Modelling the effect of emissions pricing on electricity sector investments in China

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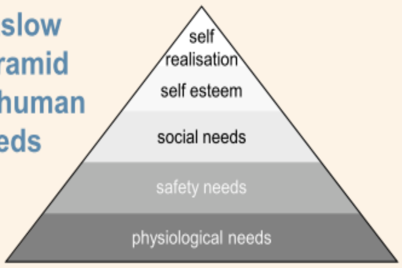
Possible energy priorities *(World Energy Council, 2010)*

Maslow pyramid of human needs

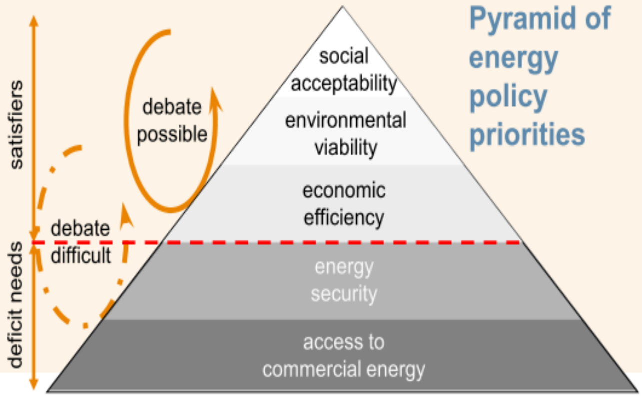


"A person who is lacking food, safety, love and esteem would most probably hunger for food more strongly than for anything else," stated the American psychologist Abraham Maslow in 1943 while formulating a theory to explain the motivational structure of a healthy person.

If Maslow were in Energy Politics…

Abraham Maslow

… he would argue that access to energy, supply security, energy costs, environmental issues and social acceptance are not subject to trade-off, but to a hierarchy: we cannot successfully address higher order needs before proposing and implementing solutions for lower order ones.



Pyramid of energy policy priorities

The elephant in the room – Climate Change

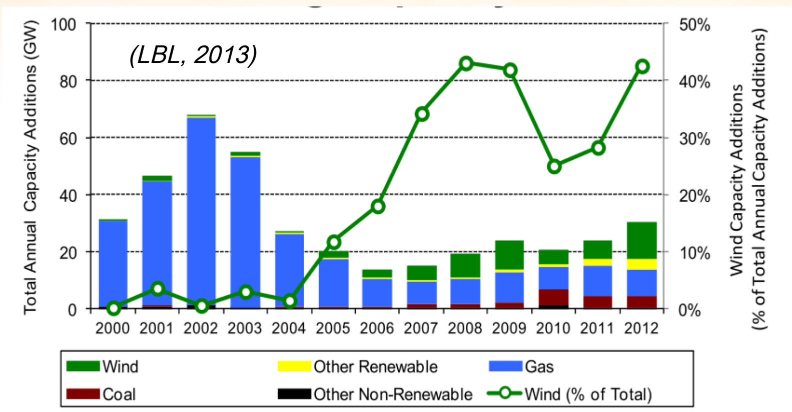
- Currently a lack of domestic and international progress, apparent loss of public and political interest and will in key jurisdictions
- … but even a dead elephant in the room is a problem
- **… and some new key jurisdictional players**

Some key new technology trends

"According to the China Electricity Council, China's wind power actually increased more than coal power production for the first time ever in 2012. Thermal (coal) power use grew by only 0.3% (12TWh)… In contrast, wind power expanded by 26 TWh. This rapid expansion brings the total amount of wind power in China to 100 TWh, surpassing China's 98 TWh of nuclear power."

ANNUAL INVESTMENT/ADDITIONS/PRODUCTION IN 2012 *(REN21, 2013)*

	New capacity investment	Hydropower capacity	Solar PV capacity	Wind power capacity	Solar water collector (heating) capacity[1]
1	**China**	**China**	**Germany**	**United States**	**China**
2	United States	Turkey	Italy	China	Turkey
3	Germany	Brazil/Vietnam	China	Germany	Germany
4	Japan	Russia	United States	India	India
5	Italy	Canada	Japan	United Kingdom	Brazil



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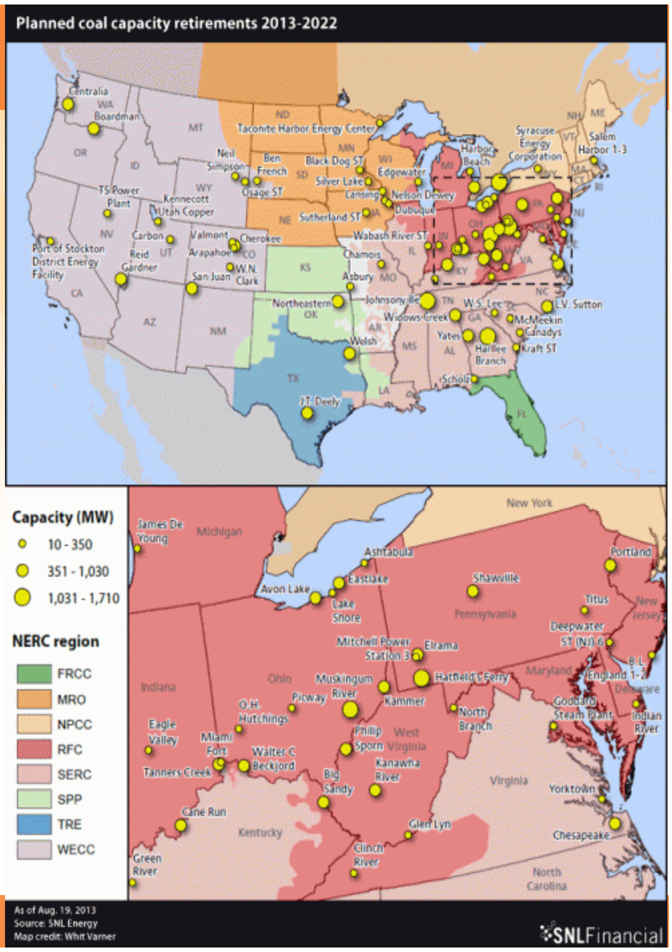
Non-climate enviro impacts also now key drivers

"China's State Council has announced that it is banning the construction of new coal-fired power plants near Beijing, Shanghai and Guangdong. The goal is to cut air pollution in the country's eastern megalopolises. The hope is that by 2017 Beijing residents will be breathing in 25% less fine particulate matter than in 2012."



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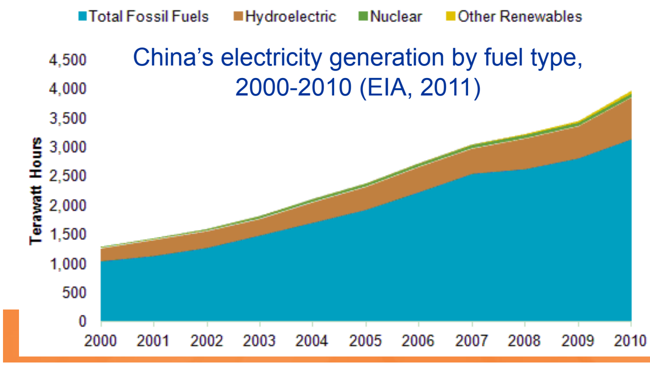
Chinese context

- Main challenges in the electricity industry in China (State Grid, 2010)
  - *Rapid rise in electricity demand and the need for additional investment to support demand growth ($50-70 billion/year of investment in generation capacity is required (IEA, 2012)).*
  - *Rising pollution – CO_2, SO_2, NO_x due to the use of coal.*
- 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.*



- Renewable and emissions reduction target
  - *Reduce CO_2 intensity by 40-45% below 2005 level by 2020*
  - *Increase the share of renewables (RE) to 15% by 2020 – 30GW of wind and 1GW of solar PV*

Looking forward

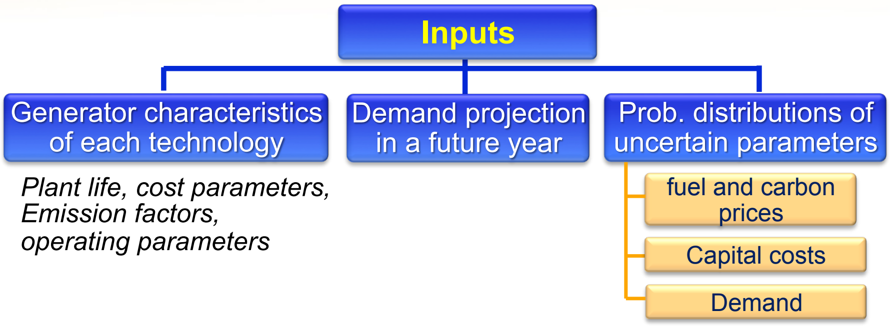
- What can sensibly be said about future electricity industry options in China?
  - Very significant risks, uncertainties and ambiguities
    - Scenarios – how to select? Sensitivity analysis – interactions?
  - … adding to existing modelling challenges for electricity industries including:
    - Industry specific technical operational issues
    - Long-lived, specific, non-reversible investments
    - Key role in broader economic development and progress

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 elasticities).*
- 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
  - ➢ *Potential synergies between carbon and other pollutant pricing mechanisms.*
  - ➢ *Implications of energy and climate policies (including RE policies) for future generation mixes in China.*

Electricity generation portfolio modelling

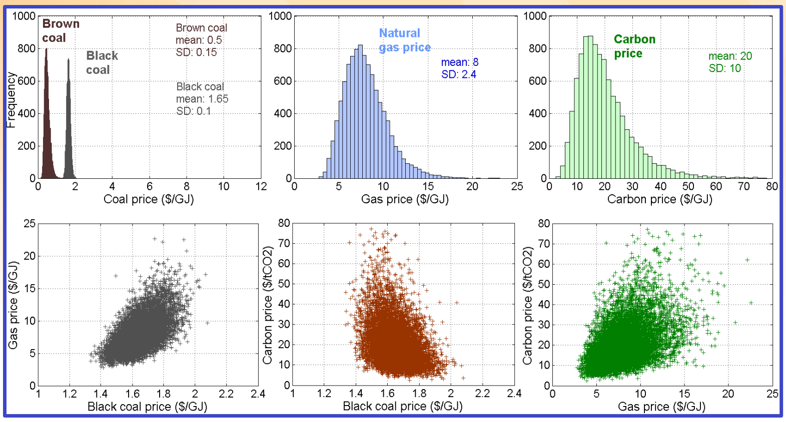
- A modeling tool to assess possible future generation portfolios given a range of ***future uncertainties (e.g. fossil fuel prices, carbon price, demand)*** and ***multiple criteria***.
- Combines conventional 'optimal mix' load-duration curve techniques with 'residual' renewables modelling, monte-carlo simulation, portfolio methods
- Model outputs can be used to explore various issues and tradeoffs between multiple criteria - ***costs, energy security and emissions***.
- Model requires a set of simple input data for particular electricity industry.



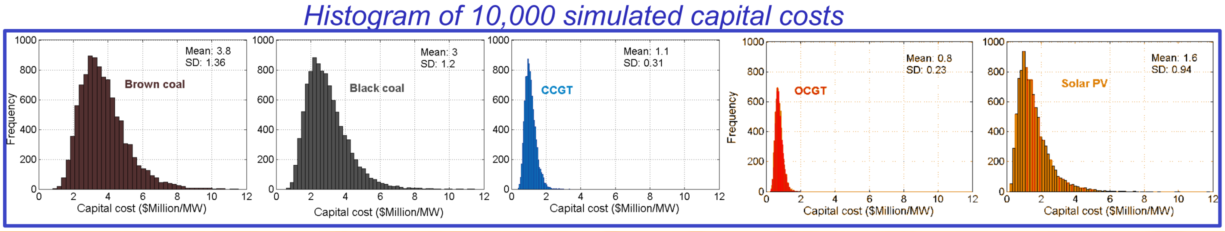
Modelling uncertainties

- 10,000 simulated fuel & carbon prices, demand and plant capital costs
- Using lognormal distribution to characterise fuel prices, carbon price and capital cost uncertainties

Histogram of 10,000 simulated fuel & carbon prices



Histogram of 10,000 simulated capital costs



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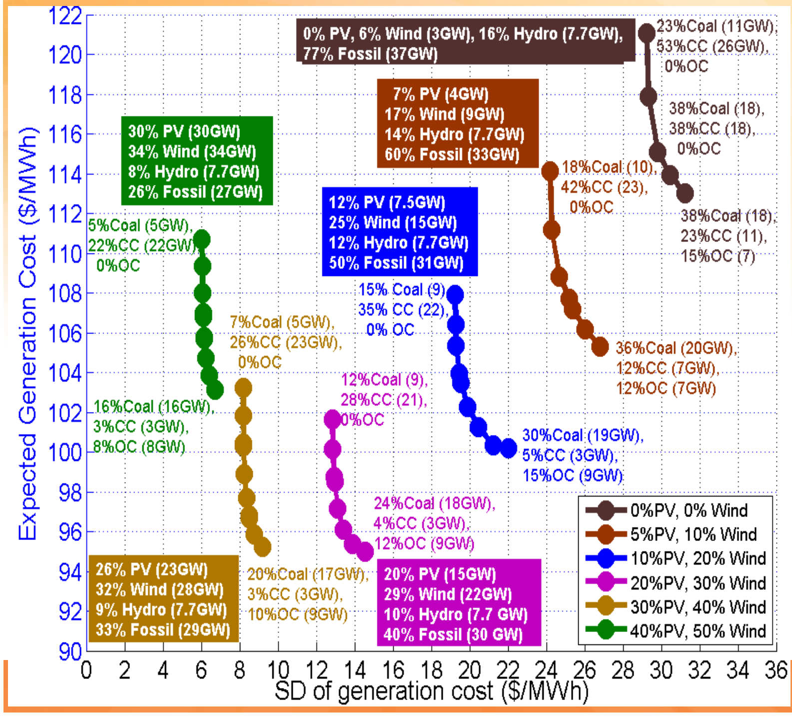
Outputs - example

Results from a case study of the NEM with high renewables



Cost VS cost risk Efficient frontier (EF) containing optimal portfolios

Reductions in both ***expected cost and cost risk (SD)*** as RE increases from 0% to 50%

(Downward movement of EF)

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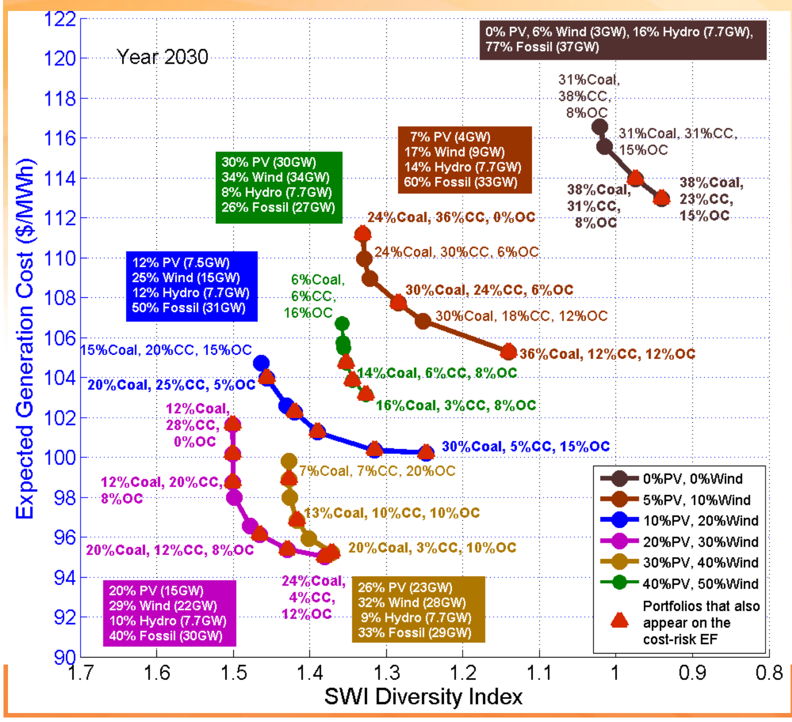
Output - Example

Results from a case study of the NEM with high renewables

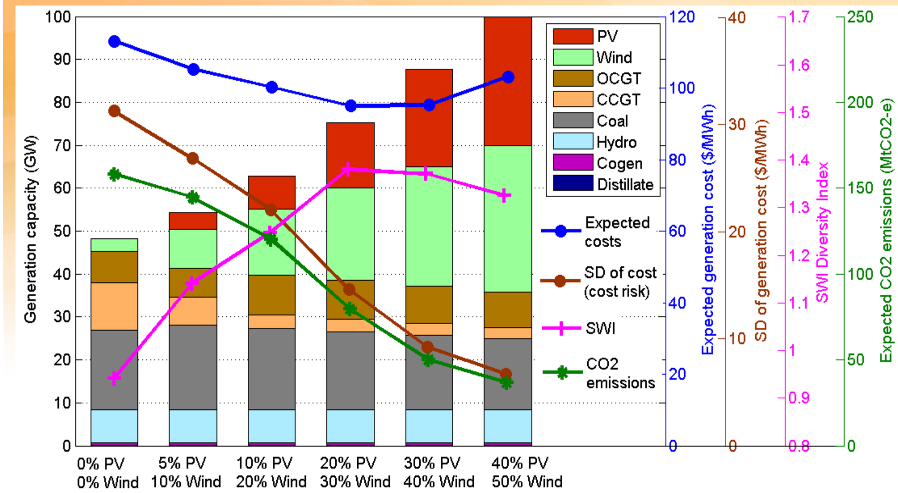


Expect cost VS fuel diversity (SWI)

Reductions in both ***expected cost and fuel diversity (SWI)*** as RE increases from 0% to 50%

(Downward movement of EF)

Output - Example



'Least cost' portfolios for each RE penetration

- ***Technology mix***
- ***Expected cost***
- ***Cost risk***
- ***Fuel diversity***
- ***CO_2 emissions***

- Decline in ***cost risk***, ***fuel diversity and CO_2 emissions*** as RE increases.
- Overall cost is minimised and fuel diversity is maximised at 50%-70% RE.

Key aspects of the model

- Simple and transparent – simple input data.
- Sophisticated approach to incorporate uncertainty and risk assessment.
- The way results are presented provides a basis for comparing tradeoffs among possible alternative future generation portfolios
  - *Taking into account wider multiple criterion electricity industry objectives (i.e. cost, risk, fuel diversity, greenhouse emissions).*
- Straightforward modifications to take into account local pollutants (in addition to CO_2 emissions).
- Intended to facilitate energy and climate policy decision-making.

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Thank you,

and

Questions?

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