BRINGING ETS SECTORS TO NET ZERO:

Key considerations for the evolution of ETS design and of complementary policies

Thematic Brief

Iryna Holovko, Santiago Ramirez Niembro, Stephanie La Hoz Theuer

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Authors:
Iryna Holovko
Santiago Ramirez Niembro
Stephanie La Hoz Theuer

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INTRODUCTION

As jurisdictions advance towards net zero, decarbonization is becoming more complex, requiring new policy tools and adjustments to existing frameworks. In particular, emissions trading systems (ETSs) will need to evolve and be complemented by well-calibrated companion policies to remain effective. Key challenges on the path to net zero include: increasing abatement costs (as "low-hanging fruit" options are exhausted and further cuts to residual and hard-to-abate emissions[1] increasingly depend on yet-to-be commercialized technologies); concerns over smaller markets as ETS covered sectors decarbonize; higher competitiveness risks on both internal and global markets; and the need to ad-dress the development and deployment of carbon dioxide removal (CDR) technologies in line with net-zero and net-negative trajectories, among others.

To tackle these challenges, changes will need to happen both within ETSs and in the broader policy mix. The paper focuses primarily on the former, exploring changes needed within ETSs and potential solutions under each consideration area (Chapter 1). The paper further explores key limitations of ETSs in driving abatement across sectors, and outlines complementary policies used across jurisdictions to tackle those limitations (Chapter 2). The paper was developed as part of ICAP technical dialog workstream with the financial support from California Air Resources Board. and served as an input to an ICAP members discussion under the Chatham House rules on 11 September 2025. Chapter 3 provides an overview of key takeaways from the discussion.

[1] In this paper, 'residual emissions' is taken to mean any emissions that reach the atmosphere after the net-zero point, ; and "hard-to-abate" emissions to mean those whose abatement feasibility is limited because of technological, economic, social or political considerations. For more details on residual and hard to abate emissions, see: Schenuit, F., Boettcher, M., & Geden, O. (2023). *"Carbon Management": Opportunities and risks for ambitious climate policy*. Stiftung Wissenschaft und Politik (SWP). https://www.swp-berlin.org/10.18449/2023C29/ ; Edelenbosch, Oreane; van den Berg, Maarten; Boer, Harmen-Sytze de; Chen, Hsing-Hsuan; Daioglou, Vassilis; Dekker, Mark et al. (2022): Mitigating greenhouse gas emissions in hard-to-abate sectors. PBL Netherlands Environmental Assessment Agency, Utrecht University. Available online at https://www.pbl.nl/sites/default/files/downloads/pbl-2022-mitigating-greenhouse-gas-emissions-in-hard-to-abate-sectors-4901.pdf. ; and Lund, Jens Friis; Markusson, Nils; Carton, Wim; Buck, Holly Jean (2023): Net zero and the un-explored politics of residual emissions. In Energy Research & Social Science 98, p. 103035. DOI: 10.1016/j.erss.2023.103035.

1 WITHIN THE ETS: ETS-RELATED CONSIDERATIONS AND DESIGN CHOICES

1.1 Role of ETS in the future policy mix

To adapt and develop the ETS design for progressive decarbonization, policy makers need to determine the role that the ETS should play in the transition within the wider poli-cy mix on the path to net-zero. Key choices include the extent to which the ETS should drive abatement in covered sectors; how the mitigation burden (both in terms of gross and net emissions) is shared across sectors inside and outside the ETS, and how this is reflected in emission caps and their trajectories; and whether the ETS should contribute to other policy goals, such as supporting the development and deployment of CDR.

A jurisdiction with a net zero target may choose to transition its ETS into also delivering net zero. But ETSs may also be structured to remain net-positive (e.g. to ensure space for residual emissions while other policies ensure the delivery of CDR), reach net-negative (e.g. to address residual emissions in non-ETS sectors, or from emissions overshoot), or even absolute zero emissions (in which case, the ETS functions as a ban on emissions). ETSs could also be phased out in favour of other, potentially more targeted, policies. Each of these options carries important implications for an ETS design evolution and for the broader climate policy mix for target achievement.[2]

The ETS's role can vary – from a primary decarbonization driver to a supportive backstop for regulatory measures. This can play out in terms of their overall role in the policy mix: e.g., in Europe, the EU ETS is seen as the key driver of mitigation in regulated sectors, whereas in California, the Cap-and-Invest Program acts as an overall reductions driver and as a backstop to other policies. This can also play out at sectoral level, with ETSs often being a primary driver of abatement in the power sector (via fuel switching and accelerated renewables integration), while in energy-intensive industry it often acts as a supportive instrument unless paired with targeted measures.

Carbon pricing in general and ETSs in particular have an important role to play in incentivizing efficiency and fuel switching, yet may not be sufficient to address barriers such as information asymmetries, innovation spillovers, infrastructure gaps, capital constraints, path dependencies, and technology uncertainty. These barriers warrant targeted, complementary policies. The remainder of this section considers how an ETS design may adapt and evolve to incentivize progressive transformation in the shorter-term and re-main effective as the transition to net-zero advances. Policies outside the ETS are the focus of section 3.

1.2 Future of competitiveness and free allocation

As decarbonization becomes increasingly costly, with stricter cap levels and rising carbon prices, it is vital to protect the competitiveness of covered industries and address the risk of carbon leak-

[2] La Hoz Theuer, S., Ortiz Rivera, V., & Biedenkopf, K., ETS, Reloaded? Designing Emissions Trading for Net-Zero and Net-Negative Societies, 2025.

age.[3] These efforts are key to ensuring the long-term viability of the ETS on the path to net-zero. Globally, free allocation remains the most widely used method to safeguard competitiveness and mitigate the risk of carbon leakage. However, free allocation inhibits the potential of carbon pricing to drive emission reductions. While the short-term price signal still provides an incentive via the opportunity cost of allowances, it is often not fully internalized by regulated entities and is insufficient to support costly decarbonization investments.[4] Moreover, the long-term sustainability of free allocation as the primary tool to prevent carbon leakage is limited overtime, as declining caps will limit the availability of allowances for free allocation.[5]

A well-designed package of measures, some within and some outside an ETS, is needed to address these risks. Within the ETS, the distribution of free allowances should, and in practice very often already is, regularly reviewed to ensure it is targeted to address any over-allocation (e.g. avoiding conventional products receiving more then they need for compliance) and to ensure that available allowances are distributed to those sectors where the benefits are greatest. Such recalibration could be done by tightening benchmarks and introducing additional conditions, influencing final allocation volumes:

Tightening of benchmarks overtime is key as their stringency plays an important role in determining the share of free allowances that entity receives and thus directly impact the effective carbon cost they face and investment decisions they make. Benchmark design should thus be regularly re-evaluated and adjusted to maintain strong abatement incentives. Uniform, product-based benchmarks that are not tied to specific technologies, fuels, or input materials are essential for maximizing the range of cost-effective abatement options available to producers and ensuring a level playing field for innovative, low-emission technologies. Benchmark stringency should be gradually and transparently increased—through periodic updates that reflect the performance of the most efficient installations and the emergence of new technologies—to avoid locking in carbon-intensive infrastructure and to send credible signals for long-term investments. Broadening benchmark boundaries to capture the decarbonization potential across entire value chains, including indirect emissions where appropriate, can enhance the incentives for deep mitigation and the transition to breakthrough processes.[6]

Dynamic allocation implies flexibility to adjust free allocation amounts to reflect recent, and ideally, actual production levels, rather than being based on historical activity Some elements of dynamic allocation are already in place in some systems, for example in California, where 'true up' allocation is done annually after the verified data for the compliance year becomes available[7]. The UK has recently consulted stakeholders on the introduction of annual adjustments based on actual activity levels, with a view to eliminating the 15% threshold[8] to better reflect real time changes in production.[9] While this approach helps to avoid under- or over-allocation, it increases adminis-

[3] Carbon leakage refers to the situation where, as a result of stringent climate policies in one country or region, companies relocate production to countries with laxer emission constraints, potentially leading to an overall increase in global GHG emissions.

[4] Acworth, W., Ackva, J., Burtraw, D., Edenhofer, O., Fuss, S., Flachsland, C., Haug, C., Koch, N., Kornek, U., Knopf, B. and Montes de Oca, M. 2017. Emissions Trading and the Role of a Long Run Carbon Price Signal: Achieving cost effective emission reductions under an Emissions Trading System. Berlin: ICAP.

[5] Acworth, W., Kardish, C., & Kellner, K., Carbon Leakage and Deep Decarbonization: Future-proofing Carbon Leakage Protection. 2020.

[6] Kuneman, E., Kardish, C., Hall, M., Acworth, W. (2022). Benchmark-based allocation in emissions trading systems: experiences to date and insights on design. Berlin: ICAP

[7] California Air Resources Board. (n.d.). Allowance allocation to industrial facilities. California Environmental Protection Agency. https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/allowance-allocation/allowance-allocation-industrial

[8] The 15% threshold is used to determine whether a significant change in an installation's activity level (compared to the historical baseline) should trigger a recalculation of free allocation.

[9] UK Government, UK Emissions Trading scheme: Free Allocation review, December, 2023. https://assets.publishing.service.gov.uk/media/657c865883ba380013e1b667/uk-ets-free-allocation-review-consultation.pdf

trative complexity due to frequent recalculations. In the response[10] to this consultation the UK announced they would not do this.

Conditional allocation can also be instrumental in channeling scarce free allowances where they are needed the most. Conditional allocation refers to the requirements or conditions that installations must meet in order to qualify for free allocation of allowances. These conditions aim to ensure that free allocation is not just a transitional measure but also an incentive for industry to adopt sustainable practices and reduce greenhouse gas emissions. Conditional allocation can be tied to specific actions or targets (e.g., energy efficiency improvements or adoption of climate neutrality plans) for covered entities to be eligible for free allocation. Some examples, based on the latest revision of the EU ETS, include:

- **Energy efficiency measures:** Conditional free allocation requires installations to implement energy efficiency improvements. The goal is to incentivize industry to adopt measures that reduce emissions while maintaining competitiveness.

- **Rewarding low-carbon production:** Allocating allowances for new low- or zero-carbon products such as green hydrogen production, and for desirable actions, such as the use of e-fuels in aviation and sustainable biofuels, as recently introduced under the EU ETS.11 This could be done by introducing new product-specific benchmarks or by switching to technology-neutral benchmarks ("one product, one benchmark"). This approach removes the disadvantage of low-carbon products had compared to high-carbon products and encourages the development of markets for low-emission products.

- **Climate neutrality plans:** Some jurisdictions tie free allocation to the submission of climate neutrality plans. These plans outline how installations will achieve net-zero emissions over time. This approach encourages long-term planning and investment in low-carbon technologies.

Conditionality can help ensure that beneficiaries of free allocation undertake cost-effective mitigation actions (the low-hanging fruit). However, as sectors decarbonize these actions will become scarcer and industries will need to invest in deeper decarbonisation options (e.g. electrification, hydrogen or CCUS/CDR). Free allocation conditions therefore may need to evolve to ensure they continue to provide an achievable and effective decarbonization incentive.

Tiered allocation refers to a system of distributing emission allowances in a way that differentiates between sectors or entities based on certain criteria, such as their risk of carbon leakage, emissions intensity, hard-to-abate status or trade exposure. Going beyond the binary classification used in most ETSs, this approach would allow entities with a higher risk of carbon leakage or a higher emissions intensity to receive a greater proportion of free allowances than those with a lower risk. Industries could be categorized into tiers based on their risk level, for example with the highest tier receiving 70-100% of the benchmark, the medium risk tier 40-70% and the low-risk tier 10-40%.[12] While this approach ensures that sectors with a higher risk of carbon leakage receive more support and low-risk sectors receive less or no free allocation, the allocation of industries to different tiers can be challenging and should be well justified to avoid unfair discriminatory treatment that leaves some industries at a disadvantage. For example, tiered allocation based on

[10] UK Government, UK Emissions Trading Scheme: Free Allocation Review Main Authority Response. https://assets.publishing.service.gov.uk/media/69272f7d9c1eda2cdf034130/uk-ets-free-allocation-review-authority-response.pdf

[11] Delegated regulation - EU - 2024/873 - EN - EUR-Lex.

[12] UK Government, The UK ETS: Free Allocation Review, 2024.

emissions intensity, farm size, or land productivity, was considered in New Zealand's ETS policy proposal for the agricultural sector but proved politically challenging due to distributional impacts.[13] California originally applied tiered allocation to industrial allocation but moved to a 100% for all industries in 2018 following legislative direction.

Beyond free allocation. Given that free allocation is not a sustainable long-term option for protecting competitiveness, and in the absence of a uniform global carbon price, alternative methods of protecting against carbon leakage must be developed further. Such methods include, for example financial compensation for indirect carbon costs (e.g. carbon costs passed on to electricity-intensive industries through electricity bills), used in parallel to free allocation in California, the UK and the EU, but also border carbon adjustments and climate clubs. The latter two are further explored in Sector 3 of this paper.

1.3 Use of revenues

ETS revenues play a critical role in accelerating decarbonization by funding innovation, de-risking investments, and addressing competitiveness concerns. While the amount of revenue collected is now significant, at USD 70 billion in 2024 alone[14], there are several competing purposes they are being used for, including addressing distributional impacts, supporting low-carbon innovation across different sectors or channeling revenue to the national or regional budgets. In 2023, only 8 ETS jurisdictions used their respective revenue for low-carbon innovation, and 17 jurisdictions used them, among others, for climate mitigation purposes.[15] Lack of revenue earmarking leads to a lack of transparency and leaves untapped potential for them to fill much wanted climate investments needs.[16]

A number of jurisdictions have existing mechanisms to use ETS revenues to further support decarbonization and address equity concerns:

- The **Greenhouse Gas Reduction Fund (GGRF) in California** channels most auction revenues (over USD 32.8 billion since 2014) to fund California Climate Investments, prioritizing projects in disadvantaged communities and low-income households. To date, over 590,000 projects have been funded cumulatively, covering a wide range of sectors and purposes. These include grants for retrofitting factories with clean technologies; support for scaling up production of green hydrogen and ultra-law-carbon transportation fuels; support for housing retrofitting and support to low-carbon transportation, including rebates for zero-emission vehicles, public transit upgrades, and active mobility infrastructure, among others.

[13] See Ministry for the Environment and Ministry for Primary Industries. 2022. Pricing agricultural emissions: Consultation document. Wellington: Ministry for the Environment, and Bognar, J. et al, Pricing agricultural emissions and rewarding climate action in the agri-food value chain, Trinomics, 2023

[14] ICAP, Status Report, 2025.

[15] ICAP, Status Report, 2024.

[16] Monar, D. C. Maximising benefits of carbon pricing through carbon revenue use: A review of international experiences, 2024.

- The **Electrification and Climate Change Fund in Québec** redistributes revenues (almost CAD 10.4 billion since 2013) targeting industrial electrification via grants for transitioning fossil fuel-based processes to electricity (e.g., aluminium smelters using hydropower) and clean tech innovation by funding green hydrogen and carbon-neutral materials like low-emission cement. It also funds building decarbonization and low-carbon public transport, including electric buses and urban mobility measures.

- **Innovation Fund under the EU ETS.** The EU ETS requires 100% of revenue to be used to support climate action and energy transformation.[17] This includes the Innovation Fund which has a EUR 40 billion budget (2020–2030) and supports large-scale decarbonization projects in breakthrough technologies by providing grants for example for hydrogen-based steel production and CCS in cement plants, sustainable aviation fuels (SAF) and maritime decarbonization projects, including vessel retrofitting for renewable fuels of non-biological origin, and electric propulsion. It also supports industrial pilots, by funding for example, electrified kilns in ceramics and chemicals sectors. The incentive provided by the EU ETS carbon price is much larger for these projects than the amount of the EU ETS-sourced funding due to the avoided carbon cost benefit to companies' business cases.

- **Utility Consignment/Consignment auctions in California and Québec.** In California utilities must consign a portion or all their free allocations to auctions, with the proceeds being returned to them and to be spent for the benefit of ratepayers (consumers), shielding them from the cost burden of the program. The majority of the proceeds are returned to consumers as on-bill climate credit distributed to residential, small business and eligible industrial customers of those utilities and the balance of the proceeds is used to support climate transition projects (e.g., renewable energy, residential energy retrofits, vehicle electrification infrastructure, etc.). Québec's consignment mechanism is designed for industrial emitters, and allow to finance GHG emission reduction technical and economic potential studies as well as GHG reduction and technological innovation projects.[18]

As allowance volumes decline under tightening caps, revenue recycling may need to become more targeted to remain effective, especially if auction revenues plateau or fall over time, if price increases do not compensate for the reduction in auctioned volumes**Error! Bookmark not defined.**,[19]. These challenges may require establishing priorities for revenue allocations, developing new distribution mechanisms and finding alternative sources of revenue to complement ETS-sourced funding.

1.4 Market design and market functioning in a smaller market

As jurisdictions advance towards net-zero targets and emissions volumes decline, ETSs are likely to face reduced market activity: fewer buyers and sellers, lower trading volumes and less frequent transactions. Smaller ETSs are thought to be more vulnerable to ineffective market functioning

[17] Use of revenues to compensate electro-intensive sectors for indirect carbon costs they have incurred is considered eligible expenditure for this purpose.

[18] Projects eligible for payment from consigned funds. https://www.environnement.gouv.qc.ca/changements/carbone/allocation-consigne/projets-admissibles-en.htm

[19] This dynamic is explored in Pahle et al. (2025), auction revenues in the EU ETS under tightening cap scenarios peak around 2025 and subsequently decline due to the decreasing volume of allowances available for auctioning, even under high-price assumptions. See (Pahle, Quemin, Osorio, Günther, & Pietzcker, 2025).

and price discovery, such as price volatility and market manipulation, raising questions about whether current market designs are fit for the challenges ahead.

A key concern in declining markets is maintaining sufficient buyers and sellers to support effective trading. Reduced participation and trading volumes can impair liquidity, increasing the risk of price volatility, market manipulation, and speculative behaviour.[20] Moreover, in smaller markets, prices may increasingly reflect temporary fluctuations or incomplete information rather than underlying abatement costs. Limited liquidity can amplify the impact of individual trades and information gaps, making prices vulnerable to volatility and misalignment with fundamentals[21]. Limited cost transparency in sectors with highly heterogeneous abatement costs, like industry, can compound these problems, as price changes may be harder to interpret and more easily affected by isolated events in smaller markets. [22] The extent to which these issues represent significant problems may well vary over time and across jurisdictions. The concerns of low liquidity and market activity are often based on the functioning of larger markets, and it remains an open question whether the same concerns would apply to systems with small volumes and fewer participants. More thinking is needed around what constitutes a "small" market, which metrics are most relevant, and under what conditions liquidity or price discovery problems actually become material for abatement incentives under a cap[23]. In this context, it is important to note that ETSs represent the only proven method of establishing and enforcing a *cap* on aggregate emissions from multiple emissions sources –and may therefore be desirable even if the market faces liquidity and price discovery constraints.

Policymakers grappling with small ETSs may need to reevaluate ETS designs. For example, policymakers could expand the scope of the ETS to include new sectors, extend coverage of existing sectors (e.g. aviation) and/or GHGs, and lower the threshold for mandatory participation in the system to include small emitters and increase market activity. The introduction of removal units could also enhance overall market liquidity, with higher trading volume from increases in gross emissions.**Error! Bookmark not defined.** Stronger market governance through holding limits, market surveillance, and transparency measures could prevent manipulation and speculation by key players in low liquidity scenarios.[24] Beyond domestic measures, linking ETSs offers a way to connect fragmented markets, enhance liquidity, and improve price stability, but these benefits often entail complex negotiations and may not be as straightforward to realise.[20]

1.5 Role of CCS

Carbon capture and storage (CCS) and utilization (CCU) technologies are expected to play a crucial role in the decarbonization of hard-to-abate emissions, many of which are covered by ETSs.[25] Most jurisdictions with ETSs in force either already have policies on CCS in place or intend to make use of CCS applications. Moreover, there is an important overlap between the sectors covered by ETSs and those in which CCS shows the most promise: the International Energy Agency's Net Zero

[20] ICAP, PMR, Emissions Trading in Practice: A Handbook on Design and Implementation, Second Edition, 2021, pp. 8, 105.

[21] Pahle, M., Quemin, S., Osorio, S., Günther, C., & Pietzcker, R., The Emerging Endgame: The EU ETS on the Road Towards Climate Neutrality, 2024, p. 2.

[22] Pahle, M., Quemin, S., Osorio, S., Günther, C., & Pietzcker, R., The Emerging Endgame: The EU ETS on the Road Towards Climate Neutrality, 2024, p. 7.

[23] Massachusetts' program may be useful case study. The number of participants is much smaller than most markets, but the Q4 2025 market monitor report describes "relatively liquid conditions" in advance of a recent compliance deadline. (https://www.mass.gov/doc/market-monitor-quarterly-report-2025-q4/download (p. 11)

[24] Quemin, S., & Pahle, M., Financials threaten to undermine the functioning of emissions markets, 2023.

[25] CCS captures and stores CO_2 from fossil energy and industrial sources or directly from the air (e.g. BECCS, DACCS), while CCU binds CO_2 into products, supporting circular carbon use and displacing fossil-based alternatives.

Roadmap[26] and the Intergovernmental Panel on Climate Change[27] have identified an important role for CCS and CCU in achieving ambitious climate targets across the energy and industry sectors, the main sectors covered by ETSs, as well as an emerging role in other sectors, mainly transport (CCU/e-fuels) and waste (e.g. CDR from biogenic waste incineration with CCS).

For hard-to-abate emissions, CCS and CCU become particularly significant. In the cement sector for example, which is regulated by most ETSs operational today, CCS and CCU applications remain essential for deep decarbonization, with industry-wide carbon capture expected to account for more than 35% of emission reductions by 2050 and to reach over 1,300 Mt CO_2 per year by 2050,[28] up from 3Mt per year as of Q1 2026.[29] CCS also has potential in the waste sector, particularly for CDR from biogenic waste incineration with CCS and waste-to-energy facilities, which are regulated under some ETSs, including the EU ETS.

Similarly, CCU offers ETS-covered sectors additional flexibility in their decarbonization strategies by creating economic value from captured carbon but also brings additional risk and complexity due to the need to ensure permanence and accurately account for the ultimate fate of the re-used carbon. For example, use of CO_2 to make cement (via carbonation) could be considered akin to permanent carbon storage. On the other hand, use of captured CO_2 to manufacture e-fuels may reduce emissions by avoiding the use of virgin fossil fuel feedstock but still result in the embedded carbon being released into the atmosphere as CO_2. By enabling the production of low-carbon fuels, chemicals and building materials, CCU can help displace fossil fuel-based inputs and/or reduce hard-to-abate emissions in industrial sectors while simultaneously supporting the development of carbon capture infrastructure and expertise.

ETSs can play an enabling role by creating a carbon price signal that improves the economic viability of CCS and CCU applications. However, current ETS allowance prices generally remain below the levelized cost of CCS applications, which means that other policies such as investment subsidies, tax credits, or carbon contracts for difference would be needed to get the technologies off the ground in the near-term. At the same time, ETS design must safeguard environmental integrity through robust monitoring and reporting, alongside clear rules to prevent double counting, such as limiting recognition to cases of permanent CO_2 storage and ensuring that embedded emissions are not counted in parallel carbon systems.

ETS design elements that can effectively support CCS and CCU include clear eligibility criteria for different technology types; robust frameworks to address permanence and reversals; MRV frameworks that enable the effective consideration of carbon recycling while avoiding double counting; and provisions to manage cross-border carbon flows, among others. In so doing, policymakers must also address broader societal concerns, including the risk of prolonging fossil fuel use, local environmental and safety risks related to CO_2 storage, and social acceptance.

Despite the importance of CCS and CCU applications within ETS-covered sectors, very few systems have established relevant provisions. A 2023 survey[30] found that only few ETSs (chiefly the EU ETS, UK ETS, Québec Cap-and-Trade System, New Zealand ETS) had CCS or CCU provisions, of which

[26] EIA, Net Zero roadmap: a global pathway to keep 1.5 °C goal in reach, 2023.

[27] IPCC, Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the IPCC, Cambridge University Press, Cambridge, UK and New York, NY, USA, 2022.

[28] Global Cement and Concrete Association, 2050 Net Zero Roadmap – 1 year on, 2021, p. 18-19

[29] IEA, Policy and financing momentum sustain CCUS progress despite setbacks, March 2026

[30] La Hoz Theuer, S., & Olarte, A., Emissions Trading Systems and Carbon Capture and Storage: Mapping possible interactions, technical considerations, and existing provisions, 2023.

only two (the EU ETS and the UK ETS) had detailed provisions. As of 2023, only Québec had facilities reducing ETS compliance obligations through CCS applications. The fast pace of innovation and technological development presents a challenge for policy makers, who may have to establish regulatory frameworks that can adapt to changing technological circumstances. However, as the pipeline of CCS projects grows, so will the need for clarification about the relationship between CCS projects and ETSs worldwide.

1.6 Role of removals

Allowing CDR within ETSs can lower compliance costs and provide flexibility for covered entities but may reduce incentives for emissions reductions within the system and delay investments in structural decarbonization.[31, 32, 33] The inclusion of CDR can help create space for hard-to-abate emissions in the ETS while reducing net emissions of the ETS as compared to a situation where the same volume of conventional allowances was to be used. The inclusion of removal units can also help address liquidity concerns, e.g. if their use leads to an increase in gross emissions (and therefore in traded volumes).[34] Yet they also face several challenges. First, the inclusion of CDR in ETSs rests on the fundamental assumption that they are equivalent to (or fungible with) abatement action, which is not a given.[35] Among many others, challenges on permanence, appropriate quantification and non-climate effects are of particular importance. Abatement deterrence, or the concern that emission reductions that could or should happen is delayed by the availability or hope for cheap and abundant removal units, is also crucial, especially where abatement deterrence results in economically inefficient high carbon lock-in.

ETS regulations must define which removal units (if any) should be eligible for use in the ETS. Eligibility criteria play a crucial role in safeguarding environmental integrity, aligning with broader jurisdictional policy objectives and preventing harm. This entails defining clear parameters for the technological and geographical scope, as well as establishing rules for certification mechanisms and vintage. Recent research has primarily concentrated on addressing technological scope, although there is significant variation in perspectives among scholars. Ultimately, decisions regarding eligibility will be shaped by societal and political preferences on decarbonization pathways and the role of the ETS in achieving these goals. [36]

Eligibility goes hand in hand with governance, and removal units can flow into ETSs in a number of ways. Among others, units can flow through a direct connection between the ETS covered entities and CDR suppliers, similarly to the use of carbon credits for compliance in California today or in the EU ETS up to 2020. Alternatively, removal units could flow through a government agency that purchases removal units in the CDR market and places them in the ETS, e.g. in unit reserves and in auctions. Finally, units could flow from the ETS covered entities themselves, if their opera-

[31] Sultani, D., Osorio, S., Günther, C., Pahle, M., Sievert, K., Schmidt, T. S., . . . Edenhofer, O., Sequencing Carbon Dioxide Removal into the EU ETS, 2024.

[32] Rickels, W., Proelß, A., Geden, O., Burhenne, J., & Fridahl, M. (2021). Integrating Carbon Dioxide Removal Into European Emissions Trading. *Frontiers in Climate*, *3*, 62. https://doi.org/10.3389/fclim.2021.690023

[33] Sultani, D., Osorio, S., Günther, C., Pahle, M., Sievert, K., Schmidt, T. S., Steffen, B., & Edenhofer, O. (2026). How the EU can utilize its carbon market to scale up carbon dioxide removal. Joule, 102395. https://doi.org/10.1016/J.JOULE.2026.102395

[34] See la Hoz Theuer, S., & Wenzel, A. C. (2025). *Inclusion of carbon dioxide removals in selected ETSs: state of play*. https://icapcarbonaction.com/en/publications/inclusion-carbon-dioxide-removals-selected-ets-state-play for an exploration of how CDR was included in several ETSs to date.

[35] Carton, W., Lund, J. F., & Dooley, K. (2021). Undoing Equivalence: Rethinking Carbon Accounting for Just Carbon Removal. In *Frontiers in Climate* (Vol. 3). https://www.frontiersin.org/articles/10.3389/fclim.2021.664130

[36] Burke, J., & Gambhir, A. (2022). Policy incentives for Greenhouse Gas Removal Techniques: the risks of premature inclusion in carbon markets and the need for a multi-pronged policy framework. *Energy and Climate Change*, *3*, 100074. https://doi.org/https://doi.org/10.1016/j.egycc.2022.100074

tions yield CDR and they are allocated compliance units by the ETS regulator. Each of these options has implications for how certification takes place, how the primary and the secondary markets for removal units are structured, complexities and transaction costs in monitoring, as well as the enforceability of limits to the use of removal units in the system.[37]

Limits to the use of removal units can be driven by a desire to limit gross emissions from covered entities, to address abatement deterrence and to allow for a gradual and cautious introduction of CDR in an ETS over time. Quantitative restrictions can be applied by controlling the *supply* of removal units – such as through a government agency managing their entry into a price stability reserve or by regulators exchanging allowances for removal units, effectively capping the number of units allowed in the market. Alternatively, limits can be placed on the *demand*. For instance, regulators might set a maximum percentage of compliance obligations that ETS-regulated entities are permitted to fulfil using CDR. Regulators could also impose sector-specific restrictions, allowing CDR use only in industries facing international competition or those with high hard-to-abate emissions. Such an approach would require revisions to the list of hard-to-abate emissions as technologies evolve and new mitigation options become available.[38]

1.7 International cooperation: linking and beyond

As jurisdictions advance toward net-zero targets, linking ETSs might emerge as a more attractive option to enhance cost efficiency, preserve market liquidity, and manage increasing abatement costs. In a net-zero context, ETSs will cover fewer emissions over time, leading to less liquid markets and steeper marginal abatement curves (See 2.4). Linking can mitigate these effects by expanding access to mitigation opportunities across borders, smoothing price volatility, and ensuring a broader range of mitigation options remain available even as the" low hanging" fruits are gone. Having a single carbon price across jurisdictions also helps address rising competitiveness and leakage concerns, especially for EITE sectors.

However, to ensure that linking supports rather than undermines net-zero ambition, specific design features need to be aligned. Cap-setting processes must ensure compatibility of long-term reduction trajectories, and rules on monitoring, reporting and verification, enforcement mechanisms, and registry interoperability remain necessary to establish trust and equivalence between systems. Additionally, if CDR and/or carbon credits play an important role for compliance, alignment on eligibility, permanence and accounting rules will be needed to avoid the risk of the less robust units undermining the more stringent system.[39]

Beyond internal ETS design, effective linking also requires a shared understanding of the role ETSs will play in the broader policy mix across jurisdictions. If partner jurisdictions apply complementary policies in different ways, this can distort price signals, create imbalances in mitigation incentives, or lead to unintended effects through the linked market (e.g., a waterbed effect). To avoid this, aligned sector specific policies, such as renewable energy deployment targets in the power sector, harmonised benchmarks and support for breakthrough technologies in industry, aligned fuel efficiency standards in transport, or common criteria for methane reductions in agriculture, can help

[37] La Hoz Theuer, S., Doda, B., Acworth, W., & Kellner, K. (2025). Emissions trading systems: Trading removals? *Climate Policy*, *25*(7), 1092–1107. https://doi.org/10.1080/14693062.2024.2434092

[38] See Mcdonald, H., & Gardiner, J. (2026). Options for implementing limits for CDR integrated into the EU ETS 1. https://openumwelt.de/server/api/core/bitstreams/1d69f2ab-7ed7-4fcc-8cbb-f823f3e2ee0e/content for an analysis of limits to CDR inclusion in the EU ETS.

[39] D. Hynes and L. Schneider. (2023). Applying Rules under Article 6 of the Paris Agreement to Linked Emissions Trading Systems. Berlin: International Carbon Action Partnership. Available online at: https://icapcarbonaction.com/en/publications/applying-rules-under-article-6-paris-agreement-linked-emissions-trading-systems

ensure that the decarbonisation driven by linked ETS are reinforced rather than offset by domestic policies.[40]

1.8 Public acceptance of carbon pricing

Under a changing political environment, and as jurisdictions transition toward net-zero targets, the political economy of emissions trading is entering a new and more complex phase. The early stages of ETS implementation often benefited from clear win-win narratives: low-cost abatement opportunities and co-benefits, such as air quality and revenue generation. However, as low-cost mitigation options are exhausted and harder-to-abate emissions in, e.g., industry, transport, and agriculture, become the focus, carbon pricing may face a rising political resistance and distributional pressures. A recent World Bank report "Balancing Act: Political Economy and the Pursuit of Ambitious Carbon Pricing in Developing Countries" highlights that resilient carbon pricing requires mobilizing and maintaining broad coalitions; designing politically feasible policies without locking in low ambition; and communicating effectively while building implementation capacity and trust.

Successful cases have mobilized actors beyond environment ministries and covered industries, engaging finance and planning agencies, low-carbon business sectors, subnational governments, and community organizations. These coalitions often form during windows of opportunity such as tax reforms, electoral cycles, or periods of international pressure, and should be a point of attention when scaling up ambition in current policies.[41]

Acceptance can erode if stakeholders doubt the fairness or competence of the system. Early, structured outreach to regulated entities; phased, transparent roll-out of updates; and clear, simple rules can be paired with programmed review-and-raise cycles and tightening rules. California's Cap-and-Invest Program, for instance, combines a steadily rising auction price floor with a price containment reserve (APCR) and a price ceiling to manage volatility and provide predictability as ambition increases.

Communicating narratives and tangible benefits is also important to maintain carbon pricing acceptance. Direct household rebates/credits, just transition funding, and community programs focusing on co-benefits can stabilize public support as prices rise. For example, in California concerns from environmental justice groups about local pollutants led to the creation of AB 617 Community Air Protection Program, directly linking the use of cap-and-invest revenues to local air quality improvements.[42] Also as described in section 2.3 above in California, a portion of allowance value is returned to households as utility bill credits, strengthening acceptance among ratepayers.[43]

[40] Santikarn, M., L. Li, S. La Hoz Theuer, & C. Haug. 2018. A Guide to Linking Emissions Trading Systems. ICAP: Berlin. Creative Commons Attribution CC BY 3.0 IGO. Available online at: https://icapcarbonaction.com/system/files/document/icap_guide_to_linking_full-report_1.pdf

[41] World Bank. 2024. Balancing Act: Political Economy and the Pursuit of Ambitious Carbon Pricing in Developing Countries. © World Bank. http://hdl.handle.net/10986/42093 License: CC BY-NC 3.0 IGO.

[42] California Air Resources Board, Environmental Justice Communities and Local Air Pollution.https://ww2.arb.ca.gov/resources/documents/faq-cap-and-trade-program?, AB617. https://www.aqmd.gov/nav/about/initiatives/environmental-justice/ab617-134

[43] California Public utilities Commission, California Climate Credit, Available at:

https://www.cpuc.ca.gov/industries-and-topics/natural-gas/greenhouse-gas-cap-and-trade-program/california-climate-credit

2 BEYOND THE ETS: ROLE OF COMPLEMENTARY POLICIES

2.1 The limits to what ETS can do on the way to net-zero

Beyond the system-specific design challenges, there are limits to the extent to which a carbon price can drive deep decarbonization across sectors. Carbon pricing can successfully induce incremental emission reductions, mostly by optimizing existing systems and slowing the growth of emissions but there is insufficient data to show that it can single-handedly deliver deep emission cuts, even at high price levels.[44] Carbon price is also not sufficient to prevent carbon lock-in as it alone does not prevent investments into carbon-emitting assets with long turnover rates such as coal power plants or internal combustion vehicles[45]. The same applies to driving sustainable and timely zero-carbon innovations - carbon price is a necessary element but not enough to overcome past technological dependencies and achieve systemic transformations[46]. Additionally, as ETSs are primarily designed to incentivize emissions reductions by making them economically attractive, they are not meant to address broader social, economic or environmental objectives.[47] The latter can be partially addressed by the targeted use of ETS revenue, but only to a limited extent as those revenue do not match the scale of required green financing and not all barriers are financial.

While ETSs are a crucial tool for reducing emissions cost-effectively, they cannot be expected to overcome the full range of barriers to deep decarbonization on their own. Some of those barriers and limitations include:

Insufficient price signals: The development, commercialization and deployment of new zero-carbon technologies require high initial investments that carbon prices alone (especially in the context of uncertain future prices) often cannot justify. While measurable emissions reductions of 5-21% have been documented at the sector and firm level across the majority of evaluated schemes[48], evidence of carbon pricing driving deep decarbonisation remains limited – largely because most schemes have operated at prices far below the levels identified as necessary for full decarbonisation, and over timeframes too short to capture long-run structural effects. Sufficiently high carbon prices can also be politically unacceptable. A coordinated set of long-term policies is therefore needed alongside an ETS to foster investments into innovative abatement technologies at scale and speed required.[49]

Infrastructure gaps: The lack of necessary infrastructure further limits the potential for sectoral decarbonization. This includes both energy and transport infrastructure (e.g. electricity grid upgrades, renewable electricity and storage, railways expansion etc.) and infrastructure for new

[44] Tvinnereim, E., Mehling M., *Carbon pricing and deep decarbonisation, Energy Policy 121, October 2018*

[45] Tvinnereim, E., Mehling M., *Carbon pricing and deep decarbonisation, Energy Policy 121, October 2018*

[46] Stern., N., Valero., A. Innovation, growth and the transition to net-zero emissions, Research Policy (50), 2021 https://www.sciencedirect.com/science/article/pii/S0301421518304063

[47] Leining, C., Insight: Why the ETS alone won't get us to net zero emissions, 2021.

[48] Döbbeling-Hildebrandt, N., Miersch, K., Khanna, T.M. et al. *Systematic review and meta-analysis of ex-post evaluations on the effective ness of carbon pricing*. Nat Commun 15, 4147 (2024). https://doi.org/10.1038/s41467-024-48512-w

[49] Stern., N., Valero., A. *Innovation, growth and the transition to net-zero emissions* , Research Policy (50), 2021 https://www.sciencedirect.com/science/article/pii/S0301421518304063

products and decarbonization solutions (e.g. hydrogen pipelines, CO_2 pipelines and storage facilities, etc.)

Market and demand barriers: Limited market demand for pricier low- or zero-carbon materials hinders their widespread adoption. Uncertainty about finding buyers for products such as green steel or cement, given their high competitiveness and limited scope for passing on costs to consumers, is another barrier to investment in technology switch.

Global competitiveness and carbon leakage: High trade exposure in a number of key industrial sectors makes it difficult for them to absorb both rising ETS costs and decarbonization investment costs, as these industries often compete with producers from regions with lower or no carbon costs. Loss of market share, both domestically and internationally, often means that their products are displaced by more carbon-intensive alternatives, effectively increasing global carbon emissions.

Non-market barriers: Especially in transport and buildings sectors, transition may be hindered not (only) by direct economic costs, but by institutional, regulatory, or informational factors. Landlord-tenant dilemma, lack of accessible information on viable efficiency improvements options and access to investment are examples of such barriers.

Political and behavioural challenges: Past dependencies, perceived or real risks of being on the losing end, often lead to resistance to change on both the producer and consumer sides. They can further lead to difficulties in expanding ETS to new sectors, delaying implementation or reforms of the existing systems, or even putting them at risk of being weakened or undone.

2.2 Designing climate policy mix – key considerations

The limitations of an ETS outlined above underline that a **broader policy mix** is necessary to drive deep decarbonization. Empirical experience over the past 25 years shows a steady increase in climate policies across sectors in both developed and emerging economies, with breakthroughs in emissions reductions most often achieved through combinations of measures rather than standalone instruments. For example, in the energy and industry sectors, 54% of significant reductions have been linked to policy mixes; for buildings and transport, the share rises to 94%.[50]

The composition of any effective mix will reflect a jurisdiction's objectives, circumstances and policy preferences. Four considerations can guide design:

(1) **Understand policy interactions:** Determining the optimal policy mix requires a clear view of how instruments interact. These interactions can be categorized into **three main groups**[51]**,** based on the effects those have on the effectiveness of ETS:

- **Complementary policies**[52] bolster the effectiveness of ETSs by creating an environment conducive to optimal operation—supporting deep emissions reductions, enabling the infrastructure and technologies regulated entities require, and improving public acceptability by addressing adverse distributional impacts. Timing matters: some instruments

[50] Stechemesser, A. et al. Climate policies that achieved major emission reductions: Global evidence from two decades. Science 385, 884 – 892 (2024) DOI: 10.1126/science.adl65

[51] See for example World Bank Group PMR, Carbon Pricing Assessment and Decision Making: A guide to adopting carbon pricing, 2021

[52] Also referred to as companion policies or enabling policies

(e.g., certain command-and-control measures) can be effective at most price levels and stages of decarbonization, while others (notably some technology policies) may become inefficient once emission-reducing options reach maturity.

- **Overlapping policies** duplicate carbon pricing effects. On the one hand, they can create unintended effects, such as surplus allowances in an ETS; on the other, they can drive additional emissions reductions and move the economy closer to the optimal abatement level. Whether an overlap is desirable depends on the calibration of each instrument, the political feasibility and stringency of specific policies, and the objectives policymakers seek to achieve.

- **Countervailing policies** offer opposing incentives to the ETS, diminishing or nullifying intended effects. While typically discouraged, understanding why they were implemented is important, as they may serve other valuable objectives for a jurisdiction—for instance, supporting lower-income groups.

An effective policy mix ensures that the necessary complementary policies are in place to help overcome the limitations of the ETS, overlaps are managed to avoid or minimize negative effects, and countervailing policies are replaced with measures that support the important objectives of those policies without diminishing the effectiveness of the ETS.

Table 1 below provides a non-exhaustive list of examples for each of the three interaction types.

Table 1: Classification of policy interactions

INTERATION TYPE	SECTORS	EXAMPLES (NON EXHAUSTIVE)
Complementary	*Energy*	Energy market reform Energy efficiency labelling and financing
	Energy, transport	Infrastructure investments (smart grids, electric vehicle charging stations, etc.)
	Energy, Industry	R&D Low-carbon industry financing Low-or zero carbon public procurement programs
	Industry	Carbon Contract for Difference (CCfD) Standards for recyclable products
	Transport	Vehicle performance standards Technology phase-out policies
Overlapping	*Energy*	Fuel and energy taxes Renewable energy support schemes (e.g. feed-in-tariffs and premiums) Energy efficiency support /green certificates Renewable portfolio standards
	Forestry	Land use and forestation regulation

INTERATION TYPE	SECTORS	EXAMPLES (NON EXHAUSTIVE)
Countervailing	*Energy, industry*	Fossil fuel subsidies Industry tax breaks and special treatment
	Forestry	Subsidies for land use change (deforestation for agriculture)
	Energy	Planning barriers for renewable projects
	Transport	Subsidies for private cars

Source: Based on World Bank, *Carbon Pricing Assessment and decision making*, section A1

(2) Tailor the policy mix across sectors: Each sector presents distinct challenges and opportunities for carbon pricing to drive decarbonization. Power, industry, transport and buildings differ in market structure, technology maturity, investment cycles and consumer salience. Understanding these specific dynamics is essential for effective ETS implementation. Tailoring strategies accordingly, e.g., infrastructure enablers for electrification and hydrogen in industry, standards and finance for building retrofits, or demand-side measures in transport—enhances overall effectiveness across the economy. **Annex 1** provides an overview of the challenges and opportunities for carbon pricing in key sectors and lists examples of complementary policies.

(3) Adapt the policy mix over time: Anticipating interaction effects before launching an ETS is critical for jurisdictions planning to introduce one. After adoption, continuous assessment and adaptation are vital to keep the mix aligned with changing economic conditions, shifting priorities, emerging technologies and the stage of the decarbonization process. For instance, while the policy package for achieving net zero in the power sector may already be relatively comprehensive, the required mix for industrial, transport and building sectors will evolve as technologies mature and understanding of effective complementary measures improves. Regular reviews help sequence instruments cost-effectively and retire measures that have outlived their purpose.

(4) Strive towards social acceptability: As ETS carbon pricing expands into sectors where costs may be directly felt by citizens, it becomes essential to add measures that address potential concerns: targeted support for vulnerable groups and small businesses, information campaigns, job transition support, and inclusive dialogue and stakeholder engagement. ETS revenue is emerging as an important source of funds to redistribute burdens and benefits, multiply the environmental effect of ETSs, and build a narrative that increases acceptance of climate action.

2.3 Complementary policies for sectoral decarbonization

A well-designed policy mix is imperative for ETS's effective functioning, and adequate companion policies are indispensable to drive deep decarbonization across various sectors. More than addressing ETS limitations, a combination of carbon pricing and targeted sectoral policies is expected to yield lower carbon prices, thus making achievement of economy-wide net-zero targets less costly.[53] These companion policies can be broadly grouped into four categories based on the type of barriers they aim to tackle. Each sector, however, needs its own tailored mix of complementary policies to address specific features and related challenges.

2.3.1 Supporting technological innovation

Full decarbonization requires the development of technological breakthroughs, which is a long, expensive and risky process for businesses. Companion policies play a critical role here at addressing the constraints on both demand and supply sides.

Supply-side policies aim to provide the necessary financial resources for research and development (R&D). These include classical **R&D grants and tax exemptions**, but also newer tools such as **carbon contracts for difference (CCfDs)** and **time-bound subsidy programmes**. Resource pooling and blending can be used to ensure sufficient scale of funding, with part of the funding coming from ETS revenues and the other parts from other sources, including innovative funding instruments such as green bonds. Public funds in form of **loan guarantees and insurance** important catalytic role by de-risking, and thus stimulating, private investments by sharing financial risks.[54] Alongside the well-known benefits of green industrial policies, certain potential risks such as market distortions, political capture and windfall profits for certain firms, as well as potential international tensions (as subsidies impact competitiveness on the international market) need to be carefully considered and mitigated in policy design.[55]

Demand-side policies are designed to help build the business case for more expensive clean products by providing a guaranteed market. **Green public procurement (GPP)**, low-carbon standards, best available technology (BAT) requirements and **sustainable aviation fuel (SAF) mandates** are examples of such policies. While GPPs can cover a wide range of environmental criteria beyond carbon content and are applicable to public authorities purchases of goods and services, **low-carbon standards** focus solely on the carbon content of goods produced or sold and can apply to both public and private sector actors, further stimulating demand. In the road transport sector, regulatory measures such as **bans on internal combustion engines** in passenger cars can yield significant CO_2 emissions reductions,[56] and even more so if combined with policies supporting electric vehicles uptake.

2.3.2 Ensuring sufficient green energy supply

Most green technologies across all sectors rely on the use of low or zero carbon energy, which must then be available in sufficient quantities, reliably and at an affordable price. This is where sectoral decarbonization policies intersect with energy policy. As discussed in the ICAP 2024 paper "ETS in the policy mix – friends and enemies", in the energy sector carbon pricing can be effective in reducing GHG emissions, but even here – in the sector where most of the GHG emis-

[53] Strefler, J., Merfort, L., Bauer, N. et al. Technology availability, sector policies and behavioral change are complementary strategies for achieving net-zero emissions. Nat Commun 15, 8440 (2024). https://doi.org/10.1038/s41467-024-52424-0

[54] IMF G-20 Note: Reaching net-zero emissions, 2021, https://www.imf.org/external/np/g20/pdf/2021/062221.pdf

[55] OECD. (2024). *Green industrial policies for the net-zero transition* (OECD Net Zero+ Policy Papers No. 2). OECD Publishing. *https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/10/green-industrial-policies-for-the-net-zero-transition_1e066699/ccc326d3-en.pdf*

[56] Morfeldt, J., Kurland, S. Johansson, D. Carbon footprint impacts of banning cars with internal combustion engines, Transportation Research Part D: Transport and Environment, Volume 95,2021,102807, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2021.102807.

sion cuts happened to date – in most of examined cases significant emission reductions are attributed to effective policy mixes.[57]

Phasing out fossil fuel subsidies is a key to both ensuring ETSs efficacy and de-blocking decarbonization by avoiding locking in both carbon-intensive infrastructure and consumer behaviour as well as by preventing misallocation of trillions of public funds that could otherwise be available for financing net-zero transition.[58] The process of phasing out fossil fuel subsidies should be carefully planned and implemented in steps to avoid disruptive effects. It should also be accompanied by complementary policies to increase efficiency and mitigate short-term price shocks through compensation and social protection.[59] Similar considerations apply to **coal use limits or phase out -** while it significantly speed up power sector decarbonization, the example of the UK highlights the importance of coordinated action to avoid unwanted spillover effects.[60]

Support for renewable power must evolve beyond simply subsidizing generation—it needs to become strategic, equitable, and support system-wide grid reliability. As energy transition advances, feed-in tariffs or fixed contracts shall be replaced with flexible pricing mechanism (for example, contracts for difference) that reward clean energy production when and where it is the most needed. Upgrades to transmission and distribution grids and expanding storage capacities are essential elements of the strategy to deliver a fossil-free energy mix. Facilitating of those includes **streamlining permitting procedures and land acquisition processes**, but also by **working on public acceptance**.[61] Clear predictable permitting timelines, designated priority zones pre-assessed for renewable energy and grid expansion projects and easing requirements for small-scale installation will help shorten lead times, improve bankability and ensure timely grid access.[62] With regard to public acceptance, perceived or real risks (e.g. loss of property market value) often lead to public resistance to infrastructure projects, and, if not addressed by policymakers, may become a new bottleneck for economy decarbonization. This also applies to the new infrastructure needed for industrial decarbonization, such as CO_2 pipelines. Early stakeholder engagement and fair benefits sharing, including through community ownership models, could be instrumental in addressing this risk.

2.3.3 Addressing non-market barriers

In many sectors, especially in those with decentralized emission sources such as transport, buildings or agriculture, non-market (non-pricing) barriers play an important role. These barriers - such as infrastructure lock-ins, informational, regulatory and behavioural hurdles - can slow or even block the uptake of low-carbon solutions.

Infrastructure lock-in is an important barrier for both transport (e.g. existing infrastructure such as gas stations for fossil fuel mobility) and buildings (long lifespans of buildings and embedded carbon in materials). For transportation, **public investments** into infrastructure for walking, cycling and public transport, sustainable rail, waterways and multimodal transport hubs (both for

[57] Based on results from Stechemesser, A. et al. Climate policies that achieved major emission reductions: Global evidence from two decades. Science 385, 884 – 892 (2024) DOI: 10.1126/science.adl65

[58] Damania, R., Balseca, E., de Fontaubert, C., Gill, J., Kim, K., Rentschler, J., Russ, J., & Zaveri, E. (2023). *Detox development: Repurposing environmentally harmful subsidies*. World Bank. https://doi.org/10.1596/978-1-4648-1916-2

[59] Damania, R., Balseca, E., de Fontaubert, C., Gill, J., Kim, K., Rentschler, J., Russ, J., & Zaveri, E. (2023). *Detox development: Repurposing environmentally harmful subsidies*. World Bank. https://doi.org/10.1596/978-1-4648-1916-2

[60] Tvinnereim, E., Mehling M., *Carbon pricing and deep decarbonisation, Energy Policy 121, October 2018*

[61] International Energy Agency. (2023). *Net zero roadmap: A global pathway to keep the 1.5 °C goal in reach (2023 update)*. https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15c-goal-in-reach-2023-update

[62] International Energy Agency. (2023). *Net zero roadmap: A global pathway to keep the 1.5 °C goal in reach (2023 update)*. https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15c-goal-in-reach-2023-update

passenger and freight transport) but also in communication infrastructure (e.g. high-speed and affordable internet) will be essential.[63] For this, **reforms to national transport budgets** and infrastructure spending priorities are required.[64] For buildings, introduction of nearly-zero (NZEB) and **zero-emissions buildings (ZEB) standards** is one practical approach to avoid further carbon lock-ins and the way to manage the replacement of building stock with new high energy performance buildings in a predictable manner. For example, a recast EU's Energy Performance of Buildings Directive (EPBD) from 2024 introduces a ZEB standard for all new public buildings from 2028 and for all building from 2030. It also requires Member States to develop **long-term renovation strategies** aiming to facilitate the cost-effective transformation of existing buildings into NZEBs.[65]

Lack of access to financial resources coupled with behavioural inertia often hinder consumers from choosing low-carbon options, e.g. choosing an EV car or public transportation rather than purchasing a new diesel car; or choosing a heat pump rather than an oil heater. **Targeted subsidies, loans, performance contracts** (e.g. via Energy Service Companie whose renumeration depend on the energy savings achieved)[66] help reduce upfront cost barriers for the energy refurbishment of buildings and incentivize the purchase of low-carbon vehicles. Special **programs targeting low-income households** and **disadvantaged communities** may be set up to ensure vulnerable citizens and communities are not left behind. In California, the Low-Income Weatherization Program (LIWP) has been in operation since 2016, providing housing retrofitting and solar installations for single-family and multifamily low-income homes in disadvantaged and farmworkers communities. The program provides technical assistance, safeguards against displacement, and ensures cost savings pass to residents.[67] While the LIWP is financed through the state's ETS revenue, other sources of funding may often need to be mobilized to expand the scope of such programs to ensure sufficiency.

Disclosure of information on energy use and **efficiency labels** for buildings and appliances are further intended to overcome another part of the information barrier by making it easy for consumers to follow their energy use, as well as to identify and compare the efficiency of products or services. An additional common barrier for energy efficiency in rental property is the landlord-tenant dilemma, where landlords lack incentive to invest in energy-saving upgrades because tenants - who pay the utility bills - reap the financial benefits. This can be addressed by solutions like **green leases** - rental agreements that includes sustainability clauses on energy efficiency, water and waste reduction - to overcome the incentive problem by ensuring both sides benefit from buildings sustainability upgrades[68]. For urban mobility, **raising awareness campaigns and providing additional incentives** (e.g. subsidized public transport fees, congestion pricing, parking restrictions, etc.) for shift from private vehicles to public, active (walking/cycling),

[63] Wang-Helmreich, H., Obergassel, W., & Lah, O. (2022). *Moving transport to net zero: What it takes to decarbonise the global transport sector* (Wuppertal Paper No. 199). Wuppertal Institute for Climate, Environment and Energy. https://epub.wupperinst.org/frontdoor/deliver/index

[64] Rode, P., Heeckt, C., & da Cruz, N. (2019). *National Transport Policy and Cities: Key policy interventions to drive compact and connected urban growth*. Coalition for Urban Transitions. https://newclimateeconomy.net/sites/default/files/2023-08/CUT2019_transport-paper_FINAL-FOR-WEB.pdf

[65] Nearly-zero energy and zero-emission buildings - European Commission

[66] European Commission Joint Research Centre. (2023, September 27). Energy Service Companies (ESCOs). E3P. https://e3p.jrc.ec.europa.eu/en/groups/energy-service-companies-escos

[67] California Housing Partnership. (2024, April). *California's Cap-and-Trade-Funded Low-Income Weatherization Program Multifamily: Impact report*. https://chpc.net/wp-content/uploads/2024/04/LIWP_PolicyBrief_2024

[68] What does a green lease mean? – Institute of Sustainable Studies

or shared (e.g. car sharing) transportation works best when combined with the development of a reliable and comfortable public transport network.[69]

2.3.4 Addressing competitiveness and carbon leakage

As long as significant differences in carbon pricing stringency persist across countries, and as jurisdictions move away from free allocation to mitigate carbon leakage risk, alternative safeguards will become increasingly necessary. New approaches outside ETSs are now being tested, namely carbon border adjustments and "climate clubs".

Border carbon adjustments (BCAs), also commonly referred to as carbon border adjustment mechanisms (CBAMs), are designed to level the playing field for domestic producers of industrial goods facing carbon costs under ETS, by addressing competition from foreign producers not facing equivalent carbon costs. CBAMs can be promising policy tools to avoid carbon leakage and provide competitiveness protection without relying on free allocation. By imposing a carbon cost on imported goods equivalent to that faced by domestic producers, CBAMs incentivize global industries to adopt cleaner production methods while ensuring that ambitious climate policies do not disadvantage domestic businesses.

On the other hand, CBAMs are a novel policy tool yet to demonstrate their full effectiveness. The first examples of such instruments are either under development – as in the UK - or in an early implementation phase, as in the EU. Their implementation can face considerable headwinds from the outset, including retaliation risks, legal challenges for potential violation of WTO rules,[70] concerns over fairness, and potential negative impacts of most affected trade partners, as well as administrative complexities and compliance burden. At the same time, evidence is accumulating that existing CBAMs - although not explicitly designed for that purpose - are accelerating the global adoption of carbon pricing among trade partners.[71] They generate important policy spillover effects by encouraging governments worldwide to consider carbon pricing and instigating broader conversations about coordinated climate policy action. This effect is particularly driven by Article 9 of the EU CBAM Regulation, which allows exporters to deduct domestic carbon prices from their CBAM obligations and thereby creates a direct financial incentive for trade partners to retain carbon revenues at home.[72]

An alternative approach of so-called "**climate clubs**" can also have its merits. A climate club is a coalition of countries that work together to reduce carbon emissions through coordinated targets and policies to achieve them. A climate club can help protect competitiveness by creating a level playing field for its member countries and industries through coordinated climate policies, while non-members may face penalties, such as the application of border carbon adjustments. Climate clubs can be a pathway to cooperation because they are based on voluntary cooperation and mutual agreement, rather than unilateral imposition, but face the myriad challenges of getting countries to agree on meaningful climate governance parameters. Climate clubs could take many shapes, from **supranational coordination as under the European Union** to discus-

[69] C4: How to drive a modal shift from private vehicles to public transport, walking and cycling. https://www.c40knowledgehub.org/s/article/How-to-drive-a-modal-shift-from-private-vehicle-use-to-public-transport-walking-and-cycling?language=en_US

[70] Greven, T. (2022). *Border carbon adjustments & climate clubs: A development perspective*. Friedrich-Ebert-Stiftung. https://library.fes.de/pdf-files/international/19892.pdf

[71] Mehling, M. A., Dolphin, G., & Ritz, R. A. (2025). The European Union's CBAM: averting emissions leakage or promoting the diffusion of carbon pricing? *Journal of Environmental Policy & Planning*, *27*(6), 687–705. https://doi.org/10.1080/1523908X.2025.2591794

[72] Clausing, K. A., Elkerbout, M., Nehrkorn, K., & Wolfram, C. (2024). *How carbon border adjustments might drive global climate policy momentum* Resources for the Future. https://www.rff.org/publications/reports/how-carbon-border-adjustments-might-drive-global-climate-policy-momentum/

sion fora. One such forum – **the Climate Club** - was launched in 2023. It operates as an inclusive intergovernmental cooperation forum for countries committed to ambitious climate action, with the aim of advancing climate mitigation policies in line with the goals of the Paris Agreement, transforming industries, and boosting international climate cooperation and partnerships.[73] It does not, however, set binding emission reduction targets or expect their members to have certain carbon price levels. So, while the CBAMs and emerging climate clubs offer promising alternatives to free allocation for carbon leakage protection, their practical effectiveness is still constrained by limited coverage, complexity of implementation, and the need for strong international cooperation. To become truly workable solutions, further progress is required in terms of harmonizing standards, ensuring WTO compatibility, and broadening participation among major trading partners and emitters.[74]

[73] The Climate Club, industry decarbonisation - The Climate Club, https://climate-club.org/

[74] Umweltbundesamt. (2022, October 27). *The EU CBAM and a climate club: Synergies and potential obstacles for full integration* (Discussion Paper). German Environment Agency. https://www.umweltbundesamt.de/sites/default/fil

3 KEY TAKEAWAYS

As jurisdictions across the globe move towards net zero, decarbonization complexity increases and existing policy frameworks require adjustment. ETSs are expected to evolve and be complemented by well-calibrated companion policies to maintain social acceptance and effectiveness in driving decarbonization.

- **The ETS alone cannot deliver net zero across all sectors**

Carbon pricing is a necessary but insufficient instrument for deep decarbonization. Non-price barriers—including infrastructure gaps, capital constraints, information asymmetries and innovation spillovers—limit the ETS's effectiveness, particularly in hard-to-abate industry, buildings and transport. A well-calibrated companion policy package is essential to unlock abatement at scale.

- **Future of competitiveness: beyond free allocation**

Continued reliance on free allocation at current levels risks locking in high-carbon technologies and delaying investment. To maintain both competitiveness protection and abatement incentives, a well-designed package of measures is needed — including tightening technology-neutral benchmarks, introducing conditional allocation, tied to reinvestment into decarbonization, and implementing tiered approaches that differentiate support based on carbon leakage risk. As cost-effective mitigation options become scarcer and cap declines, these mechanisms must continually evolve alongside complementary measures beyond free allocation. Measures including targeted compensation, border adjustment measures and climate clubs are being explored.

- **Auction revenues for public support and enabling infrastructure**

Transparent, earmarked revenue recycling—targeting vulnerable groups, financing enabling infrastructure (grids, hydrogen, CO_2 networks) and supporting innovation—builds public acceptance and multiplies environmental impact. As allowance volumes fall under tightening caps, revenue allocation will need to become more targeted and supplemented by alternative funding sources.

- **Market design must adapt to smaller, less liquid markets**

As emissions decline, reduced participation and trading volumes may eventually risk impairing price discovery and increasing volatility. Jurisdictions should proactively strengthen market governance, consider expanding scope or lowering participation thresholds, and evaluate linking opportunities to preserve liquidity and cost-efficiency while aligning ETS role and key design features to guard against unintended effects through linked markets.

- **CCS/CCU and CDR require tight governance to safeguard integrity**

Allowing CCS/CCU and CDR under an ETS can provide essential flexibility for hard-to-abate emissions, but only under strict eligibility criteria, permanence/reversal provisions, robust MRV and quantitative limits to prevent abatement deterrence. Given current cost gap between ETS allowance price and levelized cost of these technologies, complementary instruments—such as investment support and carbon contracts for difference—will be needed in the near term to bridge viability.

- **Sector-tailored companion policies are essential for addressing ETS limits**

The limits of carbon pricing alone—insufficiency to deliver deep decarbonisation or address structural barriers—suggest that coordinated, long-term policies are needed to complement the ETS. Technology and infrastructure deployment at the pace required for net zero depends on combining supply-side support (R&D, de-risking, contracts for difference) with demand-side levers (green procurement, standards, mandates) to create investable markets for low-carbon materials, products and processes. In buildings and transport, standards must be paired with affordable finance, consumer support and information tools to convert price signals into adoption. Cross-cutting measures—phasing out fossil subsidies, expanding grids and enabling infrastructure, streamlining permitting—are prerequisites for success.

ANNEX 1. SECTORAL OVERVIEWS: ROLE OF CARBON PRICING AND COMPLEMENTARY POLICY EXAMPLES

Energy

Carbon price effectiveness: Emissions trading in the energy sector can effectively reduce emissions, because emitters in this sector are large point sources – relatively easy to quantify emissions and enforce compliance - with multiple abatement options.

Carbon price limitations: Not all low- or zero-carbon technologies needed for the sector's full decarbonization are readily available at sufficiently low cost, rendering carbon price alone insufficient to incentivize their development and penetration. Also, existing energy market designs (e.g. non- or partially-liberalized markets with regulated tariffs) and capital market limitation (e.g. focus on short-term profitability, higher cost of capital due to regulatory or technology risks) can limit the ETS effectiveness and/or may require politically unsustainable carbon prices, especially in developing countries. Finally, adverse distributional impacts (real or perceived) from increased energy prices induced by market liberalization and carbon price may stir public opposition, undermining its effectiveness and making its further development politically difficult.

Examples of complementary policies:

- **Coal phase-out strategy:** to provide clear targets for ending unabated coal use.
- **Fiscal measures** (e.g. excise taxes on fossil fuels, tax rebates for renewable electricity): to provide additional incentives to consumers for switching from fossil to renewable energy use.
- **RES/EE deployment support and targets**: to stimulate development and market penetration of zero-carbon alternatives and ensure efficient use of energy[75]. Fiscal measures (e.g. tax exemptions for RES equipment) also fall under this category.
- **Electricity market reform**: to ensure carbon price signal is passed through, impacts future investment decisions and induces change in end-user behavior.
- **Green investment banks**: to help overcome the barriers to capital investments by providing guarantees and other support to de-risk innovative energy projects.
- **Enabling infrastructure development support**: to provide necessary infrastructure (smart grids, interconnectors).
- **Direct-income support to vulnerable consumers**: to provide temporary and targeted support to vulnerable consumers to shield them from adverse impacts of energy price increases and give time to adapt.
- **R&D support**: to induce technological innovations, help mature 'young' zero-carbon technologies and well-developed technologies - to spread.

[75] Often RES targets and RES support schemes (such as feed-in tariffs) are considered as overlapping policies as their implementation may (negatively) impact the effectiveness of an ETS by damping allowances demand and dragging down carbon price below desirable levels.

Industry

Carbon price effectiveness: Similarly to the energy sector, a carbon price signal has strong potential to leverage significant emissions reduction in industry by incentivizing efficiency improvements, as well as earlier retirement of most-polluting installations and investments into low-carbon alternatives.

Carbon price limitations: Breakthrough process technologies are needed, particularly for industries like cement and steel, where commercialized zero-carbon options are still limited. Companies may hesitate to invest due to concerns about competitiveness, low profit margins, and the substantial upfront capital required. Additionally, some innovations have public good characteristics, making it difficult for individual companies to justify investments. There may also be a lack of demand for more costly climate-friendly materials, hindering their adoption in the market.

Examples of complementary policies:

- **Product standards** (Carbon Disclosure, Carbon Caps.): to assess and disclose information on products emissions (voluntary or mandatory) and set embedded emissions limits for certain products.
- **Low- or zero-carbon public procurement programs**: to help create demand for low-carbon products, increasing predictability for industry.
- **R&D, CCfD and other deployment support**: to induce technological innovations, help mature 'young' zero-carbon technologies and well-developed technologies - to spread.
- **Competitiveness protection measures such as border adjustment mechanisms (BCAs)**: to prevent carbon leakage and loss of competitiveness for domestic producers as long as carbon price levels vary significantly across countries.

Transport

Carbon price effectiveness: The carbon price signal alone has lower potential for emission reductions in the transport sector than in energy sector or industry. Its effectiveness also varies depending on the type of transport fuel and often targets the easier-to-reduce incremental demand.

Carbon price limitations: Achieving deep decarbonization in the sector will require very high carbon prices, that might be politically challenging. Overcoming heavy path dependencies (slow fleet turnover, existing infrastructure for fossil fuel mobility, behavioral biases) and undesirable social impacts require extra efforts and resources.

Examples of complementary policies:

- **Fiscal measures** (e.g. excise taxes on gasoline and diesel, tax benefits and incentives for purchasing e-vehicles): to provide additional incentives to firms and households for transitioning from conventional to low-carbon transportation.
- **Public investments into public transport infrastructure**: to provide sufficient public and private low-carbon transportation options (extended railway networks, bicycle lanes, charging stations for E-vehicles).
- **Subsidies for public transport use**: to incentivize use of public transportation.

- **Vehicle performance standards, technology phase-out policies**: to speed up vehicles fleet turnover (could work better if combined with financial incentive for scraping most inefficient vehicles).
- **Direct-income support to vulnerable transport users**: to provide temporary and targeted support to vulnerable transport users (for ex. those with no access to public transportation services). It is important to ensure the design of these support policies does not subside fossil fuel use.
- **R&D and deployment support**: to improve quality and affordability of necessary low-carbon technologies (e.g. batteries) and zero-carbon fuels. Also, to ensure necessary production scaling-up and market penetration.

Buildings

Carbon price effectiveness: The carbon price signal alone has limited potential to decrease emissions in the sector but can do so if combined with a well-designed mix of other non-pricing policies. It is usually set upstream to ensure reasonable administrative burden for both regulator and end users and to effectively coordinate measures among very high number of small emitters.

Carbon price limitations: The incentive provided by the carbon price is very small while existing non-pricing barriers (e.g. landlord-tenant dilemma, lack of accessible information on viable efficiency improvements options and access to investments) are significant.

Examples of complementary policies:

- **Energy efficiency programs for varies types of buildings** (commercial, public, private): to provide necessary framework and investments, overcoming an issue of high up-front costs and lack of access to funds.
- **Minimum energy performance standards for buildings**: to create stable demand for deep energy renovation of buildings, providing the necessary predictability and incentives to innovate for all actors along the supply chain.
- **Information campaigns**: to widely spread necessary information, help overcome behavioral barriers.
- **Support to vulnerable households (direct income + buildings retrofitting programs)**: to provide temporary targeted support to vulnerable households and necessary funds for heating/cooling decarbonization in long-term.

Agriculture

Carbon price effectiveness: Experience with carbon pricing in the agricultural sector is today still very limited, with no ETS covering this sector. New Zealand and the EU carried out scoping works to explore the application of carbon pricing frameworks to the agricultural sector.

Carbon price limitations: Emissions are more dispersed and diverse as they come from different sources/biological processes (e.g. nitrous oxide from fertilizers and livestock, methane from ruminant animals). This makes robust MVR system and determination of regulation point very challenging. While regulation on farm level provides the biggest incentive for emission mitigation, the administrative burden might be too high, becoming a barrier for small farms and raising equity concerns.

Examples of complementary policies:

- **Environmental management plans for farmers** (incorporating GHG emissions): to help kick off the process of measuring and managing emissions. This should be accompanied with technical support and advisory services.
- **Information campaigns/labelling**: to raise awareness among consumers, create a market for low-carbon food and promote dietary changes (e.g. less meat and dairy consumption).
- **'Green payments' for carbon sequestration**: to reward specific measures by farmers that reduce emissions/increase sequestration.

International Carbon Action Partnership

ICAP
Alt-Moabit 96A
10559 Berlin
Germany

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