Chinese power sector emission trading simulation

14th IEA-IETA-EPRI GHG workshop

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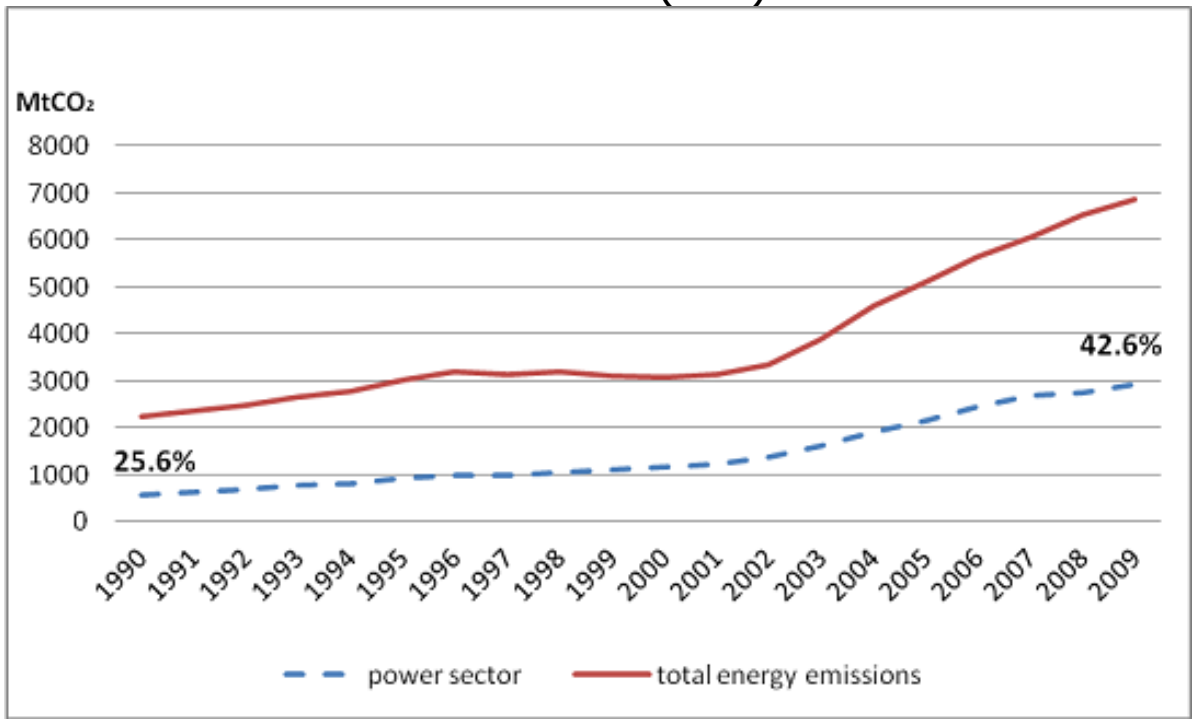
Agenda

A. Context: China, IEA
B. The simulation
C. Results
D. Conclusions & implications

Context: electricity key to climate change efforts

- China world's largest CO_2 emitter, power sector >40% of emissions
  - grew by 50% between 1990 and 2000, and doubled in the last decade
  - reached 7 billion tons of CO2 in 2010 (IEA)

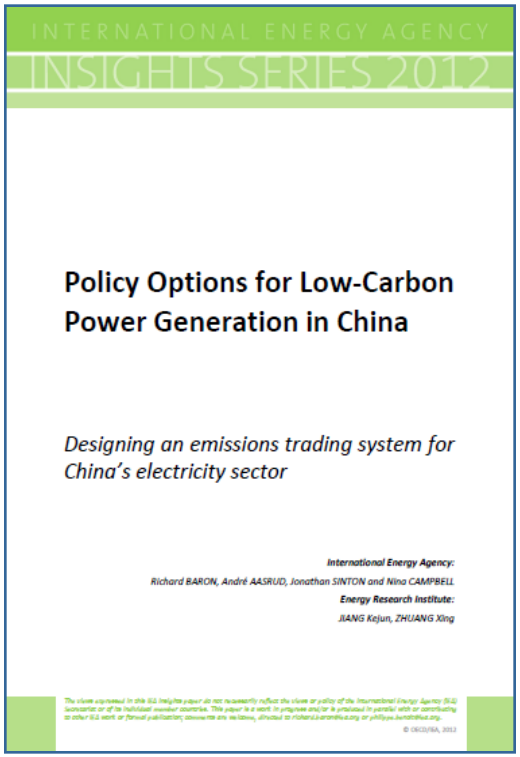


Government taking action

- China has pledged to reduce carbon emissions per unit of GDP from 2005 levels by 40-45% by 2020

- Government in testing mode:
  - Exploring how an ETS could work in five city and two province pilots
  - Has committed to introduce national emissions trading scheme, including electricity generation, by 2016

IEA context: simulation next step from prior China electricity work



- Collaborative project with Chinese partners: ERI (NDRC) and China Electricity Council (CEC)

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What can a simulation achieve?

- Can/how will generators adapt to carbon constraint and trading opportunities in a Chinese context?
  - SOE power companies
  - Power production mandates
  - Preferential tariffs for cleaner fuels
  - Horizontal business relationships
- Test different rules and policies
- Insights for a national ETS
- Give generators experience

Participation of power companies key

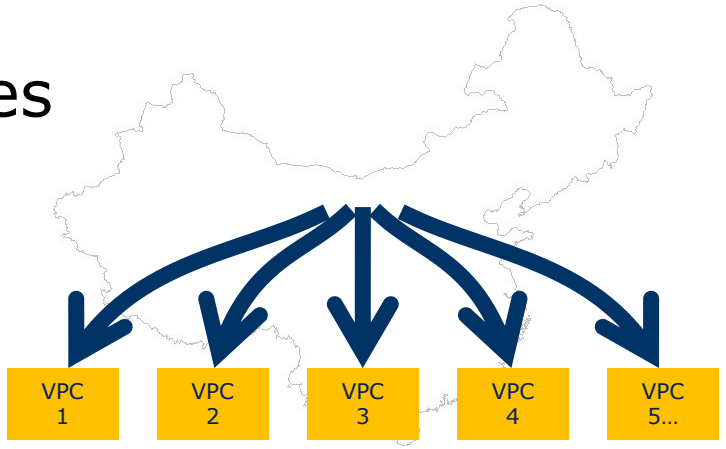
- 32 participants from nine companies, representing half China's installed capacity
- Good representation from four of China's five major generators

Generators: Facing the ETS landscape

1. Provide mandated generation…
2. …within a carbon constraint…
3. …with trading opportunities to manage constraint…
4. …while maximising profit…
5. and build new generation to meet increasing demand

Building a simulation

1. Build ‘realistic’ power companies



2. Provide growing generation obligation and carbon allowances

3. Setup renewable/fossil-fuel/nuclear power stations to own and build (calibration key)

4. Setup trading market

CBEEX setup carbon market

- CBEEX not a financial exchange so under Chinese regulations not allowed to have single market matching buyers and sellers
- Instead hosted separate buy and sell markets
- VPC places bid/offer in one market and other VPCs respond, triggering 24 hour auction

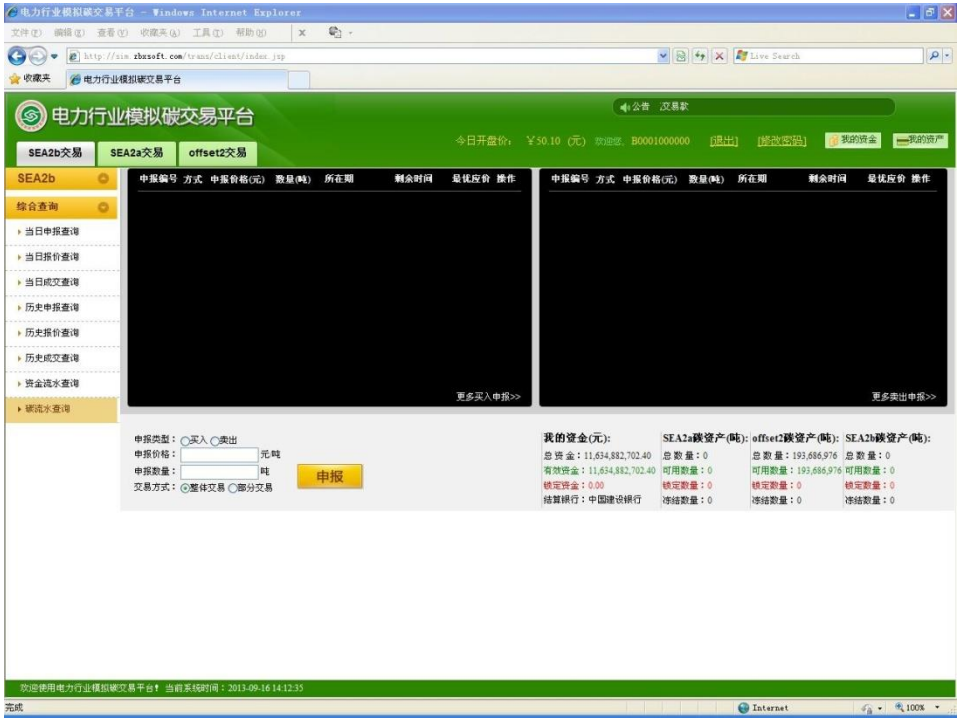
Prepare tools to help simulation

Interactive spreadsheet for VPCs to operate, test & record trades…

…and online portal to trade carbon

Fleet marginal cost of avoided CO2

Reqd Generation			1400							
Carbon			666							
				MAX PROFIT>>>>>>>>>>>>>>>>>>>>				<<<<<<<<<<<<<<<<<<<<MIN CARBON		
				Output...						
Plant	Max Output (MWh)	Carbon intensity (tCO2/MWh)	Profit ability (RMB/MWh)	1st iteration	2nd iteration	3rd iteration	4th iteration	5th iteration	6th iteration	7th iteration
A	800	0.5	50	0	0	0	30	630	#N/A	#N/A
B	600	0.7	90	600	600	600	600	0	#N/A	#N/A
C	400	0.7	58	0	0	0	0	0	#N/A	#N/A
D	550	0.4	60	440	540	550	550	550	#N/A	#N/A
E	200	0	60	200	200	200	200	200	#N/A	#N/A
F	20	0.2	60	20	20	20	20	20	#N/A	#N/A
G	40	0.8	100	40	40	30	0	0	#N/A	#N/A
H	100	1	90	100	0	0	0	0	#N/A	#N/A
I	0			0	0	0	0	0	#N/A	#N/A
J	0			0	0	0	0	0	#N/A	#N/A
K	0			0	0	0	0	0	#N/A	#N/A
L	0			0	0	0	0	0	#N/A	#N/A
	Generation			1400	1400	1400	1400	1400	#N/A	#N/A
	Profit			106600	103600	103200	101700	77700	#N/A	#N/A
	Carbon			732	672	668	659	539	#N/A	#N/A
	Emissions to buy (-) / sell (+)			-66	-6	-2	7	127	#N/A	#N/A
Least profitable/tCO2 of running plai				H	G	G	A	A	#N/A	#N/A
Dirtiest running plant				H	G	G	B	A	#N/A	#N/A
Most profitable of cleaner spare plai				D	D	A	A	#N/A	#N/A	#N/A
MWh to swap				100	10	30	600	#N/A	#N/A	#N/A
tCO2 saved per MWh swap				0.6	0.4	0.3	0.2	#N/A	#N/A	#N/A
Profit given up per MWh swap				30	40	50	40	#N/A	#N/A	#N/A
Cost of tCO2 avoided				50	100	166.667	200			



Simulation: 'running order'

- Six weeks represent six years
- Baseline week/year then five trading weeks/years
- Two trading sessions per day
- 2 sessions x 5 days x 5 weeks = 50 trading sessions
- 4 scenarios

4 scenarios test different elements

	Robust Trading • 35% of emissions coverable by offsets • Single unified market	**Limited Trading** • 5% of emissions coverable by offsets • Market divided into two regions which cannot trade allowances • One offset market for whole scenario
Different allowances Half given larger annual free allowance, and predisposed to be 'sellers'. Other half short-'buyers'	Scenario 1 **8**: 4 x Seller ; 4 x Buyer	Scenario 2 **8**: 2 x North seller ; 2 x North buyer 2 x South seller ; 2 x South buyer
Identical allowances	Scenario 3 **8**: 8 x identical VPC	Scenario 4 **8**: 4 x North 4 x South

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Generators succeeded

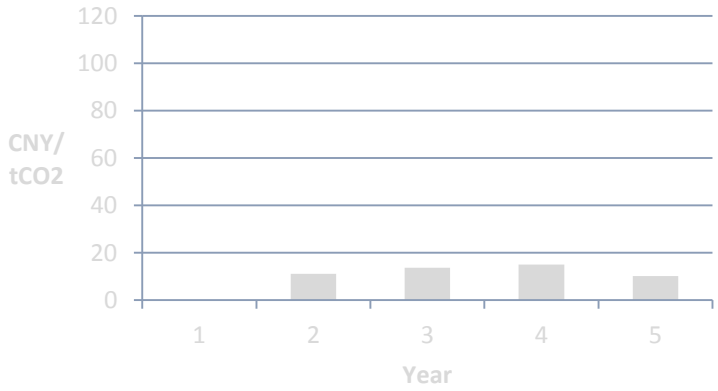
- Over 90% of VPCs met generation and carbon targets
- Different VPCs used different tactics, and changed them during simulation
- All VPCs adjusted dispatch to improve position and all-but-one built new 'clean' generation
- Tight competition: half of VPCs finished within 10% of their cohort winner

VPCs reluctant to sell to each other?

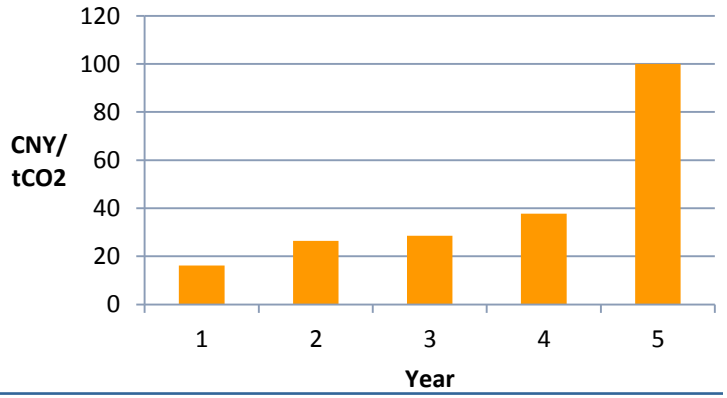
- 88% of all trade volume were offsets, where money paid goes to offset supplier
- In two scenarios offsets traded at higher price than allowances, despite the cap on their use
- Very limited reselling of offsets
- 8 of 32 VPCs did not buy carbon from another
- 6 did not use market at all

Carbon prices rose as simulation got harder

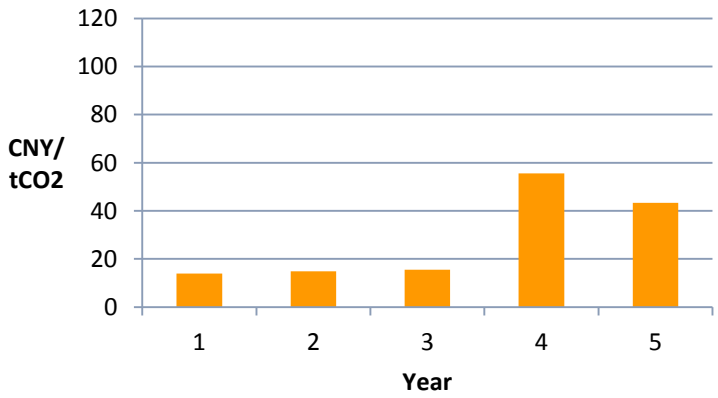
Scenario 1: pro-trade & buyer-seller VPCs



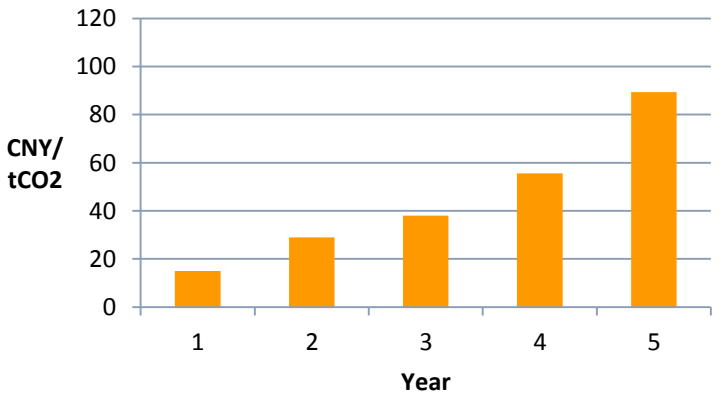
Scenario 2: stifle trade & buyer-seller VPCs



Scenario 3: pro-trade & identical VPCs



Scenario 4: stifle trade & identical VPCs



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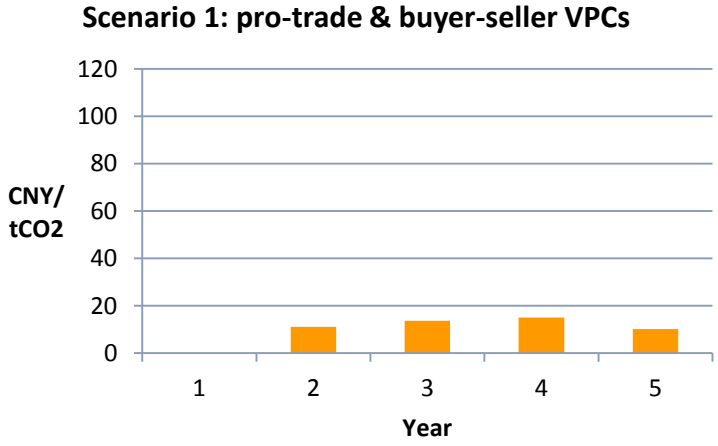
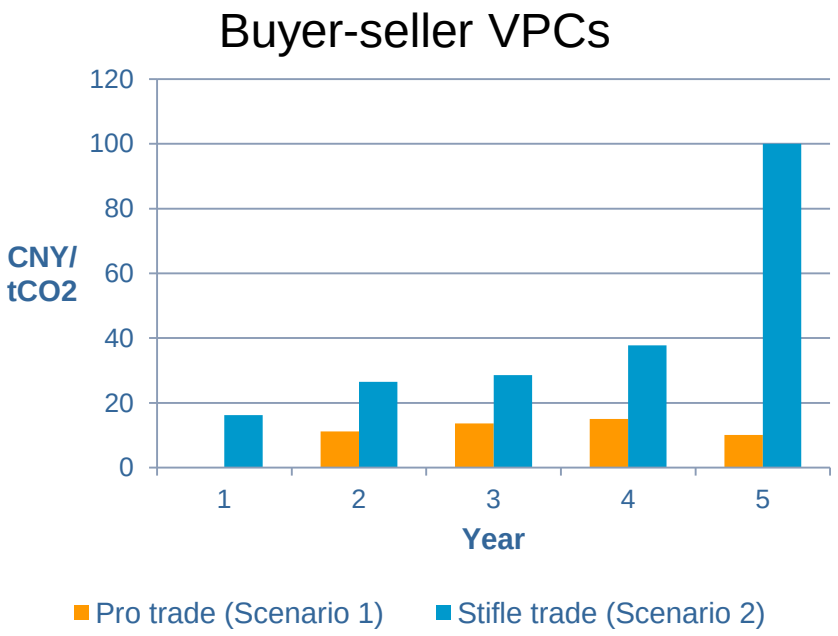
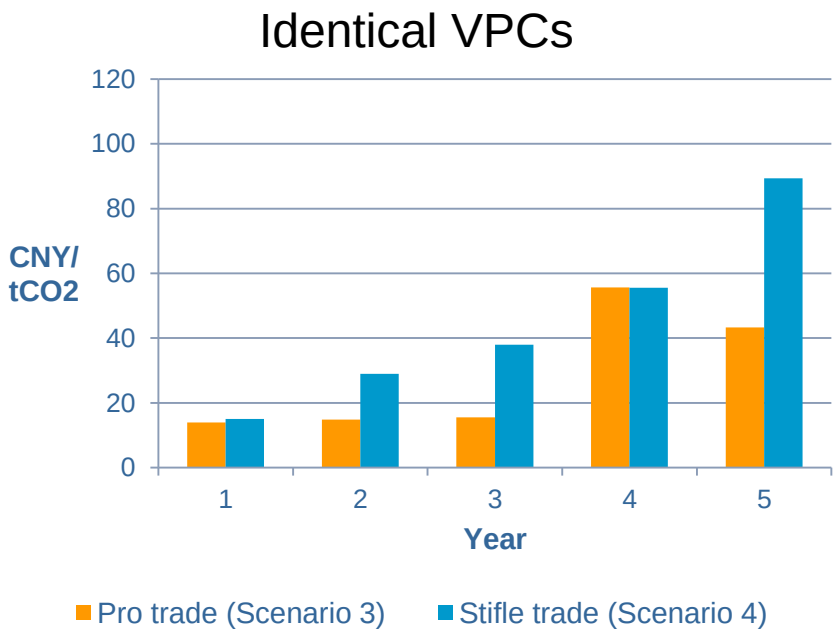
Carbon prices rose as simulation got harder



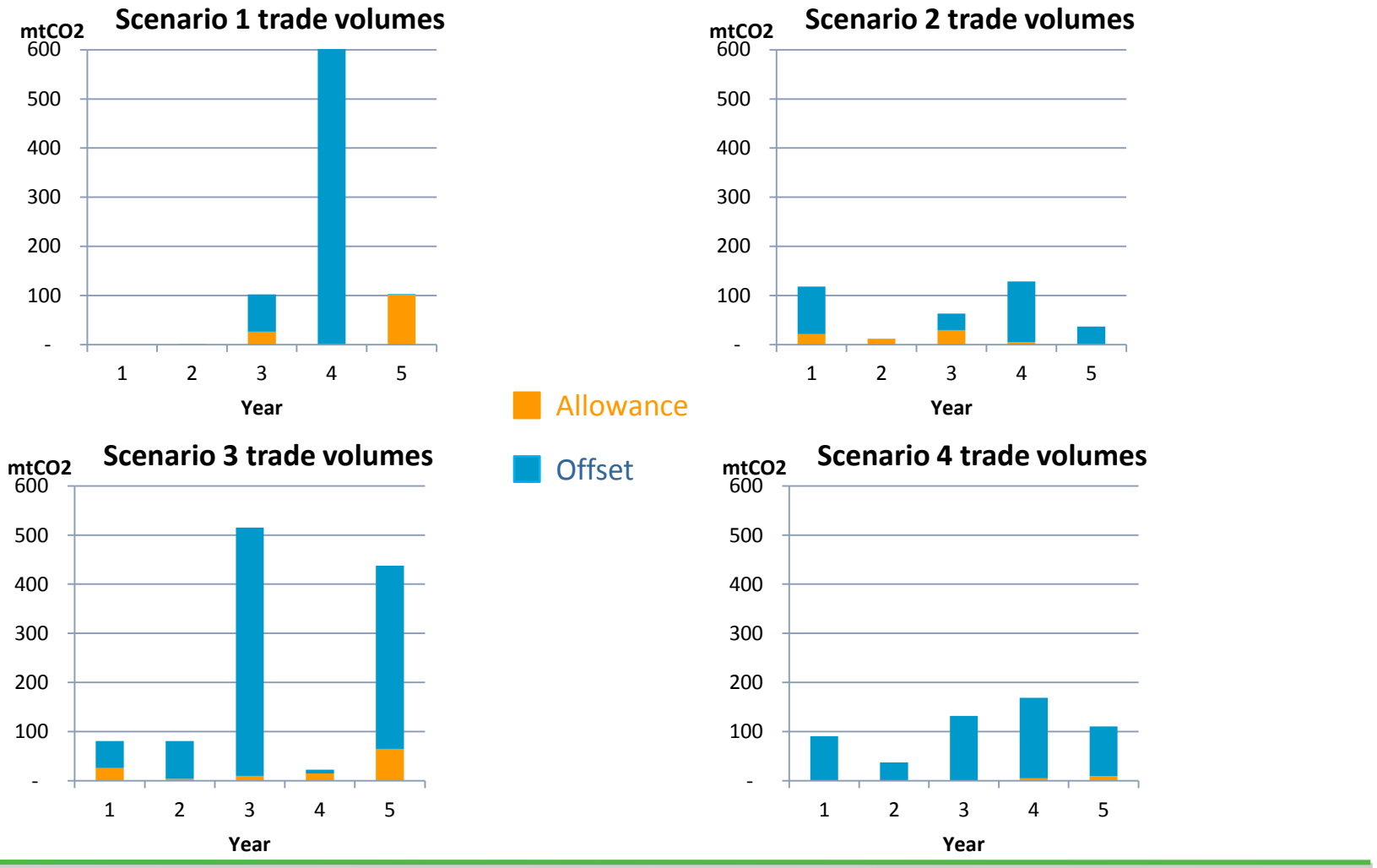
- Except where generous allowances and liberal offset rules meant constraints did not 'bite'

Compliance more expensive in stifled trading scenarios

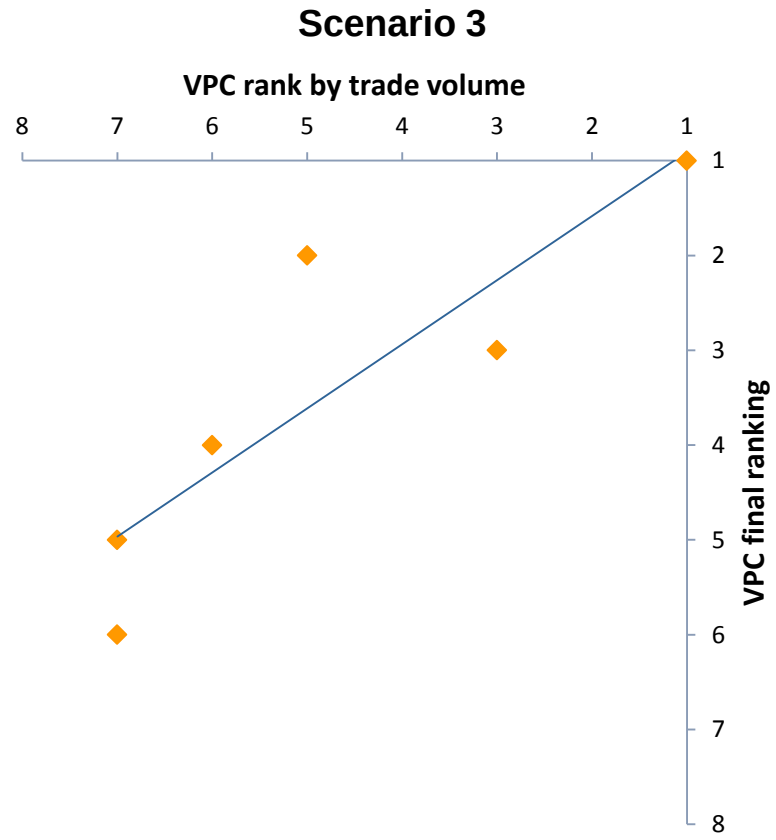


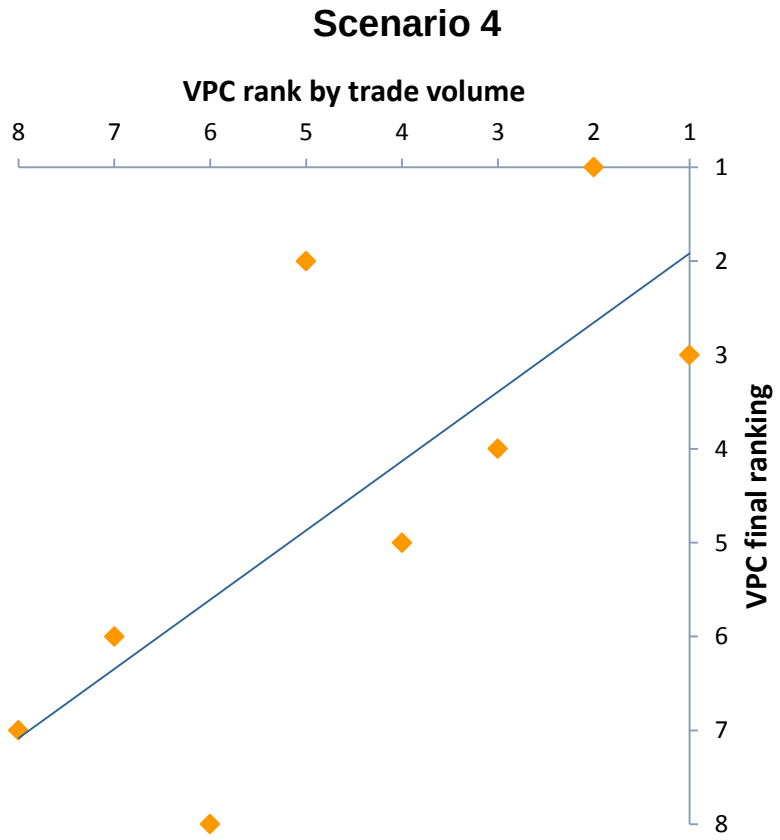


Offsets dominate



Many factors within a scenario, but generally more trading = more profit





- Excluding two loss making VPCs in scenario 3
- (Scenarios 1 and 2 segments too small to make this analysis)

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Observations for a national ETS – design

- CEC asked for free fixed allowances but:
  - How long should allowances be free for?
  - How do you choose a baseline year and reward generators who've already improved?
  - What allocation for new entrants?
- Carbon prices, and therefore compliance cost, higher in 'stifled' scenarios. So design system to enhance liquidity
- The larger the carbon market, the greater its liquidity and efficiency
- Instant trade clearing could improve efficiency
- Should tariffs paid to generators still vary by fuel? Does an ETS remove the need for a feed in tariff?

Observations for a national ETS – execution

- We assumed large offset market. Need to ensure quality of credits in that market

- Need regulatory oversight – for financial safety of generators & security of market

Thank you

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