

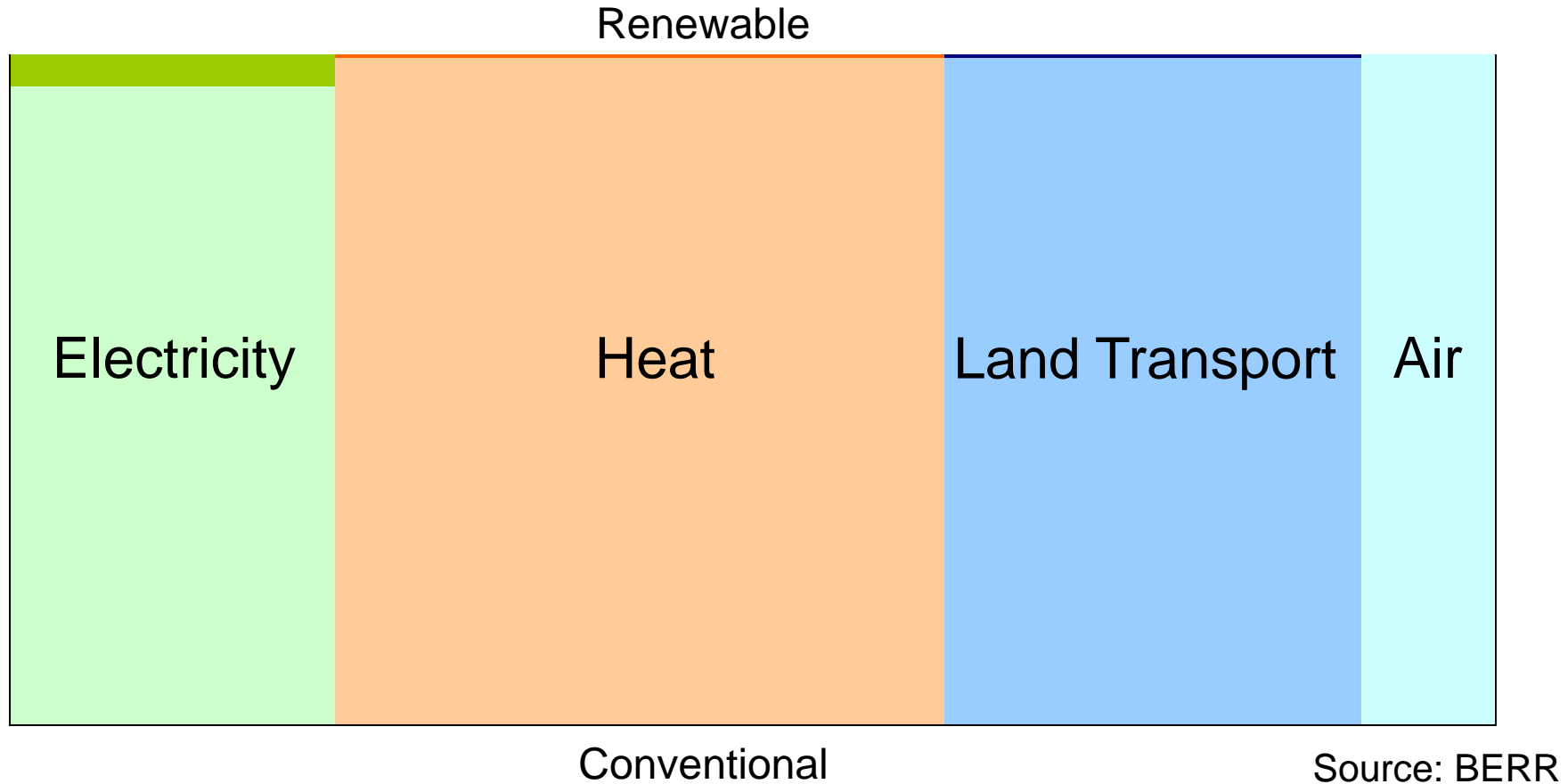
# The long-term impact of wind power on electricity prices and generating capacity

Richard Green and Nicholas V. Vasilakos

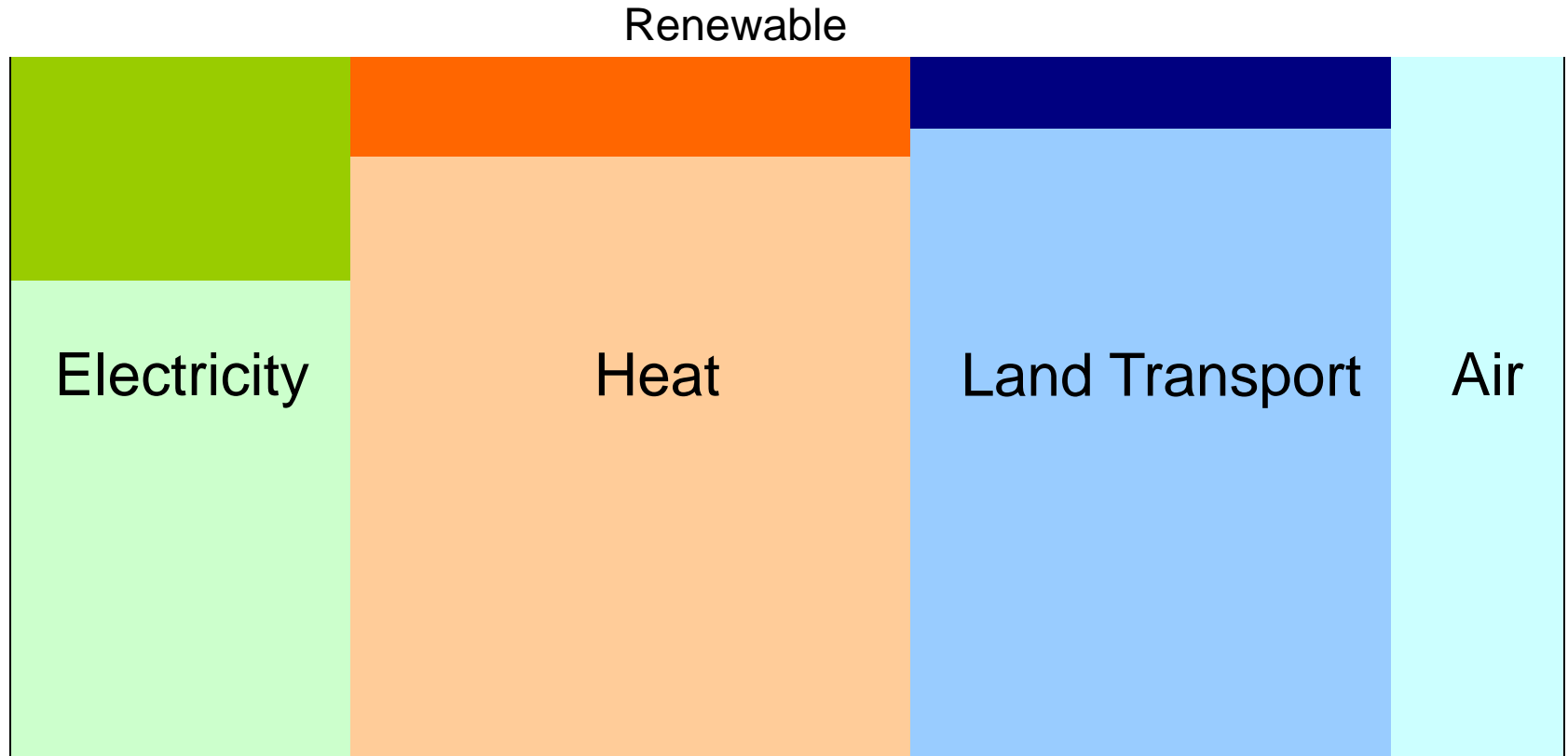
Department of Economics  
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# UK Energy in 2006



# UK Energy in 2020 (?)

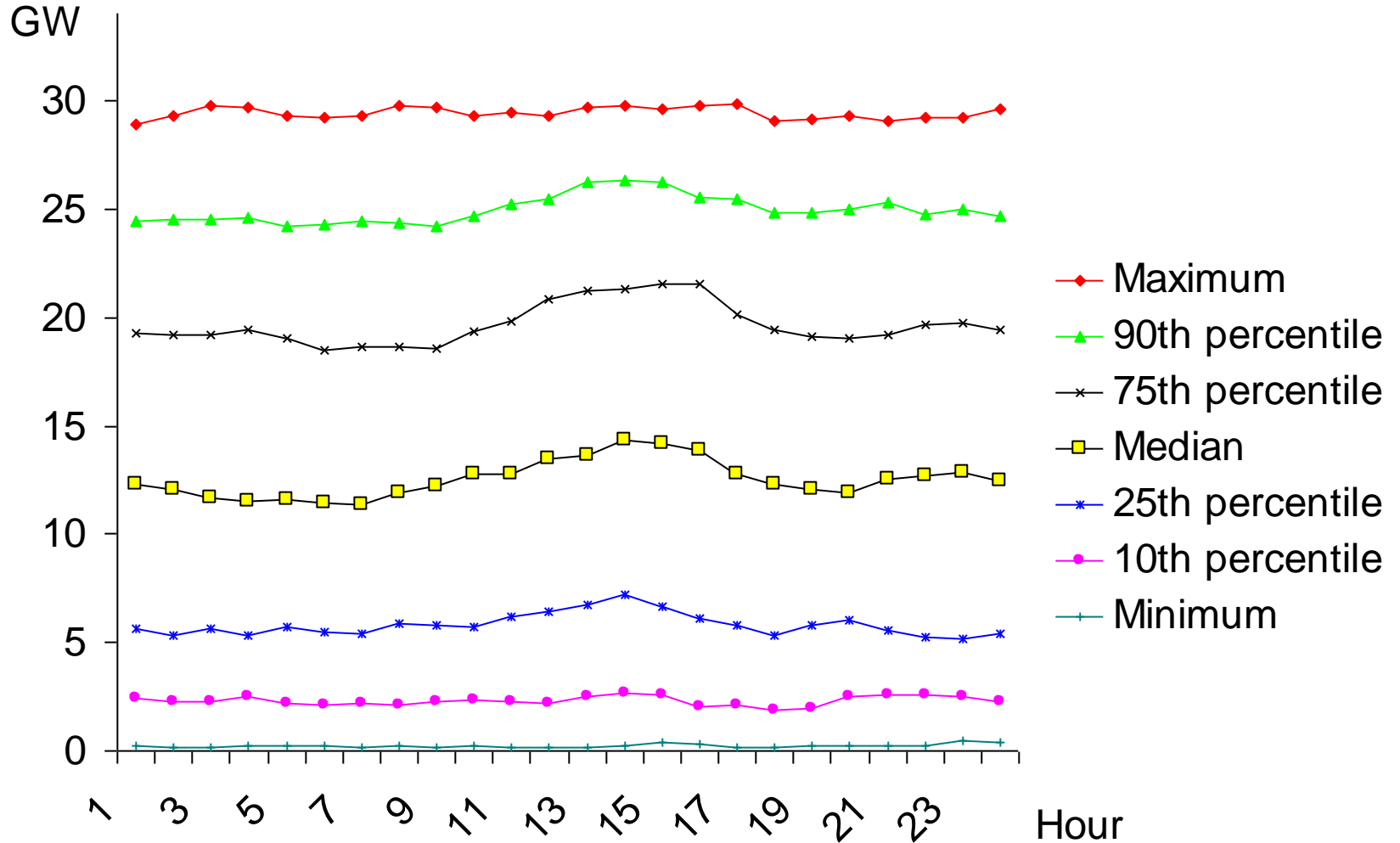


Conventional

Source: BERR

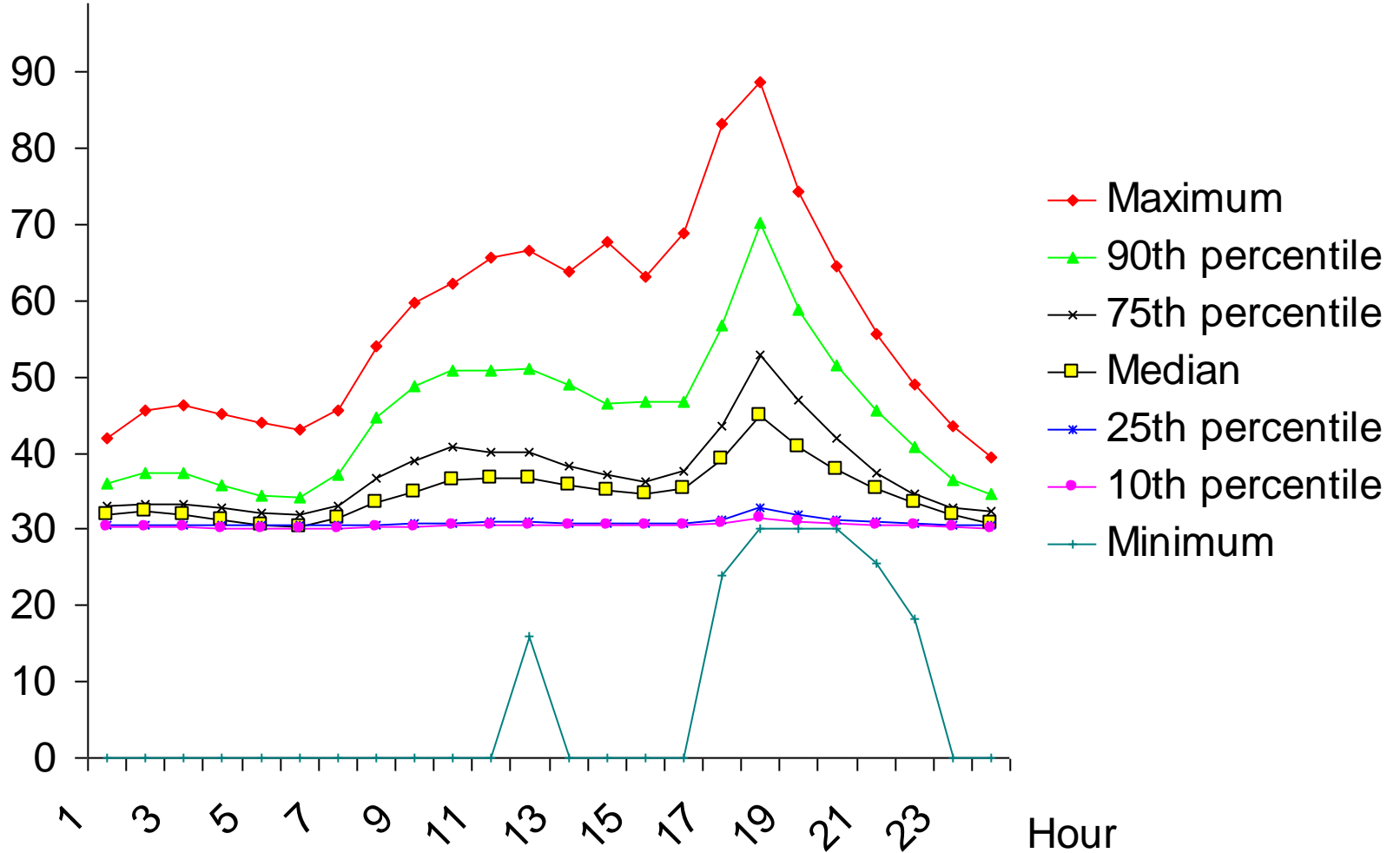


# Wind output variation - January



# Price variation due to wind - January

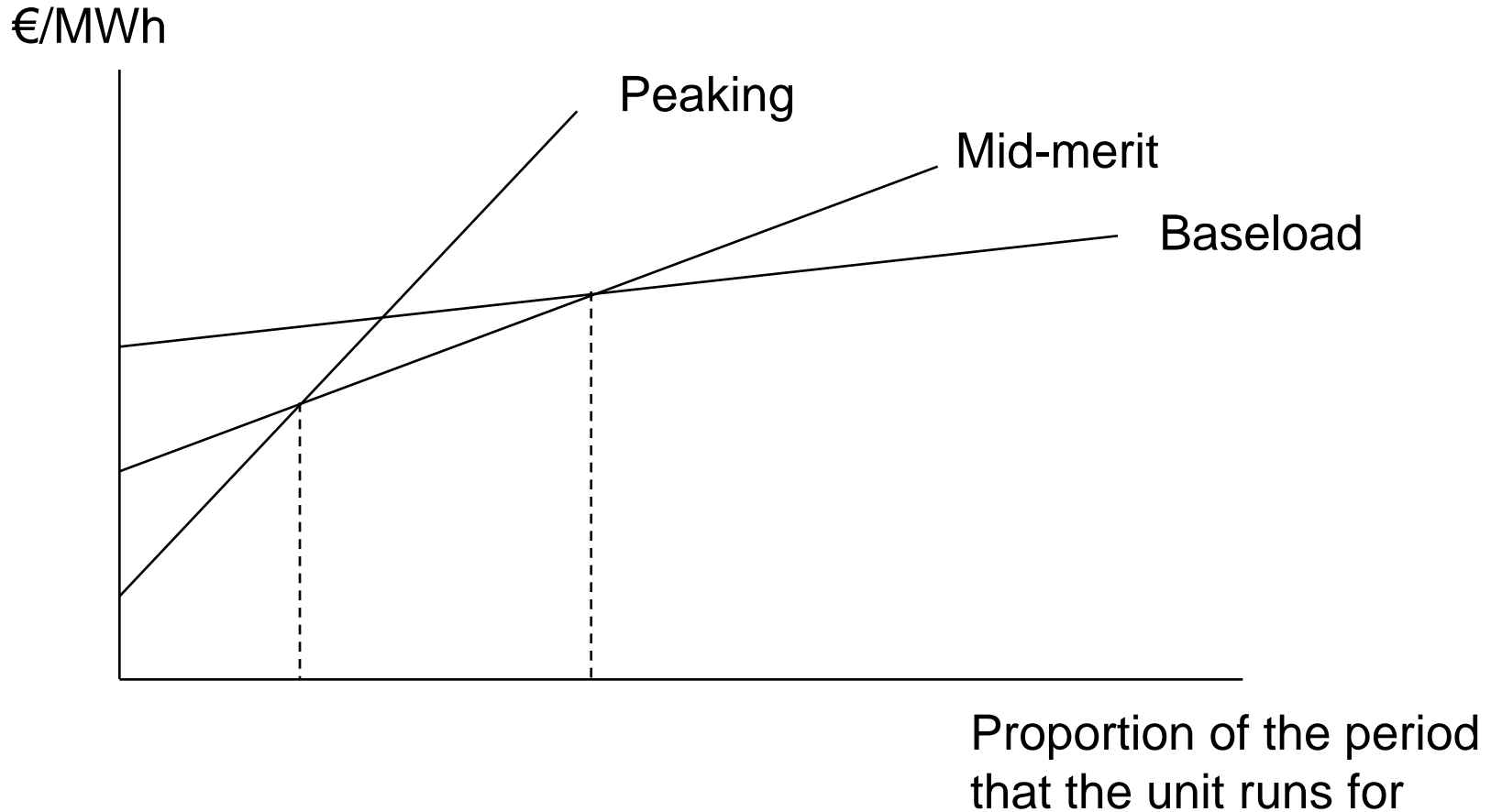
6 strategic firms



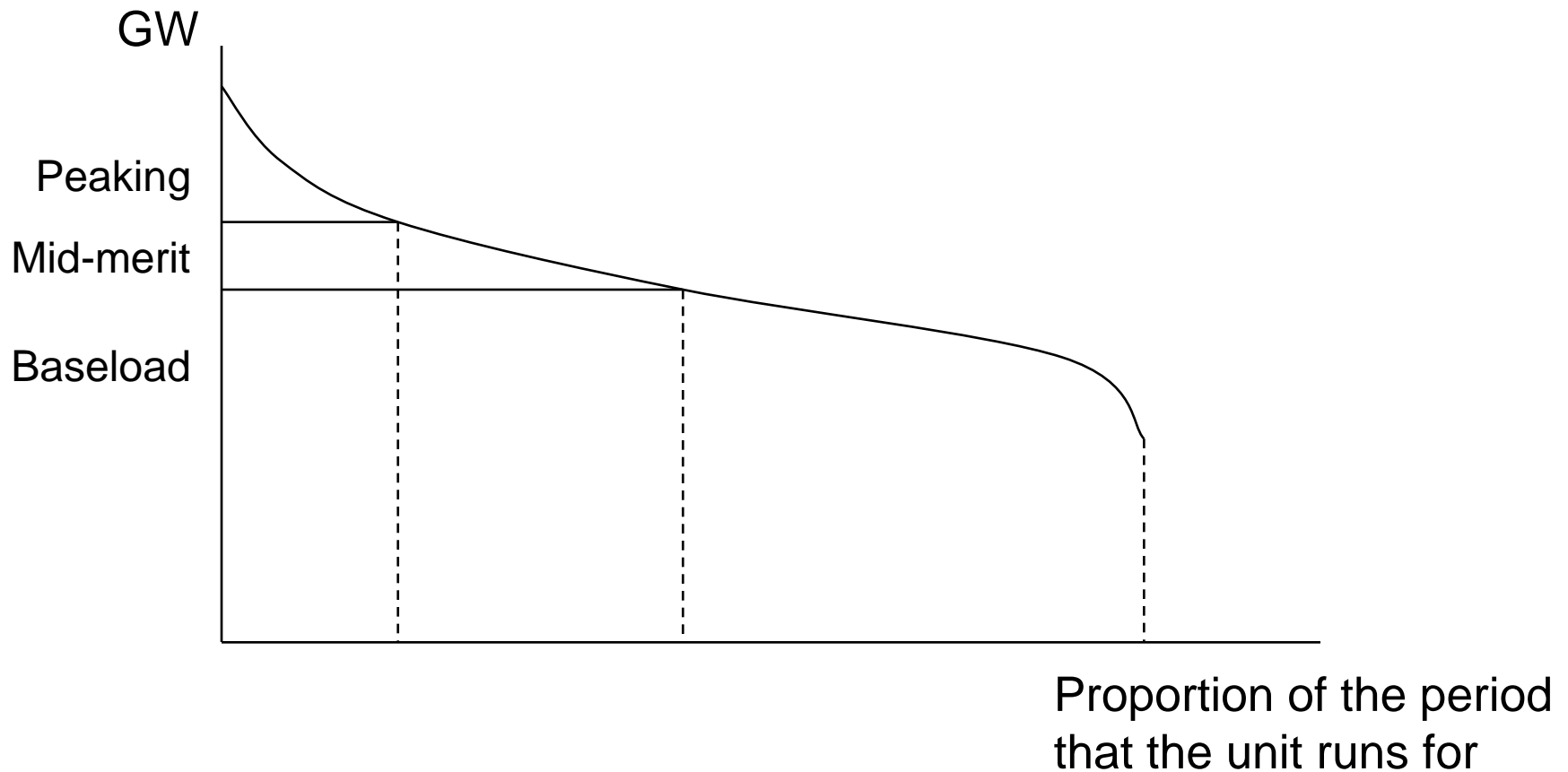
## This paper

- What does the long-term equilibrium look like?
- Consistent capacities and prices
- Price-taking and strategic behaviour
  - Supply function equilibria in both cases

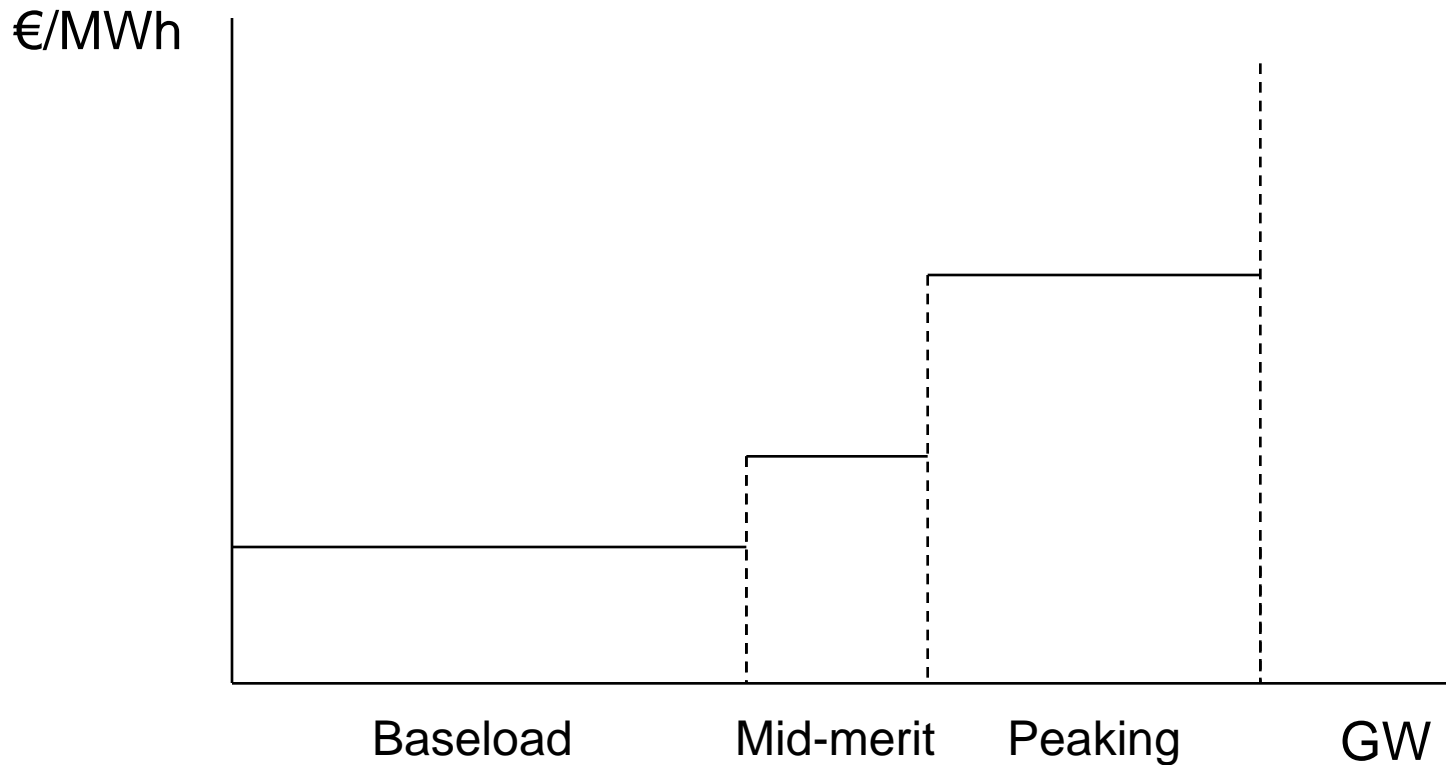
# Generating technologies and their total costs



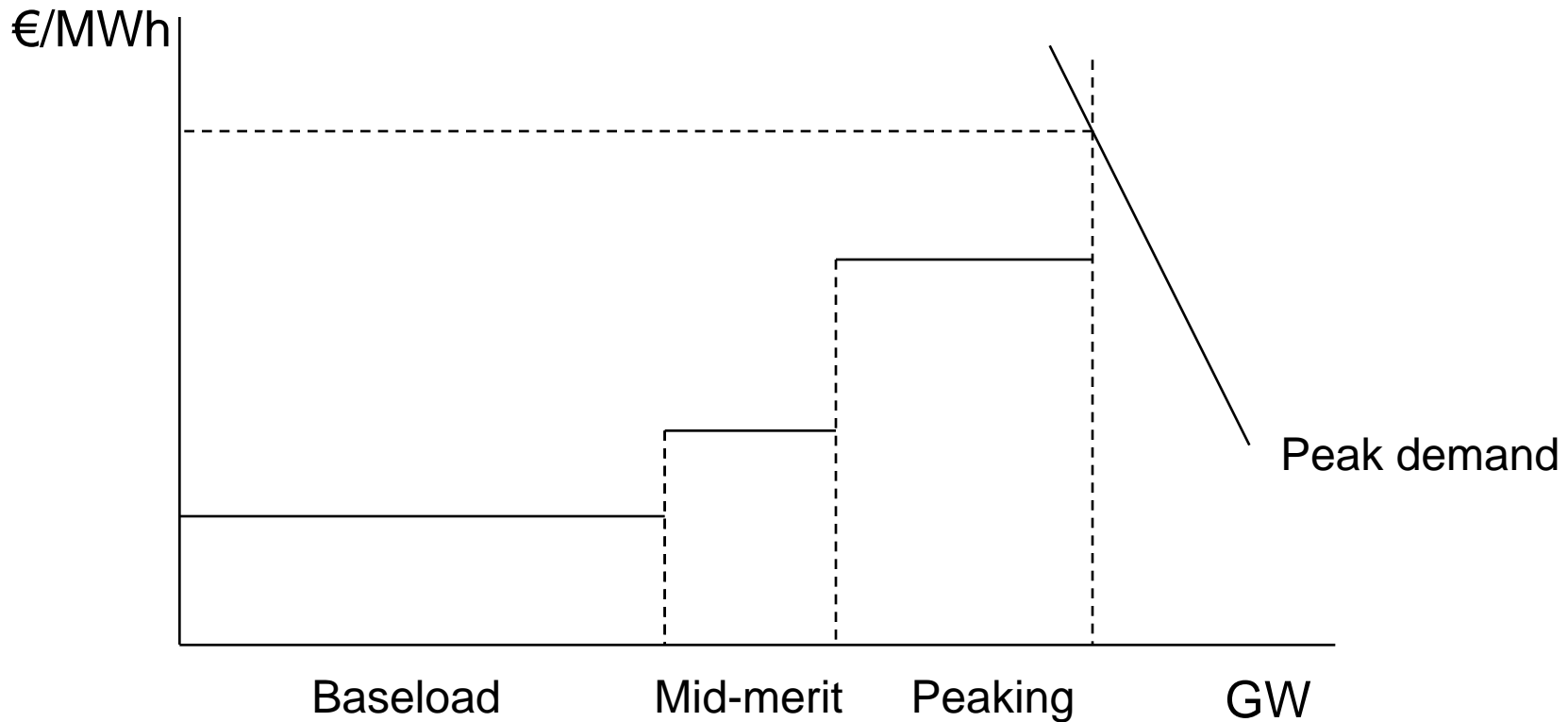
# Generating capacities: the load-duration curve



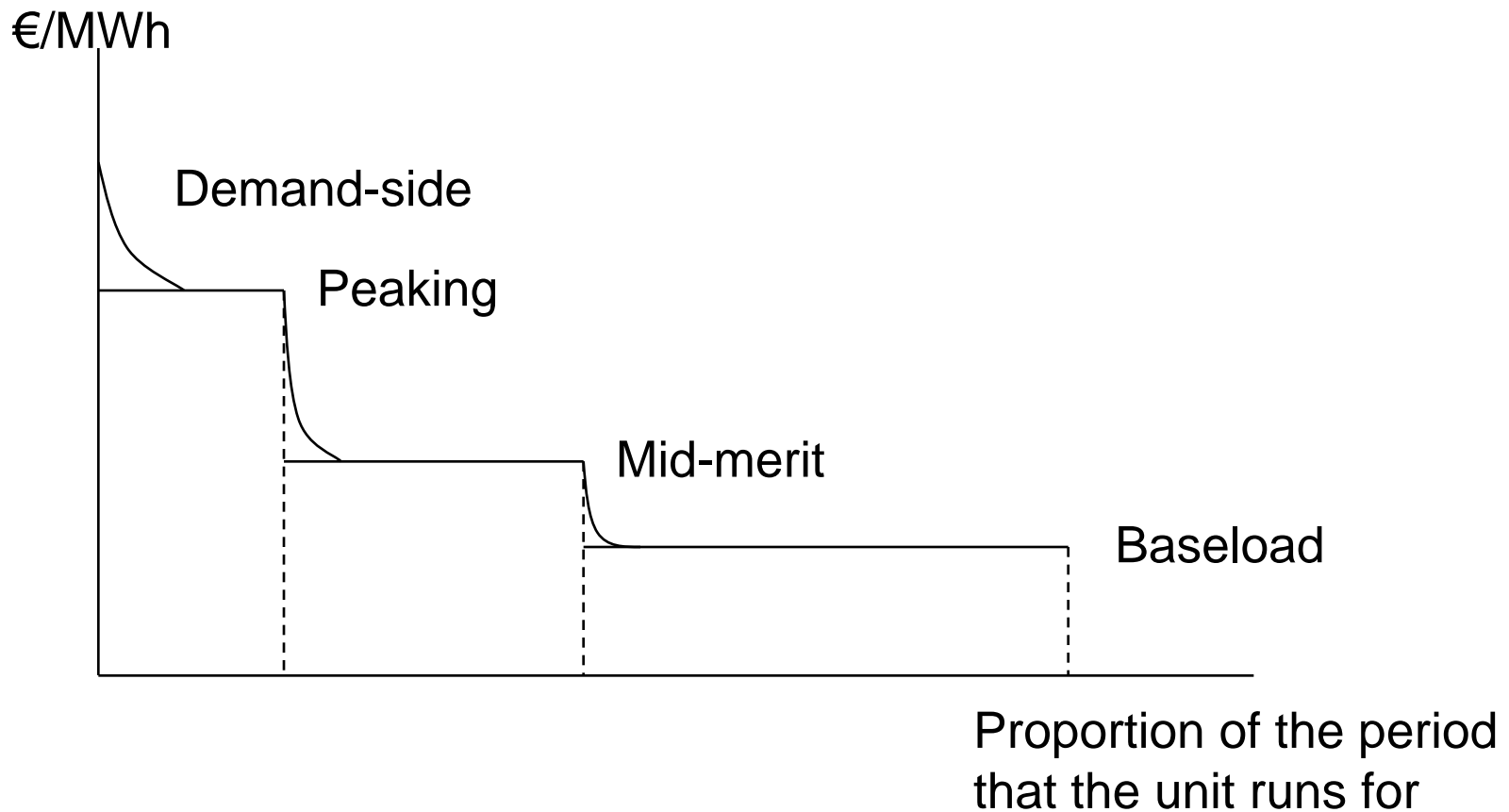
# Generating capacities: the merit order



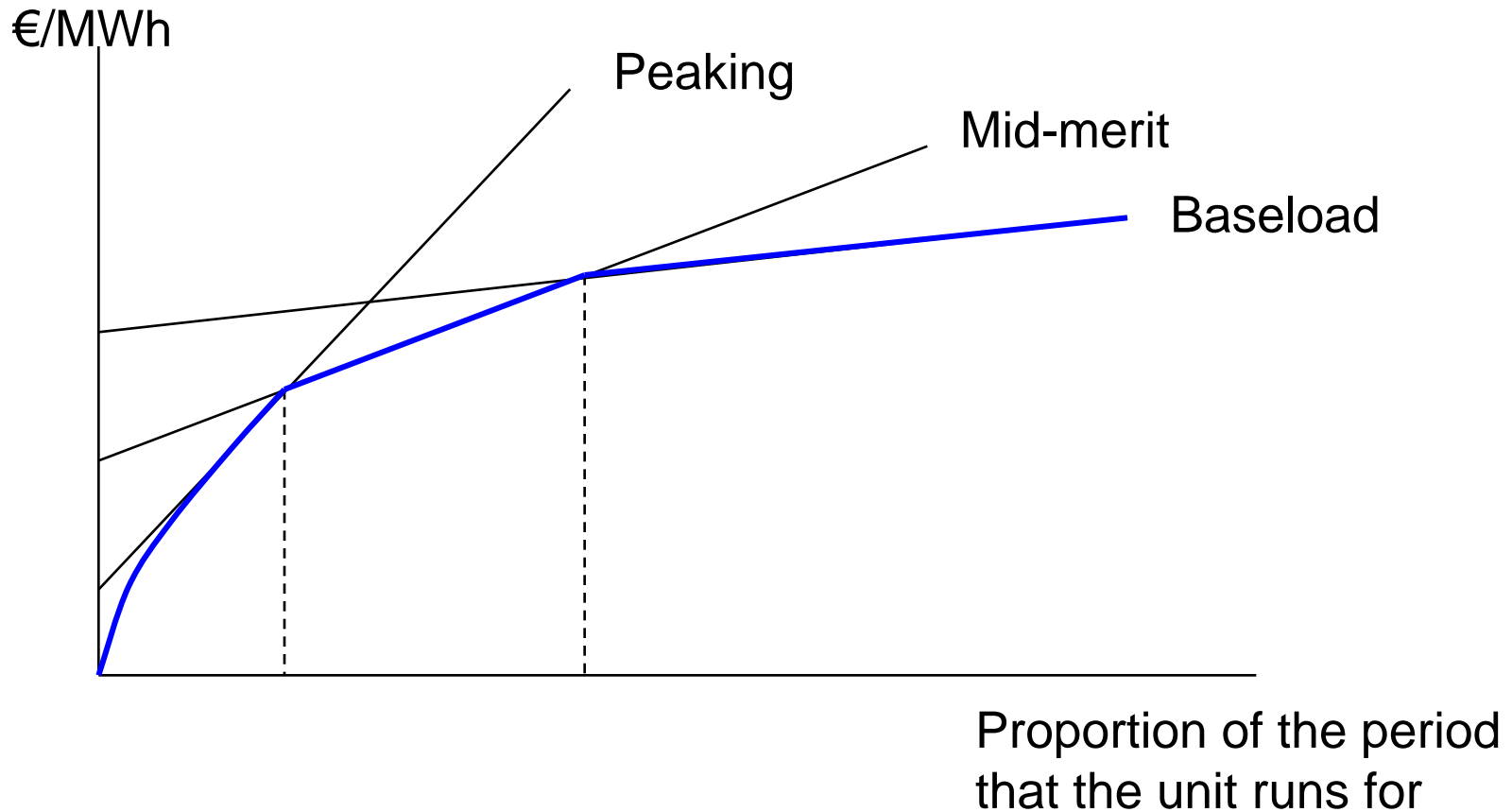
# Generating capacities: demand-side price-setting



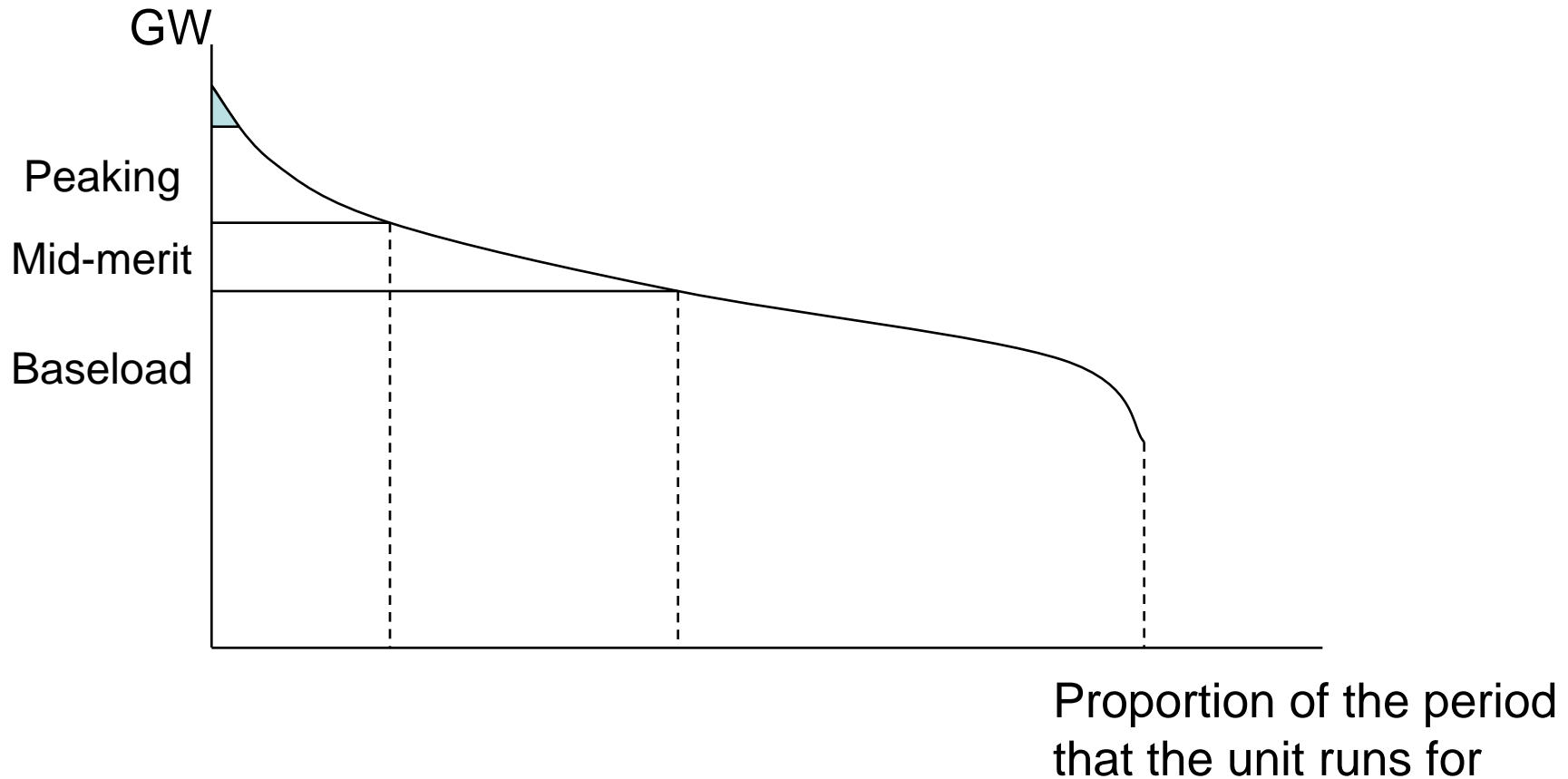
# Price-duration curve



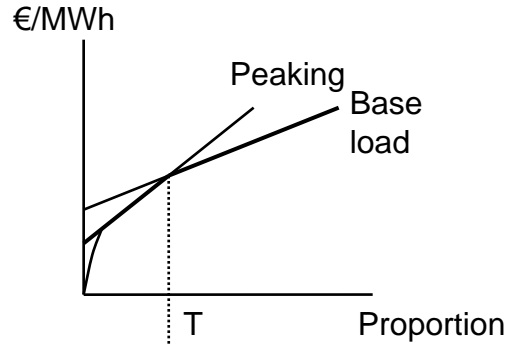
# Generating technologies, costs and revenues



# Generating capacities: the load-duration curve

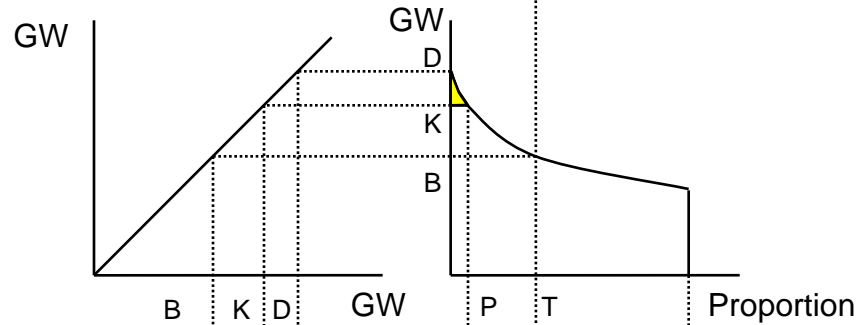


# The determination of electricity prices



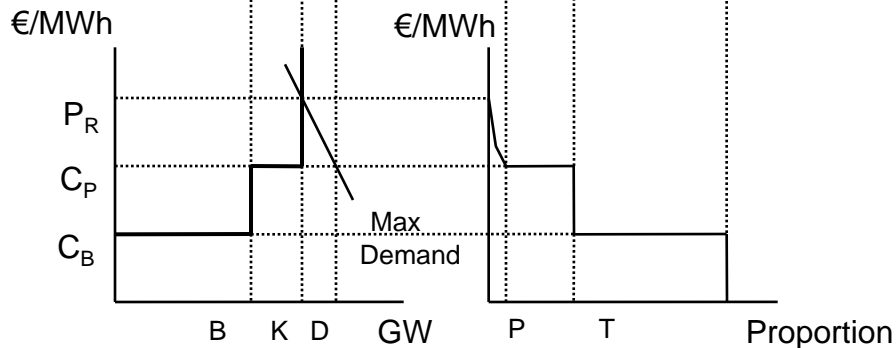
Total Costs by plant type

Reflecting line



Load-duration curve

Marginal cost and demand

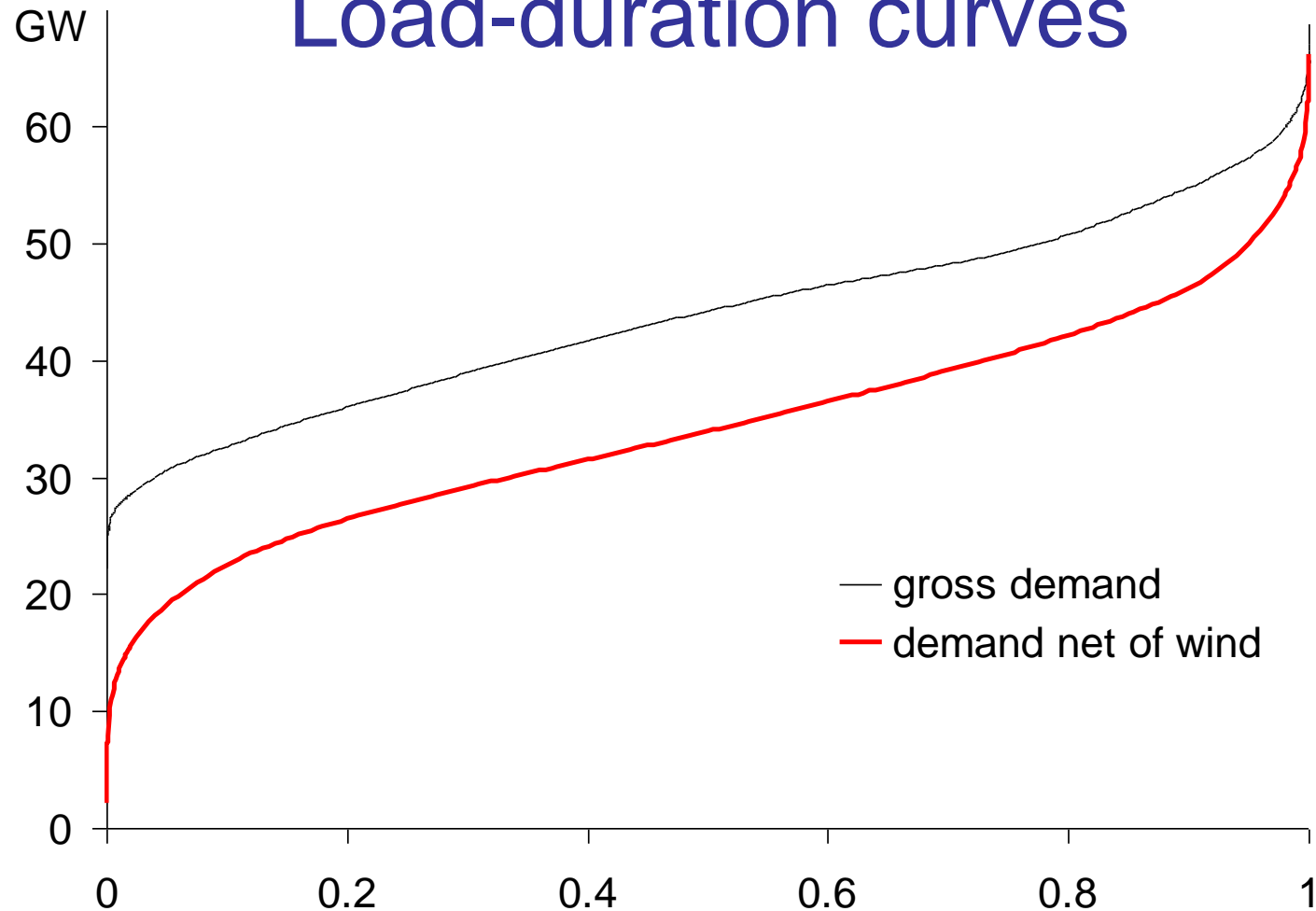


Price-duration curve

## Four thermal plant types

- Nuclear, Coal (unabated), CCGT, OCGT
- Cost estimates from House of Lords (2008) plus DTI High fuel prices and carbon at £10/tonne CO<sub>2</sub>.
  - OCGT run 0 – 600 hours / year
  - CCGT run 600 – 4,300 hours / year
  - Coal run 4,300 – 6,200 hours / year
  - Nuclear run 6,200+ hours / year

# Load-duration curves

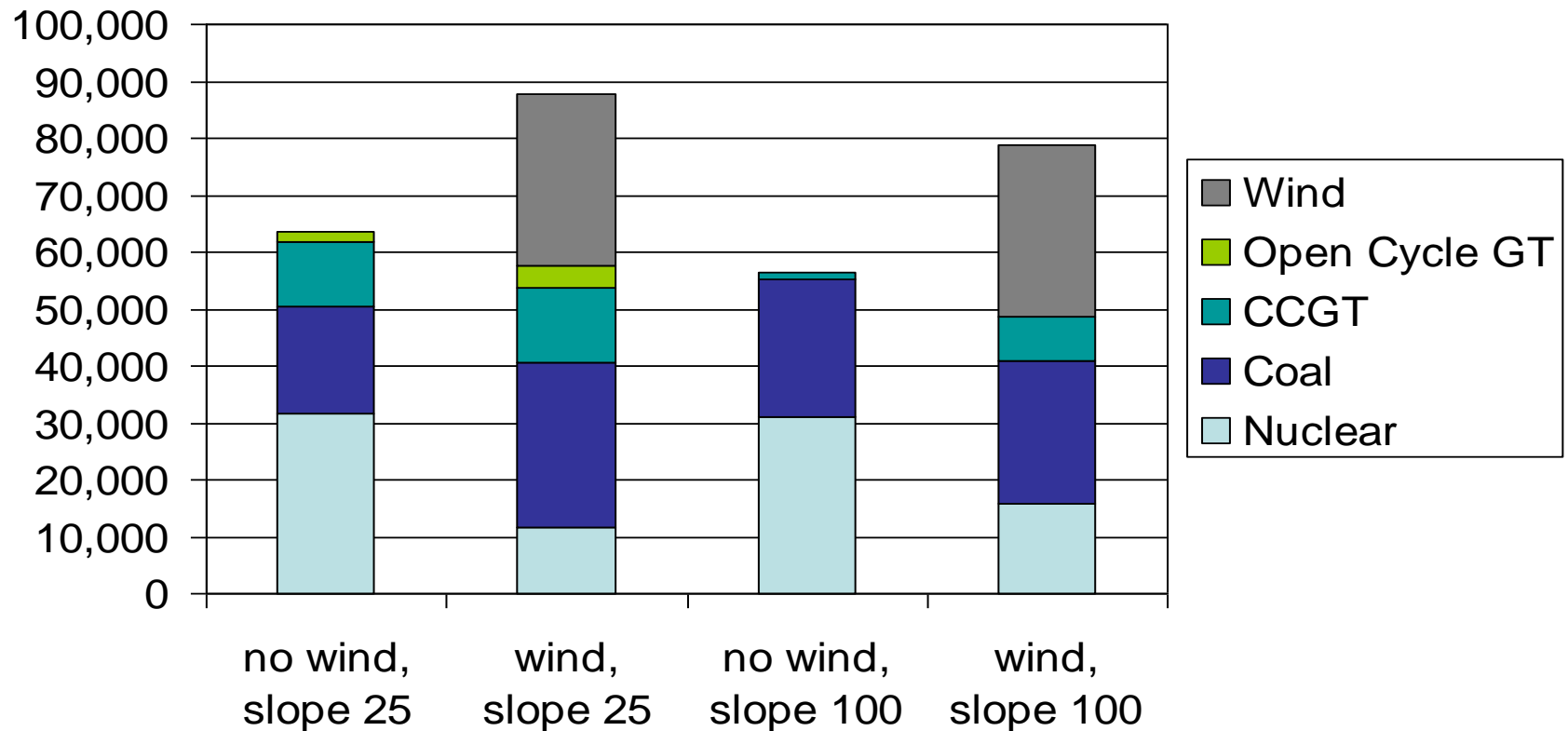


## Competitive case

- Calculate supply function with  $n = 600$
- Follows industry marginal cost curve very closely, vertical at full capacity
- Invest so marginal plant of each type makes zero profits (or  $K = 0$ )

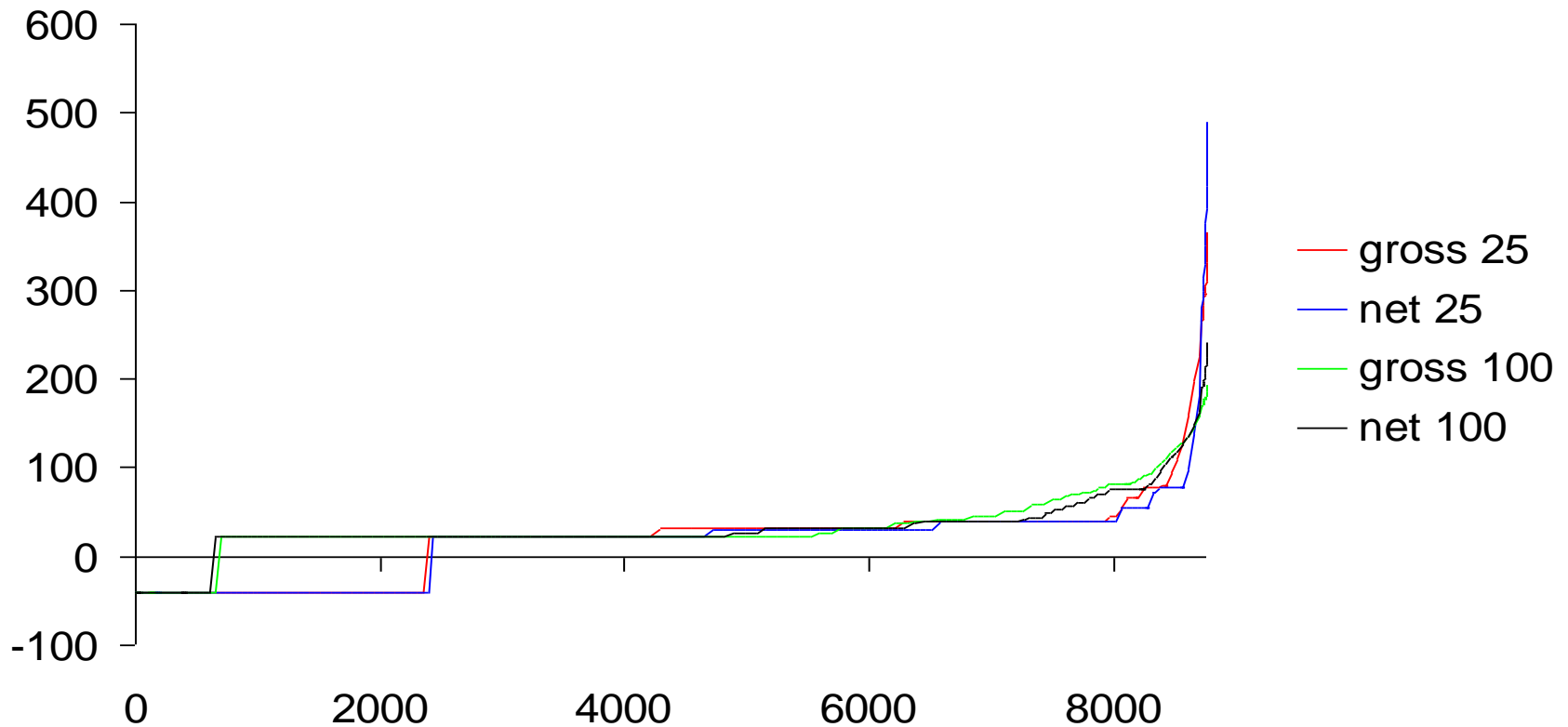
# Capacity mix

carbon cost = £10



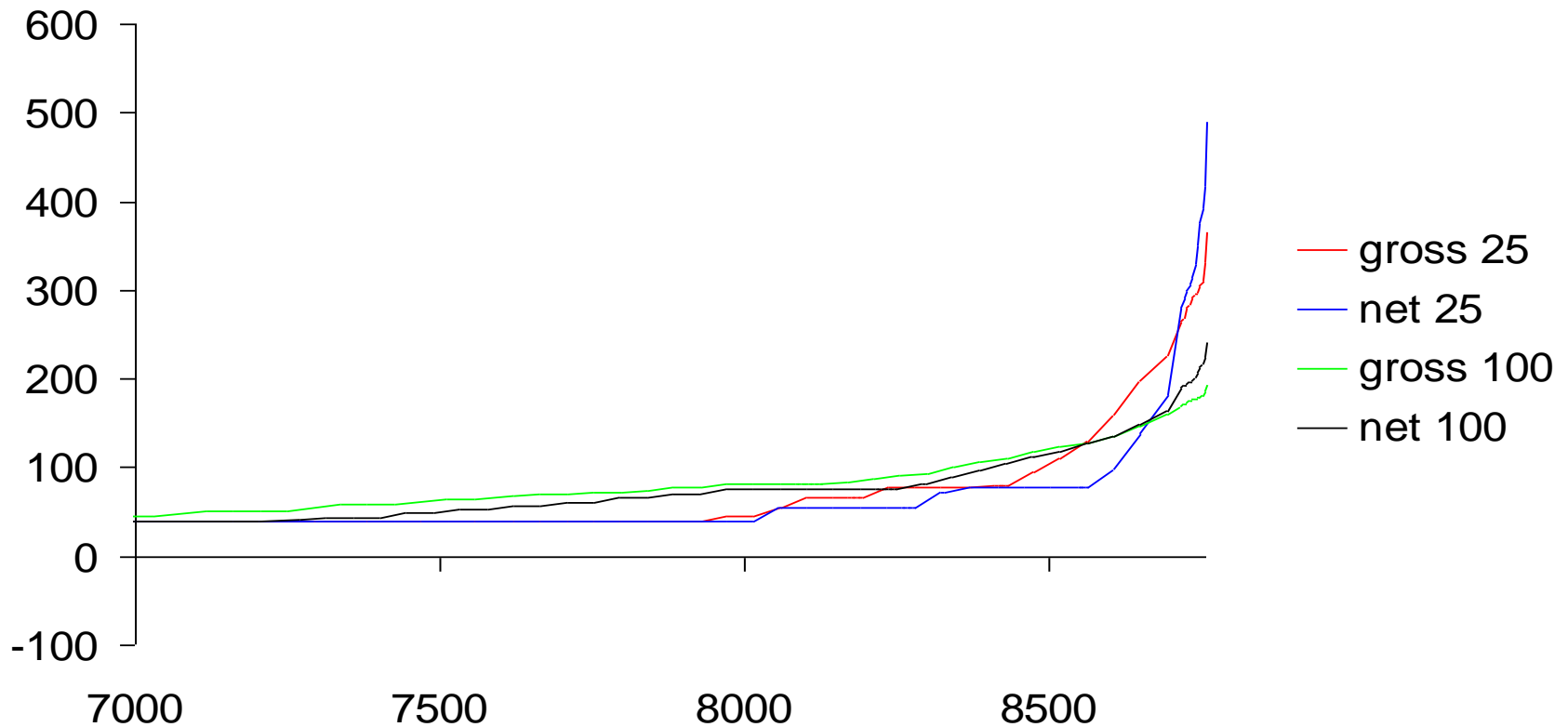
# Price duration curves

£/MWh



# Price duration curves

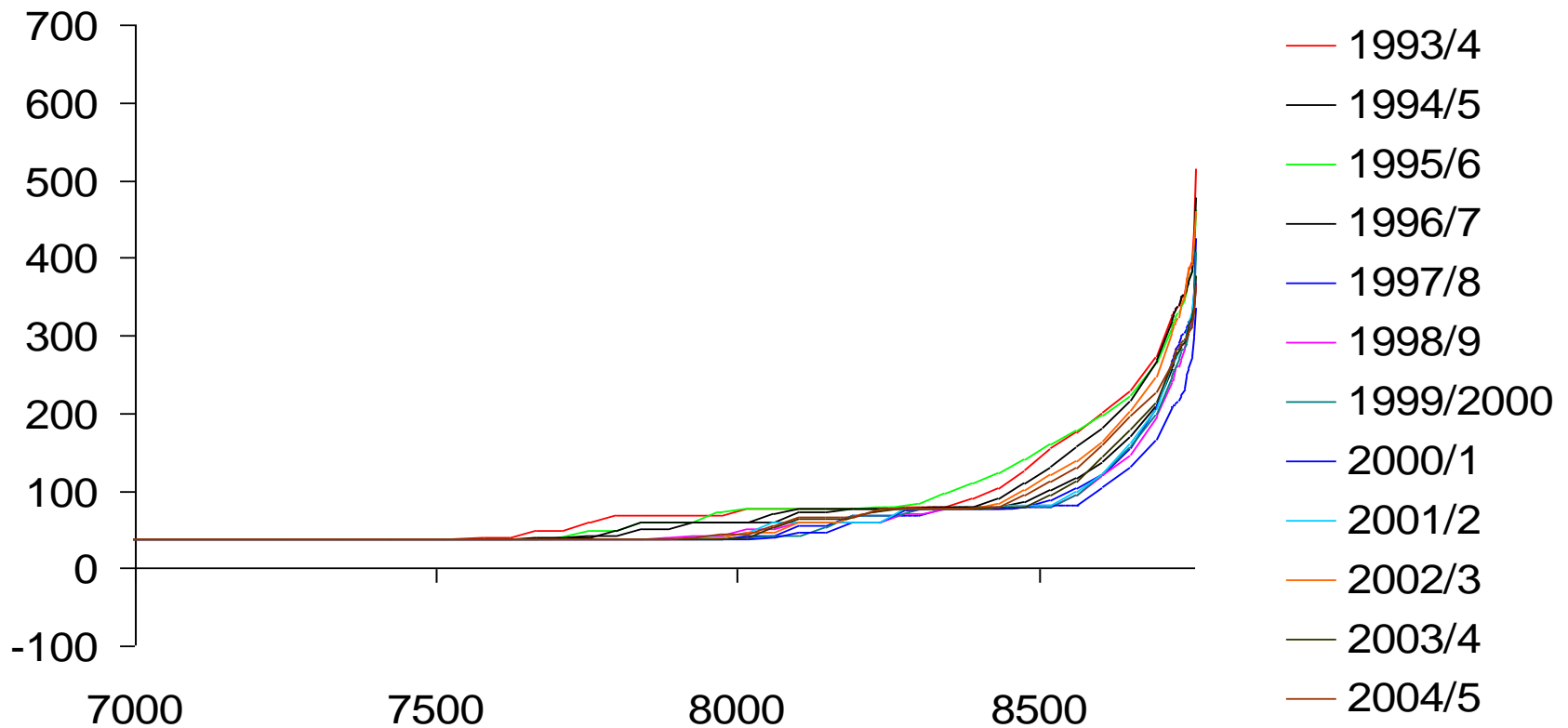
£/MWh



# Price duration curve

Demand without wind, slope = 25

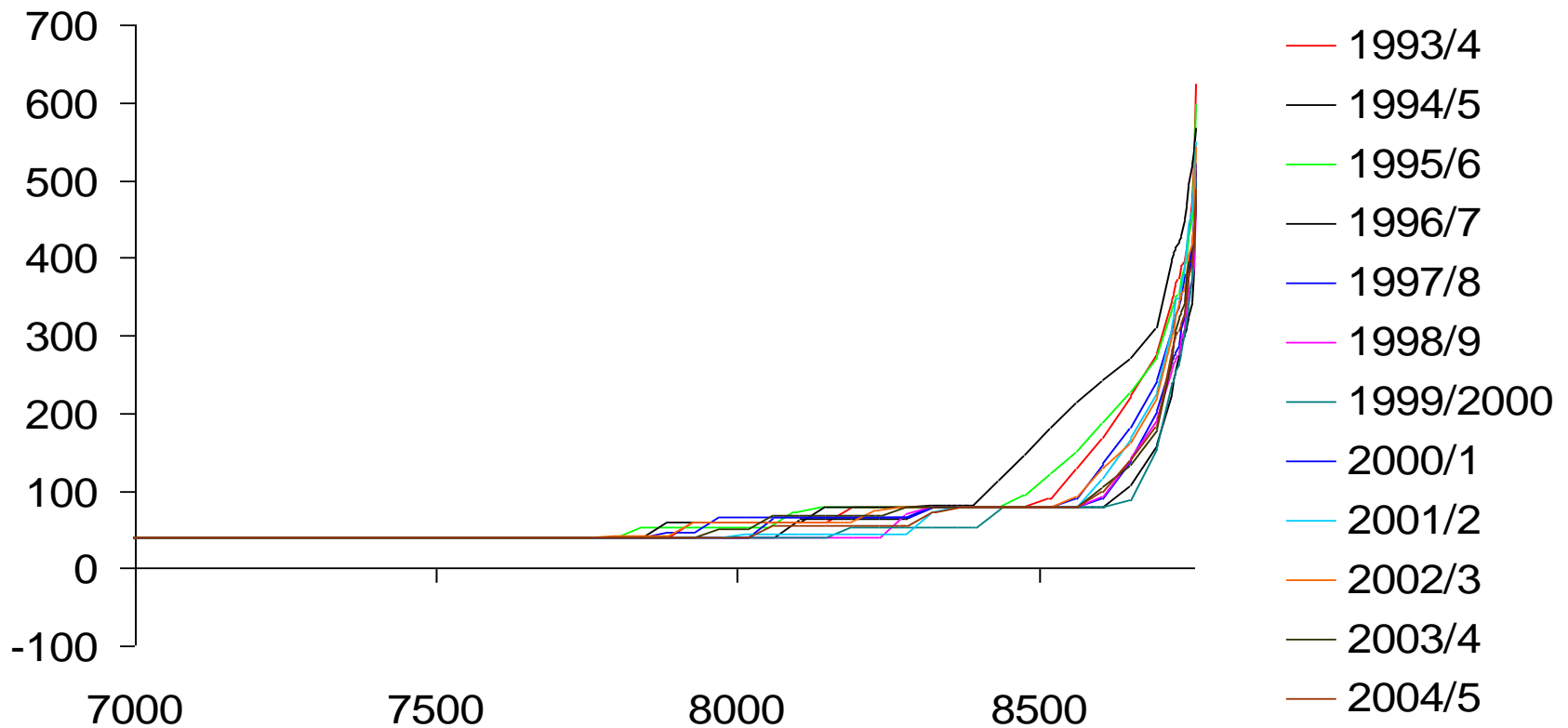
£/MWh



# Price duration curve

Demand net of wind, slope = 25

£/MWh



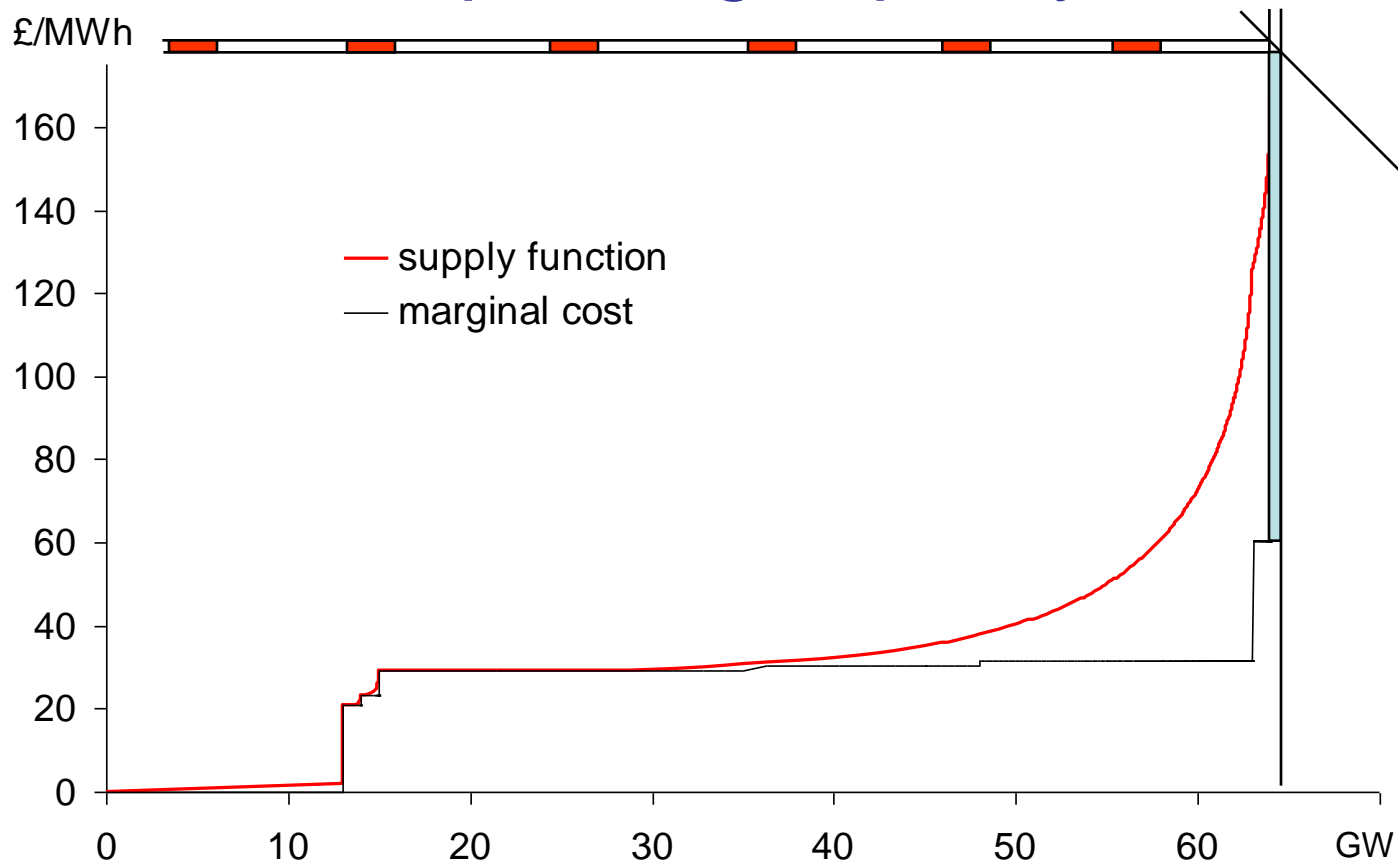
## Variation in annual profits, £ per kW (range between maximum and minimum)

			Variation without wind	Variation with wind
Nuclear plant	Carbon price £10	Slope – 25	£28 to -£26	£42 to -£16
		Slope – 100	£15 to -£19	£26 to -£24
	Carbon price £25	Slope – 25	£24 to -£22	£36 to -£33
		Slope – 100	£23 to -£19	£30 to -£28
OCGT stations	Carbon price £10	Slope – 25	£16 to -£14	£28 to -£14
		Slope – 100	£ 3 to -£12	£ 9 to -£13
	Carbon price £25	Slope – 25	£16 to -£14	£29 to -£14
		Slope – 100	£ 2 to -£13	£ 6 to -£14

## Strategic firms

- Treat the industry as if it has  $1/HHI$  identical firms
- Total quantity and price are empirically similar to results from not-too-asymmetric supply function equilibrium
- Massive saving in computational effort

# Investment by strategic firms: peaking capacity

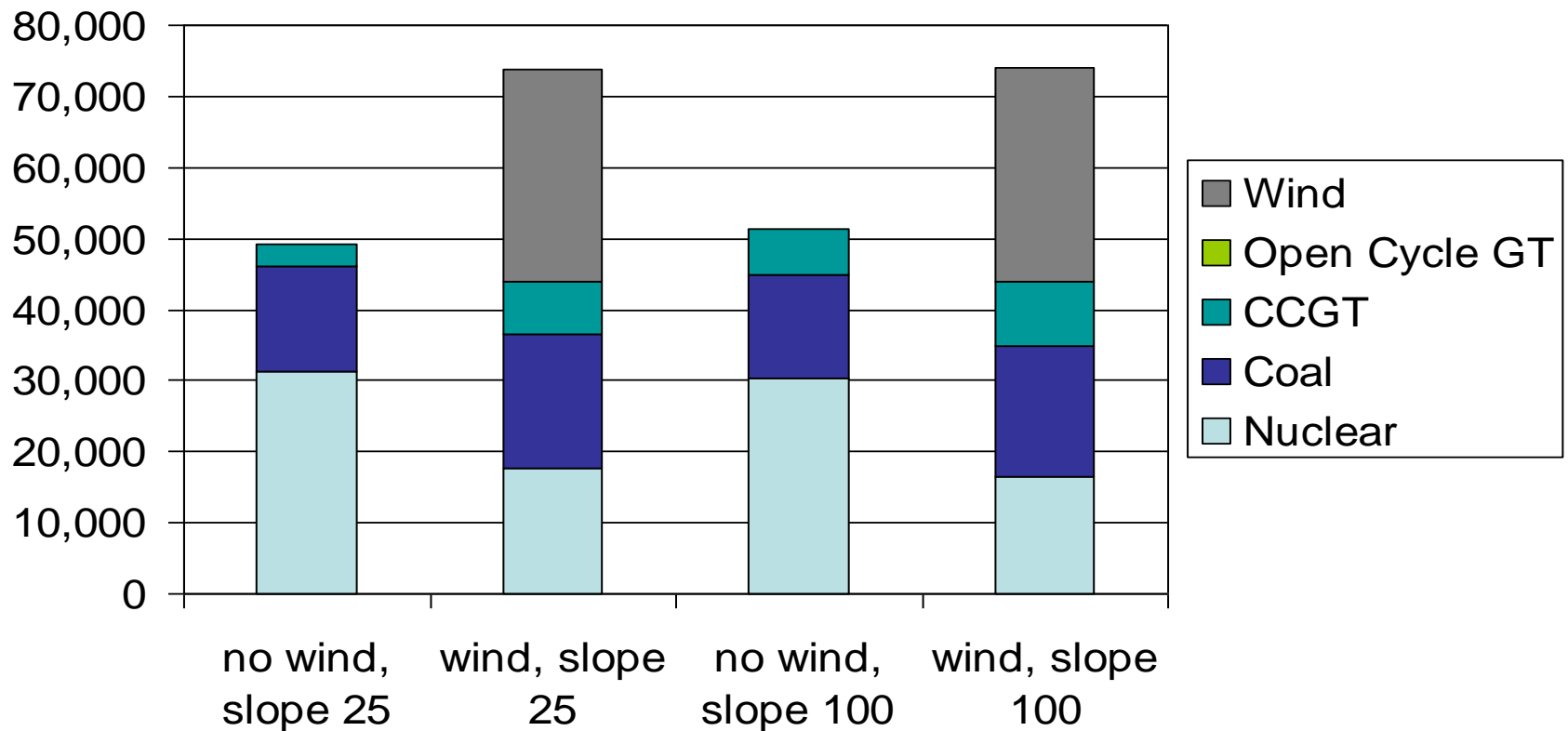


## Investment by strategic firms: other capacity

- Impact on profits of switching between two types of capacity:
  - Increase in fixed cost
  - Reduction of marginal cost
  - Change in bid  $\times$  marginal change in profits from change in bid (which equals zero)
- Implication: choose capacity mix to minimise costs, given operating patterns

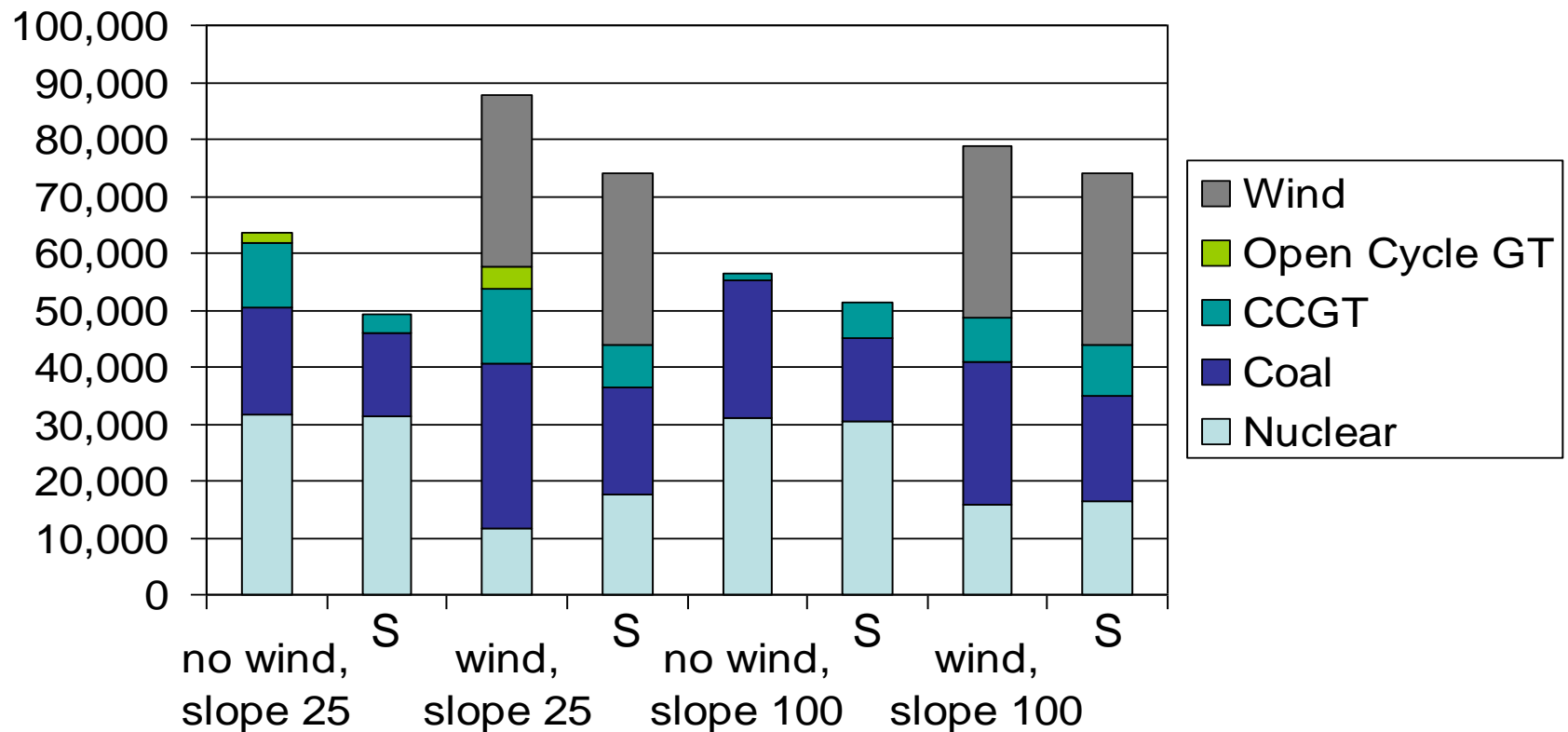
# Capacity mix

carbon cost = £10  
strategic firms



# Capacity mix

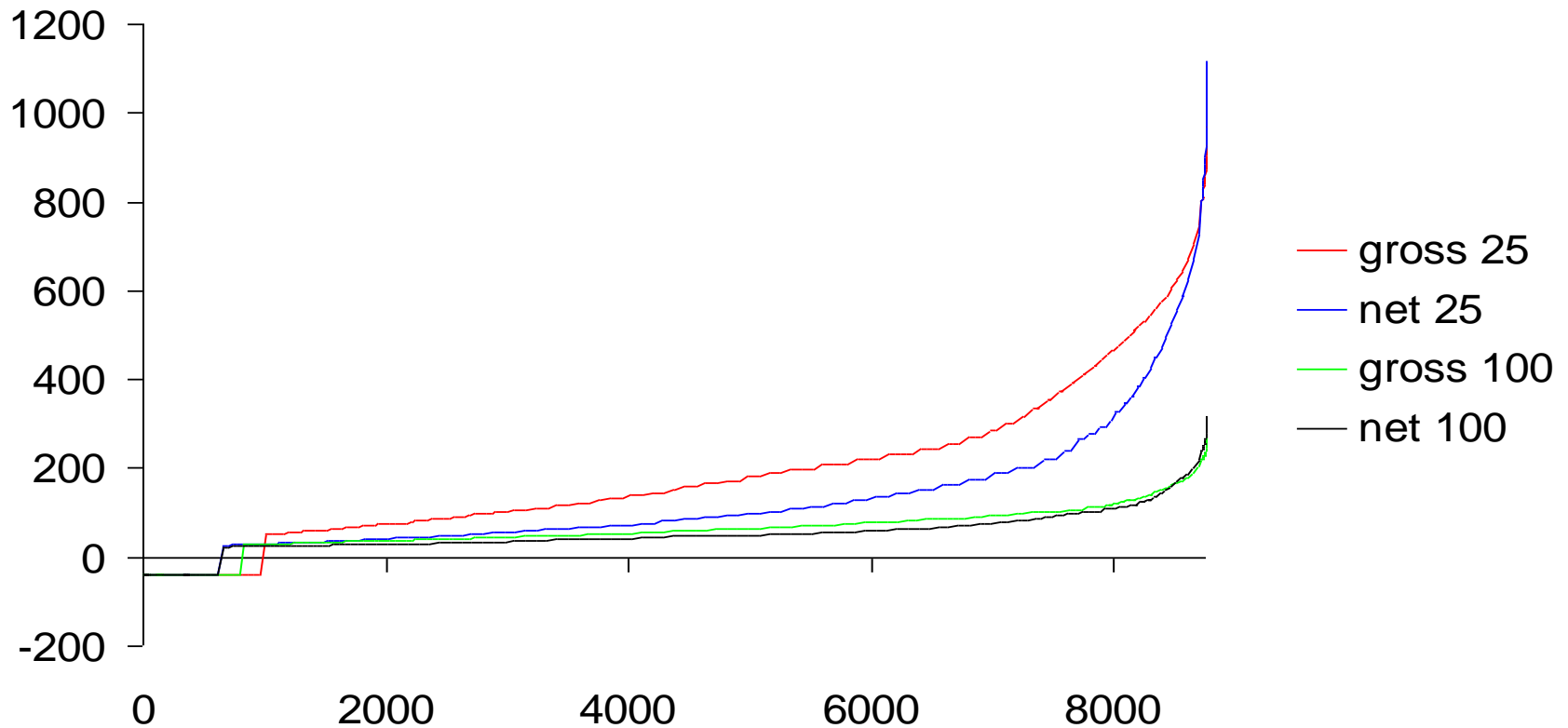
carbon cost = £10



# Price duration curves

## Strategic firms

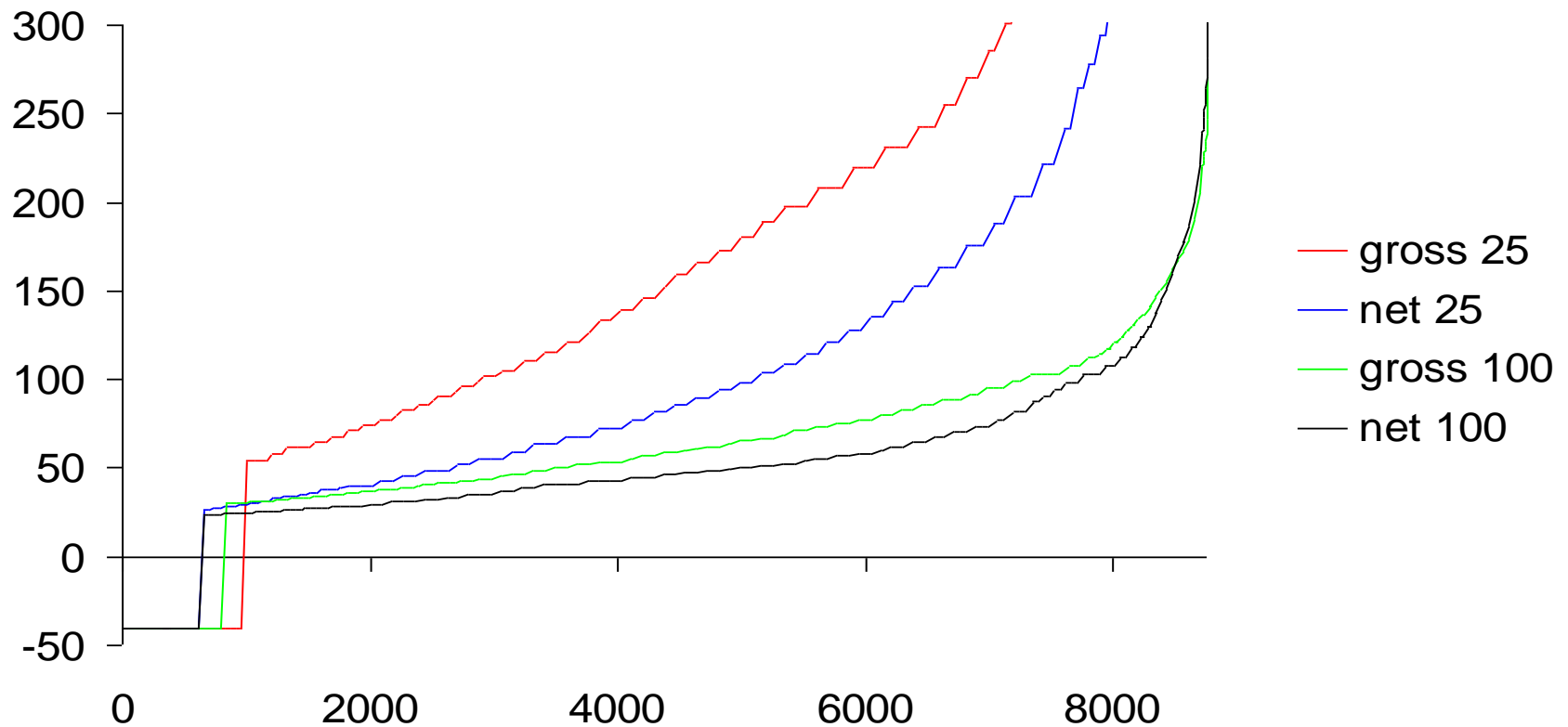
£/MWh



# Price duration curves

## Strategic firms

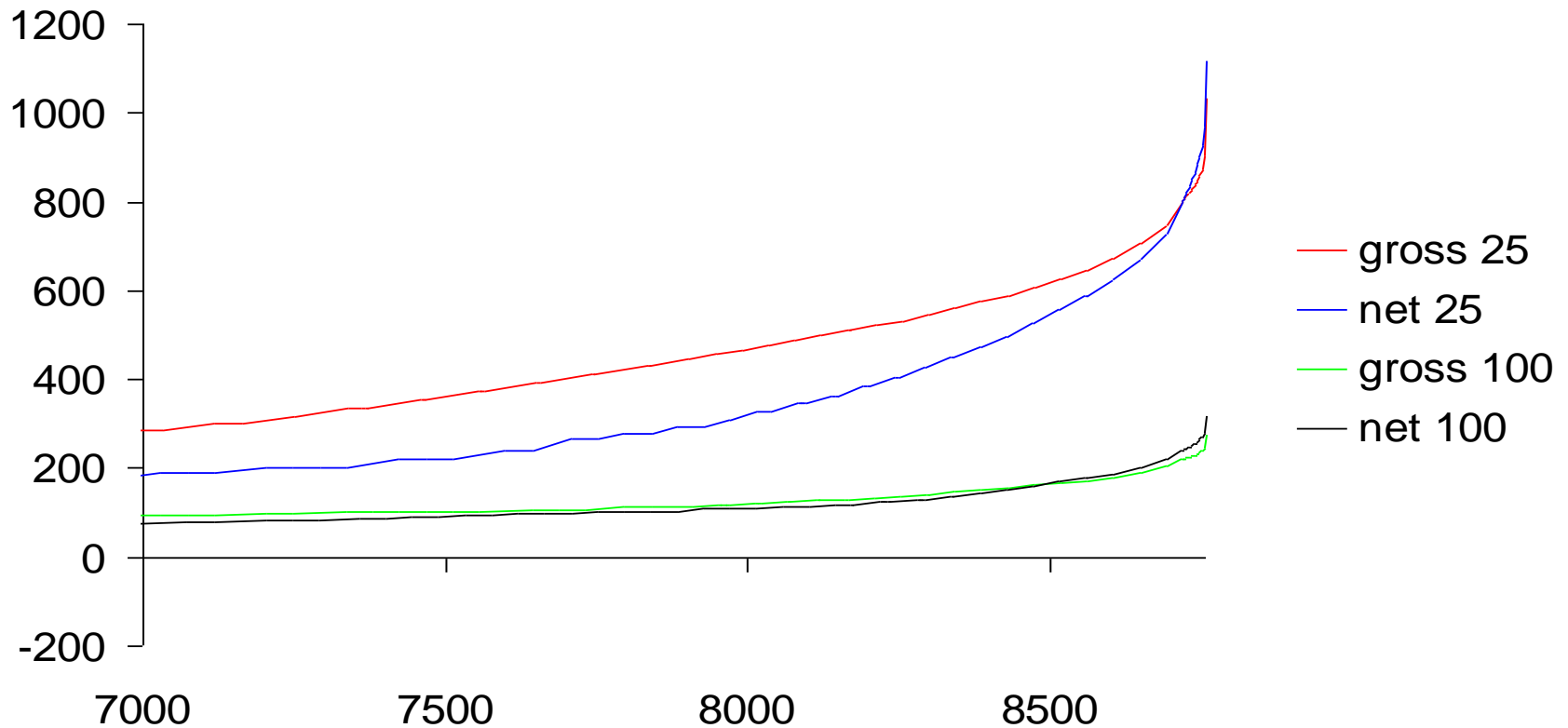
£/MWh



# Price duration curves

## Strategic firms

£/MWh

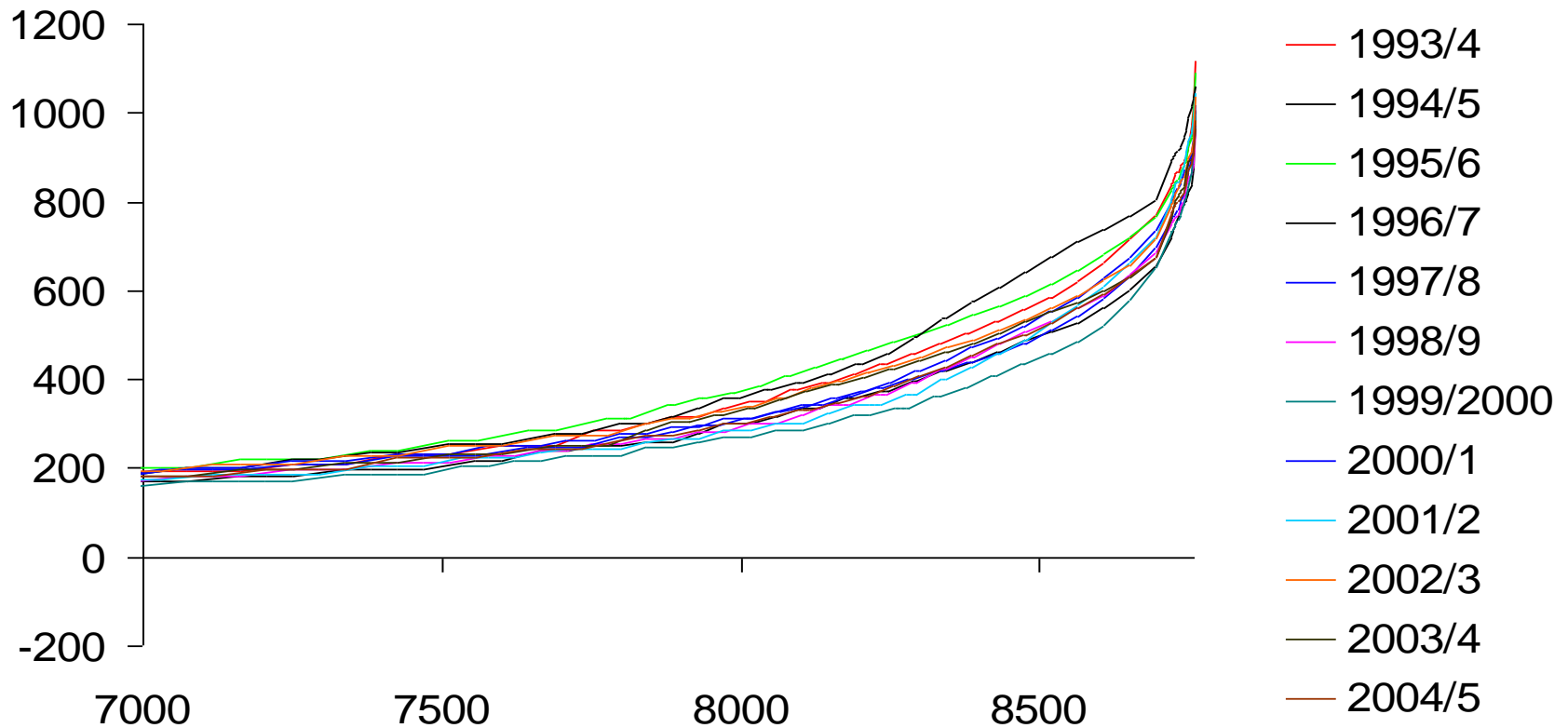


# Price duration curve

Demand net of wind, slope = 25  
Strategic firms



£/MWh

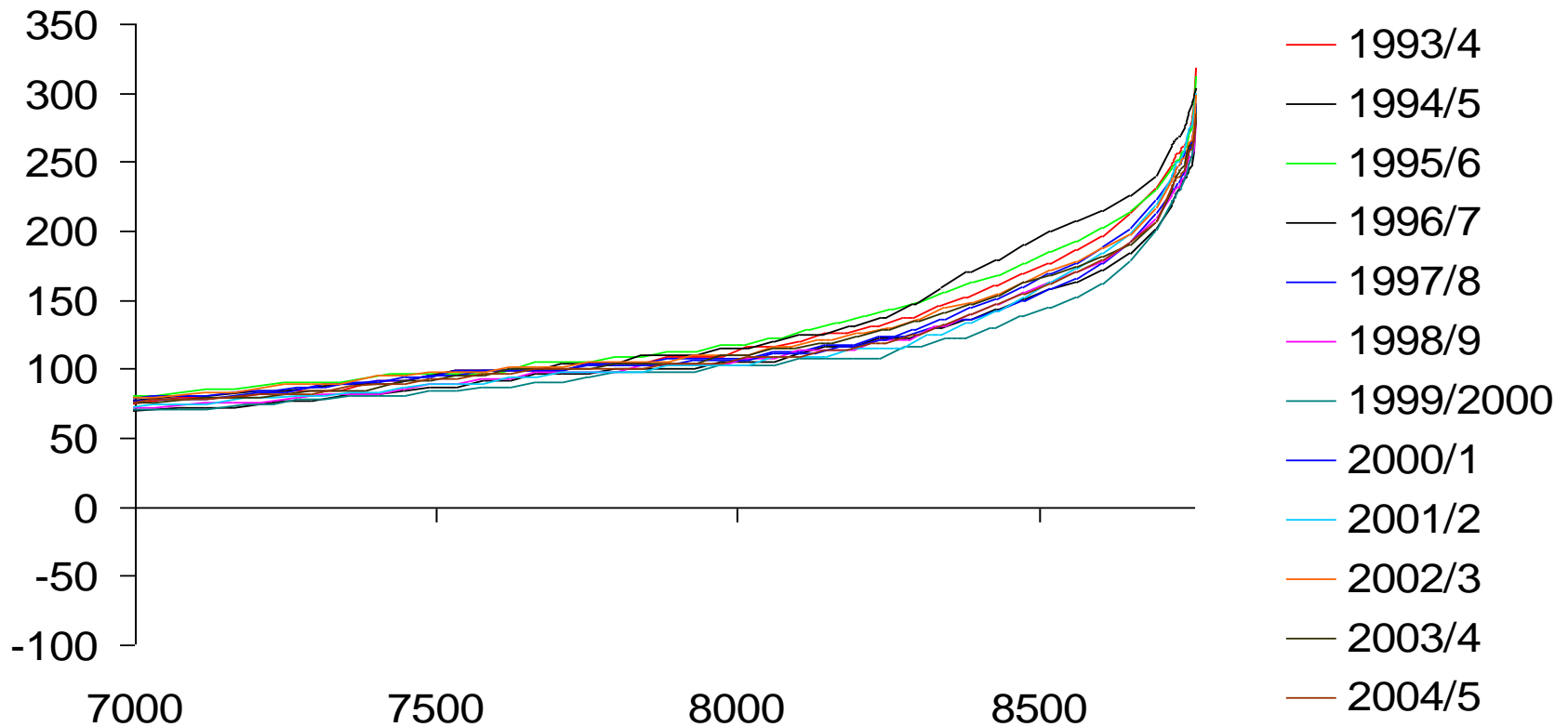


# Price duration curve

Demand net of wind, slope = 100  
Strategic firms



£/MWh



## Implications

- Introducing wind power changes the equilibrium capacity mix
  - Model does not consider operating dynamics
- More capacity will only run for short periods per year
  - Greater need for remuneration than in a market without wind

# Implications

- Demand response can mitigate market power and reduce capacity needs
- Year-to-year wind variations do affect prices and profits, but not as much as fuel prices – an area for further work!