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CO_2 Abatement from RES Injections in the German Electricity Sector: Does a CO_2 Price Help?

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Overview

- Context and scope
- Model and scenarios
- Main results
- Emission interaction effect
- Conclusions and future research

Context and scope

- Current EU energy/environment policies:
  - ETS key instrument in CO_2 mitigation
    - In place since 2005
  - At same time targets for RES
    - Also (partly) aiming at reducing emissions
- Overlapping effects
  - Emissions are capped, RES do not “reduce” emissions
  - A purely redistributive effect

- Objective of this analysis:
  - Quantify the effects of ETS and RES of the last five years in Germany and provide an evaluation of the impact and efficiency of the instruments
    - How much CO_2 ‘abatement’ from RE injections?
    - Technical viewpoint
      - Complex interaction of fluctuating RE (e.g., wind), load, and merit order of existing capacity

Model

- Classic Unit Commitment Model of Germany:
  - Optimize electricity generation with a given set of power plants
  - Input
    - Detailed power plant fleet (capacity, efficiency, fuel usage, CO_2 emission factor, technology characteristics)
    - Observed hourly load and RE injections and average monthly fuel and EUA prices
    - Imports/Exports fixed to observed values
  - Minimizing total generation and start-up costs, with perfect foresight
    - Hourly resolution
    - Pumped hydro storage endogenous
  - Output
    - Hourly generation and emissions on power plant level
  - 5 year framework (2006-2010)
- Model calibrated to observed electricity generation quantities by fuel (price results should be regarded with care)
  - Cost mark-ups
  - Availabilities

Scenarios

- **OBS**: The calibrated case with observed EUA prices and RE injections
- **NOPOL**: A no policy counterfactual with a zero EUA price and no RE injections
- **ETS**: The observed EUA price with no RE injections
- **RES**: Observed RE injections with a zero EUA price

Main results

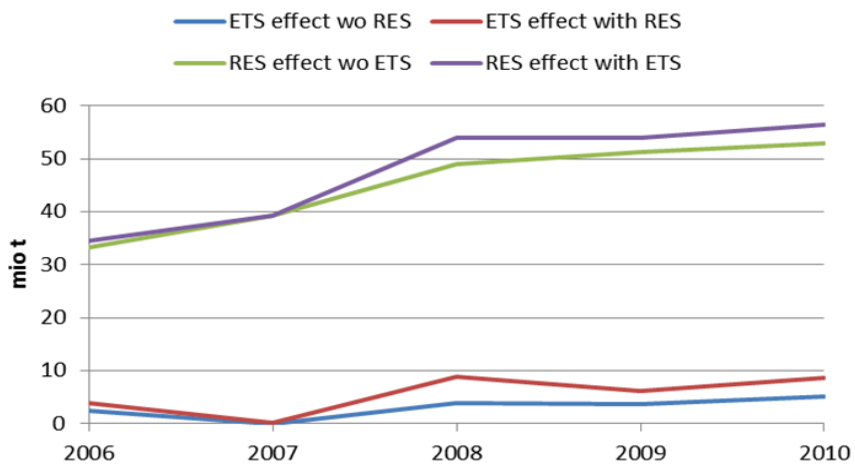
- Generation and emissions

		2006		2007		2008		2009		2010	
		[unit]	[%]	[unit]	[%]	[unit]	[%]	[unit]	[%]	[unit]	[%]
		change in generation [TWh]									
RES	RE injections	50	8%	64	10%	71	11%	74	12%	79	13%
	coal	-20	-11%	-18	-10%	-31	-17%	-34	-20%	-37	-23%
	gas	-25	-26%	-39	-34%	-35	-33%	-27	-28%	-25	-27%
ETS	coal	-4	-2%	0	0%	-7	-4%	-7	-4%	-8	-5%
	gas	4	5%	0	0%	7	7%	7	7%	8	9%
		change in CO2 emissions [Mton]									
RES		-33	-10%	-39	-11%	-49	-14%	-51	-15%	-53	-15%
ETS		-3	-1%	0	0%	-4	-1%	-4	-1%	-5	-2%

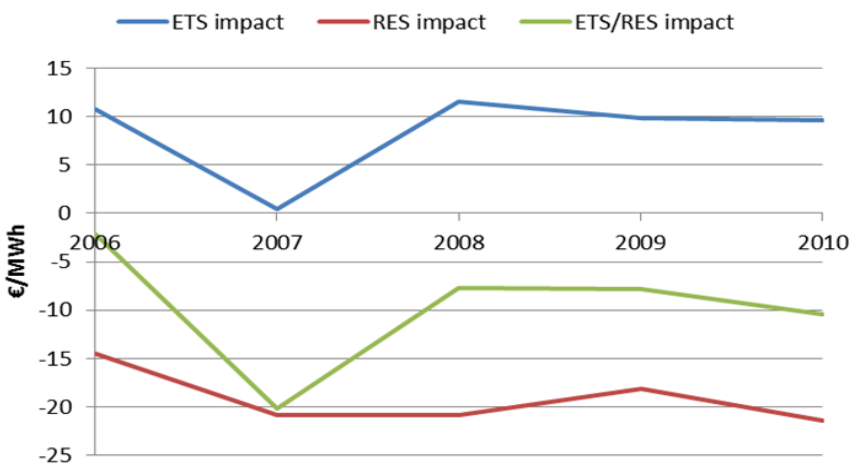
	relative to total (all fuels)
	relative to generation from specific fuel

Main results

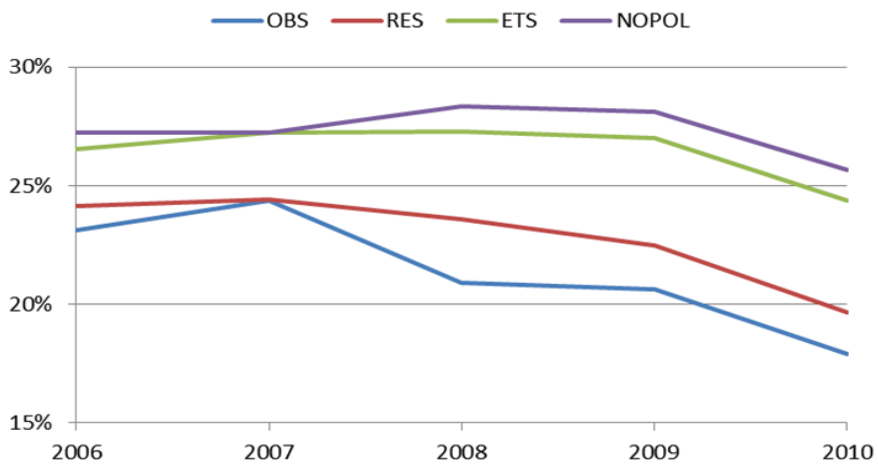
a) Emission impact



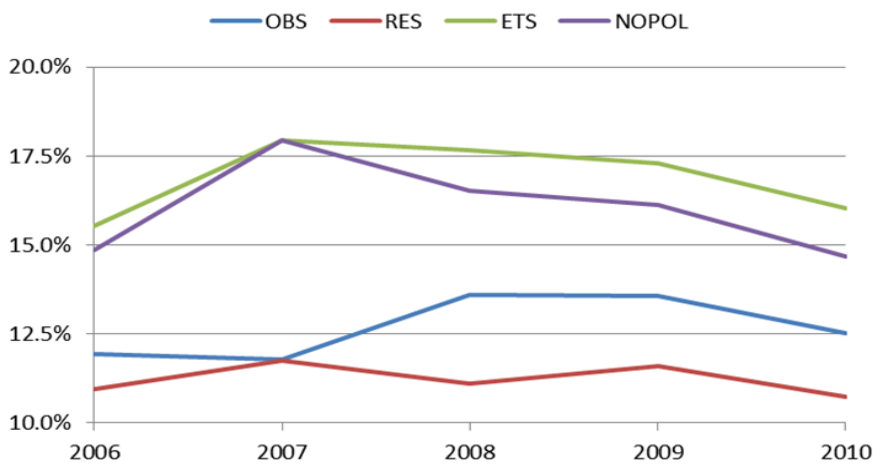
b) Price impact (compared to NOPOL)



c) Coal Share

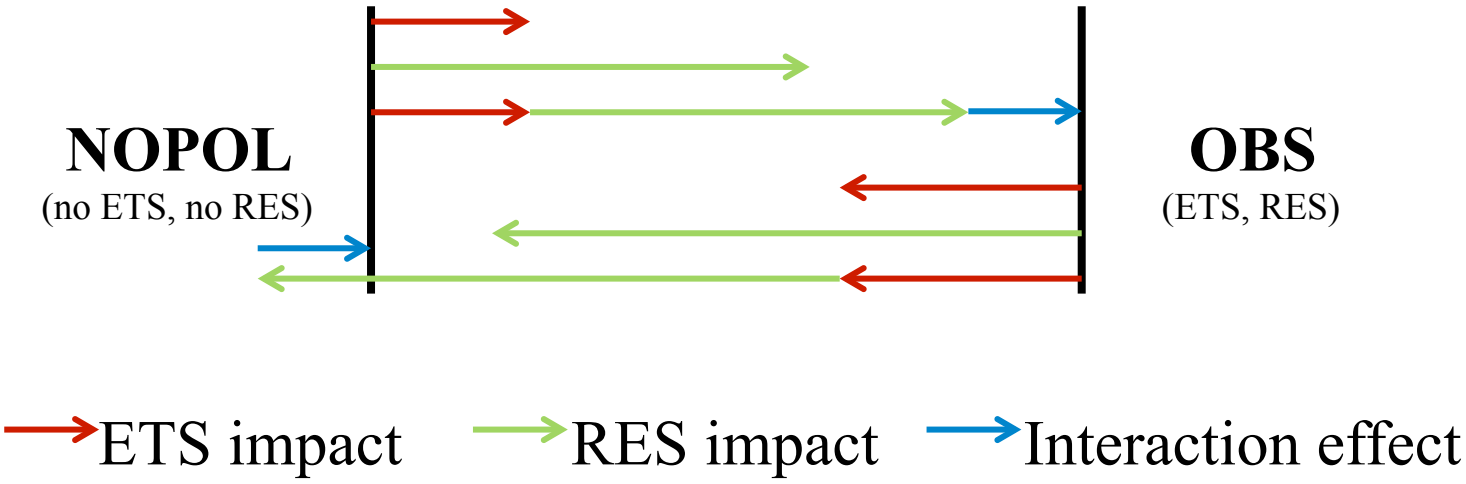


d) Gas Share



Interaction effect

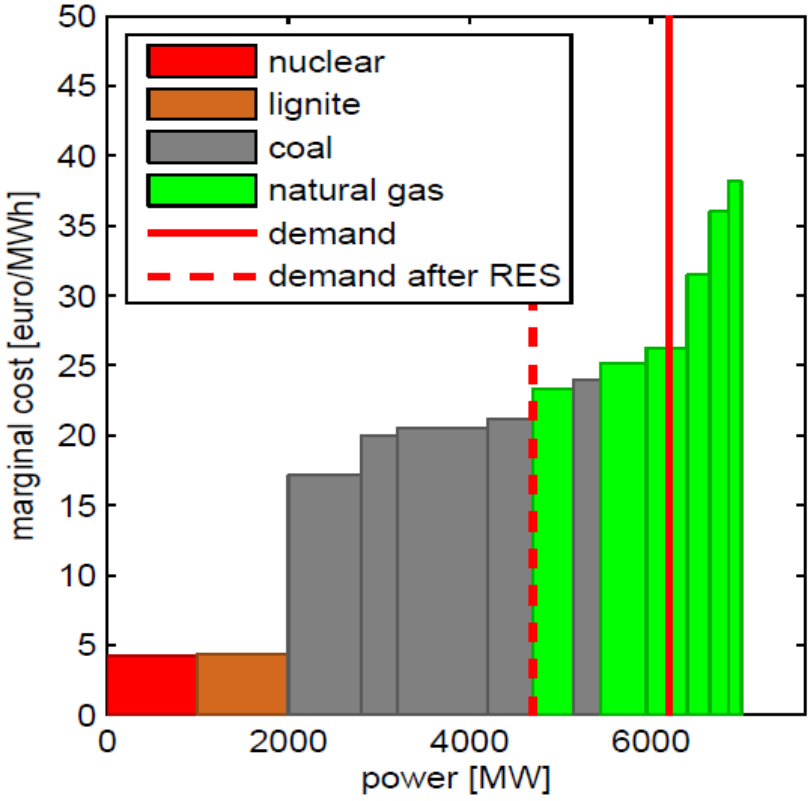
- Results indicate that impact of instrument is different when other instrument is present or not
  - Refer to this as ‘interaction effect’



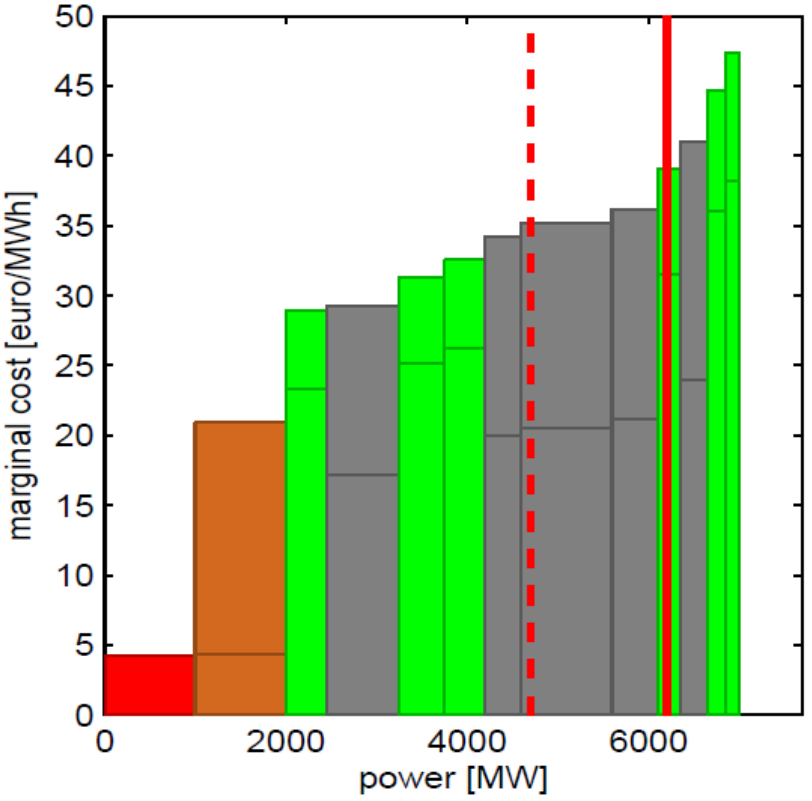
Interaction effect

- Illustrated by merit order of a methodological system

0 €/ton

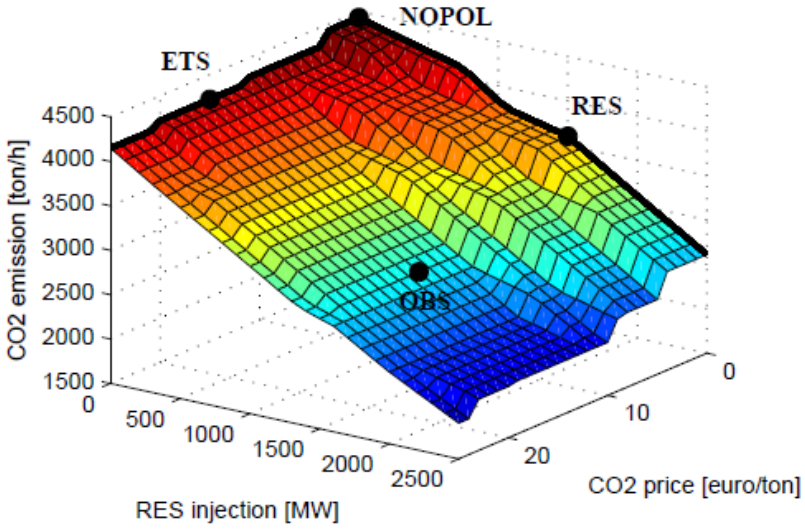


15 €/ton

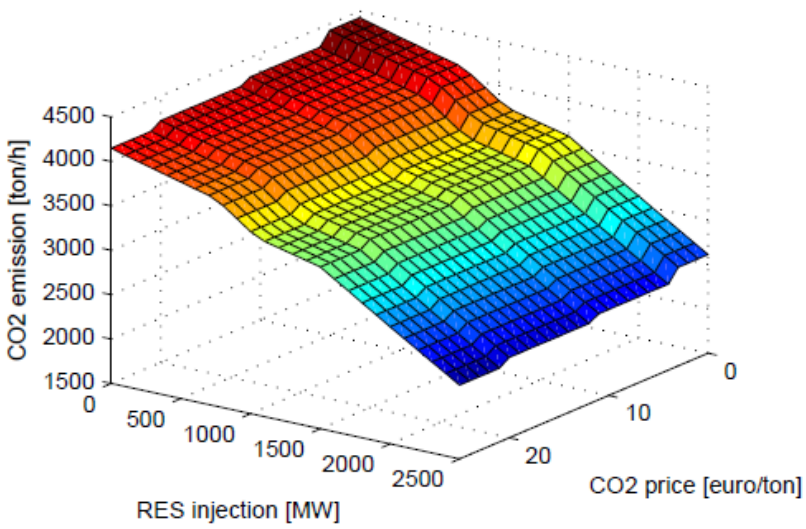


Interaction effect

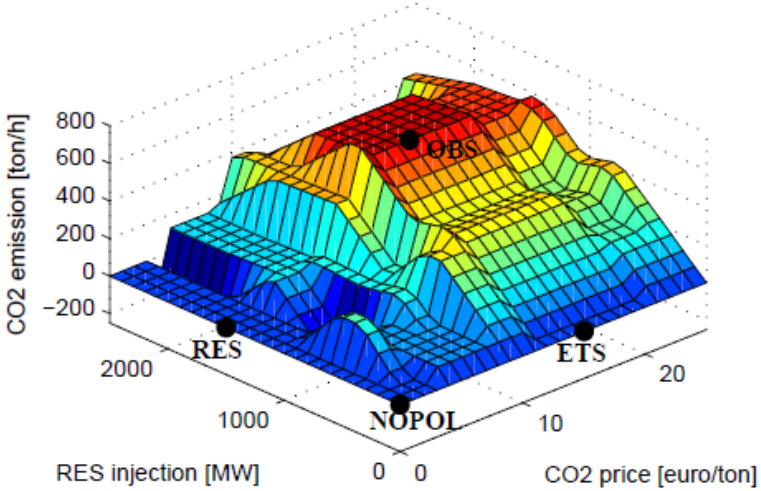
Total emission for each combination

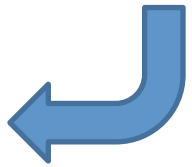


Total emission for reference plane



"Interaction effect"

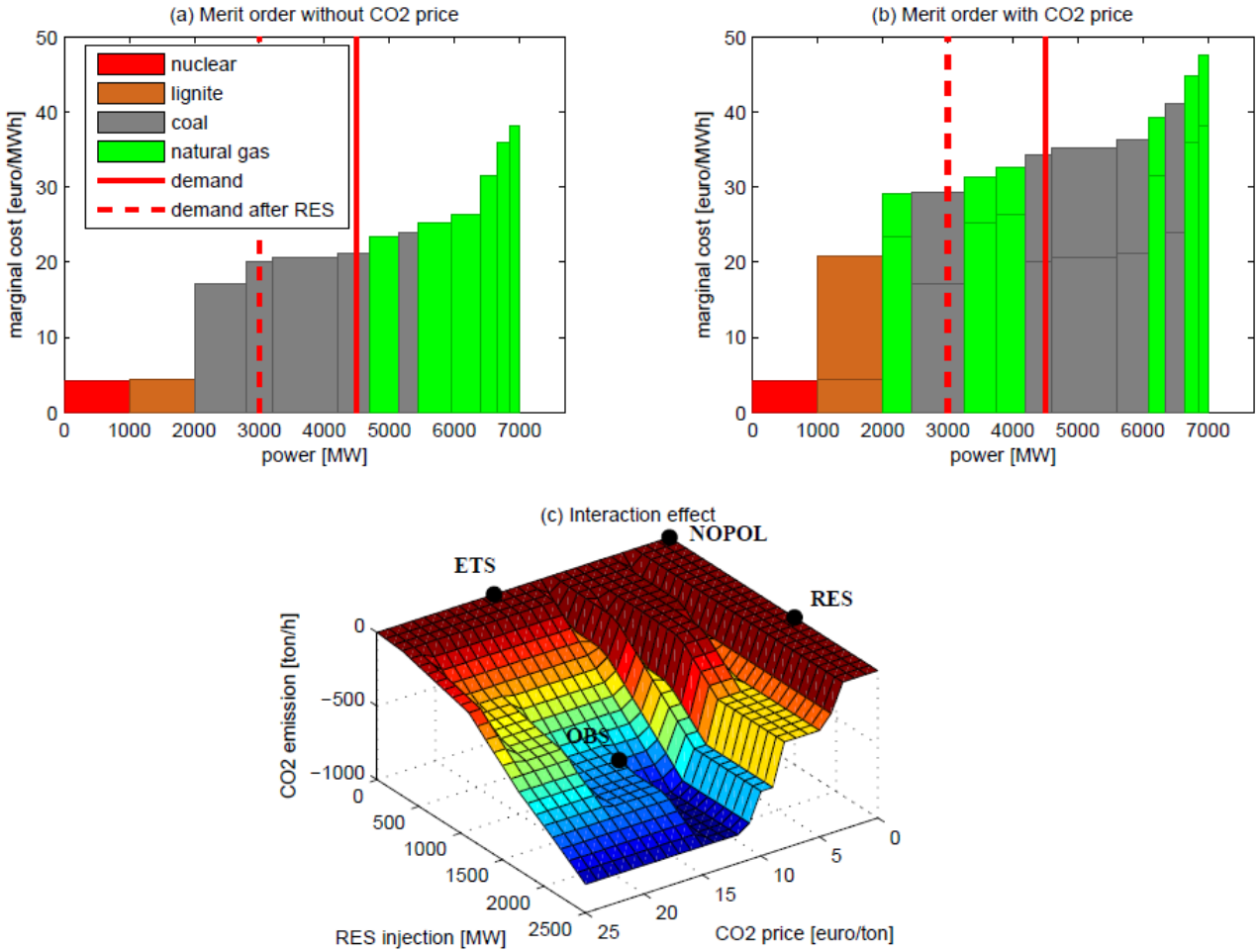




Subtracting plane 1 from plane 2

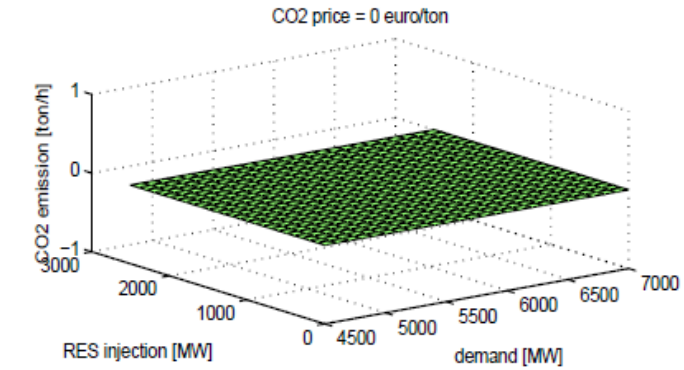
Interaction effect

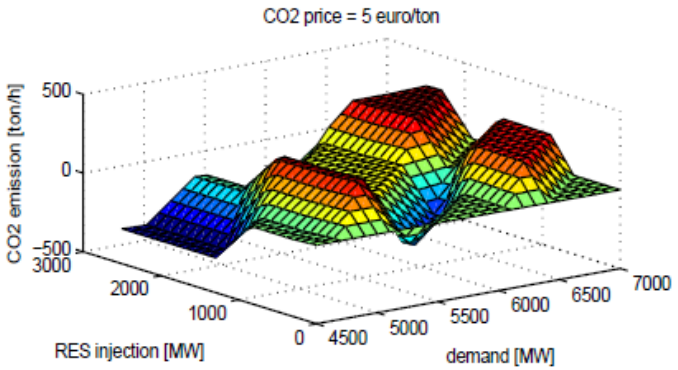
- Interaction effect dependent on reference demand
  - Could be negative

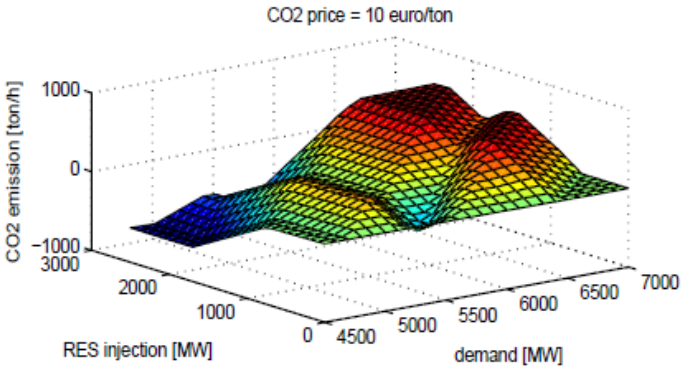


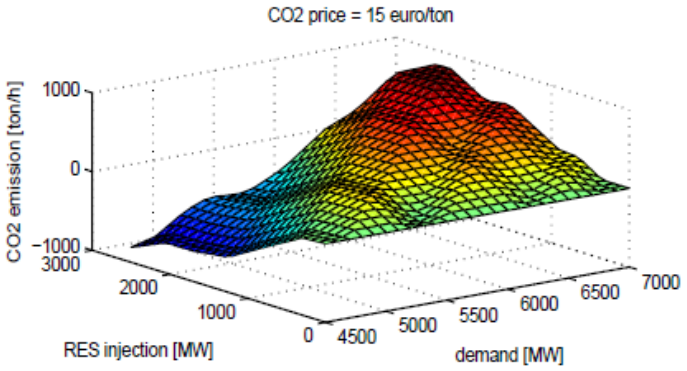
Interaction effect

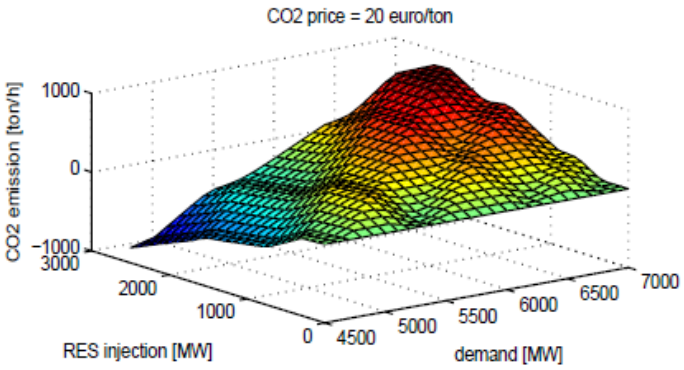
Interaction effect,
as function of
- RES injection and
- demand,
for different CO_2 prices

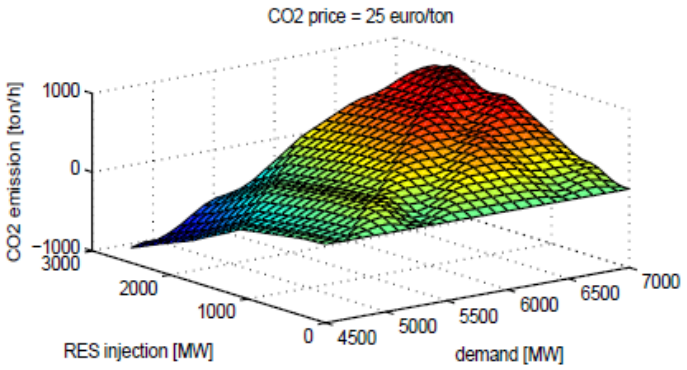






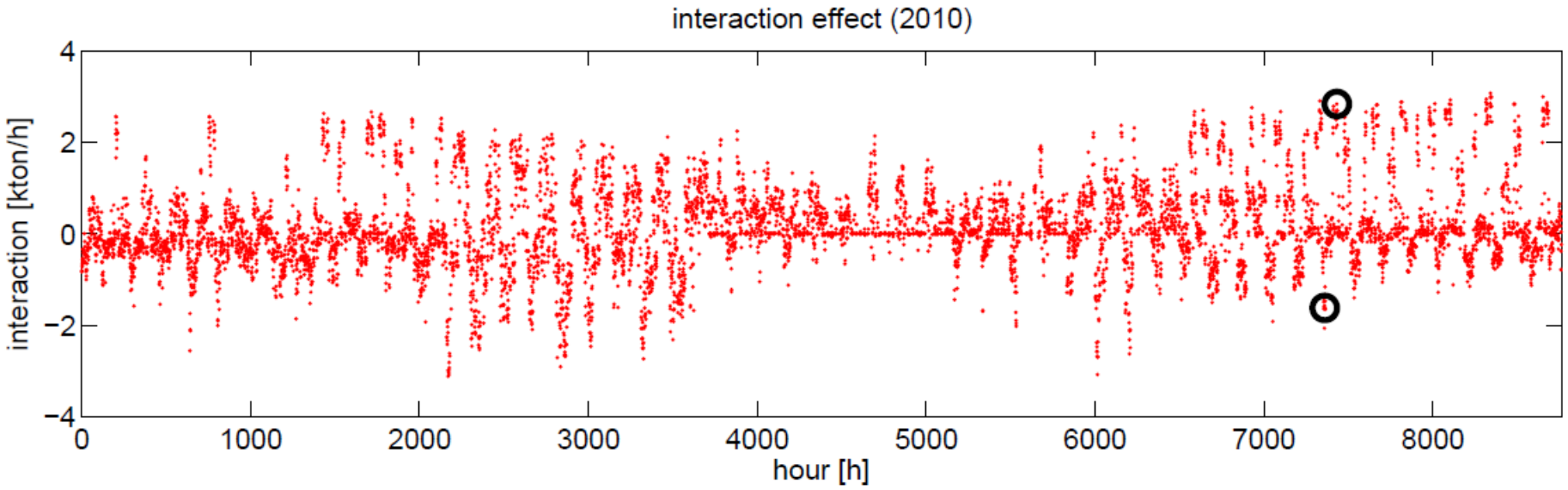






Interaction effect

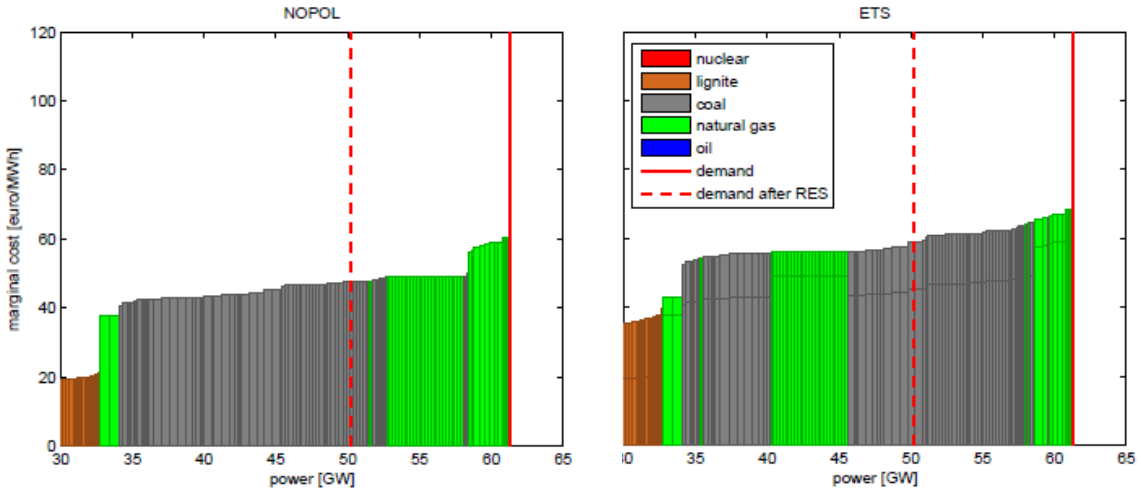
- Hourly interaction effect from simulation of Germany (2010)
  - Fluctuating heavily
  - Both positive and negative values



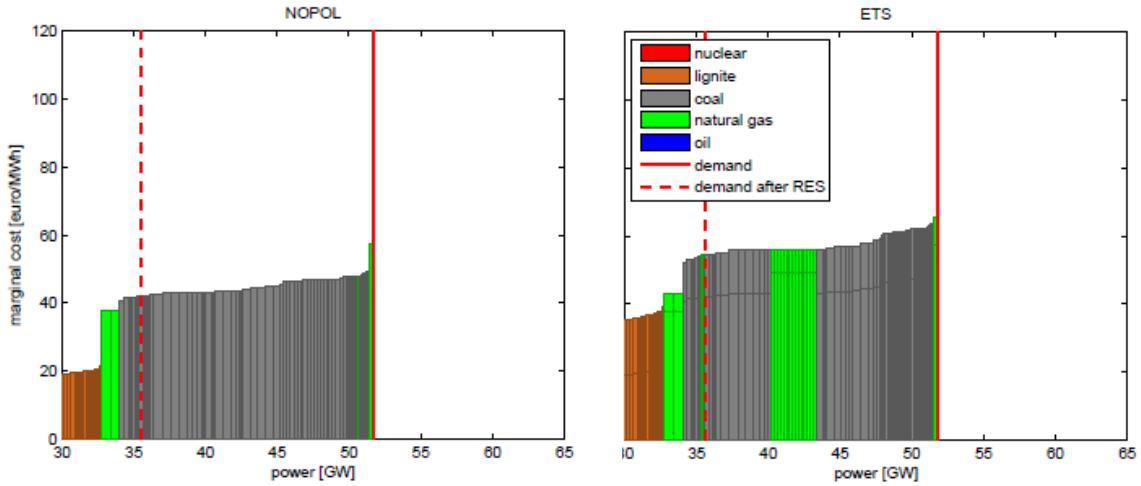
Interaction effect

- Illustration of interaction effect for 2 specific hours

Positive interaction effect



Negative interaction effect



Conclusions

- RE policy as implemented in Germany has a far greater effect on CO_2 emissions than the ETS
  - ~14% vs. 1-2%
  - About 2.5% of overall EUA demand
  - EUA price effects may be significant, especially when Spain and other MS's are included

- A CO_2 price will tend to augment the effect of RE injections but only so long as the demand is sufficiently high
  - Also a function of demand and fluctuating heavily over time
  - Still, the interaction effect is small in relation to reduction from displacing CO_2 emitting generation

Future analyses?

- Focus of this work is on emissions and generation
  - Geographic scope to be expanded
- How much is the EUA price being suppressed?
  - Need for marginal abatement cost curve
  - Price suppression could be significant
- What is the cost of CO_2 abated by RE injections?
  - Direct subsidy cost
  - Additional reserves costs and cost for back-up capacity
  - Merit order effects (the reduced wholesale price)
  - Allowance cost savings
- How much higher does EUA price need to be to bring on RE?