Optimal Portfolios for Risk-Averse Generators

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Previous study

- Awerbuch [2006] applied portfolio theory to energy costs.
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Screening curve analysis - deterministic case

£ per kW of capacity per year

- **OCGT**
  - cheaper than CCGT at $h_{crit_1}$
  - cheaper than Nuclear at $h_{crit_2}$

- **CCGT**
  - cheaper than Nuclear

- **Nuclear**
  - cheaper than OCGT and CCGT

Proportion of the year that the unit runs for
Load-duration curve - deterministic case

- GW
- $d_{\text{max}}$
- OCGT
- CCGT
- Nuclear

Proportion of the year

$h_{\text{crit}_1}$

CCGT cheaper

$h_{\text{crit}_2}$

Nuclear cheaper
Deterministic case

Demand and Supply Functions

- P5
- P4
- P3
- P2
- P1

£/MWh vs. GW
Sources of randomness

1. Fuel prices are log-normally distributed
Sources of randomness

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2. Demand is uncertain around historical bounds
Sources of randomness

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2. Demand is uncertain around historical bounds

3. Renewable output varies with stochastic load factors
Demand and Supply Functions
Demand and Supply Functions

£/MWh

GW
Demand and Supply Functions

£/MWh vs. GW
Demand is very price inelastic
Sample from 362 tranches along the load duration curve
Model flow diagram

Industry capacity mix

Initial fixed capacity input
Model flow diagram
Model flow diagram

1. Log normal distribution
2. Stochastic marginal cost of technologies
3. Electricity industry supply function
4. Equilibrium prices (clearing prices)
5. Demand function
6. Net demand (without intermittency)
7. Uniform distributed around its historical mean
8. Initial fixed capacity input
9. Industry capacity mix

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Results and Analysis
Comparison of deterministic and stochastic versions: effects of uncertainty

Investments in technologies
Carbon Price €80/tonne, Wind 15GW, Solar 76GW

- **Nuclear**: Deterministic (30 GW), Stochastic, Risk Neutral (30 GW)
- **CCGT**: Deterministic (20 GW), Stochastic, Risk Neutral (20 GW)
- **OCGT**: Deterministic (5 GW), Stochastic, Risk Neutral (5 GW)
- **Overall**: Deterministic (55 GW), Stochastic, Risk Neutral (55 GW)
Comparison of deterministic and stochastic versions: effects of uncertainty
Effects of risk-aversion at high carbon price

Investments in technologies

Carbon Price = 80 £/tonne, W=15 GW, S=7 GW

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Effects of risk-aversion at low carbon price

Investments in technologies

- Deterministic: 6.7 GW
- Stochastic, risk neutral: 49.4 GW
- Stochastic, risk aversion=0.1: 49 GW
- Stochastic, risk aversion=0.2: 48.45 GW

Carbon Price=40 €/tonne, W=15 GW, S=7 GW
Impact of more renewables

Investments in technologies

Low: Wind 15 GW, Solar 7 GW
High: Wind 30 GW, Solar 14 GW

Carbon Price 80 €/tonne

- Nuclear
- CCGT
- OCGT
- Overall

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Thank you

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Nuclear power: a hedge against uncertain gas and carbon prices?

*The Energy Journal*, 1-23.