k. As a result, $r_{k,l}$ is the composite cost of capital resulting from a financing structure involving debt and equity instruments contracted in two different years. For example, $r_{2023,2026}$ is the cost of capital resulting from a financing structure relying on loans contracted in 2026 but where the equity instruments were contracted in 2023. The two years can be different in case of refinancing. It means in the previous example that the loans contracted in 2026 are used to pay back the previous more expensive loans.

Three different scenarios are considered: a benchmark without refinancing, a situation where refinancing is enabled only for debt and a last scenario where refinancing is unlocked for all the capital input: debt and equity.

The temporal evolution of cost of capital comes from the cost of capital calculator (see Appendix 1). The debt and the renewable energy project spread are assumed equal as only clean projects are considered in this assessment. The cost of equity, and especially the small company premium (SP) was available only for PV, onshore and offshore wind. An average of this value is assumed to be a good proxy for the SP of other clean technologies.

With no refinancing

The benchmark scenario is the case without any refinancing process. It means that the funders remain the same during all the project duration, and the costs of debt and equity remain the initially agreed values. Equations 13a and 13b show the annuity $A_{i,j}$ for this case:

$$A_{i,j} = \frac{r_{i,i} * \mathrm{CAPEX_i} * (r_{i,i} * CT_i + 1)}{1 - (1 + r_{i,i})^{-LT_i}}, \qquad j - i < LT_i \text{ and } \forall i < j \qquad \textbf{(Eq. 13a)}$$

$$A_{i,j} = 0, \qquad \text{otherwise} \qquad \textbf{(Eq. 13b)}$$

with i the year when the project starts operation, j the year of payment, and where $\mathrm{CAPEX_i}$ is the amount of capital expenditure necessary for this project, CT_i is the project construction time, and LT_i is the project lifetime for a project launched in year i. The debt is paid back during the whole project operation time (the maturity of the instrument is the same as the project lifetime).

The quantity $\mathrm{CAPEX_i} * r_{i,i} * CT_i$ represents the interests accumulated during the construction time. It means that the quantity $\mathrm{CAPEX_i} * (r_{i,i} * CT_i + 1)$ represents the total amount of capital provided by funders.

With only debt refinancing

This case represents the highest debt refinancing potential, i.e., upper theoretical limit of debt refinancing. To do so, the annual cost of capital reduction that is found in the cost of capital calculation in Appendix 2 is considered as the starting point. The underlying assumption of this case is that refinancing affects only the cost of debt. It means that the investors remain the same during the whole project lifetime, but the lenders can change thanks to debt re-selling. Each year, the maturity of the new instruments is reduced by one year, and the amount of capital provided by the lenders is reduced by the amount repaid during the previous year. Thus, the payment period remains the same as the remaining lifetime of the project.

For the annuities in this case are calculated following Equations 14a and 14b:

$$A_{i,j} = \frac{r_{i,j} * C_{i,j}}{1 - (1 + r_{i,j})^{-lt_i + j - i}}, \qquad j - i < lt_i \text{ and } \forall i < j \qquad \textbf{(Eq. 14a)}$$

$$A_{i,j} = 0, \qquad \text{otherwise} \qquad \textbf{(Eq. 14b)}$$

Where i is the year when the project starts operation, j the is the year of debt repayment, and lt_i is the project lifetime for a project launched in year i. $C_{i,j}$ is the amount of capital provided by the new funders in year j for a project launched in year i, that is calculated as in Equation 15.

$$C_{i,j} = \mathrm{CAPEX_i} * (r_{i,i} * ct_i + 1) - \sum_{k=1}^{j-1} P_{i,k}^{0} \qquad \textbf{(Eq. 15)}$$

Where i is the project operation start year, j is the year of debt repayment, $\mathrm{CAPEX_i}$ is the amount of capital expenditure necessary for this project, and ct_i is the project construction time. $r_{i,i}$ is the cost of capital of the year i and $P_{i,k}^{0}$ is the first capital repayment for a project launched in year i and refinanced in year k. Equation 16 shows its calculation:

$$P_{i,k}^{0} = A_{i,k} - r_{i,k} * C_{i,k}, \qquad k \in [\![i, i + lt_i]\!] \qquad \textbf{(Eq. 16)}$$

Therefore, the amount of capital provided by the new funders can be calculated via Equations 17a and 17b.

$$C_{i,j} = C_{i,j-1} * \left(1 + r_{i,j-1}\right) - A_{i,j-1}, \qquad j \in [\![i+1, i+lt_i]\!]$$ **(Eq. 17a)**

$$C_{i,i} = \mathrm{CAPEX_i} * \left(r_{i,i} * ct_i + 1\right)$$ **(Eq. 17b)**

With both debt and equity refinancing

In this case, the project developer can benefit from both debt and equity refinancing, leading to reduction in the cost of not only debt but also equity. It means that not only the debt can be bought or renegotiated for lower cost of debt, but also the investor can be replaced during the project life. It can happen, for example, since some institutional actors are more likely to invest in brownfield assets than in greenfield ones.

The reasoning remains the same as in the calculations for the previous case. Annuities and yearly new capital provision can be calculated as in Equations 18 and 19.

$$A_{i,j} = \frac{r_{j,j} * C_{i,j}}{1-\left(1+r_{j,j}\right)^{-lt_i+j-i}}, \qquad j - i < lt_i \text{ and } \forall i < j$$ **(Eq. 18a)**

$$A_{i,j} = 0, \qquad \text{otherwise}$$ **(Eq. 18b)**

$$C_{i,j} = C_{i,j-1} * \left(1 + r_{j-1,j-1}\right) - A_{i,j-1}, \qquad j \in [\![i+1, i+lt_i]\!]$$ **(Eq. 19a)**

$$C_{i,i} = \mathrm{CAPEX_i} * \left(r_{i,i} * ct_i + 1\right)$$ **(Eq. 19b)**

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