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Mobilizing Climate Finance

Public Financial Instruments, Risk-Sharing, and Fiscal Sustainability in the Green Transition

Tillväxtanalys
Myndigheten för tillväxtpolitiska utvärderingar och analyser

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Förord

Tillväxtanalys uppdrag är att utvärdera och analysera effekterna av statens insatser för en hållbar nationell och regional tillväxt. Vi ska också ge underlag och rekommendationer för utveckling, omprövning och effektivisering av politiken.

Syftet med den här rapporten är att analysera hur offentliga finansiella instrument kan stödja klimatomställning och industriell omställning samtidigt som statens riskexponering begränsas och den finanspolitiska hållbarheten upprätthålls. Rapporten är skriven av Hossein Asgharian, professor vid Lunds universitet.

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Abbreviations

Abbreviation	Definition
ARC	African Risk Capacity
CAT	Catastrophe
CCfD	Carbon Contract-for-Difference
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CIF	Climate Investment Funds
CO_2	Carbon Dioxide
tCO_2e	Ton CO_2 equivalent
COP29	29th Conference of the Parties to the UN Framework Convention on Climate Change
CPI	Climate Policy Initiative
CRS	Creditor Reporting System
DFI	Development Finance Institution
EBA	Expert Group for Aid Studies (Sweden)
EBRD	European Bank for Reconstruction and Development
EEA	European Environment Agency
EIB	European Investment Bank
EKN	Swedish Export Credit Agency
ESG	Environmental, Social, and Governance
ETS	Emissions Trading System
EU	European Union
EU27	The 27 member states of the European Union
FIT	Feed-in Tariff
FLF	First-Loss Facility
GAIP	Global Asia Insurance Partnership
GDP	Gross Domestic Product
GET FiT	Global Energy Transfer Feed-in Tariff Program
GHG	Greenhouse Gas
GovVC	Government Venture Capital
HYBRIT	Hydrogen Breakthrough Ironmaking Technology
FSI-IAIS	Financial Stability Institute and International Association of Insurance Supervisors.
ICAP	International Carbon Action Partnership
ICMA	International Capital Market Association
IDA	International Development Association
IBRD	International Bank for Reconstruction and Development
ICE	Intercontinental Exchange
IFC	International Finance Corporation
IEA	International Energy Agency
ILO	International Labour Organization
IMF	International Monetary Fund

Abbreviation	Definition
KPI	Key Performance Indicator
KfW	Kreditanstalt für Wiederaufbau (German Development Bank)
LSFI	Luxembourg Sustainable Finance Initiative
MIGA	Multilateral Investment Guarantee Agency
MRV	Monitoring, Reporting, and Verification
Abbreviation	**Definition**
NEFCO	Nordic Environment Finance Corporation
NIB	Nordic Investment Bank
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
PPP	Public-Private Partnership
R&D	Research and Development
RBF	Results-Based Financing
Sida	Swedish International Development Cooperation Agency
SLB	Sustainability-Linked Bond
SLL	Sustainability-Linked Loan
SPV	Special Purpose Vehicle
TCFD	Task Force on Climate-related Financial Disclosures
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VC	Venture Capital
VGF	Viability Gap Funding

Sammanfattning

Allt mer ambitiösa klimatmål inom EU och Sveriges omställning till nettonollutsläpp av växthusgaser kräver storskaliga investeringar som präglas av teknisk osäkerhet, långa tidshorisonter och betydande finansieringshinder. Offentliga insatser är nödvändiga för att möta dessa utmaningar, men de exponerar samtidigt staten för såväl finansiella som icke-finansiella risker.

Syftet med denna rapport är att analysera hur offentliga finansiella instrument kan stödja klimatomställningen och industrins utfasning av fossila utsläpp, samtidigt som statens riskexponering begränsas och den finanspolitiska hållbarheten upprätthålls. För detta ändamål utvecklar rapporten en analytiskt ansats som kombinerar en genomgång av forskningslitteratur, policydokument och empiriska studier med deskriptiv kvantitativ analys av svenska klimatfinansieringsinstrument i internationell jämförelse. Rapporten behandlar ett brett spektrum av instrument, däribland bidrag, lån, ägarkapital, garantier, blandfinansiering och gröna obligationer.

Analysen visar att inget enskilt instrument är optimalt i alla lägen. En effektiv klimatfinansiering förutsätter i stället att instrumenten anpassas till projektens egenskaper, att riskdelningen mellan offentliga och privata aktörer är väl avvägd och att avtalsvillkoren utformas så att incitamenten bevaras och den offentliga exponeringen begränsas. Genomgången av Sveriges klimatfinansiering visar på både styrkor och utmaningar. Sverige kombinerar koldioxidpriser som hör till de högsta i världen, och som i första hand fungerar styrande snarare än intäktshöjande, med en bred uppsättning investeringsstöd. Stödet bygger i hög grad på direkt offentligt kapital i form av bidrag, lån och ägarkapital, vilket ger en relativt förutsägbar finanspolitisk exponering men begränsad hävstångseffekt. Samtidigt har dessa instrument i ökande utsträckning kompletterats med garantier och andra riskdelningsinstrument som syftar till att mobilisera privat kapital. Sådana instrument kan öka investeringskapaciteten, men de medför också ansvarsförbindelser och betydande nedåtrisker för staten.

Utifrån dessa resultat lämnar rapporten rekommendationer om val av instrument, instrumentens utformning och hanteringen av den samlade exponeringen. Rapporten betonar vikten av att offentligt stöd anpassas till projektens egenskaper och de finansieringshinder som dessa ger upphov till, att riskdelningsmekanismer och avtalsvillkor kalibreras så att privata aktörer behåller en reell riskexponering, samt att ett portföljperspektiv anläggs som beaktar den ackumulerade exponeringen över instrument och projekt, med stöd av förbättrad samordning mellan offentliga aktörer och systematisk utvärdering av stödprogrammen. Målet är inte att eliminera risk, utan att fördela den effektivt på ett sätt som möjliggör klimatinvesteringar och samtidigt värnar den finanspolitiska hållbarheten.

Rapporten bidrar till forskningen om klimatpolitik genom att fokusera på offentliga finansiella instrument, riskfördelningen mellan offentliga och privata aktörer samt konsekvenserna för finanspolitisk hållbarhet och statens riskhantering, illustrerat genom en fördjupad analys av det svenska fallet.

Summary

Increasingly ambitious climate targets within the European Union and Sweden's transition toward net-zero greenhouse gas emissions require large-scale investment under conditions of technological uncertainty, long-term horizons, and significant financing constraints. While public intervention is necessary to address these challenges, it also exposes governments to fiscal and non-financial risks.

This report aims to analyze how public financial instruments can support climate action and industrial decarbonization while limiting public risk exposure and maintaining fiscal sustainability. To this end, it develops a risk-aware analytical approach, combining a review of academic literature, policy documents, and empirical studies with descriptive quantitative analysis of Swedish climate finance policies and instruments in an international comparative context. The report examines a broad range of instruments, including grants, loans, equity, guarantees, blended finance mechanisms, and green bonds.

The analysis shows that no single instrument is universally optimal. Effective climate finance instead requires aligning instruments with project characteristics, ensuring appropriate risk-sharing, and carefully designing contractual features to manage incentives and limit public exposure. The review of Sweden's climate finance framework illustrates both strengths and challenges. Sweden combines carbon prices that are among the highest in the world, functioning primarily as a regulatory rather than a revenue-raising tool, with a broad set of investment support programs. It relies extensively on direct public capital through grants, loans, and equity, resulting in relatively predictable fiscal exposure but limited financial leverage. At the same time, Sweden has increasingly complemented these instruments with guarantees and other risk-sharing mechanisms aimed at mobilizing private capital. While such instruments can expand investment capacity, they also introduce contingent liabilities and significant downside risks.

Based on these findings, the report develops policy recommendations on instrument selection, instrument design, and the management of aggregate exposure. It emphasizes aligning public support with project characteristics and the financing constraints they give rise to; calibrating risk-sharing mechanisms and contractual design so that private actors retain meaningful exposure to risk; and adopting a portfolio perspective that accounts for cumulative exposure across instruments and projects, supported by improved coordination across public actors and systematic evaluation of support programs. The objective is not to eliminate risk, but to allocate it efficiently in ways that enable climate investment while maintaining fiscal sustainability.

The report contributes to existing research on climate policy by focusing on public financial instruments, the allocation of risk between public and private actors, and the implications for fiscal sustainability and public-sector risk management, illustrated by an in-depth analysis of the Swedish case.

1. Introduction

Addressing climate change has evolved from global recognition to concrete legal commitments, as reflected in milestones such as the Kyoto Protocol, the Paris Agreement, and the European Union (EU) Climate Law. In 2026, the European Union adopted a binding 2040 milestone to reduce net greenhouse gas (GHG) emissions by 90% compared to 1990 levels, updating an earlier proposal put forward by the European Commission in July 2025. This represents a significant acceleration from the previous 2030 target of a 55% reduction and creates a clearer pathway towards climate neutrality by 2050. This target is aligned with the European Commission's broader policy agenda, including the Clean Industrial Deal, which aims to make decarbonization a driver of growth by helping energy-intensive industries shift to cleaner production, strengthening the clean-tech sector as a key source of competitiveness, and promoting circular use of materials to reduce dependence on imported resources (European Commission, 2025a; European Commission, 2026). Meeting these commitments will require investment on a scale that raises fundamental questions about the respective roles of markets and the state.

1.1 Economic Rationale for Government Intervention

Clean technologies encompass a wide range of solutions that reduce environmental impacts, including renewable energy, green hydrogen, sustainable fuels, advanced materials, energy storage, and digital optimization technologies (IEA, 2020; European Parliamentary Research Service, 2025). Deploying these technologies at the scale required for industrial decarbonization depends on sustained research and development (R&D), substantial capital investment, the expansion of supporting infrastructure, and a workforce capable of adapting to new technologies and production processes (OECD, 2018; ILO, 2019; Keese and Marcolin, 2023).

The scale and complexity of this transformation raise the question of whether markets alone can deliver the required pace and magnitude of investment. Several well-documented market failures indicate that private investment alone will fall short. First, greenhouse gas emissions generate environmental externalities, imposing costs on society that are not fully reflected in market prices; these are primarily addressed through carbon pricing (Stern and Stiglitz, 2023).

Second, innovation activities often generate knowledge spillovers. Because firms cannot capture all the benefits created by their innovation, private incentives to invest in R&D are weaker than what is socially desirable, strengthening the case for public support (Armitage et al., 2024).

Third, some climate-related investments are characterized by coordination failures and network externalities, where the value of investments in charging infrastructure, hydrogen networks, or other enabling systems depends on complementary investments by other actors, making private investors reluctant to commit unless supporting infrastructure and markets develop simultaneously (Stern and Stiglitz, 2023).

Fourth, certain climate-related investments, particularly in network infrastructure such as electricity transmission grids and rail systems, may have natural monopoly characteristics, where large fixed costs and economies of scale limit competition and create a role for public financing or ownership (Mosca, 2008).

Finally, and most relevant for this report, market failures also arise from information asymmetries and financing frictions, which directly affect the ability to mobilize private capital for the green transition. Green technologies tend to be more complex and more novel than non-green ones (Barbieri et al., 2020), making them harder for investors to evaluate, and cleantech firms often face high policy dependence, capital intensity, and long commercialization horizons (Migendt et al., 2017). As a result, green innovations face severe financing constraints, especially in their early stages, driven by unproven technologies, uncertain markets, regulatory unpredictability, and return profiles that do not justify the perceived level of risk, and green start-ups remain strongly dependent on public funding despite the growth of private finance options (Mukherjee et al., 2024; see also Campiglio et al., 2024).

These failures create a role for governments in supporting innovation, providing stable policy frameworks and coordinated infrastructure development, and regulating or financing natural-monopoly networks. In particular, they motivate strengthening the financial ecosystem where information asymmetries constrain private capital, including through green finance taxonomies and improved access to climate finance for smaller firms (European Commission, 2025b).

While the financing-related market failures justify public intervention, they do not imply that the public sector should absorb risk without limits. The central policy challenge is therefore to design financial support that addresses financing constraints while maintaining appropriate risk-sharing between public and private actors and ensuring fiscal sustainability. If the state absorbs too much risk, it may weaken incentives for efficient project selection and risk management, increase moral hazard, and place unnecessary pressure on public finances. Conversely, if public support is too limited, key financing constraints may remain unresolved, preventing socially desirable investments from taking place.

1.2 Purpose, scope and contribution

Against this background, the aim of this report is to analyze how public financial instruments can support climate action and industrial decarbonization while limiting public risk exposure and maintaining fiscal sustainability, with a particular focus on Sweden. More specifically, the report addresses three questions: which policy and financial instruments are available to the public sector for supporting climate-related investment; which dimensions of projects and instruments should guide instrument choice and design; and how instruments should be selected, designed, and managed in aggregate to mobilize private capital while containing public risk.

The report focuses on public financial instruments that support climate-related investments through the provision of capital, risk-sharing, and financial incentives. Broader policy and regulatory instruments, whether they rely on monetary flows, such as carbon pricing and policy-based subsidies, or on rules and information, such as permitting processes and disclosure requirements, are covered as part of the policy landscape, but they are not the object of the report's analytical framework and recommendations. Other policy tools, such as public procurement and skills and labor-market policies, fall outside the scope of the report, as do private-to-private climate

finance markets, including voluntary carbon markets, renewable energy certificates, and specialized carbon-credit investment vehicles.

The report contributes in three ways. First, it draws on the climate finance, public finance, and public investment literatures to construct a common framework for assessing public financial instruments, allowing a broad range of instruments to be compared along the same analytical dimensions. Second, it gives explicit attention to the public-sector side of climate finance: instruments are assessed not only by their capacity to mobilize private capital but also by how they allocate risk between public and private actors and by their fiscal implications. Third, it provides a systematic overview of Sweden's climate finance instruments in an international comparison and applies the framework to derive policy recommendations on instrument selection, instrument design, and the management of aggregate exposure.

1.3 Approach

The report combines a qualitative review of academic literature, policy documents, and empirical studies on climate finance instruments with descriptive quantitative analysis. The review builds on theoretical insights and evidence from international practice, as well as Swedish government and agency materials documenting how these instruments are applied in Sweden. The quantitative analysis examines the use and composition of climate finance instruments in Sweden and compares these patterns with other countries, using data from a range of international sources, including the World Bank's carbon pricing database, the OECD, and the Sustainable Bonds Database.

The report starts with an overview of the main instruments available to the public sector to meet its climate goals: policy instruments such as carbon pricing; public financing tools, including grants, loans, and equity; risk-sharing instruments such as guarantees and contingent finance instruments; and market-based instruments for raising private capital, such as green bonds. The report then examines how these instruments have been used in Sweden to support domestic climate investments and to provide international climate finance, and places Sweden's approach in an international comparison.

Based on these overviews, the report distinguishes the key factors shaping instrument selection and design. The analysis considers both the policy and institutional conditions that may constrain instrument choice and the characteristics of projects and instruments. Instruments are then compared in terms of their respective advantages and limitations, including their capacity to mobilize private capital and their implications for public risk. Finally, we analyze how instrument selection and design can support climate investment while maintaining fiscal sustainability.

The analysis is descriptive and comparative in nature. It maps the use, composition, and design of climate finance instruments, rather than providing causal evaluations of individual programs, which lies beyond the scope of this report.

1.4 Main Findings

Our Swedish case study shows that Sweden combines long-standing carbon prices that are among the highest globally with a broad set of investment programs. Domestic climate action and industrial transition are financed mainly through non-repayable support schemes for industry and local actors, complemented by state-backed equity

funds, export and green loan facilities, credit guarantees for large green industrial projects, and fully public investment in critical transport and energy infrastructure such as rail and electricity grids. Sweden also has an active green bond market, with issuance dominated by private actors and complemented by municipalities and public agencies, while the central government's role as a green bond issuer remains limited. On the international side, Sweden provides substantial climate finance for mitigation and adaptation, mostly in the form of grants and contributions to multilateral climate funds, and ranks among the top Organization for Economic Co-operation and Development (OECD) climate donors relative to the size of its economy.

Overall, our analysis shows that Sweden is among the OECD's top performers in reducing GHG emissions. Sweden's carbon intensity is among the lowest in the OECD, and the country is in the leading group for renewable energy use.

Our comparative review of instruments shows that they differ in key characteristics, including the degree of control and information they provide to the public sector, their capacity to mobilize private capital, and how they expose the public sector to different types of financial and non-financial risks, and that each type involves distinct costs and benefits. The suitability of an instrument also depends on the characteristics of the project being supported, such as stage of development, scale and capital intensity, and commercial and operational risk. No single instrument is therefore universally optimal. Where instrument choice is not dictated by policy mandates or the nature of the investment, the appropriate choice depends on how well the instrument's characteristics fit those of the project. For example, early-stage, high-risk innovation typically calls for instruments that absorb risk, such as grants and equity, while more mature projects with revenue potential can be supported through instruments that leverage private capital, such as loans and guarantees.

The analysis further shows that instrument design is a key determinant of how risks are allocated, limited, and monitored over time, and that design matters even where policy mandates constrain the choice of instrument. Four design considerations emerge. Public support should be linked to project performance, through features such as milestone-based disbursement, ex-post evaluation, and clawback provisions. It should preserve private risk-sharing, with pricing, coverage ratios, and co-financing requirements calibrated so that private actors retain meaningful exposure. Governance and monitoring arrangements should be aligned with the nature of the instrument and the risks involved. Finally, support should not become permanent where market-based financing is viable, which calls for exit strategies and declining concessionality.

Finally, the report shows that fiscal risks must be assessed not only at the level of individual instruments, but also in aggregate. The combination of multiple instruments across projects and sectors may lead to cumulative exposure and correlated risks that are not visible when instruments are evaluated in isolation. In addition, the assessment of aggregate exposure should take into account how investments are financed, as the choice and design of fund-raising instruments affect when fiscal exposure materializes.

1.5 Outline

The remainder of the report is organized as follows. Chapter 2 outlines the key policy and regulatory frameworks that support climate action, focusing on carbon pricing

mechanisms such as carbon taxes and emissions trading systems (ETS), as well as policy-based subsidies and non-financial policy instruments. Chapter 3 explores instruments for direct financial support, such as grants, public loans, and equity, that play a central role in funding low-carbon investments. Chapter 4 analyzes blended finance structures and risk-sharing mechanisms that facilitate public–private collaboration, emphasizing how public participation can reduce risks for private investors. Chapter 5 discusses market-based instruments used to raise private capital for climate initiatives, including green bonds, transition bonds, and sustainability-linked bonds. Chapter 6 examines carbon pricing and public climate finance in Sweden, including the country's international climate contributions, and compares Sweden's approach with other countries. Chapter 7 classifies the key decision factors for instrument selection and design and examines how these relate to risk allocation and fiscal exposure, as well as the role of fund-raising instruments such as green bonds. Chapter 8 applies this analytical structure to the Swedish context to derive policy recommendations on instrument selection, instrument design, and the management of aggregate exposure. Chapter 9 summarizes and

2. Policy and Regulatory Frameworks

An effective regulatory framework is important for enabling investment, managing risk, and aligning financial flows with policy objectives. This chapter describes the main policy and regulatory instruments. Some involve monetary flows, such as carbon pricing, which imposes a cost on emissions, and subsidies, which confer financial support. Others, such as permitting processes, performance standards, and disclosure requirements, are non-financial and work through rules and information.

2.1 Carbon Pricing

Carbon pricing is one of the important elements of modern climate policy (OECD, 2018). By assigning a monetary cost to GHG emissions, it internalizes the environmental damage of climate change and creates financial incentives to reduce emissions. This section explores the main types of carbon pricing, including carbon taxes and ETS, with a focus on their core design elements, strengths, and limitations.

2.1.1 Carbon Taxes

A carbon tax sets a fixed price per ton of Carbon Dioxide (CO_2) or CO_2-equivalent emissions and is typically imposed either on fossil fuel consumption or directly on emissions from sectors such as industry and transport (Metcalf and Weisbach, 2009). The key strength of a carbon tax is that it provides price certainty, enabling businesses, industries, and households to anticipate future energy costs when making decisions about investments in cleaner technologies and energy efficiency measures. However, while a carbon tax ensures a clear price signal, it does not automatically guarantee that a specific emissions reduction target will be met. Without complementary policies such as emissions caps, sectoral targets, or subsidies for clean technologies, overall emissions may not decrease sufficiently if consumers and firms choose to pay the tax rather than change behavior (Goulder and Schein, 2013).

The design of a carbon tax policy involves several important considerations. First, the scope of coverage determines its effectiveness; policymakers must decide which fuels, sectors, and greenhouse gases are to be taxed to maximize impact across the economy. Second, the tax rate itself is important; it needs to be high enough to influence behavior meaningfully and should grow at the same rate as the return on other forms of capital to keep the incentives for emissions reductions.[1] Third, decisions around revenue use play a major role in both economic and political outcomes (Metcalf and Weisbach, 2009).

Using 1990–2012 panel data on numerous countries and regions, Dolphin et al. (2020) find that democratic systems are more likely to introduce carbon pricing policies. However, institutional and political factors do not significantly affect policy stringency. Instead, economic structure plays a central role: jurisdictions with a heavy reliance on fossil fuels (especially coal) for electricity generation and a large industrial sector are less likely to implement carbon pricing and, if they do, the resulting policy tends to be less stringent. Richer countries, as measured by GDP per capita, are both more likely to adopt carbon pricing and to set a higher effective carbon price. Similarly, according to Klenert et

[1] The optimal tax on a negative externality equals the marginal social damage. In the context of climate change, this implies that the optimal carbon tax equals the social cost of carbon (Nordhaus, 1991).

al. (2018), ambitious carbon pricing is more common in countries with high political trust and low corruption, such as Finland, Norway, Sweden, and Switzerland. In contrast, countries with greater public distrust and perceived corruption tend to have weaker climate policies and higher emissions.

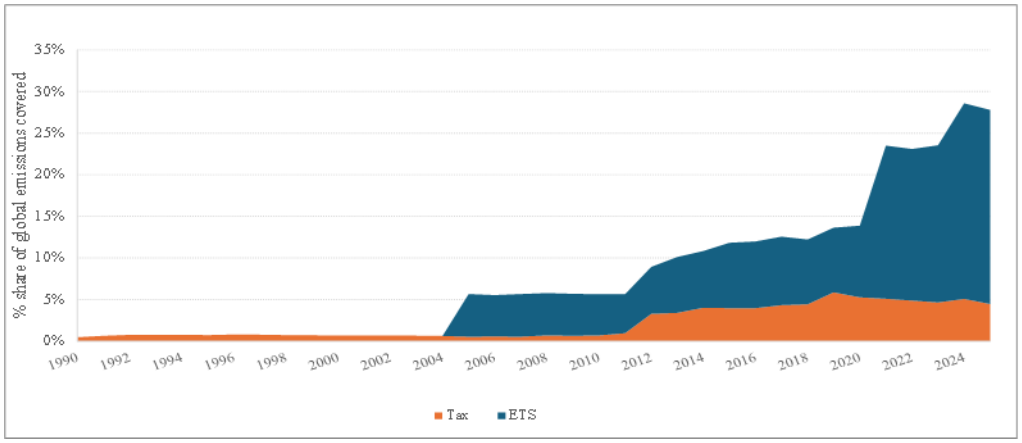
2.1.2 Emissions Trading Systems (ETS)

An ETS, or cap-and-trade system, sets a total limit (cap) on GHG emissions for all covered sectors combined and issues allowances to emitters, who can then trade them. The cap applies to the entire system, with allowances distributed or auctioned to companies within the cap. Each company must hold enough allowances to cover its emissions, but firms have flexibility to reduce emissions internally or purchase allowances from others. By design, ETS ensures emissions certainty, as total emissions cannot exceed the cap. However, the price of allowances can fluctuate depending on market conditions, creating price uncertainty that may discourage investment in long-term low-carbon technologies without stabilizing mechanisms such as price floors or ceilings (Goulder and Schein, 2013).

Several important factors determine the effectiveness of ETS design. Cap setting defines the level of environmental ambition and determines how quickly emissions will decline. Allowance allocation influences economic and distributional impacts. Flexibility mechanisms such as banking (saving allowances for future use), borrowing (using future allowances for current compliance), and the use of offsets (purchasing verified external reductions) can increase cost-effectiveness. An effective ETS operation requires strong market oversight, including transparent monitoring, reporting, verification, and enforcement systems to ensure compliance, prevent market manipulation, and maintain credibility (see Goulder and Schein, 2013 and International Carbon Action Partnership (ICAP), 2023).

Figure 1 shows the percentage of global GHG emissions covered by carbon taxes (orange) and ETS (blue) from 1990 to 2025, based on World Bank data. Since 2005, overall carbon pricing coverage has expanded significantly, mainly driven by ETS initiatives, starting with the EU ETS. ETS coverage surged after 2010 and again post-2020, reflecting major market launches and expansions in various countries. In contrast, although carbon taxes are adopted across multiple jurisdictions, their coverage has grown gradually and remains comparatively modest. By 2025, carbon pricing mechanisms cover roughly 30% of global emissions. While this reflects substantial policy progress, it also indicates that a large share of emissions remains outside direct carbon pricing coverage, which may partly reflect differences in policy adoption across countries, sectoral exemptions, and implementation constraints.

Figure 1 Global Share of GHG Emissions Covered by Carbon Taxes and ETS, 1990–2025.



Source: Own analysis based on data from World Bank.

2.2 Policy-Based Subsidies and Production Incentives

Subsidies can be loosely defined as "a government action that confers an advantage on consumers or producers, in order to supplement their income or lower their costs" (OECD, 2005, p. 16). Subsidies can be provided in both direct and indirect forms. Direct subsidies are measures where the government supports specific firms, sectors, or households through explicit transfers, such as budgetary payments, tax exemptions, or reduced tax rates. Indirect subsidies are provided through instruments like public procurement or R&D contracts, which can lower firms' effective costs and influence investment decisions without appearing as direct cash transfers (OECD, 2005). Since there is "no agreed methodology for measuring the support element in indirect support" (OECD, 2005, p. 30), we focus in this report on some examples of tax-based and non-tax-based direct subsidies.

Tax-based incentives and subsidies are financial transfers driven by policy to achieve specific climate goals through lowering the upfront or operational costs of low-carbon investments. Unlike carbon pricing, that penalizes emissions and offers an economy-wide incentive, financial support can be targeted by reducing the cost of specific climate actions and encouraging voluntary engagement by targeted households, firms, and investors. They are often easier to tailor to specific technologies or actors, helping to overcome early-stage barriers and frictions that can prevent investments. However, unlike carbon pricing, which raises revenue that can be reinvested in climate actions, financial support is costly and therefore requires careful design and oversight to ensure cost-effectiveness and fairness (OECD, 2024a).

According to an OECD (2024a) report covering 70 economies, governments in many countries use investment tax incentives to attract investors, direct capital into particular sectors or regions, and encourage specific types of investment behaviour. Tax-based incentives typically fall into four main categories: tax exemptions (a full or partial exemption from corporate income tax), reduced tax rates, tax allowances (permitting faster or enhanced deductions for expenditures), and tax credits (direct reductions in the amount of taxes owed). The use of these tools varies widely. Tax exemption is the most prevalent instrument, with 89% of economies using at least one form of exemption. In contrast, tax credits are the least common, offered in only 33% of the economies studied.

A primary application of these incentives is to advance sustainable development, with environmental protection being the most common objective. The OECD report found that two-thirds of the economies surveyed use tax incentives to improve the environmental impact of investments. This is frequently accomplished by targeting specific sectors, such as renewable electricity generation, or by incentivizing qualifying expenditures on green technologies, such as the purchase of solar photovoltaic systems or equipment to reduce industrial waste.

Beyond tax subsidies, governments also support clean energy through a range of **non-tax direct subsidies** to producers and consumers, i.e. measures delivered via budgetary transfers rather than through the tax system. In the environmental field, they can be structured, for example, as one-time financial assistance like installation rebates for solar panels or as per-unit payments for renewable electricity produced (production payments). A feed-in tariff (FiT) is an example of a specific, structured type of production payment. It provides renewable energy producers with long-term contracts at fixed, often above-market prices for the electricity they feed into the grid. FiT has been considered as highly effective in stimulating the rapid expansion of renewable energy and is used in many jurisdictions around the world (Couture and Gagnon, 2010).

2.3 Carbon Pricing versus Financial Supports

There is a trade-off between carbon pricing and support policies in climate policy design. While economists largely favor carbon taxes for their efficiency, subsidies and incentive policies often perform better in terms of political feasibility and public acceptance.

A central argument in favor of carbon pricing is economic efficiency. Broad, market-based policies such as carbon taxes ensure that emissions reductions occur where they can be achieved at the lowest cost, since all emitters face the same carbon price and adjust according to their own reduction costs (Metcalf, 2009). By internalizing the external costs of pollution, carbon pricing follows the “polluter pays” principle and provides a clear and predictable price signal, which is crucial for guiding long-term investment decisions. Empirical evidence supports the effectiveness of carbon pricing in reducing emissions. Colmer et al. (2024) find that carbon pricing reduced emissions without measurable economic losses, while renewable support improved deployment but did not necessarily reduce emissions. Döbbeling-Hildebrandt et al. (2024) document significant emissions reductions in 17 of 21 carbon pricing schemes globally, and Szasz (2023) reports stronger abatement effects under pricing mechanisms than subsidy-only approaches.

Despite their efficiency, carbon taxes face political and distributional challenges. Because energy expenditures account for a larger share of low-income household budgets, carbon taxes can be regressive without compensation measures (Klenert et al., 2018). Revenue recycling is therefore central to perceived fairness and political durability. Koh et al. (2021) show that well-designed recycling can generate economic and distributional co-benefits. Muth (2023) finds that combining transfers with climate investments strengthens political support over time. Lump-sum transfers are often perceived as fair and trust-building (Kallbekken et al., 2011), as illustrated by Canada’s federal fuel charge, where approximately 90% of revenues are returned to households (Government of Canada, 2024).

In contrast to the broad-based approach of a carbon tax, financial support policies such as subsidies are often perceived more favorably by the public and are viewed as a proactive government effort to directly stimulate technological development. However, economists frequently criticize subsidies for potential cost inefficiency, market distortion, and rent-seeking behavior if poorly designed (Metcalf, 2009; Goulder and Parry, 2008). Subsidies also create fiscal burdens that must be financed through taxation (Johnson and Toledano, 2022). Their emissions impact varies depending on context and policy design (Colmer et al., 2024; Döbbeling-Hildebrandt et al., 2024; Szasz, 2023).

Given these strengths and limitations, no single instrument is universally optimal. Effective climate policy typically requires a combination of carbon pricing, targeted subsidies, and regulatory measures rather than reliance on a single instrument (Goulder and Parry, 2008; Grubb et al., 2023). Roach and Meeus (2023) show that support costs depend heavily on how carbon pricing and subsidies interact, underscoring the need for coherent policy design. More fundamentally, the relative performance of policy instruments depends on how they affect firms' incentives to reduce emissions and invest in new technologies. Outcomes may vary with abatement costs, the extent to which firms can capture the benefits of innovation, and specific market conditions (Fischer et al., 2003). Therefore, the optimal policy mix can be context-dependent, and the economic and environmental effects of carbon pricing may vary across countries, reflecting differences in income levels, industrial structures, and energy consumption profiles (Känzig and Konradt, 2023; Berthold et al., 2024; Xu and Yang, 2024).

In conclusion, a well-designed carbon tax can provide a broad-based incentive for emissions reduction in many contexts. The revenue generated can be used to address distributional concerns and invest in public infrastructure. Simultaneously, targeted subsidies can be strategically deployed to overcome specific market failures, support emerging clean technologies, and build political momentum for more ambitious climate action. The political challenge, as highlighted in numerous studies, lies in designing a package that is not only economically sound but also perceived as fair and reasonable by the public.

2.4 Non-Financial Policy Instruments

While financial tools play an important role in mobilizing climate investment, non-financial policy instruments are also essential in forming the environment in which those investments take place. These instruments do not involve direct capital flow but instead function by removing regulatory barriers, improving predictability, and enhancing transparency and accountability across sectors. The main non-financial instruments include:

- **Streamlining permits and reducing regulatory risk**: Complex and slow approval processes are a major barrier to private investment in renewable energy and transport, especially in projects that require large infrastructure. According to the International Energy Agency (IEA), delays in getting permits for projects like solar, wind, and grid connections can take several years, increasing costs and making investments riskier (IEA, 2023). The IEA identifies these permitting bottlenecks as one of the biggest obstacles to speeding up the clean energy transition. Making

procedures more transparent and efficient is essential to reduce delays and attract more investment.

- **Establishing clear performance standards**: According to United Nations Framework Convention on Climate Change (UNFCCC) guidance**,** governments can strengthen climate and energy policy by establishing clear performance standards and disclosure requirements. Performance standards allow governments to set minimum energy-efficiency requirements or maximum emissions limits across sectors. Policy tools in this category include: (a) Mandatory Energy Performance Standards that ensure only energy-efficient appliances and equipment enter the market; (b) Vehicle fuel-economy and CO_2 standards that require manufacturers to improve the efficiency and emissions profile of new vehicles; (c) Phase-down or retirement rules that restrict or eliminate the use of older, inefficient technologies; and (d) Renewable Portfolio Standards, a related form of mandatory regulation requiring electricity suppliers to source a minimum share of power from renewable energy (UNFCCC, n.d.-a).
- **Imposing disclosure requirements**: Mandatory climate-related financial disclosure provides investors, lenders, and insurers with consistent and comparable information on firms' climate risks, governance, and strategies. This transparency reduces information asymmetry, helps prevent greenwashing, and enables capital to flow toward lower-risk, low-carbon activities. Environmental disclosure has been shown to improve market efficiency and encourage green innovation (Acheampong and Elshandidy, 2024; Wang, 2024). The recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) serve as the global benchmark for corporate reporting (TCFD, 2017).
- **Monitoring, Reporting, and Verification (MRV) Systems**: Robust MRV systems are important for tracking GHG emissions, monitoring the effectiveness of climate investments, and ensuring compliance with regulatory frameworks. At the international level, the Paris Agreement established an "Enhanced Transparency Framework" that requires all signatory countries to regularly report on their emissions and progress toward their climate targets (UNFCCC, 2018). For investors and policymakers, credible MRV provides the data needed to verify that policies are delivering their intended results and to hold actors accountable. A recent study reviewing the first five years of the EU's MRV system for large ships finds that the MRV framework has significantly improved transparency on maritime CO_2 emissions, fuel consumption, and energy-efficiency trends (Luo et al., 2024).
- **Policy and Program Evaluation**: To ensure that public resources are used effectively, governments should systematically evaluate the impact of their climate policies. Such evaluations help policymakers understand how policies work in practice and provide useful guidance for improving future policy design. Qin et al. (2024) review policy evaluation practices in Brazil, China, and India, concluding that standardized assessment guidelines enhance accountability and strengthen the influence of evaluations in policymaking. However, they note that climate policies often involve high levels of uncertainty, which calls for more advanced modeling tools and new methods that can better account for system feedbacks and long-term impacts.

These non-financial tools are not only complementary but are important prerequisites for the success of financial interventions. They create a stable and transparent ecosystem that reduces investment risks, ensuring that private and public capital can be deployed efficiently and at the scale required to meet climate goals.

However, although these regulatory instruments do not require the public sector to provide direct capital for projects, they can still impose substantial costs. Governments must invest in administrative systems, skilled personnel, and monitoring infrastructure to design, implement, and enforce such policies effectively. These are real and sometimes significant fiscal and institutional burdens, but they should be understood as long-term investments in market development and strong governance.

A key element of good policy design is assessing whether the benefits of a measure justify its costs. Environmental economists typically use cost-benefit analysis for this purpose, comparing expected social and environmental gains with implementation and compliance costs (Dehnhardt et al., 2022). The OECD similarly emphasizes that effective regulation and a stable institutional framework are essential for attracting private investment. At the same time, overly complex or burdensome rules can increase compliance costs, reduce competitiveness, slow innovation, and create unnecessary administrative work, ultimately undermining sustainable development goals (OECD, 2025a).

It should also be mentioned that an ambitious climate policy involves political costs and benefits. The costs involve potential backlashes from industries and public opposition to policies perceived as economically burdensome. On the benefit side, climate action can generate broad social and political support when framed around the opportunities it creates. Jennings et al. (2020) in their review of UK climate policymaking, highlight the co-benefits of climate action, including improved public health, enhanced energy security, economic growth, and reduced inequality. Their findings emphasize that climate policies gain more durable public backing when they are linked to wider social priorities rather than presented solely as environmental obligations.

A central theme in the literature on regulations and standards for climate is the gradual shift from voluntary to mandatory frameworks to enhance accountability and market efficiency. Literature mainly suggests that mandatory disclosure regimes are more effective, resulting in greater emissions reductions and more consistent reporting, while voluntary disclosures often face heterogeneity issues and the potential for greenwashing. Armour et al. (2022) point out that voluntary regulations do not oblige firms to provide the detailed climate disclosures investors need to assess climate risks accurately. This lack of information can lead to mispricing in financial markets and misallocation of capital, ultimately hindering progress toward the net-zero transition. Tomar (2023) suggests that mandatory disclosure policies can reduce emissions, not because regulators force firms to cut, but because visibility changes firm behavior and encourages them to improve relative to peers.

To address non-compliance with standards, data manipulation, and greenwashing some studies suggest more robust standards and the use of emerging technologies, such as satellite data, to verify reported information (see e.g., El-Jourbagy and Gura, 2022). The adoption and practice of climate disclosure may also be shaped by cultural factors. Panfilo and Krasodomska (2022) show that strong regulation can *standardize* disclosure quality across countries, but in its absence, disclosure depends much more on local culture, norms, and expectations.

3. Main Financial Instruments for Public Support

This chapter describes the instruments for the direct deployment of public capital. These direct financial support instruments are typically used to overcome significant upfront cost barriers, to fund projects with high environmental value that may not be commercially viable on their own, or to support emerging technologies in their early stages of development. By providing capital directly, the public sector can steer investment towards national priorities and absorb risks that the private market is not yet willing to take.

This chapter will explore the three principal forms of direct deployment: grants and other non-repayable finance, public concessional and non-concessional loans, and public equity. Understanding these direct deployment methods provides the necessary foundation for understanding the more complex models discussed in Chapter 4, which are designed specifically to leverage this public capital to mobilize significantly larger volumes of private investment.

3.1 Grants and Non-Repayable Finance

A grant, a non-repayable transfer of capital, is a direct payment from the government, typically awarded through a competitive application process as upfront funding for specific projects or technologies. Unlike tax credits and other tax incentives, which depend on the investor having sufficient taxable income, grants do not require the recipient to have any tax liability. This makes grants more accessible for start-ups, non-profits, or firms in their pre-profit stage (see e.g. Johnston, 2019).

Many promising technologies may face difficulties to attract private investment because their future profits are uncertain, even though their public benefits could be significant. According to Arrow (1962) markets tend to underinvest in innovation because knowledge is a public good: once it is created, it is hard to stop others from using it, so inventors cannot capture all the benefits. As a result, there is less private investment in R&D than society needs. In addition, innovation often involves high upfront costs and uncertain outcomes that discourage private investments. The paper argues that public funding is justified only when the marginal social benefits of innovation exceed the marginal social costs of public funds.

Grants do not replace loans or private investment, they complement them by taking on early-stage risks and helping demonstrate a project’s potential. By covering upfront costs or initial shortfalls, grants improve the project's risk–return profile, making it more attractive to private lenders and investors. In this way, they play a critical role in launching innovation and unlocking private capital at later stages. According to Howell (2017), a grant can turn a project from having a negative to a positive net present value. This can happen in two ways. First, the grant helps the entrepreneur keep more equity, preventing investor ownership from becoming so large that it undermines the entrepreneur’s incentives. Second, the startup can use the grant to build a prototype and show its technology works, reducing investor uncertainty.

Grants serve also as a powerful signal to the market. The technical and financial assessments carried out by a government agency before awarding a grant help certify the quality of a project, reducing information gaps for outside investors. Kleer (2010) shows that such certification attracts private investors to commit their own capital, and Howell's (2017) empirical study of U.S. energy start-ups shows that firms receiving early-stage R&D grants are significantly more likely to attract venture-capital funding and achieve long-term success. The effects are stronger for more financially constrained firms.

Within a project's capital stack, grants sit in the most junior position. While pure grants are fully non-repayable, several tailored variants also exist. According to European Commission (21), a **recoverable grant** turns into debt and is repaid alongside an existing loan, and a **convertible grant** can turn into equity, increasing the public investor's ownership stake, when agreed targets are achieved. If milestones are not met, the convertible or recoverable portion typically remains non-repayable. These variants protect recipients in failure and allow the public sector to recover value in success, improving risk-adjusted efficiency. To limit public downside, programs may build in different safeguards such as

- **Staging**: (milestones): disbursements are split into tranches and released only when specified thresholds are met. Unpaid tranches are withheld if thresholds are missed.
- **Clawbacks**: contracts allow reductions for under-performance, recovery of ineligible costs, and recovery of previously disbursed funds if obligations are not met.
- **Recissions**: cancellation of all or part of the agreement when agreed commitments are not met.
- **Penalties**: additional monetary sanctions (e.g., liquidated damages) for non-compliance, on top of any clawbacks.
- **Recalibrations**: adjusting the size or schedule of future support to reflect actual performance, for example by reducing awards or conditioning later disbursements on improved results.

Ledebur and Woodward (1990) recommend writing these remedies into legally enforceable incentive contracts, with clear performance targets, monitoring, and explicit provisions for rescission, clawbacks, penalties, and recalibration, so agencies can adjust, recover, or terminate support when firms underperform (see also The Swiss Capacity Building Facility, n.d., for repayable grants).

3.2 Public Loans

Public loans play a crucial role in financing sustainable development and climate-related infrastructure, especially in developing countries where access to private capital is often limited. According to OECD (2024b), between 2016 and 2022, loans consistently represented the largest portion of developed countries' public climate finance, mainly delivered through bilateral and multilateral channels. These instruments can be broadly categorized based on their financial terms, particularly whether they are offered on a commercial or a subsidized basis. This distinction gives rise to two primary categories of public loans: non-concessional and concessional loans. A more recent innovation, the Sustainability-Linked Loan (SLL), introduces performance-based pricing tied to environmental, social, and governance (ESG) outcomes.

3.2.1 Concessional Loans

Concessional loans are characterized by below-market interest rates, extended repayment periods, and grace periods, and are typically extended by development finance institutions (DFI), multilateral development banks, and national development banks. Their primary purpose is to support sectors or regions underserved by commercial lenders. According to the OECD (2024b) report between 2016 and 2022, 79% of loans extended by bilateral providers[2] were concessional.

Institutions such as the World Bank, the African Development Bank, and Germany's development bank KfW (Kreditanstalt für Wiederaufbau) are important providers of concessional development finance, including support for climate-related and broader development projects in developing countries (Attridge and Engen, 2019). Multilateral climate finance mechanisms, including the Green Climate Fund (GCF) and the Climate Investment Funds (CIFs), also provide concessional and blended finance for climate-related investments. At the national level, development banks, which are typically owned, administered, and controlled by the government, may offer concessional loans to sub-national entities or specific sectors to advance policy priorities, such as supporting smallholder farmers or financing the energy transition (De Luna-Martinez and Vicente, 2012).

Concessional finance is essential for projects that may not be immediately profitable but yield long-term public benefits, particularly in climate mitigation and adaptation. Beyond providing direct support, concessional loans, when they are structured in a subordinated position, can play a catalytic role by absorbing early losses during high-risk stages, thereby attracting private co-financing that would otherwise stay out. However, such loans and junior public tranches are justified only if private finance is unavailable or excessively costly without the public involvement, and the subsidy is no larger than necessary to close the financing gap (OECD, 2020). Excessive public involvement can crowd out private money by displacing commercial capital with cheaper public funds and shift disproportionate risk to the public sector by encouraging rent-seeking behaviour and moral hazard (DFI, 2017): Private lenders may relax standards if public finance covers most of the downside, and firms, particularly when their equity contribution is small, may take on riskier projects if early losses are absorbed by junior loans.

3.2.2 Non-Concessional Public Loans

Non-concessional loans are extended on market-based or near-market terms, without subsidy or grant elements. Because they follow commercial pricing, their use is tied to the financial health of the underlying project: the borrower must be able to generate sufficient revenue to service both principal and interest. Consequently, only robust, "bankable" projects are suitable candidates.

Despite being offered on commercial terms, non-concessional public loans can be attractive relative to private loans because they provide stable long-term financing, policy

[2] National government entities or agencies that directly channel climate (and other development) finance from their own country's budget to projects in other countries.

alignment, and technical support, while also signaling project quality and helping attract additional investors (see e.g., European Investment Bank (EIB), 2020).

Although these loans are non-concessional, this designation refers only to their pricing, not to their seniority; their ranking in a borrower's debt structure is determined by the institution's legal status and loan contracts rather than by whether the loan is concessional or non-concessional.

Non-concessional loans are typically provided by the ordinary capital windows of multilateral development banks, such as the World Bank's International Bank for Reconstruction and Development, as well as regional development banks like the EIB. These institutions offer non-concessional loans to countries and municipalities with higher creditworthiness and the capacity to take on commercially priced debt.

3.2.3 Green and Sustainability-Linked Loans (SLLs)

As sustainable development and climate alignment have gained prominence, lenders have increasingly adopted innovative sustainable lending instruments, notably green loans and sustainability-linked loans (SLLs). While both instruments are under the umbrella of sustainable finance, they are structurally and functionally different. Green Loans are use-of-proceeds instruments, meaning that the loan proceeds must be earmarked exclusively for environmentally beneficial activities, such as renewable energy, energy-efficient buildings, or sustainable transport. In contrast, SLLs do not restrict how the proceeds are used. Instead, their financial terms, such as interest margins, adjust based on the borrower's achievement of predefined sustainability performance targets (Kim et al., 2025). If the borrower meets agreed Key Performance Indicators (KPIs), the loan pricing is adjusted favorably (typically through a reduced margin). Failure to meet these targets may trigger an increase in margin. SLLs provide greater flexibility for borrowers compared to green loans.

Despite their promise, SLLs face significant implementation challenges. The financial incentive must be material enough to influence behavior, and the metrics must be transparent, verifiable, and aligned with long-term sustainability goals. Weak or poorly monitored KPIs risk undermining the relevance of the instrument, turning it into a symbolic gesture rather than a driver of measurable change. Kim et al. (2025) perform an extensive analysis of company level syndicated loan data from 2016–2021 and find a rapid growth in ESG-related lending, from under $10 billion to more than $700 billion, which has been driven primarily by general-purpose SLLs rather than traditional green loans tied to specific use-of-proceeds. They also show that high-transparency borrowers maintain their ESG performance, while low-transparency borrowers worsen their performance after issuance. Both high- and low-transparency borrowers incur higher issuance-related fees compared to conventional loan borrowers, suggesting that firms derive value from obtaining the SLL label itself. For high-transparency borrowers, this appears consistent with using SLLs to credibly certify pre-existing ESG commitments, whereas for low-transparency borrowers it is more consistent with reputational signaling or greenwashing.

3.3 Public Equity

Unlike debt instruments, equity financing allows public institutions to directly share in the ownership and governance of the investment project. While public finance has traditionally relied on debt instruments, public equity is also an important tool for mobilizing capital for climate-related innovation, infrastructure, and early-stage technologies. According to OECD (2024b), equity instruments in public climate finance provided by developed countries, though still a very small share, rose from US $0.8 billion in 2016 to US $2.4 billion in 2022.

By taking ownership stakes, public institutions can provide capital while also sharing in the governance and potential upside of climate-aligned investments. At the same time, equity participation has a higher risk profile than traditional debt-based financing and exposes the public sector to technological and market risks. Equity instruments are particularly relevant for high-risk, capital-intensive, and early-stage projects because they can absorb uncertainty while providing the patient, long-term finance required to support radical innovation, particularly in high-tech start-ups (Mazzucato and Penna, 2016). Public equity is also an important financing channel for infrastructure investment, helping to maintain strategic control and ensure alignment with public interest.

One important form of public equity is public venture capital (VC), where governments or publicly backed institutions act as direct risk investors by acquiring equity stakes in early-stage and strategically important private companies. VC plays a particularly crucial role in sectors such as cleantech, biotechnology, and deep tech, where innovations are often capital-intensive, technologically complex, and face long return horizons, conditions that discourage many private investors. By absorbing high start-up risk and wait longer for returns, public VC helps to de-risk innovation and attract private co-financing.

Leleux and Surlemont (2003) analyze the relationship between public and private VC in 15 European countries over 1990–1996, asking whether public VC “seeds” or “crowds out” private investors. They find that although higher public participation is correlated with smaller VC markets in cross-section, dynamic Granger-causality tests provide no evidence of either seeding or crowding out. The study also highlights that in countries with weaker investor protection, private investors are more hesitant to enter the VC market. As a result, public or publicly regulated investors (state funds, development banks, banks with state influence) make up a larger share of VC activity.

Drawing on detailed OECD data covering startups, investors, and patent activity, alongside expert surveys to identify Government Venture Capital (GovVC) programs, Berger et al. (2024) find that firms financed solely by GovVC tend to carry higher risk and underperform in follow-on fundraising and innovation metrics compared with those backed by private VC. However, these shortcomings largely disappear when GovVC co-invests alongside private investors: in these joint ventures, companies achieve similar levels of patenting activity and successful exits as purely private-VC-funded peers. The study therefore concludes that GovVC can play a valuable role in channeling finance to overlooked ventures, especially when it collaborates with the private sector.

In addition to public VC, several publicly backed green investment vehicles provide equity and equity-like financing for environmental objectives. Regional green funds and

multilateral climate investment funds, typically capitalized by public actors, invest in sustainable projects and often aim to crowd in private capital. At the EU level, the European Innovation Council Fund is a major deep-tech investor, offering blended finance and direct equity investments, usually alongside private VC to validate commercial potential (European Commission, 2025c). Another example is the Nordic Environment Finance Corporation (NEFCO), an international financial institution that provides equity, equity-like instruments, and concessional co-financing for low-carbon solutions and municipal climate infrastructure across the Nordic–Baltic region and Eastern Europe (NEFCO, n.d.). Globally, multilateral climate funds administered by development banks are central to international climate finance. Since its establishment, the Climate Investment Funds (CIF) has received more than USD 10 billion from 15 contributor countries and leveraged over USD 62 billion in co-financing for climate mitigation and adaptation projects across more than 72 low- and middle-income countries. (CIF, n.d.).

4. Blended Finance and Risk-Sharing with the Private Sector

Blended finance refers to the targeted use of public capital to mobilize additional private investment for sustainable development and climate objectives. This chapter examines how governments and public finance institutions use blended-finance mechanisms to reduce or absorb financial risk in order to attract private sector participation in climate investment. Effective risk-sharing serves several purposes: it improves the risk-return profile of climate-related investments, supports adaptation and resilience efforts, and provides protection against loss and damage associated with climate shocks.

Blended finance can act as a market creator, particularly in low-income, fragile, or conflict-affected contexts where commercial investment is limited and concessionality is needed to make projects investable. These markets often lack a sufficient pipeline of bankable projects, have high volatility, and face high environmental, social, governance, and integrity risks, conditions in which ordinary private finance is unlikely to enter without public risk-sharing (OECD, 2025b; Basile and Neunuebel, 2019). In more mature markets with stable regulatory environments and deeper investment pipelines, blended structures can be scaled to mobilize larger private capital volumes with lower levels of concessionality (OECD, 2025b). Common project types supported in these markets include renewable-power generation, energy-efficiency portfolios, climate-resilient infrastructure, and sustainable agriculture funds, often structured through layered debt/equity vehicles, guarantees, or technical-assistance facilities (Luxembourg Sustainable Finance Initiative (LSFI), 2023).

As outlined by the OECD (2020), blended finance should only be used when there is clear evidence of development outcomes that would not occur without public intervention, when private finance is unavailable or prohibitively expensive without public involvement (financial additionality), and when any subsidy is limited to the minimum level needed to close the financing gap (minimum concessionality). An important principle of blended finance is that concessional support should be temporary, and subsidies should decline as markets mature and commercial capital becomes viable on its own. Long-term reliance on concessional or non-concessional development finance can discourage market formation and create dependency traps (OECD, 2025b).

In addition, when public loans are used in blended-finance structures, governments may subordinate their own repayment to provide additional comfort to private lenders. When this happens, the contract should clearly mention who gets paid when (the cash-flow waterfall) and include limits on early interest or dividend payments to private investors. These safeguards ensure that subordination genuinely shares risk instead of being undermined by large payouts early in the project (AFME, 2016).

The following subsections describe the main instruments and structures used in blended finance and how they support risk-sharing with the private sector.

4.1 Public-Private Partnerships (PPPs)

Public-Private Partnerships (PPPs) are long-term collaborative agreements in which a public authority enters into a contract with a private entity, often for delivering

infrastructure or public services. The goal of PPPs is to attract private capital, technical expertise, and operational efficiency while maintaining public sector oversight and regulatory control. PPPs are widely used across sectors such as transportation, energy, healthcare, water, and education. PPPs typically rely on performance-based contracts, where payments are tied to service availability, efficiency, or quality standards. In a standard structure, the private partner finances, designs, builds, and operates the asset over a multi-decade period, while the public sector sets the policy framework, monitors performance, and ensures accountability. This risk-sharing model aims to promote innovation, cost-effectiveness, and long-term value for money compared with fully public delivery approaches (See World Bank, n.d., for comprehensive information on PPPs).

Several countries use PPPs to deliver climate-related infrastructure. Examples include sustainability-linked incentives in the Netherlands' A15 motorway PPP, France's use of Energy Performance Contracts for building retrofits; regulated-return PPP for UK offshore wind transmission (GOV.UK, n.d.); and Canada's long-term light-rail PPPs embedding sustainability requirements in performance payments. In emerging markets, institutions such as the International Finance Corporation (IFC) support solar parks, metro systems, and water facilities through PPP models combined with blended-finance tools.

Several blended-finance structures can be used within PPPs and other public–private financing arrangements.

- **Viability Gap Funding (VGF)** is a targeted grant mechanism designed to make commercially unattractive projects financially viable. Under a VGF arrangement, a public agency commits to cover part of the commercial viability gap between project economics and private investor requirements. These funds may be released in tranches tied to milestones, ensuring taxpayer support only materializes as the project de-risks and progresses. By bearing part of the upfront cost, VGF narrows the financing gap and allows developers to secure senior debt and equity on standard commercial terms. Many emerging-market programs, like India's infrastructure VGF scheme, have used this model to catalyze private participation in roads, ports, and clean-energy projects, showing how a relatively small grant commitment can unlock large sums of private capital (See e.g. Schur, 2016).
- **Concessional Debt Tranches,** which, as described in Chapter 3, offer terms more favorable than market rates and serve as a critical de-risking tool within blended-finance structures. Unlike standalone concessional loans, these tranches are one layer in the financing package. They can be structured as senior debt or as junior (subordinated) debt that absorbs first losses. A concessional tranche in a junior position provides an additional layer of security that may encourage private sector participation.
- **Public Junior Equity** is the equity equivalent of the first-loss mechanism. A public institution takes an equity stake in the riskiest, junior position. If the company or project loses money, the value of this public junior equity is wiped out before other investors lose capital, shielding private investors in senior equity or debt positions. By accepting a higher-risk position and potentially lower risk-adjusted returns, public junior equity improves the overall creditworthiness of the project.

In some PPPs, blended-finance structures are used to improve project bankability and attract private participation. An illustrative structure layers a relatively small grant component (for example, VGF) beneath concessional debt and public junior equity, with senior commercial debt and equity at the top of the capital stack. Each layer plays a distinct role: grants address the viability gap, concessional debt lowers financing costs, junior equity absorbs early losses, and market-rate private capital provides a substantial share of the financing (see, e.g., OECD, 2025b).

4.2 Risk-Mitigation and Credit-Enhancement Tools

A primary function of blended finance is to strategically reallocate risk to make a project attractive for private investment. Guarantees, political-risk insurance, hedging, contingent credit, and other credit-enhancement mechanisms play a pivotal role in blended finance by protecting investors against revenue, currency, and regulatory shocks. These tools act as a financial safety net, absorbing specific downside risks. The following subsections describe the most common of these instruments.

4.2.1 Credit Enhancements

Credit enhancements are mechanisms that improve a borrower's or instrument's credit profile so that private lenders are willing to finance a project on better terms. Their objective is to lower perceived risk and reduce financing costs. Credit enhancements are among the most widely used risk-sharing tools in climate finance. They provide third-party assurance, typically from a government agency, development finance institution, or international climate fund, that a portion of lenders' or investors' losses will be covered in the event of default or underperformance.

- **Guarantees** are one of the most common forms of credit enhancement. A guarantee is a formal promise by a third party (the guarantor) to take responsibility for a borrower's debt if the borrower fails to repay. In climate finance, a development bank or other public institution often serves as the guarantor. If the project defaults on its loan from a private lender, the guarantor steps in and repays the outstanding amount. Guarantees are especially important for early-stage clean energy projects, emerging market infrastructure, or innovative technologies that lack a proven track record (OECD, 2021). A guarantee creates contingent exposure from the moment it is issued, because the guarantor assumes a legally enforceable obligation if the borrower defaults. This exposure typically requires some form of risk recognition, provisioning, or capital management by the guarantor. Rating agencies and lenders treat the guarantee as a form of credit enhancement, strengthening the borrower's credit profile but also tying up the guarantor's capital. Humphrey and Prizzon (2014) suggest that guarantees can be particularly effective in crowding in private capital by targeting specific risk categories and improving investor confidence. However, they also note that high mobilization ratios do not necessarily imply low public risk, as guarantees and subordinated instruments may create substantial contingent liabilities that materialize under adverse scenarios. Guarantees may also create moral hazard by weakening incentives for private lenders or project sponsors to carefully assess and manage risk, while also involving relatively high transaction costs due to complex contractual structuring, ongoing monitoring, and contingent risk management. Their success depends on whether public institutions have the expertise and systems to assess and manage the risks they create.

- **First-Loss Facilities (FLF)** aim to raise the credit quality of senior debt and equity by absorbing early losses. Because senior investors know the first-loss tranche will take the initial "hit," the perceived probability of default on their capital falls, enabling longer loan tenors and lower spreads. An FLF can take the form of junior equity or concessional debt, or it can be structured as a partial guarantee that covers losses up to a certain amount (OECD, 2021). Unlike unfunded guarantees, junior equity and concessional debt require the public entity to use capital upfront, meaning the exposure appears on its balance sheet immediately. An important example is the Green Climate Fund's USD 150 million first-loss commitment to the Africa-focused SnCF infrastructure, which helped unlock commercial-bank and pension-fund participation in renewable mini-grids and climate-resilient water assets (Green Climate Fund, 2021).

4.2.2 Insurance Products

Insurance products similar to the credit-enhancement tools are risk-sharing instruments. It is a pay-on-trigger tool, and the insurer carries no liability in advance. It sits off the insurers' balance sheet until a contractually defined trigger is met, and the policyholder files a claim. Unlike guarantees, which directly enhance a borrower's creditworthiness and can improve borrowing terms immediately, insurance primarily transfers specific hazard or external risks to a third party. Insurers typically manage these risks through actuarial pricing, reserving, and reinsurance. Guarantees transfer credit risk while insurance transfers hazard risk (OECD, 2021; Habbel et al., 2021).

Insurance is not blended finance on its own, but it becomes part of blended-finance structures when public or concessional capital is contractually tied to the insurance mechanism, for example through premium subsidies, public provision or reinsurance of coverage (such as political-risk insurance), or other forms of risk-sharing that make coverage commercially viable (Global Asia Insurance Partnership (GAIP), 2025).

There are several types of climate related insurance including:

- **Parametric (Index Based) Weather Insurance** pays a fixed sum as soon as a weather index (rainfall, wind speed, temperature) crosses an agreed threshold, avoiding lengthy claims assessment and loss-verification processes. The instrument therefore shares climate volatility with the insurance market instead of loading it onto borrowers' balance sheets (Financial Stability Institute and International Association of Insurance Supervisors (FSI–IAIS), 2024). Parametric insurance is considered as a useful instrument in agricultural risk management, particularly in developing countries. Studies of index-based weather insurance show that reducing uninsured weather risk can increase smallholder investment and income by 20–30%, but take-up has often been limited, due to basis risk (the mismatch between the insurance payout triggered by an index and the actual loss experienced by the insured party), liquidity constraints, lack of trust, and product complexity (Carter et al., 2017).
- **Climate-related property and casualty coverage** extends standard fire-and-peril policies by adding extra protection for climate-related hazards such as floods, wildfires, coastal inundation, or extreme heat (World Bank, 2021).
- **Sovereign catastrophe risk pools**, such as Caribbean Catastrophe Risk Insurance Facility (CCRIF) in the Caribbean and African Risk Capacity (ARC) in Africa, are

regional insurance mechanisms through which multiple countries jointly purchase parametric coverage, allowing governments to receive rapid payouts after natural-hazard or climate shocks (World Bank, 2021).

- **Political risk insurance** protects investors against government-related events such as expropriation, breach of contract, currency inconvertibility, or civil disturbance. Because it is triggered by political events rather than borrower default, it sits conceptually with other insurance and hedging tools that transfer external risks to a third party (Multilateral Investment Guarantee Agency (MIGA), 2023).[3]

Recent evidence from blended-finance markets shows that climate transactions rely primarily on senior debt and equity, while risk-transfer instruments such as guarantees and insurance still account for only a small but growing share of total commitments (Convergence, 2024). The dominance of senior debt and equity may indicate that many projects are viewed as bankable once a modest level of catalytic capital is in place. The relatively limited commitment share of guarantees and insurance, however, does not necessarily imply a limited mobilization effect. According to the Climate Policy Initiative (CPI), guarantees mobilized about 26 percent of private climate finance between 2018 and 2020 and can leverage six to twenty-five times the public commitment compared with direct lending (CPI, 2024). This suggests that guarantees, although less pronounced in transaction volume, may generate disproportionately large mobilization relative to their recorded commitment share.

It should also be noted that measurement and reporting practices may understate the role of these instruments, as unfunded guarantees and insurance were not historically recorded as Official Development Assistance (ODA). However, the share of transactions involving guarantees and risk insurance has increased in recent years, likely due to revised OECD-DAC rules that now allow donors to count these instruments toward ODA targets, as well as growing market familiarity with their use (Convergence, 2024).

4.2.3 Derivatives and Hedging Tools

Derivatives and hedging, like insurance, do not provide upfront financing but transfer specific risks to a third party. They become catalytic in blended finance when public funds subsidize the premium or fee, enabling projects to secure risk protection that would otherwise be unaffordable.

- **Weather derivatives**: Index -based rainfall or temperature swaps protect budgets or project revenues when weather conditions deviate from expectations. Unlike parametric insurance, which transfers hazard risk through insurance contracts, weather derivatives hedge weather-related revenue risk through financial market instruments. A well-known example is Malawi's sovereign drought hedge: the World Bank acted as arranger and placed a rainfall option with private insurers. The option paid out if precipitation in the maize belt fell below a specified trigger. The UK's Department for International Development covered most of the premium cost, allowing Malawi to obtain several million dollars of drought protection that it could not otherwise have afforded (World Bank, 2012).

[3] Political risk insurance is closely related to international investment agreements (IIAs), which protect foreign investors from risks such as expropriation and breach of contract (Tillväxtanalys, 2019). While IIAs provide legal protection, political risk insurance offers financial compensation.

- **Catastrophe (CAT) bonds:** CAT bonds transfer extreme hazard risk to capital-market investors. In most sovereign CAT-bond transactions, the government is the "sponsor" rather than the legal issuer. The bond is usually issued by a highly rated intermediary, such as the World Bank's International Bank for Reconstruction and Development (IBRD), which sells the bond to investors. The sponsoring government pays a risk premium, which is channeled through the issuer to investors as the bond coupon. Investors receive this coupon every year unless a pre-defined catastrophe trigger (earthquake, cyclone, etc.) is hit, in which case they forfeit some or all of their principal and coupon, and the proceeds flow to the government for disaster response. In March 2020, Mexico sponsored four World Bank-arranged CAT bonds providing about US$485 million of earthquake and hurricane cover for four years; the World Bank's AAA balance sheet helped reduce issuance costs, and earlier donor grants had capitalized Mexico's disaster fund so it could afford the premium payments (World Bank, 2020a).
- **Commodity-price hedges for power and renewables**: Long-dated power-price agreements, "synthetic PPAs," or feed-in-tariff top-ups revenue for wind and solar projects whose output is sold into volatile wholesale markets. In Uganda's Global Energy Transfer Feed-in Tariff Program (GET FiT) program, KfW, the UK, and Norway provided about US $90 million in donor funds to finance results-based premium payments on top of the national FiT. These premiums function like a hedge: they guarantee developers a minimum effective tariff once the project generates electricity, thereby reducing revenue volatility (Collaboration for Development, n.d.).With this stabilized cash flow, commercial lenders can size debt more confidently, enabling higher leverage and lower interest spreads.
- **Carbon-price derivatives** (Carbon Contracts-for-Difference, CCfD) guarantee industrial investors a floor price for every ton of CO_2 they avoid. The state pays the difference when the EU ETS price falls below the agreed strike price, and receives money back when the market price rises above it. Germany launched a €5 billion CCfD program in 2023 to support the decarbonization of steel, cement, and hydrogen production, with 15-year contracts awarded through competitive auctions and funded from the federal climate budget (German Federal Ministry for Economic Affairs, n.d.). Similar price-stabilization mechanisms have also been proposed in Sweden, using two-way Contracts for Difference to stabilize electricity revenues for nuclear power producers by guaranteeing a predetermined strike price relative to market electricity prices (Government Office of Sweden, 2025a).

Similar to the insurance instruments, derivatives may show up as small portions of fundings, because their value is measured by the risk exposure they cover, while blended-finance statistics typically measure actual funds disbursed or invested.

4.2.4 Contingent Finance Instruments

Contingent-finance instruments sit between pure risk transfer and traditional lending. They do not move the underlying loss off the borrower's balance sheet, but they guarantee rapid access to funding when an adverse shock occurs, precisely when capital markets are least willing to lend. Because the funds remain undrawn until a trigger event occurs, they typically require little budget allocation upfront while still reassuring senior

investors that liquidity will be available to service debt or keep the project operating. There are several instruments of this type.

- **Stand-by credit lines** are pre-arranged loans, often from a multilateral or development bank, that can be drawn only after a specified shock, such as a declared natural disaster, a pandemic alert, or a sharp terms-of-trade swing. Examples include the World Bank's Catastrophe-Deferred Drawdown Option (World Bank, 2024) and the International Monetary Fund's (IMF) Rapid Credit Facility (IMF, n.d.). A commitment fee is paid by the beneficiary (the sovereign government or project company) to keep the credit available. That fee compensates the lender for reserving the credit line, just as an insurance premium pays an insurer to hold capacity. If the beneficiary never borrows the money, that small annual fee is the only cost. If it borrows, then it pays interest often on favorable terms. Rating agencies consider the undrawn credit line as part of the available cash, which improves beneficiary's credit profile.
- **Contingent grants and loans**: If the borrower's repayment capacity is limited, donors may blend an undisbursed line of credit with a grant component that converts to cash when a trigger event occurs. The ARC *Replica* program works this way on the grant side: member states pay a premium through national budgets and, in return, receive payouts from ARC for their pre-approved contingency plans. When a drought index breaches its threshold, ARC pays the insured government, and the World Food Program simultaneously releases a matching grant for early response. Coverage provided by ARC typically meets between 10% and 30% of each country's total disaster-financing needs (ARC, n.d.). In a paired "loan plus grant" model, such as the World Bank's International Development Association (IDA) Crisis Response Window, additional concessional IDA resources (grants and/or credits) are disbursed when a crisis trigger is met, providing rapid liquidity alongside any grant support (IDA, n.d.).

4.3 Innovative Financing Structures

There are also several innovative financing structures that can play a role in blended-finance structures, but these instruments provide somewhat different roles than the credit-enhancement, risk-transfer, and contingent-liquidity tools discussed above.

- **Results-Based Financing (RBF)**: provides payments only after predefined climate or development outcomes are achieved. Public or philanthropic funders commit these outcome payments in advance, creating a contracted revenue stream that improves the expected returns of a project once results are delivered. Although RBF, unlike guarantees or insurance, does not absorb losses or provide protection when outcomes are not achieved, it can still make projects more investable by adding a predictable source of income conditional on performance. An example of RBF in practice is the World Bank's RBF programs for off-grid solar (World Bank, 2020b), where companies receive payments per verified household connection or installed unit. A related example is the Swedish green electricity certificate system, where renewable energy producers receive certificates per unit of electricity generated (Swedish Energy Agency, n.d.-a).

- **Impact or Resilience Bonds** are performance-based securities in which investor repayment depends on whether a project achieves agreed social or climate-resilience outcomes. A Special Purpose Vehicle (SPV) is usually created to issue the bond, while the project itself is carried out by a public or private service provider. Public or donor capital supplies a first-loss tranche or guarantees the outcome payment, which encourages commercial investors to purchase the senior portion of the bond by reducing their exposure to performance risk. A well-known example is DC Water's 2016 Environmental Impact Bond. An SPV formed by Goldman Sachs and Calvert Impact Capital issued the bond to finance green-infrastructure investments in Washington, D.C. Investors received a standard coupon, and after measured results, a performance adjustment applied: investors earned a bonus if runoff reduction exceeded expectations, and absorbed a loss if outcomes were below target. The project principal remained protected unless DC Water defaulted. This structure allowed DC Water to test an innovative resilience solution while limiting its financial risk and attracting private investors (Green Finance Institute, n.d.). Motlagh et al. (2024) conducts a review of academic and practice sources since 2000 on resilience bonds. The review finds that most implementations have financed flood and hurricane resilience measures, with issuance largely dominated by government entities.[4]
- **Aggregation platforms** pool many small or fragmented climate projects into a structure that achieves the scale, standardization, and data quality required by institutional investors. Concessional support, through grants, first-loss or junior capital, and technical assistance, typically funds pipeline development, standardized documentation, and verification, enabling the aggregated pool to be financed through a single facility or securitization (United Nations Development Programme (UNDP), 2024). An example is the European Bank for Reconstruction and Development (EBRD) in cooperation with the Union for the Mediterranean Private Renewable Energy Framework, which pools and standardizes multiple small renewable-energy projects across participating countries under a common financing structure (EBRD, n.d.). A classic "issue-one-security" model is the U.S. Warehouse for Energy Efficiency Loans, which aggregated thousands of state-supported residential efficiency loans and securitized them into asset-backed securities purchased by institutional investors (Cities Climate Finance, n.d.).

[4] The Impact or Resilience Bonds are different from SLBs. Impact/Resilience Bonds are pay-for-success financing of a specific resilience project, where payments to investors adjust based on measured outcomes of a specific project. SLBs, in contrast, are ordinary corporate/sovereign bonds whose coupon adjusts if issuer-level KPIs are (not) met, and proceeds are typically for general corporate/sovereign purposes.

5. Financial Instruments to Mobilize Private Capital for Climate Action

This chapter discusses market-based instruments used to mobilize private capital for climate actions, primarily through standard market mechanisms. We focus on two of the most widely used structures: Use-of-Proceeds bonds (green and transition bonds) and Performance-Linked bonds (sustainability-linked bonds).

5.1 Green Bonds

Green bonds are fixed-income instruments, issued by governments, municipalities, or companies, in which the proceeds are assigned for projects with clear environmental or climate benefits, such as renewable energy, clean transport, sustainable construction, energy efficiency, or nature-based solutions. Although their financial structure mirrors that of conventional bonds, green bonds require issuers to follow enhanced transparency and reporting standards, typically guided by established frameworks such as the Green Bond Principles (International Capital Market Association (ICMA), 2021).

While green bonds, whether issued by public or private entities, do not directly reduce investment risk, they offer distinct advantages for both investors and issuers when compared to traditional financing instruments. For **investors**, green bonds provide a liquid fixed-income instrument that enables alignment with ESG and sustainability mandates while maintaining stability, liquidity, and credit risk profile typically associated with traditional bonds issued by the same issuer. Unlike direct equity investments in green companies, green bonds offer fixed returns and are not directly exposed to earnings or share price fluctuations, resulting in lower volatility and thereby reduced portfolio risk across various investment horizons (see e.g., Tiwari et al., 2022). These characteristics make them particularly attractive to institutional investors, such as pension funds, insurance companies, and central banks, who aim to integrate climate-aligned assets into their portfolios without compromising financial responsibilities. Furthermore, green bonds often come with transparent use-of-proceeds and reporting requirements, providing investors with clear insights into environmental impact.

From a **corporate issuer**'s perspective, green bonds serve as a strategic financing tool to support climate-related investments without changing ownership, unlike equity financing. They provide access to a dedicated pool of ESG-focused investors, broadening the investor base and potentially improving the issuer's ESG ratings and market reputation (Flammer, 2021). For **public issuers** such as governments and municipalities, green bonds offer an instrument to align fiscal policy with environmental objectives while attracting ESG-conscious investors. Because proceeds are linked to specific green projects, these bonds enhance transparency and public accountability, distinguishing them from conventional government or municipal bonds and general budget allocations (Baldi and Ferri, 2022). The clear earmarking of funds also signals credibility to markets and helps deepen sustainable financial markets.

For both corporate and public issuers, green bonds may reduce the cost of capital compared with conventional bonds through a "greenium", that is, investors accepting lower yields in exchange for environmental alignment (Caramichael and Rapp, 2024; Baker et al., 2022; Ando et al., 2024). This premium reflects investors' willingness to trade

some financial return for non-financial utility, such as preferences for environmental impact, regulatory alignment, or reputational benefits. In some cases, these reputational dynamics may also be linked to concerns about "greenwashing", where issuers are perceived as benefiting from the green label without substantial changes in underlying environmental performance. Evidence on the persistence of the greenium in secondary markets is mixed. Some studies find that the yield advantage often decreases in secondary markets as prices converge toward those of comparable conventional bonds (Ehlers and Packer, 2017), while others find that the premium can persist (Gianfrate and Peri, 2019). Overall, this suggests that the greenium may arise primarily at issuance, when strong demand from sustainability-oriented investors lowers yields, but may narrow over time as trading dynamics evolve. Although a price premium for green bonds may seem inconsistent with the principle that assets with equal risk should have the same expected return, several factors may explain why the greenium can persist. Even if an investor wanted to arbitrage the spread, doing so is often not feasible in practice. Issuers of green bonds are restricted in their use of proceeds and cannot invest borrowed funds in higher-yielding conventional bonds, and many institutional investors face short-selling constraints. Market segmentation and transaction costs also limit arbitrage opportunities. Thus, arbitrage may not be feasible for many market participants, allowing a modest greenium to exist without contradicting basic asset-pricing logic.

The combination of reputational, financial, and structural advantages makes green bonds an increasingly attractive option for companies looking to align their capital raising with environmental goals. Since the 2015 Paris Agreement, the green bond market has grown exceptionally, with issuers ranging from sovereigns and municipalities to banks and private corporations (Demski et al., 2025).

Here, we should also mention **transition bonds**, which are a variation of green bonds designed for entities in high-emitting sectors to finance projects that constitute a meaningful step toward decarbonization. Like green bonds, they are Use-of-Proceeds instruments, but they target activities that enable a significant transition rather than projects that are already low-carbon. Transition bonds are still used mainly by private issuers, but public sector involvement is gradually increasing in several countries. In Japan, state-owned enterprises and public financial institutions, such as the Development Bank of Japan, have issued transition bonds (DBJ, 2024).

5.2 Sustainability-Linked Bonds (SLBs)

In contrast to Use-of-Proceeds bonds such as green bonds, Performance-Linked Bonds, most notably Sustainability-Linked Bonds (SLBs), do not link funds to specific projects. Instead, the sustainability feature is tied to the issuer's ability to meet future, pre-defined climate targets or KPIs. This structure gives issuers greater budgetary flexibility than green bonds, while still requiring ongoing performance monitoring.

This instrument is accessible to all levels of the public sector. Sovereign governments can issue SLBs where the financial terms are linked to national targets, such as their Nationally Determined Contribution under the Paris Agreement. Similarly, municipalities and regions can tie SLB performance to local KPIs, such as targets for public transport usage or waste reduction. Finally, state-owned enterprises, such as

public utilities, can issue SLBs linked to their corporate decarbonization strategies. In all cases, a failure to meet the stated KPIs results in a financial penalty for the issuer, typically in the form of a higher interest rate paid to investors.

Introduced in 2019, SLBs quickly gained interest as a flexible alternative to green bonds, allowing issuers to raise capital for general purposes while committing to sustainability outcomes. Global issuance of SLBs surged in 2021 driven by growing demand for sustainability-aligned finance. However, after a promising start, the SLB market has faced a notable contraction. According to IFC (2025), globally, SLB issuance fell by 46% in 2024. The decline was even more pronounced in emerging markets, where issuance dropped by 53%. This contraction was primarily driven by slowdowns in China and the Latin America and Caribbean region (see also Intercontinental Exchange (ICE), 2024 and Environmental Finance, 2024). The report suggests this weak performance is due to a mix of design flaws and concerns about credibility. A key issue is that the penalties for failing to meet sustainability targets, known as coupon step-ups, are often too low to serve as a meaningful financial disincentive for issuers. Additionally, because SLBs lack a "use of proceeds" requirement, they do not earmark funds for specific projects like green bonds do, which may make them less attractive to impact-focused investors. In addition, the general factors such as rising interest rates and broader economic uncertainty have impacted all debt markets, including sustainable finance.

6. Sweden's Climate Finance: Pricing, Investment, and Global Engagement

This chapter presents the main public instruments Sweden uses to finance climate action. It covers carbon pricing and domestic climate investment programs, with a focus on risk-sharing aspects of the investment vehicles. The chapter also describes engaging private capital by using green bonds and sustainability-linked instruments and concludes with an overview of Sweden's international climate finance contributions.

6.1 Carbon Pricing

Sweden is a global frontrunner in climate action, employing a sophisticated and comprehensive mix of policies and financial instruments (OECD, 2023). Sweden's strategy has long been defined by a high carbon price and significant public investment in innovation. It introduced a carbon tax in 1991, becoming one of the first countries in the world to do so. Rather than creating a new system, it was integrated into existing fuel taxes. The tax has steadily increased over the years and today is among the highest in the world (OECD, 2023). The tax primarily targets fossil fuels consumed for heating and transport. The carbon tax is one of several environmental taxes in Sweden, alongside the energy, aviation, and vehicle taxes (Jonsson et al., 2020).

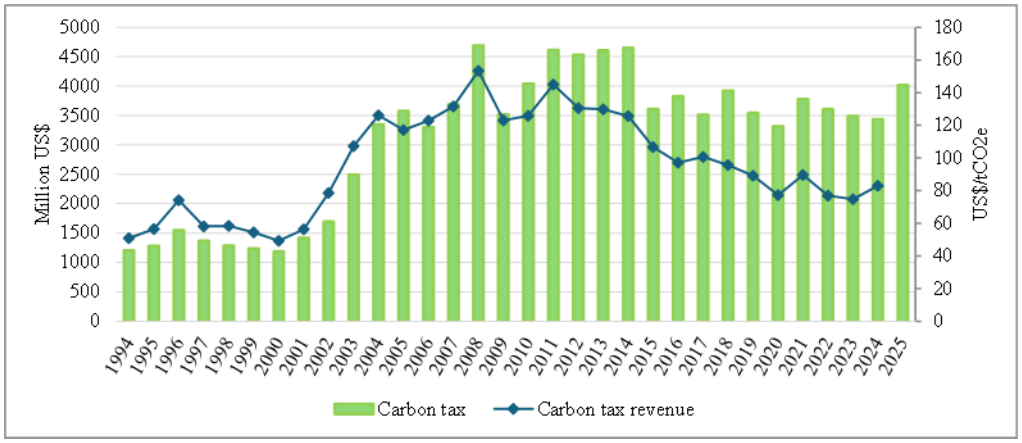
To maintain competitiveness, Sweden's carbon tax has always included significant exemptions, especially for trade-exposed industries. Due to these exemptions, Sweden's carbon tax covers about 40 percent of all GHG emitted nationally (Jonsson et al., 2020). Since 2005, large parts of industry have instead been covered by the EU ETS (typically with a lower carbon price), which regulates power generation, energy-intensive industries, and aviation, although sectors such as agriculture, forestry, and some mining activities remain outside broad carbon pricing coverage. Sweden does not have its own ETS program. Together with the EU ETS, carbon pricing covers around 80% of Sweden's GHG emissions, making it one of the most extensive carbon pricing systems globally (OECD, 2023).

The revenues from Sweden's carbon tax are not earmarked for specific climate measures but flow into the general budget. However, they can serve as a partial source of financing for climate-related programs and support for renewable energy. Revenue from the auctioning of allowances under the EU Emissions Trading System (ETS) goes primarily to national budget of the country. While this income was previously considered part of general state revenue, a new requirement introduced in June 2023 obliges member states to allocate all ETS revenues, or an equivalent financial value, to support climate action and energy transformation (not need to be spent in full in the same year that the revenue is generated). The only permitted exception is the use of revenues to compensate electricity-intensive industries for indirect carbon costs, helping to maintain industrial competitiveness during the transition (European Commission, 2024).

Figure 2 shows the carbon tax rate USD per ton CO_2 equivalent (tCO_2e) and total annual carbon tax revenues (million USD) for Sweden from 1994 to 2025, using data from the World Bank. Sweden's carbon tax has risen steadily from around USD 40tCO_2e in the early 1990s to over USD 130/tCO_2e in recent years, making it one of the highest carbon taxes globally. Between 2000 and 2008, total revenues increased sharply, exceeding USD 4

billion at their peak in 2008, just before the global financial crisis. This may reflect a combination of a rising carbon tax rate and strong economic growth, which likely led to increased fossil fuel consumption during that period. However, despite continued increases in the tax rate, carbon tax revenues have gradually declined since 2008, in particular between 2014 and 2020. This trend is likely due to multiple factors, including successful emissions reductions, decreasing fossil fuel use in heating and transport, the adoption of electric vehicles, and a shrinking taxable base due to exemptions or shifts to EU ETS coverage. In recent years, revenue levels have stabilized, possibly indicating slower emission reductions and/or more stable tax rates.

Figure 2 Tax Rate Versus Tax Revenues Sweden from 1994 to 2025.



Source: Own analysis based on data from World Bank.

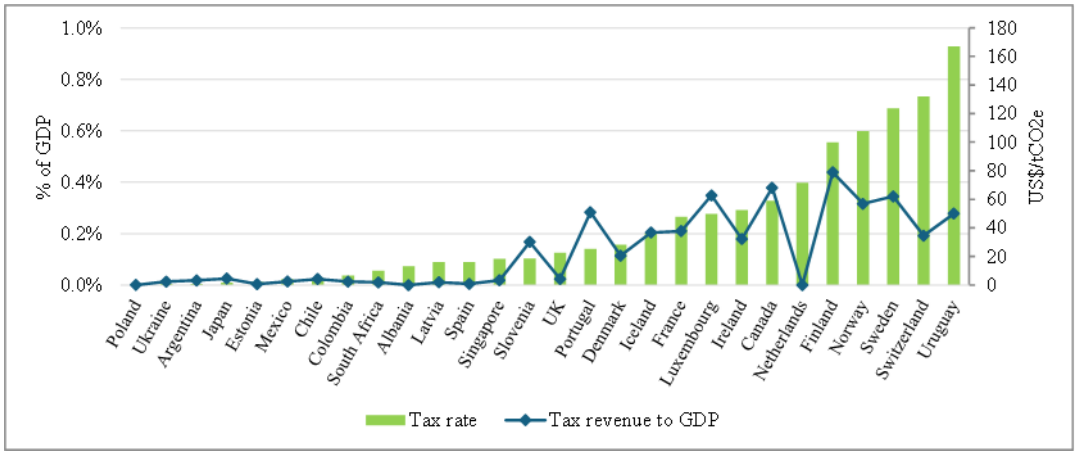
For comparison with the other countries, in Figure 3, we show the carbon tax rates and carbon tax revenues as a share of GDP across several different countries, in 2024. The left axis shows carbon tax revenue as a percentage of GDP, represented by the blue line, while the right axis indicates the carbon tax rate in US dollars per ton of CO_2 equivalent, shown as green bars. Data exclude state-level taxes for countries such as the US, Canada, and Australia. The countries are sorted based on the tax rate from low to high. GDP values are adjusted for price differences between countries and for inflation (constant 2021 prices).

The results show that most countries collect very little revenue from carbon taxes. For many economies, particularly those on the left side of the chart carbon tax revenue represents less than 0.1 percent of GDP. Even among high-income nations, the revenue share typically ranges between 0.1 and 0.4 percent of GDP. Sweden, Switzerland, and Uruguay stand out with the highest carbon tax rates, exceeding USD 120 to 160 per tonne of CO_2 equivalent. The Nordic countries other than Sweden also have a relatively high carbon tax. Despite these high rates, carbon tax revenues remain below 0.6 percent of GDP, which suggests that high carbon prices do not necessarily generate large revenues.[5] This might be explained by their relatively low emission levels, extensive coverage of emissions trading systems, and exemptions for certain sectors. Some countries such as the Netherlands, collect little or no revenue despite moderate carbon prices. Overall, the

[5] In Sweden, the carbon tax accounted for approximately 1% of total tax revenues in 2024.

figure shows that there is no clear correlation between the level of the carbon tax rate and the share of revenue in GDP.

Figure 3 Carbon tax rates versus tax revenues as a share of GDP across countries in 2024.

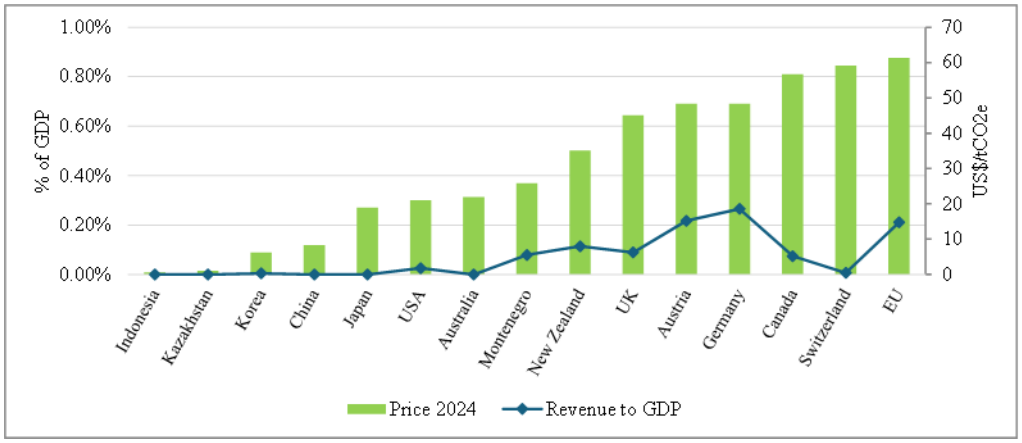


Source: Own analysis based on data from World Bank.

Figure 4 shows average carbon prices and total annual revenues as a share of GDP from ETS for countries with data in the World Bank database in 2024. The green bars represent the carbon price under each ETS in US dollars per ton of CO_2 equivalent (US$/t$CO_2$e), measured on the right axis, while the blue line shows ETS revenue as a percentage of GDP, measured on the left axis. The countries are sorted based on the carbon prices from low to high. GDP values are adjusted for price differences between countries and for inflation (constant 2021 prices).

The figure illustrates that, across most countries, ETS revenues, similar to revenues from carbon tax, represent a small fraction of GDP, typically below 0.2 percent. The EU stands out with one of the highest carbon prices, around USD 60 per ton of CO_2e, and relatively high revenue relative to GDP compared to most individual countries. Germany and Austria, which in addition to its participation in the EU ETS, operates a national ETS, also posts a high price and revenue to GDP from their national programs, while the United States shows a much lower price and revenue shares. It should be noted that in the regional Greenhouse Gas Initiative in the United States, entities get most of their allowances through auctions, and the revenues are "primarily invested in energy efficiency, renewable energy, direct energy bill assistance, and other GHG reduction programs (ICAP, 2023). Among individual countries, Switzerland has the highest carbon price.

Figure 4 ETS price versus revenues as a share of GDP across countries in 2024.



Source: Own analysis based on data from World Bank.

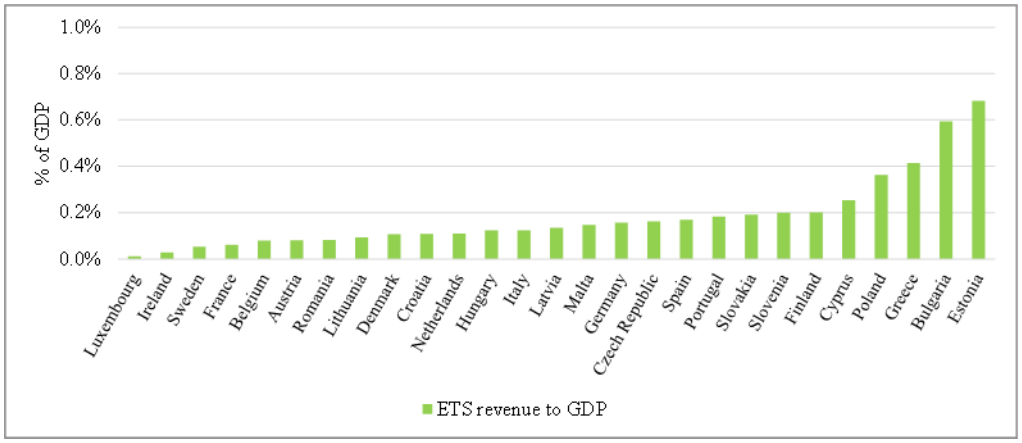
In Figure 5, we plot the share of ETS auction revenues to GDP across EU countries, in 2023, according to the European Environment Agency (EEA) Datahub[6], with reporting year 2024 (data for 2024 is not available yet). The figure shows that the share varies widely, from below 0.1% in countries like Luxembourg, Ireland, and Sweden to around 0.6% in Estonia, Bulgaria, and Greece. The volume of auction revenues depends on the structure of national energy systems and industry, as countries with more carbon-intensive sectors, such as coal-based power generation, tend to receive and auction a larger number of allowances. This implies that lower ETS revenues in countries like Sweden primarily reflect lower emissions rather than weaker policy performance. In general, higher ratios typically reflect smaller economies and larger fossil-fuel sectors, while wealthier, low-emission countries collect relatively little in proportion to GDP.

Sweden reported about €323 million in auction revenues, roughly 1% of total EU ETS auction revenue in 2023, allocated to two programs: Climate Bonus for low-emission vehicles (€113.24 million) and Klimatklivet (The Climate Leap) grants for GHG reduction (€209.862 million). Looking at the report from other countries, ETS money is primarily used in projects that cut emissions in buildings, power, and transport, while some countries, such as Germany, Greece and Poland, allocate notable amounts to mitigating costs for households/industry. It is also notable that the number and size of ETS-funded projects vary widely across countries. Some, such as Sweden, Spain, and Finland, channel revenues through a few large national programs each covering many underlying actions (e.g. Sweden's Klimatklivet). Others, like Belgium, Malta, and Croatia, list numerous small projects reflecting more decentralized systems. These contrasts mainly stem from differences in administrative structure, reporting style, and the overall scale of ETS revenues.

Overall, Figures 4 and 5 highlight that fiscal revenues from carbon pricing are modest as a share of national output. Similar to the carbon tax, this suggests that emissions trading systems are primarily designed as market-based regulatory instruments aimed at reducing emissions rather than as major sources of government revenue.

[6] https://www.eea.europa.eu/en/analysis/maps-and-charts/emissions-trading-viewer-1-dashboards.

Figure 5 The share of ETS auction revenues to GDP across EU countries in 2023.



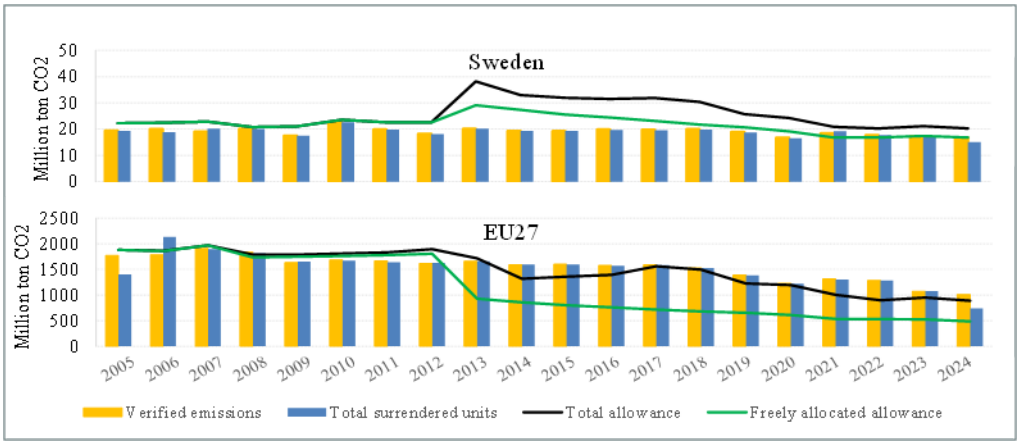
Source: Own analysis based on data from European Environment Agency (EEA) Datahub.

In Figure 6, we compare EU ETS trends in Sweden and the EU27 (the 27 member states of the EU) between 2005 and 2024. The upper panel presents data for Sweden, while the lower panel covers the aggregate EU-27. The yellow bars represent verified emissions (actual emissions reported by regulated entities), the blue bars show total surrendered units (the number of allowances and credits used to cover emissions), the black line indicates total allowances issued, and the green line shows freely allocated allowances (allowances distributed without auction). Aviation is excluded from all series.

The total and freely allocated allowances (black and green lines) show different patterns for Sweden and the wider EU. In both cases, total allowances decline over time, reflecting the progressive tightening of the EU ETS cap. The change in allowance patterns and the lower free allowances around 2013 reflect the start of Phase III of the EU ETS, which introduced major structural reforms. This phase replaced national allocation plans with a single EU-wide cap and implemented benchmark-based free allocation determined by the most efficient installations in each sector. At the same time, auctioning expanded, becoming the main method of allocation for the power sector and gradually increasing for others (European Commission, 2015).

Verified emissions (yellow bars) and surrendered units (blue bars) track closely in both Sweden and the EU27, indicating that participants largely meet their obligations within the system. Emissions have fallen steadily across the EU, which may be driven by power-sector decarbonization and industrial efficiency gains. Sweden's more gradual decline in ETS-covered emissions likely reflects several interrelated factors. First, Sweden began decarbonizing earlier than many EU member states, including through the early introduction of carbon taxation, meaning part of the relatively easier emissions reductions may already have been achieved before the EU ETS was introduced. This may have reduced the remaining potential for rapid emissions cuts within ETS-covered sectors. Second, Sweden experienced somewhat stronger economic growth than the EU average over the same period, which may have sustained industrial activity and energy demand despite rising carbon prices. According to World Bank data, Sweden's GDP grew by approximately 39% between 2005 and 2024, compared with around 29% for the EU average.

Figure 6 EU ETS trends in Sweden and the EU27 from 2005 to 2024.



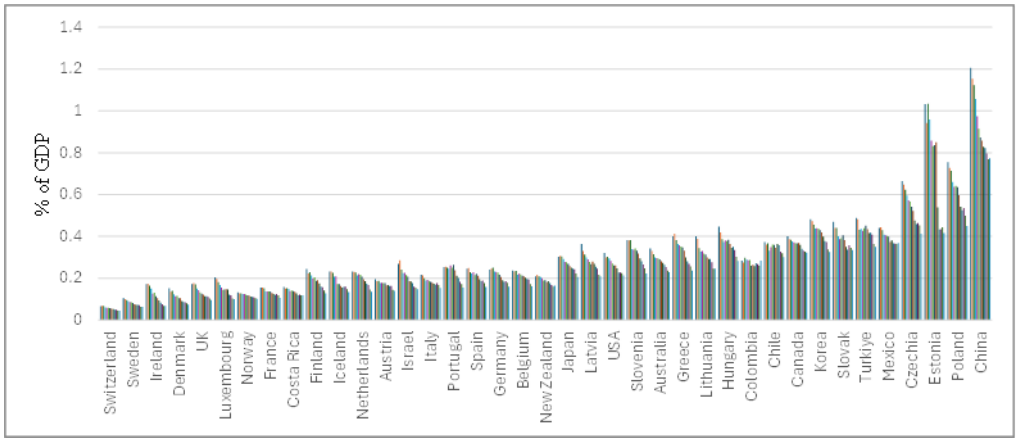
Source: Own analysis based on data from EU Emissions Trading System (ETS) data viewer

6.2 Sweden's Climate Performance and Transition Challenges

According to the OECD (2023) report Sweden is one of the OECD's top performers in reducing GHG emissions. According to the report, Sweden has achieved remarkable progress in cutting GHG emissions from about 72 million tons CO2 in 1990 to below 50 million tons in 2021, being among the lowest in the industrialized world regarding both per capita emissions and emissions intensity per unit of GDP. Sweden's vast forests and soils also act as a major carbon sink instrument (OECD, 2023). This trend of consistent emission reductions is further supported by other studies, which show that Sweden's carbon emissions fell by 27 percent between 1990 and 2018, with the largest reductions coming from the heating sector. This was achieved alongside steady economic growth, as GDP per capita increased by more than 50 percent between 1990 and 2019 (Jonsson et al., 2020).

Figure 7 shows carbon intensity relative to GDP, measured as kilograms of CO_2 equivalent per constant 2015 US dollar of output, for OECD countries plus China, during 2011-2023. The data is sorted based on countries' carbon intensity in 2023 from low to high. Sweden is among the lowest emitters, alongside other Nordic countries such as Denmark, Norway, and Finland, and far below large economies like Poland, Canada, and China, with several times higher intensity. This reflects Sweden's relatively advanced decarbonization and low-emissions economic structure. At the same time, the already low carbon intensity suggests that further emissions reductions may become increasingly challenging, relying more on technological innovation and structural transformation than on the more readily achievable reductions already realized.

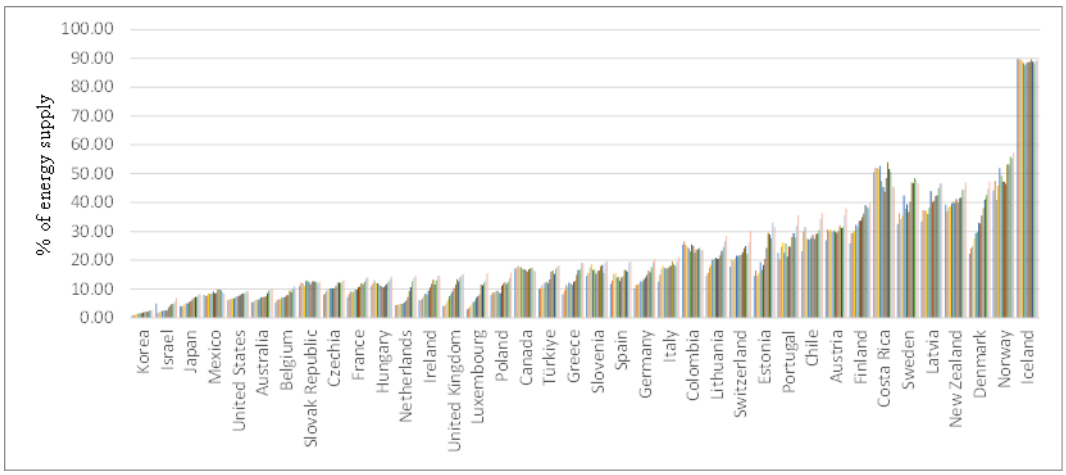
Figure 7 Carbon intensity relative to GDP OECD countries and China from 2011 to 2023.



Source: Own analysis based on data from World Bank.

Figure 8 shows the share of total renewable energy in primary energy supply for OECD countries from 2011 to 2024. Renewables include hydro, geothermal, solar, wind, tide, wave, and bioenergy sources. Countries are sorted from low to high based on their renewable energy share in 2024. Sweden ranks among the strongest OECD performers, with renewable energy accounting for around 40–45 percent of primary energy supply in 2024 and showing a gradual increase over the period. It remains below countries such as Iceland and Norway, whose particularly high shares partly reflect exceptional natural resource endowments, especially geothermal and hydropower, in addition to policy choices and technological development. Sweden is broadly comparable to other high-performing countries such as Denmark, New Zealand, Costa Rica, and Latvia. Many OECD countries remain at substantially lower levels, although most show an upward trend over the period.

Figure 8 The share of renewable energy in primary energy supply, OECD countries, 2011-2024.



Source: Own analysis based on data from OECD.

Despite the strong record shown above, the country faces pressing challenges in meeting its future climate goals. By 2030, Sweden is legally bound to cut emissions in sectors outside the EU ETS by 63% compared to 1990 levels (Government Office of Sweden 2021). Sweden's long-term target is to reduce GHG emissions to net zero by 2045 at the latest and achieve negative emissions thereafter. According to the OECD (2023) report,

electricity demand is projected to roughly double by 2045, driven by the electrification of transport, industry, and heating. With today's electricity mix already 98% fossil-free, primarily from hydro, nuclear, and wind power, Sweden's path to net zero by 2045 requires transforming its energy system, not mainly by decarbonizing electricity, but by doubling supply and expanding the grid, according to the report. The massive investments in fossil-free steel, battery production, and hydrogen reshape the economy toward this goal, but they also create new challenges; most municipalities in developing areas in Sweden face housing shortages and industries face growing demand for skilled labor to sustain expansion (OECD 2023).

6.3 Domestic Climate Investment Strategies

This section describes the most important domestic public investment strategies to reach Sweden's long-term climate goals.[7] We group instruments into three types based on their degree of risk-sharing with the private sector:

- **Non-repayable (de-risking) supports** that lower or eliminate early-stage private risk and cost. Once paid, it normally has no further financial exposure to the public sector.
- **Risk-sharing finance** that places public capital at risk alongside private capital and create ongoing exposures if projects underperform.
- **Fully Public (non-shared) investments**: The state or municipalities finance and own the assets and bear the costs and operational risks.

It should also be added that Sweden complements investments with a mix of additional policies, including the Green Certificate Scheme, (elcertifikat, Swedish Energy Agency, n.d.-a), voluntary agreements with industry that encourages industries to go beyond legal minimums (Kemi, n.d.), and legislation such as the Climate Act, adopted in 2017, which establishes a legally binding framework to pursue policies consistent with the national goal (Naturvårdsverket, n.d.-a). Alongside these policies, the government also provides support for reskilling and upskilling, ensuring that industrial transformation creates sustainable jobs and benefits local communities (OECD, 2023). While these measures are not financial instruments in a narrow sense, they affect relative prices, reduce investment risk, and improve expected returns for low-carbon technologies. They can therefore be considered as complementary facilities to support the effectiveness of the public investment strategies that are the main focus of this report. The remainder of this section therefore concentrates on more direct financial instruments, classified according to their degree of public–private risk-sharing.

6.3.1 Non-Repayable Public Investment Programs

This category includes tools that make projects cheaper and safer to finance, without putting public money at ongoing risk. For private actors, these measures reduce early-stage technical and delivery risk and lower financing costs, helping projects become bankable and attract private debt and equity financing, without involving public credit or equity. The primary instrument in this category is grant. Grants are direct, non-repayable

[7] Climate adaptation and resilience strategies, such as investments in flood protection, forestry management, and climate-resilient infrastructure, are also part of Sweden's broader climate agenda, but are not covered in this report. Sweden faces relatively moderate climate risks, and adaptation is generally addressed through sectoral and local infrastructure policies implemented by municipalities and regional authorities, rather than through dedicated national funding instruments (Krisinformation.se, 2023).

funding without exposing the public sector to losses beyond the initially paid amount. However, because grants typically do not involve repayment obligations or ongoing contractual claims, it provides limited control and monitoring capacity once funds are paid, unless reimbursement is tied to milestones and ex-post verifications.

Agencies such as the Swedish Energy Agency and Vinnova play a key role in financing Sweden's clean-tech transition through grants. The Swedish Energy Agency administers Industriklivet (The Industrial Leap), a program launched in 2017 to support the decarbonization of heavy industry. It provides funding in three key areas: reducing industrial GHG emissions, achieving negative emissions via biogenic CO_2 capture and storage, and supporting innovative, high-impact technologies that can broadly reduce emissions. Industriklivet has a total budget of SEK 653 million in 2026 and can finance projects running until 2033, with the annual allocation decided as part of the government's budget bill (Swedish Energy Agency, n.d.-b).

Notable examples of projects supported by the Swedish Energy Agency include HYBRIT (Hydrogen Breakthrough Ironmaking Technology), a fossil-free steel initiative launched in 2017 by SSAB, LKAB, and Vattenfall (two of the three owners are state-owned) with government support, which produced the world's first fossil-free steel (Vattenfall, n.d.). The Agency also supports research and innovation in carbon capture (IEA Bioenergy, 2023), renewable hydrogen (Swedish Energy Agency, 2024), and bioenergy technologies (Bio+ Portal, n.d.) to support industrial decarbonization. Another major example is the €6.5 billion initiative H_2 Green Steel (rebranded in 2024 as Stegra), launched in 2020 to build large-scale fossil-free steel plants powered by renewable hydrogen (Financial Times, 2024). Although established as a private enterprise, the project has received €265 million in funding from the European Commission, alongside initial grant support of €100 million and an additional SEK 390 million awarded in 2025 by the Swedish Energy Agency (Fuel Cells Works, 2024; H2View, 2024; Swedish Energy Agency, n.d.-c). In addition to grants, Stegra has benefited from a credit guarantee issued by the Swedish National Debt Office.

Vinnova funds innovation projects across multiple sectors, including early R&D support for Northvolt, a Swedish battery manufacturer founded in 2016 to develop sustainable batteries that help secure Europe's green energy supply[8] (Vinnova, n. d.). Another example of Vinnova's contribution is its co-funding of Drive Sweden, 17 strategic innovation programs that supports pilot and demonstration projects in digitized, connected, and shared mobility solutions for new sustainable transport technologies (Drive Sweden, n.d.).

In parallel, Sweden operates investment programs at the local level. Klimatklivet (The Climate Leap), is a funding program for local and regional climate investments administered by the Environmental Protection Agency and County Administrative Boards, established in 2015 and partially funded by the EU Recovery and Resilience Facility (OECD 2023). This program provides grants to local and regional projects that reduce GHG emissions, including biogas production, public transport, and industrial process changes. Since its launch in 2015, Klimatklivet has allocated SEK 19.7 billion to

[8] In recent years, Northvolt has faced significant financial and operational challenges and filed for bankruptcy in March 2025.

more than 27,500 investments that in various ways contribute to the green transition (Naturvårdsverket, n.d.-b).

Similar non-repayable public investment programs are widely used across advanced economies to support early-stage climate innovation. Nordic peers, Finland (Business Finland, Finnish National Climate Fund), Norway (Enova SF), and Denmark (EUDP, Innovation Fund Denmark), operate similar grant-based support for industrial decarbonization and clean tech R&D. The European Commission's Innovation Fund is one of the largest international sources of non-repayable climate financing (European Commission, n.d.). In the United States, the U.S. Department of Energy funds large-scale clean energy projects through non-repayable grants and cooperative agreements, supporting decarbonization technologies (U.S. Department of Energy, n.d.-a). While the overall objective is shared, programs differ in how they structure disbursement, reporting, and post-payment control. In Sweden, agencies such as the Swedish Energy Agency and Vinnova generally apply milestone-based disbursement and ex-post reporting, with audit and review rights and the possibility of repayment in cases of misuse or non-compliance. However, they typically lack contractual claw-back clauses tied to specific performance outcomes (Swedish Energy Agency, n.d.-d; Vinnova, 2025).

Compared with Sweden's relatively trust-based administrative tradition, U.S. federal grant systems are characterized by a relatively formalized compliance framework under the Uniform Guidance (2 CFR Part 200), which includes detailed monitoring requirements and explicit remedies for noncompliance, including payment withholding, suspension, termination, and exclusion from future federal funding (2 CFR § 200.339, Legal Information Institute, 2024). Similarly, at the EU level, the Innovation Fund operates under the standard Model Grant Agreement, which sets out a formalized framework for documentation, verification, and performance-based disbursement. Beneficiaries must retain records demonstrating both proper implementation of the project and, where applicable, the achievement of agreed results. If implementation or results cannot be adequately substantiated, the European Commission may proportionally reduce or recover the grant (see Articles 20 and 28 in the European Commission's model grant agreement; European Commission, 2022).

6.3.2 Risk-Sharing Finance

Sweden increasingly uses instruments that put public capital side-by-side with private investors or borrowers. These types of engagement create ongoing exposures if projects underperform. The degree of exposure and control varies across instruments.

- **Equity investment:**

Risk-sharing through equity investment has a high degree of financial risk in exchange for high information and monitoring rights. The government can influence strategies but shares decisions with other owners.

Investment entities like Almi Invest and Saminvest use equity-based financing to support early-stage cleantech ventures and strengthen the national VC ecosystem. Almi Invest is a wholly state-owned early-stage investor. It manages roughly SEK 3.5 billion in equity across eight regional funds and a national GreenTech fund, and has backed some 900 startups to date, often as a bridge to private VC. Its GreenTech fund alone, with SEK 1.2

billion under management, focuses specifically on CO_2-reducing cleantech investments, demonstrating Sweden's use of public capital to de-risk and catalyze private financing in climate-smart ventures (Almi, n.d.).

Saminvest is also a government-owned VC firm, established in 2016 to strengthen Sweden's VC ecosystem by filling gaps where private capital is insufficient. Acting primarily as an anchor investor, it commits commercial-basis capital, approximately SEK 6 billion under management, to privately managed funds and business-angel programs, spanning life-science, tech, and other sectors from pre-seed through growth stages. By investing alongside private backers and fostering new fund managers, Saminvest helps innovative Swedish companies access the capital and expertise they need to scale (Saminvest, n.d.).

- **Loans**

Loan financing, being senior to equity, entails lower exposure to project failure and provides no share of profit beyond the contractual interest payment. It offers a lower degree of control and relies on contract-based (covenant) monitoring.

Sweden employs market-based loan instruments to support its climate transition. Domestically, the Swedish Export Credit Corporation and the Swedish Export Credit Agency (EKN; Exportkreditnämnden) offer green loans and export guarantees at market rates to companies exporting clean-technology solutions. Sustainability-linked loans (SLLs) are also well-established in the Swedish and broader Nordic financial markets. Although these are primarily offered by private banks, state-owned institutions like Swedish Export Credit Corporation have also introduced sustainability-linked financing, where loan terms are tied to the borrower's climate targets. These loans typically offer lower interest margins to companies that make measurable progress toward goals such as carbon neutrality (Swedish Export Credit Corporation, 2024).

To respond to rising electricity demand, the government has committed to a major expansion of nuclear power. In 2024–2025 it introduced state-backed loans and risk-sharing mechanisms (including a new state aid framework) to enable investment in new reactors. Government loans may finance construction, testing, and preparatory work, but require equity contributions from developers and are to be repaid in instalments once reactors become operational. These measures are designed to support a broad range of actors-state utilities, municipalities, and private developers, thereby approximating a more neutral financing environment (Government Office of Sweden, 2025b).

- **PPP/Blended structures:**

The use of traditional PPP adoption has been limited in Sweden compared with many other countries. According to Swedish National Debt Office (2021), this reflects both the government's strong fiscal position, which reduces the need for private financing, and the perception that PPPs tend to raise overall costs. Despite limited use, Sweden has implemented a few notable PPP projects, though most are not climate-specific. One example with an indirect climate impact is the Arlanda Express, a high-speed rail link between Stockholm and Arlanda Airport, developed under a 45-year build-operate-transfer concession. While primarily intended to improve airport access, the project indirectly supports climate goals by shifting passengers from road to electrified rail. This

project shows how a state can deploy viability-gap funding through a blended support package, which includes a capital grant, in-kind assets (track access), a subordinated loan, and credit guarantees, which improved bankability and enabled the private A-Train consortium to finance and operate the line (Swedish National Audit Office,2016).

- **State credit guarantees for green industry**

Beyond traditional PPPs, Sweden uses blended finance structures and credit-enhancement tools to share risk with the private sector. Domestically, the Swedish National Debt Office is authorized to issue state-backed credit guarantees covering up to 80 percent of commercial loans for large-scale green industrial projects in Sweden.[9] Eligible sectors include biofuel refineries, hydrogen plants, and fossil-free steel manufacturing. Guarantees can extend up to 15 years and substantially reduce risk weights for banks, enabling firms to secure cheaper, longer-term financing for decarbonization (Swedish National Debt Office, n.d.). An example is a guarantee issued to support Stegra, covering 80 percent of a €1.2 billion loan provided by a consortium of banks (Swedish National Debt Office, 2023).

Sweden also provides risk-sharing instruments through other public institutions. EKN offers green guarantees for Swedish exporters of climate-aligned technologies, lowering the risk for lenders and opening high-risk foreign markets. The agency also offers a Green Credit Guarantee for green investments and working capital in Sweden (EKN, n.d.).

Internationally, public risk-sharing instruments are increasingly adopted across Europe and North America to mobilize private investment in domestic clean energy and industrial decarbonization. Similar to Sweden's Almi and Saminvest, most OECD countries operate state-backed investment or development funds (e.g., Export and Investment Fund of Denmark, Finland's Climate Fund, Germany's KfW Capital, and the United Kingdom's British Business Bank).

Public loan and guarantee schemes are also central to the EU's InvestEU program, which aims to mobilize over €400 billion in of public and private sustainable investment by allocating €29.1 billion in EU budget reserves as a guarantee to cover potential losses or defaults on projects financed under the program. This leverage effect allows partner banks to extend substantially larger volumes of loans and equity than the amount directly covered by the guarantee (European Commission, 2025d). In the United States, U.S. Department of Energy's Loan Programs Office (LPO) is authorized to provide guarantees for up to US $40 billion in new clean energy loans, supported by US $3.6 billion in federal credit subsidy funds to cover potential defaults (U.S. Department of Energy, n.d.-b). Structurally, however, Sweden's risk-sharing framework may be relatively more conservative, with limited use of blended finance and PPPs, which reflects its strong fiscal position and a policy preference for maintaining public control (Swedish National Debt Office, 2021). In this way, Sweden keeps most climate and innovation finance on-balance-sheet (through direct grants, loans, and equity via state entities) and thereby limits long-term contingent liabilities and provides a more

[9] This program has recently been paused pending an evaluation of its design and effectiveness. The outcome of this review may influence the future role of credit guarantees in Sweden's climate investment framework (Government Office of Sweden, 2025c).

predictable risk profile, but at the cost of reduced financial leverage and higher public capital involvement.

6.3.3 Fully Public (Non-Shared) Investments

For critical networks and public-good assets, such as electricity grids, railways and roads, and water, Sweden typically relies on direct public investment, with the state or municipalities financing and owning the assets. In this model, the public sector bears full financial exposure to project risks, as it absorbs both costs and potential losses without sharing them with private actors. While this approach concentrates fiscal exposure, it does not necessarily imply a higher overall level of risk compared to risk-sharing arrangements. Rather, it reflects a different risk profile, as the probability and nature of risks are affected by factors such as long planning horizons, different incentive structures, and the high degree of visibility and control.

To promote alternatives to air travel, Sweden is investing in high-speed trains (SJ 250, Zefiro Express) and rail infrastructure (e.g., Ostlänken and North Bothnia Line). These investments are supported by major loans, including SEK 1.5 billion from the Nordic Investment Bank (NIB) in 2020 (NIB, 2020) and SEK 1.75 billion from EIB in 2023 (EIB, 2023). In 2023 the government shifted strategy away from a comprehensive national high-speed rail program toward selected high-speed corridors and upgrades to existing lines (Burroughs, 2023).

There is also substantial state support for modernizing the electricity grid and expanding the electric vehicle charging network. Transmission-grid upgrades are primarily direct public investments implemented by the state transmission system operator, Svenska kraftnät, which is responsible for developing and maintaining Sweden's national electricity grid and plans extensive expansions through 2033 (Svenska kraftnät, n.d.). By contrast, distribution networks and EV charging infrastructure are often delivered by private or municipal actors under regulated frameworks and with support from state-backed programs and grants administered by the Swedish Energy Agency (Swedish Energy Agency, n.d.-e).

Finally, the rollout of green bonds and loans, especially through Kommuninvest, has funded infrastructure such as onshore wind farms and electric bus fleets, supporting both clean energy and sustainable transport at municipality level (UNFCCC, n.d.-b). While the financing takes the form of public loans, the assets are publicly owned and operated, so the underlying investment is direct public.

Similar to Sweden, direct public investment is a tool for climate-relevant infrastructure across developed economies, especially in energy transmission, public transport, and water systems. Nordic countries and Germany maintain large publicly owned utilities, such as Statnett and Statkraft (Norway), Energinet (Denmark), and TenneT (Germany), that undertake grid expansion and renewable integration projects similar to Sweden's Svenska kraftnät. In the United States, the Infrastructure Investment and Jobs Act (2021) commits over $550 billion over fiscal years 2022 through 2026 in new Federal investment in infrastructure (U.S. Department of Transportation, n.d.).

6.4 Mobilizing Private Finance through Public Green Bonds

The Swedish state and municipalities mobilize private finance by issuing use-of-proceeds green bonds. While these bonds help attract private capital for public climate projects, they remain standard debt instruments with a green label: the credit risk stays with the public issuer, and investors do not share the underlying project risk.

Sweden has played a pioneering role in the development of municipal and corporate green bond markets. In 2013, the Swedish real estate company Vasakronan issued the world's first corporate green bond, with the total amount of 1,300 MSEK, financing energy-efficient, environmentally certified buildings (Vasakronan, 2013). Since then, a growing number of Swedish corporates, including energy firms, banks, and real estate developers, have used green bonds as part of their climate finance strategies and internal ESG commitments.

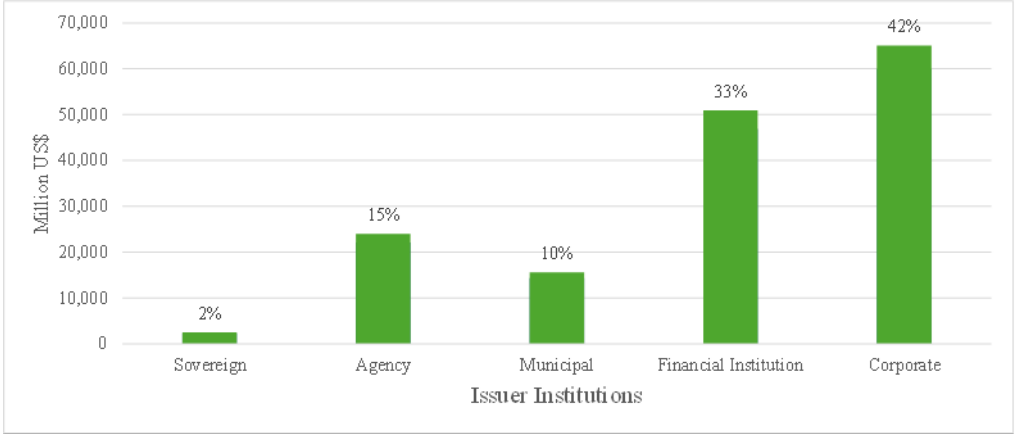
At the local government level, Swedish municipalities have been active early adopters of green bond issuance. Cities such as Gothenburg (also in 2013, with the total amount of 500 MSEK), Stockholm, Lund, and others have issued green bonds to finance investments in public transport, electric buses, sustainable urban infrastructure, and district energy upgrades. These municipal bonds are typically linked to local climate targets.

At the sovereign level, the Swedish National Debt Office issued the country's first sovereign green bond, raising SEK 20 billion to finance public investments in climate-related public expenditures including clean transport and renewable energy. As stated by the Swedish National Debt Office, the green bond program aims not only to fund green projects, but also to signal policy credibility, improve market transparency, and catalyze private sector participation in the green finance market (Swedish National Debt Office, 2020).

Figure 9 shows the cumulative total amount of green bonds issued in Sweden since 2013, including sustainability bonds with environmental objectives. The data is disaggregated by issuer type, corporate, municipal, agency[10], and sovereign entities. The distribution of green bond issuance in Sweden reveals a clear dominance of the private sector in driving climate-related financing. As shown in the figure, corporate issuers account for the largest share of cumulative issuance at 42%, followed by financial institutions at 33%, highlighting the strong engagement of market-based actors in sustainable investment. In contrast, public sector entities, including municipalities (10%), agencies (15%), and the sovereign (2%), represent a smaller, though still significant, portion of total issuance. This pattern suggests that while public finance plays a catalytic and enabling role, the bulk of capital mobilization for green investments in Sweden has been led by private and semi-private actors.

[10] In sustainable bond databases and financial market classifications, the term "agency" often refers to entities that are publicly owned, government-backed, or operate with a public service mandate, rather than formal government agencies. In the Swedish context, issuers such as Akademiska Hus (state-owned university property manager), Kommuninvest (municipal financing cooperative), Swedish Export Credit, and Vattenfall (state-owned energy utility) are typically classified as "agencies".

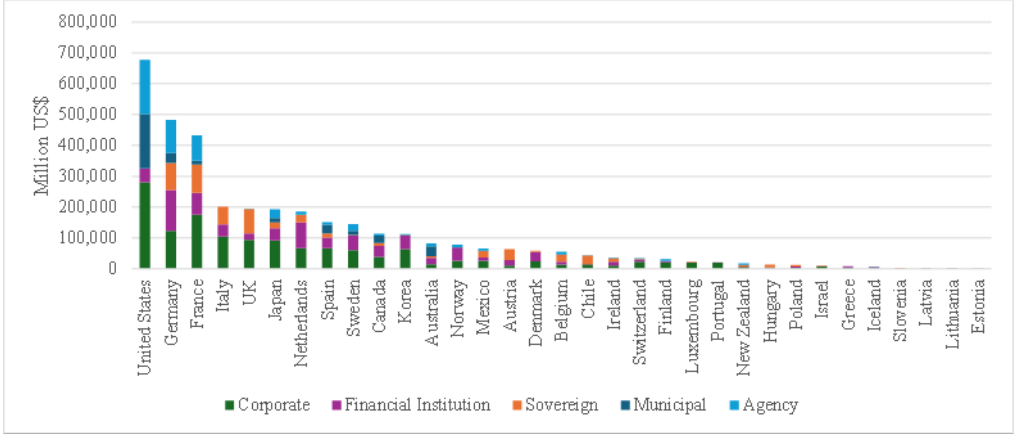
Figure 9 Cumulative Green Bond Issuance in Sweden (MUSD).



Source: Own analysis based on data from Sustainable Bonds Database.

Internationally, many countries have used sovereign green bonds to align public finances with climate goals. Figure 10 shows the cumulative green bond issuance from 2013 to 2024 for OECD countries. The United States emerges as the single largest issuer, with over USD 677 billion in cumulative green bonds. This is largely driven by the scale of its municipal green bond market, supported by tax incentives[11] and deep sub-national capital markets. In contrast, Germany and France have a balanced distribution of green bond issuance between public and private entities, with a significant share coming from sovereign issuer, reflecting the maturity of their national sustainable finance strategies. While corporate issuers dominate in some countries such as Italy and the UK, the share of public sector issuance is notably high in several smaller economies such as Belgium, Austria, and Chile.

Figure 10 Cumulative Green Bond Issuance in OECD countries (MUSD).



Source: Own analysis based on data from Sustainable Bonds Database.

[11] It should be noted that in the US, the core subsidy for most municipal bonds is the federal tax exemption on interest (the green label itself does not affect the tax). That exemption is a federal tax expenditure (foregone revenue) and affects borrowing costs and the relative public/private mix.

6.5 Sweden's International Climate Finance Commitments

In addition to its domestic investments, Sweden is a provider of international climate finance. Its contributions support mitigation and adaptation projects in low- and middle-income countries, delivered through a mix of bilateral aid and multilateral climate funds.

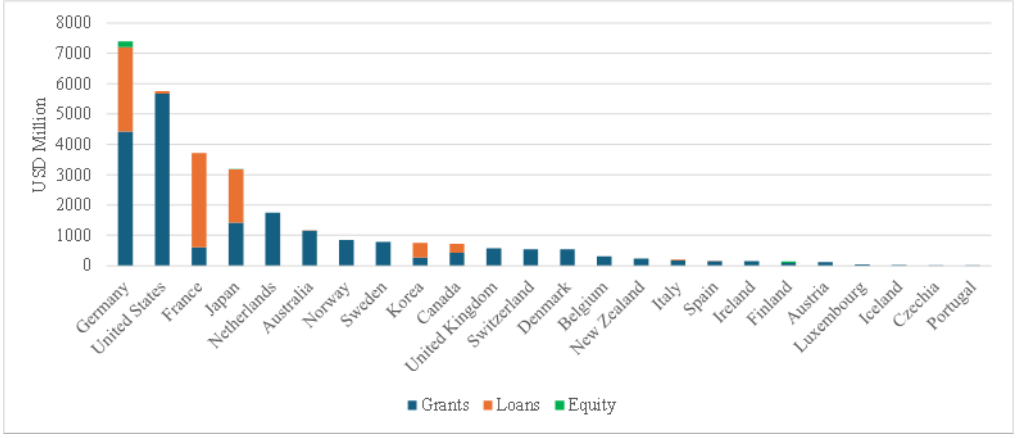
Figure 11 presents 2023 climate finance disbursements by major OECD donor countries, as reported in the OECD Creditor Reporting System (CRS) database. We include only two categories of aid: climate change mitigation (efforts to reduce or limit GHG emissions or to enhance GHG removal) and climate change adaptation. Other environmental aid, such as biodiversity-related financing, is excluded. We only include disbursements for which climate objectives are identified as either a principal or significant project purpose. Only donors with more than USD 200 million in total disbursements are shown

The figure shows that in 2023, Germany led OECD member contributions to climate action with roughly USD 7.4 billion in combined grants and loans (about USD 4.4 billion in grants and USD 2.8 billion in loans), followed closely by the United States at USD 5.8 billion (predominantly grants). France and Japan each exceeded USD 3 billion, with France relying more on concessional loans and Japan a mix of grants and loans. Equity investments (shown in green) were negligible across all donors. This distribution underscores the continued reliance on grant financing for climate projects, with loans playing a significant but secondary role among the largest contributors.

According to the Figure, Sweden ranked among the top 10 OECD donors in 2023, disbursing approximately USD 800 million in climate-related grants. This is primarily done through two channels. The first channel is bilateral aid, i.e. fundings provided directly to other countries. The Swedish International Development Cooperation Agency (Sida) is the main government agency for administering the foreign aid. A significant portion of this aid is directed towards climate mitigation and adaptation projects in developing nations. In 2023, Sida committed SEK 5.2 billion in bilateral climate aid in the form of below-market loans and grants delivered via trust funds and financial intermediary funds that emphasize global public goods, including climate resilience and renewable energy projects (Government Office of Sweden, 2024). Sida, Sweden also provides concessional loans to developing countries for climate adaptation and mitigation projects (Expert Group for Aid Studies (EBA), 2024).

The second channel is through multilateral contributions, i.e., fundings pooled by multiple donor countries into an international institution or fund. Sweden is a long-standing contributor to global climate funds such as the Green Climate Fund, the Global Environment Facility, and World Bank–managed trust funds. At the 29th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP29) in Baku, Sweden announced a significant scaling-up of its international climate finance. This included a SEK 8 billion pledge to the Green Climate Fund (2024–2027) and a SEK 670 million contribution to the Green Climate Fund for 2024 (Government Office of Sweden, 2024). These institutions channel concessional loans and grants to developing countries for mitigation and adaptation.

Figure 11 Climate Finance Disbursements by Major OECD Public Donors in 2023.



Source: Own analysis based on data from OECD CRS Database

Sweden also channels regional support through institutions such as NIB. For example, in 2024, NIB extended a SEK 300 million loan facility to Falkenbergs Sparbank for on-lending to small and medium-sized enterprises, with 50% of the facility dedicated to environmental projects such as energy-efficiency upgrades and sustainability investments (NIB, 2024).

7. Key Decision Factors for Public Support Instruments

The previous chapters have examined the main regulatory and financial instruments available to support climate action. Drawing on policy documents, academic literature, and evidence from Sweden's implementation, the report has described how instruments such as carbon pricing, grants, loans, equity, guarantees, blended finance arrangements, and green bonds differ in their objectives, institutional design, and fiscal implications. While this descriptive and comparative analysis provides an overview of available tools, it does not in itself answer a central policy question of how the public sector should choose among these instruments when designing support for climate investments. Effective public support requires an assessment of how different instruments interact with the conditions under which climate investments take place. Instrument suitability depends both on the context in which instruments are applied and on their characteristics.

Building on the literature review and the assessment of available instruments and Sweden's policy practice in Chapters 2–6, this chapter identifies and classifies key factors relevant for the selection and design of public support instruments.

As discussed in Chapter 6, instrument choice may, to some extent, be influenced by formal mandates and legal requirements, as well as broader political priorities and strategic objectives. An example is a policy measure introduced at the EU level in June 2023 that obliges member states to allocate all revenues from the EU ETS, or an equivalent financial value, to climate and energy-related investments. Such provisions define the scope and form of national support instruments by linking public revenues to specific climate objectives. Beyond formal mandates, governments may select particular instruments to stimulate innovation, mobilize private capital, or secure the long-term provision of public goods and infrastructure. For example, critical infrastructure investments may mainly rely on direct public ownership to maintain public control over strategic assets and ensure reliable services aligned with social and welfare objectives.

Where such constraints are not binding, instrument selection and design are primarily influenced by two key factors: the characteristics of the projects being supported and the characteristics of the instruments themselves. These characteristics determine how risks, responsibilities, and potential returns are distributed between the public and private sectors. Project characteristics include the project's stage of development, scale and capital intensity, and commercial and operational risk profile. Instrument characteristics, in turn, can be distinguished along three key aspects: the degree of control and monitoring they provide, their leverage effect, and the magnitude, timing, and nature of fiscal exposure and associated risks. Instrument selection is thus a question of how well an instrument's risk profile, control, and leverage properties fit the financing constraints arising from the project's characteristics.

Table 1 provides a stylized summary of these characteristics based on the discussion in earlier chapters, while Sections 7.1–7.2 classify and elaborate on them, drawing on the preceding instrument-level analysis.

In addition to instruments that allocate public funds to climate investments, the public sector also uses fund-raising instruments, such as green bonds, to mobilize capital. Although these instruments do not directly determine project-level risk allocation, they affect the scale and fiscal management of public climate expenditures, as well as the participation of private investors in public climate spending. Section 7.3 analyzes the role of fund-raising instruments in the overall analytical structure.

Table 1 Project and instrument characteristics.

	Typical project characteristics	**Instrument characteristics**		
		Control & monitoring	**Leverage effect**	**Risk profile & fiscal exposure**
Grants	Early-stage; high uncertainty	Active admin. control	Limited	Full fiscal exposure
Concessional loans	Scale-up; revenue prospects but elevated risk	Contractual compliance	Moderate	Credit risk; implicit subsidy
Market loans	Mature; stable cash flows	Contractual compliance	Limited	Credit risk; recovery potential
Equity/VC	High uncertainty; long horizon	Ownership and governance control	Moderate	High financial risk; potential upside
PPPs	Large-scale; long-lifetime	Contract-based control	Potentially high	Long-term fiscal commitments
Guarantees	Capital-intensive; financing constraints	Limited control after issuance	High	Contingent exposure; tail risk
First-loss	High downside risk	Limited control; subordinate	High (catalytic)	Concentrated downside exposure
Insurance	Event-driven risks	Limited control; trigger-based	Limited (risk transfer)	Predictable costs; risk transferred
Derivatives	Price and cash-flow risks	Limited control; market-based	Limited (risk transfer)	Limited exposure; risk transferred
Contingent finance	Trigger-based risks	Limited control; trigger-based	Moderate (supports creditworthiness)	Contingent and bounded exposure

7.1 Project Characteristics

Projects may differ in many characteristics. Building on the discussion in previous chapters, this report focuses on three characteristics that are particularly important

because they give rise to financing constraints that influence the suitability of different forms of public support: stage of development, scale and capital intensity, and commercial and operational risk.

7.1.1 Stage of Development

A central distinction concerns the stage of development. Early-stage and innovation-oriented projects are typically characterized by high technological uncertainty, long time horizons, and limited or uncertain revenue streams. As a result, projects may struggle to attract sufficient private finance despite potentially generating significant long-term climate and innovation benefits. Public support at this stage is therefore often directed toward instruments that reduce upfront costs and risks, most often grants and, in some cases, public equity, such as public VC. These instruments support testing, demonstration, and early deployment rather than generating reliable financial returns.

Financing gaps may also arise at later stages of the innovation process, particularly between demonstration and commercialization, where projects face very large capital requirements despite increasing technological maturity (Armitage et al., 2024). While technological risks tend to decline as projects mature, financial and market risks, including demand uncertainty, input-price volatility, and uncertain future revenues, often remain significant. At the same time, projects are more likely to have identifiable revenue streams and commercially viable business models, making debt and risk-sharing instruments more feasible than in earlier stages. Public support is therefore more frequently provided through loans, guarantees, and other risk-sharing instruments that improve access to finance and reduce specific risks without fully insulating private investors from potential losses.

For mature technologies with established business models and predictable revenue streams, financing constraints are often less severe, and projects may increasingly rely on commercial finance. In such cases, the justification for direct public financial support is generally weaker, unless specific financing constraints or market failures remain.

7.1.2 Scale and Capital Intensity

Project size and capital intensity constitute another important dimension for instrument selection. Smaller projects typically require more limited capital and can often be financed through single instruments, such as grants or standard loans. By contrast, large-scale investments in energy systems and industrial facilities involve substantial capital commitments and long asset lifetimes. These projects, excluding public infrastructure, typically involve privately owned production facilities. They require significant upfront capital, face technological and market uncertainty, and depend on future demand for low-carbon products. In practice, such projects are often supported through combinations of grants, loans, guarantees, and other risk-sharing instruments, since no single instrument is typically able to address both the large financing requirements and the multiple sources of technological, financial, and market risk involved.

The significance of these financing requirements depends not only on the size of the project itself but also on the financial capacity of the actors undertaking it. A given investment may be relatively easy to finance for a large, established firm with access to capital markets, but difficult for a smaller or younger firm with limited collateral and financing options. As a result, grants and equity instruments may play a larger role in

supporting small firms, whereas larger firms are generally better positioned to rely on loans, guarantees, and other debt-based instruments (Olmos et al., 2012).

7.1.3 Commercial and Operational Risk Profile

In addition to stage and scale, the commercial and operational risk profile of a project also influence instrument choice. Some projects are financially viable but face specific risks, such as price volatility and demand uncertainty. These risks may discourage private investors. In such cases, public support is often more effective when it focuses on managing these risks rather than providing direct funding. Typical examples include renewable energy projects such as wind or solar parks, where revenues depend on uncertain electricity prices, or industrial projects producing low-carbon materials, where future demand and price premiums are uncertain. Instruments such as first-loss facilities, hedging tools, and contingent finance can address these risks by providing protection or liquidity when predefined events, such as price declines, demand shortfalls, or adverse market conditions, occur. Rather than providing upfront subsidies, these instruments improve the risk-return profile of projects by reducing exposure to specific downside risks that may otherwise discourage private investment.

7.2 Instrument Characteristics

In addition to policy constraints and project characteristics, the characteristics of the instruments themselves are also important factors in instrument selection. Drawing on the review of instruments in earlier chapters, this section classifies the three key characteristics that determine how risks, responsibilities, and potential returns are allocated between public and private actors: instruments' risk profile, degree of control, and leverage effect. The risk profile describes the magnitude, type, and timing of public exposure. Control and monitoring determine how this exposure is managed and how incentives are aligned between public and private actors. The leverage effect reflects how public financial commitments mobilize private capital and how risks are distributed between actors.

7.2.1 Risk Profile

A central characteristic of public support instruments is the type, magnitude, and timing of the risks they create for the public sector. From a public-sector perspective, it is important to distinguish between fiscal risks, which affect public budgets directly, financial risks related to losses or returns on public capital, and non-financial risks, such as social, environmental, or political consequences if supported projects fail or underperform.

Instruments vary not only in the magnitude of public risk they involve, but also in the type of risk and in how and when that risk materializes. Non-repayable instruments such as grants and subsidies involve direct and predictable fiscal costs. This provides budgetary certainty because public costs are known upfront, but it also implies that public funds are committed regardless of project outcomes. If projects fail to deliver expected results, this may result in low value for money rather than additional financial losses. In addition to fiscal costs, unsuccessful grant-supported projects may entail non-financial risks, including missed climate targets or delayed technological progress. However, appropriate instrument design, such as staged disbursement or the ability to

adjust or discontinue support, can reduce the risk of continued funding of underperforming projects (Olmos et al., 2012).

Public equity investments imply higher financial uncertainty than grants, as returns depend on project performance, but they also offer potential financial upside. Equity typically gives the public sector a degree of influence, which may help reduce financial risk and increase the probability of project success, but this may also expose the public sector to non-financial risks, such as political and reputational risks because of involvement in corporate governance and decision making.

For loans, fiscal and financial exposure depend on borrowers' ability to repay, introducing credit risk but allowing for partial or full recovery of public capital if projects perform as expected. Compared with equity, loans generally involve lower political and reputational exposure, as public involvement is less visible and does not imply ownership or governance responsibilities. In the case of concessional loans, fiscal exposure also arises from the concessional terms themselves, which imply an implicit subsidy relative to market-based lending even when loans are fully repaid.

In case of PPPs, fiscal exposure often materializes gradually through contractual payments, availability payments, revenue guarantees, or other long-term commitments. While PPPs can transfer certain construction or operational risks to the private sector, they also expose the public sector to non-financial risks, such as limited flexibility to adjust contracts over time and challenges in ensuring service quality and accountability over long-term contractual arrangements. In addition, since the public sector can usually borrow at lower cost than private project companies, shifting financing to private partners may increase overall financing costs (Swedish National Debt Office, 2021).

Fiscal exposure for risk-mitigation and credit-enhancement instruments is uncertain in timing and magnitude. Because exposure materializes only if specific risks are realized, these instruments reduce short-term budget impacts but complicate fiscal planning and risk management. Compared with grants or equity, these instruments generally involve lower upfront fiscal outlays, as exposure is contingent rather than immediate. However, because public exposure is contingent on future events, the fiscal costs of these instruments may be difficult to predict and can become substantial under adverse scenarios. Guarantees are a particularly important example, as they may create significant tail risks in the absence of careful assessment of expected losses, appropriate capital allocation, and transparent reporting.

7.2.2 Control and Monitoring Requirements

Another central characteristic that differs across instruments is the degree of control and monitoring they allow. Effective oversight can reduce financial risks, such as misuse of funds or underperformance, and non-financial risks, including failure to deliver climate outcomes, reputational damage, or long-term lock-in to ineffective projects. However, the appropriate level of control should reflect the trade-off between reducing these risks and the administrative costs associated with monitoring and enforcement.

A key reason why control and monitoring are necessary is the presence of information asymmetries between project developers and the public sector. Innovators and firms typically have more detailed knowledge about project risks, costs, and feasibility than the

public sector. When public support absorbs part of the downside risk, these information asymmetries can create incentive problems. As discussed in earlier chapters, excessive risk coverage may encourage moral hazard, for example if private lenders relax credit standards or firms undertake riskier projects because early losses are absorbed by public funds. Effective evaluation procedures, reporting requirements, and contractual safeguards are therefore essential to mitigate incentive distortions and ensure that public support remains proportionate to identified financing gaps.

Instruments such as grants and public equity can potentially enable relatively high levels of public control, although through different mechanisms. Grants typically involve administrative forms of control, including application procedures, eligibility criteria, reporting requirements, and ex-post reviews. Public equity can provide control through ownership and governance rights, such as board representation and voting power. Such oversight is particularly relevant for early-stage or high-risk projects, where uncertainty is high and public authorities seek closer involvement to manage both financial and non-financial risks. At the same time, these arrangements require administrative and institutional capacity on both the public and private side.

Loans and guarantees involve a different balance between control and monitoring. While these instruments may include contractual conditions and reporting requirements, they rely heavily on financial discipline and the incentives of borrowers and private lenders. Monitoring therefore is mostly focused on financial performance and compliance with contractual terms rather than on the details of project implementation. This can reduce administrative burden and shift some risk management to market actors, but it also limits the public sector's direct influence over project decisions once financing has been provided.

In instruments such as PPPs and risk-mitigation or credit-enhancement arrangements, public control is mainly through contractual design rather than direct involvement in project implementation. In PPPs, implementation responsibility is mainly delegated to the private partner, increasing the importance of contract design, enforcement, and renegotiation capacity over long time horizons. Similarly, for guarantees and related instruments, monitoring focuses on compliance with predefined conditions and trigger mechanisms specified in financial agreements. While this reduces the need for continuous public supervision, it places more emphasis on careful ex-ante design and clear specification of when and how public commitments are activated.

7.2.3 Leverage Effect

The third key characteristic concerns the degree and form of public capital involvement, and in particular the leverage effect, i.e., the extent to which public financial commitments mobilize additional private capital. Instruments that are explicitly designed to crowd in private finance include guarantees, other credit-enhancement tools, and PPP arrangements, all of which aim to increase total investment without a proportional increase in public spending. At the same time, higher leverage may come at the cost of reduced public control, higher fiscal uncertainty, or delayed rather than reduced public exposure. Moreover, leverage ratios should be interpreted with caution, as they capture the volume of private capital mobilized relative to public commitments but do not necessarily reflect the amount of risk ultimately borne by the public sector.

The leverage effect of public investment instruments does not depend only on instrument type, but also on how instruments are designed and applied in practice. Grants, loans, and equity investments can also mobilize private capital when they are designed to address financing constraints that would otherwise prevent investment, such as high upfront capital requirements, uncertain future revenues, or technological risk.

However, high leverage ratios do not necessarily imply lower public risk or reduced financial responsibility. PPPs illustrate this clearly. While they can mobilize substantial volumes of private capital, private financing is often repaid through long-term public payment commitments. As a result, public financing responsibility may be spread over time but still remain over the life of the project. Similarly, risk-mitigation and credit-enhancement instruments involve limited or contingent public commitments rather than upfront spending, but public exposure may materialize if predefined events occur. These instruments may therefore display high leverage in accounting terms, while in practice the extent of risk transfer depends on how exposure is shared between public and private actors and whether public liabilities are genuinely reduced rather than postponed.

7.3 Fund-Raising Instruments

In addition to decisions about how public funds are allocated to climate transition investments, the public sector also faces choices regarding how these funds are raised. Investment instruments determine how risks, responsibilities, and potential returns are shared between public and private actors at the level of individual projects. Fund-raising instruments, by contrast, define how public resources are mobilized over time and how financial burdens are distributed across taxpayers and investors. They therefore affect intertemporal risk-sharing and fiscal exposure at the sovereign level.

Carbon pricing plays a particularly important role, as it simultaneously generates public revenues and provides incentives to reduce emissions. Revenues from carbon taxes and the EU ETS contribute to public budgets and are, in part, earmarked or politically linked to climate and energy-related spending. This creates a connection between emission pricing and the financing of climate transition investments, even when revenues are not formally tied to specific projects. In this sense, carbon pricing functions both as a regulatory instrument and as a fiscal resource that expands the public sector's capacity to finance climate action.

In addition to tax-based revenues, as described in Chapter 5, most countries rely on market-based fund-raising instruments, including the issuance of green bonds. Unlike carbon pricing, which also influences investment incentives, green bonds primarily serve a funding function by raising capital from financial markets for climate-related expenditure. Although the financial structure of green bonds mirrors that of conventional sovereign bonds, the labeling and reporting requirements introduce enhanced transparency and accountability regarding the use of funds. While green bonds do not change the underlying risk of the supported investments, they may influence borrowing conditions at issuance compared with conventional bonds. By attracting a broader base of sustainability-oriented investors, they can increase demand for sovereign debt and, in some cases, lower borrowing costs or improve other issuance terms. In addition, by financing climate expenditures through public borrowing, green bonds allow governments to fund investments upfront while committing to repay the debt over time

through interest and principal payments. This spreads the fiscal burden across future periods rather than requiring immediate budgetary spending.

Overall, fund-raising instruments affect the macro-level conditions under which climate investments are financed. Although they work differently from investment instruments, they are an integral part of a risk-aware climate finance strategy, as they determine how public commitments are funded and how financial risks are distributed across time and stakeholders.

8. Policy Recommendations for Risk-Aware Climate Finance

As discussed in this report, Sweden's climate policy builds on a combination of carbon pricing and an active green industrial policy. In recent years, rising electricity demand, energy security concerns, and the objective of reaching net zero emissions by 2045 have shifted the policy mix toward greater use of targeted public support instruments. While carbon pricing remains important and provides a cost-effective incentive for emissions reductions, Sweden, like China, the US, and many European countries, is increasingly turning toward green industrial policy, including targeted investments in renewable energy and innovation alongside major state support for nuclear power (Andersson and Finnegan, 2025; Government Office of Sweden, 2025b). The expansion of such support instruments implies larger and more direct public financial commitments and increases the importance of managing fiscal risks, as illustrated by the public exposure associated with the bankruptcy of Northvolt (Andersson and Finnegan, 2025).

The purpose of this report is not to question whether governments should engage in green industrial policy, but to examine how public support can be designed to achieve climate policy objectives while keeping public risk exposure within fiscally sustainable limits.

Based on the discussion in Chapter 7, a central conclusion is that no single instrument is universally optimal. The suitability of different forms of public support depends on the characteristics of the projects being supported, the characteristics of the instruments used, and the financing constraints they are intended to address. The following sections consider how this applies in the Swedish context, focusing on how the public sector can support large-scale climate and industrial investments while containing risk exposure through appropriate instrument selection, instrument design, and the management of aggregate exposure.

8.1 Instrument Selection

The choice of instrument is sometimes defined by legal mandates, political commitments, or institutional arrangements. This applies, for example, to the use of auction revenues from the EU ETS, Sweden's international climate finance, and investments in public goods and infrastructure. In such cases, policymakers may have limited discretion over which instruments can be used.

Where instrument choice is not predetermined, instrument selection should reflect the fit between project characteristics and the properties of the instruments being used. Different projects face different financing constraints depending on their stage of development, scale, capital requirements, and risk profile. Likewise, public investment instruments differ in their implications for public risk exposure, leverage, and control. Instrument choice should therefore be guided by the specific financing barriers that prevent otherwise desirable investments from taking place, rather than by a preference for particular instruments.

- **Adopt a stage-sensitive instrument mix**

Public support varies across stages of development and financing needs. Early-stage innovation is primarily supported through grants and public equity instruments, while larger-scale deployment projects increasingly rely on combinations of grants, loans, guarantees, and other risk-sharing mechanisms. This reflects the transition from technological uncertainty toward larger financing needs and the increasing importance of mobilizing private capital. In practice, large-scale transition projects often require combinations of instruments, reflecting the fact that multiple financing constraints may exist simultaneously.

At the program level, the Swedish instrument mix described in Chapter 6 is broadly consistent with a stage-sensitive approach, with grants and public equity primarily supporting earlier-stage innovation and loans, guarantees, and other risk-sharing instruments playing a larger role in commercial deployment. To what extent support is stage-appropriate at the level of individual projects has not been assessed in this report.

- **Match instruments to the nature of the financing constraint**

Instrument selection should not be based solely on a project's stage of development. Different projects may face different types of financing constraints even at similar stages of maturity. Some projects are primarily constrained by technological uncertainty or limited access to capital, while others are financially viable but face specific market or operational risks, such as price volatility, demand uncertainty, or revenue fluctuations. In such cases, instruments that share or mitigate risk, including guarantees, first-loss facilities, insurance mechanisms, hedging instruments, or contingent finance, may be more effective than direct funding because they address the underlying source of uncertainty rather than providing general financial support.

- **Balance private capital mobilization and public risk exposure**

Instruments that achieve high leverage by attracting large volumes of private finance may nevertheless expose the public sector to significant downside risk through guarantees, subordinated financing arrangements, or other forms of risk sharing. The Swedish experience highlights that appropriate instrument selection requires consideration of public risk exposure alongside the ability to mobilize private capital. The recent challenges faced by projects such as Stegra illustrate this trade-off. State guarantees and other forms of public support can improve access to financing and accelerate strategic transition investments, but they may also create substantial contingent liabilities if projects fail to perform as expected. High leverage should therefore not be interpreted as evidence of low public risk exposure.

The central challenge is therefore to ensure that public risk exposure remains proportionate to the financing gaps being addressed and the public benefits expected from successful projects. Public support should be sufficient to enable socially desirable investments that would otherwise not occur, but not greater than necessary to address the underlying financing constraints. Excessive support may weaken incentives for efficient risk management, create moral hazard, and transfer an unnecessarily large share of project risk to the public sector.

Determining the appropriate level of support requires balancing the expected fiscal and financial losses borne by the public sector against the expected social and climate benefits generated by successful projects. In practice, this implies considering both the probability and magnitude of potential losses and the extent to which public intervention contributes to emissions reductions, technological progress, energy security, or other public policy objectives.

8.2 Instrument Design

While instrument selection determines the type of support provided, instrument design determines how risks are allocated between public and private actors, how exposure is limited, and how performance is monitored over time. Even where policy mandates constrain instrument choice, design remains an important determinant of both project outcomes and public risk exposure. The discussion in this report highlights four important design considerations.

- **Linking public support to project performance**

Public support should remain conditional on project performance. This is particularly important for grants and other forms of non-repayable support, where public exposure is realized upfront and cannot normally be recovered. Mechanisms such as ex-ante project assessment, milestone-based disbursement, reporting requirements, ex-post evaluation, clawbacks, rescission provisions, penalties, and recalibration of support can reduce information asymmetries and limit the risk of continued support to underperforming projects. Alternative grant designs, such as recoverable and convertible grants, extend this logic by allowing partial recovery of public funds or public participation in upside gains when projects succeed.

In Sweden, grant-based programs generally rely on milestone-based disbursement and ex-post review, providing control over implementation and costs. However, compared with some international programs, there is relatively limited use of performance-based clawbacks and outcome-linked conditions. While stronger performance requirements may improve accountability and reduce public risk, they also increase administrative costs and compliance burdens. The appropriate level of control therefore depends on project characteristics, including scale, complexity, technological uncertainty, and the level of public exposure.

- **Preserving appropriate private risk-sharing**

Public support should address financing gaps without eliminating private incentives to manage risk. Excessive protection of private actors may weaken market discipline, increase moral hazard, and transfer disproportionate downside risk to the public sector.

This consideration is particularly relevant for loans, guarantees, and other risk-sharing instruments. Key design parameters include pricing, coverage ratios, loss-sharing arrangements, seniority structures, co-financing requirements, and eligibility criteria. High guarantee coverage ratios or extensive first-loss protection may increase leverage and mobilize private capital, but may also transfer an excessive share of downside risk to taxpayers.

Similarly, in blended-finance structures, subordinated public capital can play an important role in attracting private investment. However, repayment priorities and

distribution rules should be carefully designed to ensure that private investors retain meaningful exposure and that public support remains proportional to the financing gap being addressed.

- **Strengthening governance, monitoring, and accountability**

Oversight mechanisms should be aligned with the nature of the instrument and the risks involved. Grants typically rely on administrative controls, while public equity provides influence through ownership and governance rights, including board representation and voting power. Loans and guarantees rely more heavily on contractual compliance and financial monitoring, whereas PPPs depend on long-term contract management and enforcement. Beyond project- and instrument-level oversight, systematic evaluation of the effectiveness of support programs themselves is needed to inform their future design and the allocation of public support, a gap identified in a recent audit of Swedish support programs, which have recommended establishing such evaluation (Swedish National Audit Office, 2024).

The appropriate level of oversight and evaluation should balance the benefits of risk reduction and accountability against the administrative costs associated with monitoring and enforcement. Effective governance is particularly important where public support addresses significant technological uncertainty or where large volumes of public capital are at risk.

- **Limiting long-term public exposure**

A final principle is that public support should not become permanent where market-based financing is viable. Exit strategies, declining concessionality, sunset clauses, and periodic reassessment can reduce long-term public exposure and encourage the transition to commercially sustainable financing.

For public equity, this implies clear exit strategies and governance arrangements that allow public capital to be recycled. For concessional lending, concessional elements should gradually decline as technologies mature and financing constraints diminish. In PPPs and other long-term contractual arrangements, transparency, clear risk allocation, and robust monitoring mechanisms are essential to prevent the accumulation of unforeseen fiscal commitments over time.

8.3 Managing Aggregate Exposure and Fiscal Sustainability

Beyond individual instrument choices and their design, public climate finance must also be managed at the aggregate level.

- **Within projects**

Within individual projects, combining different instruments may sometimes improve both project viability and the allocation of risk between public and private actors. For example, combining grants with repayable instruments, such as loans, guarantees, or equity, under a single funding agreement can address non-commercial costs or early-stage risks while preserving financial discipline and enabling partial recovery of public funds (European Commission, 2021). This allows public support to target specific financing gaps without fully absorbing project risks, thereby improving the efficiency of public capital use. However, such combinations require careful design and sequencing.

Without clear criteria for continuation, adjustment, or withdrawal of support, the use of multiple instruments within the same high-uncertainty projects may amplify public exposure rather than reduce it. Cases such as Northvolt and Stegra, which combine several forms of public support across agencies, illustrate how exposure to a single project can accumulate across instruments and institutions.

- **Across projects and sectors**

At a broader level, when multiple instruments are used across projects, sectors, and stages of development, total public exposure may be underestimated if instruments are assessed individually. Managing climate finance therefore requires a portfolio perspective that considers the combined use of instruments and the resulting cumulative fiscal exposure. In Sweden, several large-scale transition projects combine grants from multiple public actors with subsequent loans and guarantees under conditions of high uncertainty. When such projects fail, public exposure can accumulate across instruments and institutions. If multiple projects are concentrated in similar technologies or sectors, adverse market developments or sector-specific shocks may trigger correlated losses. In such cases, contingent liabilities from guarantees and other credit-enhancement instruments may materialize simultaneously, generating sudden fiscal pressure despite limited initial budgetary impact.

Risk diversification should therefore occur across projects, not only within individual projects. This requires coordinated information on public commitments and risk exposure across projects, sectors, and support instruments; without it, aggregate exposure may be underestimated. Sweden already has important elements of such reporting: the Swedish National Debt Office publishes an annual risk analysis of the central government's guarantee and lending portfolio, including assessments of concentration risk and loss covariation (Swedish National Debt Office, 2026). However, this reporting covers guarantees and loans, while grants, public equity, and other forms of support directed to the same projects or sectors are administered and monitored separately by different agencies. To what extent Swedish exposure is concentrated cannot currently be assessed given the lack of a consolidated overview.

Extending existing risk reporting to provide a consolidated view across projects, instruments and agencies would therefore be a natural first step. Implementing this is not without challenges: public commitments are distributed across multiple agencies, different instruments expose the public sector to risks that vary in timing, magnitude, and probability, and monitoring practices differ across instruments. The administrative costs of broader coordination should therefore be weighed against the benefits of improved oversight.

- **Across investment and financing decisions**

At the fiscal level, aggregate exposure must also be considered together with how public climate investments are financed. General taxation provides stable and predictable funding and finances expenditures directly through current budgets. Carbon pricing instruments, including carbon taxes and revenues from the EU ETS, play a dual role, generating public revenues while also providing incentives for emissions reductions, thereby linking financing with policy objectives. Borrowing through instruments such as green bonds allows governments to finance investments upfront while repaying the

associated debt over time through interest and principal payments. This spreads the fiscal burden across future periods and broadens the investor base. From a risk perspective, fund-raising instruments primarily affect when and how fiscal exposure materializes, rather than reducing the underlying investment risk.

The choice of funding mix ultimately involves broader questions of fiscal and debt policy, including the framework for central government borrowing, which lie beyond the scope of this report.

9. Summary and Conclusion

The transition toward a climate-neutral economy requires a fundamental transformation of energy-intensive industries and the rapid scaling of clean technologies. The investments involved are exposed to well-documented market failures, including knowledge spillovers and, in particular, the information asymmetries and financing frictions that make early-stage and capital-intensive climate projects difficult to finance privately. This creates a case for targeted public intervention to bridge financing gaps and mobilize capital for industrial decarbonization.

This report provides a risk-aware analytical approach to guide the Swedish public sector in navigating these challenges. By mapping available financial instruments and analyzing their use, the analysis shows that instrument selection, where not constrained by policy and institutional conditions, must be informed by project-specific characteristics and the inherent properties of the instruments themselves. Sweden is currently among the OECD's top performers in decarbonization, combining one of the world's highest carbon prices with a diverse mix of grants, state-backed equity, and credit guarantees to support low-carbon investment.

The analysis concludes that no single instrument is universally optimal, and effective climate finance depends on aligning instrument choice and design with the conditions under which investments take place. From a policy perspective, the analysis carries implications in three areas: instrument selection, instrument design, and the management of aggregate exposure.

First, instrument selection should be guided by the fit between project characteristics and instrument properties. Public support should target clearly identified financing constraints rather than substituting broadly for private capital. Grants and public equity are best suited to early-stage, high-uncertainty projects, while loans, guarantees, and other risk-sharing instruments are generally more appropriate for mature, capital-intensive investments. At the same time, instruments that mobilize large volumes of private capital do not necessarily reduce public risk, and high leverage should not be mistaken for low exposure. For commercially viable projects, public intervention should be limited to avoid crowding out private investment.

Second, instrument design should ensure that public support shares, rather than absorbs, risk. The objective is not to eliminate uncertainty but to allocate it efficiently. Design features such as performance-based conditions, pricing, coverage ratios, and co-financing requirements determine whether private actors retain meaningful exposure to downside risk, and oversight should be aligned with the instrument and the risks involved. Support should not become permanent where market-based financing is viable. Over time, systematic evaluation of the effectiveness of support programs is needed to inform both instrument design and the allocation of public support.

Third, public risk must be managed at the portfolio level, not only at the level of individual instruments or projects. When multiple instruments are combined across projects, sectors, and technologies, total exposure can accumulate, become correlated, and be underestimated, particularly where support is concentrated in a few large and uncertain projects. This calls for improved coordination across public actors and

systematic monitoring of aggregate exposure. Aggregate exposure should also be assessed together with how investments are financed, as fund-raising instruments such as green bonds affect when fiscal costs materialize rather than the underlying investment risk.

For Sweden, these implications converge on a question of balance. The current reliance on grants, loans, and equity provides relatively predictable exposure but requires substantial public capital, while the growing use of guarantees mobilizes private investment but shifts downside risk to the public sector. The policy challenge is not to choose between these approaches, but to combine them in a way that maintains incentives, limits fiscal vulnerability, and avoids excessive concentration of risk.

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