# *Should coal replace coal? Electricity in Ireland post 2025*

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# *Motivation*

- *By 2025 Ireland will need to replace its large coal plant in Moneypoint*
- *Power stations take a long time to build and last for a long time.*

- *2008 All Ireland fuel mix:*
  - *~60% natural gas*
  - *~20% coal*
  - *~7% peat*
  - *~6% wind*

# *Goals*

- *What is the cheapest option?*
- *What happens when fuel and carbon permit prices vary?*
- *How do the different plant options interact with the increasing amount of wind in the All-Ireland electricity market?*
- *Are there issues of security of supply?*

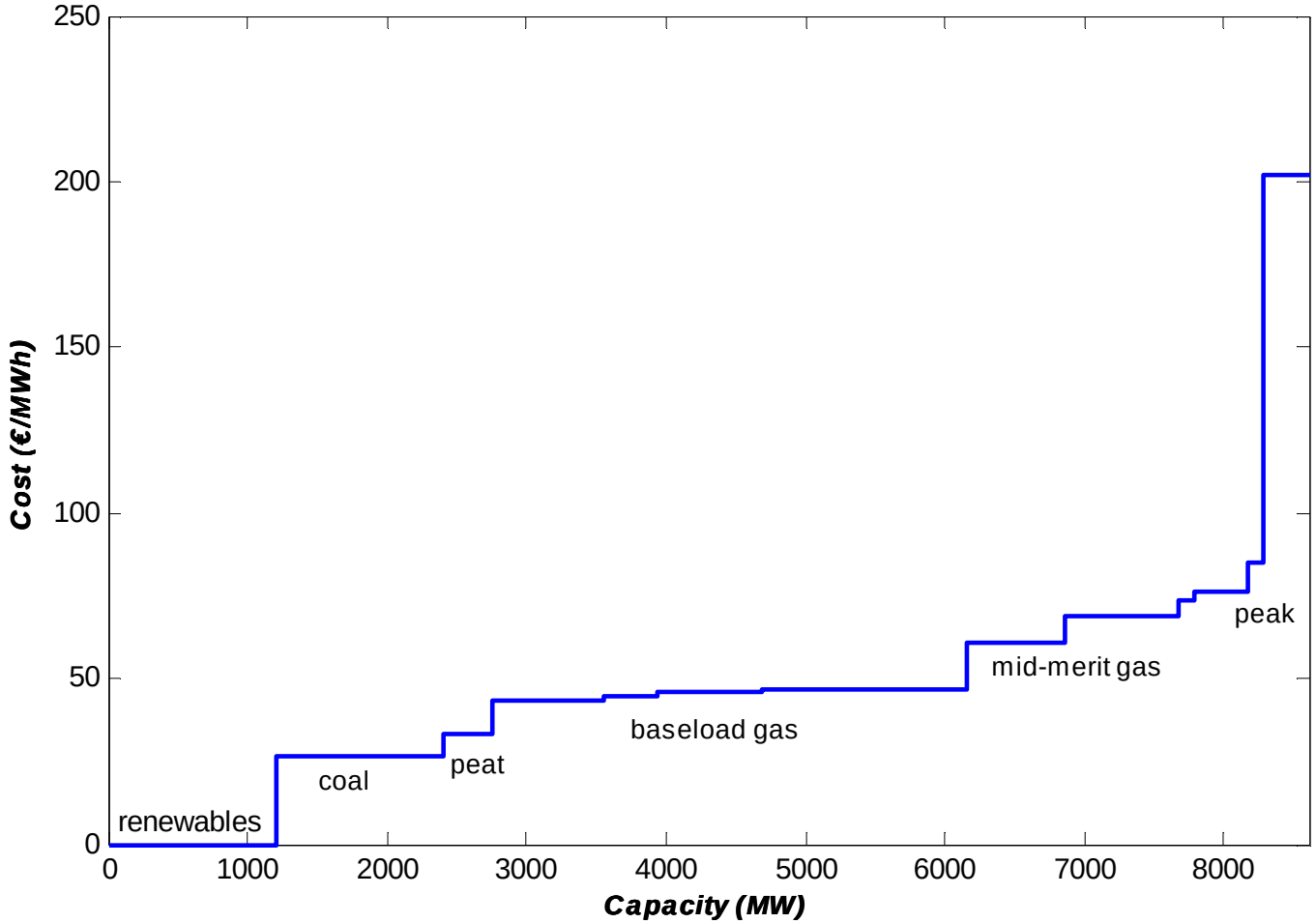
# *Living in an uncertain world*

- *In past year high fuel volatility*
  - *Oil $160/barrel July 2008*
  - *Oil $32/barrel January 2009*
  - *(natural gas prices follow)*
- *High carbon permit price volatility*
  - *Basically 0 at the end of the first round of ETS (end of 2007)*
  - *Maximum around €30/tonne*

# *Single Electricity Market (SEM)*

- *All Island Market in operation since November 2007*
- *Bid energy costs into mandatory pool*
- *All required generators receive the bid price of the marginal station.*
- *Capacity payments mechanism – Provide incentives for investment*
- *Subject to EU ETS carbon permit price.*
- *Supply and demand, must always match, storage is expensive.*

# *Optimal dispatch model, each ½ hour*
# *All-Ireland merit order, end of 2007*



# *Key assumptions*

- *No transmission constraints within systems*
- *No ramping costs for thermal plants*
  - *Wind is curtailed to keep baseload plants running at minimum efficient capacity*
- *Optimal use of interconnector, as perfect arbitrageur*
- *GB modelled as Ireland - pool with capacity payments – with GB-specific input data*
- *2025 snapshot (no dynamic effects)*

# *Scenarios*

- *levels of interconnection (900-1900MW)*
- *Oil (and gas) prices*
  - *Low oil $30/barrel*
  - *Medium oil $60/barrel*
  - *High oil $110/barrel*
- *Carbon permit prices*
  - *Low €20/tonne $CO_2$*
  - *Medium € 49/tonne of $CO_2$*
  - *High € 85/tonne of $CO_2$*
- *wind capacity in Ireland (2000-6000MW)*
- *Wind load profiles (2005-2008)*

# *Cost assumptions, 2007€*

| | Coal, PC | Coal, IGCC w/CCS | Natural Gas CCGT | Nuclear |
|---|---|---|---|---|
| Weighted Average Cost of Capital % | 8 | 8 | 8 | 11.5 |
| Overnight cost (€/kW) | 1279 | 2057 | 664 | 3500 |
| Lifetime of plant (years) | 40 | 40 | 25 | 40 |
| Availability, yearly % | 90 | 85 | 89 | 90 |
| Thermal Efficiency %, Net Calorific Value | 46 | 38 | 58 | 33 |
| Waste/Emissions costs | ETS | $CO_2$ trans&stor + ETS | ETS | €0.91/MWh |
| Cost uncertainty | 1 | 3 | 1 | 3 |

# *Combined Cycle Gas Turbine (CCGT)*

- *Capacity costs are low and reliable*
- *Volatile fuel costs*
- *Unstable supplies?*
- *Currently 60% of electricity generated comes from gas. Diversification?*
- *Moderate emissions*

# *Coal – Pulverised Coal (ultra) supercritical*

- *Moderate – high capital costs*
- *Relatively stable fuel prices*
- *Abundant fuel source / stable supplies*
- *Currently about one fifth of electricity generated in Ireland comes from coal*
- *High emissions*

# *Coal – IGCC with Carbon Capture and Storage (CCS)*

- *High capital costs (needs pipelines/storage for $CO_2$)*
- *Unproven technology*
- *Relatively stable fuel prices*
- *Abundant fuel source / stable supplies*
- *Currently about a quarter of electricity generated comes from coal*
- *Low emissions*

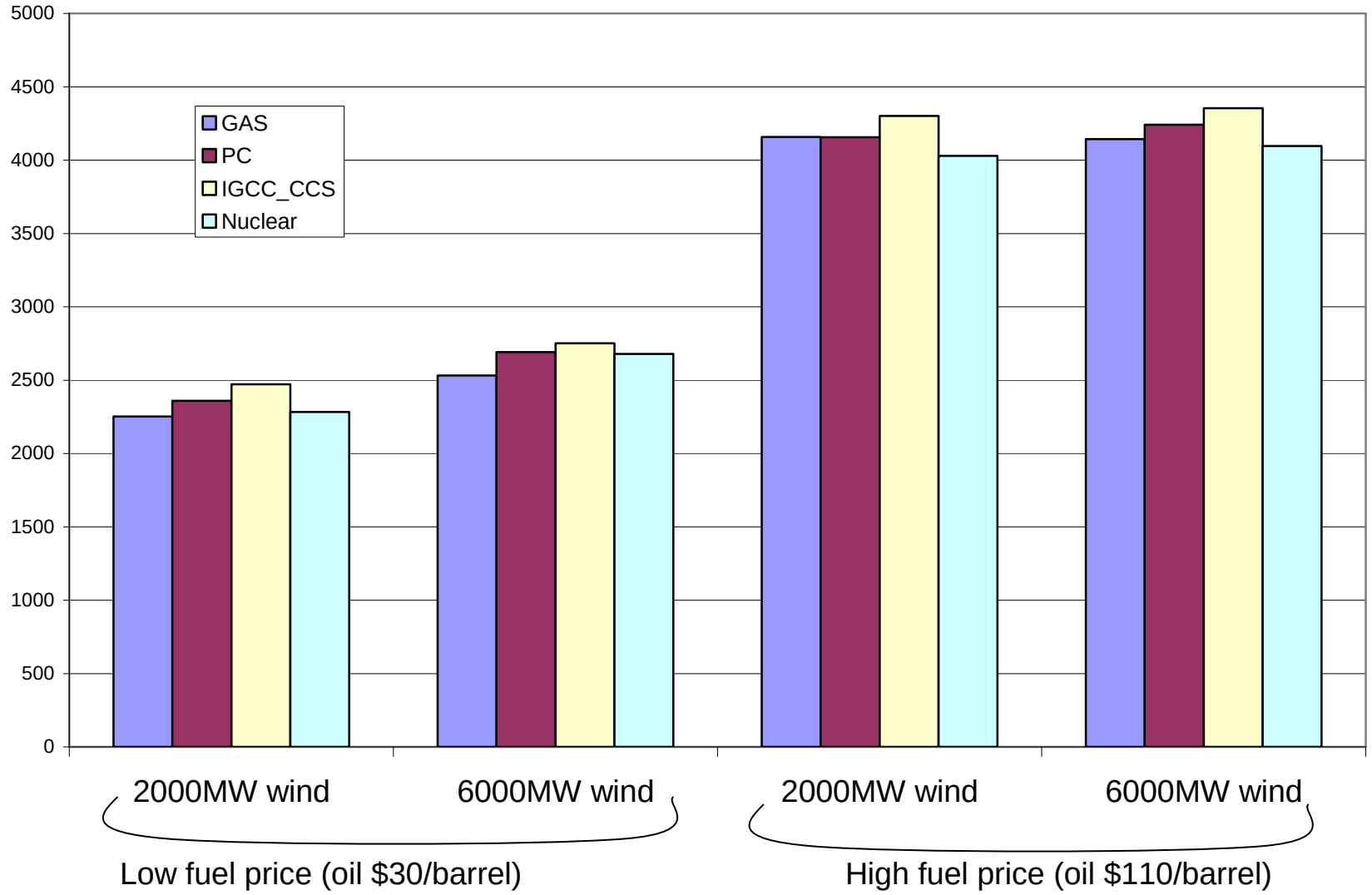
# *Nuclear*

- *High capital costs*
- *No fully built plant with new generation technology*
- *Abundant cheap fuel source / stable supplies*
- *Large inflexible plant, needs additional backup*
- *Public support / planning issues*
- *Nuclear waste*
- *Low emissions*

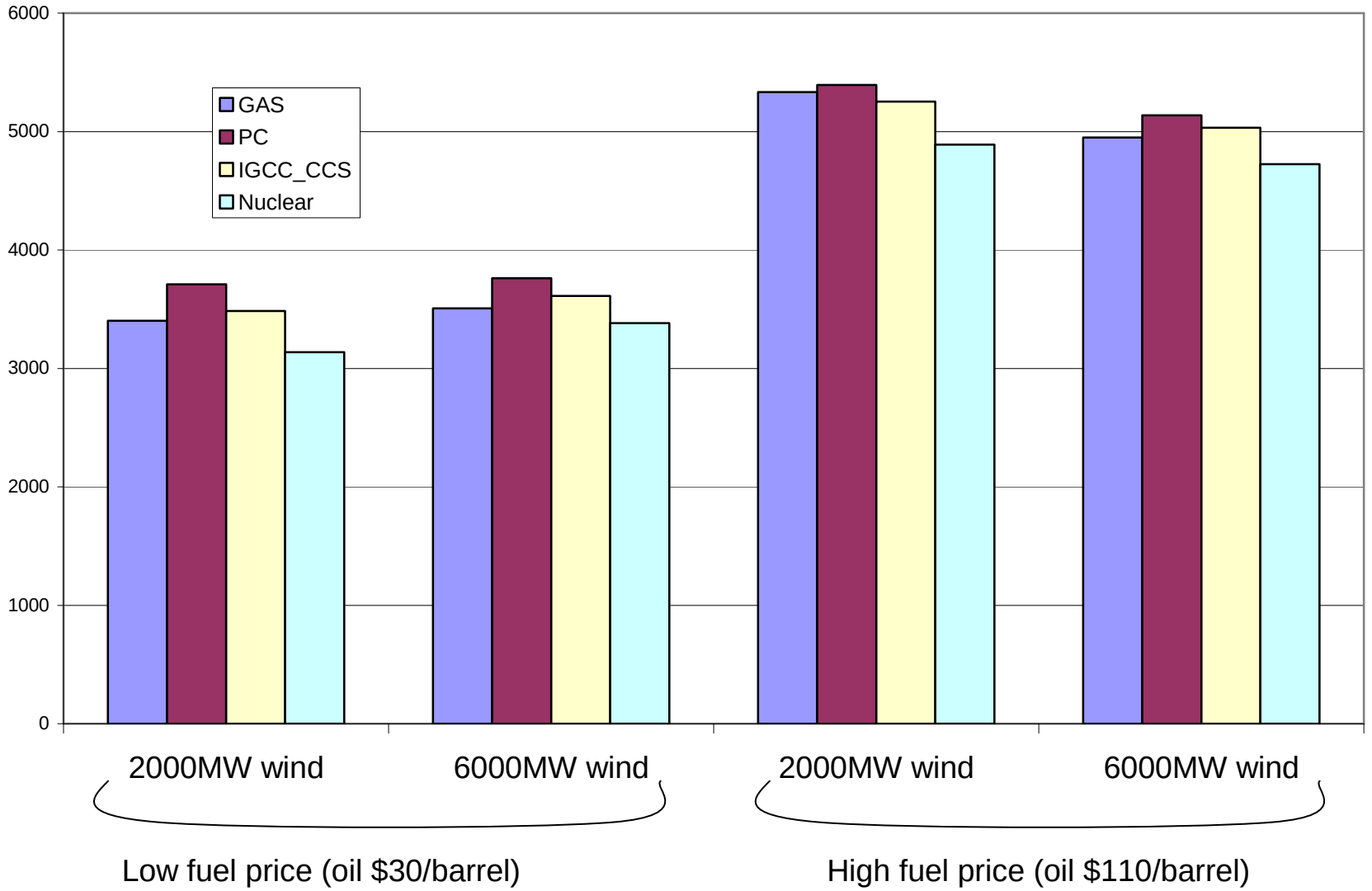
# *Elements of total system cost*

- *Fuel and carbon cost*
- *O&M cost*
- *Annualized capital cost of plants (and interconnection)*

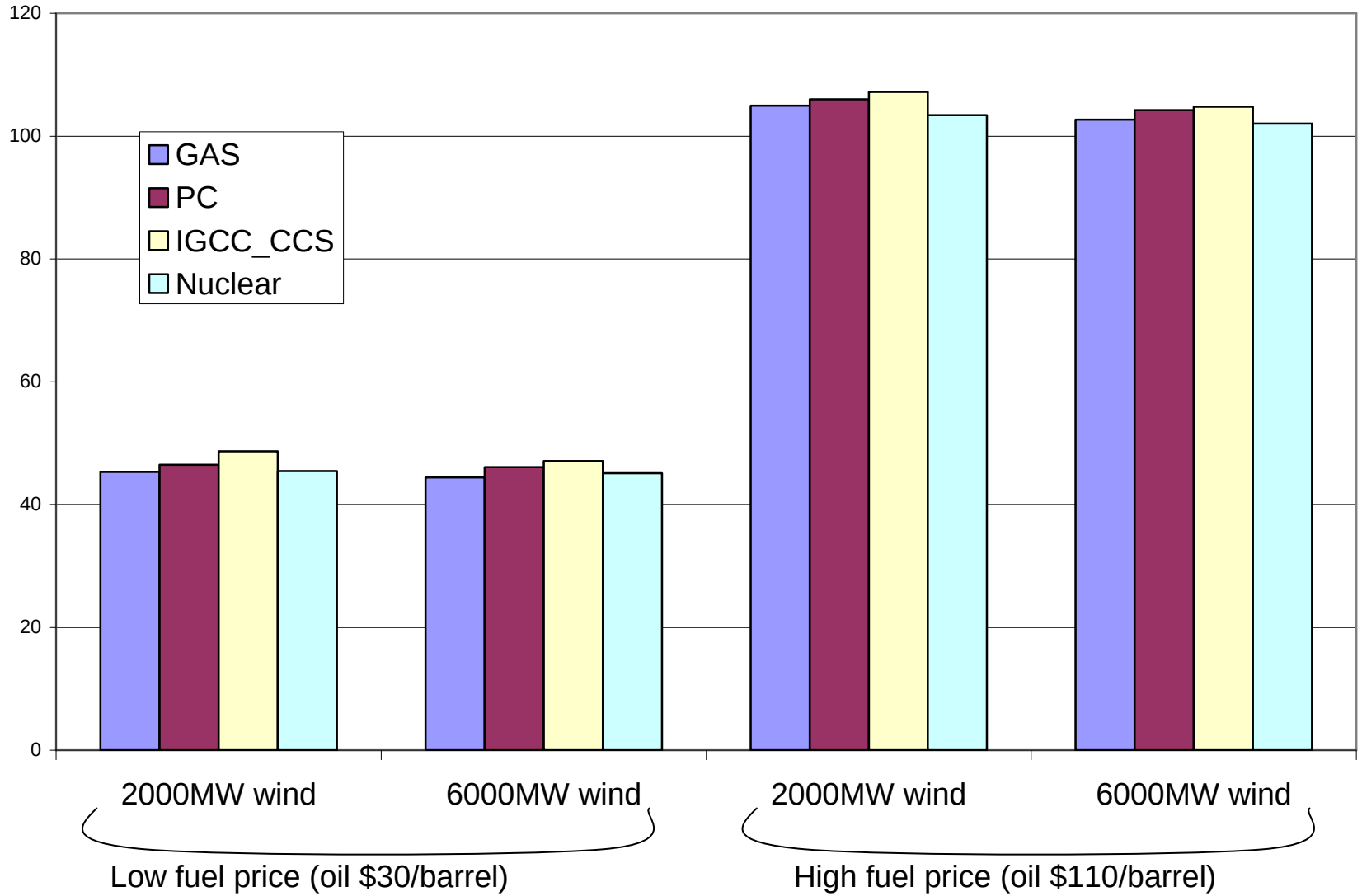
# *Annualised net cost to electricity system, € million*
# *Low Carbon (€20/tonne of $CO_2$) – Interconn. 1400MW*



# *Annualised net cost to electricity system, € million*
# *High Carbon (€85/tonne of $CO_2$) – Preliminary results*



# *Average short run cost electricity, €/MWh*



# *Conclusions*

- *There is no silver bullet.*
- *System marginal price is fairly stable across baseload generation options.*
- *CCGT cheap at low fuel prices: need to consider security of supply .*
- *When the carbon price is high nuclear appears cheapest, although nuclear unlikely in Ireland.*
- *We do not take into account tax regimes. When companies are taxed on profits, difference in capital costs is smaller after taxes.*
- *This is a 'snapshot' analysis. Dynamic analysis would be insightful.*

# *Cost assumptions, 2007€*

| | Coal, PC | Coal, IGCC w/CCS | Natural Gas CCGT | Nuclear |
|---|---|---|---|---|
| Weighted Average Cost of Capital % | 8 | 8 | 8 | 11.5 |
| Overnight cost (€/kW) | 1279 | 2057 | 664 | 3500 |
| Lifetime of plant (years) | 40 | 40 | 25 | 40 |
| Fixed O&M costs (€/kW/year) | 66 | 79 | 16.2 | 56.3 |
| Variable O&M costs (€/MWh) | 1.01 | 1.48 | 0.04 | 1.99 |
| Availability, yearly % | 90 | 85 | 89 | 90 |
| Thermal Efficiency %, Net Calorific Value | 46 | 38 | 58 | 33 |
| Waste/Emissions costs | ETS | $CO_2$ trans&stor + ETS | ETS | €0.91/MWh |
| Cost uncertainty | 1 | 3 | 1 | 3 |

# *Fuel prices, €/MWh, 2007€*

| | Coal | Oil | DO | Gas | Peat | Nuclear |
|---|---|---|---|---|---|---|
| Low | 11.2 | 25.1 | 46.0 | 19.4 | 12.0 | 5.85 |
| Medium | 11.2 | 46.1 | 84.7 | 35.6 | 12.0 | 5.85 |
| High | 11.2 | 67.2 | 123.3 | 51.9 | 12.0 | 5.85 |