KU LEUVEN

System effects challenging the European energy market

William D’haeseleer
KU Leuven Energy Institute / EnergyVille

Setting the Stage / Context

- Energy Strategy Drivers – **Sustainable Energy Provision**
  - Security of Supply

1 January 2006 & 2009

August 14 2003

KU LEUVEN

Setting the Stage / Context

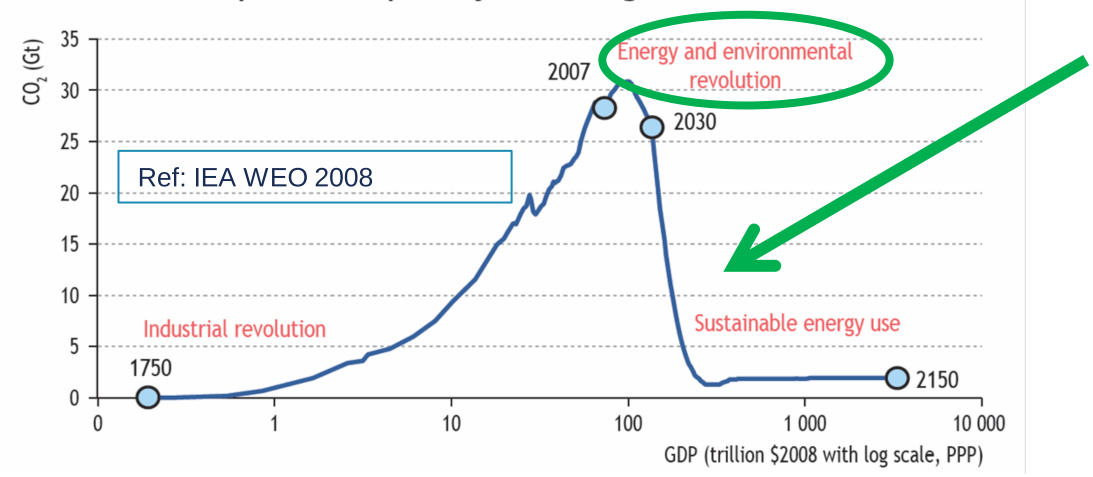
- Energy Strategy Drivers – **Sustainable Energy Provision**
  - o Security of Supply
  - o Affordability & Competitiveness

KU LEUVEN

Setting the Stage / Context

- Energy Strategy Drivers – **Sustainable Energy Provision**
    - Security of Supply
    - Affordability & Competitiveness
    - Clean Energy Conversion (Climate Change)

Figure 4.3 • Historical link between energy-related CO_2 emissions and economic output, and the pathway to achieving a 450 Scenario



But …Uncertainties

- **uncertainties** – often “ignored”
    - Economic & financial crisis (€) → investments?
    - Uprisings in MENA?… Geopolitics Ukraine, Turkey, Iran…?
    - Future energy prices? High or low?
    - Shale gas? Also in Europe? How about China?
    - Biofuels?
    - Carbon Capture & Storage (CCS)? …
    - Role of nuclear power?
    - Role of synthetic gas and hydrogen in far future?
    - Unstable regulatory framework

A Priori Observations

- World primary energy mix *is*,
  and is *expected to remain*,
  fossil based...

- 2010 ... ~ 80% primary energy is fossil
  2050 ... ~ 60% to 77% fossil (depending on scenarios)

- Three major end-use sectors:
  - Electricity
  - Heat (buildings & industry)
  - Transportation

Security of Supply

- Energy supply interuptions do happen!

- Structured delineation of SoS

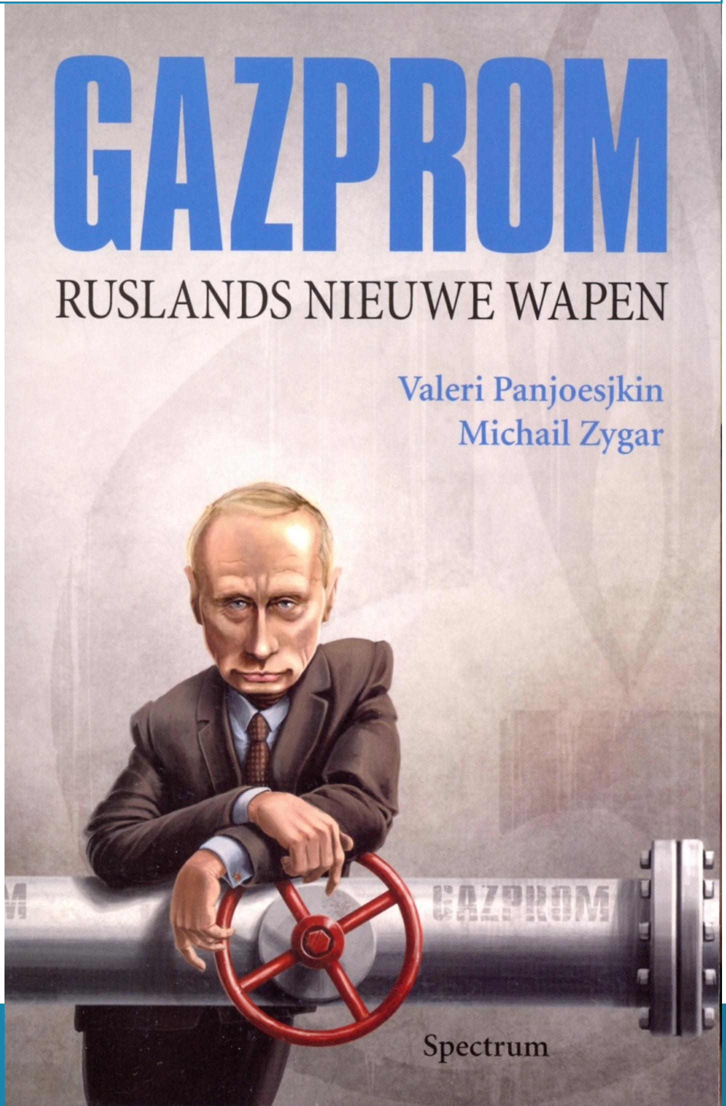
Security of Supply

- Energy supply interuptions do happen!

- Structured delineation of SoS

SoS – Natural Gas

Russia's new weapon

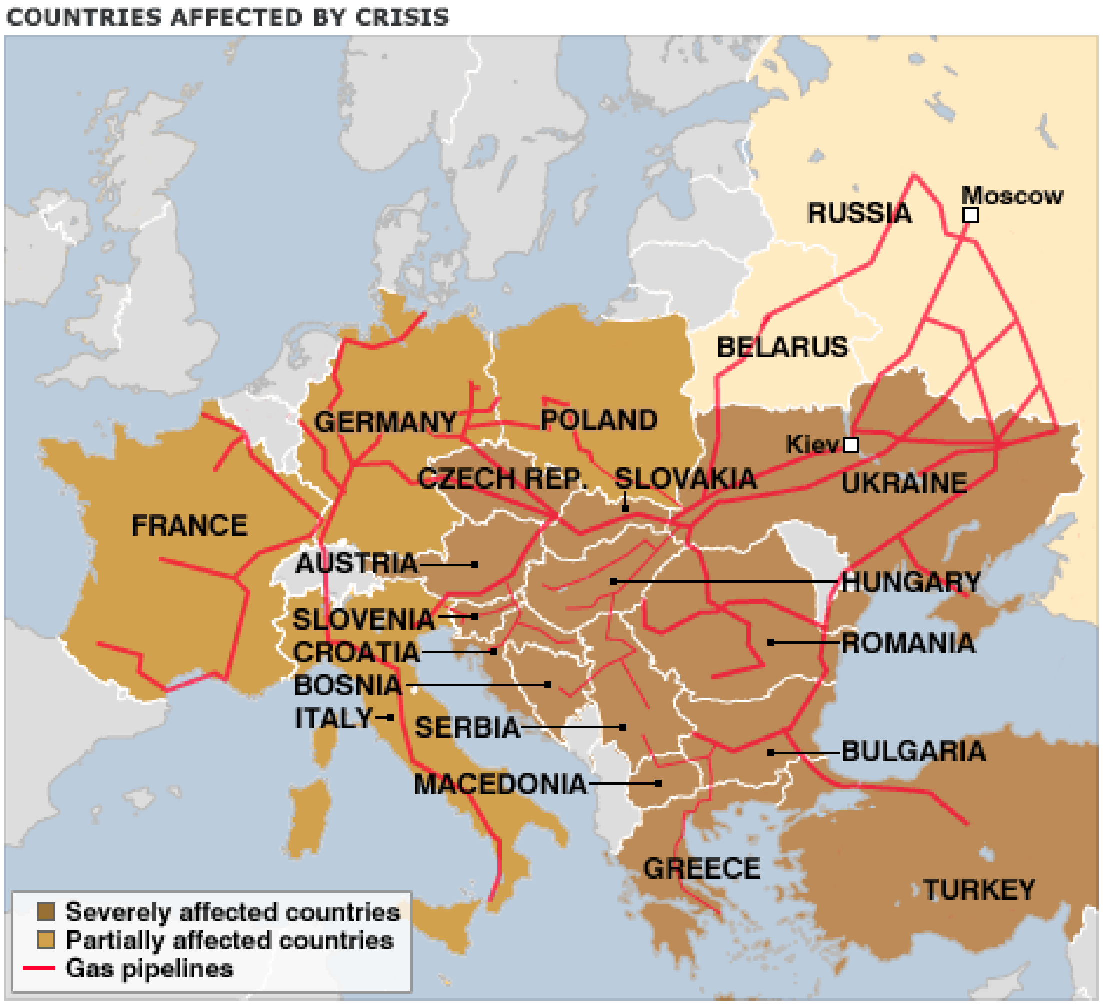


Book published in 2008 …

KU LEUVEN

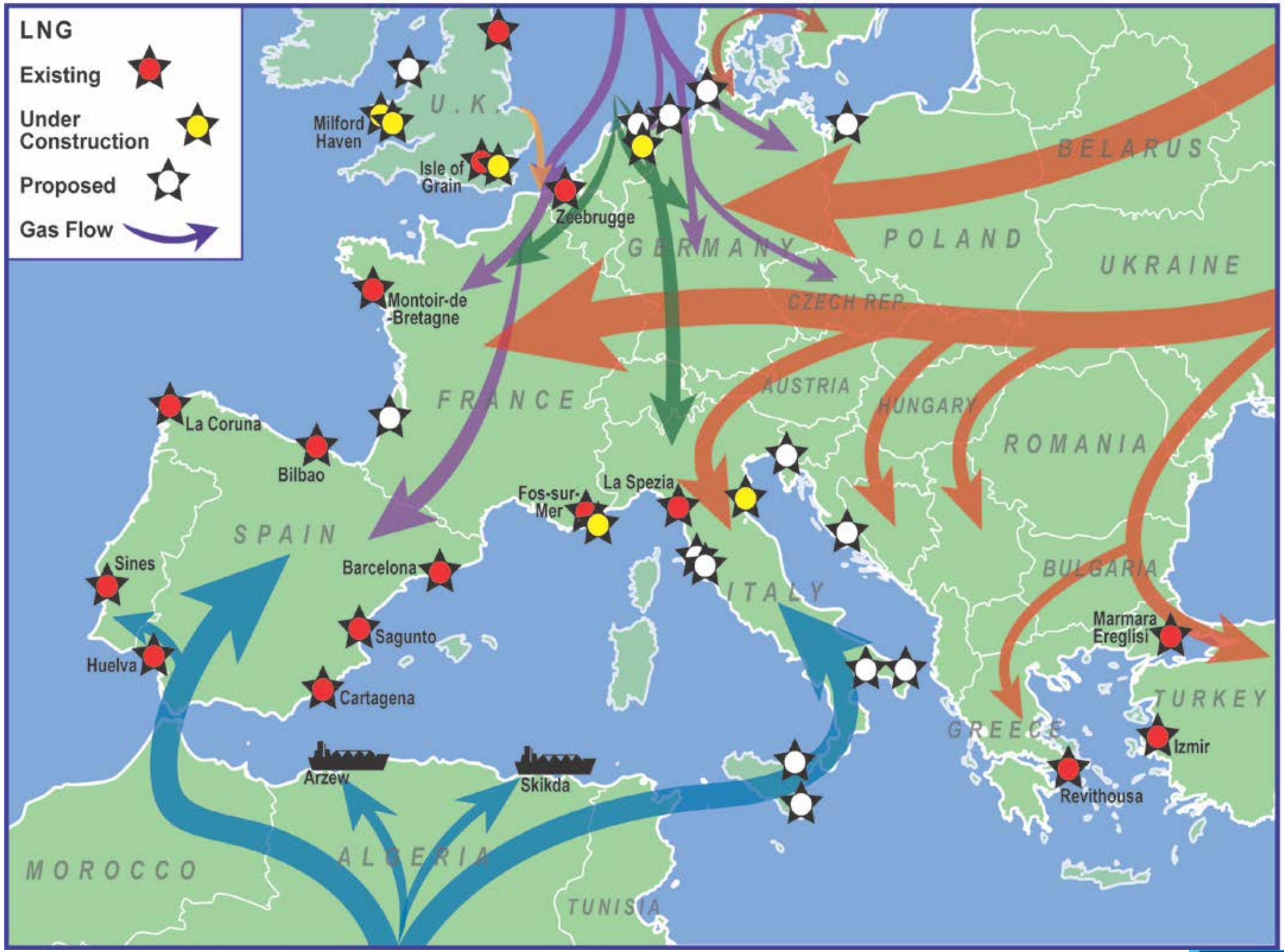
January 01 2009

Russia – Ukraine conflict Jan 2009



KU LEUVEN

Gas flows in Europe



OK

To be avoided !

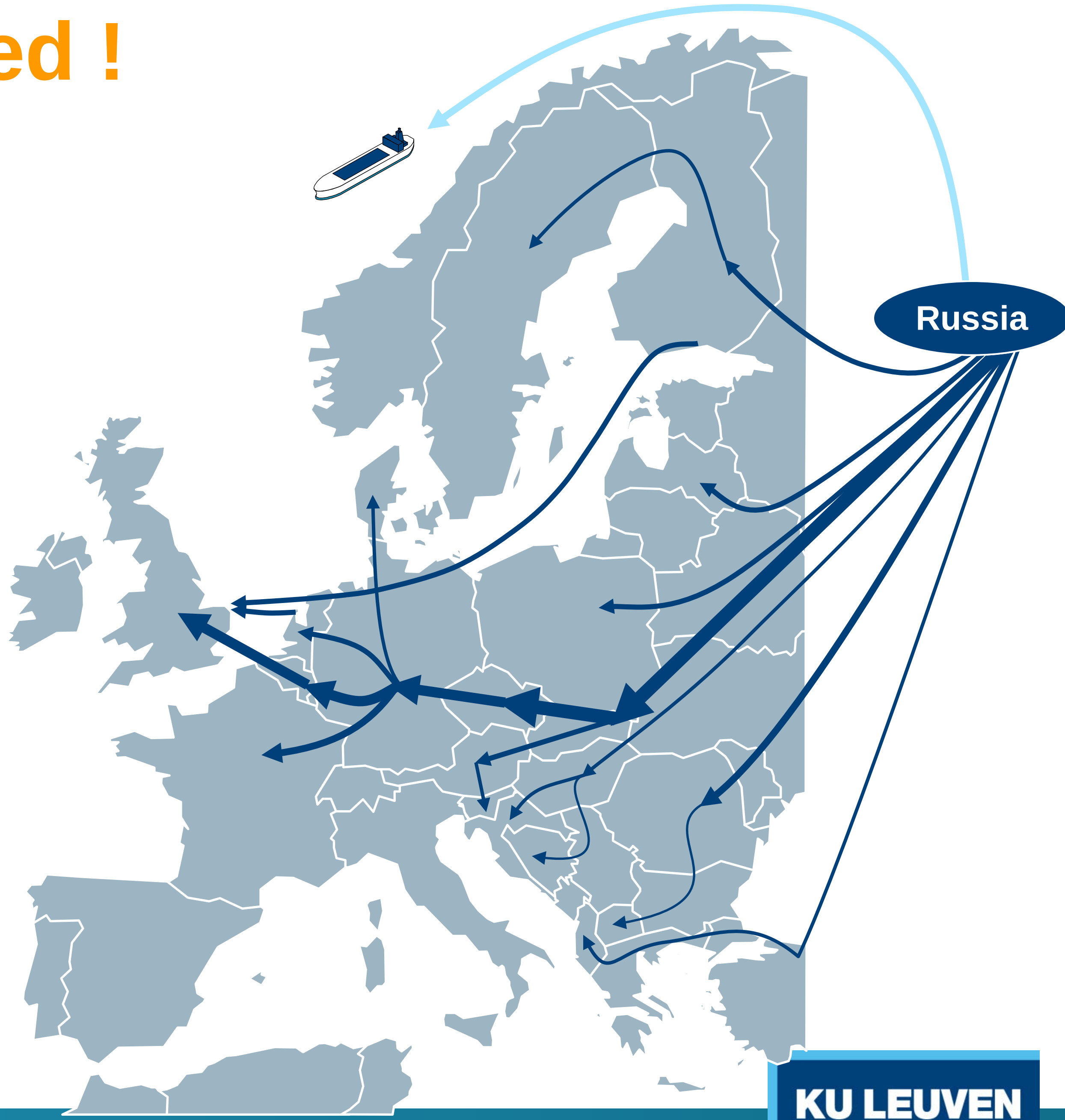
Avoid

unidirectional

or

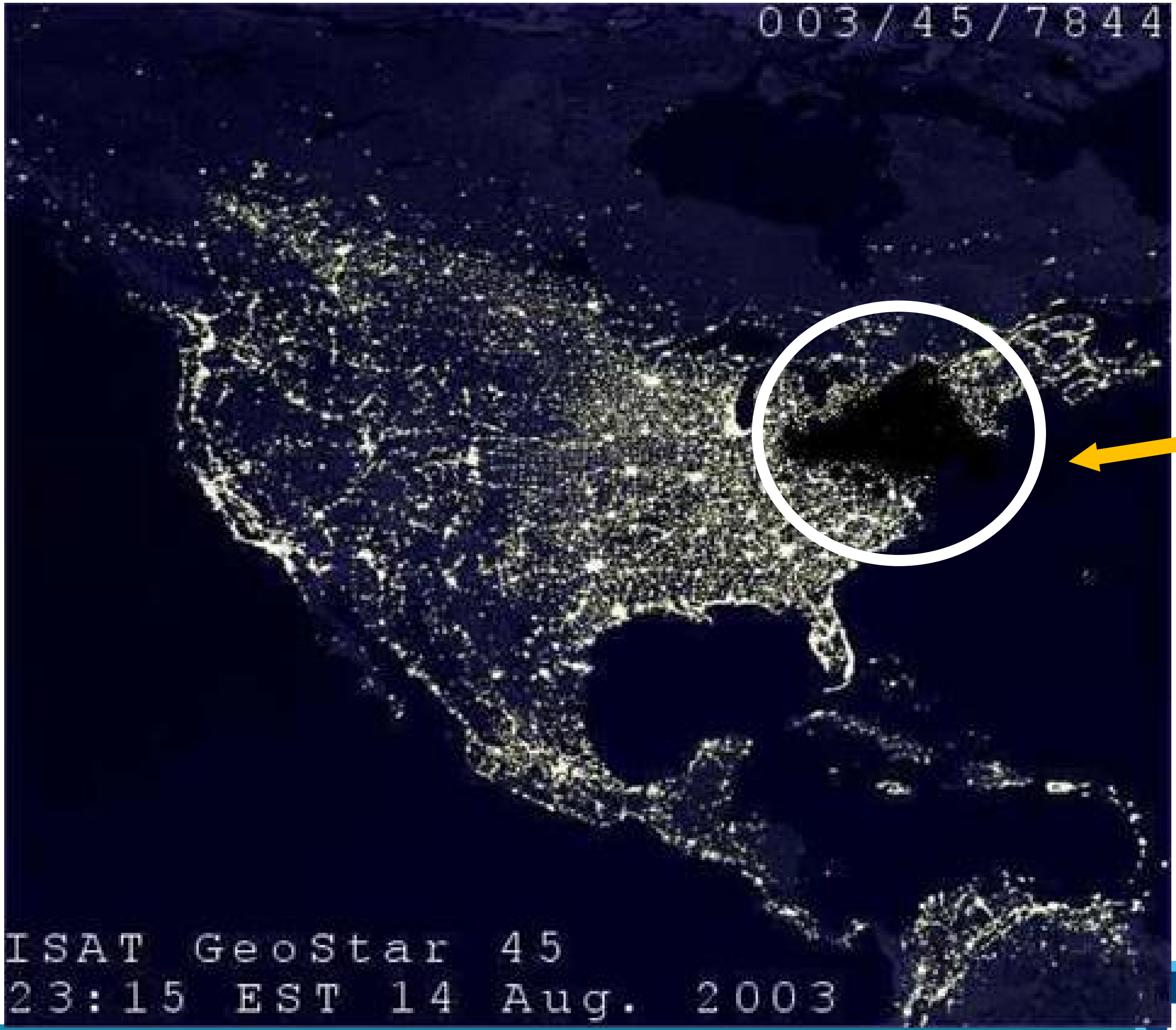
unilateral

dependence !



Source: Wood Mackenzie / Fluxys

SoS - Electricity



KU LEUVEN

SoS - Electricity

New York by night .... on August 14 2003 ...

Security of Supply

- Energy supply interuptions do happen!

- Structured delineation of SoS

Preliminary Reflections

- SoS ≠ Import Independence
  - E.g., *Belgium, Japan,…*
- What is the meaning of national borders?
  - E.g., *USA / Canada* or *EU*
- But need for liquid well-functioning markets & stable geo-political situation

→ Dangerous if only *one* energy form and from *one* supplier

→ Possible abuse (self-centered actions) by countries or big companies ??

→ Geopolitical unstable situations…(Middle East, Russia, China…) ??

KU LEUVEN

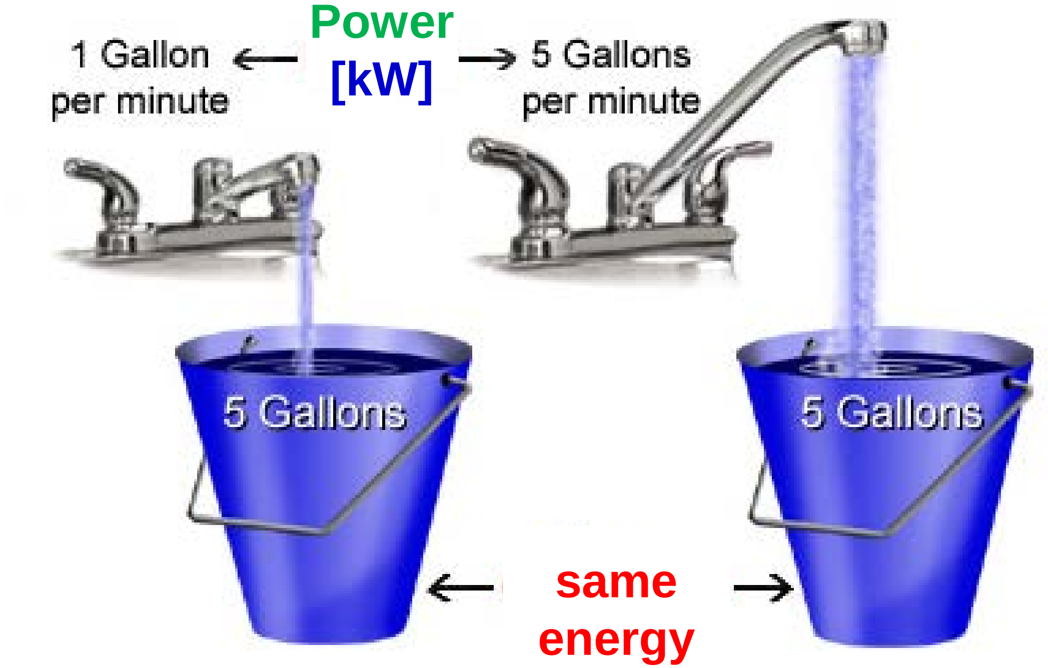
Preliminary Reflections

- Need to distinguish between
  - **Energy** (as time integral of power)
  - **Power** (as derivative of energy)

  - Power is a flow, a flux,
  - Instantaneous power

    ↔ installed power or capacity

Energy versus Power



Power
[kW]

same
energy
=
an
amount
[kWh]

SoS – Structured definition

1. **Strategic Security of Supply**

2. **Adequacy**

3. **Avoiding Black outs or Sudden Cuts**

SoS – Structured definition

1. **Strategic Security of Supply**
2. **Adequacy**
3. **Avoiding Black outs or Sudden Cuts**

SoS – Structured definition

(1) Strategic Security of Supply

= Continued provision of *primary* fuels/sources *to satisfy the request of the end consumer, given that all means exist to get the energy flux from producer to consumer*

This level concentrates on the

producer countries

SoS – Structured definition

(1) Strategic Security of Supply

1. **<u>Physical availability</u> of primary energy sources**

   enough non-empty wells (reserves), coal mines, uranium mines

   For oil, partly the issue of "peak oil"

SoS – Structured definition

(1) Strategic Security of Supply

1. Physical availability of primary energy sources
   - enough non-empty wells (reserves), coal mines, uranium mines
   - *For oil, partly the issue of "peak oil"*
2. **Sufficient investments in production capacity in producer countries**
   - e.g., investments in oil & gas production – also peak oil

SoS – Structured definition

(1) Strategic Security of Supply

1. Physical availability of primary energy sources
   - enough non-empty wells (reserves), coal mines, uranium mines
   - *For oil, partly the issue of "peak oil"*
2. Sufficient investments in production capacity in producer countries
   - e.g., investments in oil & gas production – also peak oil
3. **Geopolitics**
   - unpredictable…
     - … (Iran… Ukraine/RF… Middle East…)

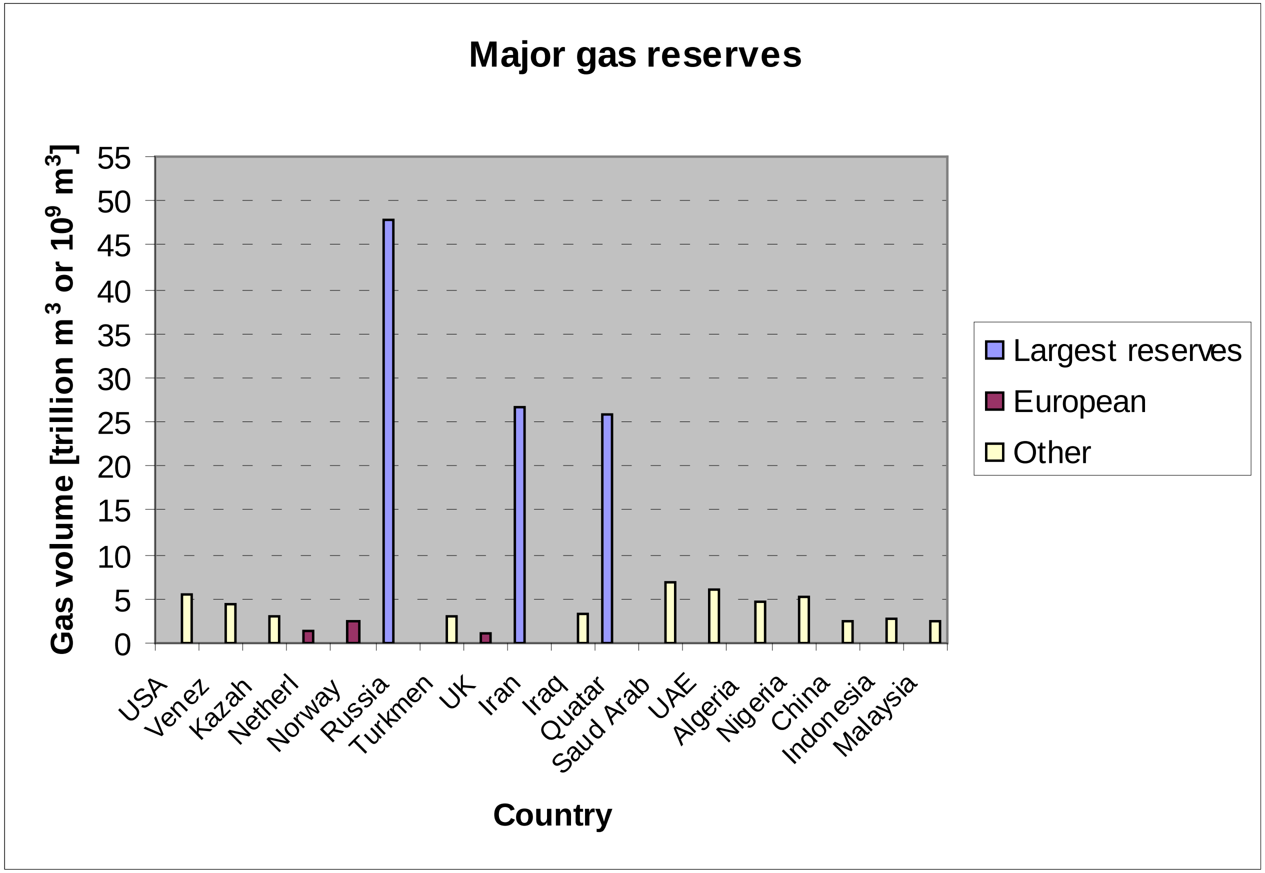
KU LEUVEN

Geopolitics

Geopolitics

Geopolitics

Conventional gas reserves ... Important for Europe...



KU LEUVEN

SoS – Structured definition

1. **Strategic Security of Supply**
2. **Adequacy**
3. **Avoiding Black outs or Sudden Cuts**

SoS – Structured definition

(2) Adequacy

= Sufficient *investments* in <u>consumer</u> and or <u>transit</u> countries

KU LEUVEN

SoS – Structured definition

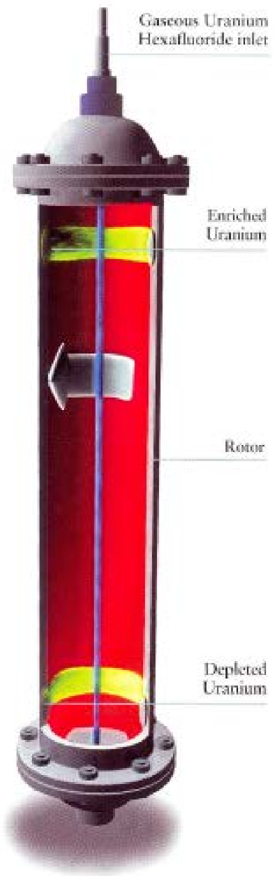
(2) Adequacy

A – Electric power plants, HV grid, high-p NG pipelines, LV and low-p distribution grid, oil refineries, U-enrichment plants

installations need to be able to cope with baseload, peak load & variable load (transient flexibility, variability, unpredictability)

Adequacy

Simplified Cross-Section of a Centrifuge



Cascades of Centrifuges. URENCO Company.

Adequacy

SoS – Structured definition

(2) Adequacy

A – Electric power plants, HV grid, high-p NG pipelines, LV and low-p distribution grid, oil refineries, U-enrichment plants

installations need to be able to cope with baseload, peak load & variable load (transient flexibility, variability, unpredictability)

B – Transit pipelines (NG), LNG ships, cross-border HV lines, oil-tanker fleet,…

assure more than one single route/means

Adequacy

Adequacy

Transit Russian gas through the Ukraine

KU LEUVEN

Adequacy

Nord Stream

SoS – Structured definition

(2) Adequacy

Issues that may hamper “adequacy”:

→Nature of ***liberalized*** *markets* (economic risk) -- investors demand a higher IRR

→Unstable ***regulatory*** situation

- → Conflict with environmental policy
- → Uncertain regulatory character; price caps

→Complex permitting/licensing processes

SoS – Structured definition

(2) Adequacy

Issues that may hamper “adequacy”:

→ ***Circumstantial*** influencing elements

- → Financial market expectations/tendencies
- → Energy policy expectations (green papers, intentions)
- → Political uncertainties (attitude of political authorities wrt private investment; ideological tensions in governments on investment choices to be made)
- → Too low electricity prices (driven by RES); small load factors

SoS – Structured definition

1. **Strategic Security of Supply**
2. **Adequacy**
3. **Avoiding Black outs or Sudden Cuts**

SoS – Structured definition

(3) Avoiding sudden cuts (black outs)

= make sure that the overall system performs as “expected” (for end customer) even in case of <u>unexpected</u> events

i.e., capacity to absorb transients, dynamics, mishaps

= issue of **reliability/security**

→ **redundancy** (e.g., N-1 rule)

→ related to **maintenance, control strategies**,…

SoS – Structured definition

(3) Avoiding sudden cuts (black outs)

Cope with storms,…

Need redundancy

N-1

KU LEUVEN

SoS – Structured definition

(3) Avoiding sudden cuts (black outs)

Good maintenance

KU LEUVEN

SoS – Structured definition

(3) Avoiding sudden cuts (black outs)

Good dispatch & control strategies

KU LEUVEN

Solutions… for SoS

Solutions… for SoS

General principles

- Energy efficiency (reduce demand)

  - Avoiding kWh and Joules (‘*energy*’)
  - Mitigate peak loads (‘*power*’)

→ **Energy prices must be ‘sufficiently’ high**

Solutions… for SoS

General principles

- Functioning markets
  - Primary + secondary energy carriers
  - Energy available for those willing to pay for it

Global market?

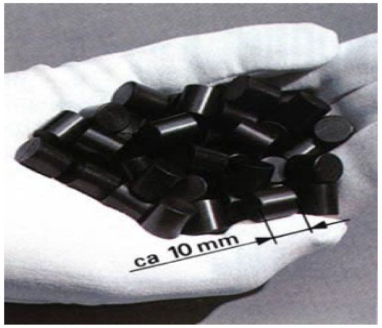
- Oil, coal, gas/LNG

KU LEUVEN

Solutions… for SoS

General principles

- Diversity; spread risk→ portfolio analysis
  - Types of fuels/renewables



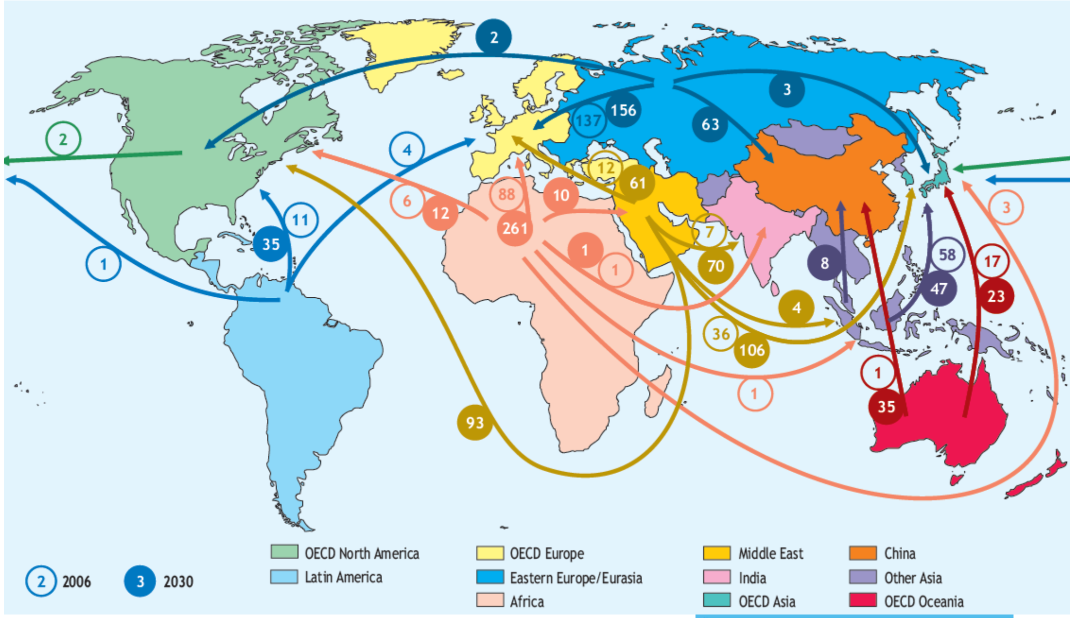
UO_2 pellets.


Fuel rods.

Solutions… for SoS

General principles

- Diversity; spread risk→ portfolio analysis
  - Types of fuels/renewables
  - Origin of the fuels

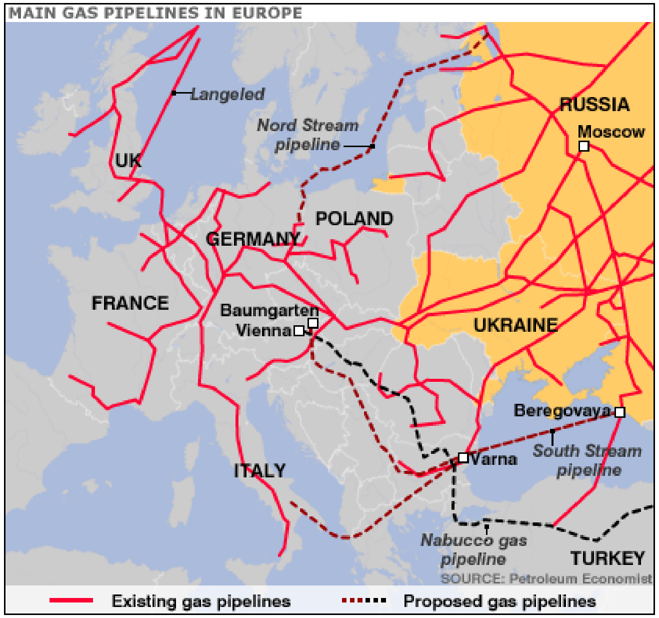


KU LEUVEN

Solutions… for SoS

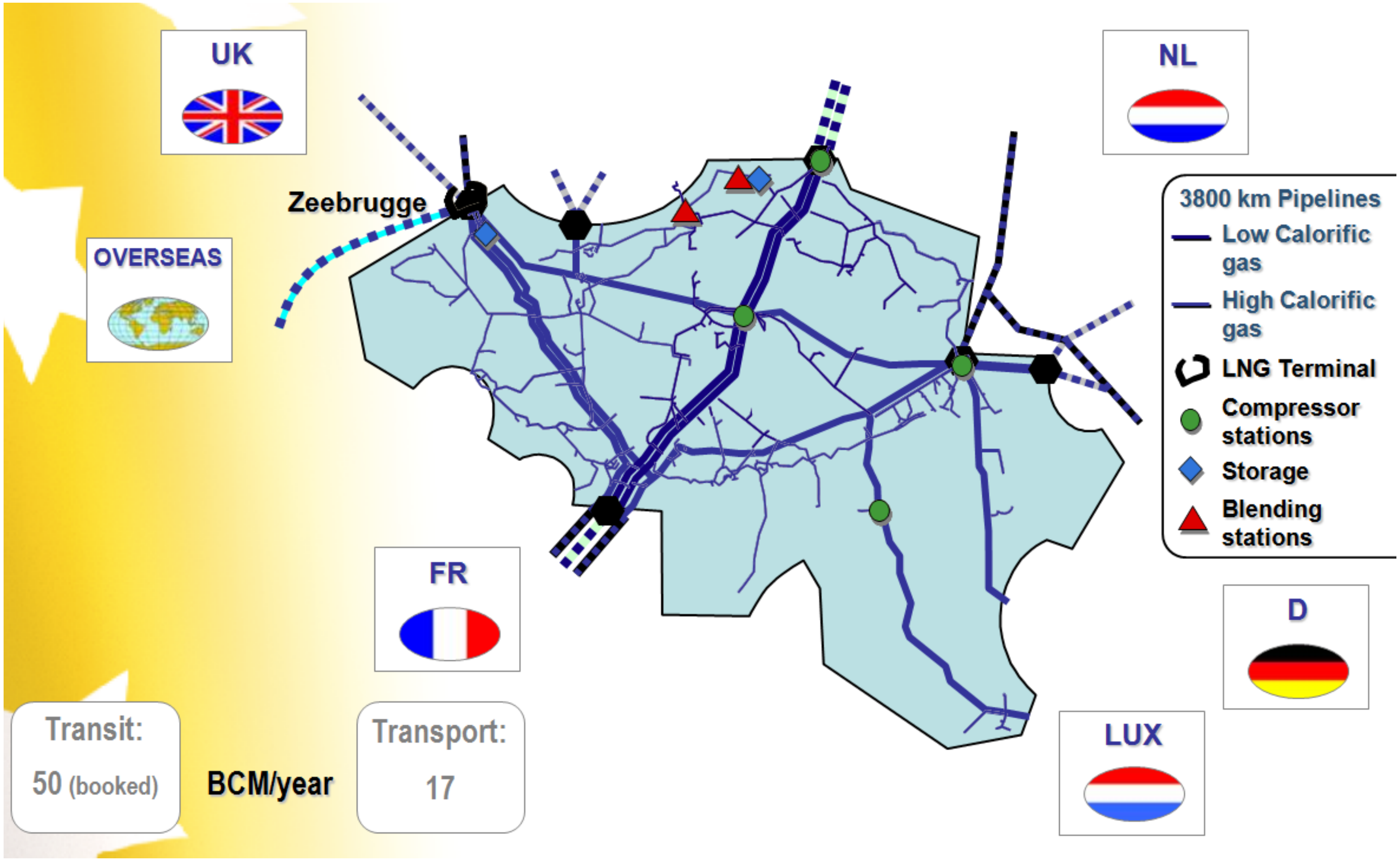
General principles

- Diversity; spread risk→ portfolio analysis
  - Types of fuels/renewables
  - Origin of the fuels
  - Routes



KU LEUVEN

Solutions… for SoS



Solutions… for SoS

General principles

- Diversity; spread risk→ portfolio analysis
  - Types of fuels/renewables
  - Origin of the fuels
  - Routes
  - Types of technologies

Solutions… for SoS

General principles

- Storability
    - Of primary fuels (oil IEA 90 days, for gas?, positive point for U, coal, biomass)

Solutions… for SoS

General principles

- Storability
  - Of primary fuels (oil IEA 90 days, for gas?, positive point for U, coal, biomass)
  - Of secondary carriers
    - Gasoline / diesel stocks
    - Electricity: hydro-pump stations, batteries (plug-in hybrids,…)
    - Gas (on way to consumer): linepack
    - Heat buffers

Solutions… for SoS

Strategic security

- International agreements
  - Bilateral/multilateral
- Frame cooperation in organizations
  - IEA, IAEA, WTO, …
- Solidarity within regions/alliances
  - EU, North America, OECD…
- Guarantee security of demand
  - E.g., long term gas contracts

Solutions… for SoS

Adequacy

- Allow/Stimulate sufficient investments
  - EU:
    - stable regulatory framework (otherwise no new plants!)
    - allow pass on regulated costs via tariffs (otherwise no smart grid!)
  - Provide adequate licensing/permitting framework
  - Capacity Mechanisms (?) … to be discussed

Solutions… for SoS

Operational reliability

- Load/supply predictability & response
- Careful planning, maintenance strategies
- Redundancy, optimized system operation
- Market design
    - Prevent abuse of dominant players, unbundling,…
- Market instruments
    - Interruptible contracts

Conclusions on SoS

SoS - most important elements:

→ **Temporal and spatial dimension**

→ **Diversity of supply & technologies**

→ **Sufficient investments**

→ **Flexibility, redundancy, control, storability**

→ **Stable regulatory framework / solidarity**

→ **Functioning markets**

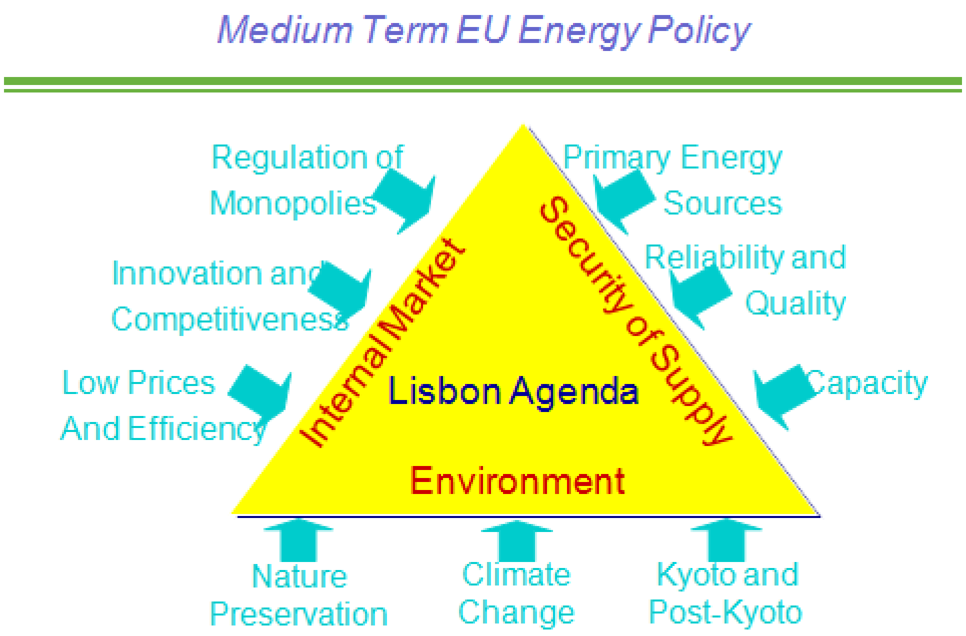
KU LEUVEN

EU’s implementation

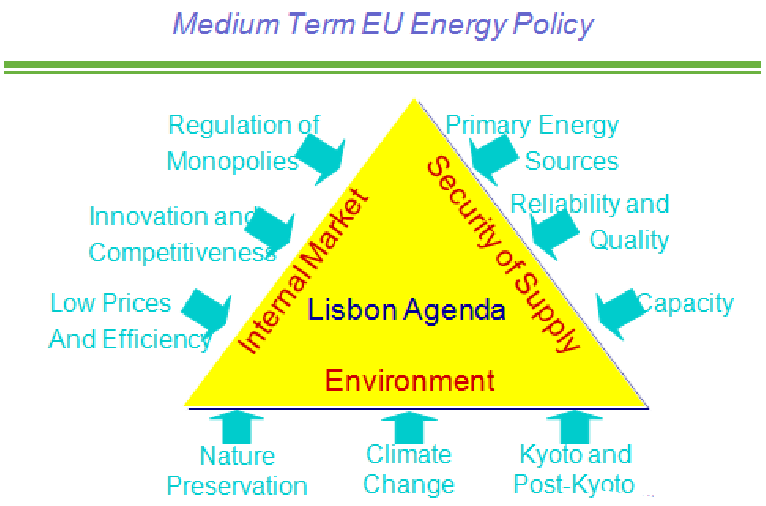
EU's implementation

Major challenge to satisfy all three simultaneously

EU's **trilemma** !



EU's implementation



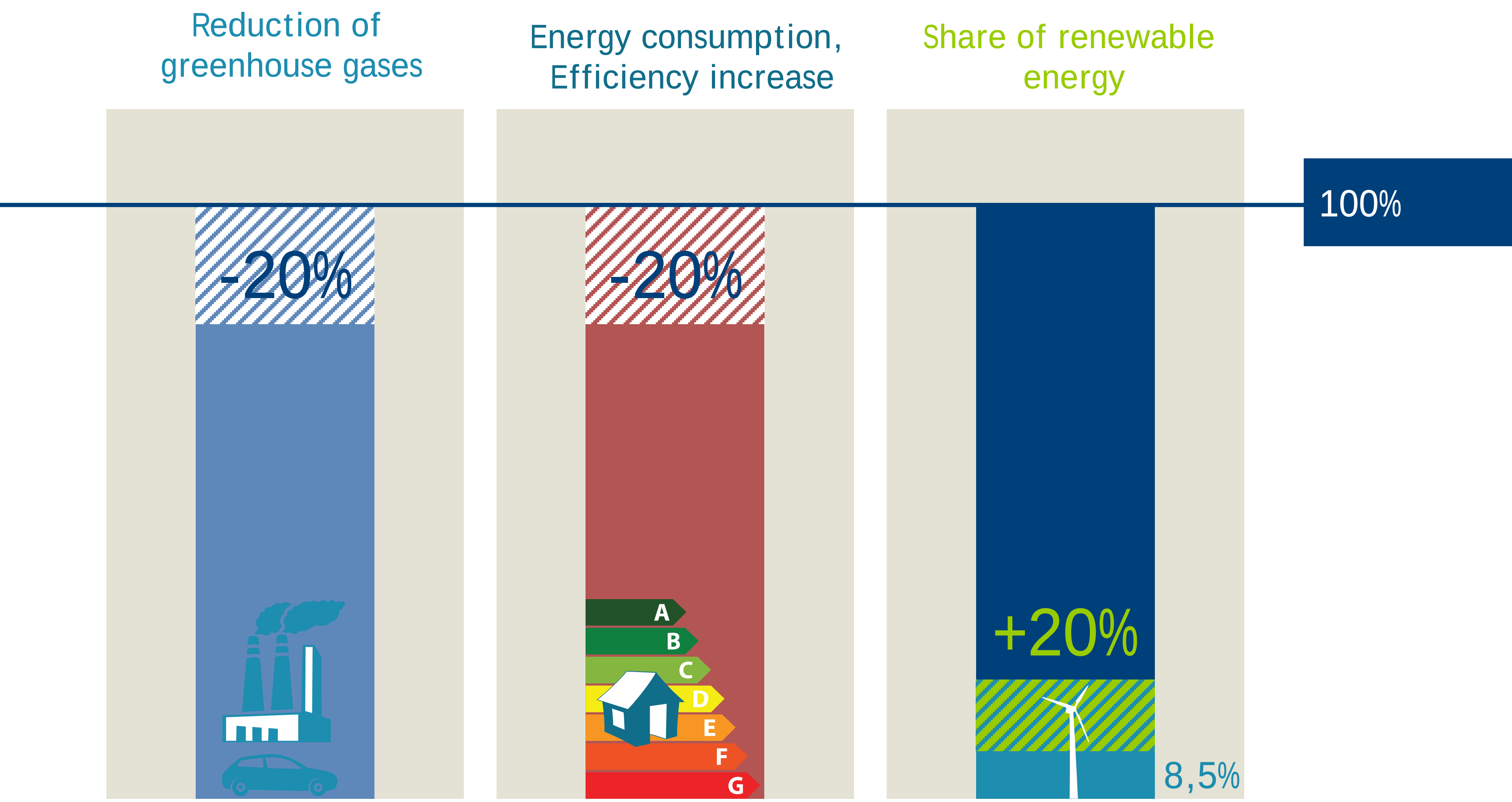
Major challenge to satisfy all three simultaneously

EU's **trilemma** !

- Objectives
  - 2020 targets (20-20-20)
    - By EU considered as "given" / "decided" / to be implemented
  - 2030 as intermediate step
    - Long enough to do something; close enough to say meaningful things
  - 2050 vision (reduction CO_2 by > 85%)
    - Need **energy revolution / paradigm shift**

KU LEUVEN

EU 20-20-20 targets by 2020



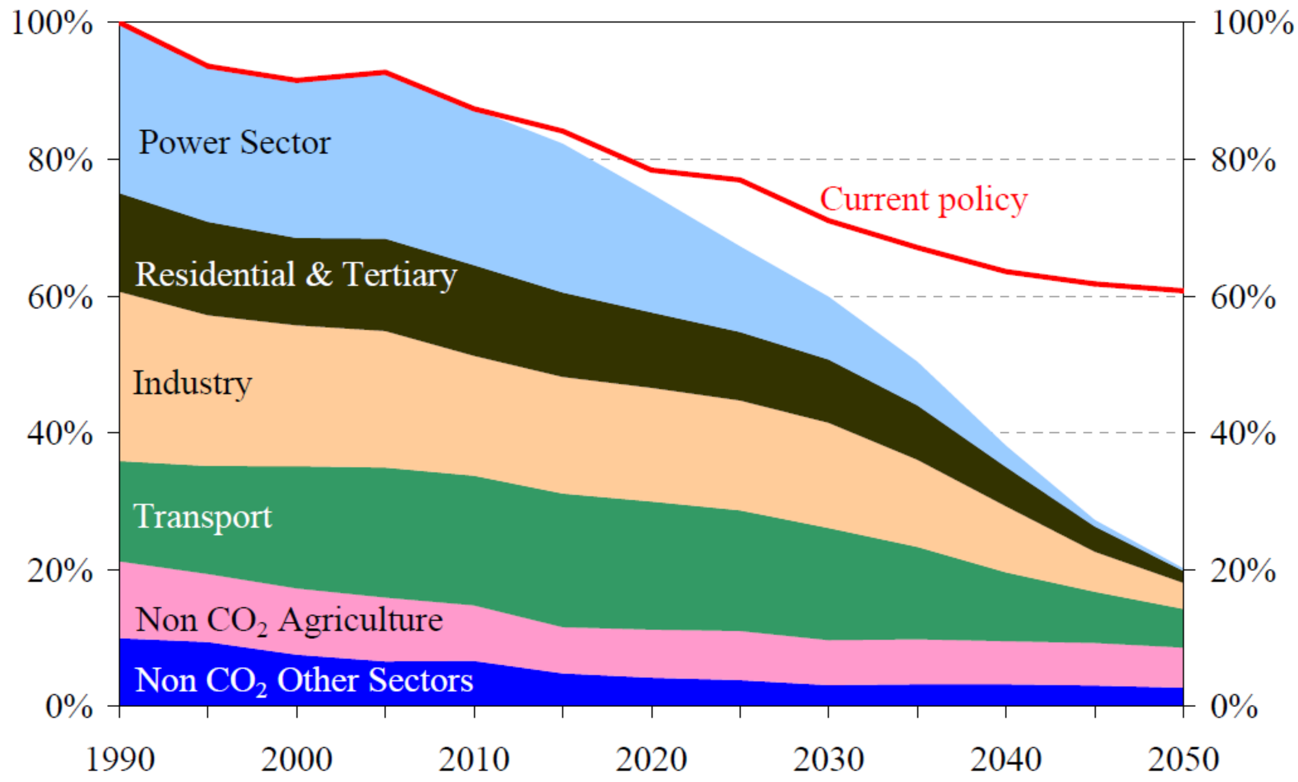
William D'haeseleer

KU LEUVEN

EU’s long-term CO_2 reduction targets

Climate Change Roadmap - 2050

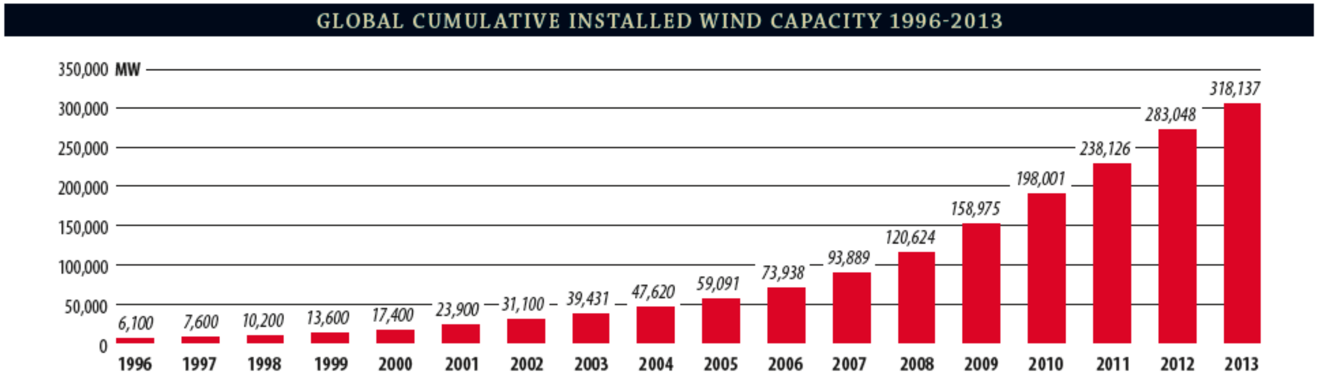
Figure 1: EU GHG emissions towards an 80% domestic reduction (100% =1990)

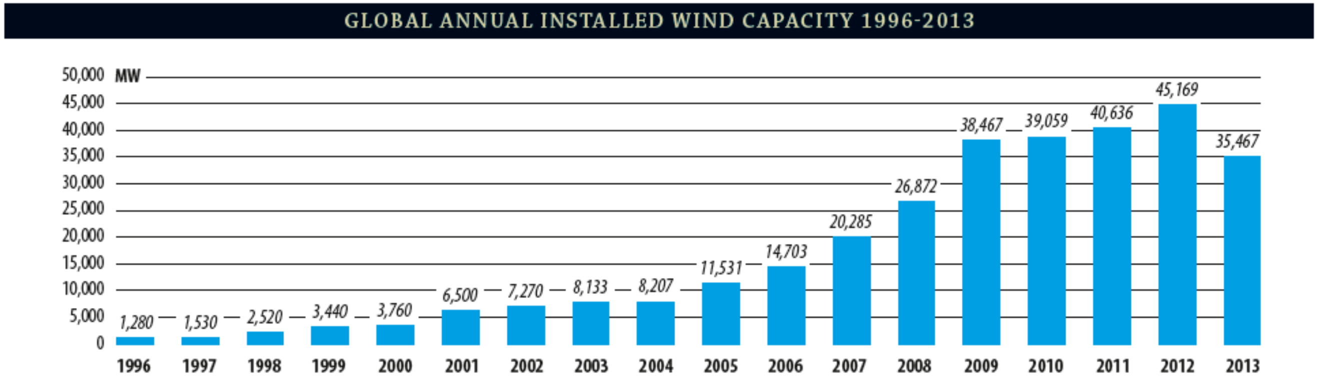


Reference: European Commission COM(2011) 112/4

EU’s implementation - currently

Wind evolution worldwide



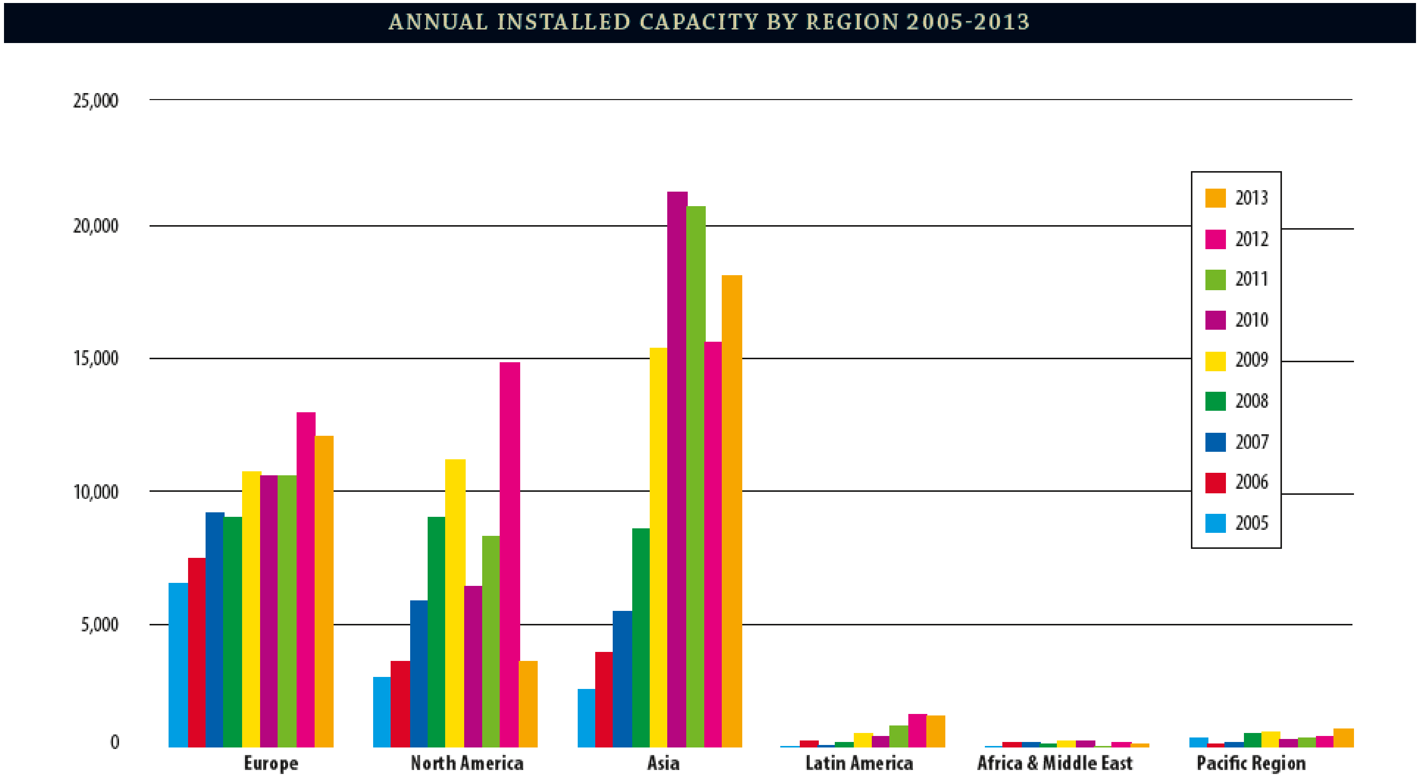


Ref: GWEC 2014

KU LEUVEN

EU's implementation - currently

Wind annual installed capacity worldwide per region

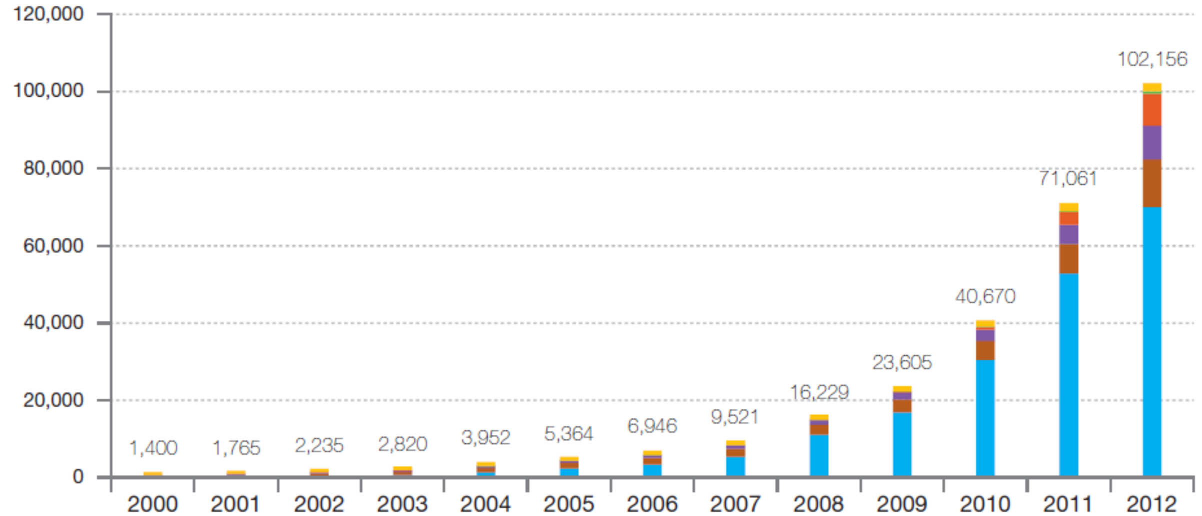


Ref: GWEC 2014

EU's implementation - currently

PV evolution worldwide

Figure 1 - Evolution of global PV cumulative installed capacity 2000-2012 (MW)



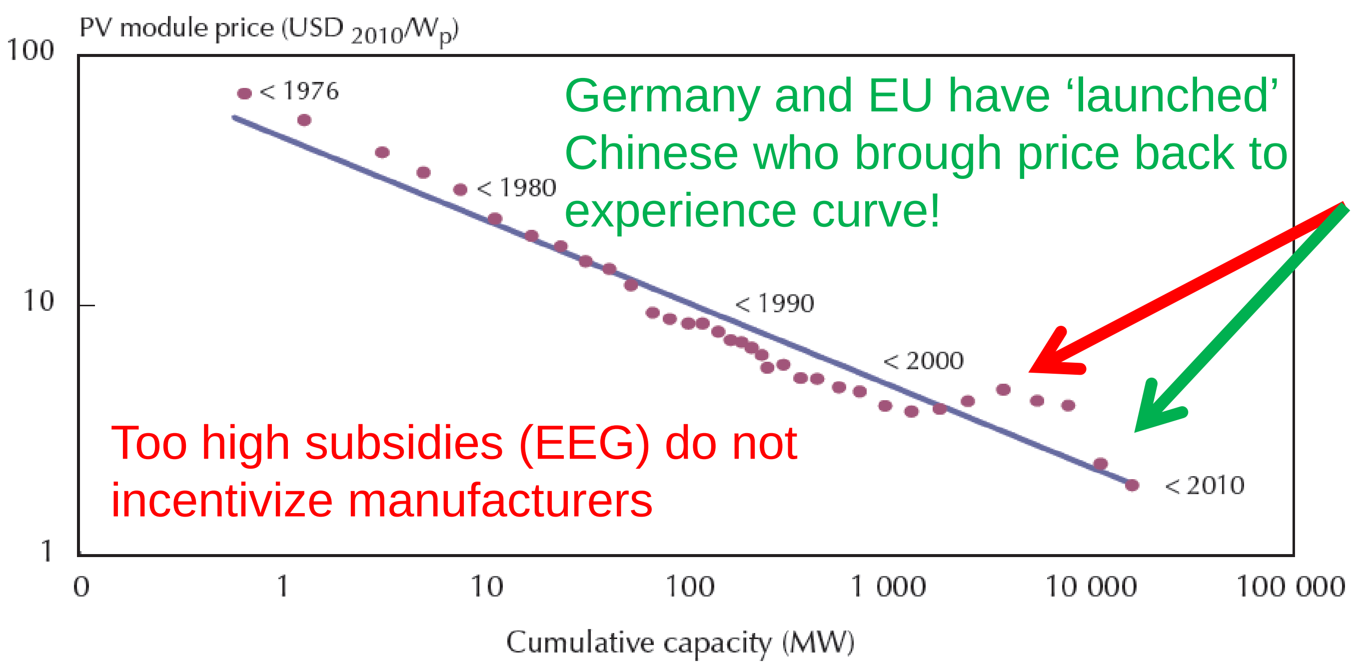
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ROW	751	807	887	964	993	1,003	1,108	1,150	1,226	1,306	1,590	2,098	2,098
MEA	n/a	n/a	n/a	n/a	1	1	1	2	3	25	71	192	601
China	19	24	42	52	62	70	80	100	140	300	800	3,300	8,300
Americas	146	178	225	290	394	501	650	863	1,209	1,752	2,780	4,959	8,717
APAC	355	495	686	916	1,198	1,500	1,825	2,096	2,631	3,373	4,956	7,628	12,397
Europe	129	262	396	598	1,305	2,289	3,281	5,310	11,020	16,850	30,472	52,884	70,043
Total	**1,400**	**1,765**	**2,235**	**2,820**	**3,952**	**5,364**	**6,946**	**9,521**	**16,229**	**23,605**	**40,670**	**71,061**	**102,156**

Ref: EPIA 2012

Cost aspects RES

Ref: IEA Deploying Renewables

Figure 2.13 **Cost degression of solar PV modules, 1976-2010**



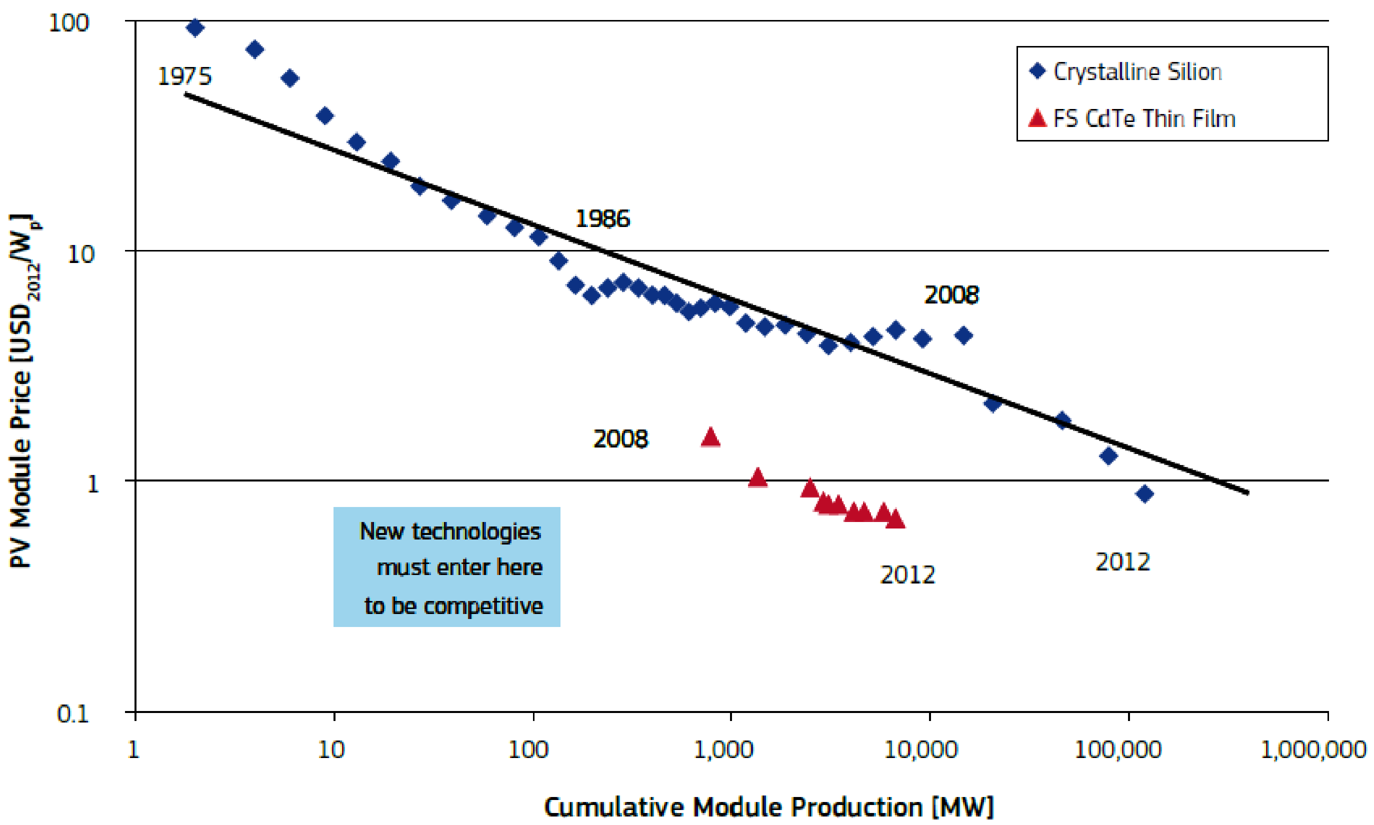
Source: Breyer and Gerlach (2010).

→**Good for worldwide price PV**
→**Bad for EU & US PV industry**

Key point

Historically, every doubling of installed capacity coincided with a 19.3% reduction of PV module prices.

Cost aspects RES



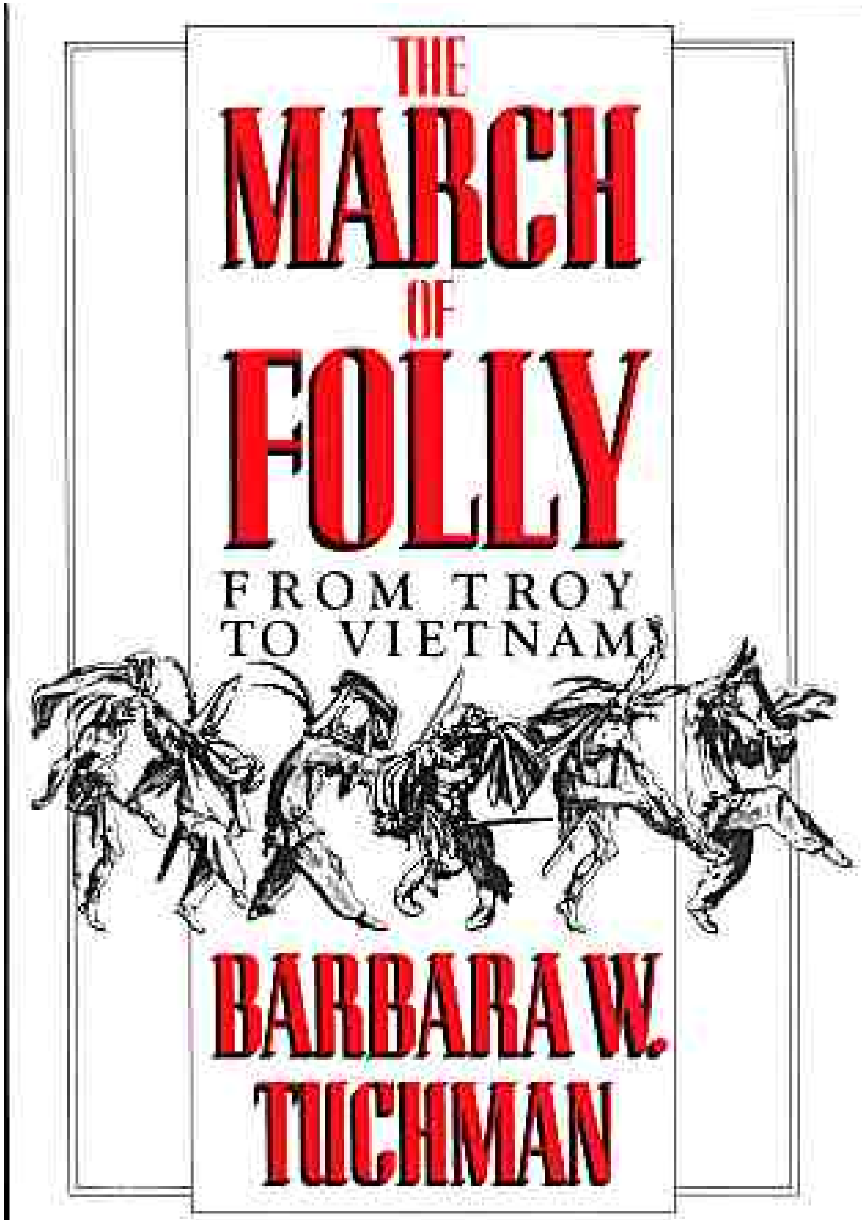
Ref: JRC 2013

EU's implementation - currently

- All this progress seems to be too nice to be true...
  And it is...

- There are major *system effects* that have been neglected and that may jeopardize further success of RES deployment!

- One has gone too rapidly recently, with *danger of losing support of population!*



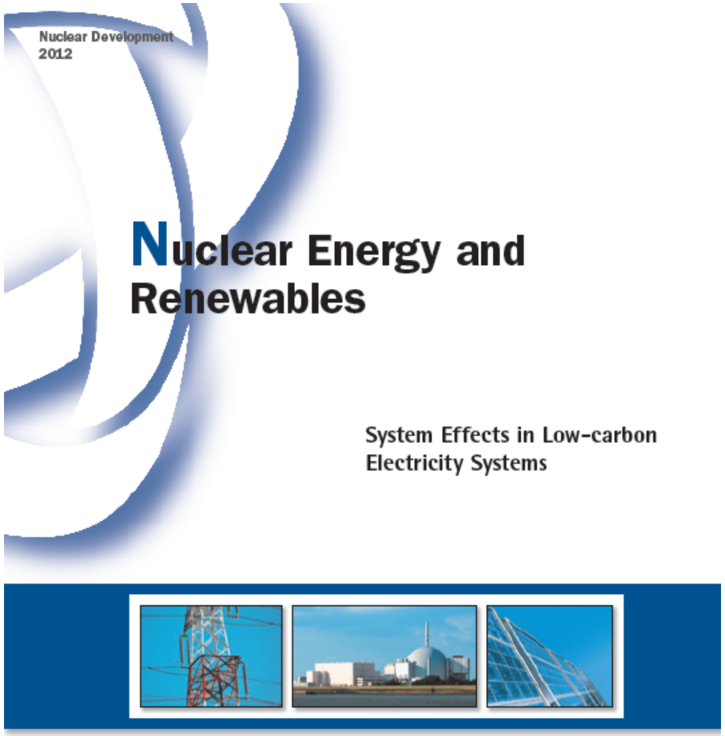
THE MARCH
OF FOLLY

Pursuit of policy

contrary to self-interest

KU LEUVEN

Cost aspects RES – system costs



Comprehensive document giving overall cost figures, end 2012.

Is currently being scritinized – numbers to be confirmed or contested.

OECD

NEA

Available at: http://www.oecd-nea.org/ndd/pubs/2012/7056-system-effects.pdf

KU LEUVEN

Cost aspects RES – system costs

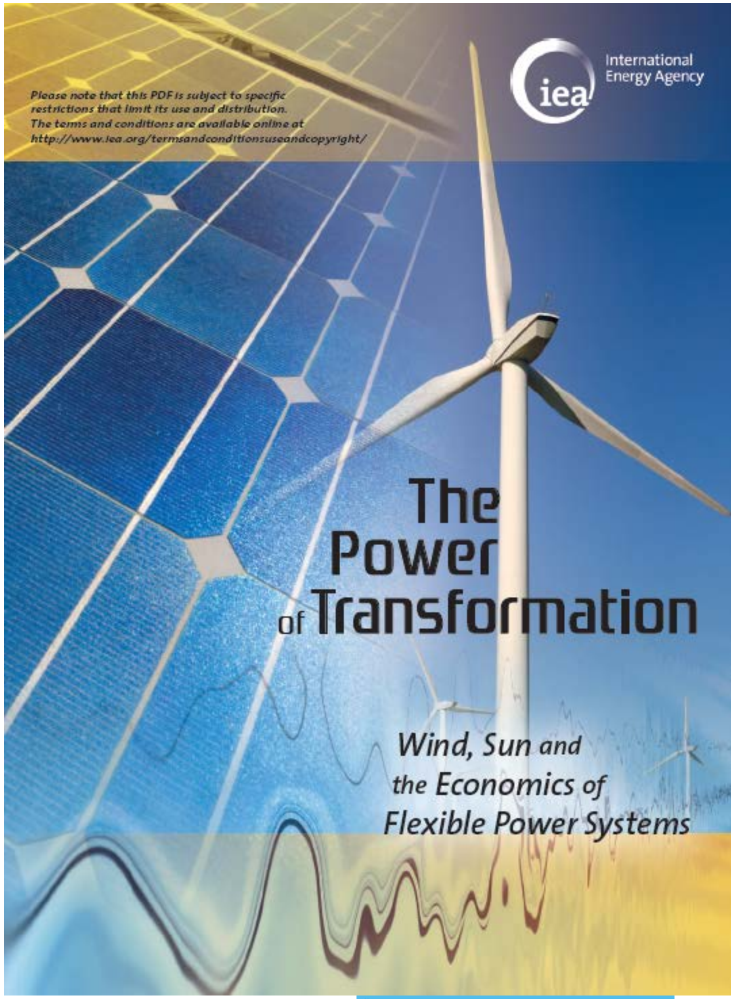
Recently released: February 26, 2014

States in Executive Summary (ES):

«… a major finding of this publication is that large shares of VRE (up to 45% in annual generation) can be integrated <u>without significantly increasing power costs</u> in the long run. However, cost-effective integration calls for a system-wide transformation.»

?? IEA/OECD in contrast with NEA/OECD ??

Not quite… ES is not in line with main report!

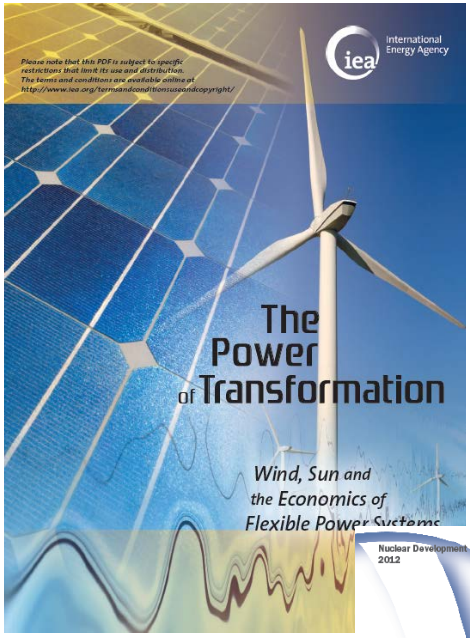


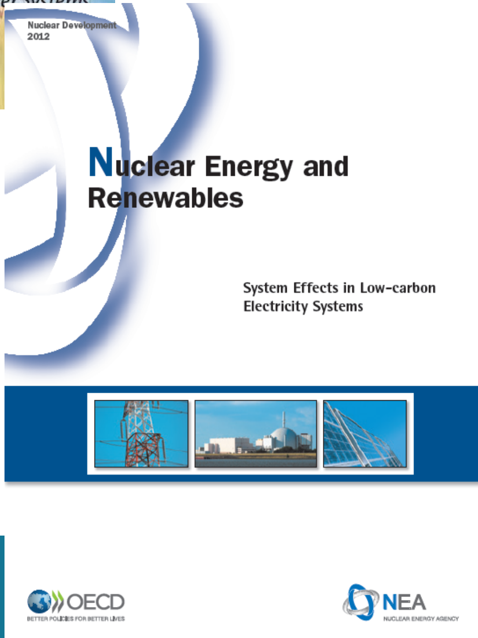
KU LEUVEN

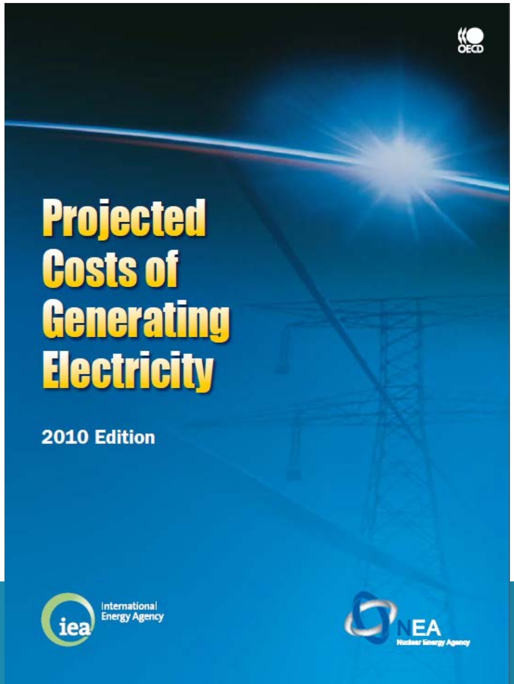
Cost aspects RES – system costs

- Currently exercise to “reconcile” both studies in the 2015 revision of the joint IEA/NEA report : **“Projected Cost of Generating Electricity”**

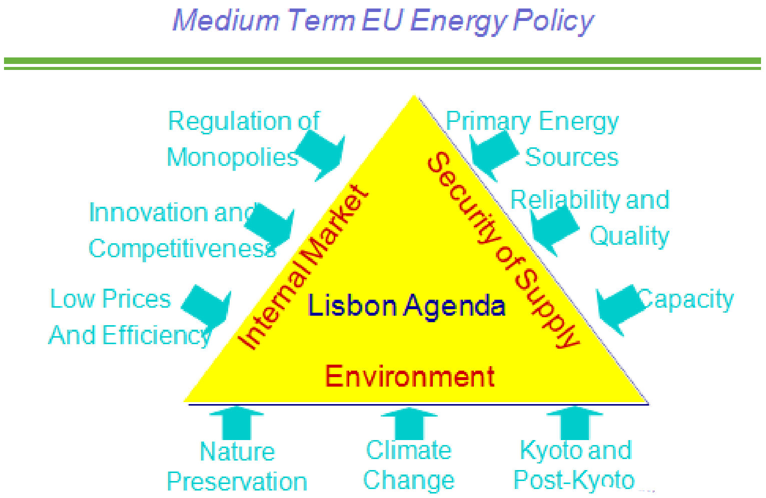
  written by two authors of IEA and NEA!







EU's implementation - recall



Major challenge to satisfy all three simultaneously

EU's **trilemma** !

- Objectives
  - 2020 targets (20-20-20)
    - By EU considered as "given" / "decided" / to be implemented
  - 2030 as intermediate step
    - Long enough to do something; close enough to say meaningful things
  - 2050 vision (reduction CO_2 by > 85%)
    - Need **energy revolution / paradigm shift**

KU LEUVEN

EU's implementation

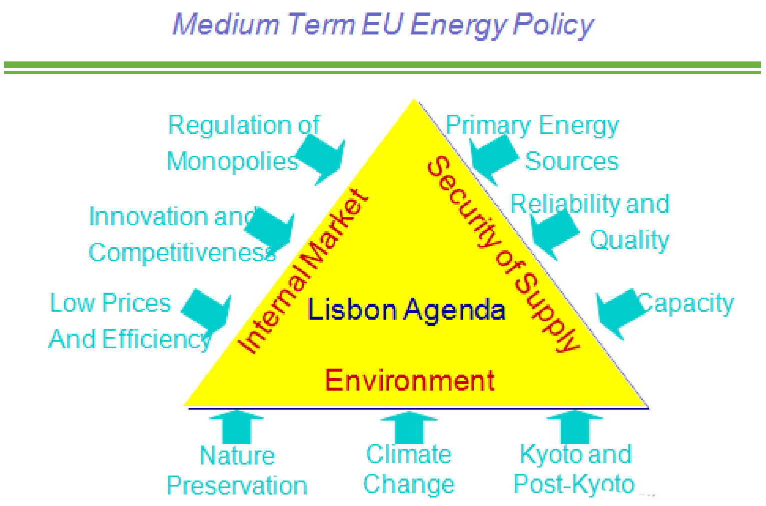
Major challenge to satisfy
all three simultaneously

EU's **trilemma** !

Textbook example of
"well intended measures"
but ...

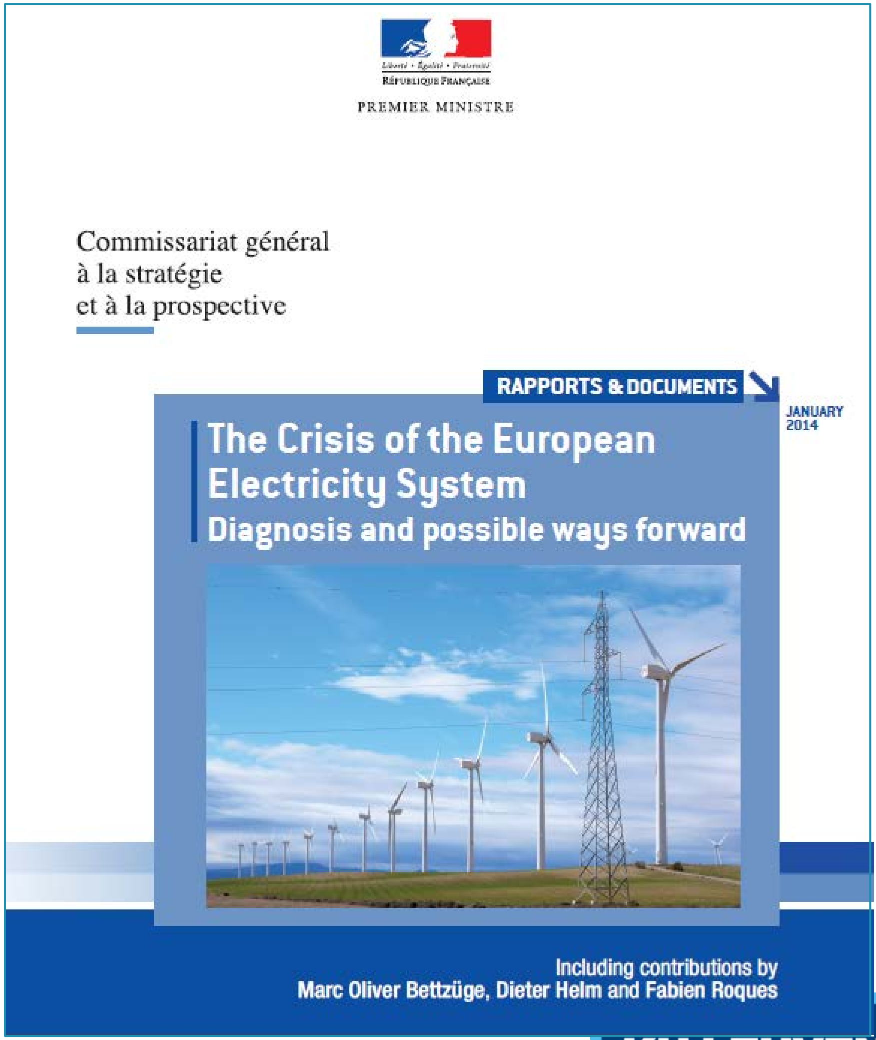
because *lack of system thinking*
serious issues / problems

→ EU electricity market in cirisis !!



KU LEUVEN

French Report January 2014



EU’s implementation

Issues / challenges / problems in the EU market

- Technical challenges
- Market-integration problems
- Consequences for the CO_2 emissions
- End-electricity prices for end consumers

EU's implementation

Consequences of renewables quota in end-energy terms (1)

- Total end energy = electric energy + fuel for heat + fuel for transportation
- EU requirement by 2020: 20% of end energy from RES
- For transportation only 10% ... → for electric sector ~ 34%
- Expectations / outcome ("steered" by differentiated *subsidies*):
  - Hydro ~ only small increase possible
  - Biomass ~ moderated increase (protests against co-combustion, imported biomass pellets, sustainability questions)
  - Wind onshore + offshore / ENOH onsh ~ 2200h/a offsh ~ 3500 h/a
  - Solar photovoltaics (PV) / ENOH NW Europe ~ 800-1000 h/y
- Total: 8760 h/a → low capacity factors of these intermittent sources

EU's implementation

Consequences of renewables quota in end-<u>energy</u> terms (2)

- Capacity factors intermittent sources (wind + PV):
  - Wind onshore + offshore / CF ~ 25% - 30%
  - Solar photovoltaics (PV) / CF ~ 10-12%
- To produce 34% electric energy with something that operates only 10-12% or 25-30% of the time, you must install a large amount of installed power (called "capacity") → leads to massive overcapacity
- If there is a lot of wind and sun, and low demand (e.g., weekends), then <u>too much electricity produced</u>
- But sometimes in case of cold spell (cfr winter Feb 2012) – with temp inversion... little wind and 'dark' (hence no PV) at 17.00h-18.00h, when peak demand arises in NW-Europe! → <u>very little RES electricity produced</u>

KU LEUVEN

EU’s implementation

Consequences of renewables quota in end-energy terms (3)

- *Intermittency*: defined as “variable” and “partly unpredictable”
- How deal with massive “intermittency” in electricity system?
  - Back up reserves from *flexible dispachable thermal plants* (+ & -)
  - Electric *storage* (large scale electric storage not available)
  - Expansion of *transmission grid*
  - Encourage *active demand response* (ADR)
  - *Curtailing* of superfluous RES production / review priority access
  - Mitigate on *local level via smart grids*

EU's implementation

Issues / challenges / problems in the EU market

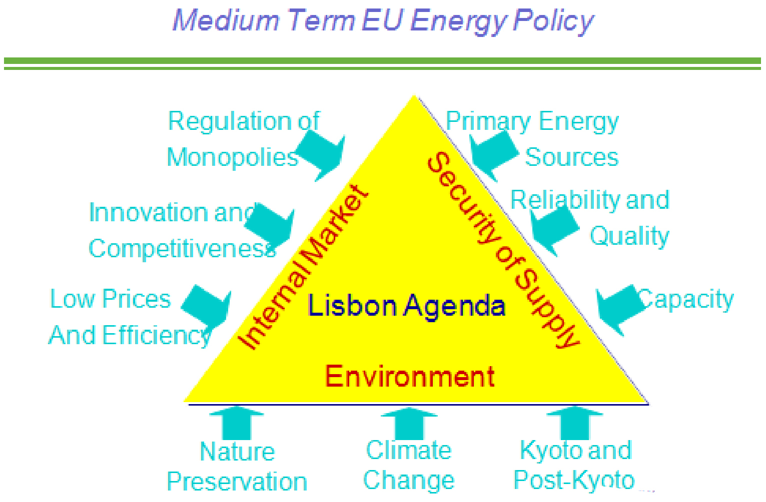
- Technical challenges
- Market-integration problems
- Consequences for the CO_2 emissions
- End-electricity prices for end consumers

EU's implementation

Major challenge to satisfy
all three simultaneously

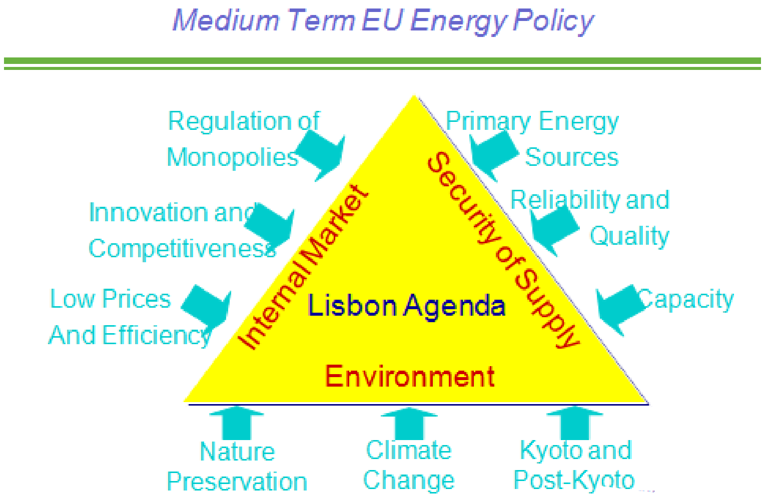
EU's **trilemma** !

- Objectives
  - 2020 targets (20-20-20)
    - By EU considered as "given" / "decided" / to be implemented



KU LEUVEN

EU's implementation – technical issues



Major challenge to satisfy all three simultaneously

EU's **trilemma** !

- Objectives
  - 2020 targets (20-20-20)
    - By EU considered as "given" / "decided" / to be implemented

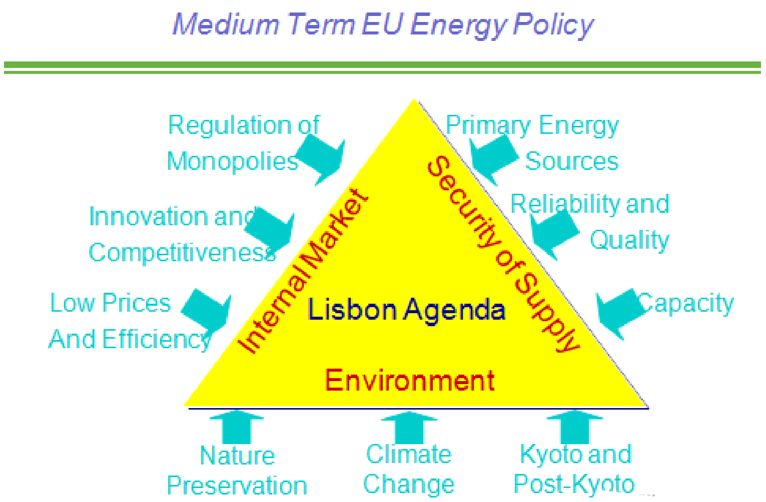
→ 33 % renewable electric *energy*
→ installed capacity of only wind & sun ~160% of average demand level
→ highly intermittent & non-controllable / need thermal plant back up !

KU LEUVEN

EU's implementation – technical issues

Major challenge to satisfy all three simultaneously

EU's **trilemma** !



- Objectives
  - o 2020 targets (20-20-20)
    - By EU considered as "given" / "decided" / to be implemented

Technical challenge!!

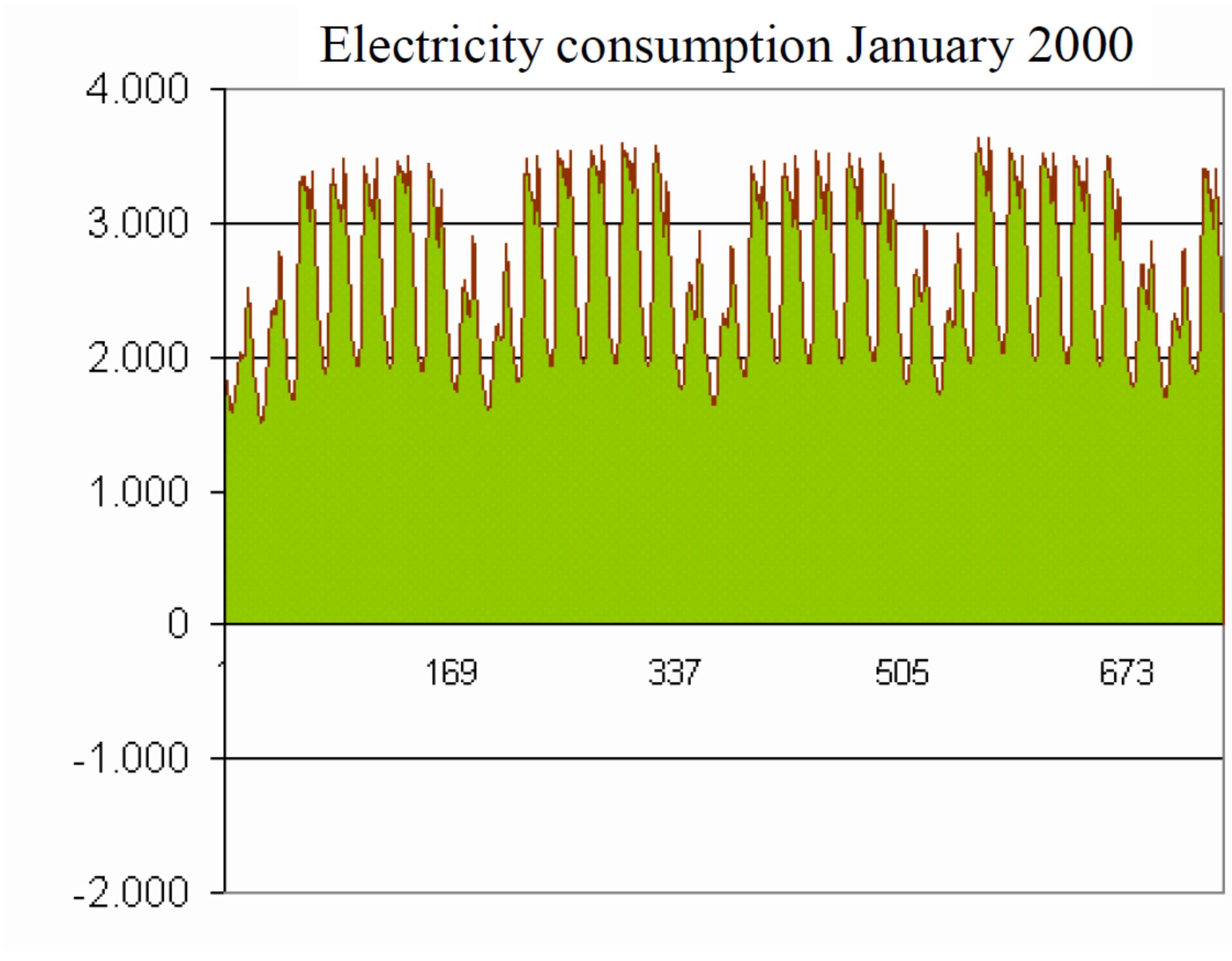
→ often serious over production / too much electricity
→ thermal plants must balance very quickly

KU LEUVEN

EU's implementation – technical issues

Case: January 2000

Example Denmark

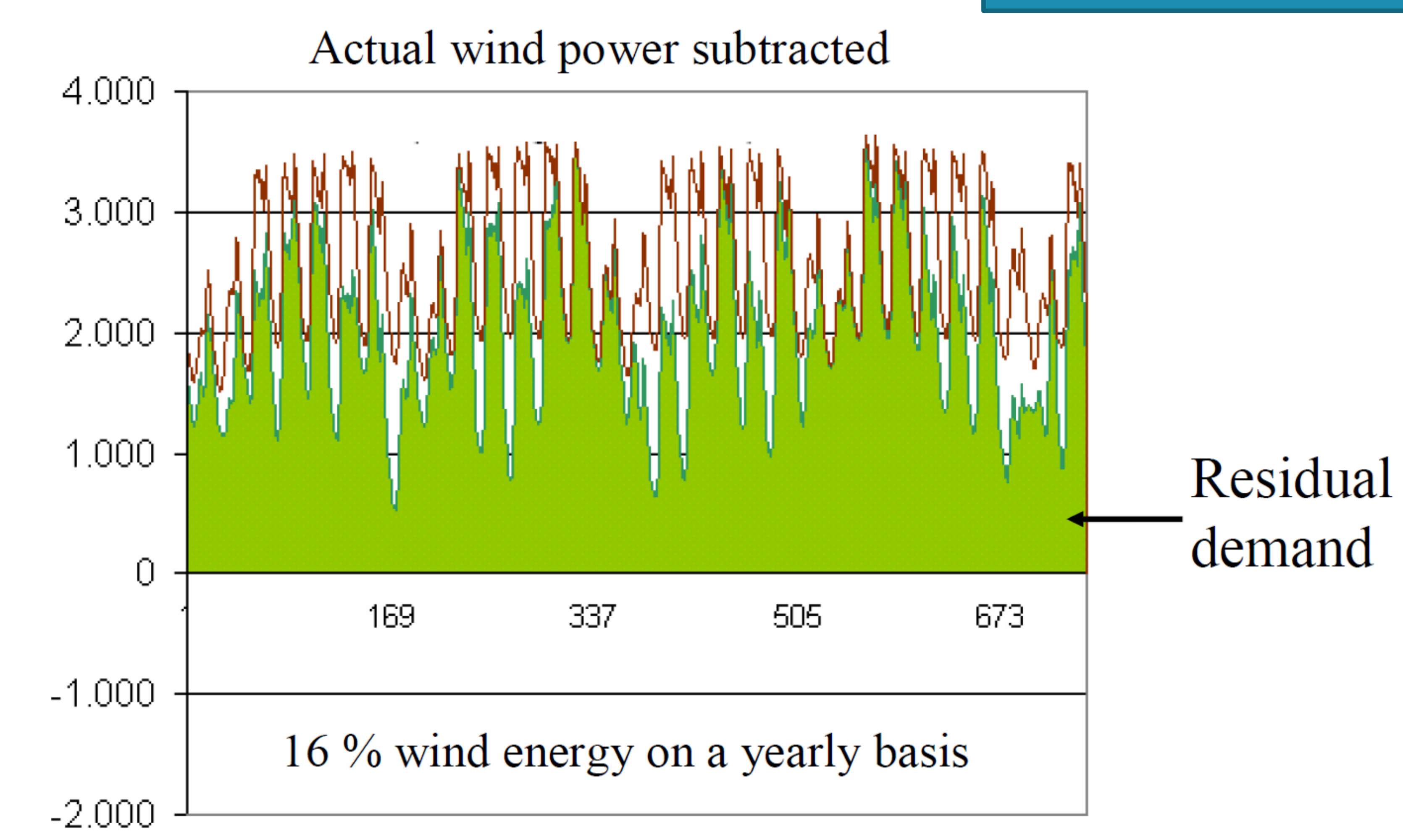


Ref. F. Bach, ELTRA

EU's implementation – technical issues

Case: January 2000

Example Denmark

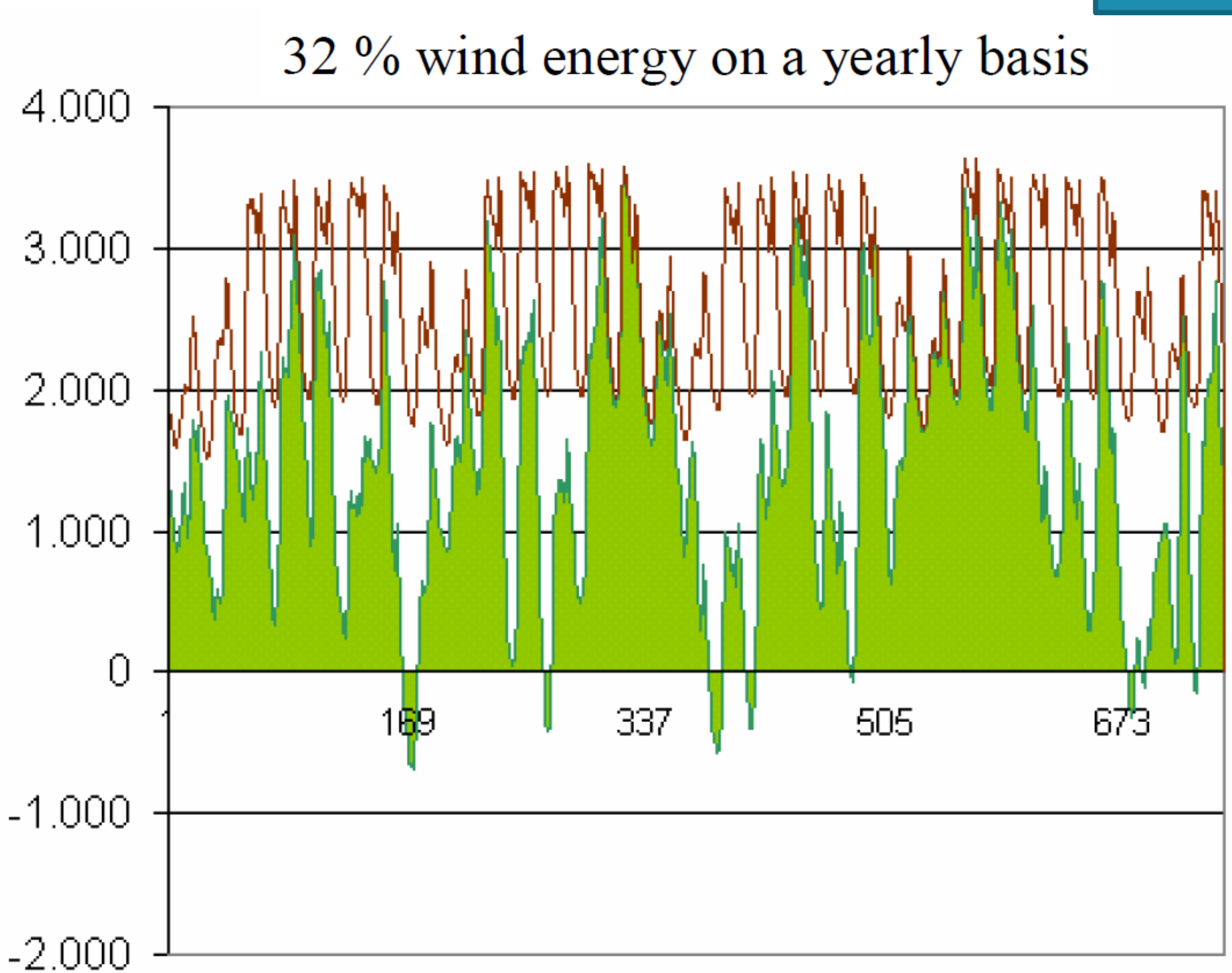


Ref. F. Bach, ELTRA

EU's implementation – technical issues

Case: January 2000

Example Denmark

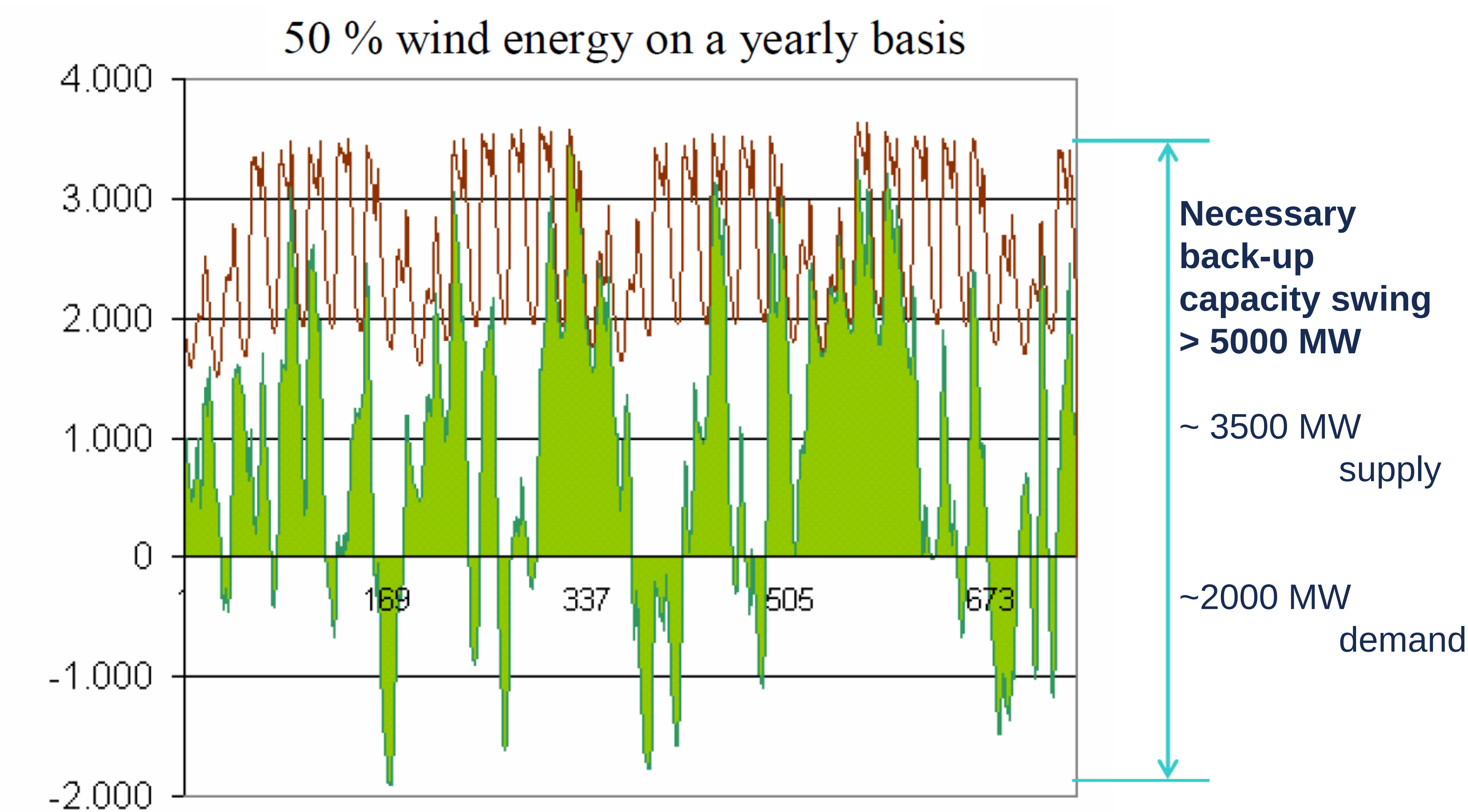


Ref. F. Bach, ELTRA

EU's implementation – technical issues

Case: January 2000

Example Denmark



Ref. F. Bach, ELTRA

EU's implementation – technical issues

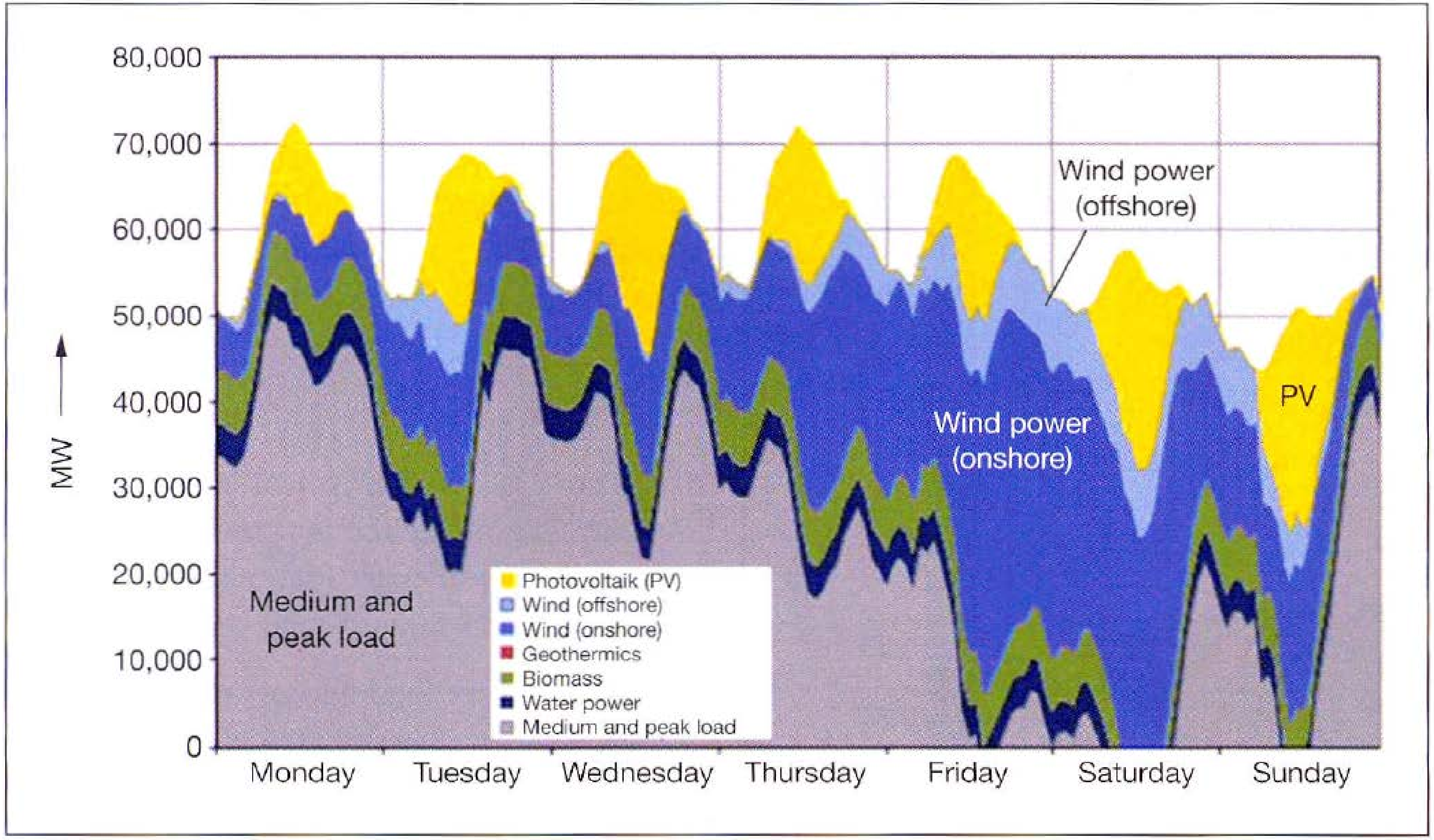
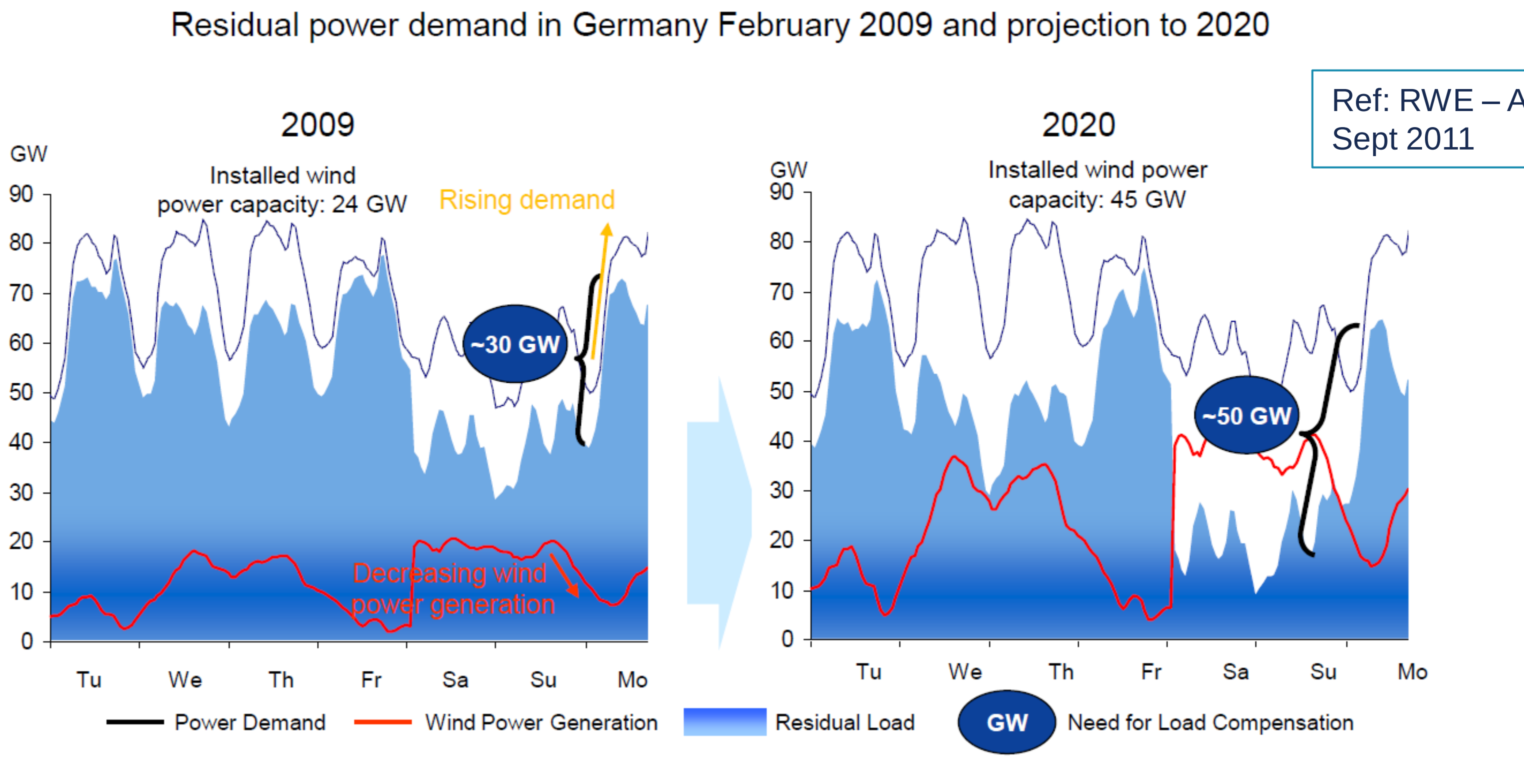


Figure 1. Power generation across one week in July 2020, BEE scenario [6].

Ref: Lehner & Schlipf, VGB Powertech, 8/2011

EU's implementation – technical issues

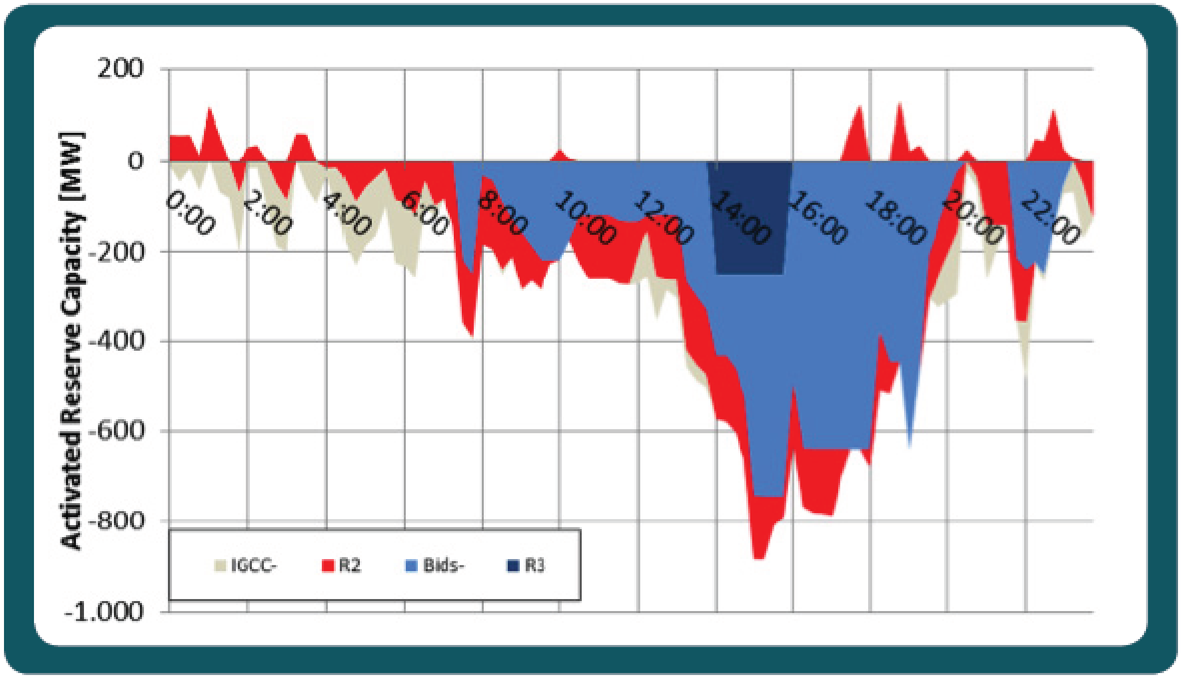


Ref: RWE – ALSTOM
Sept 2011

→ thermal plants must balance very quickly

→ **challenging requirements for thermal power plants!**

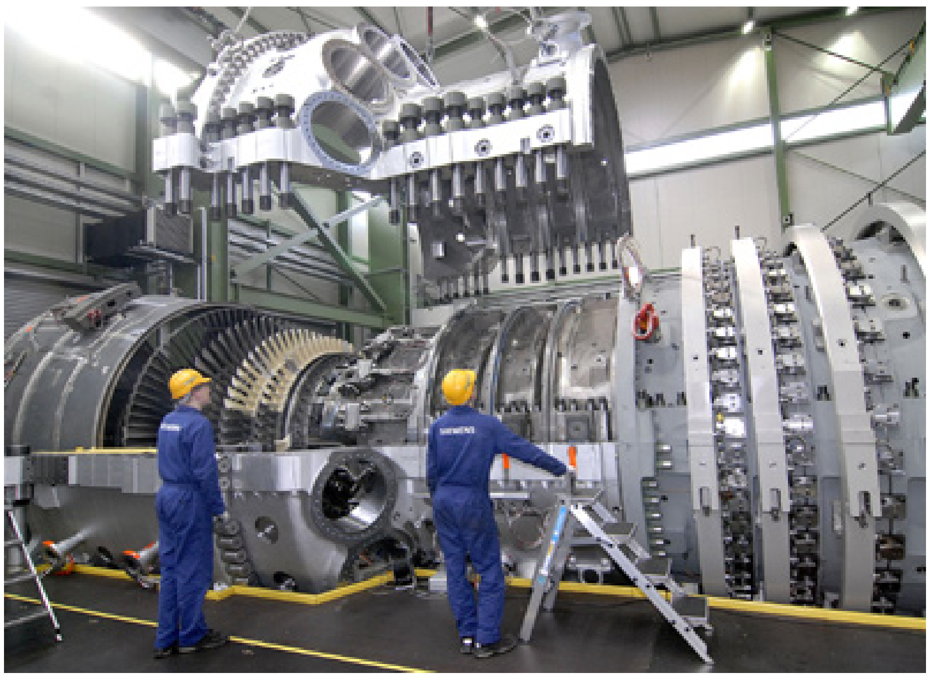
EU’s implementation – technical issues

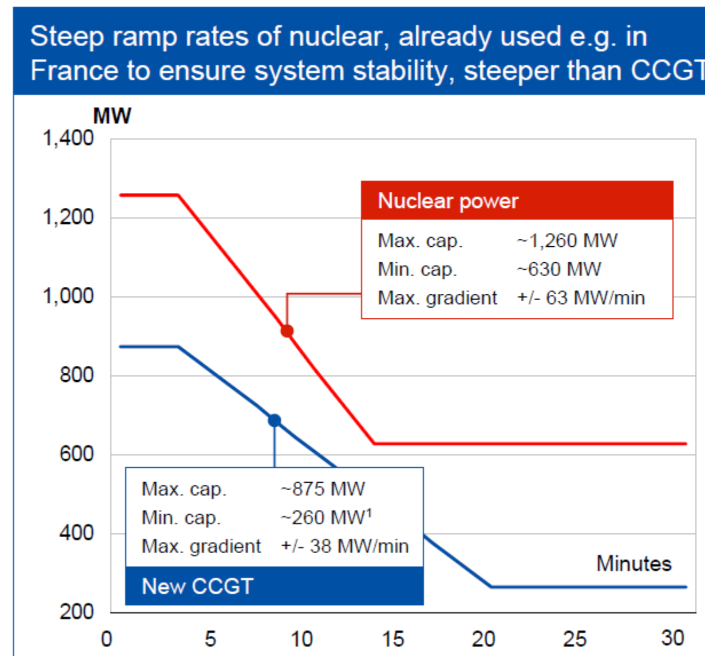


Upward (positive) and downward (negative) regulation volume on April 1, 2013

EU's implementation – technical issues

- What are critical generation-technology parameters?
  - Ramp rates compatible with technology
  - Overall dynamic behavior

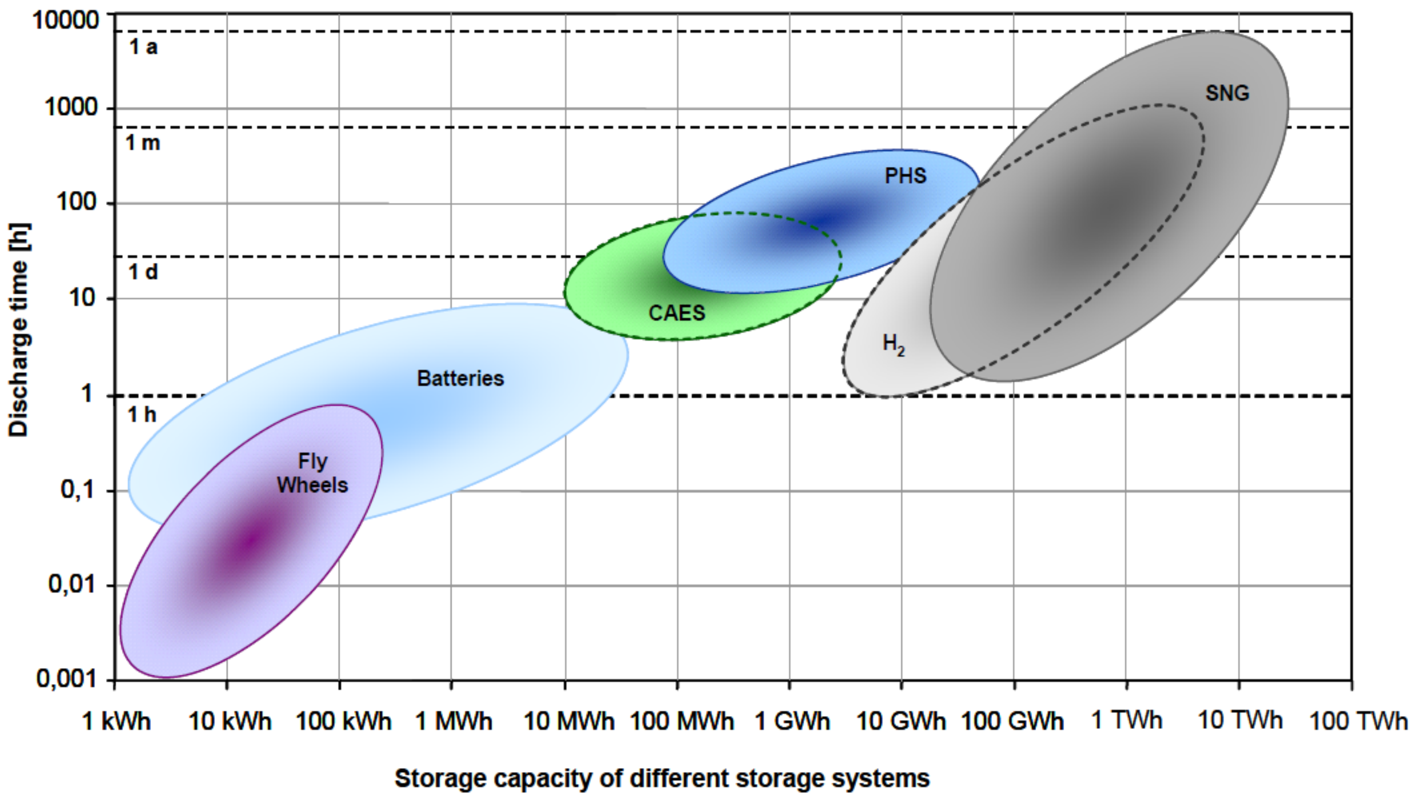




KU LEUVEN

EU's implementation – technical issues

Comparision of storage capacity and discharge time of RE-SNG

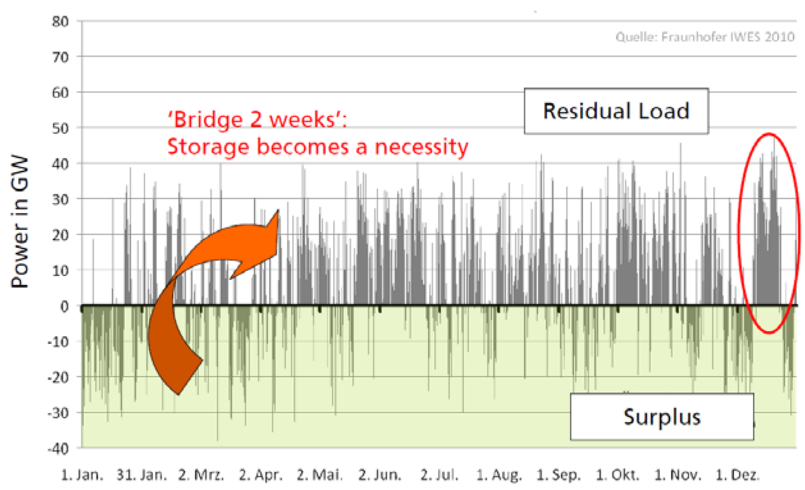


Different solutions for different tasks: ancillary vs. arbitrage

EU's implementation – technical issues

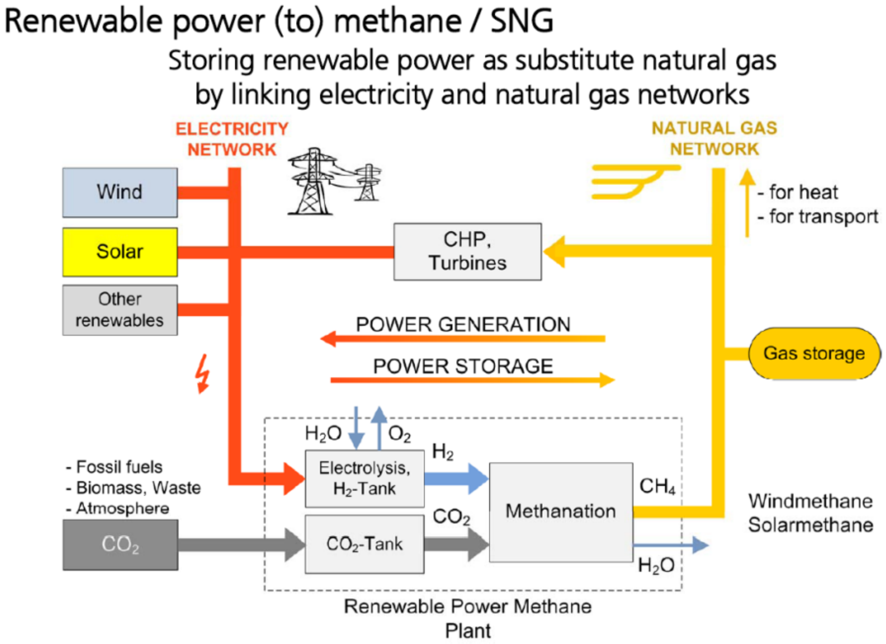
- To what extent will there be a shift of imbalance/fluctuations to other carriers/networks?
  - Shift to synfuel storage?

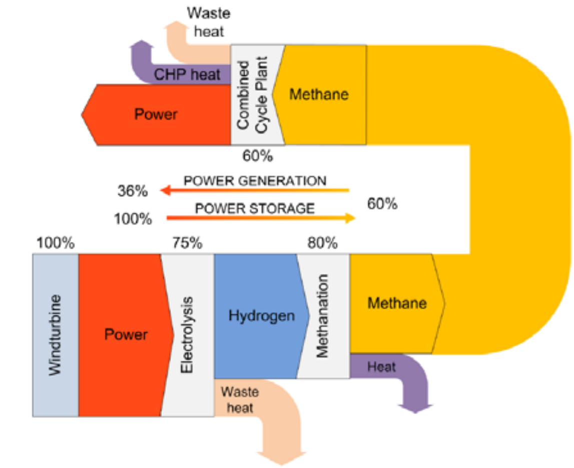
Energy scenario of the German govt. for 2050 (80% RES)



EU's implementation – technical issues

- To what extent will there be a shift of imbalance/fluctuations to other carriers/networks?
  - Shift to synfuel storage?



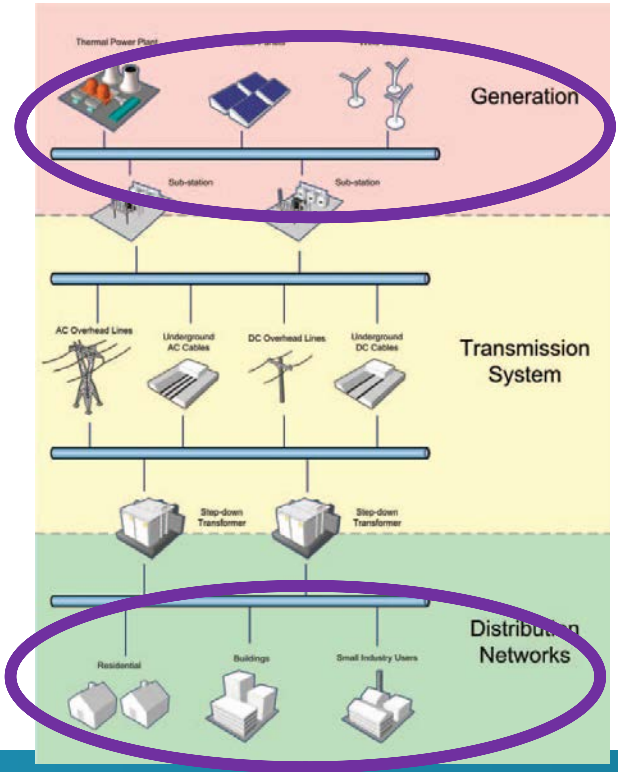


60-65% SNG
35-40% Power
50-60% CHP
Vs. 0% due to power cut off / power curtailment

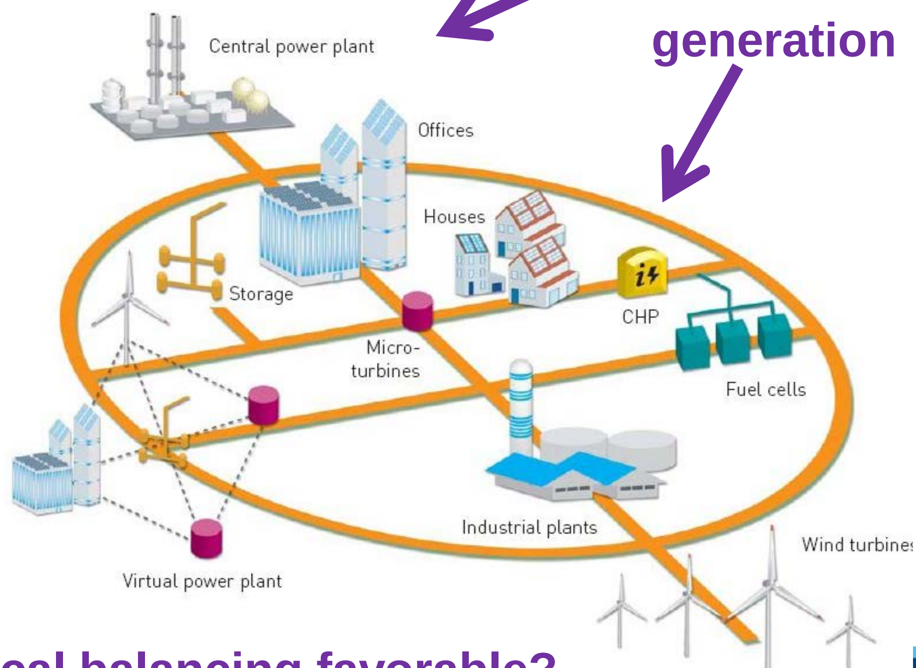
KU LEUVEN

EU's implementation – technical issues

- Where to perform the balancing (at which level)?
  - Should houses/neighborhoods/cities aim for a net load profile as flat as possible?
  - What are the proper objective functions?



Centralized & decentralized generation



Local balancing favorable?

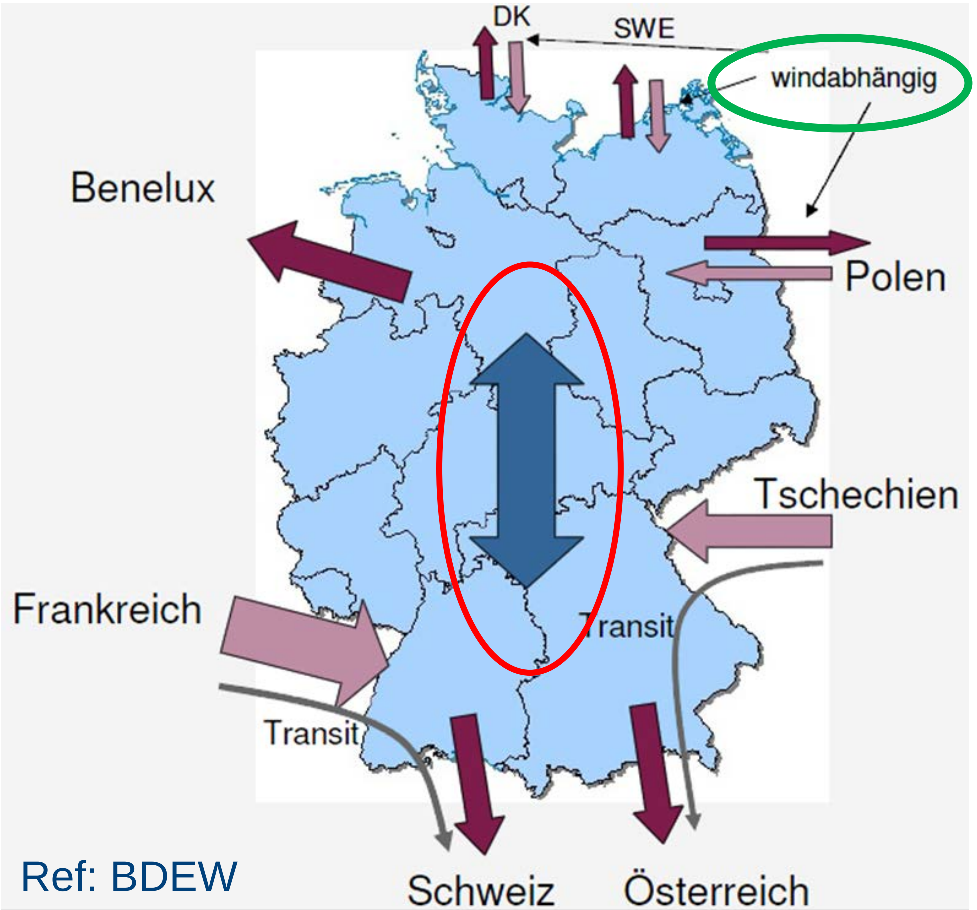
EU’s implementation – technical issues

Unplanned flows (loop flows / transit flows)

- Grids guide power flow from generation to consumption
- Electric power follows path of least resistance / impedance
- Transmission capacity high-voltage line:
  - Part needed for unexpected occurences
  - Must keep part for unintended flows (driven by electric resistance)
  - Remainder for actual commercial cross border transactions

EU’s implementation – technical issues

Unplanned flows (loop flows / transit flows)



Ref: BDEW

Typical exchanges between Germany and neighboring countries

Major problem in DE:
insufficient lines N → S

Wind in North
NPPs shut down in South
Industrial demand in South
PV in South

KU LEUVEN

EU's implementation – technical issues

Unplanned flows (loop flows / transit flows)

Netzausbau: Insbesondere Nord-Süd-Trassen notwendig

bdew
Energie. Wasser. Leben.

KKW-Abschaltungen verschärfen die Lastfluss-Situation

Ausbaustrecken gem. „dena I"

Abschaltungen Moratorium + KKW Brunsbüttel

Umwelt Bundes Amt
Für Mensch und Umwelt

Aktuell rd. 10% oder 80 km des Netzausbaus gemäß „dena I" realisiert, weiterer Ausbaubedarf von rd. 3.600 km gem. „dena II"

Mid 2012 ~214 km established

PERMITS !

VEN

EU’s implementation – technical issues

Unplanned flows (loop flows / transit flows)

- **CEE Region**: DE→PL→CZ→AT→DE and DE→CZ→DE
- **CWE Region**: DE→NL→BE→FR→DE

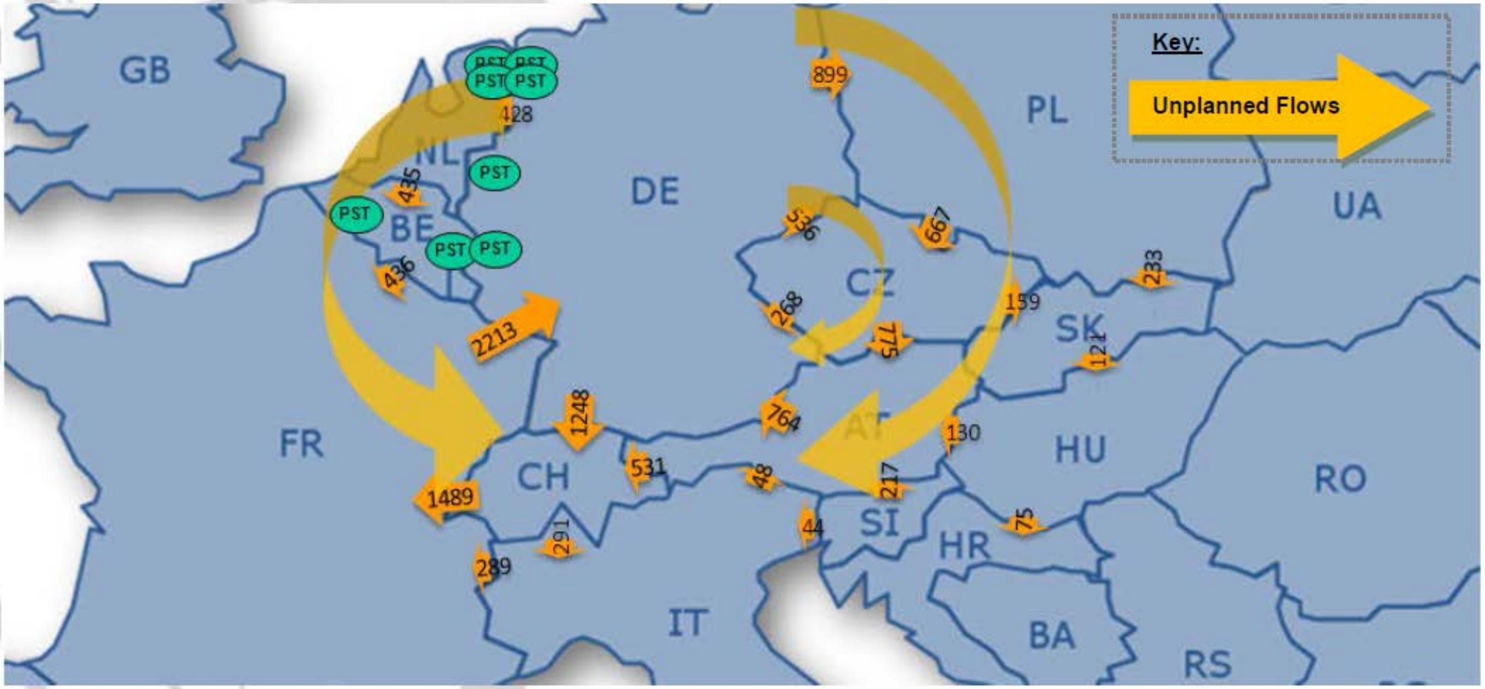


Figure 4. Average Unplanned Flows in Europe [MW], 01.2011–12.2012

Ref: CEPS et al, Jan 2013

EU’s implementation – technical issues

Unplanned flows (loop flows / transit flows)

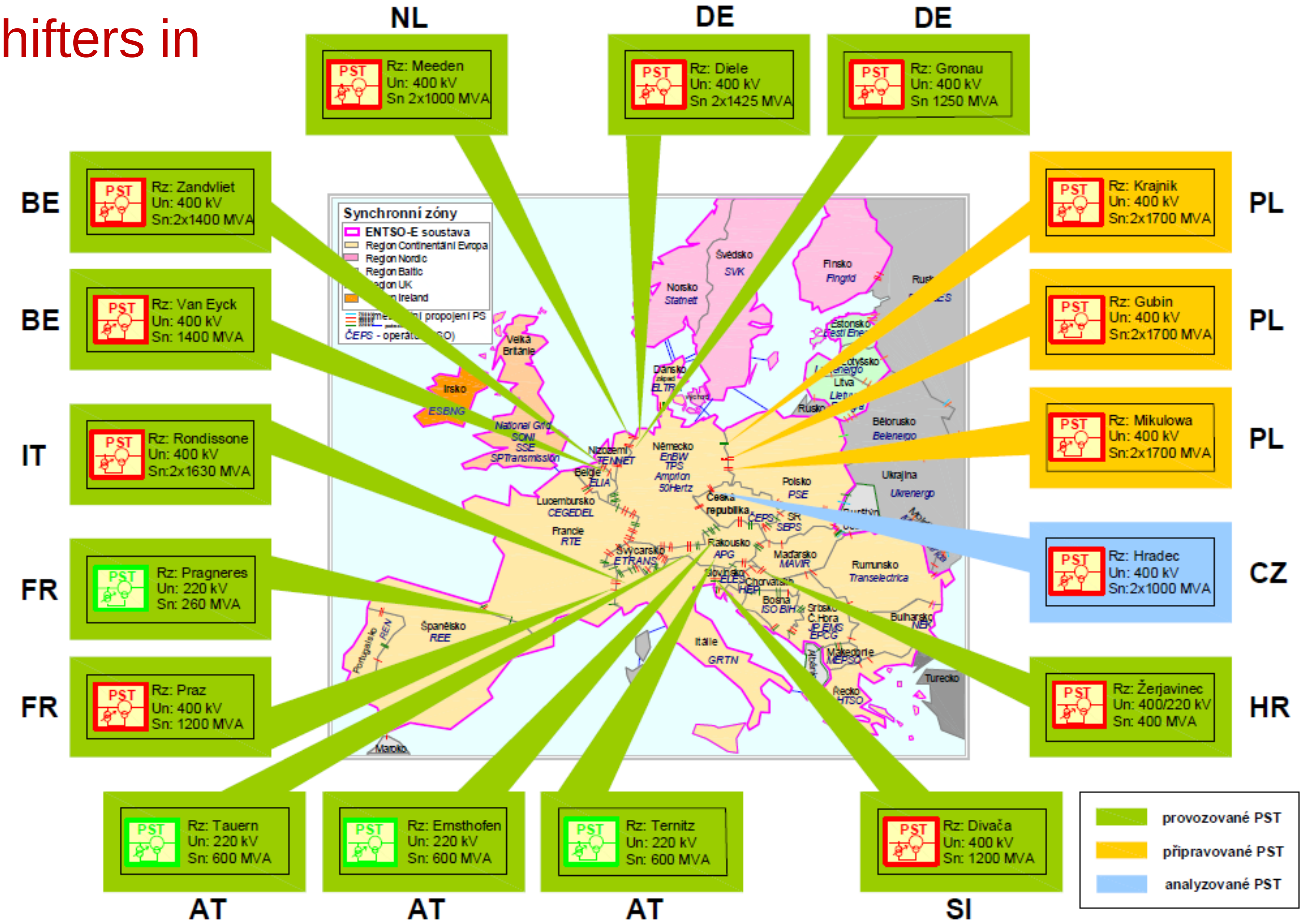
- Can be “avoided” via *phase-shift transformers*

  = a faucet/valve to “control” the flows (i.e., inhibit unplanned flows)
- But system becomes much more “nervous”...

KU LEUVEN

EU’s implementation – technical issues

Phase shifters in Europe



Source: Polish Energy Regulatory Office

KU LEUVEN

EU's implementation

Issues / challenges / problems in the EU market

- Technical challenges
- Market-integration problems
- Consequences for the CO_2 emissions
- End-electricity prices for end consumers

KU LEUVEN

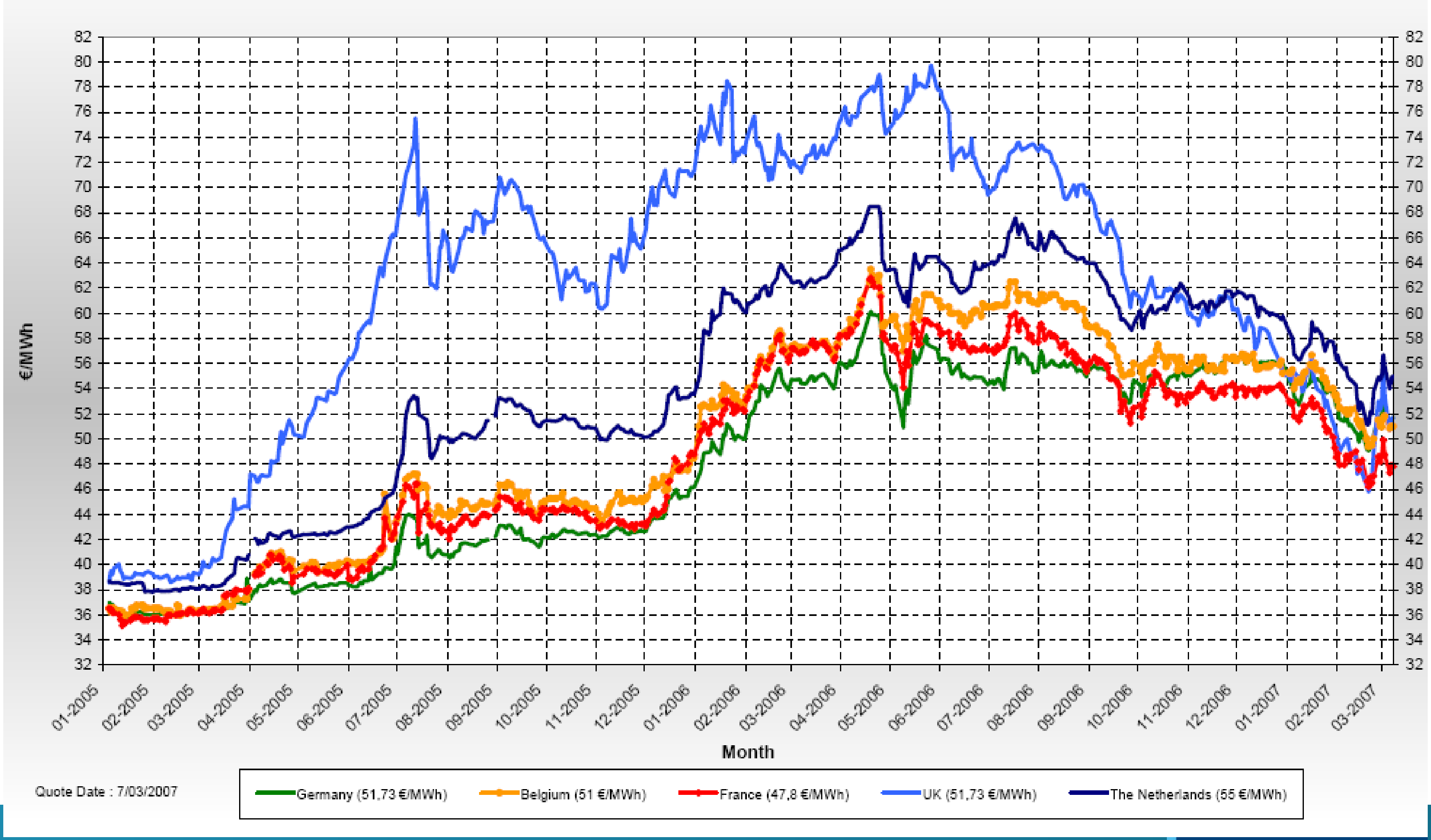
EU’s implementation – market issues

- Common EU electricity market started in 1996,...then 2003, ...then 2009
- At present ‘third package’ being implemented
- Better European coordination through ENTSO-E, ACER
- Unbundling (generation, transmission, distribution, supply)
- “Alligned” grid codes...

- Market integration elements in place, was bearing fruits...

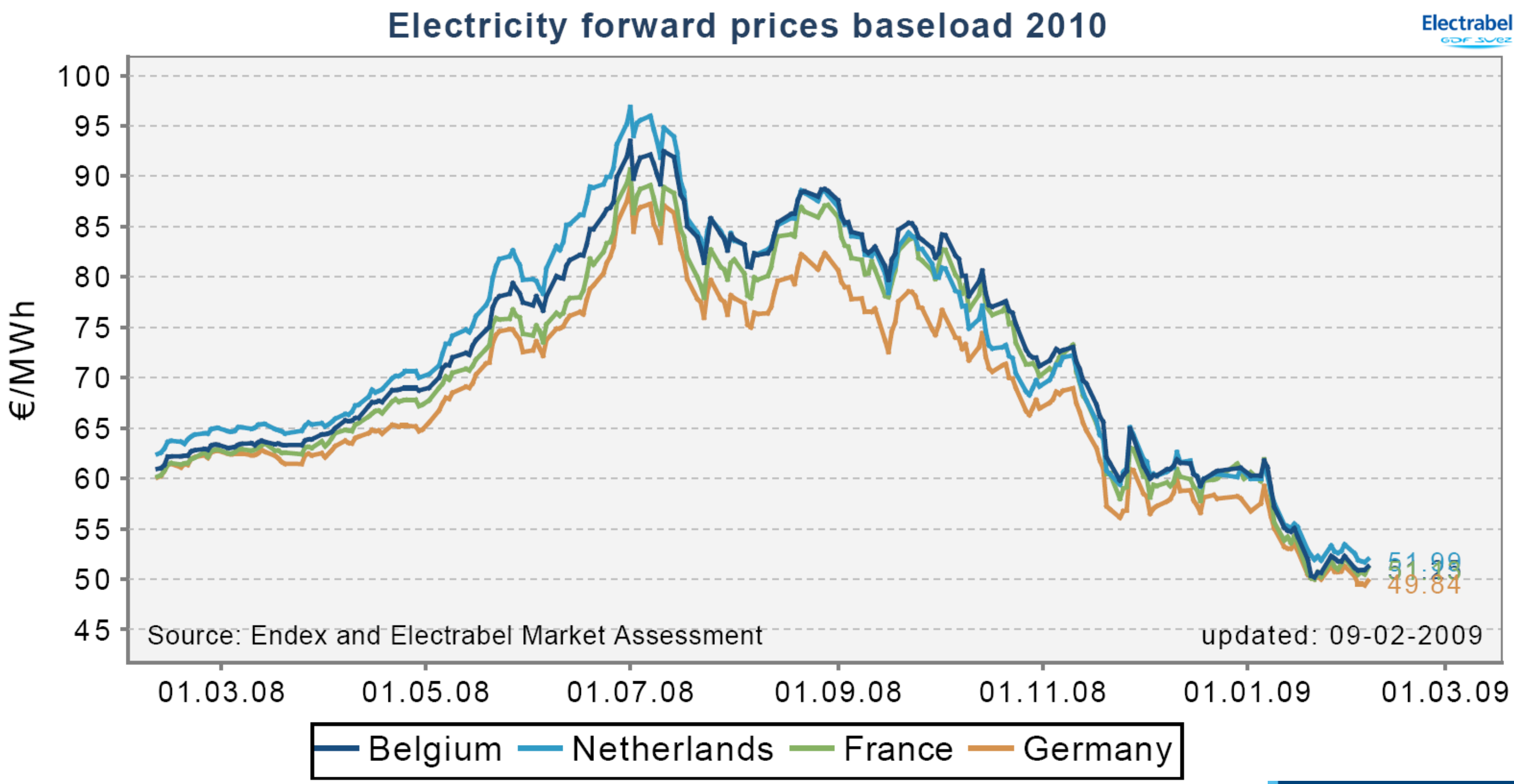
EU’s implementation – market issues

Convergence electricity prices point towards working market



EU’s implementation – market issues

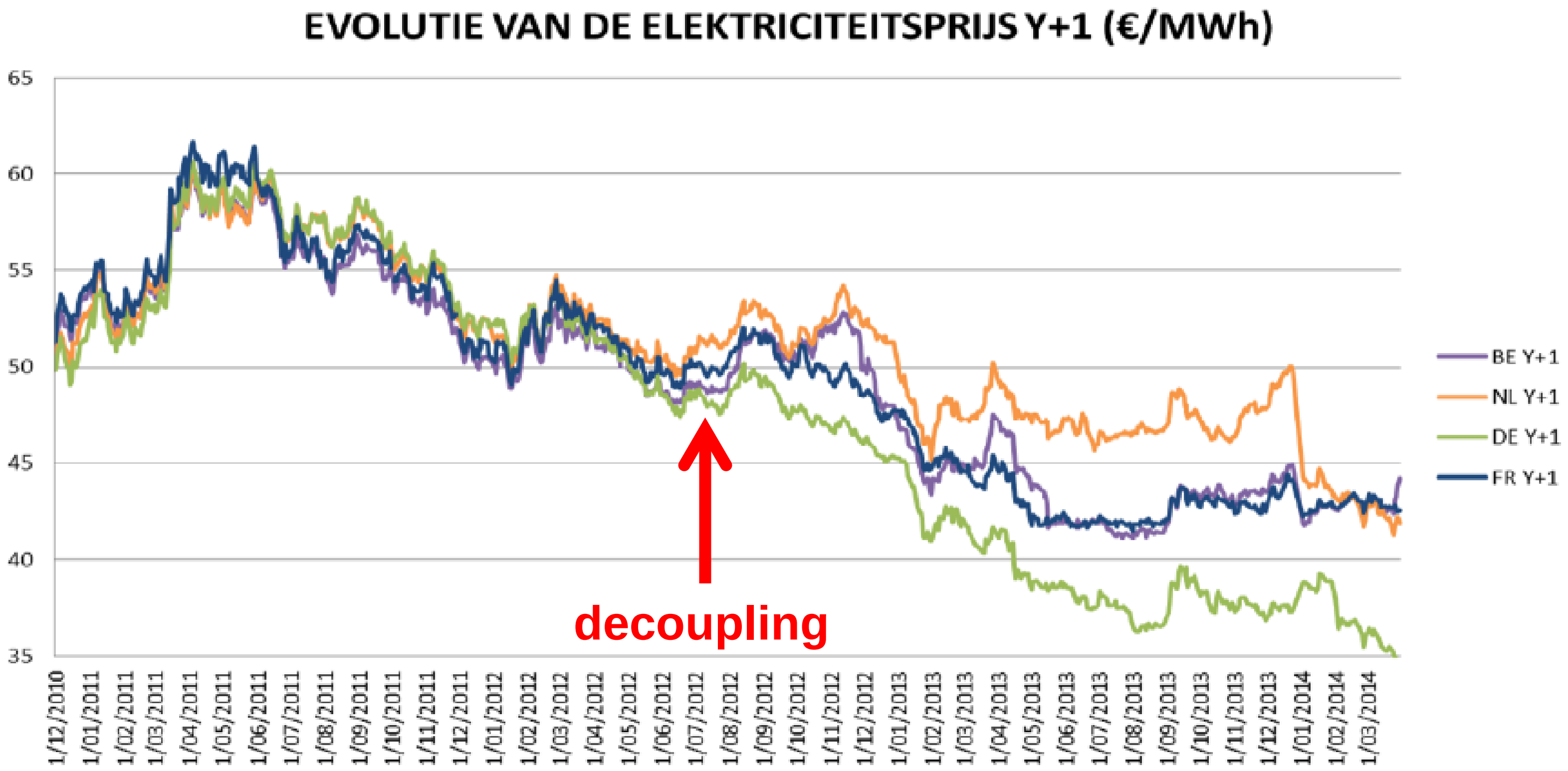
Convergence electricity prices point towards working market



Ref: Electrabel – GDF SUEZ

EU's implementation – market issues

But ... Recent developments... !!!

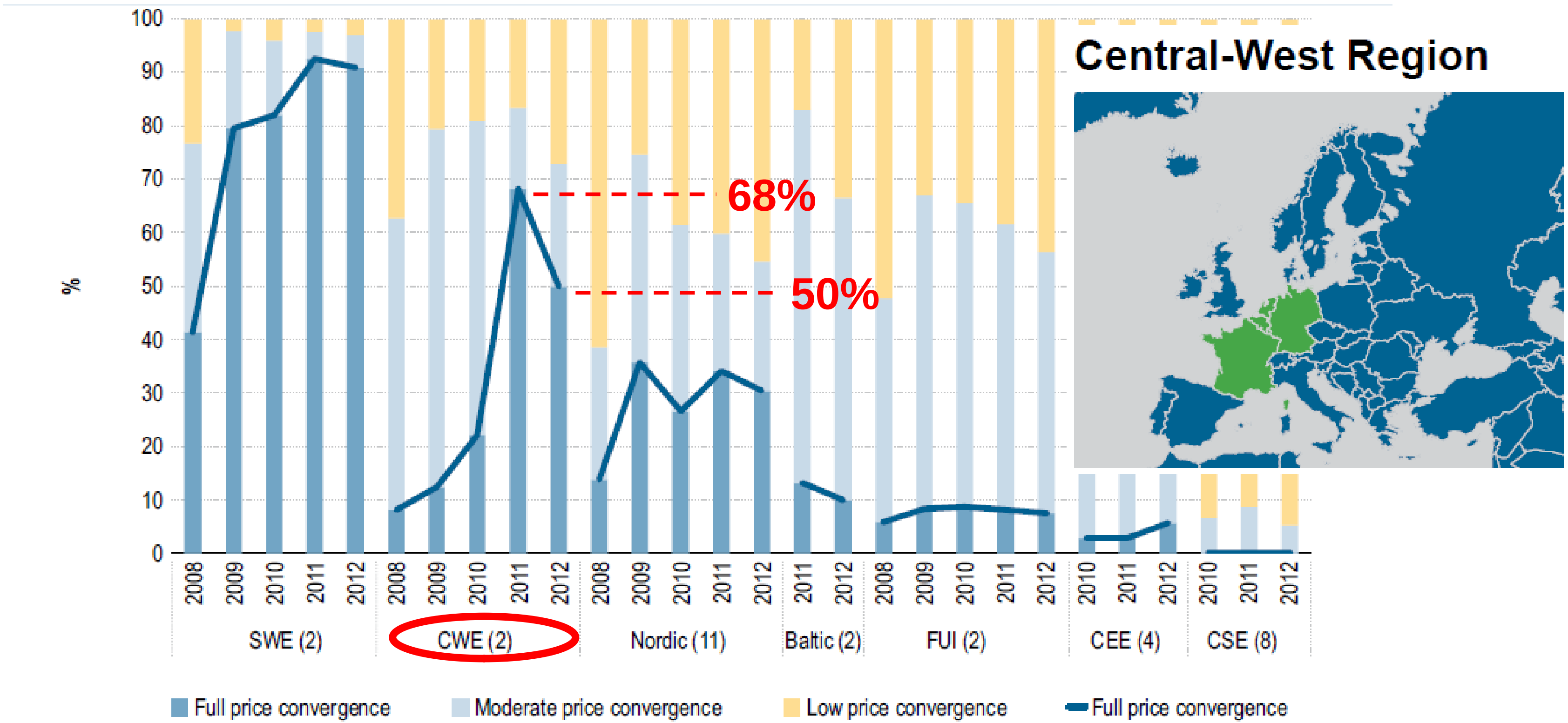


EU’s implementation – market issues

But ... Recent developments... !!!

Figure 13: Price convergence in Europe by region (ranked) – 2008 to 2012 (%)

Source: ACER, 2013



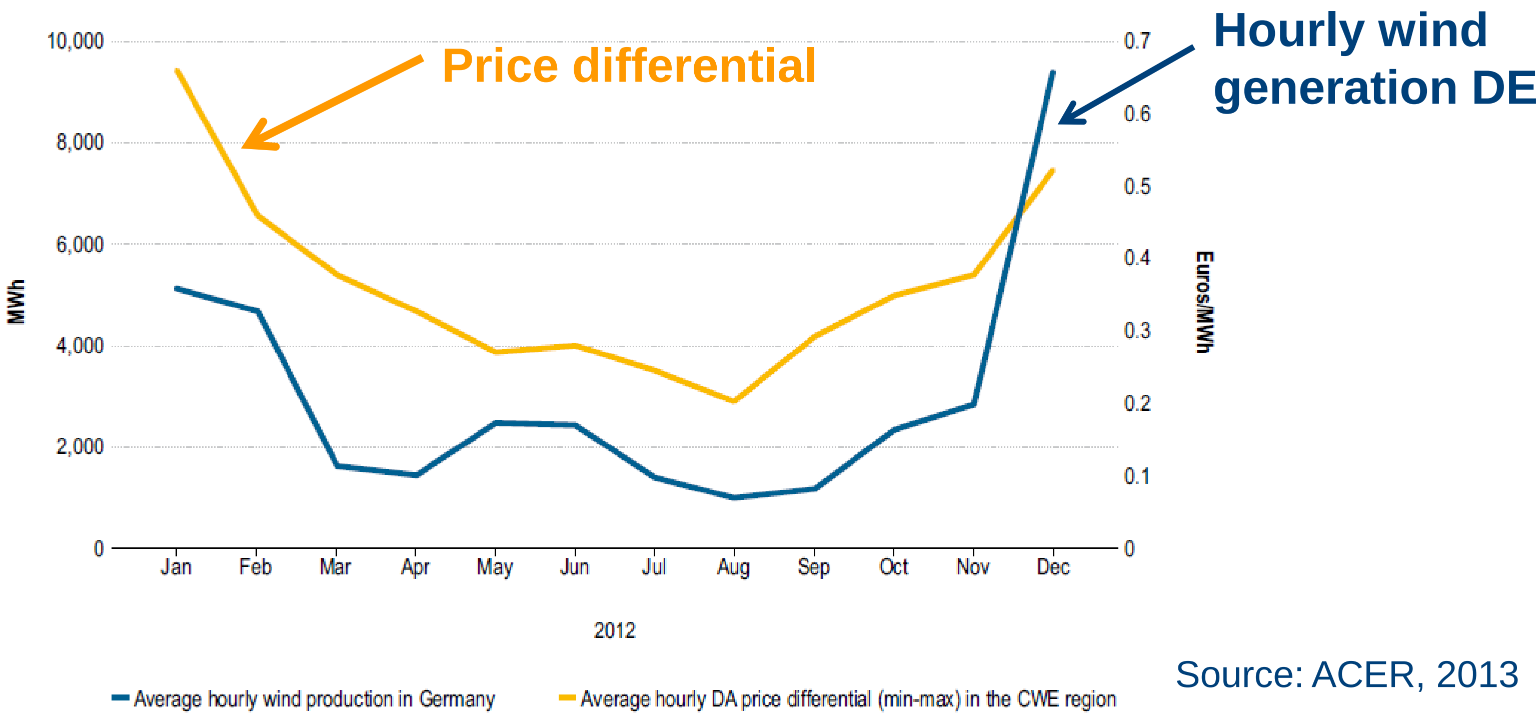
Source: Platts, PXs and data provided by NRAs through the Electricity Regional Initiatives (ERI) (2013) and ACER calculations

Note: The numbers in brackets, e.g. SWE(2), refer to the number of bidding zones per region included in the calculations.

EU's implementation – market issues

But ... Recent developments... !!!

Figure 14: Monthly average hourly wind production in Germany compared to price differentials in the CWE region – 2012 (MWh and euros/MWh)



Source: ACER, 2013

Source: Platts and German TSOs (2013) and ACER calculations

Note: The price differentials are calculated as the hourly difference between the maximum and minimum price of the bidding zones of the CWE region. In 2012, the lowest price was recorded in Germany for around 70% of the periods.

EU’s implementation – market issues

But ... Recent developments... !!!

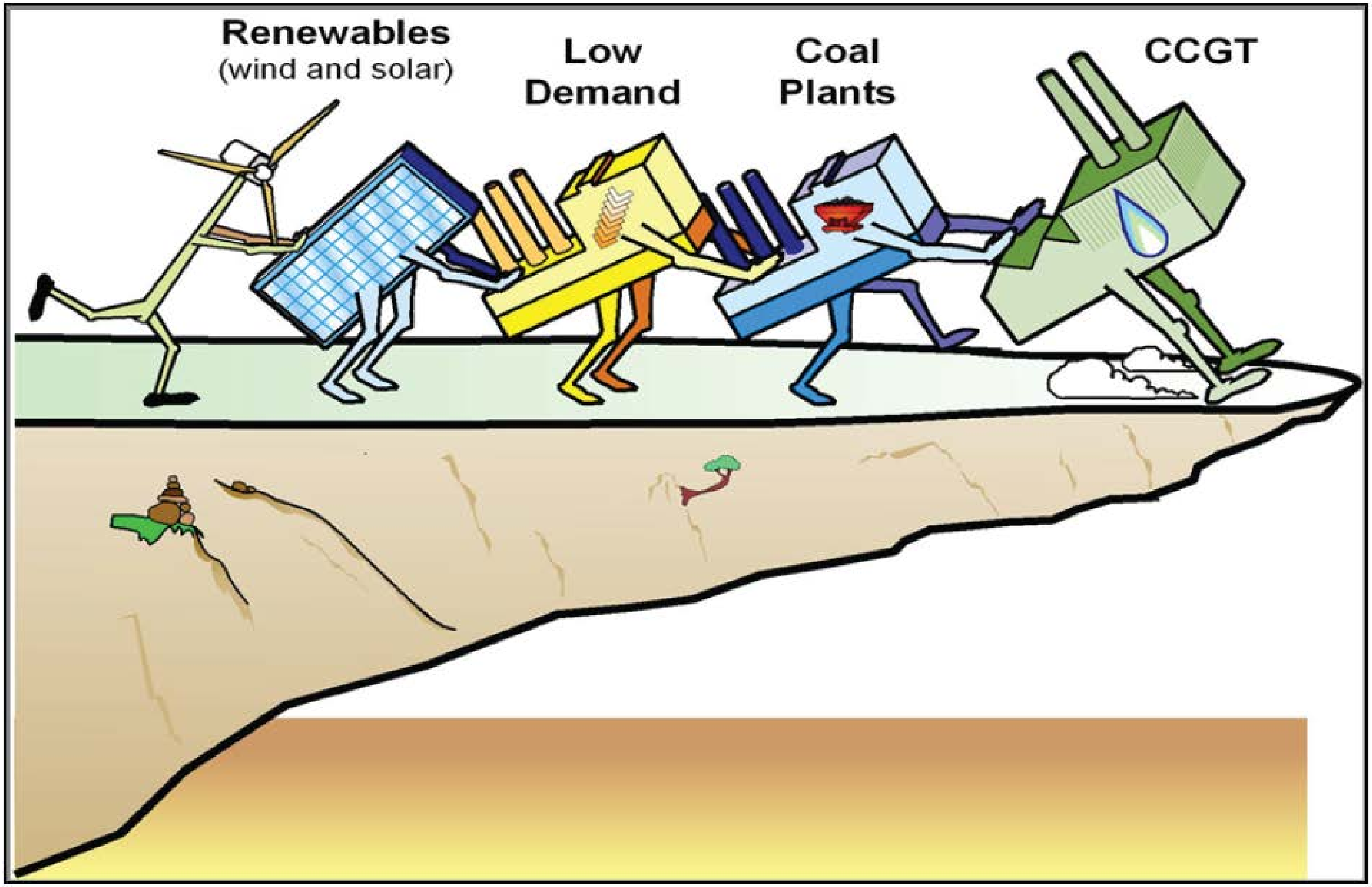
- *Decoupling prices* shows ‘poorer’ functioning of market
- *Lower* <u>wholesale</u> prices seem to be good news (?)
- But they lead to <u>major problems</u> for *owners/operators of thermal plants which are needed for balancing*!
- And ironically, <u>end-consumer prices increase</u> rather than decrease (to pay for the levies/subsidies)

EU's implementation – market issues

But ... Recent developments... !!!

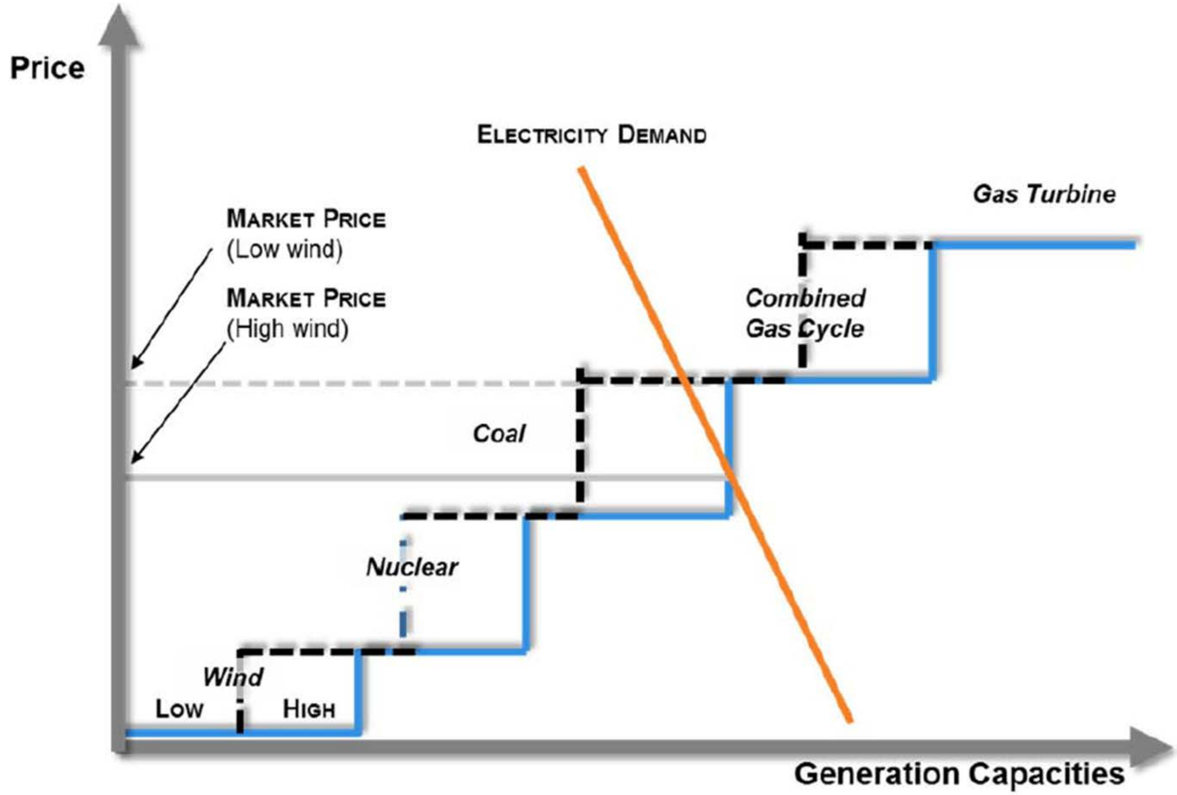
- These effects were not foreseen in "liberalized market design"...
- Due to massive injection of zero marginal cost generation (RES)
- Most efficient & flexible plants (CCGTs) are pushed out of merit order ... Tendency for mothballing
- Leads even to <u>negative</u> wholesale prices !!
- Need completely different philosophy whith massive RES, where 'holding' capacity ready is remunerated... → capacity mechanisms

EU’s implementation – market issues



EU's implementation – market issues

The merit order effect of RES

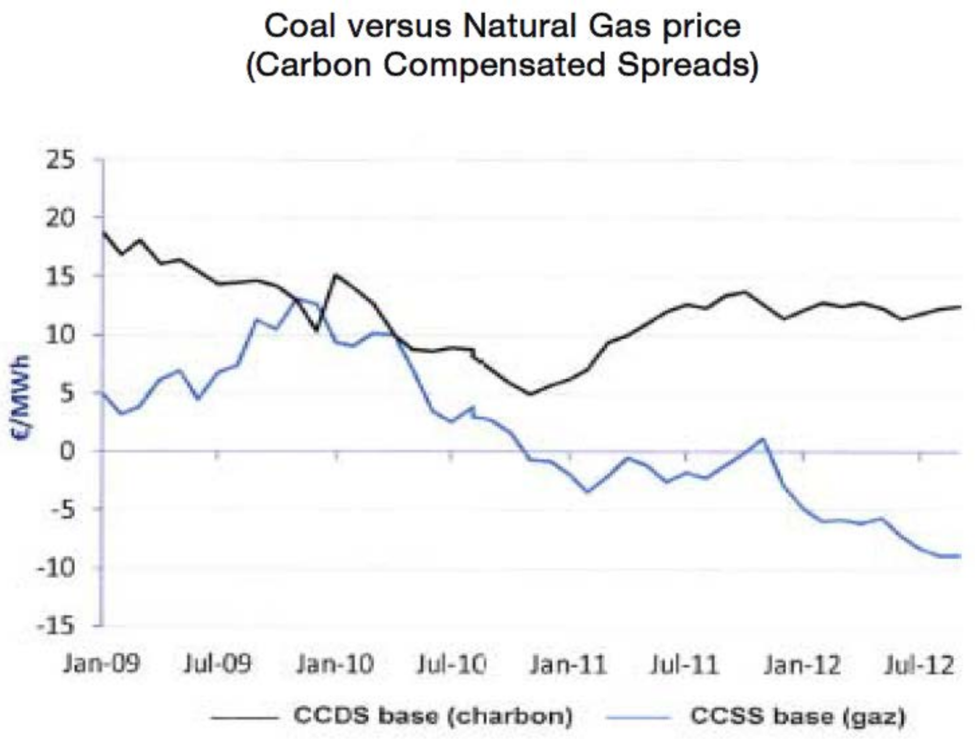


Ref: F. Roques in "The crisis of the European Electricity System" – FR 2014

KU LEUVEN

EU's implementation – market issues

Prices too low for covering operational cost of gas plants



Evolution of CDS and CSS between 2009 and 2012 – Source: GDF Suez

Spread = difference price & production cost = gross profit

KU LEUVEN

EU's implementation – market issues

The "missing money problem" !!

- The most efficient plants (gas-fired combined cycles – CCGT) are pushed out of the merit order

→ their capacity factor becomes too low to recover investments

→ the prices are too low to cover operating costs

→ **many CCGTs are currently shut down and will be mothballed or shut down permanently!**

→**Risk: insufficient capacity (generation adequacy) to do the back up**

KU LEUVEN

EU’s implementation – market issues

Negative wholesale prices

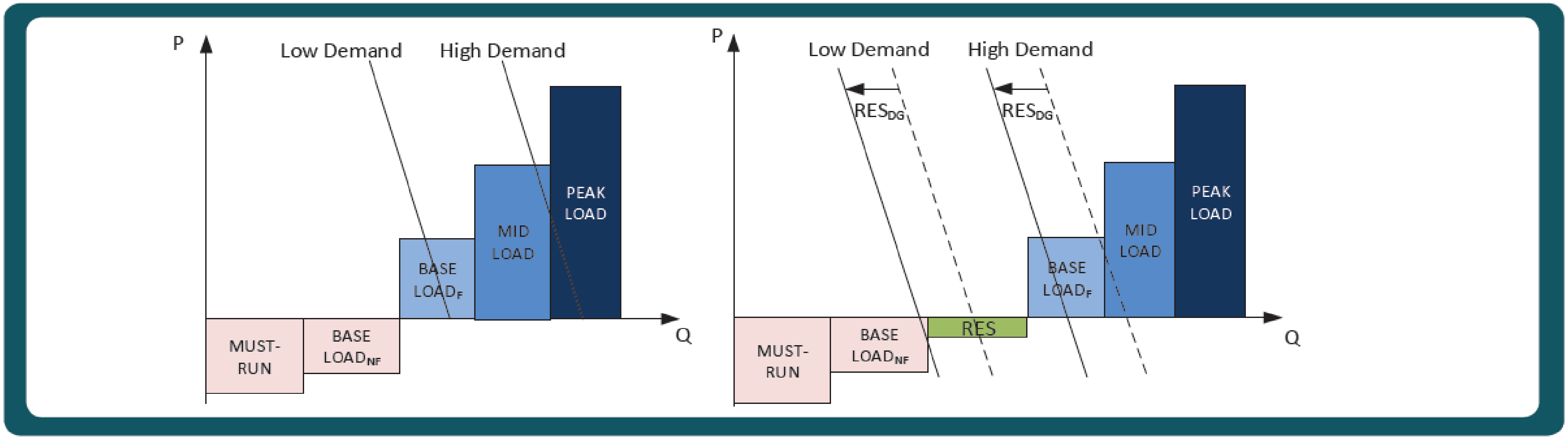


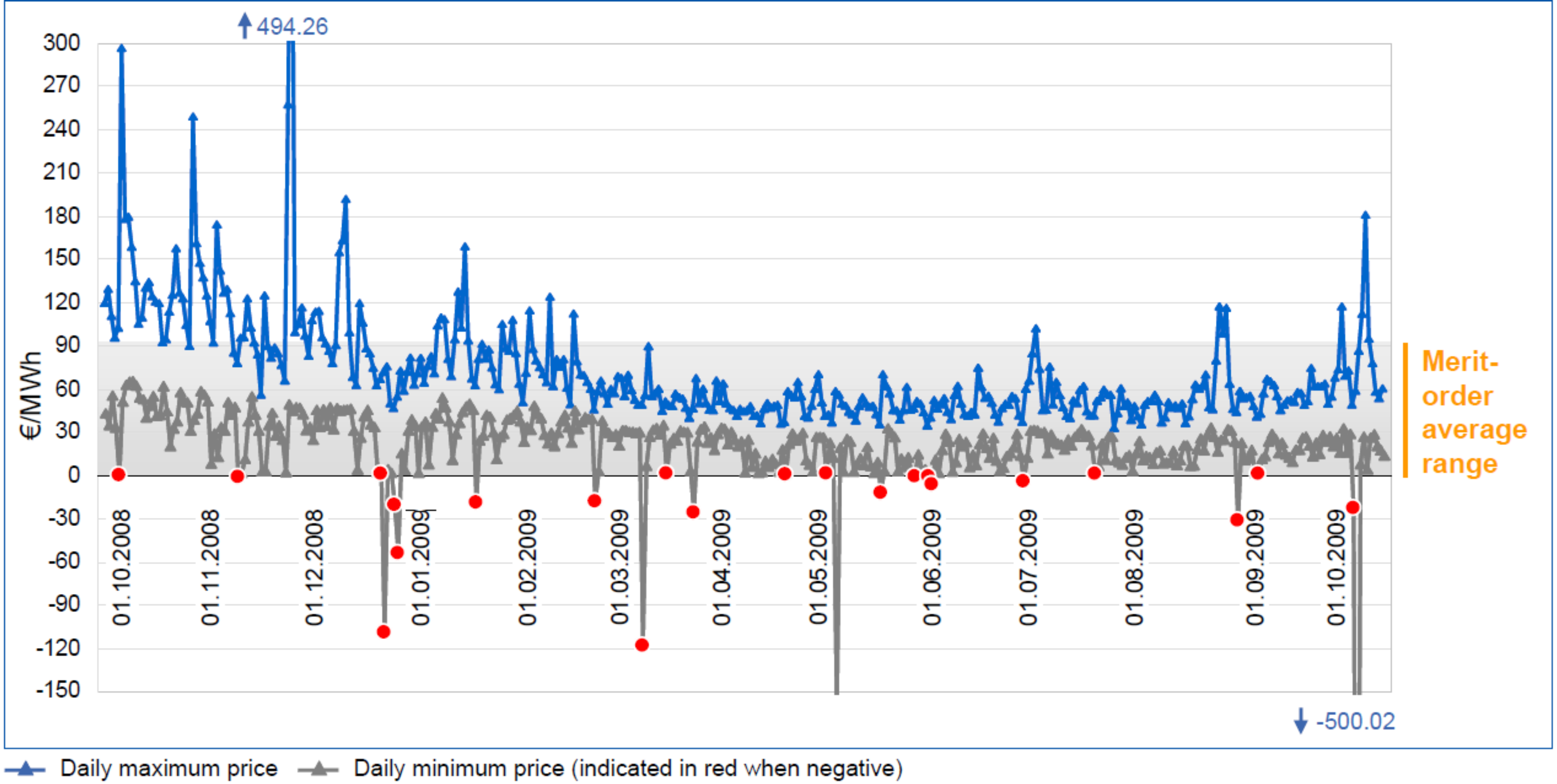
Figure 2: Practical merit order without (left) and with renewable energy sources (right); RES_{DG} expected renewable generation production of distributed nature; F flexible; NF non-flexible

Ref: Factsheet 2014-1 KULv EI

EU's implementation – market issues

Negative prices in Germany in period October 2008-October 2009

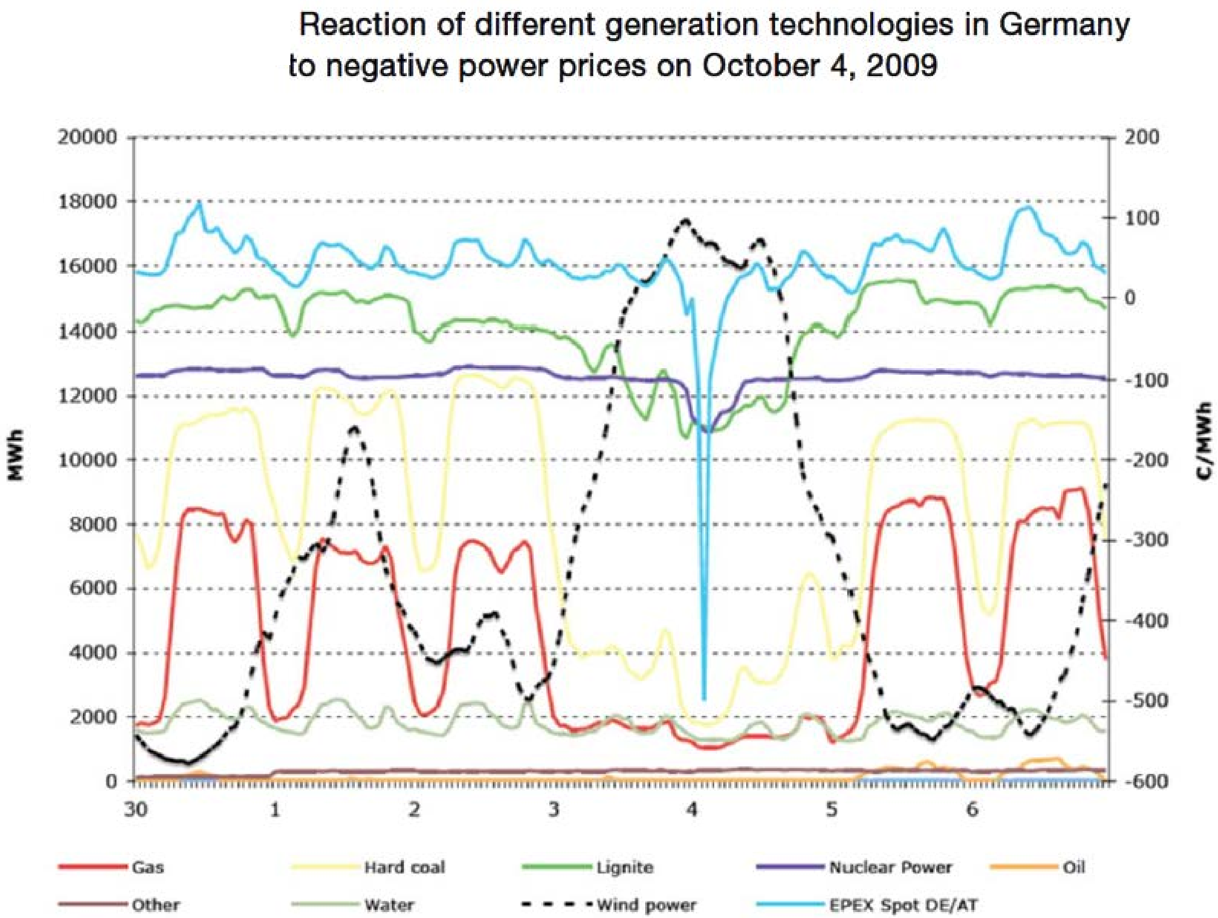
Growing proportion of renewables leads to higher price volatility. October 2008 to October 2009:
60 hours with negative prices; highest price reached: +€500/MWh, lowest -€500/MWh



Source: EEX spot prices.

KU LEUVEN

Negative Wholesale Electrivity Prices



Source: Vassilopoulos P. (2010) based on EEX Transparency and EPEX Spot data

Ref: F. Roques in "The crisis of the European Electricity System" – FR 2014

KU LEUVEN

EU's implementation – market issues

Belgium: the "missing money problem" + nuclear phase out

Recall:

→**Risk: insufficient capacity (generation adequacy) to do the back up**

- In case of shortage, peak prices would skyrocket!
- But peak prices not high enough to compensate "losses"
- Need for **capacity remuneration mechanisms**

- In Belgium: combined with nuclear phase out...
- → "**Strategic Reserves**"

Lessons Learned on Missing Money

- Generation adequacy at stress
  - Major decrease of flexible generation capacity
  - Uncertain generation from renewables
  - Forced outage of Doel 3 & Tihange 2

- Result:
  - High dependency on (uncertain) imports to meet peak demand
  - Challenging integration of the growing share of renewables due to loss of flexible generation capacity

KU LEUVEN

EU’s implementation

Issues / challenges / problems in the EU market

- Technical challenges
- Market-integration problems
- Consequences for the CO_2 emissions
- End-electricity prices for end consumers

A shared effort between sectors and MS

GHG Target:

-20% compared to 1990

-14% compared to 2005

EU ETS

-21% compared to 2005

Non ETS sectors

-10% compared to 2005

27 Member State targets, stretching from -20% to +20%

EU's implementation

Consequences for the CO_2 emissions

Second & Third Phases 2012-2014

EU’s implementation

Consequences for the CO_2 emissions

- Very low prices for CO_2 emission permits (“allowances”)
- Due to
  - economic crisis (less CO_2 emissions) in 2008-2014
  - “banking” of allowances from phase 2
  - massive injection RES with priority access → reduces demand for fossil generation → reduces demand for CO_2 allowances → lower CO_2 prices

    *i.e., highly subsidized RES effectively **subsidize cheap coal** by keeping the CO_2 penalties low !!*

EU’s implementation

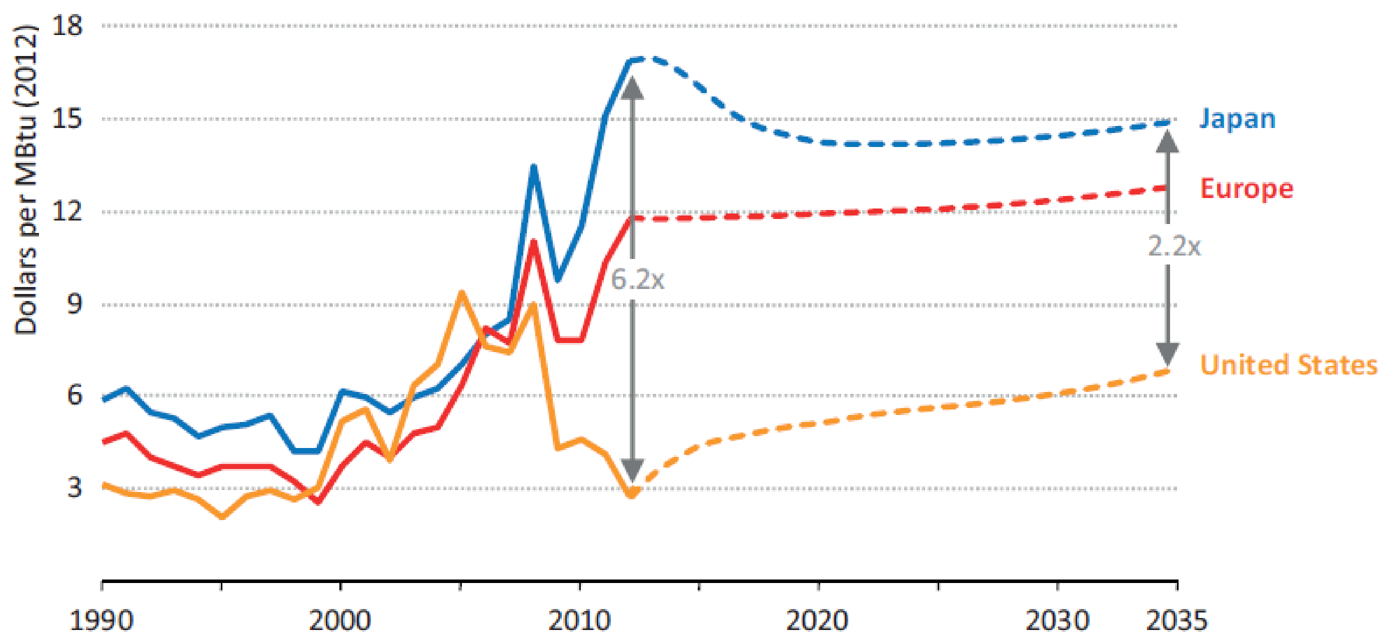
- Consequences of shale gas in US for CO_2 emissions in DE

- System effect due to low gas prices in USA – shale gas
- Gas extremely cheap in the USA

EU's implementation

Consequences of shale gas in US for CO_2 emissions in DE

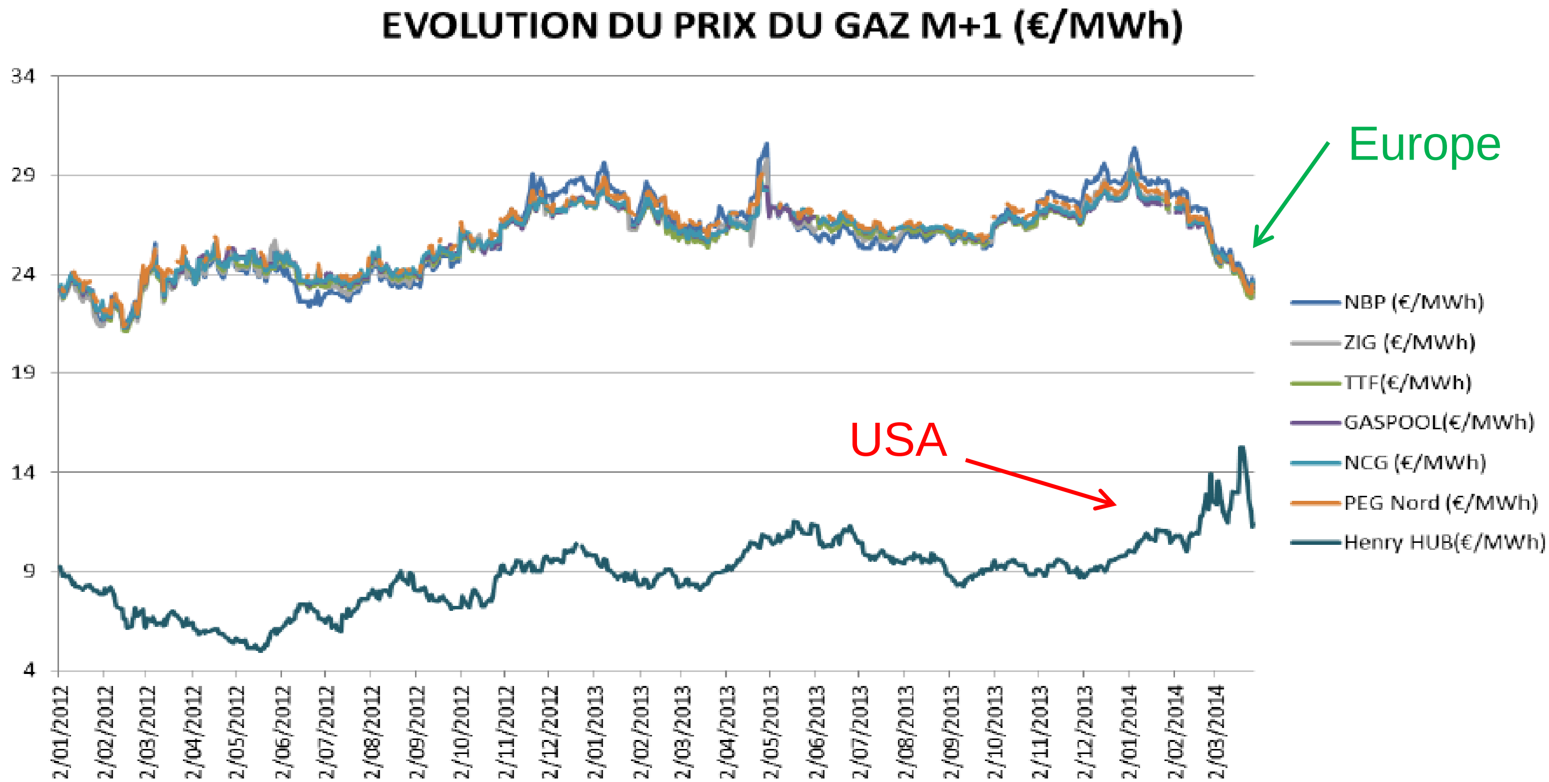
Figure 1.3 ▷ Natural gas prices by region in the New Policies Scenario



IEA WEO November 2013

EU's implementation

Consequences of shale gas in US for CO_2 emissions in DE



Source: CREG, 2014

EU's implementation

Consequences of shale gas in US for CO_2 emissions in DE

- System effect due to low gas prices in USA – shale gas
- Gas extremely cheap in the USA
- Gas pushes coal out of merit order in USA
- US coal demand decreased
- Lower coal prices
- USA coal offered to world market ... shipped to Germany
- Cheap US coal used in German coal fired plants

→ CO_2 emissions electricity generation have gone up!

- But does not matter in EU since ETS, only price increase EUAs
- **In mean time: world emissions CO_2 up up up**

KU LEUVEN

EU’s implementation

Issues / challenges / problems in the EU market

- Technical challenges
- Market-integration problems
- Consequences for the CO_2 emissions
- End-electricity prices for end consumers

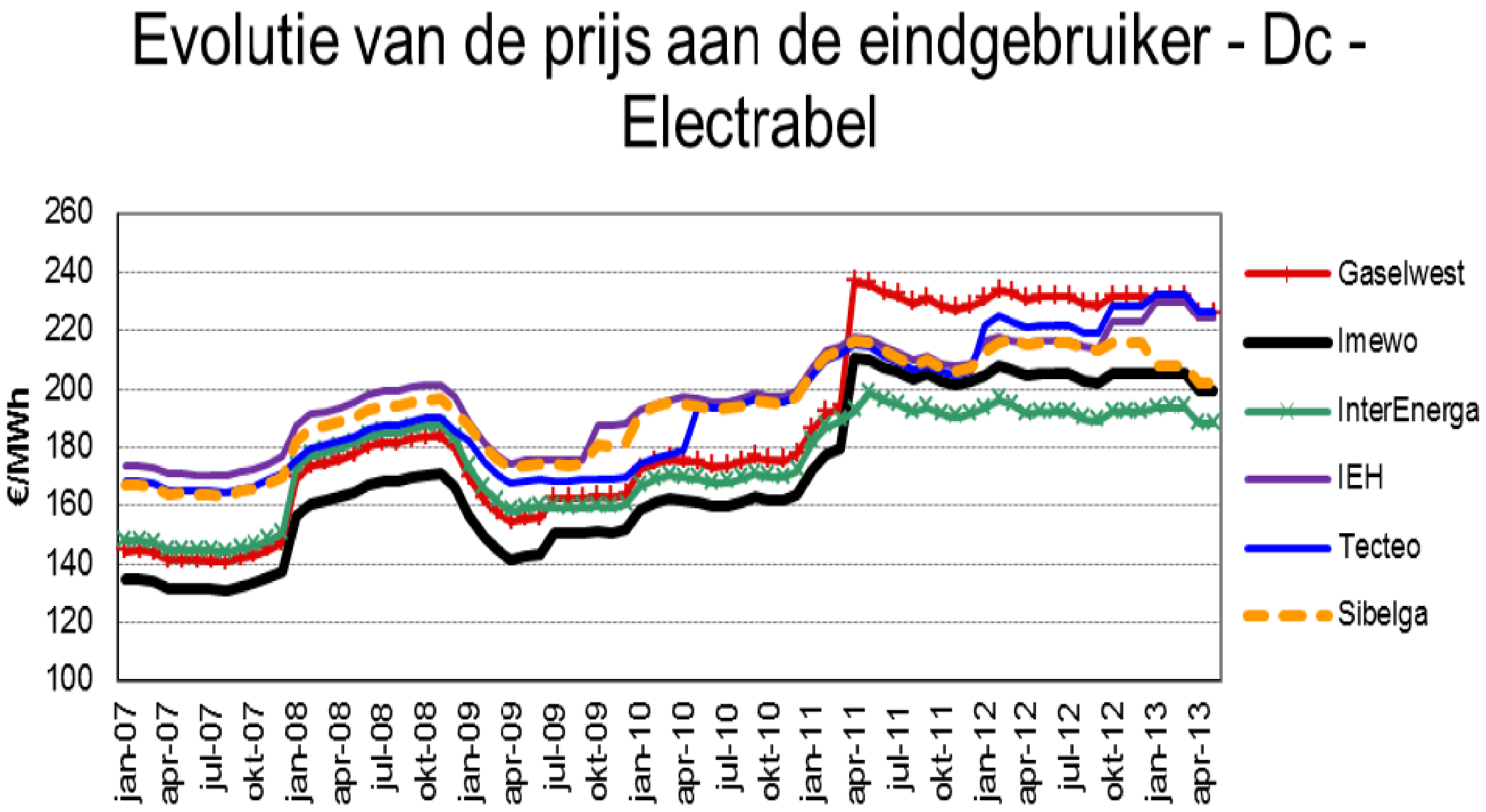
Decomposition of energy retail prices
Electricity

- Consider following consumers *(following CREG report)*
  - Household (“Dc”)
    - Electricity 3,500 kWh/y
  - Professional consumers
    - Electricity 160,000 kWh/y, low voltage (“Ic”)
    - Electricity 160,000 kWh/y, medium voltage (“Ic1”)

- Evolution of price from January 2007 till May 2013

Decomposition of energy retail prices
Electricity

- Evolution of final price – domestic consumer



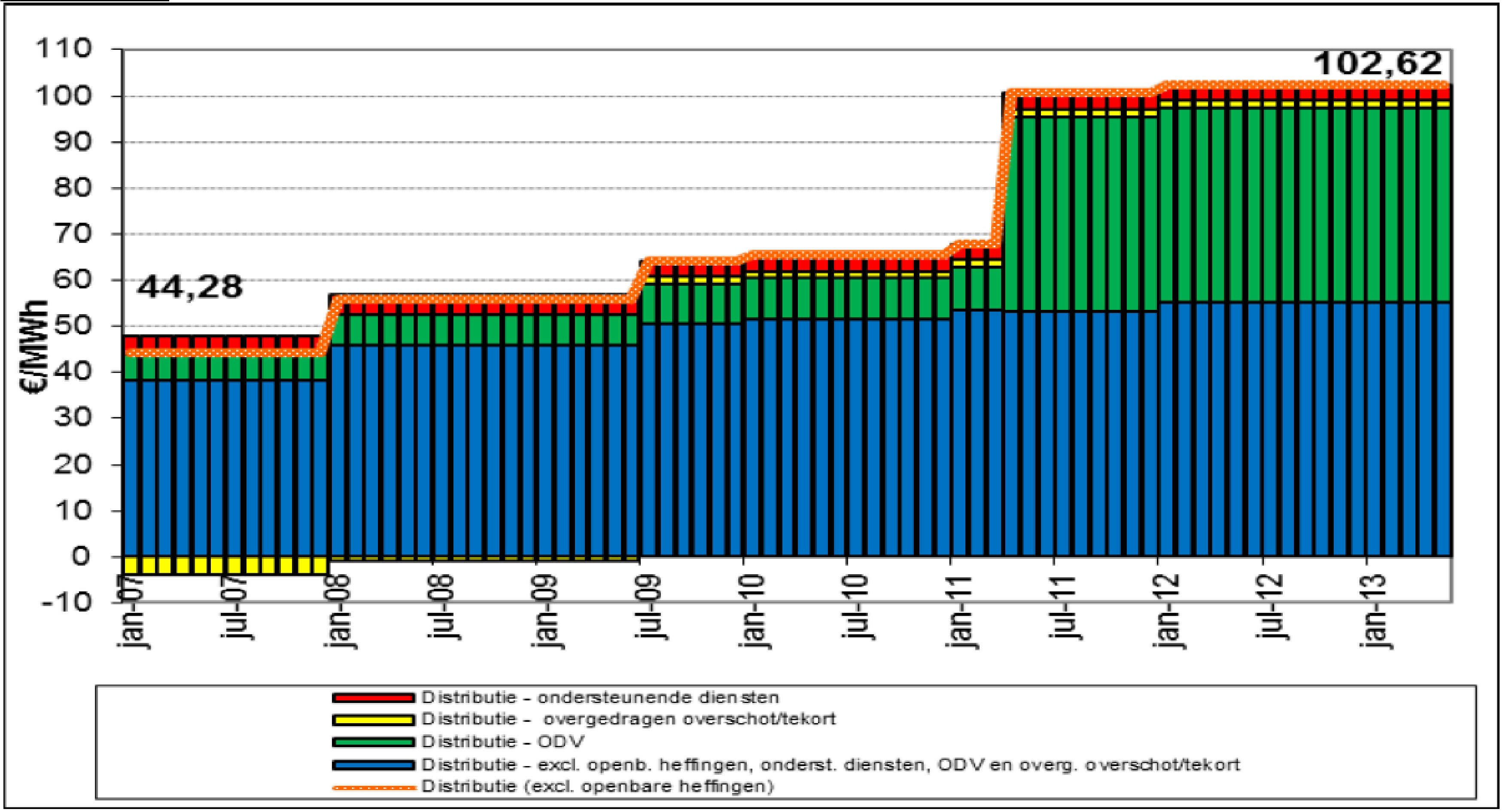
Source: CREG, 2013

Decomposition of energy retail prices
Electricity

- Evolution and composition distribution tariff

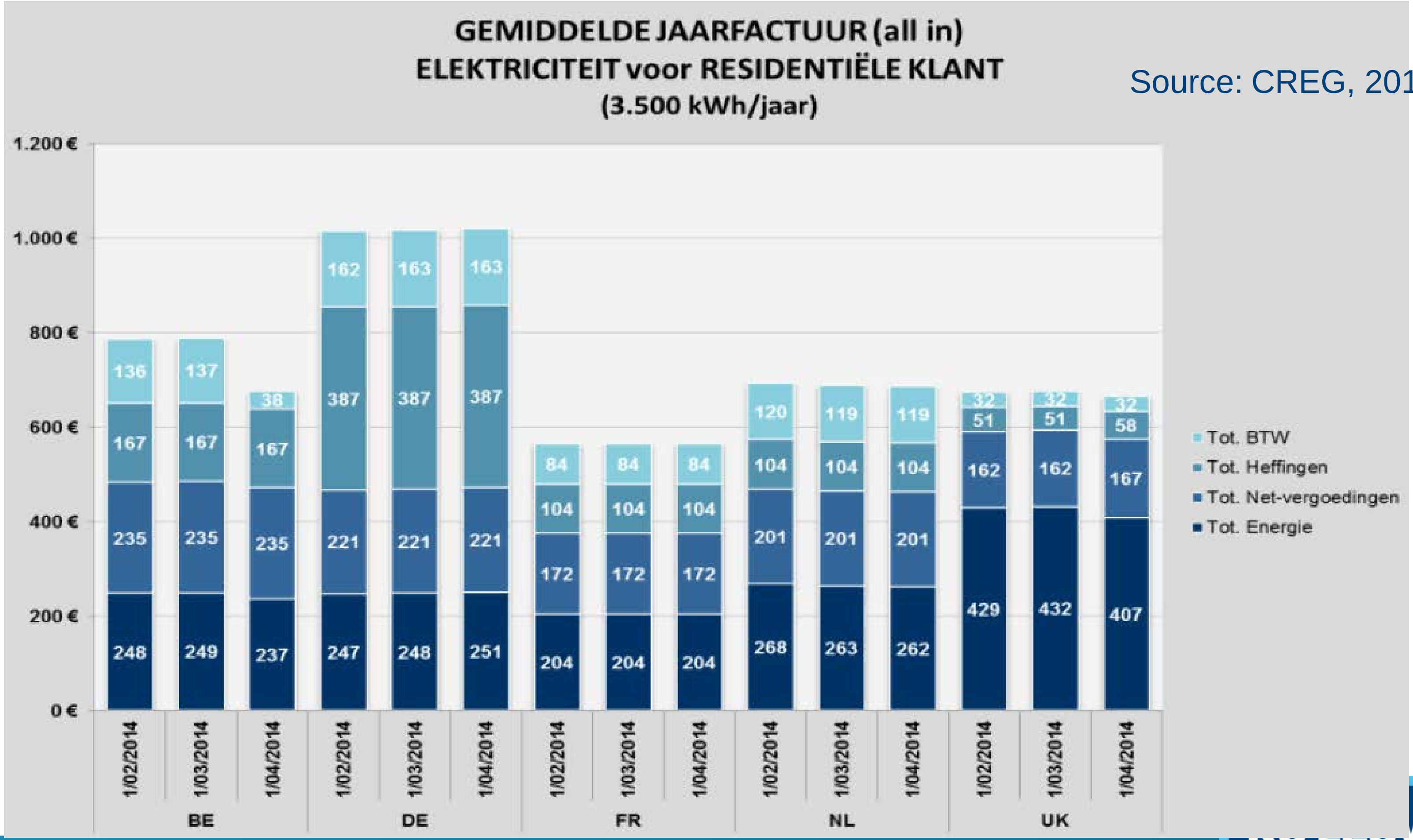
Source: CREG, 2013

Figuur 6.1. – **Dc – Gaselwest - €/MWh**



International positioning
Electricity

- Comparison neighboring countries – domestic consumer

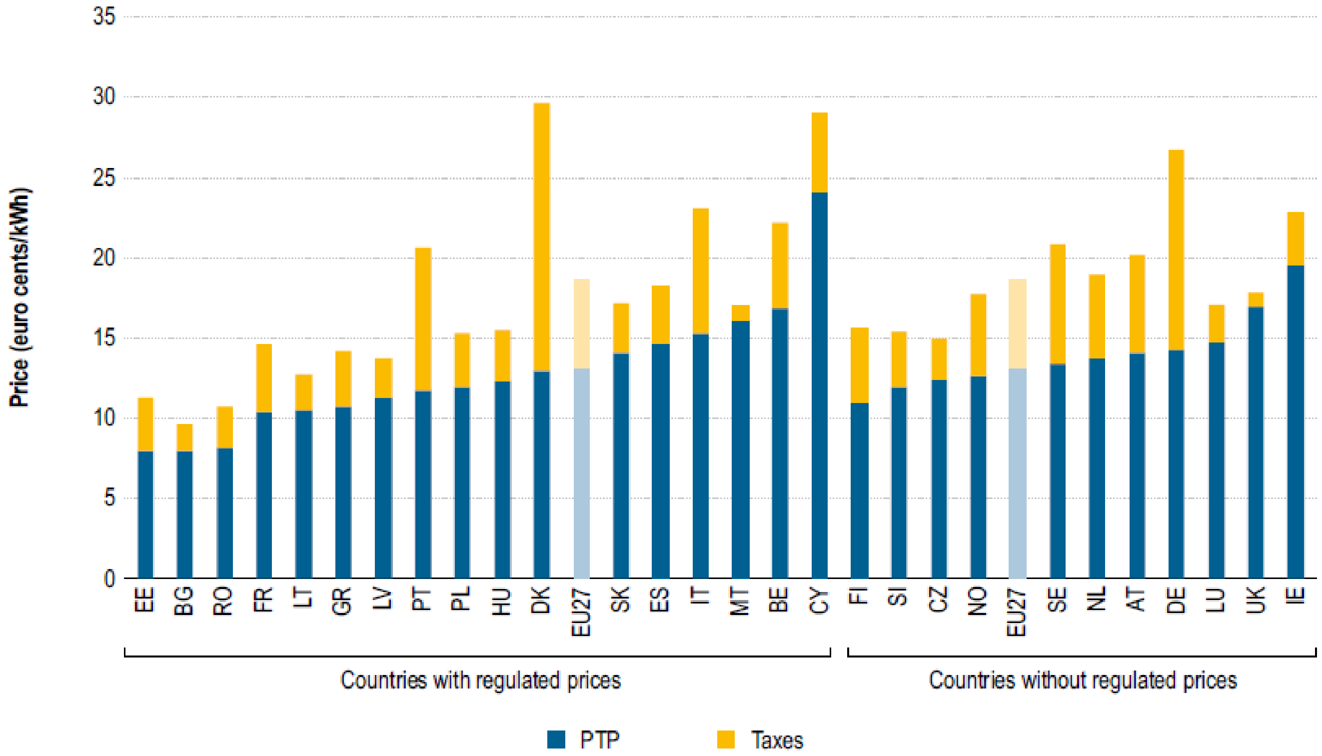


Source: CREG, 2014

International positioning
Electricity

- EU comparison – domestic consumer

Figure 3: Electricity POTP and PTP for households – Europe – 2012 (euro cents/kWh)



Source: ACER, 2013

Source: ACER, based on Eurostat (25/5/2013), DC: 2,500-5,000kWh

Note: Within each group, MSs are ranked according to the PTP level.

Solutions? Energy System Integration

- Electric power sector is driving force for dramatic change due to massive RES injection
  - Intermittent
  - Overcapacity
  - Electricity difficult to store
  - Zero marginal cost PV and wind
- Interaction with the transportation sector (V2G/G2V – PHEV)
- Effects also in the gas sector
  - Fluctuating gas demand in CCGTs due to RES
  - But gas can be useful storage intermediary (P2G)

Solutions? Energy System Integration

ELSEVIER

Contents lists available at ScienceDirect

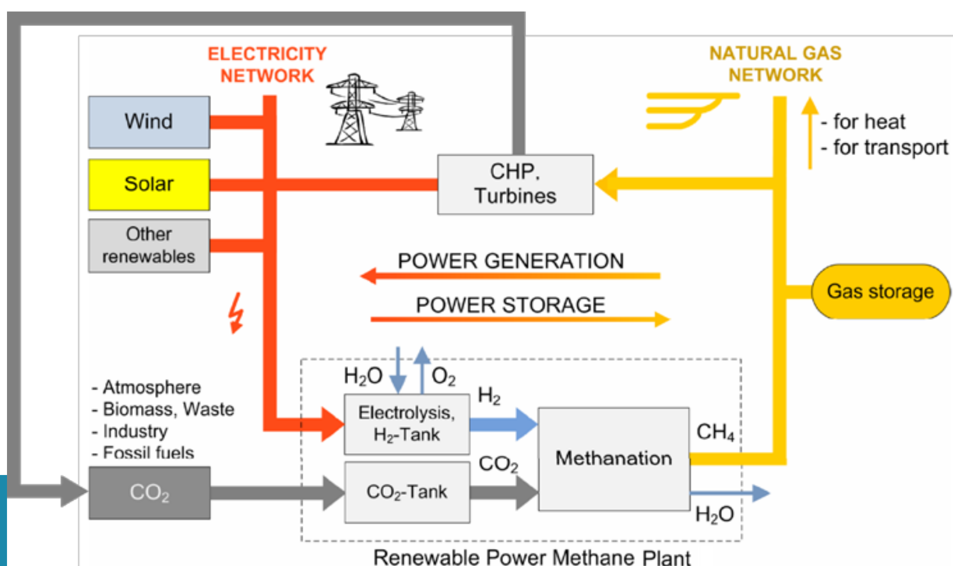
Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Impact of unpredictable renewables on gas-balancing design in Europe

Nico Keyaerts, Erik Delarue, Yannick Rombauts, William D'haeseleer *

University of Leuven (KU Leuven) Energy Institute, TME Branch (Applied Mechanics and Energy Conversion), Celestijnenlaan 300A, P.O. Box 2421, B-3001 Leuven, Belgium



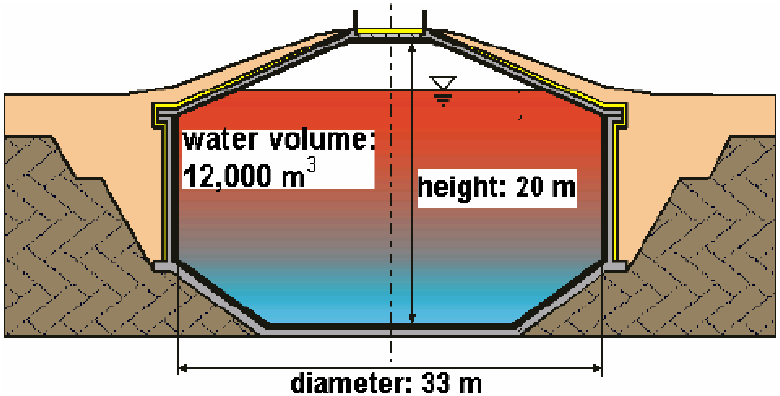
Solutions? Energy System Integration

- Good opportunities in heating sector

ESI in Thermal Sector

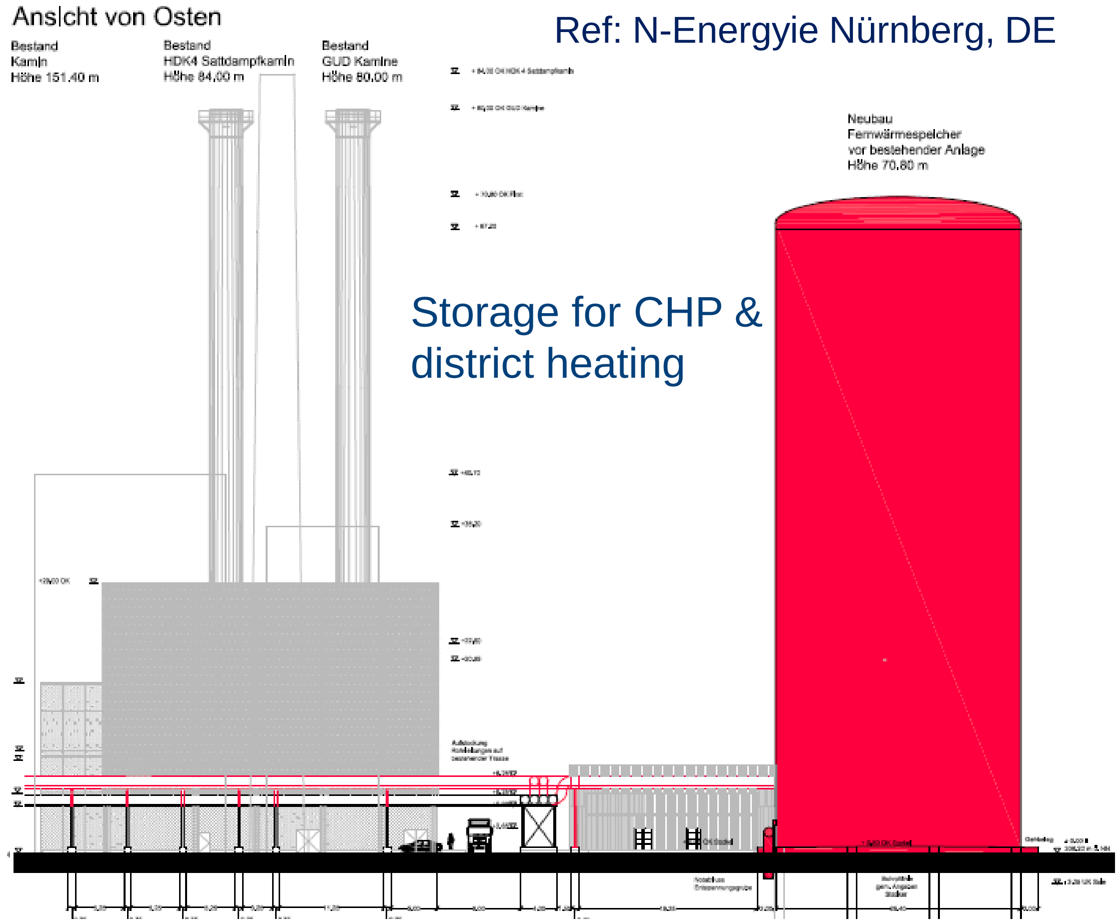
Thermal storage in hot water

Originally:
seasonal hot water storage



Ref: Solites, DE

Ref: N-Energyie Nürnberg, DE



Storage for CHP & district heating

Can be used to dump superfluous electric energy
→ "electric boilers" – used in Denmark!

KU LEUVEN

ESI in Thermal Sector

Thermal Storage via Electric Heating
Virtual Electricity Storage via ADR

	Electricity demand (TWh)	Share in total residential water heating (%)
Australia	28	41
Canada	63	23
France	51	40
Germany	84	27
Ireland	6	32
Italy	29	26
Japan	161	14
Netherlands	17	13
Spain	48	10
United Kingdom	80	9
United States	542	23

IEA, ETP 2014

ESI in Thermal Sector

Virtual Electricity Storage via ADR

→ *Thermal storage in buildings through **Heat Pumps** (HP)*

- Can be considered as an electricity ‘dump’
- But thermal mass of building acts as a thermal buffer
- Can shift with electric power delivery to HP
- Is effectively a virtual electricity storage (via **ADR**)

Conclusions

- The challenges on energy provision are daunting
  - SoS
  - Environment (mostly CO_2)
  - Affordability
- Many uncertainties...

- Energy issue is very complicated because interactions
  → more need to study the system effects

- A careful energy-policy reflection on the EU level is necessary – to be taken out of ideological sphere...

Energy Ville

KU LEUVEN