Centre for Energy and Environmental Markets

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Modelling future electricity generation portfolio investment under a carbon price

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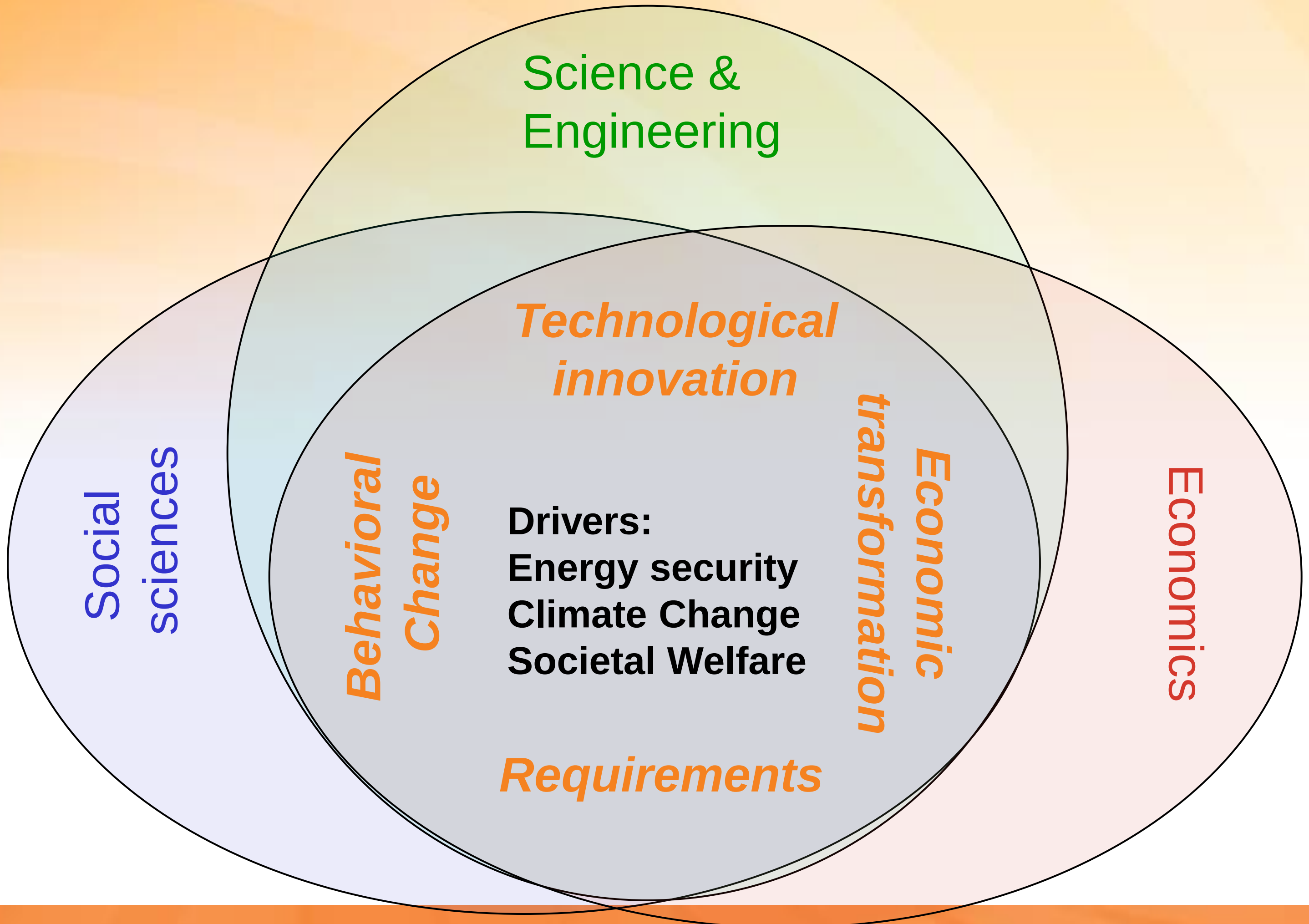
CEEM's Vision

The Centre for Energy and Environmental Markets inspires and informs the transition to a more sustainable energy future nationally and internationally through objective interdisciplinary research.

Key interdisciplinary perspectives & tools required to address challenges – CEEM's key strength



Objectives of Australia/China collaboration

- Develop a techno-economic generation portfolio investment model for China's electricity industry
  - Taking into account key uncertainties such as future carbon prices, fossil fuel prices and electricity demand (including elasticity).
- Apply the model to explore potential impact of a highly uncertain carbon price and other pollutant pricing mechanisms on future electricity industry investments in China
  - Synergies between carbon and other pollutant pricing mechanisms.
  - Implications of energy and climate policies (including RE policies) for future generation mixes in China.
- Collaboration with Tsinghua University
  - Dr. Wang Yu, Dr. Tong Qing – *Scenario development including main assumptions used for the modelling*.
  - A/Prof. Gu Alun and A/Prof. Teng Fei – *Demand and generation data*

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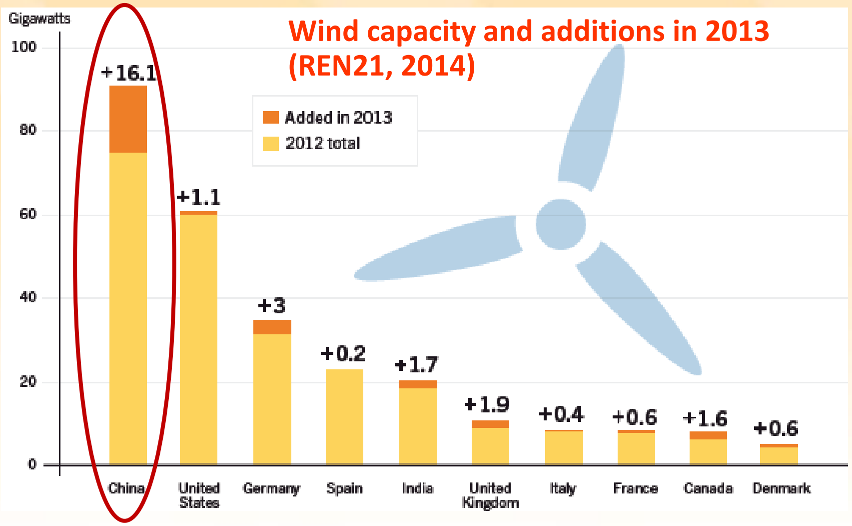
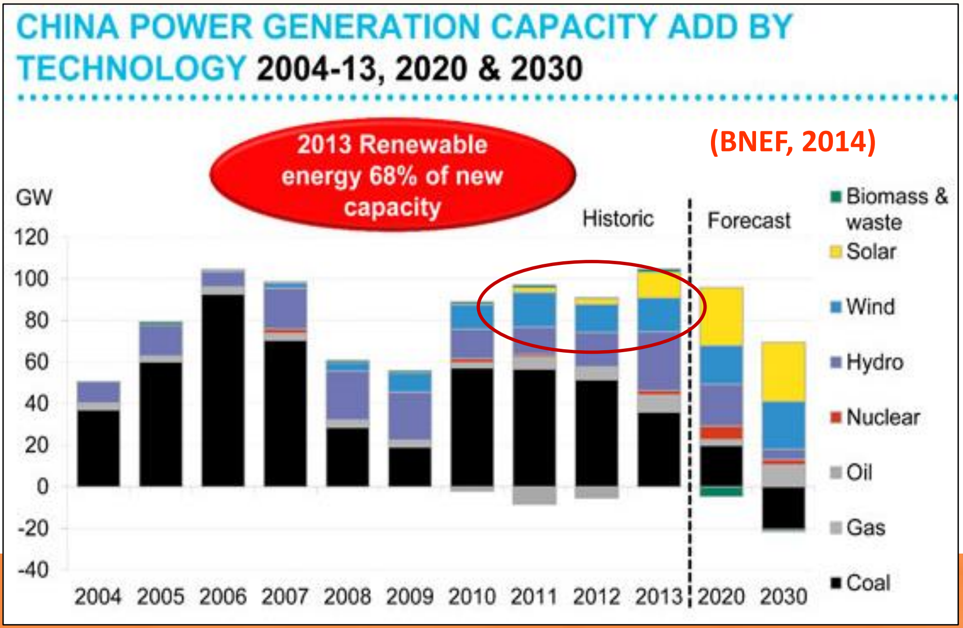
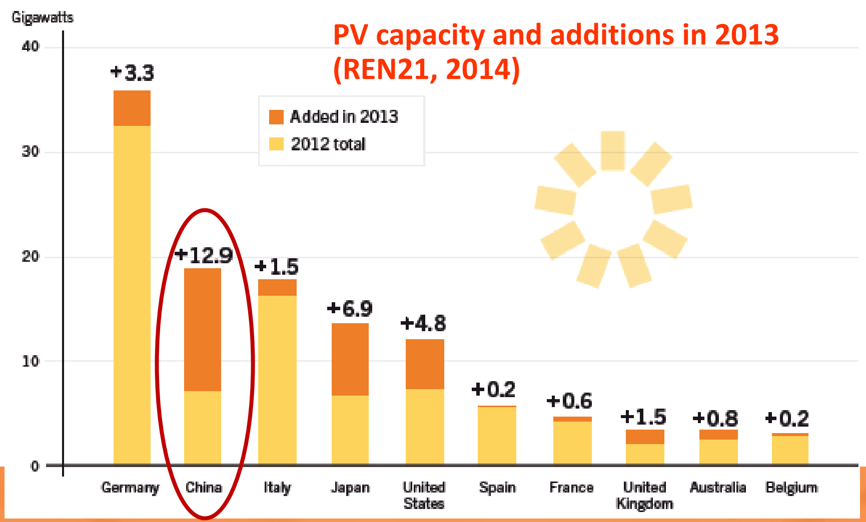
Key technology trends

- Rapid growth in wind and PV
  - China’s wind generation has now increased faster than coal power production
  - Wind has surpassed nuclear in electricity generation
- What about the future of coal?



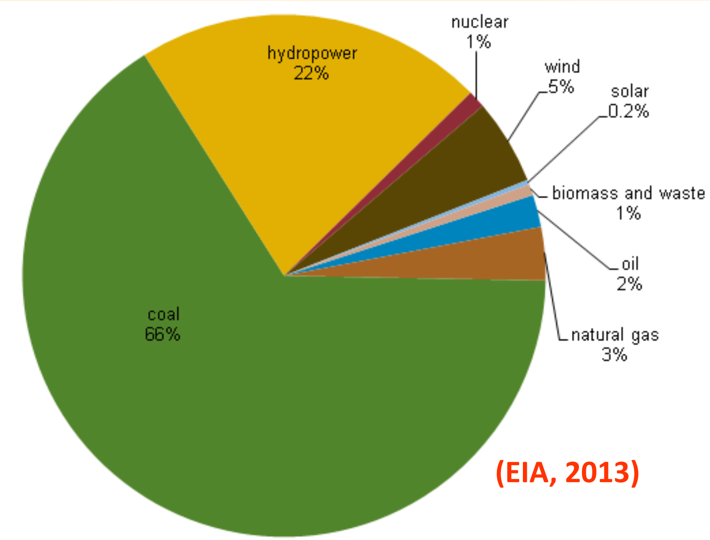




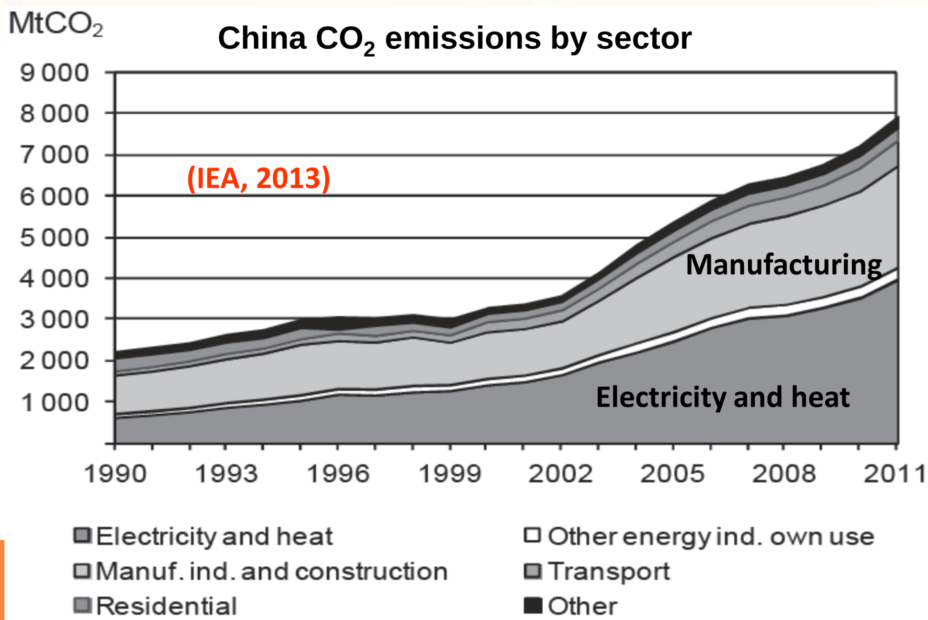
Chinese context

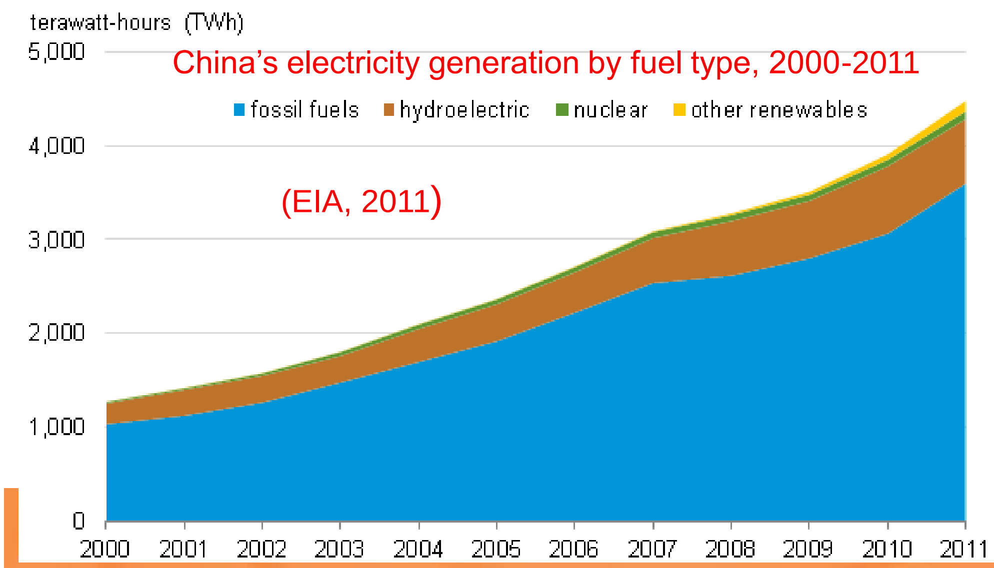
Main Challenges in the electricity industry

- Rapid rise in demand
- Energy security concerns (fuel import)
- Large sum of investment in additional capacity ($50-70 billion/yr)
- Rising pollution CO_2, NO_X, SO_2, PM (coal dominant)



China's installed capacity by fuel, end 2012





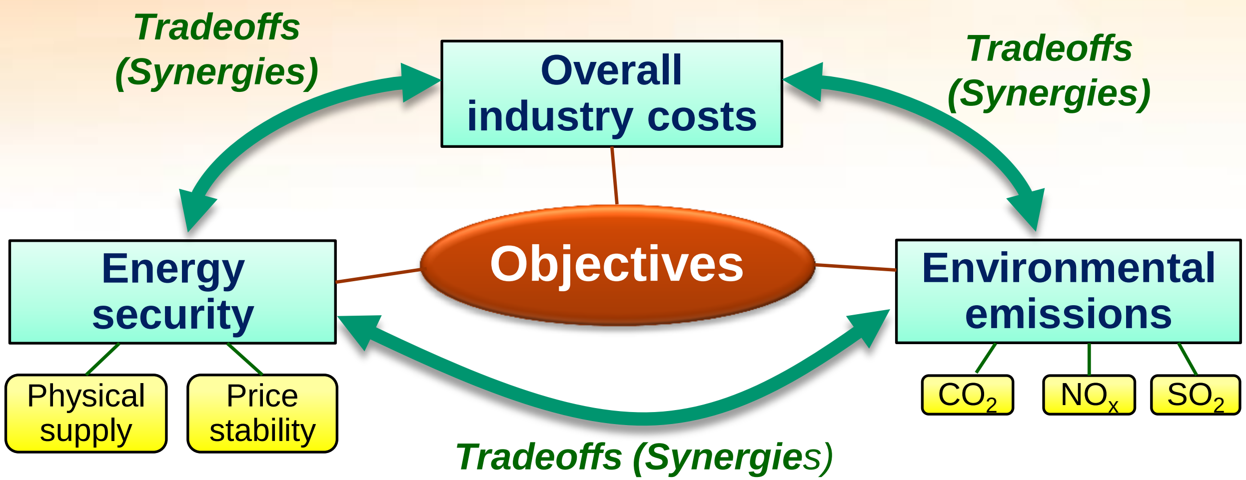
Main drivers in electricity industry investment

- Renewable and emissions reduction target
  - Reduce CO_2 intensity by 40-45% below 2005 level by 2020
  - Increase the share of renewables (including nuclear) to 15% by 2020
- RE and climate policy measures
  - Emission Standard of Air Pollutants for Power Plants
  - FiT, promotion fund, compulsory grid connection, subsidy, tax benefits
- Energy market reform and introduction of carbon markets
  - Increased uncertainties in fossil-fuel prices and carbon and other pollutant pricing mechanisms
  - Linkages between electricity, fuel and carbon markets.

Looking Forward

What can sensibly be said about future electricity industry options in China?

- Very significant risks, uncertainties
- Multi-objective nature (industry costs, environment, energy security)



What about renewable technologies ?

High cost and Intermittent power supply

- **Coal** – cheap to run but high emissions.
- **Gas-fired** - energy security concerns (due to fuel import) but low emissions.
- **Nuclear** - expensive to build but zero operating emissions.

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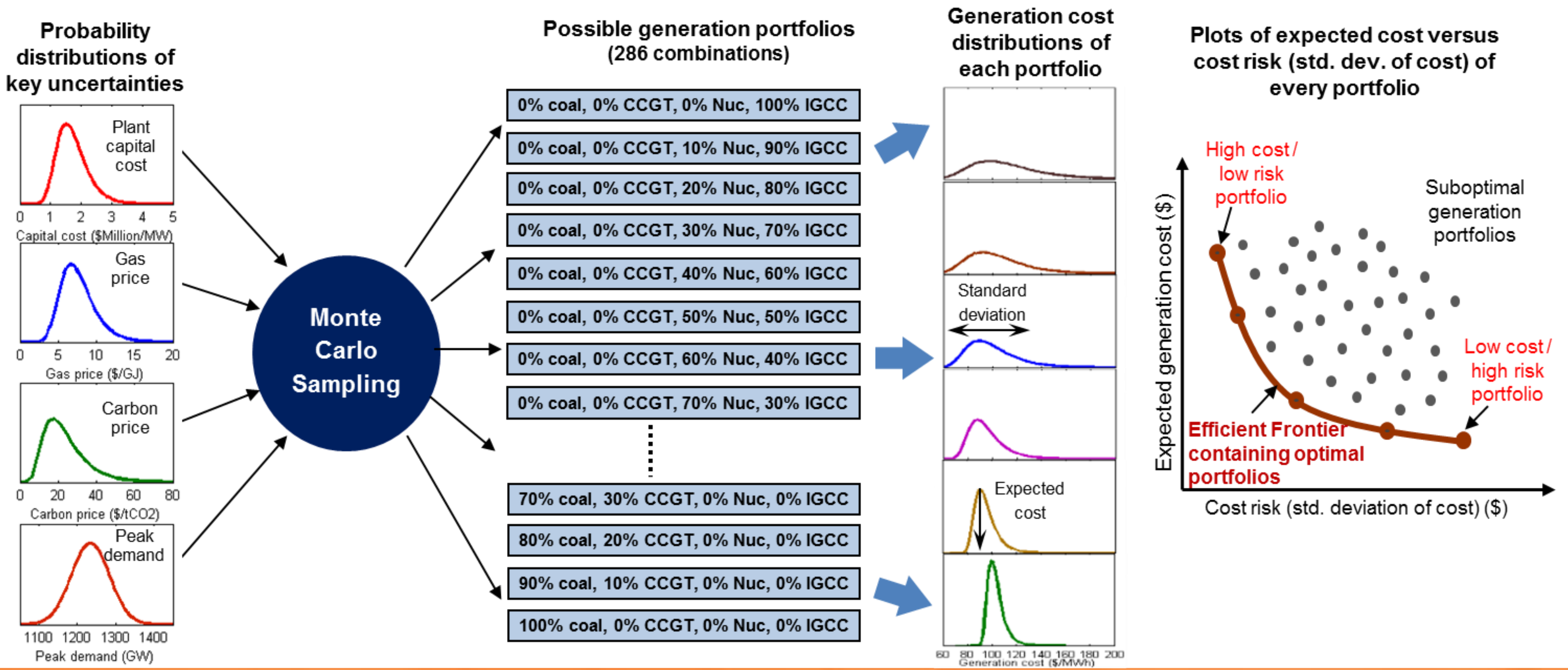
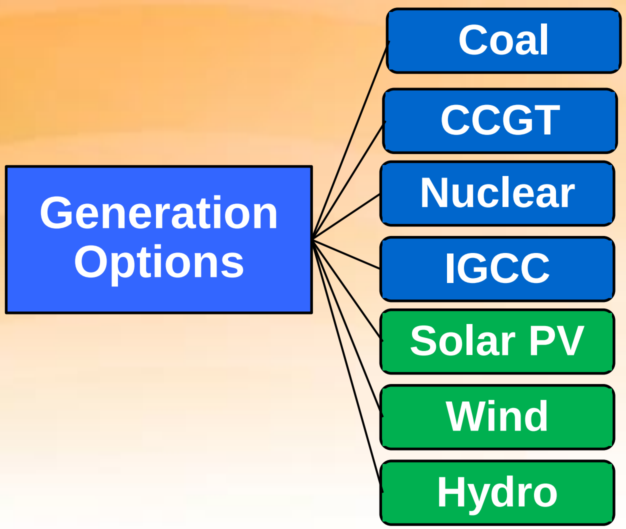
Probabilistic generation portfolio modelling

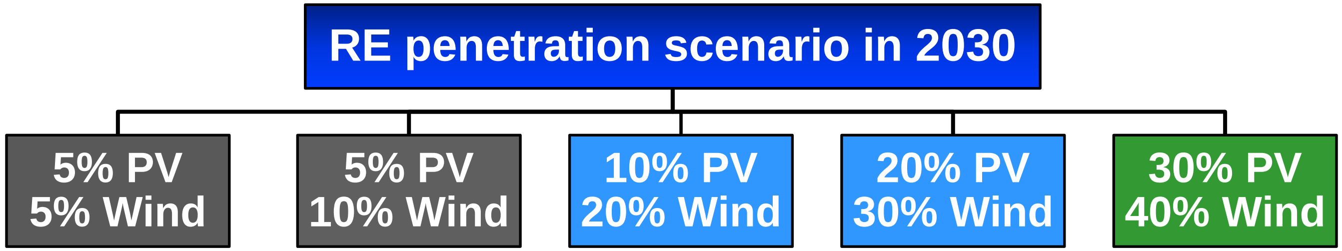
- A modeling tool to assess possible future generation portfolios given a range of *future uncertainties* (e.g. fossil fuel prices, carbon price, demand)
- Model outputs can be used to explore various issues and tradeoffs between multiple criteria - *costs, energy security and emissions*



Modelling future generation portfolios in China



- Examining different generation portfolios for 2030 in the context uncertain fuel prices, carbon pricing, demand, plant capital costs.
  - Seven main generation options
  - Consider different wind and PV penetrations
  - Different mixes of fossil-fuel technologies
- Existing capacity is taken into account



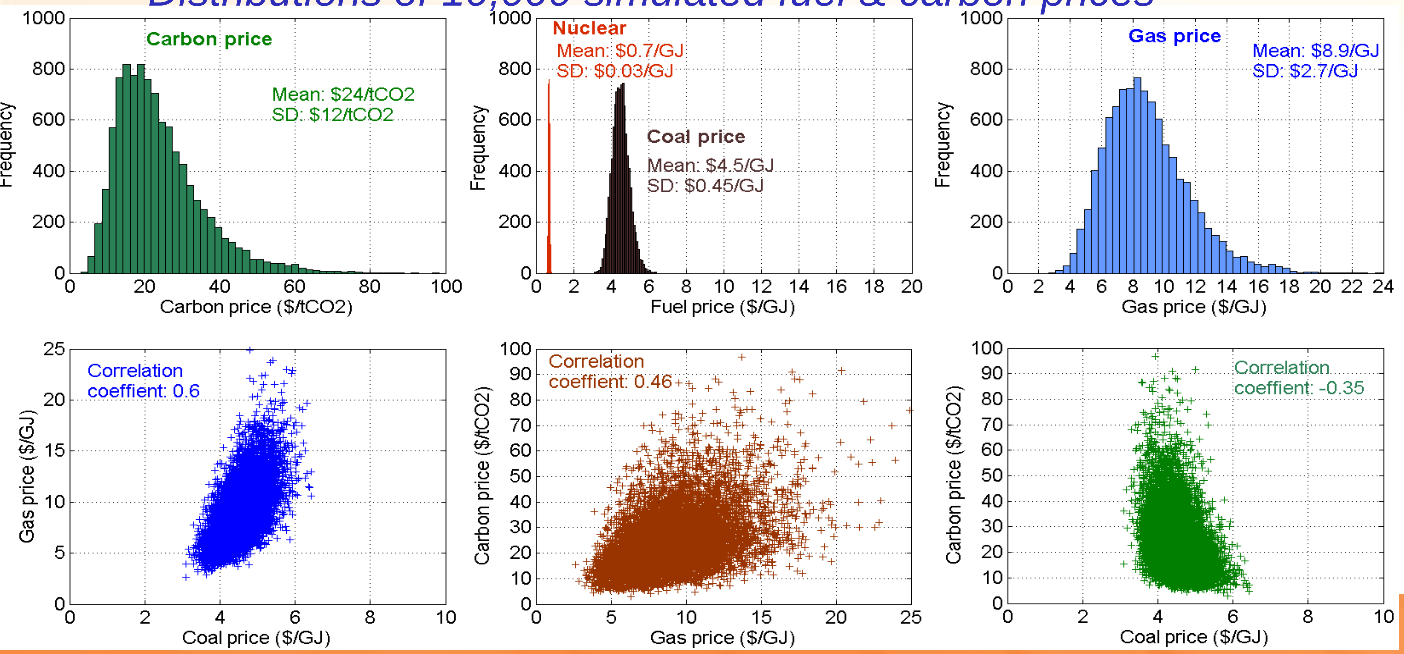
- Central estimate of carbon price is $24/tCO_2$
- Environmental externality costs are included (control costs)

Modelling Inputs

Inputs

- **Generator data of each technology**
  - Cost and technical parameters
- **Hourly demand, wind, PV and hydro generation for 2030**
  - Simulated based on 2012 data
- **Prob. dist. of uncertain variables**
  - Fuel & carbon prices
  - Electricity demand
  - Plant capital costs

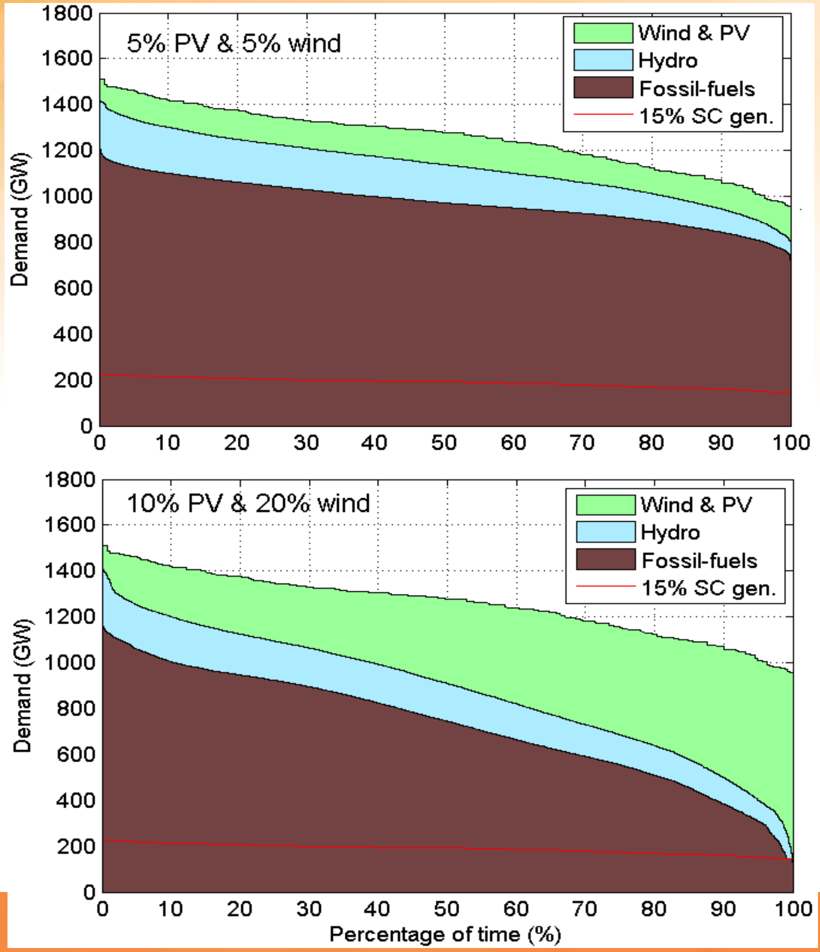
Distributions of 10,000 simulated fuel & carbon prices

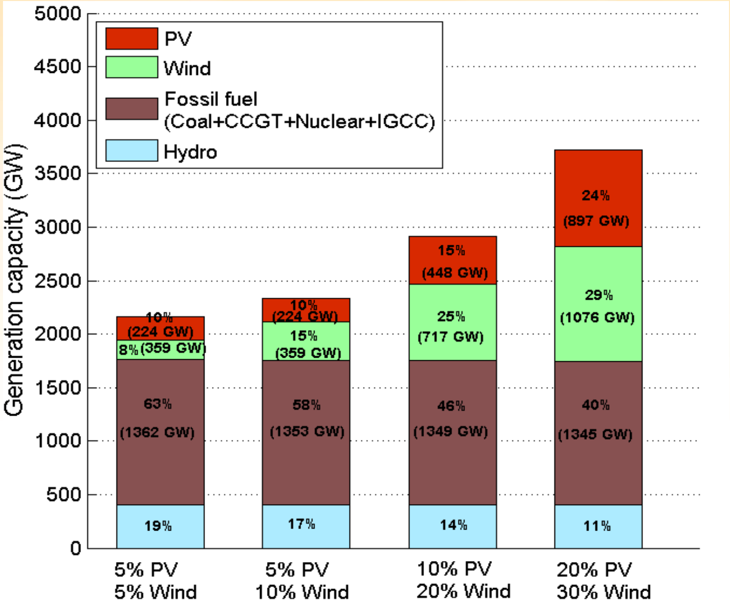


Overall cost and emissions of each portfolio is calculated for 10,000 simulated fuel prices, carbon price, demand, capital costs.

Generation portfolios and dispatch

- Merit order dispatch in each period of the ***Load Duration Curve***.
- Priority dispatch for PV, wind and hydro – *treat as negative demand.*

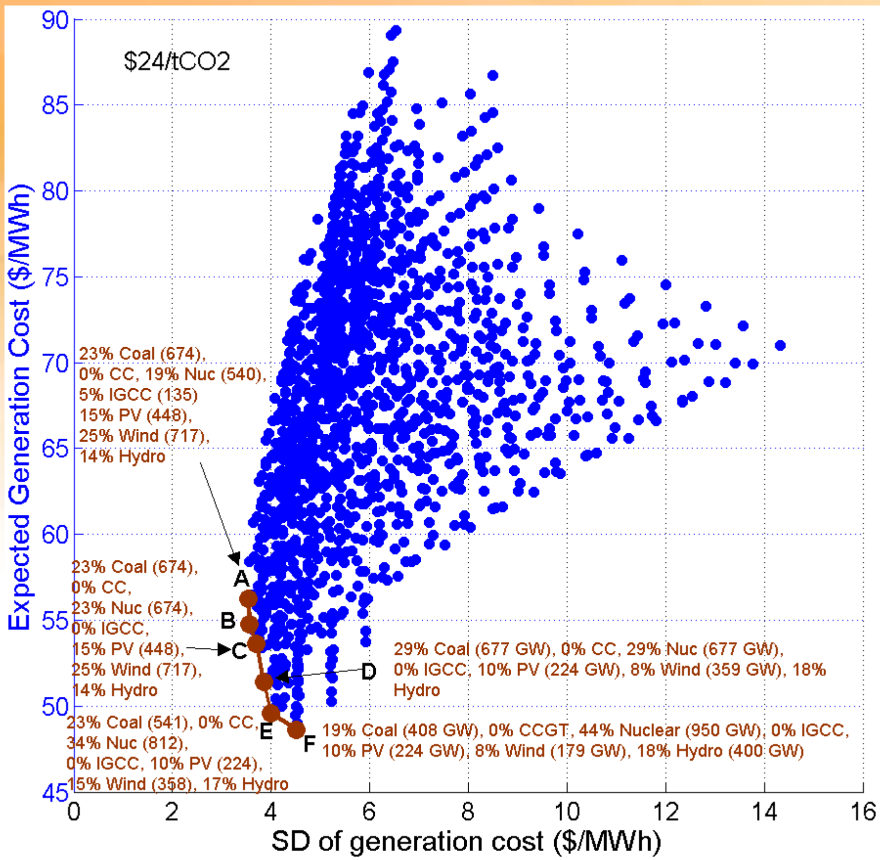




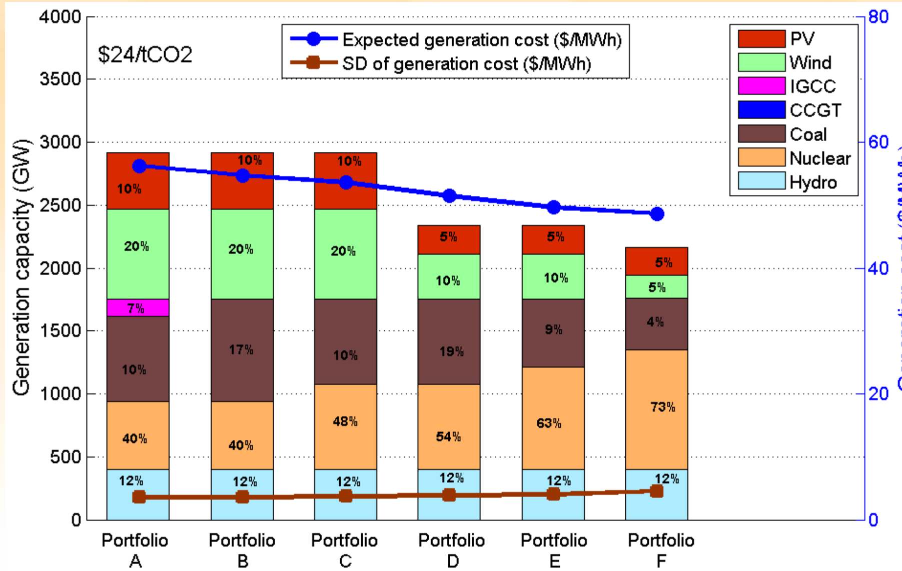
For each RE penetration scenario

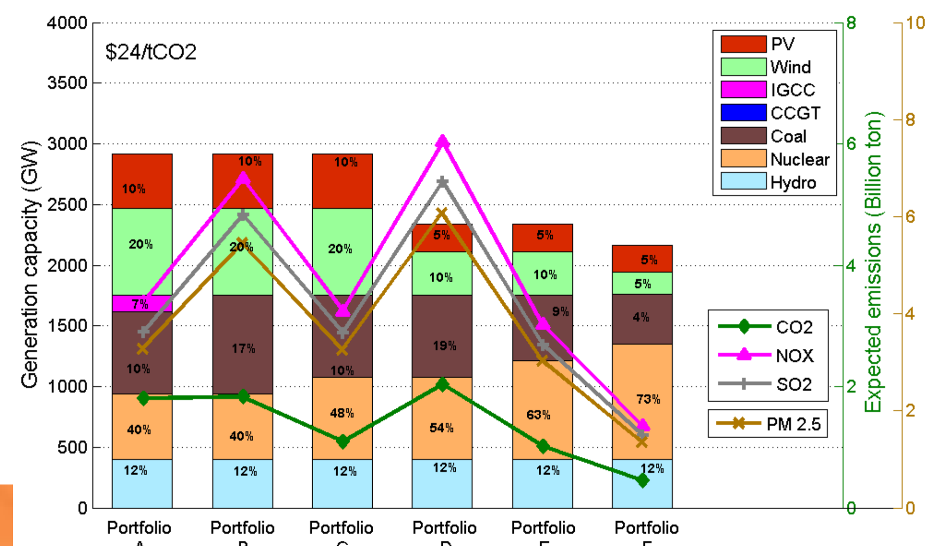
- Analyse different possible permutation of ‘fossil-fuel’ generation mixes
  - 1430 generation portfolios in total

Optimal generation portfolios (cost vs cost risk)

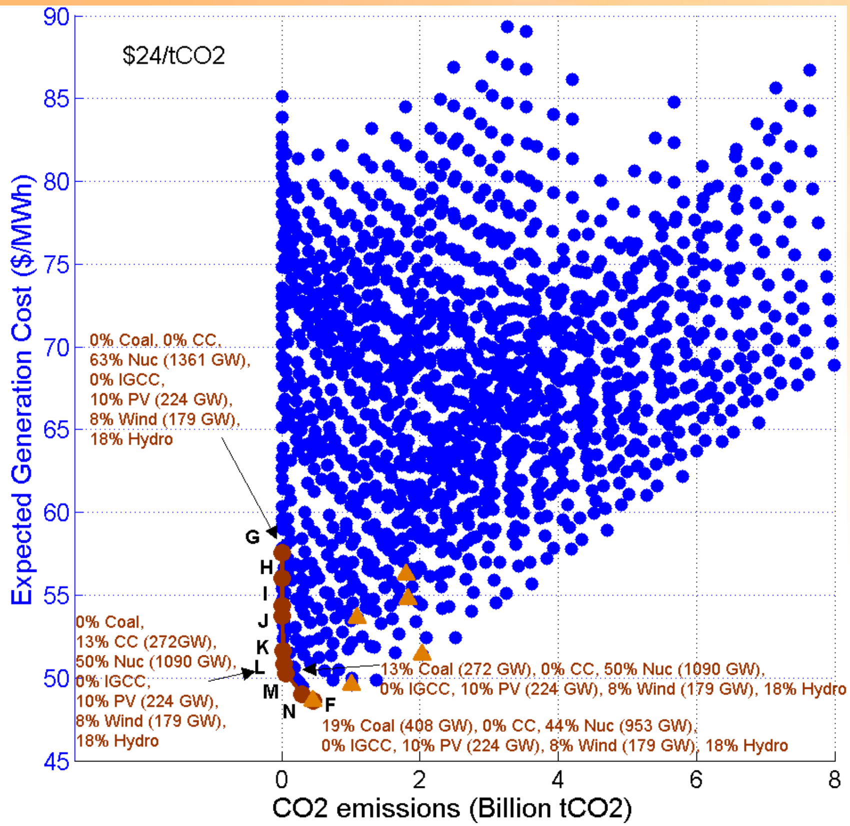


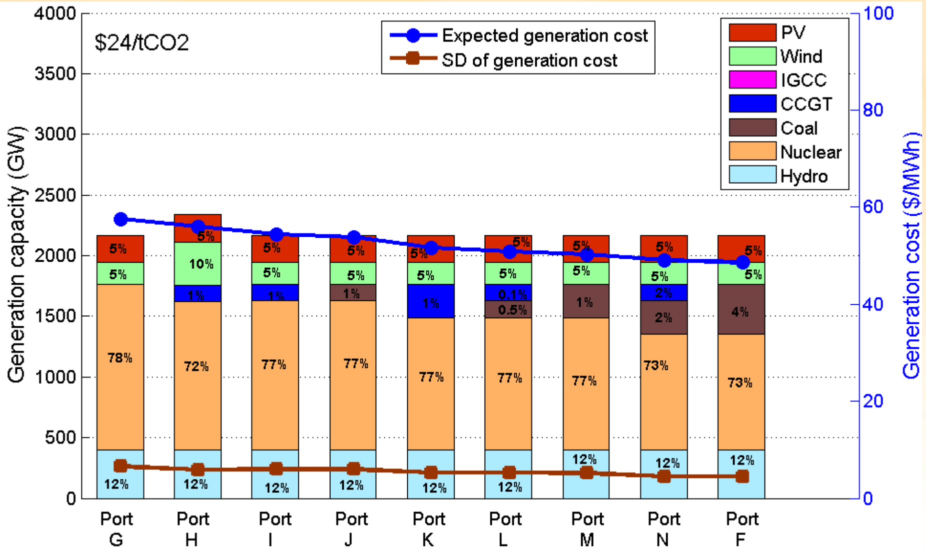
Cost VS cost risk Efficient frontier containing optimal portfolios

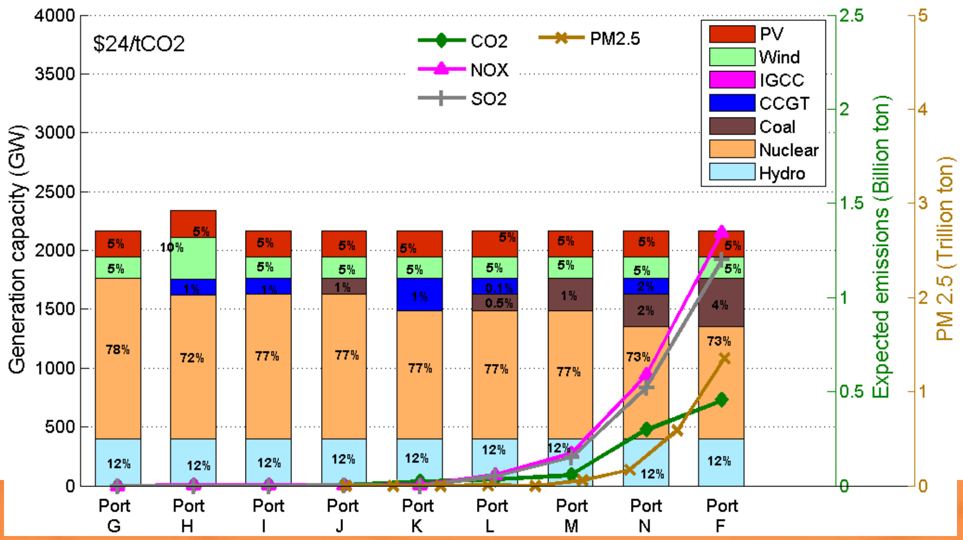




Optimal generation portfolios (cost vs emissions)

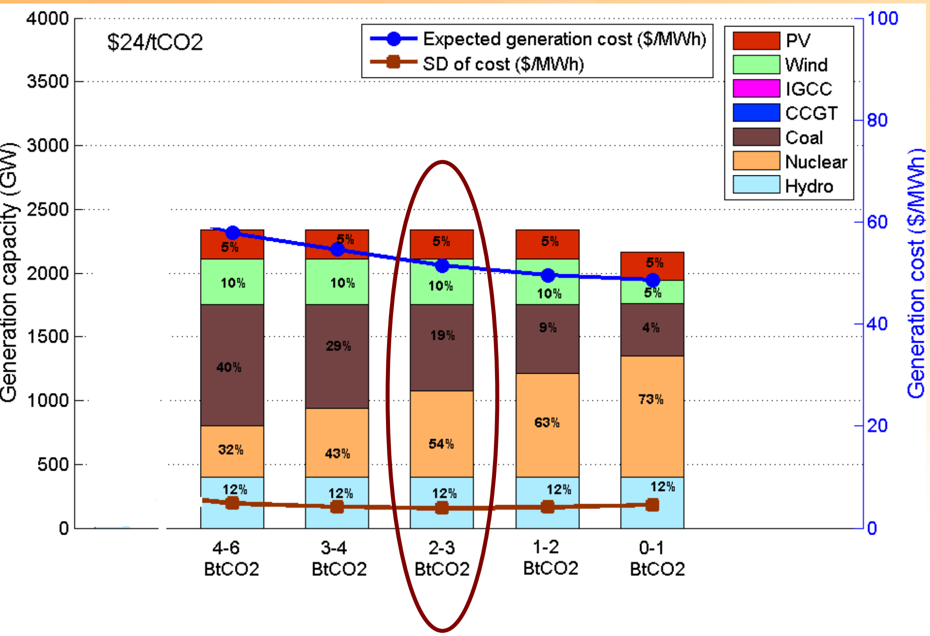


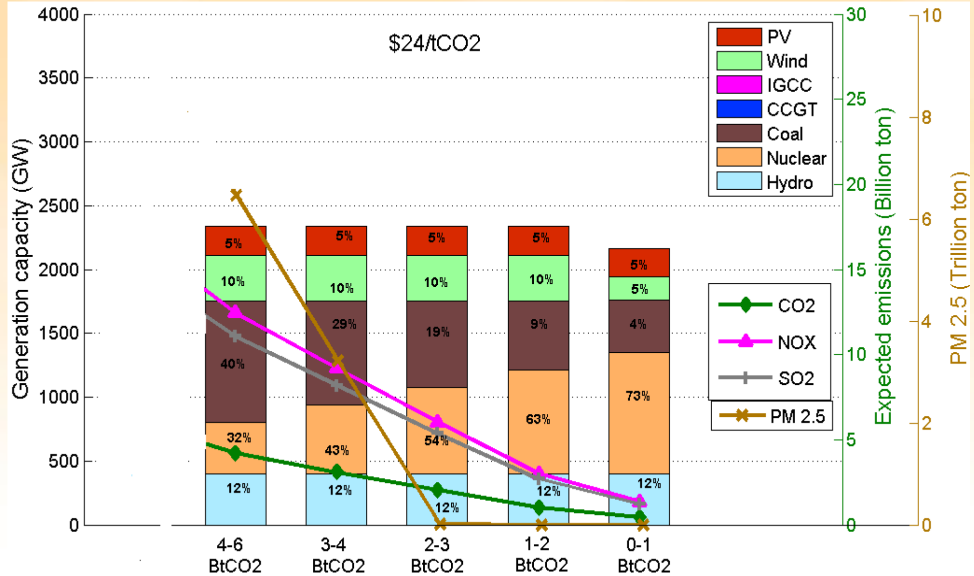




Cost VS emissions Efficient frontier

Least cost options for achieving emission targets





- Nuclear appears to be a cost effective option in reducing emissions.
- No new coal capacity would be required.
- Wind and PV is also an effective emission mitigation option (15% of energy is sourced from PV and wind)
- None of the least cost portfolios for achieving any level emission reductions in 2030 contain CCGT or IGCC.

Comparing China and Australia

- The same modelling was applied to the *Australian National Electricity Market (NEM)* for 2030 (different cost structure, similar carbon pricing)

	China	NEM
?	Nuclear appears to be a cost effective option in reducing risk and emissions in the elec. industry	Nuclear is not considered in the modelling
✓	CCGT does not have any role in future generation portfolios (due to high and uncertain gas prices)	CCGT does not have any role in future generation portfolios (due high and uncertain gas prices)
✓	Wind and PV provide effective cost risk and emission mitigation (~ 15% penetration at $24/tCO_2$)	Wind and PV provide effective cost risk and emission mitigation (~15-20% penetration at $20/tCO_2$)
?	OCGT is not considered	OCGT plays an important role in providing peaking capacity to support RE generation
✓	No new coal capacity would be required. Existing coal as intermediate/peaking capacity	No new coal capacity would be required. Existing coal capacity as intermediate/peaking capacity
?	IGCC investment is unattractive	IGCC is not considered

Technology	Capital cost -2030 ($Million/MW)	
	China	NEM
Coal-fired	0.5	3.1
CCGT	0.4	1.1
Nuclear	1.7	4
IGCC	1.2	5.5
PV	1.5	1.6
Wind	0.8	1.7

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Thank you,

and

Questions?

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