Modelling the impact of emissions trading in Greek Electricity Sector

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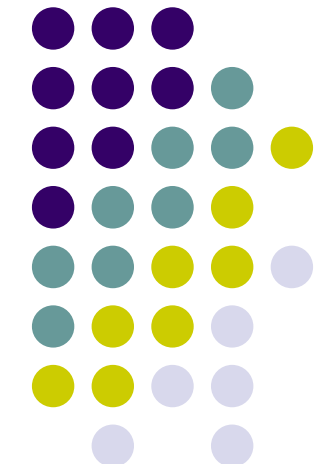
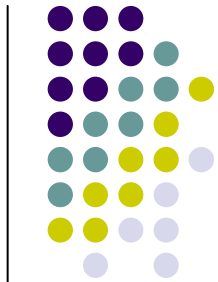
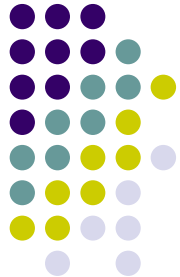


Introduction

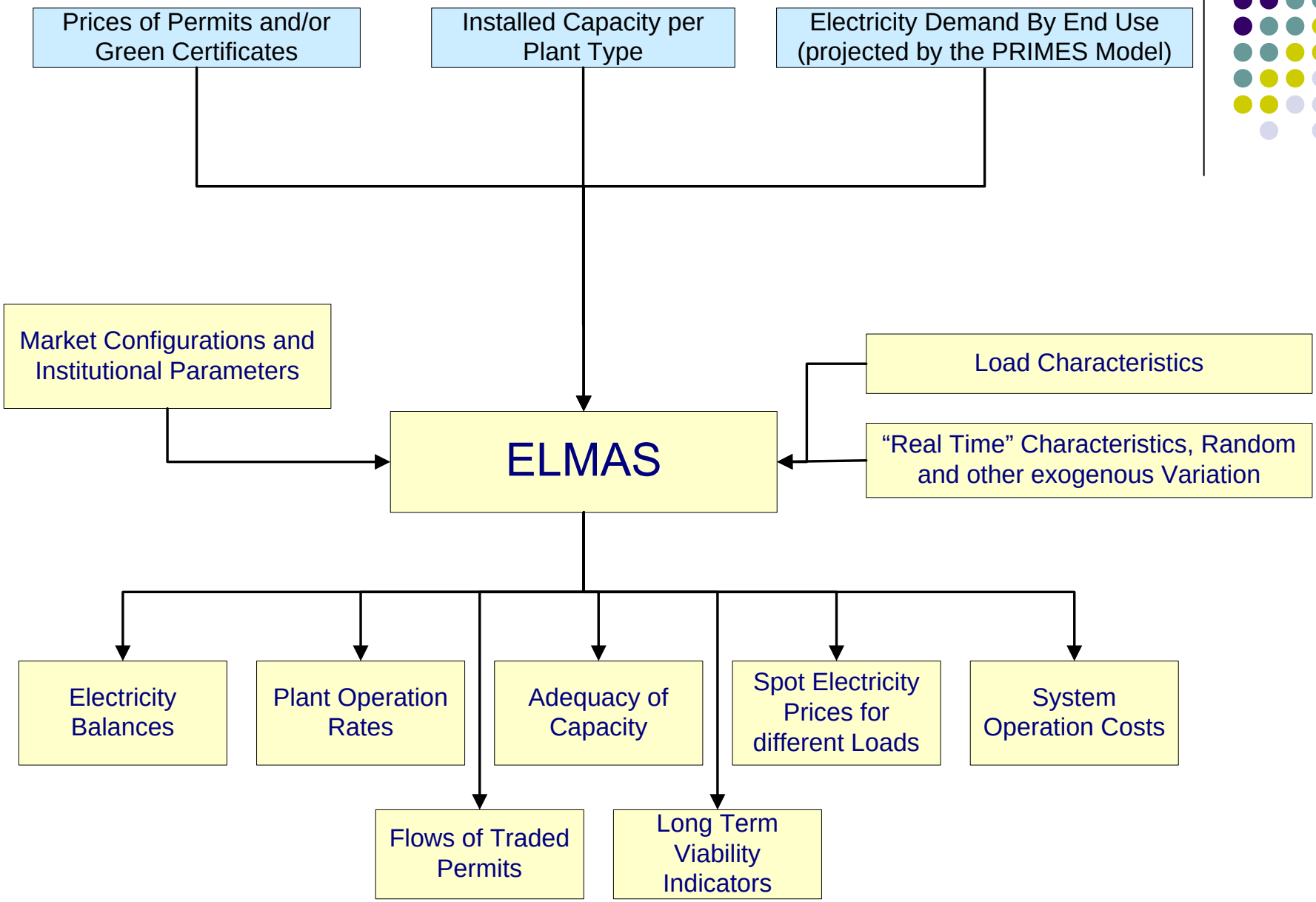


- In the context of the ETRES project NTUA has developed a high resolution (in terms of time) and detailed Electricity Market Simulator (ELMAS):
  - Necessary in view of imminent liberalisation of Greek electricity market:
    - Market structure will be radically different than present
    - This could be important for patterns of RES penetration with modifications in the policies promoting it.
  - Allows hourly load representation and individual plant and operator identification using detailed data obtained from actual operation

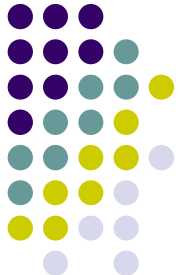
ELMAS Model of Greek electricity market operation



- The ELMAS model is a new tool (unique of this type in Greece) and is likely to interest many potential users within Greece especially in view of liberalisation, evaluation of potential for renewable sources, adequacy of power plant commitments, investment risks, and many issues regarding market regulation

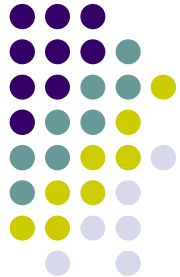

Prices of Permits and/or Green Certificates
Installed Capacity per Plant Type
Electricity Demand By End Use (projected by the PRIMES Model)
Market Configurations and Institutional Parameters
Load Characteristics
ELMAS
"Real Time" Characteristics, Random and other exogenous Variation
Electricity Balances
Plant Operation Rates
Adequacy of Capacity
Spot Electricity Prices for different Loads
System Operation Costs
Flows of Traded Permits
Long Term Viability Indicators

ELMAS Key Features



- It considers 43 electricity end uses, each with its own load characteristics.
- Capability of identifying individual plants (for major units) or meaningful classifications of smaller ones (e.g. wind power plants).
- A Nash type oligopolistic competition formulation adopted
  - Identifies individual players of different sizes and distinct capacity and cost structures.
- An equilibrium is generated
  - i.e. a point where any action by a player will lead to a deterioration of their profitability given the actions of competitors

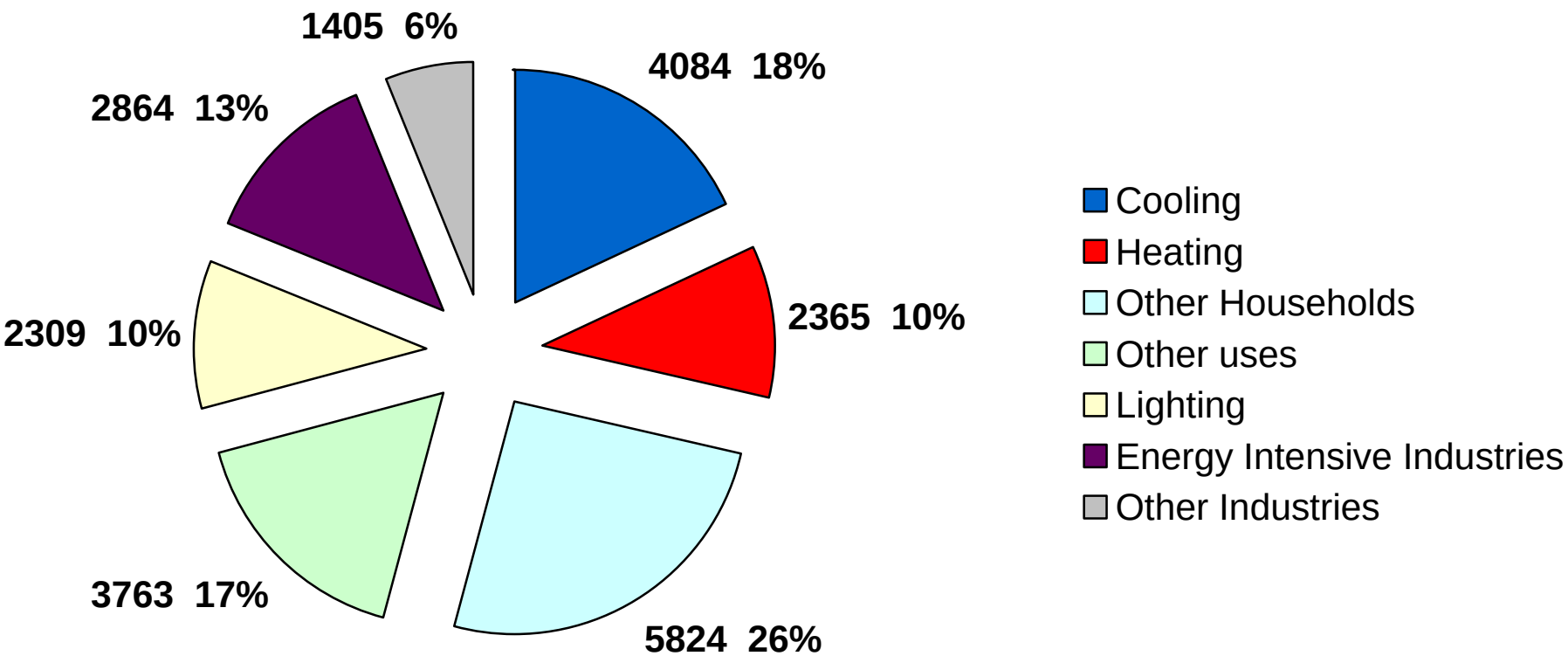
ELMAS Key Features (cont.)



- Size and cost structures are important:
  - Emergence of market leaders and effective price takers.
- Only “short-term” marginal conditions considered:
  - Long-term viability can be examined “ex-post”.

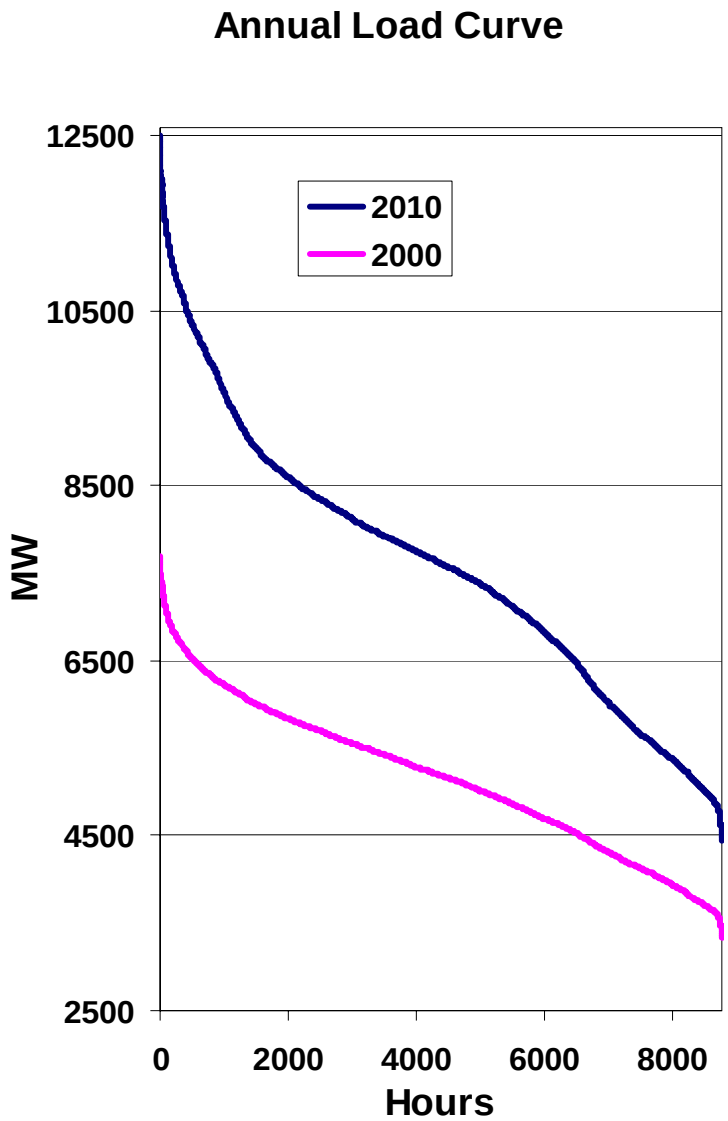
Demand projection for 2010

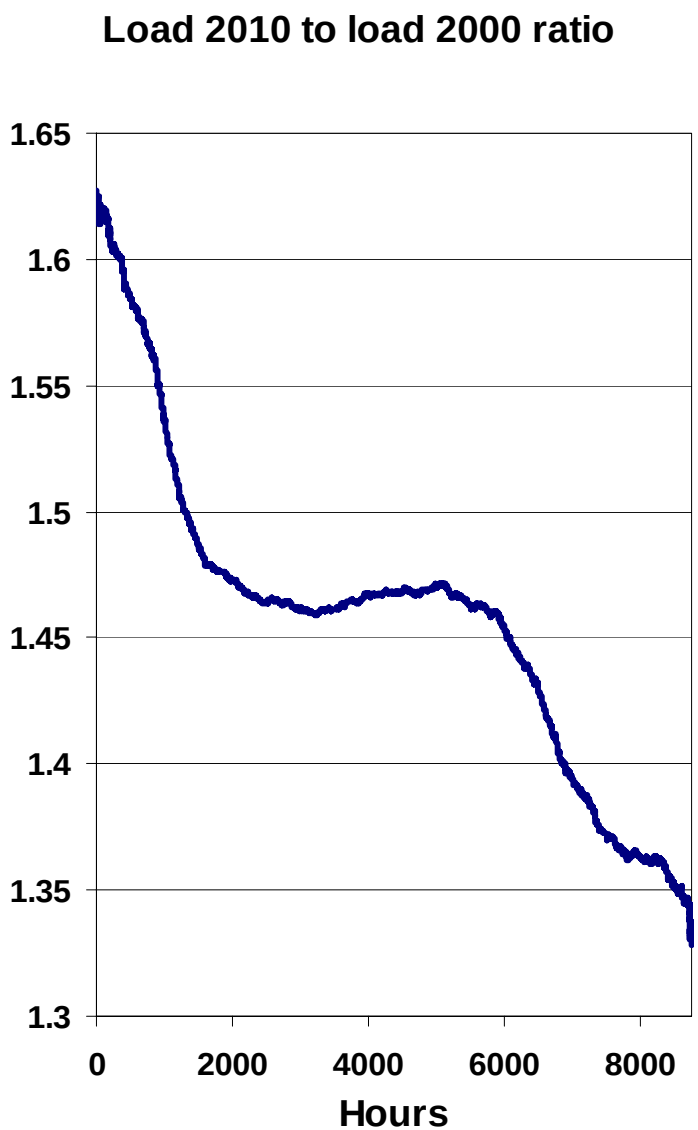
Demand increase from 2000 in GWh by use



¾ of the total demand increase is attributed to end uses that accentuate the peaking characteristics of the load

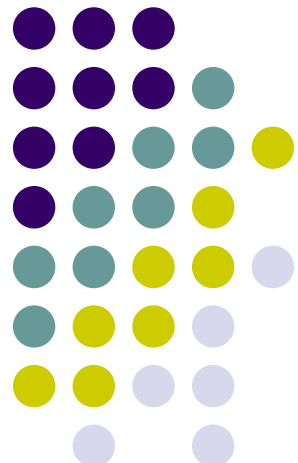
Changes in annual load



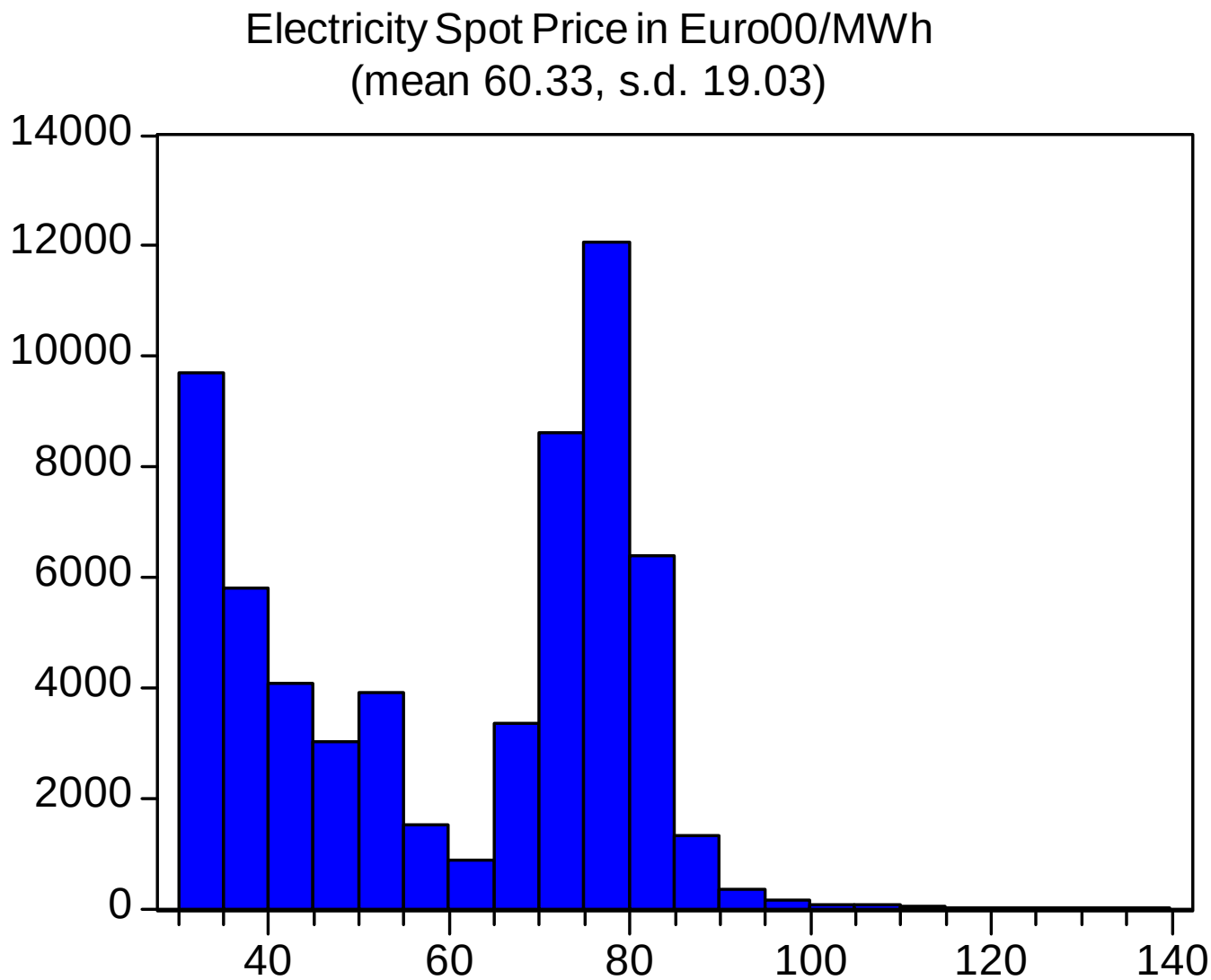


ELMAS Model of E3Mlab/NTUA

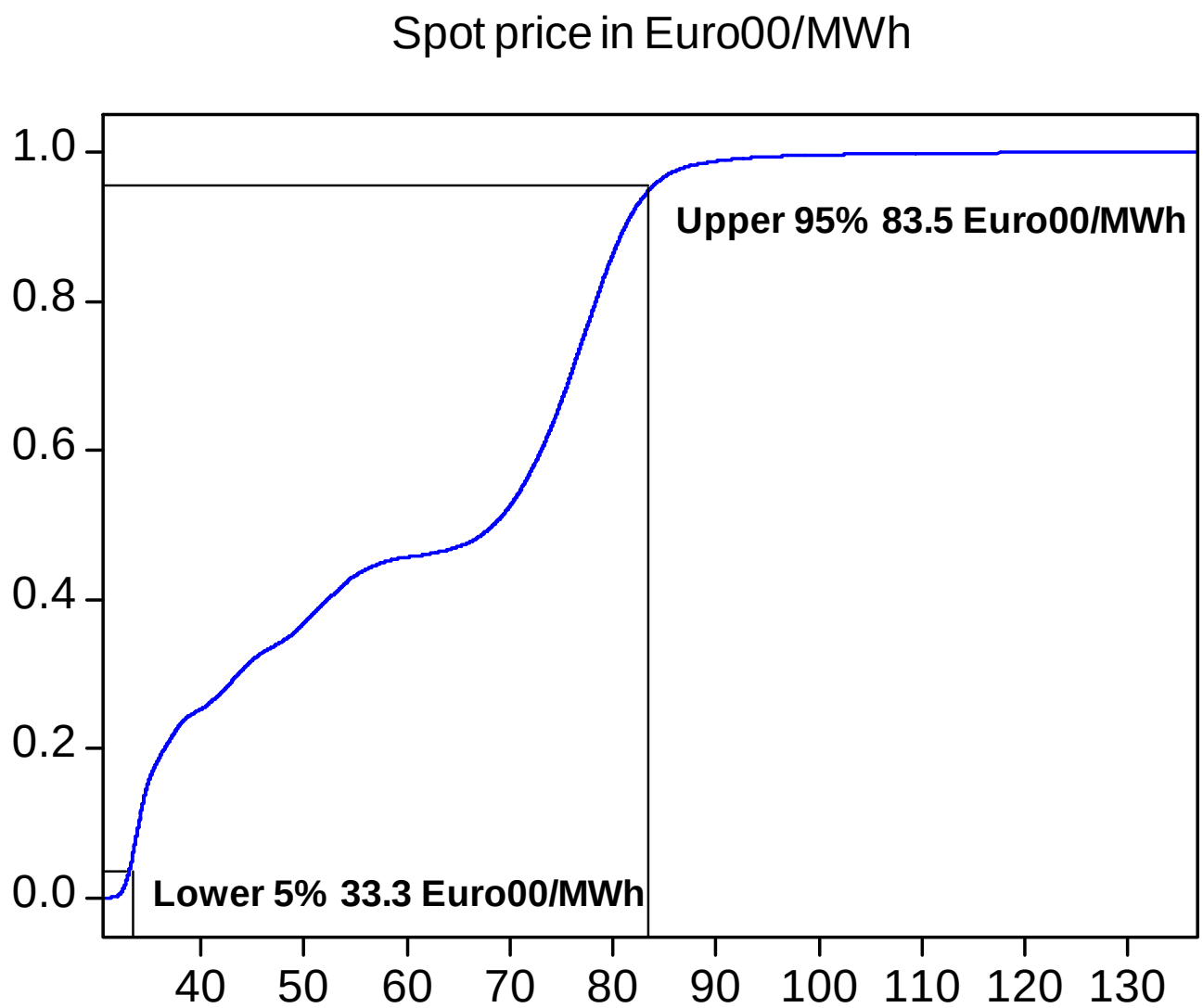
Results for 2010



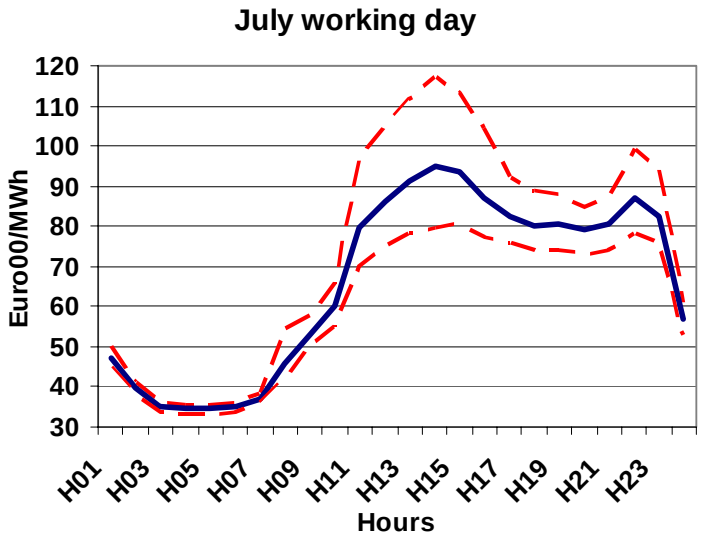
Spot price distribution in 2010

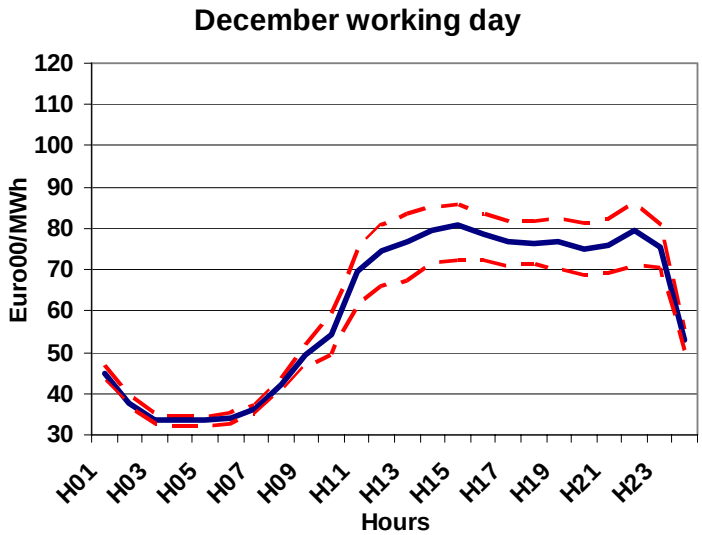


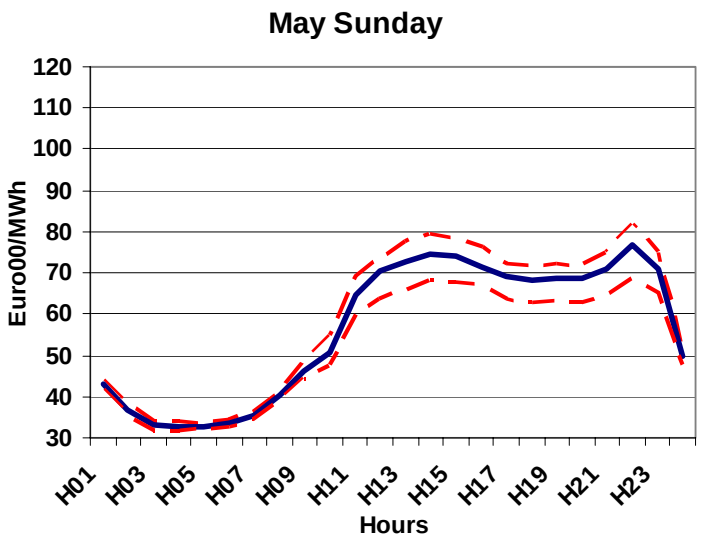
Spot price cumulative distribution

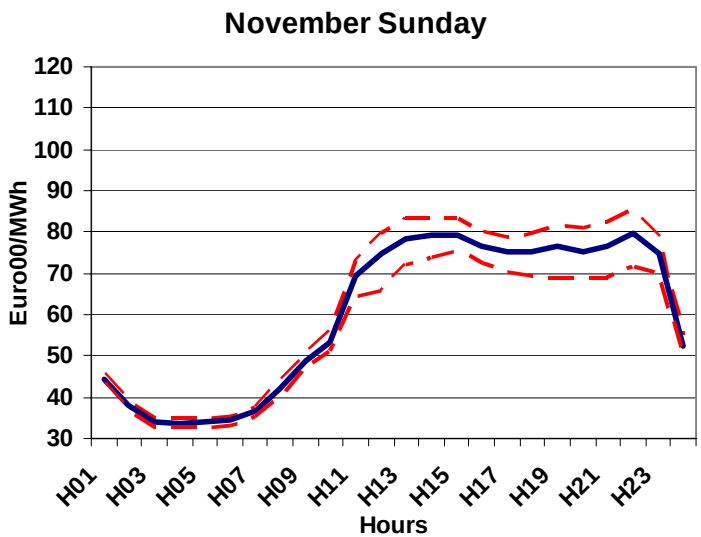


Spot price per hour in typical days in 2010

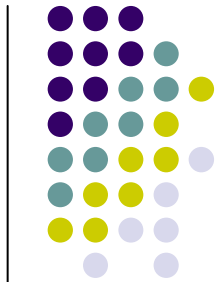






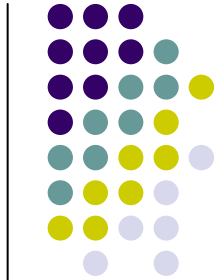


Simulating climate change policy to the Kyoto horizon



- Commission directive on permit trade
- Finalisation experiencing considerable delays
  - Role of “flexibility” instruments i.e. JI, CDM.
  - Provisional NAPs for trading sectors are too generous to these sectors. Casting doubts on:
    - Creation of market for trading sectors
    - Adequate policies and measures for non-trading sectors
- Finalisation of NAPs is not expected before mid 2005.
- Preliminary permit trade exercise assumes:
  - 10 Euro00/tn CO_2 permit price
  - No transaction costs (perfect permit market)
  - Free permit allocation according to grandfathering principle.

Description of Cases

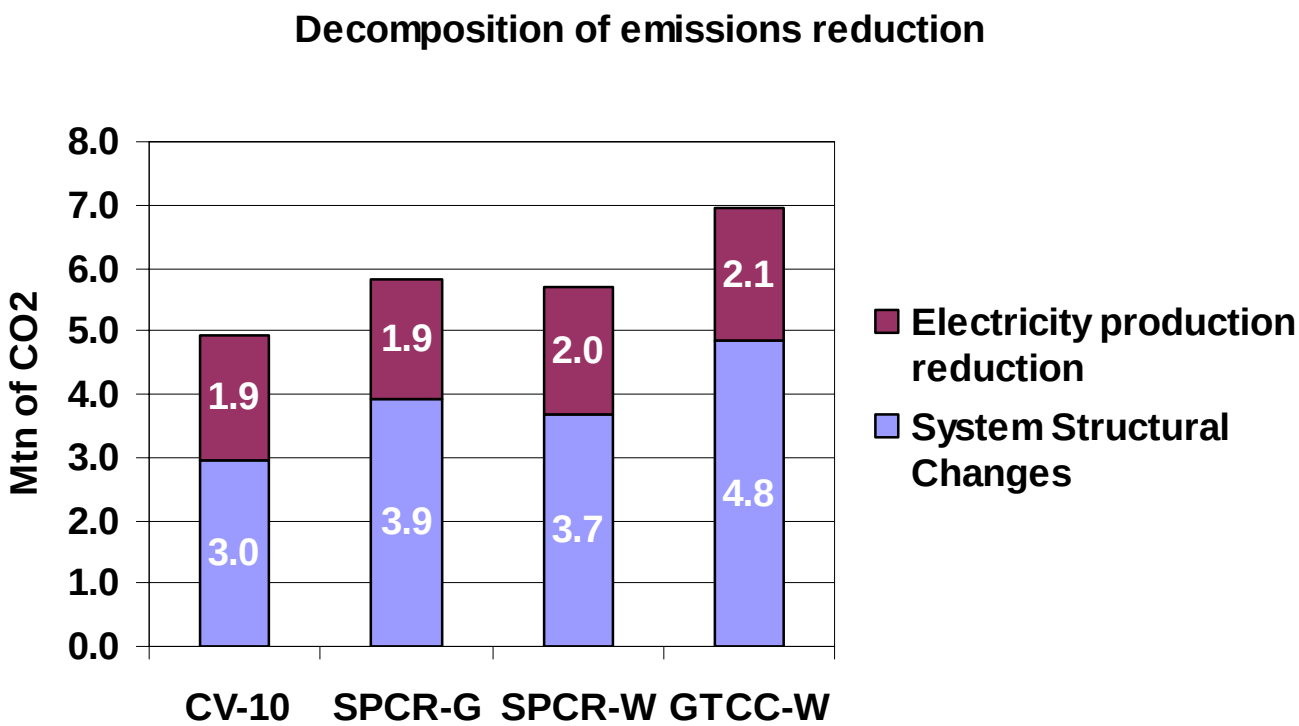


- Reference scenario; no explicit climate policy (REF)
- 10 Euro00/tn CO2 permit price without changes in capacity structures (CV-10)
- Canceling planned investment of 330MW supercritical lignite in Florina and replacing it with an additional 400MW GTCC (SPCR-G)
- Canceling planned investment of 330MW supercritical lignite in Florina and replacing it with 1400MW wind turbines (SPCR-W)
- Canceling planned investment of a 400MW GTCC and replacing it with 1400MW wind turbines (GTCC-W)

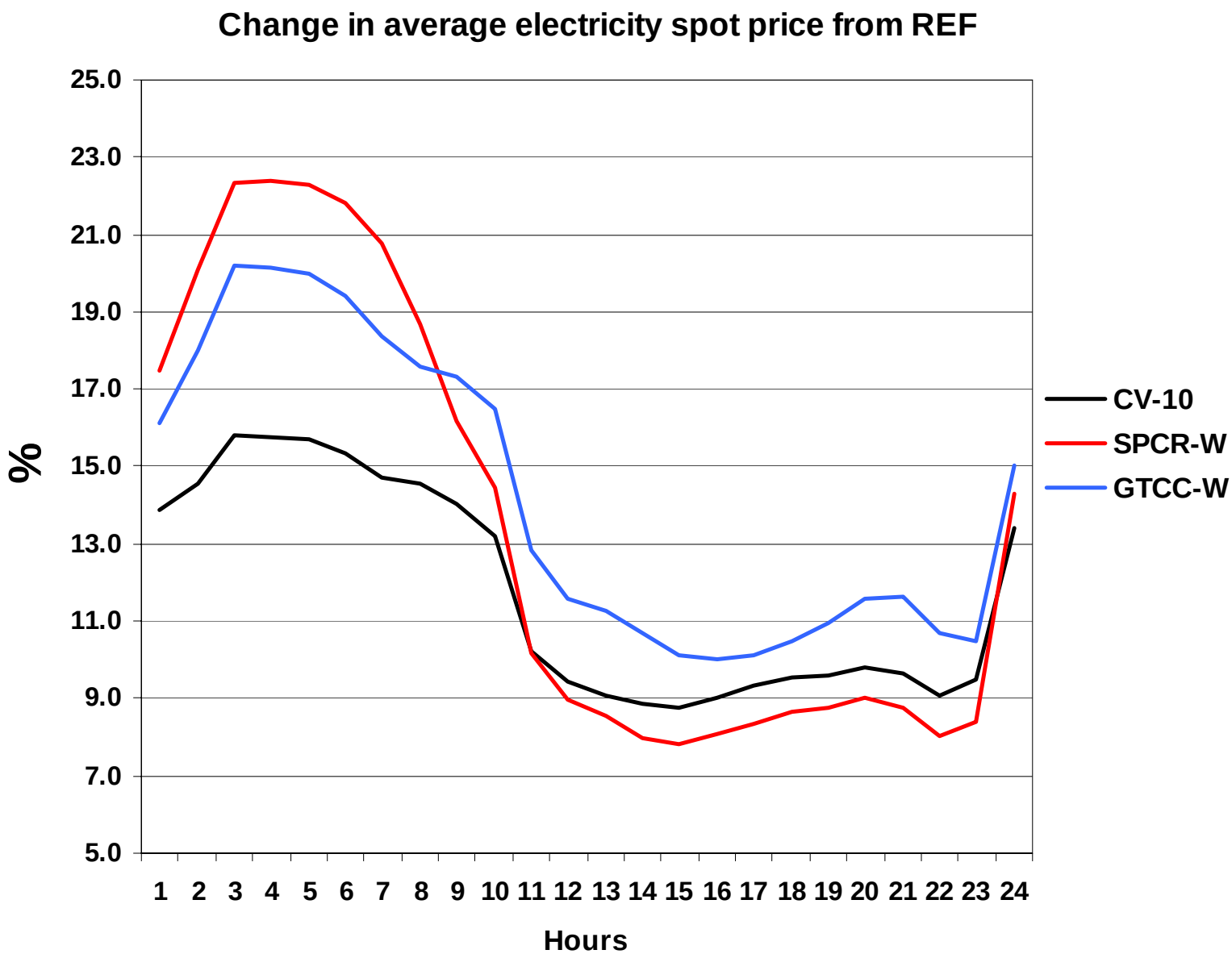
- Support to wind power assumed to be continued as in reference in all scenarios (passed to final consumer).
- Technical-economic characteristics:
  - Supercritical lignite (highly cost effective for base load supply):
    - Capital Cost: 1500 Euro00/Kw,
    - Efficiency: 45%
  - GTCC:
    - Capital Cost: 550 Euro00/Kw
    - Efficiency: 60%
  - Wind:
    - Average availability assumed unchanged in cases of high wind contribution

Results comparison (Overview)

		Changes from REF			
		CV-10	SPCR-G	SPCR-W	GTCC-W
Final Demand	(%)	-2.9	-2.9	-3.4	-3.6
Imports	(GWh)	766	745	617	595
Exports	(GWh)	-171	-166	-124	-141
Mean Electricity price	(Euro/MWh)	6.6	6.4	7.1	7.9
CO2 emissions	(Mtn)	-4.9	-5.8	-5.7	-6.9



Results comparison (Prices)



Results Comparison (Wind)

Probability of exceeding certain thresholds in spot electricity price

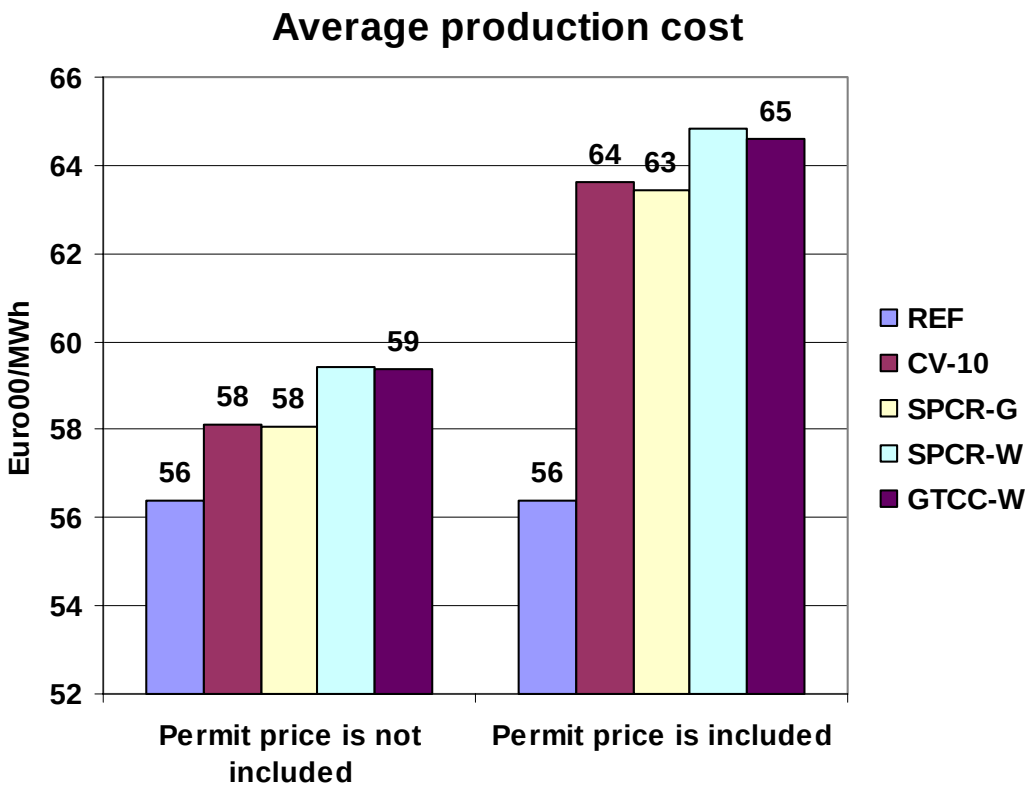
(prices are expressed in Euro00/MWh)

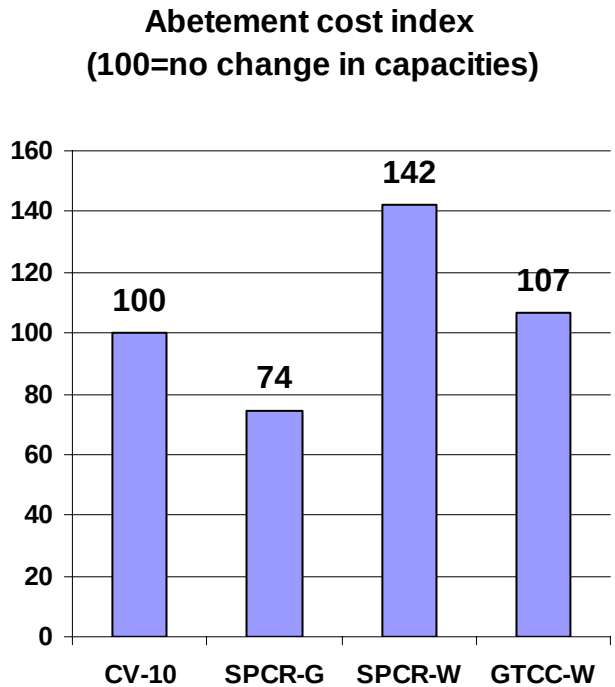
	April (13h-18h)			Summer (11h-23h)	
	SPCR-G	GTCC-W		SPCR-G	GTCC-W
<70	3	9	>90	31	50
<75	26	31	>100	4	7

Wind speed variability tends to introduce additional variability is spot prices due to the increased reliance on wind power.

When some of the highest demand loads occur, a combination of high dependence on wind capacity and atmospheric calm accentuates some of the most extreme spot price events

Change in system cost





Conclusions

- The model is operational and tested
- Uncertainty is important for insights
- Market competition matters for results
- Unit elasticity for carbon abatement
- Importance of high efficient solid fuel power
- Apparent conflict between gas and wind (Slutsky type effect)
- Major trade-off between environment-cost
- Model ready to run sophisticated scenarios