

Markets for Pollution Allowances

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This version: Fall 2017

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Cap-and-Trade Programs

Sulfur Dioxide and Nitrogen Oxides Emissions

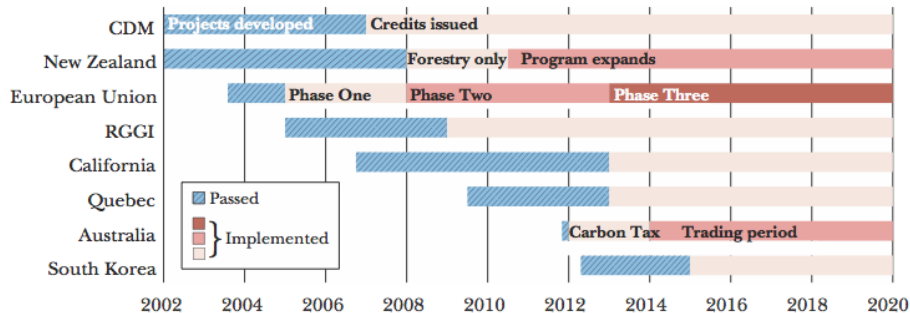
- The U.S. Acid Rain Program
 - ▶ Established under the 1990 Clean Air Act Amendment.
 - ▶ 1995 – Current

Cap-and-Trade Programs

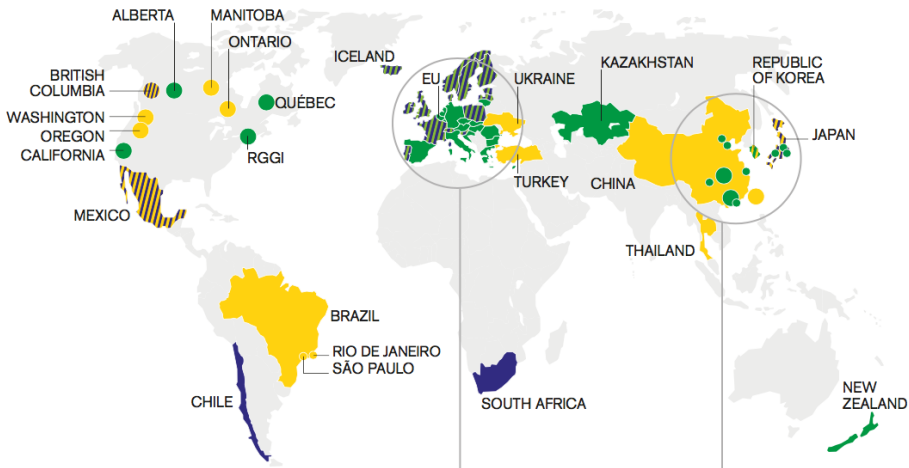
Greenhouse Gas Emissions

- The European Emissions Trading System (EU ETS)
 - ▶ 2005 – Current
- The New Zealand Emissions Trading Scheme (NZ ETS)
 - ▶ 2008 – Current
- The Regional Greenhouse Gas Initiative (RGGI)
 - ▶ Northeastern U.S., 2009 – Current

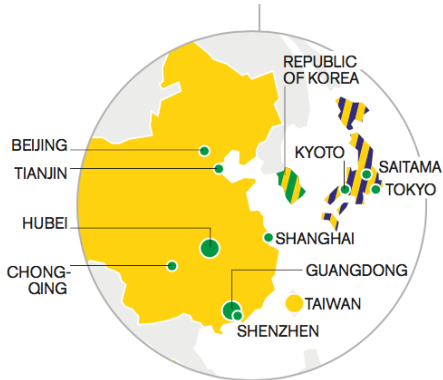
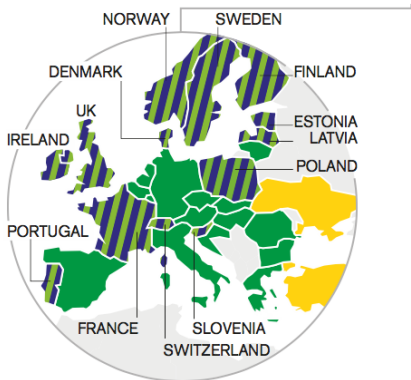
Timeline for Selected GHG Emissions Trading Programs



Source: Newell, Pizer, and Raimi (2013)



Carbon pricing instruments around the world. Source: World Bank (2015)



Tally of carbon pricing instruments



- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled
- ▨ ETS implemented or scheduled, tax under consideration
- ▨ Carbon tax implemented or scheduled, ETS under consideration

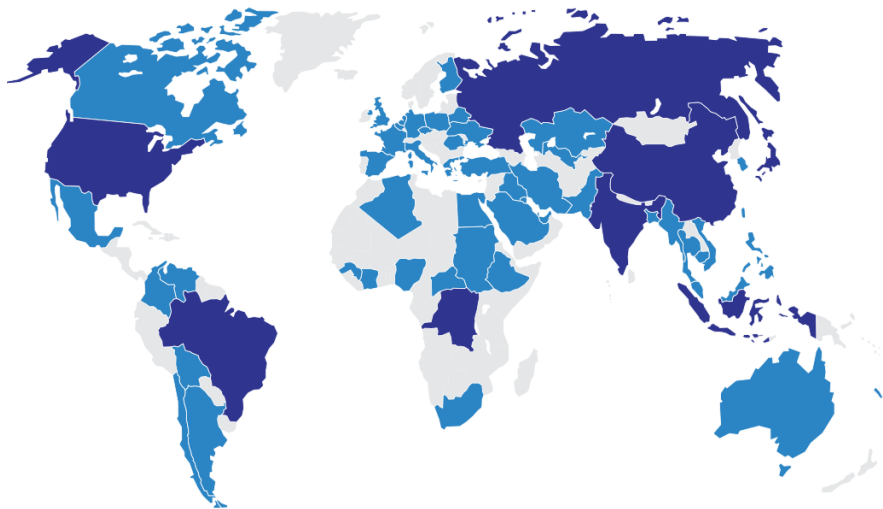
Carbon pricing instruments around the world. Source: World Bank (2015)

Major Greenhouse Gas Sources

<i>Rank</i>	<i>Source</i>	<i>Gas</i>	<i>MMT CO₂e</i>	<i>Share</i>	<i>Cumulative Share</i>
1	Fossil fuels	CO ₂	5,637.0	79.9%	79.9%
2	Agricultural soil management	N ₂ O	265.0	3.8%	83.7%
3	Nonenergy use of fuels	CO ₂	138.0	2.0%	85.6%
4	Landfills	Methane	132.0	1.9%	87.5%
5	Enteric fermentation	Methane	126.2	1.8%	89.3%
6	Ozone depleting substance substitutes	HFC	110.4	1.6%	90.8%
7	Natural gas systems (methane)	Methane	102.4	1.5%	92.3%
8	Coal mining	Methane	58.5	0.8%	93.1%
9	Iron and steel production	CO ₂	49.1	0.7%	93.8%
10	Cement manufacturing	CO ₂	45.7	0.6%	94.5%
11	Manure management	Methane	41.4	0.6%	95.1%

Source: Metcalf and Weisbach (2008) based on data from U. S. Environmental Protection Agency (2008).

Note: Emissions are measured in millions of metric tons (MMT) of CO₂e (carbon dioxide equivalent). Enteric fermentation takes place in the digestive systems of ruminant animals such as cows.



Total GHG emissions per country: ● >1,000 MtCO₂e/year ● 100–1,000 MtCO₂e/year ● <100 MtCO₂e/year

GHG emissions by country. Source: World Bank (2014)

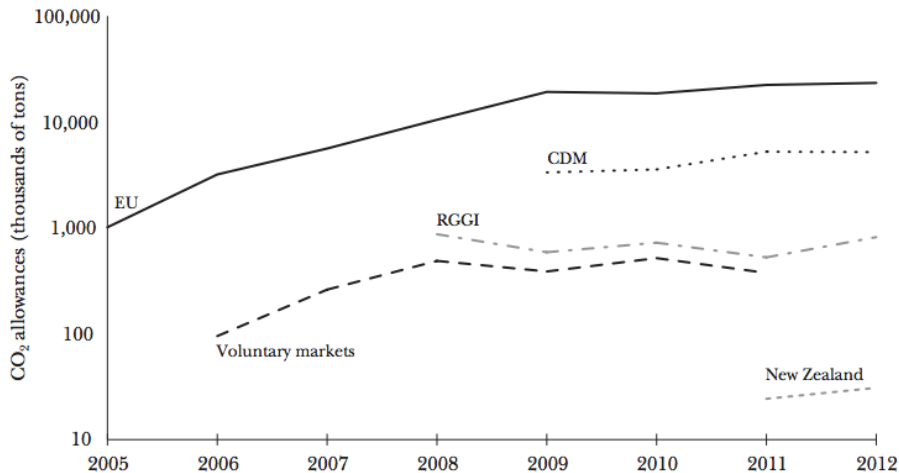
U.S. Greenhouse Gas Emissions by Sector

<i>Sector</i>	<i>Emissions</i>	<i>Share</i>
Electricity	2,378	34%
Transportation	1,970	28%
Industry	1,372	19%
Agriculture	534	8%
Commercial	395	6%
Residential	345	5%
Total	7,054	

Source: U.S. Environmental Protection Agency (2008), Table ES-2.

Note: Emissions are measured in millions of metric tons of CO₂e (carbon dioxide equivalent). The total in the bottom row includes emissions from U.S. territories not included in the other row entries.

Volume of CO₂ Allowance Trades (daily average)

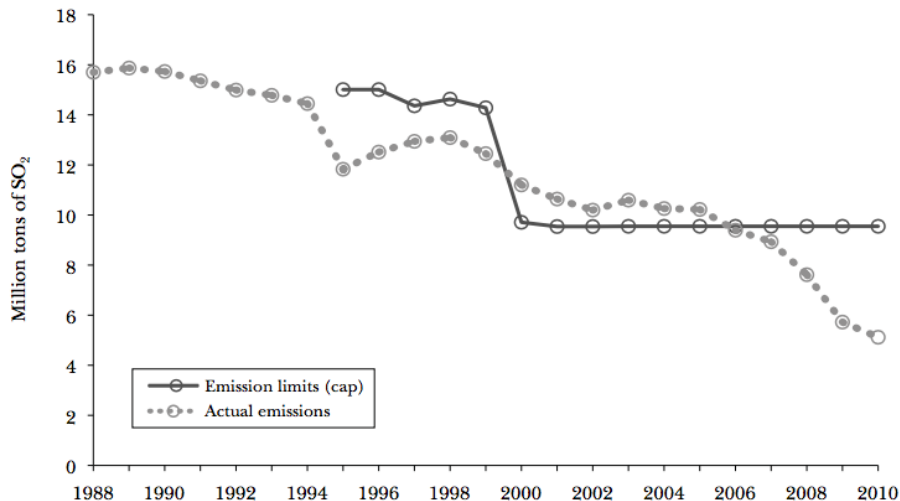


Source: Newell, Pizer, and Raimi (2013)

Performance

- Most cap-and-trade programs have succeeded in reducing emissions to and below the targeted levels.
- Studies generally show that cap-and-trade programs have brought significant cost reductions relative to conventional regulatory approaches.

U.S. SO₂ Caps and Emissions



Source: Schmalensee and Stavins (2013)

**Estimated Annual US Benefits and Costs of
the SO₂ Allowance Trading Program; Title IV,
Clean Air Amendments of 1990**

(billions of US 2000 Dollars)

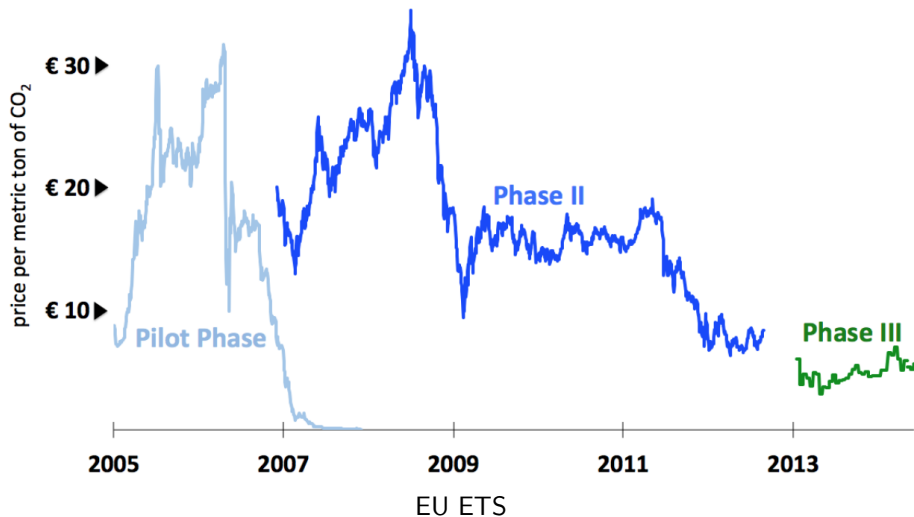
Benefits	
Mortality	50–100
Morbidity	3–7
Recreational visibility	2–3
Residential visibility	2–3
Ecosystem effects	0.5
Total	59–116
Costs	0.5–2.0
Net benefits	58–114

Source: Burtraw, Krupnick, Mansur, Austin, and Farrell (1998); Burtraw (1999); Chestnut and Mills (2005); Banzhaf, Burtraw, Evans, and Krupnick (2006).

Some Challenges: Emissions Leakage

- Emissions leakage could occur when regulations in a lower-level jurisdiction are nested within a cap-and-trade system in a higher-level jurisdiction.
 - ▶ Under a national cap, regional efforts to induce further emissions reductions will result in emissions being transferred to other regions rather than being truly reduced. Same applies to an international cap.
 - ▶ The U.K. climate change levy (CCL), for example, imposes a tax on CO₂ emissions that electric power generators must pay in addition to the price they pay for emissions allowances from the EU ETS. The effect of this policy will likely increase emissions in the rest of Europe.

Some Challenges: Price Volatility



Some Challenges: Price Volatility

- Problems in the EU ETS due to:
 - ▶ Lack of inter-temporal banking and borrowing in Phase I
 - ▶ Lower emissions demand due to recession and weak recovery
 - ▶ Over-generous cap
- Partial solutions:
 - ▶ Inter-temporal banking and borrowing
 - ▶ Price floor and ceiling
 - ▶ Flexible cap

China's Cap-and-Trade Programs

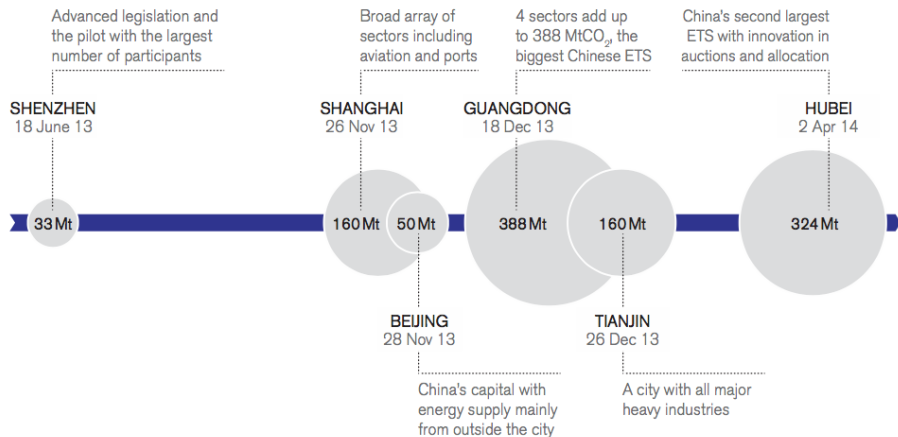
- China currently has 7 pilot programs in operation since June 2013.
- Sectors covered:
 - ▶ Industry: all
 - ▶ Power: Beijing, Tianjin, Hubei, Guangdong, Shenzhen
 - ▶ Buildings: Beijing, Shanghai, Shenzhen
 - ▶ Transportation: Shanghai
 - ▶ Aviation: Shanghai (domestic airlines)
- Some other notable features:
 - ▶ Guangdong and Hubei auction parts of their permits
 - ▶ Shenzhen and Tianjin allow individual investors and financial institutions to trade permits.

China's Cap-and-Trade Programs

	Shenzhen	Shanghai	Beijing	Guangdong	Tianjin	Hubei
Starting date	June 18, 2013 ¹⁶²	November 26, 2013 ¹⁶³	November 28, 2013 ¹⁶⁴	December 18, 2013 ¹⁶⁵	December 26, 2013 ¹⁶⁶	April 2, 2014 ¹⁶⁷
Traded volumes¹⁶⁸ (ktCO₂e)	0.250	0.239	0.096	0.126	0.140	1.608
Average price¹⁶⁹ (CNY) [\$US]	75.2 [12.4]	31.4 [5.2]	52.6 [8.7]	61.8 [10.2]	34.7 [5.7]	24.7 [4.1]

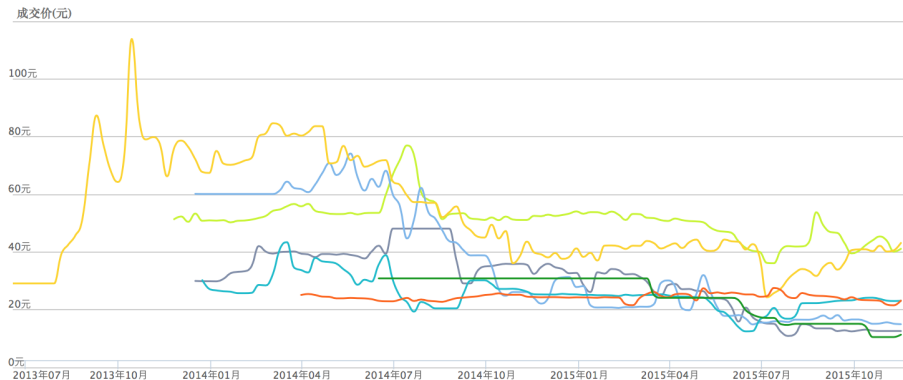
Source: World Bank (2014)

China's Cap-and-Trade Programs



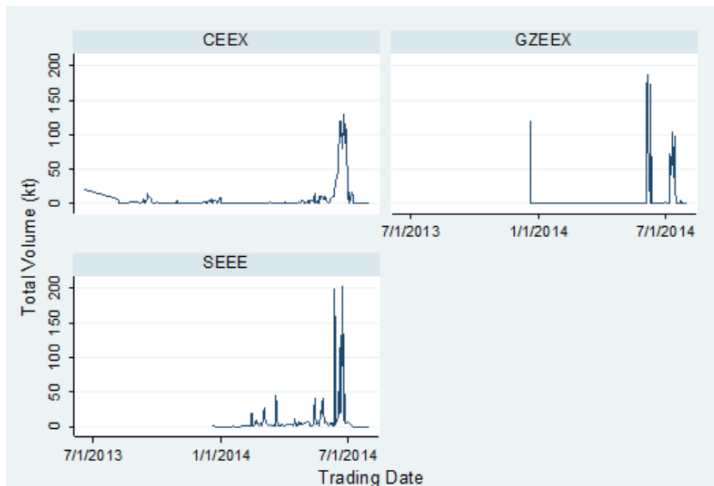
Source: World Bank (2014)

China's Cap-and-Trade Programs



Beijing: Lime; Shanghai: Grey; Guangdong: Blue; Tianjin: Cyan; Shenzhen: Yellow; Hubei: Red; Chongqing: Green; Source: tanpaifang.com

China's Cap-and-Trade Programs





Daily Trading Volume in Shenzhen (CEEX), Guangdong (GZEEX) and Shanghai (SEEE). Source: Munnings et al. (2014)

Reference I

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Reference II

-  The World Bank. 2014. "State and Trends of Carbon Pricing." Washington, DC.
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