

(Updated, 30 January 2023)

ECONOMICS OF CLIMATE CHANGE MITIGATION, CARBON MARKET AND OTHER MARKET INSTRUMENTS

IN 00.41: Climate Change Challenges and Responses

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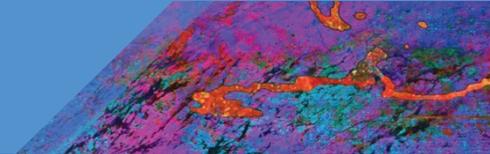
7 February 2023



Key Questions

1. What do the economics of climate change tell us about the needs for climate change mitigation?
2. Why do we need to put a price on Carbon? What are the approaches of putting a price on Carbon?
3. What type of carbon markets exist globally and how they work?
4. What is Carbon Tax? How they are implemented?

This lecture focuses on the economic rationales of climate change mitigation and carbon pricing as a tool to enable climate change mitigation. It will explore existing direct and indirect way to put price on carbon, through carbon emission trading systems and the carbon tax schemes from around the world.

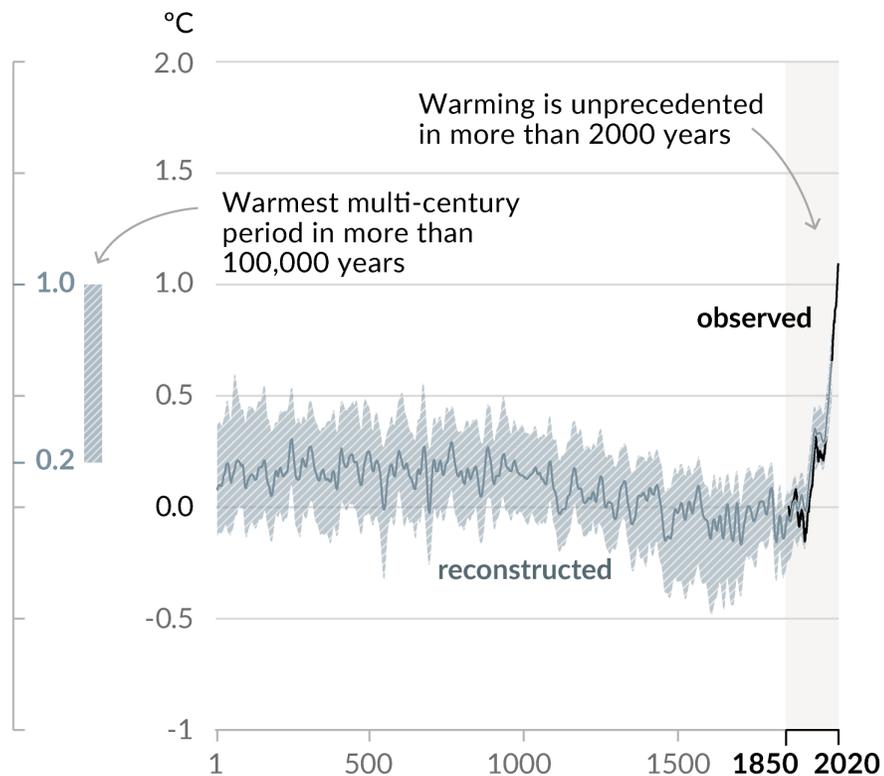


Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

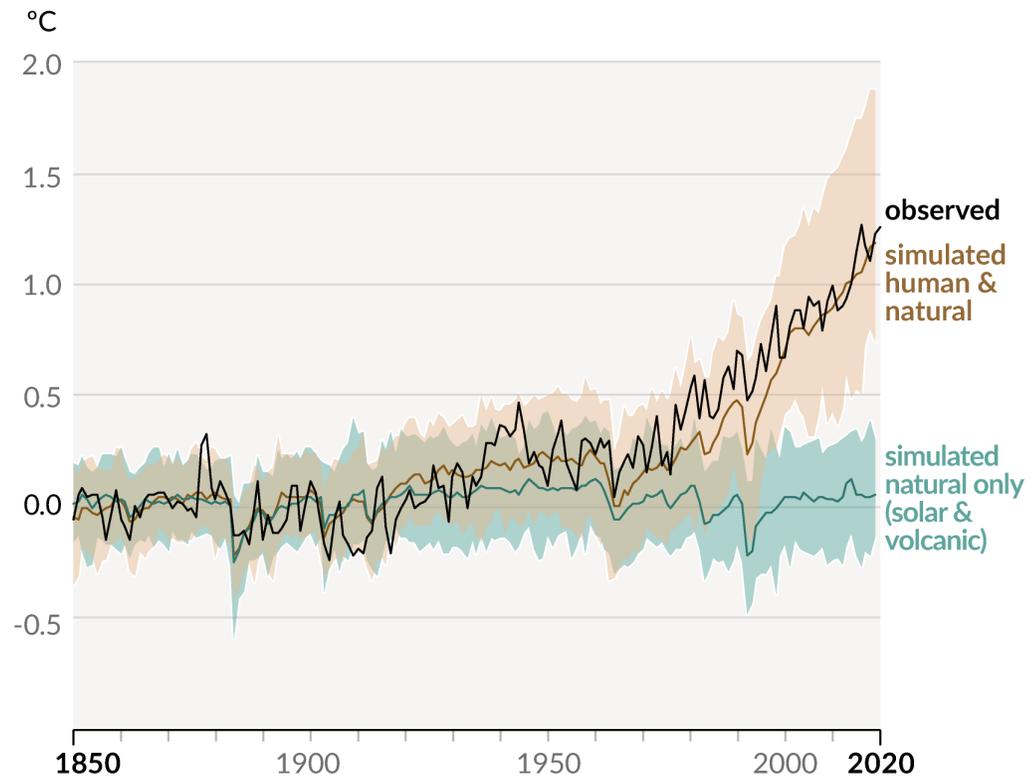
Figure SPM.1

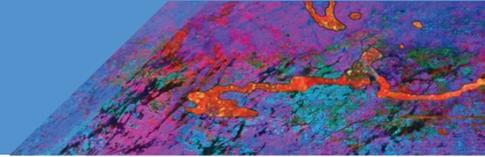
Changes in global surface temperature relative to 1850-1900

a) Change in global surface temperature (decadal average) as **reconstructed** (1-2000) and **observed** (1850-2020)



b) Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850-2020)

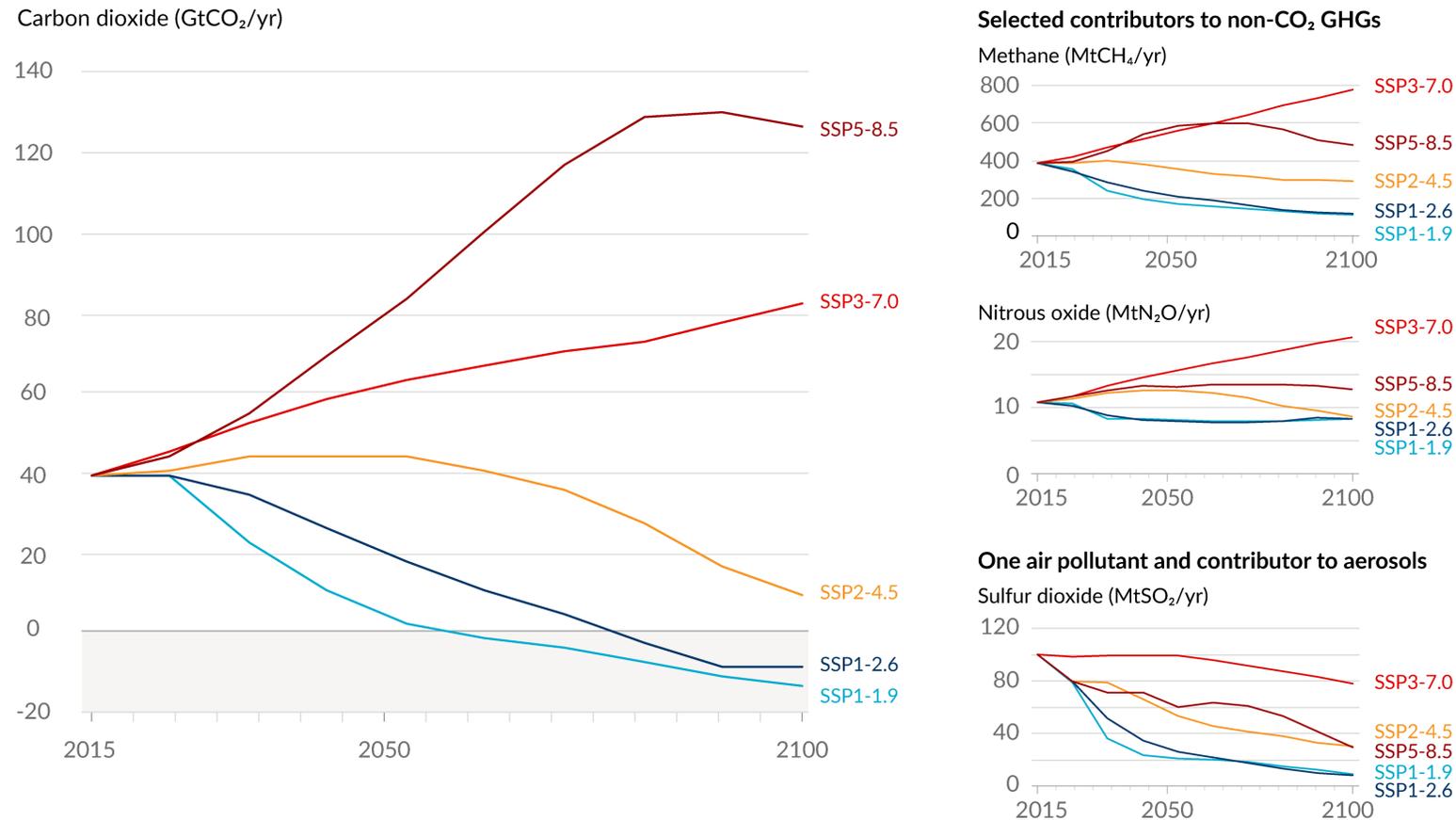




Future emissions cause future additional warming, with total warming dominated by past and future CO₂ emissions

Figure SPM.4

a) Future annual emissions of CO₂ (left) and of a subset of key non-CO₂ drivers (right), across five illustrative scenarios

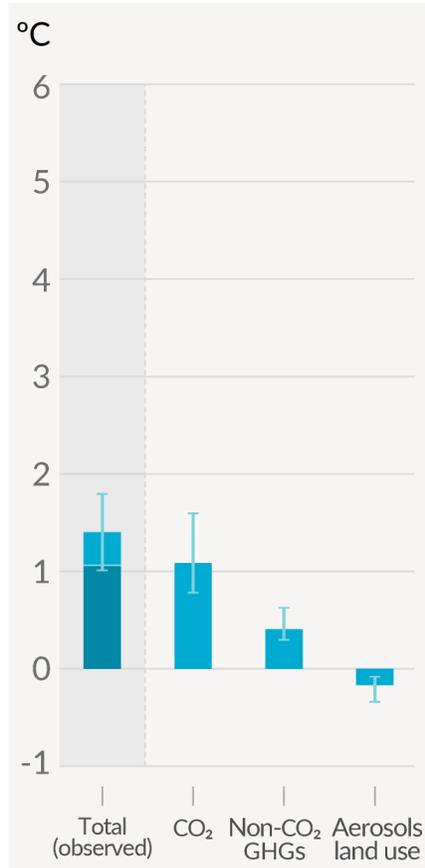


Future emissions cause future additional warming, with total warming dominated by past and future CO₂ emissions

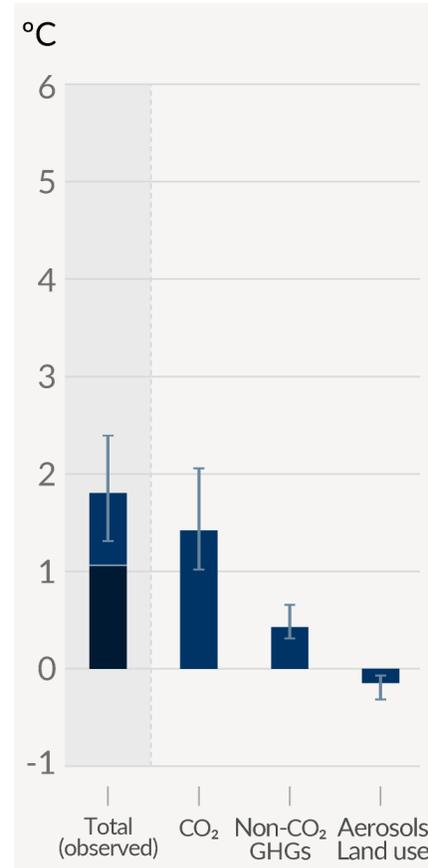
Figure SPM.4

Change in global surface temperature in 2081-2100 relative to 1850-1900 (°C)

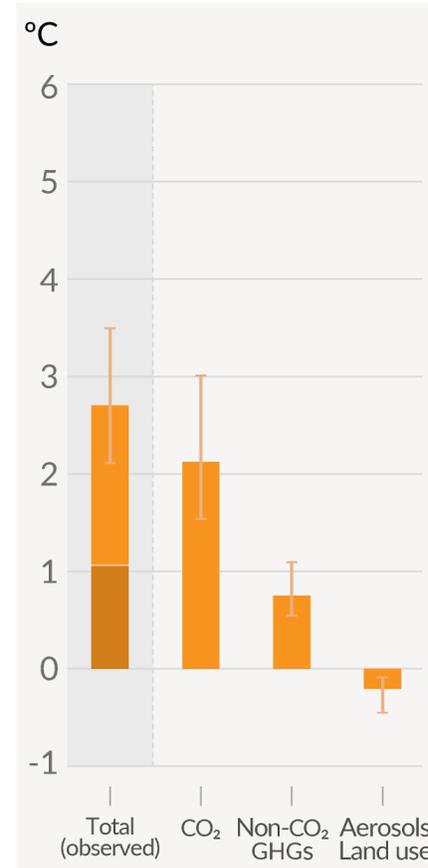
SSP1-1.9



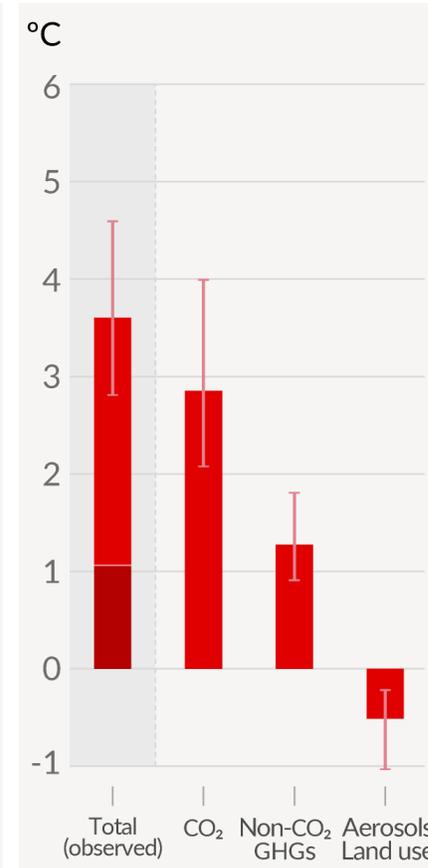
SSP1-2.6



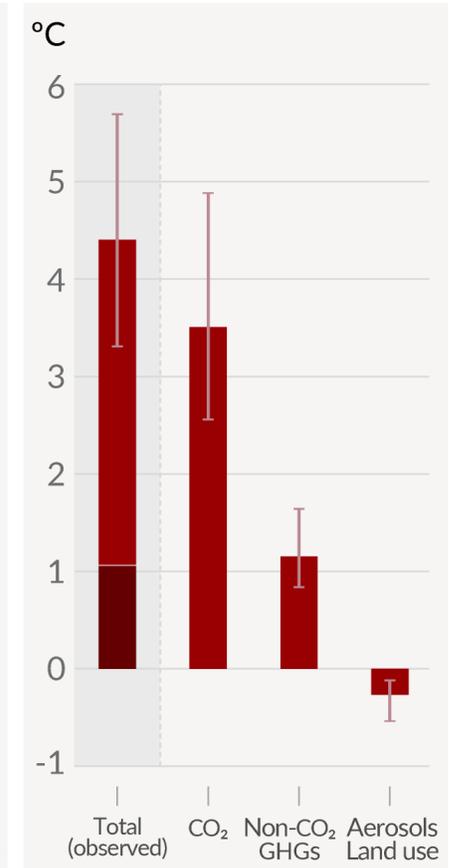
SSP2-4.5



SSP3-7.0



SSP5-8.5

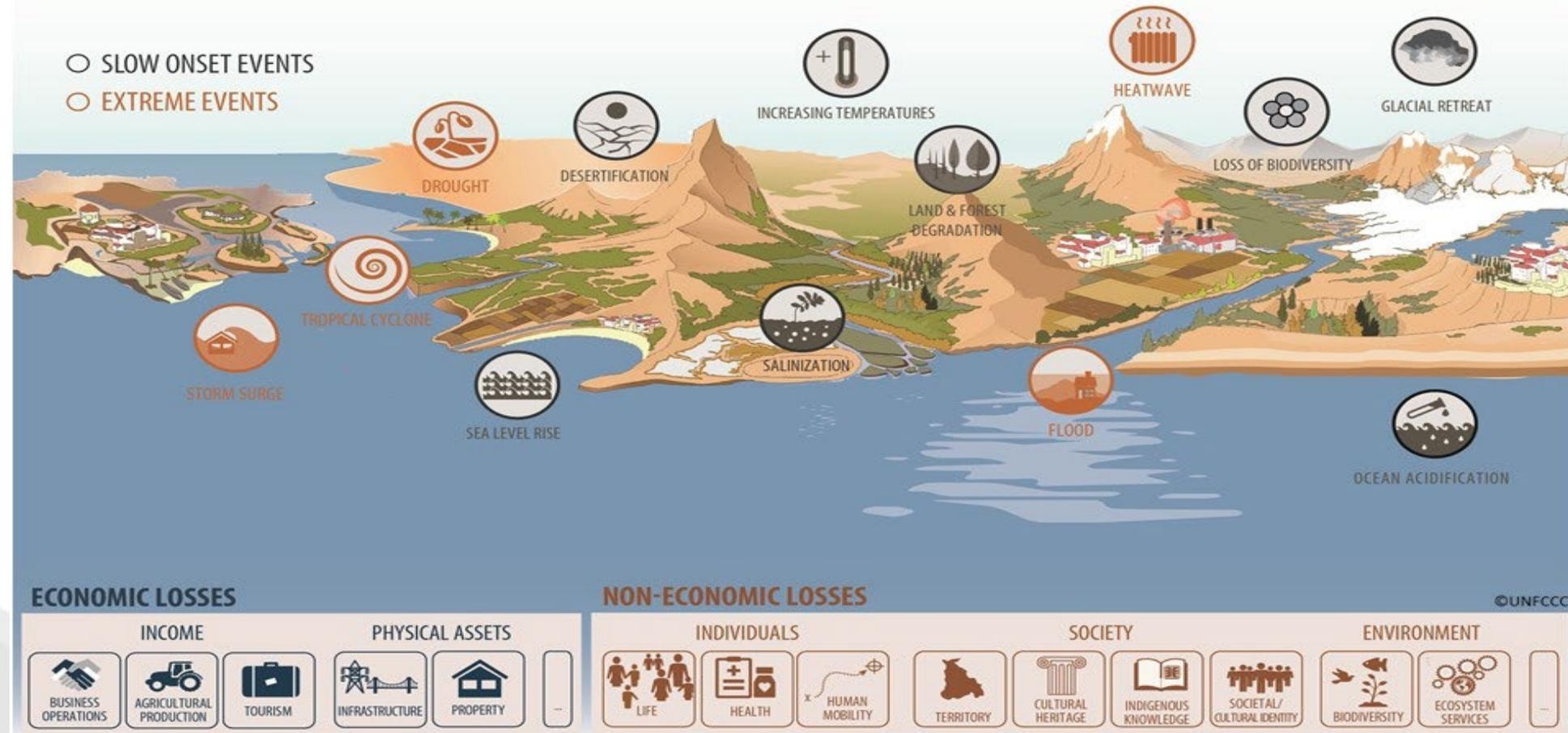
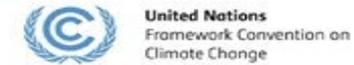


What do the economics of climate change tell us about the needs for climate change mitigation?



Loss and Damages Associated with Climate Change are diverse

LOSS AND DAMAGE ASSOCIATED WITH THE IMPACTS OF CLIMATE CHANGE



Climate change costs

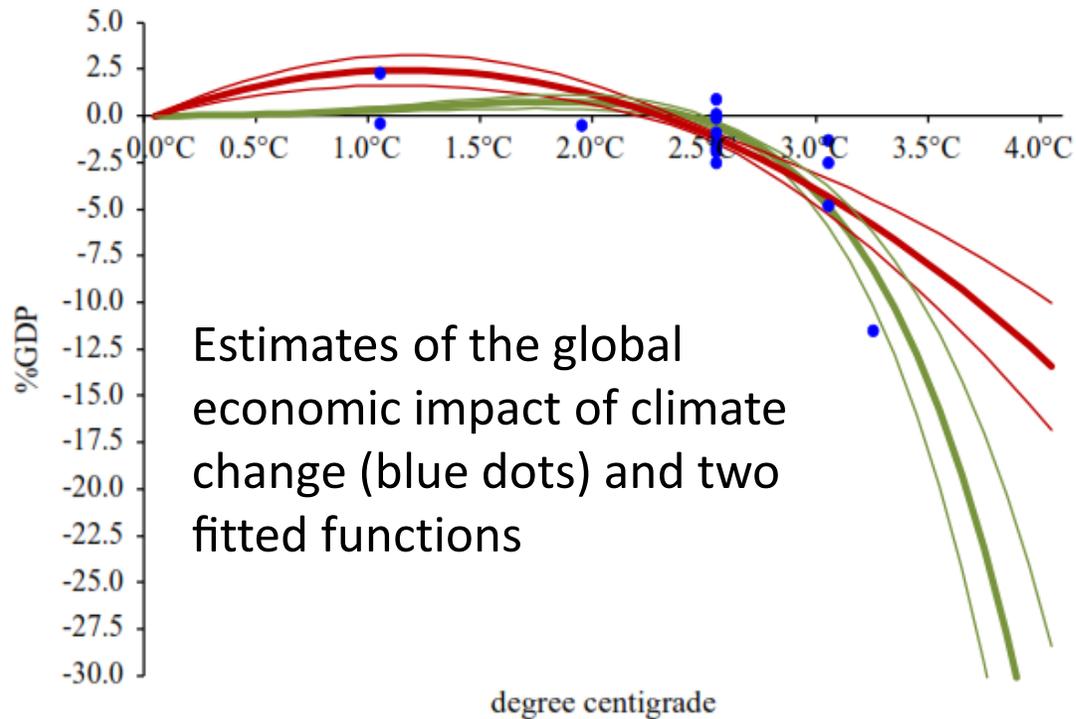
1. Total costs of climate change:

- The costs of mitigating GHGs
- The costs of adaptation to climate impacts
- The (damage) costs after adaptation (when adaptation activities cannot mitigate climate change impacts fully)
- **Total cost** = costs of mitigation + costs of adaptation + cost of residual damages – *benefits of climate change impacts (if any)*

2. To what level climate should be stabilized? 2 degree? 1.5 degree? (and corresponding level of GHG emissions)

- Should be stabilized at the level where “total cost is minimum”

Climate damages



Richard S.J. Tol (2013), *Targets for global climate policy: An overview*, *Journal of Economic Dynamics & Control*, 37: 911-928

Estimates of the welfare loss due to climate change (as equivalent income loss in percent); estimates of the uncertainty are given in bracket as standard deviations or 95% confidence intervals.

Study	Warming (°C)	Impact (%GDP)
Nordhaus (1994b)	3.0	-1.3
Nordhaus (1994a)	3.0	-4.8 (-30.0 to 0.0)
Fankhauser (1995)	2.5	-1.4
Tol (1995)	2.5	-1.9
Nordhaus and Yang (1996) ^a	2.5	-1.7
Plamberk and Hope (1996) ^a	2.5	-2.5 (-0.5 to -11.4)
Mendelsohn et al. (2000a) ^{a,b,c}	2.5	0.0 ^b 0.1 ^b
Nordhaus and Boyer (2000)	2.5	-1.5
Tol (2002a)	1.0	2.3 (1.0)
Maddison (2003) ^{a,d}	2.5	-0.1
Rehdanz and Maddison (2005) ^{a,c}	1.0	-0.4
Hope (2006) ^{a,e}	2.5	0.9 (-0.2 to 2.7)
Nordhaus (2006)	2.5	-0.9 (0.1)
Nordhaus (2008)	3.0	-2.5
Maddison and Rehdanz (2011) ^a	3.2	-11.5
Bosello et al. (2012)	1.9	-0.5

^a Note that the global results were aggregated by the current author.

^b The top estimate is for the “experimental” model, the bottom estimate for the “cross-sectional” model.

^c Mendelsohn et al. only include market impacts.

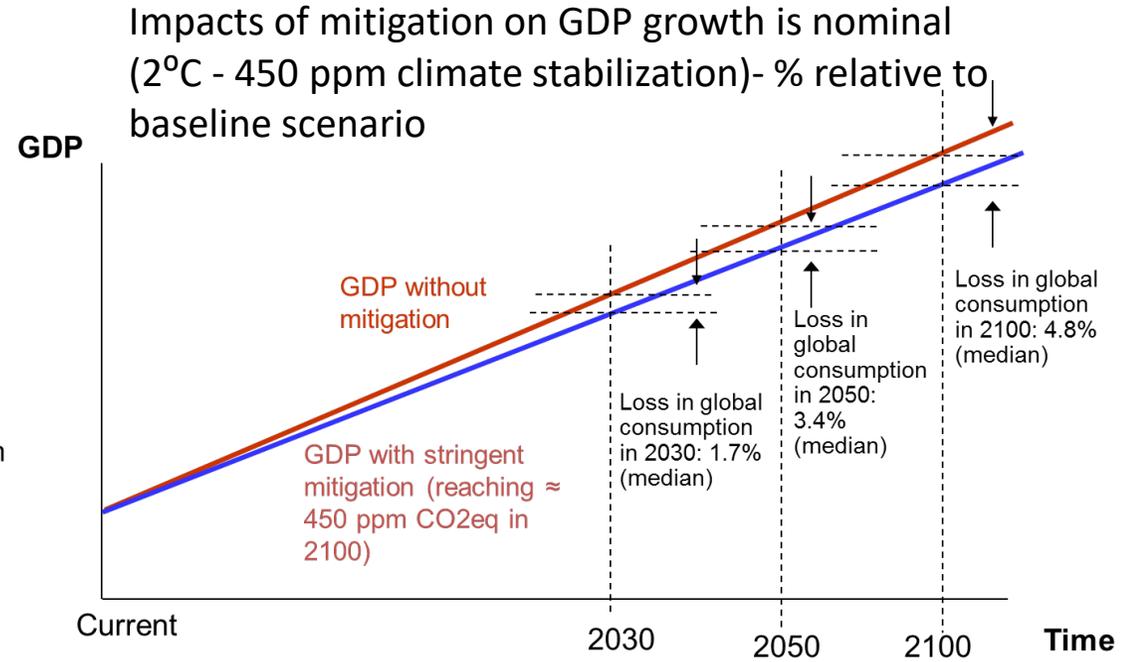
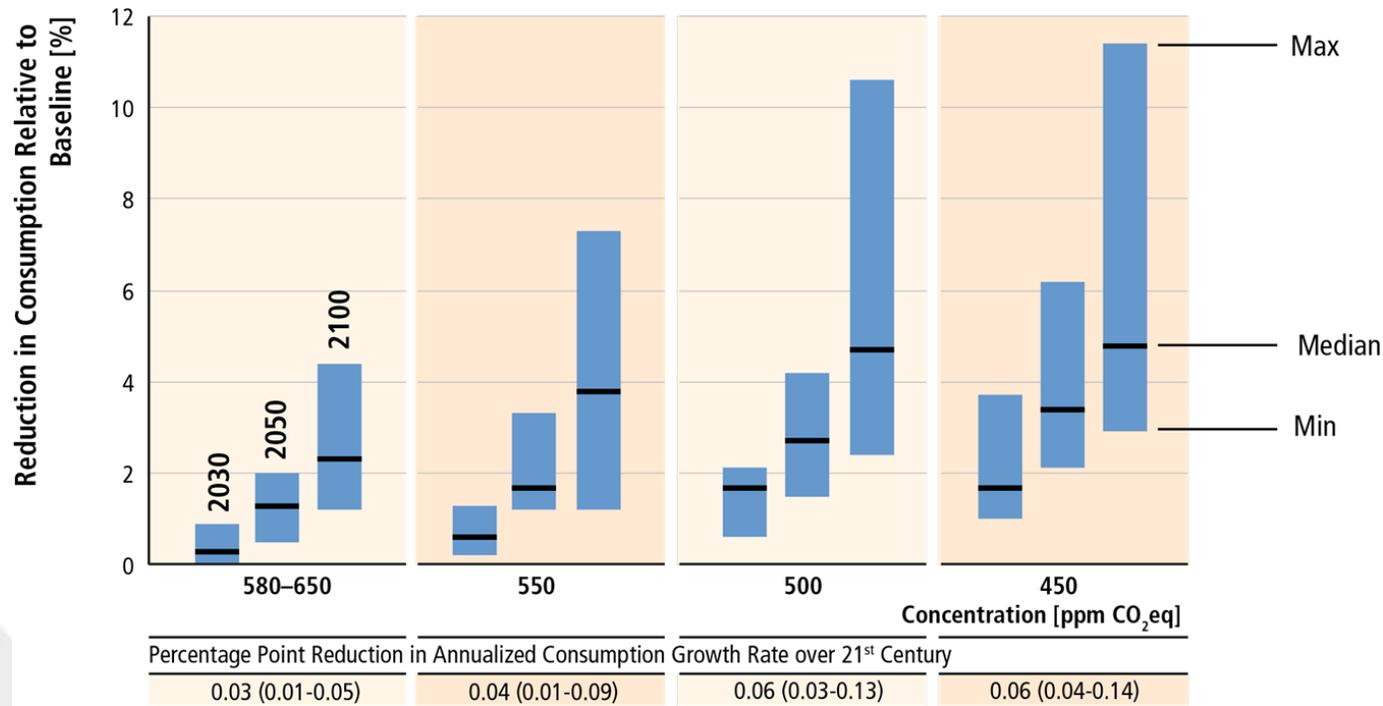
^d Maddison only considers non-market impacts on households.

^e The numbers used by Hope are averages of previous estimates by Fankhauser (1995) and Tol (2002a); Stern et al. (2006) adopted the work of Hope.

Stern review on economics of climate change

1. 2006 report commissioned by UK government to assess the evidence of climate change's impact and the climate costs
2. Very influential report that shaped many debates
3. Damage cost is equivalent to losing of about 5% of GDP each year; however if broader range of risks and impacts are considered, it could go to 20% of GDP
4. If the world is to stabilize climate change to 500-550 ppm CO₂eq, the cost of mitigation would be equivalent to losing global GDP each year by around 1%
5. Concludes that the benefits of climate change actions far outweigh the cost of inaction; early action is strongly favored
6. Is it in line with other studies? → Yes, but it is in higher cost-band of published literatures (low discount rate !!)

Costs of mitigation of climate change



Estimates do not include the benefits of reduced climate change as well as co-benefits and adverse side-effects of mitigation

Co-benefits: Such as cleaner air, greener land, safe and secure energy, less waste, a stronger economy, health and well-being etc

Climate Change Mitigation 2014, WG3's contribution to 5th Assessment Report of IPCC, 2014 April

- The IPCC says that the longer we wait to mitigate more, the higher would be the costs of mitigation in medium to long term.

Optimal climate change

- In climate change, costs are cost of mitigation, and benefits are damage avoided
- In a static optimum: *Marginal costs* (MC) should be equal to *Marginal benefits* (MB), means

$$\frac{\partial \text{Benefits}}{\partial \text{Emission}} = \frac{\partial \text{Costs}}{\partial \text{Emission}}$$

- But, in case of climate change which involves stock and flow problems →
- MC should be equal the Net Present Value of the Marginal Benefits, i.e.

$$\frac{\partial C_t}{\partial E_t} = \sum_s \frac{1}{(1+r)^s} \frac{\partial B_{t+s}}{\partial E_t}$$

'Climate Economics', Richard Toll, Edward Elgar, 2014.



Optimal carbon pricing

- Economists believe that the most cost-effective method to reduce GHG is by putting price-tag on them
- If we put price on emissions, people will emit less
- If the 'price of GHG emissions', is higher than the 'cost of abatement' of measures, then those measures will be implemented in market/society

Carbon pricing approaches

- **'Social cost of carbon' approach**
 - For economic efficiency, carbon price should be equal to the 'social cost of carbon'
 - Social cost is the 'damage cost' of climate change impact
- **Shadow price approach**
 - Mitigation target/goals oriented; not based on damage costs !!
 - Carbon price = marginal carbon abatement cost (MAC) of mitigation goal
 - Need to estimate MAC function which sorts abatement measures in terms of \$/tCO₂e and inform how much mitigation can be achieved at what price?

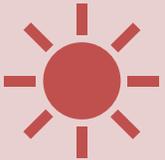
Carbon price is yet low



To reach the temperature goals of the Paris Agreement, we need high carbon price

US\$40-80/tCO₂ by 2020

US\$50/tCO₂- US\$100/tCO₂ by 2030



BUT less than 4% emissions covered by current carbon prices are in the price range needed by 2030 (World Bank, 2022).

Mandatory carbon pricing

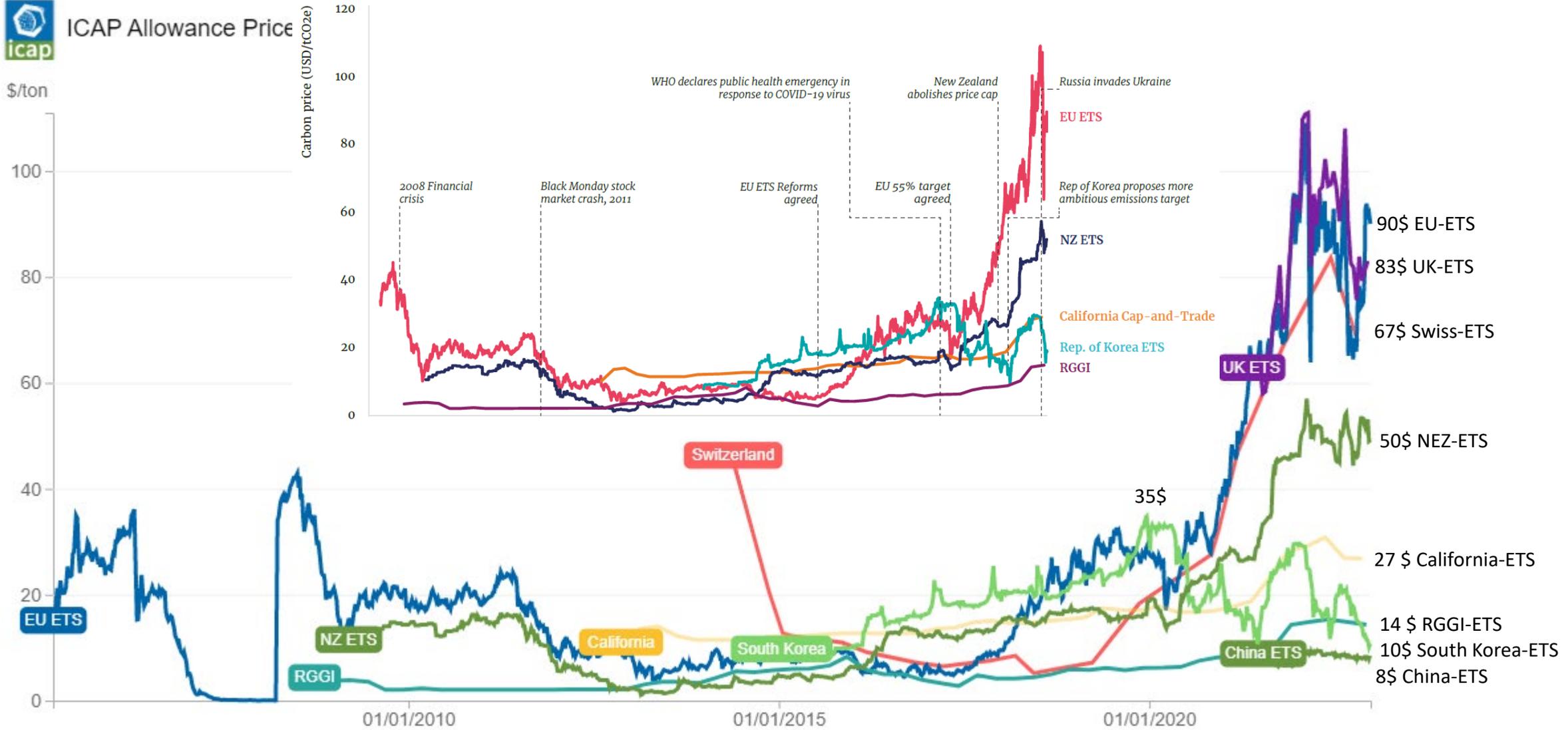
- Globally 70 initiatives, incl tax and ETS, cover 11.86 bnTCO₂e (23.2% of global GHG emissions)
- ETS under consideration in Vietnam, Thailand, Taiwan, Indonesia and Pakistan
- Carbon tax in Singapore and Indonesia
- China has nation wide ETS and several past pilot markets



ICAP Allowance Price

\$/ton

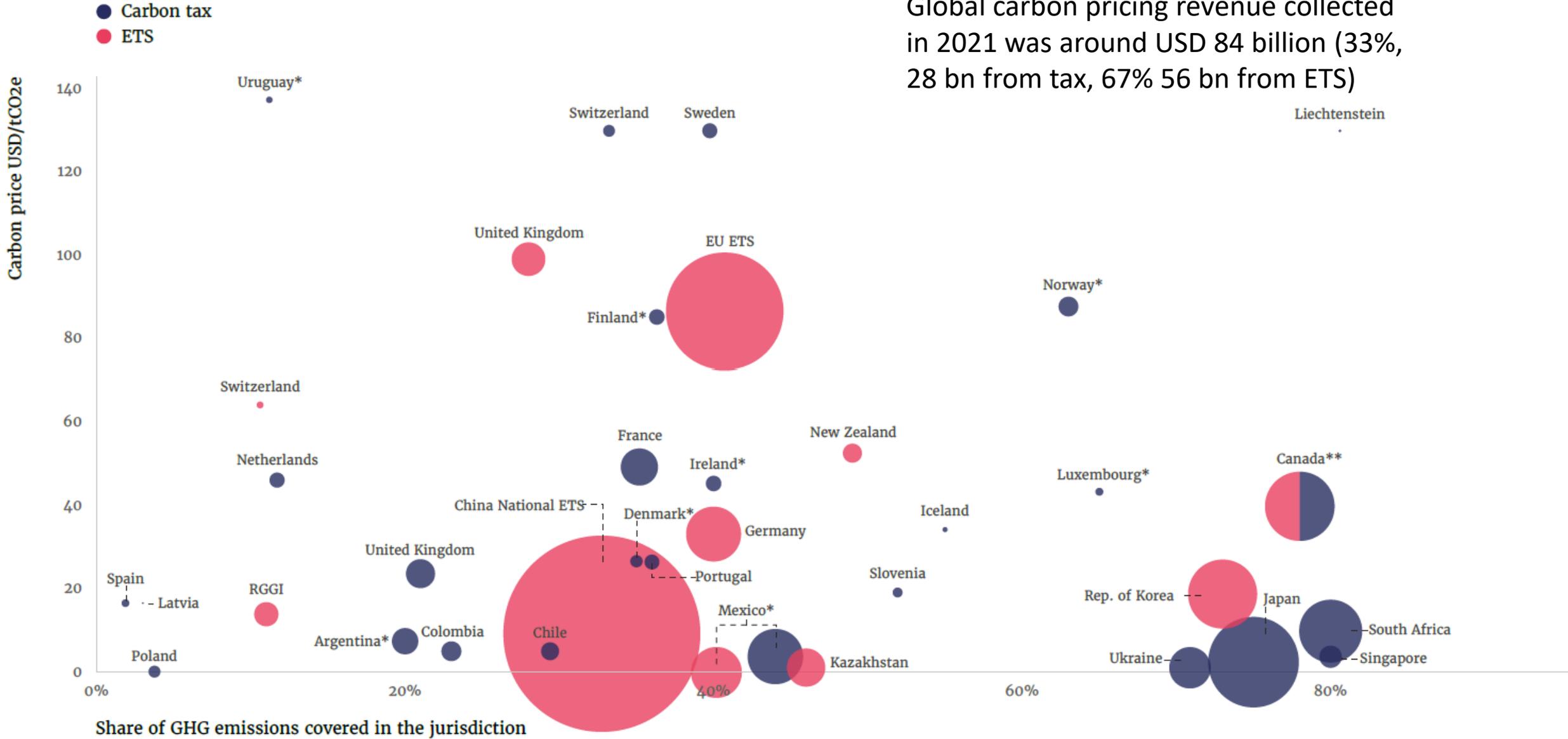
Carbon price (USD/tCO₂e)

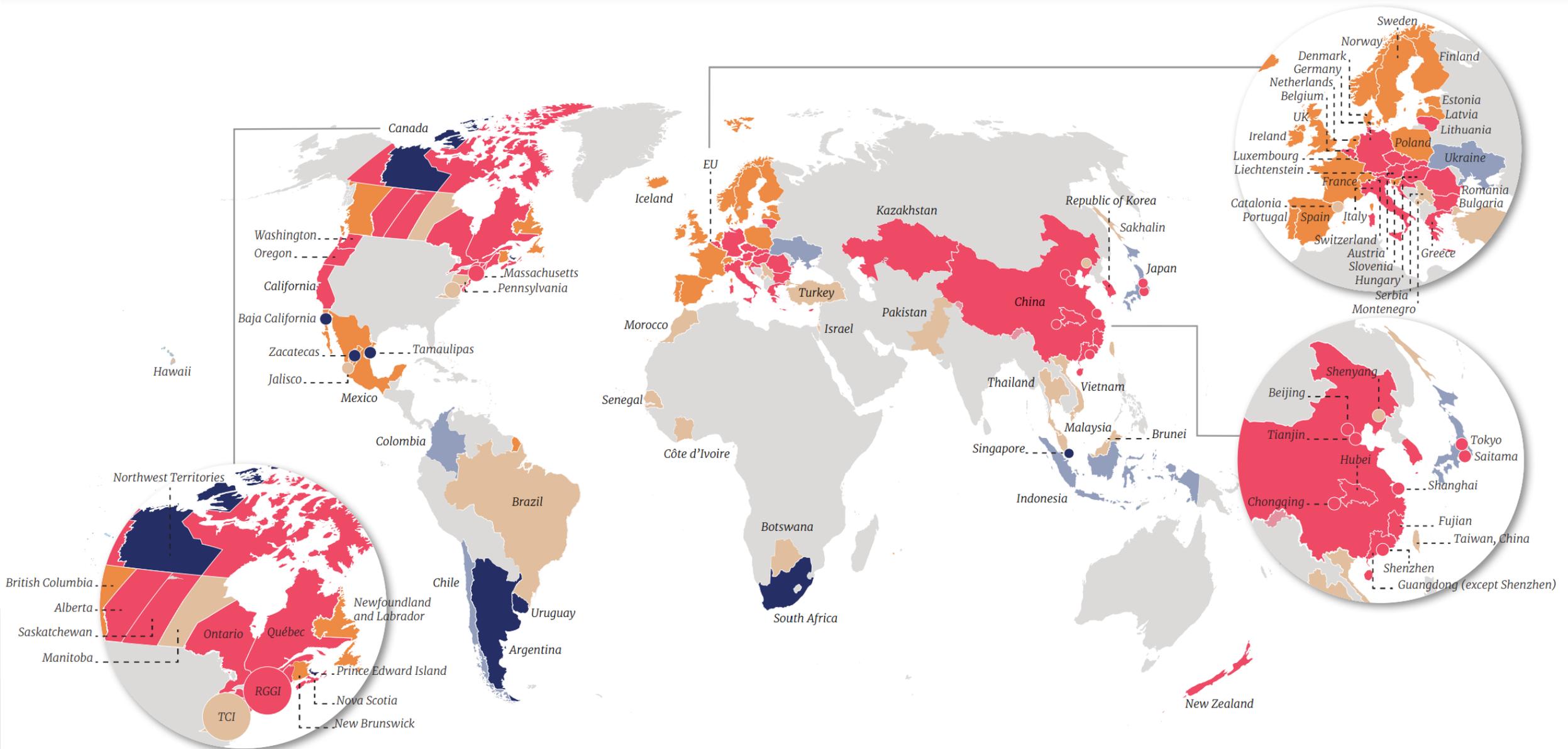


<https://icapcarbonaction.com/en/ets-prices>

State and Trends of Carbon Pricing 2022, The World Bank

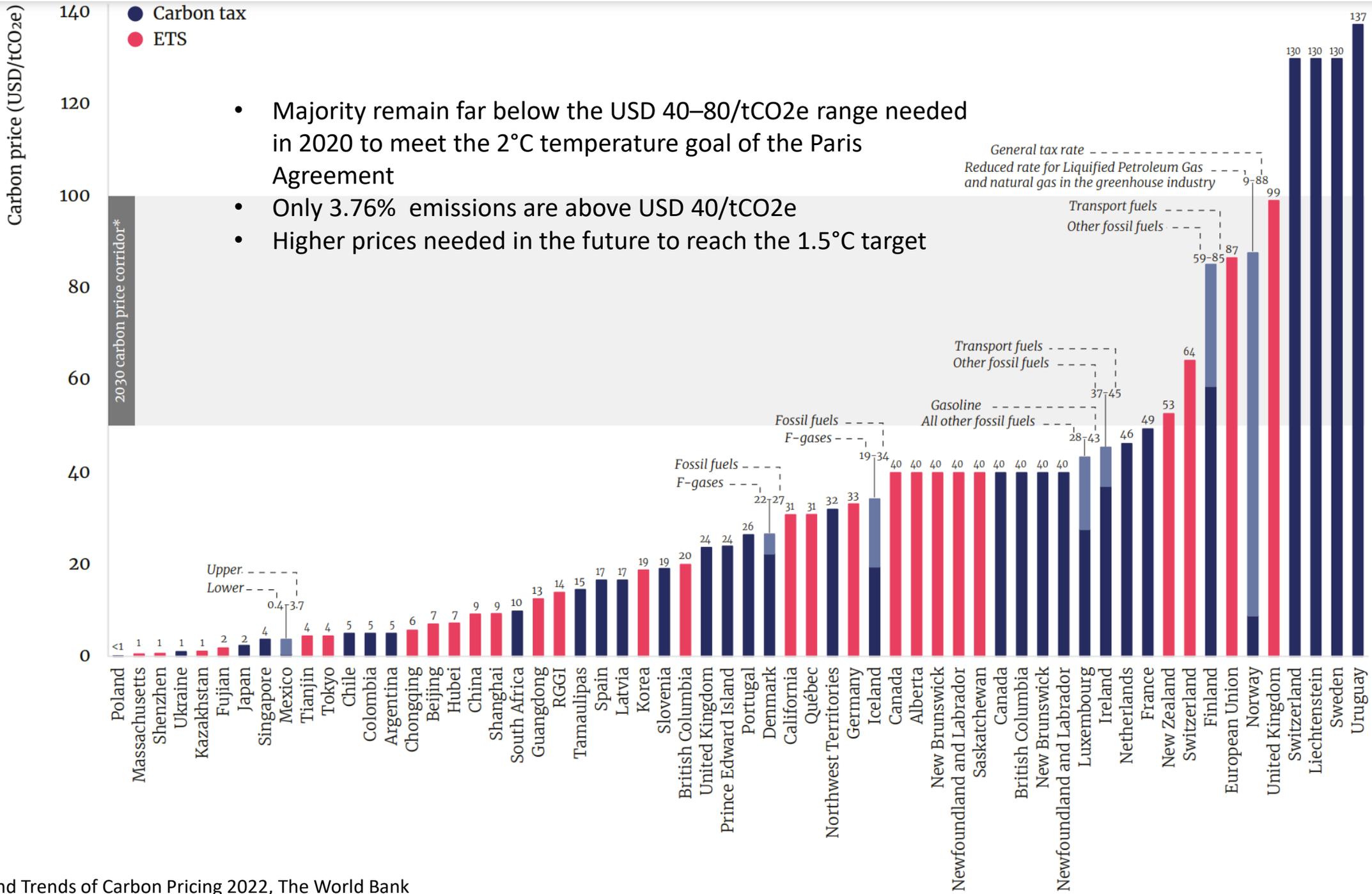
Global carbon pricing revenue collected in 2021 was around USD 84 billion (33%, 28 bn from tax, 67% 56 bn from ETS)





- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS and carbon tax implemented or scheduled

- ETS implemented or scheduled, carbon tax under consideration
- Carbon tax implemented or scheduled, ETS under consideration
- ETS or carbon tax under consideration



Carbon Tax and Carbon Trading

Carbon Tax

- Price-based, provides stable price signal to market/investors, less uncertain, usually
- able to impose higher price than ETS

Emission Trading

- Quantity-based, good for emission targets, better economic efficiency (emitter can choose the lowest-cost mitigation options across covered-sectors), needs a well-functioning market, need many participants to trade, transaction cost could be high, need better management/operating capacity of regulator

Other ways of doing carbon pricing

- Border carbon tax adjustment
- Offset mechanisms (CDM, voluntary market, CORSIA, bilateral such as JCM)
- Results-based climate finance (RBCF) (e.g. REDD+)
- Internal carbon pricing (in institutions)
- Implicit carbon pricing (policy)

Carbon taxes in practice

35 carbon tax initiatives

27 nations

Cover
2.99 GtCO₂e or
5.5% of global
GHG emissions
(2021)

Singapore (2019)
and now
Indonesia

1990	Finland adopts first carbon tax Poland carbon tax
1991	Sweden carbon tax Norway carbon tax
1992	Denmark carbon tax
1995	Latvia carbon tax
1996	Slovenia carbon tax
2000	Estonia carbon tax
2008	Switzerland carbon tax British Columbia carbon tax
2010	Ireland carbon tax Iceland carbon tax India Clean Environment Cess
2012	Australia Carbon Pricing Mechanism
2013	United Kingdom Carbon Price Floor
2014	France carbon tax Mexico carbon tax Australia Carbon Pricing Mechanism repealed
2015	South Africa publishes Carbon Tax Bill Portugal carbon tax
2016	Canada announces national Carbon Price Floor
2017	Alberta carbon tax Chile carbon tax Colombia carbon tax Singapore carbon tax announced

CARBON TAX GUIDE: A Handbook
for Policy Makers, The World Bank,
March 2017.

World Bank (2022)
https://carbonpricingdashboard.worldbank.org/map_data



AIT

Carbon tax

- Singapore, 5 S\$/tCO₂e (for 2019-2023) applied uniformly to all sectors including energy-intensive and trade-exposed sectors; but government plans to reach a carbon tax rate of
 - SGD 25/tCO₂e to 2024 and 2025
 - SGD 45/tCO₂e in 2026/27
 - SGD 50-80/tCO₂e (36-58 USD/tCO₂e) by 2030.
 - companies may also surrender high quality international carbon credits to offset up to 5% of their taxable emissions from 2024
- Indonesia, 2.02 US\$/tCO₂ (30,000 Rupiah/t) for coal fired power sector (postponed twice April and July 2022 to 2023)



Table 1. CO ₂ content and tax rates for fossil fuels @ \$49/metric ton of carbon dioxide equivalent (mt CO ₂ -e)		
Fuel	CO ₂ content ¹	Tax @ \$49/mt CO ₂ -e
Natural gas and coal <i>(Upstream or midstream approach)</i> ²		
Natural gas	53.12 kg/mcf	\$2.60/mcf
Anthracite	2,578.68 kg/short ton	\$126.36/short ton
Bituminous	2,236.80 kg/short ton	\$109.60/short ton
Sub-bituminous	1,685.51 kg/short ton	\$82.59/short ton
Lignite	1,266.25 kg/short ton	\$62.05/short ton
Petroleum		
<i>Midstream approach</i> <i>(representative fuels):</i>		
Gasoline	8.89 kg/gallon	\$0.44/gallon
Diesel, home heating oil	10.16 kg/gallon	\$0.50/gallon
Jet fuel	9.57 kg/gallon	\$0.47/gallon
<i>Upstream approach:</i>		
Crude oil	432 kg/bbl ³	\$21.17/barrel
¹ Source: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm . CO ₂ content parameters represent OTA's assessment of tax-relevant emissions and should not be considered definitive for any carbon tax that may be enacted. ² For natural gas and coal, upstream and midstream approaches differ in the point in the supply chain at which the fuel is taxed but not the form of the fuel or the per-unit fuel tax at the point of taxation. ³ Source: https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references		

3.78 liter = 1 gallon
 Natl avg price/gallon for regular gasoline (Jan 25, 2023) = 3.48\$

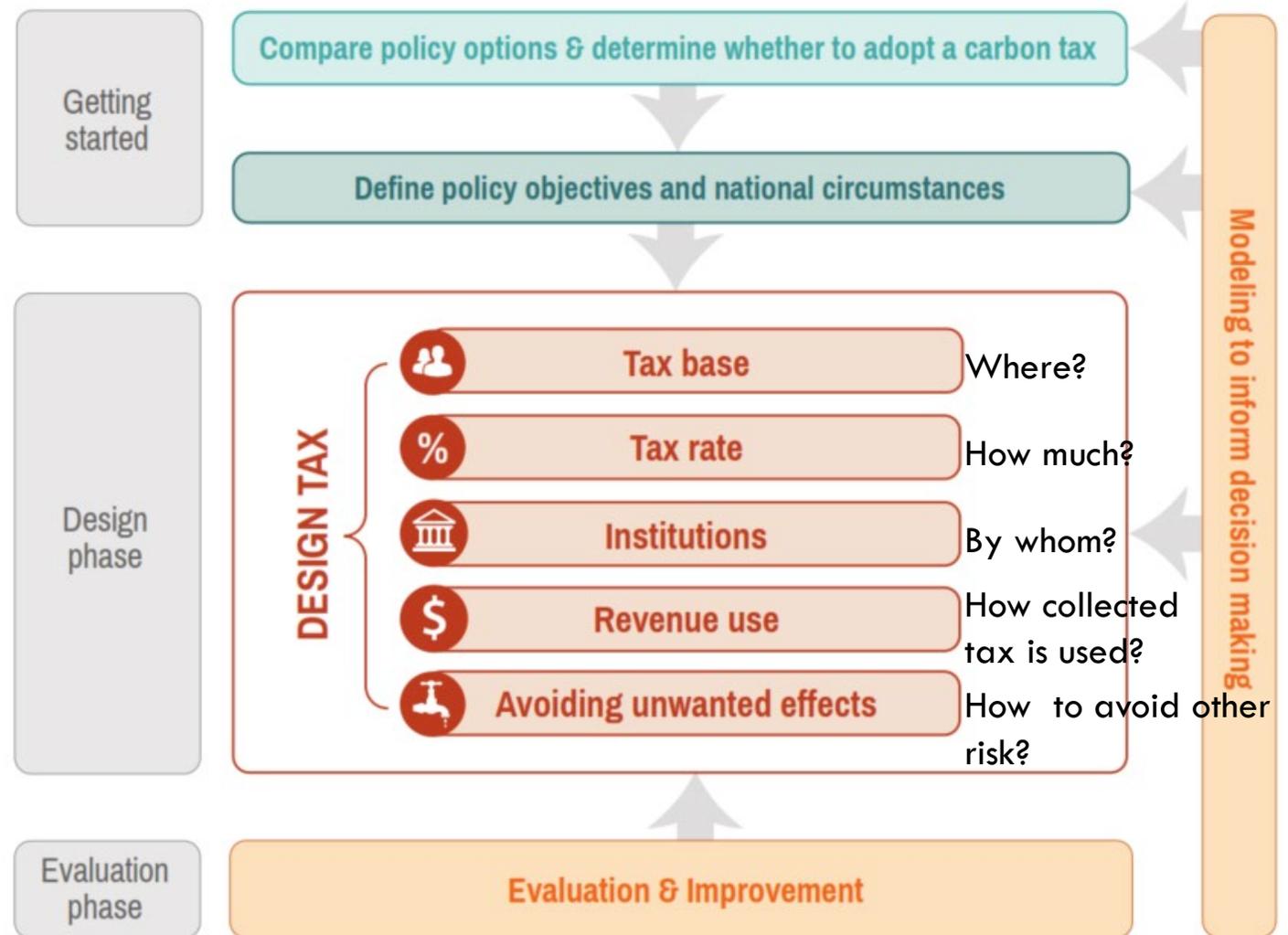
12.6% increase in gasoline price by imposing 49\$/tCO₂e tax!!!

<https://www.carbontax.org/issues/implementation/>

HOW CARBON TAX WORKS?

1. Taxing goods/processes which produce GHG emissions
2. Targeting carbon-intensive goods/processes to incentivize emission reductions, imposing tax as \$ per ton of CO₂e
3. Important to ascertain if price signal will be effective in emission reduction behavior (price elasticity)

Stages of Carbon Tax Design



FIVE STEPS OF CARBON TAX DESIGN

CARBON TAX GUIDE: A Handbook for Policy Makers, The World Bank, March 2017 (pp 14).

Define the tax base	Determine the tax rate	Address potential undesirable effects	Determine use of revenues	Ensure oversight and compliance
<ul style="list-style-type: none"> ✓ Decide which sectors to cover ✓ Decide which gases to cover ✓ Choose the points of regulation ✓ Choose the entities to regulate and set thresholds (if relevant) 	<ul style="list-style-type: none"> ✓ Determine the basis for setting the tax rate ✓ Determine how the rate will develop over time ✓ Consider using modeling to predict the effects of different tax rates on meeting policy objectives 	<ul style="list-style-type: none"> ✓ Assess the risk of the tax leading to carbon leakage or producing negative distributional effects ✓ Consider the costs and benefits of adopting measures to mitigate risks ✓ Consider the costs and benefits of different measures ✓ Develop criteria to determine eligibility for assistance measures (if relevant) 	<ul style="list-style-type: none"> ✓ Calculate projected revenue from the carbon tax ✓ Determine whether to redistribute revenues, lower income taxes, increase spending, or to do all three ✓ Decide whether to allow offsets 	<ul style="list-style-type: none"> ✓ Map the required roles and functions for administering the tax ✓ Determine whether these roles and functions can be carried out with existing capacities or require new roles to be defined and different capacities ✓ Establish clear procedures and ensure coordination of key entities ✓ Include clear and meaningful penalties for noncompliance

Types of Carbon Markets

1. Offset Market related to UNFCCC- Clean Development Mechanism
2. Regulated/Compliance Carbon Market (ETS/Cap-and-Trade)
3. Unregulated/Volunteer Carbon Market
4. CORSIA/ICAO Market/IMO/BOCM-JCM
5. REDD+ Carbon Market
6. Carbon-Insetting in Corporate Sector (internal carbon pricing)
7. Further Prospects under Paris Agreement

1. Offset Market – Clean Development Mechanism

- Projects in developing countries can earn certified emission reduction (CER) credits
- Each CER credits are equivalent to one tonne of CO2
- CERs can be traded and sold
- CER can be used by developed-countries with emission-reduction-commitments to contribute (a part) of their Kyoto Protocol emission reduction targets
- What CDM should do?
 - Contribute to sustainable development in developing countries
 - Give some flexibility to industrialized countries on meeting their emission reduction targets
 - Supports adaptation fund (2%)

Countries included in Annex B to the Kyoto Protocol and their emissions targets

Country	Target (1990** - 2008/2012)
EU-15*, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
US***	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	0
Norway	+1%
Australia	+8%
Iceland	+10%

By 2019 end

- Over 250 methodologies

Not doing great because world efforts shift away from Kyoto Protocol

Clean Development Mechanism (CDM)



Administered by UNFCCC

Established in 1997

Type International

Registered activities 8142

Credit name Certified Emission Reductions (CERs)

Credits issued (MtCO₂e) 2002

Credits retired or cancelled (MtCO₂e) 1192

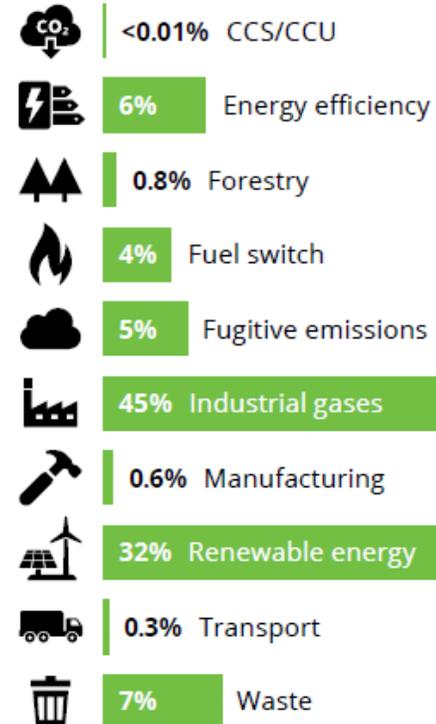
Geographic coverage Any Non Annex I country of the Kyoto Protocol¹⁴²

Countries with projects 111

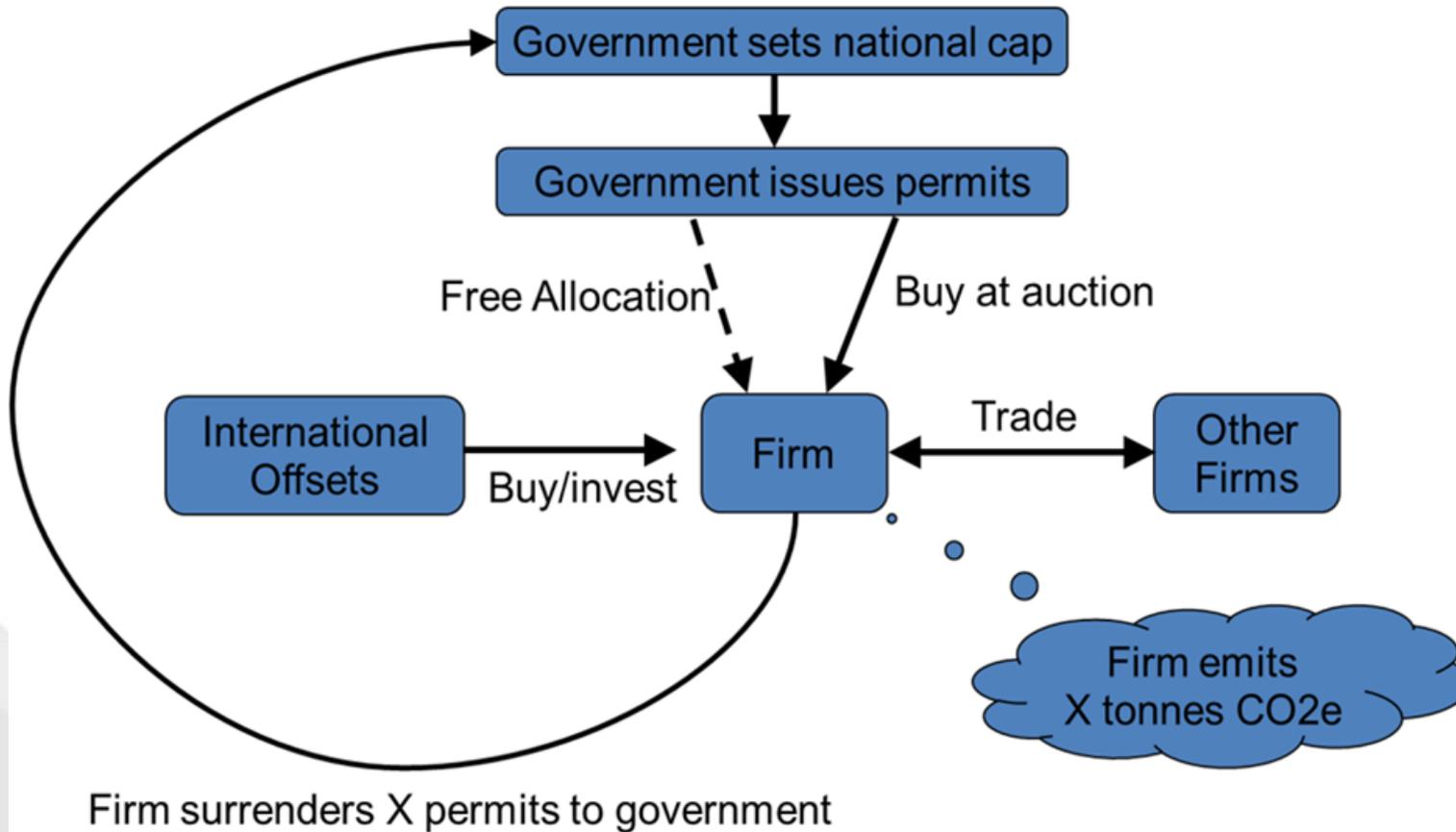
Price data for 2019 US\$0.15–0.24/tCO₂e¹⁴³

Carbon pricing initiatives accepting issued credits for compliance Colombia carbon tax, CORSIA¹⁴⁴, EU ETS, Mexico carbon tax, Republic of Korea ETS, South Africa carbon tax

Sectoral coverage 10 sectors

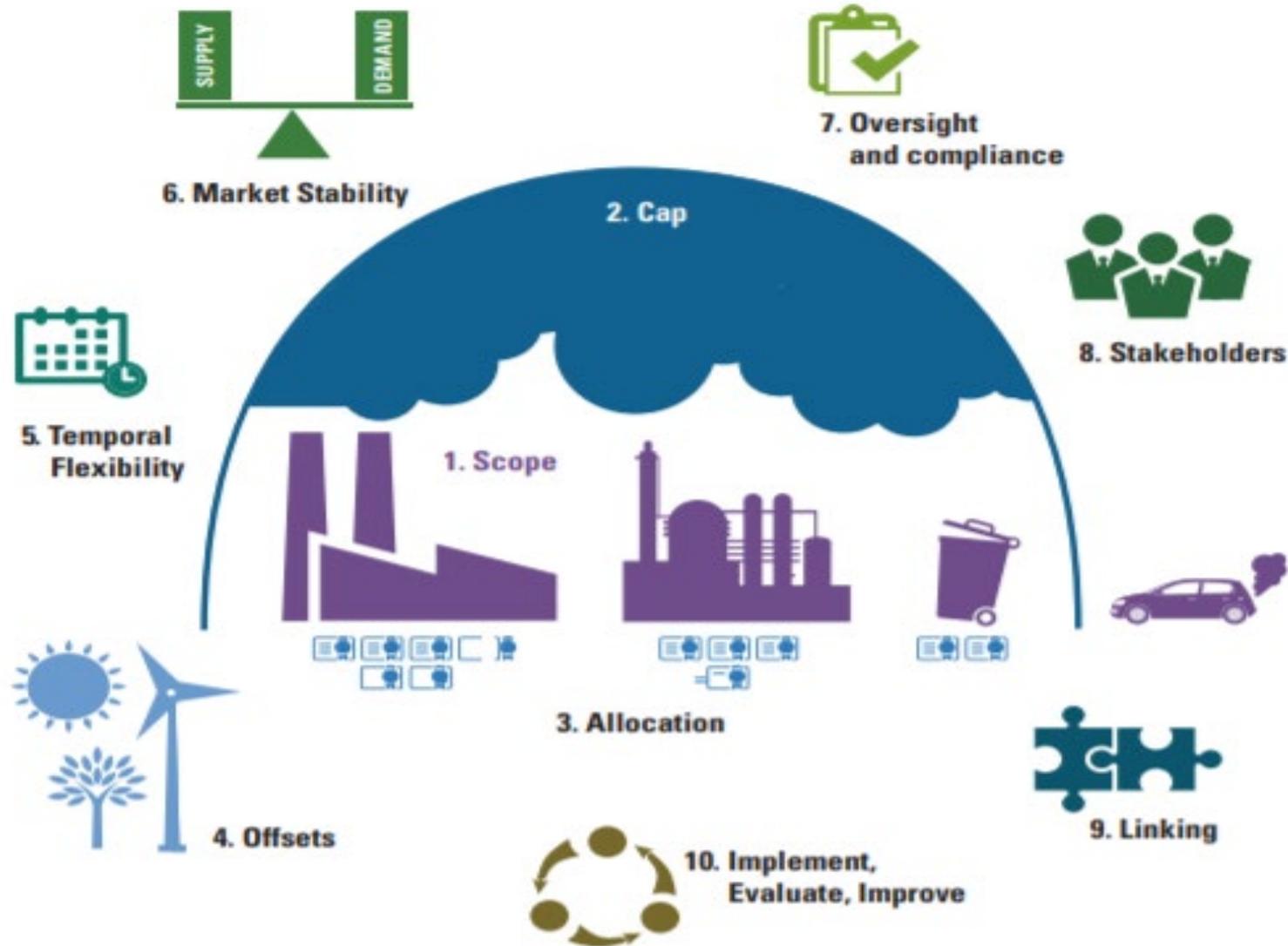


2. The basic mechanics of carbon trading scheme



- **Allocation**: Regulator sets overall caps and allocates to installation under the cap
- **Trading**: Firms buy more permits or sells excess permits to be under permit holdings
- **Monitoring**: Regulator monitors total emission of firms
- **Compliance**: Regulator checks if all installations under cap have enough permits for emissions

2. Regulated/Compliance Carbon Market (ETS/Cap-and-Trade)



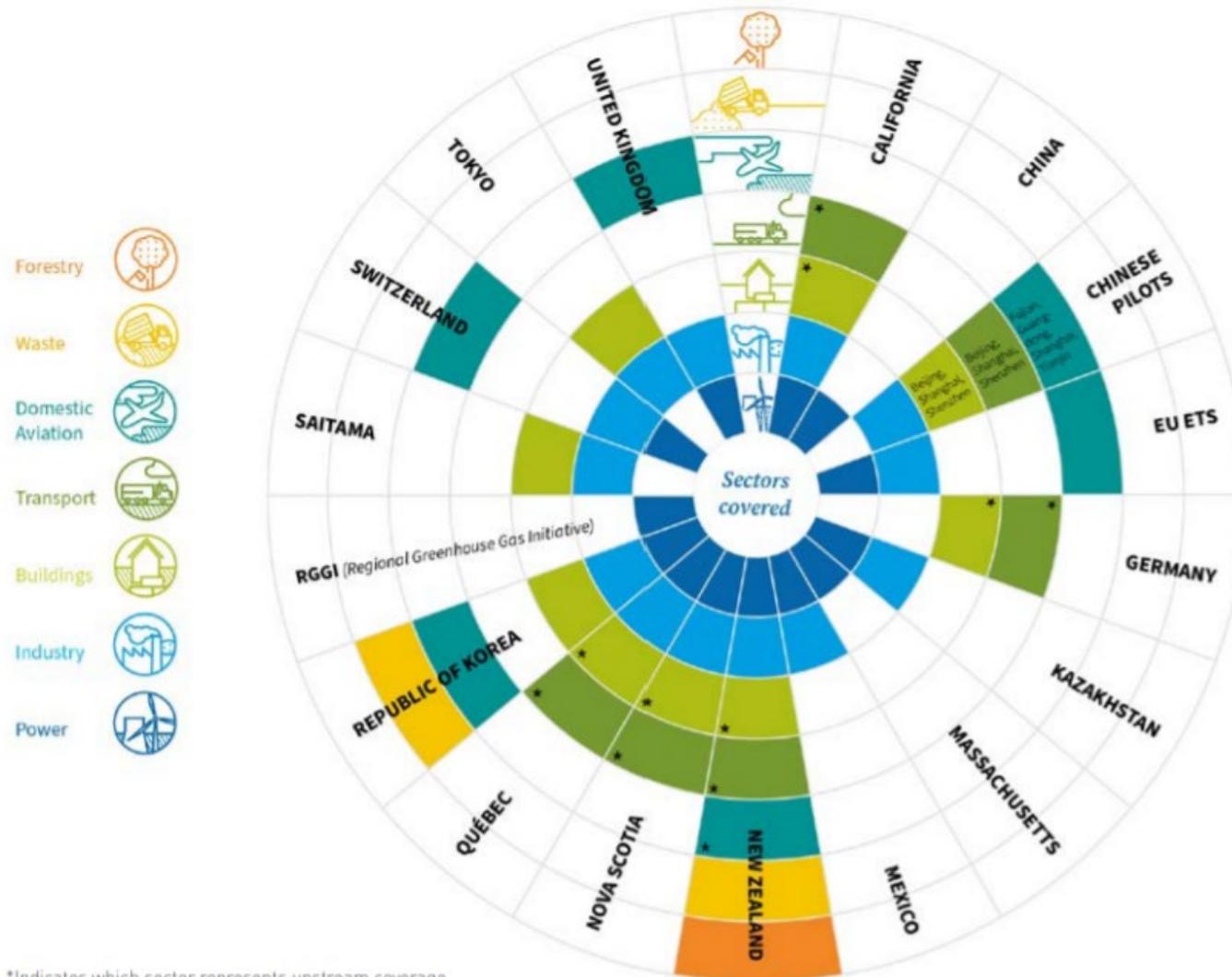
Alberta	Australia *	Brazil *	California
China *	EU	India	Japan *
Kazakhstan *	Mexico	New Zealand *	Norway
Québec	RGGI	Republic of Korea *	South Africa *
Switzerland	Tokyo	UK	Taiwan *

<http://www.ieta.org/The-Worlds-Carbon-Markets>

Design of Emission Trading Systems (ETS)

- ✓ Regulator
- ✓ Type of cap: absolute vs intensity
- ✓ Total cap size and changes in cap over time
- ✓ Sector/gases covered
- ✓ Allowance allocation rule (how much allocated? Free or auction or hybrid, how allowance revenue used?)
- ✓ Compliance period (s)
- ✓ Compliant carbon units/commodities
- ✓ Trading methods
- ✓ Monitoring, reporting and verification (registry and oversight, regulation)
- ✓ Banking and borrowing provisions'
- ✓ Offsets and flexibilities
- ✓ Price containment measures
- ✓ Punitive measures for non-compliance
- ✓ Allocation rules for new entrants and rules for opt-out
- ✓ Linkages with other ETS markets- and other carbon commodity

Sectors covered in many ETSs



European Union Emission Trading System (EU-ETS)

- EU-ETS Began operation in 2005
- EU28 plus 3 (Liechtenstein, Norway and Iceland); over **11,000 industrial installations** and **airlines** operating between them
- Goal: 21 percent reduction by 2020 from 2005 levels (43% by 2030)
- Covers about half of Europe's CO₂ emissions (@ 45% GHG)
- Traded sector of industry:
 - carbon dioxide (CO₂) from
 - power and heat generation, energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals
 - commercial aviation
 - Nitrous oxide (N₂O) from production of nitric, adipic and glyoxylic acids and glyoxal
 - Perfluorocarbons (PFCs) from aluminium production
- Non-traded sector: Others such as transportation sector (except aviation), agricultural sector

EU-ETS developments

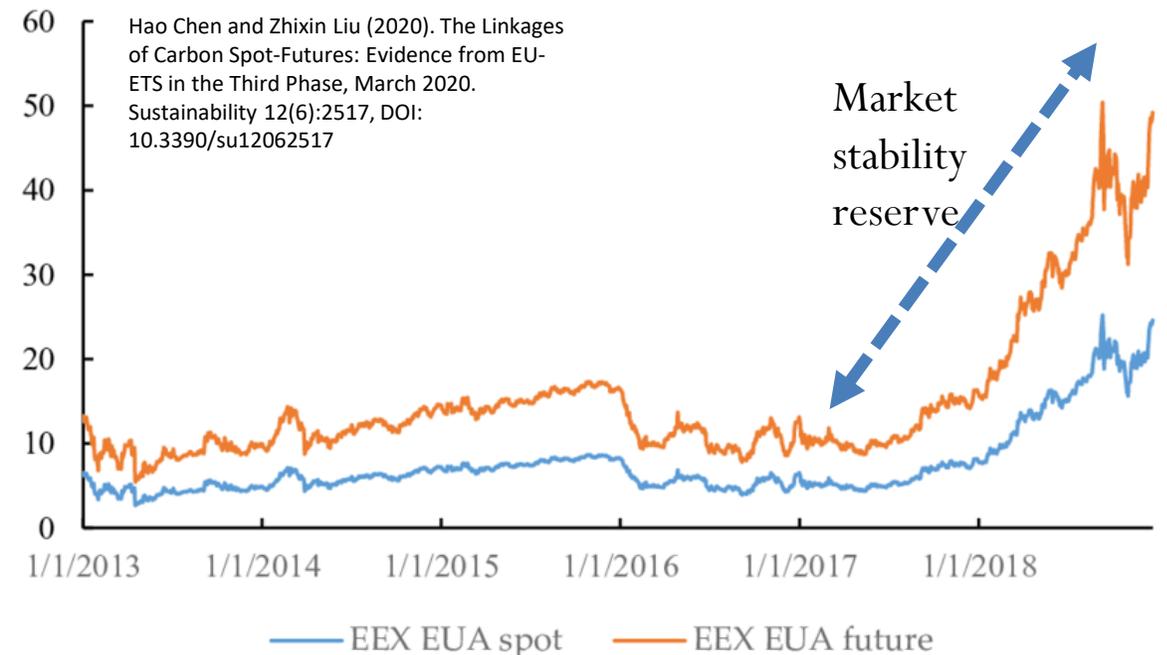
Key features	Phase 1 (2005–2007)	Phase 2 (2008–2012)	Phase 3 (2013–2020)
Geography	EU27	EU27 + Norway, Iceland, Liechtenstein	EU27 + Norway, Iceland, Liechtenstein Croatia from 1.1.2013 (aviation from 1.1.2014)
Sectors	Power stations and other combustion plants ≥20MW Oil refineries Coke ovens Iron and steel plants Cement clinker Glass Lime Bricks Ceramics Pulp Paper and board	Same as phase 1 plus Aviation (from 2012)	Same as phase 1 plus Aluminium Petrochemicals Aviation from 1.1.2014 (aviation from 1.1.2014) Ammonia Nitric, adipic and glyoxylic acid production CO ₂ capture, transport in pipelines and geological storage of CO ₂ Aviation

Key features	Phase 1 (2005–2007)	Phase 2 (2008–2012)	Phase 3 (2013–2020)
GHGs	CO ₂	CO ₂ , N ₂ O emissions via opt-in	CO ₂ , N ₂ O, PFC from aluminium production
Cap	2058 million tCO ₂	1859 million tCO ₂	2084 million tCO ₂ in 2013, decreasing in a linear way by 38 million tCO ₂ per year
Eligible trading units	EUAs	EUAs, CERs, ERUs Not eligible: Credits from forestry, and large hydropower projects.	EUAs, CERs, ERUs Not eligible: CERs and ERUs from forestry, HFC, N ₂ O or large hydropower projects. Note: CERs from projects registered after 2012 must be from Least Developed Countries

https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

EU-ETS Fourth phase: 2021–2030

- In February 2018, European lawmakers approved the EU ETS phase 4 (2021–2030)
 - Changing the linear annual cap reduction from 1.74 per cent to 2.2 per cent
 - A temporary doubling of the yearly withholding rate of surplus allowances into the Market Stability Reserve (MSR) to 24 per cent until 2023
 - Share of allowances to be auctioned is set at 57 per cent; after 2026, this will decrease linearly to 0 per cent in 2030
 - Low-carbon funding mechanisms for phase 4: the Modernization Fund and the Innovation Fund



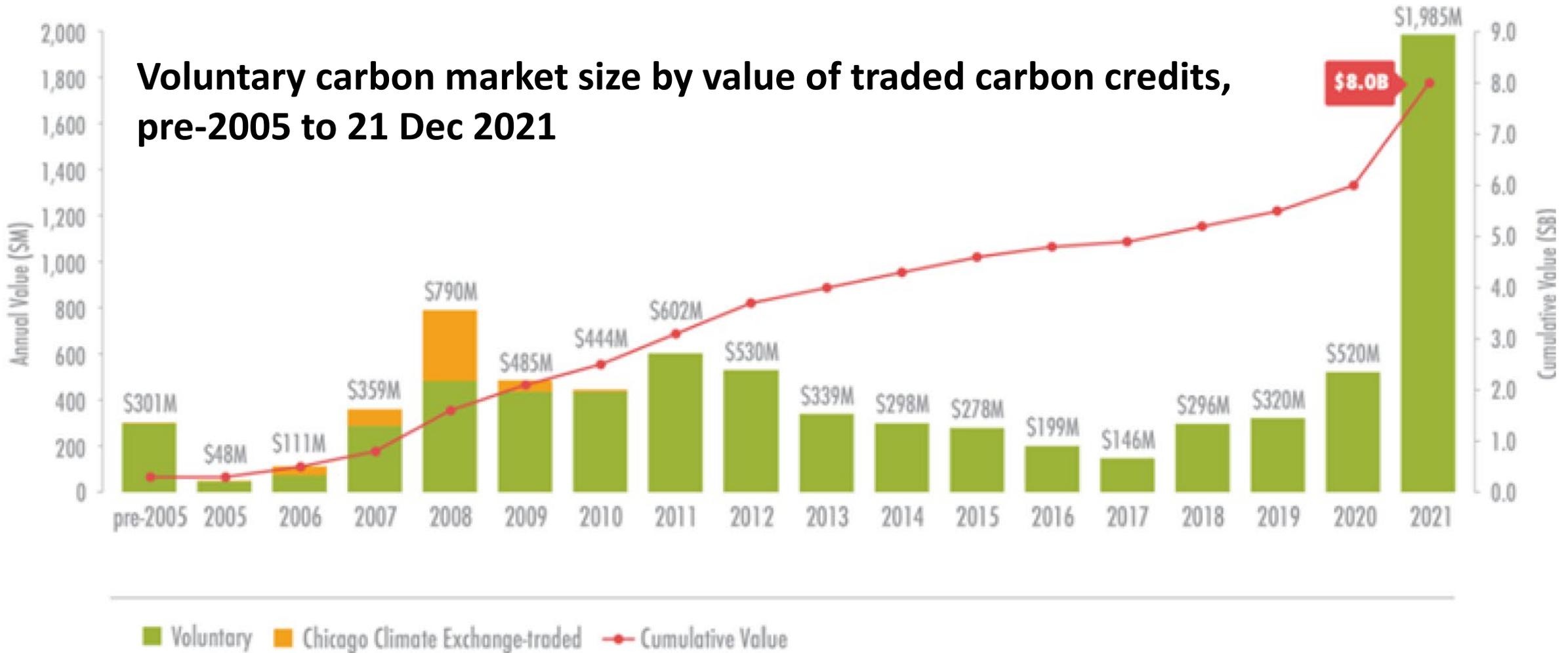
China National ETS China

launched national ETS in Dec 2017 (politically) → long-delayed and expected to launch from middle of this year (2021).

Features	Details
GHG Covered	CO2
Sectors covered and thresholds	<p>Power sector (including combined heat and power, as well as captive power plants of other sectors). The scope is expected to be gradually expanded to finally cover a total of eight sectors: petrochemical, chemical, building materials, steel, nonferrous metals, paper, and domestic aviation. There is no specific timeline for this expansion.</p> <p>INCLUSION THRESHOLDS: Entities with annual emissions of ~26,000 tCO2 (energy consumption of more than 10,000 tce) in any year over the period 2013-2015.</p>
Cap	~3,300 MtCO2e/year (30% of national CO2 emissions)
Allocation	Free Allocation: Free allocation is expected to be based on subsector benchmarks with export adjustments for changes in actual production. Will change in future (test in 2017)
Banking and borrowing	Expected to allow banking across compliance phases, but not to allow borrowing
Compliance Period	1 year
Number of Entities liable	2,225 approx https://www.argusmedia.com/en/news/2174467-china-to-launch-national-emissions-trading-scheme http://mee.gov.cn/xxgk2018/xxgk/xxgk03/202012/W020201230736907682380.pdf

3. Voluntary carbon market since 2005

Voluntary carbon market size by value of traded carbon credits, pre-2005 to 21 Dec 2021



State of the Voluntary Carbon Market 2022, Q3

<https://www.ecosystemmarketplace.com/carbon-markets/>

- Cumulative Market Volume Tops 8 Billion \$
- Annual value tops 1.98 Bn in 2021
- Corporate pledges keep Voluntary Markets going

Voluntary carbon market transaction volumes, prices and values by category 2020-21

	2020			2021		
	VOLUME (MtCO2e)	PRICE (USD)	VALUE (USD)	VOLUME (MtCO2e)	PRICE (USD)	VALUE (USD)
FORESTRY AND LAND USE	57.8M	\$5.40	\$315.4M	227.7M	\$5.80	\$1,327.5M
RENEWABLE ENERGY	93.8M	\$1.08	\$101.5M	211.4M	\$2.26	\$479.1M
CHEMICAL PROCESSES / INDUSTRIAL MANUFACTURING	1.8M	\$2.15	\$3.9M	17.3M	\$3.12	\$53.9M
WASTE DISPOSAL	8.5M	\$2.69	\$22.8M	11.4M	\$3.62	\$41.2M
ENERGY EFFICIENCY / FUEL SWITCHING	30.9M	\$0.98	\$30.4M	10.9M	\$1.99	\$21.9M
HOUSEHOLD / COMMUNITY DEVICES	8.3M	\$4.34	\$36.2M	8.0M	\$5.36	\$43.3M
TRANSPORTATION	1.1M	\$0.64	\$0.7M	5.4M	\$1.16	\$6.3M
AGRICULTURE	0.5M	\$10.38	\$4.7M	1.0M	\$8.81	\$8.7M

State of the Voluntary Carbon Market 2022, Q3

<https://www.ecosystemmarketplace.com/carbon-markets/>

Why firms and individual engaged in voluntary market?

- Global good- Philanthropy
- Green image/branding through off-sets of their own emissions- corporate social responsibility, ethics, reputation, supply chain risk
- Risk management (preemptive strategies)- so that they will not be subjected to stringent compliance market
- As a preparation for entering into regulatory market formally (pre-compliance)

Voluntary Carbon Market Standards

All voluntary standards require that offsets be:

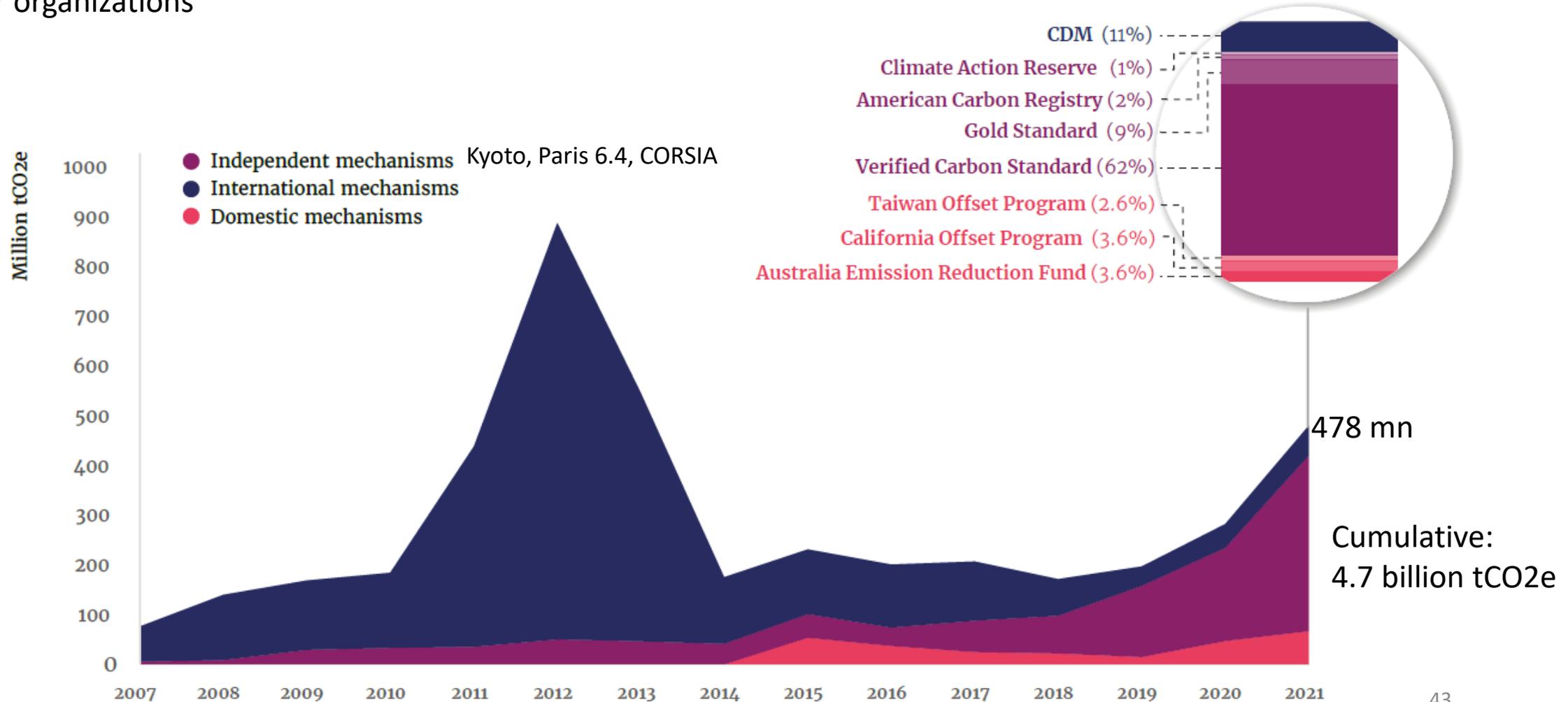
- **Real:** there has to be evidence that the project actually removed or prevented emissions;
 - **Additional:** the emissions reductions would not have occurred without those project activities;
 - **Measurable:** the volume of emissions reductions can be accurately measured; a
 - **Verifiable:** a neutral, third-party auditor has verified the emissions reductions.
-
- **International standards:** An organization or authority issue certificate who specify a clear standard to be meet to receive Carbon Offset Certificate
 - **Over ten independent standards exist** that offer methodologies to guide development of carbon offset project
 - **Standardization** of methodology, verification, tracking (registry) are extremely important to buyers and sellers
 - Somebody has to 'issue' the credit certification with unique identifier
 - **The 'offset' has to be marked 'retire' in registry if purchaser claim their own carbon offset**

Global volume of issuances by crediting mechanism category

Demand derives from a range of compliance obligations established under international agreements and national laws, as well as voluntary commitments adopted by companies, governments, and other organizations

Market

- International compliance markets
- Domestic compliance markets
- Results-based finance
- Voluntary carbon market



4. CORSIA-ICAO Market/IMO

CORSIA

- **Carbon Offsetting and Reduction Scheme for International Aviation:** At the 39th Assembly (Oct 2016) of the International Civil Aviation Organization (ICAO) adopted the CORSIA. As of 1 January 2023, 115 states have announced their intention to participate in CORSIA.
 - Stabilize net emissions from international aviation at 2020 levels
 - Pilot phase (2021-2023), phase 1 (2024-2026) and phase 2 (2027-2035)
- CORSIA has the potential to generate demand for around 2.5 gigatons of CO₂e offset between 2021 and 2035

International Maritime Organization (IMO)

- **April 13, 2018:** The International Maritime Organization's Marine Environment Protection Committee adopted an initial strategy to reduce GHG emissions from international shipping. International shipping represented 740 mntCO₂ in 2018
- **The strategy:** Peaking GHG emissions from the sector as soon as possible, a reduction of annual GHG emissions by at least 50 percent by 2050 compared to 2008, while at the same time pursuing efforts toward full decarbonization
- **IMO adopted global data collection system** for fuel consumption for ships from October 2016, which entered into force in March 2018.

<https://www.imo.org/en/ourwork/environment/pages/ghg-emissions.aspx>

Carbon Market Prices of CORSIA-eligible Emissions Units Transactions by Project Category¹



Project Category ³	2020 ² Prices (in USD/tCO ₂ eq)		2021 ² Prices (in USD/tCO ₂ eq)	
	Weighted Average	Spread Between Min & Max	Weighted Average	Spread Between Min & Max
Energy Efficiency /Fuel Switching	<i>See Other</i> ³	<i>See Other</i> ³	2.52	14.01
Forestry and Land Use	9.35	17.70	11.76	16.00
Renewable Energy	1.28	18.94	1.19	18.06
Waste Disposal	<i>See Other</i> ³	<i>See Other</i> ³	20.67	45.40
Other ⁴	4.25	44.79	18.92	15.32
<i>All Categories</i>	<i>4.89</i>	<i>46.94</i>	<i>3.08</i>	<i>46.94</i>

¹ Transactions included here must have had a unique Project ID assigned by the corresponding carbon standard's registry

² For 2020: 1 January – 31 December; for 2021: 1 January – 5 November

³ EM Data on specific Project Categories is published only if there are at least three EM Respondents per category; otherwise, data is included under Other.

⁴ Other includes Agriculture and Household Devices (for 2020 it also includes Energy Efficiency/Fuel Switching and Waste Disposal) - details on each Project Category definition are available on the EM website.

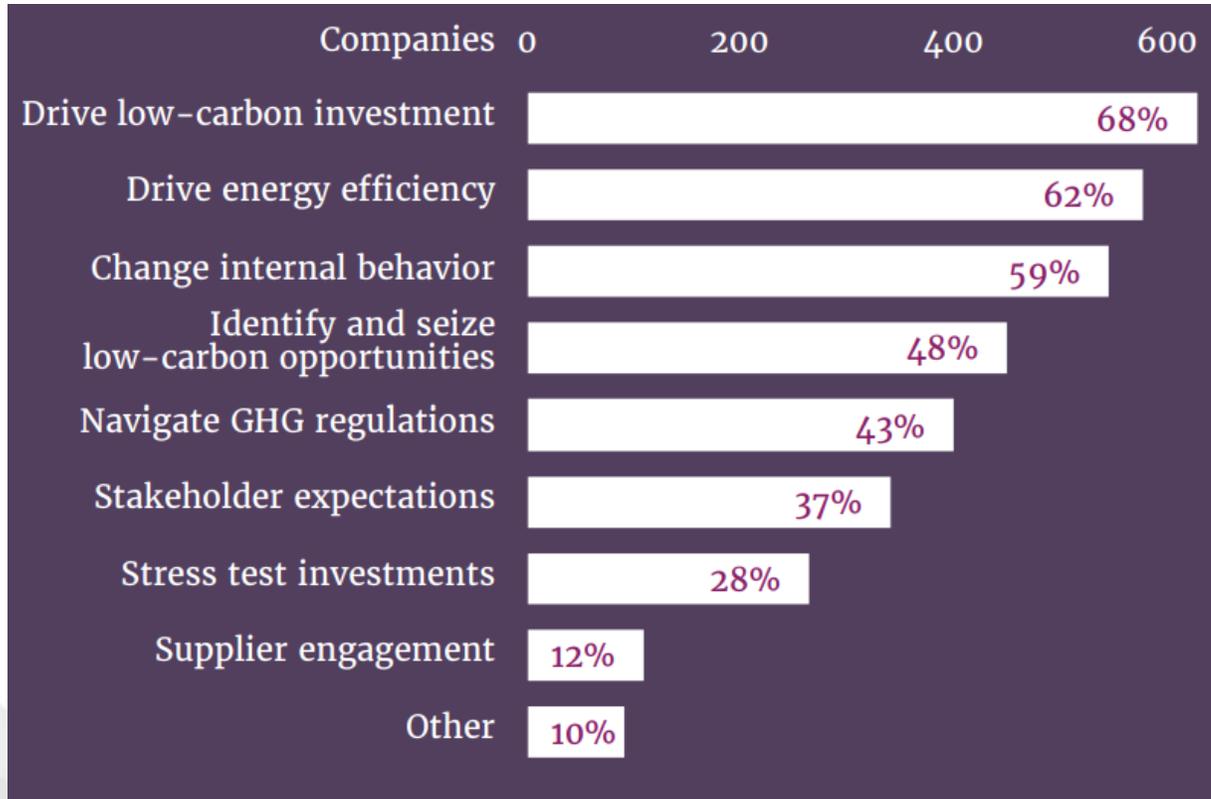
Data from American Carbon Registry (ACR), Clean Development Mechanism (CDM), Climate Action Reserve (CAR), Gold Standard (GS), and Verra
<https://www.ecosystemmarketplace.com/articles/now-available-corsia-eligible-carbon-market-data-from-ecosystem-marketplacecao-environment-corsia-newsletter/>

Joint Crediting Mechanism (JCM/BOCM) Japan

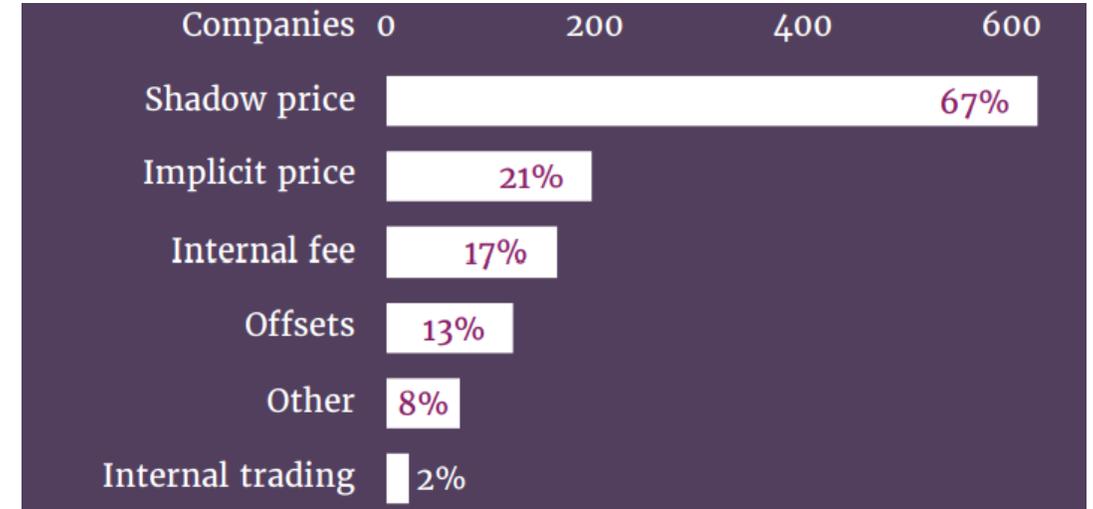
- Compliments CDM as Japan is out from 2nd Kyoto period, and Paris Agreement Article 6.2
- Signed bilateral document with 25 countries
- Japan invests/provides low-carbon technology/products/service etc in emissions reduction projects/programs and get GHG offsets credits (similar to CDM)
- Started as non-tradable credits but with trading possibilities
- Total 227 projects registered and operating and are at various stages (as of Nov 2022)
 - <http://gec.jp/jcm/about/>
- 40 projects in 11 countries have already issued credits and shared with host country and Japan (Indonesia, Thailand, Mongolia, Vietnam, Palau, Kenya, Cambodia, Saudi Arabia, Maldives, Bangladesh, Lao) – as of December 2022

5. Carbon Insetting in Corporate Sector – Internal Carbon Pricing (ICP)

State and Trends of Carbon Pricing 2022, The World Bank, Washington DC



Type of ICP



- Shadow price – Goal-based
- Implicit price: Based on company's spending to cut carbon emissions on projects like renewable energy and/or costs of complying to government regulations
- Majority remain below the USD 50-100/tCO₂e → out of 950 companies disclosed to CDP, 68% at USD 50/tCO₂e or below; 18% between USD 50 and USD 100/tCO₂e; fewer than 100 companies over USD 100/tCO₂e

Motivation for implementing an internal carbon price by corporate sector

Internal carbon pricing type and amount

Price type	Median price per tonne (US\$)
Implicit price	\$27
Internal fee	\$18
Internal trading	\$27
Offsets	\$6
Shadow price	\$28

Shadow pricing is most common pricing type with highest median value price

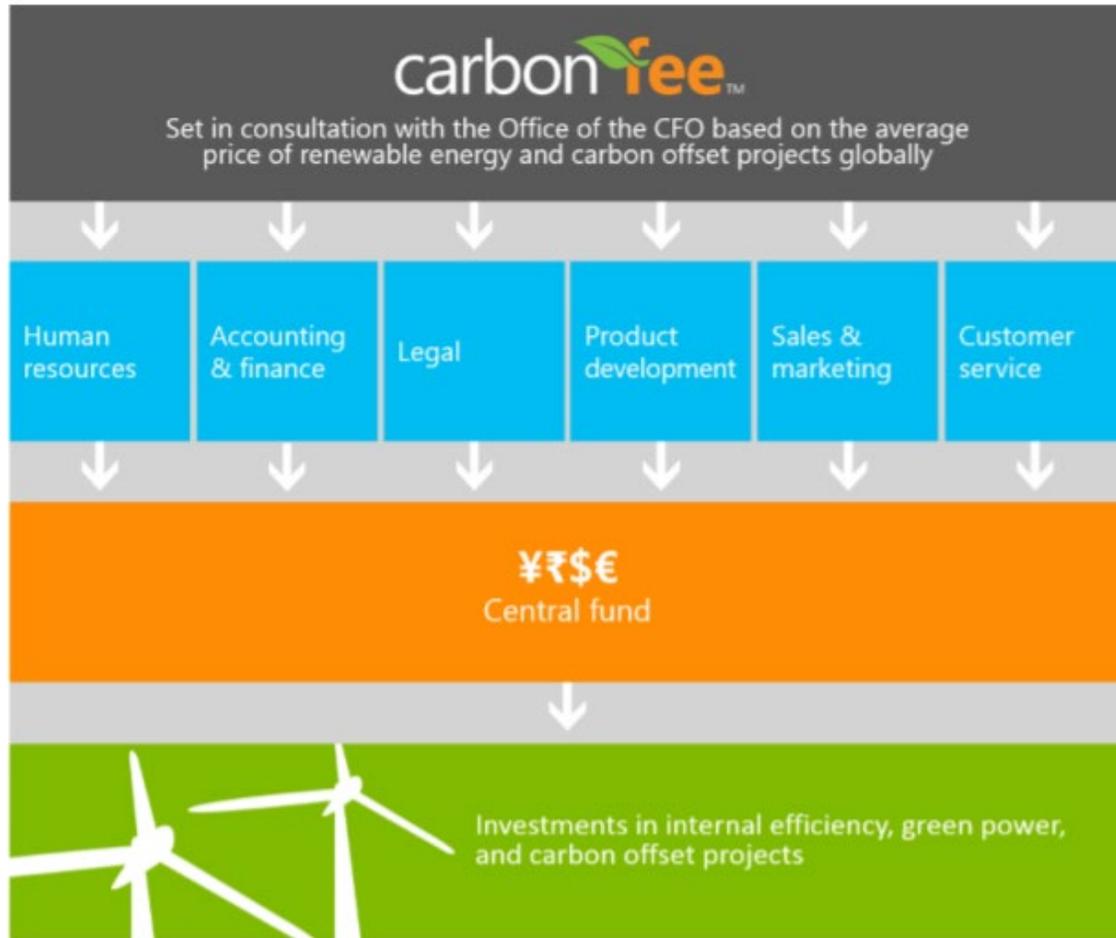
- **Shadow price** mechanism sets a hypothetical carbon cost to identify climate risks and opportunities. They are used in investment decisions, but no actual financial flows are generated – can also be used in R&D and procurement decisions
- **Internal fee** results actual financial flows – affects operational decisions. Moreover, revenue from fee can be used for low-carbon fund or be re-distributed to promote low carbon practices (Microsoft)
- **Implicit prices** are derived from investment-needs to achieve certain climate- or energy-energy targets ex-post and uses this value as a benchmark to guide future development

Industry	Median Price USD
Apparel	\$82
Biotech, health care & pharma	\$43
Financial Services	\$17
Food, beverage & agriculture	\$28
Fossil Fuels	\$28
Hospitality	\$16
Infrastructure	\$35
Manufacturing	\$28
Materials	\$28
Other services	\$20
Power generation	\$23
Retail	\$23
Transportation services	\$20

https://cdn.cdp.net/cdp-production/cms/reports/documents/000/005/651/original/CDP_Global_Carbon_Price_report_2021.pdf

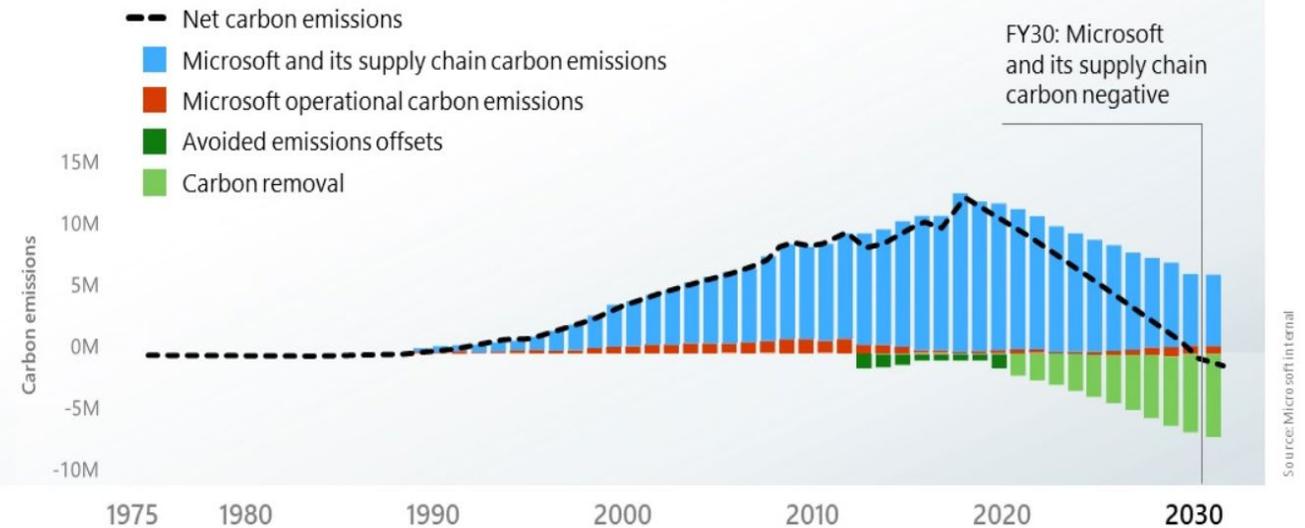
CDP_Global_Carbon_Price_report_2021

Microsoft



Microsoft's pathway to carbon negative by 2030

Annual carbon emissions



<https://www.microsoft.com/en-us/environment/carbon/our-approach>
<https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/>

<https://www.c2es.org/site/assets/uploads/2017/09/business-pricing-carbon.pdf>

6. Carbon pricing in Paris Agreement

- **Article 6 'rule book' of the Paris Agreement completed in COP-26 in Nov 2021:** Parties can voluntarily cooperate on the implementation of their NDCs to facilitate their ambitions in mitigation and adaptation actions.
 - Article 6.2 sets guideline and robust accounting framework for internationally transferred mitigation outcomes (ITMOs)
 - The operationalization of the mechanisms under Article 6 is key for enabling carbon pricing. See Article 6.4 decision in COP26 → <https://unfccc.int/documents/309980>
- Article 6.4 starts a new multilateral mechanism similar(?) to former Clean Development Mechanism in Supervisory Board to approve 6.4 projects—while potentially allowing some technical flexibility (possibly simplifies methodological complexity of CDM)
- A recent study showed that ITMO transfer and the growth in carbon prices can drive a significant increase in financial flows and the market value could exceed \$1 trillion (2015 US\$) per year in 2050 https://www.ieta.org/resources/Resources/Net-Zero/Final_Net-zero_A6_working_paper.pdf

For more discussions on completed Rulebook for Article 6, please see here
<https://www.iisd.org/articles/paris-agreement-article-6-rules>

Key Takeways

- Pricing carbon is key for transformative change – that realization are building up, and on multiple fronts
- Carbon Market are evolving in many new ways despite that it might not be as fast as we want
- The design features of ETS markets are getting more sophisticated
- The price of carbon in these markets are yet low but slowing building on
- Post Paris Agreements developments are key

Thank you

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