

Introduction to Permit Trading

- Tradable permits work by addressing the *property rights* problem
 - Permits give a firm a property right to emit a certain level of a pollutant, but no more
 - A firm needs to obtain the right to exceed the limit by purchasing more permits
 - If the firm does not want to use all of its permits, it can sell them to someone else

Introduction to Permit Trading

- Two types of trading programs:
 - Credit trading programs
 - Firms can sell credits generated by reducing emissions more than required
 - Offset programs are an example
 - Cap-and-trade programs
 - Government makes a centralized decision as to how much pollution is allowed, then distributes permits to all participants

Introduction to Permit Trading

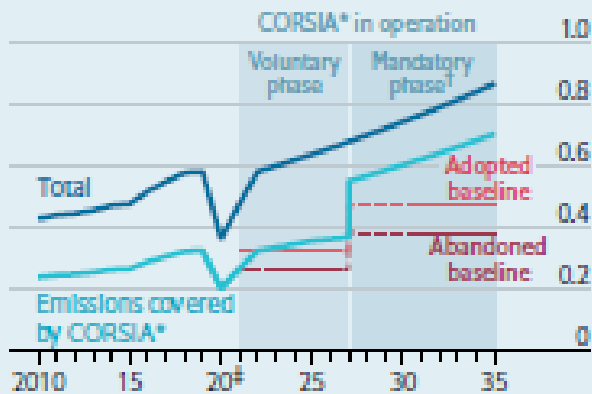
- How permits work:
 1. Government begins by setting the desired level of emissions
 - Thus, like command and control policies, the government has control over the final amount of pollution
 2. Firms are issued permits to emit pollutants
 - Only the desired number of permits is issued
 - Thus, the amount of pollution is assured
 3. Firms can buy and sell permits
 - Firms with higher MAC will be willing to buy permits from firms with lower MAC

Implementation Issues

- Initial allocation of permits
 - Auction permits to highest bidder
 - At least initially, additional trading shouldn't be needed, as permits go to firms willing to pay the most
 - Raises revenue for the government
 - Equal distribution among firms
 - May seem fairer, but what if firms are of different sizes.
 - Historical emissions rates (more permits to bigger polluters).
 - To reduce pollution by 10%, give each firm permits equal to 90% of their current emissions
 - Penalizes early actors. Should firms that have already reduced get fewer permits?
 - CORSIA article is an example: baseline year matters

Coarse correction

CO₂ emissions from international aviation
Estimated, tonnes bn



*Carbon Offsetting and Reduction Scheme for International Aviation [†]From 2027 CORSIA is mandatory for most countries, increasing the covered emissions [‡]Forecasts use a central scenario for the pace of airlines' recovery

Source: International Council on Clean Transportation

Source: "Selling a new CORSIA," *The Economist*, July 4, 2020, 57-58.

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 - CORSIA article is an example: baseline year matters
- Combined systems are possible (e.g. hold back some permits for auction)

Implementation Issues

- Initial allocation of permits
 - If the market is competitive, the market should yield an efficient solution no matter what the initial allocation
 - However, the effects on individual firms (e.g. who benefits by selling permits, versus needing to buy them), will be different

Implementation Issues

- Establishing trading rules
 - For a market to work, transactions costs must be low
 - However, at the same time, monitoring and enforcement will be necessary
 - Need to track both emissions and the number of permits each firm has
 - Are offsets allowed?
 - Usually have higher transaction costs
 - Should offsets with other geographic jurisdictions be allowed?
 - Who should be able to participate?
 - Should environmental groups or private individuals be able to buy permits and then not use them?
 - Which firms participate?
 - The EU-ETS, discussed later, illustrates the importance of these decisions

Implementation Issues

- Interaction with other policies
 - Because there is a hard cap, other policies that affect emissions may lower permit prices
 - E.g. in the EU-ETS, if an individual country adds additional regulations (e.g. UK carbon tax), demand for permits falls
 - Because supply is fixed, the price falls, but emissions do not change
 - This is known as the “waterbed” effect
 - Can address the waterbed effect by adding a price floor
 - If prices cannot fall below the price floor, emissions fall instead. Some permits go unused.

Implementation Issues

- Geographic considerations:
 - For some types of pollution (e.g. CO₂), where it is emitted doesn't matter
 - For others, (e.g. carbon monoxide in a city), location does matter
 - A tax system would deal with this by charging higher fees in areas where pollution is a bigger concern

Implementation Issues

- Ways for permit system to deal with geographic concerns:
 - Ambient-based permit system: permits needed for pollution as measured at each receptor
 - E.g. a firm downwind might need to buy two permits from a firm upwind to be able to emit one unit of pollution

Implementation Issues

- Ways for permit system to deal with geographic concerns:
 - Ambient-based permit system: permits needed for pollution as measured at each receptor
 - Limit trading to within regions

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- Ways for permit system to deal with geographic concerns:
 - Ambient-based permit system: permits needed for pollution as measured at each receptor
 - Limit trading to within regions
 - Limits trades to areas where the emissions have the same effect
 - For example, New York State has tried to prohibit NY power plants from selling SO₂ permits to plants in neighboring states
 - The EPA divides the country into two regions (East and West) for NO_x trading
 - However, such rules may prohibit some beneficial trades
 - This also limits competition, which might keep the market from working correctly

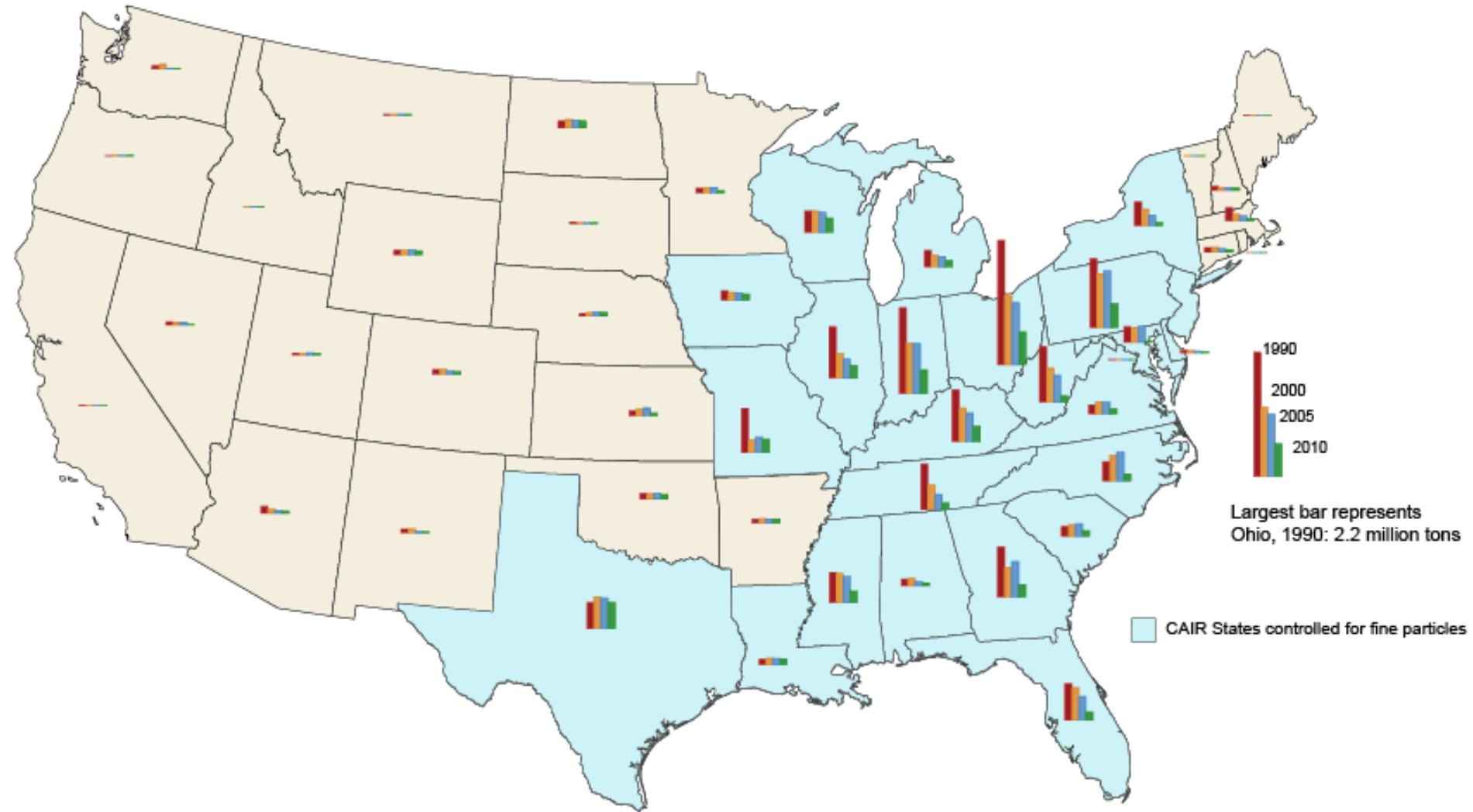
Implementation Issues

- Incentives for innovation
 - The incentives for innovation are the same as with an emissions fee
 - Consider two cases:
 - A firm has enough permits to cover its pollution.
 - The opportunity cost of polluting is that it cannot sell a permit
 - Thus, innovation not only lowers marginal abatement costs, but allows the firm to sell more permits
 - A firm does not have enough permits to cover its pollution
 - The opportunity cost of polluting is that the firm must buy a permit
 - Thus, innovation not only lowers marginal abatement costs, but saves the firm from the need to buy additional permits
 - Remember that innovation need not lower *total* emissions, since the number of permits remains the same

SO₂ Permits: Motivation for 1990 Clean Air Act

- Before the 1990 Clean Air Act, SO₂ and NO_x were only regulated as local pollutants
 - Plants could build large smokestacks to carry emissions away
- Results of the 1970 & 1977 Acts
 - Emissions, and acid rain, remained a problem
 - Because of BACT regulations, firms had incentives to extend lives of units
 - By 1985, 83% of SO₂ emissions came from plants that didn't meet 1971 standards for new units
- Heterogeneity of plants made market solution useful

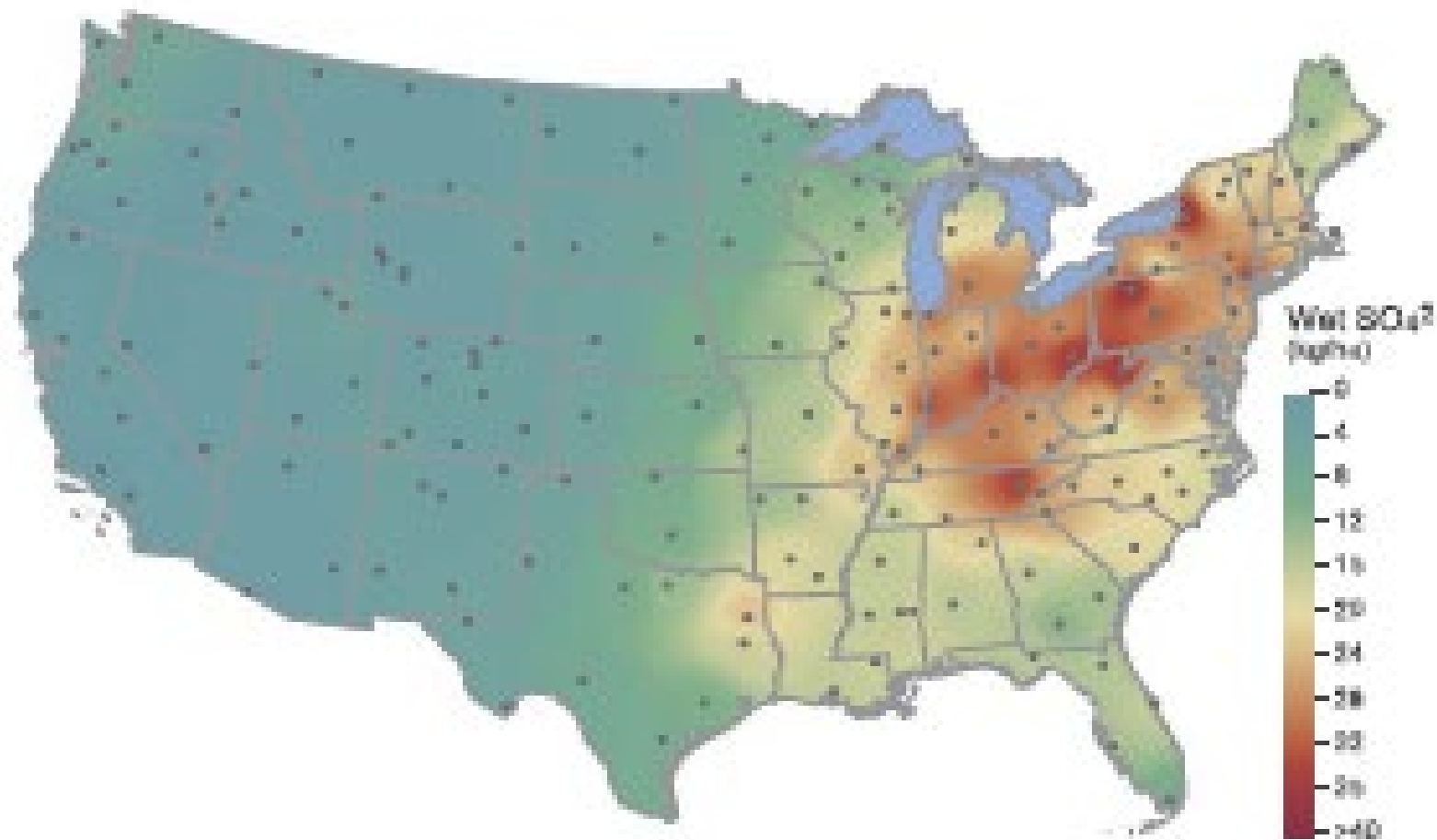
State-by-State Annual SO₂ Emission Levels for CAIR and ARP Sources, 1990–2010



Source: EPA, 2011, http://www.epa.gov/airmarkt/progress/ARPCAIR10_01.html

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Figure 20a: Annual Mean Wet Sulfate Deposition, 1989-1991



Source: National Atmospheric Deposition Program

History of SO₂ regulation in the U.S.

- 1990 Clean Air Act
 - Goal: Reduce emissions by 10 million tons (1/2 of 1980 levels) by 2010
 - Note level set based on possible threshold effect and political goals, not cost-benefit analysis
 - Created a national market
 - Began a system of tradable permits for SO₂
 - Removed individual emissions requirements
 - Initial permits were freely allocated
 - To maximize political support
 - Since most plants were under cost-of-service regulation, cost savings expected to be passed on to consumers

Implementation

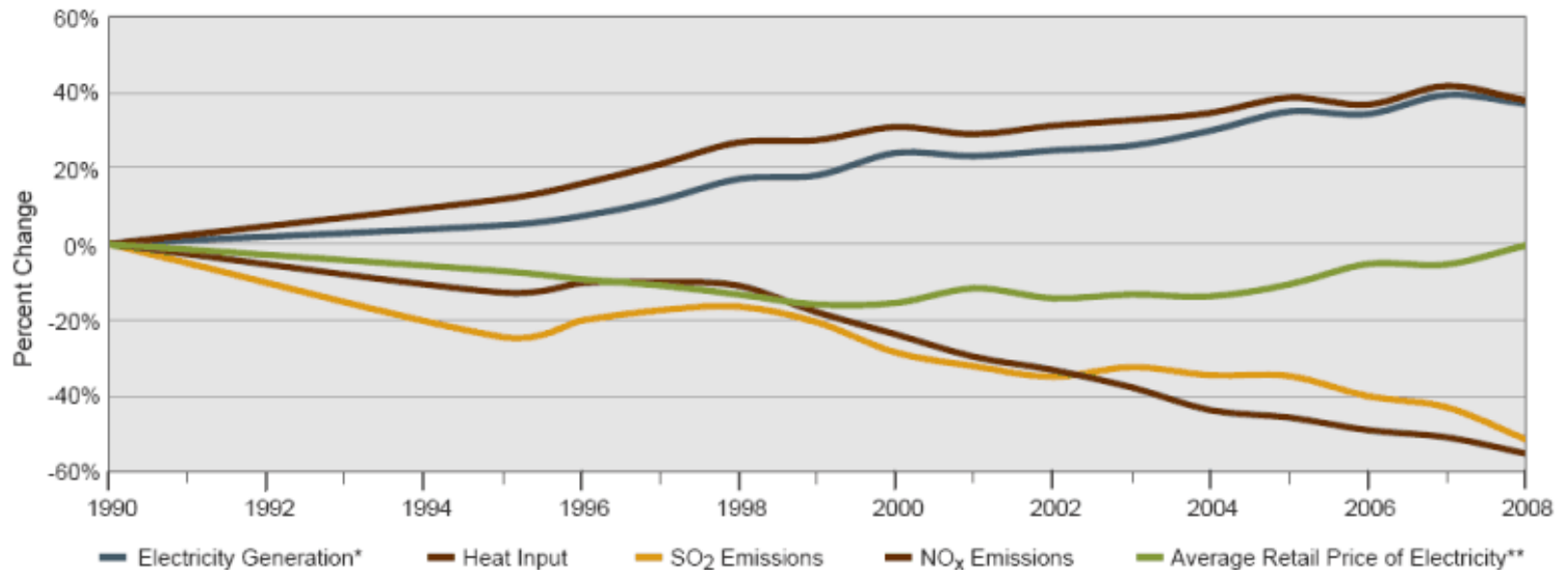
- Phase I (1995-1999)
 - Permits required for the 263 dirtiest plants
 - Permits allocated based on current emission levels
 - 2.8% held back and auctioned
 - Purpose: to stimulate trading
- Phase II (2000+)
 - Limits total SO₂ emissions to 8.95 million tons by 2010
 - Achieved by 2007
 - Permits required of virtually all plants

Monitoring

- Firms use Continuous Emissions Monitoring (CEM) and report data to the EPA
- All trades are recorded by the EPA
- At the end of each year, a firm's total emissions cannot exceed their final allocation of permits
- Initial \$2,000/ton fine for exceeding permits, adjusted for inflation over time

What happened

Trends in Electricity Generation, Fossil Energy Use, Prices, and Emissions from the Electric Power Industry, 1990–2008

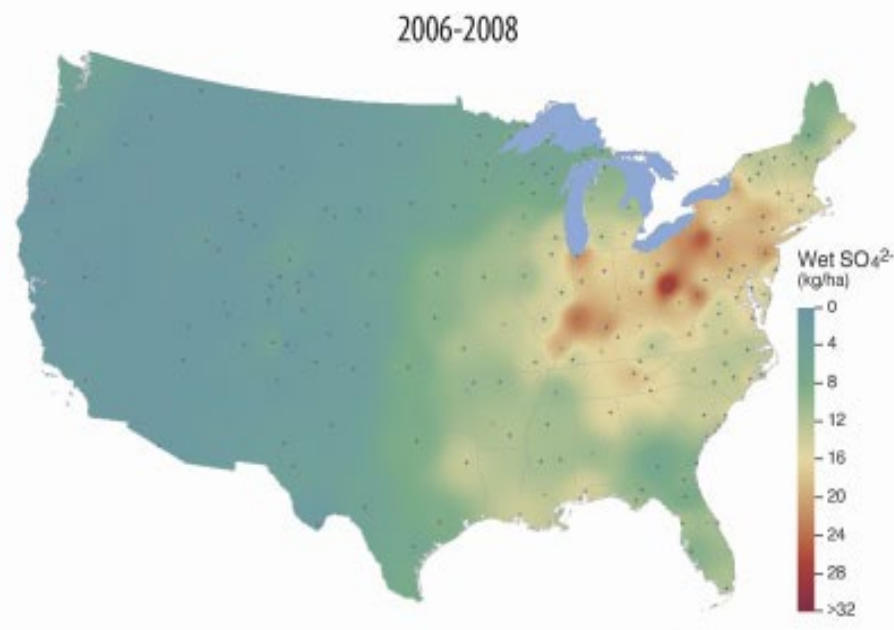
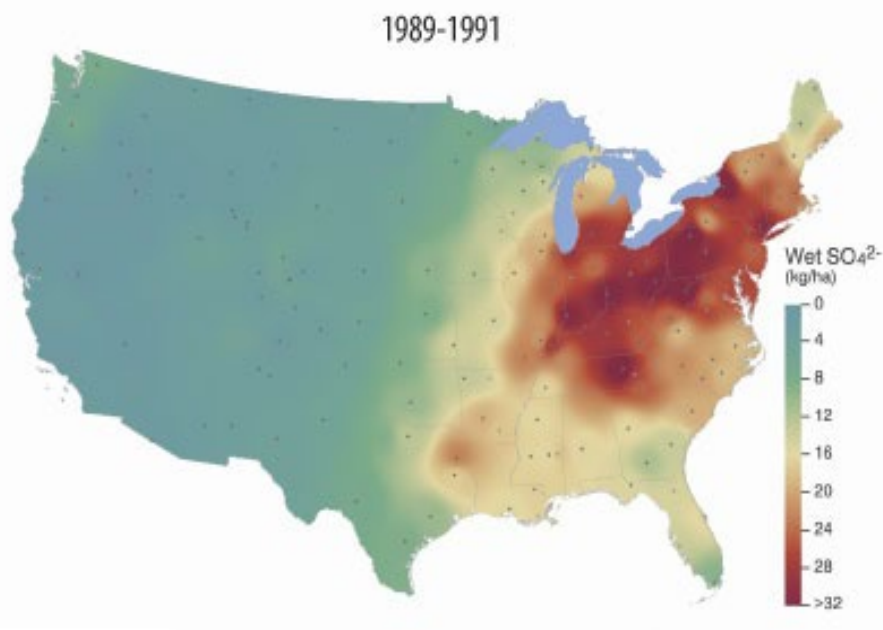


* Generation from fossil fuel-fired plants.

** Constant year 2000 dollars adjusted for inflation.

Source: Energy Information Administration (electricity generation, retail price); EPA (heat input and emissions, representing all affected ARP units), 2009

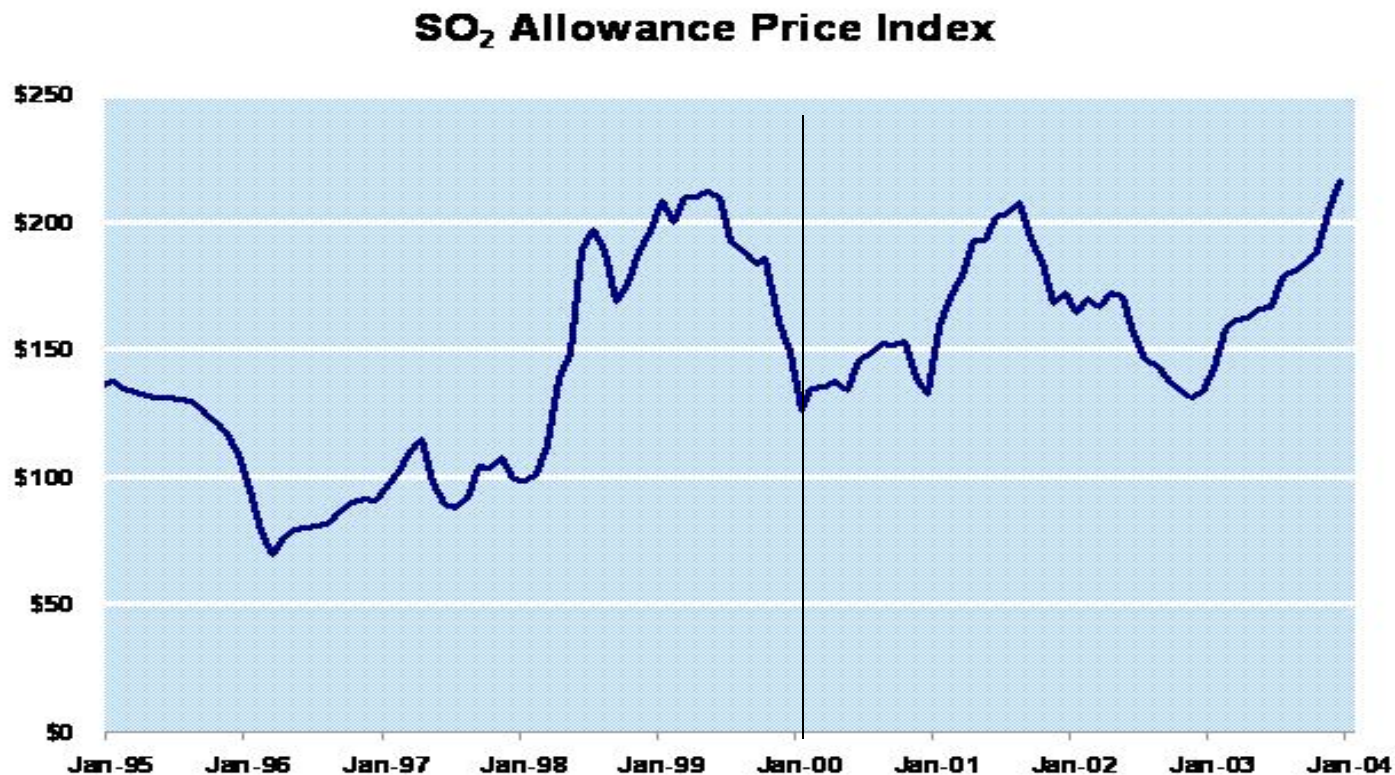
Acid Rain Has Been Reduced



What happened

- The initial price of permits was lower than expected
 - Early projections between \$250-\$500/ton
 - Actual prices:
 - Phase I: \$100-\$150/ton
 - Phase II: Initially around \$215
- Compliance has been excellent

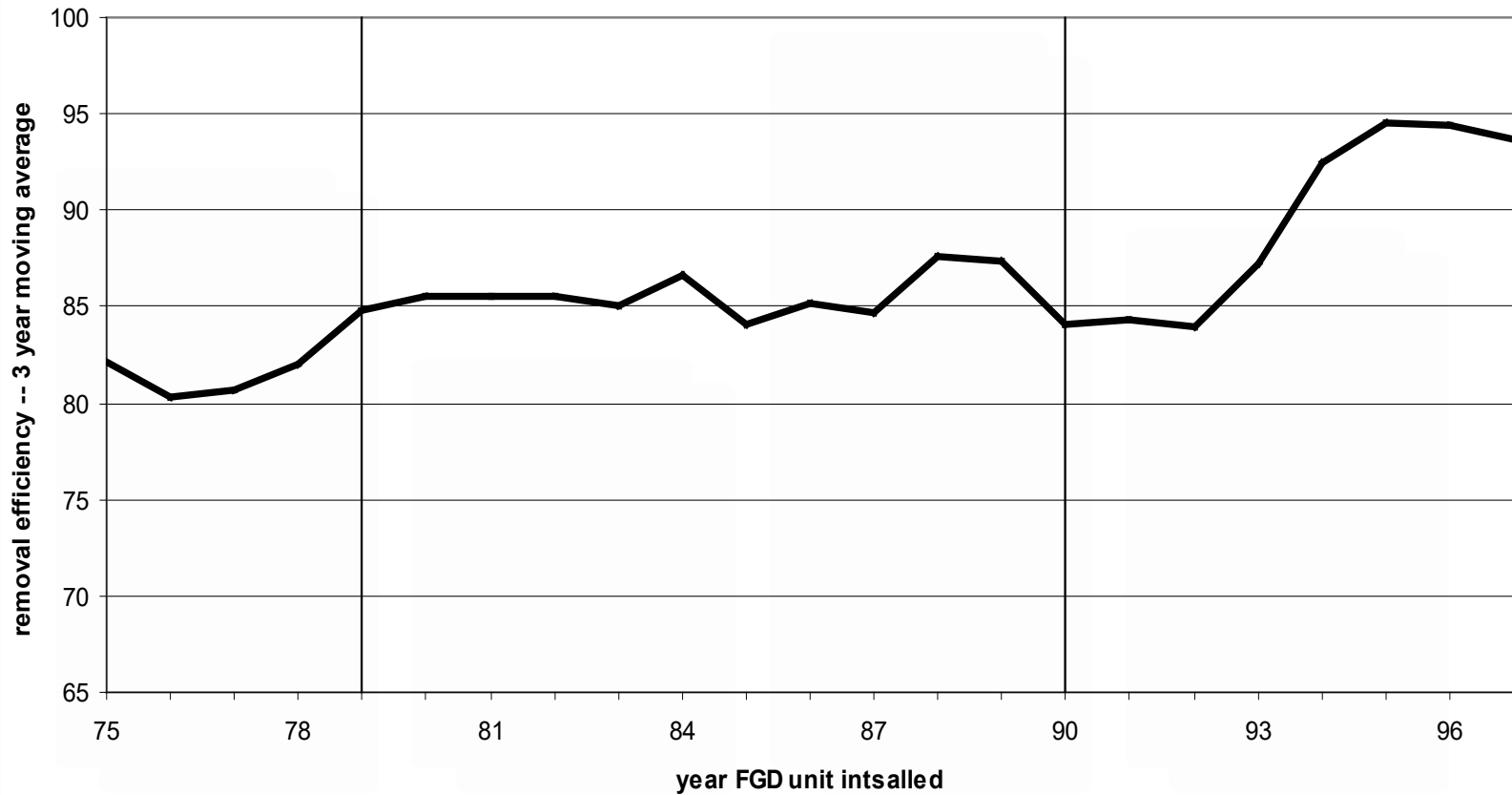
What happened – initial allowance prices



What happened

- Why were initial prices lower than expected?
 - Flexible regulations permitted use of low-sulfur coal
 - Note interaction with other policies
 - At the same time, without policies encouraging scrubber usage, even more switching may have occurred
 - Innovation led to cheaper technologies

Removal efficiency of new scrubbers



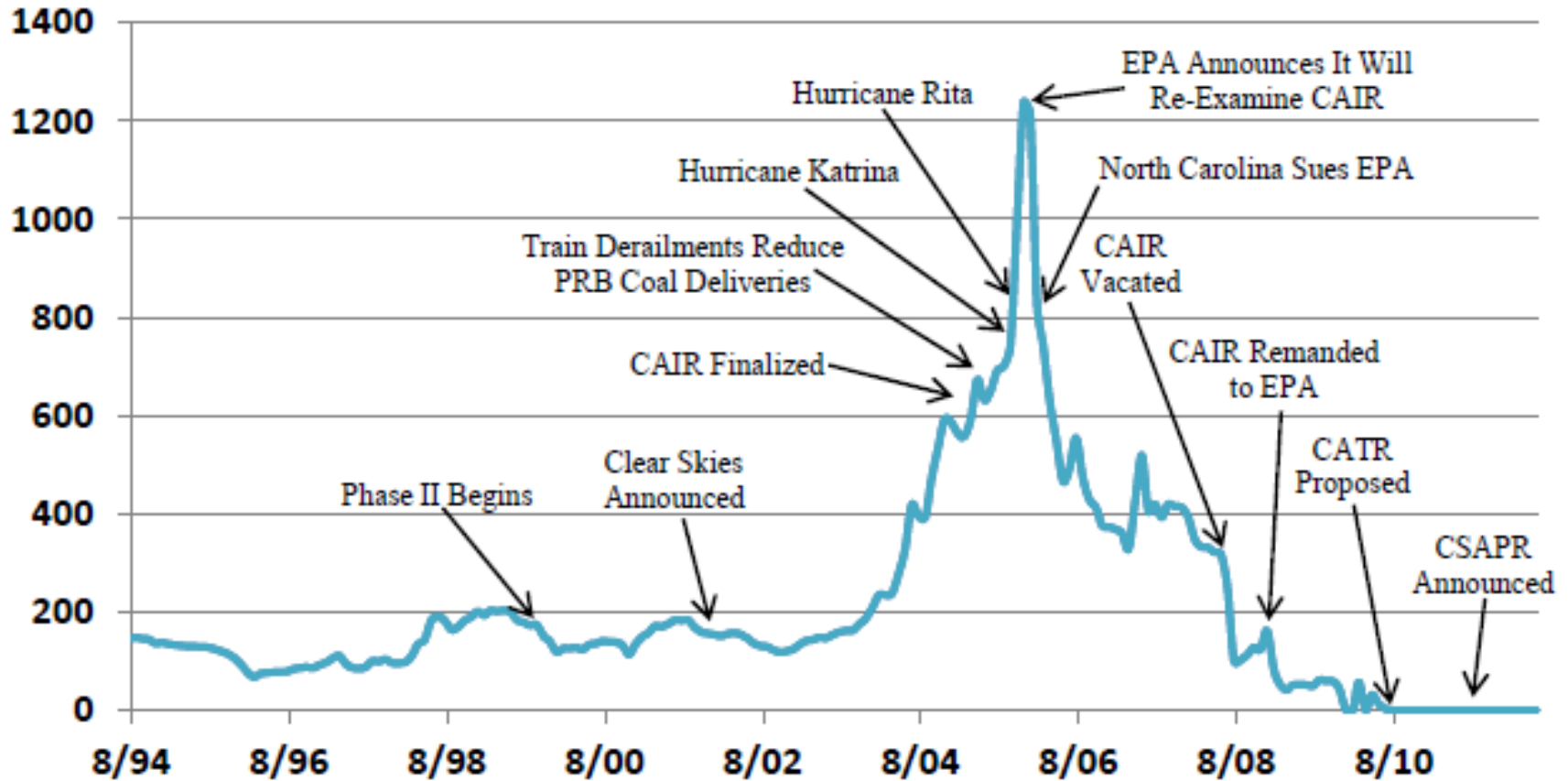
What happened

- Why were prices lower?
 - Flexible regulations permitted use of low-sulfur coal
 - Innovation led to cheaper technologies
- Simulations suggest costs were 15-90% lower than under command and control

What happened

- However, changing regulations led to price spikes and eventual market collapse
 - 2005: Clean Air Interstate Rule (CAIR) proposed lowering SO₂ emission cap 70%
 - Because of banking, permit prices peaked over \$1,200/ton

SO2 Allowance Prices (1995 \$ per ton)

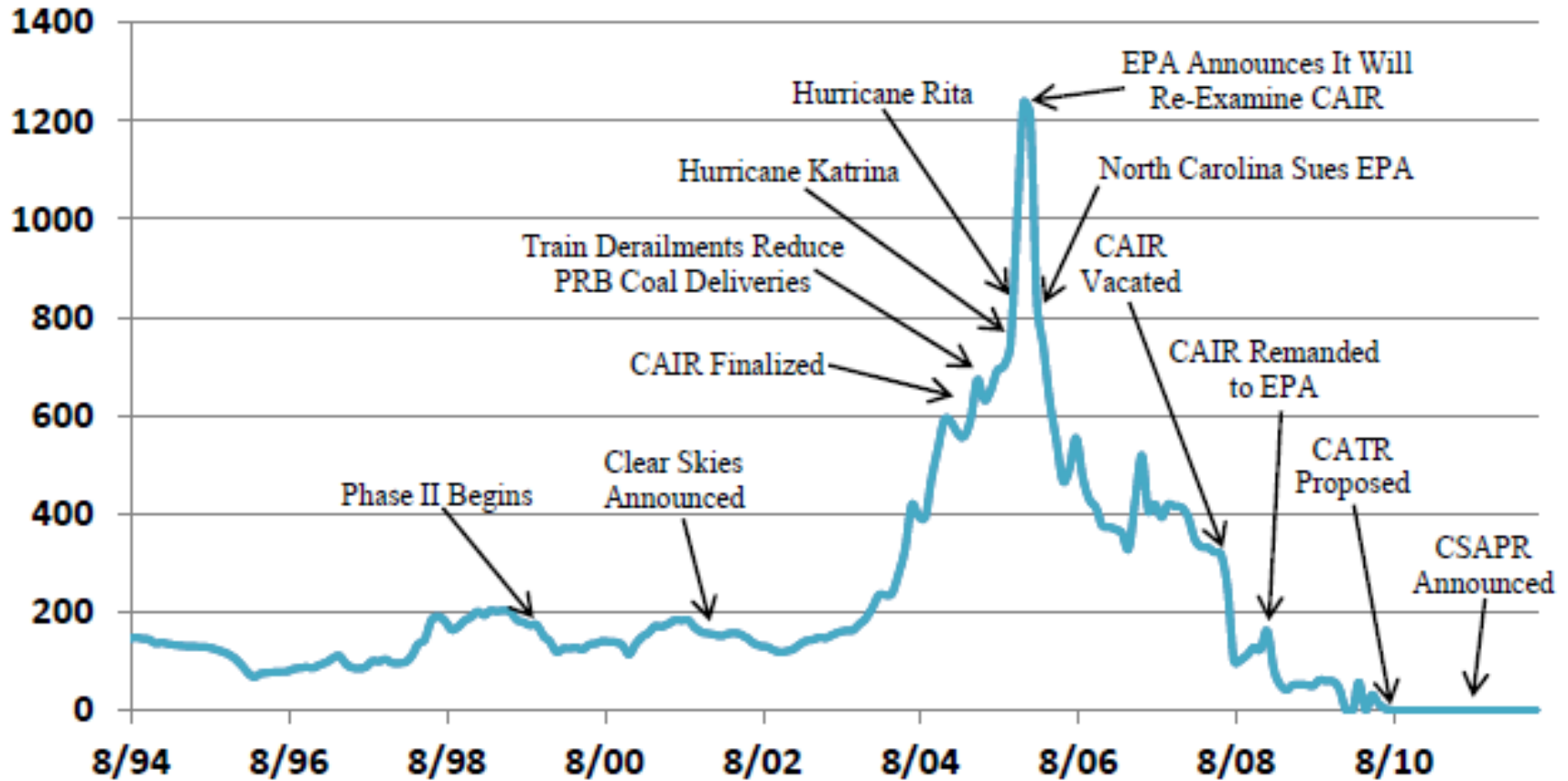


Source: Schmalensee/Stavins (2013)

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 - 2005: Clean Air Interstate Rule (CAIR) proposed lowering SO₂ emission cap 70%
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 - 2008: Circuit Court of Appeals invalidates CAIR and unlimited interstate trading
 - Prices fell from \$315/ton to \$115/ton in a single day

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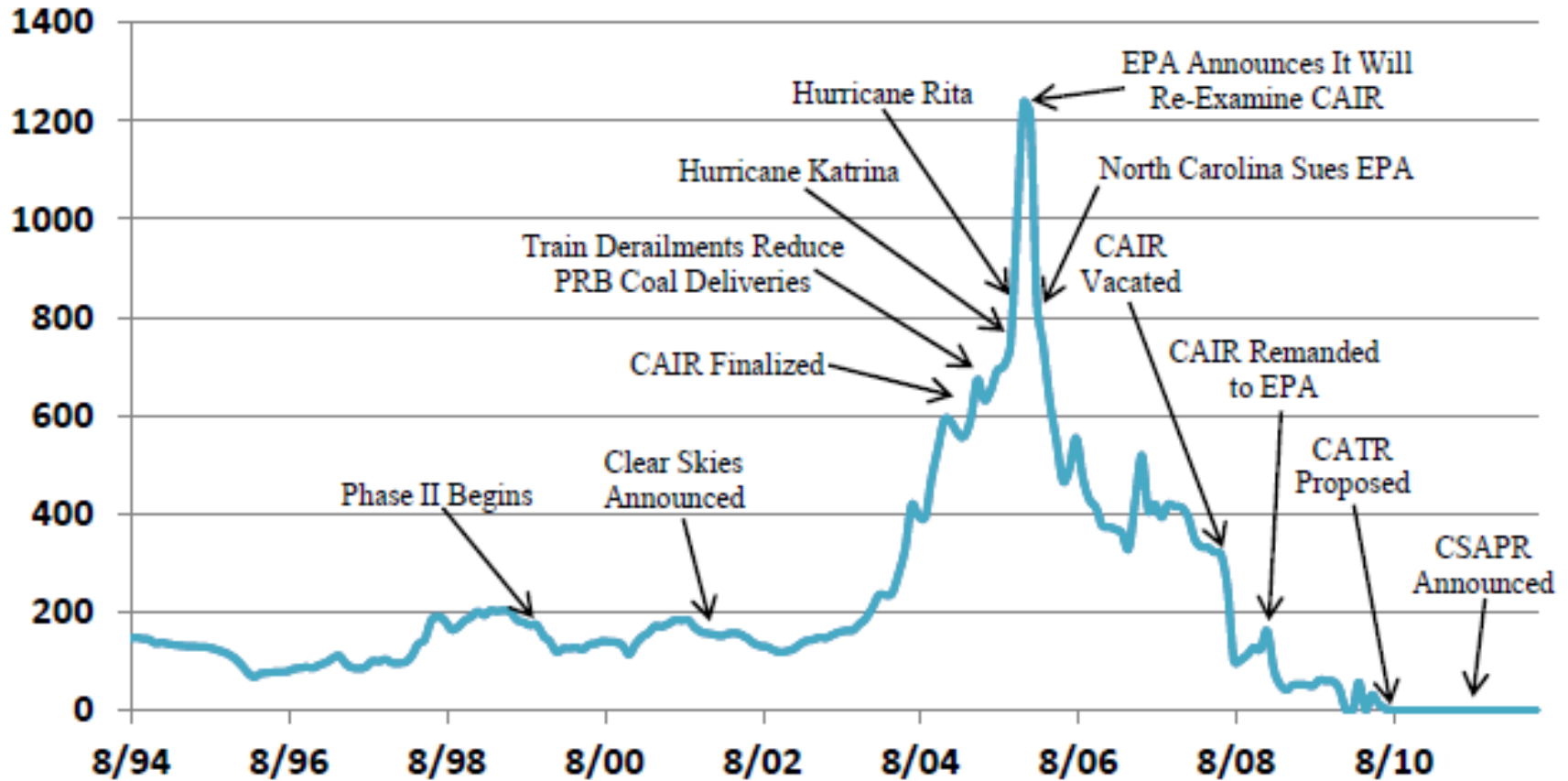


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 - 2012 permit prices are below \$1/ton
 - Cross-State Air Pollution Rule (CSAPR) finalized July 6, 2011. Took effect in 2015 after several court challenges
 - Trading allowed among sources in the same program, but maintains strict emissions ceilings in each state
- Key lesson: What the government creates can be taken away
 - Policy uncertainty becomes a concern!

Permits and Climate Change: EU-ETS

- EU Emissions Trading Scheme (EU-ETS)
 - World's largest carbon market: accounts for nearly 90% of the value of global carbon markets
 - Helps Europe meet its emission reduction goals
 - Started to help the EU meet its commitments from the Kyoto Protocol
 - In July 2021, the European commission devised plans to achieve carbon neutrality by 2050, including a 55% net reduction in GHG emissions by 2030

Permits and Climate Change: EU-ETS

- EU Emissions Trading Scheme (EU-ETS)
 - Based on an overall cap on carbon emissions from Kyoto, the EU sets a national CO₂ emissions limit for each country
 - From this, the EU has specified the industries that will participate in trading
 - Initially, four industries could trade:
 - iron and steel
 - some mineral industries (e.g. cement)
 - energy production
 - pulp and paper
 - Implemented in phases
 - Phase I: 2005-2007
 - Phase II: 2008-2012
 - Phase III: 2013-2020
 - Included more industries and a lower cap
 - More permits to be auctioned
 - Phase IV: 2021+

Permits and Climate Change: EU-ETS

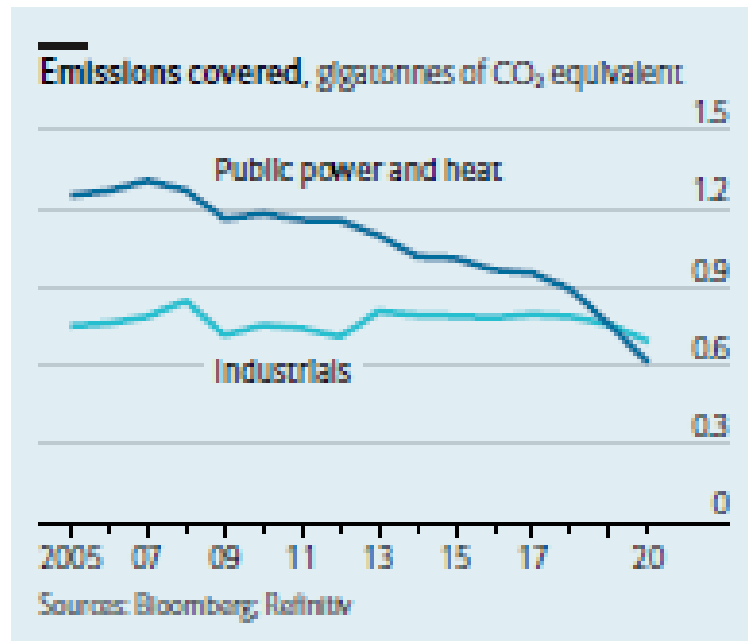
- Control over permits is given to each country
 - Each country gets allowances based on its national cap in Kyoto. It faces two allocation decisions:
 1. Total allowances are spread between the trading & non-trading sector
 2. Permits in the trading sector must be allocated among individual firms.
 - Some permits (initially about 3%) set aside for new entrants
 - Most permits were freely allocated at first
 - Now, more than half are auctioned off
- Makes predicting outcomes hard, as we don't know how many permits will be available for trade
 - Also makes it difficult for an individual country to control emissions from its trading sector, because market prices will be determined by the allocation decisions of all countries
- Countries have incentives to give more allowances to industries that trade goods

Permits and Climate Change: EU-ETS

- Use of offsets
 - Allowed use of Clean Development Mechanism (CDM) projects
 - Disallowed certain project types
 - Supervision by CDM Executive Board
 - As a result, offsets widely used
 - Allowed to cover 11% of emissions
 - CDM credits were even cheaper than ETS allowances

Permits and Climate Change: EU-ETS

- What happened?
 - Overall, emissions were down about 3.4% in 2005, compared to a BAU baseline
 - Electric utility industry did not have enough permits, but other sectors did

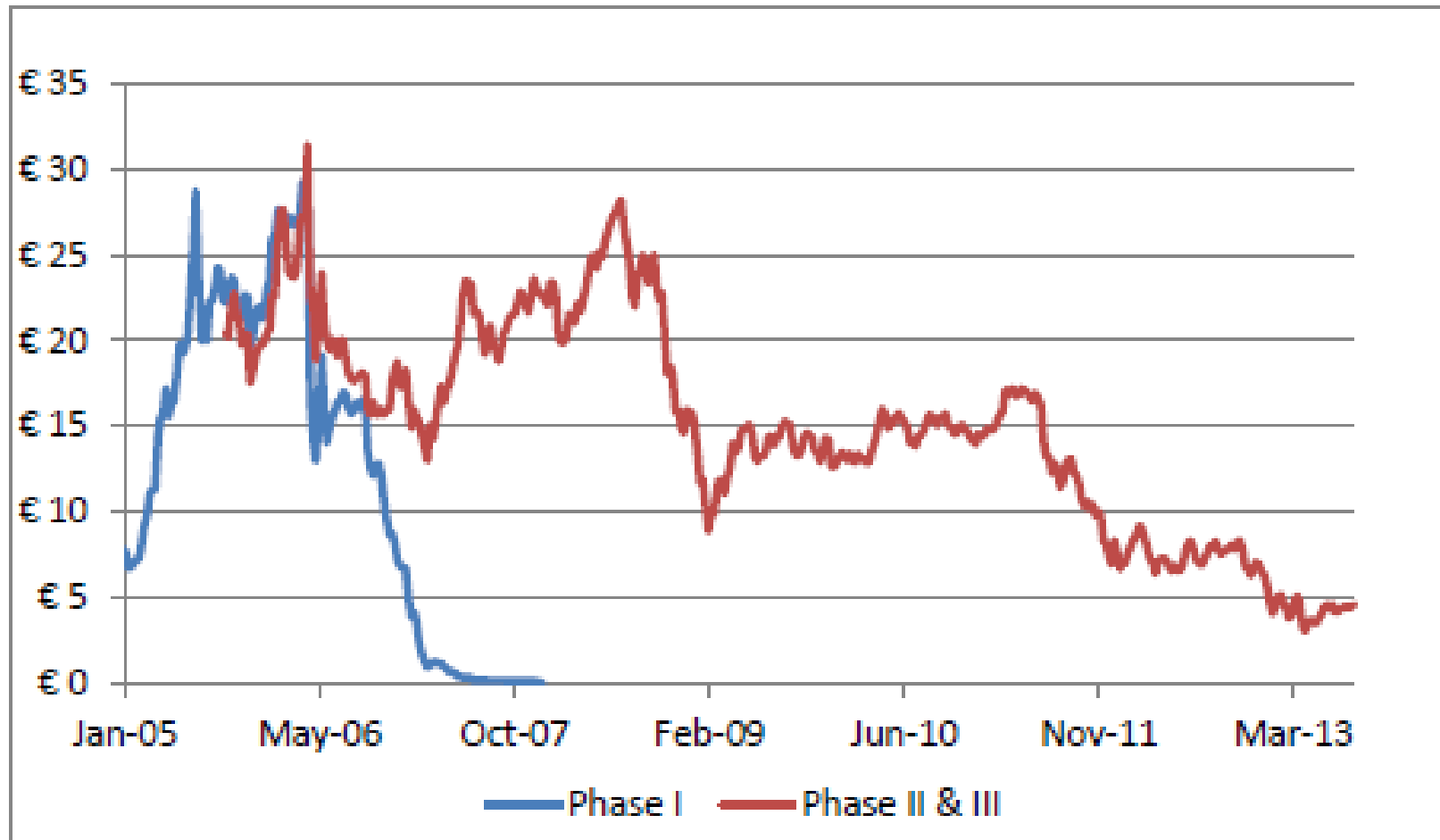


Source: "Coming into its own," *The Economist*, February 27, 2021, 63-64.

Permits and Climate Change: EU-ETS

- But permit prices soon collapsed
 - When EU ETS began on January 1, 2005, price was €8.38
 - By end of 2005, price was €21.10
 - In 2006, data for 2005 revealed that emission reductions were greater than necessary
 - Prices bottomed-out at €8.45 on November 13

Figure 4: Prompt-future Prices for EUA in Phase I and Phase II & III.



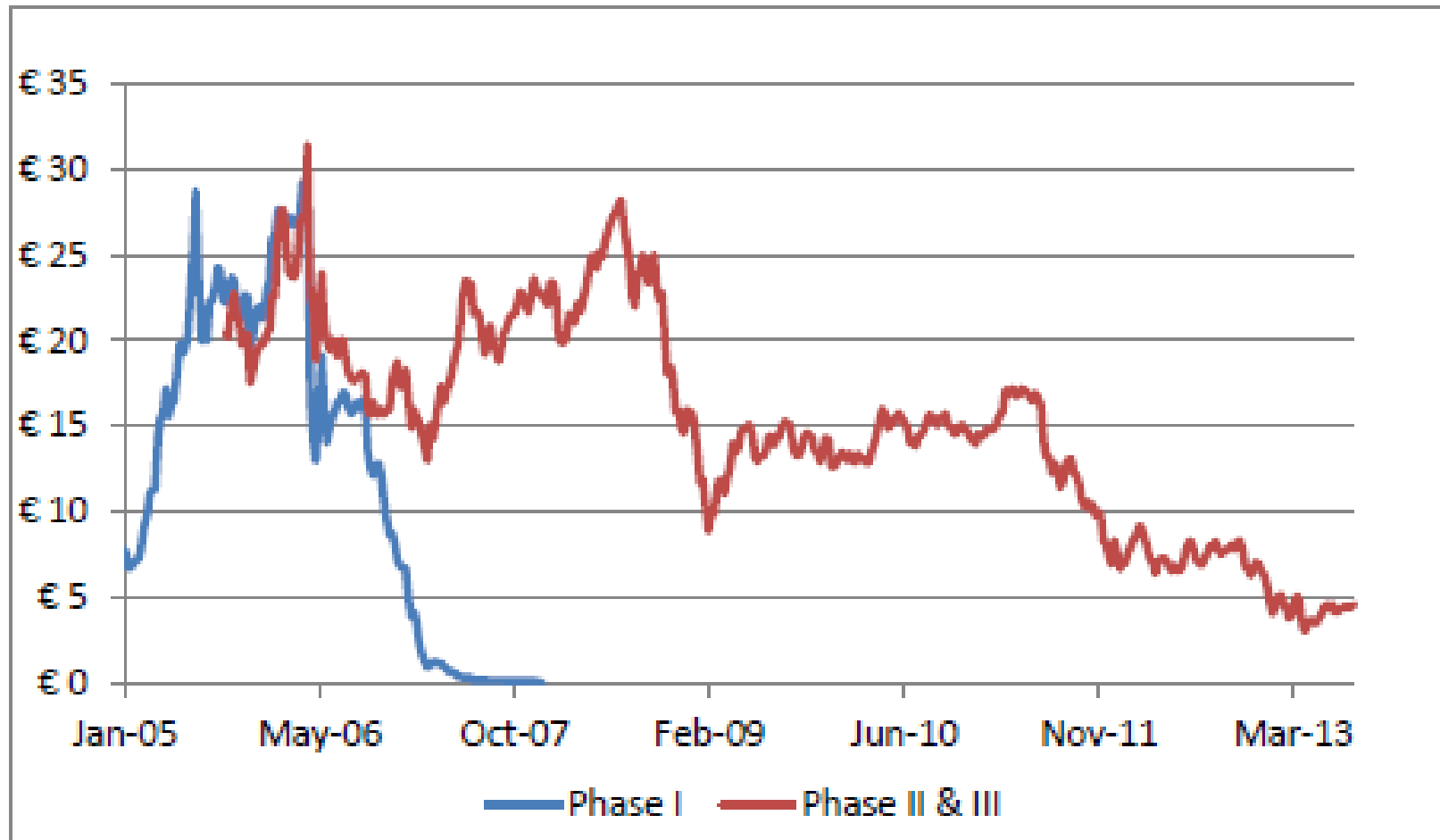
Source: Point Carbon.

Source: Ellerman *et al.* (2014)

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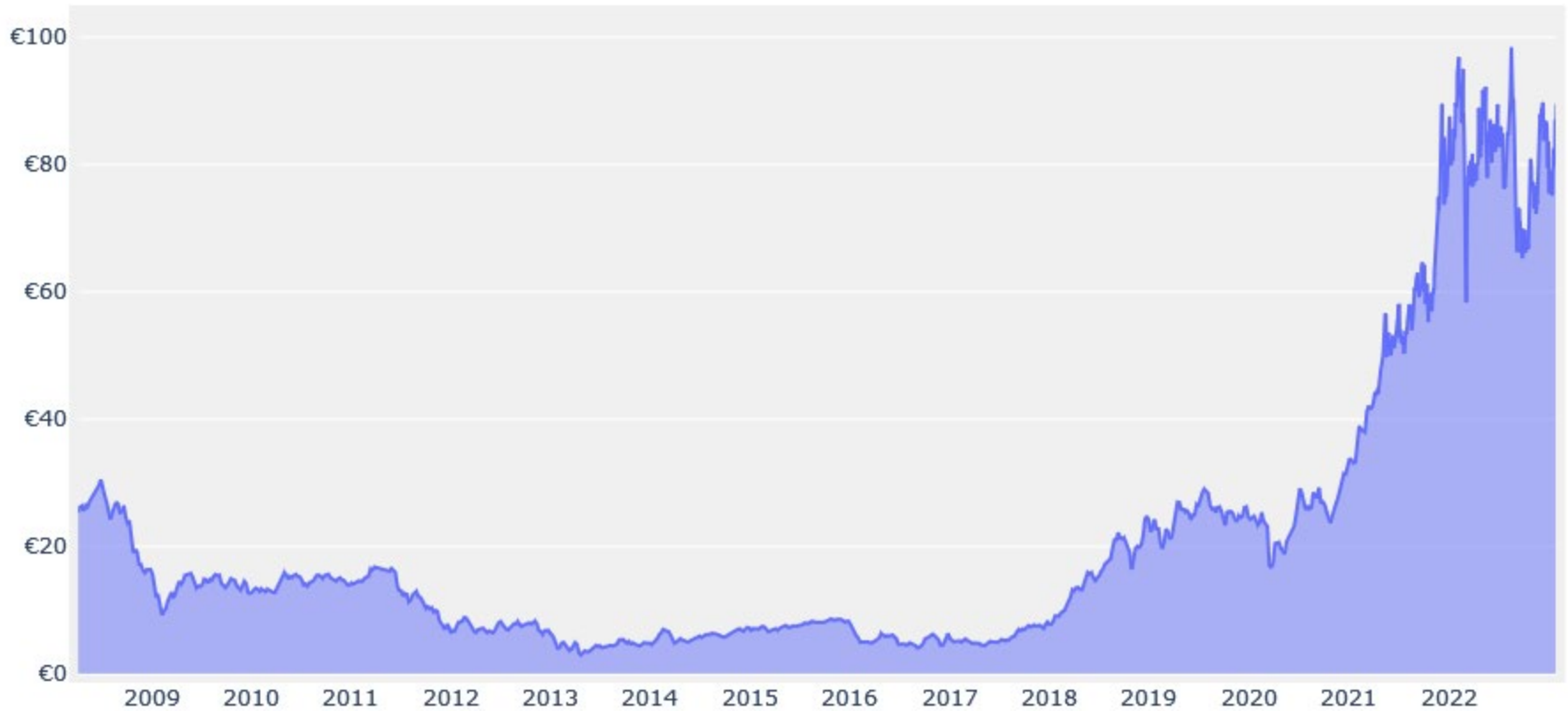
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 - Traded in €5-10 range
 - Phase III, which begin in 2013, includes more industries and a lower cap
 - But didn't lead to higher prices
 - In December 2013, the European Parliament approved a rescue plan for EU-ETS
 - Would delay allocation of a third of new permits scheduled for 2014-16
 - Hoped to drive up price, but little immediate impact as markets anticipated the change. Price still below €4 in 2016
 - Began to grow in early 2018

Permits and Climate Change: EU-ETS

- Phase 4 began in 2021. New rules announced in 2018, Key changes:
 - Cap falls by 2.2% per year. Goal is to reduce emissions 43% compared to 2005 levels
 - Most allowances (57%) now sold at auction
 - Market Stability Reserve (MSR)
 - If total number of allowances in circulation (e.g. banked for future use) exceeds 833 million tons, 24% of the total are withheld in the following year's auction
 - Placed in MSR, which cannot be bought or sold
 - If bank of unused allowances falls below 400 million tons, 100 million allowances will be taken out of MSR and put back into circulation
 - Starting in 2023, MSR cannot exceed previous year's auction volume
 - Any extras are permanently removed from circulation
 - Addresses “waterbed effect”
 - With a firm cap, other reductions simply reduce permit prices
 - MSR reduces, but does not eliminate waterbed effect
 - Prices rose after phase 4 announced
 - Nearly €95 in February 2023

EU-ETS allowance prices

CO2 emission allowance



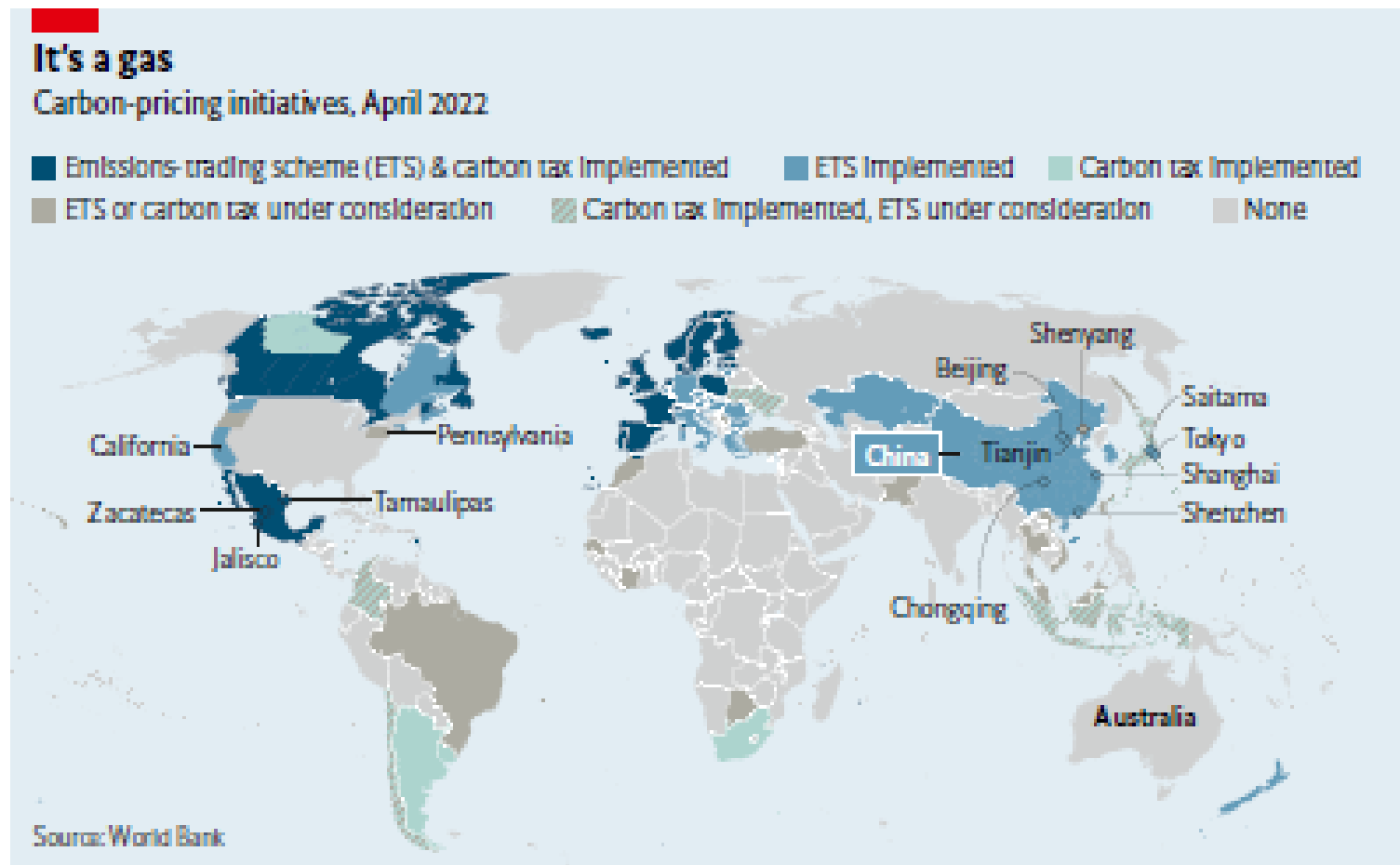
Permits and Climate Change: EU-ETS

- Compare to U.S. SO₂ program:
 - E.U. program larger
 - Around 11,500 sources, compared to about 3,000 in U.S.
 - E.U. program decentralized
 - Value of allowances higher
 - Worth around \$41 billion, compared to about \$5 billion worth of SO₂ permits
 - However, required reductions much greater for U.S.
 - Thus, price per permit is lower in EU
 - Data was a problem for CO₂
 - Unlike the SO₂ market, there wasn't good baseline data at the individual unit level
 - Made initial allocation difficult

Other Greenhouse Gas Trading Markets

- By the end of 2021, over 21% of global emissions covered by carbon pricing
 - Most often through cap-and-trade

Worldwide Carbon Pricing, 2022



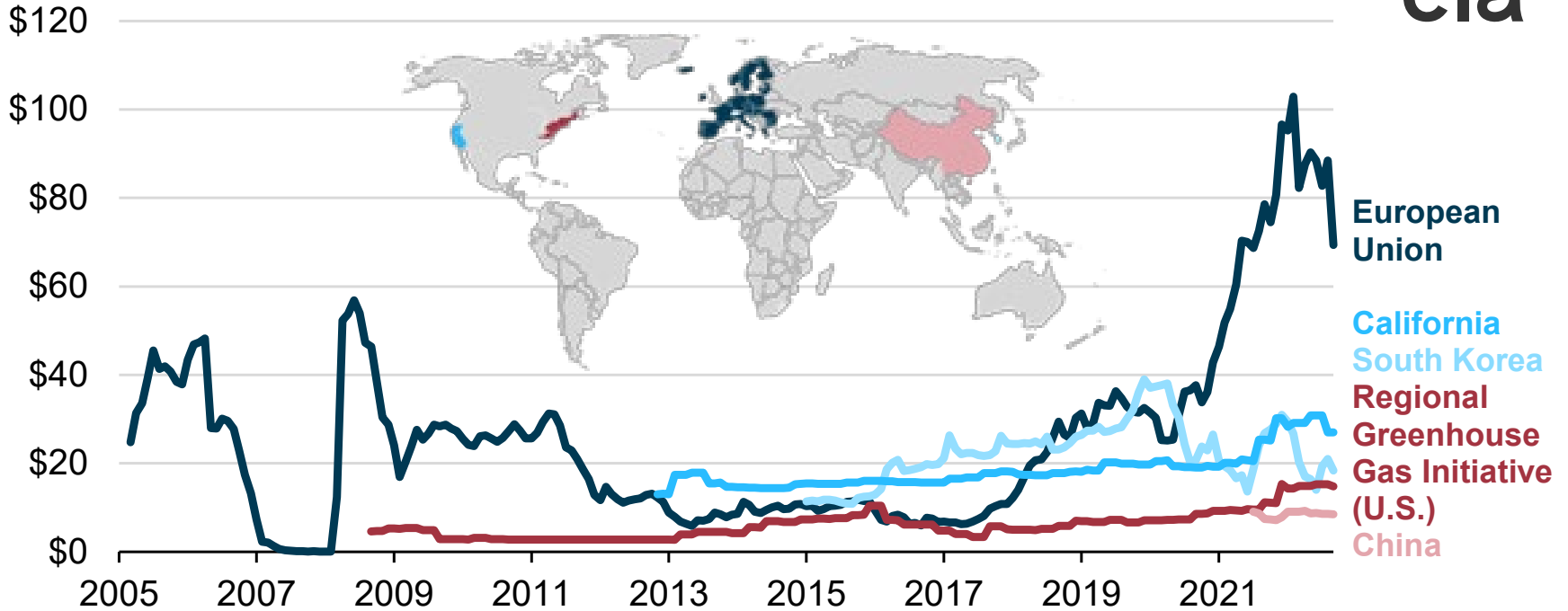
Source: "Up in the air," *The Economist*, May 28, 2022, 67-68.

Other Greenhouse Gas Trading Markets

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 - *Questions:* How well do these work? What are their strengths and weaknesses?

Average monthly CO₂ allowance price in select major emissions trading programs (Jan 2005–Sep 2022)

2022 U.S. dollars per metric ton of CO₂



Source: EIA Today in Energy, December 13, 2022, <https://www.eia.gov/todayinenergy/detail.php?id=55000>

Other Examples

China's New Emissions Market

- China's emissions trading market began February 1, 2021
 - Initially, it only covers the electric power sector
 - Ultimate goal is to cover at least 70% of China's GHG emissions.
 - Trading will be rate-based (e.g. emissions per unit of electricity output)
 - Thus, allows for future economic growth
 - Firms only need to pay for 20% of the emissions that exceed their cap, and fines are low
 - Benchmarks are based on the type of fuel
 - Based on the average carbon intensity of each sector
 - Thus, rewards better than average performance within sectors, but doesn't encourage fuel switching
 - Allowance price has been around \$8/ton

China's New Emissions Market

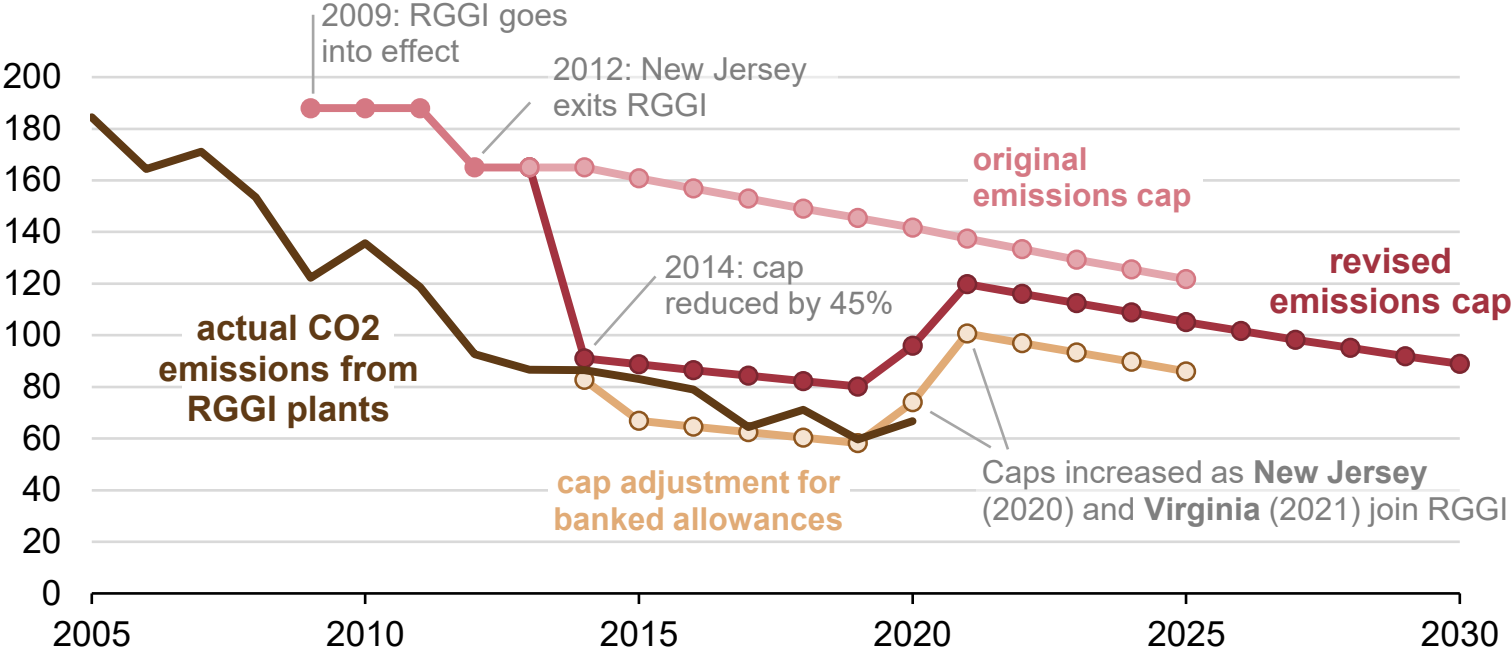
- China's proposed emissions trading market
 - Challenges
 - Many energy companies are state-owned
 - Prices often set by administrators, rather than the market
 - » Higher prices from abatement might not be passed on to consumers
 - Dispatch of power determined by planners, rather than by costs
 - » Lowest cost power not necessarily chosen first
 - Need accurate monitoring of emission for enforcement
 - This has been a problem with earlier environmental policies in China
 - China proposed third-party verification of emissions to address
 - Penalties for enforcement left to provinces
 - National environmental agency does not have authority to issue penalties for non-compliance

Regional Climate Markets in the U.S.

- The Regional Greenhouse Gas Initiative (RGGI)
 - Currently includes 11 northeastern states (6 New England states, plus NY, MD, DE, and NJ) committed to reducing CO2 emissions from power plants
 - NJ left but rejoined in January 2018; VA joined in 2020
 - Goal of capping emissions at current levels in 2009, and reducing emissions 10% by 2019.
 - Initially allowed emissions were 188 million tons CO2 annually through 2014
 - This then fell 2.5% per year through 2018
 - Announced plans for extending RGGI in 2017
 - Because of recession, initial cap appeared unlikely to be binding
 - Thus, after a 2012 review, the states agreed to a lower cap beginning in 2014
 - 2021 cap is nearly 120 million short tons (larger than previous years because VA joined)

RGGI Emission Caps

Regional Greenhouse Gas Initiative (RGGI) carbon dioxide (CO₂) emissions and caps million short tons



Source: EIA Today in Energy, March 23, 2021. <https://www.eia.gov/todayinenergy/detail.php?id=47256>

Regional Climate Markets in the U.S.

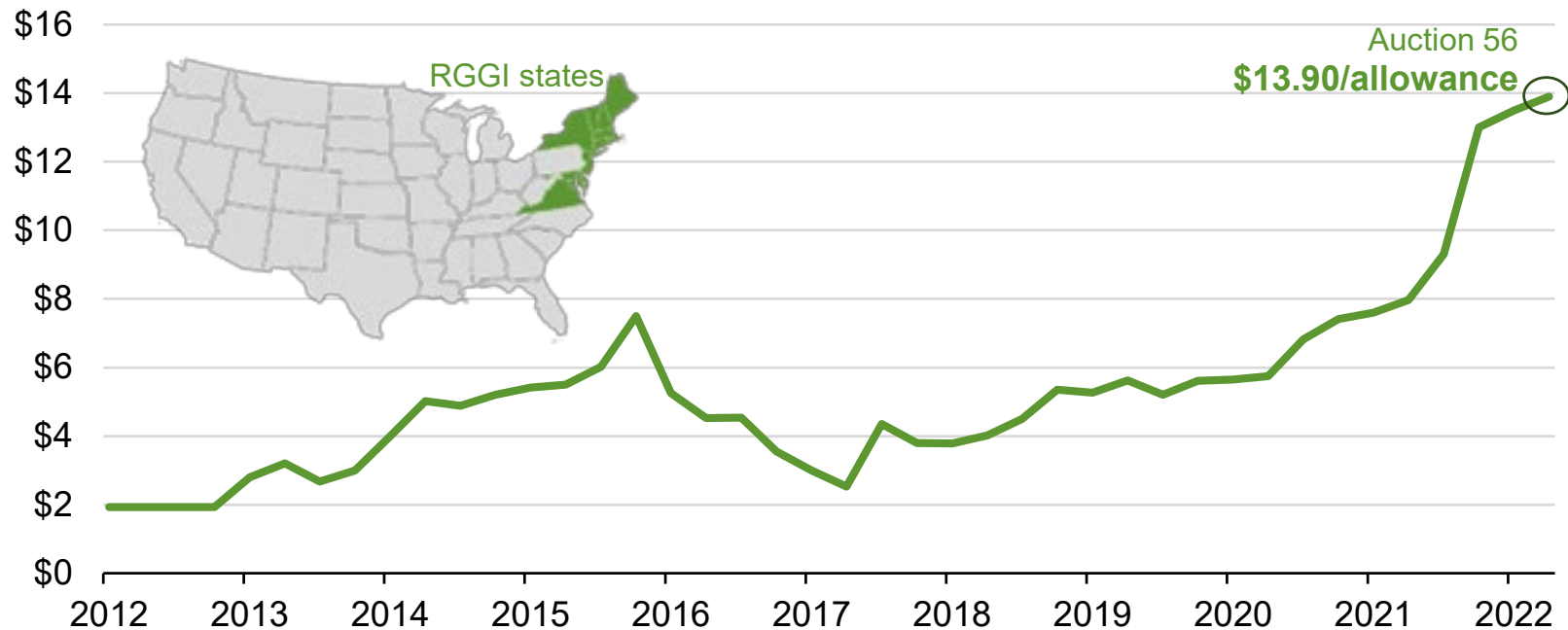
- How RGGI works
 - States are apportioned their share of allowances from the overall cap
 - States set limits for carbon dioxide emissions, and can decide how many to auction versus freely allocate
 - Each state must auction at least 25%
 - Most states auction nearly all permits
 - Revenues support clean energy technology
 - Auctions are held quarterly
 - Proceeds from permit auction will be used for energy-saving and renewable energy programs in each state
 - Auctions have raised over \$1 billion in revenue
 - Utilities bid for allowances, which can be sold later
 - Covers power plants of 25 MW or more burning at least 50% fossil fuels
 - Banking allowed
 - Compared to EU-ETS, RGGI is more restrictive about the number of outside credits plants can use to offset emissions
 - Offsets allowed for 3.3% of a plant's emissions, or about half of their obliged reductions

Regional Climate Markets in the U.S.

- RGGI prices
 - RGGI includes both a price cap and price floor
 - Extra permits held in reserve and released if price hits the cap (\$13.91 in 2022)
 - The minimum reserve price is the lowest allowable bid (\$6.42 in 2022)
 - Unsold allowances retired after three years
 - Tightens cap if there is an unexpected surplus
 - Price history
 - Two “pre-compliance” auctions were held
 - 9/25 price: \$3.07/ton CO₂
 - 12/17 price: \$3.38/ton CO₂
 - Prices fell to a low of \$1.86/ton in 2010
 - Prices are low because emissions cap overestimated current CO₂ output, which fell between 2005 & 2006
 - Estimated 2007 emissions were 172.4 million tons CO₂, although cap for 2009 is 188 million tons CO₂
 - With more stringent cap, rose to \$5.50/ton in 2015
 - Last clearing price: \$12.99/ton in December 2022

RGGI allowance prices

Regional Greenhouse Gas Initiative (RGGI) allowance clearance price (Mar 2012–Mar 2022) 
dollars per allowance (one allowance = one short ton of carbon dioxide)



Source: EIA Today in Energy September 8, 2022. <https://www.eia.gov/todayinenergy/detail.php?id=53759>

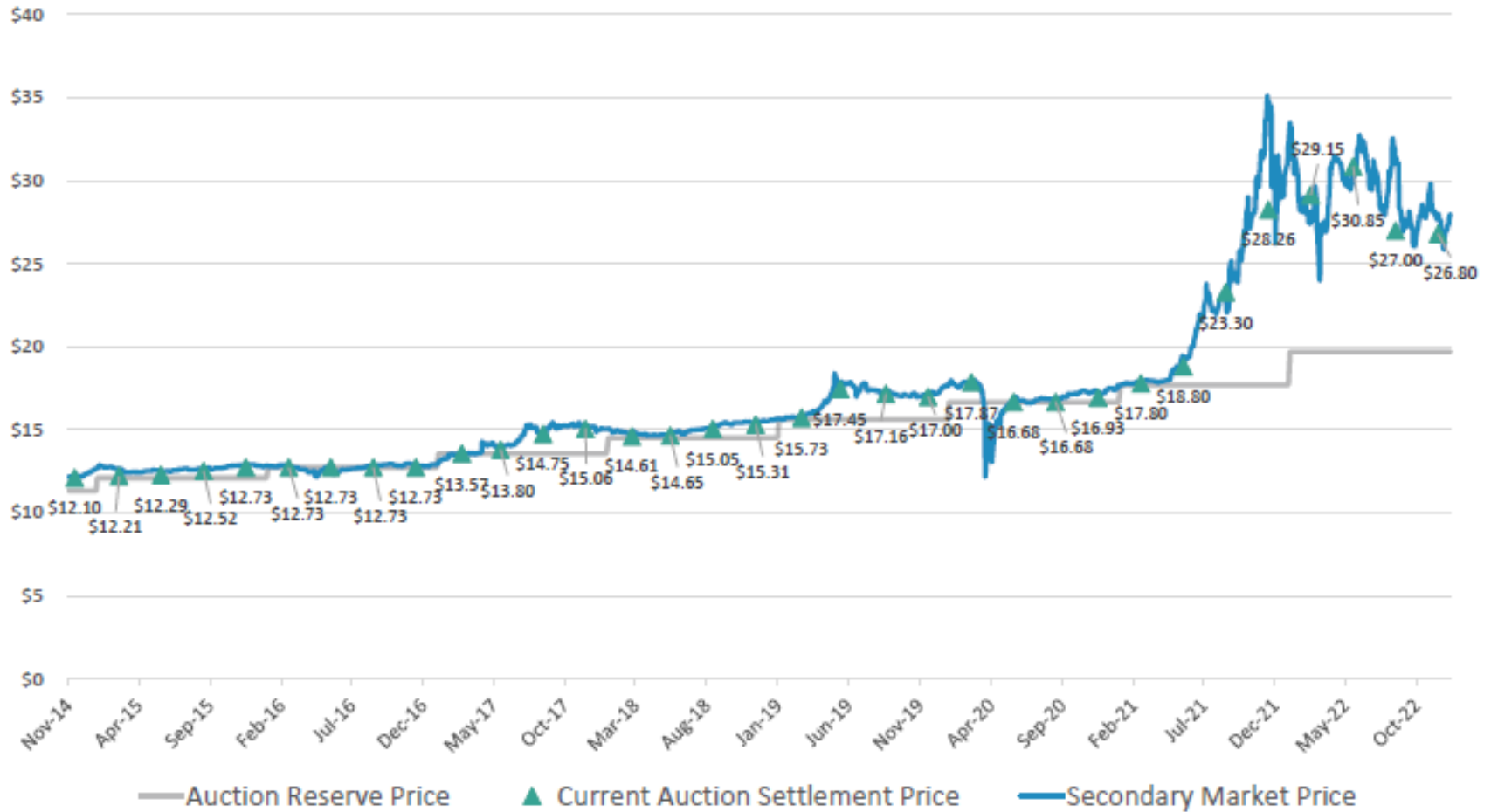
Regional Climate Markets in the U.S.

- California AB-32 Cap and Trade
 - Established in 2006 to reduce California GHG emissions to 1990 level by 2020
 - The law includes several components: cap and trade is just one part of it
 - Cap and trade market began in 2013
 - By 2015, covered 85% of state emissions
 - Most permits initially allocated freely
 - Banking allowed
 - Has a price ceiling and price floor
 - Prices were around \$11-\$14/ton in 2014
 - Allows offset projects for up to 49% of reductions

Regional Climate Markets in the U.S.

- 2017: California's new target reduces emissions by 40% by 2030
 - Up to now, other policies have had a bigger effect on emissions than cap-and-trade
 - But, most easy things have been done
 - Cap-and-trade expected to account for up to $\frac{1}{4}$ of emission reductions by 2030
 - Some offsets allowed, but these will be phased out over time
 - Most permits will be auctioned, creating revenue
 - Free allocation to industries that may relocate
 - Maintains a ceiling on permit prices

California and Québec Carbon Allowance Prices



Source: California Air Resources Board, <https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/carbonallowanceprices.pdf>