Electricity Policy
Research Group

UNIVERSITY OF CAMBRIDGE

SUPERGEN

Wind Power and Market Power in Electricity Markets

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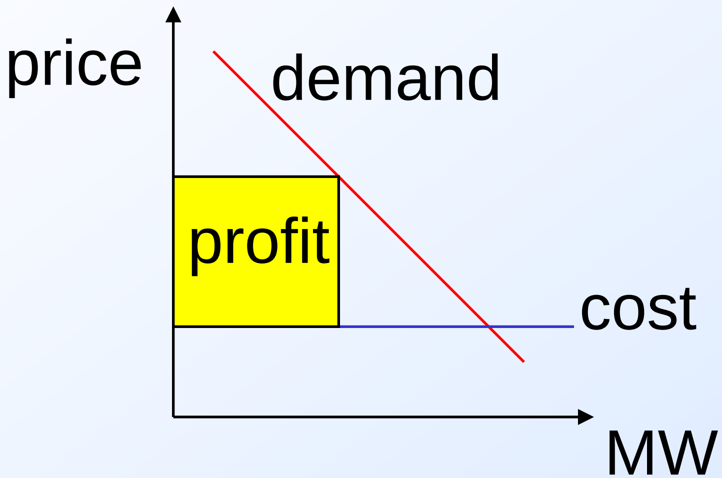
Outline

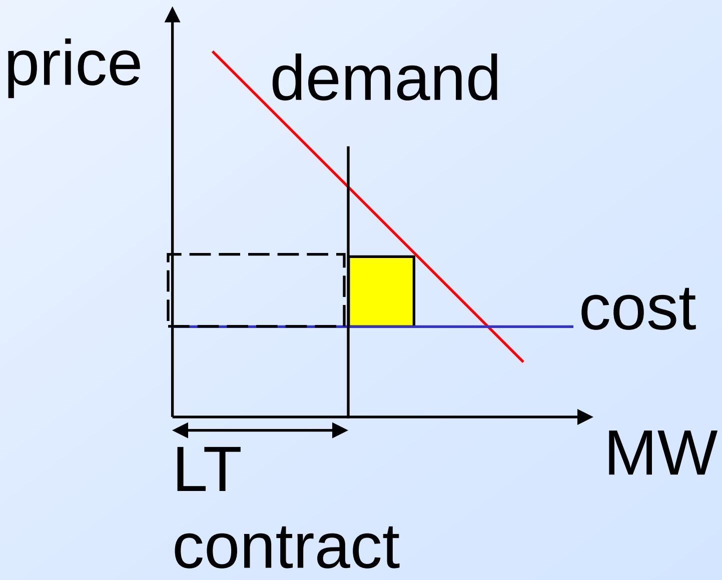
- LT contracts mitigate market power in spot markets
- LT contracting infeasible for unpredictable output
- Electricity – impact of volatility
  - Competitive case
  - Strategic case with LT contracts
- Numerical results
  - Monopoly
  - Duopoly
  - Forward contracting
  - Option contracting
  - Sensitivities

Long-term contracting – standard solution for MP

Reduces spot market volume q_s

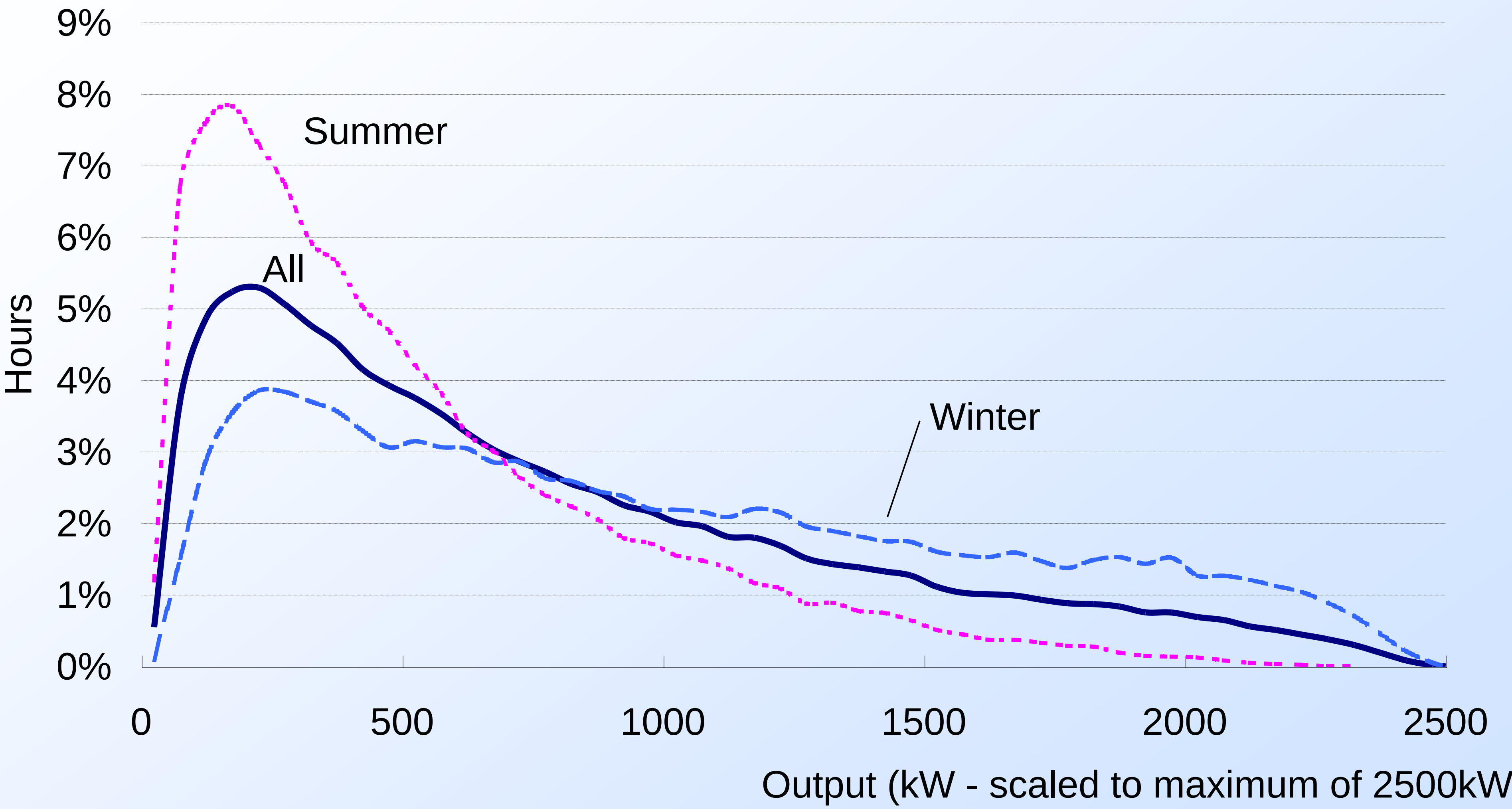
- Increases demand elasticity $\frac{dq_s}{dp_s}\frac{p_s}{q_s}$
- Reduces exercise of market power





Ref: Allaz and Villa 1993

Long-term contracting not possible for wind



Competitive case – how are revenues affected

- Demand

$$p = D_0 - bD_T$$

- Generation costs

$$C_g(Q_g) = \alpha Q_g + \frac{\beta}{2} Q_g^2$$

- Competitive price

$$p = D_0 - b(Q_g + Q_{w,0} + \varepsilon_w) = MC_g = \alpha + \beta Q_g$$

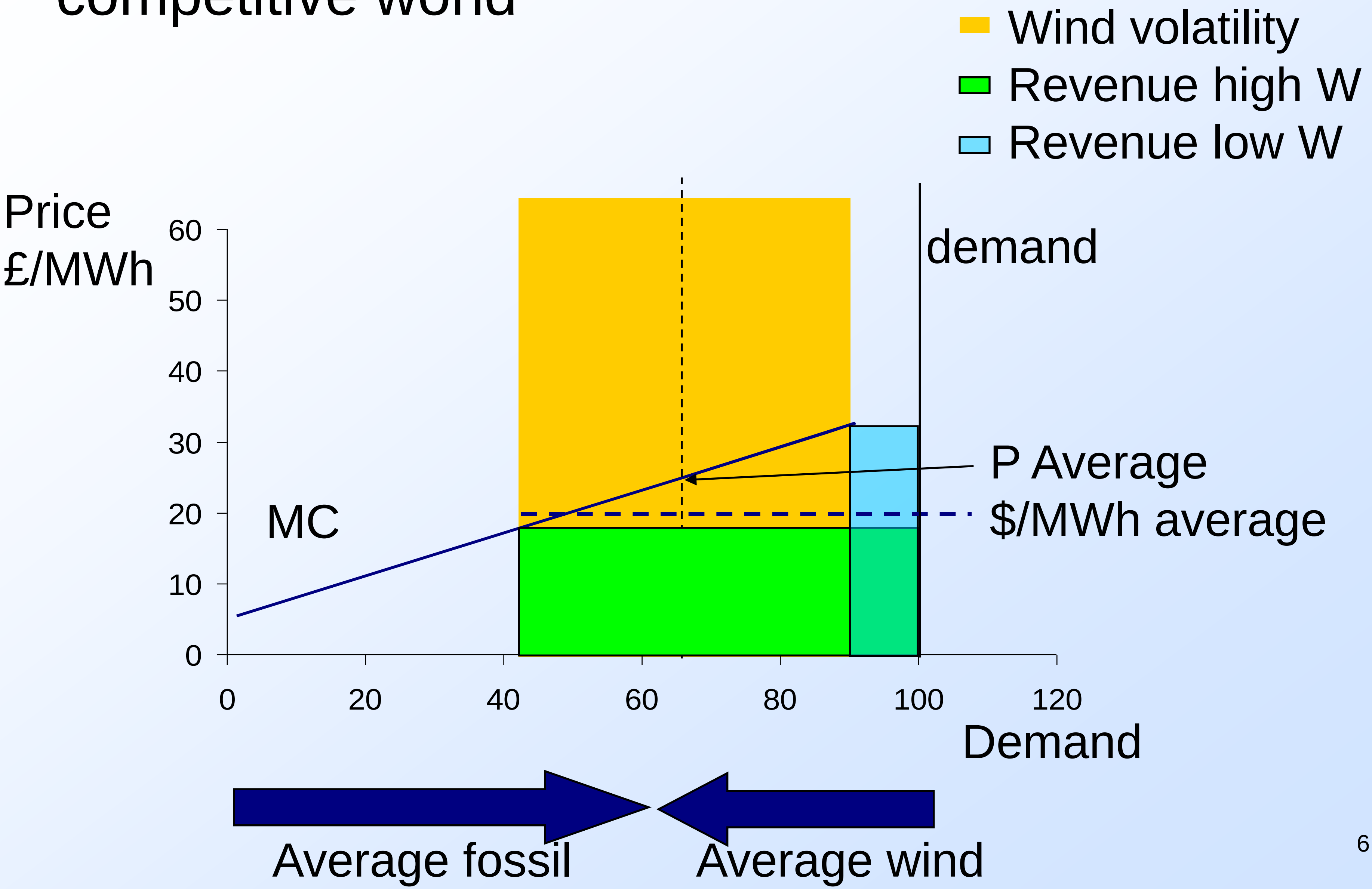
- Equilibrium output conventional (competitive)

$$Q_g = \frac{D_0 - b(Q_{w,0} + \varepsilon_w) - \alpha}{b+\beta}, \quad p = \frac{\beta(D_0 - b(Q_{w,0} + \varepsilon_w)) + b\alpha}{b+\beta}$$

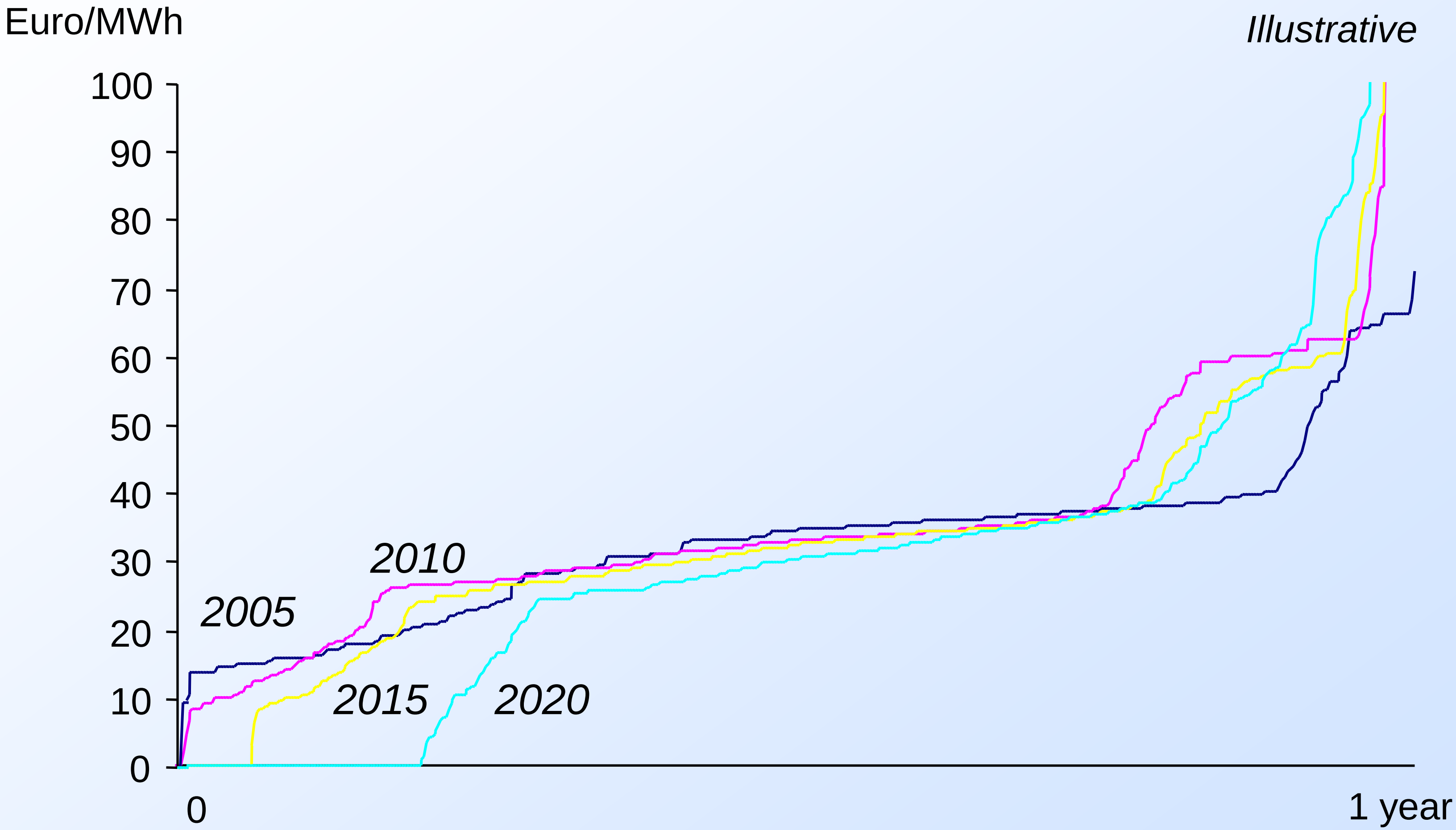
- Equilibrium profit wind

$$E[\pi_w] = E[p(Q_{w,0} + \varepsilon_w)] = p_c^* Q_{w,0} - \frac{b\beta}{b+\beta} \sigma_w^2$$

Output volatility decreases wind revenue competitive world



Price response should achieve optimal market solution



Strategic output choice – what changes?

- Monopolist's profit function

$$\pi_g = p(Q_g - L_g) + zL_g - C(Q_g)$$

$$= (D_0 - b(Q_g + Q_{w,0} + \varepsilon_w))(Q_g - L_g) + zL_g - \alpha Q_g - \frac{\beta}{2}Q_g^2$$

- FOC for optimal output choice

$$Q_g = \frac{D_0 - bQ_{w,0} + bL_g - \alpha - b\varepsilon_w}{2b+\beta}$$

- Implies the following expected profits

$$E[\pi_w] = p_m^* Q_{w,0} - \frac{b(b+\beta)}{2b+\beta}\sigma_w^2$$

- Compared to competitive case

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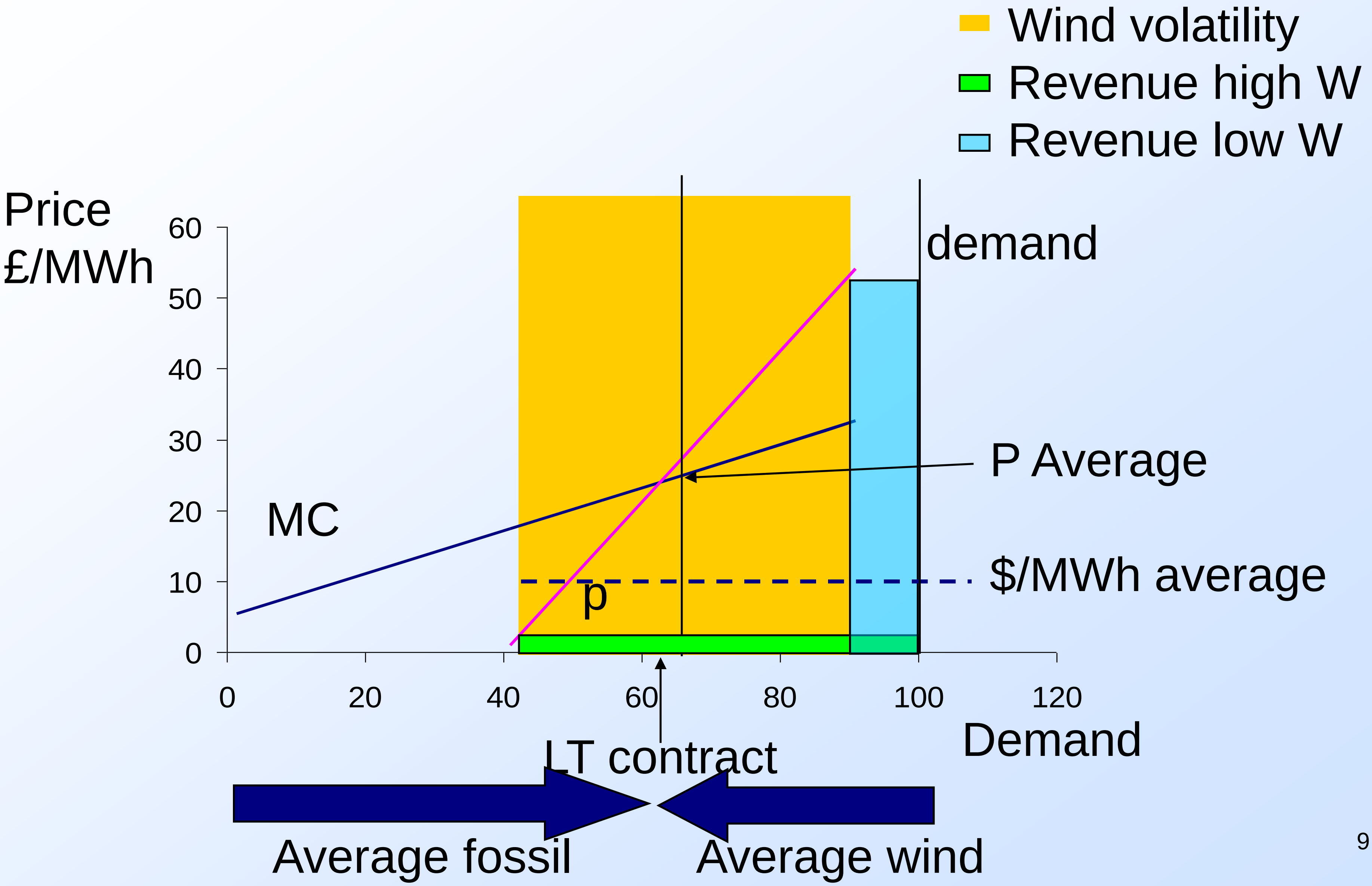
$$E[\pi_w] = p_c^* Q_{w,0} - \frac{b\beta}{b+\beta}\sigma_w^2$$

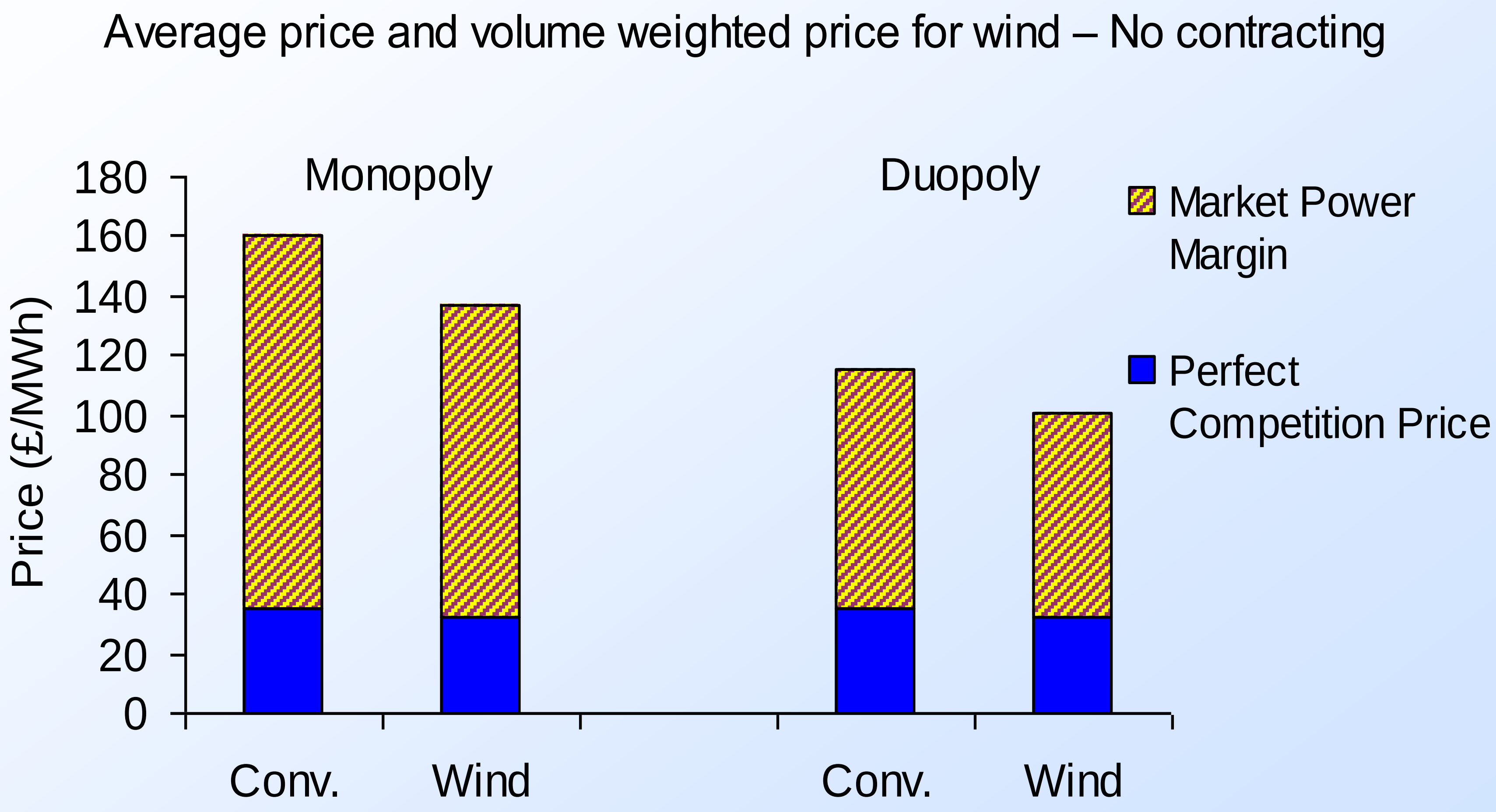
But MP of conventional G amplifies effect



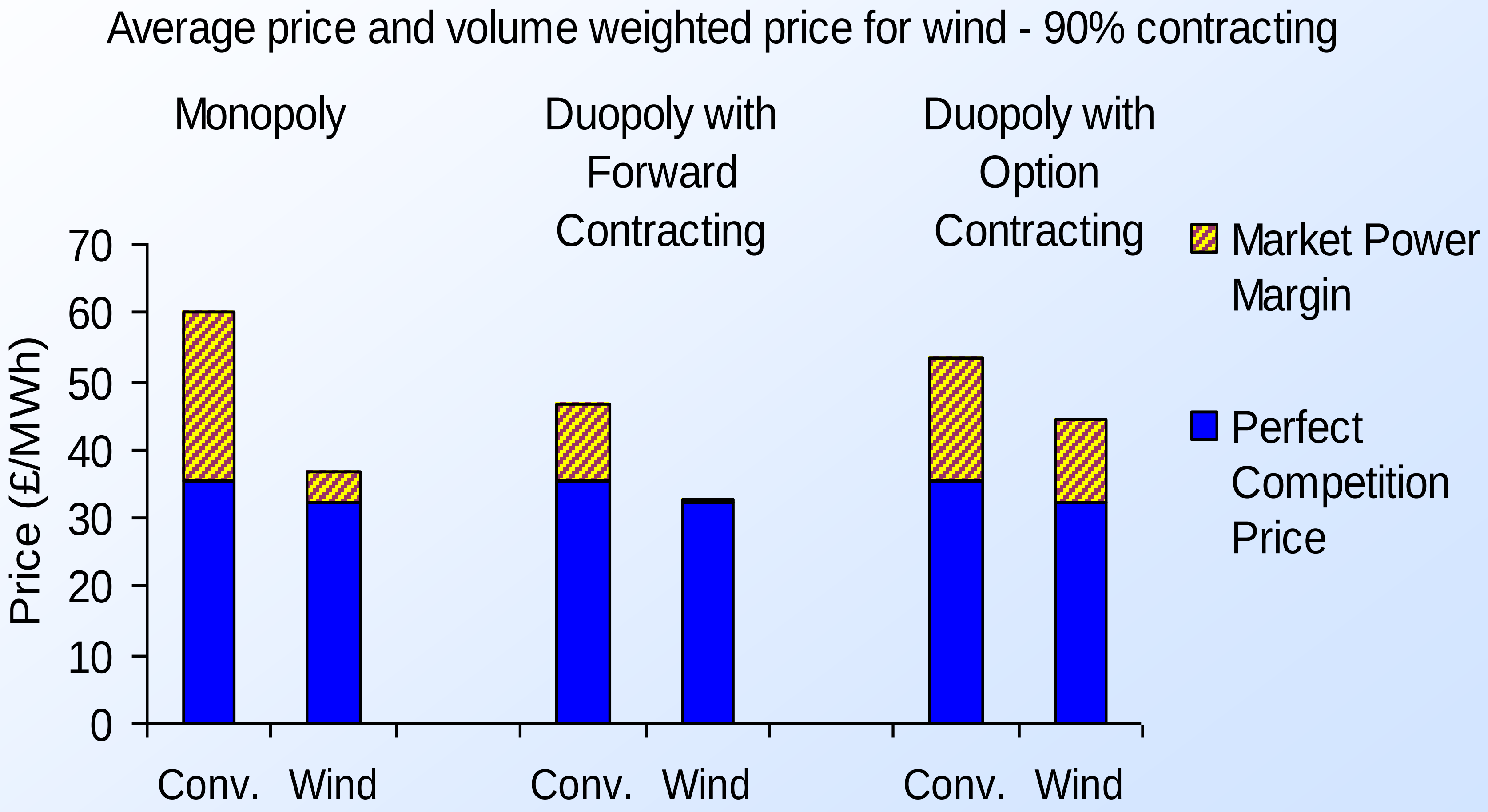
Numerical Model Baseline Assumptions

- Demand Elasticity: 0.1
- Wind share of total output: 30%
- Variance of wind: 0-60% output share on uniform distribution

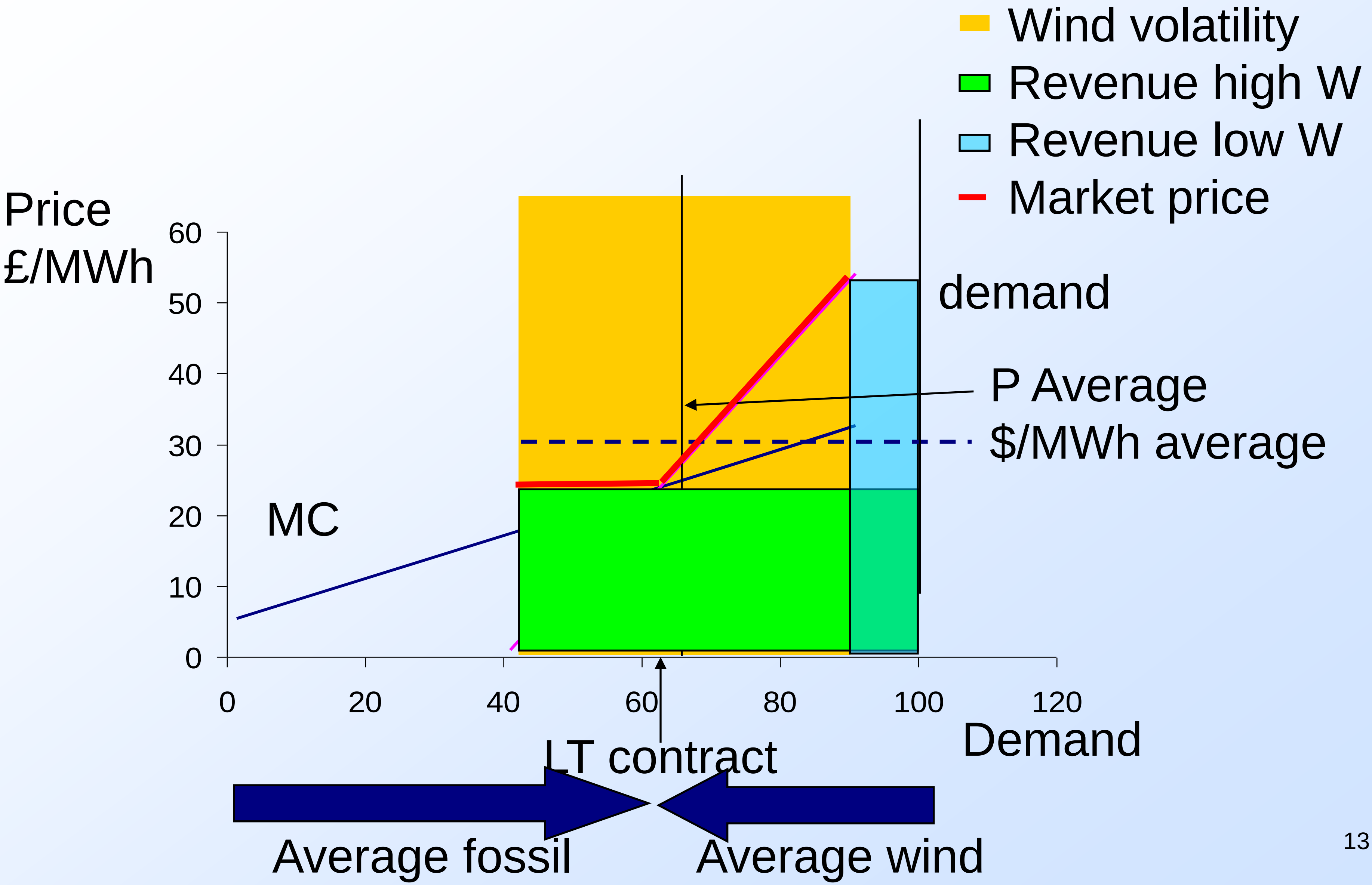
Wind has a large market power markup but proportionately less than conventional generator(s)



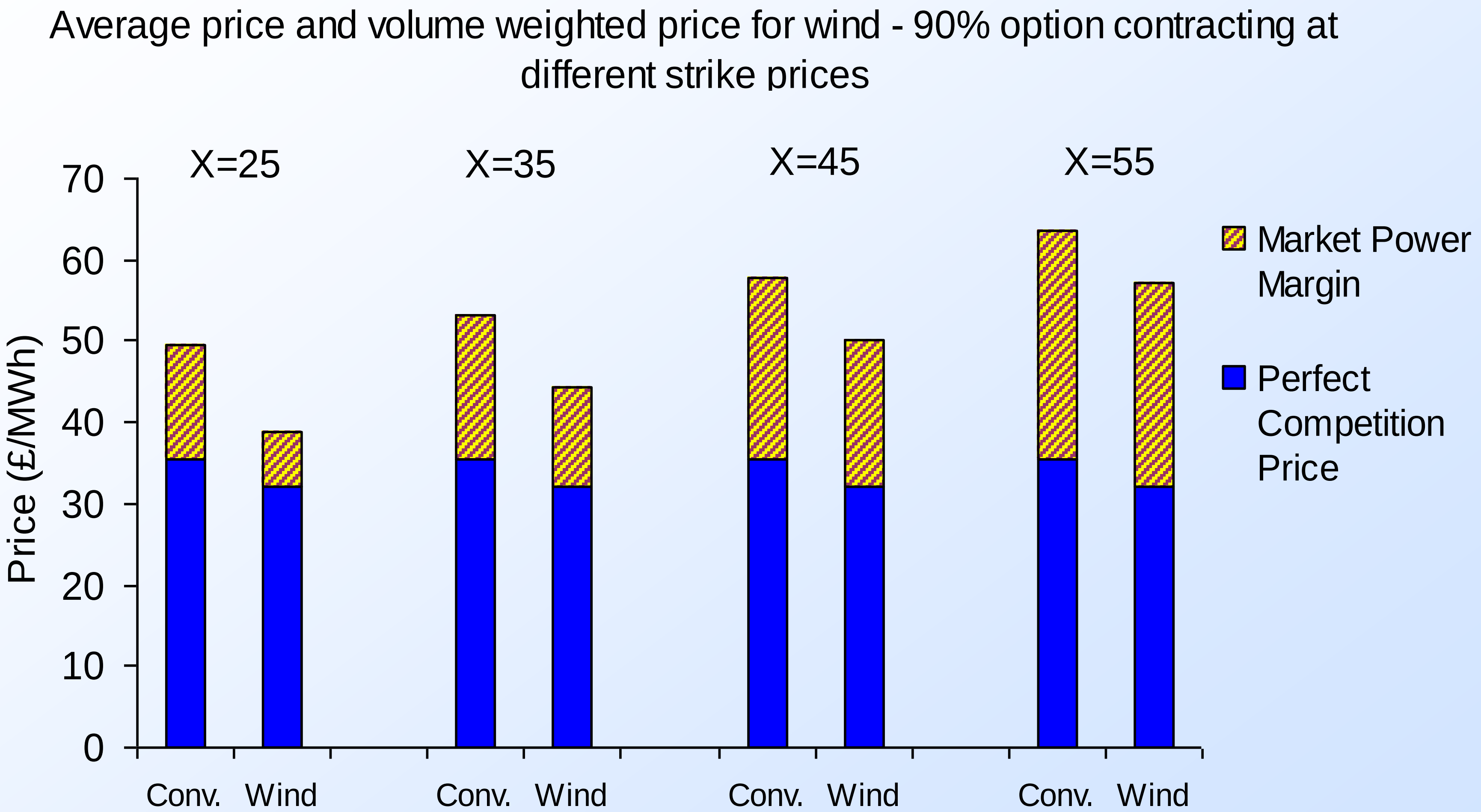
With contracting, the markups for conventional and wind are smaller but size of intermittency effect remains the same
→ Relative bias against wind is exaggerated



The role of option contracts

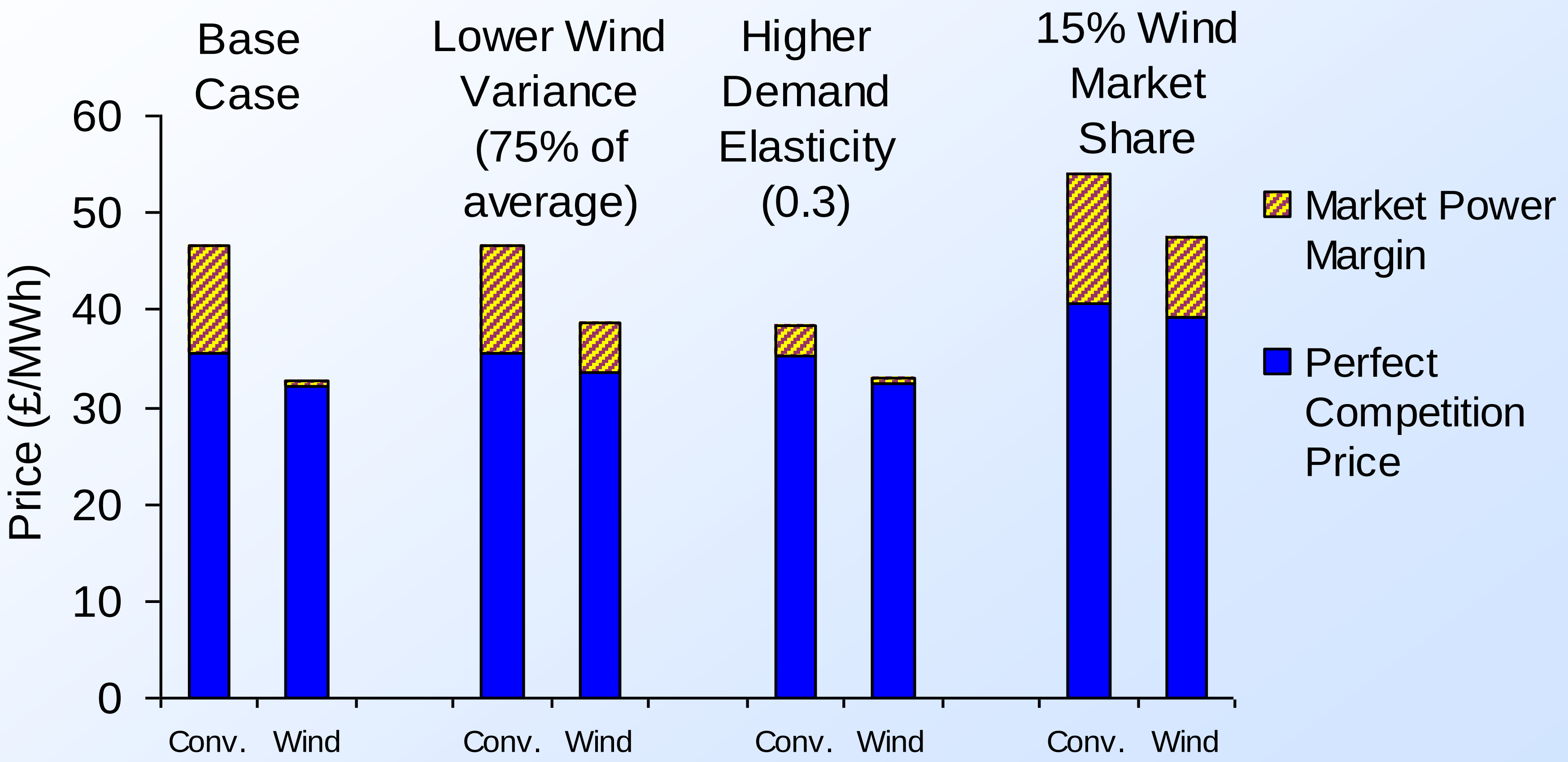


Higher strike prices reduces market power mitigation but also reduces relative bias against wind



- **Lower wind variance → Smaller bias against wind**
- **Higher demand elasticity → Smaller markups and smaller bias**
- **Smaller wind market share → Larger markups and smaller bias**

Average price and volume weighted price for wind – different scenarios



Intertemporal constraints influence price formation

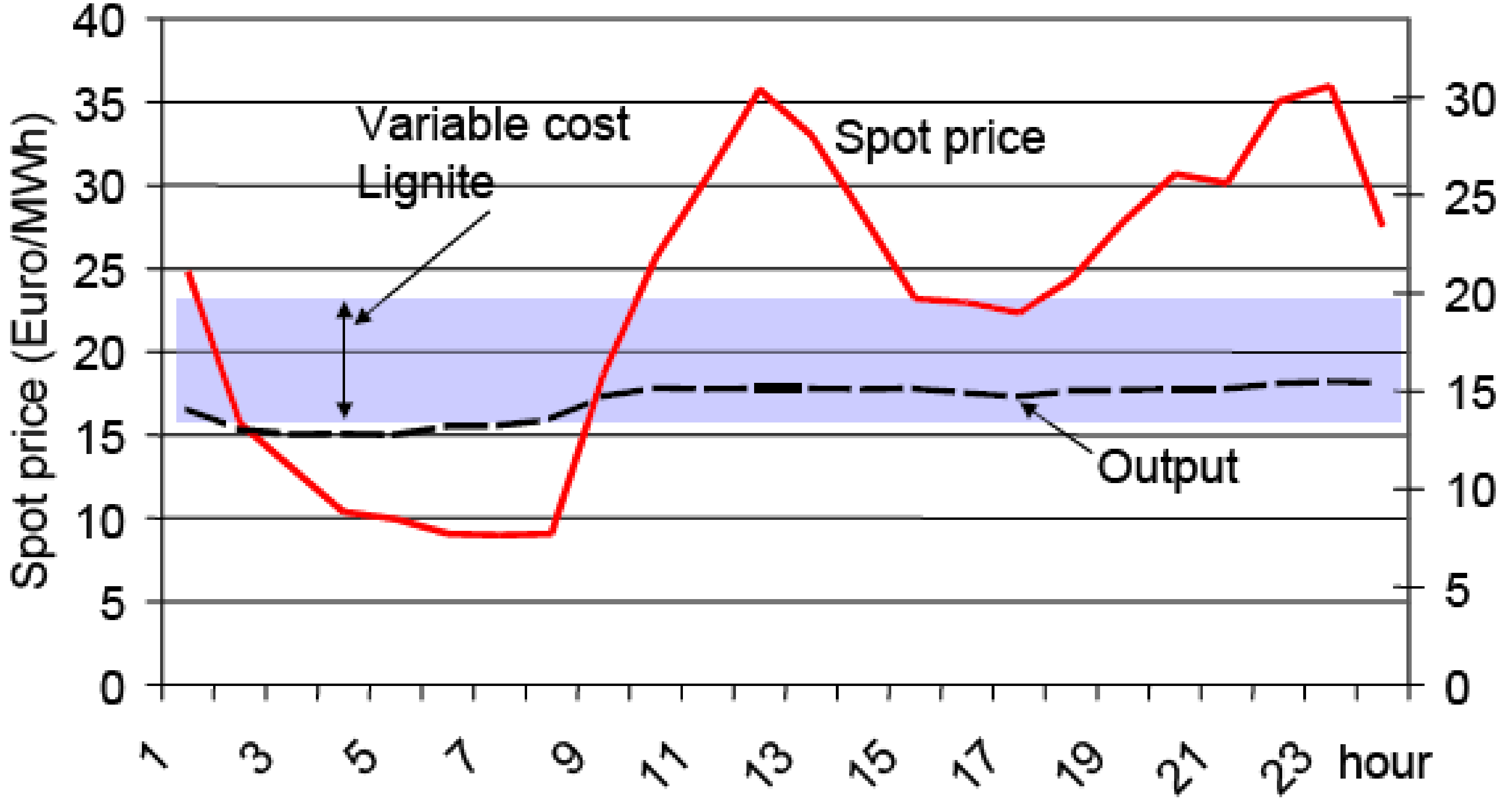
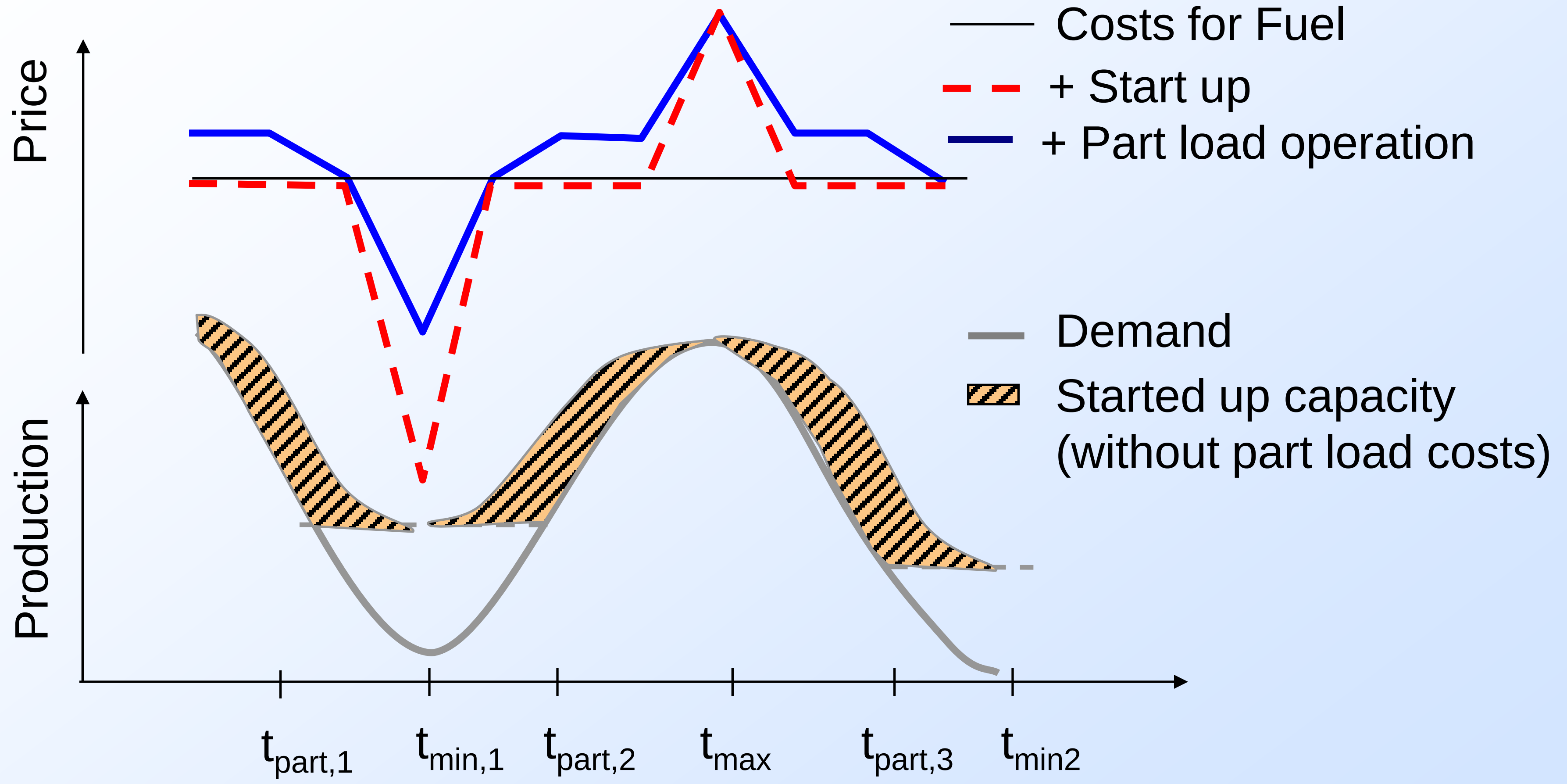


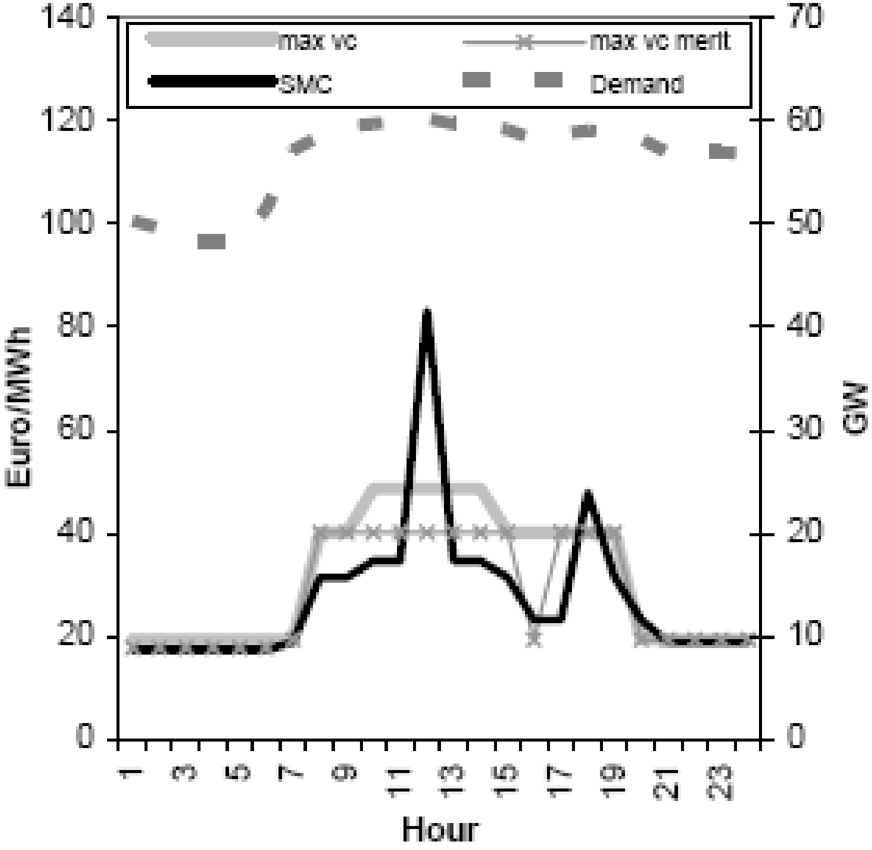
Figure 1 Spot power prices, variable cost and production of lignite, Germany 14.5.2006

Müsgens, F. and Neuhoff, K., 2006, Modelling Dynamic Constraints in Electricity Markets and the Costs of Uncertain Wind Output, EPRG Working Paper 05/14

Energy prices with inter-temporal constraints



Simulation results - deterministic



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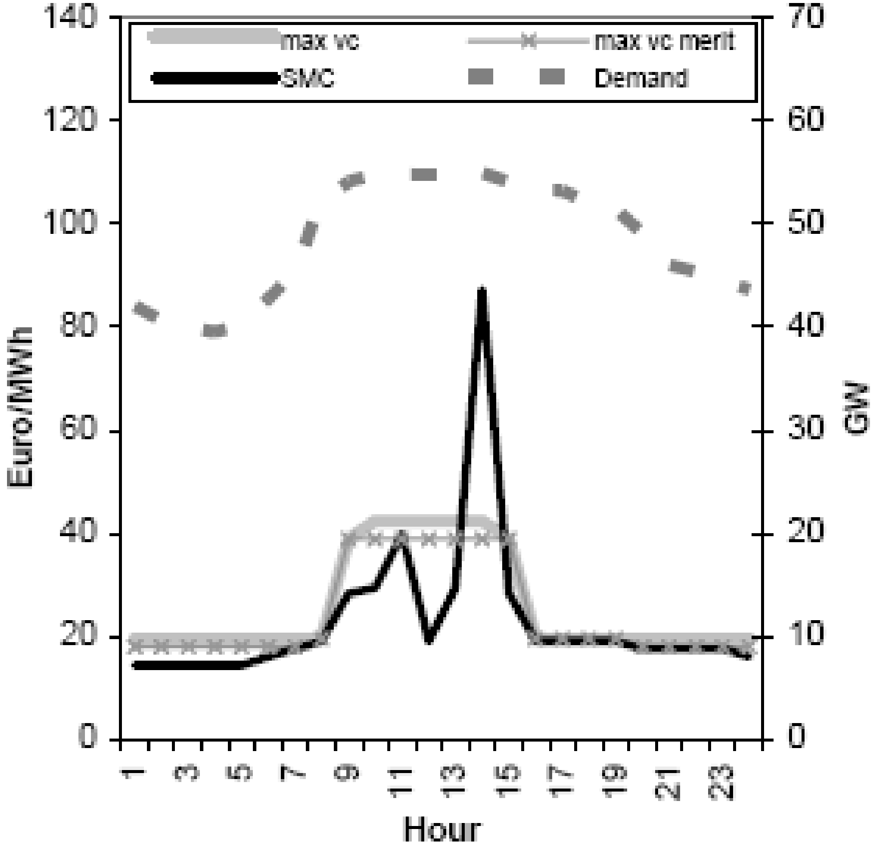

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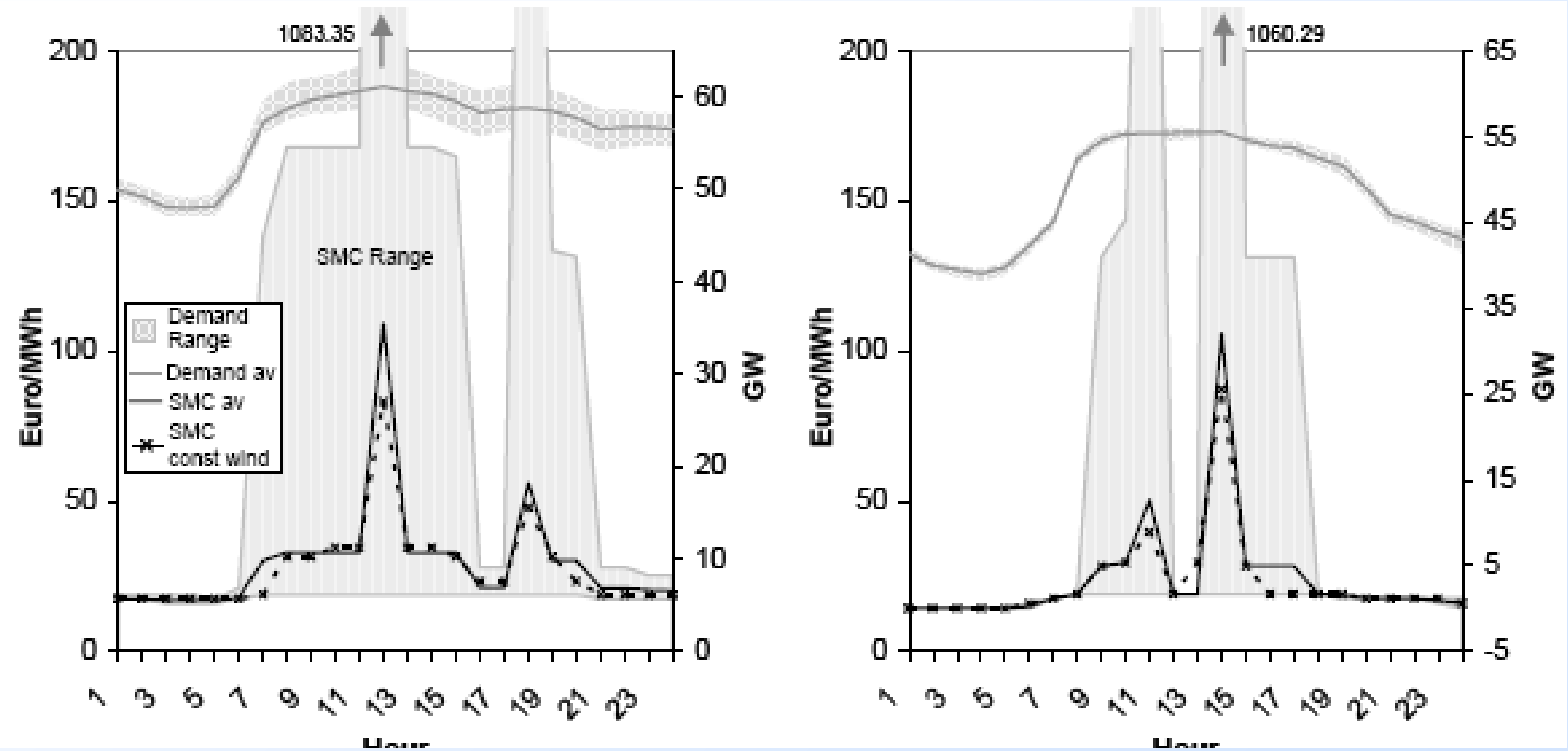
Simulation results – uncertainty and spot price



January *July*

Conclusions

- Technological bias → Intermittent generation benefits less from market power than conventional generation.
- Long-term contracting helps mitigate market power but actually exaggerates bias against intermittent generation.
- Options contracting results in less bias against intermittent generation.
- Possible policy implications:
  - Encourage or enforce more option contracting.
  - More stringent market power monitoring and mitigation.