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The impact of the EU ETS on electricity prices

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Workshop “Ex-post analysis of the EU Emissions Trading Scheme”,
University of Vigo, November 16, 2007

Introduction

- Review process of EU ETS
- EC/DG Environment: 3 input studies:
  - NERA, ENTEC and ECN
- ECN study: “The impact of the EU ETS on electricity prices”
- Purpose of presentation:
  - Discuss analytical approaches and major results of study

- Qualifications:
  - Preliminary results (not for public dissemination)
  - Views expressed are personal and not necessarily those shared by EC/DG Environment

Objectives of ECN/DG ENV study

- Analyse interlinkages between EU ETS with fuel and power markets, in particular carbon cost pass-through to electricity prices in 2005 and 2006.

- Evaluate policy options to reduce “unintended” side effects of carbon cost pass-through (such as ‘windfall profits” to producers or “competitive losses” to power-intensive industries).

Analytical approaches to reach study objectives

1. Theoretical analyses (i.e. chapter 4 of final report)
2. Literature analyses (chapter 5)
3. Empirical & statistical analyses (chapter 6)
4. Model (COMPETES) analyses (chapter 7)
5. Policy analyses (chapter 8)

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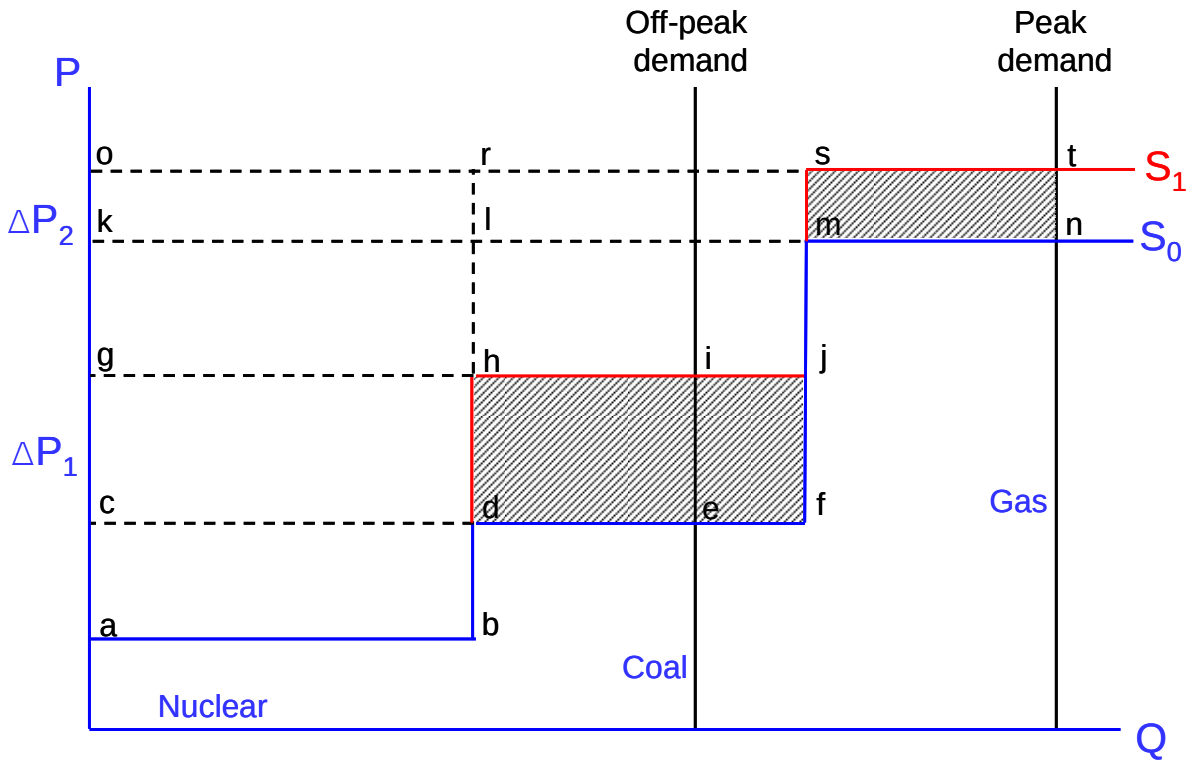
Theoretical analyses

Reference case (for both theoretical, empirical-statistical and model analyses)



Change in power prices and generators profits due to emissions trading for different load periods and production technologies

Major assumptions of reference case

- Supply curve: few (standard) technologies, no changes in the merit order, static (no plant closures or new entrants)
- Demand curve: inelastic; only two load periods
- Allocation: auctioning or perfect grandfathering
- Price setting: full competition, perfect markets, no regulation, prices are set by variable (fuel, carbon) costs of marginal technology
- Profit maximization

Impact of allocation on power prices

- Auctioning or *perfect* grandfathering: same effect on output prices (and efficiency): pass-through of opportunity costs to power prices (i.e. *primary price increasing/taxing effect of emissions trading, regardless allocation of allowances)*
- EU ETS, however, is characterised by *imperfect* grandfathering, i.e. (i) updating allocation to incumbents, (ii) contingent allocation ('closure rules') and (iii) free allocation to new entrants.
- Implications of these allocation provisions: power prices are reduced (*secondary,* price *decreasing/subsidizing effects of allocation), depending on:*
  - The expected value of the allowances concerned
  - The (long-run) price responsiveness of power demand
  - The flexibility of the CO2 budget (i.e. JI/CDM credits)
  - The harmonisation of the allocation provisions
  - The technology bias of the allocation system

Other factors affecting CO_2 cost pass-through to power prices

- Market structure (full competition, oligopoly, monopoly)
- Market regulation
- Market imperfections
- Changes in merit order
- Other strategies besides profit maximization

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Literature analyses

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Summary overview of empirical studies on impact of EU ETS on power prices

Study	Country	Market	Period	PTR (%)
Bauer and Zink (2005)	DE	Forward	Jan-June 2005	100
Bunn and Fezzi (2007)	UK	Spot	2005	42
Chernyavs'ka and Gulli (2007)	IT	Spot	2005 2006	0 -50 to 200
FE (2006)	NL	Forward	2005	4 to 108
Honkatukia et al (2006)	Finland	Spot	Feb. 05 - May 2006	75 to 95
Levy (2005)	FR, DE, IT, ES, UK	Spot	Jan-June 2005	-180 to 220
Riechmann et al (2006)	UK, NL, Scandinav.	Forward	2005	89-98
Sijm et al. (2005, 2006a and 2006b)	DE, NL DE	Forward Spot	2005 2005	39-117 50-250

Major findings of empirical studies

- Significant pass-through of carbon costs to power prices is confirmed for:
  - Forward markets (2005): Germany, the Netherlands, the UK, and Scandinavian countries
  - Spot markets: Italy (2006) and Finland (2005-2006)

- Empirical estimates of pass-through rates vary widely depending on:
  - Country concerned
  - Markets analysed (spot/forward; peak/off-peak)
  - Period considered
  - Data used
  - Assumptions and estimation method applied

Summary overview of model studies on impact of EU ETS on power prices

Study	Country	Model	CO_2 price	Pass-through
IPA (2005)	UK	Dynamic	15-25	5-16 €/MWh
Kara et al. (2006)	Finland	Static	20	15 €/MWh
Linares et al. (2006)	Spain	Dynamic	7-15	3-5 €/MWh
Oranen (2006)	Nordpool	Static	20	8-578%
Sijm et al. (2005 and 2006b)	DE, FR, Nl, BE	Static	20	1-19 €/MWh (60-80%)
Linboe et al. (2007)	Germany, Nordpool	Dynamic	Free allocation to new entrants results in lower power prices, higher emissions, higher social costs and other distortions	
Hobbs et al. (2006); Zhao et al. (2007)	US	Dynamic		

Major findings of model studies

- Common assumption: generators pass on full opportunity costs of CO_2 (i.e. Pass-Through Rate is 100%)

- Actual PTR is usually lower than 100% depending on:
  - Market structure
  - Demand elasticity
  - Fuel mix (marginal technology)
  - Load period
  - Free allocation to new entrants
  - Model assumptions and data used

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Empirical & statistical analyses

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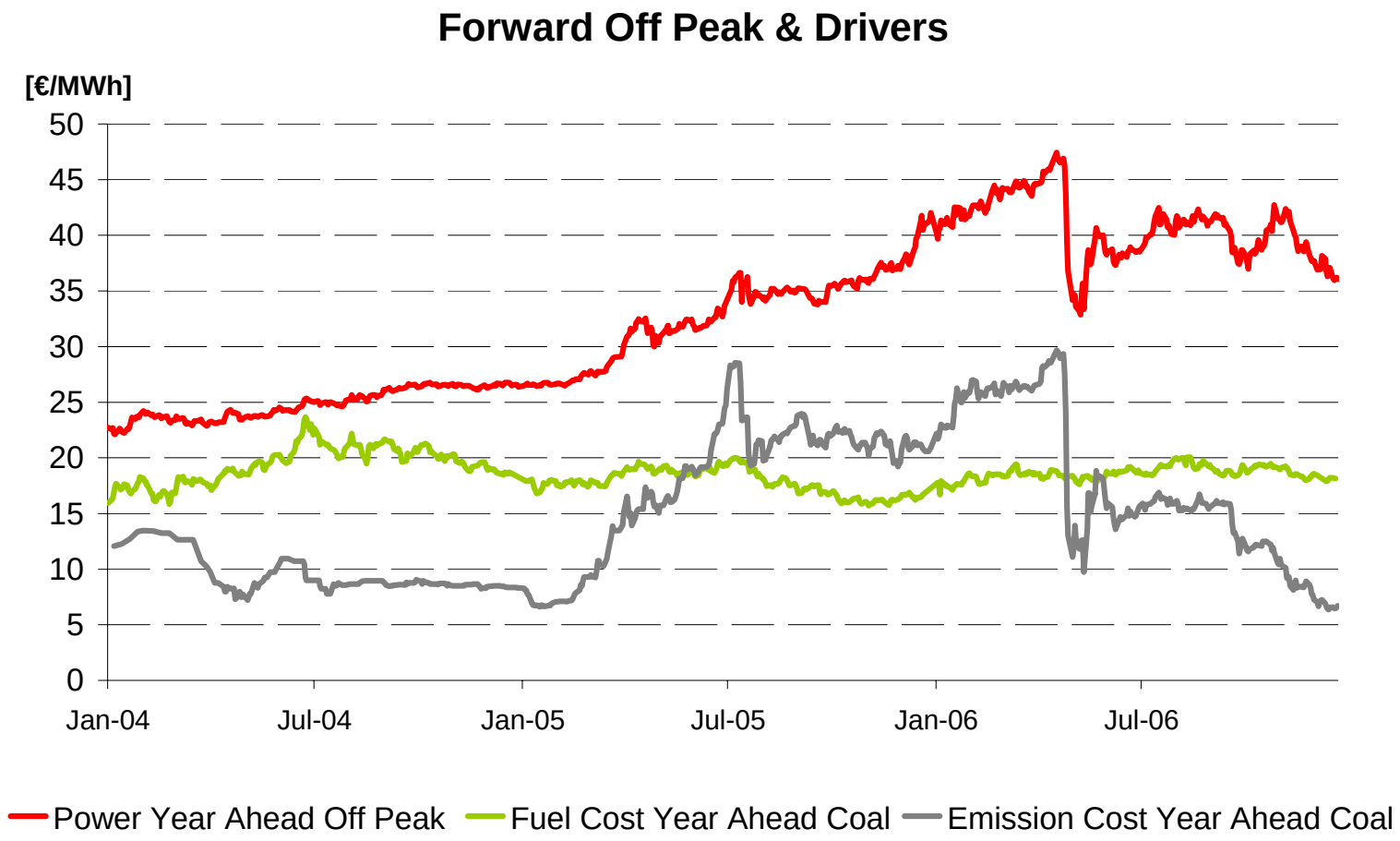
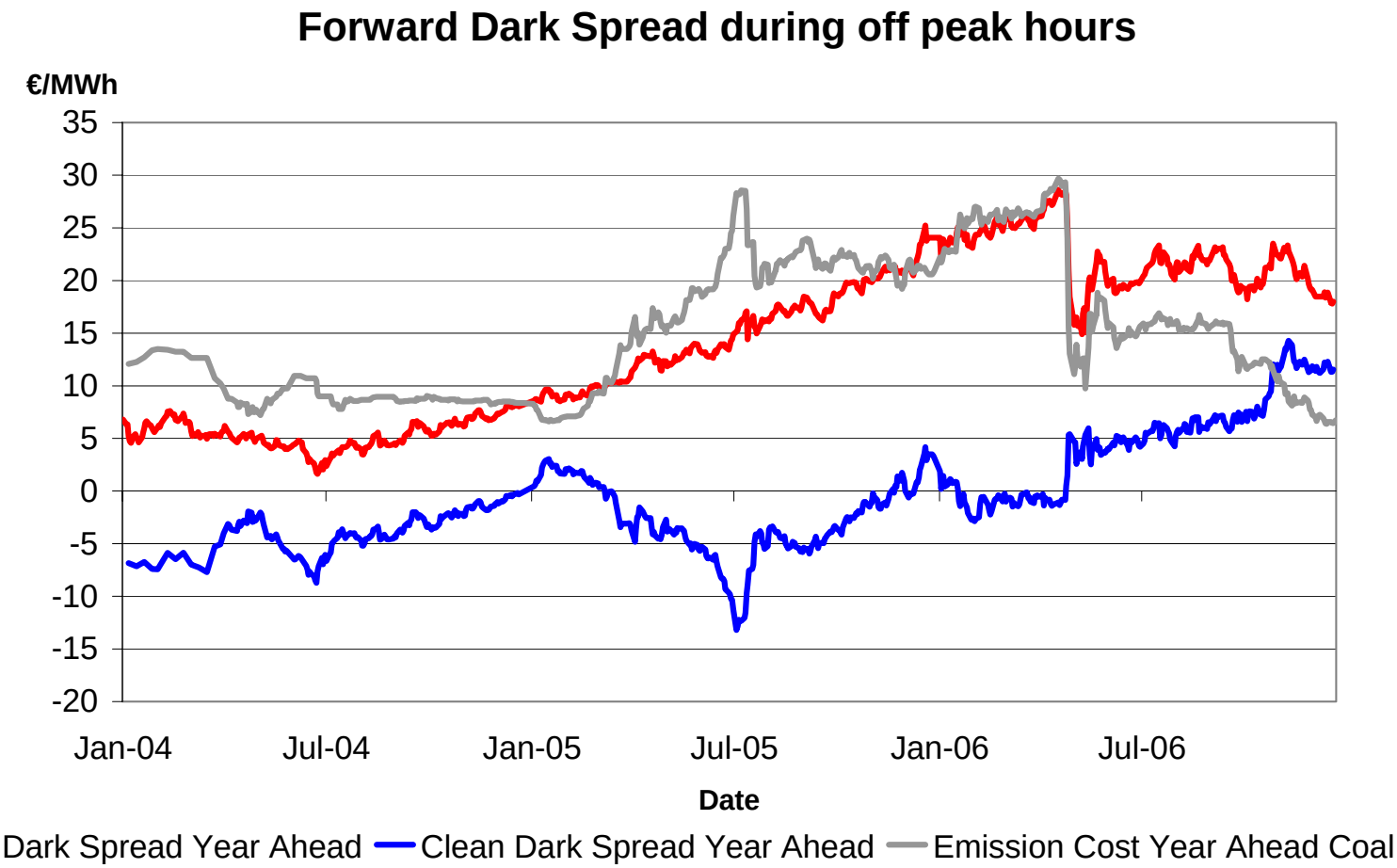
Coverage & type of analyses

- Coverage:
  - 9 EU ETS countries: FR, DE, IT, PL, ES, SE, CZ, NL and UK
  - Wholesale markets:
    - Spot & forward (i.e. year-ahead)
    - Peak & off-peak
  - Retail markets:
    - Households
    - Power-intensive industries
  - 2005 and 2006 (compared to 2004)
- Type of analyses:
  - Trends in power prices and fuel/carbon costs
  - Trends in (clean) power spreads
  - Estimates of carbon cost pass-through rates

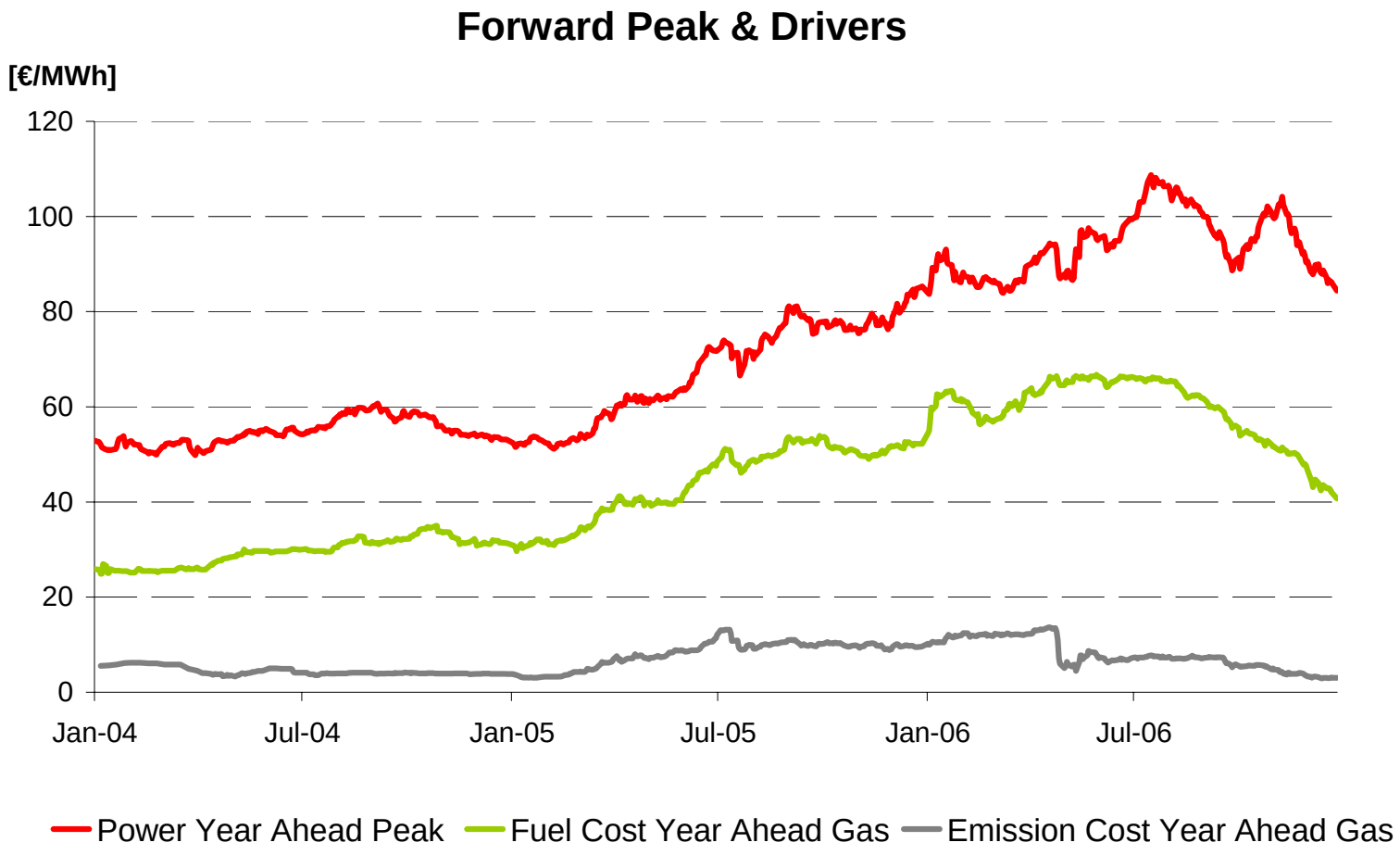
Germany: trends on fuel, carbon and power markets (Year-ahead, off-peak, 2004-2006)



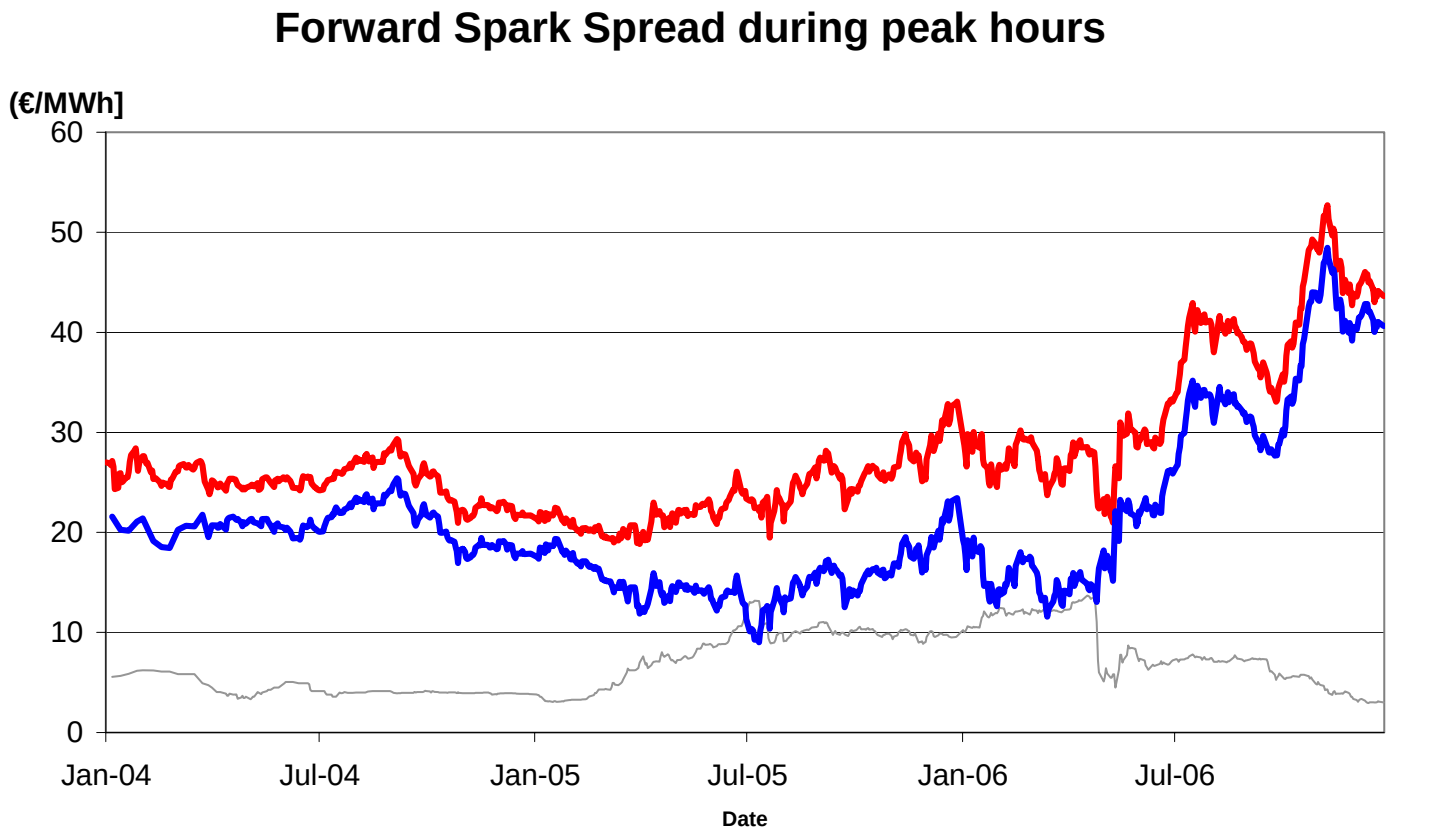
Germany: trends in power spreads & emission costs (Year-ahead, off-peak, 2004-2006)



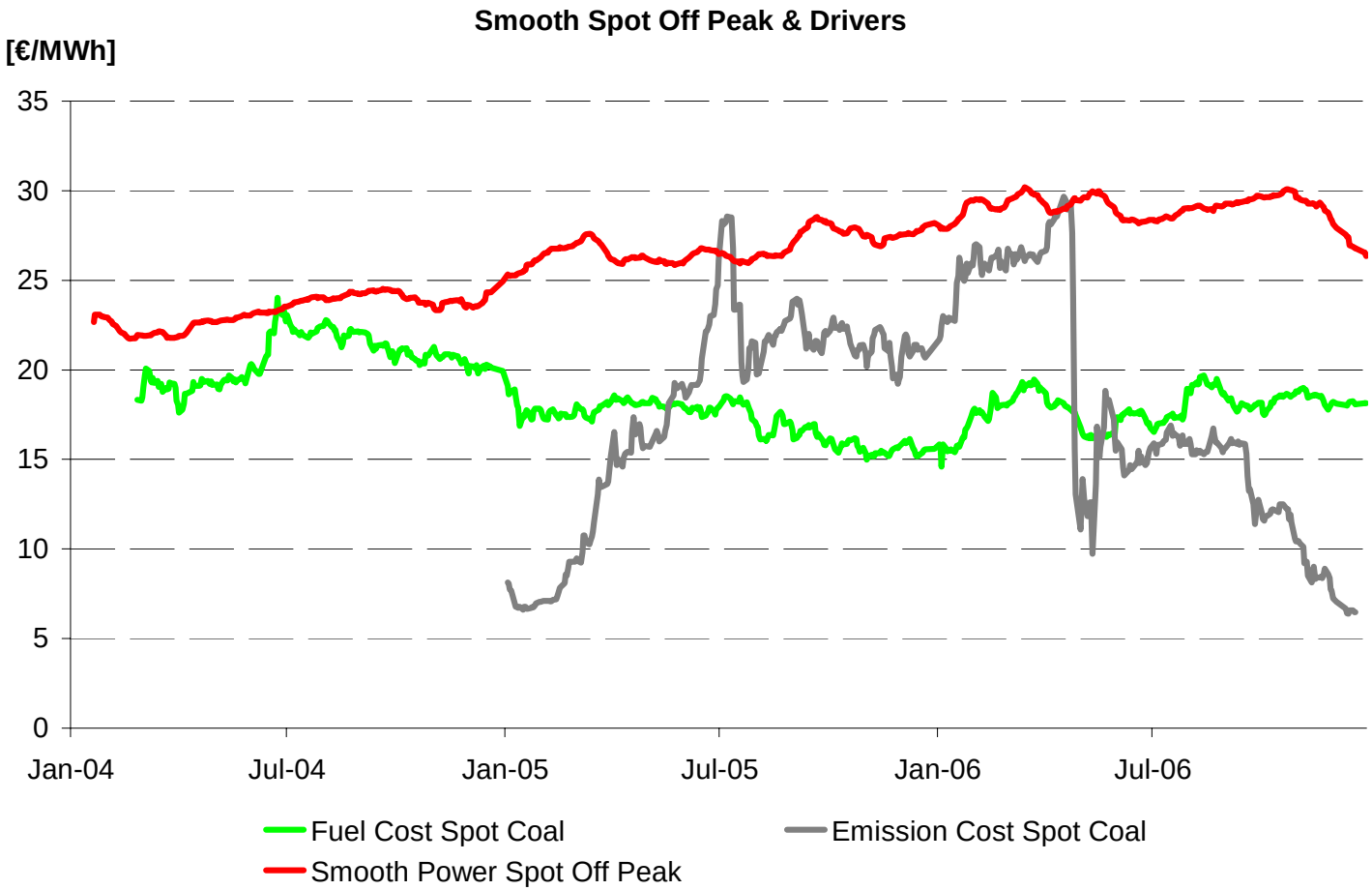
The Netherlands: trends on fuel, carbon and power markets (Year-ahead, peak, 2004-2006)



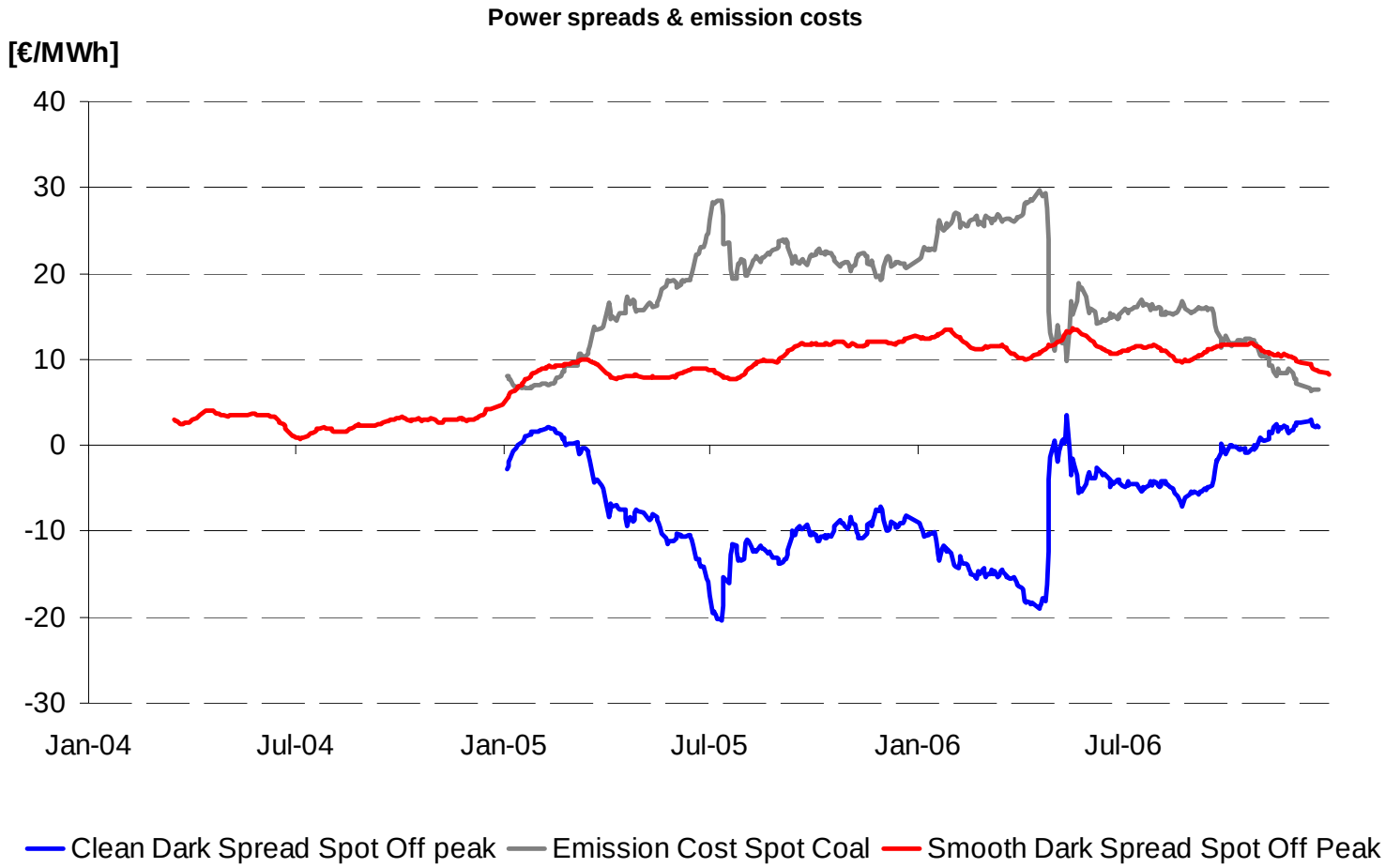
The Netherlands: trends in power spreads & emission costs (Year-ahead, peak, 2004-2006)



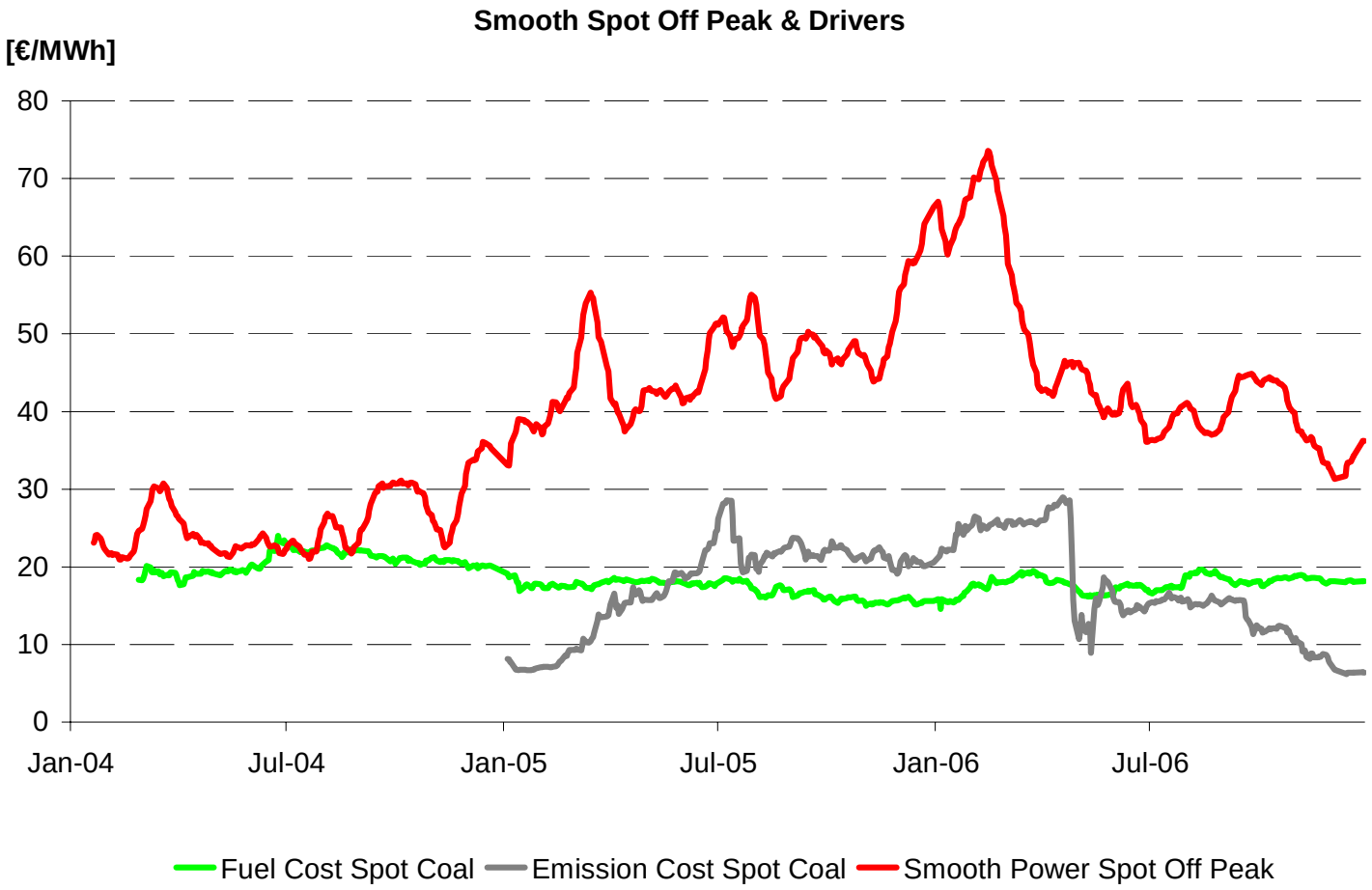
Poland: trends on fuel, carbon and power markets (spot, off-peak, 2004-2006)



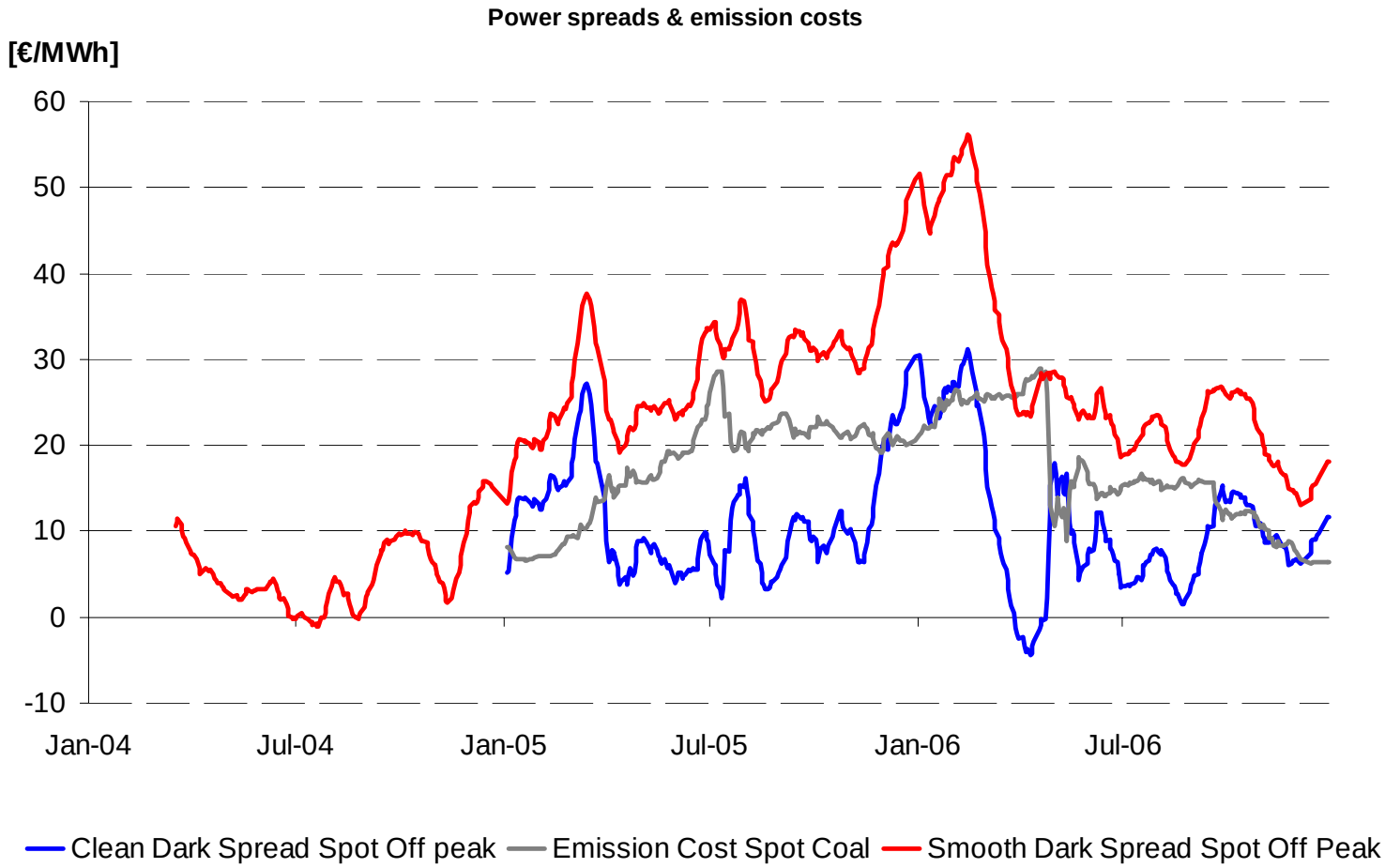
Poland: trends in power spreads & emission costs (Year-ahead, off-peak, 2004-2006)



Spain: trends on fuel, carbon and power markets (spot, off-peak, 2004-2006)



Spain: trends in power spreads & emission costs (Year-ahead, off-peak, 2004-2006)



All EU9 countries analysed: trends on fuel, carbon and power markets (2004-06)

- Significant increases in forward power prices and (dark) spreads, notably for peak products between early 2005 and mid-2006.
- Similar trends on spot markets, although less clear due to high volatility of spot prices.
- Increases in forward prices between early 2005 and mid-2006 are due to increases in fuel costs (gas/oil) and carbon costs (notably in case of coal).
- Link between spot prices and fuel/carbon costs is less clear due to other factors affecting spot prices.
- Over short periods the link between carbon and power prices is rather clear (notably March-July 2005 and April-May 2006).
- Over longer periods, this link is less clear due to other factors affecting power prices.

Estimating pass-through rates (PTRs)

- Basic assumptions:
  - During the observation period (e.g. ‘peak 2005’), changes in power prices are primarily due to changes in fuel/carbon costs.
  - Pass through of fuel costs is 100%

- Basic regression equation:

$$Y_t = (P_t - F_t^{c,g}) = \alpha + \beta_1 CO2_t^{c,g} + \varepsilon_t$$

- Data used:
  - Hourly/daily prices of power, fuel and carbon markets
  - Tests for stationarity
- Estimation method:
  - Ordinary Least Squares (OLS)

Forward markets: estimates of pass-through rates (2005-2006)

	FR	DE	SE	NL	UK winter	UK summer
2005						
Peak	0.66	0.60	Na	1.34	2.28	1.87
Off-peak	0.40	0.41	Na	0.40	1.82	1.03
Base	Na	Na	0.53	Na	Na	Na
2006						
Peak	0.58	0.57	Na	1.10	1.36	1.38
Off-peak	0.59	0.64	Na	0.38	0.66	0.60
Base	Na	Na	0.62	Na	Na	Na

Note: all estimates are statistically significant at 1% level.

Forward markets: major findings on estimated pass-through rates (PTRs)

- All 22 estimates are statistically significant at 1% level.
- Most (14) PTRS range between 36 and 66%, while 5 estimates are slightly above 1.0 (between 103 and 138%).
- Relatively low or high PTRs can be explained by the data, methodology and/or assumptions applied, notably:
  - One single price-setting technology per load period
  - Generic fuel efficiencies
  - Other factors besides fuel/carbon costs affect changes in power prices.
- Nevertheless, overall conclusion: carbon costs are passed through (fully) by power producers on all forward markets analysed (in FR, DE, SE, NL and UK), but it is very hard to estimate exact, unbiased PTRs and, hence, these rates have to be interpreted with due care.

Spot markets: basic estimation approach

- Basic approach: similar to forward market estimates (one technology; generic fuel efficiencies, power prices are carbon/fuel cost-driven).
- In general, first-try PTR estimates were not satisfactory (see table next slide):
  - Only 17 out of 36 estimates are statistically significant at 10% level.
  - 13 out of 36 estimated PTRs lie outside the range of -0.5 and 1.5 (notably for peak products).
- Results can be explained by:
  - Spot prices are set by a variety of technologies (with specific fuel efficiencies)
  - Spot prices are often set by other factors than fuel/carbon costs.

Spot markets: first-try estimates of pass-through rates (2005-2006)

	FR	DE	IT	PL	ES	SE	CZ	NL	UK
2005									
Peak	1.96*	1.76*	-1.71*	0.06	2.36	0.48*	1.50*	1.92	3.70*
Off-peak	0.98*	0.82*	1.80	0.09	0.67	0.35*	0.44*	0.19	0.70
2006									
Peak	1.18*	0.92*	-0.88*	-0.04	-1.66*	0.44	-0.71	0.68*	0.98
Off-peak	0.75*	0.86	-2.88	0.00	-1.24	0.82*	-0.27	1.21	1.53

Note: estimates with a star (*) are statistically significant at 10% level.

Spot markets: alternative estimation approaches

- Alternative approaches:
  - Multi/variable technology approach
  - Multi/differentiated period approach
  - Data outlier approach
- While results of the multi technology/period approaches turned out to be less successful than expected, the estimated PTRs of the data outlier approach proved to be promising (“work in progress”).
- Overall (preliminary) conclusion: carbon costs are passed through (fully) on all spot markets analysed, except Poland, while estimates for Italy and Spain are (still) inconclusive.

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Model analyses

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Major characteristics/advantages of COMPETES model

- Detailed, static simulation model of wholesale power market, including (i) all major EU ETS countries, (ii) all major generation technologies, and (iii) 12 different load periods.
- Model enables to analyse the impact of different factors on pass-through of carbon costs to power prices at different CO_2 prices. These factors include differences in (i) market structure, (ii) fuel mix/switch, and (iii) demand responsiveness, at different carbon prices (i.e. 20/40/80 €/t).
- Other advantages of COMPETES model:
  - Analyse impact of EU ETS on carbon emissions, differentiated by changes in supply (dispatch) and demand
  - Analyse impact of EU ETS and allocation (auctioning versus grandfathering) on generators profits.

Major results of COMPETES analyses (1)

- **Scenario**: perfect competition, no demand response, 2006 data calibration (including carbon price of 20 €/tCO_2)
- **Change in power prices**:
  - EU-20: +13 €/MWh (Hungary-Poland: 9-19 €/MWh)
  - EU-20: +29% (Portugal-Poland: 17-82%)
- **Pass-through rate**:
  - Marginal: EU-20: 93% (UK-Italy: 56-122%)
  - Average: EU-20: 176% (Poland-France: 118-363%)
- **Changes in generators' profits**:
  - Due to ETS-induced price changes ("Windfall A"): +16 bn € (+22%)
  - Due to free allocation ("Windfall B"): +20 bn € (+27%)
  - Total ("Windfall profits A + B): +35 bn € (+49%)
- **Reductions in CO_2 emissions (all 20€/t scenarios)**:
  - Due to fuel switch (dispatch): 81-133 MtCO2
  - Due to demand response: 0-82 Mt CO2
  - Total: 112-215 MtCO2 (i.e. 10-20% of reference emissions)

Major results of COMPETES analyses (2)

- **Scenario**: perfect competition, no demand response, 2006 data calibration (including carbon price of 40 €/tCO_2)
- **Change in power prices**:
  - EU-20: +27 €/MWh (Hungary-Poland: 19-38 €/MWh)
  - EU-20: +29% (Portugal-Poland: 40-164%)
- **Pass-through rate**:
  - Marginal: EU-20: 93% (UK-Italy: 78-111%)
  - Average: EU-20: 190% (Poland-France: 121-374%)
- **Changes in generators' profits**:
  - Due to ETS-induced price changes ("Windfall A"): +37 bn € (+42%)
  - Due to free allocation ("Windfall B"): +39 bn € (+31%)
  - Total ("Windfall profits A + B): + 75 bn € (+70%)
- **Reductions in CO_2 emissions (all 40€/t scenarios)**:
  - Due to fuel switch (dispatch): 123-165 MtCO2
  - Due to demand response: 0-198 Mt CO2
  - Total: 165-321 MtCO2 (i.e. 15-33% of reference emissions)

Major results of COMPETES analyses (1)

- **Scenario**: oligopolistic competition, 0.2 price elasticity, 2006 data calibration (including carbon price of 40 €/tCO_2)
- **Change in power prices**:
  - EU-20: +21 €/MWh (Belgium-Poland: 9-38 €/MWh)
  - EU-20: +31% (Belgium-Poland: 7-164%)
- **Pass-through rate**:
  - Marginal: EU-20: 71% (Denmark-Poland: 51-100%)
  - Average: EU-20: 163% (Belgium-France: 85-394%)
- **Changes in generators' profits**:
  - Due to ETS-induced price changes ("Windfall A"): +17 bn € (+14%)
  - Due to free allocation ("Windfall B"): +29 bn € (+19%)
  - Total ("Windfall profits A + B): +47 bn € (+33%)
- **Overall findings:**
  - Pass through, windfall profits and emissions reductions are higher under (i) perfect competition (compared to oligopolistic competition) and (ii) low demand responsiveness to price changes

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Policy analyses

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Policy considerations

- Arguments pro CO_2 costs pass-through:
  - In line with economic theory and normal business practices
  - Contributes to reaching carbon reductions at the lowest social costs (efficiency)

- side-effects" of pass-through:
  - Higher (windfall) profits to power producers due to (A) higher power prices, notably benefiting non- (or low-)fossil generators, and (B) free allocations of allowances, particularly benefiting (high) fossil producers.
  - Higher power prices for large-scale, energy-intensive, internationally competing industries (loss of competitiveness, less domestic output, carbon leakage).
  - Higher power prices for households and other small-scale, low-income consumers (adverse distributional effects, double taxation).

Options to address ‘side effects’

- Options to change the allocation system:
  - Indirect (free allocation)
  - Auctioning (+ recycling)
  - Benchmarking (+ relative cap)
- Other options:
  - Profit taxation (+ recycling)
  - Price regulation (wholesale, retail, carbon markets)
  - Reducing carbon prices (lower cap; JI/CDM inflows)
  - Encouraging power market competition
  - State aid to energy-intensive industries (EIIs)
  - Promoting EII’s strategies (energy saving, cogeneration)
  - Border tax adjustments
  - Long term options (global climate regime; innovations)

Policy option	Intended effect		Other effects/comments	Feasibility
	Power price	Windfall profits (A/B)		
1. Indirect (free) allocation	No	No (A) Yes (B)	•Compensates (only) covered EIIs •Double compensation •Perverse power use effects	•Questionable
2. Auctioning + recycling	No	No (A) Yes (B)	•Most efficient price signal •Recycling: compensation + other benefits •(Adverse) effects on industrial competitiveness	•Sheltered sectors: feasible •Other sectors: questionable
3. Relative benchmarking / output-based allocation	Yes	Yes (A/B)	•Less environmental certainty •Less efficient •Administrative demanding	•Sheltered sectors: questionable •Other sectors: feasible
4. Taxation + recycling	No	Yes (A/B)	•Recycling: compensation + other benefits •Hard to determine exact windfall profits •Tax both categories of windfall profits?	•Hard to implement

Policy option	Intended effect		Other effects/comments	Feasibility
	Power price	Windfall profits (A/B)		
5. Price regulation: - wholesale - retail - carbon	 Yes Yes Yes	 Yes (A) No (B) Yes (A) No (B) Yes (A/B)	•Against market liberalisation •Risks of market disruption •Less environmental effectiveness	•Questionable
6. Reducing CO_2 price - lower cap - more JI/CDM	 Yes Yes	 Yes (A/B) Yes (A/B)	•Less (domestic) emission reductions •Less dynamic efficiency (?)	•Feasible
7. Encouraging power sector competition	No	No	•Paradox: more competition may reduce oligopolistic pricing/profits, but increase CO_2 cost pass through and ETS induced windfall profits	•Difficult, feasible, but not effective to address EU ETS adverse effects

Policy option	Intended effect		Other effects/comments	Feasibility
	Power price	Windfall profits (A/B)		
8. providing state aid to Energy Intensive Industries (EIIs)	No	No	•May violate EU state aid rules •Adverse competitive effects •Adverse fiscal effects	•Questionable
9. Promoting EII strategies: - Energy saving - Self generation - long term contracts	 No No No	 No No No	•Lack of cost-effective options •Several constraints •Only temporary solution (‘hedging’)	•Limited feasibility •Limited feasibility •Feasible
10. Border tax adjustments	No	No	•Trade conflicts? •Compatible with WTO rules (only when auctioning)?	•Perhaps feasible (more study/discussion needed)
11. Long-term options: - global climate policy regime - technological innovations	 No Yes	 No Yes (A/B)	•Avoids leakage and adverse competitive effects •Enhances dynamic efficiency	•Difficult, but maybe feasible in the long run • Feasible in the long run

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Some conclusions, policy implications and points for discussion

Is carbon pass through a problem?

- No, it is a rational (intended) effect
- Yes; although overstated generally by energy-intensive industries, some sectors do suffer
- The competitive position of the energy-intensive industries in a carbon constrained environment is a general policy issue (i.e. not a specific ETS issue) and, hence should be treated as such

Are windfall profits a problem?

- Yes, although several qualifications can be made, EU ETS induced windfall profits are a problem – notably those due to the free allocation of allowances – as they raise all kinds of efficiency, equity and, hence, legitimacy questions with regard to this system.

Will carbon pass through & windfall profits continue in the future?

- Yes (widely accepted practice), although impact in the long run will be mitigated by induced additional investments in generation capacity
- However, free allocations (and resulting windfall profits) undermine incentive structure towards carbon reducing investments
- A shift of free allocation towards auctioning will have a beneficial impact on carbon reducing investments, reduce (windfall) profits of fossil generators, but most likely not have a (significant) impact on cost pass through or windfall profits of non-fossil generators

Are there feasible policies to address EU ETS induced increases in power prices and windfall profits?

- There is no ‘silver bullet’ or any specific policy option that addresses both EU ETS induced increases in power prices and (both categories of) windfall profits without adverse, socio-economic effects.
- However, there is a sensible mix of policy options conceivable that can address some effects, including auctioning (power & sheltered sectors), benchmarking (other, exposed sectors), stabilising CO2 prices (increased market transparency; long-term policy certainty), and/or introducing Border Tax Adjustments.