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Carbon Markets

The Beginning of the Big Carbon Age

ESG Report

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Executive summary

> With governments escalating climate policymaking, we believe carbon pricing is the best gauge of the stringency and efficacy of such policies.

Carbon Pricing – The Best Climate Action Barometer: With governments escalating climate policymaking, we believe carbon pricing is the best gauge of the stringency and efficacy of such policies. Just as the question on climate actions is not "if" but "when," the question on carbon price is less about how high it will go but when over $ 100/ton will be reached, as it is simply a prerequisite of the net-zero transition. The longer nations defer taking action, the higher and faster carbon prices would have to rise to achieve the current climate objectives. Growth in carbon markets will have wide-ranging implications for climate finance, corporate strategy, and global trade.

Carbon Prices in the Spotlight, but Still Too Low: Despite prices in the world's top-3 most liquid carbon markets having doubled on average in 2021, the global weighted-average carbon price is still only $ 28/ton, too low to incentivize tangible decarbonization activities. Carbon prices need to reach $ 130/ton by 2030 and $ 250/ton by 2050 in advanced economies to meet net-zero ambitions, according to the International Energy Agency (IEA). It is critical for advancing decarbonization technologies. Our ROE of a Tree analysis shows a carbon price of more than $ 50/ton is required for carbon removal forestry projects. We estimate a carbon price of >$ 85/ton is needed for blue hydrogen to compete with grey hydrogen, while >$ 100/ton is needed to justify carbon capture projects in heavy industries and even higher to displace fossil fuels in use in various hard-to-abate sectors.

Emergence of Big Carbon Markets: Compliance carbon markets (CCM) (i.e., market-driven emission trading systems [ETS]) and carbon taxes currently cover 22% of global emissions. The former accounts for 75% of those carbon schemes and has an aggregate market value of ~$ 270 billion. We believe this figure could easily reach more than $ 1 trillion in the coming years driven by higher carbon prices and the expansion of emissions coverage, while trading value could be multiples of that driven by improved accessibility and liquidity. Growth of big carbon markets is still in the early stages, and we view carbon markets as an emerging asset class that could potentially rival the global oil market in size. Key drivers of carbon markets, include:

- **Tougher Climate Policies:** The carbon market is an important legislative tool for governments to bridge the gap between climate ambitions and policy actions. This includes strengthening emission-reduction mandates and expanding to harder-to-abate sectors. The EU ETS is doing both, while China's nascent carbon trading scheme aims to do the latter. The EU's Carbon Border Adjustment Mechanism (CBAM) also ties carbon to international trade.
- **Improved Accessibility and Liquidity:** Over the past year, several major commodity houses and corporates in the oil & mining space have expanded their carbon trading desks. Exchanges are rapidly building out futures contract offerings, which are supporting a new breed of carbon financial products. Enhanced market liquidity enables compliance entities to hedge their own carbon exposure and bring different participants into the market.
- **Carbon as an Investment Hedge:** Carbon as a mature alternative asset class could also attract institutional investors. Investments in carbon allowances could offer downside protection in a disorderly transition as carbon prices would need to rise to compensate for the lack of policy actions. In the short term, carbon could also be an inflation hedge.

Article 6 Paves the Way for Credible Carbon Offset Markets: Article 6 of the Paris Agreement creates a common rulebook for what can qualify as a carbon credit (i.e., by restricting the criteria) and how it can be used for different purposes (i.e., by addressing double counting concerns). For nations, this means increasing the flow of climate financing, particularly for developing countries most in need. For developers, this broadens the sources of financing for the most innovative carbon mitigation and removal projects higher up on the abatement cost curve. For corporates, this redefines the use of carbon credits in the net-zero strategies, which can be used to either neutralize unavoidable emissions (via carbon removal credits) and/or make compensation claims. Ultimately, we believe these developments will fuel demand of high-quality carbon credits, which in turn will lift prices in the voluntary carbon markets. Enhanced credibility in the voluntary carbon markets could enable them to grow substantially from the current ~$ 1 billion to $ 50–100 billion by 2030.

Implications for Investors: In our view, the "greenflation" risk is to the upside in the next three to five years driven by higher carbon and fossil fuel prices. A $ 50/ton carbon price would add ~$ 21/Bbl to oil and ~$ 2.70/MMBtu to natural gas prices, or a substantial 25% and 55% to today's WTI and NYMEX price levels, respectively. Meanwhile, underinvestment in energy supply (both traditional and clean energy) could drive energy prices higher in the early stages of the transition. The Credit Suisse economics team estimates that a $ 10/ton increase in the price of carbon emissions (across the entire economy) would lower global GDP by 0.4% and add close to 0.5 percentage points to global inflation. In a carbon price shock, the initial impact will be felt more by energy consumers than by energy suppliers, which means carbon intensity is relevant for businesses across all parts of the economy. Conversely, higher carbon/energy cost should accelerate all decarbonization efforts, with renewables, hydrogen, carbon capture, and energy efficiency as the largest beneficiaries.

David Bleustein
Global Head of Securities Research

Why the world needs higher carbon prices

In our view, higher global carbon prices are the most efficient and technology-agnostic method to decarbonize the world at the scale and speed necessary to achieve ambitions of net zero emissions by 2050. Private sector capital reallocation and technology-specific incentives (such as electric vehicle subsidies and solar/wind tax credits) can go a long way toward achieving that goal, but a lack of consistency, transparency, and standardization ultimately makes them insufficient. Meanwhile, gradually rising carbon prices should accelerate emission reductions in areas that have low cost of abatement, drive new technology innovations, and incentivize carbon removal investments such as nature-based solutions and carbon capture. However, ultimately, carbon prices that in turn raise the cost of carbon-intensive goods are most effective in driving demand changes that are critical to moving the world toward a low-carbon economy.

To reach net zero emissions by 2050, the IEA's latest World Energy Outlook estimates that carbon prices need to be in place in all regions and reach $ 130/$ 250 per metric ton by 2030/2050 in advanced economies and $ 90/$ 200 per metric ton in major emerging economies (China, Brazil, Russia, and South Africa). The IEA's CO_2 price projections take into consideration government policy measures, such as coal phase-out plans, efficiency standards, and renewable targets. Without the support of such climate policies, carbon prices needed to support actions based on the marginal cost of abatement would be significantly higher, such as those laid out in the Intergovernmental Panel on Climate Change (IPCC) and The Network for Greening the Financial System (NGFS) scenarios.

Figure 1: IEA CO_2 Price Projections (Considering Policies) – in USD per Metric Ton

Announced Pledge (Countries with Net Zero Pledge)	2030	2040	2050
Advanced Economies	USD 120	USD 170	USD 200
China	USD 30	USD 95	USD 160
Emerging Market & Developing Economies	USD 40	USD 110	USD 160

Net Zero by 2020	2030	2040	2050
Advanced Economies	USD 130	USD 205	USD 250
Major Emerging Economies*	USD 90	USD 160	USD 200
Other Emerging Market & Developing Economies	USD 15	USD 35	USD 55

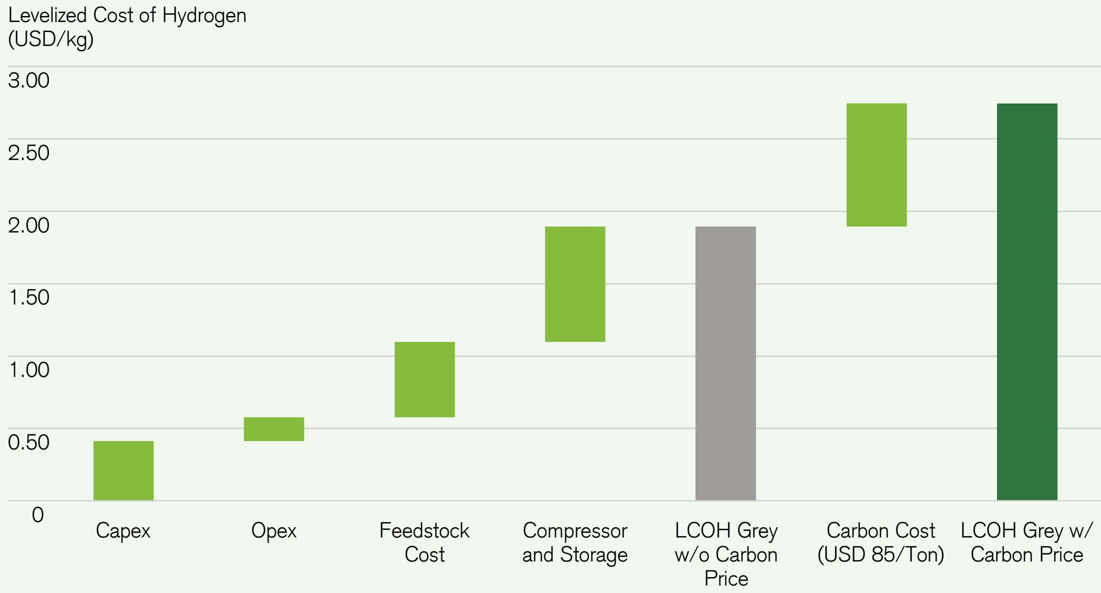
*China, Brazil, Russia, and South Africa

Source: IEA

Higher Carbon Prices Are Also Critical to Providing Economic Signals for Decarbonization

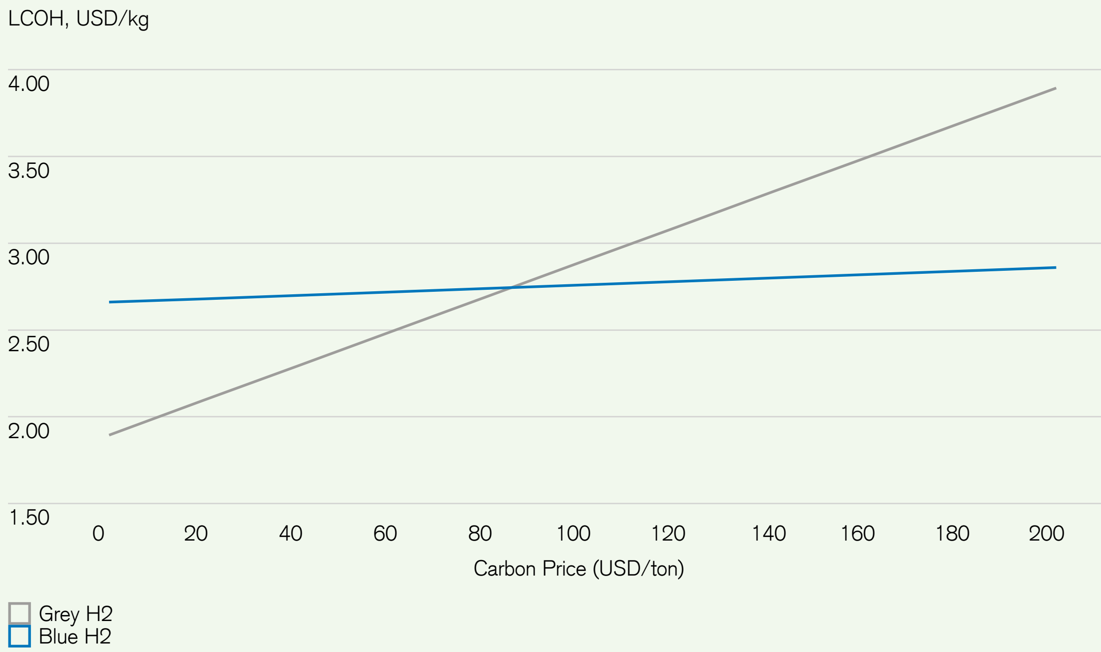
Higher carbon prices will enable blue and green hydrogen to reach cost parity with grey hydrogen. Blue hydrogen achieves parity with grey hydrogen when carbon prices equal carbon capture costs. Currently, our analysts estimate the levelized cost of hydrogen (LCOH) for grey H_2 is ~$ 1.90/kg, assuming natural gas prices of $ 2/MMBtu without any carbon price. Meanwhile, the cost of blue hydrogen is estimated at ~$ 2.66/kg, assuming a carbon capture cost of ~$ 0.77/kg (carbon capture cost of $ 30/ton and carbon processing cost of $ 20/ton). As every $ 10/ton of CO_2 cost increases the cost of grey hydrogen by ~$ 0.10/kg, we estimate this makes blue hydrogen competitive with grey hydrogen at a carbon price of >$ 85/ton. Similarly, the levelized cost of green hydrogen today is estimated at a significantly higher ~$ 4.90/kg. Theoretically, assuming no technology/economy of scale improvements (which we believe is unlikely), a carbon price of >$ 300/ton would be needed for green hydrogen to reach parity with grey hydrogen.

Figure 2: Levelized Cost of Grey Hydrogen



Source: Credit Suisse

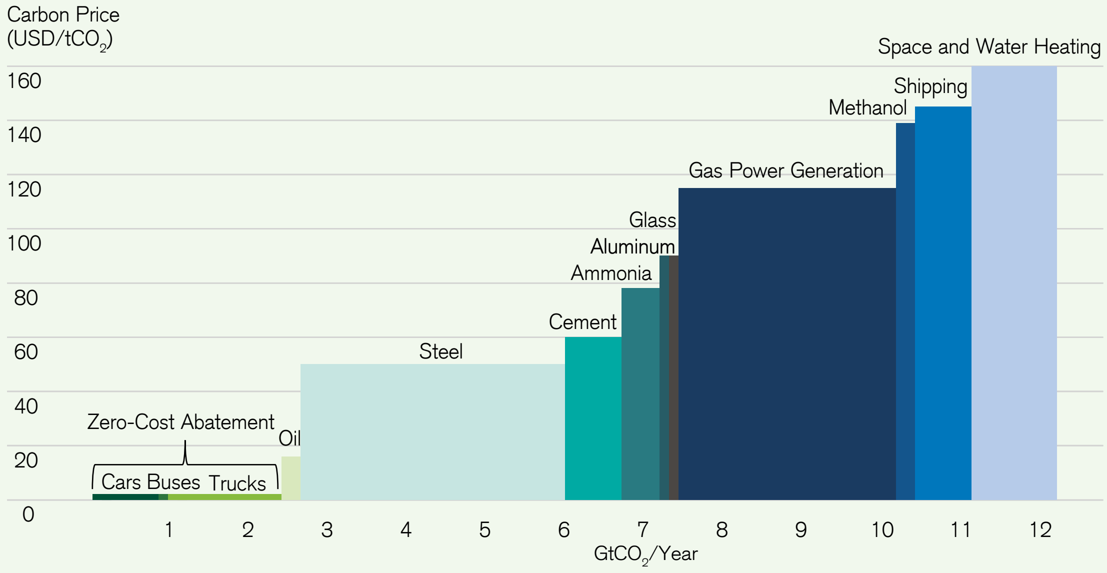
Figure 3: Blue Hydrogen Is Competitive at a Carbon Price >$ 85/Ton



Source: Credit Suisse

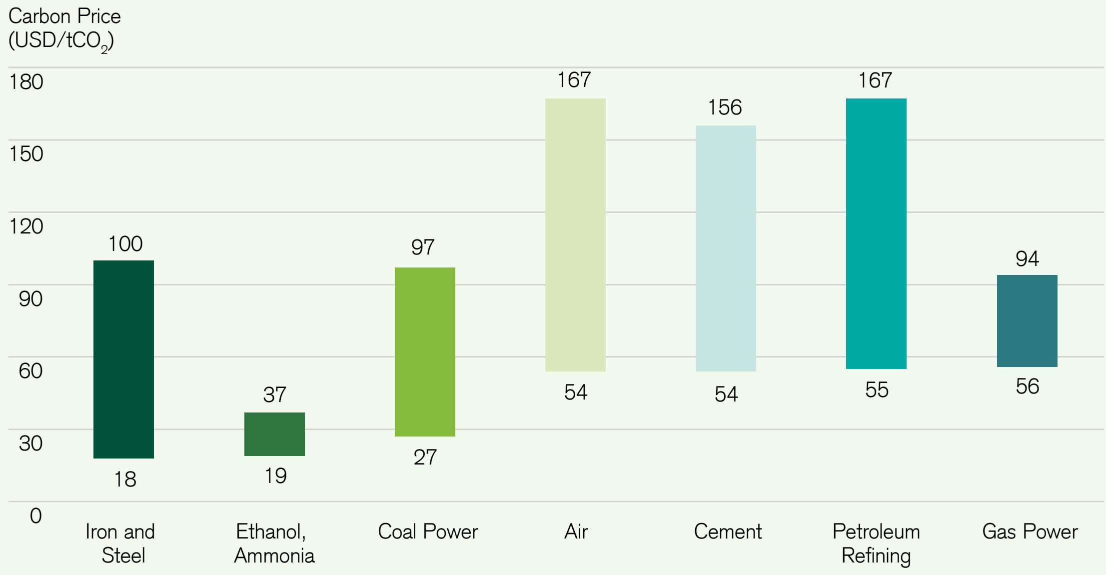
Longer term, even at a $ 1/kg green hydrogen price assumption for 2050, BloombergNEF (BNEF) estimates that carbon prices of $ 50-160/ton are needed for hydrogen to compete with the cheapest fossil fuels in use in various hard-to-abate sectors. For example, at a $ 1/kg hydrogen cost, a carbon price of $ 50/ton would be needed to switch to green hydrogen in steel making, $ 60/ton to use hydrogen for heat in cement production, $ 78/ton for ammonia synthesis, and $ 90/ton for aluminum and glass manufacturing. In aggregate, BNEF estimates 20% of greenhouse gas (GHG) emissions from fossil fuels and industry could be abated for a carbon price less than $ 100/ton, assuming a hydrogen cost of $ 1/kg. At higher hydrogen prices, the breakeven carbon price would also be proportionately higher.

Figure 4: Carbon Price Needed to Make $ 1/kg Green Hydrogen Competitive in Various Industrial Sectors



Source: BloombergNEF

Figure 5: Carbon Price Needed to Support Carbon Capture, Utilization, and Storage for Various Hard-to-Abate Sectors

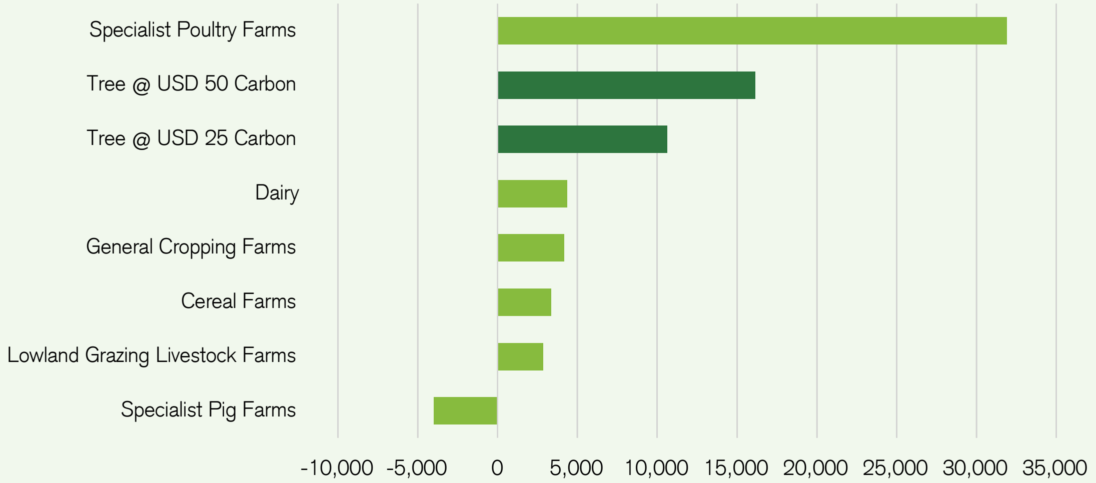


Source: BloombergNEF

For carbon capture and storage (CCS) projects, the carbon price is simply the revenue line if there is no other economic benefit from the use of the carbon captured, such as for carbon sales or sales of by-products. While project economics depend heavily on the purity of the CO_2 stream (higher concentration equates to better economics), Credit Suisse found that a $ 50/ton carbon price is needed to generate a 12% IRR for a project with 60% CO_2 concentration. The IRR improves to 20% at a price of $ 100/ton. In a rising carbon price environment, our Global Infrastructure team believes CCS will be economic in most regions during the current planning cycles for many infrastructure companies, particularly for emission-intensive industries (see Compelling Carbon Capture Considerations). BNEF estimates carbon capture at ethanol and ammonia plants require a carbon price of just $ 19-37/ton owing to high CO_2 concentration, while steel and coal power plants need ~$ 60/ton at the mid-point of the range. However, most other hard-to-abate sectors require a median carbon price of >$ 100/ton.

Carbon prices are also critical to support the development of nature-based solutions. In our report, The ROE of a Tree, we showed that forests play a key role in addressing climate change, as typical mature trees can capture ~22 kg of CO_2 per year, according to sources such as the Food and Agricultural Organization (FAO). At present, the world's forests absorb ~30% of CO_2 emissions; however, deforestation activity since 1990 has resulted in the loss of ~420 million hectares of forest – an area equivalent to eight times the size of France, or almost half of the US. While the need to plant trees in order to help reduce emissions to net zero seems a logical progression, we also showed higher carbon prices are needed to incentivize farmers. Based on a carbon price of $ 50 for each ton of CO_2 stored, we calculate that planting a tree could yield an IRR of over 11%, while its NPV could be at least 7x that of most traditional farming activities.

Figure 6: The NPV of One Hectare of Trees vs. Farming Activities (US$)



Source: Credit Suisse

Emergence of big carbon markets

Global carbon prices are on the rise

The value of carbon markets is reaching record highs as global climate actions gained unprecedented momentum in 2021. Carbon permits in the EU's ETS reached a record high of 89 euro per metric ton in December, tripling the year-ago levels and significantly outperforming equity indices. Reviving post-COVID economic activities, anticipation of the EU's tightening climate policies, and more recently elevated natural gas prices have all fueled higher demand for EU carbon permits.

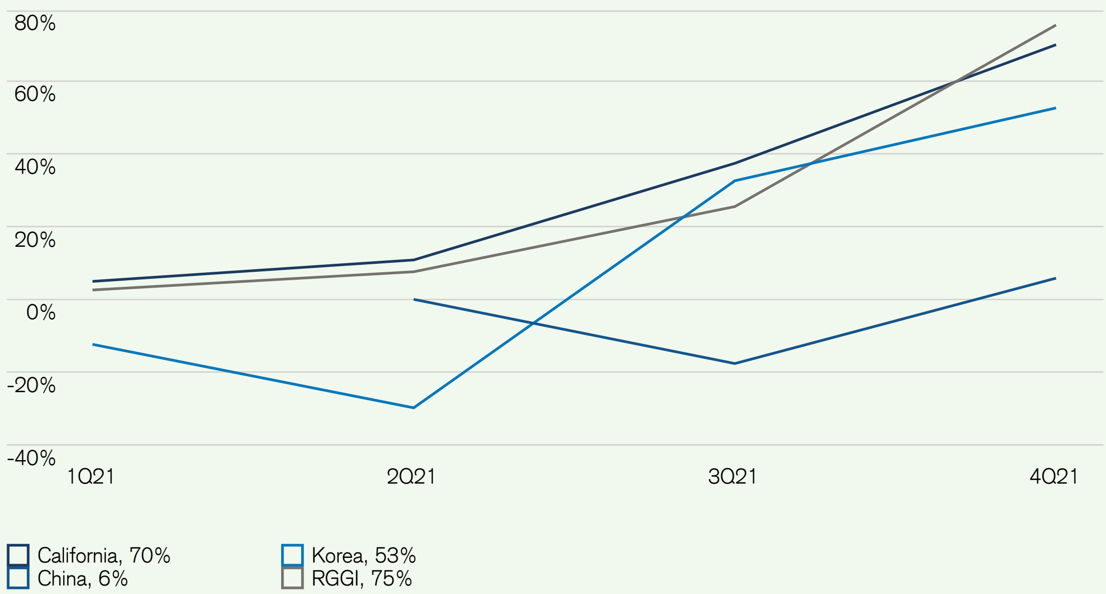
Similar dynamics are playing out in other regional schemes where prices for carbon permits in the California cap-and-trade market and the north-east's Regional Greenhouse Gas Initiative (RGGI) were up 70% and 75% in 2021, respectively.

Such strong price actions across the world's three most liquid carbon markets put a spotlight on carbon as a barometer for global climate policy actions and as an emerging asset class.

Figure 7: EU ETS Carbon Permit Performance

Source: the BLOOMBERG PROFESSIONAL™ service, Credit Suisse

Figure 8: Carbon Prices in Key Compliance Markets (ex-Europe)



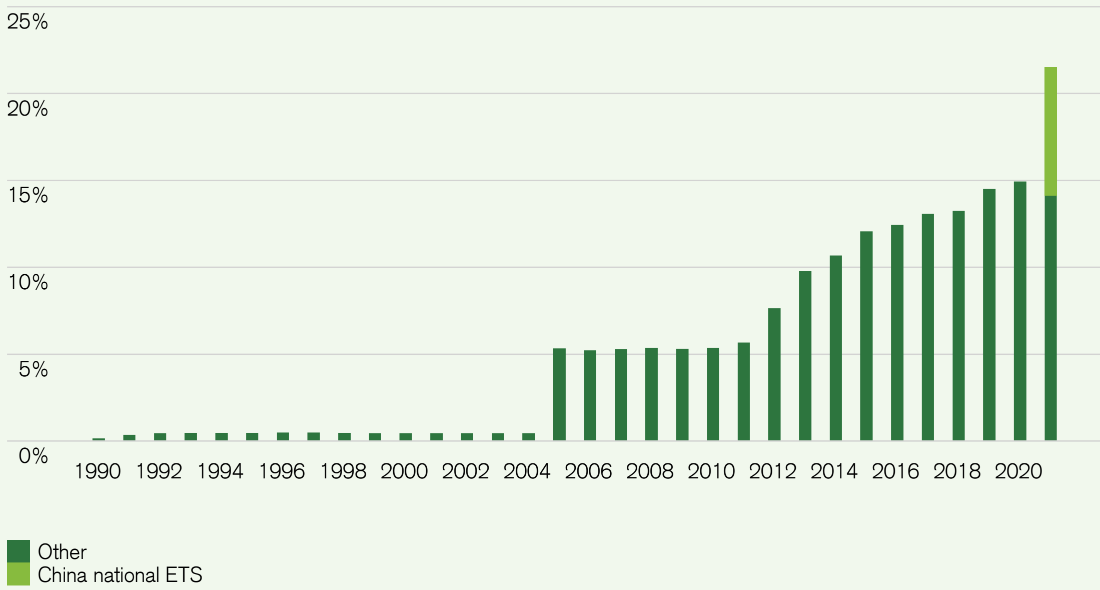
Source: CARB, RGGI, Shanghai Environmental and Energy Exchange, Korea Exchange, Credit Suisse

How large can carbon markets become?

More than 60 carbon markets and taxes have been implemented around the world, covering 11.6 $GtCO_2e$, or 22% of global greenhouse gas emissions. The global compliance carbon markets, in which carbon allowances are traded and regulated by mandatory national/sub-national regimes, account for ~75% of those total emissions covered and have a carbon market-weighted average price of ~$ 28/ton. The rather low prices are primarily due to the world's largest carbon scheme – China's national ETS – trading at just ~$ 8.50/ton (as of YE21), which makes up over 50% of the emissions covered under implemented CCMs.

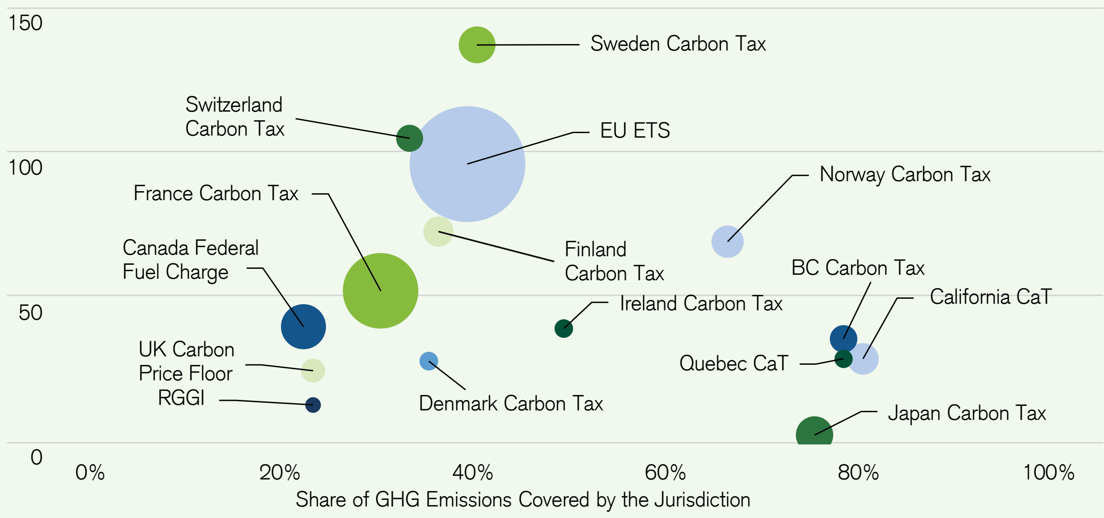
Still, even at current prices, we estimate the market value of CCMs totals over $ 270 billion, with the EU and UK ETS – two schemes with the highest carbon prices – making up 63% of that value while accounting for less than 20% of the covered emissions. China, given its large emission footprint, accounts for ~16% of the total CCM value. (See Figure 11.)

Figure 9: Share of Global Emissions Covered by Carbon Schemes



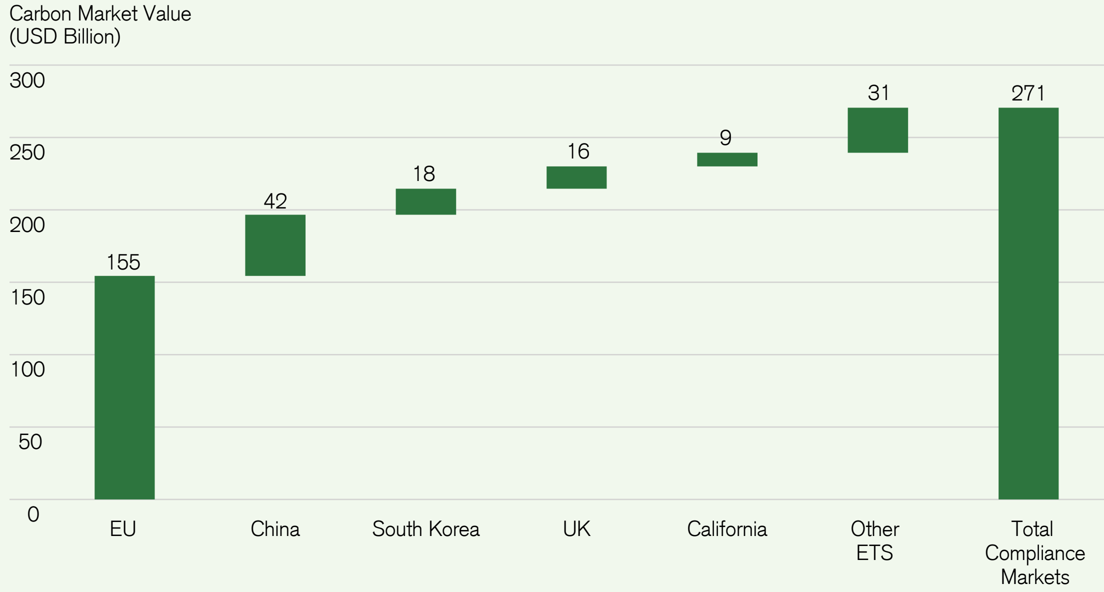
Source: World Bank, Credit Suisse

Figure 10: Carbon Price, Share of Emissions Covered, and Carbon Pricing Revenues of the Largest 15 Initiatives*



*Revenue based on full year 2020, which excludes China national ETS and UK ETS Source: World Bank, Credit Suisse

Figure 11: Breakdown of the Current Market Value for Key Carbon Markets



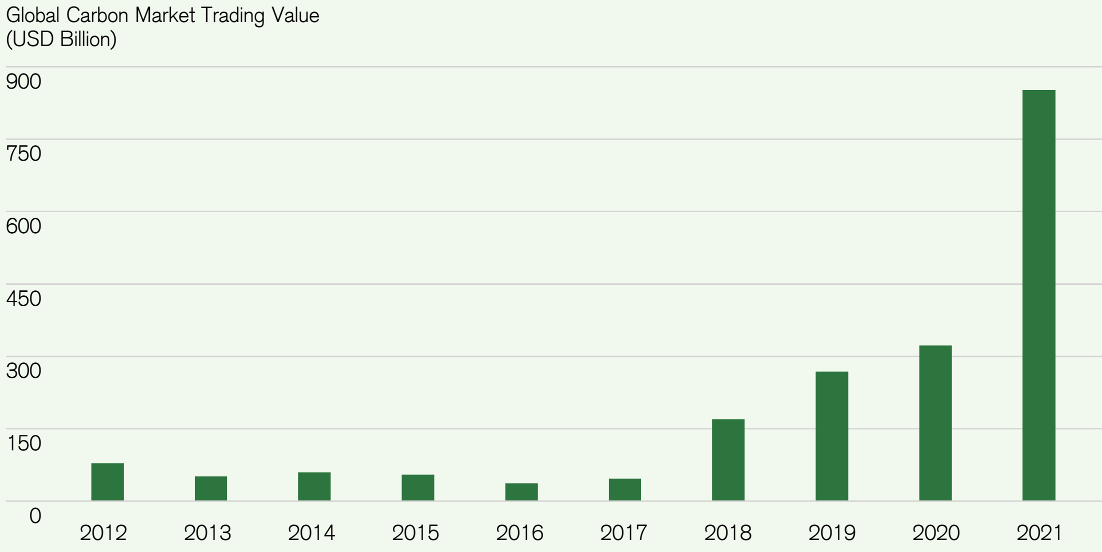
Source: BNEF, ICAP, CARB, Shanghai Environmental and Energy Exchange, Korea Exchange, Credit Suisse

According to an annual review of global carbon markets by data provider Refinitiv, the total trading value of global carbon markets reached a record high $ 851 billion in 2021, up 164% vs. 2020 and well above 2012-2017 average of just ~$ 55 billion annually. While prices were strong across markets, volumes were also up 24% YoY. The Intercontinental Exchange (ICE) reported that it saw a 26% YoY increase in environmental contracts traded last year to 18 billion tons of carbon allowances across EU, UK, California, and RGGI markets, which was equivalent to ~$ 1 trillion in notional value (including futures and options). ICE represents ~95% of global exchanged traded volumes[1].

The EU ETS is the most liquid market, with trading turnover nearly 10x the annual emissions cap, and accounts for 90% of the global carbon trading value. The California cap-and-trade market is the second most liquid but is much smaller and lower in price. UK ETS is picking up in volume despite having just launched in May 2021.

1 Per ICE disclosure – ICE Carbon Futures Index Family

Figure 12: Global Carbon Market Annual Trading Value



Note: Refinitiv values include spot, auctions, and futures but not options
Source: Refinitiv, Credit Suisse

While carbon markets are still tiny compared to the multi-trillion dollar oil and gas markets, industry experts believe the growth potential is significant. Wood Mackenzie estimated that the global carbon market could grow to $ 22 trillion by 2050. Trafigura, one of the world's leading commodity-trading houses, expects the value of the carbon market to exceed the oil market's value by 2030, or even as soon as 2025 if more immediate action is taken and regulations are enacted[2].

We believe such projections on carbon markets are ambitious but not unrealistic, as doubling average prices (to $ 50/ton, well within what's needed to meet the world's carbon abatement trajectory) and doubling emissions coverage (to ~35%, achievable by just expanding sector coverage of existing schemes) would bring market value to over $ 1 trillion and trading value multiples of that.

Using EU ETS as a more concrete example, its market size is set to expand under the EU's Fit for 55 legislation, with the scheme expected to include the shipping sector by 2023. Under the proposal, a separate new carbon scheme is expected to start for the road transport and buildings sectors in 2026, though it is not yet clear whether they will receive a separate allowance or one that is interchangeable with those in the existing EU ETS. Trading activities could grow even more, due to not only greater participation from the financial market participants but also increased market participation from industrial compliance entities whose carbon exposure has so far been shielded by freely allocated carbon allowances. However, free allowances are expected to fall due to tighter performance benchmarks. In addition, under the current proposal, for sectors covered under the CBAM, free allowances will begin to phase out starting in 2026 to zero by 2036. The combined effect of the scope expansion and greater market trading activities has the potential for the EU ETS markets (including the new one) to be multiples of their current size over the next ten years.

Figure 13: Carbon Market Trading Volume and Value in 2021

Global Carbon Markets	Total Volume Traded (Million Tons)	Total Trading Value (Million Euros)	Share of Total Value (%)
Europe	12,214	682,501	89.9%
UK	335	22,847	3.0%
North America*	2,680	49,260	6.5%
China	412	1,289	0.2%
South Korea	51	798	0.1%
New Zealand	81	2,505	0.3%
CERs**	38	151	0.0%
Total	**15,811**	**759,351**	

*Markets include California, Quebec, and RGGI.
**Represent carbon offset credits traded in primary and secondary markets.
Source: Refinitiv, Credit Suisse

Figure 14: 2020-21 ICE Exchange-Traded Activities for the Most Actively Traded Carbon Markets

	2020 Market Activity					2021 Market Activity				
Most Liquid Carbon Markets	Emission Cap (Gt CO_2e)	Average Price (USD/Ton)	Market Value (USD Bn)	ICE Emissions Traded (Bn Units)	ICE Traded Value (USD Bn)	Emission Cap (Gt CO_2e)	Average Price (USD/Ton)	Market Value (USD Bn)	ICE Emissions Traded (Bn Units)	Est. ICE Traded Value (USD Bn)
EU ETS	1.82	USD 29.0	USD 52.7	12.3	USD 351	1.61	USD 63.9	USD 103	15.2	USD 972
California Cap and Trade	0.39	USD 17.1	USD 6.7	1.9	USD 30.0	0.38	USD 22.4	USD 8.4	2.4	USD 53.8
RGGI*	0.10	USD 6.4	USD 0.6	0.23	USD 1.5	0.12	USD 9.6	USD 1.2	0.35	USD 3.3
UK ETS**						0.16	USD 76.3	USD 11.9	0.26	USD 19.5
Total			**USD 60**	**14.4**	**USD 383**			**USD 124**	**18.2**	**~USD 1,000**
2021 vs. 2020 Change								**107%**	**26%**	**161%**

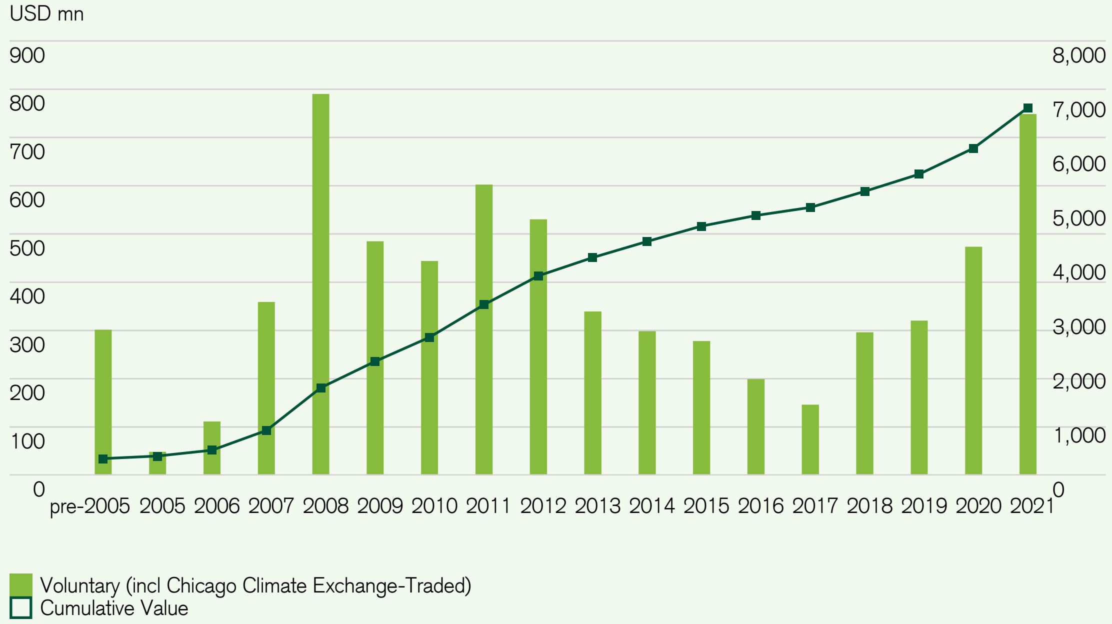
*RGGI emission unit is based on short tons rather than metric tons.
**UK ETS was launched in May 2021 as reflected in average price and trading activities.
Note: ICE trading volume and values include both futures and options.
Source: ICE, Credit Suisse

2 Based on comments quoted in WSJ article "Energy Traders See Big Money in Carbon-Emissions Markets" on September 1, 2021.

Voluntary carbon offset markets are complementary to compliance markets

While voluntary markets have grown substantially in the past few years, they still pale in size relative to the compliance market with an annualized traded value of more than $ 1 billion (extrapolating from a total of ~$ 750 million through the end of August). The market has failed to develop more meaningfully due to a lack of standardization and low credibility around the quality of credits. However, with finalization of Article 6 of the Paris Agreement (discussed starting on page 5), voluntary markets could see substantial change, which would drive increasing demand from the private sector and investments in supply.

Figure 15: Market Size by Traded Value of Voluntary Carbon Offsets, Pre-2005 to August 31, 2021 ($ Million)



Source: Ecosystem Marketplace

The longer-term market size potential of the voluntary carbon offset market will largely be demand driven as, by definition, it is voluntary. The complexity of corporate ESG strategies will determine (1) whether and to what extent carbon offset credits are used as part of emission reduction options; and (2) what type of carbon offset credits will be in demand, which will drive pricing.

On the demand side, The Taskforce on Scaling Voluntary Carbon Markets (TSVCM) projects the carbon offset market will reach a demand of 1-2 $GtCO_2$ by 2030. Trove Research, an independent research group, sees demand at a lower 0.5-1.5 $GtCO_2$, with the view that not all corporates will have 1.5 degree emission targets and be engaged in the carbon offset market. BNEF's forecast is in-line with Trove, estimating that demand for credits from corporates to reach net-zero goals could reach 1 $GtCO_2$ by 2030 and exceed 5 $GtCO_2$ by 2050.

On the pricing side, it will largely depend on the type of carbon credits being pursued. The avoidance-type projects favored historically in the market, such as avoiding deforestation and clean energy developments, are low-cost options that are priced in the $ 10-15/ton range. At the high end of the price range are removal projects, such as reforestation and direct air capture, and the cost of these carbon offset credits could reach >$ 200/ton, according to BNEF. It is likely that realistic market prices would reflect corporates' internal cost of carbon used for their business operations, which are likely to mirror prices in compliance markets.

Figure 16 shows various scenarios for the size of voluntary carbon markets by 2030, with the market size ranging from $ 10 billion at the low end (reflecting largely the status quo of the oversupply of low-quality credits) to more than $ 200 billion at the high end if it is removal credits only. The former seems unlikely to us given avoidance carbon credits are explicitly excluded in the new Article 6.4 carbon scheme and outside stakeholders are making companies accountable for their emission reduction strategies. We believe an annual market size of $ 0-100 billion by 2030 is realistic at a carbon price of $ 50-100/ton with 1 $GtCO_2$, which compares to current traded volumes of ~360 $MtCO_2$ per annum.

Figure 16: Voluntary Carbon Market Scenarios for 2030

Scenario	Pricing (USD/Ton)	Demand ($GtCO_2$/Year)	Market Size (USD Billion)
Taskforce on Scaling Voluntary Carbon Markets (TSVCM) Projections			
Prioritization of Low Cost Supply	USD 10-USD 20	1-2	USD 10-USD 40
Preference for Local Supply	USD 50-USD 90	1-2	USD 50-USD 180
Trove Research			
Trove Research	USD 20-USD 30	0.5-1.5	USD 10-USD 40
BloombergNEF Projections			
Maintaining Status Quo (primarily low-quality credits)	USD 11	1	USD 11
SBTi Scenario (removal project credits only)	>USD 200	1	>USD 200
Hybrid Scenario (gradual phase-in to removal only)	USD 48	1.7	USD 80

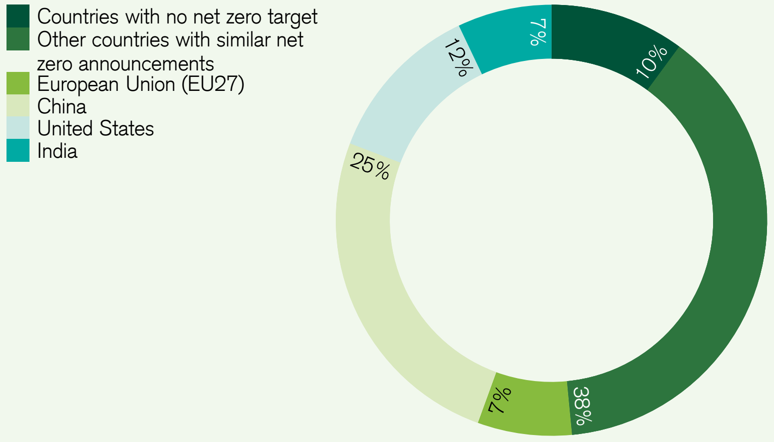
Source: BloombergNEF, Trove - Future Size of the Voluntary Carbon Market, TSVCM – Final Report, Credit Suisse

Key drivers of carbon market growth

Government policy actions

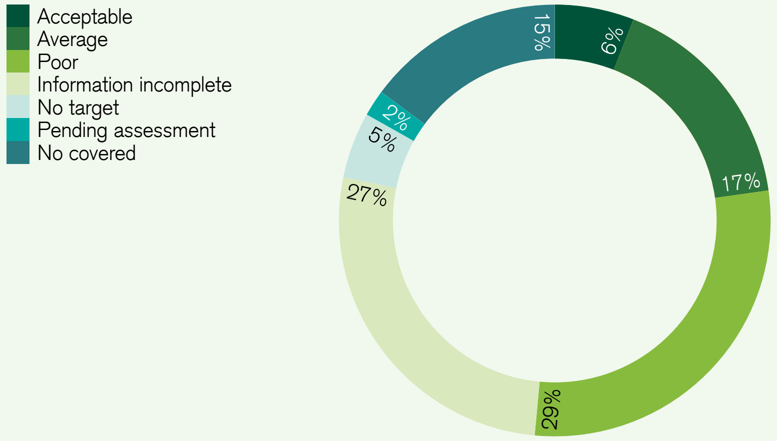
If 2021 was the year of net-zero goal setting, the focus going forward is squarely on implementation. The world today remains far from the trajectory of achieving net-zero emissions by 2050. However, as governments look to bridge the gap between climate actions and ambitions in the coming years, carbon markets should become an even more important legislative tool to incentivize real-world changes. This is the case in Europe and even China as both aim to expand coverage of existing ETS to more sectors over the coming years.

Figure 17: Over 140 Countries Covering ~90% of Global GHG Emissions Have Announced or Are Considering Net-Zero Targets…



Source: Climate Action Tracker

Figure 18: …But So Far Only ~6% Have Defined Their Targets in an "Acceptable" Way as Many Continue to Debate Best Paths Forward



Source: Climate Action Tracker

Carbon trading schemes should ultimately reflect the marginal cost of abatement either to avoid emitting carbon or to remove carbon from the atmosphere. Key considerations that contribute to a market-driven carbon price include the following:

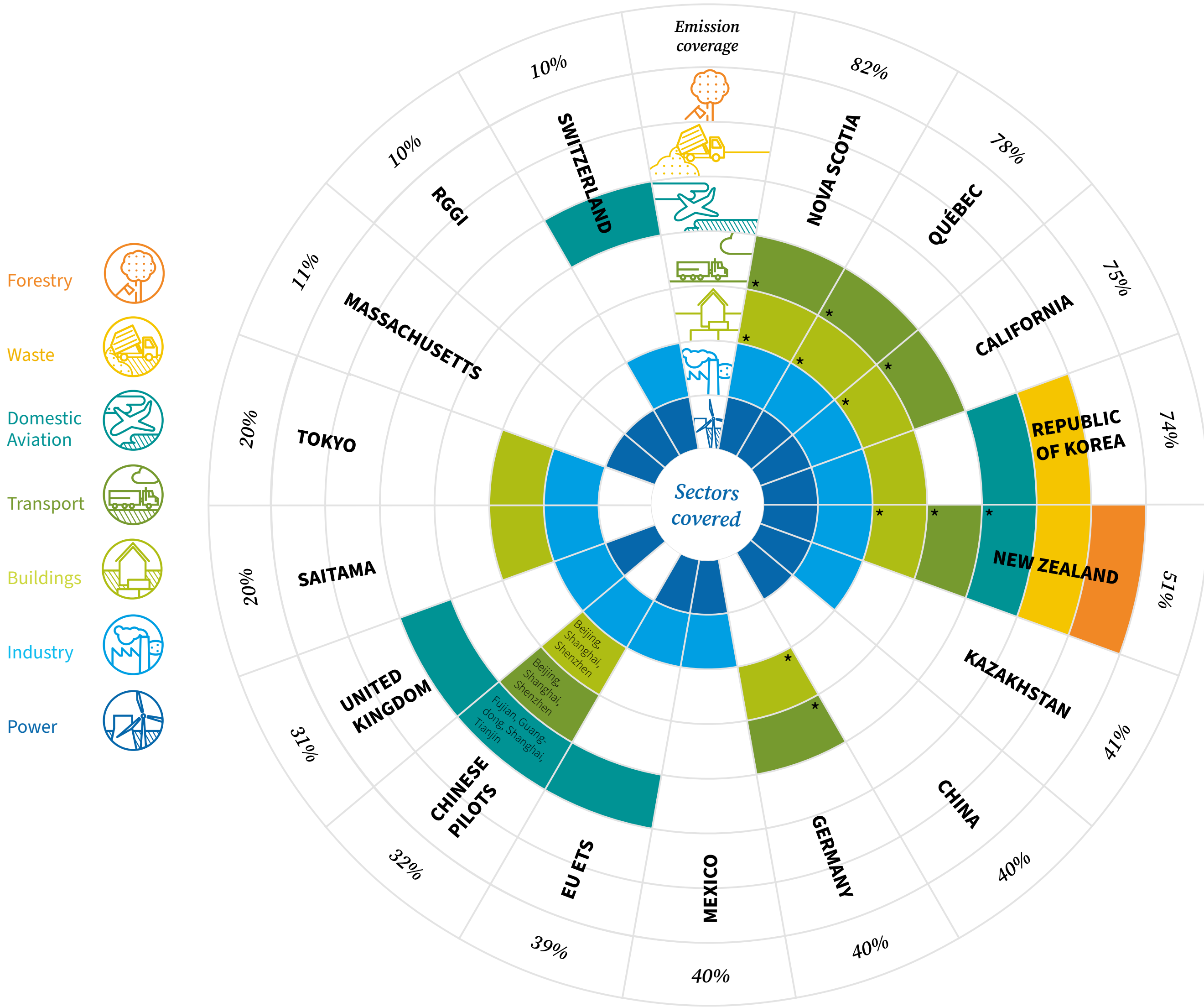
1. The pace of reduction required (e.g., a higher rate of decline would result in a faster price increase as low-cost mitigation options are being exhausted);
2. The sources of emissions being covered (e.g., inclusion of hard-to-abate sectors would result in higher carbon prices); and
3. Additional provisions such as free allocation of carbon credits for certain sectors and if and what type of carbon offsets are allowed to be used to meet compliance.

Following COP26, it is clear that all three of these drivers are trending in the direction of greater stringency, with questions only around magnitude and speed of change. We expect countries to update their emission-reduction targets under the Paris Agreement to better align with their stated net-zero ambitions. Sector coverage should also improve as mitigation efforts move beyond the power sector to other hard-to-abate sectors, such as buildings and transport.

According to BNEF data, current CCMs on average cover only ~37% of the emissions generated in the markets they regulate. The power and industry sectors are most frequently included in an ETS today (as shown in Figure 21) given emissions from these sectors are easier to measure and account for than in others. However, to achieve decarbonization economy wide, other sectors will also need to be added to ETS. This is the case for the EU ETS as well as future plans for China ETS.

Lastly, carbon offsets are likely to see a step-change in stringency of qualification criteria owing to the Article 6 agreement, which we discuss in detail starting page 5.

Figure 19: Scope and Sector Coverage of Existing Emissions Trading Systems



Note: Systems are listed clockwise in decreasing order of share of aggregate emissions covered, with the numbers in the outermost ring indicating the share of aggregate emissions covered by the system. Upstream coverage is indicated with an asterisk (*). Source: ICAP. (2021). Emissions Trading Worldwide: Status Report 2021. Berlin: International Carbon Action Partnership.

New developments enhance carbon market accessibility and liquidity

As carbon markets grow in size, resources are being allocated across the financial value chain to enhance the accessibility and liquidity of these markets. Participants in carbon markets are not only companies that need to control emissions, but also commercial banks, investments banks, carbon funds, and private equity funds. These participants make the market more liquid and promote innovation in carbon financial products and services.

Over the last year, major commodity trading houses, such as Vitol and Trafigura, have been building up their trading capabilities to participate in both the regulated credit allowance and voluntary carbon offset markets. Similar dynamics are panning out at major oil and mining companies, which enable them to manage their own carbon compliance cost and enhance market liquidity.

From an accessibility standpoint, exchanges are rapidly ramping up offerings in the environmental space. Currently, the Intercontinental Exchange (ICE) and European Energy Exchange (EEX) are the two largest platforms for trading of carbon compliance credits. In early 2022, ICE also plans to launch a global carbon futures contract based on a blend of the three most liquid carbon markets schemes – Europe's ETS, RGGI, and California's cap-and-trade scheme.

Beyond compliance markets, carbon offset futures are also seeing significant growth. Last March, CME Group launched CBL Global Emissions Offset futures contract, which is backed by carbon offset credits. In August, the CME Group expanded its offering with a CBL Nature Based Global Emissions Offset futures contract, which is underpinned by Verra's Verified Carbon Standard (VCS). In November, ICE announced plans to launch similar nature-based solutions carbon offset futures that are certified under Verra's VCS and Climate, Community, and Biodiversity (CCB) Standards programs.

Growth in futures markets is also supporting a new breed of carbon allowance ETFs. The largest one, KarneShares Global Carbon ETF, with a current market value of $ 1.7 billion, mirrors the performance of IHS Markit's Global Carbon Index and doubled in 2021.

Figure 21: Key Exchanges and ETFs Involved in Carbon Trading and Investment Offerings

Exchange/Product	Offerings/Description
Futures/options	
Intercontinental Exchange (ICE)	Futures and options on EU allowances (EUAs), UK allowances, California carbon allowances (CCAs), California carbon offsets and Regional Greenhouse Gas Initiative (RGGI) allowances
European Energy Exchange (EEX)	Spot, futures and options trading of EU ETS allowances, including EU aviation allowances and EUAs, as well as related spreads
Nodal Exchange (part of EEX Group)	Physically delivered futures and options for CCAs, RGGI carbon allowances and sulfur dioxide (SO2)/nitrogen oxide (NOx) emission allowances, among other environmental products
CME Group	RGGI allowance futures and options, in-delivery month EUA futures and options, California low-carbon fuel standard futures and CCA vintage-specific futures; also recently launched nature-based global emissions voluntary offset (N-GEO) futures and global emissions voluntary offset (GEO) futures
Nasdaq	Suite of EUA futures, including daily futures contracts, quarterly futures contracts for six rolling years and a pre-delivery option for EUA net sellers to fulfill collateral requirements
Exchange traded funds (ETFs)	
KraneShares Global Carbon ETF (KRBN)	Benchmarked to IHS Markit's Global Carbon Index, which offers broad coverage of cap-and-trade carbon allowances by tracking the most traded carbon credit futures contracts; currently, the index covers the EUA, CCA, and RGGI
KraneShares European Carbon Allowance Strategy ETF (KEUA)	Benchmarked to IHS Markit's Carbon EUA Index, which tracks the most traded EUA futures contracts
KraneShares California Carbon Allowance Strategy ETF (KCCA)	Benchmarked to IHS Markit's Carbon CCA Index, which tracks the most traded CCA futures contracts

Source: Credit Suisse estimates

Carbon as a new investment asset class

Clear steps forward on global climate actions combined with improvements in market size, accessibility, and liquidity are creating an environment that we believe is ripe for the emergence of big carbon markets. This is concurrent with growing interest from the investment community to not only properly price carbon risks in their investment portfolios but also enhance their risk-adjusted returns. In a scenario of a delayed and disorderly transition, direct investments in carbon allowances could offer downside protection, as carbon prices would need to rise to compensate for the lack of policy actions. In the short term, carbon allowances could also be viewed as an inflation hedge, as higher demand for fossil fuels results in higher carbon emissions, which in turn leads to more demand and higher prices for carbon credits.

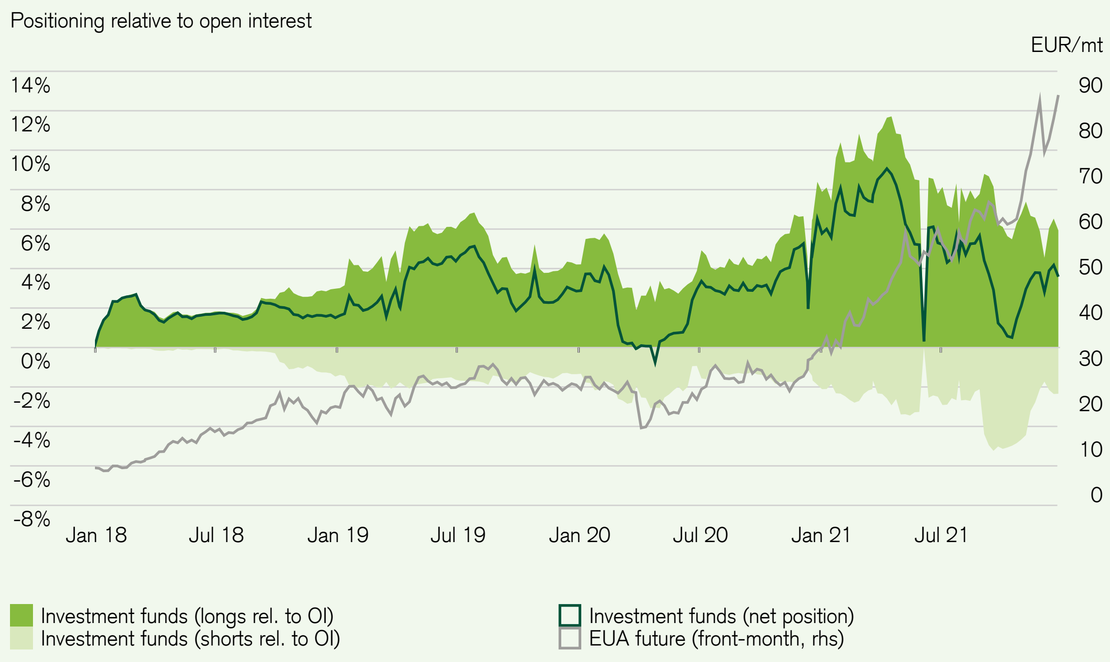
A joint paper from GIC, the Singapore Economic Development Board (EDB), and McKinsey estimated that direct carbon investments of approximately 0.5-1.0% could neutralize the negative impact of climate risks on the returns of a 60/40 reference portfolio. Moreover, a 5% allocation could enhance annualized returns by 50-70 basis points over 30 years (versus the expected return for a regular reference portfolio of approximately 4%) under climate transition scenarios. With sustainability now a priority for the over $ 100 trillion asset management industry, even a small allocation could result in substantial demand relative to the size of carbon markets today.

Carbon already garnered growing interest from investors in 2021, attracting direct (carbon credits and derivatives) and indirect (exchange-traded funds) investments. According to BNEF, the group of net position holders that are not under EU directive increased to 874 holders in June 2021, more than double that of June 2020. Similarly, the percentage of open interest held by investment funds (most indicative of non-compliance-related activities) also grew in 2021 vs. 2020.

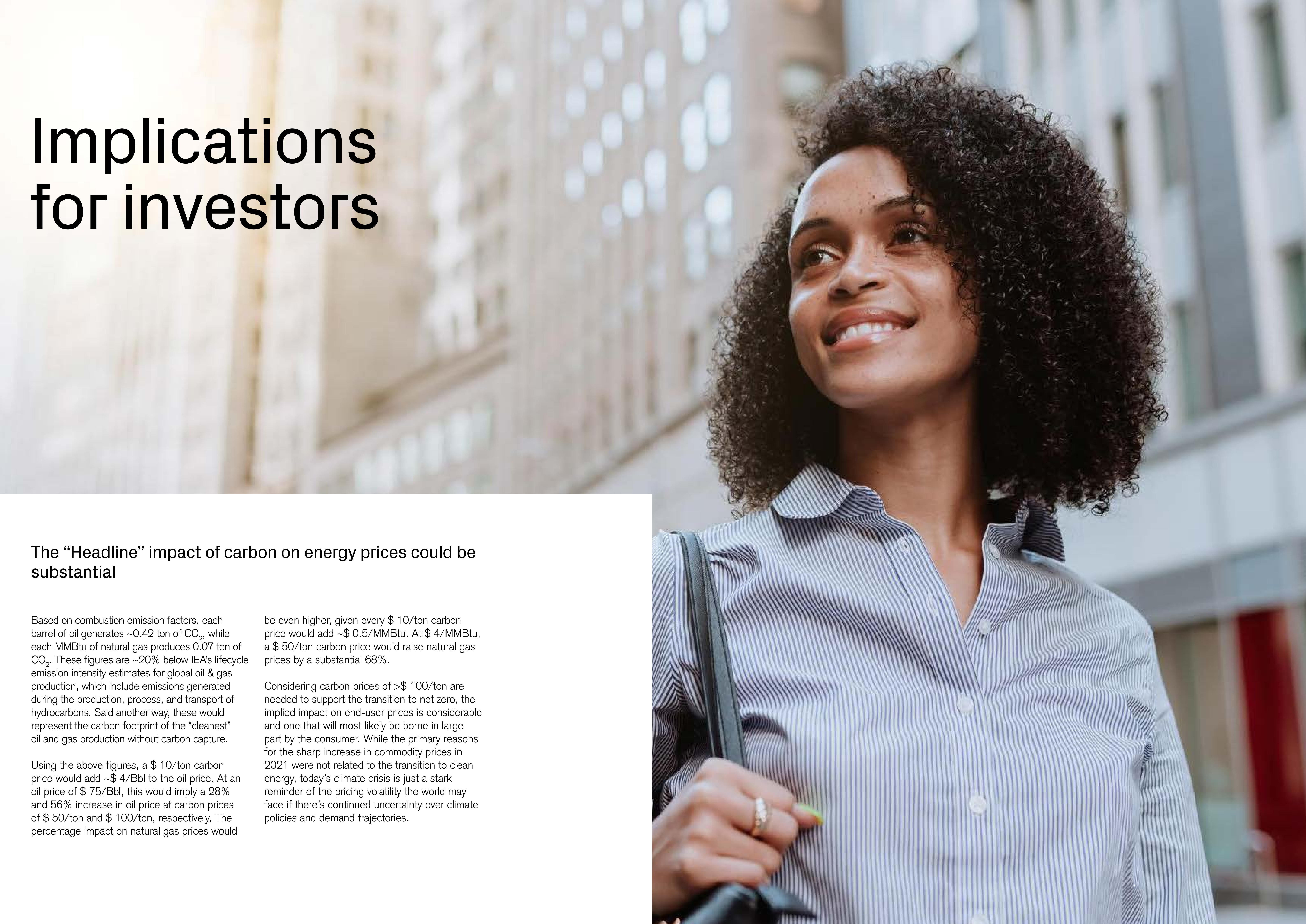
With the surge in carbon prices, there is also growing discourse around whether increasing speculative activity may be undermining the functioning of emissions markets, so much so that the EU commissioned the European Securities and Markets Authority (ESMA) to do a study to assess the impact of trading and derivatives on the carbon market. The preliminary analysis did not find any disruptive effect on the market. In fact, the increase in financial entities are largely proportionate to the overall expansion of the EU ETS and noted that the positions held by investment funds as open interest are still quite small.

This is consistent with our findings. As shown in Figure 21, the rise in carbon prices in late 2021 actually coincided with a drop in the investment fund's net exposure in the market, underscoring that it is not trading but market supply/demand fundamentals that are driving the price action.

Figure 22: EU ETS Carbon Allowance Investor Positioning



Source: Company data, Credit Suisse estimates



Implications for investors

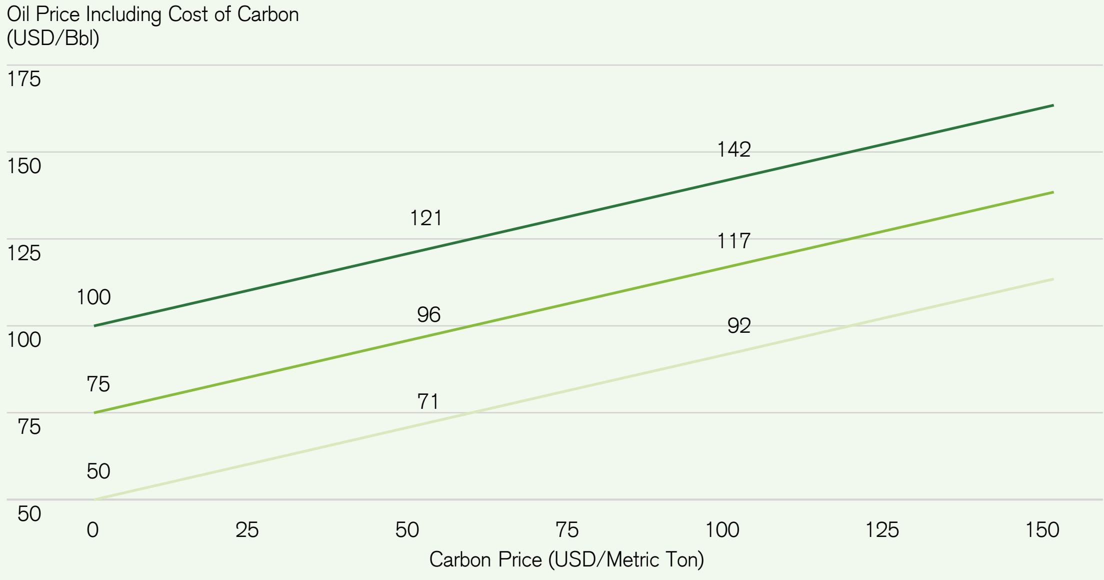
The "Headline" impact of carbon on energy prices could be substantial

Based on combustion emission factors, each barrel of oil generates ~0.42 ton of CO_2, while each MMBtu of natural gas produces 0.07 ton of CO_2. These figures are ~20% below IEA's lifecycle emission intensity estimates for global oil & gas production, which include emissions generated during the production, process, and transport of hydrocarbons. Said another way, these would represent the carbon footprint of the "cleanest" oil and gas production without carbon capture.

Using the above figures, a $ 10/ton carbon price would add ~$ 4/Bbl to the oil price. At an oil price of $ 75/Bbl, this would imply a 28% and 56% increase in oil price at carbon prices of $ 50/ton and $ 100/ton, respectively. The percentage impact on natural gas prices would be even higher, given every $ 10/ton carbon price would add ~$ 0.5/MMBtu. At $ 4/MMBtu, a $ 50/ton carbon price would raise natural gas prices by a substantial 68%.

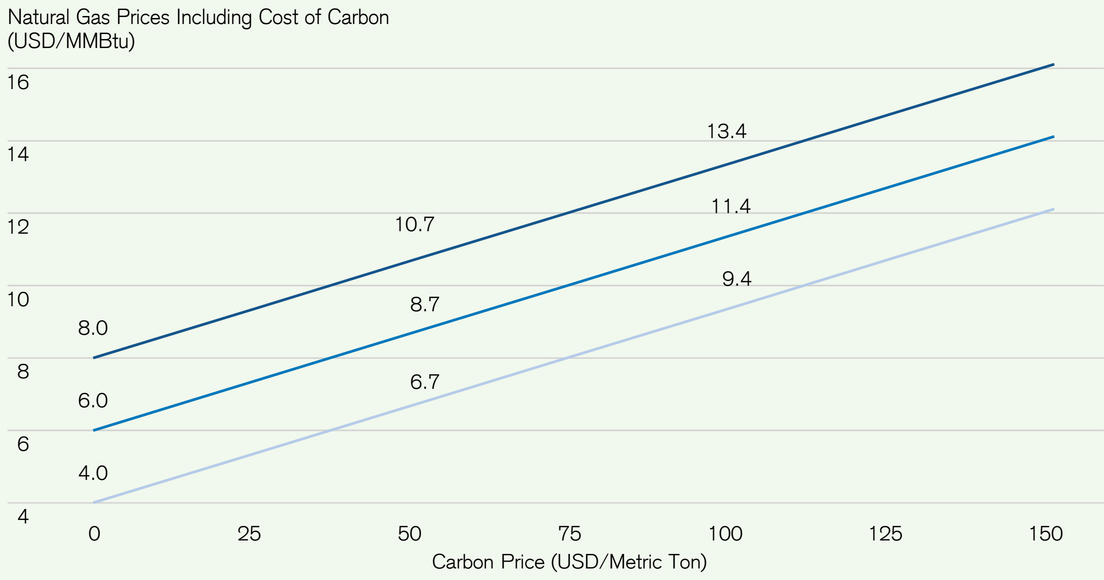
Considering carbon prices of >$ 100/ton are needed to support the transition to net zero, the implied impact on end-user prices is considerable and one that will most likely be borne in large part by the consumer. While the primary reasons for the sharp increase in commodity prices in 2021 were not related to the transition to clean energy, today's climate crisis is just a stark reminder of the pricing volatility the world may face if there's continued uncertainty over climate policies and demand trajectories.

Figure 23: Carbon-Adjusted Oil Prices at Various Carbon Price Levels

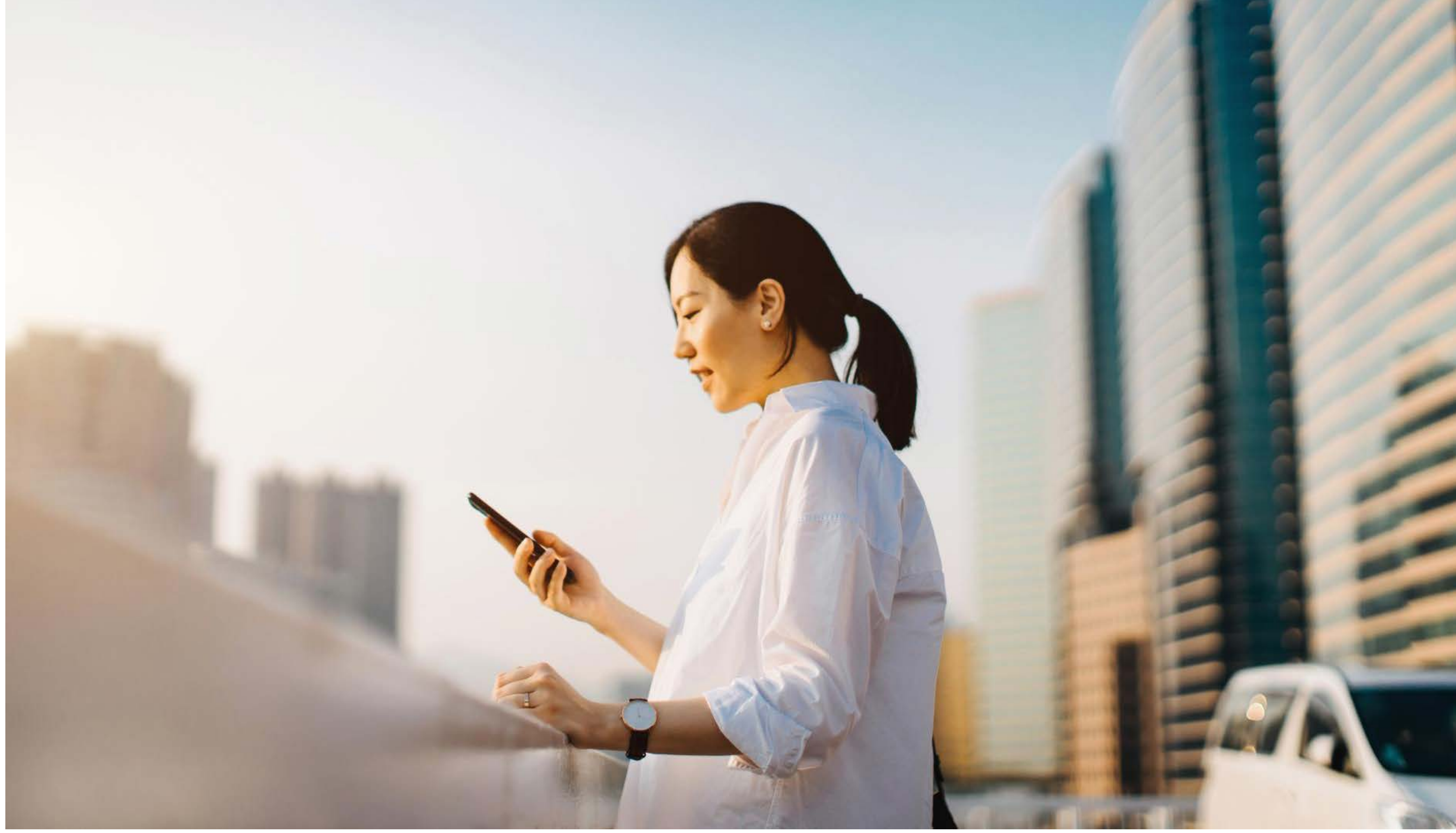


Source: IEA, Credit Suisse

Figure 24: Carbon-Adjusted Natural Gas Prices at Various Carbon Price Levels



Source: IEA, Credit Suisse

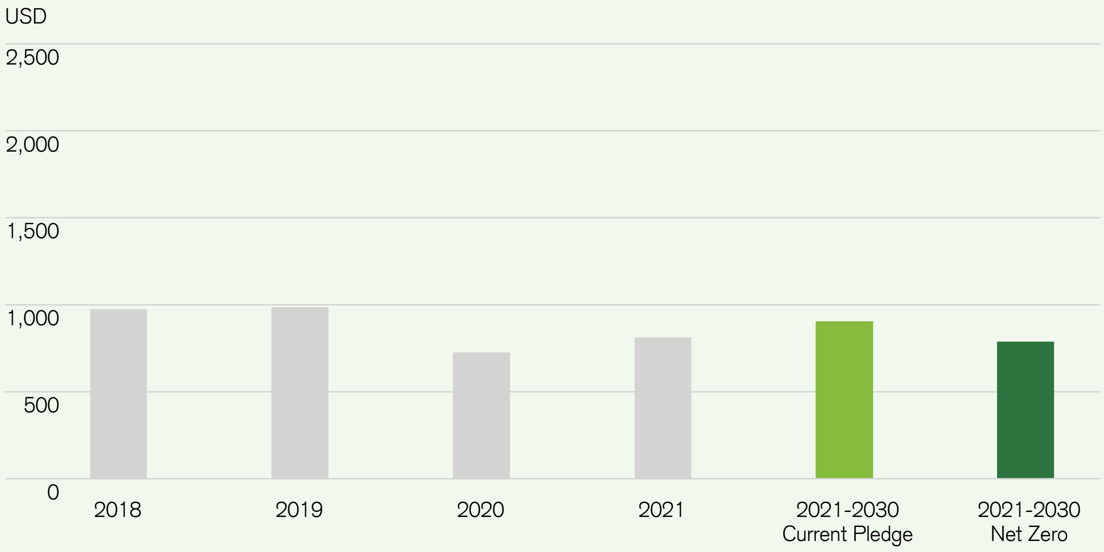


High carbon and high fossil fuel prices during the early phase of the transition

In the long run, higher fossil fuel prices (whether or not they are driven by carbon prices) should move demand away from carbon-intensive products to "greener" consumption. However, such demand changes take time. In the meantime, market uncertainty – driven by a lack of clarity around government policies and demand trajectory – is causing a structural underinvestment in traditional energy supply. The rise of ESG and sustainable investing is further dis-incentivizing growth (as producers had done in past cycles). In fact, the Credit Suisse energy team is expecting the US upstream producers to have a <50% reinvestment rate in the next several years, some of the lowest levels in decades.

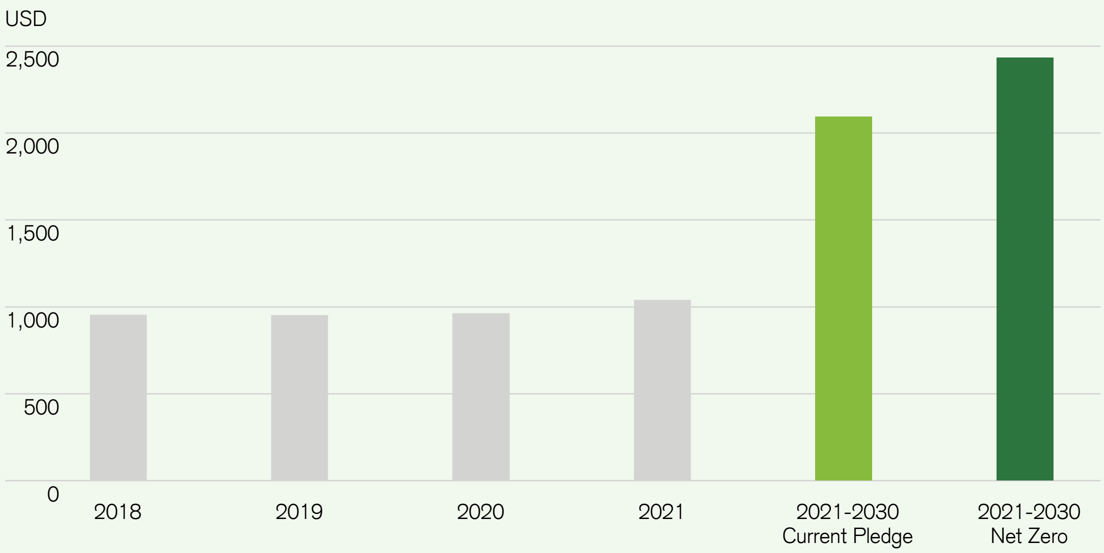
The IEA has also warned that there is a strong risk the energy transition could prompt increased price volatility in the years ahead if economies do not move faster one way or the other. On one side, the amount being spent on fossil fuels is geared toward a world of stagnant or falling demand for these fuels. (See Figure 24.) Oil and gas spend is one of the very few areas that is reasonably well aligned with the net-zero emission scenario. On the other hand, clean energy and infrastructure spending remains far short of what is required to meet rising energy demand (See Figure 25.) If the future is to be powered by clean energy, then it needs to happen quickly or global energy markets will likely face a volatile period ahead.

Figure 25: Annual Investments in Fossil Fuel Supply ($ Billion)



Source: IEA, Credit Suisse

Figure 26: Annual Investments in Clean Energy, Energy Efficiency, and Infrastructure ($ Billion)



Source: IEA, Credit Suisse

Risk of “Greenflation” is to the upside

The Credit Suisse economics team has discussed the topic of “greenflation” in depth in its 2022 economic outlook and in the report, The cost of carbon pricing after COP26. The team estimates each $ 10/ton increase in the price of carbon emissions (across the entire economy) would lower global GDP by 0.4% and add close to 0.5 percentage points to global inflation. However, we believe the timing and context in which higher carbon prices are implemented will matter immensely to the actual economic performance.

While we expect the longer-term impact on inflation to be muted (in part due to the disinflationary effect of lower renewable costs), we believe the “greenflation” risk is to the upside over the next three to five years. This is due to a combination of higher carbon prices driving up relative prices of carbon-intensive products and underinvestment in both traditional and clean energy supplies causing energy costs to spike. This is in addition to the team’s expectations of structurally tighter labor markets and more expansive fiscal policy over the coming years.

The ultimate impact will depend on politics: how aggressively climate action is enforced, how much of the impact on households is mitigated, and how the accompanying macroeconomic policy stance evolves. We believe all of this adds greater uncertainty and volatility in the years ahead.

Carbon price shock will first affect energy consumers

Carbon prices ultimately raise the cost of doing business, as it puts a price on something that is essentially free currently. Firms that are less able to pass on higher costs to consumers will be most affected in the short term, and those that see demand erosion as a result of higher costs will be most affected over the long run. With the convergence of global carbon markets and acceleration of climate policy actions, we believe carbon pricing will no longer just apply to companies exposed to mandatory carbon compliance regimes. Instead, we believe all companies will need to be evaluated based on their carbon competitiveness. Minimizing a portfolio’s carbon intensity over time will be essential to optimizing investments’ risk-adjusted return.

To manage such risks, it is important to assess the (1) carbon intensity of companies, (2) ability to pass through higher cost and demand elasticity, and (3) trajectory of emissions in the future. The latter two require an understanding of the business model and pricing dynamics as well as more granular analysis of a company’s capital allocation and strategic planning.

In Figure 26, we show the index-weighted carbon intensity of S&P 500 sectors, defined as a security’s scope 1 and 2 tons of greenhouse gas emissions normalized by dollar sales generated. It is notable that the utilities sector has by far the highest exposure to carbon with a 2.5% weighting, accounting for 43% of the overall index’s emissions. This is not surprising given that power generation is the largest fossil fuel-consuming sector.

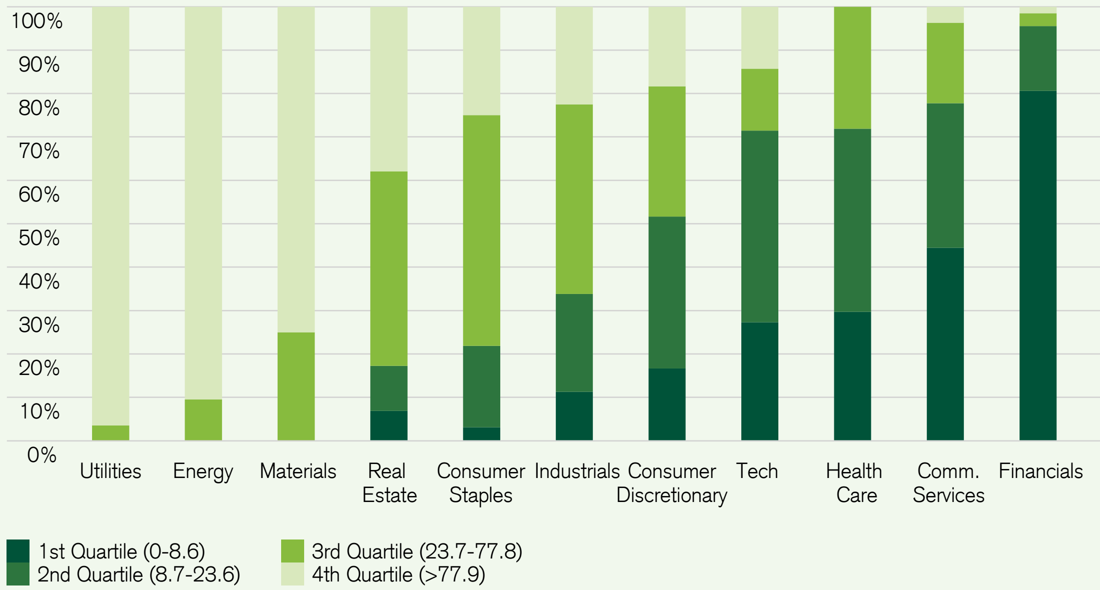
However, what is interesting is that the most carbon-intensive companies (defined as 4th quartile in Figure 28) are not just limited to the obvious sectors such as utilities, energy, and materials but exist in all sectors with the exception of health care. This indicates that no generalization can be made on the carbon exposure of businesses, which makes it even more important for investors to differentiate companies based on their carbon competitiveness.

Figure 27: Index-Weighted Average Carbon Intensity* by Industry for S&P 500, S&P 500 Growth, and Value Indices**

	S&P 500			S&P 500 Value			S&P 500 Growth		
S&P Sectors	**Portfolio Market Cap Weighting**	**Wtd Avg Carbon Intensity**	**Portfolio Carbon Weighting**	**Portfolio Market Cap Weighting**	**Wtd Avg Carbon Intensity**	**Portfolio Carbon Weighting**	**Portfolio Market Cap Weighting**	**Wtd Avg Carbon Intensity**	**Portfolio Carbon Weighting**
Utilities	2.5%	59.6	43.0%	5.1%	119.8	49.6%	0.1%	1.7	4.2%
Materials	2.5%	18.5	13.4%	3.9%	26.7	11.0%	1.2%	10.6	26.9%
Energy	3.4%	21.5	15.5%	6.0%	39.0	16.1%	0.8%	4.7	11.9%
Industrials	7.8%	11.5	8.3%	12.6%	17.7	7.3%	3.2%	5.5	13.8%
Information Technology	28.7%	5.6	4.0%	12.1%	4.6	1.9%	44.6%	6.6	16.6%
Consumer Discretionary	12.0%	8.1	5.8%	7.3%	10.7	4.4%	16.4%	5.6	14.3%
Financials	11.3%	4.7	3.4%	15.9%	9.1	3.8%	6.8%	0.3	0.8%
Consumer Staples	6.1%	3.2	2.3%	10.9%	6.0	2.5%	1.5%	0.6	1.4%
Real Estate	2.7%	2.7	1.9%	3.3%	4.1	1.7%	2.1%	1.4	3.5%
Health Care	13.1%	2.1	1.5%	15.9%	2.2	0.9%	10.3%	2.0	5.1%
Communication Services	10.0%	1.0	0.7%	6.9%	1.7	0.7%	13.0%	0.6	1.6%
Total	**100%**	**138.5**	**100%**	**100%**	**241.5**	**100%**	**100%**	**39.5**	**100%**

*Carbon intensity defined as tCO_2e/$ million sales in 2020
**index composition using SPY, IVW, IVE ETFs as proxy
Source: MSCI, the BLOOMBERG PROFESSIONAL™ service, Credit Suisse

Figure 28: Breakdown of Companies in Each Industry in 1st (lowest intensity) Through 4th (highest intensity) Carbon Quartiles (in Ton/$ Million Sales)



Source: MSCI, Credit Suisse

Industries that benefit from higher carbon prices

Higher carbon prices will serve to accelerate all decarbonization efforts from avoidance to mitigation to absolute removal. In our report Decarbonising themes and stocks, we provided key summaries for a range of themes exposed to the topic. The dominant growth areas are as follows:

- **Renewables #1 Beneficiary:** We expect secular demand growth for both solar and wind energy, which are the most scalable and cheapest forms of renewable/clean energy generation. However, to scale renewable power significantly, energy storage and transmission infrastructure are also critical growth drivers. Energy storage is currently dominated by lithium-ion batteries, though we do see opportunities for other chemistries (e.g., hydrogen, flow batteries, etc.). On transmission and distribution components/technologies, a clear beneficiary of this theme is high-voltage direct current (HVDC) transmission systems, which are the most cost-effective and -efficient solution for long distance power transmission. Cable providers as well as high- and low- to medium-voltage power equipment providers should see rising demand.
- **Hydrogen:** Hydrogen can be used as heating energy in industrial processes, such as the production of steel, cement, and chemicals. It is an industry feedstock for fertilizer and refining, as well as a storage option to balance seasonal variations in electricity demand and generation from renewables. The green hydrogen market is relatively undeveloped and not yet fully commercial, as production costs need to reach levels that make it competitive with grey hydrogen and fossil fuel technology. However, at higher carbon prices (Credit Suisse estimates ~$ 85/ton), blue hydrogen could reach price parity with grey hydrogen, enabling the acceleration of blue hydrogen growth.
- **Carbon Capture:** CCS is needed to decarbonize hard-to-abate sectors, such as steel, cement, and fertilizer production. The Global CCS institute estimates that more than 2,000 CCS facilities will be needed by 2040 (vs. ~50 in operation or development today) to achieve capture levels required under the IEA's Sustainable Development Scenario (SDS) case. However, the economic returns of CCS can be challenged without higher carbon prices. Our analysts estimate that carbon prices of $ 50-100 per ton are needed to generate a 12-20% IRR for a carbon capture project with a medium concentration source (60% CO_2).
- **Nature-Based Solutions (NbS):** Higher carbon prices, particularly in the carbon offset market would incentivize NbS investments. The UN estimates that NbS investments will have to triple by 2030 and increase fourfold by 2050 if the world is to keep warming to <2.0°C, mostly in re/afforestation, given the massive global footprint of forests, and silvopasture (planting trees on agricultural land).
- **Energy Efficiency:** Solutions here focus on buildings (the building envelope, heating technologies, heat pumps, cooling products, lighting, appliances and equipment, and data centers and data-transmission networks), transport (electric vehicles mainly, but also sustainable fuel for airlines and shipping), and industry (improving energy efficiency using digitization and automation).
- **Circular Economy:** Extending the lifespan of a (perishable) product and moving toward a reuse-or-recycle approach to consumption are key for a circular economy and require new products. Higher carbon prices, in particular through CBAM, would accelerate circular economy in steel production. Our Steel global sector team estimates that additional steel scrap volumes available until 2030 should be sufficient to produce c190m t/y of steel through the less carbon-intensive electric arc furnace (EAF) process – about 10% of global steel production. CBAM accelerates the growth in EAF penetration, especially in China, but at the cost of virgin iron ore and coking coal demand.
- **Coal-to-Gas Switching in APAC:** Given the sheer scale of coal as a form of electrical power or industrial heat (e.g., steel and cement), we see gas as a beneficiary in the initial phase of decarbonization that CBAM accelerates. This should benefit US gas producers, as the US is on track to become the largest supplier of liquefied natural gas (LNG) globally, growing from 18% of the market today to over 30% by 2030, per CS estimates.

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