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Planning the Offshore North and Baltic Sea Grid: A Study on Design Drivers, Welfare Aspects, and the Impact on the National Electricity Markets

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DRAFT STUDY FOR PUBLIC CONSULTATION

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Offshore Grids in the North Sea ?
Long-Term Hopes and Short-Term Reality – Discussion

Prof. Dr. Christian von Hirschhausen

Main Theses

1. There may be risk that Germany falls behind the offshore targets due to slow progress of projects
2. "Offshore" is specific due to the peculiar risk structure of the projects, the multilateral structure [and the large volumes of renewables to be harnessed]
3. Technical risks are considerable, but progress is rapid and will continue to be so
4. Financial risks: project finance and merchant finance seem to be inappropriate to kick-start the offshore expansion
5. Regulatory risks: innovative regulatory solutions or simple cost-plus?
6. Offshore may not advance because some stakeholders may not want it to advance ("honni soit qui mal y pense")

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German “Netzentwicklungsplan 2012”: 13 GW installed capacity in 2022, 28 GW in 2032

Offshore wind farms in Operation (2012)

Wind farm	Installed capacity (in MW)	Planned capacity (in MW)
EnBW Windpark Baltic 1	48,3	48,3
BARD Offshore 1	95	400
Testing area "alpha ventus"	60	60
Total	**203,3**	508,3

Additional capacity of projects under construction or ordered works contracts: 2.1 GW

Additional capacity of permitted projects: 7.0 GW

Additional capacity of planned projects (Applying for permission): 30.0 GW

Source: Bundesnetzagentur (2011), BSH (2012), Dena (2012), FTD (2012)

Will construction of German wind farms speed up in 2012?

Project	Key facts	Current Progress
Borkum West II	• AWZ northsea • 80 turbines • 400 MW	• Under Construction • Start of operation: 2013 • Connected to the grid in 2013 (DolWin 1)
RIFFGAT	• 12 nm zone northsea • 44 turbines • 108 MW	• Construction of foundation will start summer 2012 • Start of operation: 2014 • Connection to the grid already tested in 2013 (RIFFGAT)
Nordsee Ost	• AWZ northsea • 48 turbines • 295 MW	• Construction of foundation will start summer 2012 • Start of operation: 2014 • Connected to the grid with one year delay in in 2014 (HelWin 1)
Global Tech I	• AWZ northsea • 80 turbines • 400 MW	• Works contracts awarded, Construction will kick off spring 2012 • Start of operation: 2013 • Connected to the grid in 2013 (BorWin 2)
Baltic 2	• AWZ baltic sea • 80 turbines • 288 MW	• Works contracts awarded, Construction will kick off mid 2012 • Start of operation: 2013 • Connected to the grid in 2013 (50 Herz Baltic 2)

Source: Tennet (2012), 50 Hertz (2012), 4Coffshore (2012)

Planned German Offshore grid in North and Baltic Sea

German North Sea Grid

Source: http://www.tennettso.de/site/Aufgaben/offshore/unsere-projekte

German Baltic Sea Grid

Source: http://www.50hertz.com/de/2730.htm

German grid development may not meet offshore targets either

Project	Operator	Capacity (in MW)	Connected wind farms	In Operation
Alpha Ventus (AC)	TenneT	60	Alpha Ventus	2009
BorWin1	TenneT	400	BARD Offshore 1	2010
Baltic 1 (AC)	50 Hertz	48	EnBW Baltic 1	2011
Riffgat (AC)	TenneT	108	Riffgat	2012
BorWin2	TenneT	800	Veja Mate, Global Tech 1	2013
Baltic 2 (AC)	50 Hertz	288	EnBW Baltic 2	2013
HelWin1	TenneT	576	Nordsee Ost	Delayed in 2014
DolWin1	TenneT	800	Borkum West II, Borkum Riffgrund, MEG Offshore 1	2013
Nordergründe (AC)	TenneT	111	Nördlicher Grund	2014
SylWin1	TenneT	864	Wind farms close to Sylt	2014
DolWin2	TenneT	900	Gode Wind II	2015
HelWin2	TenneT	690	Amrumbank West	2015
Total until 2015		**5,645**		
Total until 2022 (Additional planned capacity included)	TenneT	**11,945**		

Source: Tennet (2012a), Tennet (2012b), 50 Hertz (2012)

Offshore wind projects in UK do better but nevertheless there is a gap between tendered and actually built projects

Awarded capacity in first and second leasing round (2001/2003) and extension round (2010): 9.8 GW

Offshore wind farms (2012)

Wind farm	Number of projects	Capacity (in MW)
In operation	16	1,858
Under construction	6	2,359
With planning consent	6	1,224
Total	**28**	**5,441**

Additional capacity of projects (pre-planning or applying for permission): 40,000 MW

Source: renewableUK (2012)

UK offshore wind farms in operation

Project	Key facts
Barrow	• 30 turbines • 90 MW
Beatrice	• 2 turbines • 10 MW
Blyth Offshore	• 2 turbines • 4 MW
Burbo Bank	• 25 turbines • 90 MW
Gunfleet Sands I	• 30 turbines • 108 MW
Gunfleet Sands II	• 18 turbines • 65 MW
Kentish Flats	• 30 turbines • 90 MW
Lynn & Inner Dowsing	• 54 turbines • 194 MW

Project	Key facts
North Hoyle	• 30 turbines • 60 MW
Ormonde	• 30 turbines • 150 MW
Rhyl Flats	• 25 turbines • 90 MW
Robin Rigg	• 60 turbines • 180 MW
Scroby Sands	• 30 turbines • 60 MW
Thanet	• 100 turbines • 300 MW
Walney I	• 51 turbines • 184 MW
Walney II	• 51 turbines • 184 MW

Source: renewableUK (2012)

Projects under construction make siginificant progress and will be in operation mostly in 2012

Project	Key facts	Start of operation	Status
Sheringham Shoal	• 88 turbines • 316.8 MW	2012	Already generates electricity since July 2011
Greater Gabbard	• 140 turbines • 504 MW	2012	108 out of 140 turbines are installed
Lincs	• 75 turbines • 270 MW	2012	Under construction
London Array I	• 175 turbines • 630 MW	2012	First turbines installed in January 2012
Teesside	• 27 turbines • 62.1 MW	2012	Construction of foundation will start summer 2012
Gwynt y Mor	• 160 turbines • 576 MW	2014	Construction of foundation has started in January 2012

Source: renewableUK (2012), The Crown Estate (2012)

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"Offshore" is specific due to the peculiar risk structure of the projects

	Wind Farm Operator	Transmission Operator
Technical risks	• Construction risks – Long term aspects – Scour • Availability of installation vessels • Effects on wildlife • Maintenance	• New voltage levels for underground (150 kV, 220 kV) • Connections offshore • HVDC in meshed systems
Financial risks	• Price risks • Operation costs	• Timing
Regulatory risks	• Liability risk ("Haftungsrisiko") • Regulatory regime • Ex-post expropriation	• Liability risk ("Haftungsrisiko") • Regulatory regime, mark-up, etc. • Onshore connection • Bottleneck onshore ("Hinterland")

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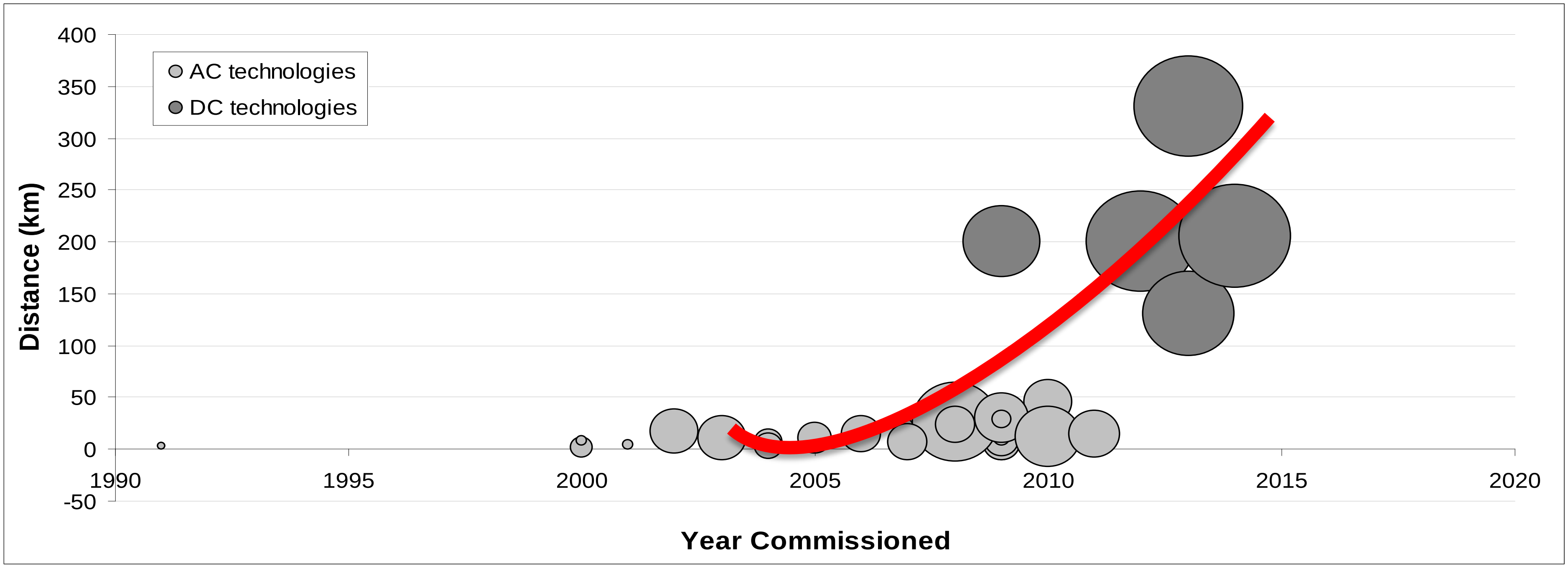
Overview of existing connections:

Farm to shore

Existing farm-to-shore connections over time

(bubbles size = power, min. 4 MW and max. 864 MW)

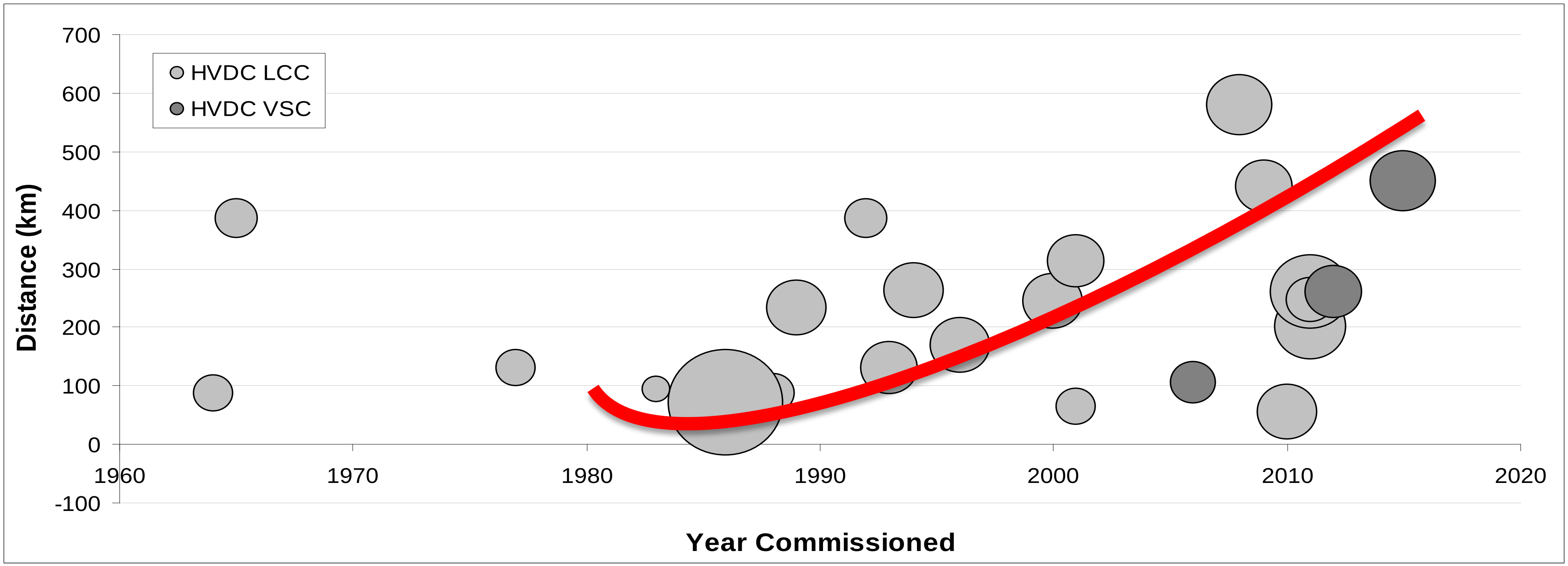


Two types of farm to shore connections	"Old" farm to shore	"New" farm to shore
	unique wind farm; near shore; small capacity	several wind farms, far to shore; high capacity

Overview of existing connections:
shore to shore

Existing HVDC shore-to-shore connections over time

(bubbles size = power, min. 130 MW and max. 2000 MW)



Over time wide ranges of distance and scale since the 80s and mostly CSC HVDC technologies

In the recent years first applications of VSC HVDC, progressively increasing the distance

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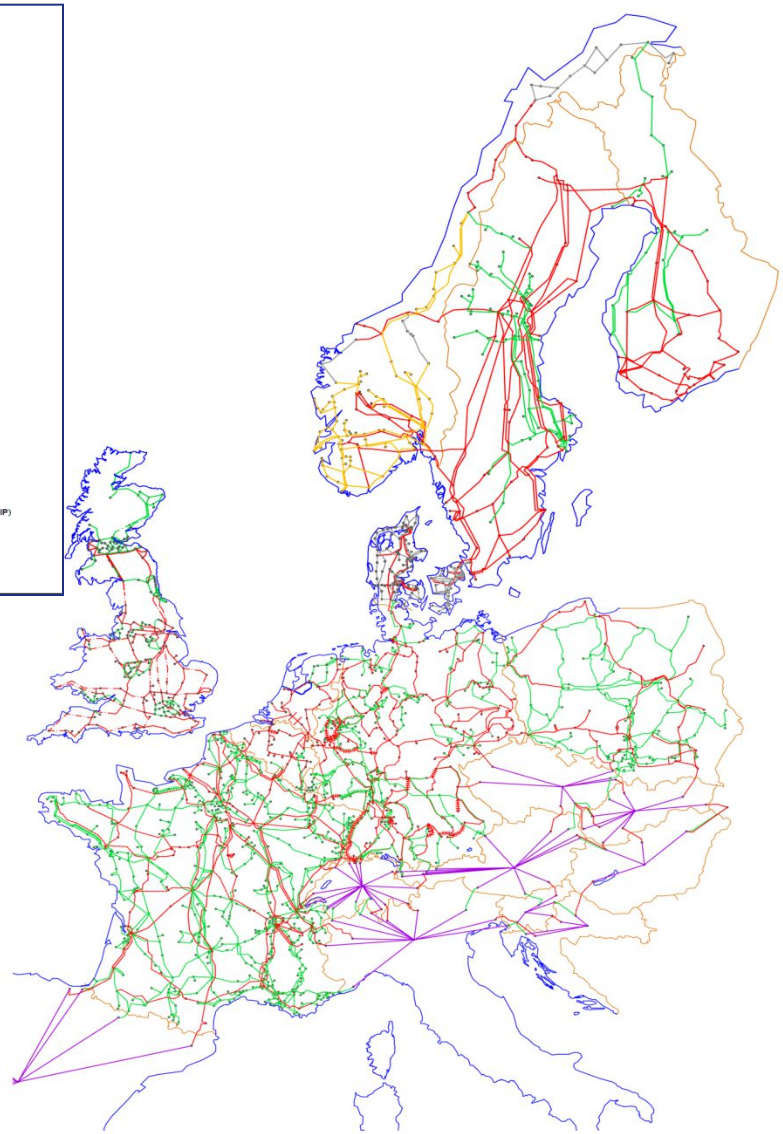
Modeling Approach: Egerer, Kunz and von Hirschhausen, 2012

Model Scope:

- Three separated AC control zones
- Connected by HVDC offshore grid
- Reference year: 2009

- Nodes 2069
- AC lines 2877
- DC lines 8

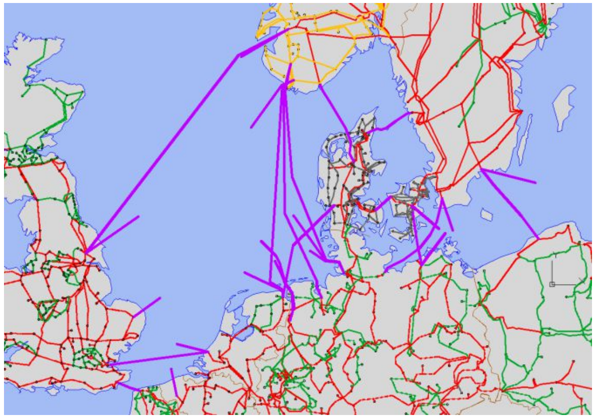


Time resolution:

- 80 non-consecutive reference hours
- Season (2x), demand (10x), wind (4x)
- Free allocation of hydro reservoir generation

Scenarios

Trade scenario:



- Separate wind integration and trade connectors
- Point-to-point connectors between two countries

Meshed scenario:

- Combined wind integration and trade capacity
- Meshed offshore system

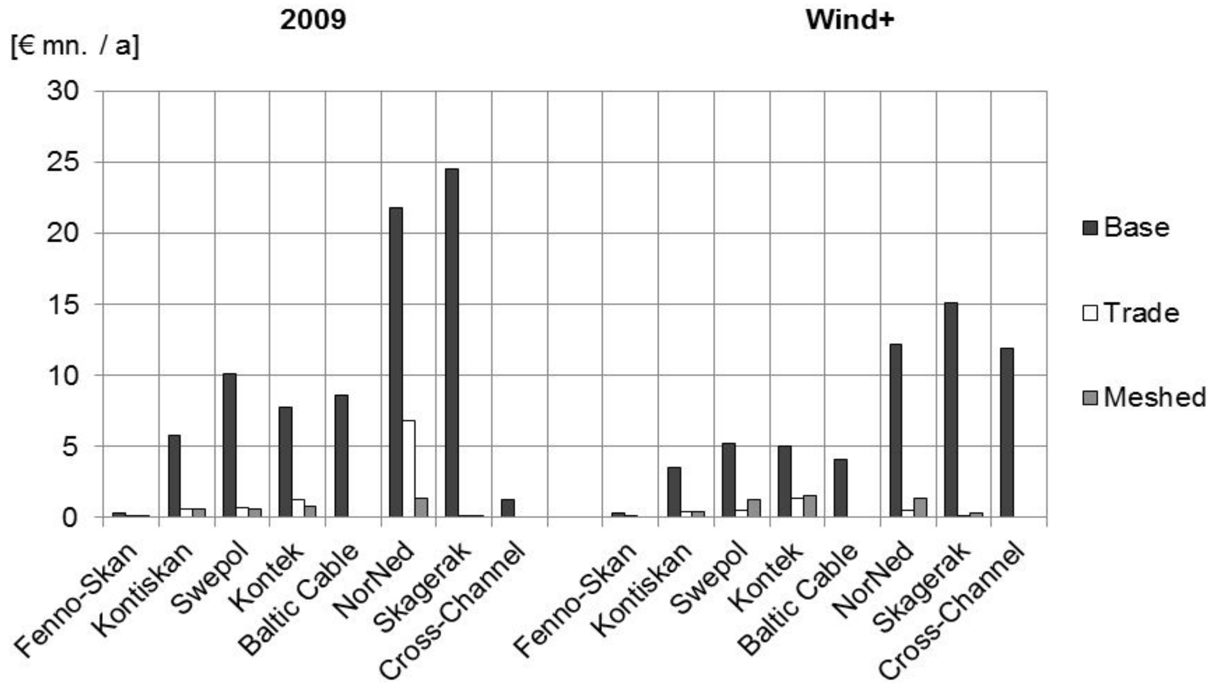
Wind+ scenario:

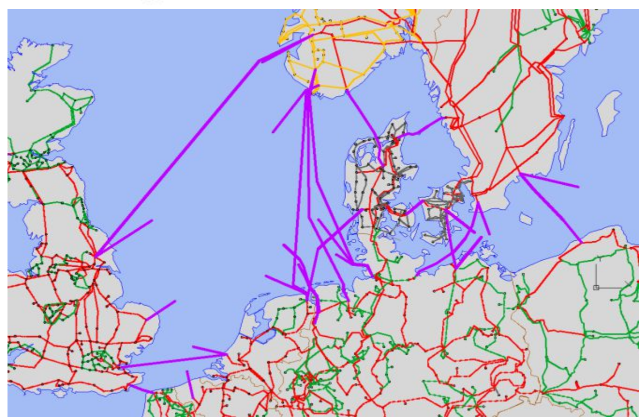
- Additional on- and offshore wind generation capacity
- Data based on 2020 figures of OffshoreGrid Project

Congestions rents insufficient to cover expansion costs

Congestion rents of HDVC interconnectors highly sensitive to new transmission capacity:

- Few more merchant projects can foster sufficient congestion rent to be profitable
- Risk that follow-up investments cut into profits
- If expectation that ongoing market integration with new transmission capacity, early investors (NorNed, 2009) profits but how about second generation (BritNed, 2011) or third generation (NorthConnect, 2020)





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„Make transmission as “unexciting” (“boring” or “uneventful”) as possible“!!!

The simple idea behind this simple scheme [average participation scheme] that is in use in several countries is just to make the business of transmission investment as “unexciting” (“boring” or “uneventful”) as possible. Sophistication and complexity in transmission planning – “leaving it to the market”, for instance - only cause indecision by investors, higher capital costs and – most frequently – lack of investment.

Olmos and Pérez-Arriaga (2009): A Comprehensive Approach for Computation and Implementation of Efficient Electricity Transmission Network Charges. MIT CEEPR Discussion Paper 09-010.

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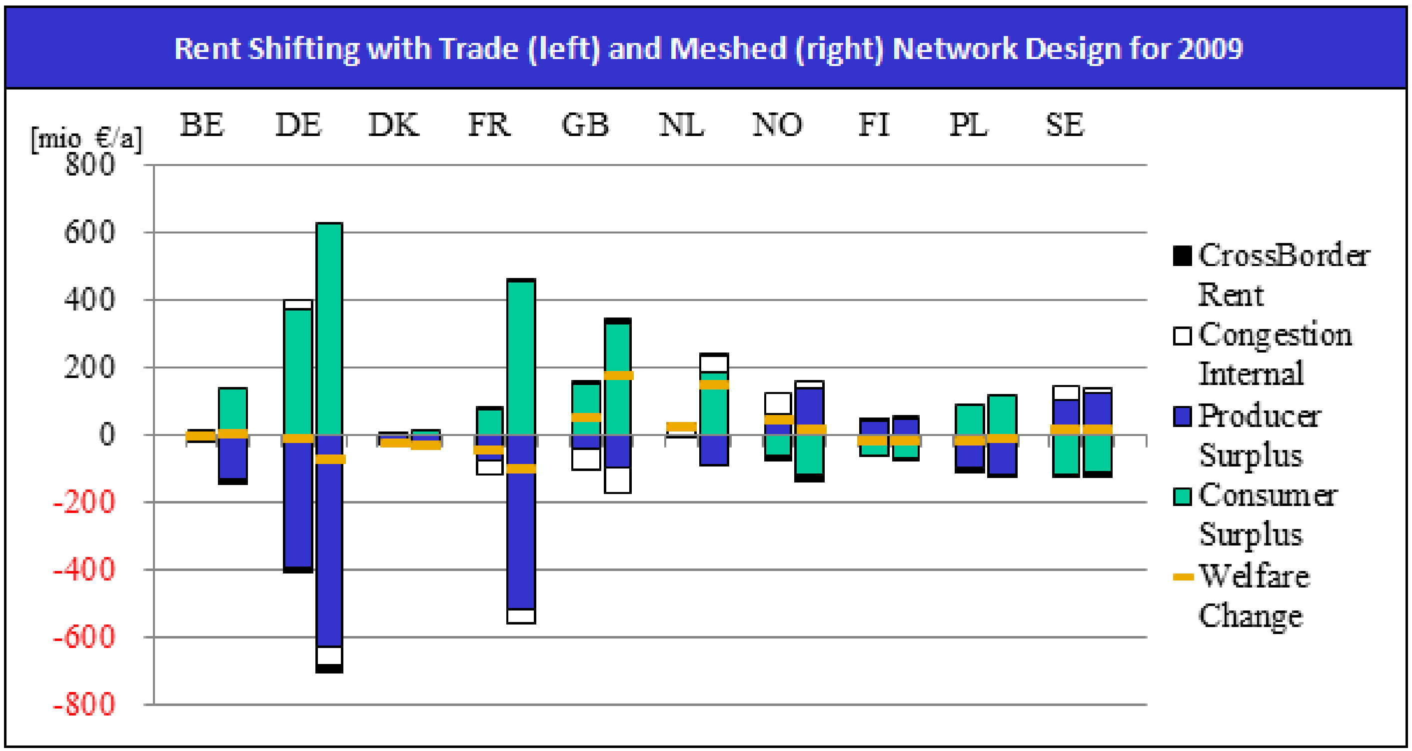
Results: National welfare implications (I)

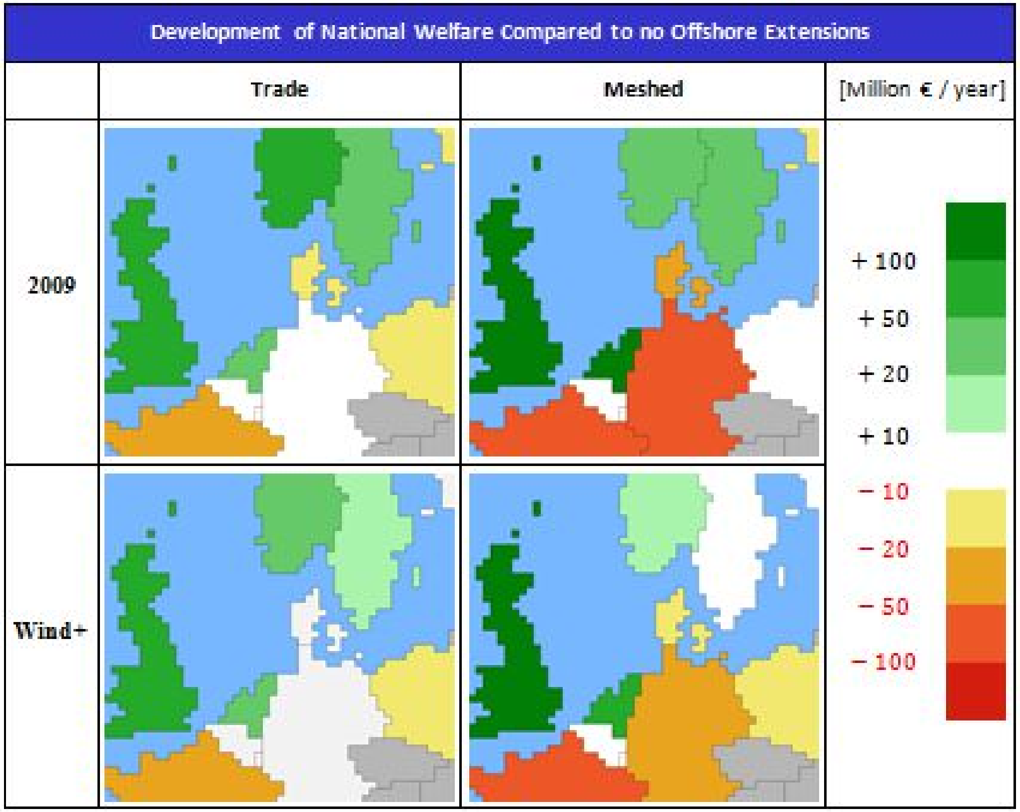
Change in national consumer and producer rents:

- Strong national rent shifting effects in most countries
- Meshed network leads to higher rent shifting (stronger price convergence)
- Some countries experience higher internal congestion with offshore connectors
- More wind in the system creates similar results (reservoirs!)



Results: National welfare implications (II)

- Different designs have strong impact on welfare gains/losses
- Meshed network sees higher overall welfare gains than trade scenario
- Tendency of winners and losers for all scenarios
  - Isolated countries with excessive and flexible generation capacity gain welfare (GB, NO, SE)
  - Largest net importer (NL) gains by lower prices
  - Traditional exporting countries lose some export share (FR, DE)



Conclusion

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Thank you for your attention!

Contact

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