

The value of demand response

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Overview

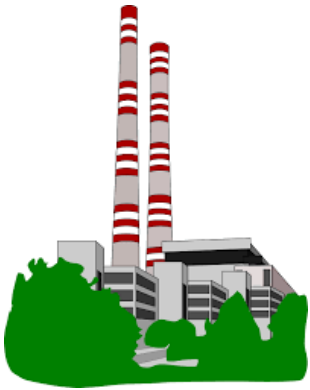
- Background and research questions
- Methodology
- Data
- Test cases
- Results
- Summary

Background and Research Questions

- Energy systems based on renewable energy sources (RES) have an increasing demand for flexibility
 - Traditional sources of flexibility: mainly supply side and (pumped) storage
 - Our focus: demand response
- Research questions: How does...
 - ... demand response affect the costs for different consumers?
 - ... demand response affect generator profits and investments?
 - ... demand response affect CO₂ emissions?
 - ... the presence of market power change the above impacts?
- Contribution
 - We follow a game-theoretic approach where profit-maximising firms interact in equilibrium rather than following a least-cost optimisation
 - Consideration of market power
 - Consideration of market investments
 - Consideration of RES uncertainty
 - Distinction between different consumer groups

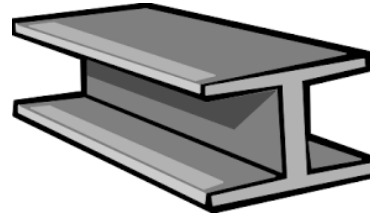
Game Theory Model

Generators:



- Maximise profit
- Decisions:
 - Generation
 - Investment/Decommission
- May exert market power

Consumers:

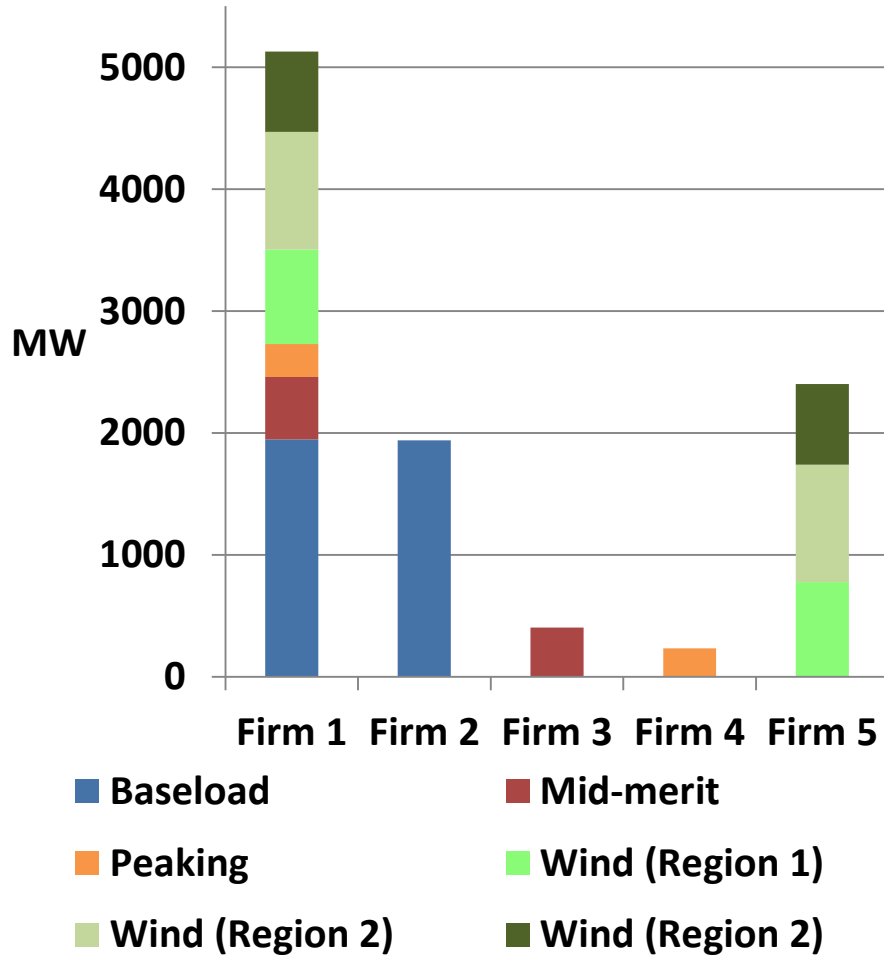


- Minimise costs
- Decisions:
 - PV or micro generation
 - Load shifting

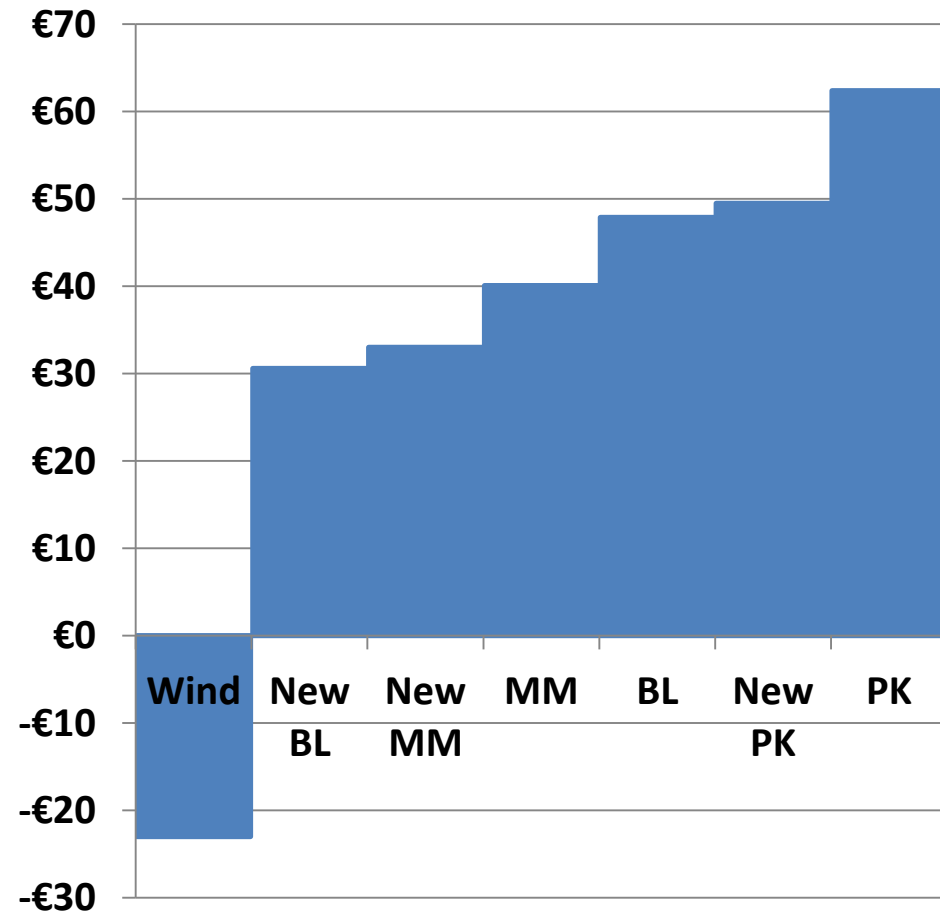
- Mixed Complementarity Model & Bender's Decomposition

Generators

Initial Generation portfolio

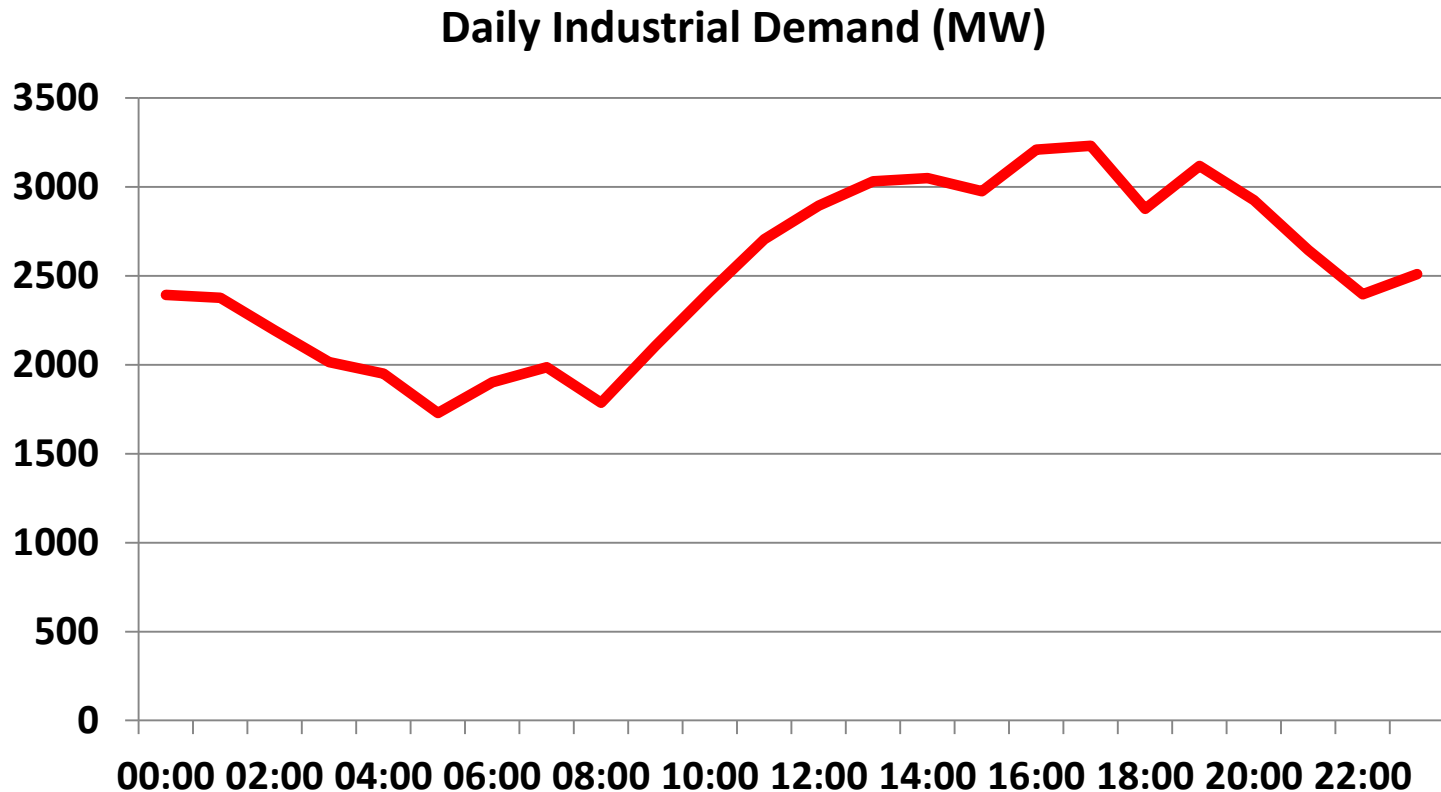


Marginal costs



Consumer groups (Industrial)

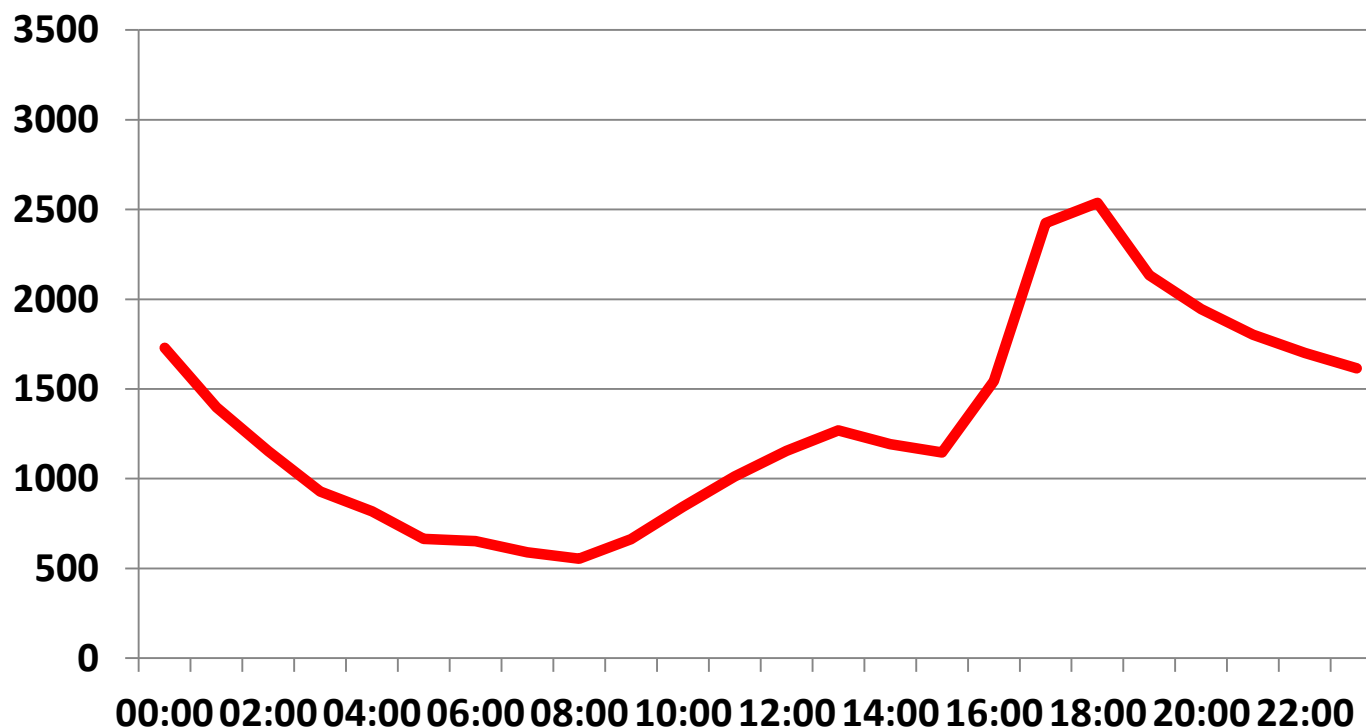
		Annual Demand	% of total demand	Shift-able load/hour
Group 1	No micro or PV	18.82 TW h	56%	10% of peak demand
Group 2	With micro (150MW)	2.82 TW h	8%	
Group 3	With PV (20MW)	0.47 TW h	1%	



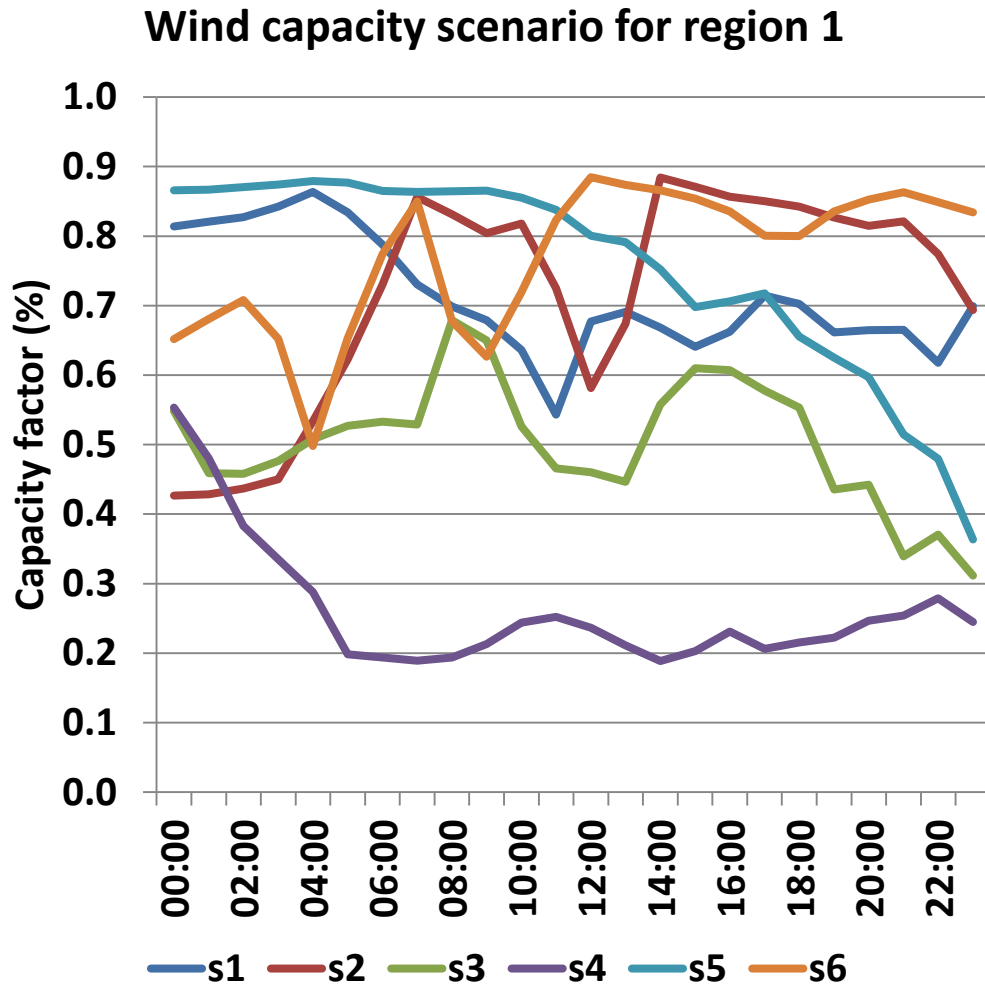
Consumer groups (Residential)

		Annual Demand	% of total demand	Shift-able load/hour
Group 4	No micro or PV	10.86 TW h	31%	
Group 5	With micro (150MW)	0.48 TW h	1%	10% of peak demand
Group 6	With PV (30MW)	0.48 TW h	1%	

Daily Residential Demand (MW)



Renewables uncertainty in the Model



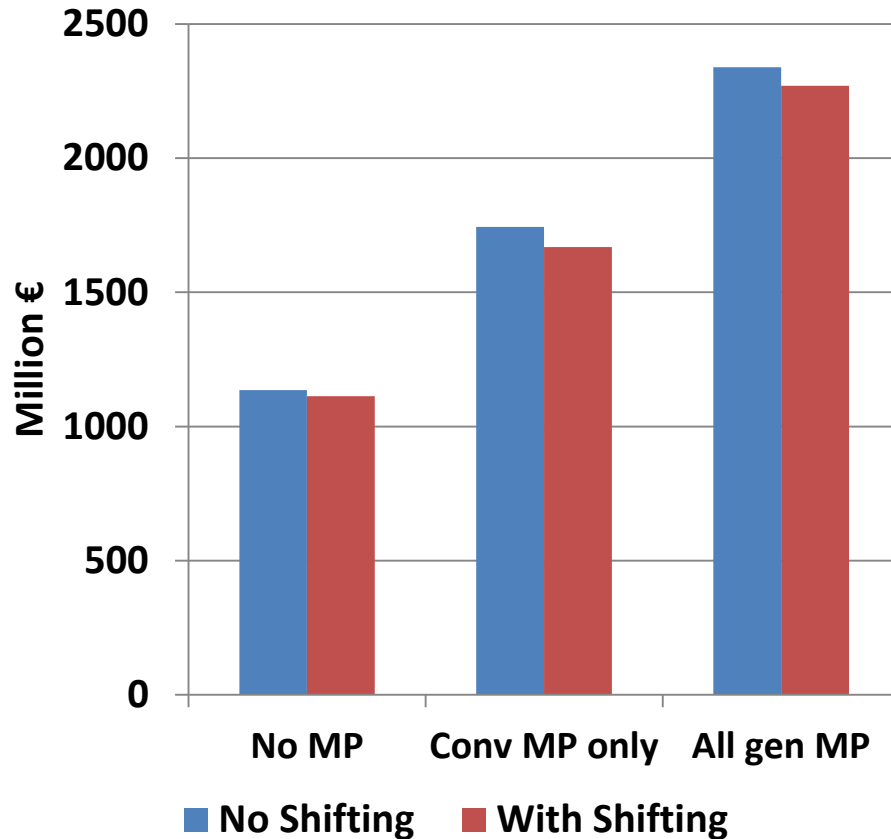
- Similar capacity factors scenarios for uncertain PV generation

Test cases

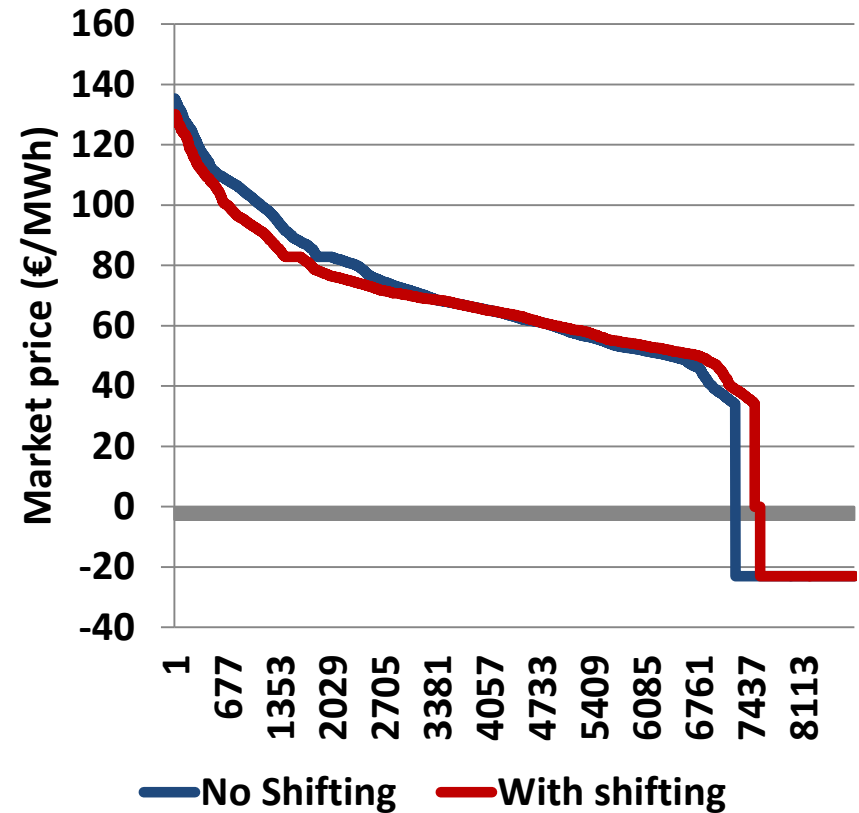
- Simulate Irish electricity market for 2025
- Three Market Power cases:
 1. No Market Power
 2. All generators have market power, except wind
 3. All generators have market power
- All cases considered with and without load shifting
 - Assume the presence of demand aggregators

Results

Consumer costs



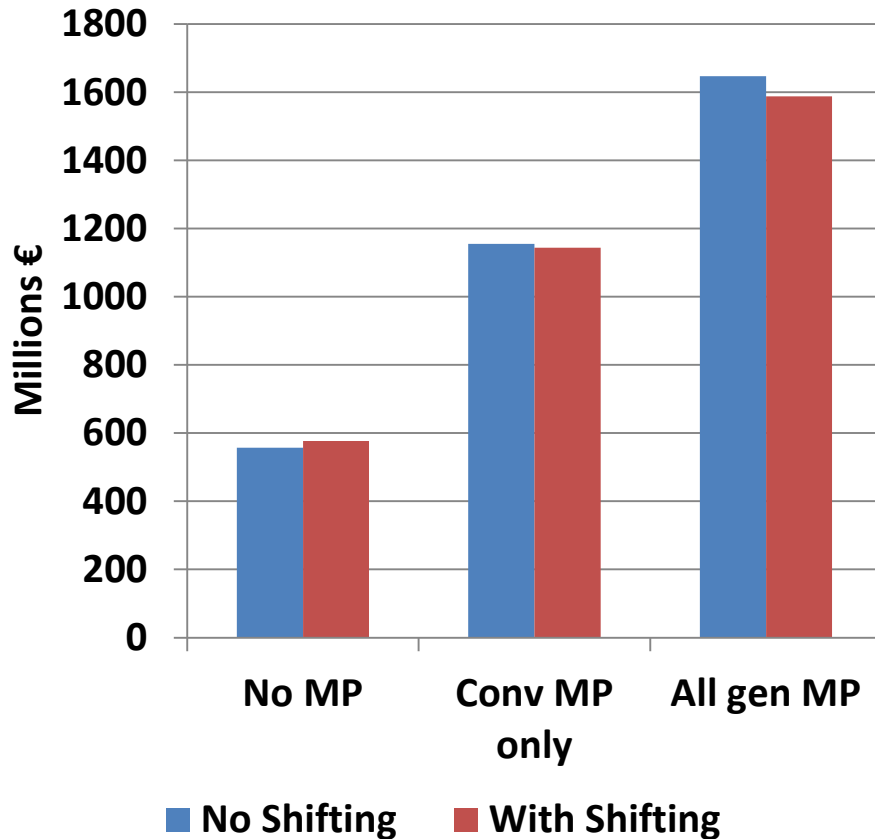
Price Duration Curve



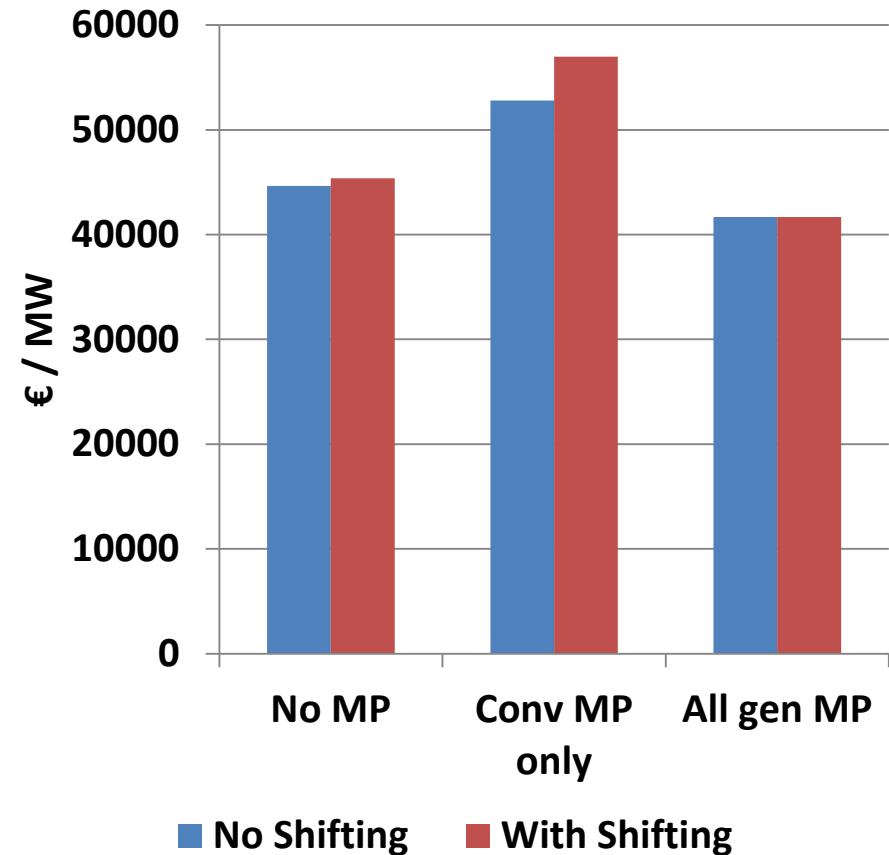
- Consumer groups with micro generation see costs increase with shifting in presence of market power
- Value of shifting slightly higher for residential consumers, and for consumers with own PV generation

Results

Profits



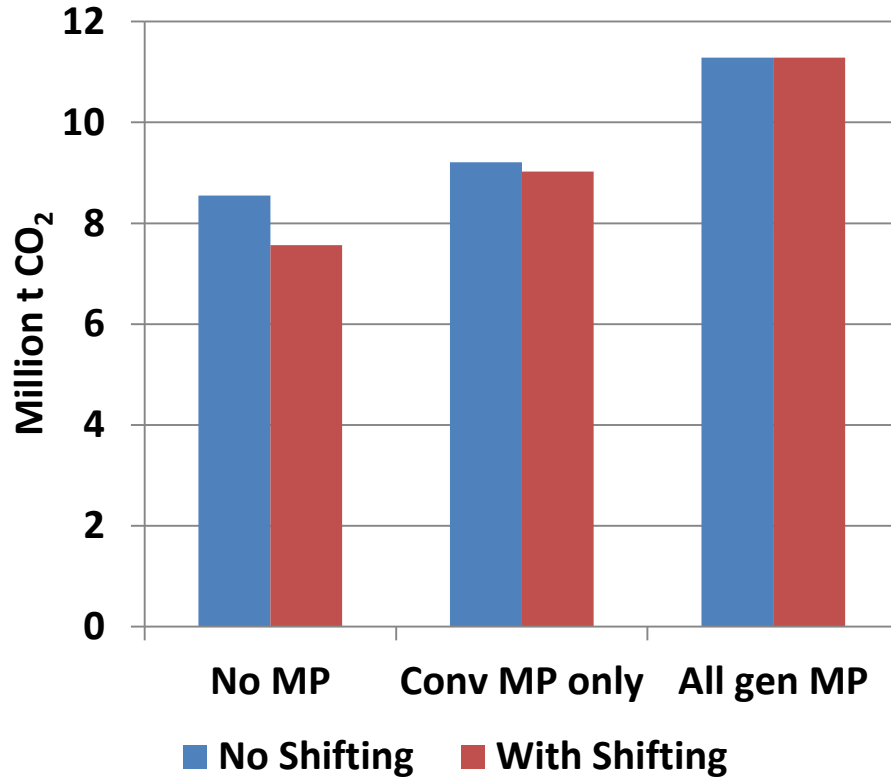
Capacity prices



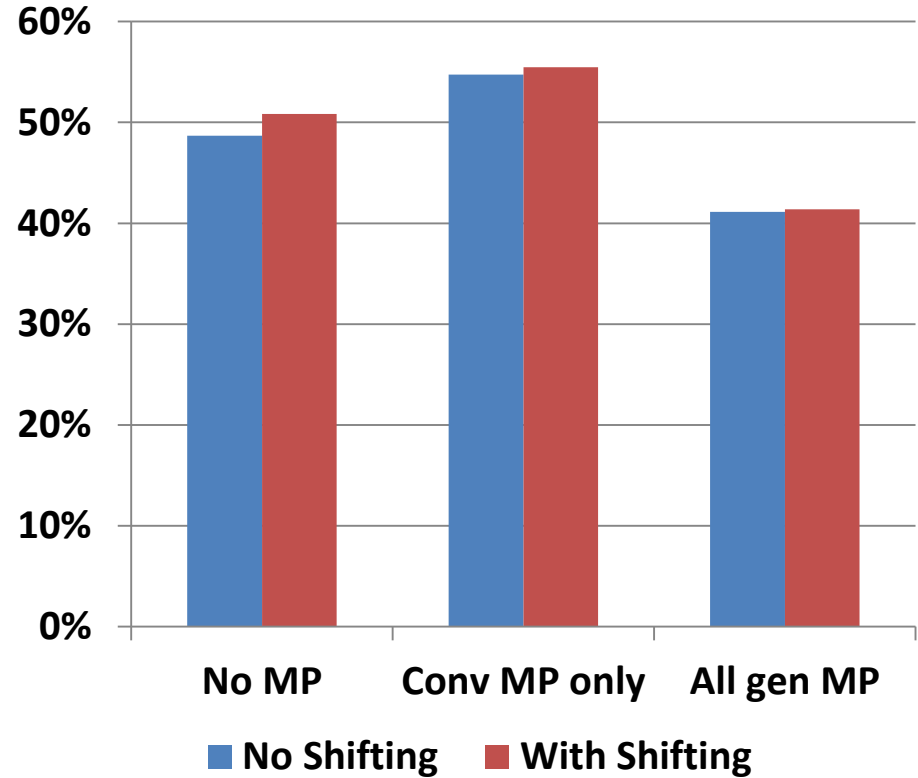
- Profits increase/decreases differ depending on generating technology

Results

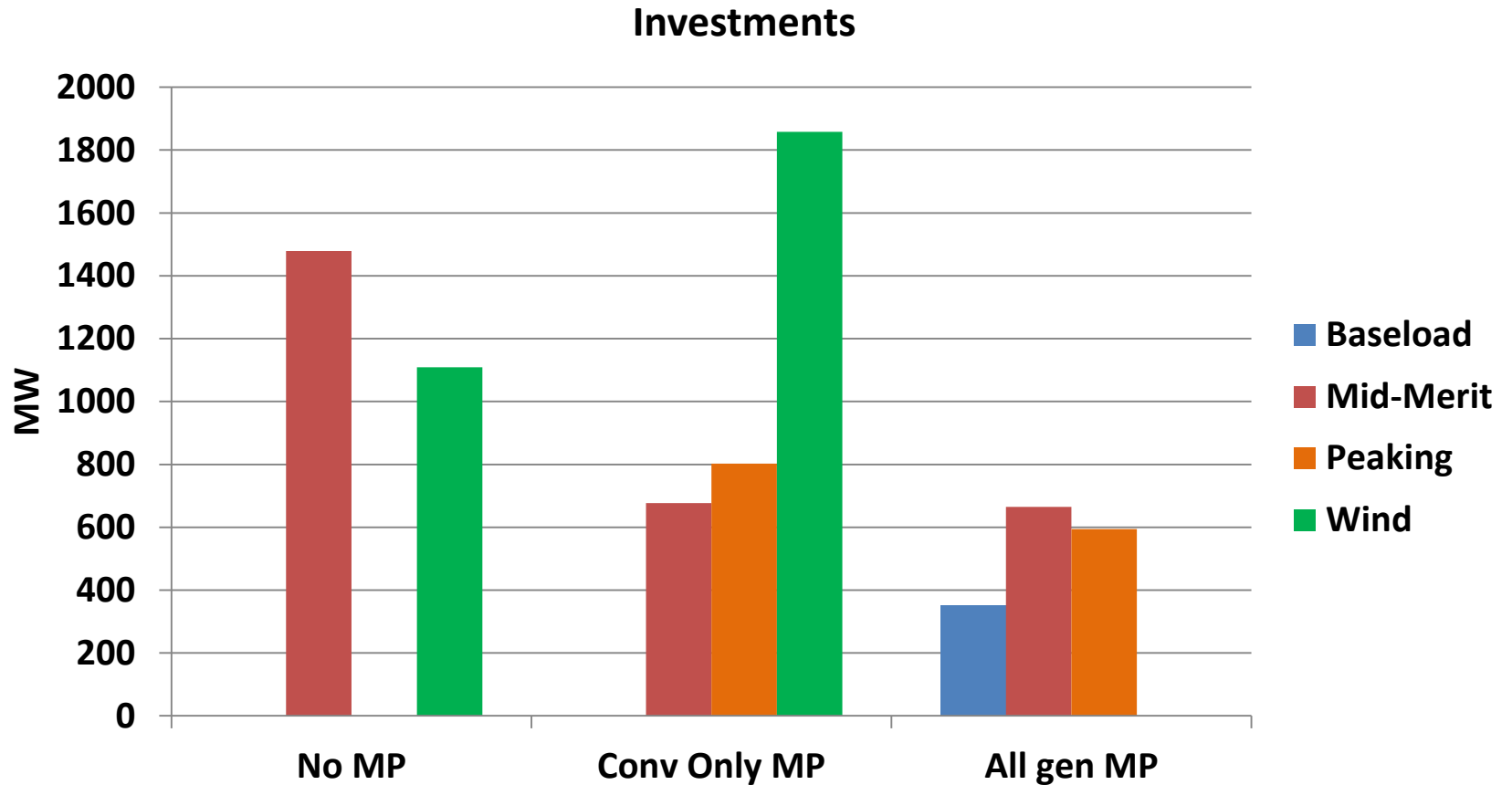
Emissions



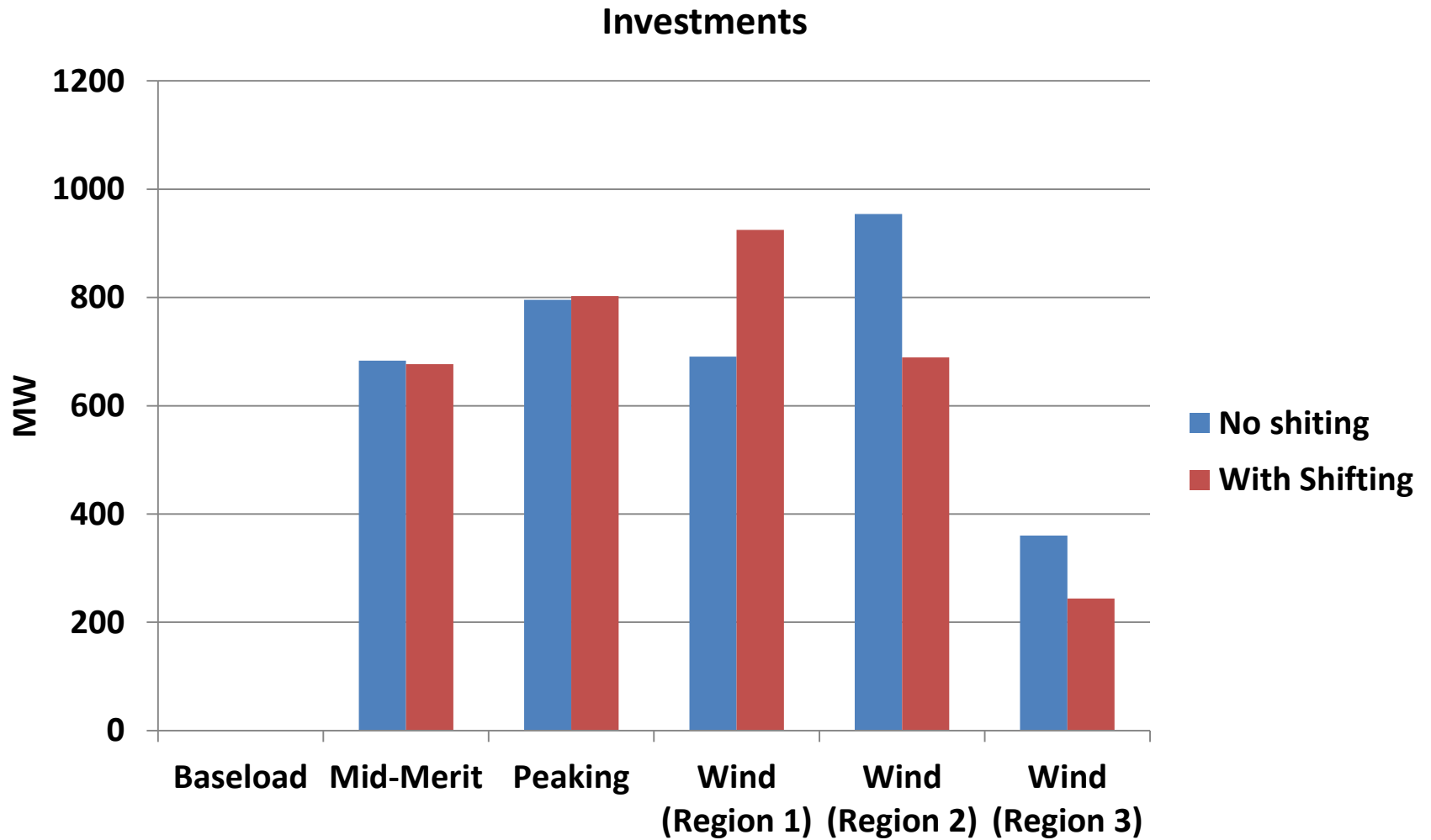
RES Share



Results



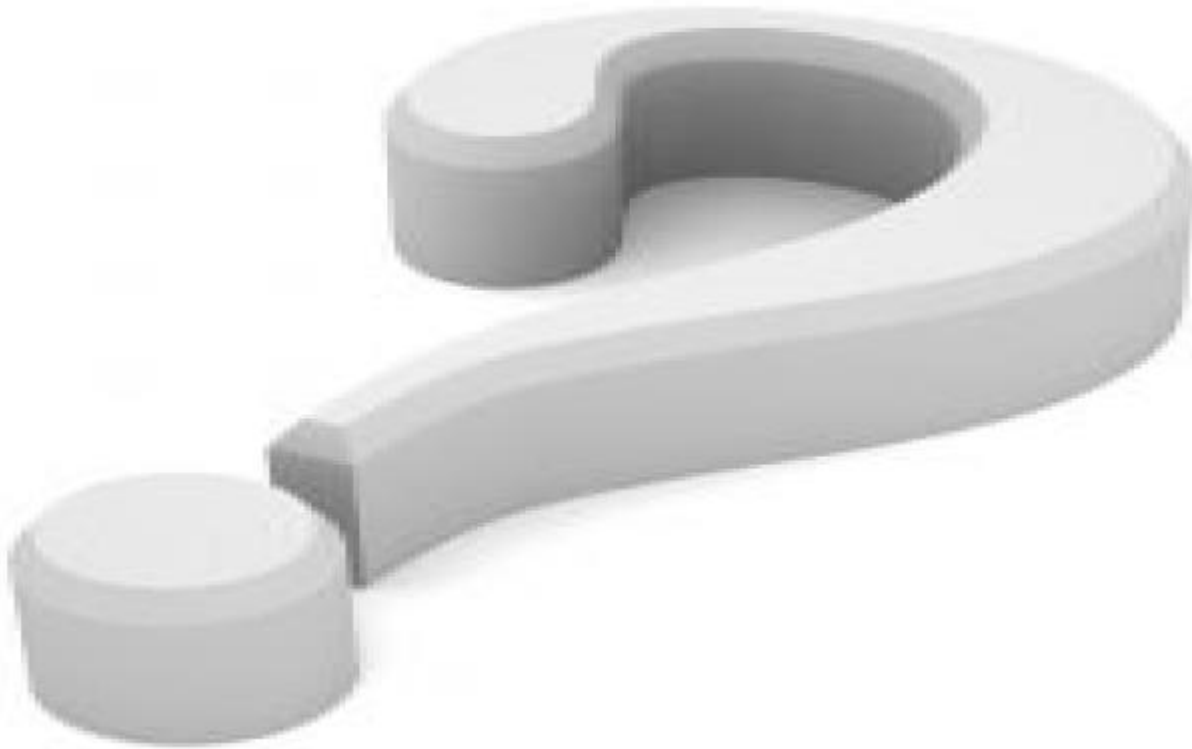
Results



Summary

- Simulated Irish electricity market for 2025 using game theoretic model
- Impact of Demand Response...
 - reduces consumer costs
 - varying effect on generators' profit
 - increases RES share which decreases emissions
- Market power increases profits, consumer costs and emissions
 - Also has a varying effect on capacity prices & RES share
- Both DR and MP have a varying effect on investments in new generation

Questions



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