Carbon-Pricing Instruments

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Policy Analysts Favor Carbon-Pricing. What is it?

- **Two major forms: Carbon Tax & Emissions Trading**

- **Carbon Tax (levy)**
  - Tax on carbon content of fossil fuels, not on CO_2 emissions *per se*
  - Revenue can be used for variety of purposes, including reducing distortionary taxes, compensating burdened parties, funding R&D
  - Compliance cost is certain, but quantity of resulting emissions is uncertain

- **Carbon Emissions Trading System (Cap-and-Trade)**
  - Allocate allowances for carbon content of fossil fuels, not emissions
  - Allocation can be via free distribution or by auction
    - Auction revenue can be used for same purposes as above
  - Allow trading: supply & demand for allowances generates a price
  - Quantity of resulting emissions is set, but compliance cost is uncertain

Policy Analysts Favor Carbon-Pricing. Why?

1. **No other feasible approach can provide meaningful emissions reductions**
2. **Least costly approach in short term (heterogeneous abatement costs)**
3. **Least costly approach in long term: incentive for carbon-friendly technological change -- innovation (& diffusion)**

- **Note: carbon pricing may be *necessary*, but is *not sufficient*. Why?**
  - Other market failures: *principal-agent* problem (e.g. energy-efficiency investments in renter-occupied buildings)
  - … And *public-good* nature of information spillovers (e.g., Apple & Blackberry)

What Might a National Carbon Tax Look Like?

- **Upstream tax on carbon-content of the three fossil fuels – coal, natural gas, & petroleum**
  - CO_2 emissions roughly proportional to carbon content (contrast with SO_2)
  - Combine with tax credit for CCS

- **Example: Tax of $100/ton of CO_2 (~ $360/ton of C)**
  - Increase cost of coal-fired electricity generation by ~ 400%
  - Increase cost of natural gas-fired electricity generation by ~ 100%
  - Increase gasoline prices by ~ $1.00 per gallon

- **Overall cost depends – in part – on use of revenues (cutting distortionary taxes)**

What Would National Cap-and-Trade Look Like?

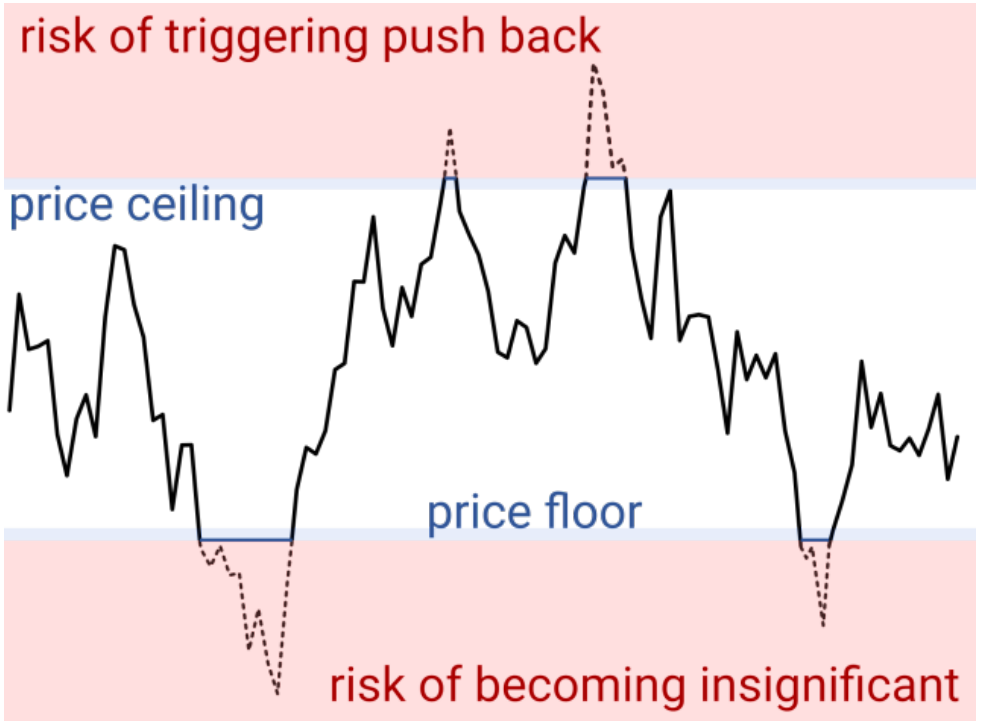
- **Upstream regulation on carbon-content of three fossil fuels**
  - CO_2 emissions roughly proportional to carbon content (contrast with SO_2)
  - Combine with credit for CCS
  - Similar to upstream approach used for leaded-gasoline phasedown in 1980s

- **Allocation is a separate decision from point of regulation**
  - Freely allocate ("grandfather")
  - Auction
  - Combination

- **Overall cost depends – in part – on use of any auction revenue**

National Hybrid Instrument

- **Combination of price & quantity instruments**
- **Cap-and-trade system**
  - And government promises to sell additional allowances at stated price (expands cap),
  - and government sets a minimum price in auctions
    - Creates price (abatement-cost) ceiling and price floor: "price collar"
    - Reduces cost uncertainty
    - As collar narrows, cap-and-trade system becomes a tax



Basic Consequences of Carbon Pricing for Fossil Fuels

- **Coal**
  - **Greatest impacts globally due to high carbon content (electricity generation)**
    - Immediate impacts on electricity dispatch
    - Long-term impacts on investment in new capacity
    - Long-term impacts on retirement of existing capacity
- **Natural Gas**
  - **Smaller impacts, because of lower carbon content**
  - **And demand increase – in short term – due to substitution for coal (in USA)**
    - But likely effects of anticipated carbon pricing small *compared with* effects of increased supplies due to horizontal drilling & hydraulic fracturing
- **Oil**
  - **Potentially significant impacts muted in the very short term …**
    - Limited substitutes for liquid fuels in transportation sector means relatively *high* marginal CO_2 abatement *costs*; so a *cost-effective* portfolio would *not* target oil
  - **But increasing penetration of EVs, growth of biofuels (ag waste, used cooking oil), and greater fuel efficiency → petrol demand may decline post-2026**
    - Effect muted by growing demand for aviation fuel and for petrochemicals

Economic Impacts will Vary Across *& Within* Sectors

- **Fuels & Energy Generation**
  - Bad news for coal (*ceteris paribus*), even in short term; mixed for natural gas, possibly muted for oil
  - Good news for renewables, and possibly for nuclear (again, *ceteris paribus*)

- **In other sectors, climate policies increase energy costs, so simple rule-of-thumb:**
  - *Bad news* for sectors that use energy (i.e., *all sectors*), but …
  - *Can be good news* for producers of energy-consuming durable goods (Boeing, Airbus)
  - *Particularly bad news* for some consumers of those same energy-consuming durable goods (United Airlines, Lufthansa, etc.)

Many Examples of Carbon-Pricing Systems

- **Many** examples of carbon price programs
- **Don't** bother trying to read table (from Stavins 2020)

Table 1
Implemented and Scheduled Carbon-Pricing Initiatives, 1990–2020

Initiative	Type	Status	Type of Jurisdiction	Jurisdiction	Year	GHG Emissions ($MtCO_2e$)
Alberta Carbon Competitiveness Incentive Regulation	Trading	Implemented	Subnational	Alberta	2007	120
Alberta Carbon Tax (repealed, May 2019)	Tax	Implemented	Subnational	Alberta	2017	109
Argentina Carbon Tax	Tax	Scheduled	National	Argentina	2019	79
Australia Emissions Reduction Fund Safeguard Mechanism	Trading	Implemented	National	Australia	2016	381
BC Greenhouse Gas Industrial Reporting and Control Act	Trading	Implemented	Subnational	BC	2016	0
BC Carbon Tax	Tax	Implemented	Subnational	BC	2008	42
Beijing ETS	Trading	Implemented	Subnational	Beijing	2013	85
California AB-32/AB-398 Cap-and-Trade System	Trading	Implemented	Subnational	California	2012	378
Canada Federal Output-Based Pricing System	Trading	Scheduled	National	Canada	2019	?
Canada Federal Carbon Tax	Tax	Scheduled	National	Canada	2019	?
Chile Carbon Tax	Tax	Implemented	National	Chile	2017	47
China National ETS	Trading	Scheduled	National	China	2020	3,232
Chongqing ETS	Trading	Implemented	Subnational	Chongqing	2014	97
Colombia Carbon Tax	Tax	Implemented	National	Colombia	2017	42
Denmark Carbon Tax	Tax	Implemented	National	Denmark	1992	22
European Union ETS	Trading	Implemented	Regional	European Union plus Nor., Ice., and Lich.	2005	2,132
Estonia Carbon Tax	Tax	Implemented	National	Estonia	2000	1
Finland Carbon Tax	Tax	Implemented	National	Finland	1990	25
France Carbon Tax	Tax	Implemented	National	France	2014	176
Fujian ETS	Trading	Implemented	Subnational	Fujian	2016	200
Guangdong ETS	Trading	Implemented	Subnational	Guangdong	2013	366
Hubei ETS	Trading	Implemented	Subnational	Hubei	2014	162
Ireland Carbon Tax	Tax	Implemented	National	Ireland	2010	31
Japan Carbon Tax	Tax	Implemented	National	Japan	2012	999
Kazakhstan ETS	Trading	Implemented	National	Kazakhstan	2013	183
Korea ETS	Trading	Implemented	National	Korea	2015	453
Latvia Carbon Tax	Tax	Implemented	National	Latvia	2004	2
Liechtenstein Carbon Tax	Tax	Implemented	National	Liechtenstein	2008	0
Massachusetts Cap-and-Trade System	Trading	Implemented	Subnational	RGGI States	2018	10
Mexico Carbon Tax	Tax	Implemented	National	Mexico	2014	307
New Zealand ETS	Trading	Implemented	National	New Zealand	2008	40
Norway Carbon Tax	Tax	Implemented	National	Norway	1991	40
Poland Carbon Tax	Tax	Implemented	National	Poland	1990	16
Portugal Carbon Tax	Tax	Implemented	National	Portugal	2015	21
Quebec Cap-and-Trade System	Trading	Implemented	Subnational	Quebec	2013	67
Regional Greenhouse Gas Initiative	Trading	Implemented	Subnational	RGGI States	2009	94
Saitama ETS	Trading	Implemented	Subnational	Saitama	2011	7
Shanghai ETS	Trading	Implemented	Subnational	Shanghai	2013	170
Shenzhen ETS	Trading	Implemented	Subnational	Shenzhen	2013	61
Singapore Carbon Tax	Tax	Scheduled	National	Singapore	2019	42
Slovenia Carbon Tax	Tax	Implemented	National	Slovenia	1996	5
South Africa Carbon Tax	Tax	Scheduled	National	South Africa	2019	360
Spain Carbon Tax	Tax	Implemented	National	Spain	2014	9
Sweden Carbon Tax	Tax	Implemented	National	Sweden	1991	26
Switzerland ETS	Trading	Implemented	National	Switzerland	2008	6
Switzerland Carbon Tax	Tax	Implemented	National	Switzerland	2008	18
Tianjin ETS	Trading	Implemented	Subnational	Tianjin	2013	118
Tokyo Cap-and-Trade System	Trading	Implemented	Subnational	Tokyo	2010	14
UK Carbon Price Floor	Tax	Implemented	National	United Kingdom	2013	136
Ukraine Carbon Tax	Tax	Implemented	National	Ukraine	2011	287
Washington State Clean Air Rule	Trading	Implemented	Subnational	Washington	2017	58

Source: World Bank Group (2018).
Note: GHG = greenhouse gas; $MtCO_2e$ = metric tons of carbon dioxide equivalent; BC = British Columbia; ETS = emissions trading system.

Worldwide Status of Carbon Pricing

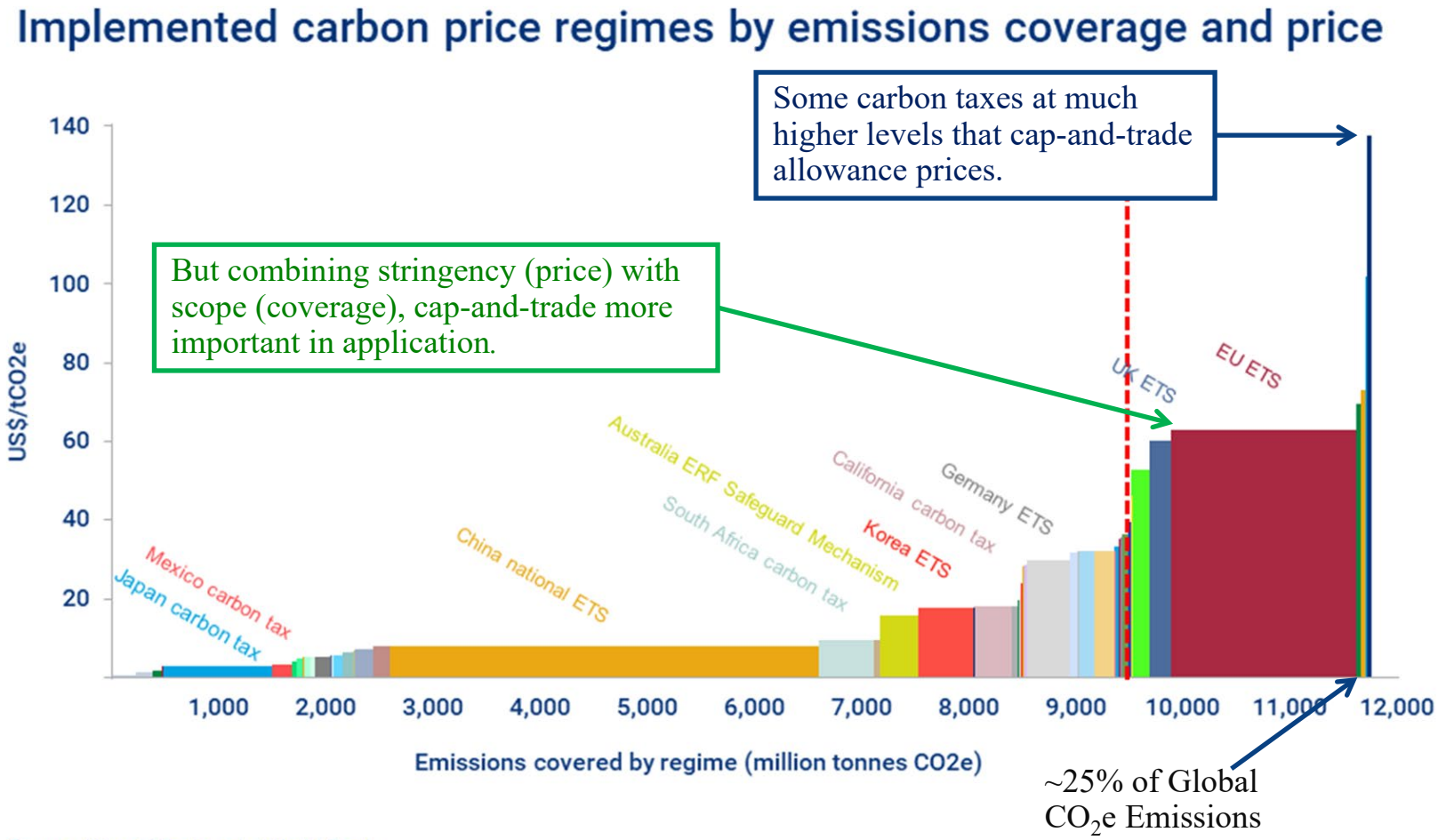
- **Major CO_2 emissions trading regimes in place & announced** (as of July 1, 2024)
  - European Union Emissions Trading System — $68/ton (2008-)
  - Washington State Cap-and-Invest — $56/ton (2022-)
  - New Zealand Emissions Trading Scheme — $41/ton (2008-)
  - California's AB-32/398 GHG Cap-and-Trade System — $38/ton (2013-)
  - Regional Greenhouse Gas Initiative — $21/ton (2009-)
  - South Korea Emissions Trading Scheme — $18/ton (2015-)
  - China's National Carbon Trading Market — $14/ton (2022-)

- **Selected carbon (and related energy) taxes** (no prices given, because many not CO_2 taxes but energy taxes, and exemptions very common)
  - Finland (1990), Norway (1990), Sweden (1991), Denmark (1992), Costa Rica (1997), British Columbia (2008), Switzerland (2008), Ireland (2010), Iceland (2010), Japan (2012), Mexico (2012), United Kingdom (2013), Chile (2014), France (2014), South Africa (2016)

- **Other jurisdictions will *not* employ carbon pricing, but will use *performance standards* and/or *technology standards* instead**
  - Less cost-effective than carbon pricing
  - Muted/distorted price signals
  - Still, in some cases will place an implicit shadow-price on carbon

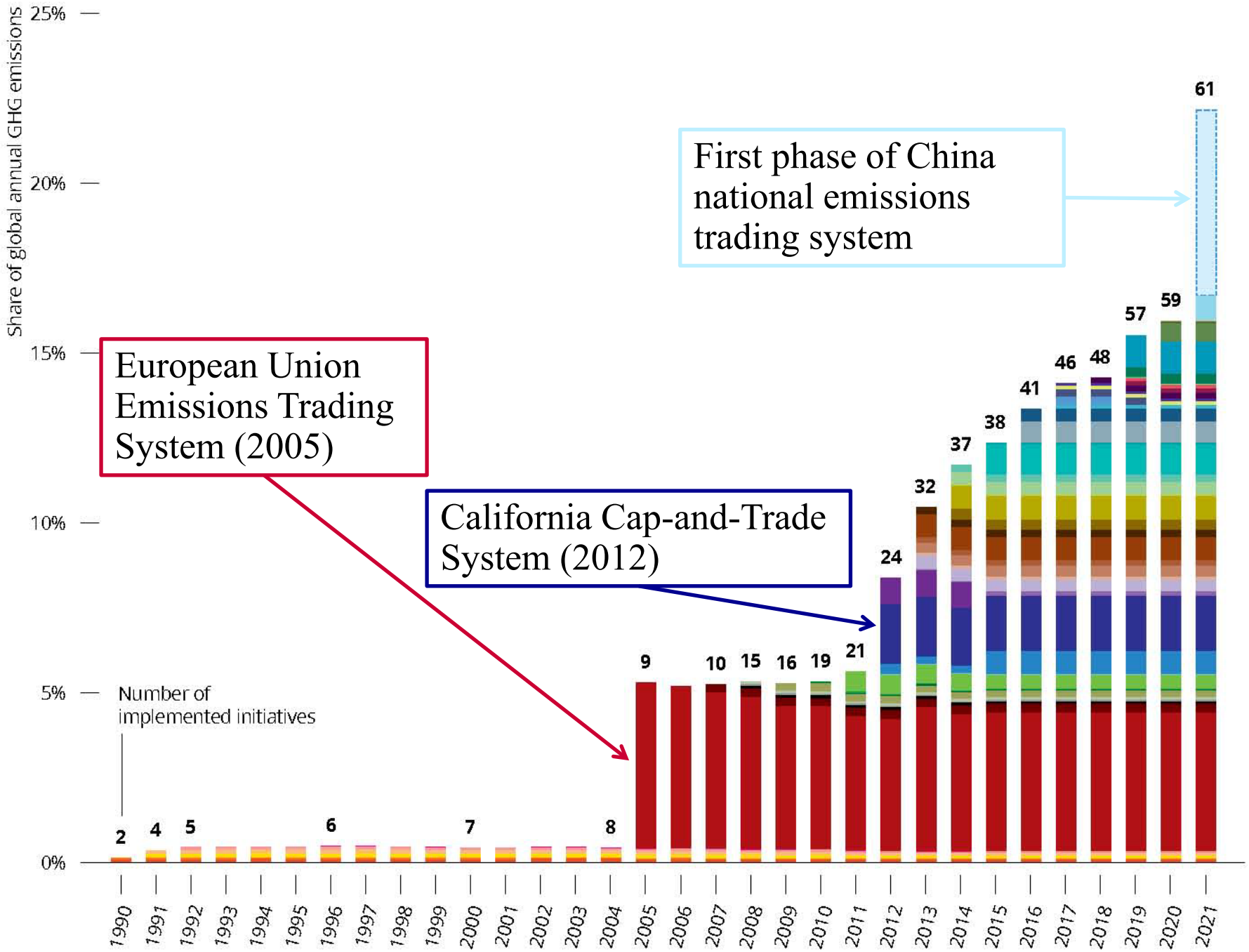
Carbon Prices and Emissions Coverage of Implemented Policies

Of 70+ carbon-pricing systems in place, about half are carbon taxes and half trading



Source: Wood Mackenzie, World Bank

Carbon Pricing Implemented Worldwide, 1990-2021



Source: World Bank, State and Trends in Carbon Pricing [content (worldbank.org)]

Comparing Carbon Taxes & Carbon Cap-and-Trade

- **Major Premises**
  - In large economies, carbon-pricing will likely be an essential *part* of any *meaningful long term* climate change policy
  - Less agreement regarding choice of specific carbon-pricing policy instrument: carbon tax or emissions trading (cap-and-trade)

- **Key Question** (among others)
  - Which approach will be *superior* in terms of relevant criteria, including but not limited to cost-effectiveness, efficiency, and distributional equity?

  - Stavins, Robert N. “"The Relative Merits of Carbon Pricing Instruments: Taxes versus Trading".” Review of Environmental Economics and Policy 16, no. 1 (2022): 1-21.

- **One Major Conclusion** (among others)
  - *Specific design* of carbon taxes and cap-and-trade will be *more consequential* than the *choice* between the two instruments.

Comparing Carbon Taxes & Cap-and-Trade: Similarities & Symmetries

- Of 14 examined attributes, some appear at first to be key differences, but differences *fade* on closer inspection (and *depend* on specifics of design)
- **Perfectly Equivalent in regard to:**
  - *Incentives for emission reduction* – both can be upstream on carbon content of fuels
  - *Aggregate abatement costs* – both are c/e, same incentives for tech change, offsets
  - *Effects on competitiveness* – both can lessen impacts via border adjustments
- **Nearly Equivalent**
  - *Possibilities for raising revenue* – cap-and-trade (CAT) can auction, but given Congressional committee structure, revenue recycling more difficult w/CAT
- **Similar**
  - *Costs to regulated firms* – CAT can freely allocate allowances, but tax can provide inframarginal exemptions below specified level of emissions
  - *Distributional impacts* – can be designed to be roughly equivalent

Comparing Carbon Taxes & Cap-and-Trade: Differences & Distinctions

- **Some Distinctions:**
  - *Transaction costs* – volume discounts on transaction costs can violate *independence property* (Stavins 1995)
- **Subtle Differences**
  - *Performance in presence of uncertainty* – Weitzman rule (1974), *stock* externality (Newell & Pizer 2003), but *persistent effects* of technology shocks (Karp & Traeger 2018) leads to *positive correlation* between benefits & costs (Stavins 1996)
  - *Linkage with other jurisdictions* – easier w/CATs, but taxes can also be linked
- **Significant Differences**
  - *Carbon-price volatility* – problem only for CAT, but price collars & banking
  - *Interactions w/complementary policies* – issue w/CAT; tax eliminates "waterbed"
  - *Market manipulation* – need regulatory oversight for this, and for tax evasion
  - *Complexity and administrative requirements* – CAT more complex, but will a simple tax remain simple as it works its way through legislature?

Hybrid Policy Instruments and a Policy Continuum

- Many remaining differences *diminish with implementation*
- *Hybrid* ***policies*** that mix features of tax and cap-and-trade *blur distinctions*
- **Result:** ***Dichotomous choice between carbon tax and cap-and-trade can become a choice of design elements along a policy continuum***
- Design of instruments can be *more consequential* than choice between the two
- Note that track record of ***70***+ carbon-pricing policies worldwide contrasts with ***176***+ countries with renewable energy policies or energy efficiency standards, ..
  - … and another ***110*** national and sub-national jurisdictions with feed-in tariffs.

Can Carbon-Pricing Be Made More Politically Acceptable?

- **One promising approach could be through *judicious policy design* (which may *depart* from first-best design):**
  - *Phase in* taxes/caps over time (rather than dynamically efficient time path)
  - *Earmark revenues* from tax/auction to finance additional climate mitigation (in contrast to optimizing system via cuts in distortionary taxes)
  - *Use revenues for fairness* purposes, such as with lump-sum rebates or rebates targeted to low-income and other particularly burdened constituencies (tax with "carbon dividends" or "cap-and-dividend")
- **Another approach is *better design* of second-best *non-pricing* instruments.**
- **But – for the longer term – *ongoing research* on carbon-pricing itself is very much warranted,**
  - particularly if it can be carried out in the context of *real-world politics*, and *focuses* on policies that are *likely* at some point to prove politically *feasible*.

What about Subsidies?

- **Carbon-pricing with a tax or trading system may be first-best, but ..**
  - … politicians strongly prefer giving out benefits rather than imposing costs
- **So, what about subsidies?**
  - Why not subsidize the use of renewable energy rather than taxing fossil fuels?
  - Aren't these policy instruments symmetric, in which case a subsidy is first-best (potentially efficient, or at least cost-effective)?
  - No, these instruments are *not* symmetric; and subsidies are *not* first-best policy instruments.
- **But we can still examine subsidies as potentially effective second-best policy instruments …**

Summary on Taxes vs. Subsidies

- **With a *market failure* due to the dirty-generation climate externality …**
- **When *externality is internalized*, *less* fossil fuels *and less* overall electricity are used, given the higher prices**
- **Politically, it is *appealing* to try to achieve this outcome by subsidizing clean energy**
  - But because this subsidizes the market-clearing price for *all electricity* (with no corresponding externality justification), then **overall electricity consumption increases**
  - Also, it's *necessary to raise tax revenue* to pay for the subsidy (DWL)
  - And it can mean a *great deal of revenue*, because not only the marginal units receive the subsidy, but all of the *infra-marginal* ones as well (those who "would have done it anyway" – later w/energy efficiency)

- **What about cap-and-trade? Are there lessons that can be learned from experience?**

Lessons from Design, Implementation & Performance of Cap-and-Trade Policies

Specific Elements of Design

- *Banking* (i.e., saving allowances for use in future compliance period) very important economically – large share of gains from trade [Lead, SO_2]
  - Absence of banking can lead to price spikes & price collapse [RECLAIM, EU ETS]
  - Some programs limit number of allowances that can be banked, and length of time they can be held
  - Banking reduces longer-term stringency, but overall program emissions goals met
  - Borrowing (using future emissions allowances now) has not been allowed
- *Price collars* are valuable
  - Changing economy can render cap non-binding [RGGI, EU ETS] or drive prices to excessive level [RECLAIM]
  - Price collar feasible via auction price floor & allowance reserve [RGGI, AB-32]
- *Constraints on offset use* → thin market → ineffective cost containment [RGGI, AB-32]

Lessons from Design, Implementation & Performance of Seven Cap-and-Trade Policies (continued)

Leakage and Competitiveness

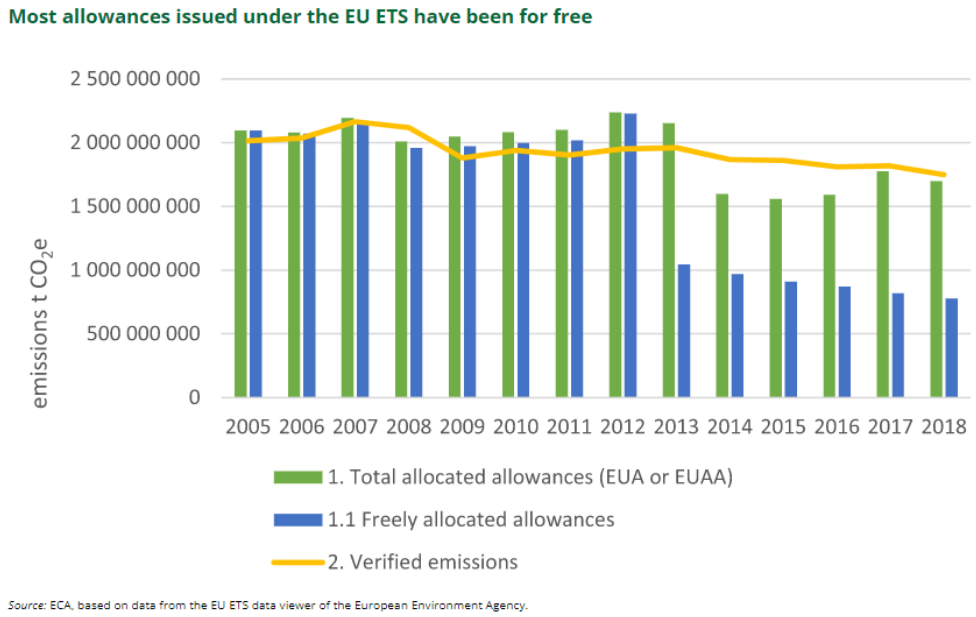
- Shift in comparative advantage to jurisdictions w/lower costs → *leakage*
- *Political concerns* re emissions & economic leakage and related competitiveness impacts
- *Reality* can range from non-existent [Lead] to potentially serious [RGGI]
  - Most likely to be *serious* if limited geographic scope, particularly in power sector due to interconnected electricity markets [RGGI, AB-32]
- Although free allocation *fosters political support,* free allocation *per se* does *not* address leakage/competitiveness (inframarginal) [EU ETS, but changes going forward]
  - But *output-based updating* system makes allocations *marginal* [AB-32]
- But, ultimately, *only way to eliminate* leakage/competitiveness risk is through broader (national & international) coalitions of action

Key Example: European Union Emissions Trading System

- **CO_2 cap-and-trade system across the EU** (world's largest in scope until Chinese system)
- **Downstream system covers electric utilities & large industry (40% of emissions)**
    - Why a downstream system? EU institutional and political factors
    - Later addition of some aviation, but …….. U.S. & China objections
- **Multi-year periods with declining cap**
    - 2005-07 Pilot (Phase 1)
    - 2008-12 Kyoto (Phase 2)
    - 2013-20 Phase 3
    - Post-2020 Phase 4 (-1.74%/year (part of December 2020 commitment to cut emissions by 55% below 1990 level by 2030, and reach net-zero by 2050)
- **Offsets formerly allowed up to 13% of emissions; moving to zero**

Free Allocation Intended to Address Competitiveness

- **Free allocation intended to evolve to full auctioning by 2027**
- **2014 full auction for electricity and begin phase out of free allocation for industrial sources**
- **Free allocation intended to address leakage & competitiveness impacts**
  - Will that work?
  - What else might they try?



Carbon Border Adjustment Mechanism (CBAM)

- **Theory of Carbon Border Adjustment Mechanism:** Compensate at the border for lack of comparable regulation to mitigate competitiveness impacts
- In July 2021, European Commission proposed the **CBAM**, which **places a carbon price on imports for select products**, agreed in December 2022; payments begin in 2026 for 2025 **imports of cement, iron and steel, aluminum, fertilizer, electricity, and hydrogen.**
- **Importers buy carbon certificates (pay tariff) equal to the carbon content they would have paid via EU ETS if manufactured in the EU**

European Commission

EU ETS Performance: Emissions Reductions

Figure 5: Index of verified emissions

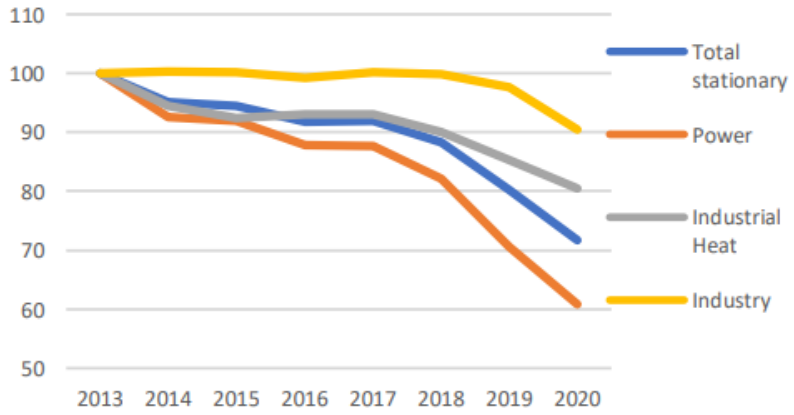
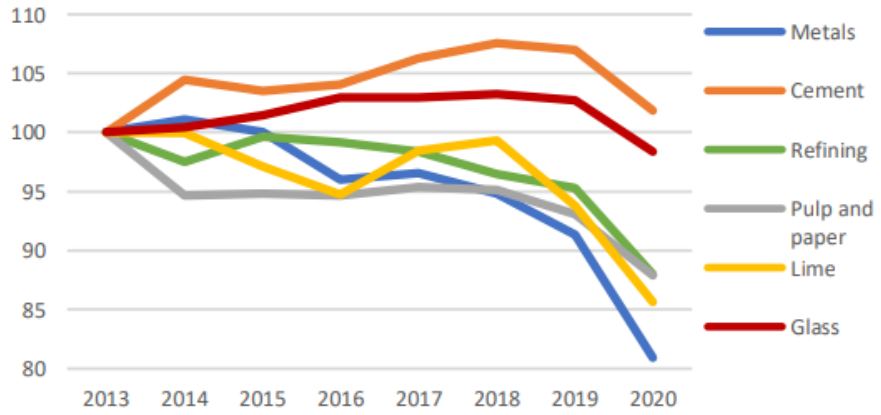


Figure 6: Index of verified emissions for selected industrial sectors

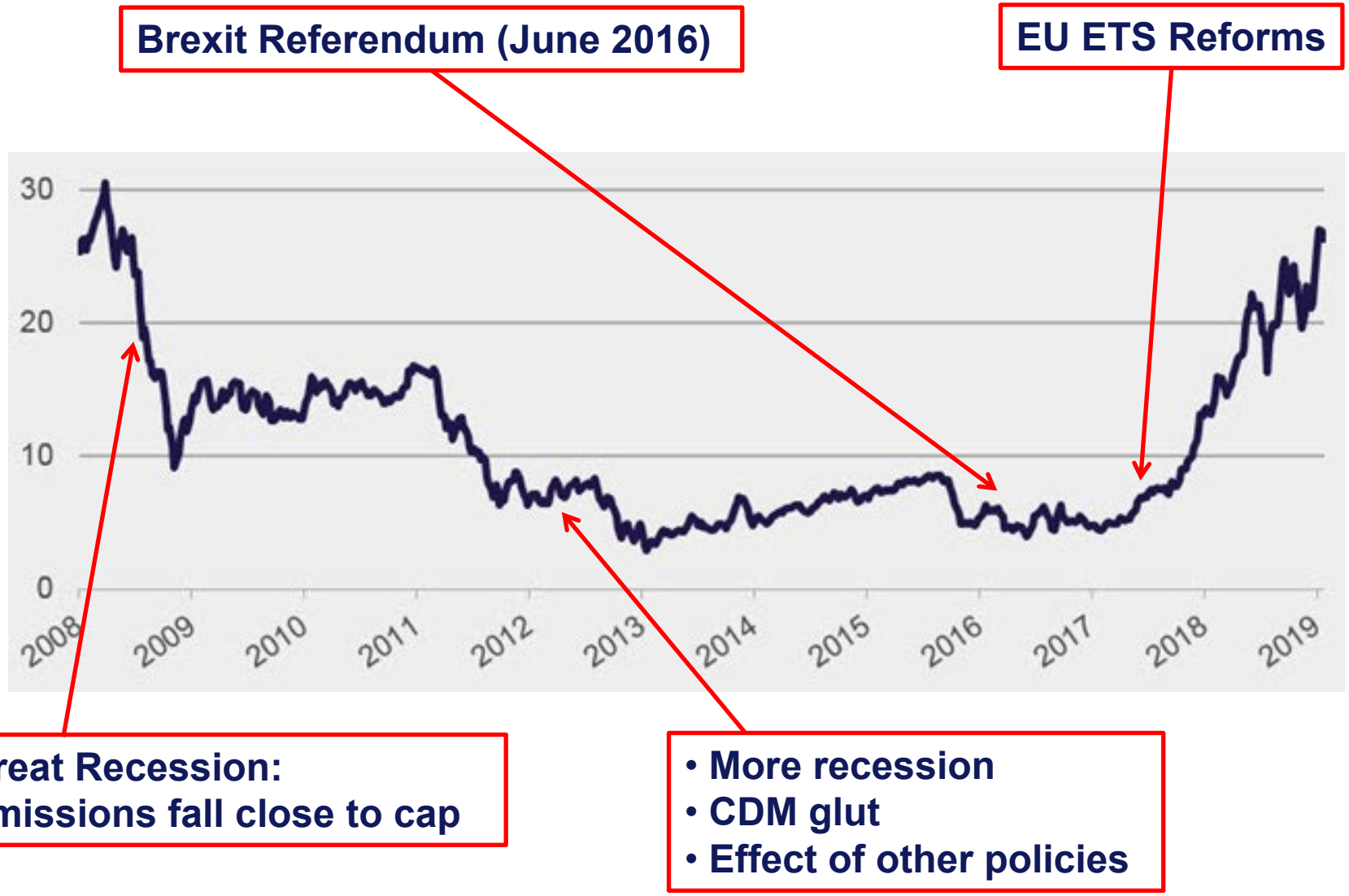


Source: BloombergNEF and ERCST elaborations on EUTL, 2021

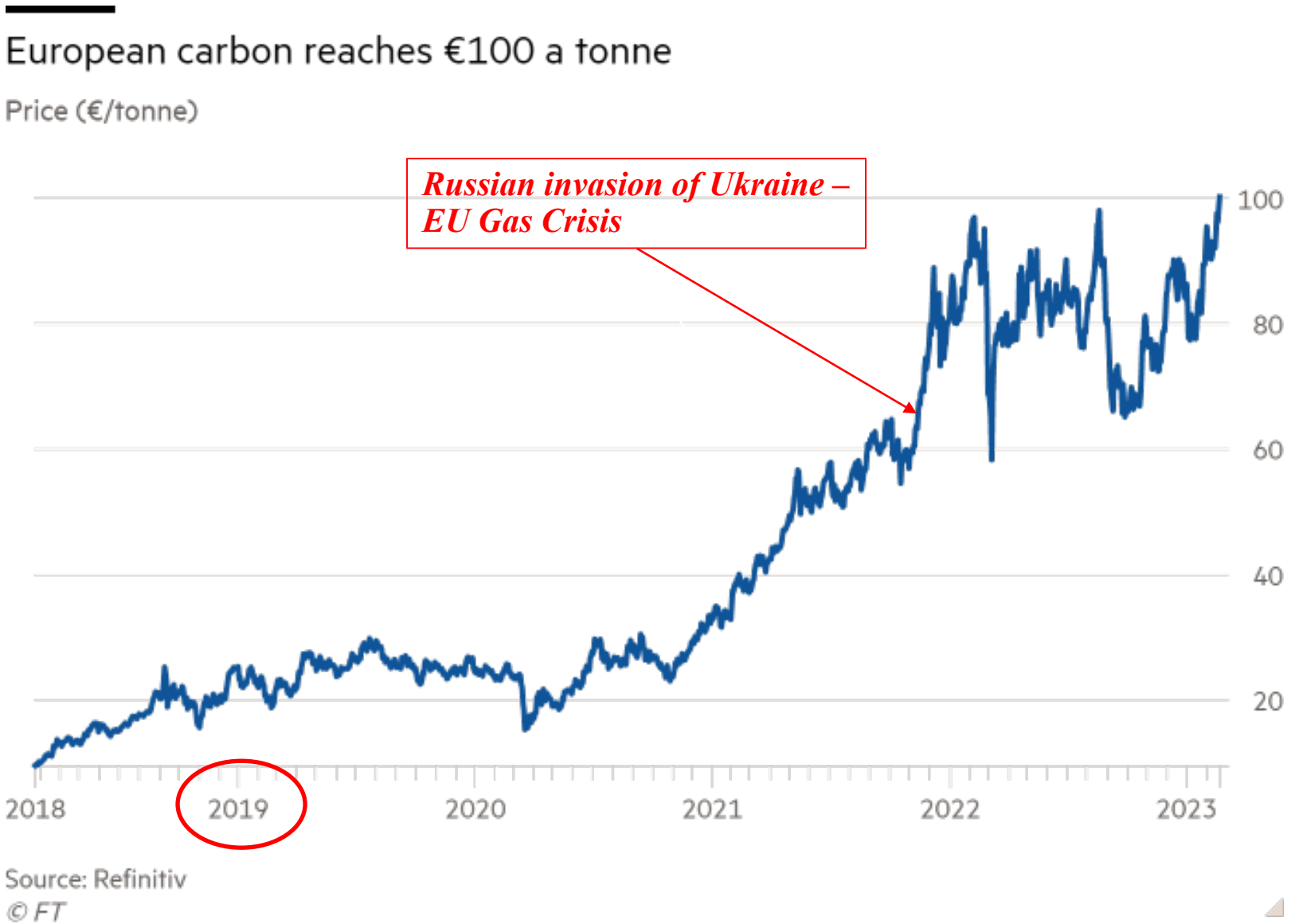
Overall Performance of the EU ETS

- **Placed a price on carbon** for about 7% of global GHG emissions
- **Significant reductions**
- **Mechanism in place** for bringing about further limitation of GHG emissions
- **More than other regions/nations have done**
- **But recession & complimentary policies kept prices low, until …**
- … EU ETS Reforms (Backloading, Market Stability Reserve, etc.) drove prices up …

EU ETS Allowance Prices, 2008-2019



EU ETS Allowance Prices, 2018-2023



Key Take-Aways

1. Policy analysts favor carbon-pricing instruments: feasibility, short-term cost-effectiveness, incentives for technological change
2. Carbon pricing (carbon tax, cap-and-trade, or hybrid) has very positive impacts on renewables, and very different effects on coal, natural gas, & oil markets
3. Equal numbers of carbon tax and cap-and-trade systems implemented globally, but cap-and-trade systems appear more important (price x coverage)
4. Choice between two approaches is choice of design elements along a policy continuum; so, design can be more consequential than selection of either
5. Carbon-pricing instruments can be made more politically acceptable through departures from economists' first-best design
6. Cap-and-trade can be *effective*, but cap needs to be significantly *below* BAU; economy-wide systems *feasible*, but downstream, sectoral systems *common*
7. Banking *important*, and price collar *valuable* – leads to a hybrid system; free allowance allocations foster *political support*, but have problems
8. Leakage/competitiveness *big political issue*, but free allocation *does not help*
9. EU ETS *most important application* to date to climate change; well designed, but not perfect