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Implementing a German capacity market:

How does it affect the German and Dutch electricity markets in combination with a high share of intermittent renewables in 2020?

Marit van Hout, Unit Policy Studies
Energy, Supply & Industry Group, ECN

Joint work with J. de Joode, O. Ozdemir, P. Koutstaal (ECN)

BAEE Research Workshop

28 – 9 – 2012

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(1) Problem Statement

- Traditional focus vs. new focus electricity markets
- Peak units generate in less hours and increase of price volatility
- Consequences:

(1) "Missing money" problem

(2) Less incentive to invest due to higher risk for potential investor not to get acceptable economic returns.

- How can these problems be mitigated?

(1) Energy storage

(2) Smart meters/grids

(3) Investments in (cross-border) interconnection capacity

(4) **Capacity Market** design as a financial instrument to give incentive to invest in generation capacity, e.g.:

- Strategic Reserves
- Capacity Payments
- Capacity Requirements

(2) Problem Statement

- Several countries discuss the possibility of implementing a capacity market mechanism
- What if only Germany introduces a capacity requirement?

Research Question:

What is the impact of a German capacity market in combination with high intermittent generation on generation capacity investments and the Dutch electricity market in 2020?

- Approach: simulations w/wo German capacity market using
- **Dynamic optimal generation investment** model (Dynamic COMPETES)
- **Static optimal dispatch** model (Static COMPETES)

Dynamic COMPETES model

- **Endogenous:**
  - investments in 2020 in gas fired, coal fired, lignite PC

- **Main exogenous inputs:**
  - Sample 1000 hours of a year
  - 2010 installed capacities
  - 2020 RES installed capacity and other non-endogenous technologies
  - Marginal costs, availability and demand
  - Cross-border transmission capacity
  - Investment costs in Euro/kW
  - Discount rate (10%)
  - Economic Lifetime
- Perfectly competitive market (except demand side response)
- Both variable and fixed costs considered when optimizing investments
- Objective: minimize total investment + operational costs of EU electricity system
- Optional additional constraint: reserve capacity requirement in Germany

German capacity market assumptions

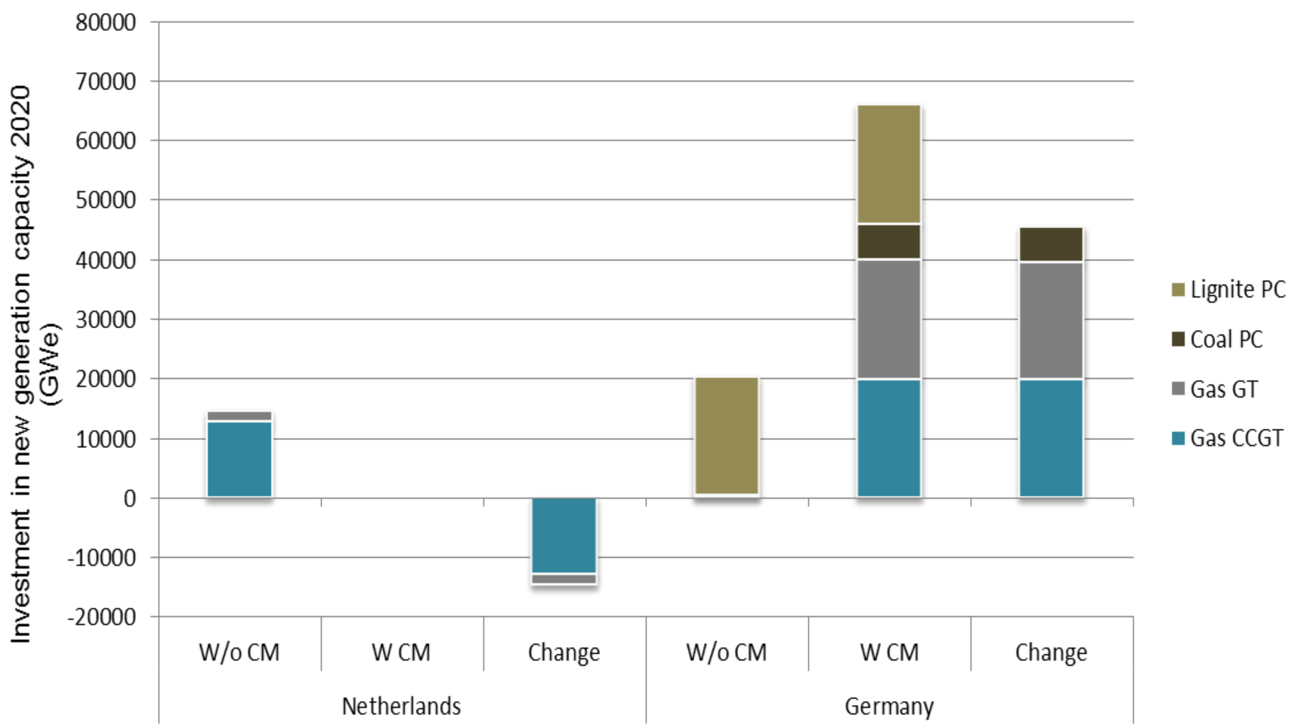
- Central auction where only German generation capacity is auctioned
- Capacity requirement at 115% of peak demand (15% reserve cap)
- Wind capacity credit of 5%, Solar 0%
- Value Of Lost Load (VOLL) = 10.000 Euro/MWh

- Reflects WTP consumer for reliability of supply
- VOLL 10.000 vs. VOLL 50.000
- In case of German capacity requirement; level VOLL no impact on German investments

Static COMPETES model

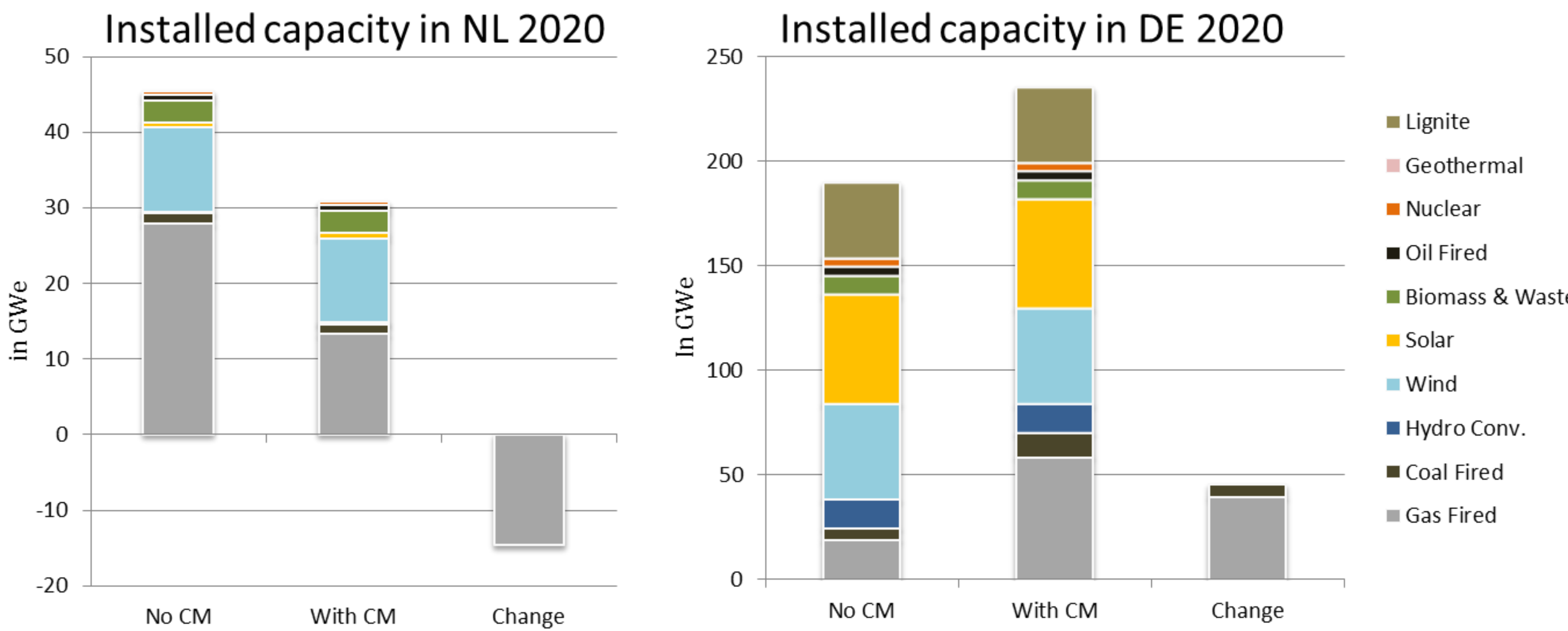
- Objective: minimize total operational costs in EU subject to system constraints
- Perfectly competitive market
- No loop flows taken into account
- In case demand has to be curtailed price = 10.000 euro/MWh
- **Main exogenous inputs:**
  - Installed generation capacities (from dynamic model)
  - Demand and intermittent generation of 8760 hours
  - Marginal costs, availability and hourly demand
  - Cross-border transmission capacity
- **Analysis focusses on general output Dutch and German electricity market:**
  - Electricity market prices
  - Production per technology
  - Imports/exports on cross-border Germany-Netherlands interconnection
  - CO_2 emissions

Results dynamic model



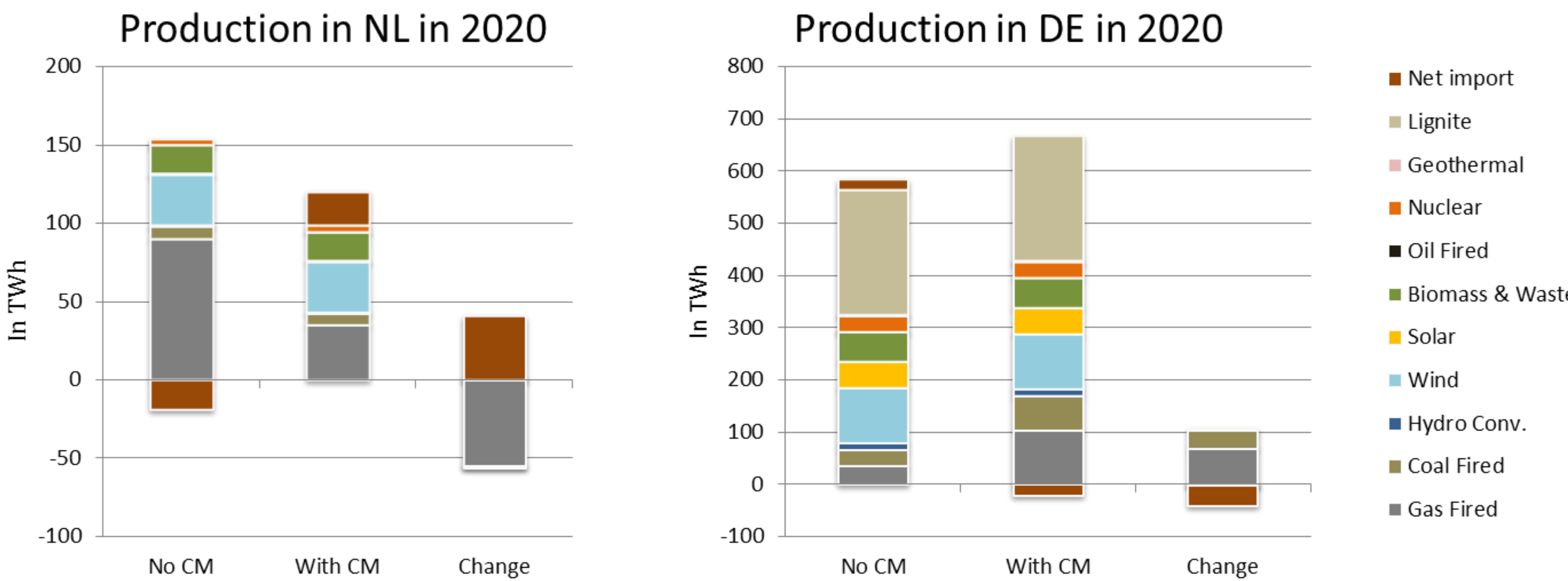
- With Capacity mechanism, no investments in NL in 2020
- Germany increases investments in gas and coal units (69% higher investments wrt W/O CM)

Installed Capacity in Germany and the Netherlands in 2020



- NL: Installed gas fired capacity reduces with **53%**
- DE: Installed gas fired capacity increases with **factor 3** and coal fired with **factor 2**
- NL: Share intermittent capacity in total installed capacity, with CM: 29%, No CM: 26%
- DE: Share intermittent capacity in total installed capacity, with CM: 42%, no CM: 52%

Impact on production



- NL becomes a net importer, Germany a net exporter
- In NL, production from gas fired units decreases with 61%
- In DE, production from gas fired units almost triples
- In DE, production from coal fired units doubles

Results: Impact on other indicators

		Netherlands			Germany		
Indicator	**Unit**	**Without CM**	**With CM**	**Change (%)**	**Without CM**	**With CM**	**Change (%)**
Total electricity production	[TWh / year]	153.6	98.3	-36%	564.3	667.0	18%
Average electricity price	[Euro / MWh]	70.1	61.8	-12%	99.0	61.1	-38%
Total CO2 emissions	[Mton / year]	37.6	18.7	-50%	289.4	343.9	19%
CO2 intensity of production	[Ton / MWh]	0.24	0.19	-22%	0.51	0.52	1%

- Total production in NL reduces with 36% (DE increases with 18%)
- Average weighted electricity price decreases 12% (DE: 38%)

- Total CO2 emissions in NL reduce by about a half (in DE increases with 19%)

- CO2 intensity of production in NL decreases by 22%
- CO2 intensity of production in DE increases with 1% (increase production & emissions balanced)

➢ DE higher intensity than NL due to significant share of lignite (highest emissions in kg/GJ)

Conclusions & Discussion

Implementation of Germany capacity mechanism in 2020:

- Affects investments in gas fired units in NL
- Reverses net flow on cross-border interconnection between NL and DE
- Reduces total CO_2 emissions and CO_2 intensity of production in NL
- Increases total CO_2 emissions in DE, but CO_2 intensity of production remains about the same

- Not all capacity market designs can be (easily) modeled
- Perfectly competitive market (i.e., no market power)
  - ➢ Market power could affect the level of investments (withholding of capacity)
- Need for further research on capacity market in Europe

➢ e.g. possibilities and bottlenecks of an overall EU capacity market?

Thank you for your attention, any questions?

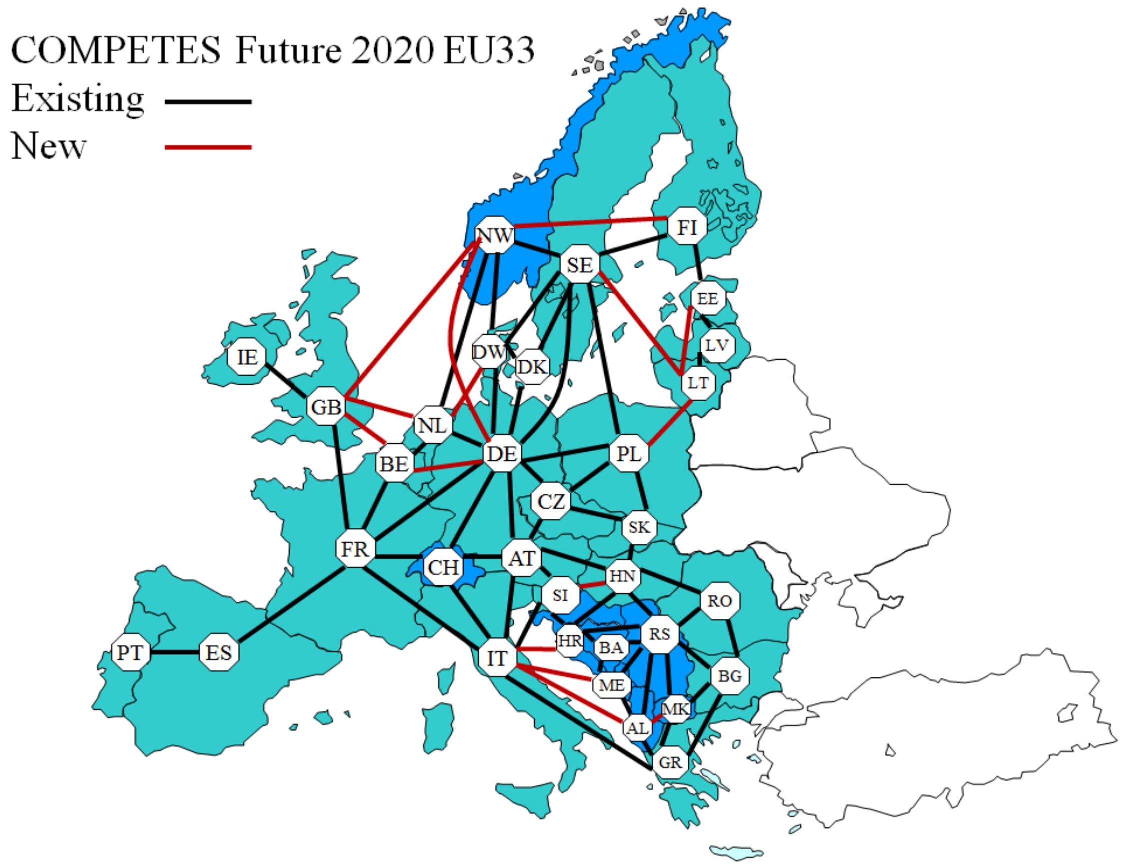
Source picture:
shanghaiist.com

References

[1] Cramton P., Stoft S. (2006) "*The Convergence of Market Designs for Adequate Generating Capacity*". Center For Energy and Environmental Policy Research, 06-007 WP (White Paper for the Electricity Oversight Board).

[2] Brunekreeft G., Damsgaard N., De Vries L., Fritz P., Meyer R. (2011) *"A Raw Model for a North European Capacity Market".* Discussion Paper. Elforsk Rapport 11:30.

Additional Slide- COMPETES physical representation



Additional slide- costs, emissions and economic lifetime

		Investment Costs (€/kW)		Fuel Costs (€/GJ)		Maintenance Costs (€/MWh)		Fuel Emissions (kg/GJ)	Economic Lifetime (Years)
Fuel	Fuel Type	2010	2020	2010	2020	2010	2020		
BIOMASS	Co-firing	1800	1700	1.97	3.49	2.6	2.6	0	30
BIOMASS	Standalone	2450	2150	1.97	3.49	2.3	2.3	0	30
COAL	PC	1500	1425	1.97	3.49	2.5	2.5	94.6	40
COAL	IGCC	2200	2050	1.97	3.49	2.5	2.5	94.6	40
GAS	CCGT	750	725	5.06	8.4	2.5	2.5	56.1	30
GAS	CHP	750	725	5.06	8.4	2.5	2.5	56.1	30
GAS	GT	450	425	5.06	8.4	2.5	2.5	56.1	30
GEO	-	3000	2700	0	0	1.7	1.7	0	30
HYDRO	Conventional	2500	2400	0	0	1	1	0	50
HYDRO	Pump Storage	2500	2400	0	0	1.2	1.2	0	50
LIGNITE	PC	1700	1625	1.07	2.59	2.5	2.5	101.2	40
NUCLEAR	-	3000	3000	0.06	0.06	0.5	0.5	0	45
OIL	-	800	750	8.23	11.96	2.5	2.5	74.3	30
RESE	Others	3700	3200	0	0	1.7	1.7	0	20
SUN	PV	2550	2000	0	0	0	0	0	25
WASTE	Standalone	2450	2150	0	0	2.5	2.5	73.6	30
WIND	Onshore	1150	1125	0	0	1.5	1.5	0	25
WIND	Offshore	3300	2950	0	0	2	2	0	25
SUN	CSP	5000	4200	0	1	0	0	0	25