Centre for Energy and Environmental Markets

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Value of Large-Scale PV Generation in Future Low-Carbon Electricity Portfolios

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1. PV in future electricity industries

Growing concerns over climate change and the security of electricity supply due to uncertainties in fossil-fuel prices and their availability have contributed to the rapid growth of large-scale renewable energy (RE) generation over recent decades. Solar photovoltaic (PV) in particular has received growing attention given its rapid technology progress and dramatic price reductions in recent years. Energy and climate policies such as carbon pricing is likely to be one of the critical factors in driving future generation investment towards large-scale PV generation. However, there is continuing uncertainty surrounding climate change policies and the level of future carbon price. Additionally, increased uncertainties in capital costs and demand growth have also increased the challenge in generation investment decision-making.

Generation investment and planning is influenced by diverse and potentially conflicting criteria involving generation costs, cost risks and carbon emissions, which are all key determinants for the sustainability of the electricity industry. Yet, the nature of the potential tradeoffs and synergies among these criteria are highly complex and context specific.

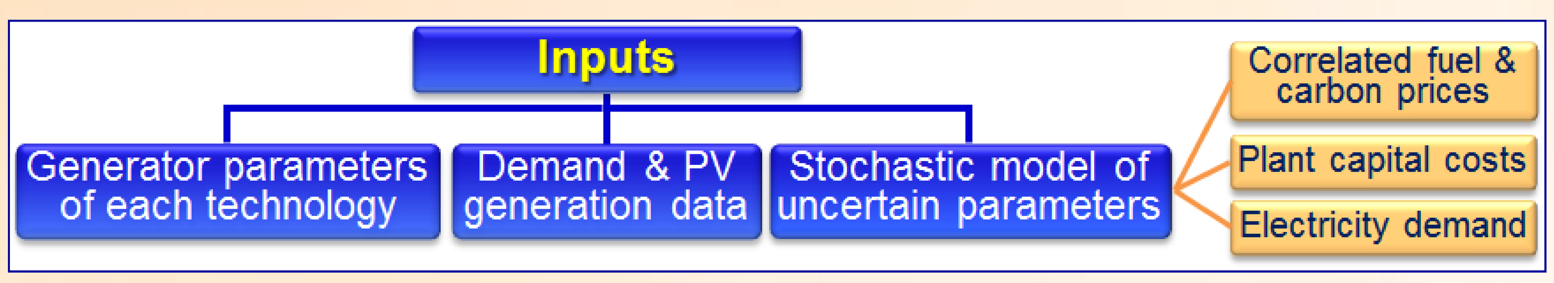
A key question is what role RE technologies, particularly PV, might play in future generation portfolios in addressing these challenges.

2. Research Aims

- Analysing future generating plant portfolios with PV against multiple policy objectives including overall industry costs, associated cost risks and CO_2 emissions given a range of future uncertainties.
- Gaining high-level insights into the potential impact of different PV penetrations and carbon prices as well as their interactions.

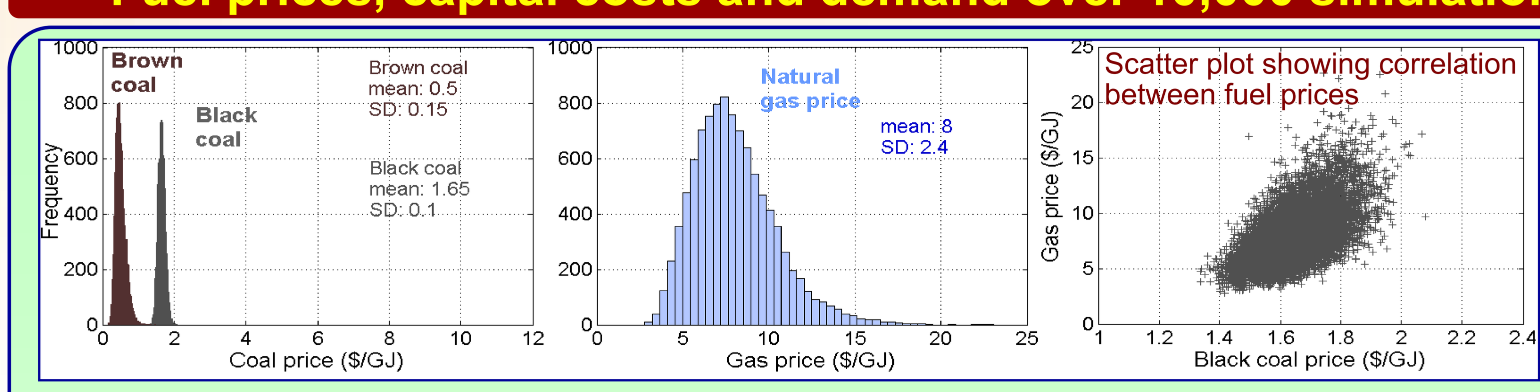
3. Methodology

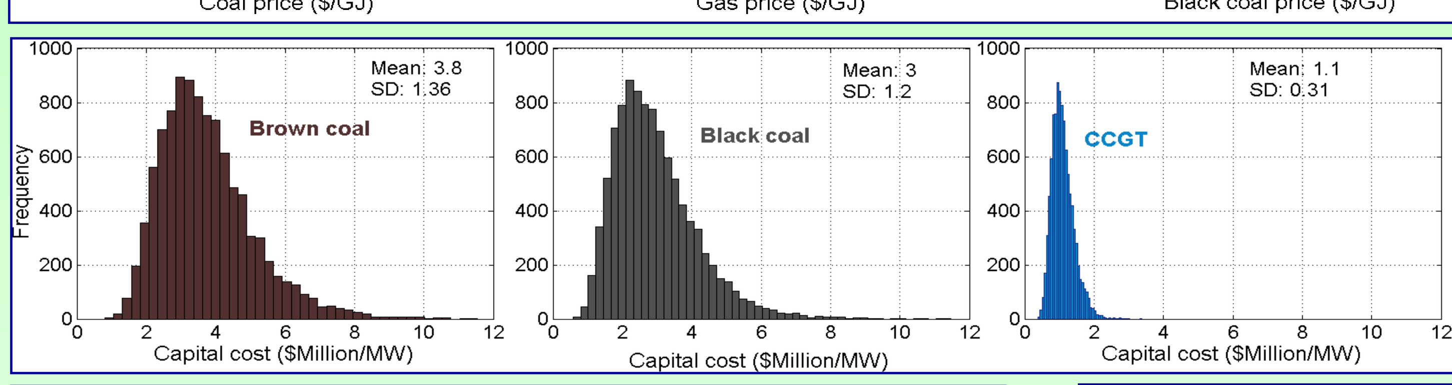
- Employing a probabilistic generation portfolio planning tool which combines optimal load duration curve (LDC) generation mix concepts with Monte Carlo simulation (MCS) and portfolio analysis techniques
  - Incorporating uncertainties into key cost assumptions using MCS.
  - Determining portfolio generation costs, cost risks and emissions.
  - ***Efficient Frontier (EF)*** showing tradeoffs between expected costs and cost risks (standard deviation) for different portfolios .
- Prioritised dispatch for PV (based on hourly simulated performance) as it can offset the need to dispatch fossil-fuel generation.

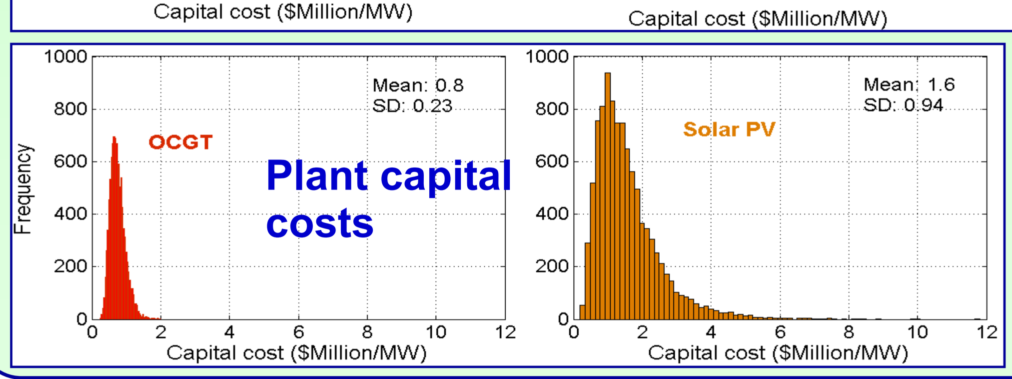


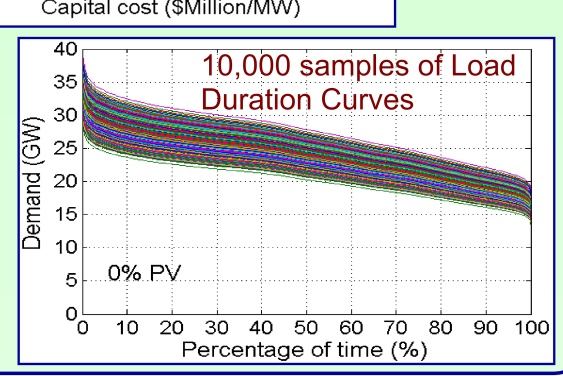
Technology	Capital cost	Operating cost	Emissions
PV	High	Very low	None
Coal-fired	High	Low	High
CCGT	Moderate	Moderate & volatile	Moderate
OCGT	Low	High & volatile	Moderate

Fuel prices, capital costs and demand over 10,000 simulations



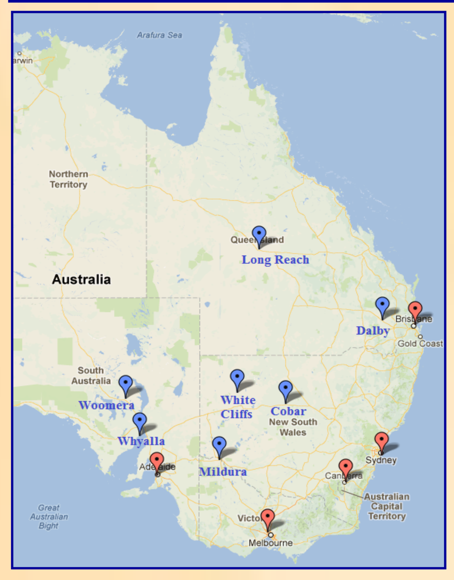




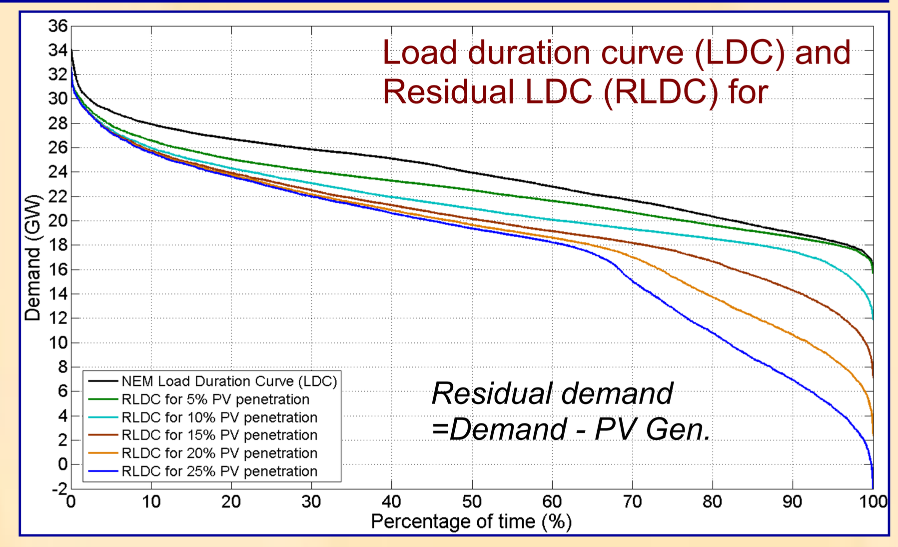


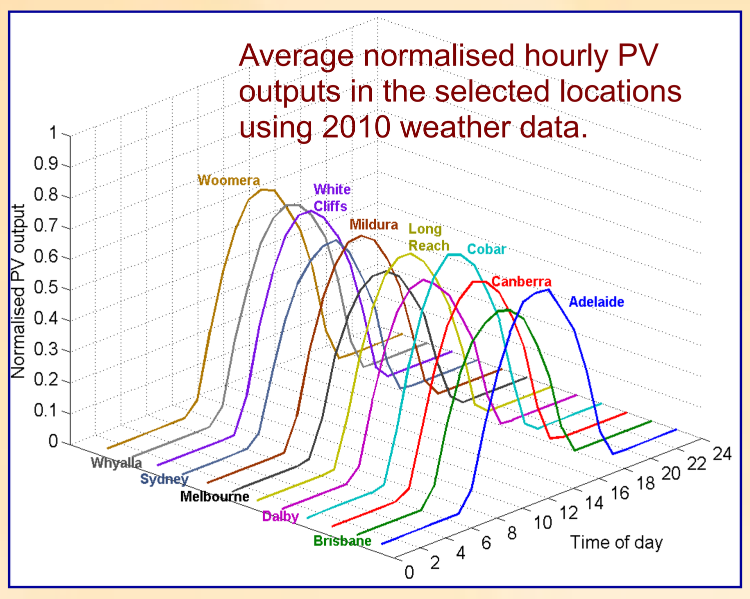
4. NEM Case Study

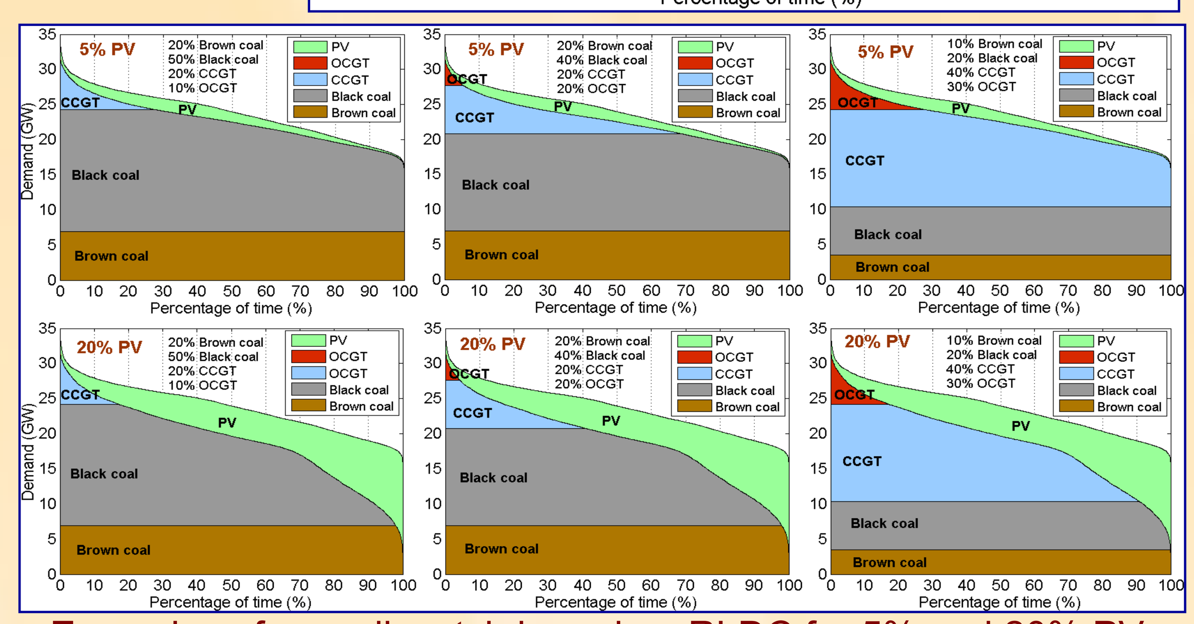
- Brown & black coal, CCGT, OCGT and PV generation options.
- Using 2010 hourly demand and simulated PV generation in the NEM and fuel prices and new-build technology costs in 2030 (source: 2012 AETA by BREE).
- Consider different PV penetrations and expected carbon prices for a range of thermal generating plant portfolios.



- **PV plants are modelled in 12 selected locations across the NEM in both cities and regional areas.**
- **Include high-level transmission cost estimates.**

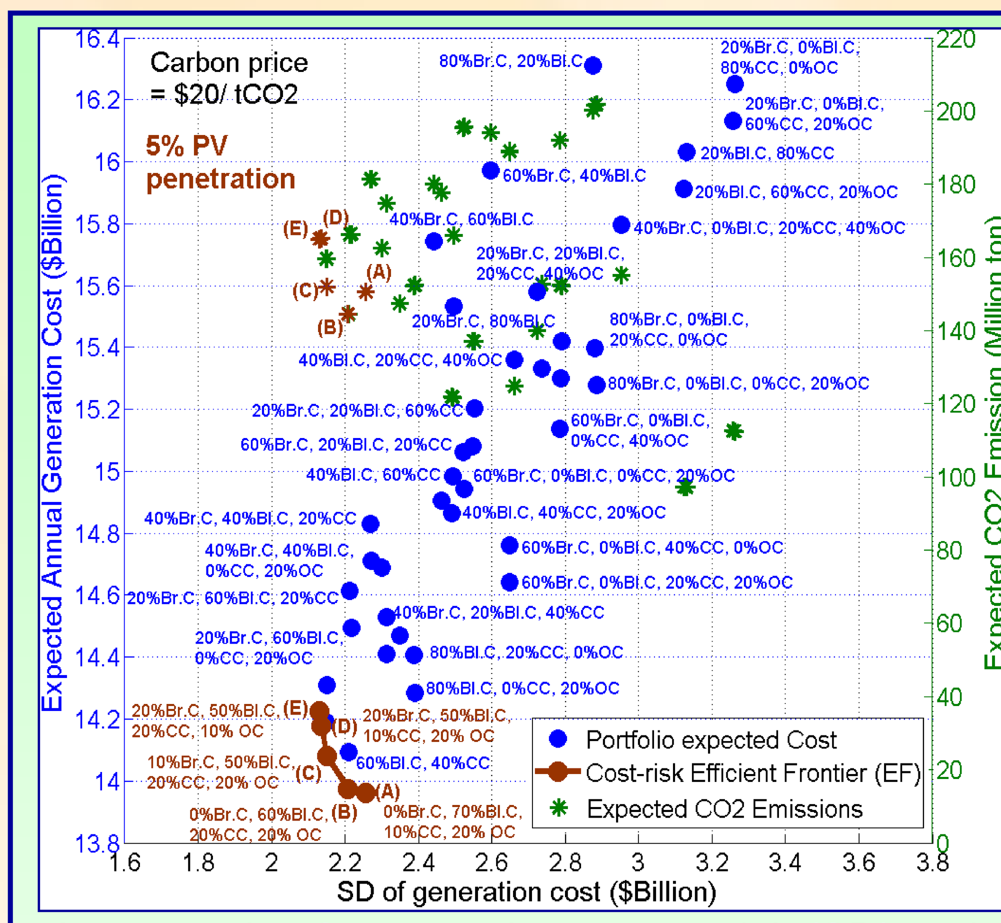




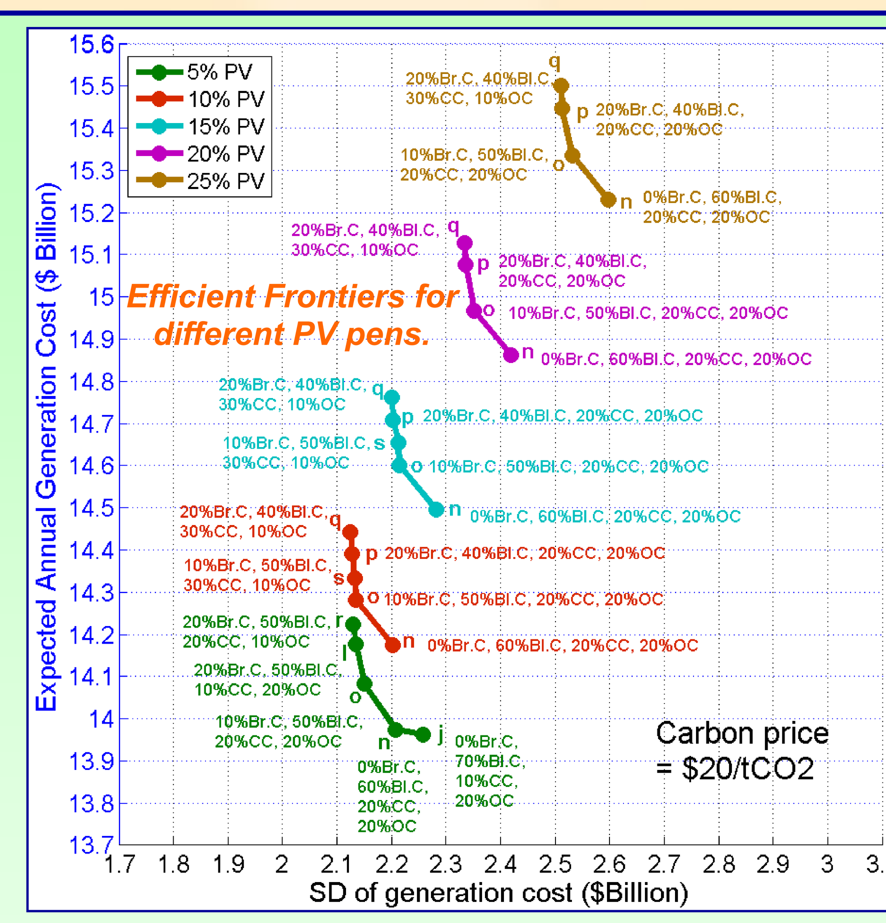


Examples of gen. dispatch based on RLDC for 5% and 20% PV

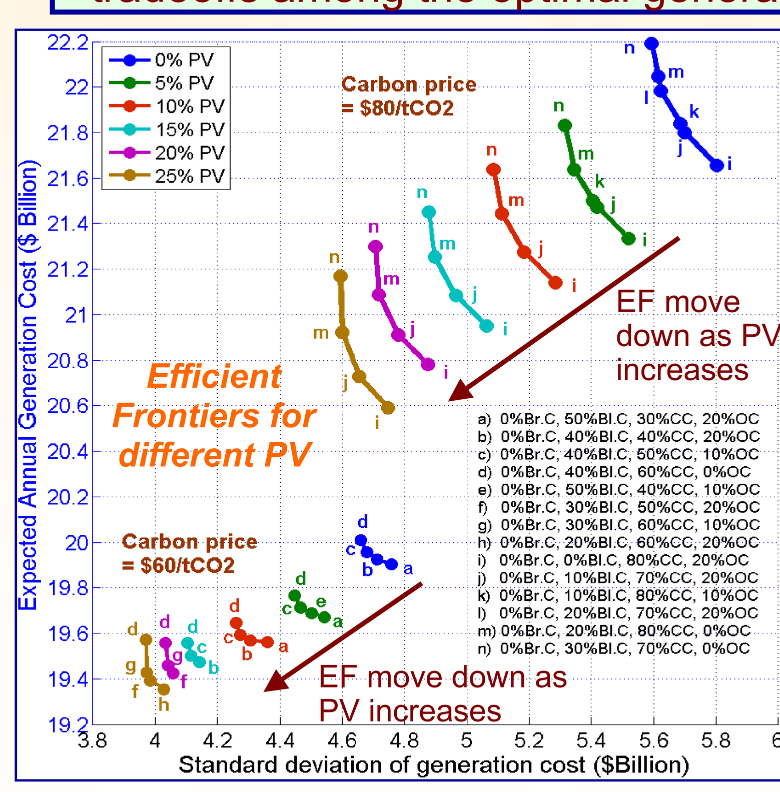
Impact of PV and carbon price on expected cost, cost risks and emissions



An example of expected cost, cost risk (SD) and emissions of different generation portfolios for a $20/tCO$_2$ and 5% PV. The ***EF*** indicates cost-risk tradeoffs among the optimal generation portfolios.

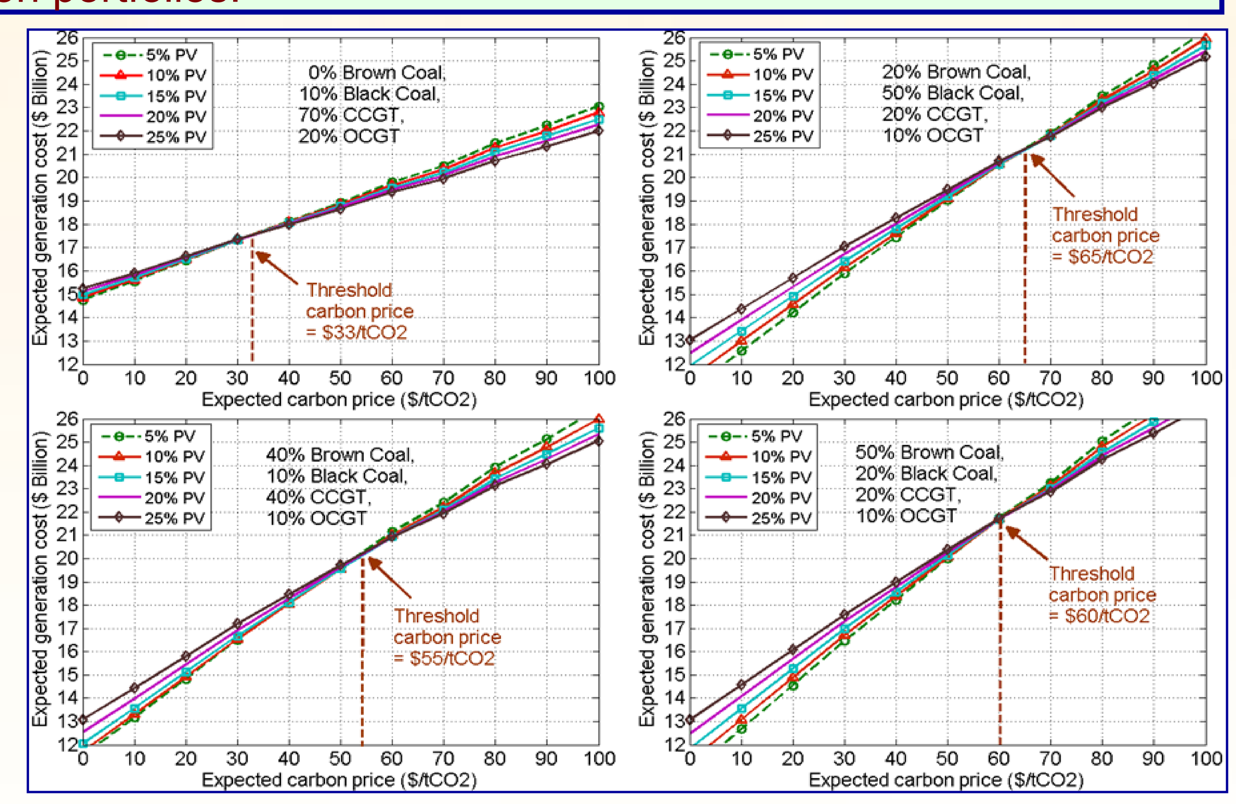


For low carbon prices (i.e. $20/tCO$_2$), higher PV increases the industry costs & cost risks.



For higher carbon prices (i.e. $60/tCO$_2$):

- higher PV can reduce the overall costs and cost risks as indicated by the EFs.
- Optimal portfolios contain less coal.



- Higher PV would increase the expected portfolio costs for only a range of carbon prices.
- At the "*threshold*" carbon price, portfolio costs begin to decrease with higher PV. This price depends on the technology mix (influenced by gas-fired generation).

5. Conclusions

- PV generation is valuable for reducing emissions and hedging against fossil-fuel price uncertainty (by reducing fossil-fuel consumption).
- At modest carbon price (below the IEA estimates and treasury modelling), PV can help reducing the overall industry costs in addition to cost risks and emissions.

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