Third Summer School
"Economics of Electricity Markets", Ghent University (FEB), Sep.1-4, 2015

- Tuesday, September 1st, 2015
  - 10.00 – 12.30 : Electricity in Europe; a changing landscape - Johan Albrecht, Ghent University
  - 13.30 – 15.30 : Wholesale electricity markets - Guido Cervigni, Universita Bocconi
  - 16.00 – 18.00 : Competition policy in the electricity industry - Guido Cervigni, Universita Bocconi

- Wednesday, September 2nd, 2015
  - 09.00 – 10.15 : How to calculate the cost of a black-out? - Danielle Devogelaer, Federal Planning Bureau
  - 10.30 – 12.45 : Transmission, ancillary services and system management - Hubert Lemmens, Elia
  - 13.30 – 16.15 : Future challenges for DSOs - Walter Van den Bossche, Eandis

- Thursday, September 3rd, 2015
  - 09.00 – 12.00 : Electricity markets and power exchanges; the perspective of BELPEX - Yves Langer, Senior Market Development Manager van APX/Belpex (http://www.belpex.be/)
  - 13.30 - 16.00 : Electricity trading game for the participants (Alois Tost)
  - 16.15 - 17.30 : Presentations by participants
  - 19.00 : workshop dinner

- Friday, September 4th, 2015
  - 09.00 – 12.30 : Electricity generation costs and system effects in low-carbon electricity systems – Marco Cometto, OECD/NEA, Paris
  - 14.00 – 17.30 : Ghent city exploration

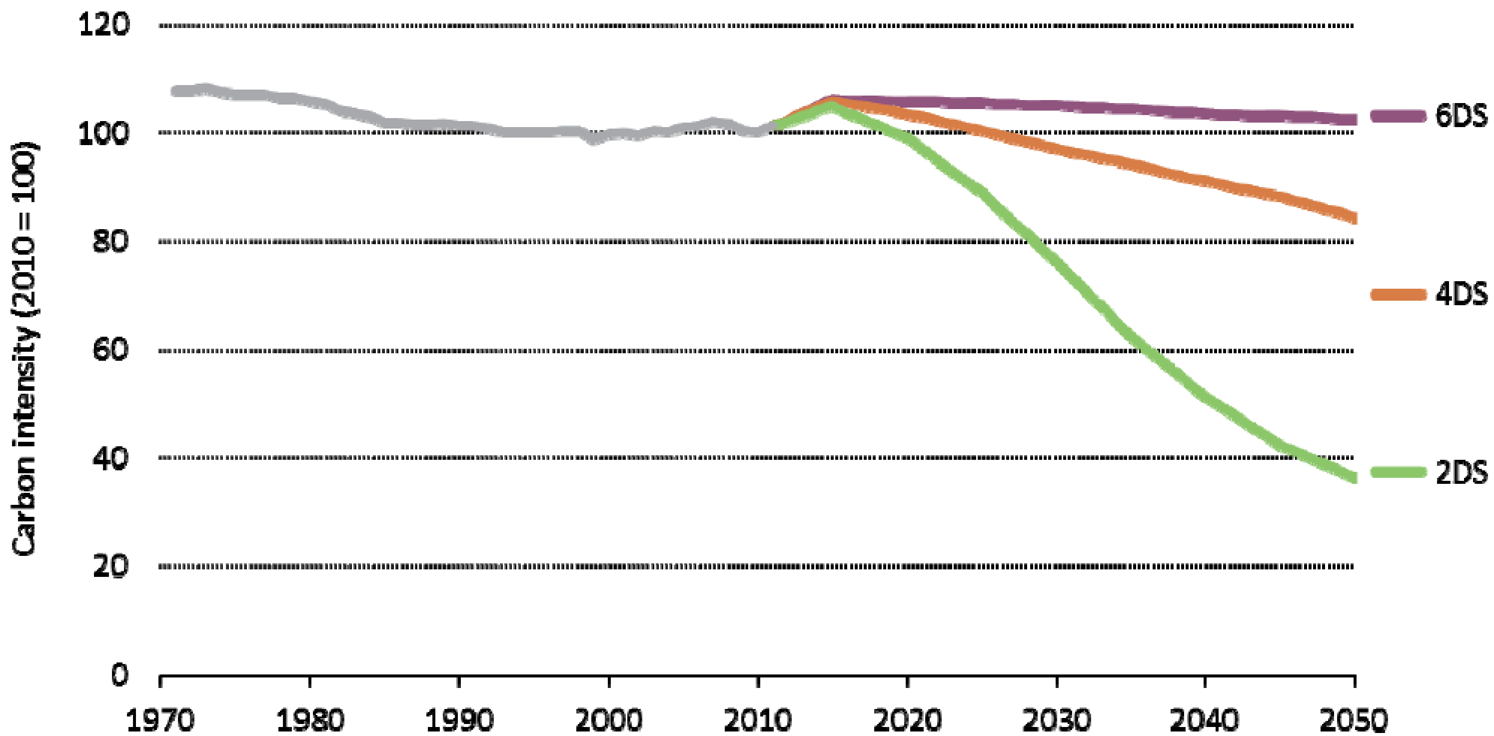
Electricity Markets in Europe: a changing landscape…

Johan Albrecht
Faculty of Economics & Business Administration

UNIVERSITEIT GENT

Electricity will become even more important…

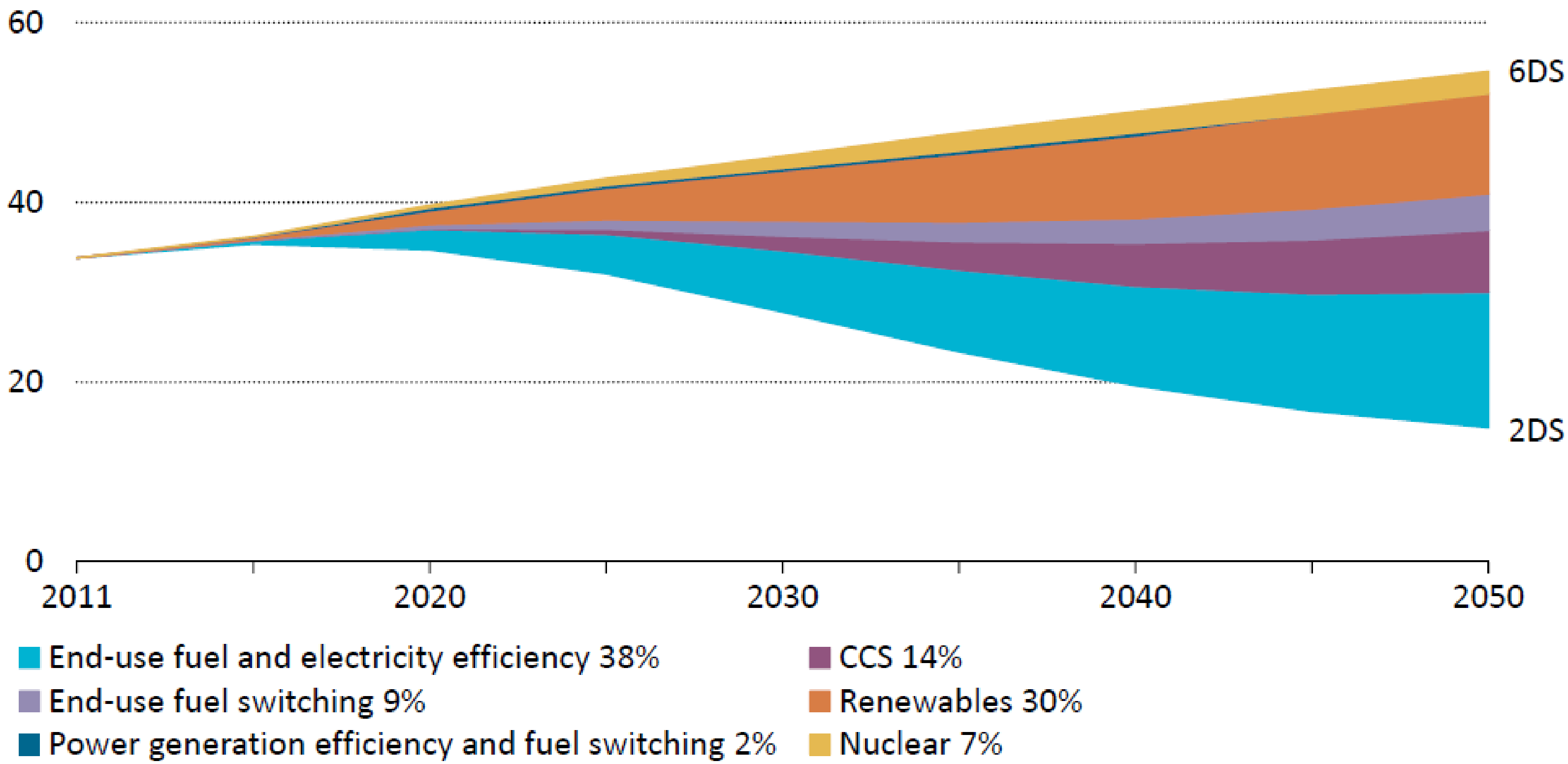
Towards COP21 in Paris…



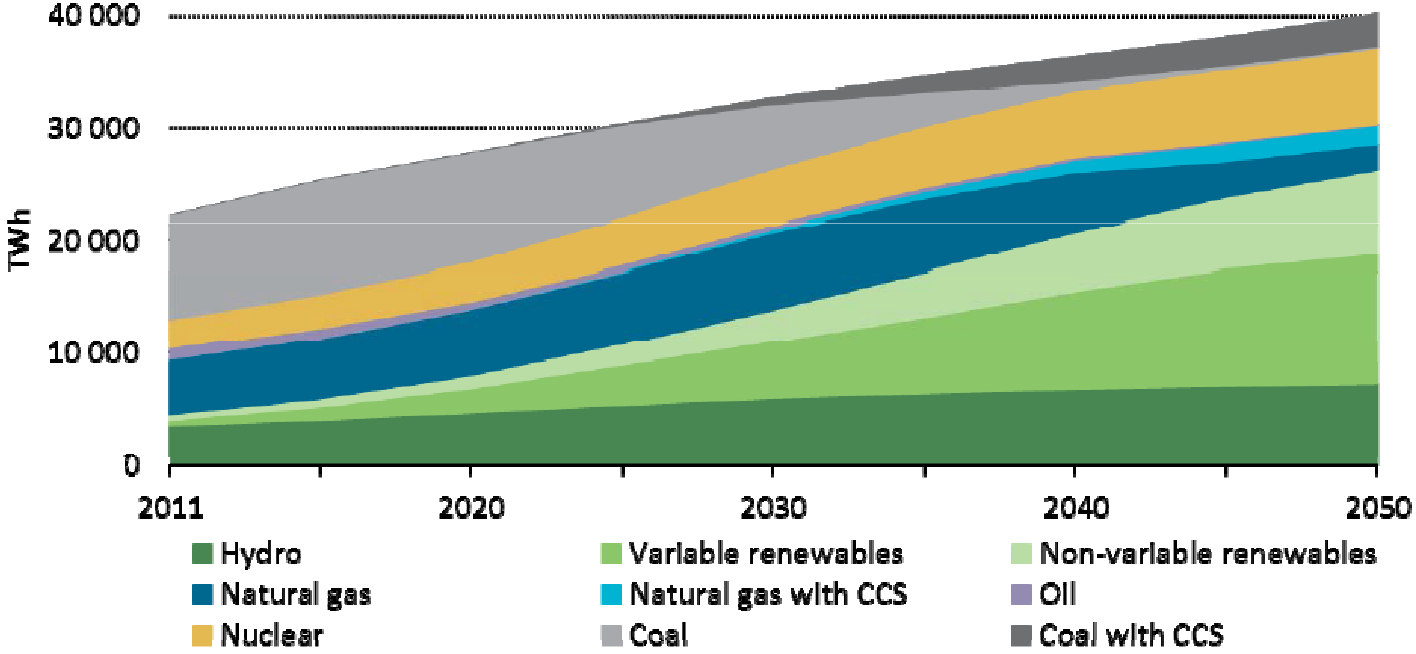
The political will to make meaningful progress at a global scale has yet to be demonstrated

International Energy Agency

A transformation of the complete energy infrastructure is needed



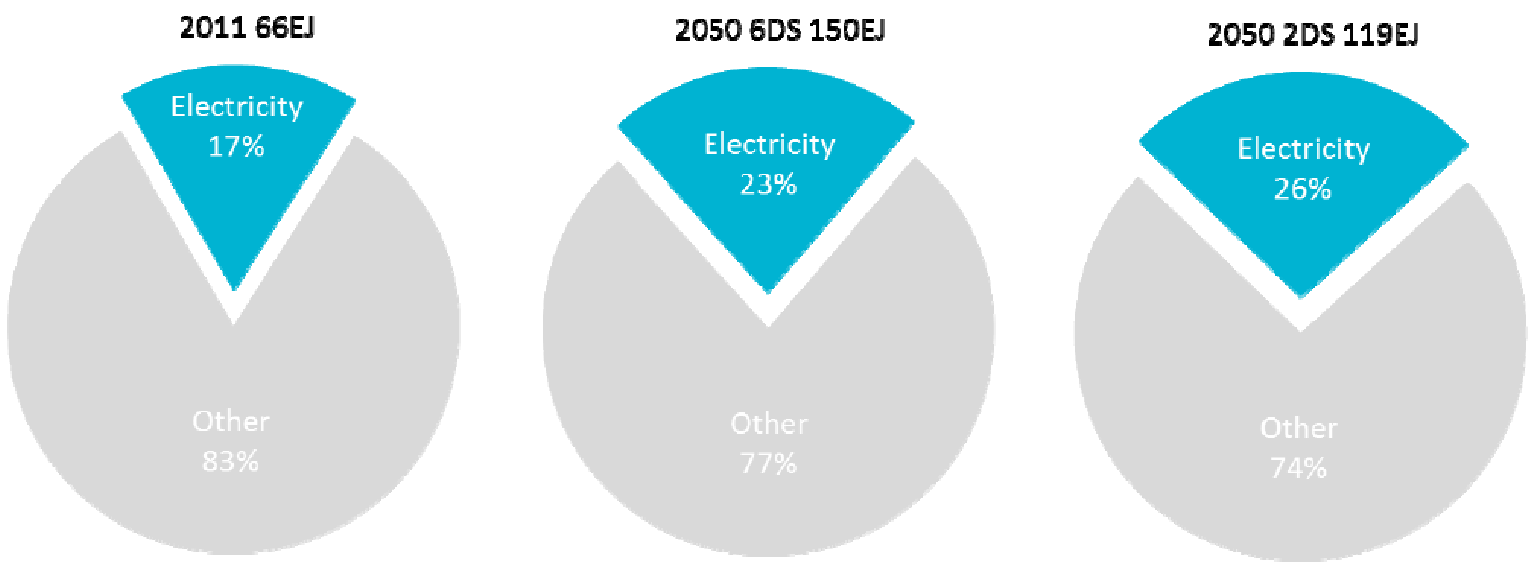
Electricity generation; a share reversal



- Generation today:
  - Fossil fuels: 68%
  - Renewables: 20%
- Generation 2DS 2050:
  - Renewables: 65%
  - Fossil fuels: 20%

International Energy Agency

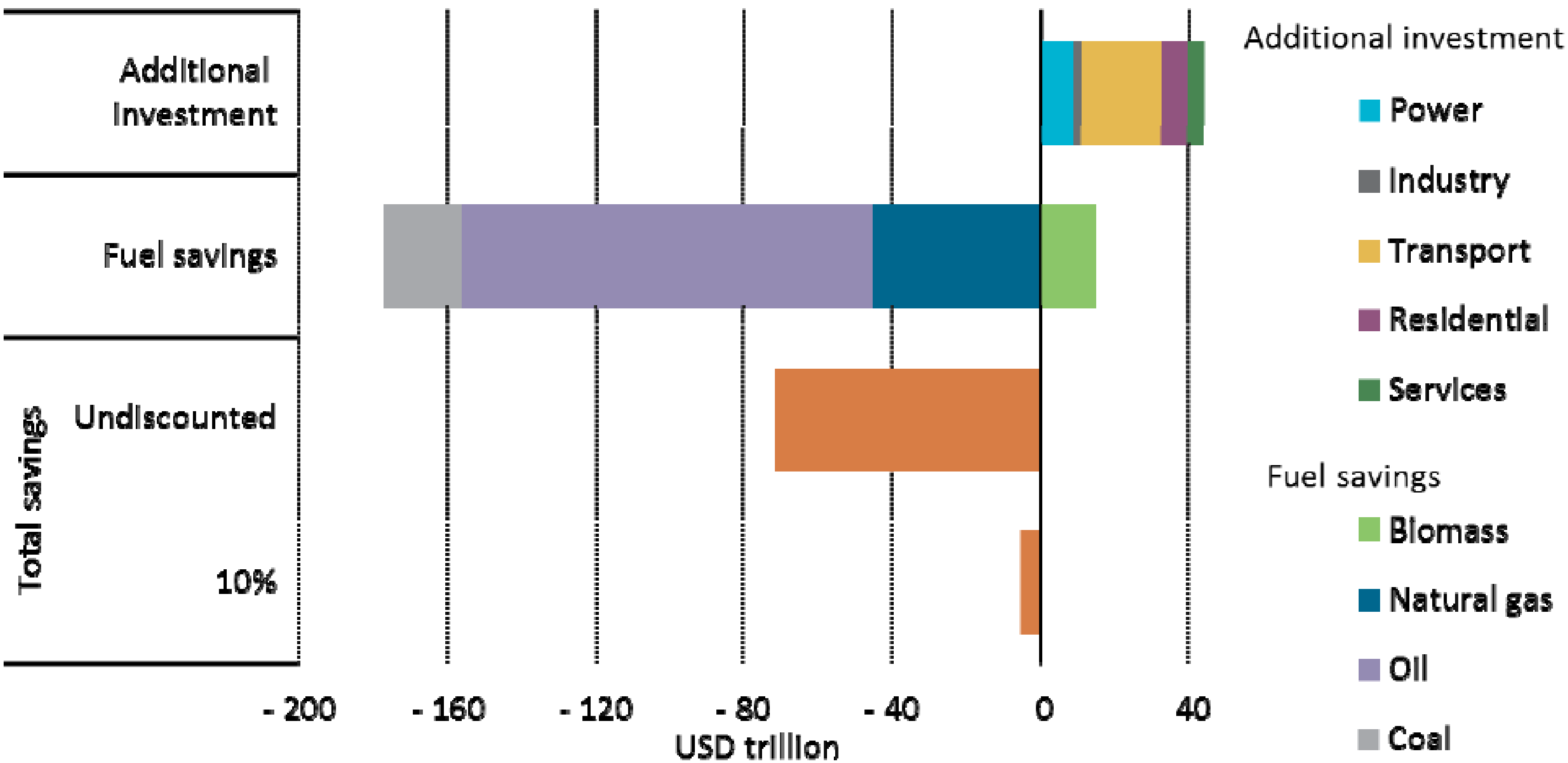
Harnessing the potential of electricity



*Increasing electricity consumption and its share of overall energy usage demands our attention – for **ALL** forward-looking scenarios*

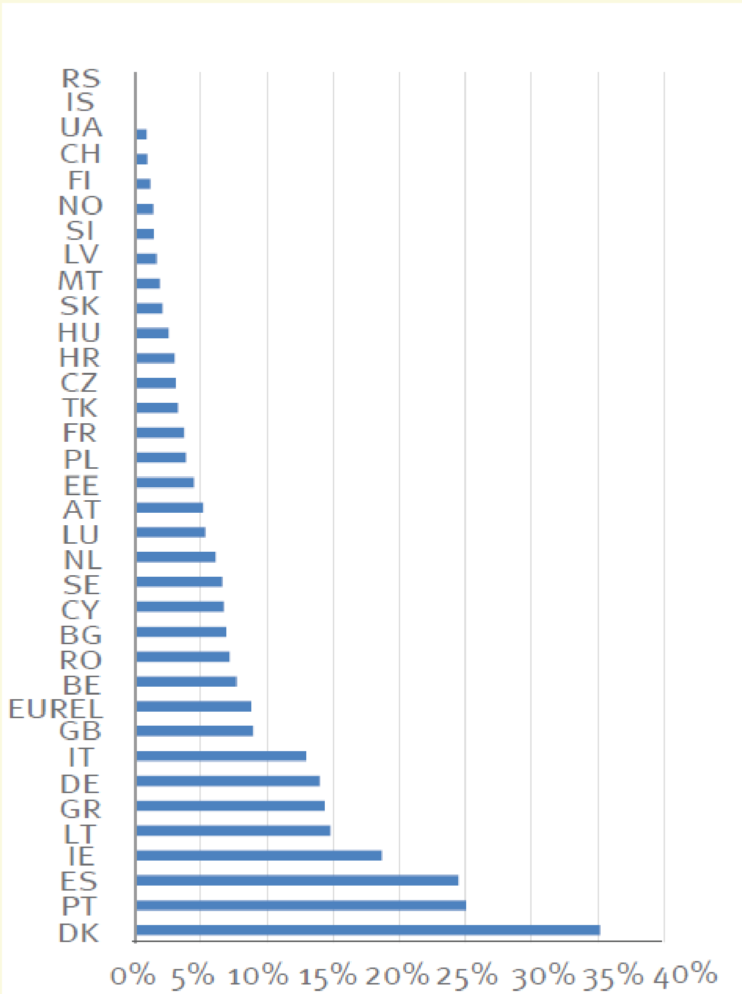
International Energy Agency

A massive but cost-efficient investment programme



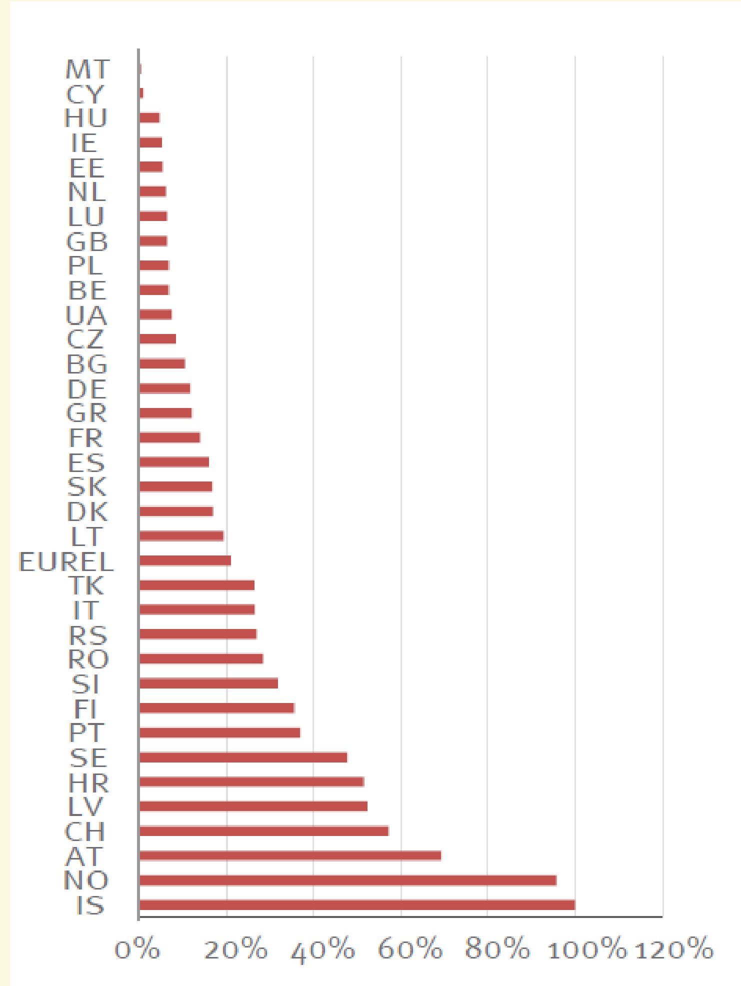
Some observations from Europe (where the energy transition already kicks in…)

Figure 2: Share of variable RES * in the 2013 power mix



** Variable RES includes wind and solar*

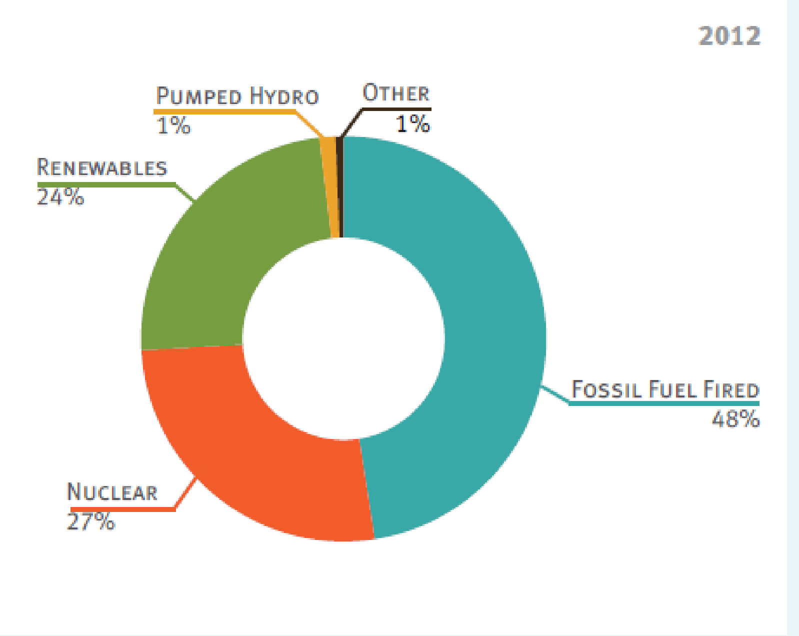
Figure 3: Share of non variable RES in the 2013 power mix**

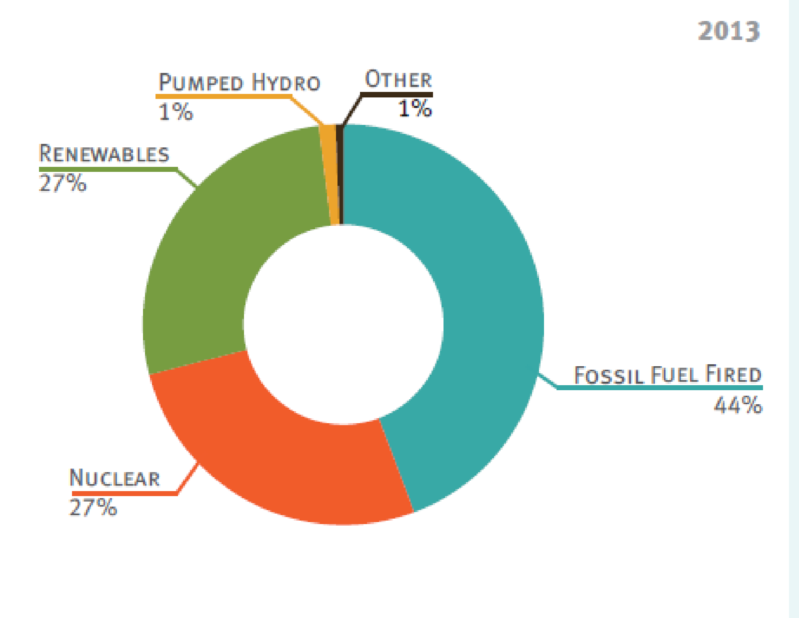


*** Non variable RES includes hydro, biomass, biogas and bioliquids, geothermal and other remaining renewable sources*

Source: Eurelectric 2015

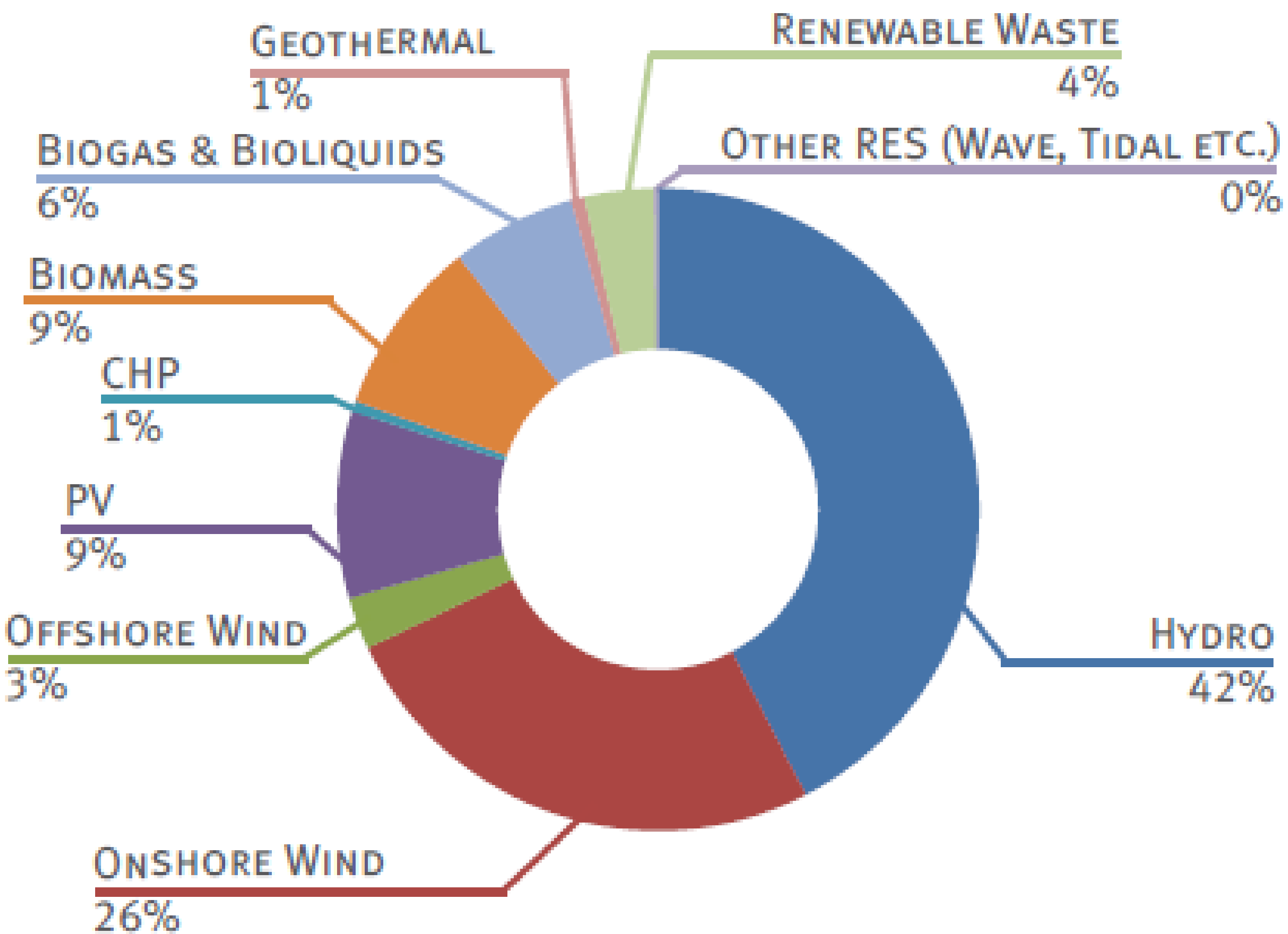
FIGURE 8: ELECTRICITY PRODUCTION BY PRIMARY ENERGY – EU28





Source: EURELECTRIC

FIGURE 9: THE SHARE OF RENEWABLE ENERGY SOURCES IN THE TOTAL EU-28 RENEWABLES GENERATION MIX FOR 2013



Source: EURELECTRIC

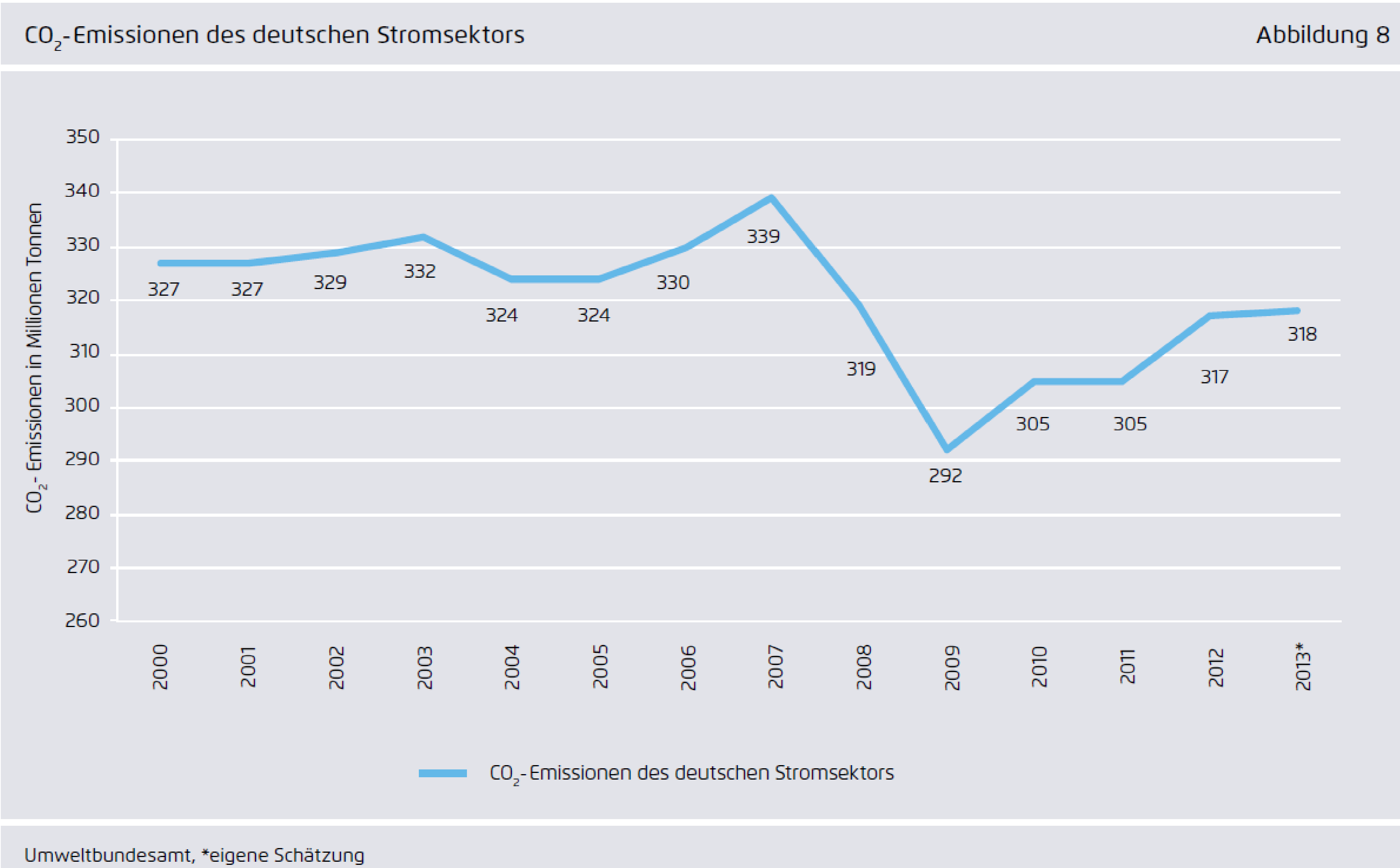
Table 2: Example of countries with a high Peak Solar and Peak Wind Production

PEAK SOLAR						
	Peak Solar powered generation in 2013 in 15 min interval	Date of Peak Solar generation			Final consumption in the 15 minutes of peak solar production	% covered by Solar
Germany	5988	21	Jul	2013	10743	56%
Belgium	2.062	20	Apr	2013	7.119	29%

PEAK WIND						
	Peak Wind powered generation in 2013 in 15min interval	Date of PeakWind generation			Final consumption in the 15 minutes of peak wind production	% covered by Wind
Denmark	4.892	22	Oct	2013	4.914	99%
Portugal	3.864	10	Dec	2013	6.654	58%

Source: EURELECTRIC

CO_2 from power generation on the rise in…Germany



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No. 013/13 | Berlin, 25.02.2013

Joint press release by the Federal Environment Ministry and the Federal Environment Agency (UBA)

Greenhouse gas emissions up by 1.6 percent in year 2012

Emissions still 192 million tonnes under Kyoto targets for years 2008 to 2012

According to the first preliminary calculations and estimations of the Federal Environment Agency (UBA), greenhouse gas emissions in Germany rose by 1.6 percent in 2012. Nevertheless; Germany clearly exceeded its reduction target under the Kyoto Protocol. When compared with 1990 greenhouse gas emissions in 2012 have dropped by 25.5 percent; a 21 percent

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Gas or coal-based electricity?

Electricity generation	From gas Jan-Jun 2011 (in GWh)	From gas Jan-Jun 2012 (in GWh)	Relative growth (in %)	From coal Jan-Jun 2011 (in GWh)	From Coal Jan-Jun 2012 (in GWh)	Relative growth (in %)
Germany	40984	34749	-15	129399	140008	8
Spain	40696	35790	-12	16803	27656	65
UK	71894	48109	-33	52422	70991	35

Bron; IEA (2012)

CCGT Tessenderlo; ultra-efficient (57%) but idle…

Low-carbon electricity love story under serious stress…

- March 2009, 61 CEO’s electricity companies (+70% of total EU power generation) signed a Declaration committing to action to achieve **carbon-neutrality by 2050**.
- 2009 ***Power Choices*** study examining how this vision could be made reality
- Eurelectric (2013): *‘**Power Choices Reloaded**: Europe's Lost Decade?’ : “European policy is not sending a clear signal. Instead it offers **several conflicting and contradictory signals**. For an investor it is almost impossible to identify a clear path through the **regulatory jungle**. In contrast to the coherent objective of the European internal energy market, we experience a variety of different and not very stable national policies for low-carbon….”*

When the energy transition with renewables, electrification and efficiency investments is the answer, what was the initial question?

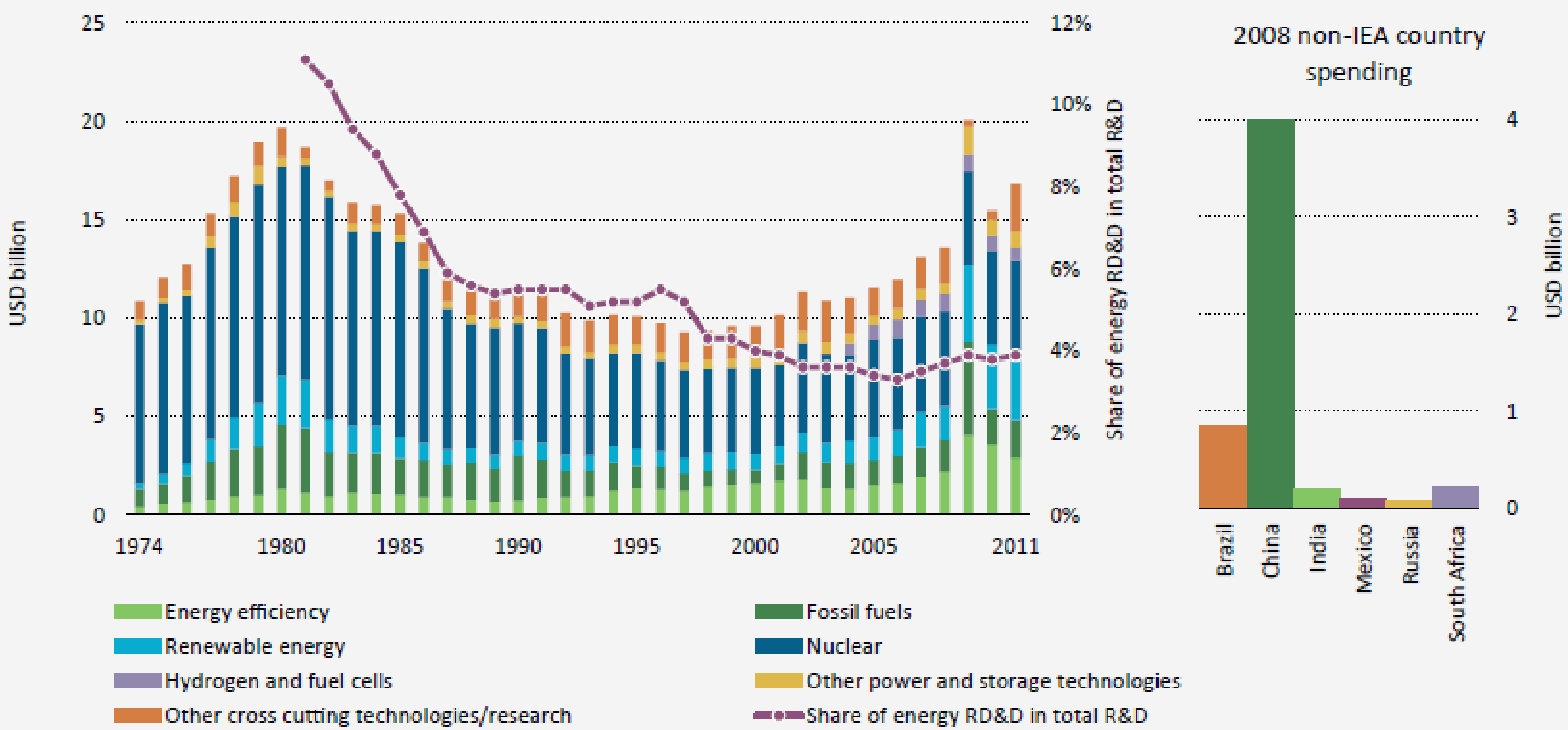
The fossil energy system made us very rich, but also makes us…

Resilience: fossil fuels 82% TPES, modern RES 1% (modern RES 0.1% in 1973)

- Who made or designed the global energy system?
- Problems: CO_2, ***short-term*** allocative efficiency, price volatility (risk for inflation & recessions)
- **Market failure 1**; no price on CO_2
- No G8 & G20 agreement; *too risky, CO_2 price triggers only mature technologies*
- **Market failure 2**; € 544 billion fossil subsidies
- Coal subsidies in EU; prolonged up to 2018

Market failure 3; historical underinvestment in energy-related RD&D

Figure 5.3 Government energy RD&D expenditure in IEA member countries



Source: IEA; Kempner *et al.*, 2010.

Table 12.2 ▶ Estimated public-sector low-carbon energy technology current spending, needs and gap to achieve BLUE Map outcomes in 2050

	Annual investment in RD&D needed to achieve the BLUE Map scenario outcomes in 2050	Current annual public RD&D spending	Estimated annual RD&D spending gap
	(USD million)[1]	(USD million)[2]	(USD million)
Advanced vehicles (includes EVs, PHEVs + FCVs; energy efficiency in transport)	22 500 – 45 000	1860	20 640 – 43 140
Bioenergy (biomass combustion and biofuels)	1 500 – 3 000	740	760 – 2 260
CCS (power generation, industry, fuel transformation)	9 000 – 18 000	540	8 460 – 17 460
Energy efficiency (industry)[3]	5 000 – 10 000	530	4 470 – 9 470
Higher-efficiency coal (IGCC + USCSC)[4]	1 300 – 2 600	850	450 – 1 750
Nuclear fission	1 500 – 3 000	4 030	0[5]
Smart grids	5 600 – 11 200	530	5 070 – 10 670
Solar energy (PV + CSP + solar heating)	1 800 – 3 600	680	1 120 – 2 920
Wind energy	1 800 – 3 600	240	1 560 – 3 360
Total across technologies	50 000 – 100 000	10 000	40 000 – 90 000

Source: IEA, ETP 2010

Global R&D gap $ 40 - $ 90 bill/yr

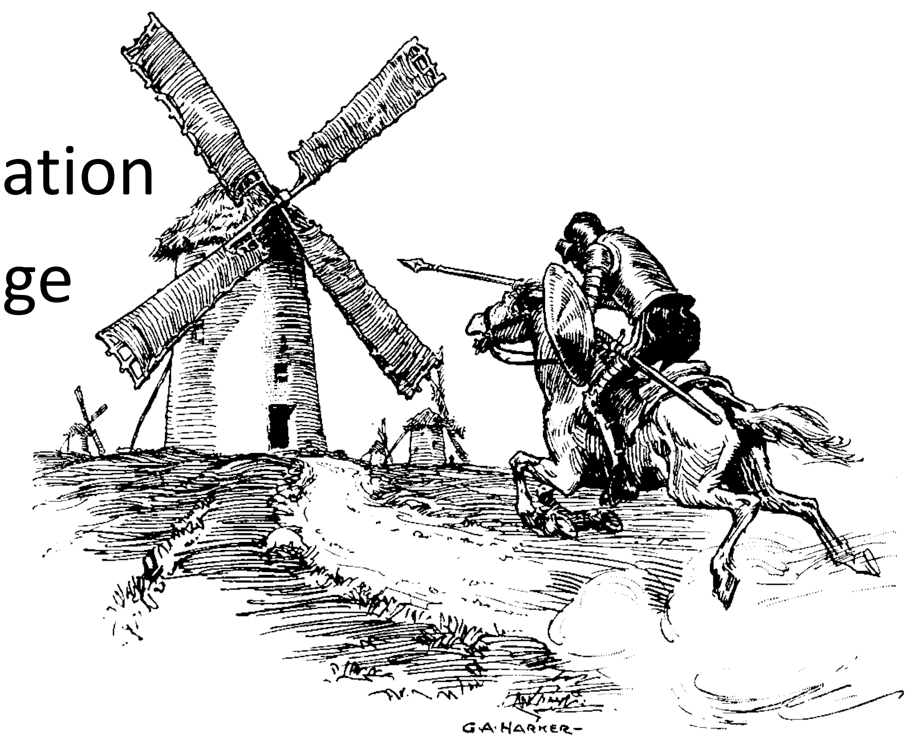
- WEO 2013: $ 544 bill fossil subsidies (mainly non-OECD)
- RES deployment subsidies of $ 101 billion per year (EU € 57 billion, of which € 20 billion in Germany); will expand to $ 220 billion by 2035
- ***Policymakers avoid explicit signals (like carbon prices), prefer hidden mechanims, avoid transparency***
- ***No carbon price-> Soviet-style economic planning***

Europe: alone in G8/G20

- "Yes, we can!" : 20/20/20, Low-carbon Economy, 2050 Roadmap, *Energiewende,…*
- Without a price on CO_2 (failure of ETS)
- Without supporting energy R&D
- **With soft post-2020 targets**
- National targets -> fragmentation
- With energy cost disadvantage

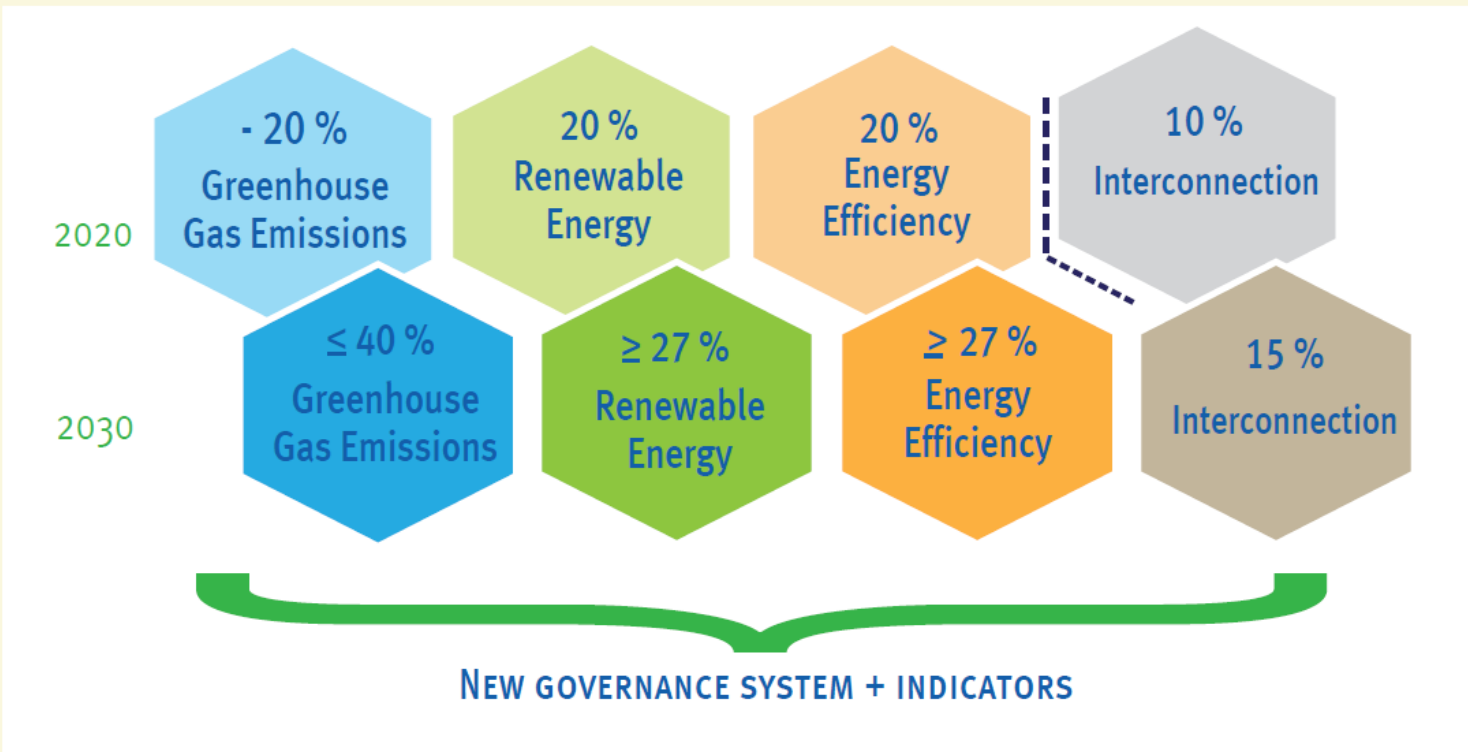
of **+ $ 130 bill** to US industry

(WEO 2013)



Climate policy framework

FIGURE 5: AGREED HEADLINE TARGETS – 2030 FRAMEWORK FOR CLIMATE AND ENERGY



Source: European Commission 2030 Framework for Climate & Energy, outcome of the October 2014 European Council

Electricity markets

Electricity markets; some basics

- Defining electricity markets: introduction
- Market institutions before and after the liberalisation
- Electricity prices + price composition
- European recession and investment climate
- Long-term challenges

Defining electricity markets

An introduction

Defining electricity markets/systems

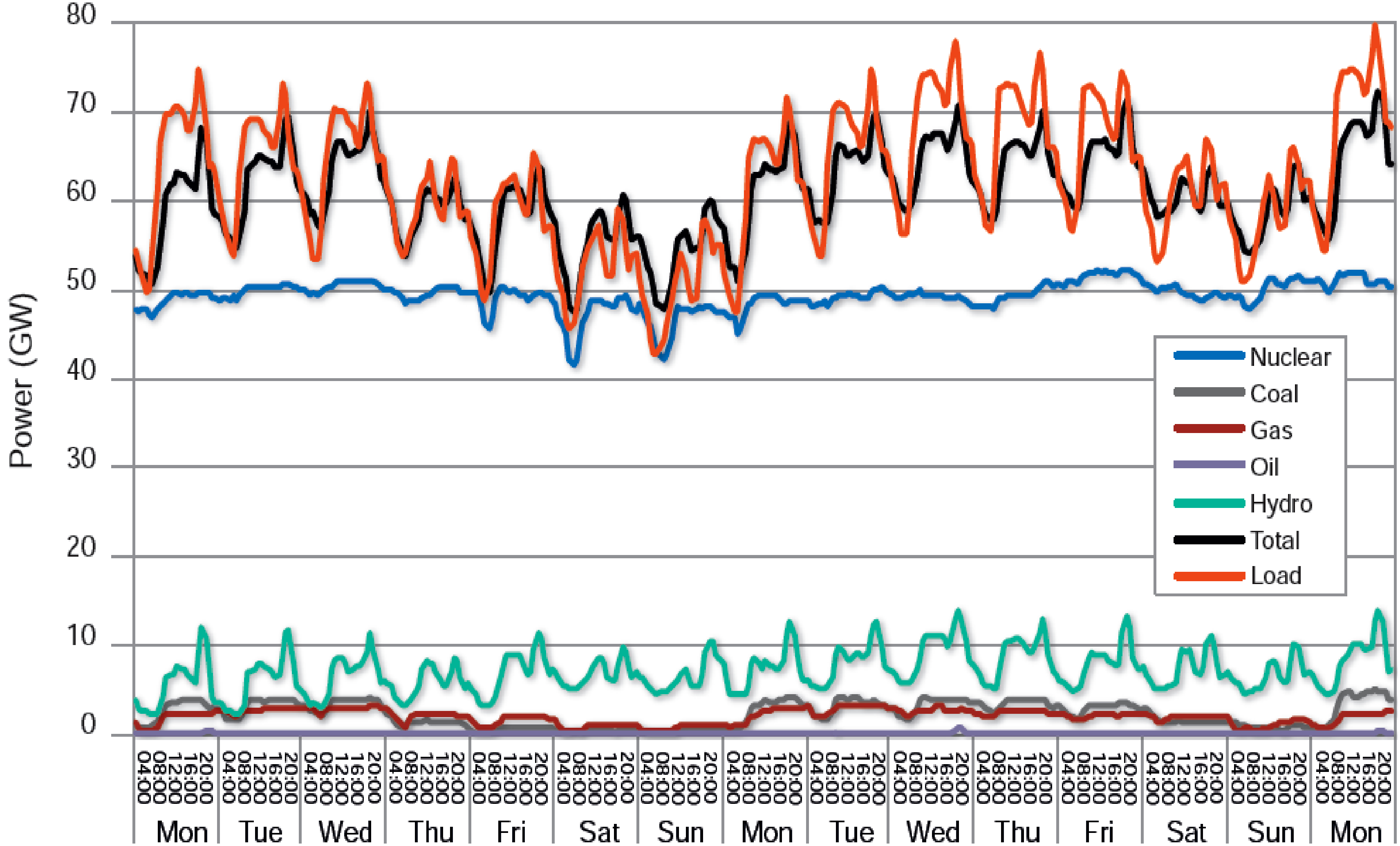
- Market: meeting place for buyers and sellers
- Electricity; instantaneous but also intertemporal equilibrium between demand (load) and supply (generation)
- Electricity system is designed to follow a variable load – technologies selected based on their load following ability
- Efficiency: market designs should support 'optimal' combination of generation and balancing technologies

Table 3.2: The load following ability of dispatchable power plants in comparison

	Start-up time	Maximal change in 30 sec	Maximum ramp rate (%/min)
Open cycle gas turbine (OCGT)	10-20 min	20-30%	20%/min
Combined cycle gas turbine (CCGT)	30-60 min	10-20%	5-10%/min
Coal plant	1-10 hours	5-10%	1-5%/min
Nuclear power plant	2 hours - 2 days	up to 5%	1-5%/min

Source: EC JRC, 2010 and NEA, 2011a.

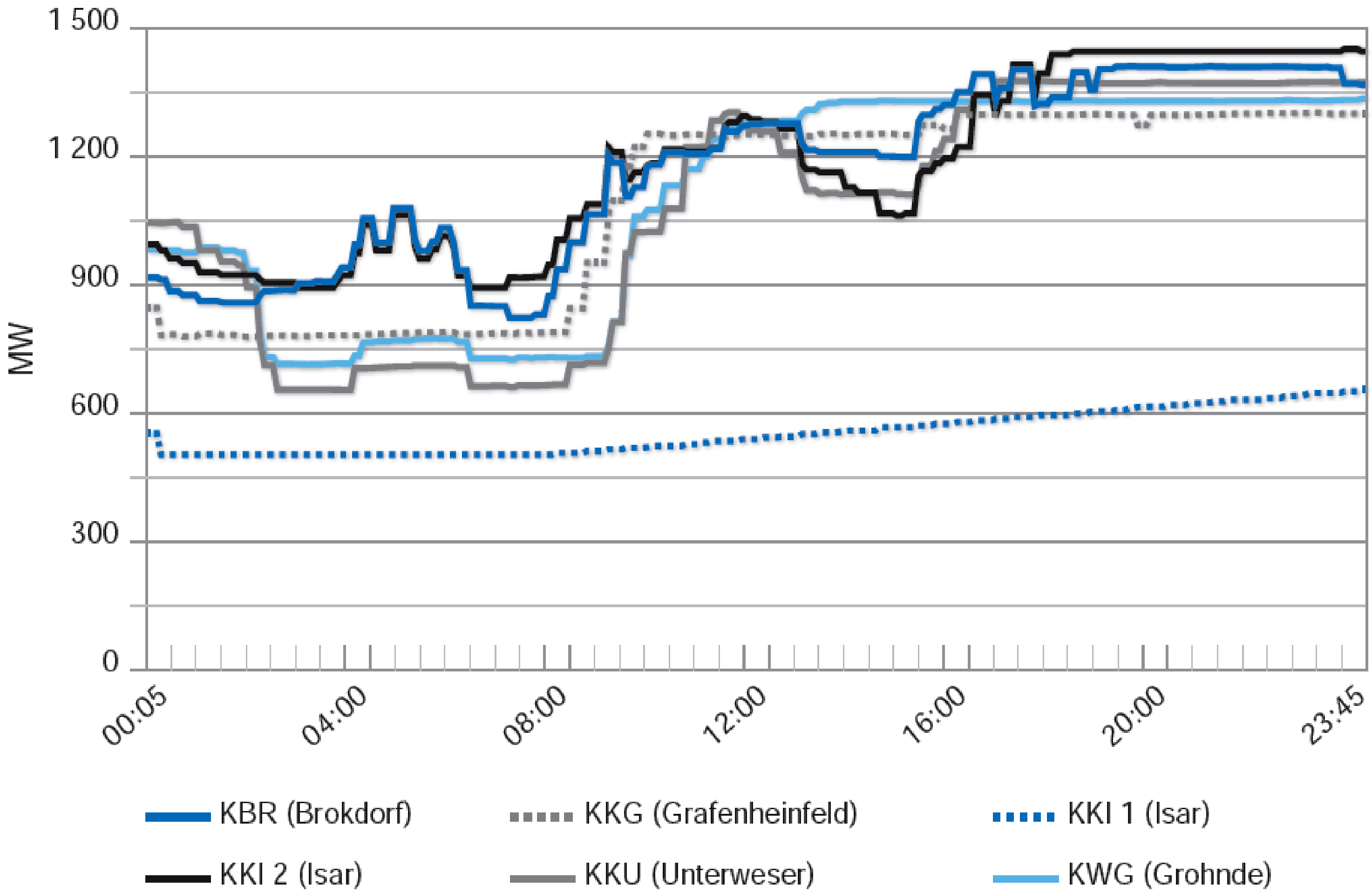
Figure 3.2: Example of the electricity generation in France during 2 weeks in November 2010



Source: Based on RTE data – Réseau de Transport d'Électricité, France.

Even nuclear plants can follow the load

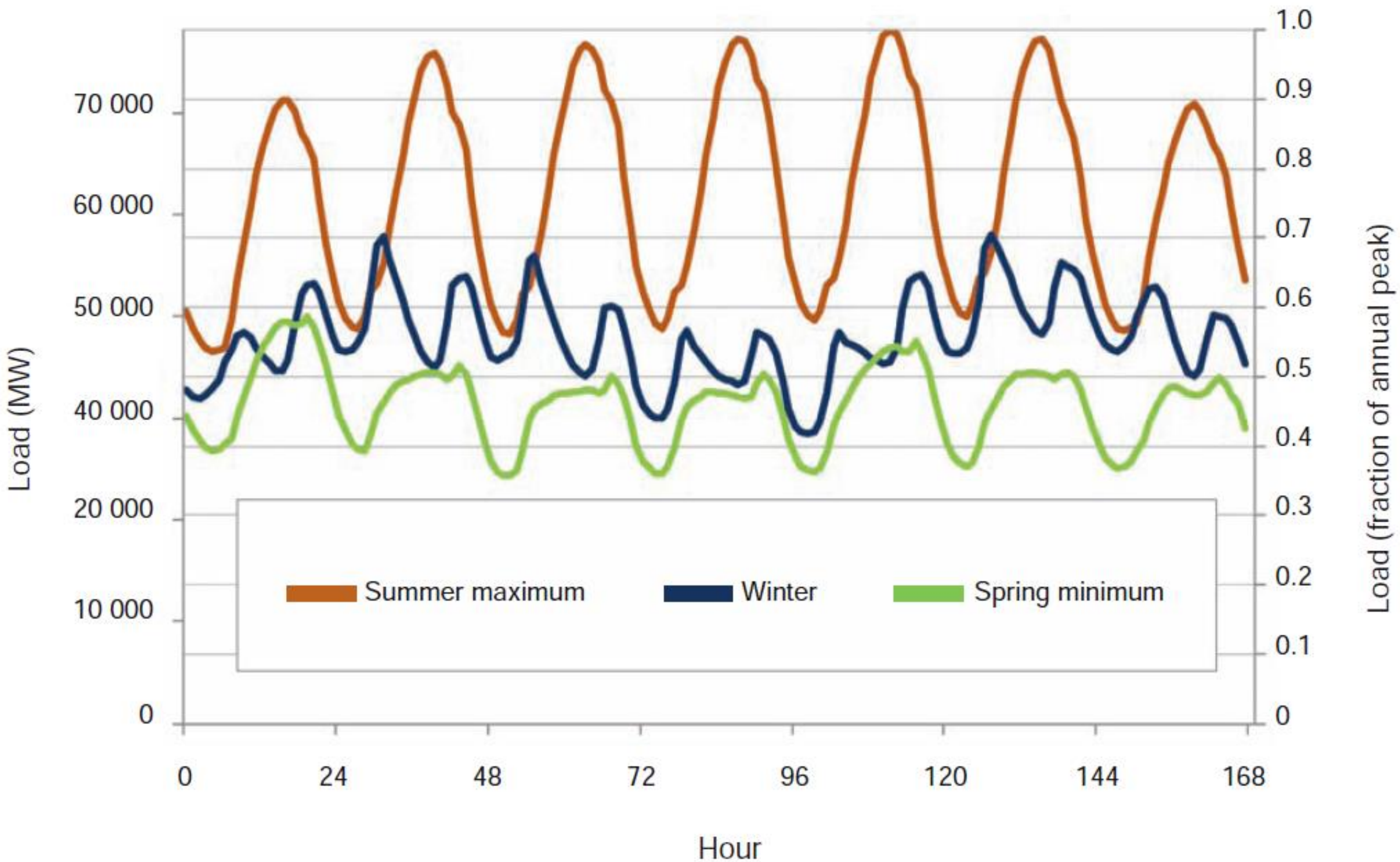
Figure 3.4: Load following operations of E.On nuclear units in Germany



Source: Courtesy of E.ON Kernkraft, Germany.

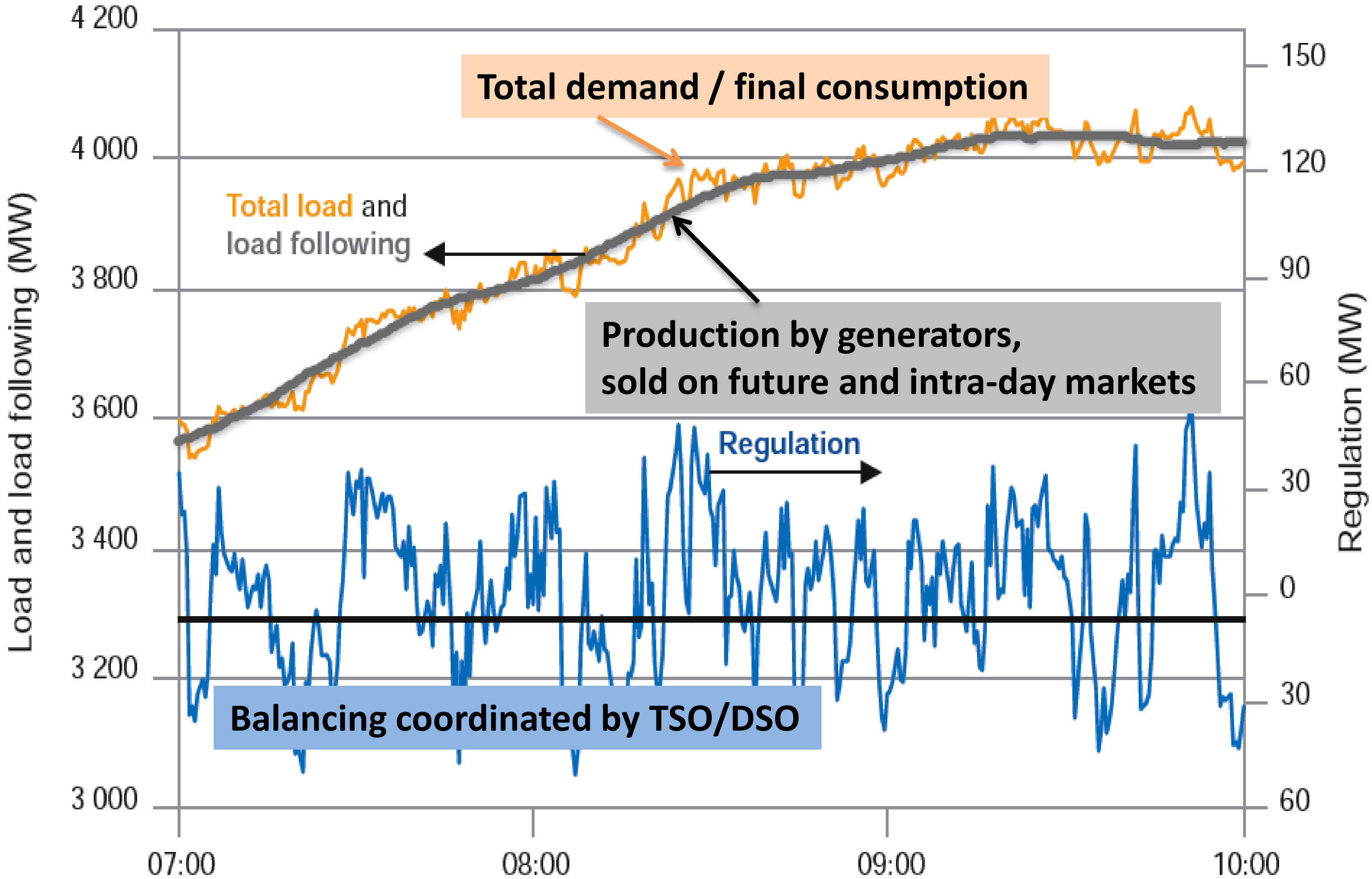
Seasonal load & peak variance; Texas (US)

Figure 2.1: Hourly electricity demand curve in Texas (ERCOT) for 3 weeks in 2005



Source: Denholm *et al.*, 2010.

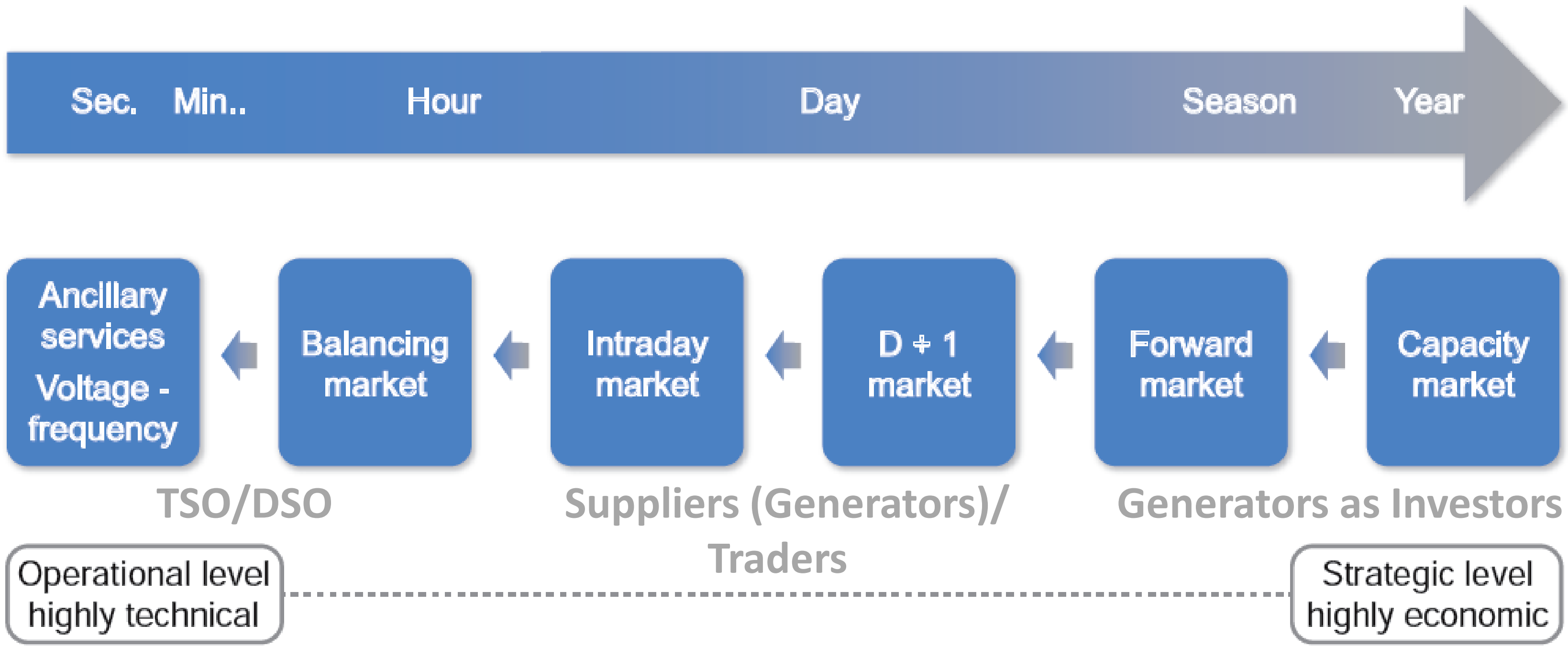
Figure 2.2: System load following and frequency regulation



Note: Electricity load curve, morning ramp-up.

Source: Kirby, 2004 (courtesy of the Oak Ridge National Laboratory, US Department of Energy).

System needs -> market designs



<u>Ancillary services</u> (managed by TSO/DSO): frequency & voltage control, spinning & standing reserve, black start capacity, remote automatic generation control, grid loss compensation and emergency control actions.

System needs -> market design 2

- **Market for ancillary services**: TSO/DSO contract generators, large users -> fee for offered capacity services – « network costs » on your invoice
- Intraday and forward **'energy-only' markets**: D&S of electricity on platforms – « electricity cost » on your invoice
- **Capacity markets**: generators negotiate/receive incentives to invest, e.g. subsidy per installed MW CCGT capacity – « network costs » on your invoice (or not on your invoice – financed from general taxes)
- Debate on capacity markets in Europe; 'energy-only' markets apparently do not trigger sufficient investments in new capacity…

Market institutions before and after the liberalisation

Let's go back to 1980s

- Electricity landscape with heavily <u>regulated</u> vertically integrated companies (national/regional/local monopolies)
- Regulation: *security of supply* (grid stability, flexibility, balancing), *investment cycle* (follow expected demand), *final prices* (« **cost-plus » system**) & (global) *profit margin*
- **Vertically integrated**: generation, transmission, local distribution, security of supply – **internal optimisation of activities and investment decisions; single business model to optimize complete value chain**, e.g. generation strategy considers capacity of transmission grid and ability to balance under extreme circumstances
- Utilities sell **energy services,** including system reliability and system adequacy, all priced per MWh finally consumed
- Cross-subsidies at retail level to offer lower prices to industry

Vertically integrated companies

- Prices; depending on investment cycles, technological choices, industrial policy (cross-subsidies), geography, …
- Different electricity prices *can* distort *free competition & isn't life too easy for big utilities with guaranteed profit margins??*
- To assess desirability of this model, you have to ask whether electricity is just a commodity or provides a social service with external benefits
- 'Old' invoice at retail level : electr + network costs + taxes
- EC: electricity is a commodity -> liberalize to increase competition -> **market model = energy-only market (EOM)**

Economic life in 1980s

- Utilities and national planning organisations project expected demand (ST, MT & Long Term) and propose necessary investments (generation + network)
- Governments approve investment plans and eliminate market uncertainty (technical uncertainty remains)
- After investments came on-line: period with overcapacity (esp. with nuclear, less with smaller gas-powered plants) followed by tighter markets as economy grows (explains investment *waves*)
- Closed markets with regulated prices to recover capital costs; prices mainly follow capital cost (see French case) : depreciated assets (after 15 to 20 yrs) lead to lower retail prices
- Once depreciated, old assets remain operational at low cost (marginal) and de facto compete with new or planned generation assets
- EU today: many assets date from before 1970!

« Cost-Plus » & investment cycle (FR); price follows investm cycle

Evolution of Electricity Investments in France (1955-2011)

Power generation and network investments in constant 2007 Euros; billion Euros on the left-axis
Tariffs in red (industrial tariffs in real terms, Euros/MWh on the right-axis) are linked to investment effort since the first oil shock in 1974 (start of nuclear program) **source: EDF**

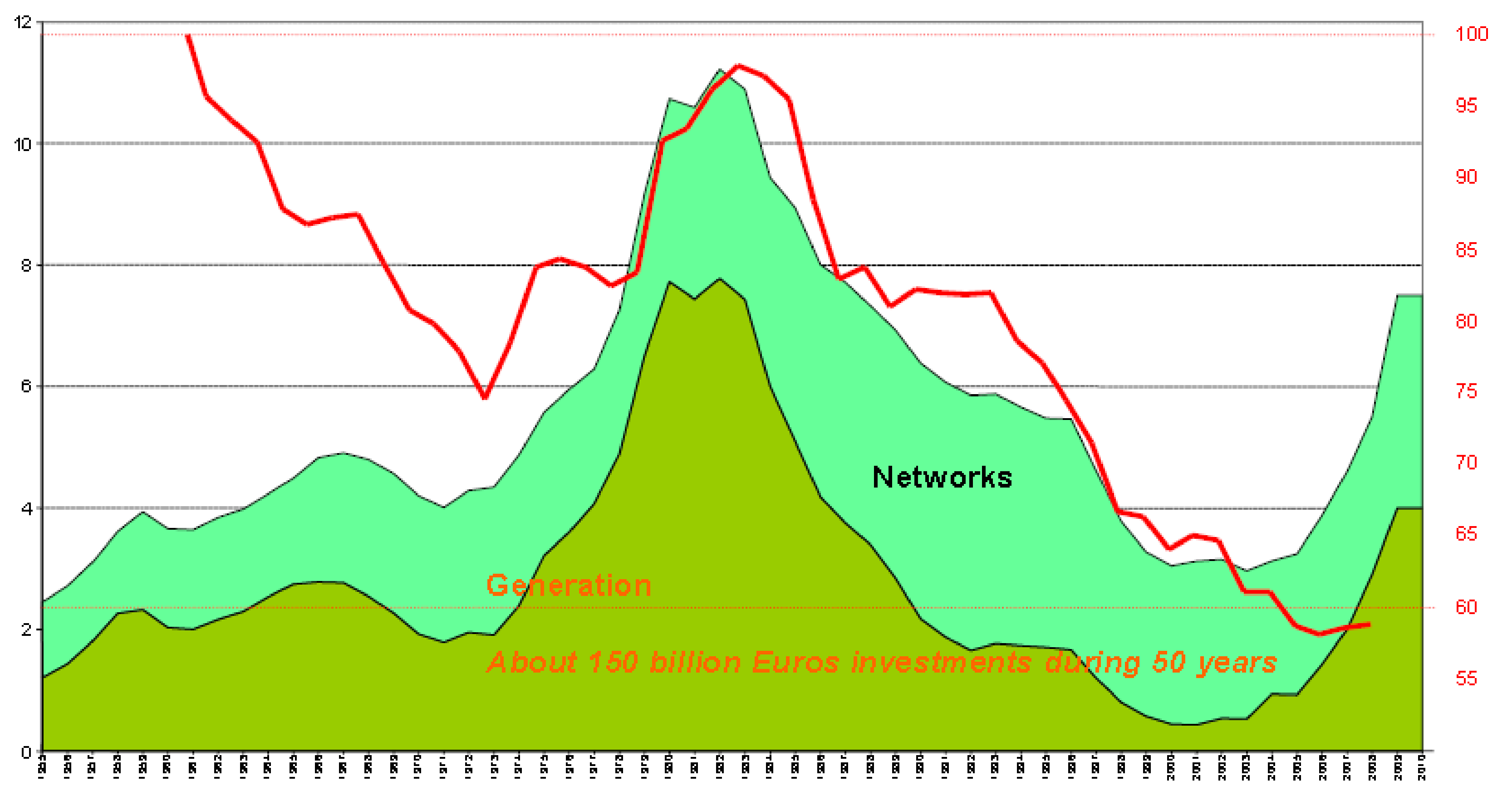
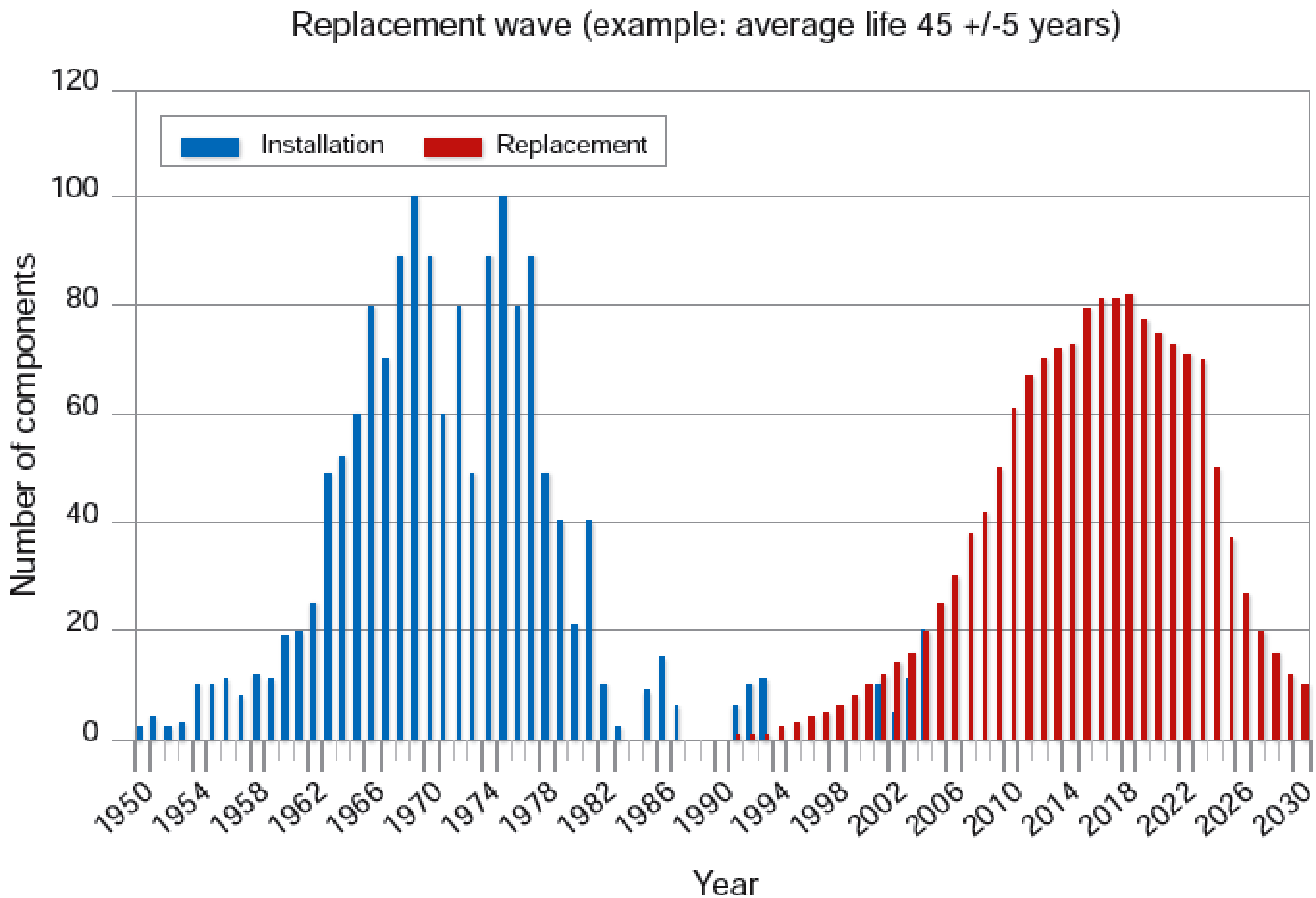


Figure 6.1: Installation of distribution assets over time



Note: Historic and future expected investments of a typical Dutch DSO.

Source: Gaul *et al.*, 2005 and Jongepier, 2007.

The liberalisation and market integration project

- Directive 96/92/EC concerning common rules of the internal market in electricity (the First Electricity Directive) and Directive 98/30/EC on common rules for the internal market in natural gas (the First Gas Directive)
- 2002: national and international electricity and gas trading platforms, e.g EEX.com
- 2003: Second Energy Package (SEP)
- 2005: EC inquiry about functioning of internal market
- 2009: Third Energy Package (TEP) for the electricity and gas markets : stringent unbundling rules , new agency to coordinate the actions of the national regulatory authorities (NRAs), the formation of ‘European Network of Transmission System Operators’ for electricity and gas
- TEP completed by the end of 2014 (in theory)

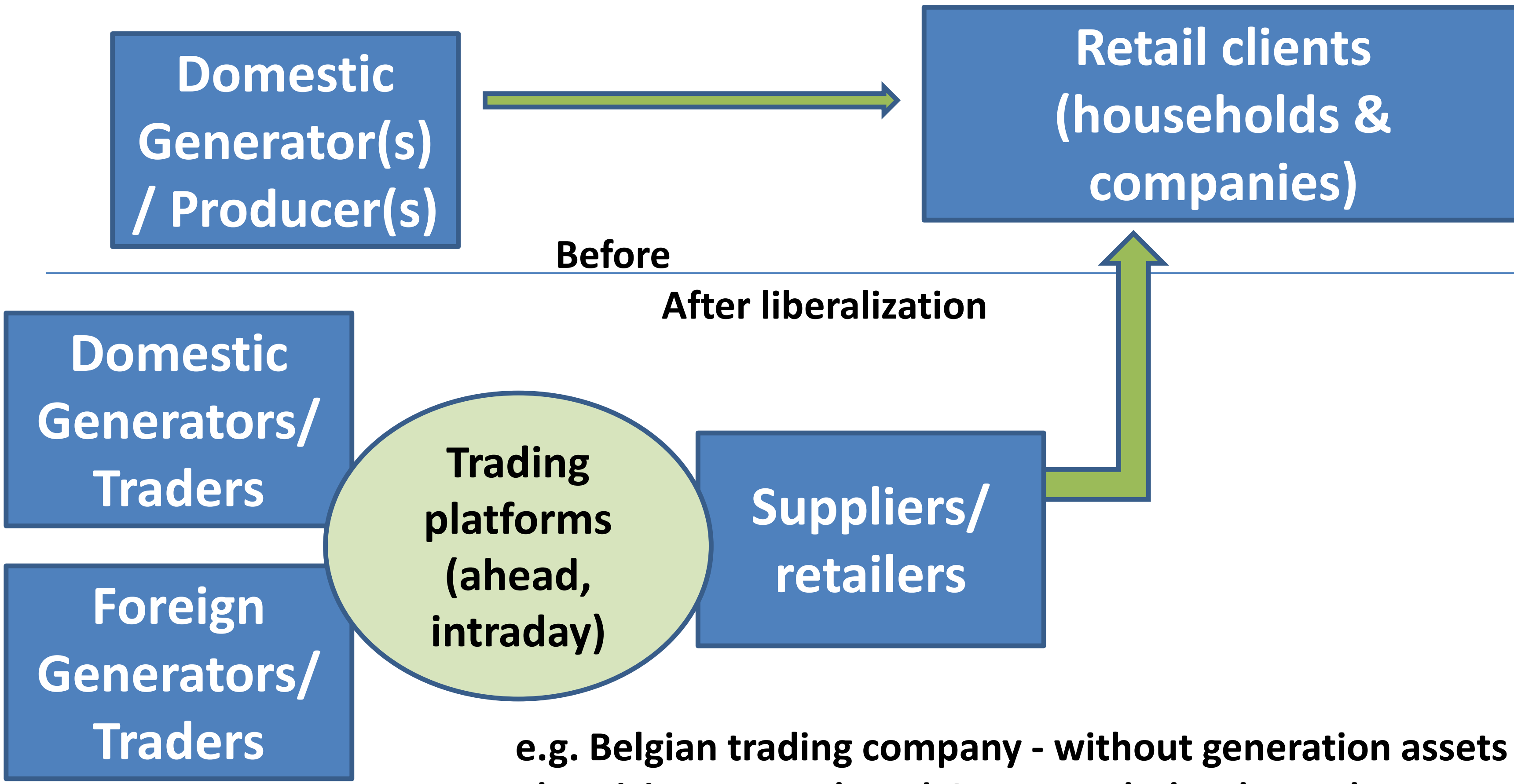
The landscape in 2014

- Generation only // generation and supply (with trading) // trading only // distribution (DSO) // transmission (TSO)
- Regulation: *security of supply*, plus *new* policy targets (climate policy GHG-20% by 2020, 20% RES-quota by 2020)
- TSOs (together with DSOs) ensure security of supply, but cannot influence generation choices e.g. more weather-based generation demands more efforts in terms of balancing and back-up -> *costs/risks are externalized*
- Electricity generation company only sells electricity as a commodity and does not consider system behavior
- Each company has only one activity (no cross-subsidies) in a much more uncertain environment (and targets 15% ROI)

The landscape in 2014 (2)

- *No price, investment cycle and profit regulation anymore* (forbidden in theory, still existing at retail level in many MS)
- Life time of electricity (system) assets is still 30 to 50 years – can these investments be triggered in free and unpredictable markets??
- In all MS, you can buy shares of publicly listed companies (e.g. Belgian TSO Elia did buy German TSO 50 Hertz), you can set-up your own energy company (lowest financial barrier for trading companies targetting industrial consumers)

Who is *retailing* before/after liberalization?



e.g. Belgian trading company - without generation assets - buys electricity on Dutch and German wholesale markets to sell to Belgian and French industrial companies

Electricity prices + price composition

Wholesale prices 2005-2011 (CWE)

Figure 3.10: Daily electricity prices on the EEX during 2005-2010

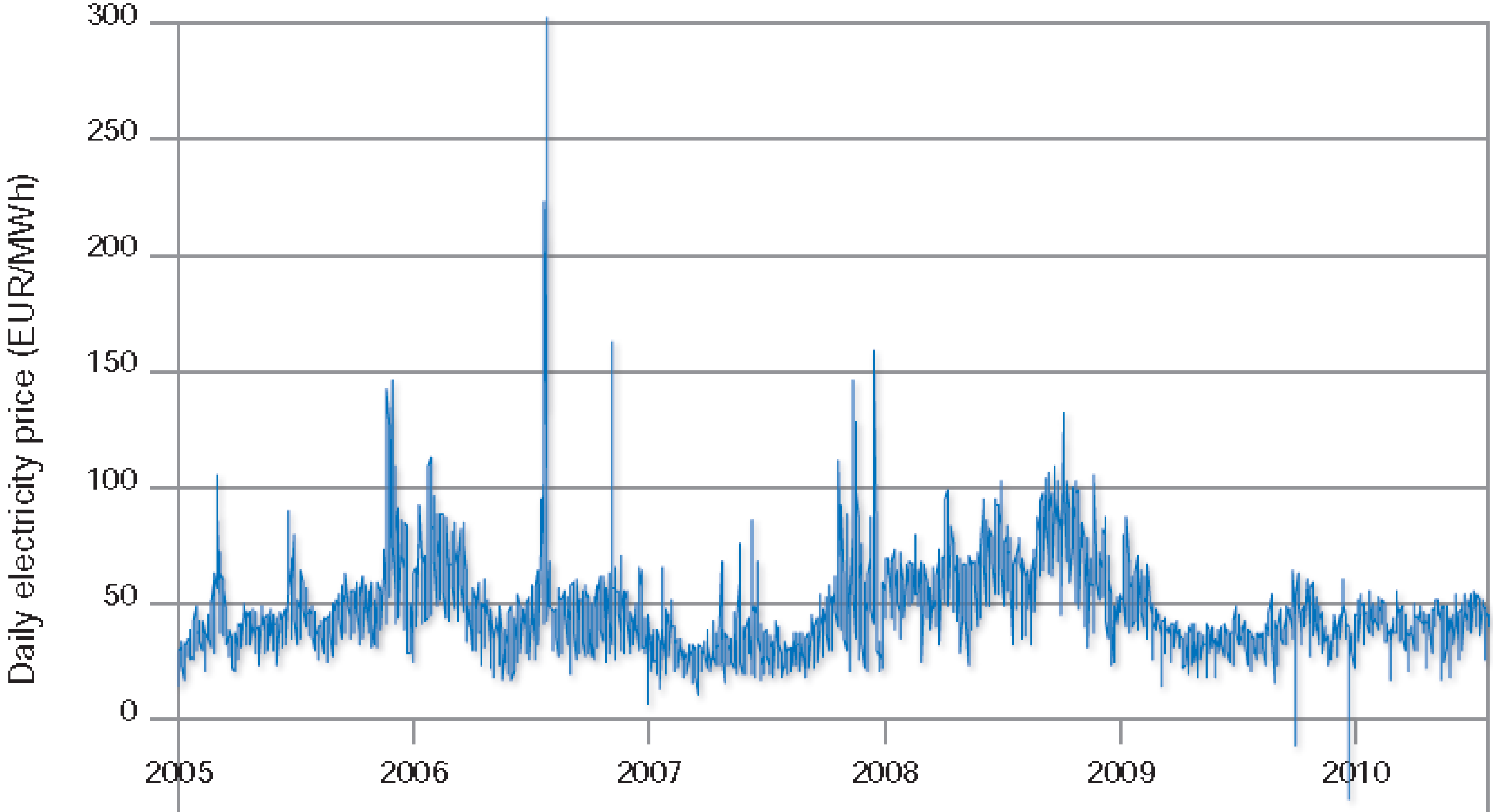
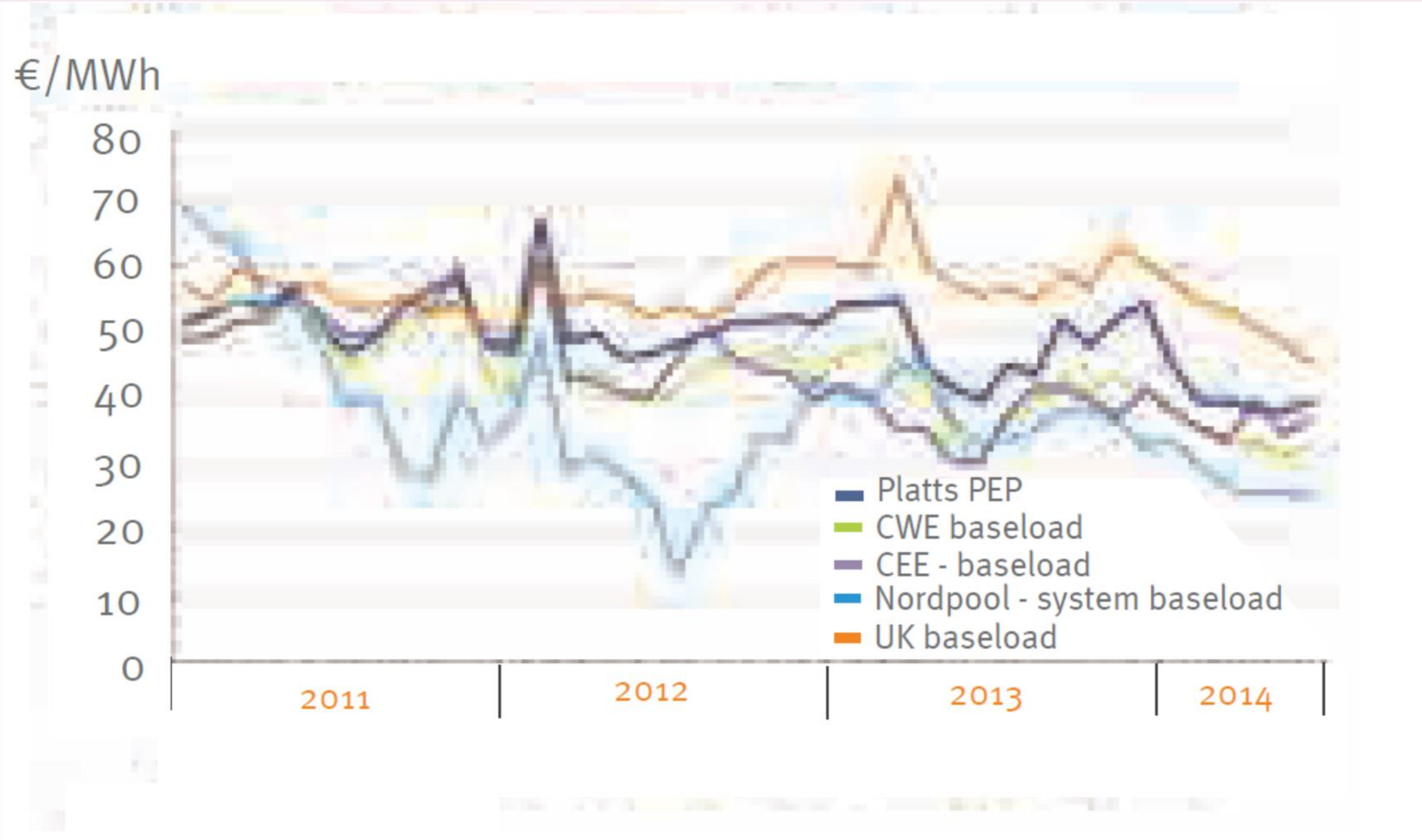


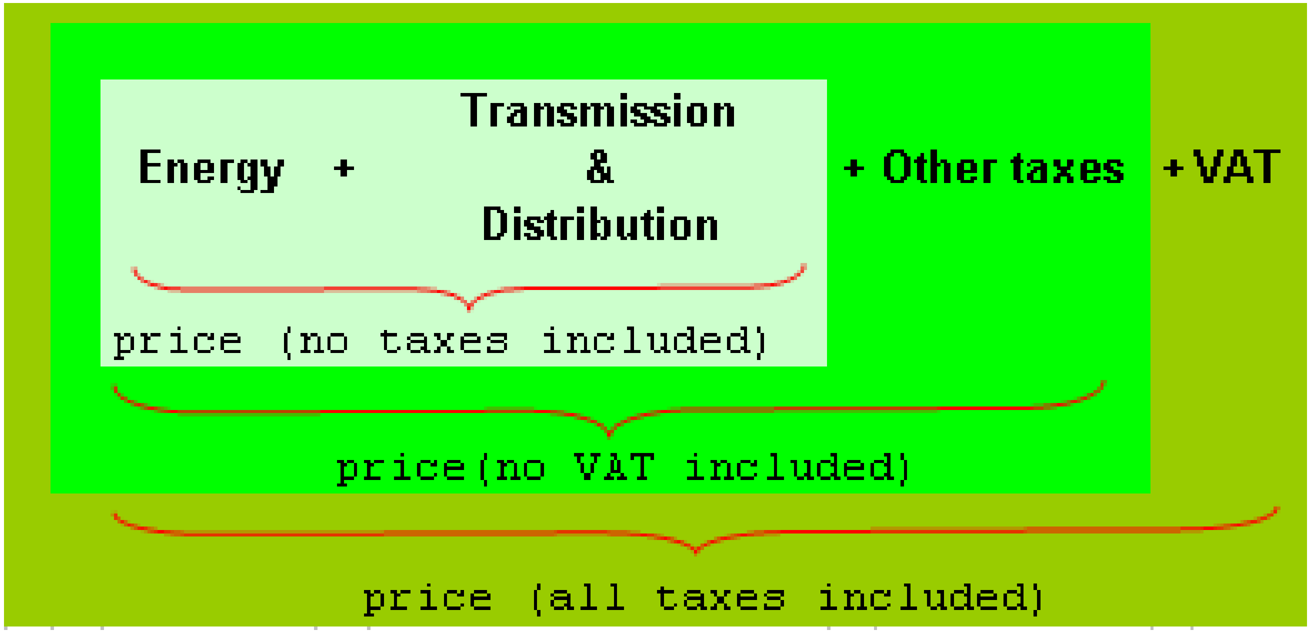
Figure 13: Comparisons of the Platts PEP and monthly electricity baseload prices in regional electricity markets (CWE, CEE, Nordpool and the UK)



Source: European Commission 2030 Framework for Climate & Energy, outcome of the October 2014 European Council

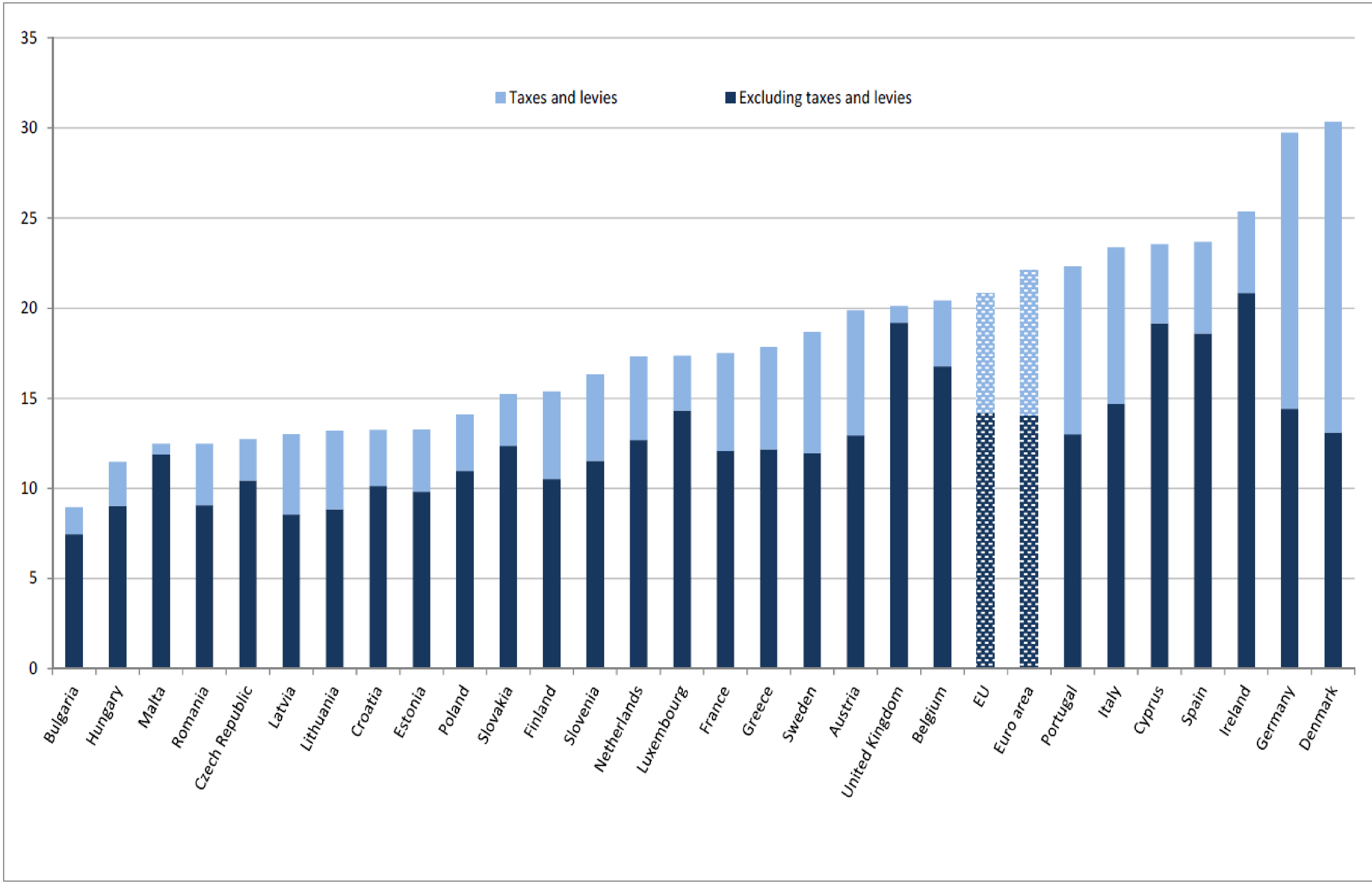
Retail electricity invoice today

- Retail invoice = electricity + network + taxes *(as it was before the liberalisation)*



Average electricity price for households per 100 kWh in 2nd half of 2014

(in €, all taxes and levies included)

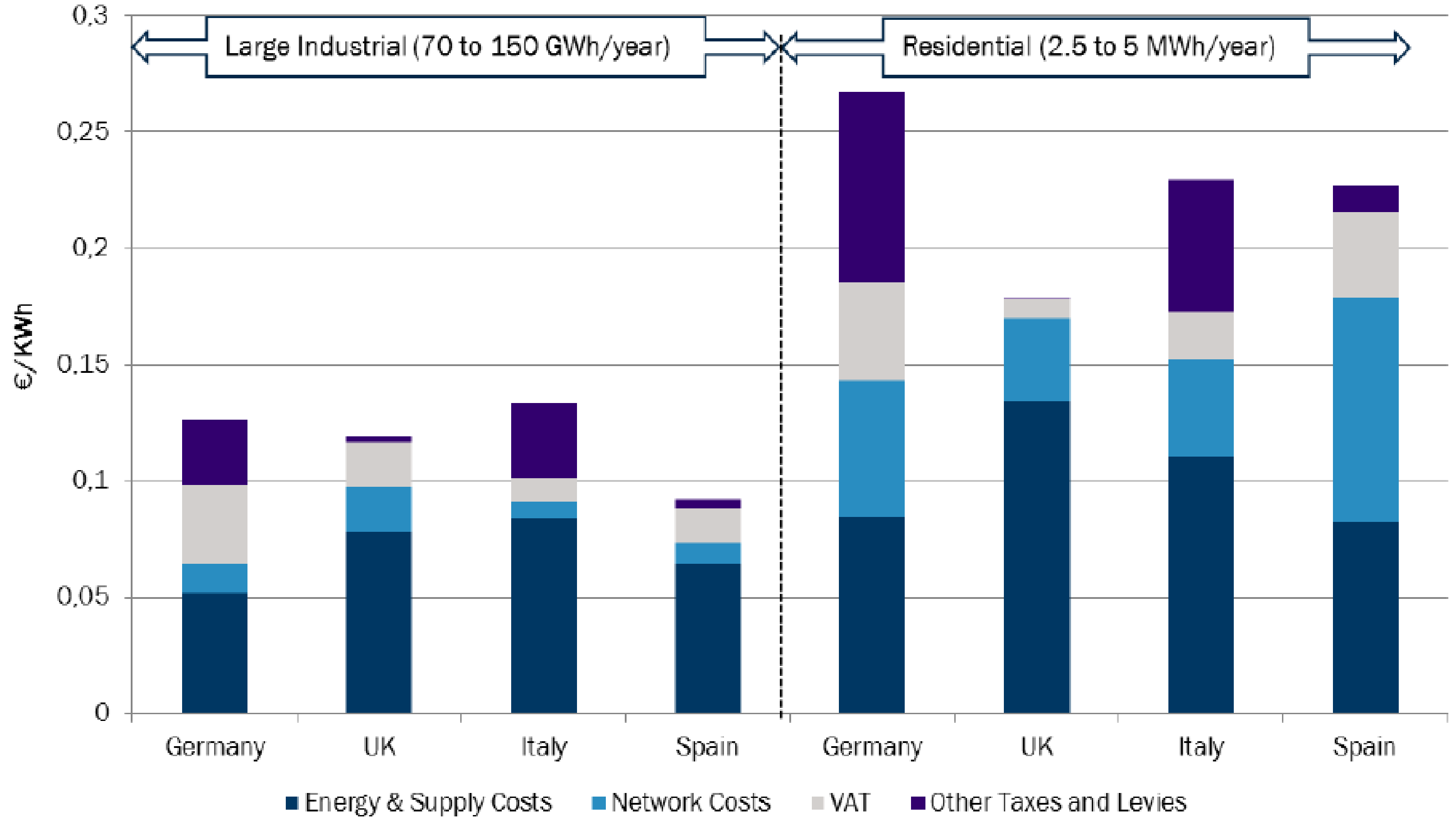


Source; Eurostat (2015). 92/2015

Household[1] electricity prices including all taxes and levies

	Average price per 100 kWh in 2nd half of 2014			Price change, in %*	Share of taxes and levies in average price
	in national currency	in euro	in PPS	2nd half 2014/ 2nd half 2013	
EU	**-**	**20.8**	**20.8**	**2.9%**	**32%**
Euro area[4]	**22.1**	**22.1**	**21.3**	**2.7%**	**36%**
Belgium	20.4	20.4	18.1	-7.8%	18%
Bulgaria	17.5	9.0	19.5	1.5%	17%
Czech Republic	352.0	12.7	19.6	-10.2%	18%
Denmark	226.1	30.4	22.0	3.2%	57%
Germany	29.7	29.7	28.5	1.8%	52%
Estonia	13.3	13.3	17.9	-3.1%	26%
Ireland	25.4	25.4	23.1	5.4%	18%
Greece	17.9	17.9	20.8	5.2%	32%
Spain	23.7	23.7	26.0	4.1%	21%
France	17.5	17.5	15.6	10.2%	31%
Croatia	101.2	13.2	20.6	-1.2%	23%
Italy	23.4	23.4	23.1	0.6%	37%
Cyprus	23.6	23.6	27.4	-5.0%	19%
Latvia	13.0	13.0	13.7	-4.2%	34%
Lithuania	45.5	13.2	21.5	-5.2%	33%
Luxembourg	17.4	17.4	14.2	5.6%	18%
Hungary	3 556.6	11.5	20.8	-9.9%	21%
Malta	12.5	12.5	16.5	-26.2%	5%
Netherlands	17.3	17.3	15.7	-9.6%	27%
Austria	19.9	19.9	17.8	-1.5%	35%

Figure 6: 2012 retail price breakdown for residential and industrial end consumers



Source: Eurostat.

Who is supporting the transition?

FIGURE 16: POLICY SUPPORT COST AND TAX LEVELS BORNE BY DOMESTIC CUSTOMERS IN 2012 (BY COUNTRY AND EU AVERAGES (DOTTED LINES))

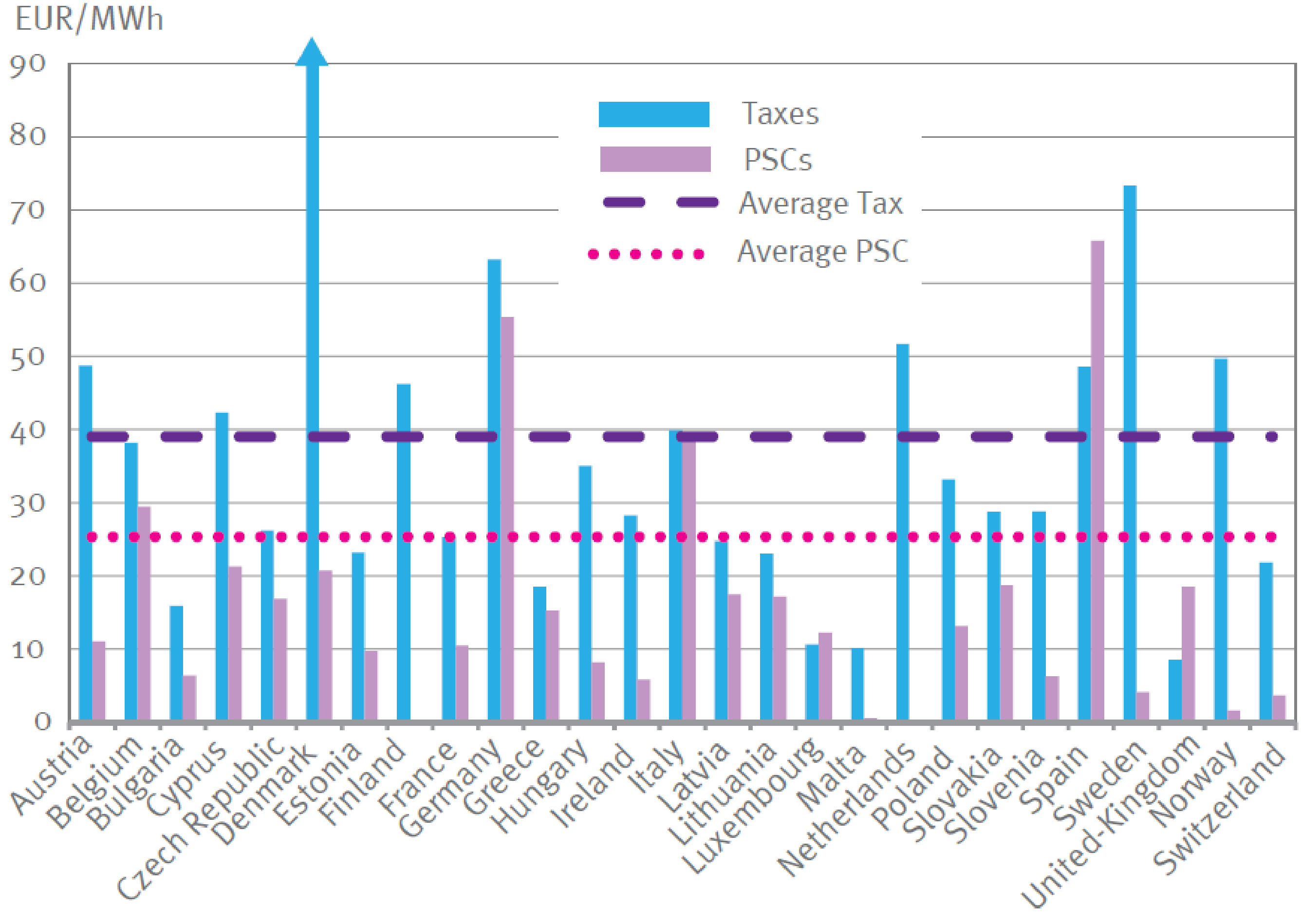
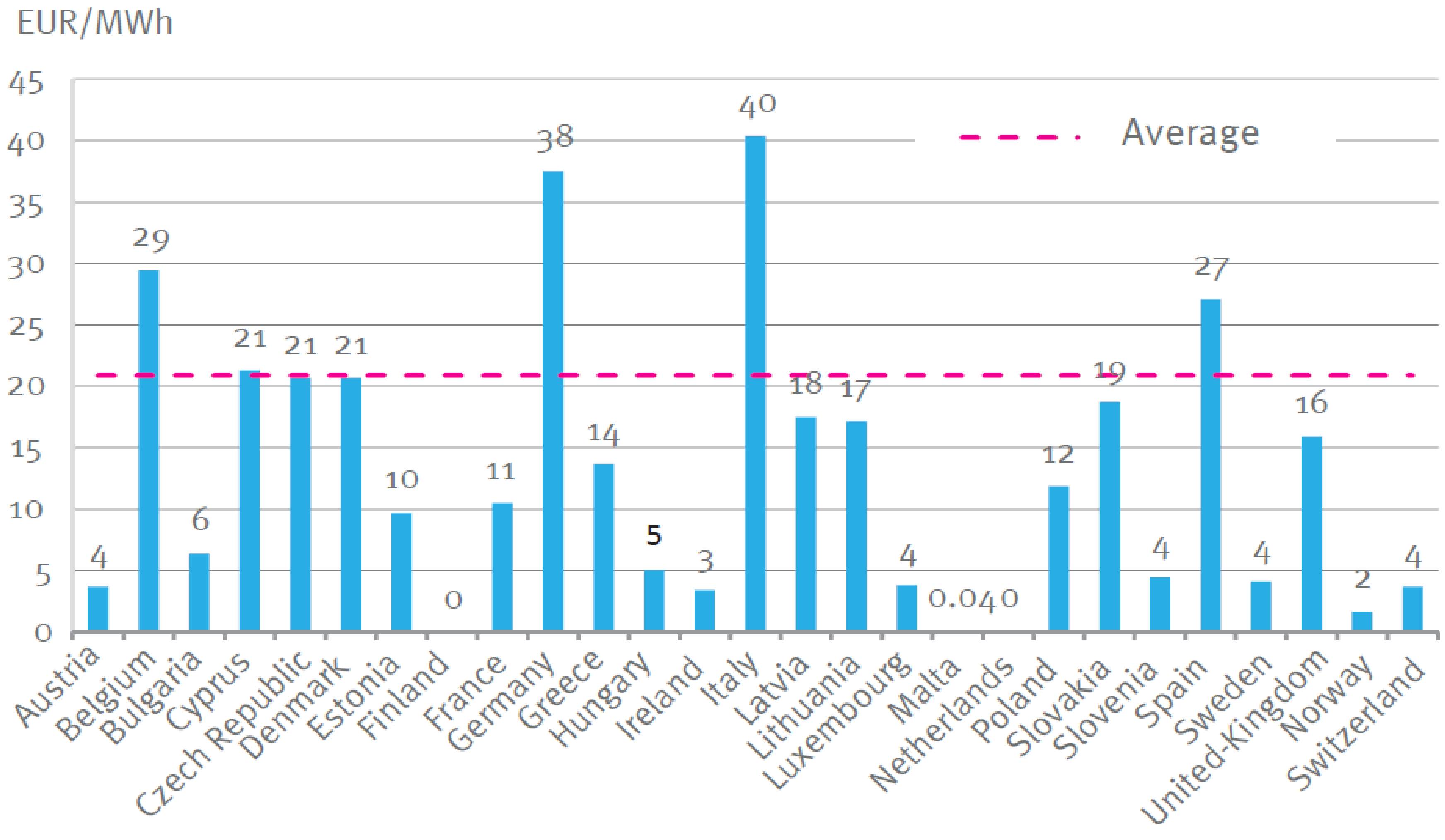
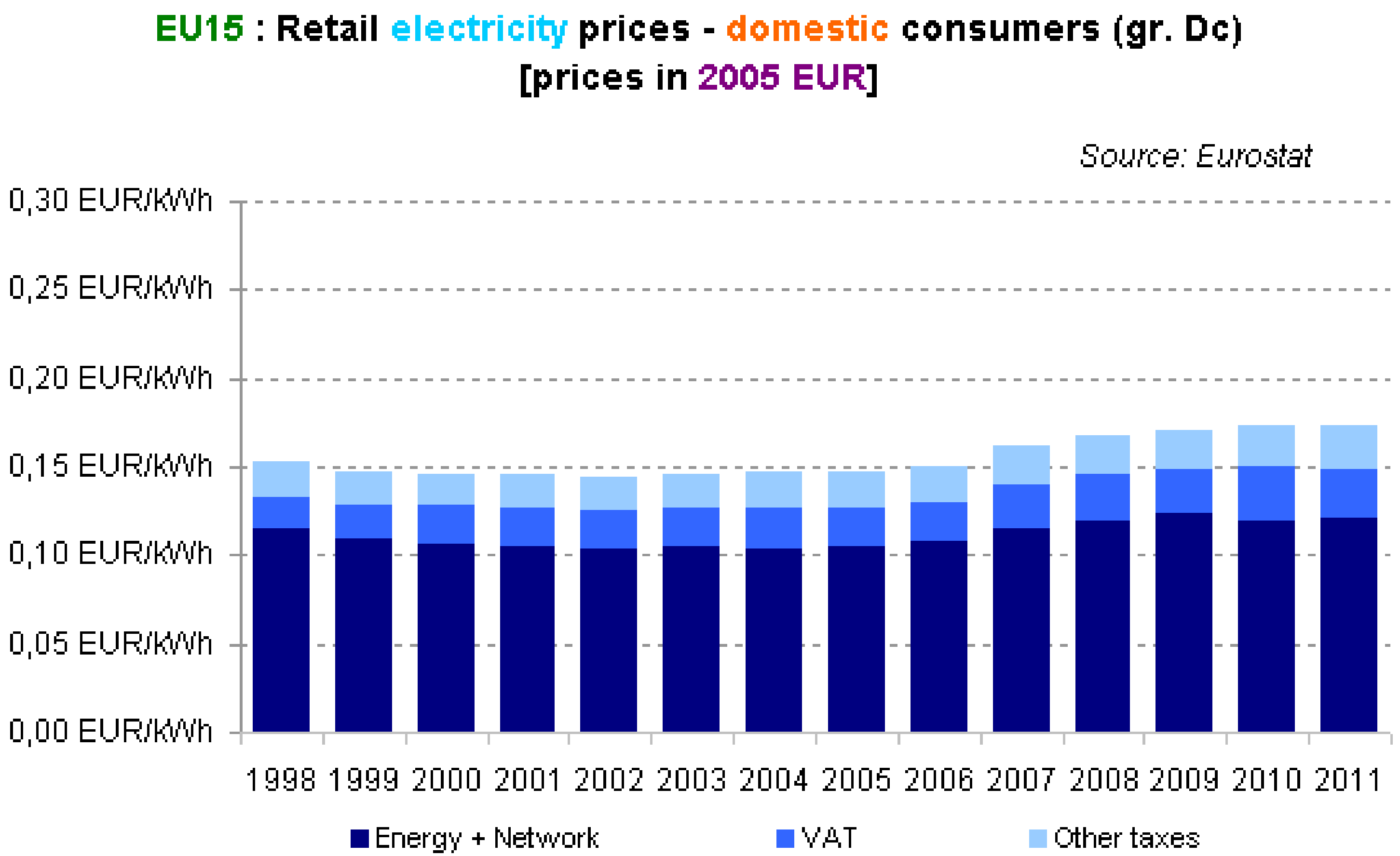


FIGURE 17: POLICY SUPPORT COSTS BORNE BY INDUSTRIAL CUSTOMERS IN 2012 (BY COUNTRY AND EU AVERAGES (DOTTED LINES))

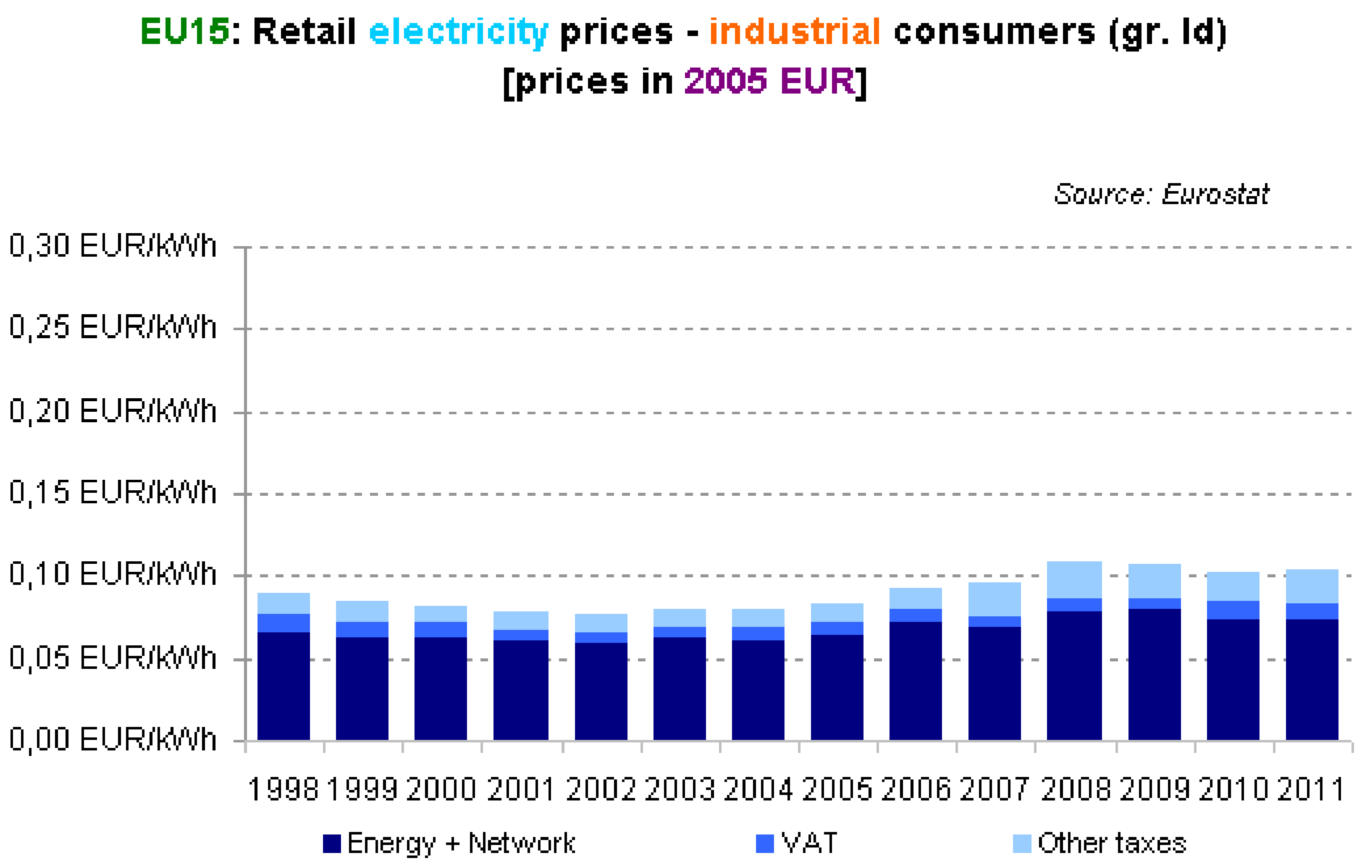


EU-15 retail prices for households, 1998-2011



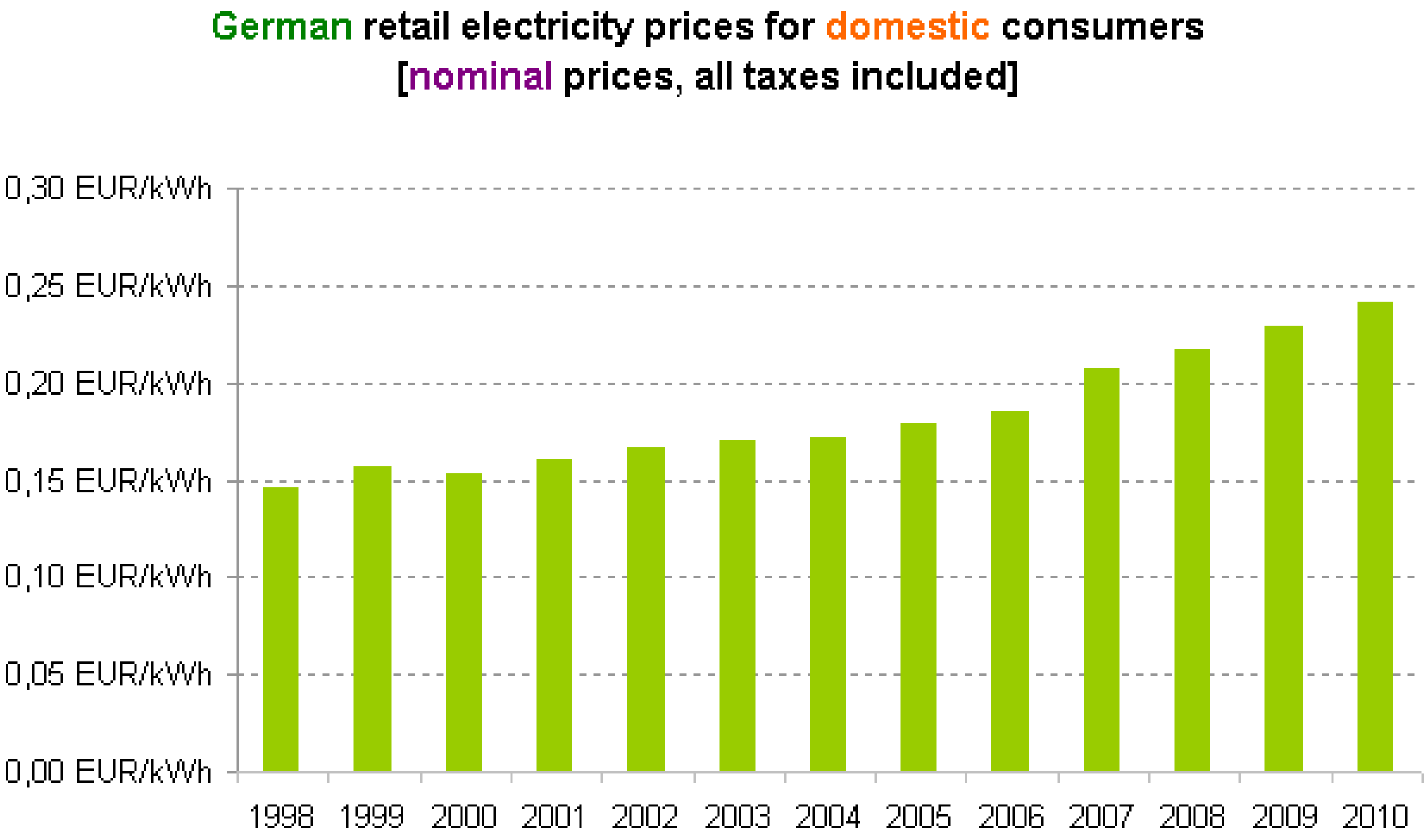
Note: Prior to 2007 the following Eurostat end consumer categories were used:
Households - Dc (Annual consumption: 3 500 kWh of which night 1 300)

Lower prices for industrial consumers



Note: Prior to 2007 the following Eurostat end consumer categories were used:
Industry - Ie (Annual consumption: 2 000 MWh; max. demand: 500 kW; annual load: 4 000 hours)
Industry - If (Annual consumption: 10 000 MWh; max. demand: 2 500 kW; annual load: 4 000 hours)
Industry - Ig (Annual consumption: 24 000 MWh; max. demand: 4 000 kW; annual load: 6 000 hours)

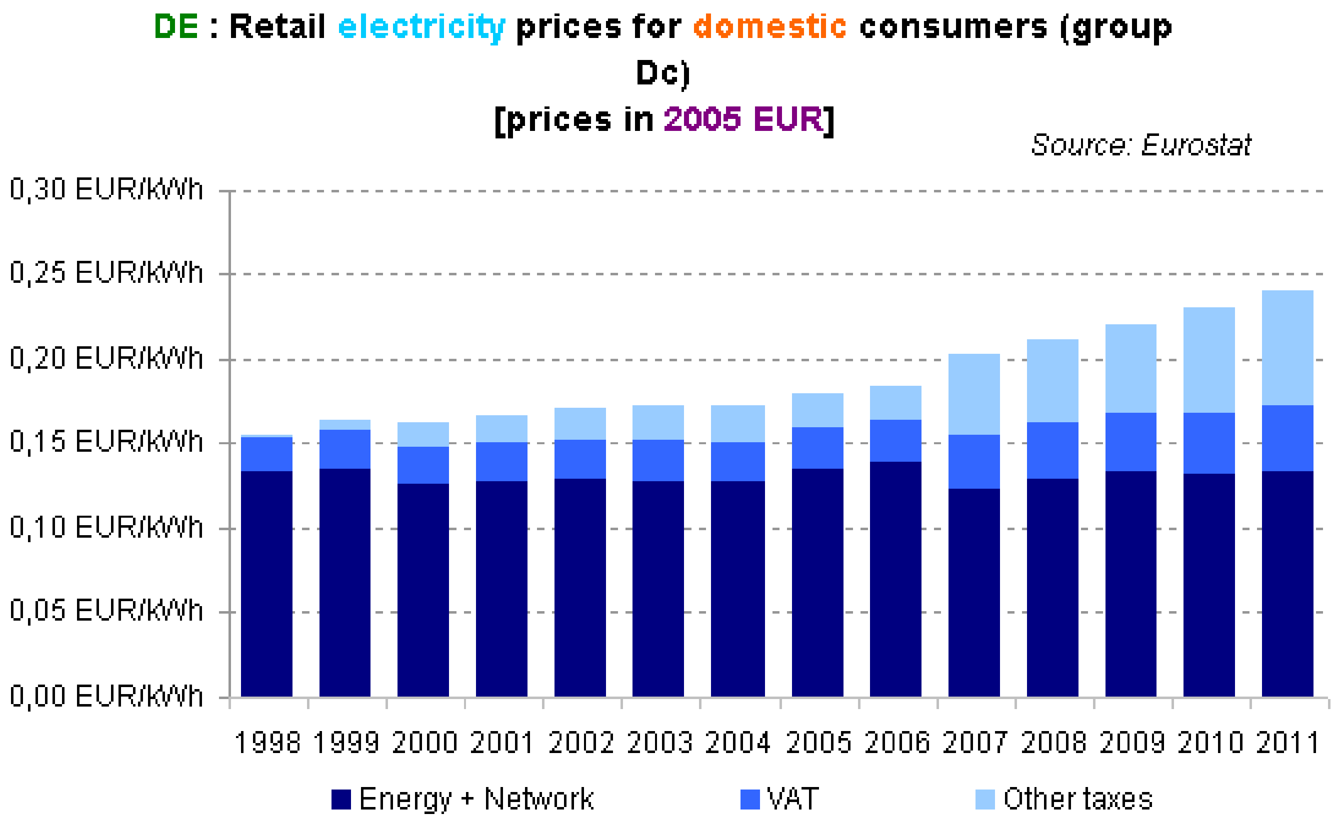
Rising retail prices in Germany…



Note: Prior to 2007 the following Eurostat end consumer categories were used:
Households - Dc (Annual consumption: 3 500 kWh of which night 1 300)

Source: Eurostat

… conceal flat commodity prices but strong increase of electricity taxes



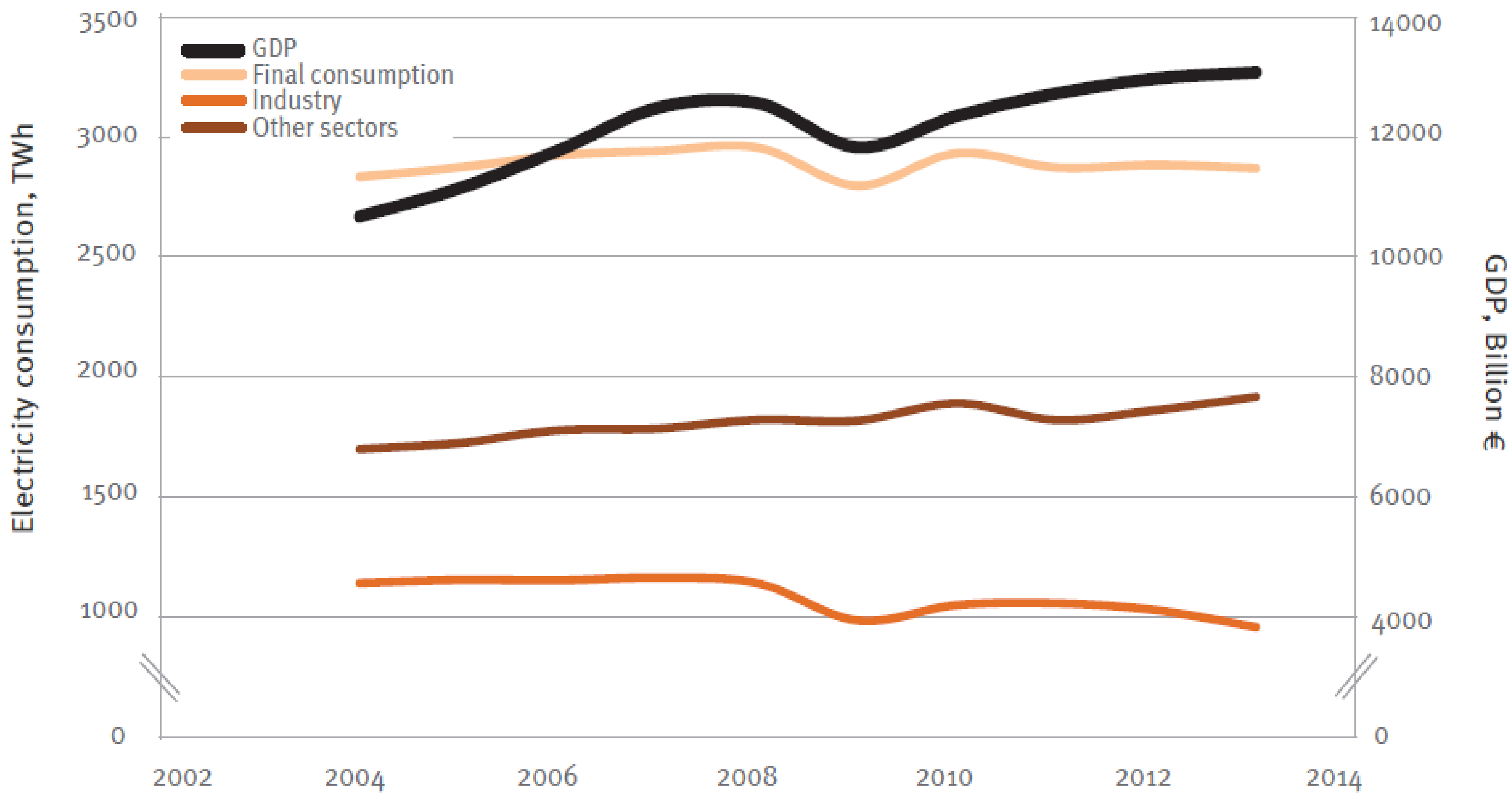
Note: Prior to 2007 the following Eurostat end consumer categories were used:
Households - Dc (Annual consumption: 3 500 kWh of which night 1 300)

Some conclusions

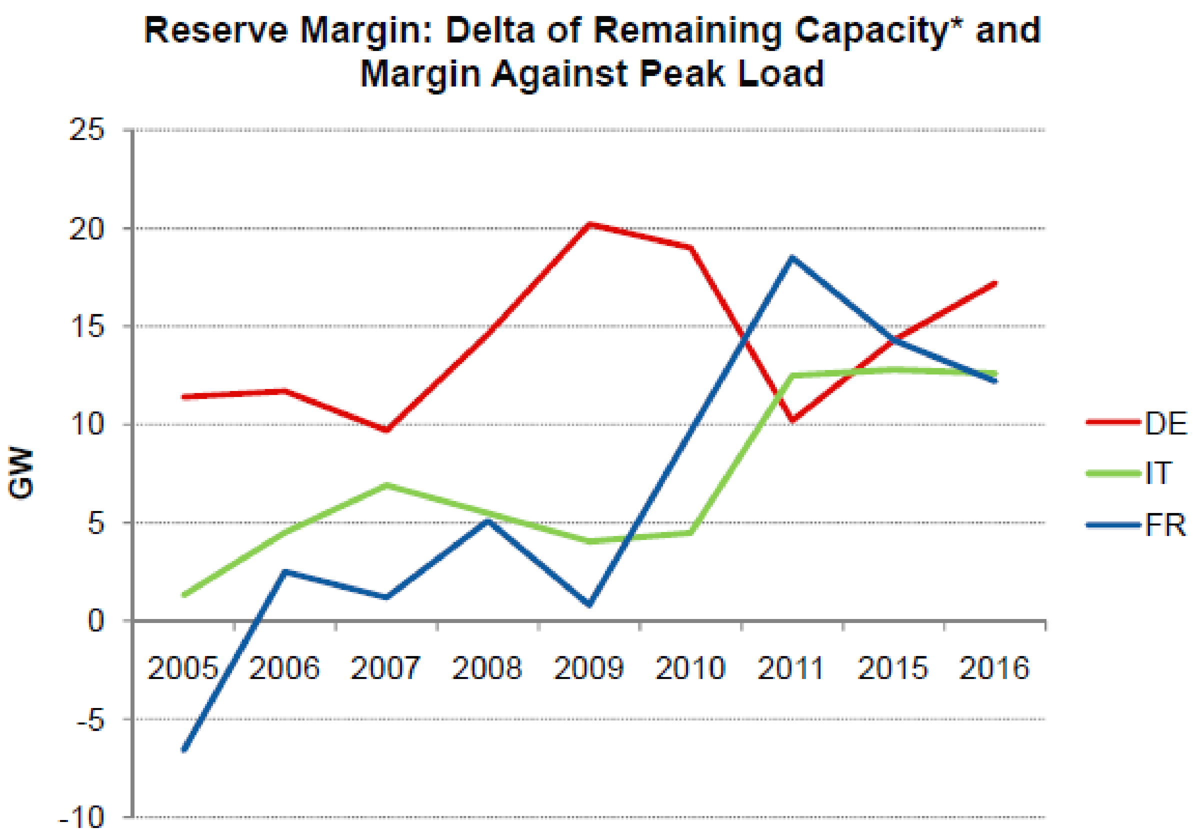
- With the ongoing liberalisation and market integration, retail prices still differ because of differences in national tax systems and policies with respect to network costs
- Retail prices slightly increased since 1998, retail price variation remained
- The aim of the EU energy policy was "*to ensure that EU consumers receive the full benefits of market opening in terms of lower domestic bills for electricity and gas "*

European recession and evolution of electricity demand

- Electricity consumption in EU (Eurelectric, 2015)



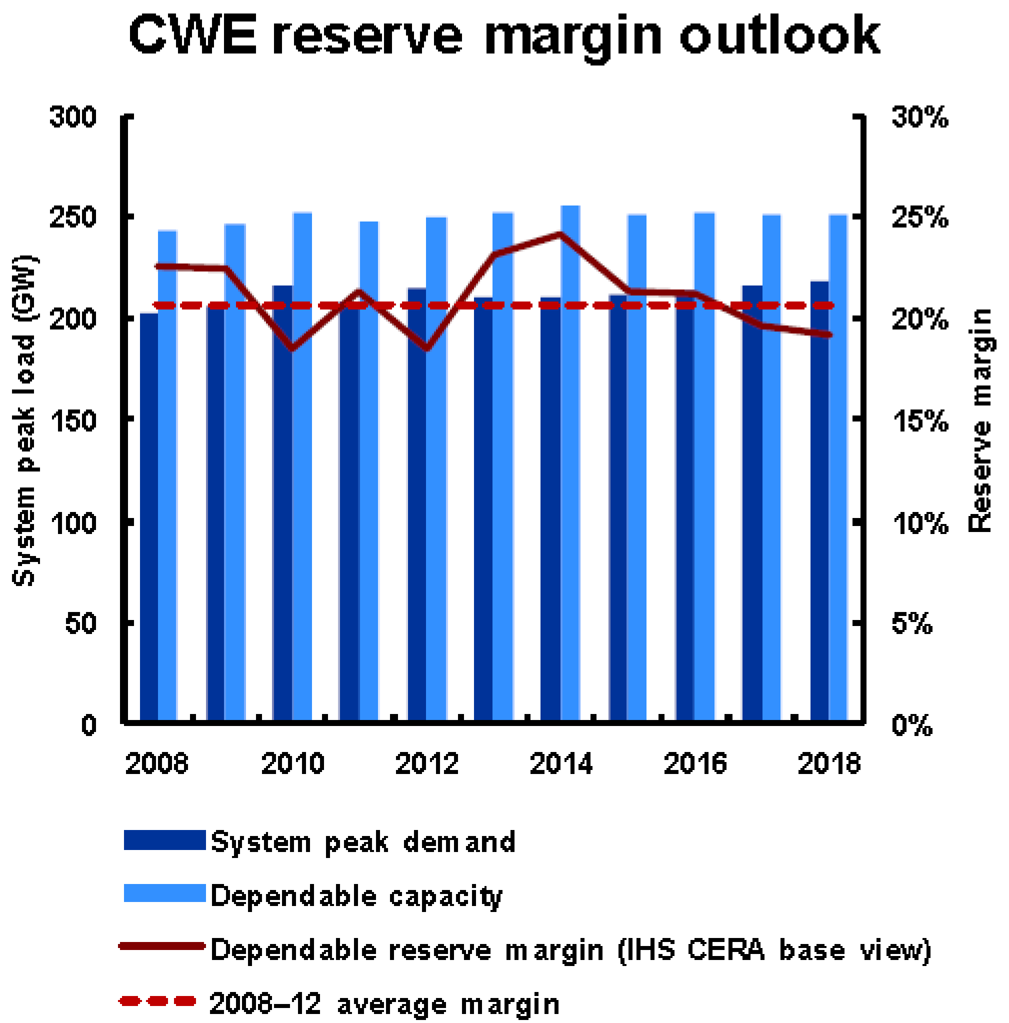
Reserve margin {NL+FR+DE}: > 15/20 % up to 2018



*Remaining Capacity is that part of Net Generating Capacity left on the system to cover any unexpected load variation and unplanned outages at a reference point

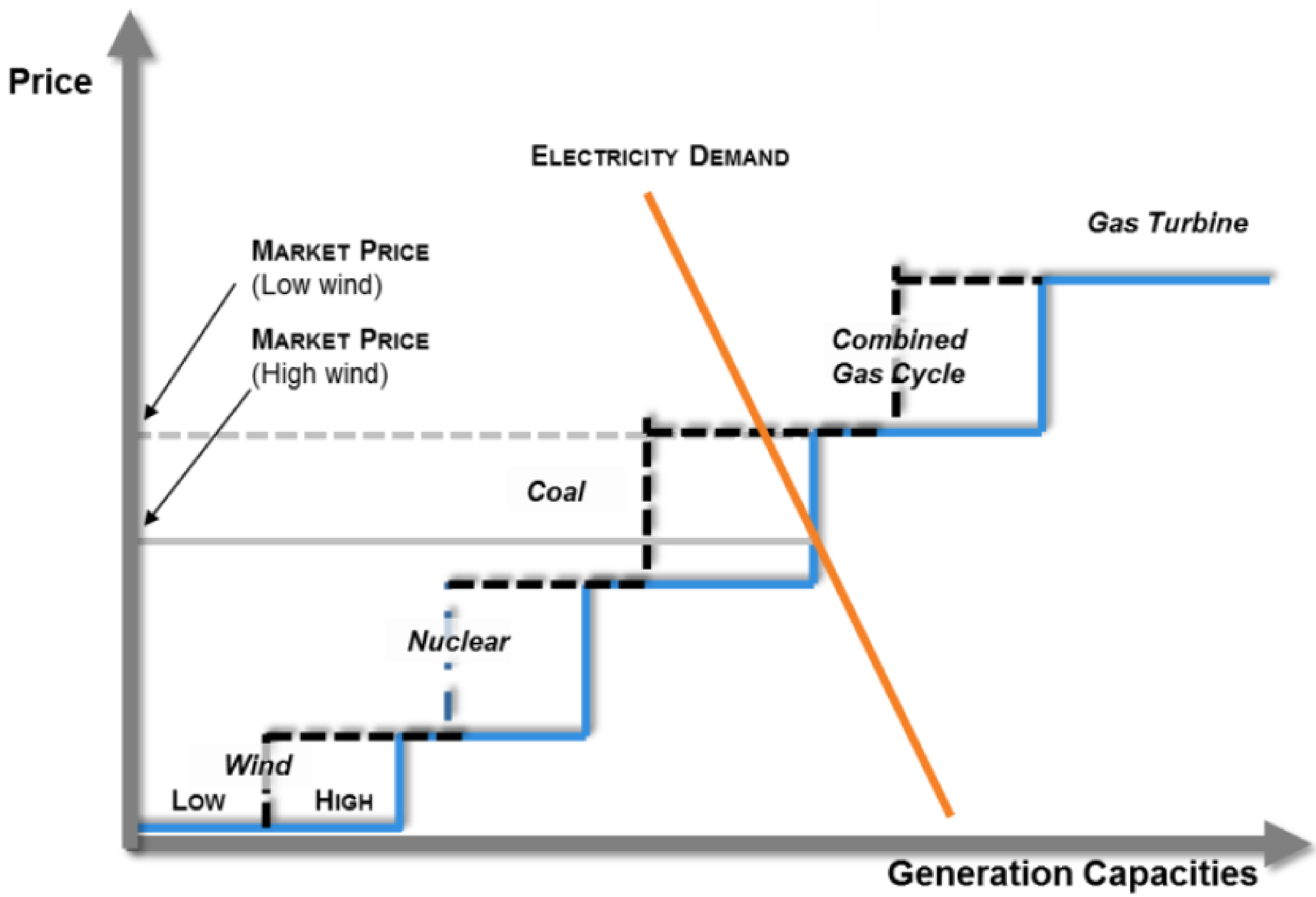
Bron: Axpo Market Analysis

IHS CERA: CWE reserve margin outlook



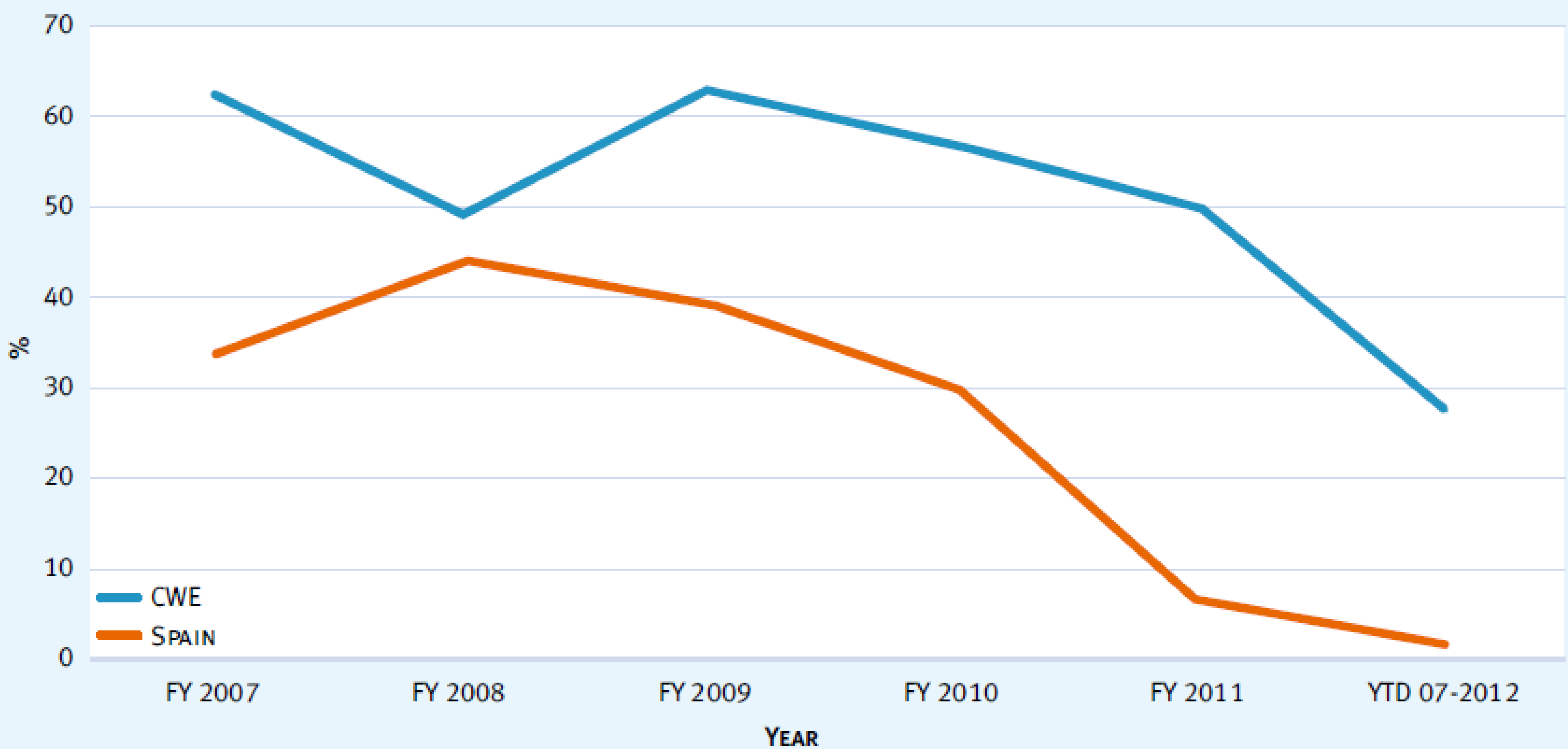
Merit order effect (supply = Σ marginal cost)

Figure 10 – The merit order effect of RES



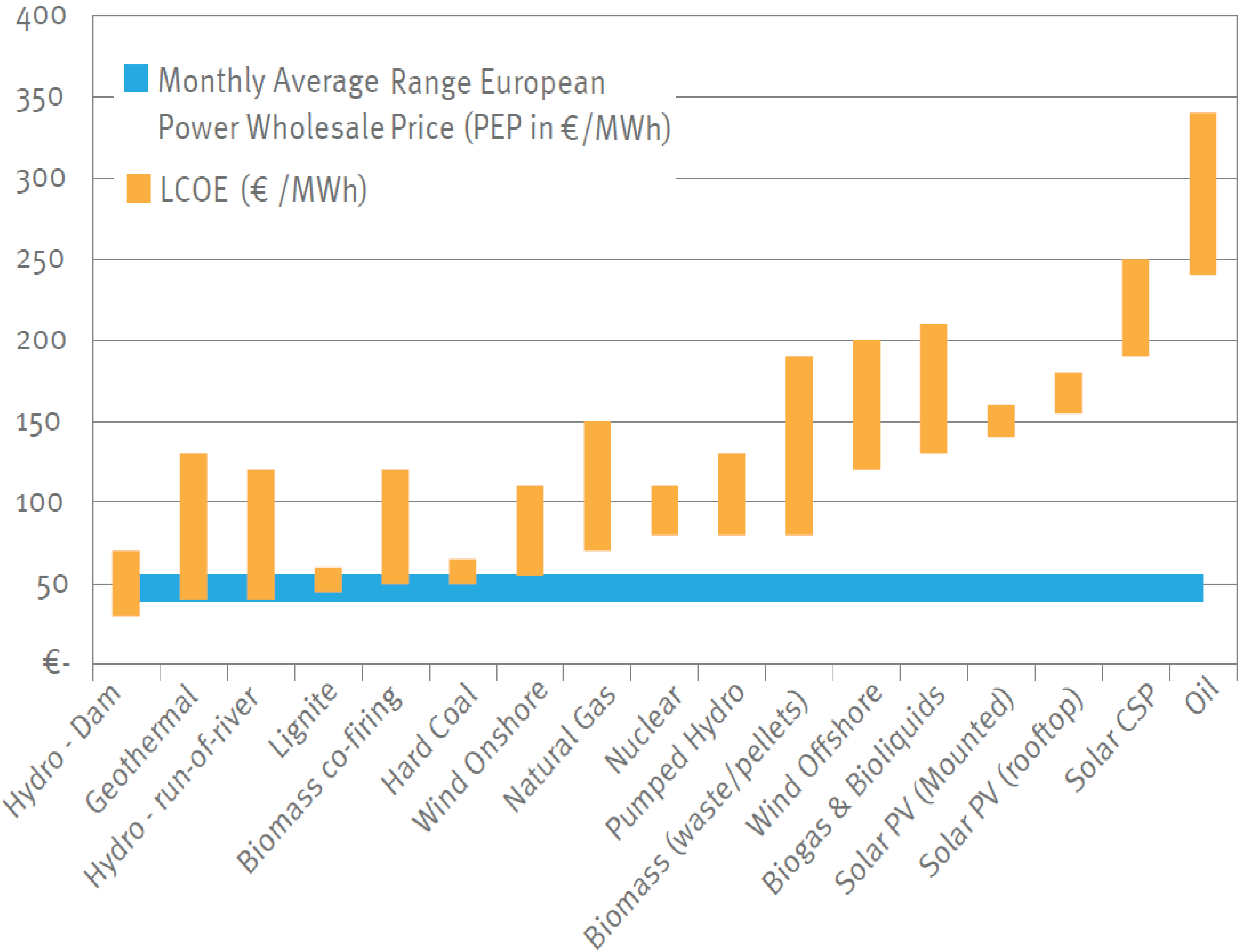
Impact on existing assets: CCGT

Figure 4: Running hours of CCGTs in Spain and Central-Western Europe



Source: EURELECTRIC

FIGURE 6: LEVELISED COST OF ELECTRICITY (€/MWh) AT REALISED FULL LOAD HOURS IN 2013 COMPARED WITH AVERAGE RANGE OF EUROPEAN ELECTRICITY WHOLESALE PRICE IN 2013[4] [5]



Electricity in CWE: no market-driven investments

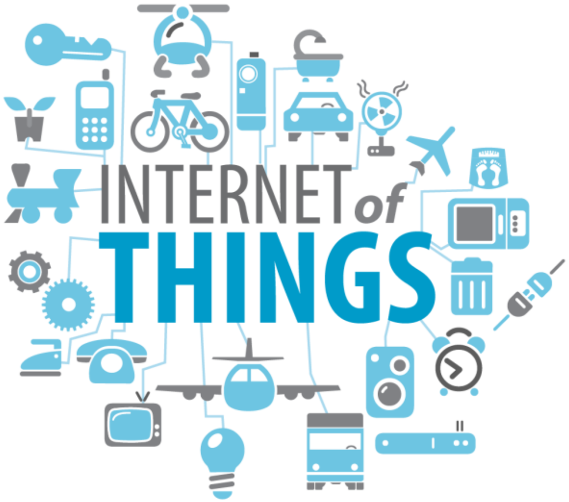
- Overcapacity; wholesale market price electricity CW Europe: € 75/MWh in 2007 / € 40 - 45/MWh today
- Even lower electricity prices are possible
- Efficient markets: price expectations trigger investment behavior
- 2013-2025: a lot of old capital (fossil & nuclear) needs to be replaced
- Alternative; longer use of inefficient capital
- Low prices -> coal replaces gas (wholesale prices reflect marginal costs)

Some conclusions

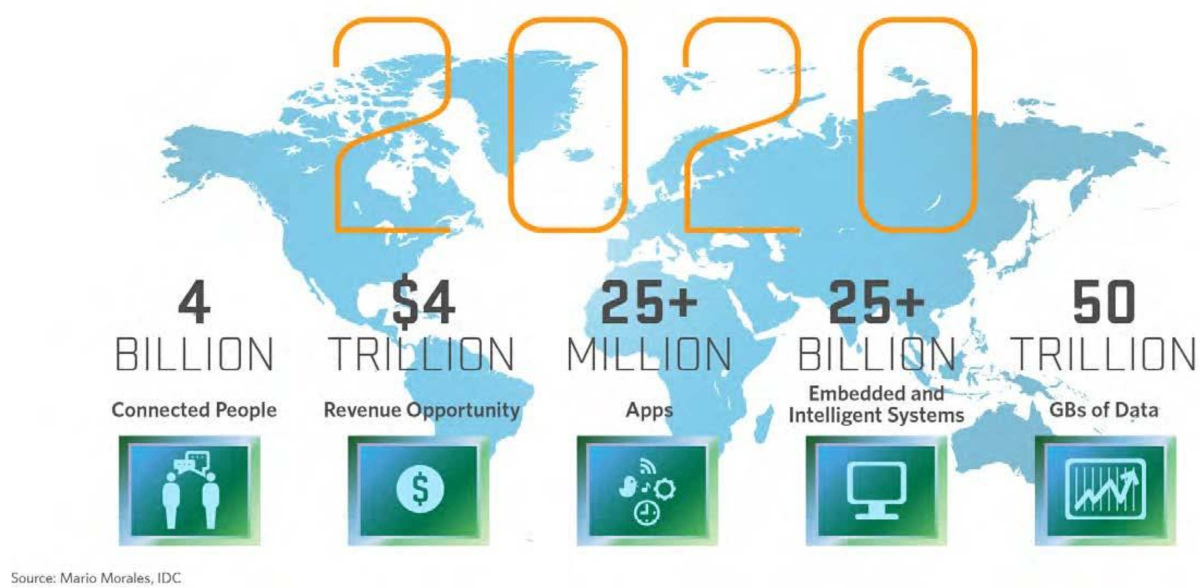
- Electricity landscape undergoes a very radical transformation (~unbundling, contestability)…
- with an uncertain institutional outlook (# capacity mechanisms)…
- while the Europe wants to decarbonize and imposes investments in new RES capacity with low LFs…
- inserting a subsidized and sheltered market segment in liberalised markets…
- leading to an increasing variability of generation and more complications to follow the demand for electricity…
- which is shrinking for the first time since 1960…

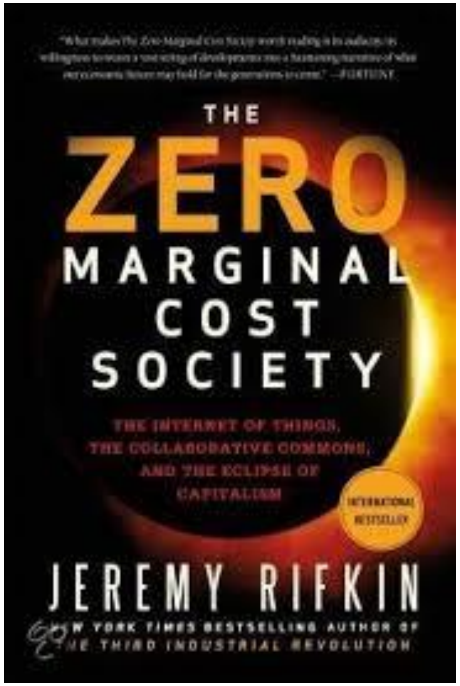
Electricity: long-term challenges

- Energy transition with subsidized market intervention increases short-term energy security risks in Europe; European utilities depreciated 51 GW assets
- Energy transition consistent with European Energy-Only Market (EOM) model?
- While the platform revolution knocks on the door…



Platform “Challenges”





Internet of Things:

Communication Internet
+ Energy Internet
+ Logistic Internet

Global Utilities, Autos & Chemicals

Will solar, batteries and electric cars re-shape the electricity system?

Batteries and solar at the tipping point: Electricity users will become generators

Solar systems and batteries will be disruptive technologies for the electricity system. Steeply declining battery and solar system costs will enable multiple new applications. In this note, we focus on the impact on the utilities and auto sectors. Our proprietary model suggests a payback time as low as 6-8 years for a combined EV + solar + battery investment by 2020 – unsubsidised. We see Europe, and in particular Germany, Italy and Spain, leading this paradigm shift due to high fuel and retail electricity prices.

EVs entering the mass market, battery demand could grow exponentially

We forecast a c10% EV and plug-in hybrid penetration in Europe by 2025. While the initial growth should predominantly be driven by incentives and carbon regulation, the entry into the mass market should happen because EVs will pay off. The expected rapid decline in battery cost by >50% by 2020 should not just spur EV sales, but also lead to exponential growth in demand for stationary batteries to store excess power. This is relevant for an electricity mix with a much higher share of (volatile) renewables.

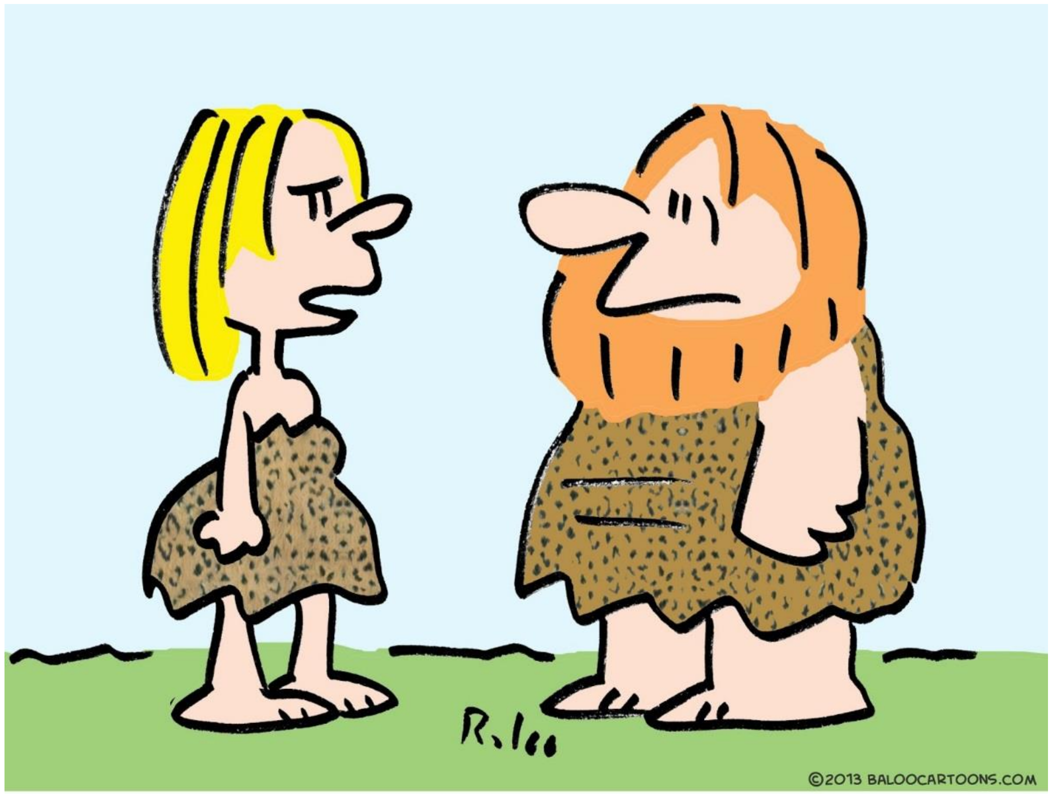
Prosumers / Collaborative commons

- Local storage; Tesla, Daimler, Google,…
- 1 new car = 100 kW (idle for 94% of time)
- Chevrolet Bolt 2018, Nissan Leaf 2 2018, VW e-plan 2018,…
- before 2020; electric cars @ € 25 000 / 400 km range
- BE: 480 000 new cars (ICE) sold in 2015
- 50 000 electric cars @ 100 kW = 5 000 MWp capacity
- Microgrids without smart meters (US, Port of Rotterdam,…)

Internet of things

- CRM debate targets ‘missing money problem’ in top-down uni-directional flow models with passive & ignorant consumers
- All price mechanisms keep consumer as passive as possible
- Microgrid experiments; consumers shift 20 to 40% of load (Toyota City Verification Project)
- ICT will mobilize the power of the consumer in all economic sectors, including electricity/energy
- Internet of Things; regulators should not try to follow…

The energy transition; a learning experiment



"Well? — now that we've learned to talk, aren't you going to admit that you were wrong?"

- Ernest Rutherford (1871-1937):
  « Gentleman, we have run out of money. It's time to start thinking. »
- *« Let's organize a summer school! »*