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Market Behaviour with Large Amounts of Intermittent Generation

(preliminary – please do not quote without permission)

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Background and motivation

- EU renewables target by 2020: 20%
- For UK:
  - 15% renewable energy
  - c. 40% renewable electricity…
  - …great part of which is likely to be wind.
- Impact on market prices? profits? risks?
- Precursor to a study of investment…

Literature overview

- Sinden (2007) assesses patterns of winds and potential outputs, using **average correlations**.
- Elders et al (2008) suggest alternative scenarios for the amount of thermal plant in GB and overall level of demand.
- Optimal level of investment in wind: Strbac et al (2007), Kabouris and Vournas (2004), Neuhoff et al (2008).
- Market power: Twomey and Neuhoff (2005)
  - Wind generators receive less than average price of power
  - Market power exacerbates the inverse relationship between price and wind generation
  - Long term contracts may partly alleviate this effect

Data & Methodology

- Two components: theoretical model (based on Green, 2008; Yago et al, 2007) enhanced by actual hourly wind data for representative stations across GB.
- Hourly wind speeds drawn from Midas UKMO 1990-2005, which are then converted to output using standard conversion rules.
- Our dataset currently contains 15-17 stations, with at least one from each of the nine geographic wind regions as defined by BWEA.
- Earlier work confirms low wind speed correlations between selected regions.

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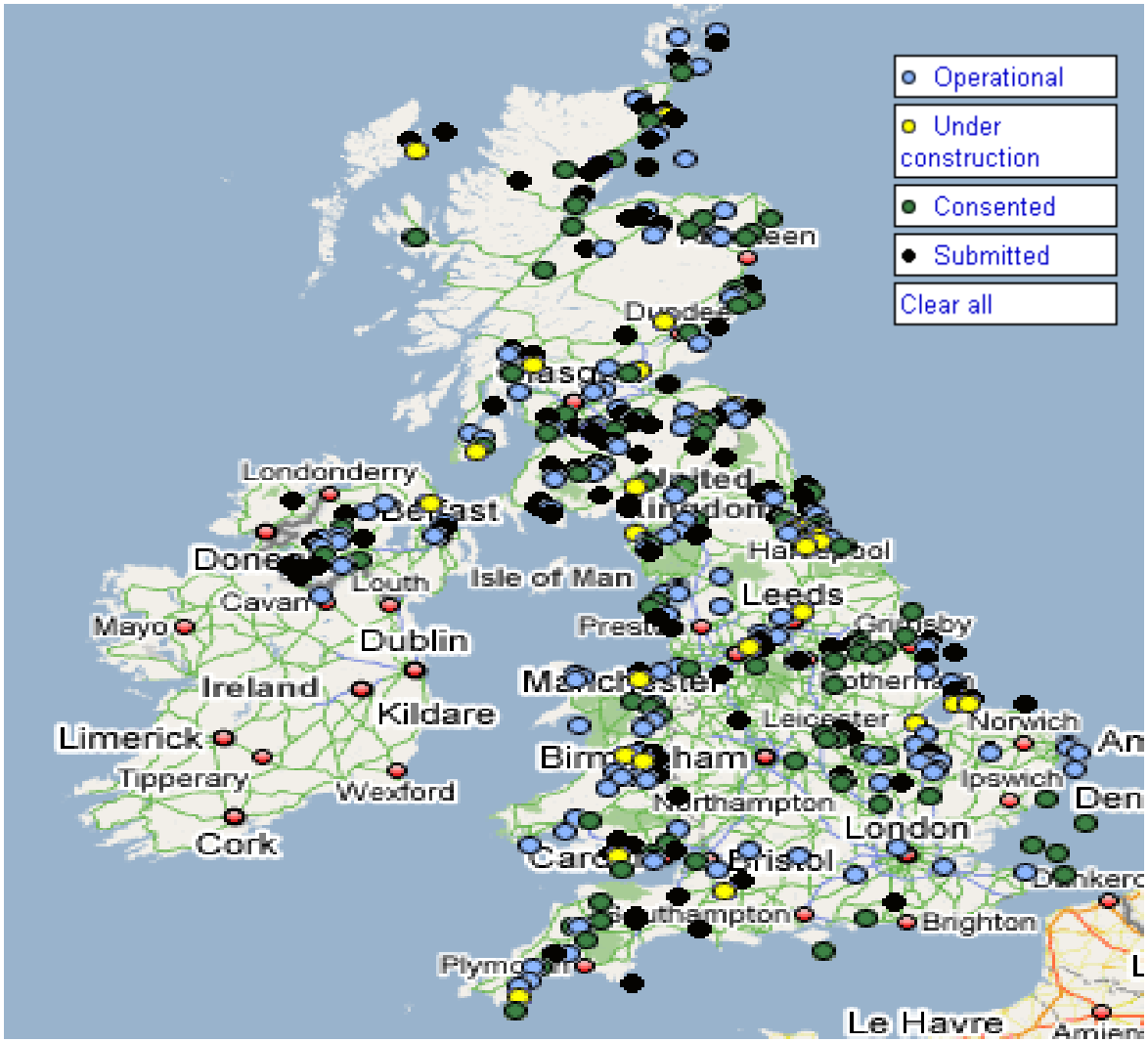
Wind capacity in the UK (MW)

	S Eng.	N Eng.	Wales	S Scot.	N Scot.	Offshore
Existing	237	166	305	642	525	404
Constructing	49	114	16	535	117	457
Consented	356	376	143	928	546	2270
Application	314	634	299	2566	1528	2385
Total wind	956	1290	763	4671	2717	2740

Onshore	10396	Total	19152

Source: British Wind Energy Association

Wind farms in the UK (BWEA)



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Selected wind stations

The Model - General

- Based on Green (2008) and Yago et al (2007).
- Symmetric generators compete in supply functions, offering a schedule of prices and quantities to the market.
- Nuclear stations treated as non-strategic
- Industry cost function based on data from “2006 Energy Review” (DTI, 2006) – by type of plant.
- Start-up costs are currently not included.

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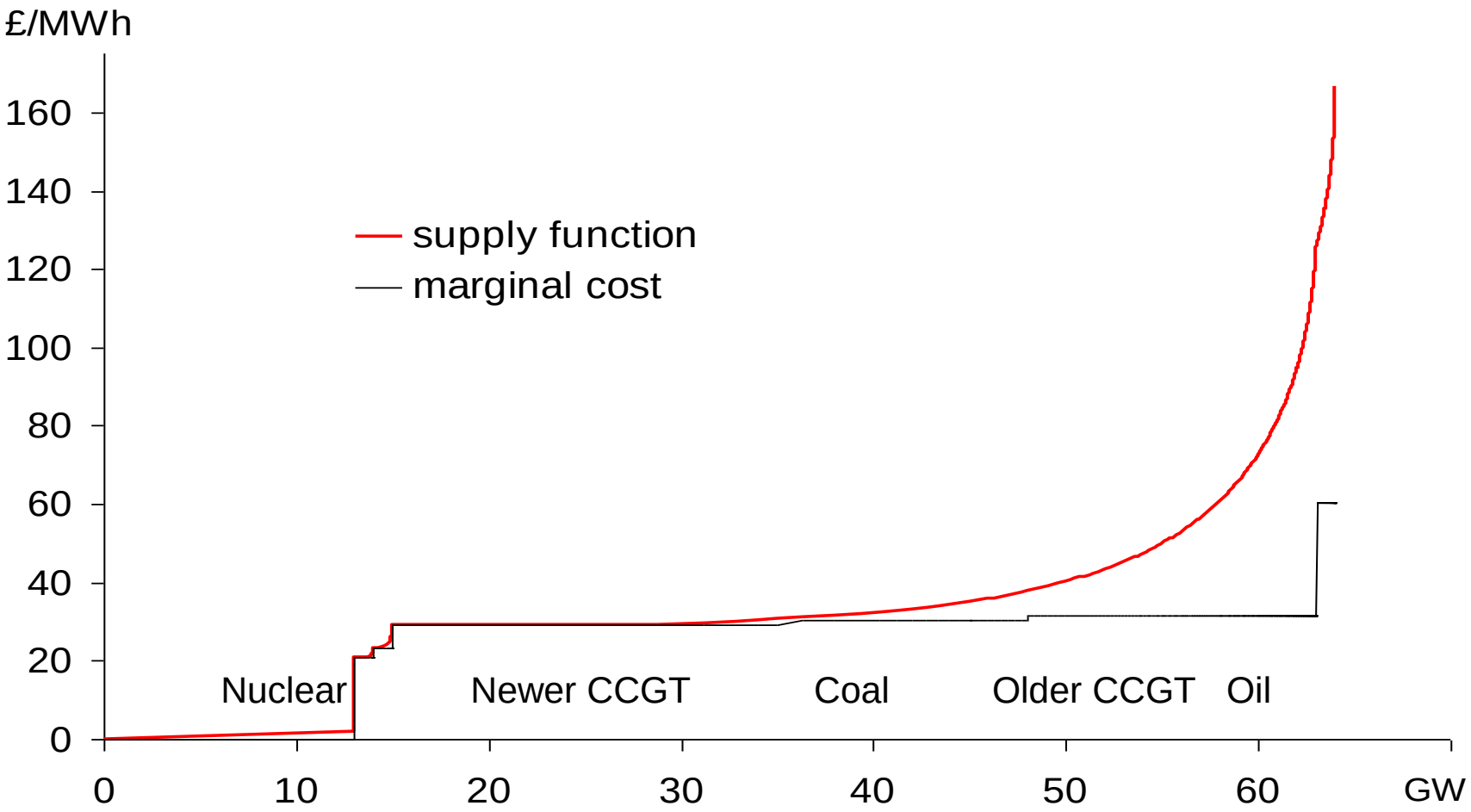
Industry supply function - thermal power



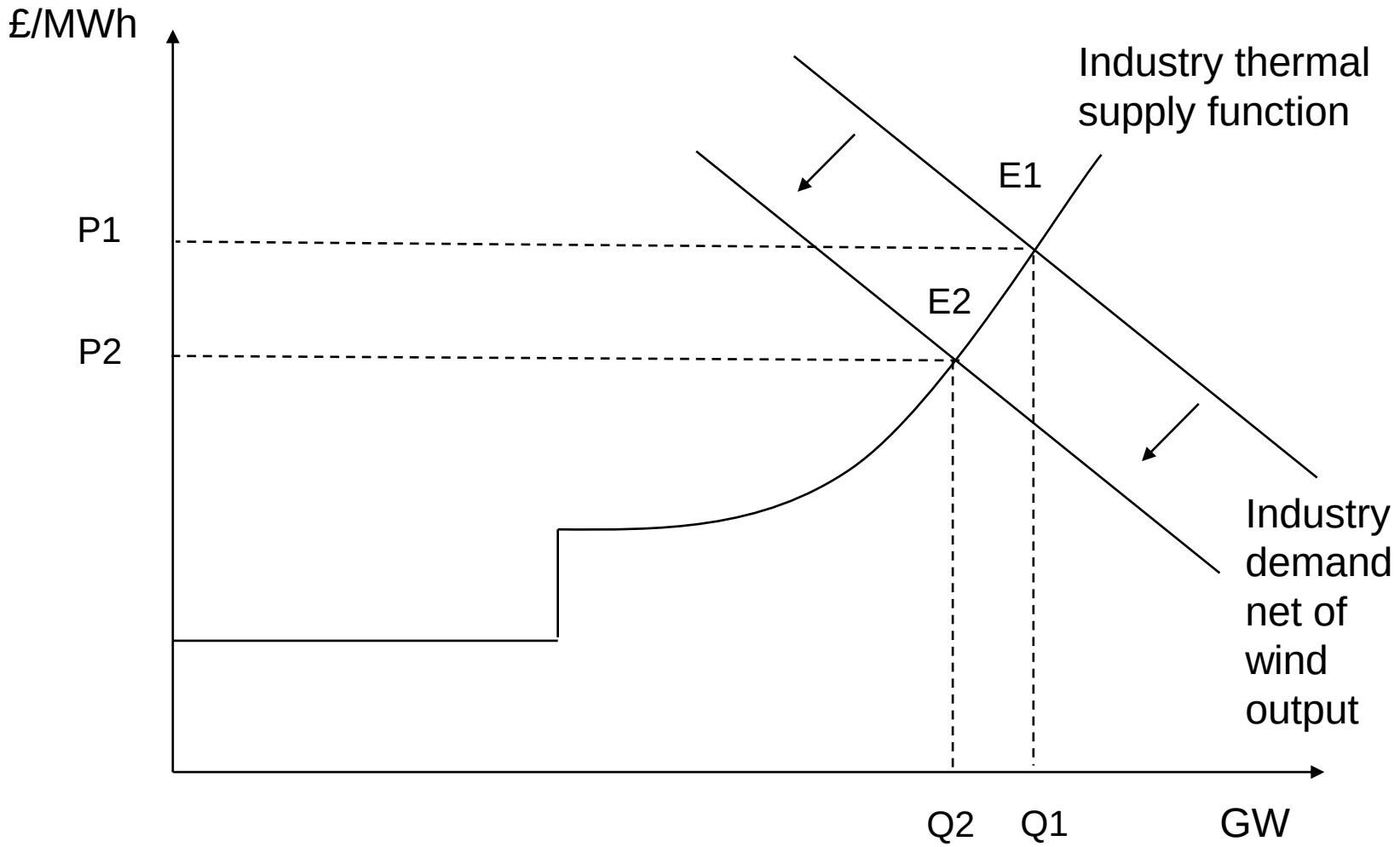
Renewable output

- Generation profiles for dispatchable renewable stations
- Wind output based on wind speed cubed
- Sample station output multiplied by regional capacity
- Offshore output based on national onshore output
- Profile for every January day 1990-2005

The Model – Equilibrium

- (Hourly) Equilibrium prices determined by intersecting:
  - Thermal supply curves
  - Demand curves, net of renewable output:
    - Demands scaled up from average weekday demands and prices during January 2004
    - Assumed demand growth of 1.1% a year to 2020.
    - Linear demand slope of -80MWh per £/MWh
- Market power: two scenarios are currently considered; equivalent to 2 and 6 firms

Deriving market equilibrium



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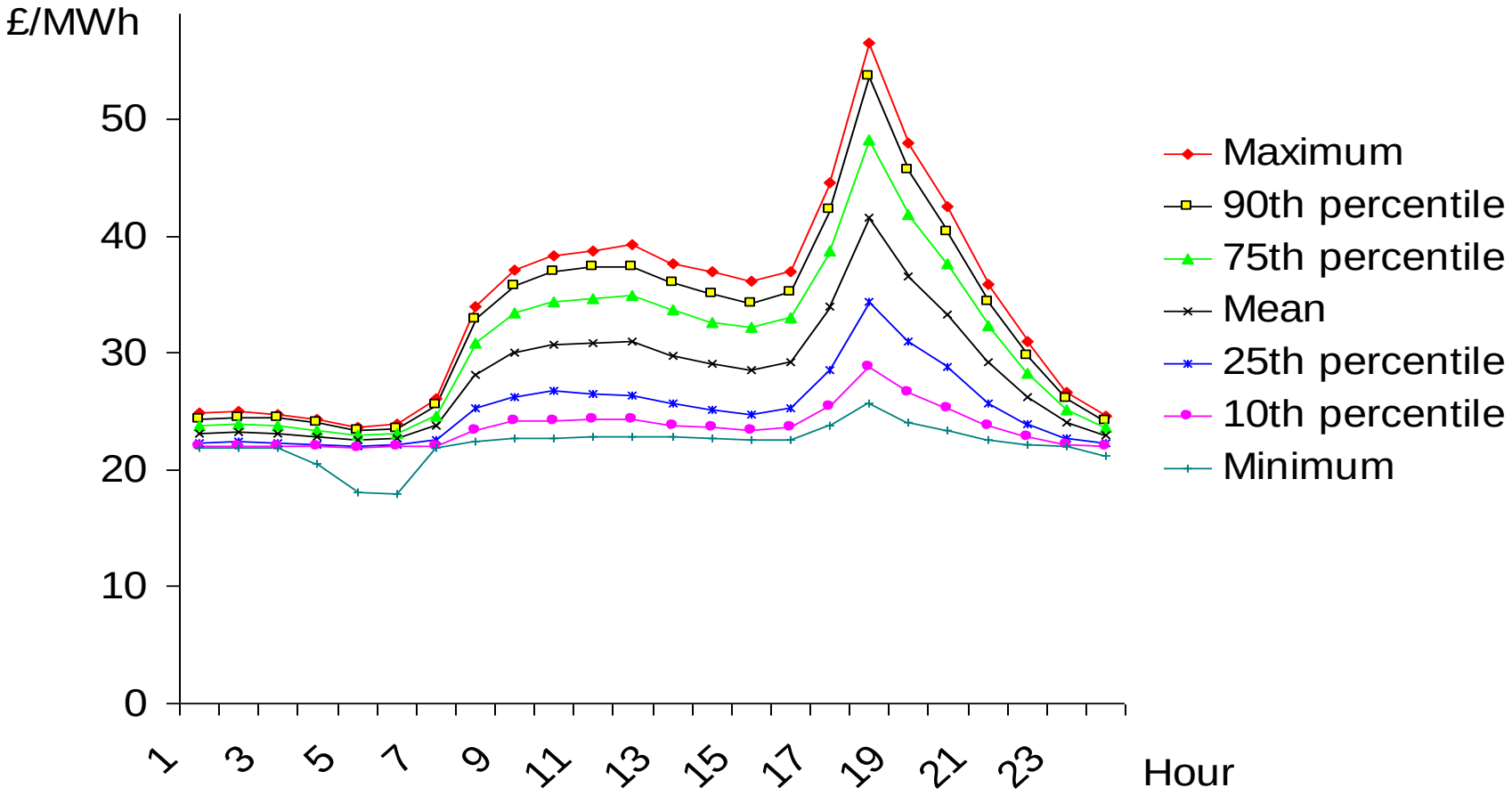
Price variation due to wind - 6 strategic firms



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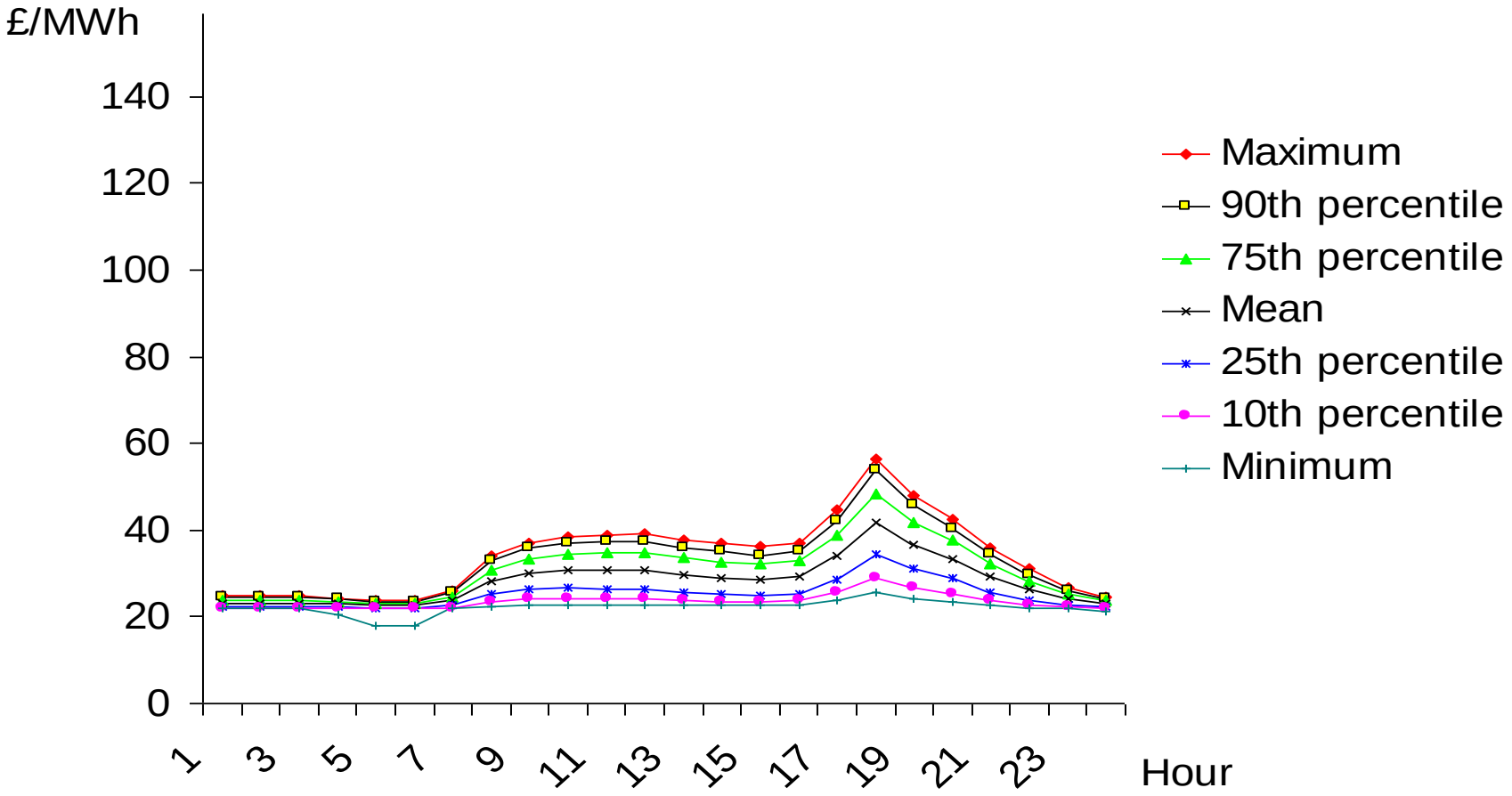

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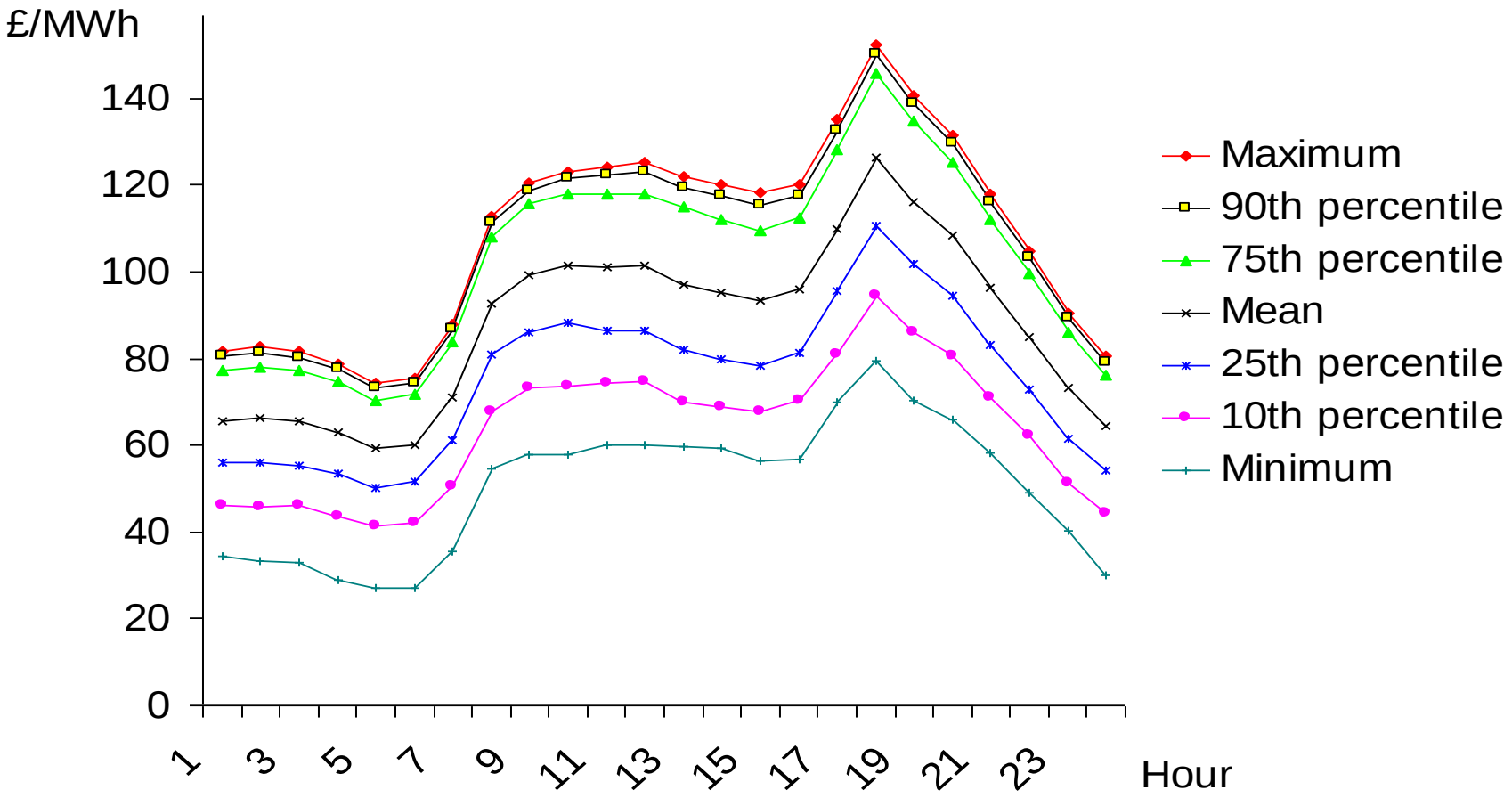
Price variation due to wind - 2 strategic firms



Do hourly variations matter?

- Generators make long-term investment decisions
- Will short-term variability deter them?
- Calculate monthly revenues for each year of wind observations
  - Assumes demand pattern repeated every day

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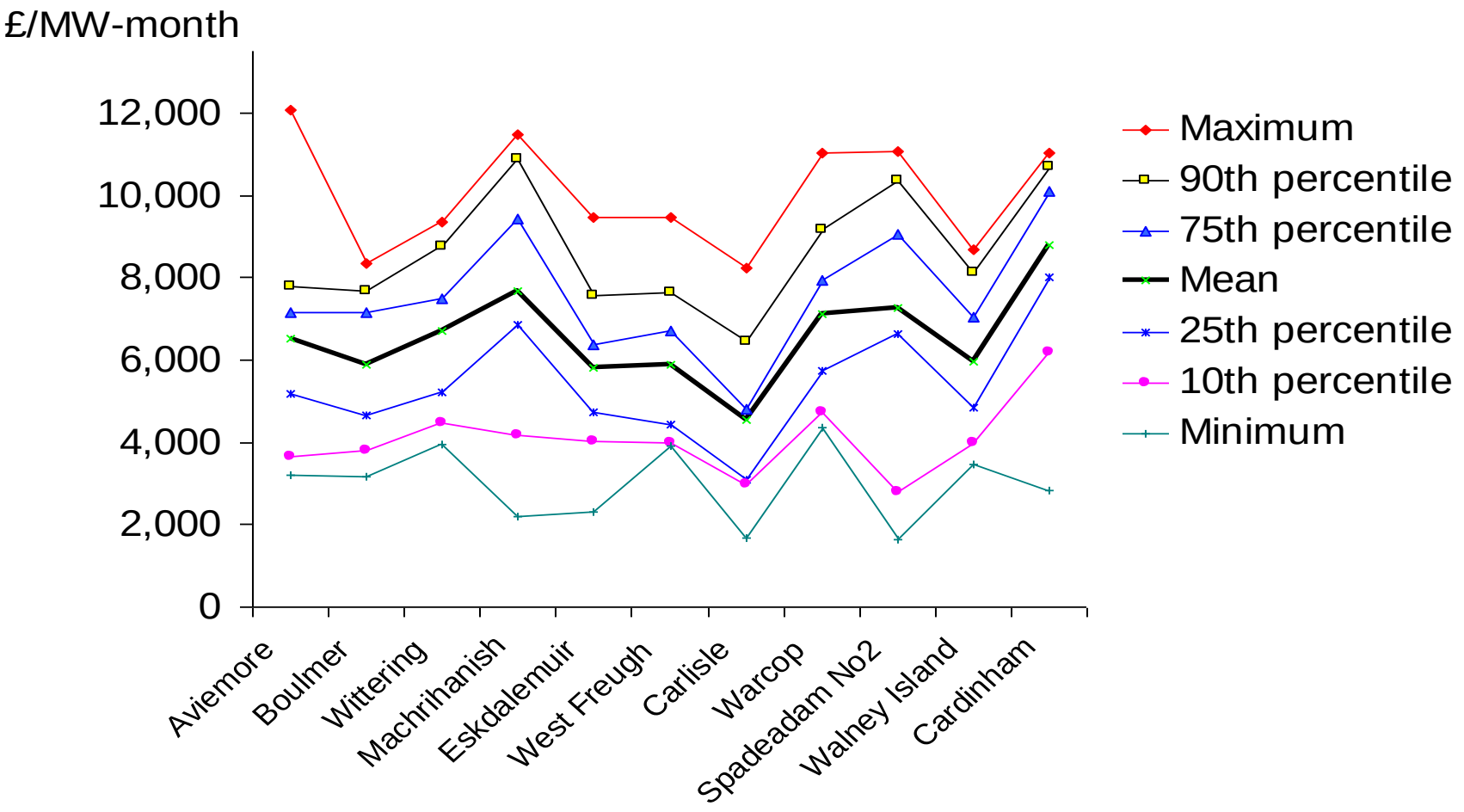
Revenue variation due to wind - 6 strategic firms



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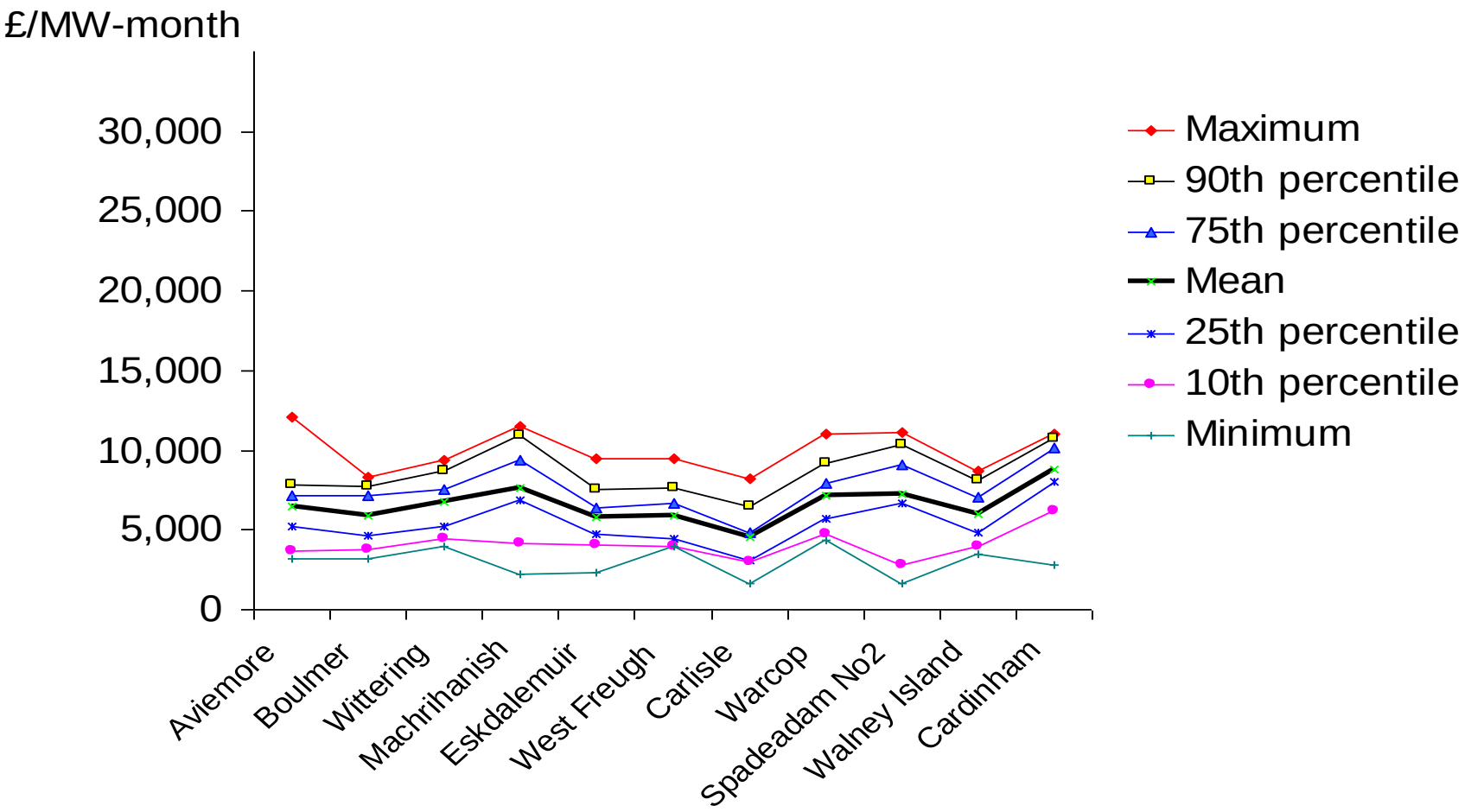
Revenue variation due to wind - 6 strategic firms



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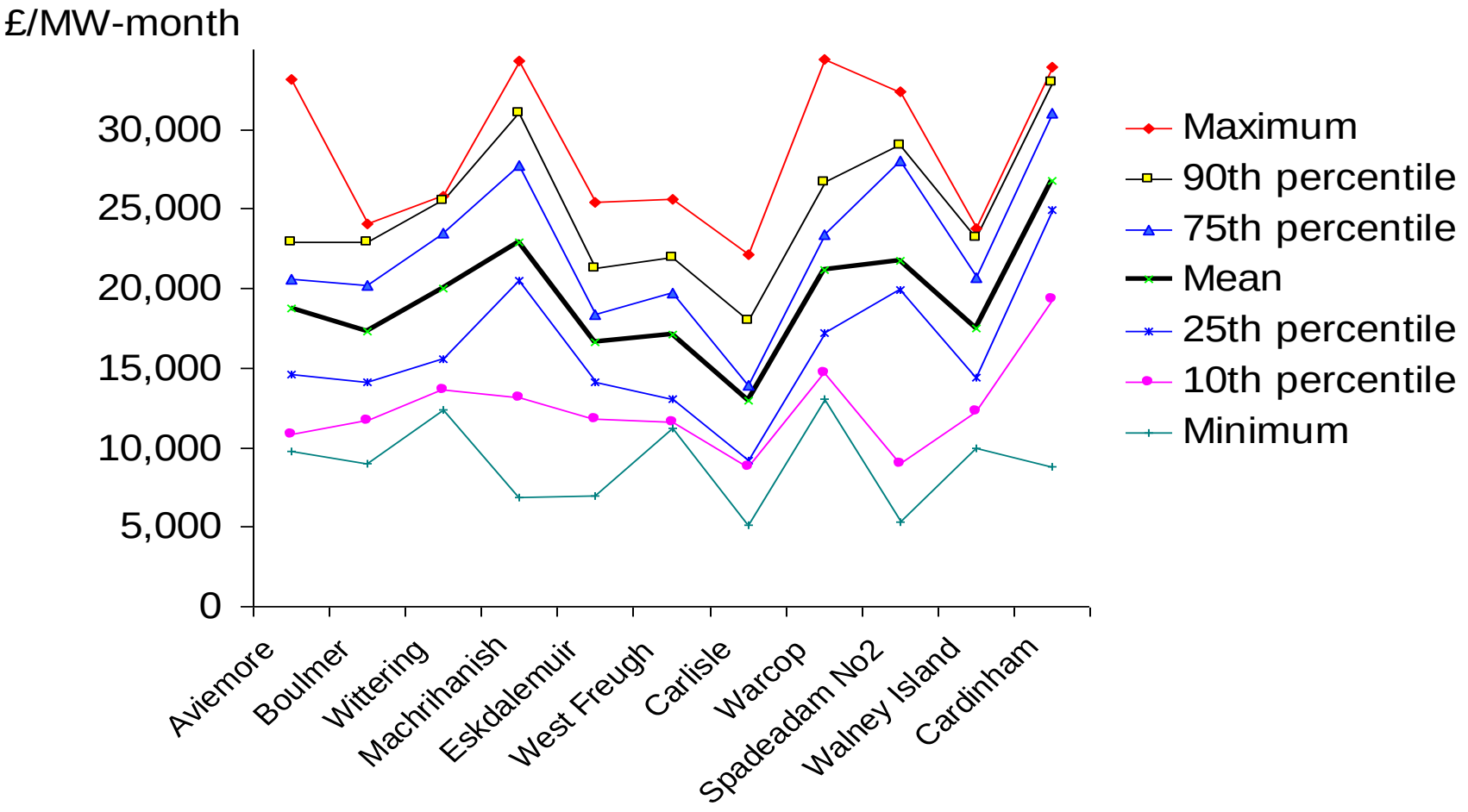
Revenue variation due to wind - 2 strategic firms



Conclusions and future plans

- Prices in January are highly variable
- So are monthly revenues
- Need to extend to other months
- Further work:
  - Optimal wind dispersion – trade-off between wind speed and correlation?
  - Consider cost-based thermal models
  - Implications for investment