Lecture 21: Market-based Environmental Regulations in Practice

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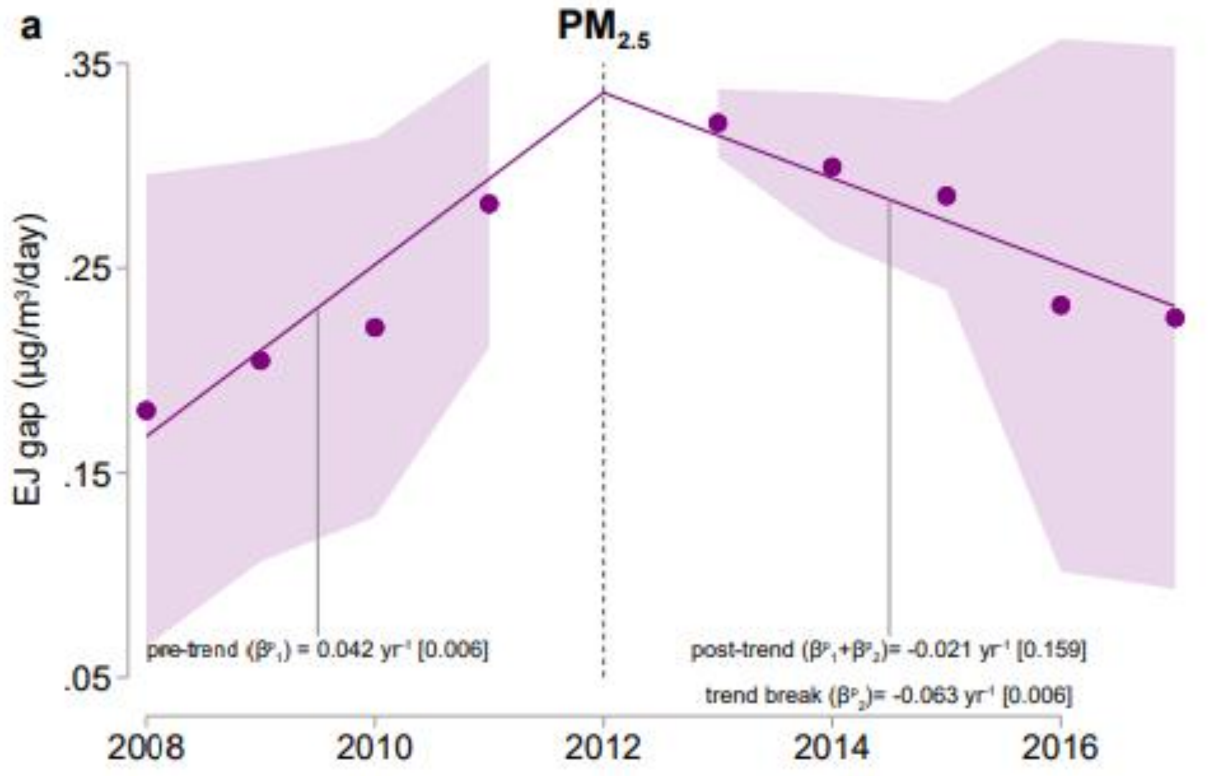
Environmental Economics
Econ 475

Part 1: Controversy Around Hernandez-Cortes and Meng

Recap

Last week, we saw from [Hernandez-Cortes and Meng (2022)]() that California's C&T program decreased EJ gaps within the state:

- 8.5% annual decrease in PM 2.5 emissions relative to control facilities
- 6.5% annual EJ gap percent change for PM 2.5



Controversy

[Hernandez-Cortes and Meng (2022)] was *very* controversial when a prior version in 2020 was released.

[Danny Cullenwald and Katie Valenzuela's response in 2020].

A critique of "Do Environmental Markets Cause Environmental Injustice? Evidence from California's Carbon Market," a 2020 NBER working paper by Danae Hernández-Cortés and Kyle C. Meng

DECEMBER 01, 2020 BY DANNY CULLENWARD

When this working paper was released, it was our ardent hope that the technical flaws and clear research bias would prevent it from being used to inform deliberations on climate policy. As time has passed, however, and it has become apparent that this paper is being used to undermine legitimate critiques of carbon pricing programs like California's cap-and-trade program, we feel it is our responsibility to highlight the errors in method and assumptions present in this paper.

Cullenwald’s Critique

Five errors highlighted:

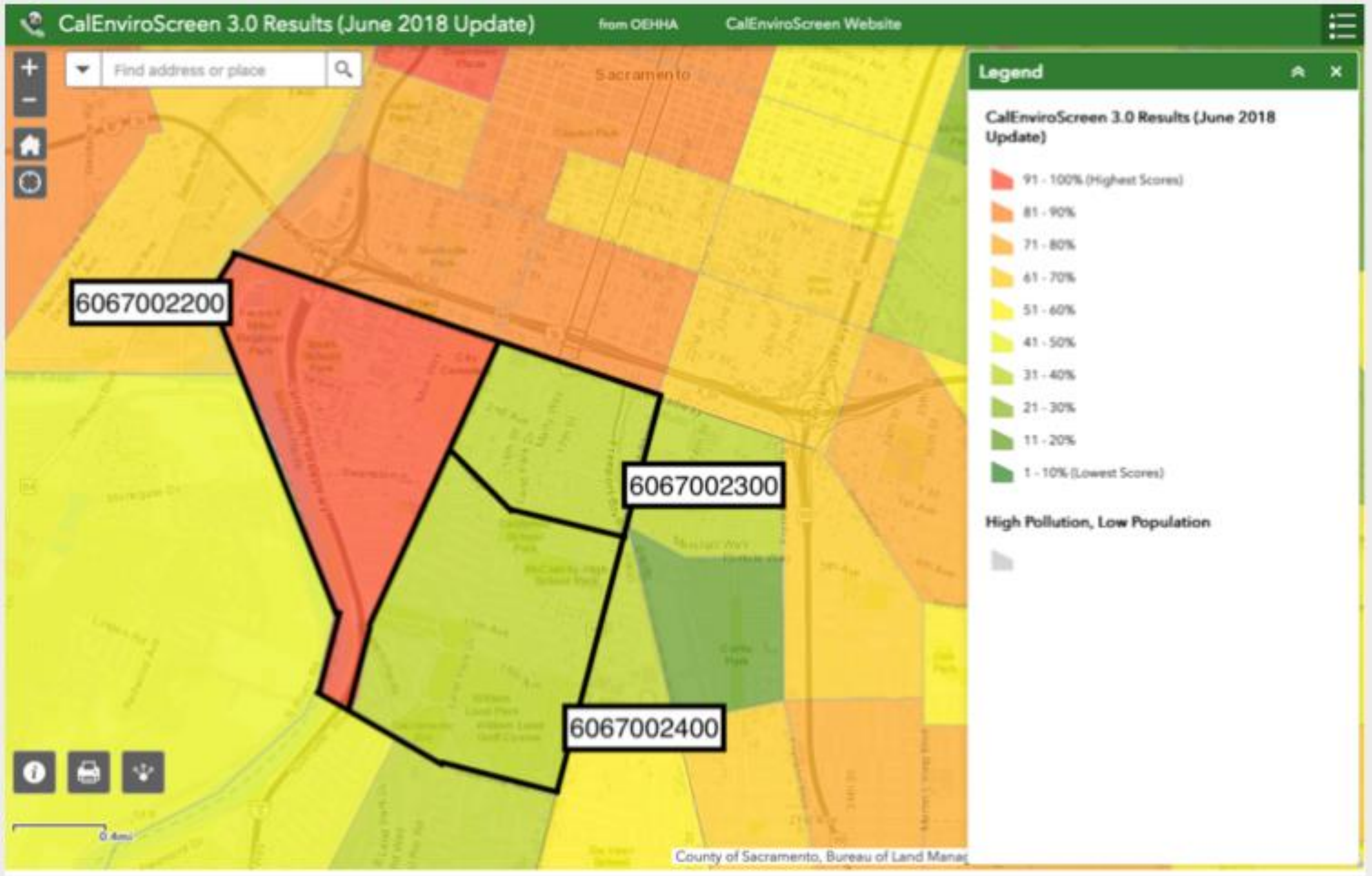
1) Inaccurate definition of environmental justice communities
2) Data quality issues with emissions reporting and monitoring
3) Control group bias
4) Omitted variable bias
5) The question is not cap-and-trade vs. nothing

Image source.

Cullenwald's Critique

1) Inaccurate definition of environmental justice communities

- Zipcode vs. neighborhood



Cullenwald's Critique

2) Data quality issues with emissions reporting and monitoring

- ambient pollution at any location is composed of emissions originating from many sources

Table S2: Correlation between HYSPLIT-driven and ambient pollution exposure

	(1)	(2)	(3)	(4)
	Outcome is ambient ln exposure			
	ln NO_x	ln SO_x	ln $PM_{2.5}$	ln PM_{10}
HYSPLIT-driven ln exposure	0.16***	0.09	0.09***	0.09***
	[0.03]	[0.07]	[0.03]	[0.02]
Zip codes	95	32	86	94

2020 paper.

Table S5: Correlation between HYSPLIT-driven and ambient pollution concentrations

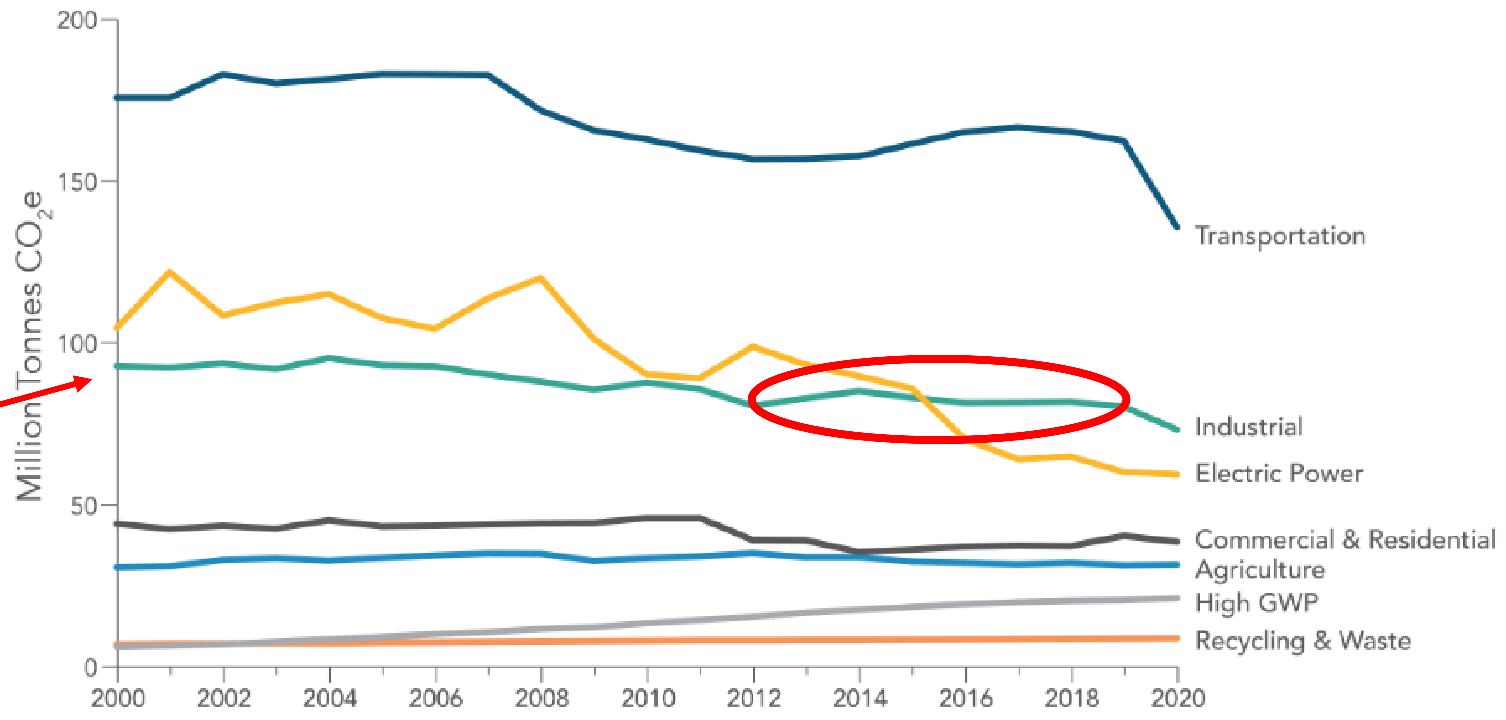
	(1)	(2)	(3)	(4)
	Outcome is ambient asinh(concentration)			
	$PM_{2.5}$	PM_{10}	NO_x	SO_x
HYSPLIT-driven asinh(concentration)	0.860	0.625	0.436	0.231
	(0.154)	(0.137)	(0.148)	(0.207)
	[<0.001]	[<0.001]	[0.004]	[0.272]
Zip codes	133	160	121	39

2022 paper.

Cullenwald's Critique

2) Data quality issues with emissions reporting and monitoring

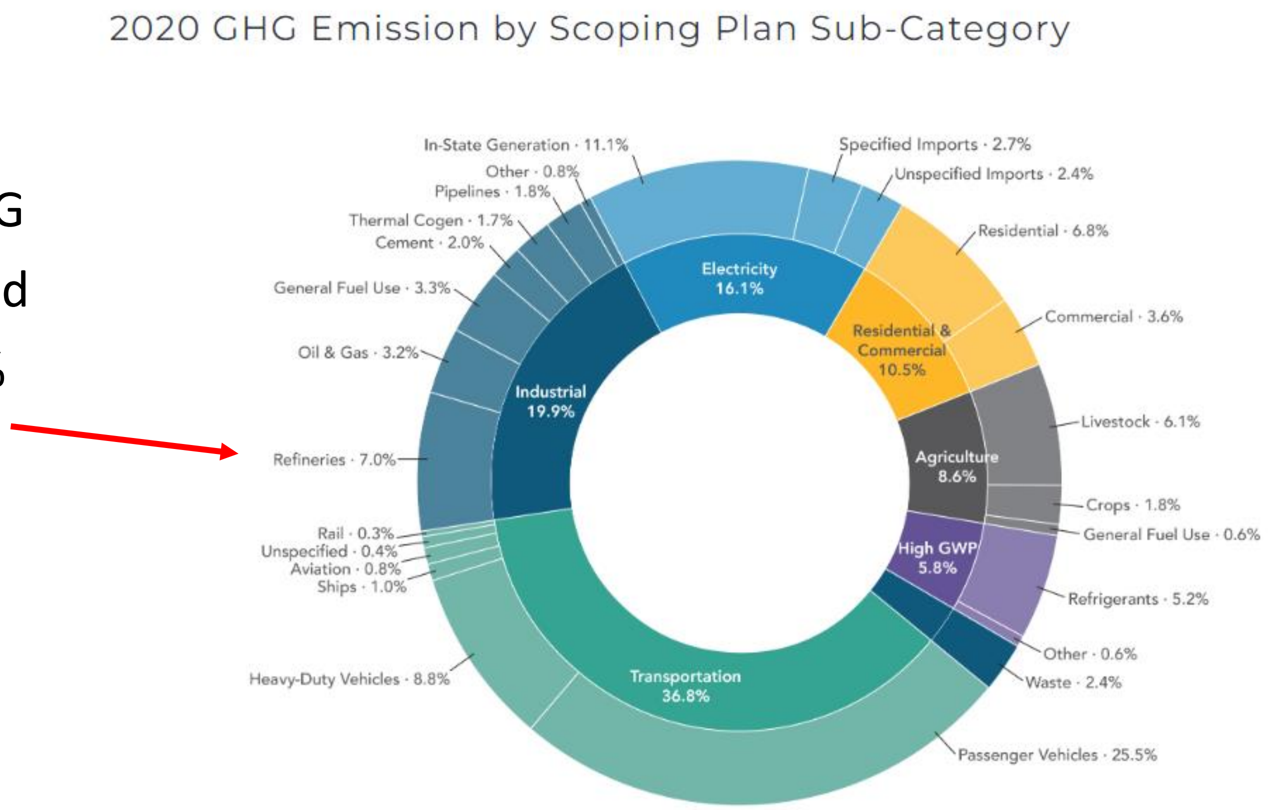
California's own data show industrial emissions not improving much.



Cullenwald's Critique

3) Control Group Bias

- Facilities over 75th percentile of GHG emissions dropped, all refineries and electricity generators dropped. 70% of reported California 2008-2012 GHG emissions excluded

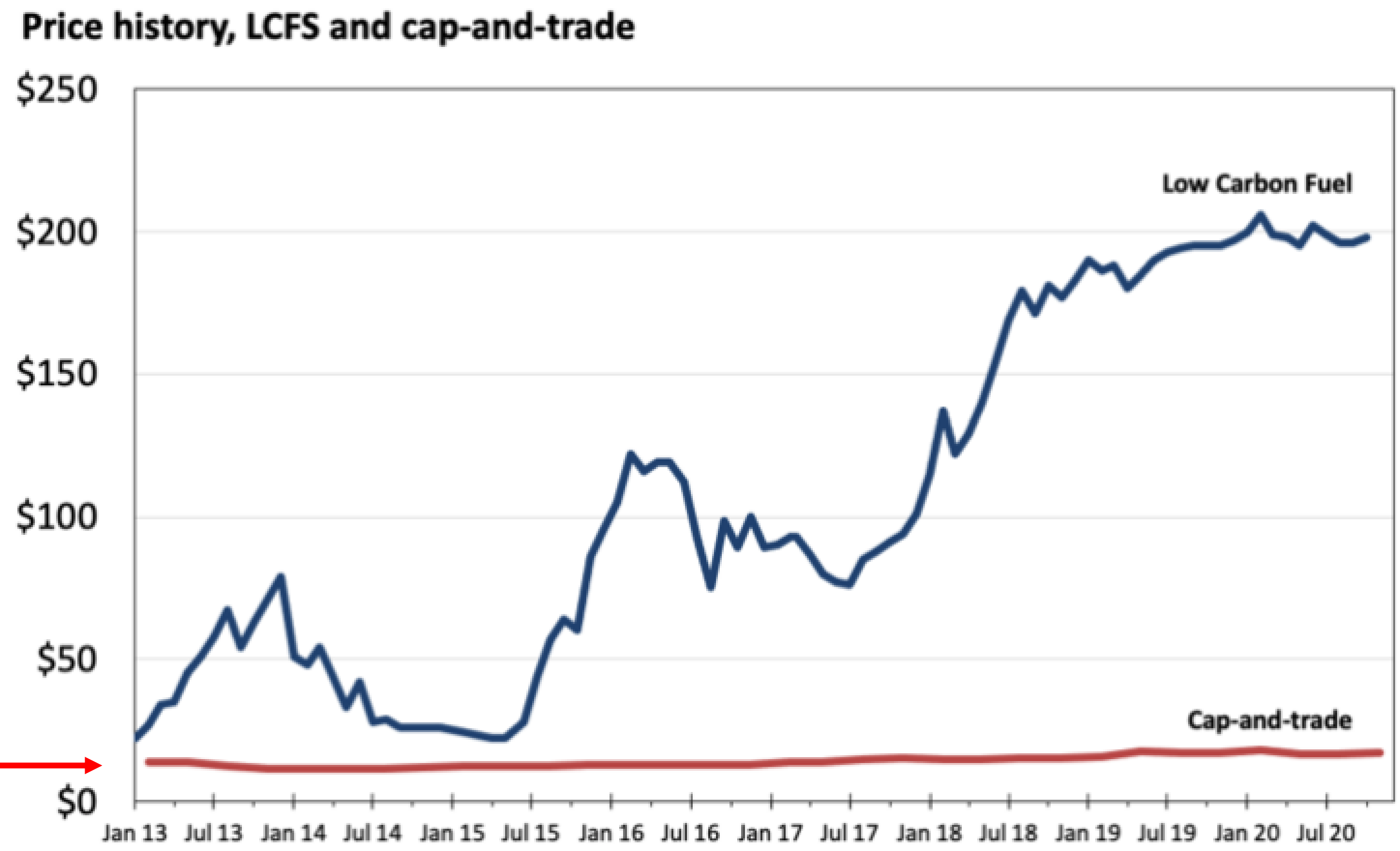


Cullenwald's Critique

4) Omitted variable bias

Low carbon fuel standards are also a cap and trade at the same time (started 2011). LCFS prices increased rapidly while C&T didn't move.

C&T price not generally binding (see Cullenwald et al, 2019).



Cullenwald's Critique

4) Omitted variable bias

Low carbon fuel standards affect refineries, largest sector within industrial category.

Table S12: EJ gap effect robustness: including large emitters, electricity generators, and refineries

	(1) $PM_{2.5}$	(2) PM_{10}	(3) NO_x	(4) SO_x
pre-trend (β_1^p)	0.209	0.223	0.084	0.139
	(0.137)	(0.147)	(0.092)	(0.096)
	[0.132]	[0.134]	[0.366]	[0.154]
trend break (β_2^p)	-0.431	-0.477	-0.348	-0.199
	(0.188)	(0.201)	(0.134)	(0.094)
	[0.026]	[0.021]	[0.012]	[0.039]
post-trend ($\beta_1^p + \beta_2^p$)	-0.222	-0.254	-0.264	-0.060
	(0.059)	(0.063)	(0.062)	(0.021)
	[<0.001]	[<0.001]	[<0.001]	[0.007]
Trend pct change ($100 * \beta_2^p/\beta_1^p$)	-206.402	-213.745	-414.288	-143.527
	(48.897)	(54.661)	(314.152)	(36.385)
	[<0.001]	[<0.001]	[0.187]	[<0.001]

Cullenwald's Critique

5) The question is not cap-and-trade vs. nothing. Argues for:

1. Stronger cap and trade with fewer allowances
2. More prescriptive regulations on releasers
3. More of both policies

"It's not news that a flawed program is better than no program at all, but that's all the paper looks at."

Two Perspectives

Adopting a weak cap-and-trade program has led to prolonged and higher emissions in environmental justice communities than if California had adopted a stringent carbon pricing policy or relied instead on non-market mechanisms that would have been targeted at the pollution reductions our communities need.

- Cullenwald and Valenzuela

More generally, despite these findings for California, market-based environmental policies should not be used explicitly to address environmental justice concerns. Market-based policies are intended for allocative efficiency and not distributional objectives… environmental justice problems need environmental justice policies.

- Hernandez-Cortes and Meng

A Response to Cullenwald

!!!

Crocker, T. 1966. "The structuring of atmospheric pollution control systems. The economics of air pollution." *The economics of air pollution. New York, WW Norton & Co*, 61–86.

Cummiskey, Kevin, Chanmin Kim, Christine Choirat, Lucas R. F. Henneman, Joel Schwartz, and Corwin Zigler. 2019. "A Source-Oriented Approach to Coal Power Plant Emissions Health Effects."

Currie, Janet, John Voorheis, and Reed Walker. 2020. "What Caused Racial Disparities in Particulate Exposure to Fall? New Evidence from the Clean Air Act and Satellite-Based Measures of Air Quality." National Bureau of Economic Research Working Paper 26659.

Part 2: Market-Based Instruments in Practice

Market-Based Instruments in Practice

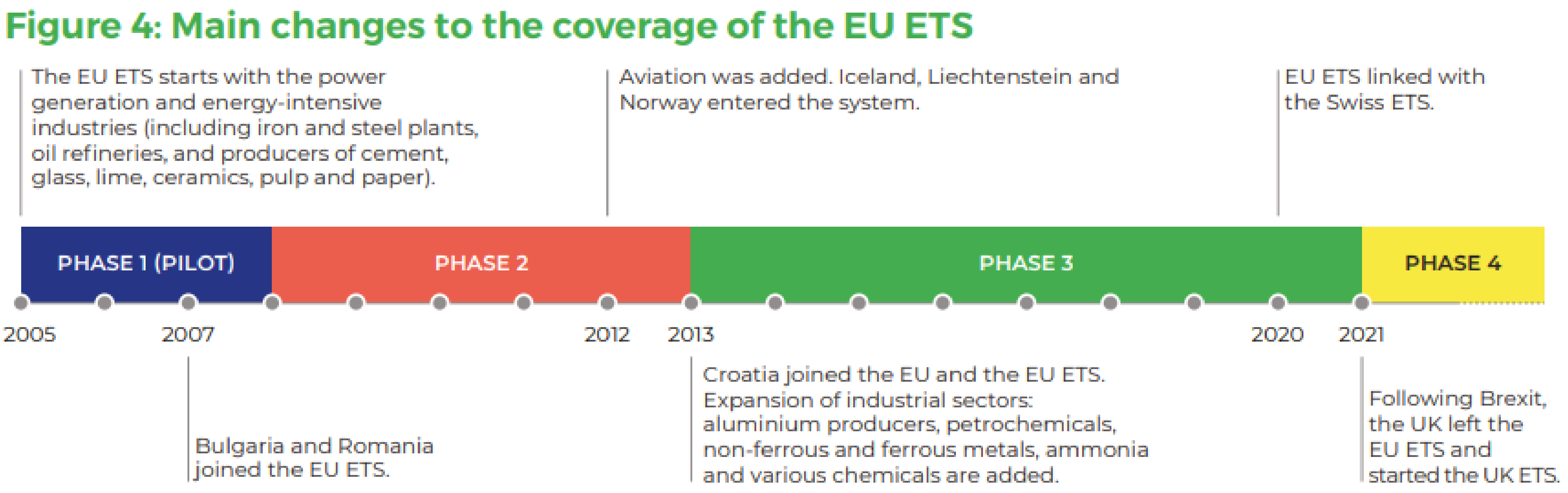
Outline:

1) EU Emissions Trading System
2) Other Market-based GHG Policies
3) Differences Across Policies at Complete GHG Elimination

EU Emissions Trading Market

Largest GHG cap-and-trade in the world (before 2021).

- Four phases.
- 27 countries
- 40% of EU GHGs
- 12,000 entities



Source: Carbon Market Watch.

General Features

- Carbon neutrality by 2050, 55% net reduction by 2030.
- Partly auction (57% as of Phase 3), partly free allowances.
- Allowances targeted to protect against leakage.
  - Heavy industries like steel receive allowances (close to [95% of emissions]() in heavy industry).
  - Aviation receives allowances and flights to non-EU states do not count towards total
  - Electricity generally not eligible for free allowances

Concerns with EU ETS

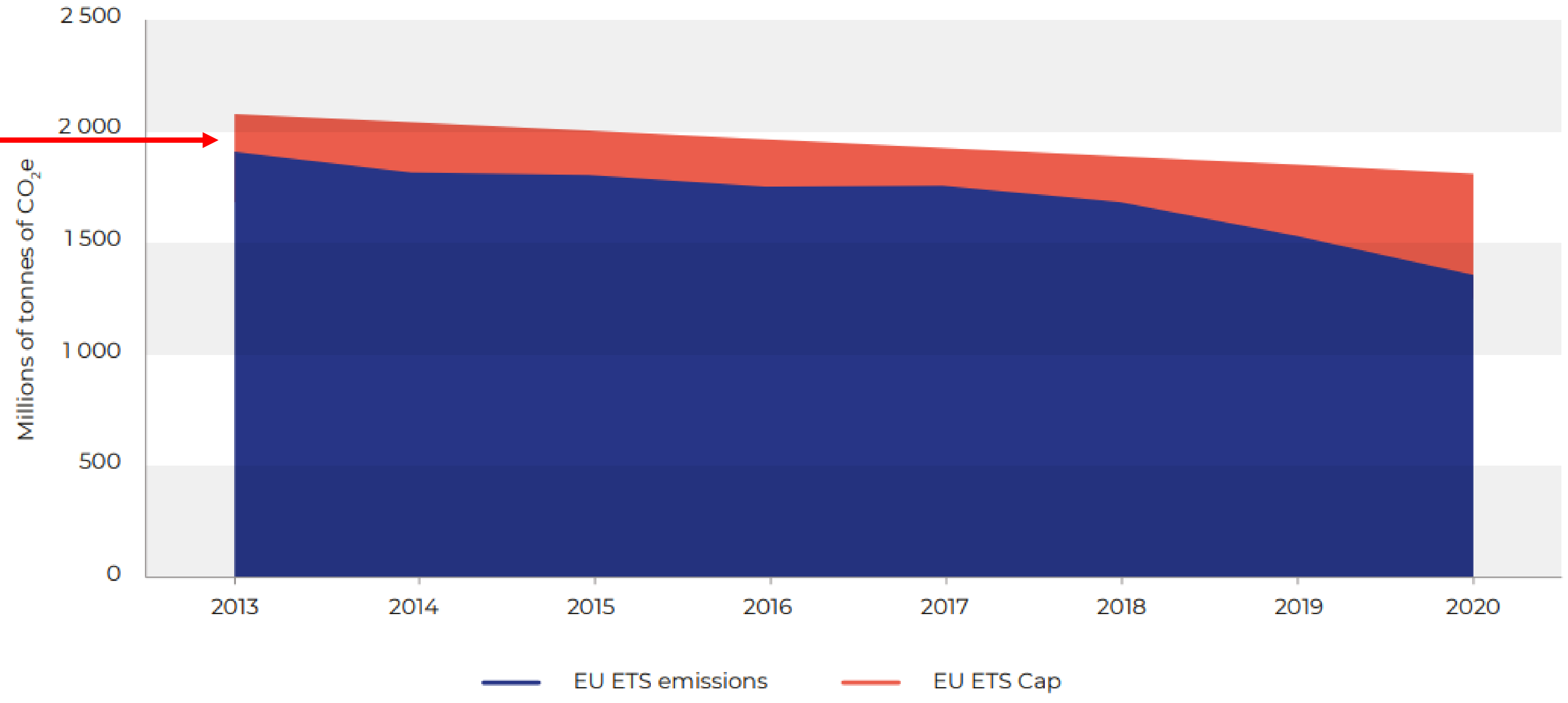
Early hiccups and other concerns:

- Over-allocation of allotments
- International offsets
- Fraud and misreporting
- Windfall profits

Overallocation of Allotments

Excess credits

Figure 5: EU ETS emissions vs. the cap



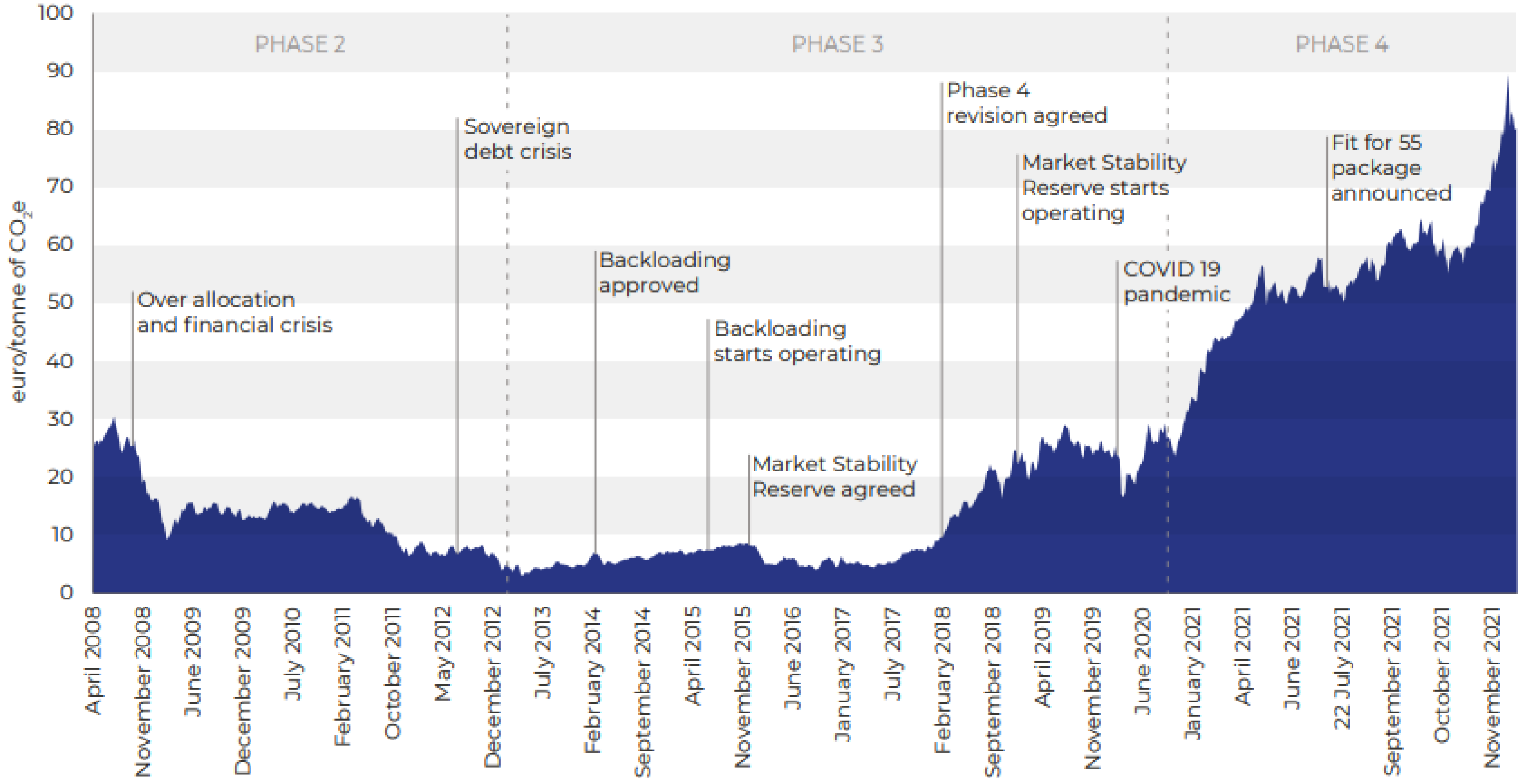
Source: Carbon Market Watch.

EU Emissions Trading Market Allowance Prices over Time

Over-allocation impacts on prices clearly visible.

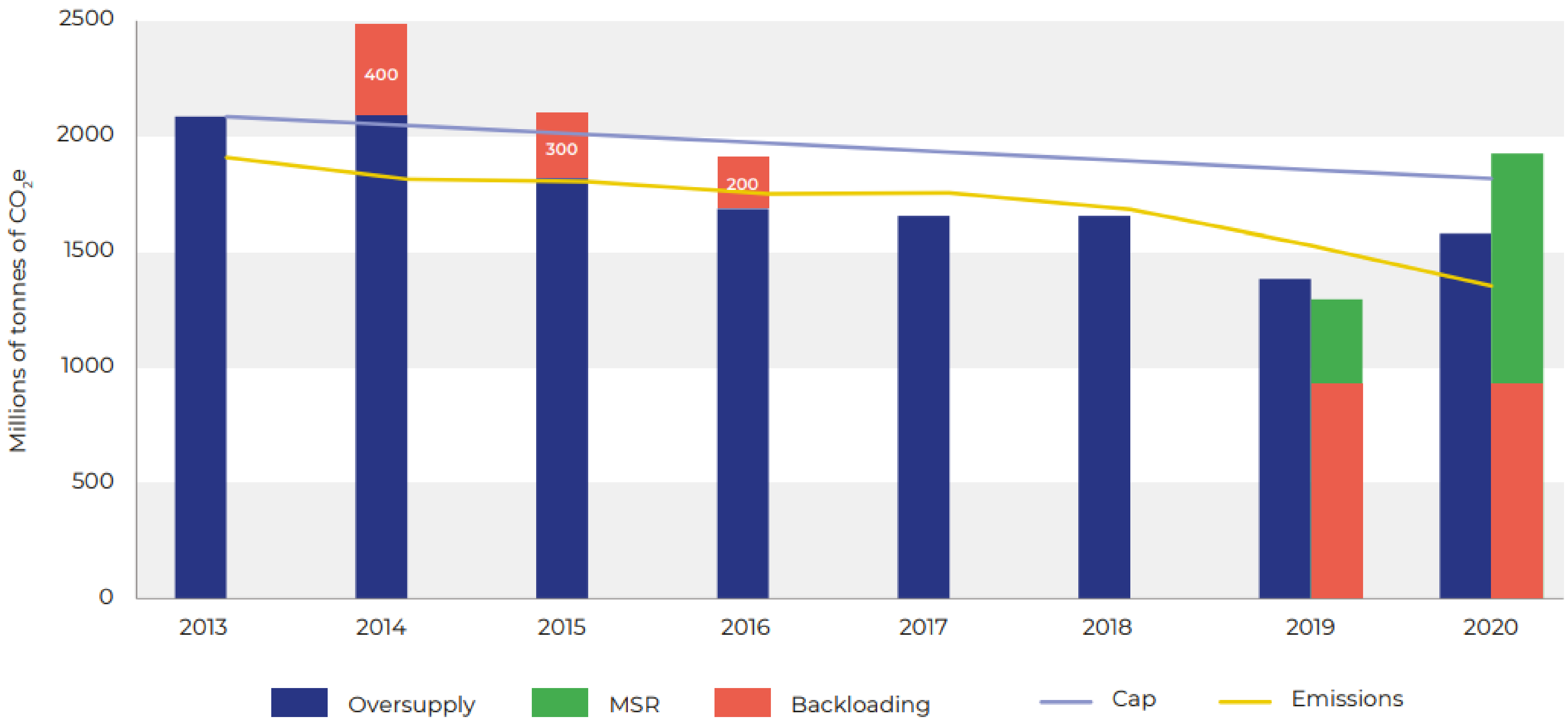
Offsets, financial crisis lowering output, high cap led to near collapse of prices in 2014.

Figure 8: EU carbon prices since the start of Phase 2



Source: Carbon Market Watch.

Figure 9: Oversupply in the EU ETS during Phase 3



Source: Carbon Market Watch.

Problems with Offsets

Over 1 billion international offset credits entered the market by 2012. Limited to 500m by 2020.

Why a concern?

- Additionality
- Permanence
- Verification

[Great summary of issues with carbon offsets by John Oliver.]

Aside: Planting Trees?

Above: John Liu's work (see "Regreening the desert" documentary.)

Right: Zai in Kenya

Trillion Trees Initiative & Great Green Wall in the Sahara?

- 80% of planted trees have died.
- Monoculture tree forests susceptible to disease
- Ultimately not enough mitigation in trees
  - 7.6 billion tons absorbed by trees of 36 billion tons CO_2e

More success with permaculture:

- Zai, swales, step irrigation, bunds and water farming in Rajasthan.

Also, paying indigenous cultures to maintain land.

EU ETS Market Stability Reserve

MSR started operation in 2018. Keeps over-supply in check by purchasing allowances:

- Some backloaded allowances (that had been pushed from 2013 to later in the decade) purchased by MSR.
- Reduces allowances in circulation by a specific share from the prior year excess; will start to retire these in 2023.

International offsets scaled back from 2013-2020 and then prohibited in 2021.

2012	2013	2014	2015	2016	2017	2018	2019	2020
-1.94%	2.20%	-4.93%	-0.61%	-2.88%	0.23%	-4.10%	-9.09%	-11.44%

Source: Carbon Market Watch.

EU ETS Other Concerns

Value-added tax fraud:

- Companies buy carbon allowances in one country without a VAT, sell in another with the tax (pocket difference).
  - 5B EUR in damages from VAT fraud.

Under-reporting:

- 30M in under-reported emissions at a Bulgarian coal plant.

Windfall Profits

In Phase 1 & 2, electricity generators passed opportunity cost of freely-acquired allowances on to consumers in the form of higher prices (Sigm et al., 2006).

Table 3: Industry windfall profits by sector in million EUR 2008-2019

Sector	Windfall profits from surplus	Windfall profits from international offsets	Windfall profits from average cost pass-through	Total windfall profits
Refineries	-1800	630	12,460	11,300
Petrochemicals	600	320	4010	5000
Cement	3000	310	6630	10,300
Iron and steel	-710	850	16,000	16,100

EU ETS Other Features

Innovation Fund:

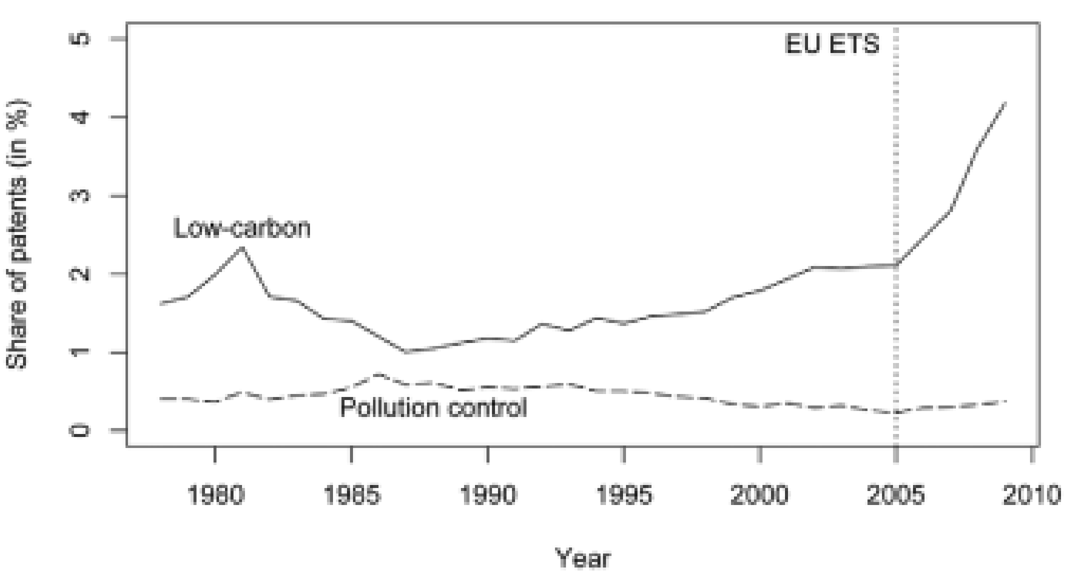
- Collects 20B EUR from auctions for subsidizing development of low-carbon technologies.

Modernization Fund:

- Collects 25B EUR from auctions for modernizing the electricity sector and upgrading the grid in lower-income EU member states.

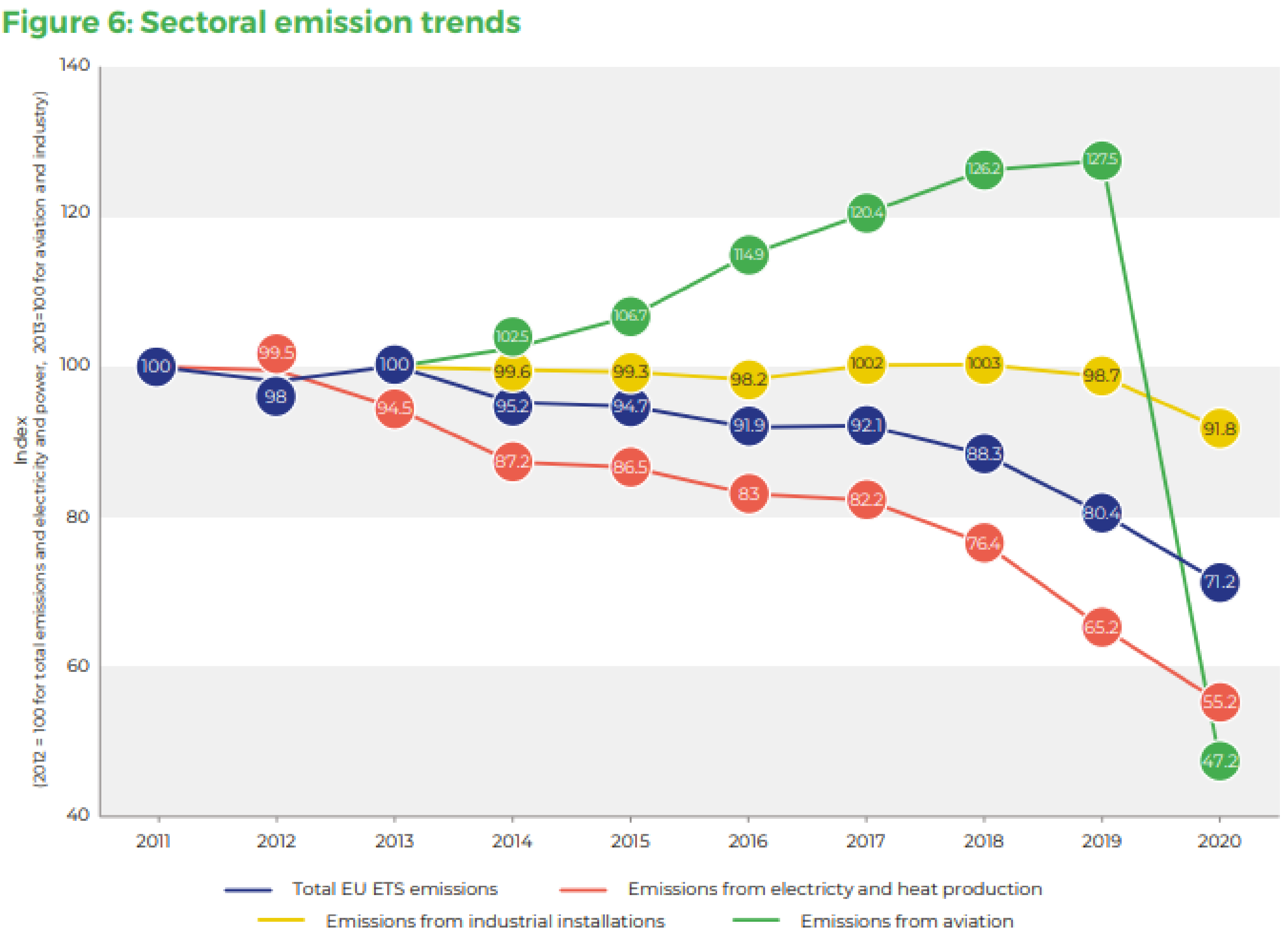
10% increase in low-carbon patents in industries covered by C&T

FIGURE 1.—SHARE OF LOW-CARBON PATENTS, 1978–2009



Source: [Calel and Dechezlepetre (2016).]()

Is it working?



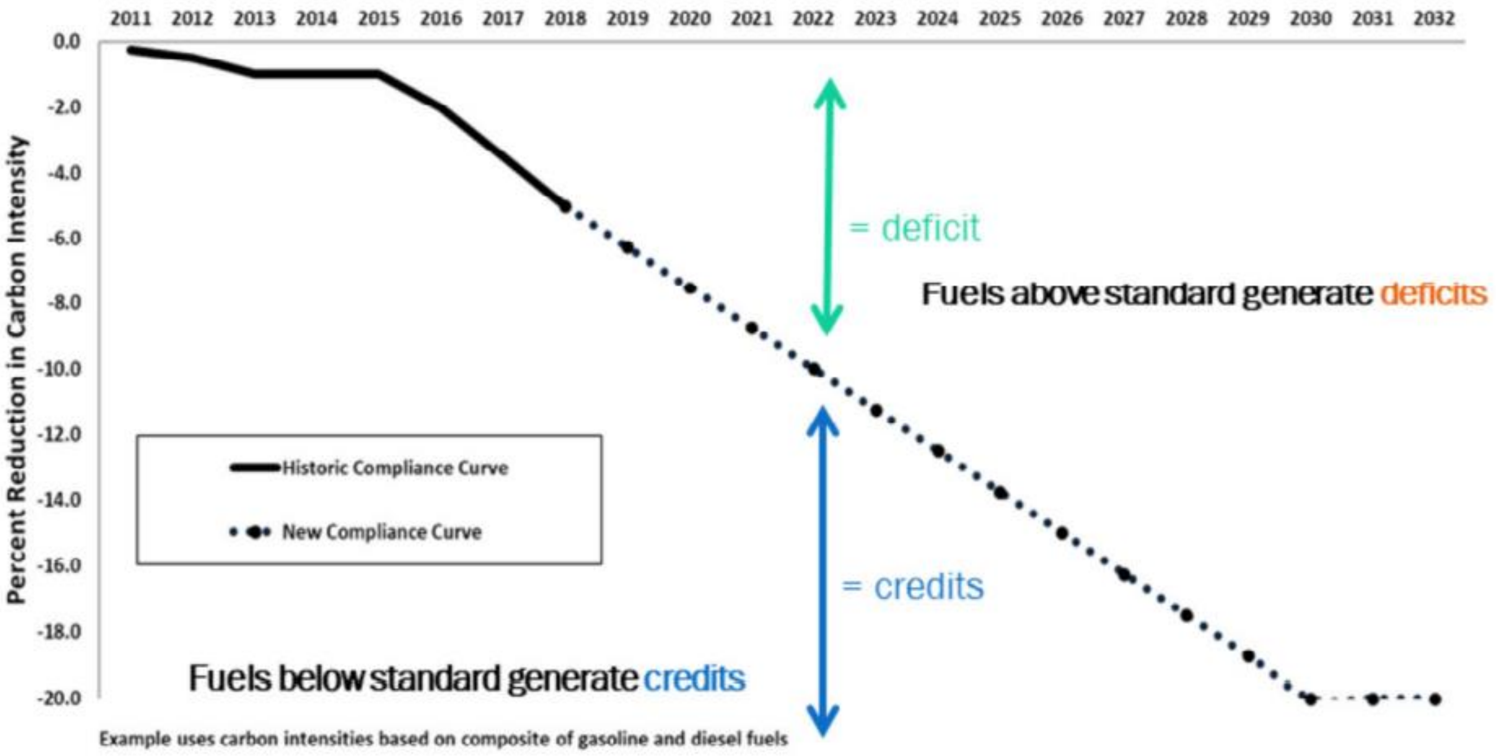
Source: Carbon Market Watch.

Carbon Market-based Policies in Borenstein and Kellogg (2022)

- Carbon pricing
  - Carbon tax
  - Cap and trade
- Intensity Standard
  - Emissions intensity standard
  - Clean energy standard
- Subsidizing Clean Energy
  - Zero-emissions energy subsidies
  - Zero-emissions capital subsidies

Emissions Intensity Standard

- Set target annual carbon intensity standard for gasoline, diesel, and replacement fuels.
  - Intensity is measured in grams of CO2 per megajoule.
- Firms buy and sell until carbon intensity standard is met.
- Acts as a tax on higher, and subsidy on lower fuel intensities.



Renewable Portfolio Standards

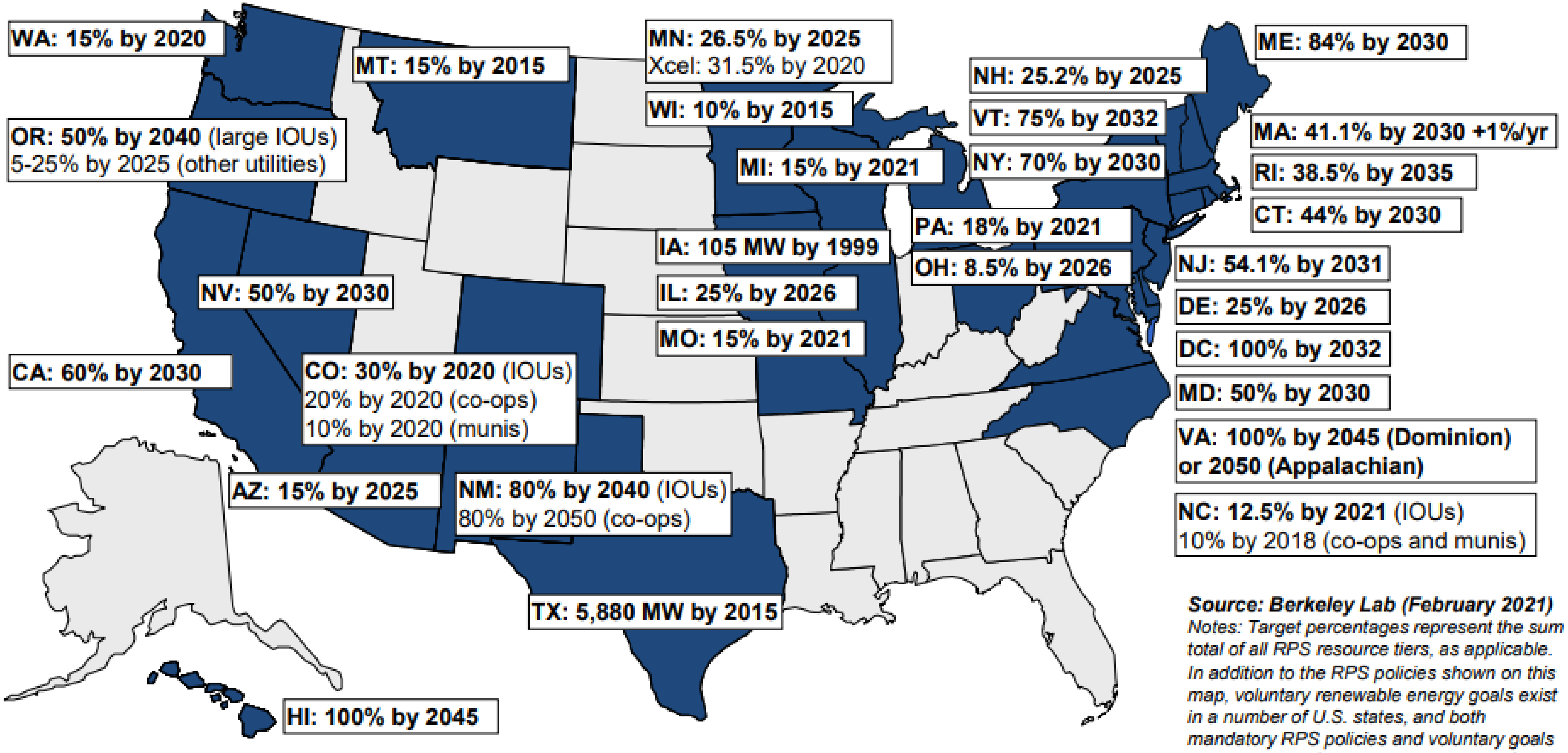
$$\frac{renewables}{fossil\ fuel + renewables} > RPS$$

Renewables Portfolio Standard	A requirement on retail electric suppliers… To supply a minimum percentage or amount of their retail load… With eligible sources of renewable energy
Typically	Backed with penalties of some form
Often	Accompanied by a tradable renewable energy certificate (REC) program to facilitate compliance
Never	Designed the same in any two states

Source: [Berkeley Lab (2021).]

RPS Policies Exist in 30 States and DC

Apply to 58% of Total U.S. Retail Electricity Sales



Source: Berkeley Lab (February 2021)

Notes: Target percentages represent the sum total of all RPS resource tiers, as applicable. In addition to the RPS policies shown on this map, voluntary renewable energy goals exist in a number of U.S. states, and both mandatory RPS policies and voluntary goals exist among U.S. territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).

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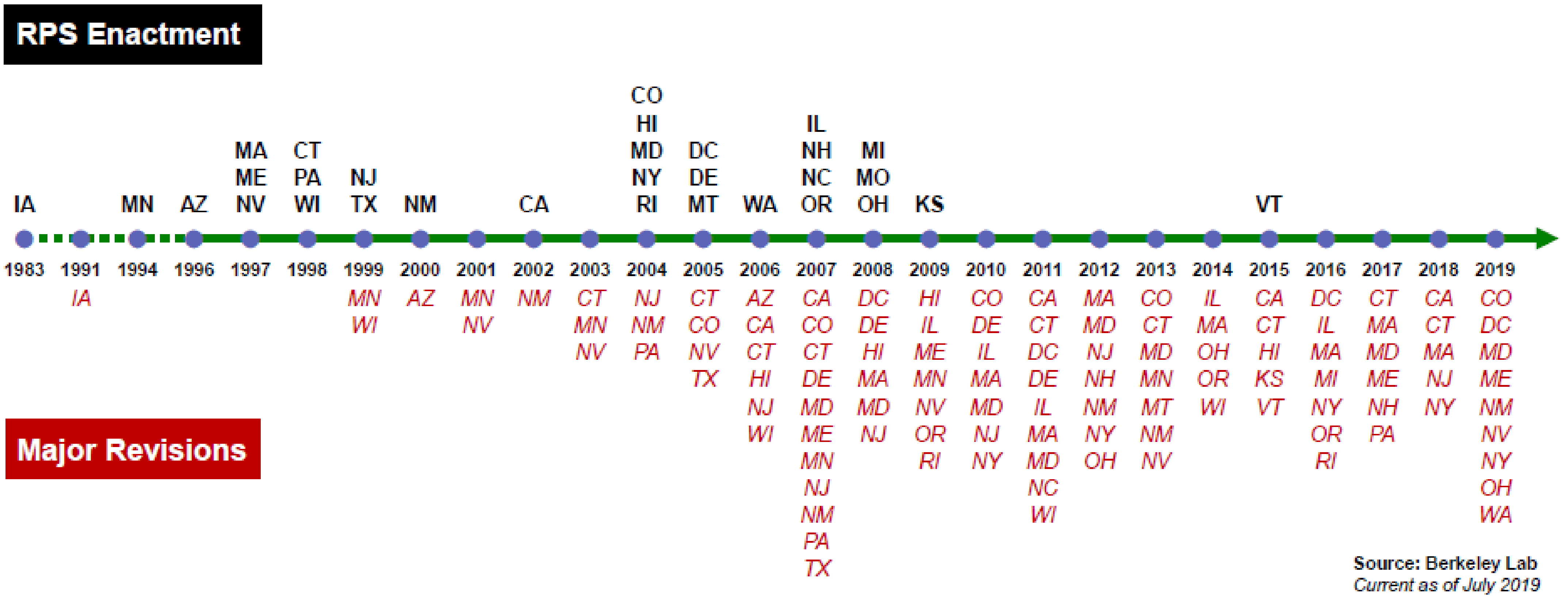
Source: Berkeley Lab (2021).

Most RPS Policies Have Been on the Books for a Decade or More

But states continue to make regular and significant revisions



Source: Berkeley Lab (2021).

Renewable Portfolio Standards

After passage RPSs, reduce emissions 10-25% seven years after revisions to RPS standards.

- Electricity prices increase 11%
- Cost per ton of abatement is $50-298, generally above $100.
- Most costs come from extending transmission lines across states.
  - i.e., likely more expensive than traditional C&T.

Source: [Greenstone and Nath (2020).]

Comparing Intensity Standards

- Emissions Intensity Standard vs. Clean Energy Standard:
  - Clean energy standard differentiates between "clean" and "dirty" but not within these categories
    - Determining which generators produce within category reflects private marginal cost of each generation (not carbon emissions)
  - EIS has lower emissions but higher prices effect than CES

Comparing Intensity Standards

Pros and cons compared to other carbon strategies:

- Lower electricity prices than with carbon pricing, but higher than no standard
    - Revenue neutral – trading of compliance credits subsidizes cleaner generators and taxes dirtier generators
- Higher electricity generation than under carbon tax
- Less price volatility but more quantity volatility than an emissions cap, and more price volatility but less quantity volatility than a carbon tax.

Subsidizing Clean Energy

- Types of subsidies:
  - Zero-emission energy subsidy (MWH production tax credit)
  - Zero-emission capital subsidy (investment tax credit)

- Production tax credit vs. investment tax credit
  - Investment tax credit only subsidizes capital, which does not incentivize the most cost-efficient input mix of capital and labor.
    - Investment tax credit will be costlier than production tax credit for the government.

Subsidizing Clean Energy

Pros and Cons compared to other market-based policies:

- Zero emission energy production tax credit standard differentiates between “clean” and “dirty” but not within these categories
  - Like clean energy standard but no budget neutrality
- ZES has higher generation and higher emissions, but lower electricity prices than CES

Some Caveats

Carbon pricing may not end up being that much more efficient than other market-based policies:

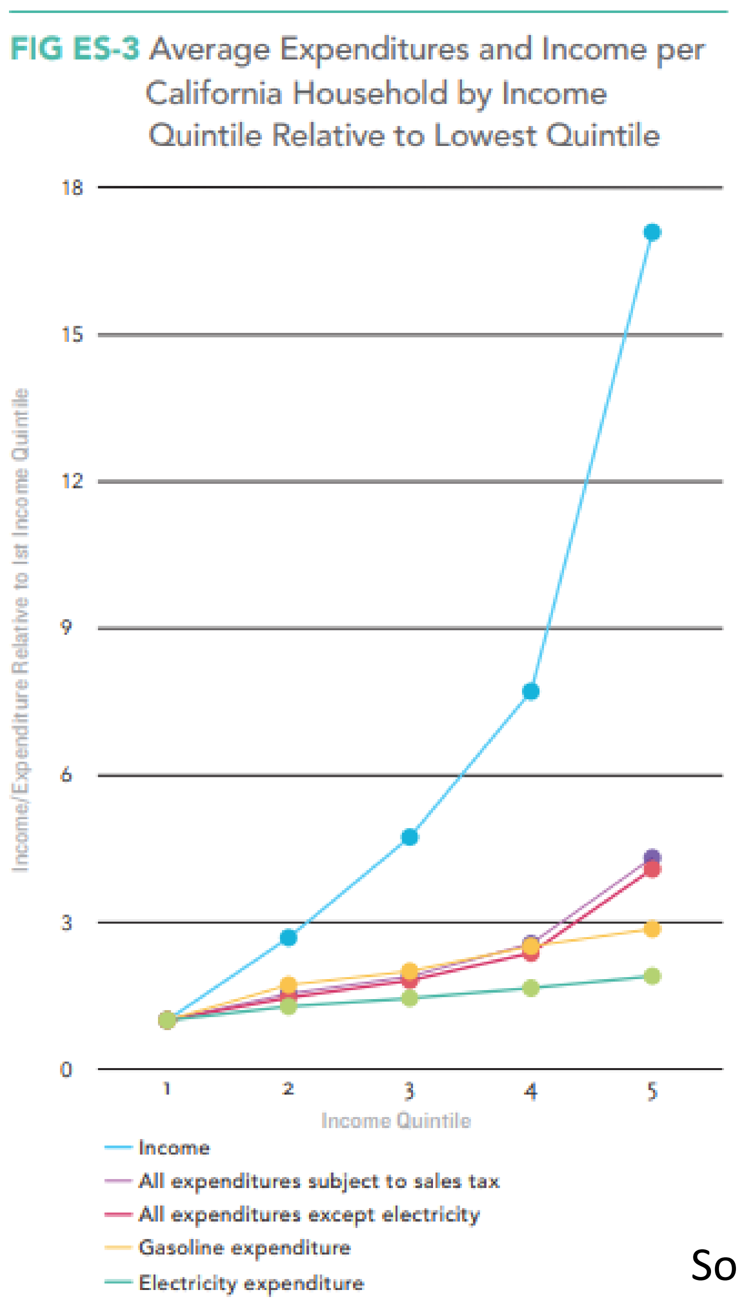
- Retail price faced by consumers is substantially higher than wholesale electricity prices due to markups
  - Since residential prices already exceed total SMC, further electricity price increases induced by carbon pricing would exacerbate the DWL for consumers.
- Electricity is increasingly a substitute fuel for transportation
- Regressivity of taxes complicates picture

Are Pollution Taxes Regressive?

Pollution regulations, and carbon taxes in particular, likely regressive:

1. Cost of living as proportion of income is higher
2. Goods that use energy more expensive
3. Abatement is capital intensive, affecting capital-labor share of production

Really depends on how the revenue from market-based instruments is used.



Source: [Borenstein, Fowlie, Sallee (2021).]()

Part 3: Policies under Complete Elimination of GHGs

Complete Elimination of GHGs

At complete elimination of GHGs, or 100% renewables:

- C&T, intensity standard and clean electricity standards all have the same:
  - Electricity price
  - Electricity generation
  - Government revenues ($0)
- Subsidies have lower electricity price and higher electricity generation

Complete Elimination of GHGs

Policy	GHG emissions intensity	Electricity price	Electricity generation	GHG emissions	Government revenue
Carbon pricing					
Carbon tax (CT)	zero	highest	lowest	zero	zero
Cap-and-trade	zero	same as CT	same as CT	zero	zero
Intensity standards					
Emissions intensity standard (EIS)	zero	same as CT	same as CT	zero	zero
Clean energy standard (CES)	zero	same as CT	same as CT	zero	zero
Subsidizing clean energy					
Zero-emissions energy subsidies (ZES)	zero	lower than CT	higher than CT	zero	negative
Zero-emissions capital subsidies (ZCS)	zero	same as ZES	same as ZES	zero	more negative than ZES

Complete Elimination of GHGs
Transition Path

We just saw that carbon pricing and intensity standards may be equally efficient at the point of complete elimination of GHGs.

But what about the level of emissions during transition?

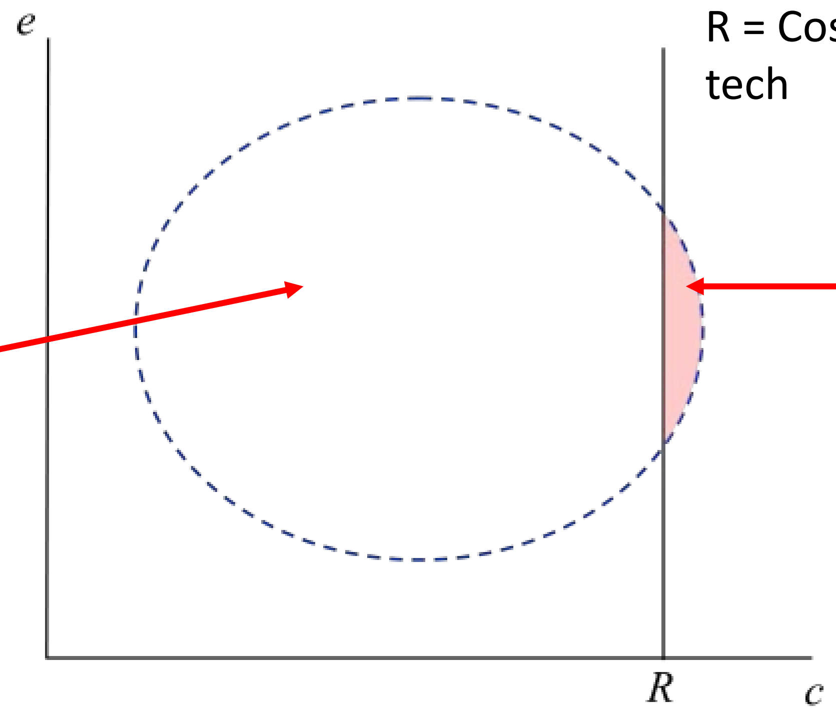
- Clean energy standard should have higher emissions during transition
- Zero-emissions subsidy also has higher emissions, is costlier to the government, lower electricity price and higher consumption

Baseline Conditions

(a) No correlation between c and e, no policy

CO2e tons of emissions per MWH

R = Cost of zero-emissions tech



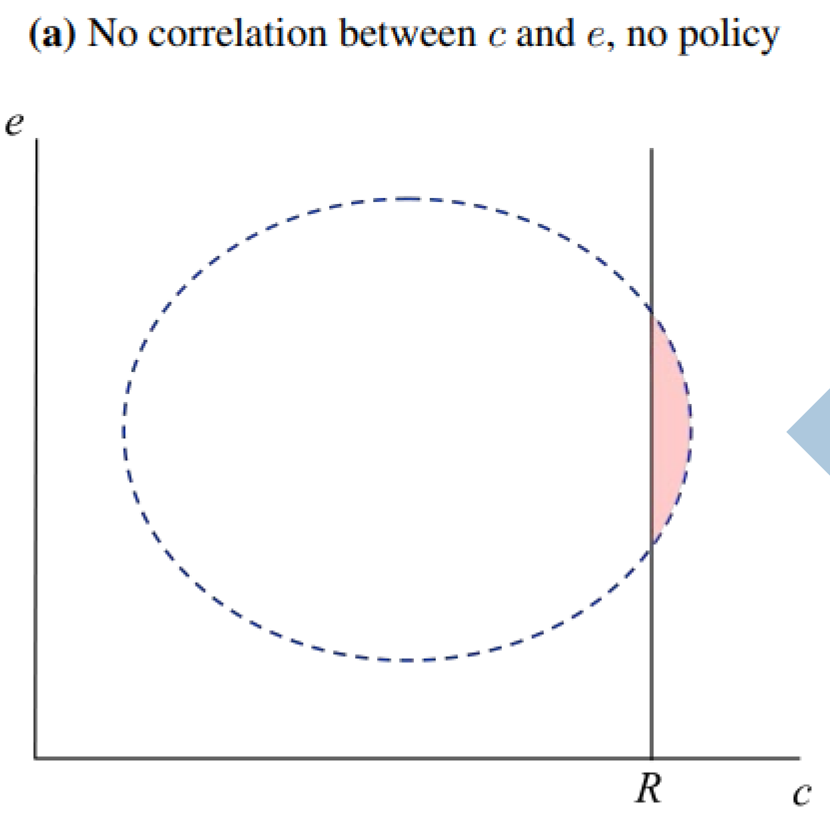
Area = total MWH generated by *fossil fuel* units

GHG generators priced-out by zero-emission sources

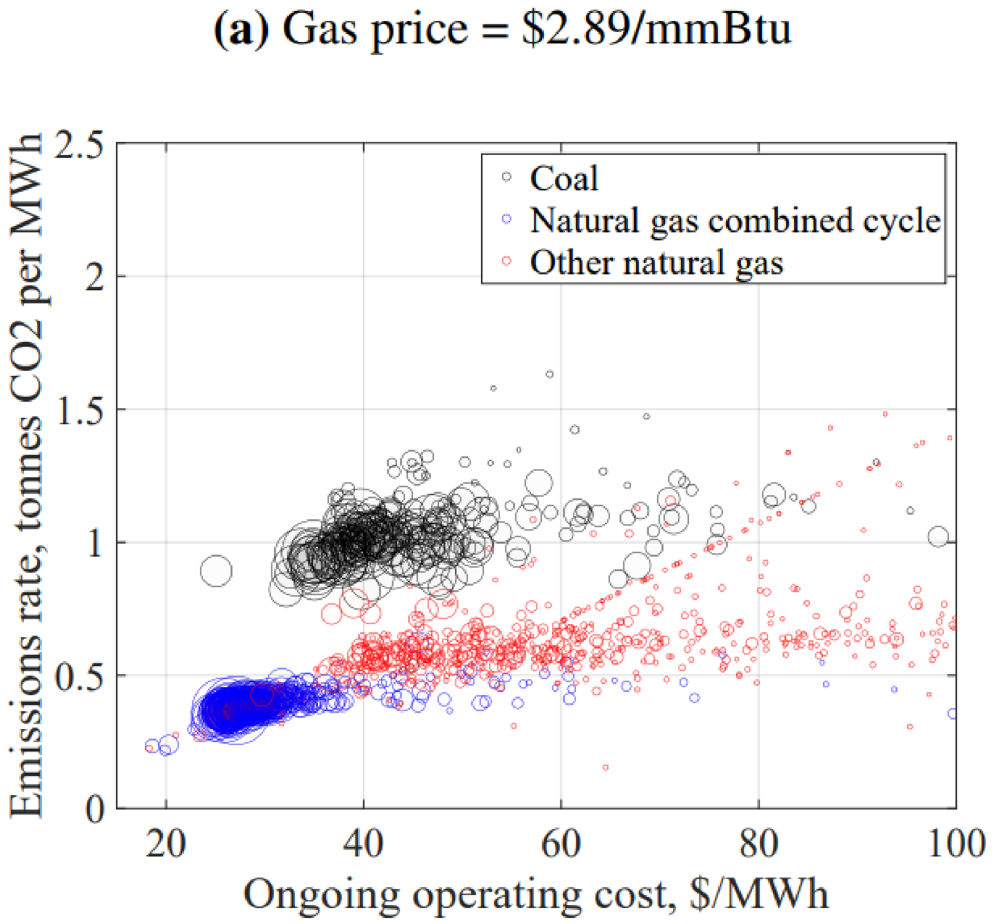
Operating cost per MWH

Baseline Conditions

CO2e tons of emissions per MWH



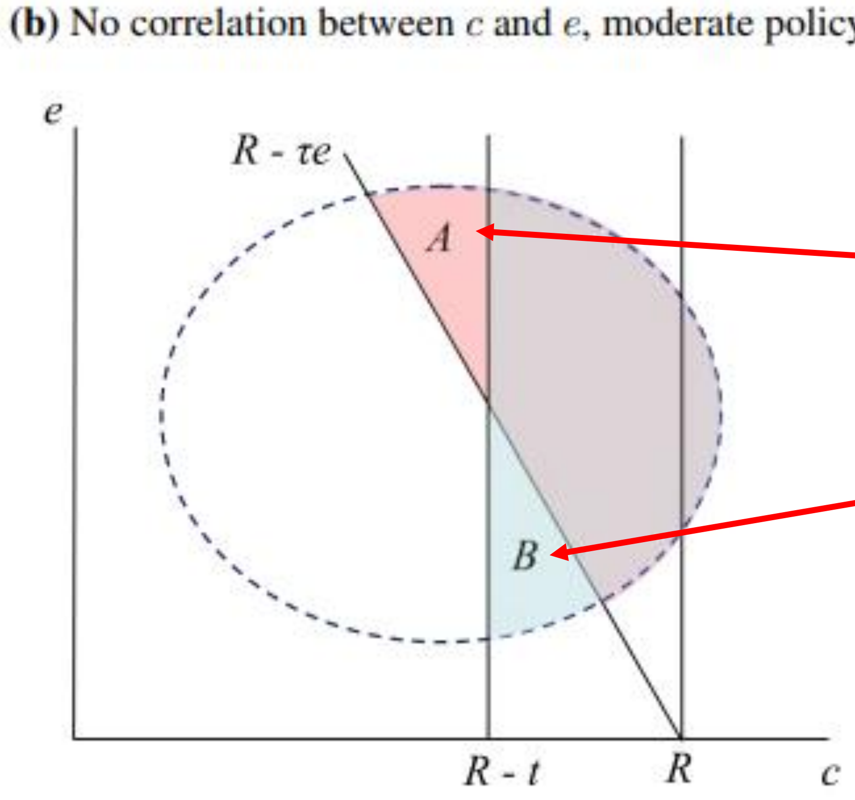
Operating cost per MWH



Tax vs. Clean Energy Standard

CO2e tons of emissions per MWH

Area = total MWH generated by *fossil fuel* units



Operating cost per MWH

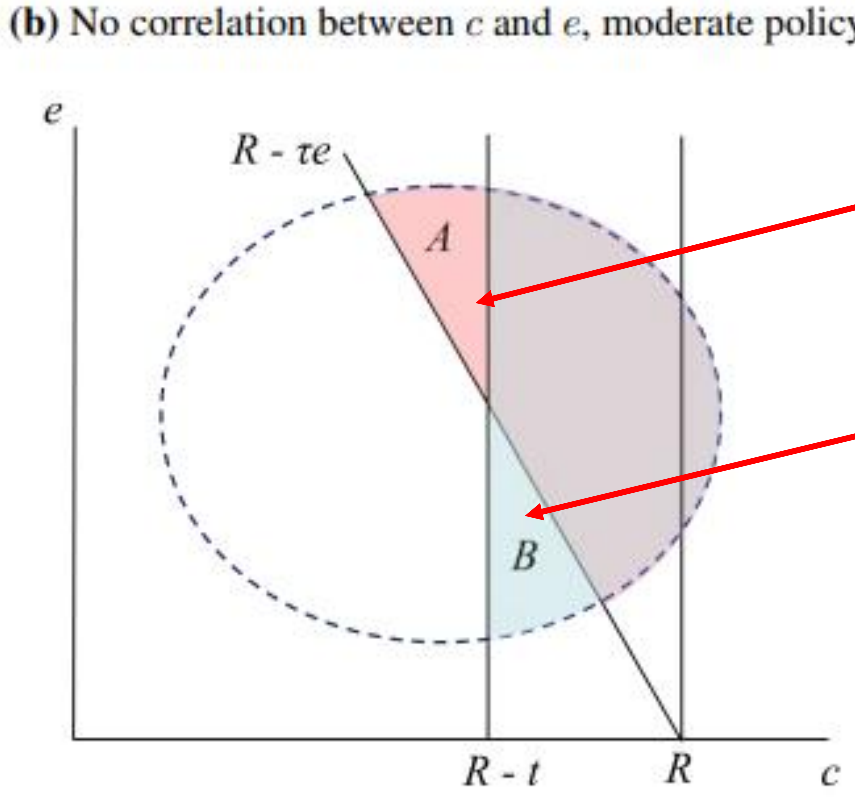
Add tax t or CES equivalent to t.

- Tax: generators with cost te + c > R priced out (A)
- CES: Generators with costs t + c > R are priced out (B)

Tax vs. Clean Energy Standard

CO2e tons of emissions per MWH

Area = total MWH generated by *fossil fuel* units



Operating cost per MWH

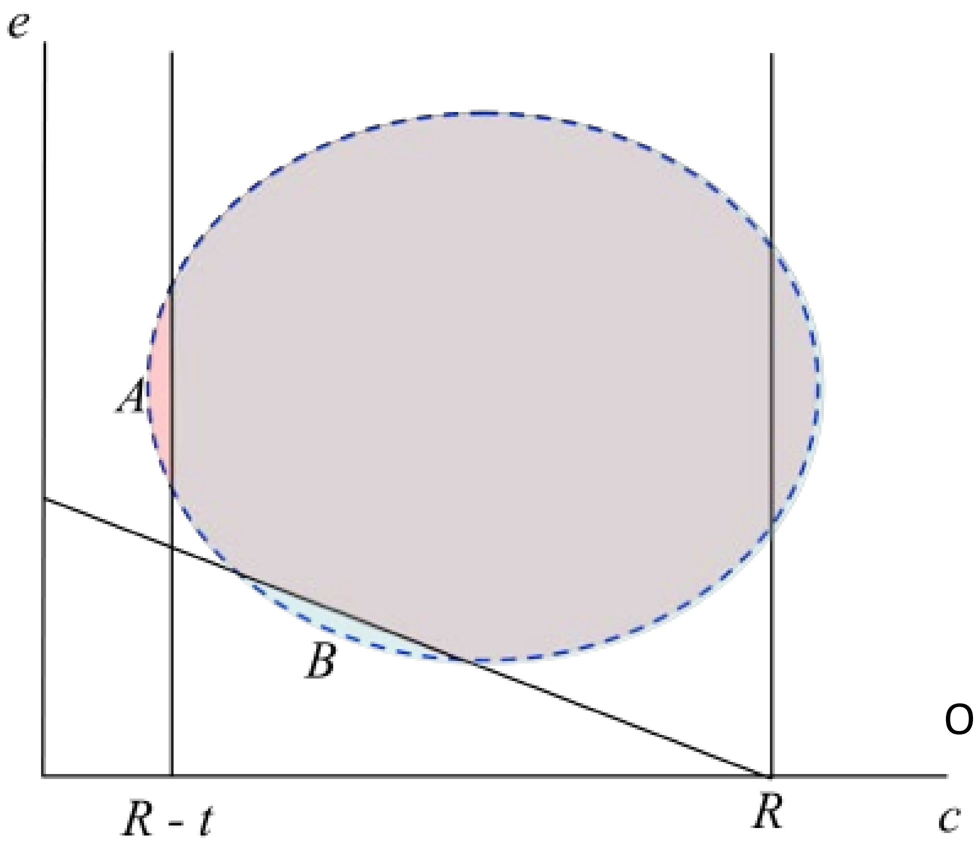
A: Highest emission but lower cost generators are priced out

B: Higher cost but lower emissions generators priced out

Tax vs. Clean Energy Standard

(c) No correlation between c and e, stringent policy

CO2e tons of emissions per MWH

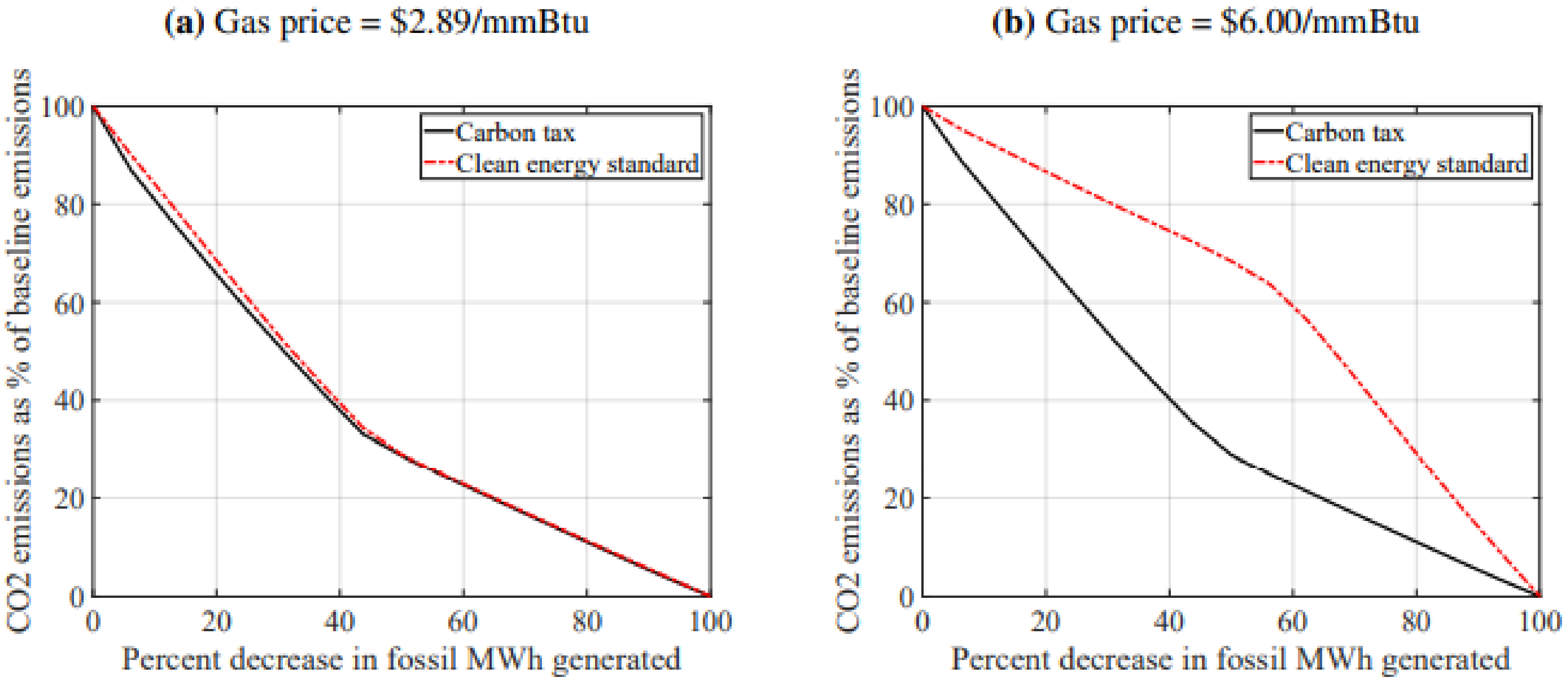


Operating cost per MWH

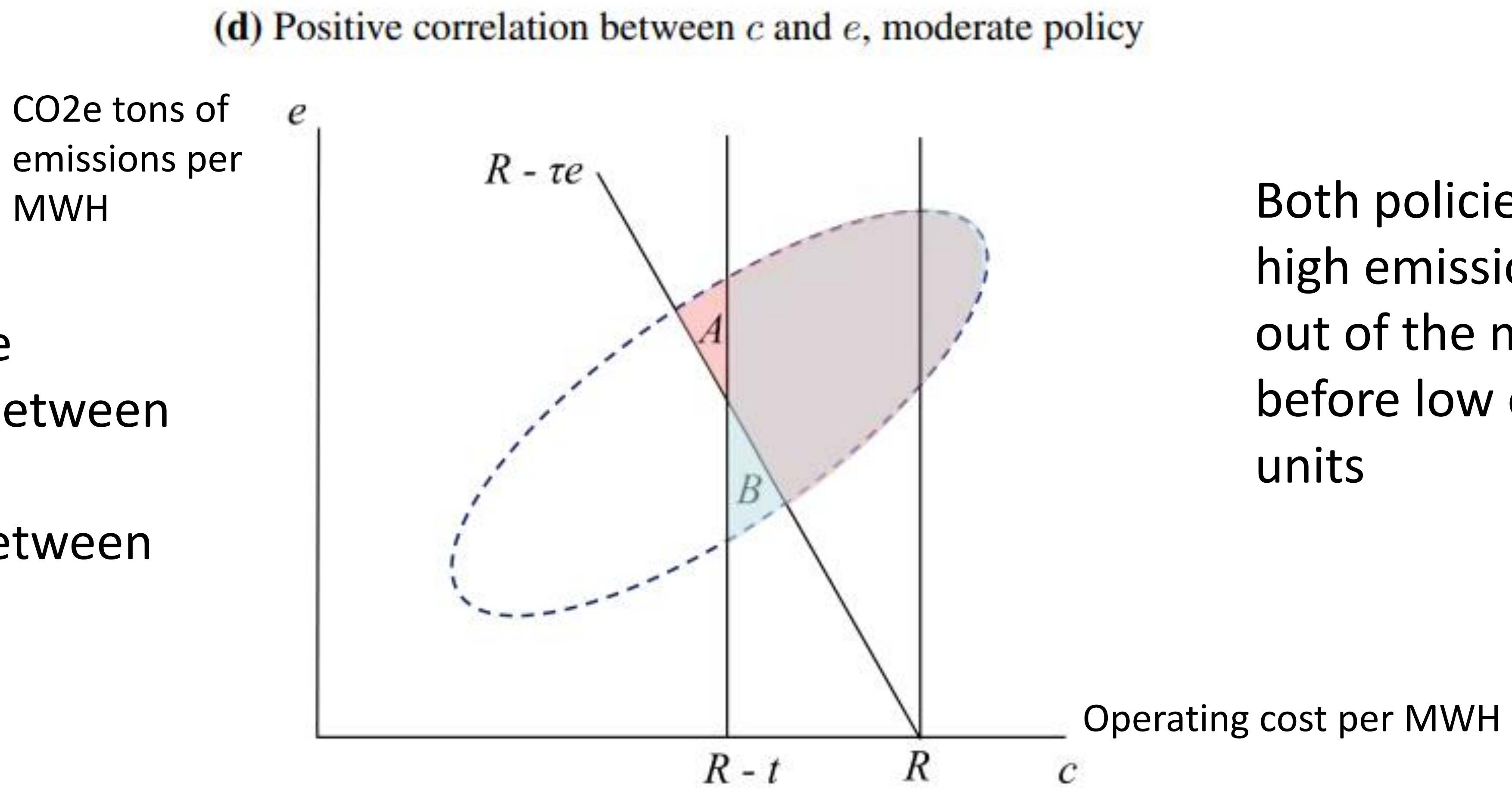
With strictest policies, less difference between tax and CES.

Tax vs. Clean Energy Standard

With lower gas prices, fairly minimal difference between CES and carbon tax.
Why?



Tax vs. Clean Energy Standard



With positive correlation between c and e, less difference between policies.

Both policies push high emissions units out of the market before low emissions units

Borenstein and Kellogg (2022)

Conclusions:

- With carbon equivalent at zero emissions, tax, cap and trade, and intensity standards have the same efficiency implications.
- Relatively low excess emissions of clean energy standard at current gas prices, and yet lower prices.
- Lower prices could be efficiency enhancing with high mark-ups.
  - What about equity?

Next class

Have a nice Thanksgiving. Our next class is one week from today, Monday, November 28th.

Your assigned materials for this lecture are two recent videos in the Resources for the Future seminar series.

- WV vs. EPA Video
- IRA Video