Markets for Pollution Allowances

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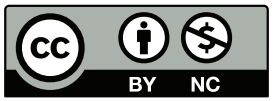

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Cap-and-Trade Programs

Sulfur Dioxide and Nitrogen Oxides Emissions

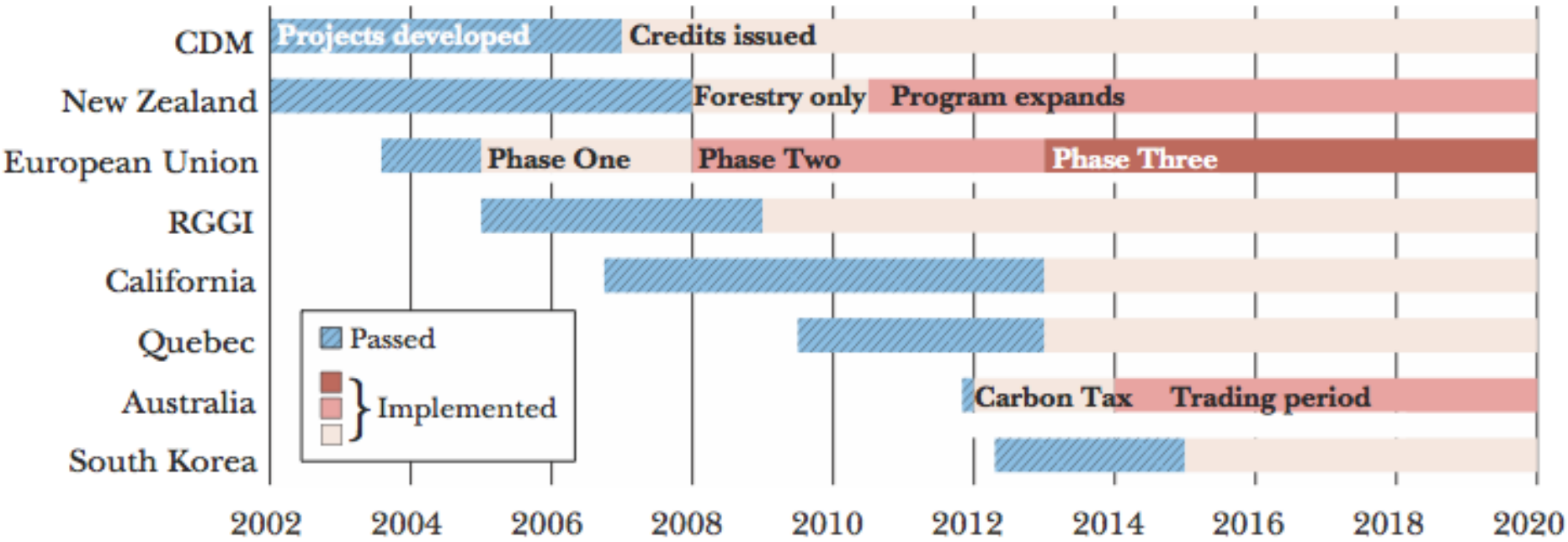
- The U.S. Acid Rain Program
  - Established under the 1990 Clean Air Act Amendment.
  - 1995 – Current

Cap-and-Trade Programs

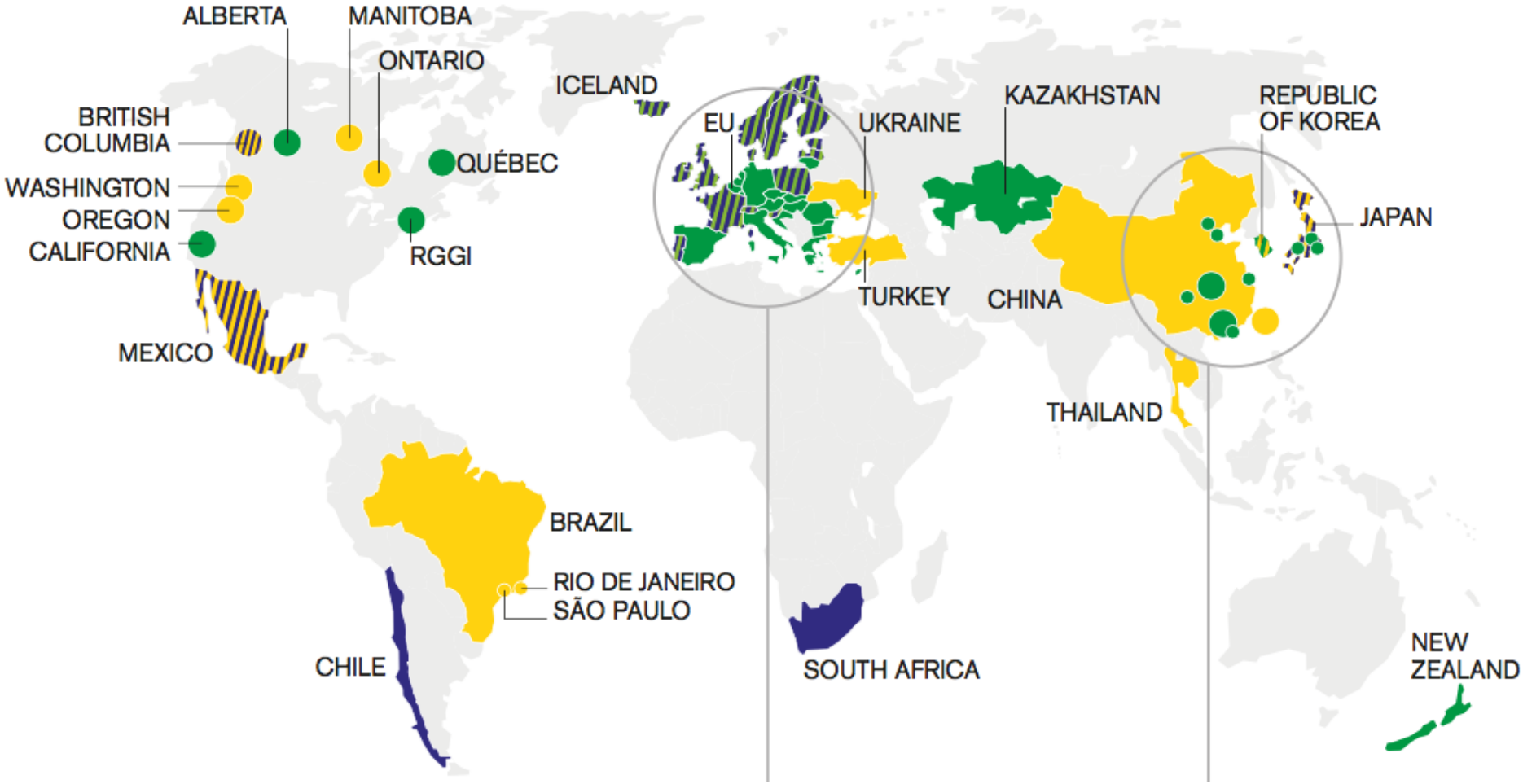
Greenhouse Gas Emissions

- 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

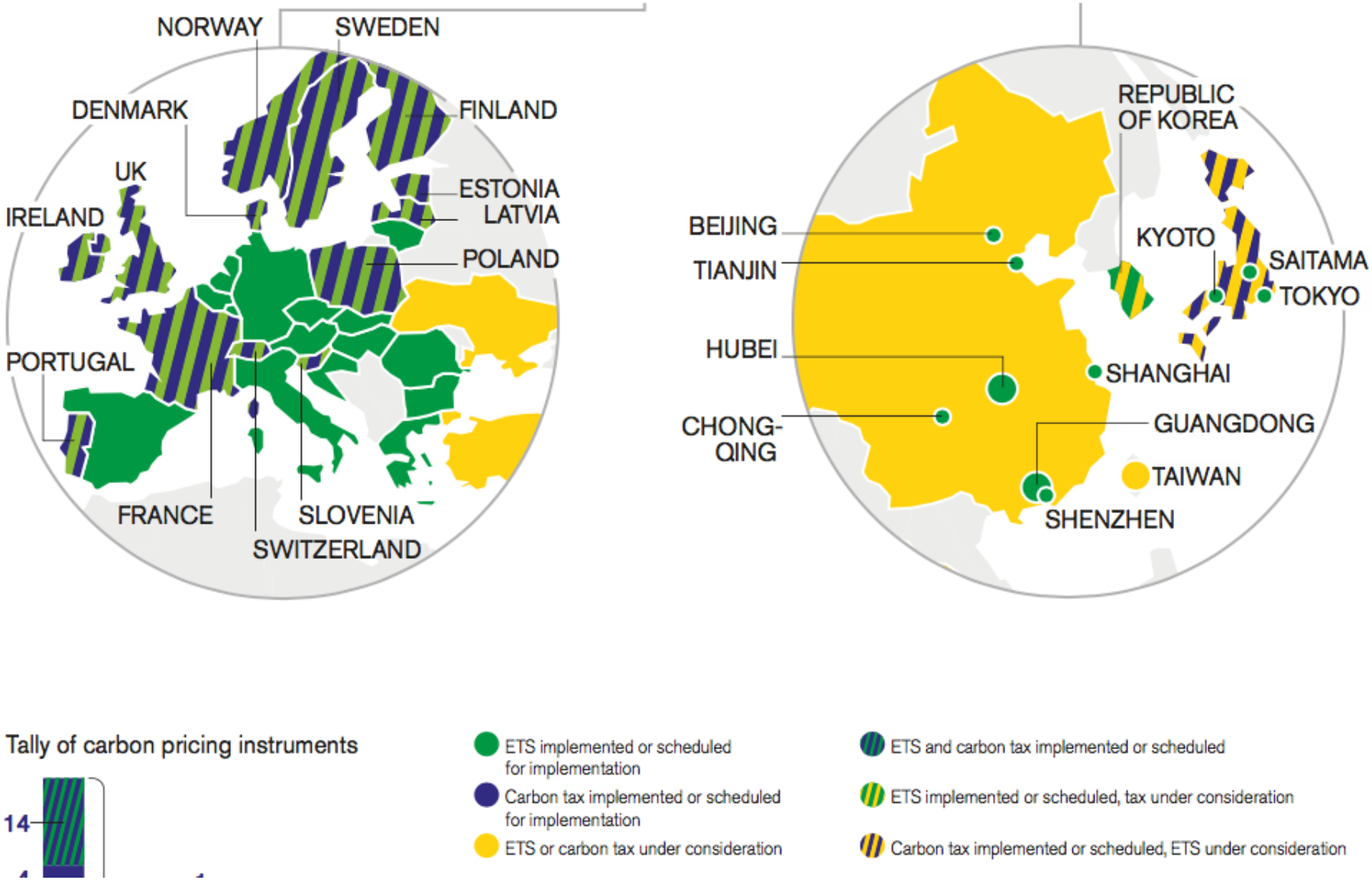
Timeline for Selected GHG Emissions Trading Programs



Source: Newell, Pizer, and Raimi (2013)



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

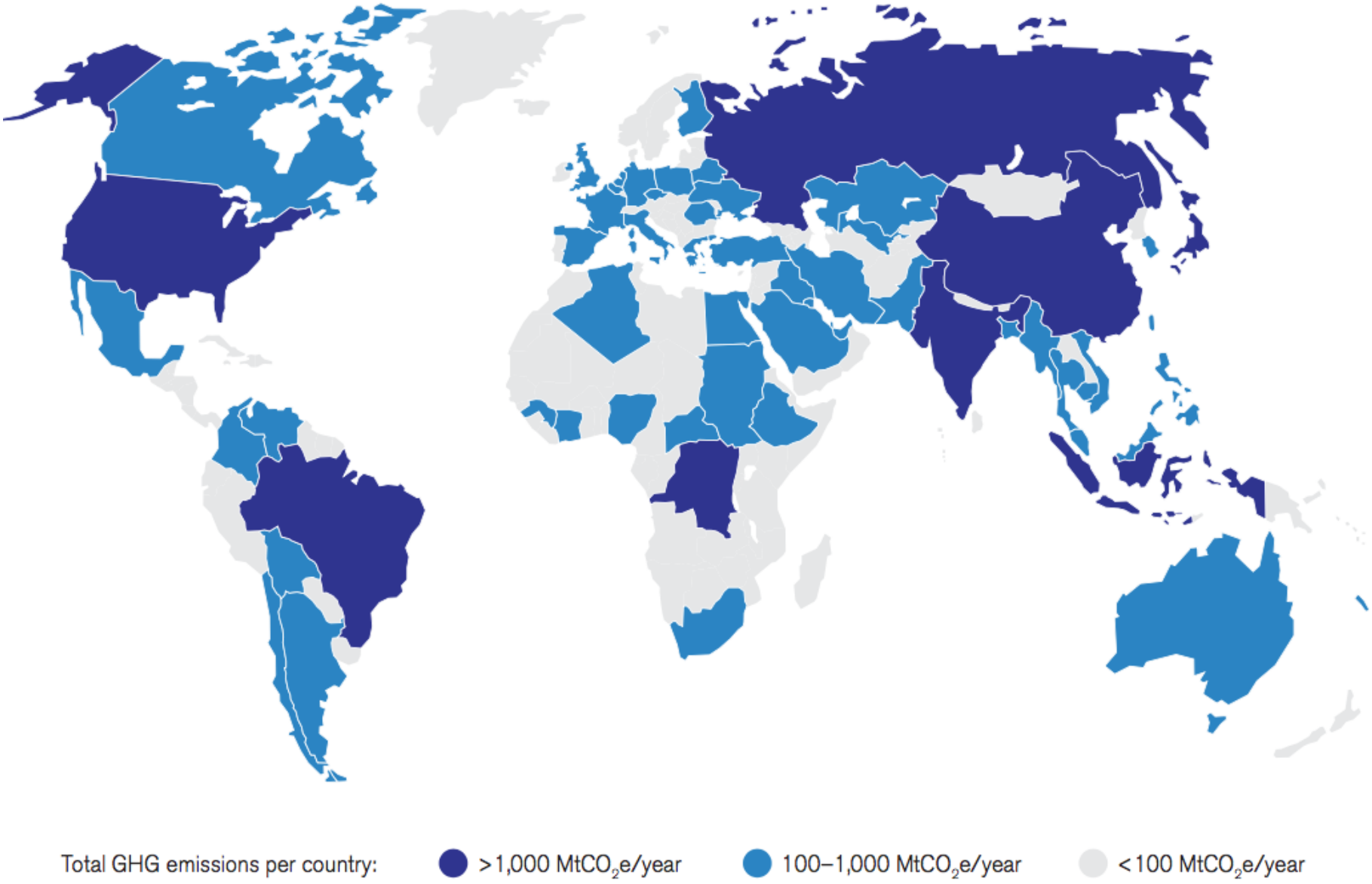


Carbon pricing instruments around the world. Source: World Bank (2015)

Major Greenhouse Gas Sources

Rank	*Source*	*Gas*	*MMT CO_2e*	*Share*	*Cumulative Share*
1	Fossil fuels	CO_2	5,637.0	79.9%	79.9%
2	Agricultural soil management	N_2O	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 CO_2e (carbon dioxide equivalent). Enteric fermentation takes place in the digestive systems of ruminant animals such as cows.



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

U.S. Greenhouse Gas Emissions by Sector

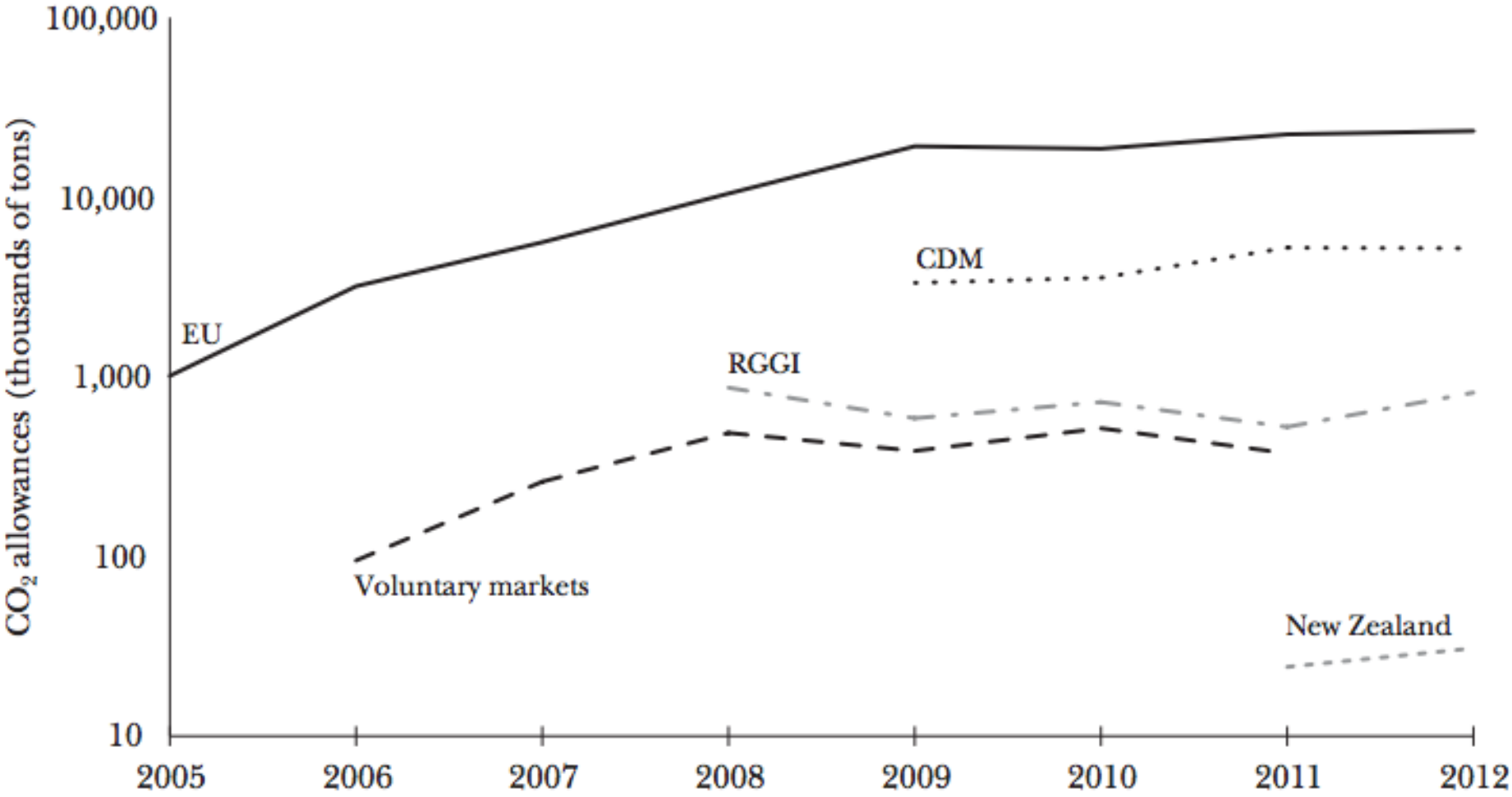
Sector	*Emissions*	*Share*
Electricity	2,378	34%
Transportation	1,970	28%
Industry	1,372	19%
Agriculture	534	8%
Commercial	395	6%
Residential	345	5%
Total	**7,054**	

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

Note: Emissions are measured in millions of metric tons of CO_2e (carbon dioxide equivalent). The total in the bottom row includes emissions from U.S. territories not included in the other row entries.

Volume of CO_2 Allowance Trades

(daily average)

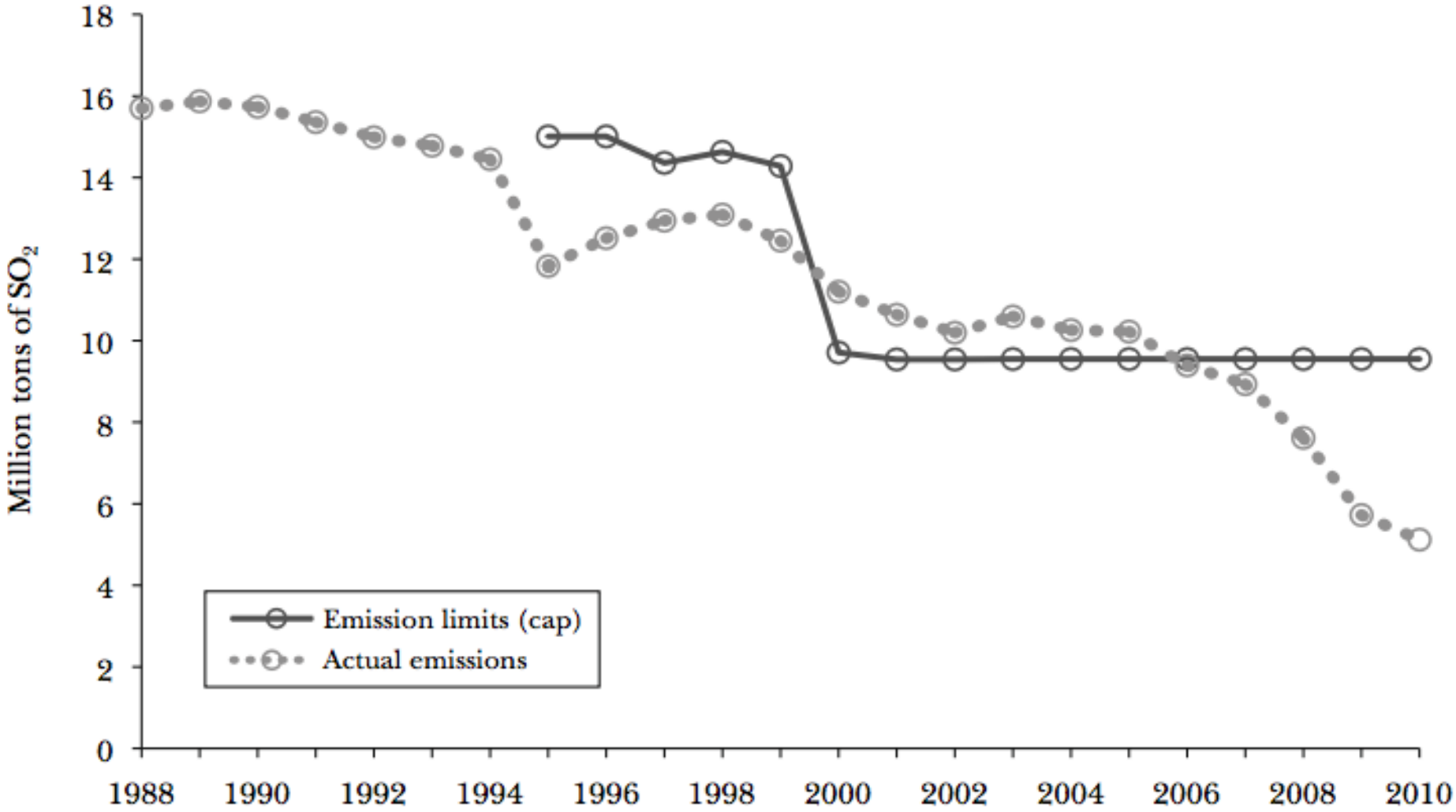


Source: Newell, Pizer, and Raimi (2013)

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 SO_2 Allowance Trading Program; Title IV, Clean Air Amendments of 1990

(billions of US 2000 Dollars)

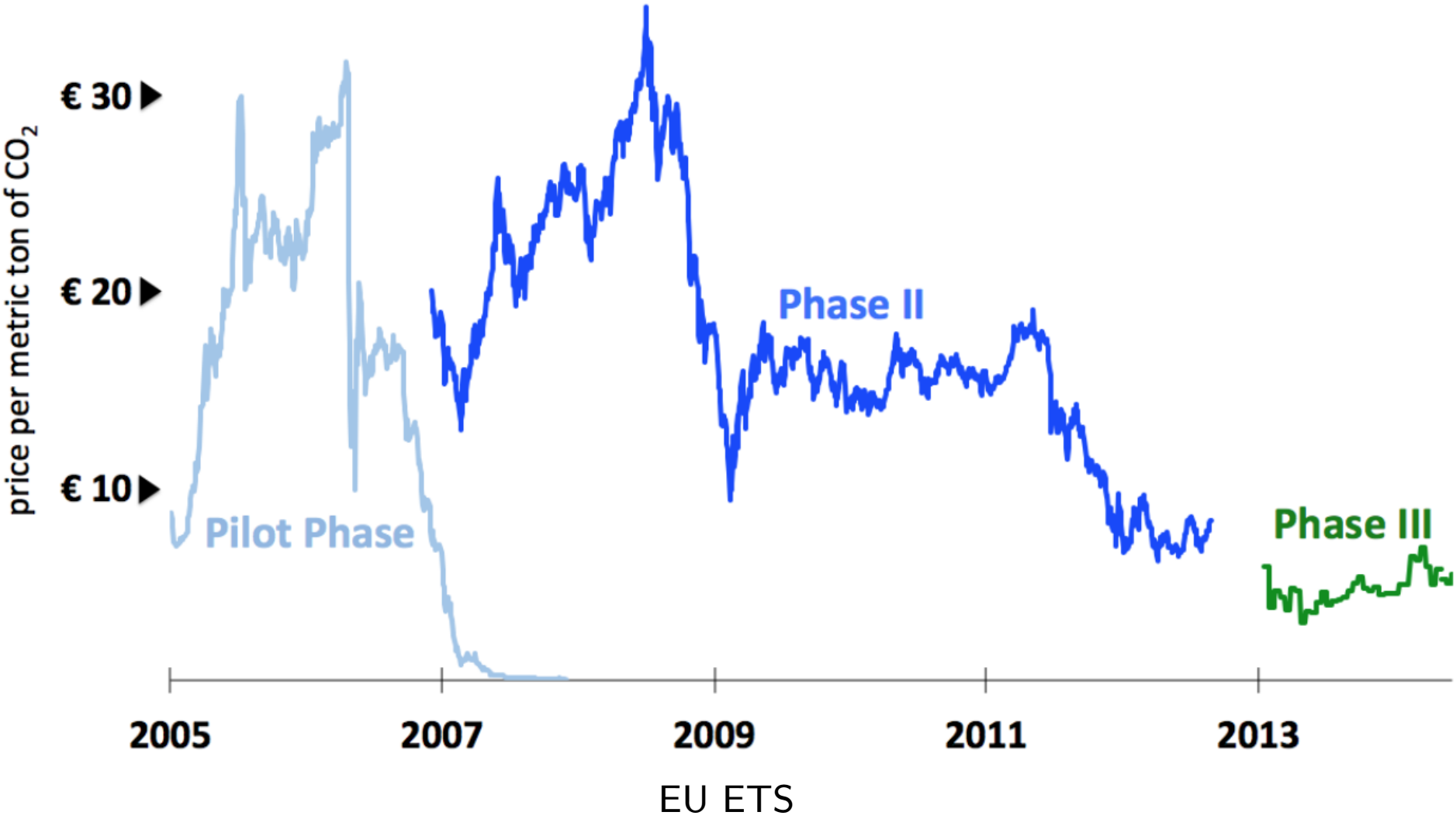
Benefits	
Mortality	50–100
Morbidity	3–7
Recreational visibility	2–3
Residential visibility	2–3
Ecosystem effects	0.5
Total	**59–116**
Costs	**0.5–2.0**
Net benefits	**58–114**

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



EU ETS

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

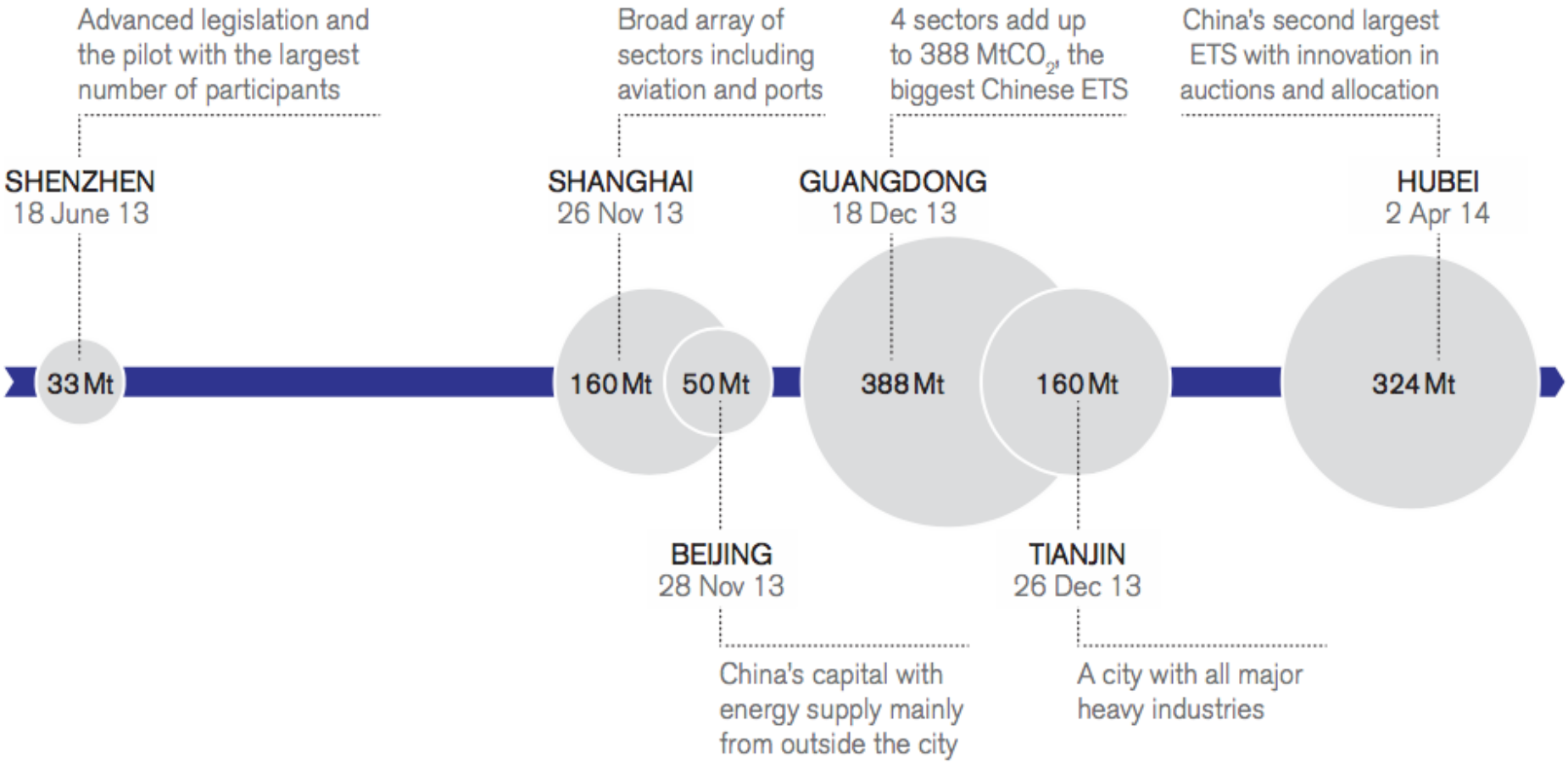
- China has announced a plan to launch a national cap-and-trade program in 2017.
- Currently 7 pilot programs in operation since June 2013.
- Sectors covered:
  - Industry: all
  - Power: Beijing, Tianjin, Hubei, Guangdong, Shenzhen
  - Buildings: Beijing, Shanghai, Shenzhen
  - Transportation: Shanghai
  - 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 volumes[168] ($ktCO_2e$)	0.250	0.239	0.096	0.126	0.140	1.608
Average price[169] (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]

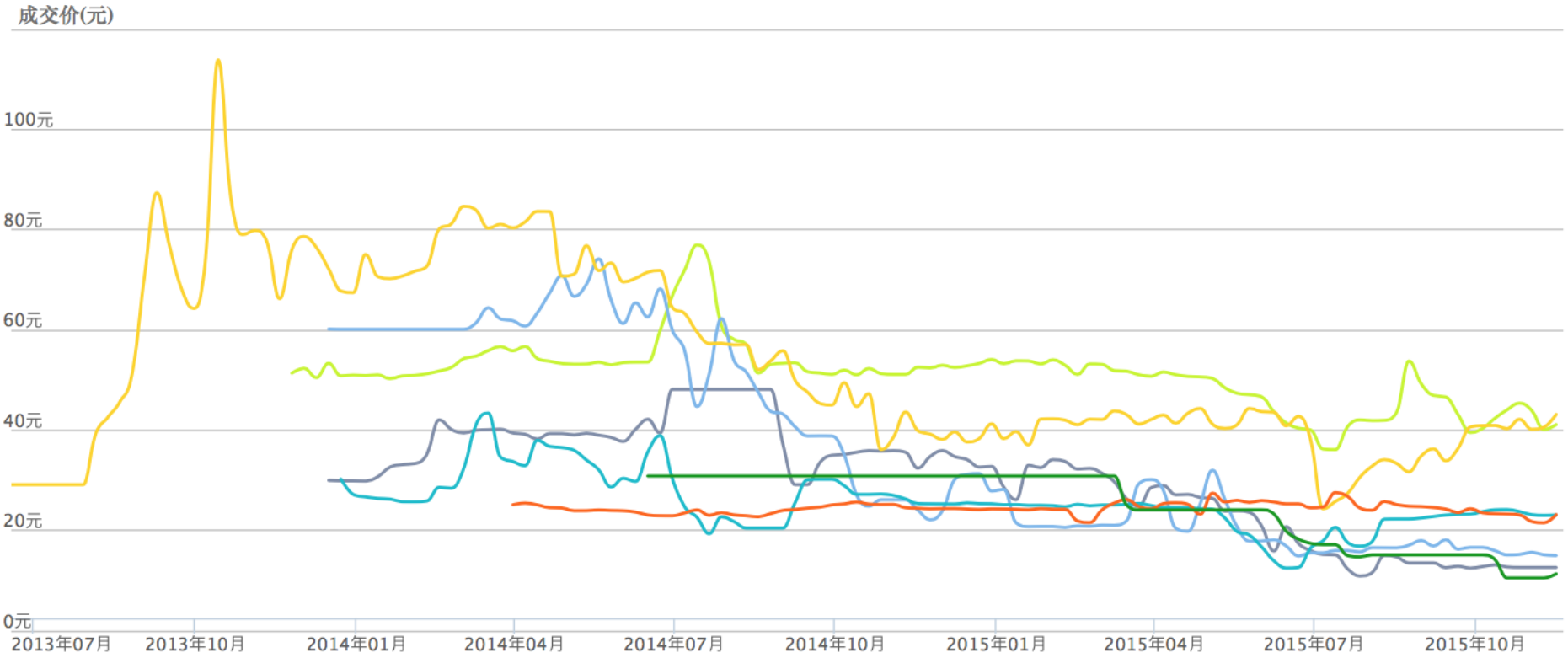
Source: World Bank (2014)

China's Cap-and-Trade Programs



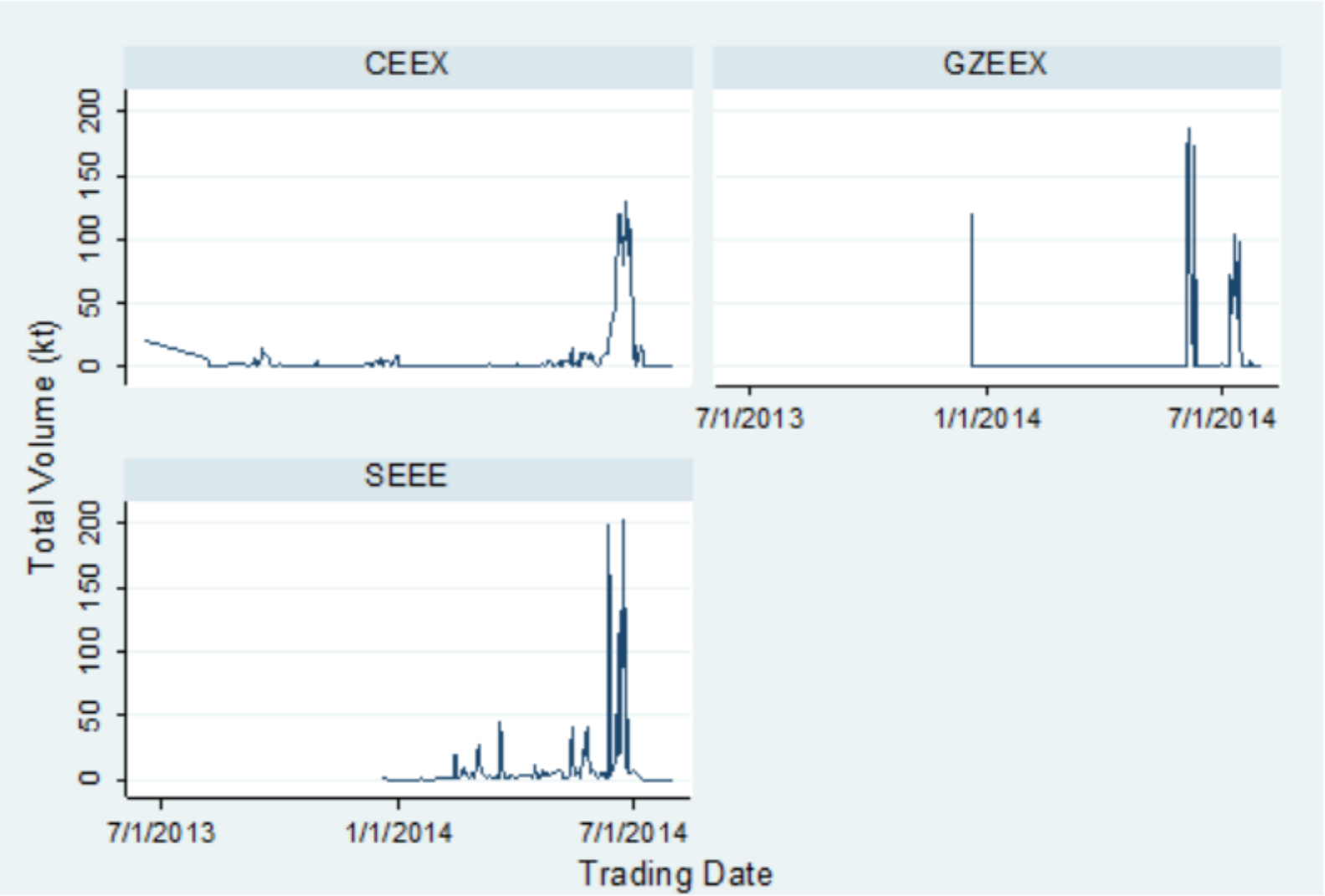
Source: World Bank (2014)

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: RFF (2014)