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Germany´s Energy Transition and its Effect on European Electricity Spot Markets

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Germany´s *Energiewende (Energy Transition)*

Source: European Energy Review, 2012

- **Fukushima**: 11th of March 2011…
- **Atomaustiegsgestz** (Nuclear Phase Out):
  - shutting down eight nuclear power plants and the successive closures of the remaining nine nuclear plants until 2022
- **Renewable Energy Resource Act 2012**:
  - aims to increase the electricity generated from RES-E to at least 35% until 2020 and then gradually to at least 80% by the year 2050 (RESA, 2012)

Why could it matter….?

1. Increasing market integration

2. Increasing trade

3. Intermittency of RES-E

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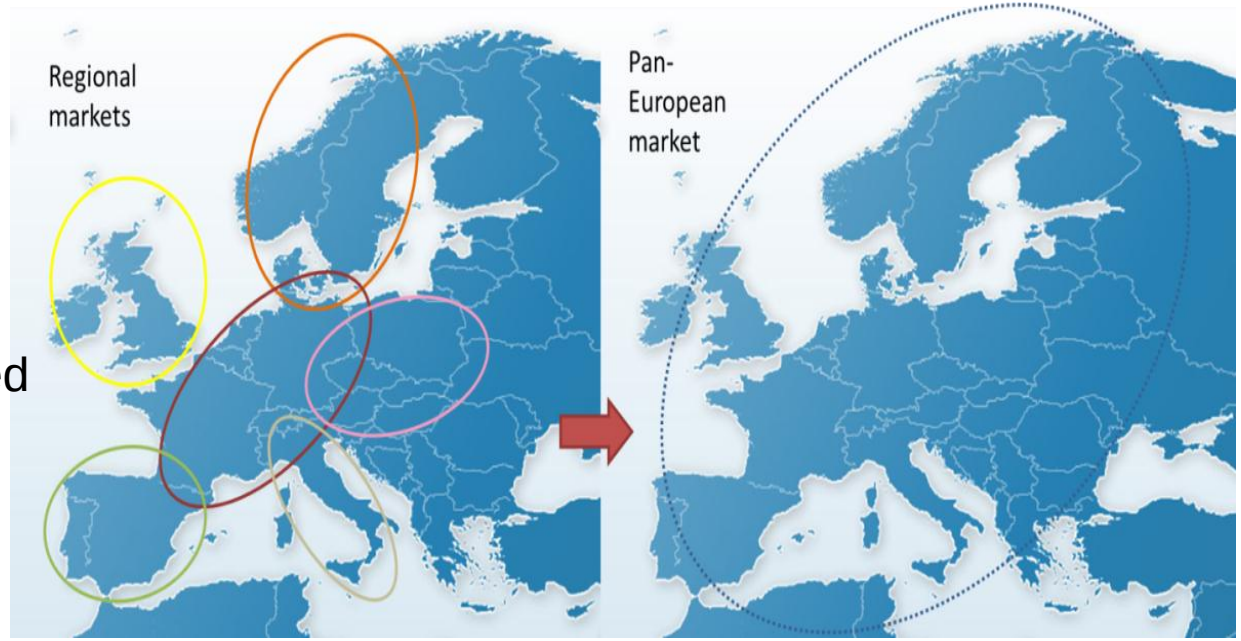
1. Increasing Market Integration

- EU Directive 96/92/EC, 2003/54/EC and 2009/72/EC defines common rules for generation, transmission and distribution of electricity
- Prior liberalization:
  - interconnection with other countries has the main function of securing stable operation of the European electricity network
- Post liberalization:
  - flows have been dictated by market mechanisms & increased Market Coupling



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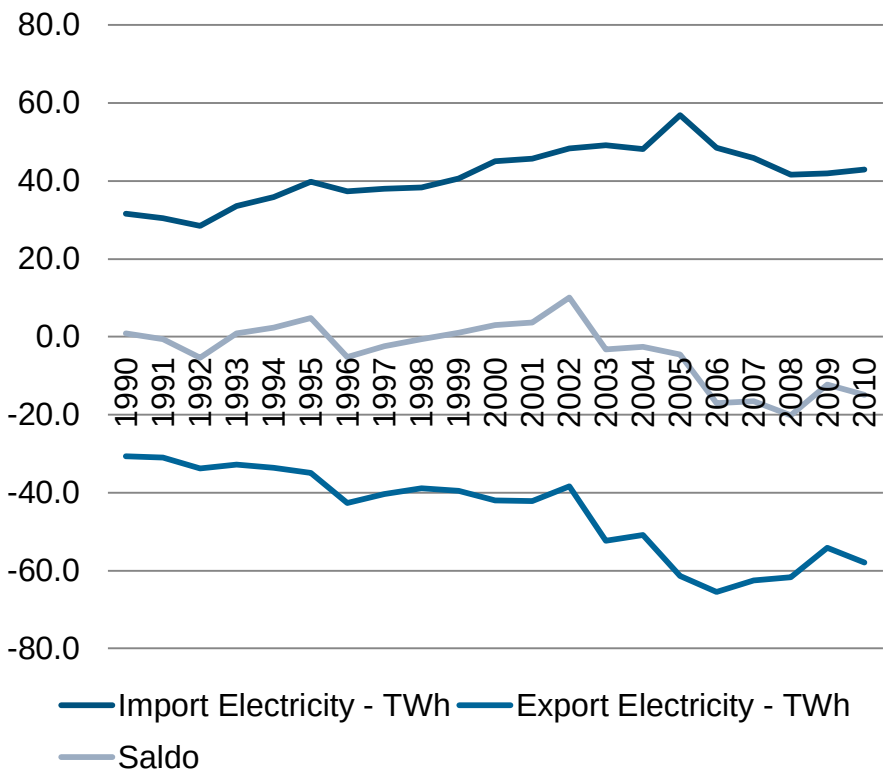
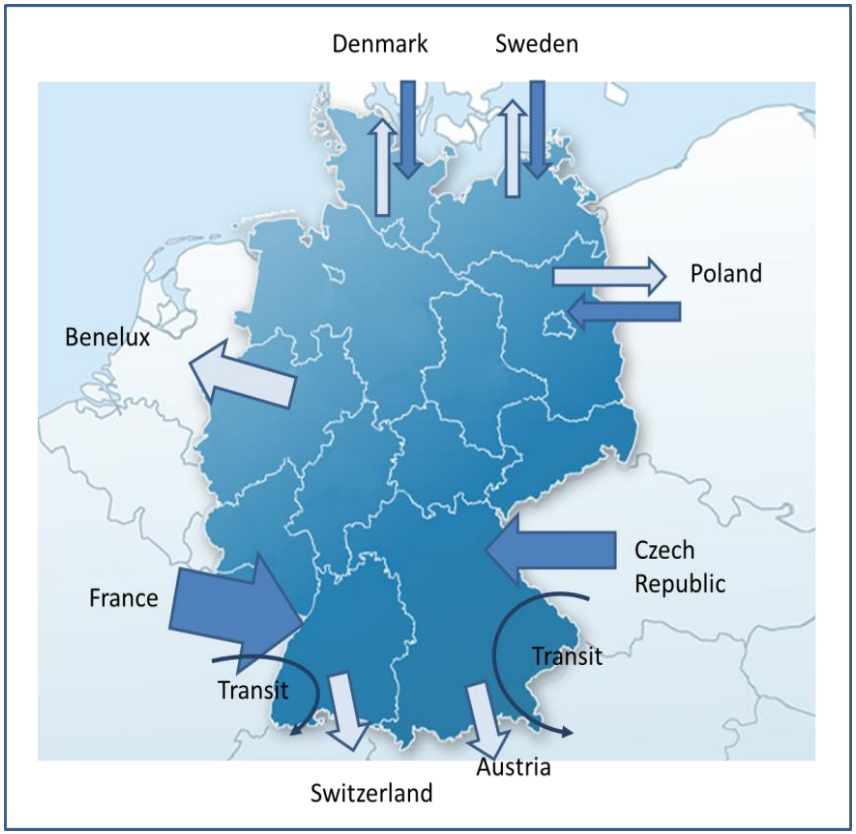
2. Trade Germany



Source: European Commission 2012



Source: BDEW, 2012

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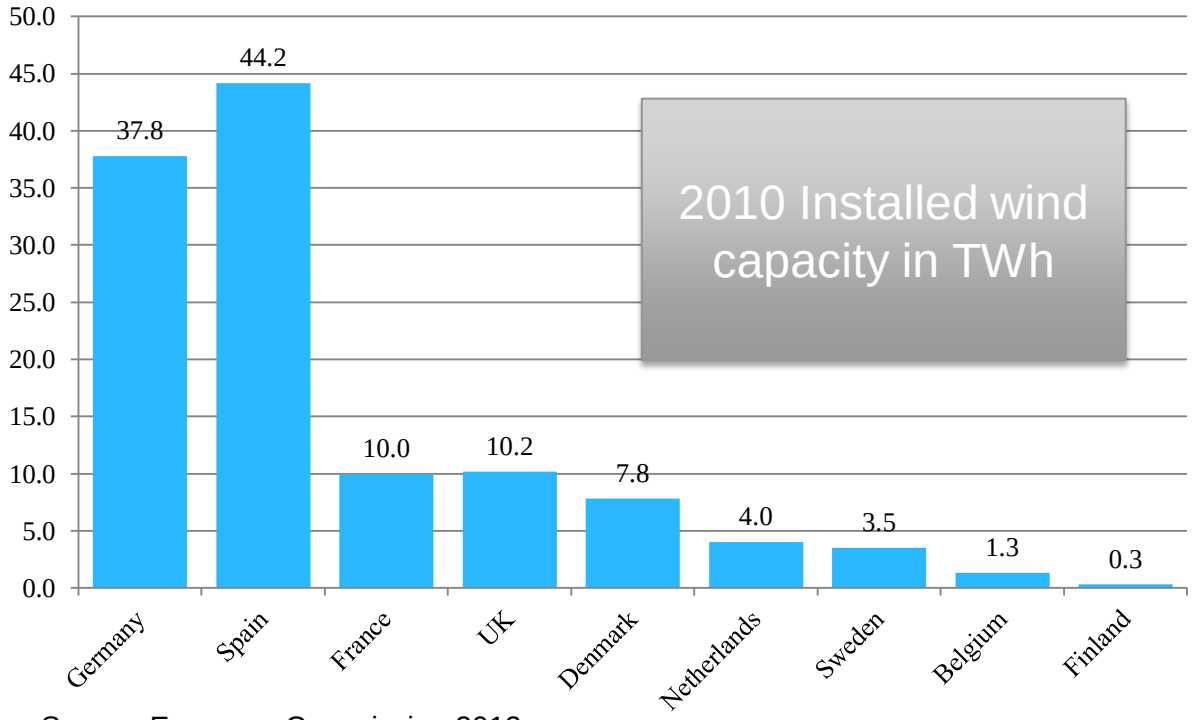
3. Intermittent RES-E

1. German wind generated electricity enjoys ***priority dispatch*** and sets prices



Source: European Commission 2012

2. ***Merit Order Effect:*** *decrease in spot prices*

3. **increase in volatility** (Woo et al., 2011; Milstein and Tishler, 2011; Green and Vasilakos, 2010)

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To Date: Focus on National Markets

- Merit Order Effect and increased volatility have been assessed ***within one market***

Bosco et al. (2007): *"[...] post-reform European price series have generally been* ***studied in isolation*** *and the issue of the interdependency in the price dynamics of neighboring markets has largely been ignored."*

Green Paper : *"choices made by one Member State inevitably have an* ***impact on*** *the energy security of its* ***neighbors*** *and of the Community as a whole…(*EUROPE, 2006)."

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Present Study: Assessment of Effects in other Markets

1. Increasing market integration
2. Increasing trade
3. Intermittency of RES-E

Aim of research:
Assess the potential effects of Germany´s energy transition on level and **volatility** of electricity spot prices in Germany and in other European countries

MGARCH (multivariate generalized autoregressive conditional heteroscedasticity models with constant and time varying correlations)

Multivariate Volatility Analysis

1. Definition of univariate GARCH models to remove predictable component
2. Conditional variances obtained from univariate GARCH models used to estimate the conditional correlation matrix

- Constant Conditional Correlation (CCC) model, Bollerslev (1990)

$$H_t = D_t R D_t = \rho_{ij} \sqrt{h_{iit} h_{jjt}}$$

- Dynamic Conditional Correlation model (DCC) Tse and Tsui (2002), Engle (2002)

$$H_t = D_t R_t D_t$$

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Data

	Min	Mean	Max	Std.Dev	Skewness	Excess Kurt.	JB	ADF
France	15.13	50.51	89.83	9.90	0.31	1.61	62.76	-1.13
Germany	7.21	49.47	72.06	8.21	-0.47	1.23	50.10	-0.90
Netherlands	21.04	49.96	73.04	7.96	-0.37	0.62	19.45	-0.82
Nordpool	0.00	55.26	134.80	19.86	0.46	1.21	48.57	-0.12
Spain	3.13	41.83	67.35	10.53	-0.90	1.10	93.41	-0.61
Switzerland	15.66	54.86	80.33	8.75	-0.32	1.03	30.98	-1.04
UK	27.10	44.47	110.92	8.28	1.93	10.83	2774.00	-1.03
Belgium	15.11	50.03	206.10	11.74	4.72	60.80	79497.00	-1.58
Wind actual	0.00	0.01	0.13	0.01	4.75	33.85	25960.00	-8.51
Wind pl.	0.00	0.03	0.25	0.02	2.90	17.33	7011.40	-6.15

Non-normal and fat-tailed

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Univariate Level Analysis

	FR		GER		NL		NP		ES		CH		UK		BEL	
FR_1	**0.53 (0.09)**	**6.02**	0.04 (0.06)	0.64	0.05 (0.06)	0.78	0.01 (0.05)	0.19	0.18 (0.12)	1.55	0.05 (0.07)	0.65	-0.06 (0.06)	-1.02	**0.25 (0.09)**	**2.66**
GER_1	-0.02 (0.10)	-0.16	**0.31 (0.07)**	**4.53**	0.21 (0.07)	3.04	-0.09 (0.06)	-1.49	-0.02 (0.14)	-0.11	0.05 (0.08)	0.63	0.09 (0.07)	1.34	0.06 (0.11)	0.58
NL_1	-0.05 (0.13)	-0.39	**0.21 (0.08)**	**2.52**	**0.33 (0.08)**	**4.03**	0.07 (0.08)	0.97	**0.51 (0.17)**	**3.09**	-0.08 (0.10)	-0.79	**0.18 (0.09)**	**2.15**	-0.07 (0.13)	-0.56
NP_1	**0.09 (0.03)**	**3.16**	**0.07 (0.02)**	**3.56**	**0.08 (0.02)**	**4.49**	**1.02 (0.02)**	**58.30**	**-0.08 (0.04)**	**-2.24**	**0.08 (0.02)**	**3.54**	**0.08 (0.02)**	**3.96**	**0.10 (0.03)**	**3.50**
ES_1	0.05 (0.03)	1.91	**0.07 (0.02)**	**3.98**	**0.07 (0.02)**	**3.95**	0.01 (0.02)	0.40	**0.70 (0.03)**	**21.00**	0.02 (0.02)	1.01	**0.06 (0.02)**	**3.57**	**0.08 (0.03)**	**3.16**
CH_1	**0.16 (0.07)**	**2.23**	0.02 (0.05)	0.35	-0.01 (0.05)	-0.13	-0.05 (0.04)	-1.17	**-0.47 (0.09)**	**-5.15**	**0.65 (0.06)**	**11.60**	-0.09 (0.05)	-1.90	0.13 (0.07)	1.77
UK_1	0.10 (0.06)	1.67	**0.13 (0.04)**	**3.36**	**0.12 (0.04)**	**3.18**	-0.04 (0.04)	-1.11	0.15 (0.08)	1.93	0.03 (0.05)	0.75	**0.57 (0.04)**	**14.70**	**0.12 (0.06)**	**2.06**
BEL_1	0.00 (0.09)	-0.04	-0.02 (0.06)	-0.30	-0.01 (0.06)	-0.22	0.00 (0.05)	-0.06	-0.12 (0.12)	-1.02	-0.01 (0.07)	-0.15	0.00 (0.06)	-0.02	**0.21 (0.09)**	**2.33**
Pl. pntr..	-0.23 (0.13)	-1.79	**-0.72 (0.09)**	**-8.51**	**-0.61 (0.08)**	**-7.22**	**-0.17 (0.08)**	**-2.09**	0.02 (0.17)	0.12	**-0.22 (0.10)**	**-2.14**	-0.12 (0.09)	-1.34	-0.21 (0.13)	-1.56

1. Positive own mean spill over
2. Planned wind penetration negative association with electricity spot prices

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Constant Conditional Correlations

	FR	*GER*	*NL*	*NP*	*ES*	*CH*	*UK*	*BEL*	*pl. pntr.*
FR		0.68	0.75	0.22	0.18	0.61	0.28	0.94	-0.12
		21	35.75	4.1	3.47	17.09	6.22	127.7	-2.75
GER	0.66		0.8	0.36	0.11	0.57	0.26	0.67	-0.35
	19.38		47.31	7.76	1.98	16.79	6.12	18.31	-8.8
NL	0.75	0.79		0.3	0.16	0.63	0.3	0.72	-0.29
	34.26	44.49		6.97	3.64	21.72	7.99	31.13	-7.54
NP	0.21	0.36	0.29		-0.02	0.2	0.16	0.21	-0.14
	4.21	8.08	6.95		-0.54	4.84	4.26	3.72	-3.72
ES	0.17	0.08	0.15	-0.03		0.22	0.01	0.19	-0.01
	3.23	1.5	3.36	-0.66		4.87	0.19	3.39	-0.28
CH	0.6	0.56	0.62	0.19	0.2		0.23	0.59	-0.15
	16.35	15.99	20.78	4.73	4.41		5.69	15.17	-3.97
UK	0.27	0.26	0.3	0.16	0.01	0.22		0.26	-0.11
	6.39	6.1	7.94	4.15	0.2	5.46		5.46	-3.08
BEL	0.94	0.65	0.72	0.21	0.18	0.58	0.26		-0.12
	120.2	17.18	29.75	3.85	3.1	14.58	5.53		-2.65
act. pntr.	-0.08	-0.24	-0.19	-0.08	-0.05	-0.09	-0.09	-0.07	
	-1.64	-5.54	-4.76	-2.1	-1.1	-2.2	-2.52	-1.41	

Most correlations are significant and positive

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Dynamic Conditional Correlations

	FR	GER	NL	NP	ES	CH	UK	BEL	pl. pntr.
FR		0.72	0.79	0.24	0.19	0.64	0.27	0.96	-0.12
		22.61	33.06	4.17	3.46	17.7	5.26	189.2	-2.38
GER	0.7		0.81	0.37	0.12	0.6	0.26	0.71	-0.35
	20.66		42.5	7.37	1.94	16.89	5.21	21.24	-7.69
NL	0.78	0.81		0.31	0.16	0.66	0.29	0.76	-0.28
	31.79	40.09		6.31	3.22	21.18	6.47	28.92	-6.3
NP	0.23	0.37	0.3		-0.02	0.22	0.15	0.24	-0.12
	4.21	7.62	6.21		-0.38	4.71	3.4	4.08	-2.78
ES	0.18	0.09	0.15	-0.03		0.21	0.01	0.2	-0.01
	3.23	1.52	3	-0.56		4.29	0.29	3.38	-0.15
CH	0.63	0.58	0.65	0.21	0.2		0.23	0.63	-0.16
	16.44	15.92	20.14	4.57	4.01		4.95	16.27	-3.59
UK	0.26	0.26	0.29	0.14	0.01	0.22		0.26	-0.1
	5.42	5.3	6.51	3.26	0.32	4.75		4.88	-2.47
BEL	0.96	0.69	0.75	0.23	0.18	0.62	0.25		-0.12
	179.8	19.76	27.61	4.1	3.11	15.11	4.96		-2.3
act. pntr.	-0.1	-0.24	-0.19	-0.07	-0.06	-0.11	-0.09	-0.09	
	-1.8	-4.96	-4.01	-1.61	-1.2	-2.25	-2.26	-1.62	

1. EDCC better than TTDCC
2. $(\boldsymbol{\theta_1}, \boldsymbol{\theta_2})$ significant
3. $(\boldsymbol{\theta_1}, \boldsymbol{\theta_2})$ sum to less than 1
4. Likelihood ratio rejects hypothesis of constant correlations

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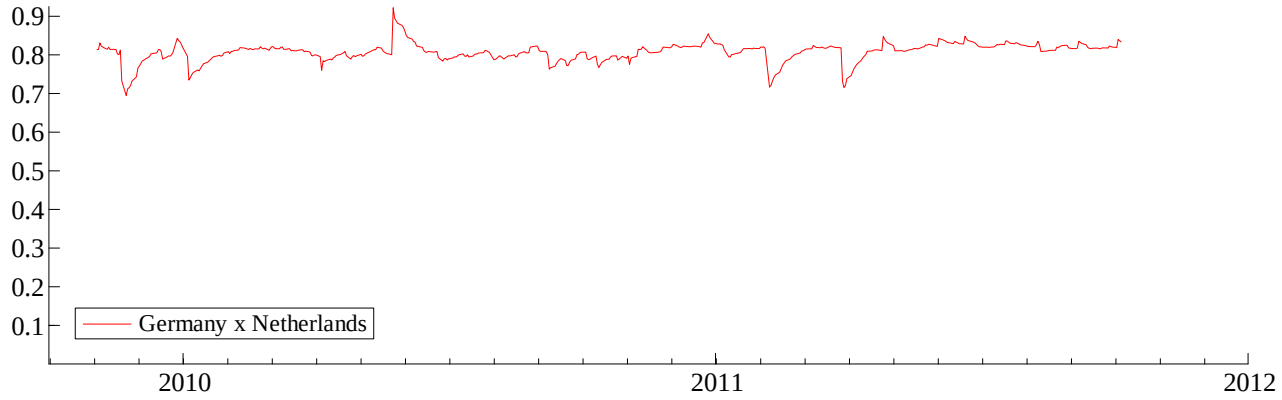
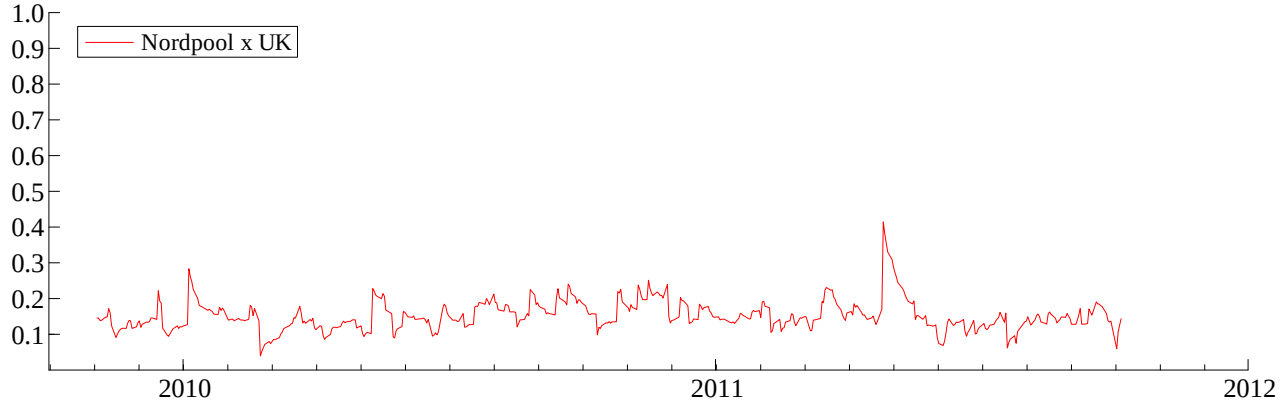
Dynamic Conditional Correlations Example



GER & NL: strong correlation relationship



NP & UK: weak correlation relationship

Main Findings

- Univariate analysis:
  - high levels of wind penetration in Germany had a direct bearing on European electricity prices,
  - more noticeable when forecasted wind penetration was considered

- Multivariate analysis:
  - Rejection of constant correlations
  - Negative associations between forecasted wind penetration levels were confirmed in all countries, except Spain
  - Associations stronger for forecasted wind penetration compared to actual metered wind output
  - Belgium, Spain, Nordpool and France insignificant (actual penetration)

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Conclusion and Future Research

- Choices made by one State in the European Union can inevitably impact the energy security of its neighbors
- Germany´s trade partners generate electrical power using nuclear technologies/ fossil fuels, some of which are to be phased out as well

- How much more RES-E can the system absorb?
- How much integration is necessary to absorb RES-E?

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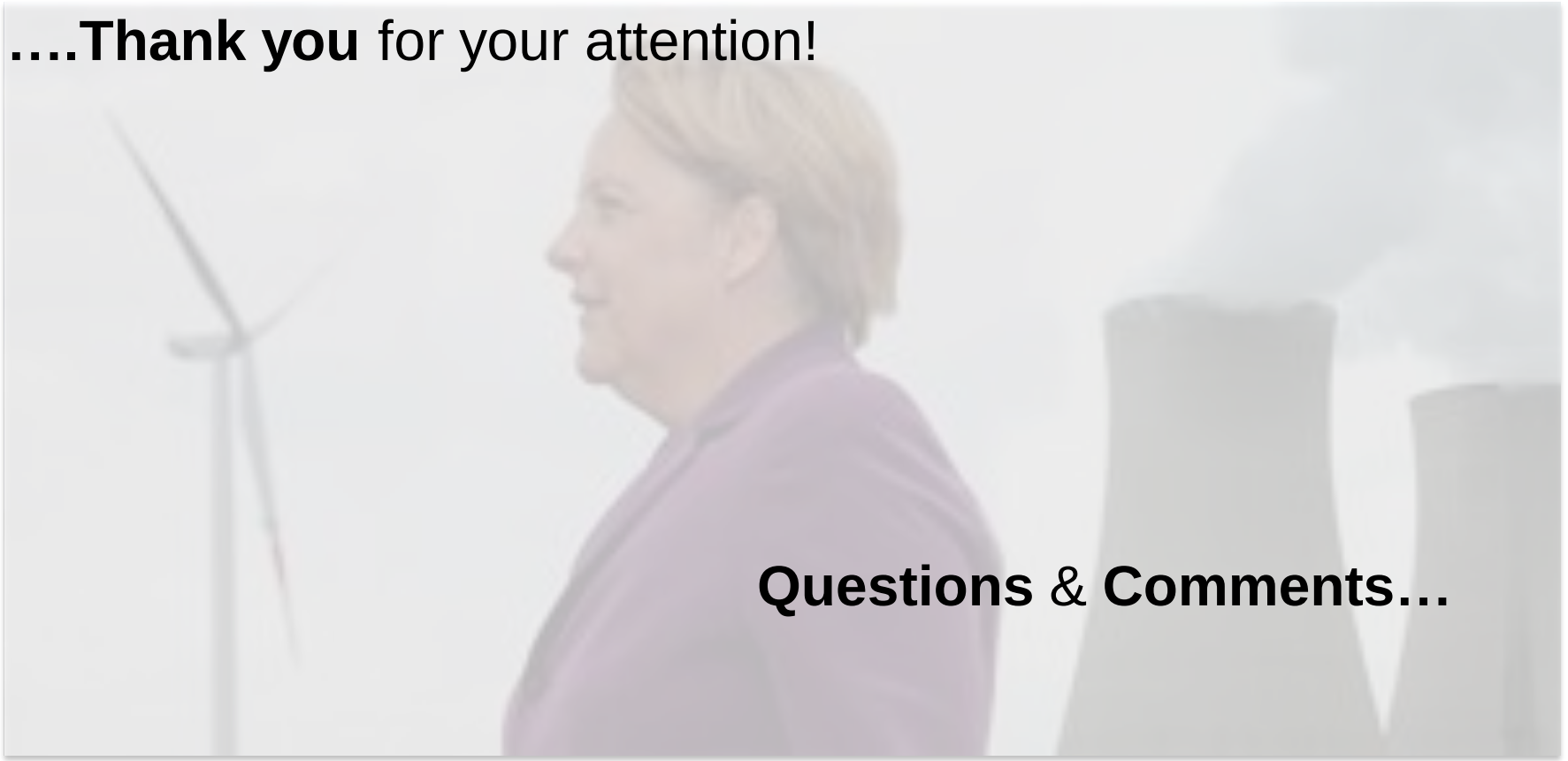

….Thank you for your attention!

Questions & **Comments…**

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References

1. Bosco, B., Parisio, L., Pelagatti, M., Baldi, F., 2006. Deregulated wholesale electricity prices in Europe. Mimeo, Universit`a di Milano-Bicocca.
2. Engle, R.. 2002. Dynamic conditional correlation – A simple class of multivariate GARCH models, Journal of Business & Economic Statistics. Vol. 20, No. 3, pp. 339-350.
3. European Commission, 2001. "DIRECTIVE 2001/77/EC." Official Journal of the European Union.
4. European Commission, Country Factsheet-EU 27 member states, 2012 { http://ec.europa.eu/energy/observatory/countries/countries_en.htm; last accessed 01/08/2012}
5. Green, R.; Vasilakos, N., 2010. Market behavior with large amounts of intermittent generation. Energy Policy. Vol. 38, pp. 3211-3220.
6. Le Pen, Y.; Sévi, B. 2010. Volatility transmission and Volatility Impulse Response Functions in European electricity forward markets. Energy Economics, Vol.32, Issue 4, pp. 758–770.
7. Renewable Ressource Act, 2012. Act on granting priority to renewable energy sources (Renewable Energy Sources Act – EEG) {http://www.bmu.de/files/english/pdf/application/pdf/eeg_2012_en_bf.pdf; last accessed 20/808/2012}
8. Tse, Y.K., Tsui, A.K.C., 2002. A multivariate generalised autoregressive conditional heteroscedasticity model with time-varying correlations. Journal of Business and Economic Statistics Vol. 20 (3), pp. 351–362.
9. Worthington, A.C., Kay-Spratley, A., Higgs, H., 2005. Transmission of prices and price volatility in Australian electricity spot markets: a multivariate GARCH analysis. Energy Economics Vol.27 (2), pp. 337–350.
10. Woo, C.K.; Horowitz, I.Moore, J. Pacheco, A. 2011. The impactofwindgenerationontheelectricityspot-marketpriceleveland variance: TheTexasexperience. Energy Policy Vol. 39, pp. 3939-3944.
11. Veka, S., Lien,G., Westgaard, S., Higgs, H., 2012. Time-varying dependency in European energy markets: an analysis of Nord Pool, European Energy Exchange and Intercontinental Exchange energy commodities. The Journal of Energy Markets. Vol. 5 Iss. 2.