ELECTRICITY MARKETS, AND THE ROLE OF RENEWABLES & NUCLEAR

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SURVEY

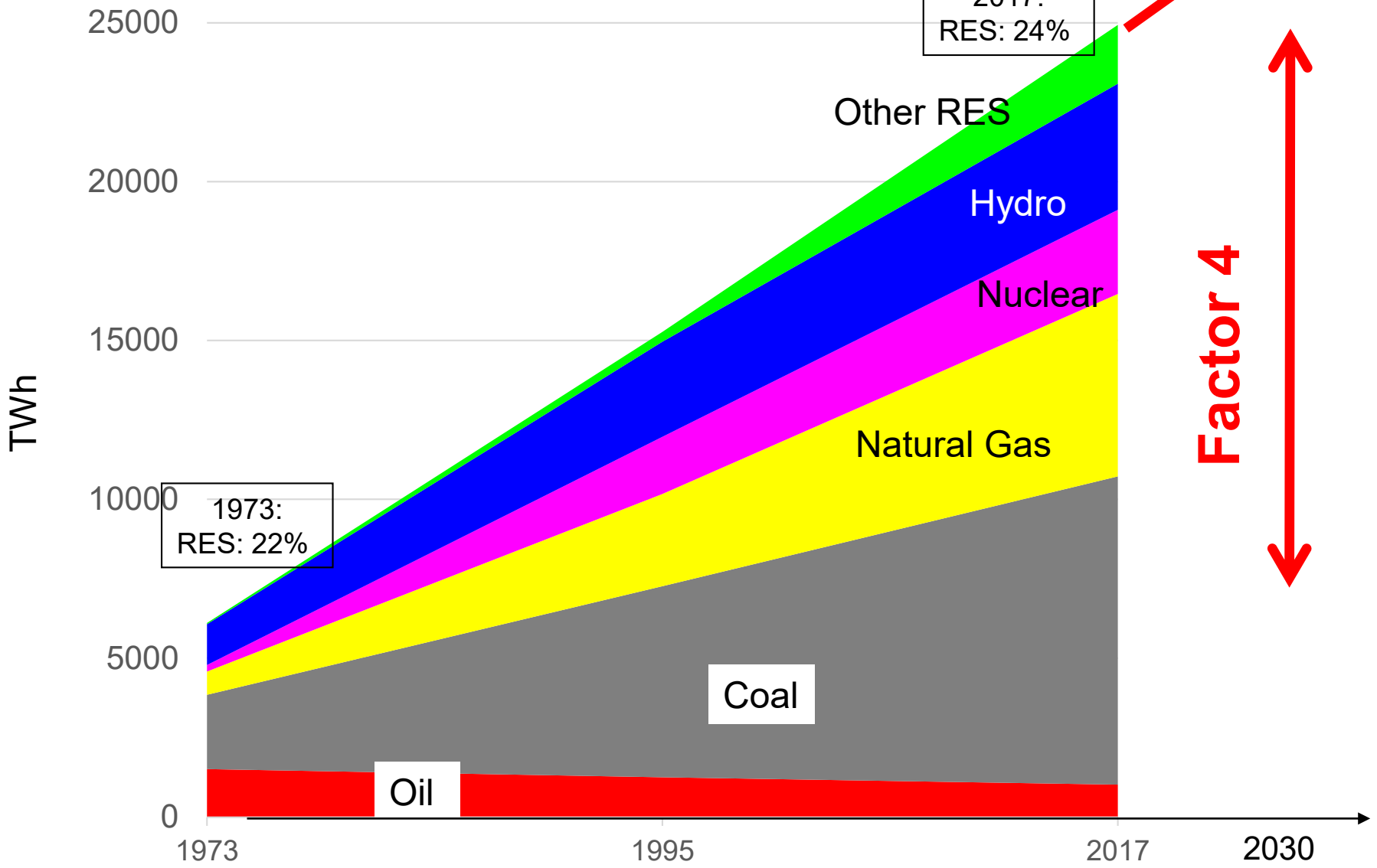
1. Introduction: Historical background
2. How prices come about (theory)
3. Environmental issues: CO2-prices
4. How prices developed in Europe
5. Electricity generation costs
6. Recent developments of nuclear
7. The role of Renewables
8. Conclusions

OUR LIFE: PERMANENTLY UNDER

ELECTRICITY

Electricity – THE universal technology for providing energy services

WORLD-WIDE TREND IN ELECTRICITY CONSUMPTION



Source: IEA (2018)

WHAT IS IMPORTANT WITH RESPECT TO FUTURE ELECTRICITY?

1. INTRODUCTION: CORE OBJECTIVE

- How to provide access to electricity „optimal“ from societies point-of-view?
- What is the optimal political „structure“? Private, price (de-)regulation ….
- How to bring about a transformation to a sustainable electricity system?
- Coal vs nuclear vs renewables vs natural gas?

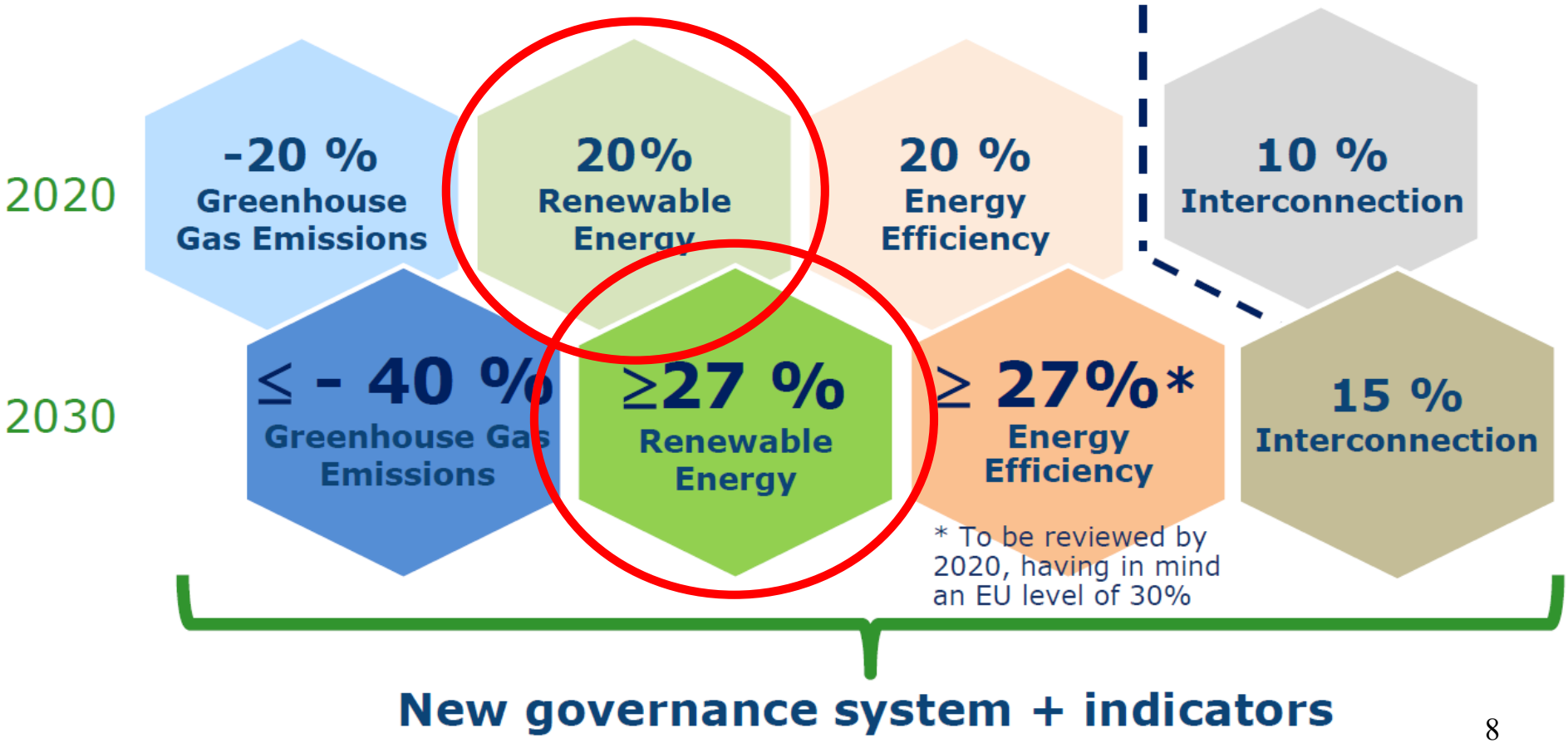
THE EU-DIRECTIVE(S) 1

The European Commission's main expectation …. was the belief that

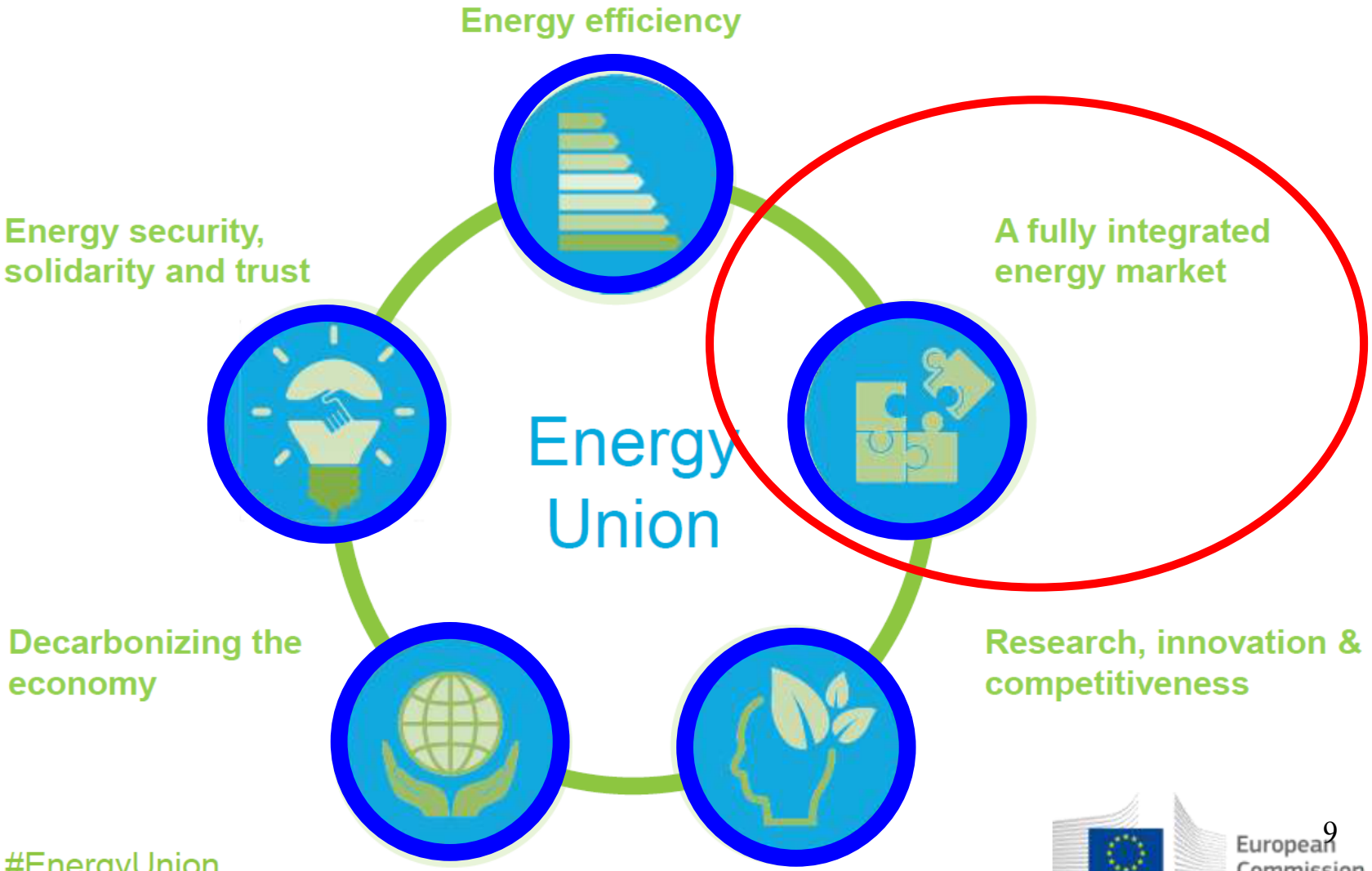
"market forces [would] produce a better allocation of resources and greater effectiveness in the supply of services"

- **Intentions of the EC directive:**
  - → **Competitive markets**
    - → **lower electricity prices**
      - → **more environmentally benign**

Strategic decision by European Council in 2014



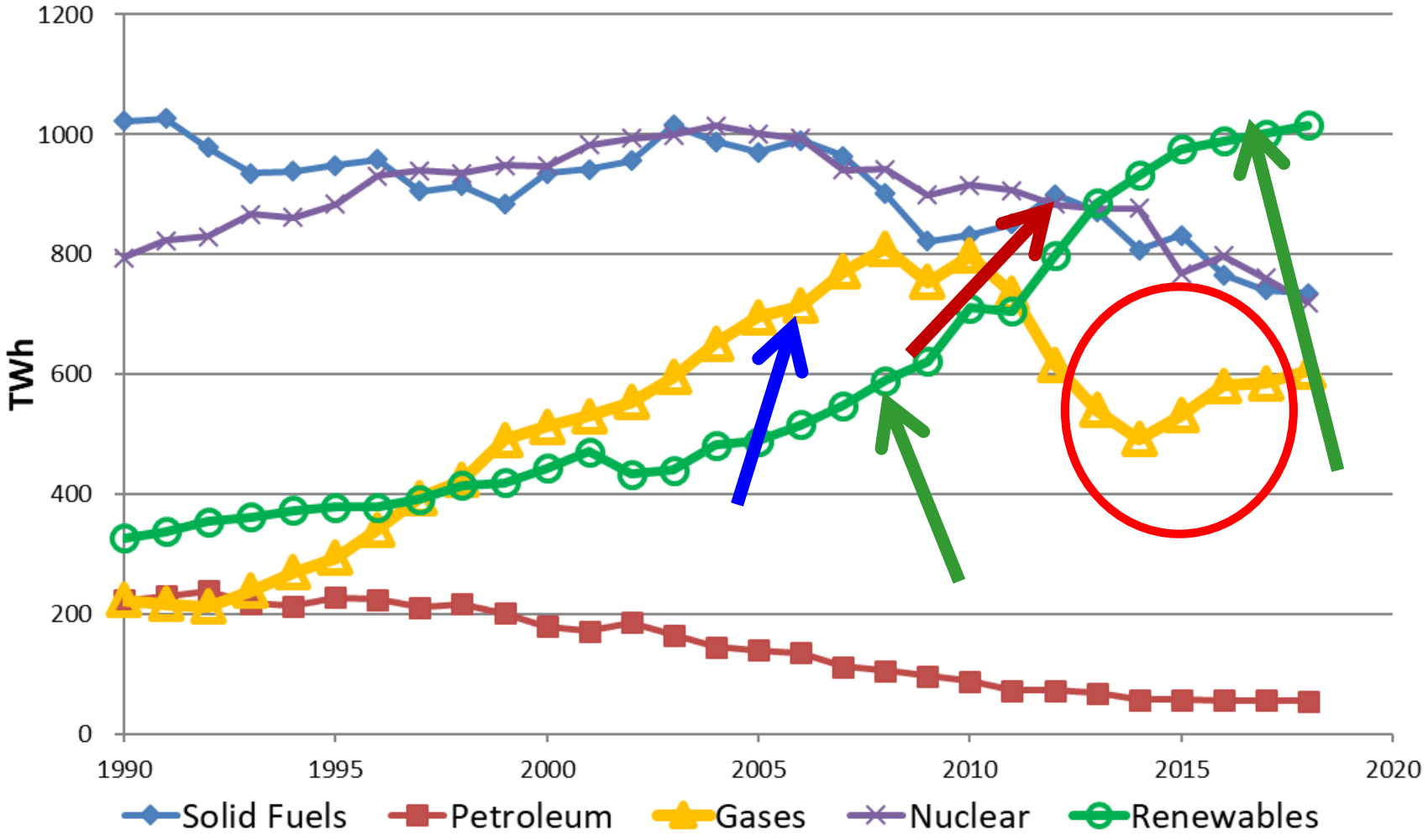
Energy Union Strategy



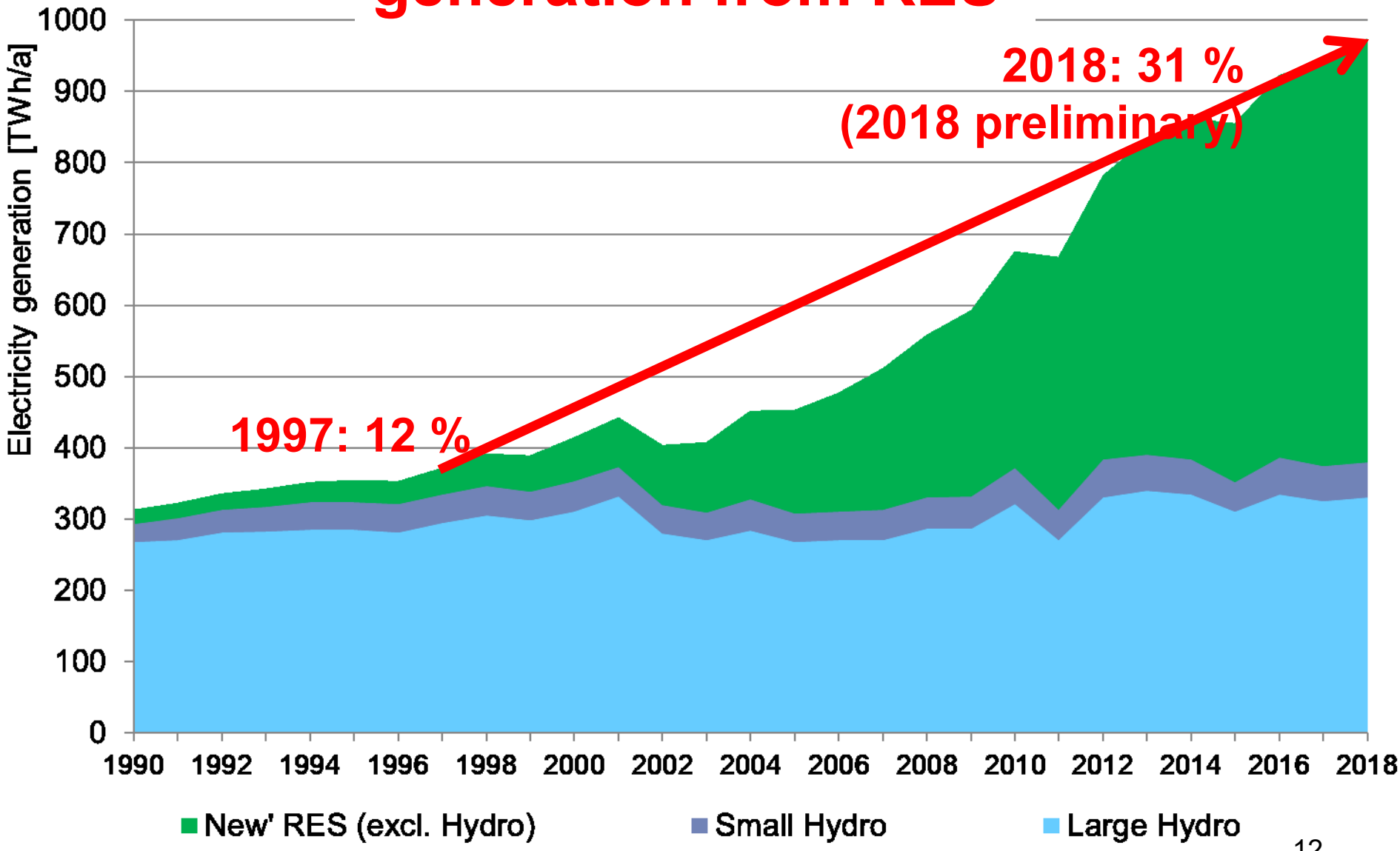
THE CLEAN ENERGY PACKAGE

Structure of the Package

Electricity generation EU-28



EU-28: Electricity generation from RES

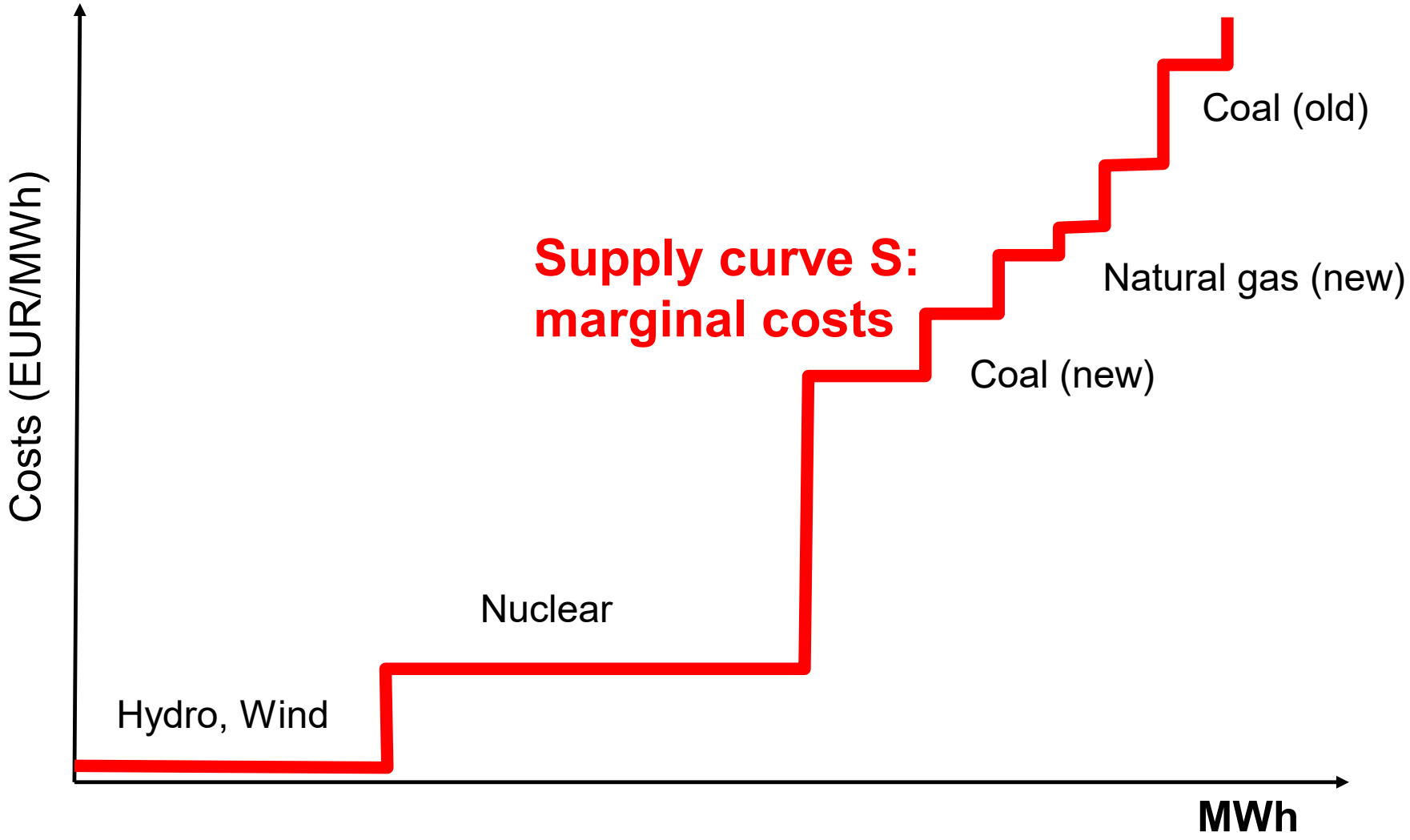


Source: EUROSTAT, own estimations

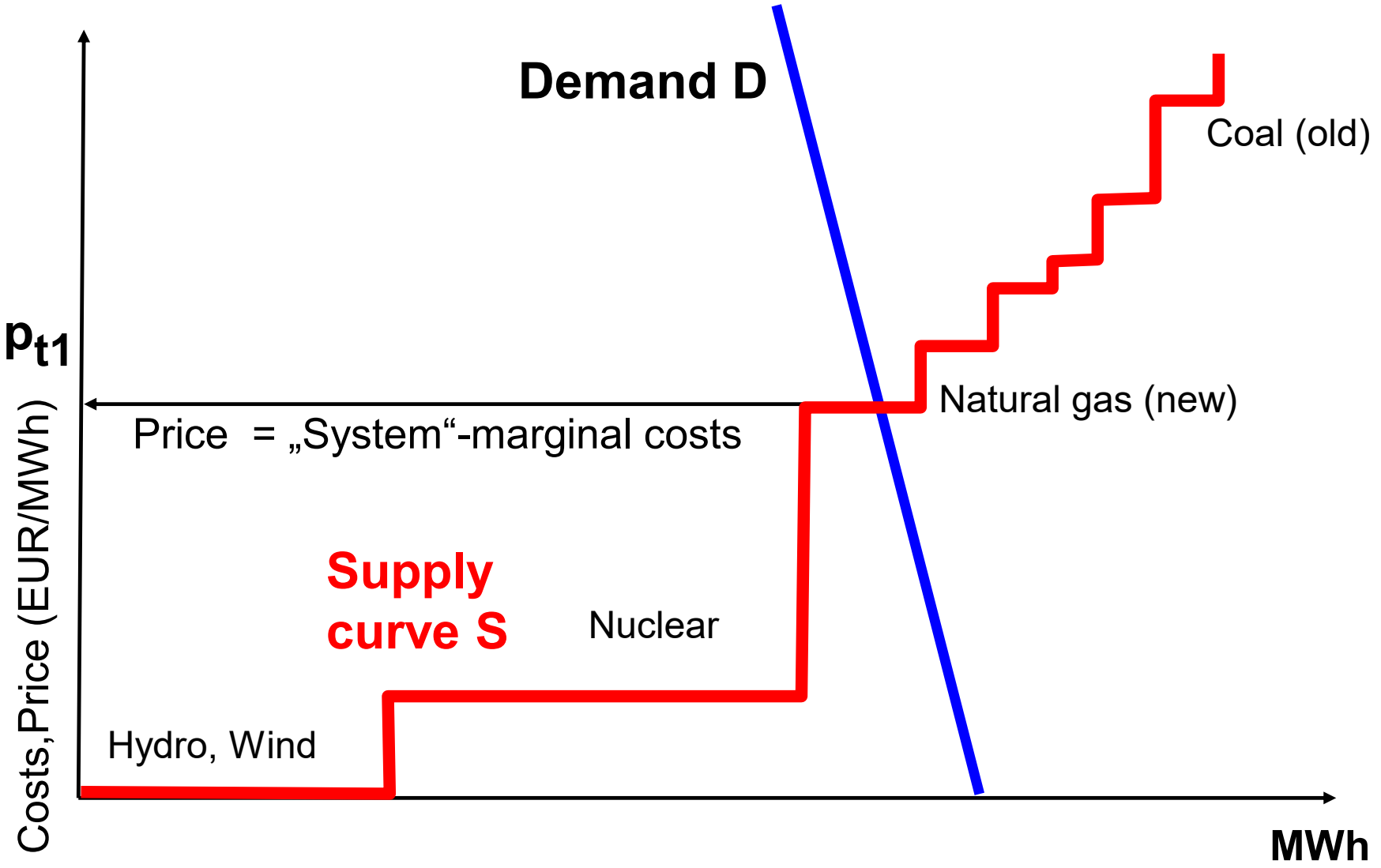
2. How prices come about

THE *MERIT-ORDER* CURVE OF SUPPLY

based on short-term marginal costs (MC)



BASIC PRINCIPLE OF COMPETITION: PRICE = MARGINAL COSTS



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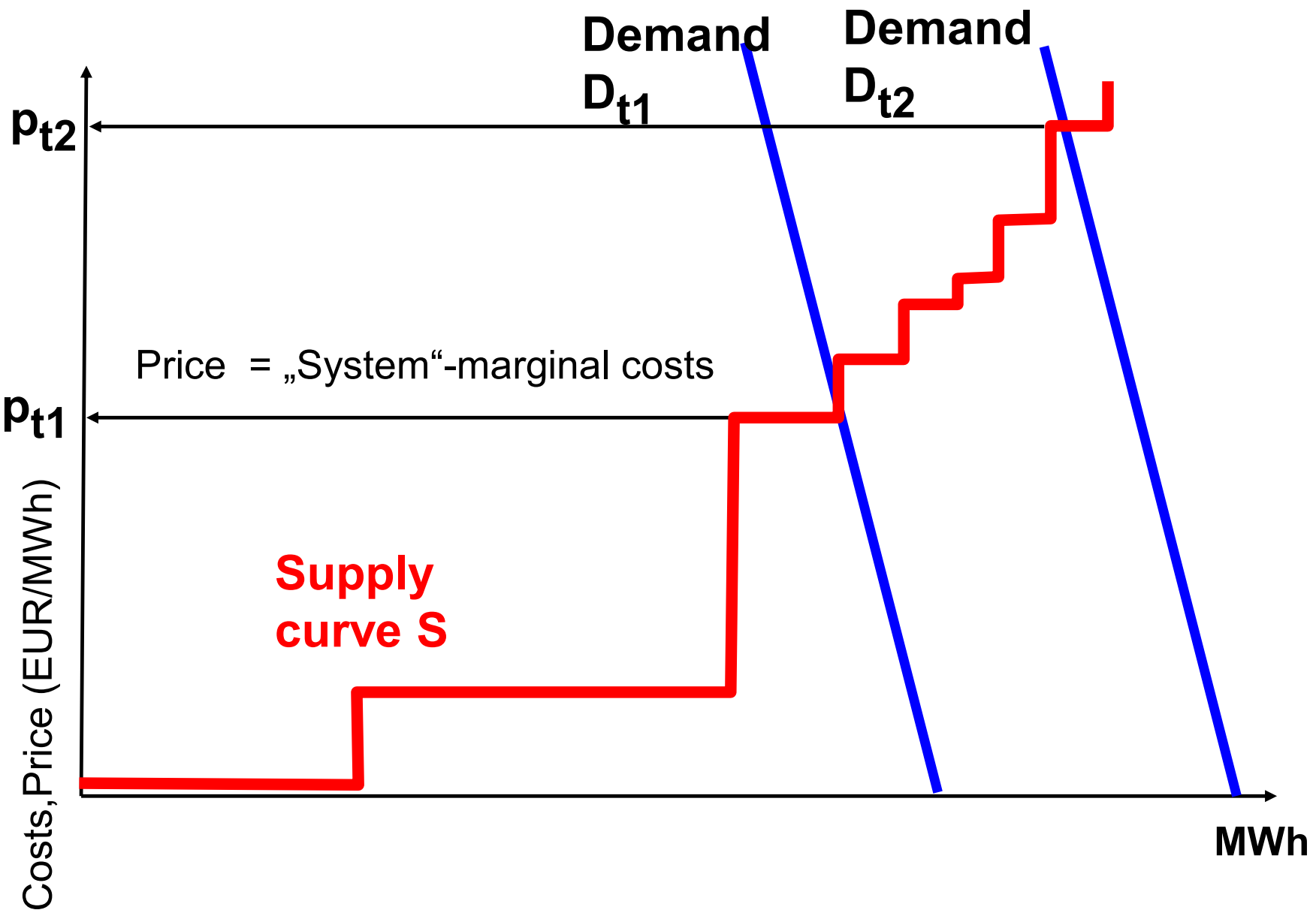
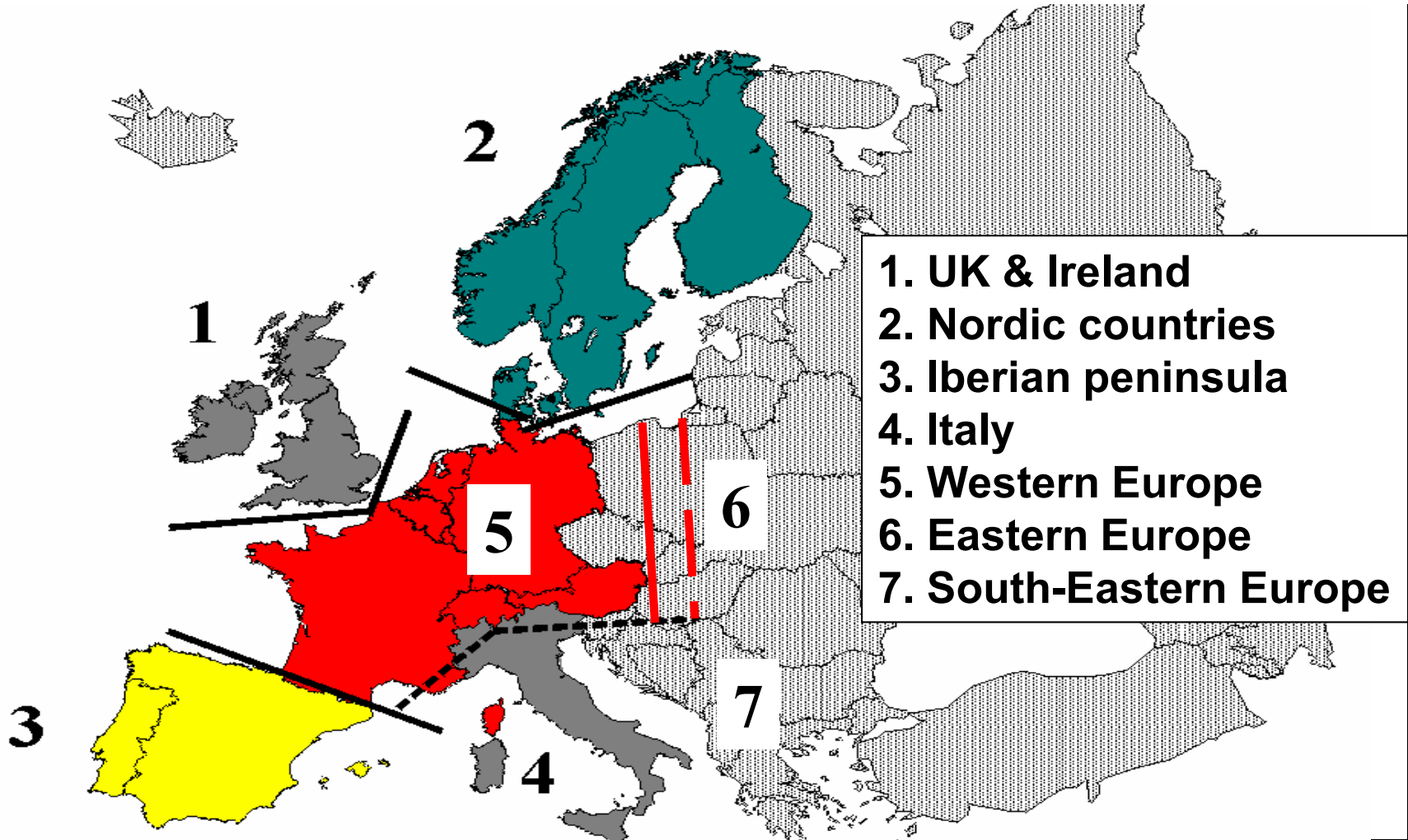
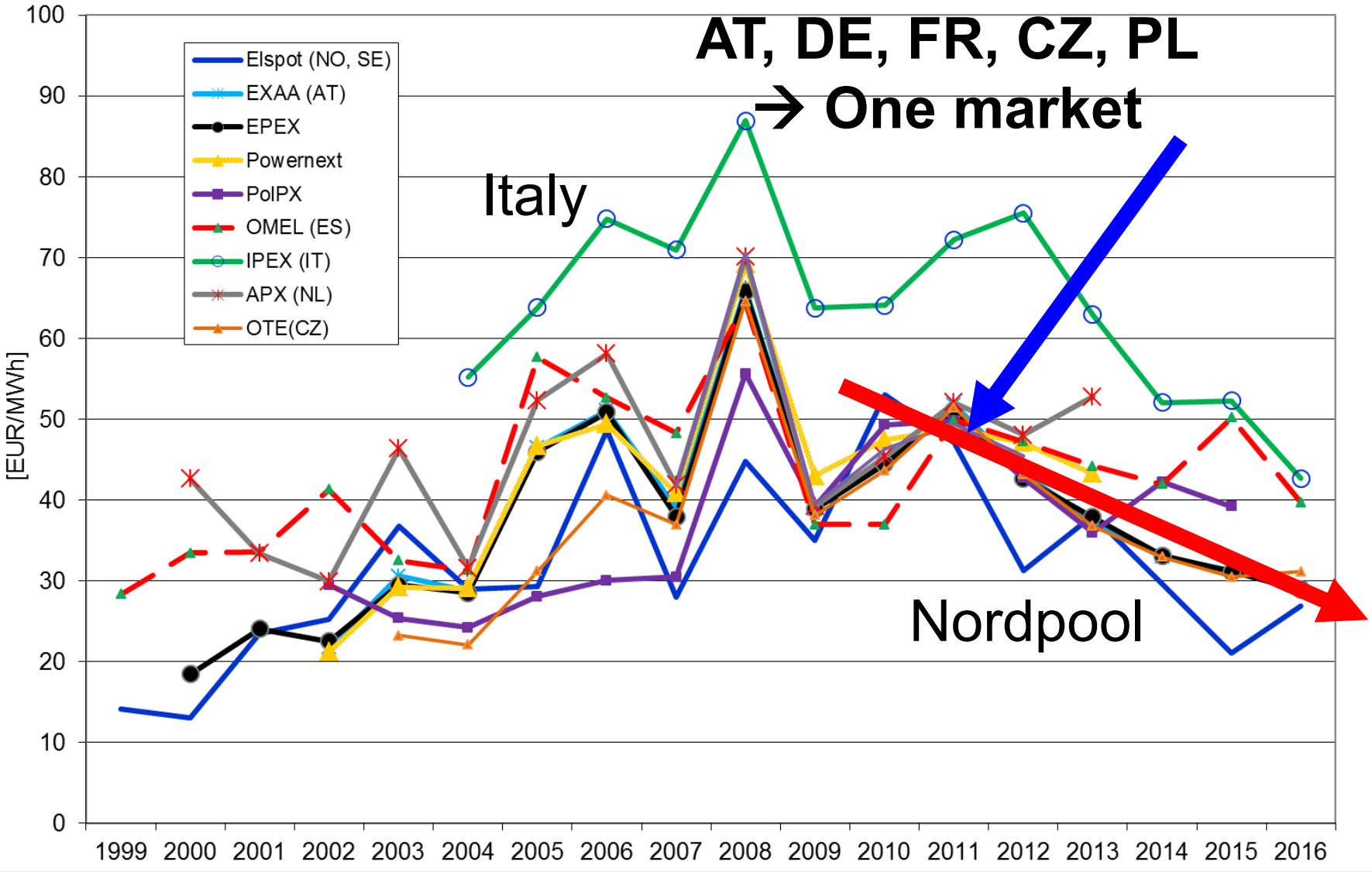


4 HOW PRICES DEVELOPED IN EUROPE

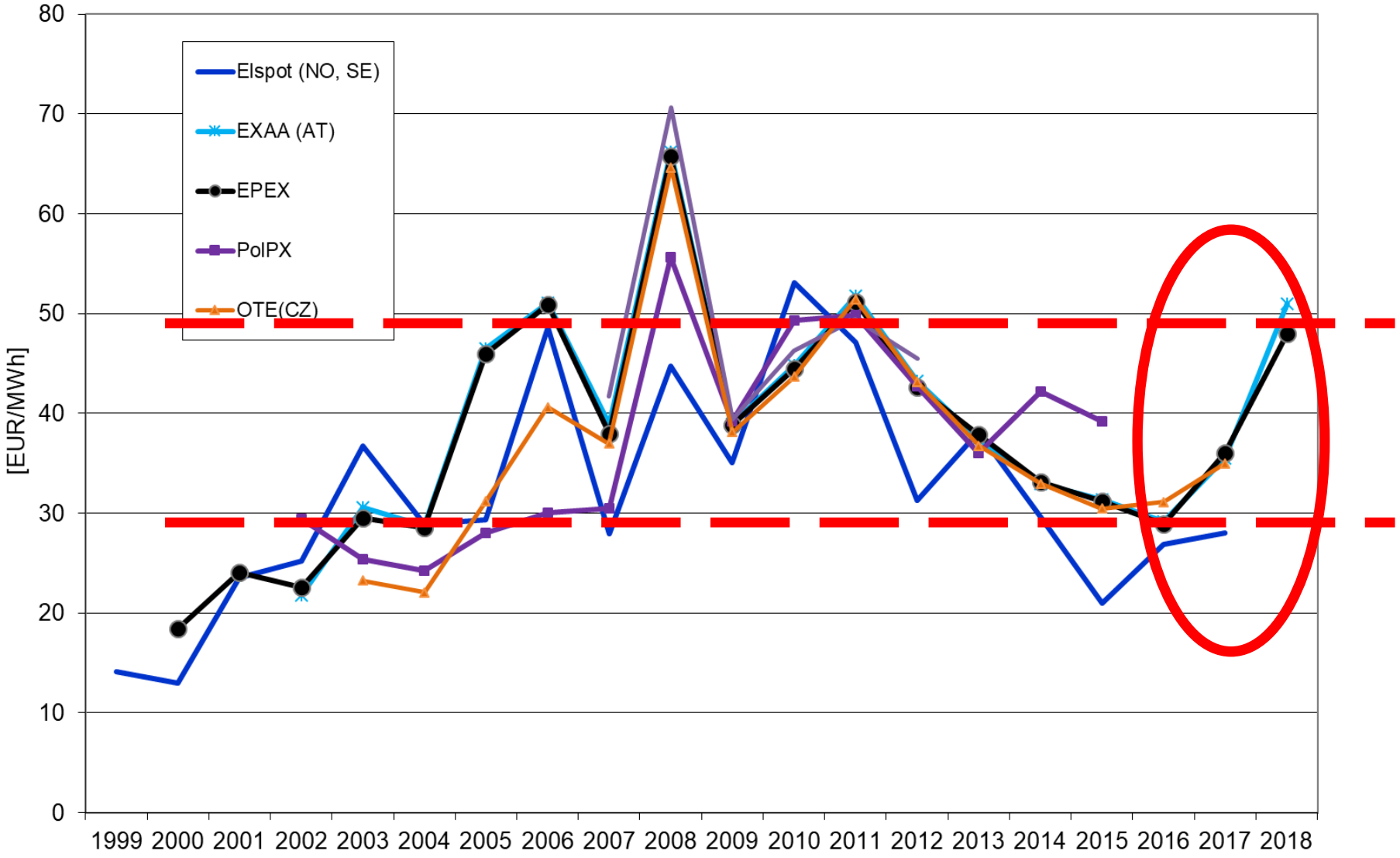
EUROPEAN ELECTRICITY SUB-MARKETS



Development of day-ahead electricity prices in Europe per year (1)



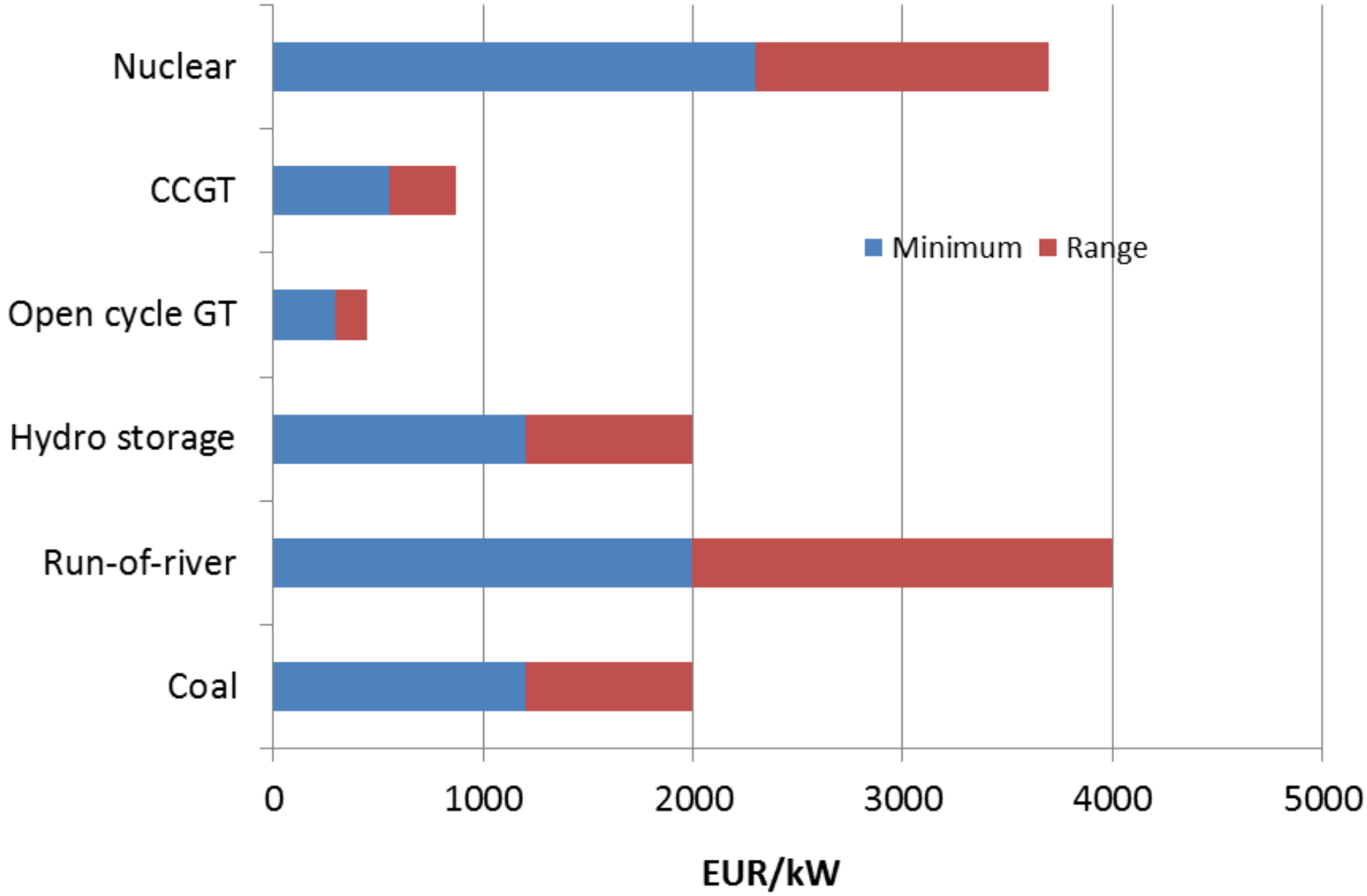
Development of day-ahead electricity prices in Europe per year (2)



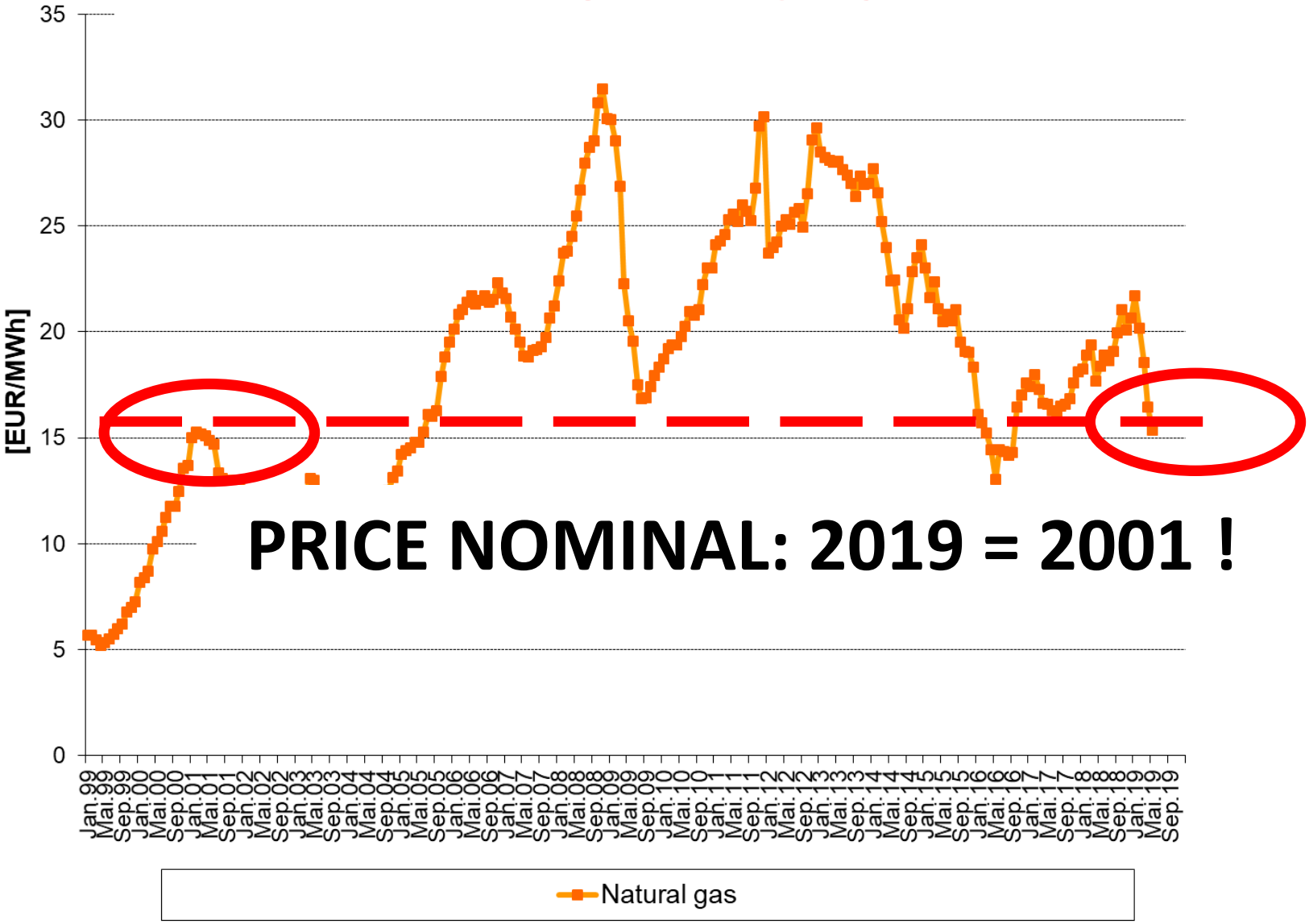
WHAT ARE IMPORTANT IMPAC PARAMETERS ON ELECTRICITY PRICES AND COSTS?

Investment costs

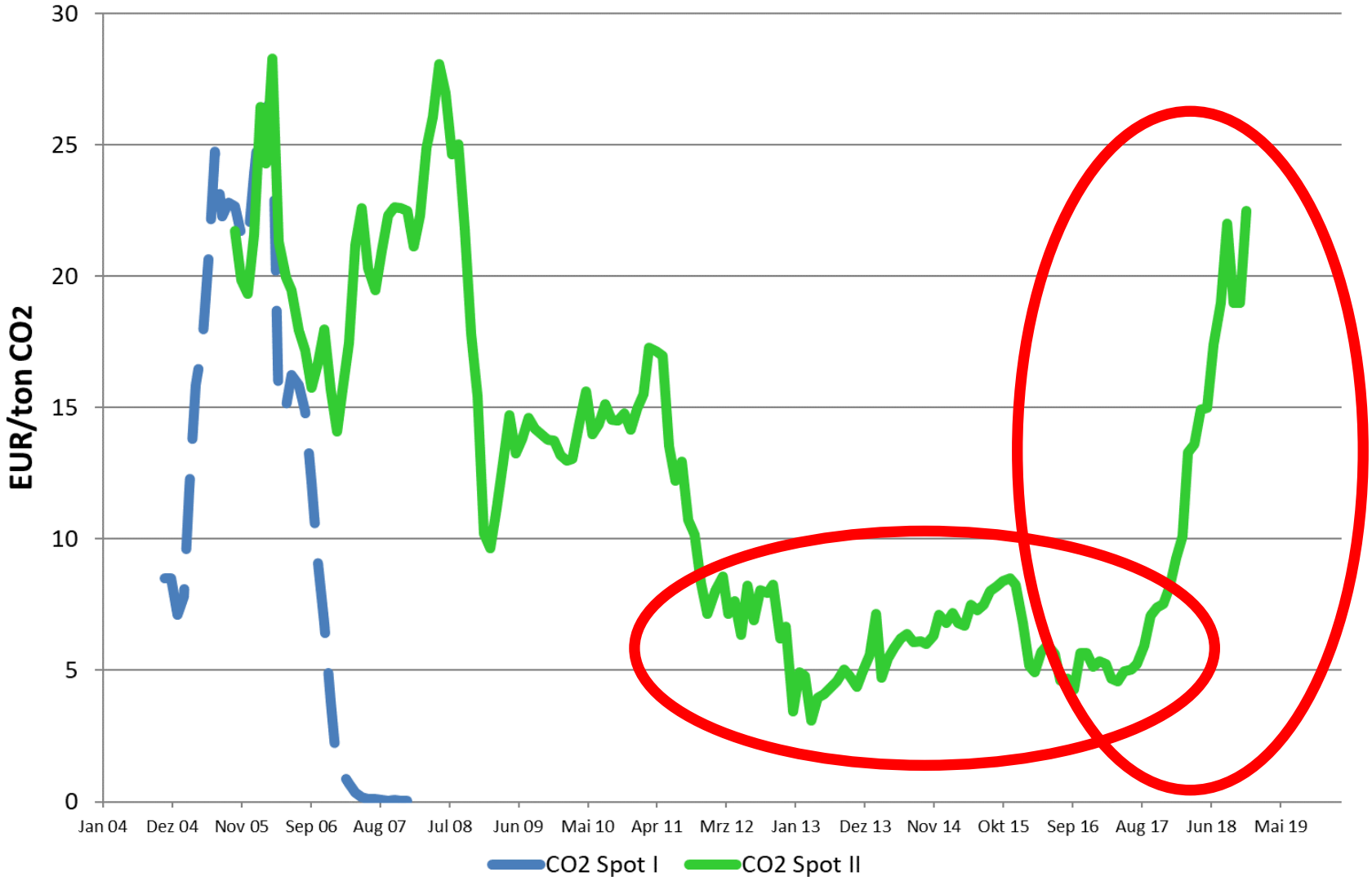
Electricity generation Conventional 2018



WHOLESALE MARKET PRICE OF NATURAL GAS

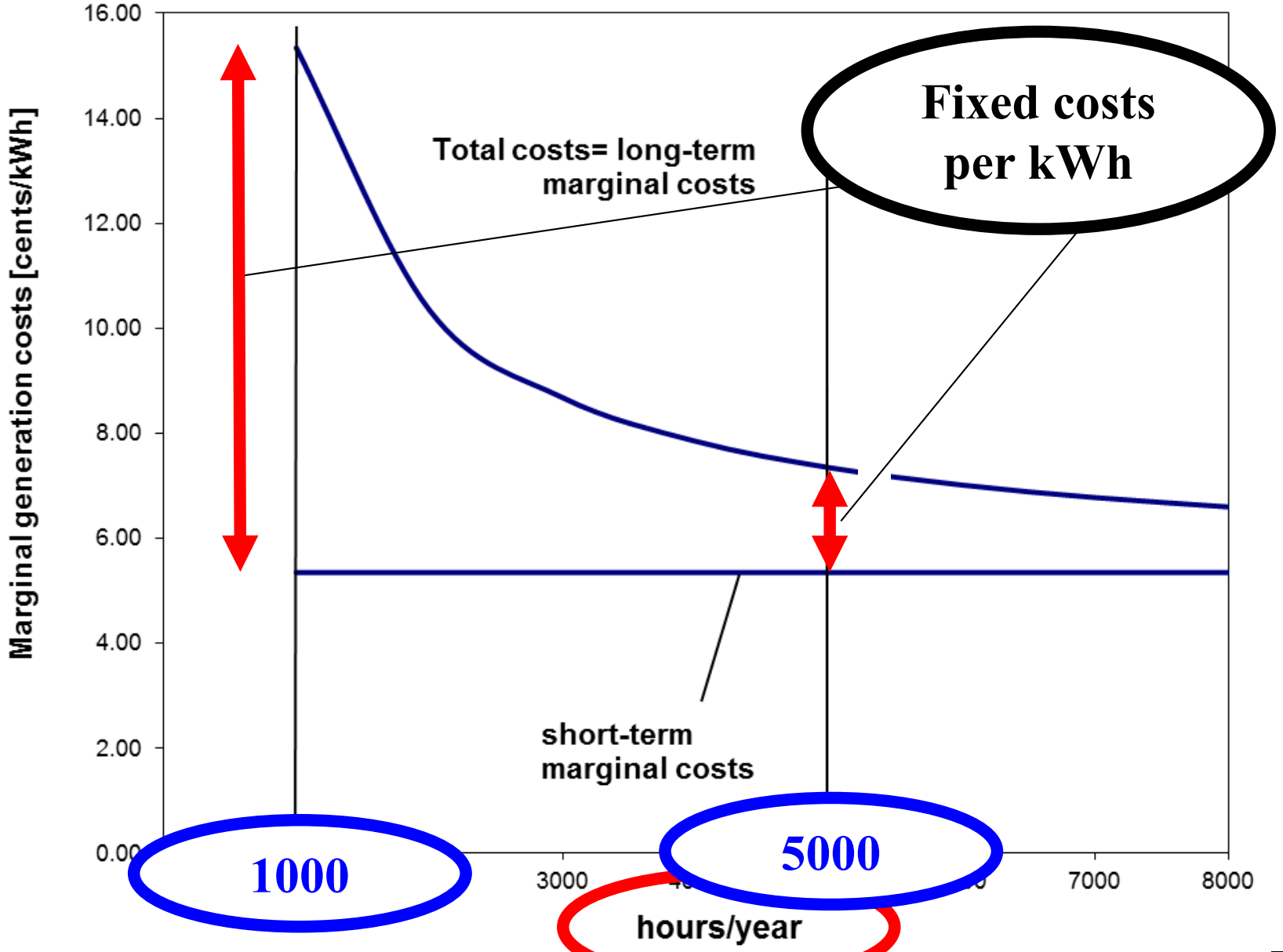


3 ENVIRONMENTAL ASPECTS – THE CO2-PRICE



THE CO2-PRICE IN THE ETS IN THE LAST 4 YEARS

Generation costs CCGT



Example: Costs of electricity generation from CCGT

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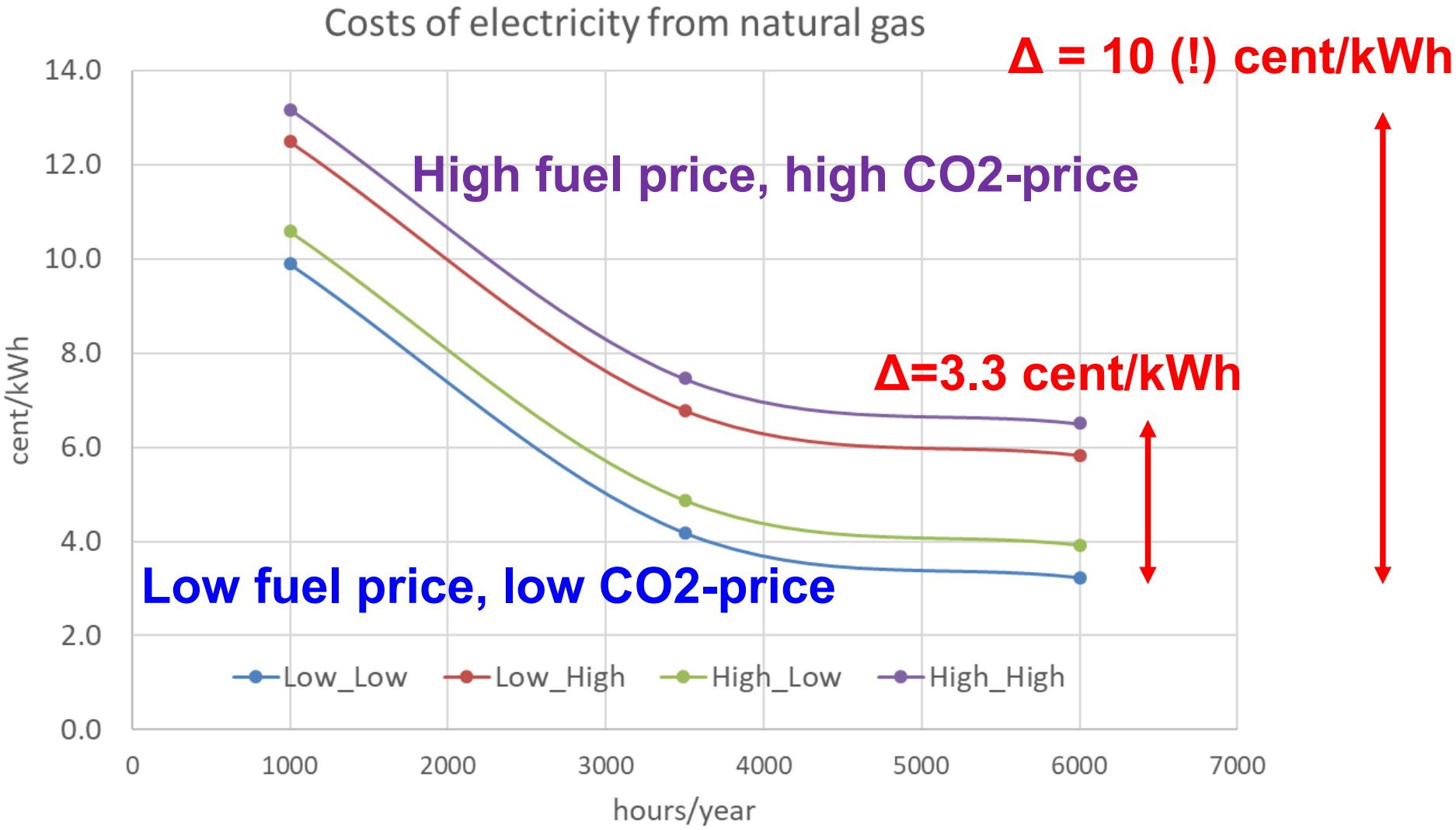
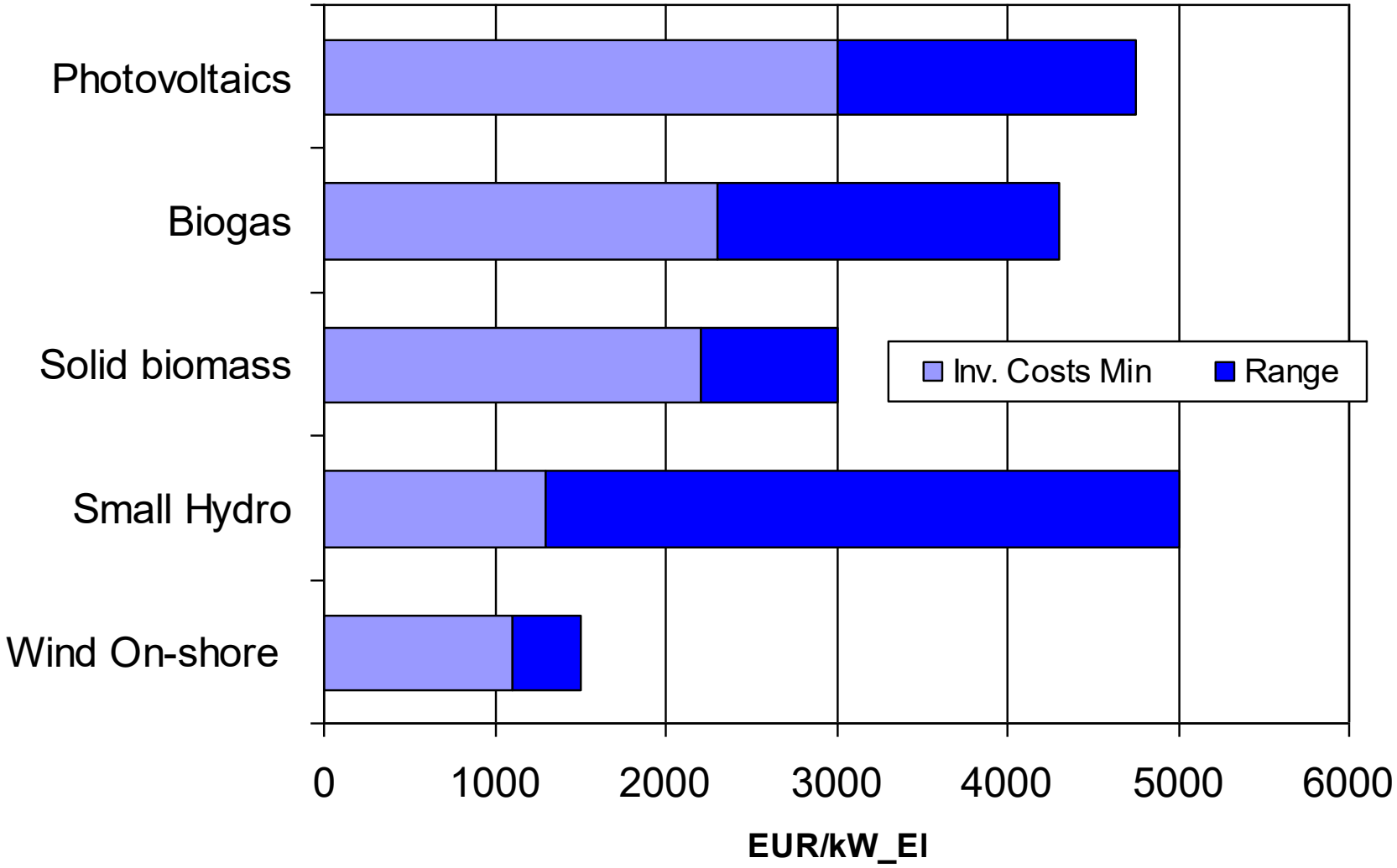


Investment costs

Electricity from new renewables 2010



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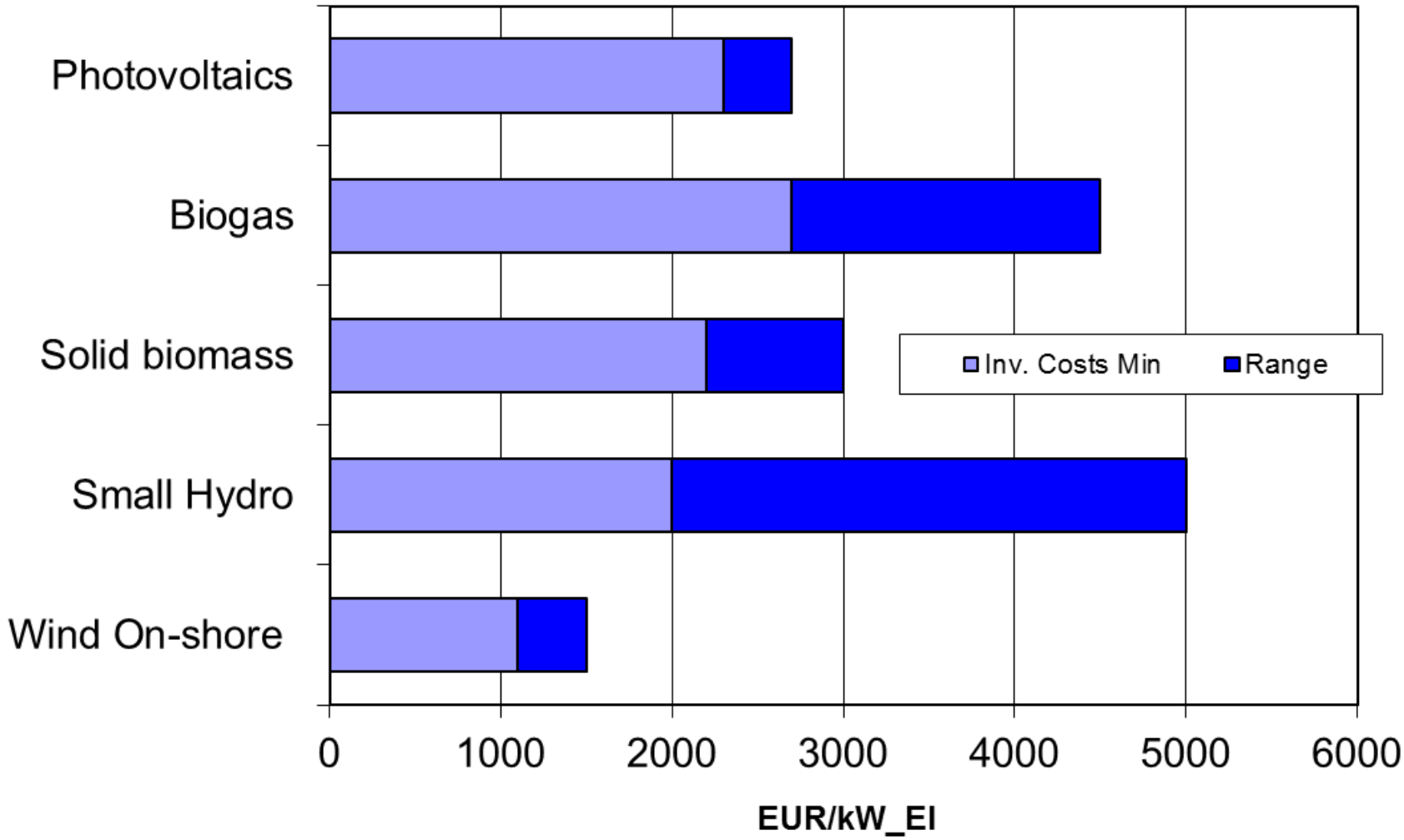

Generation costs

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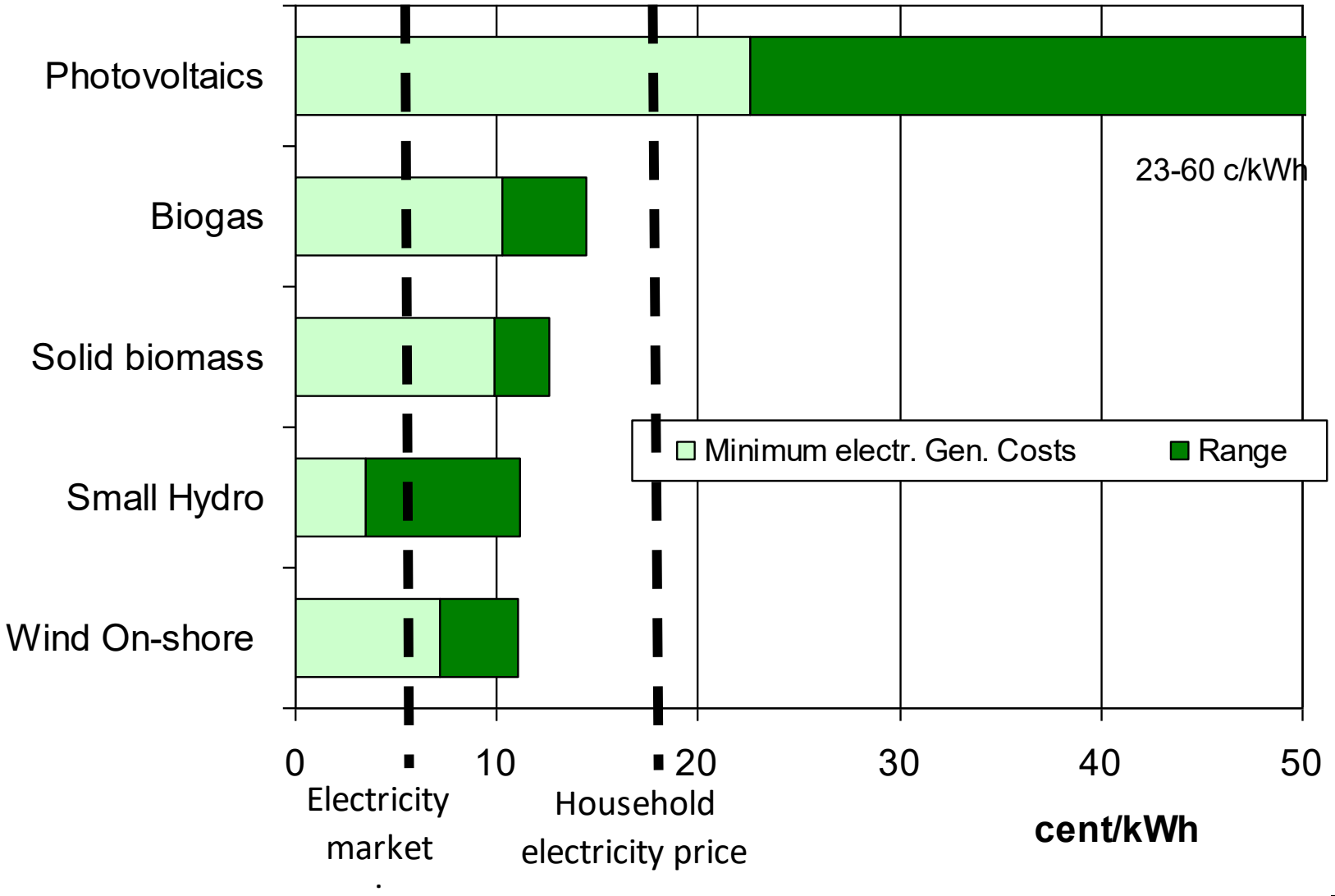
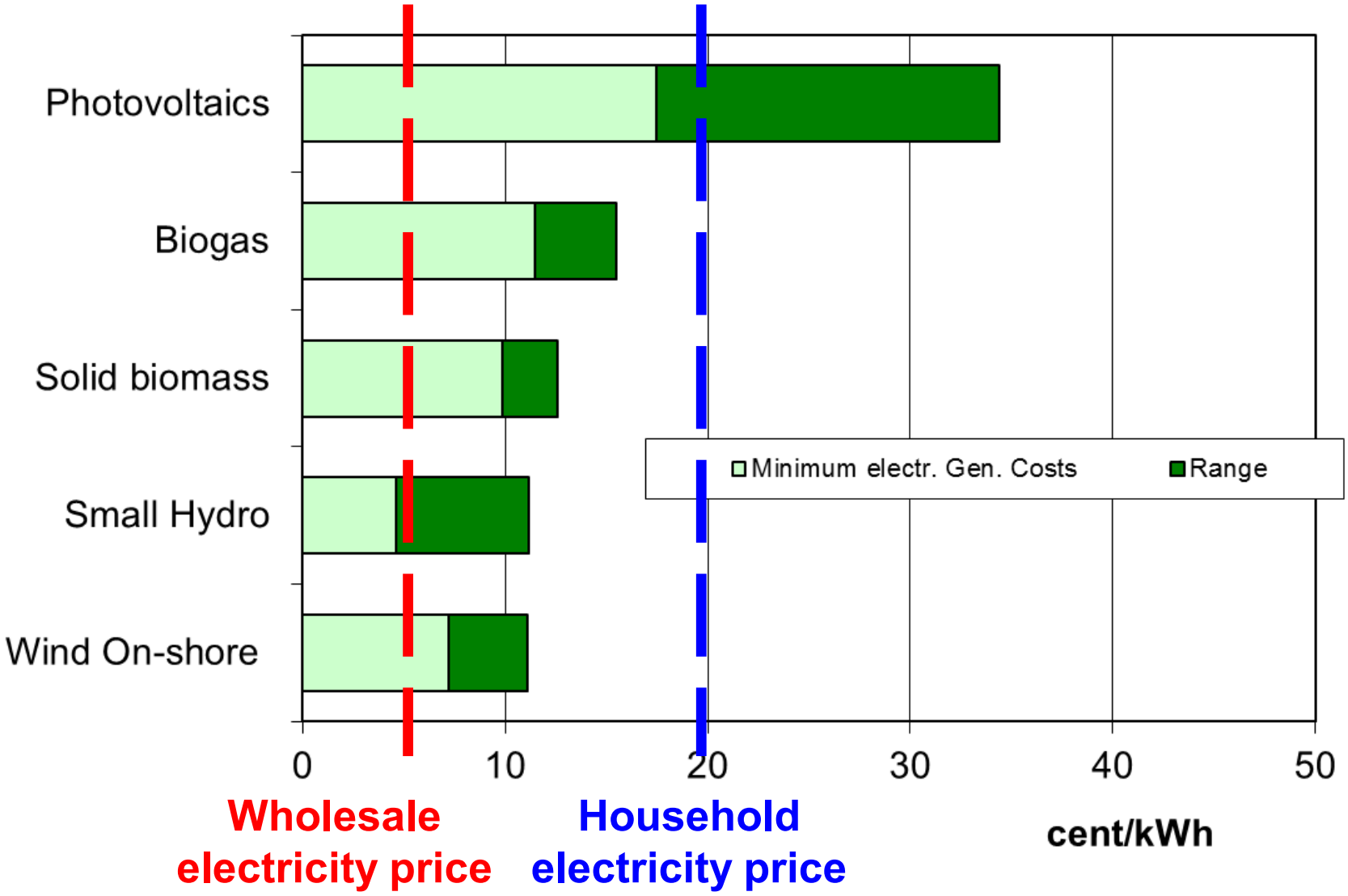


Generation costs

Electricity from new renewables 2018



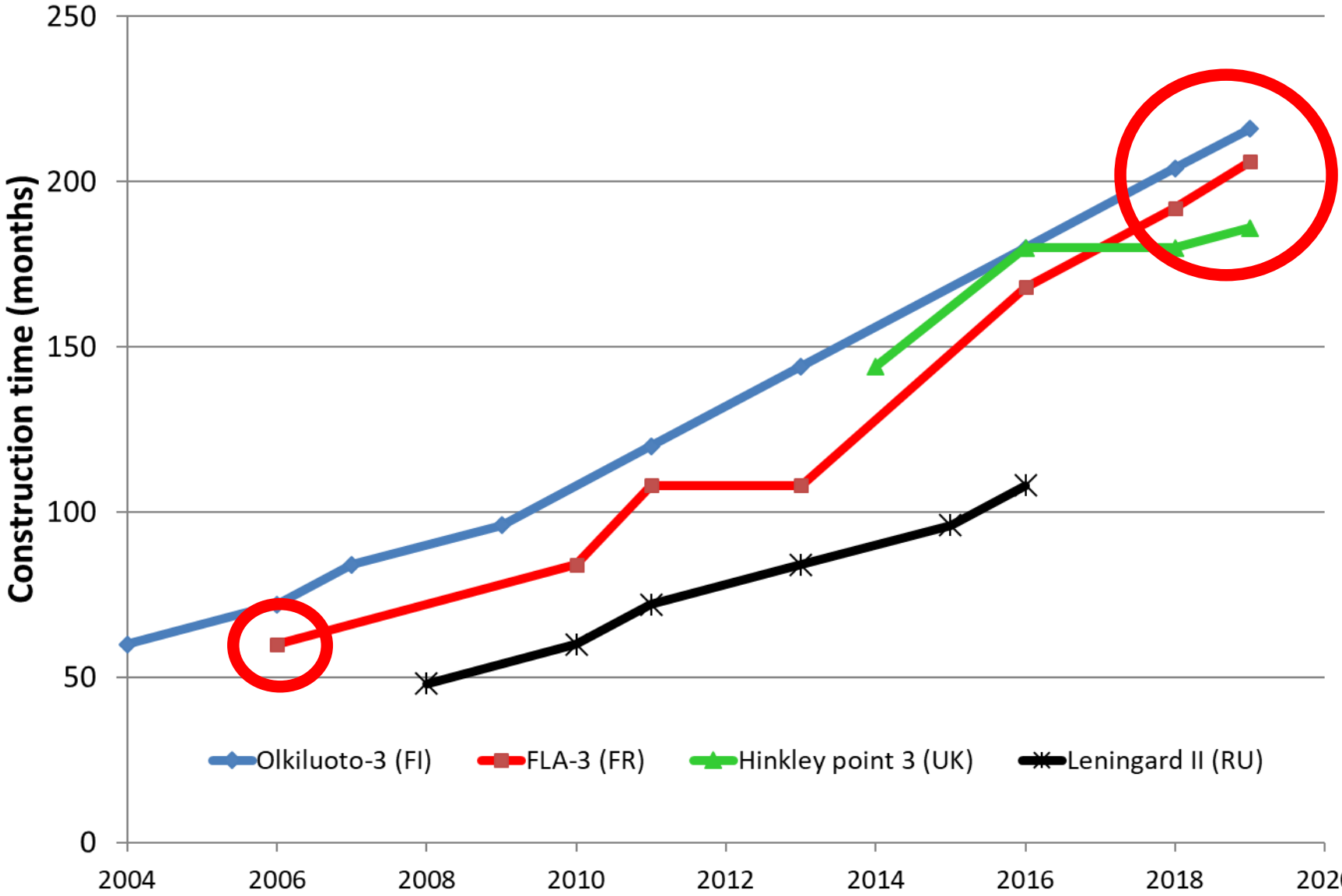
6. RECENT DEVELOPMENT OF NUCLEAR COSTS

- Olkiluoto-3 (Finland): Construction started in 2004, now expected to be completed 2019 (originally: 2009); 1600 MW

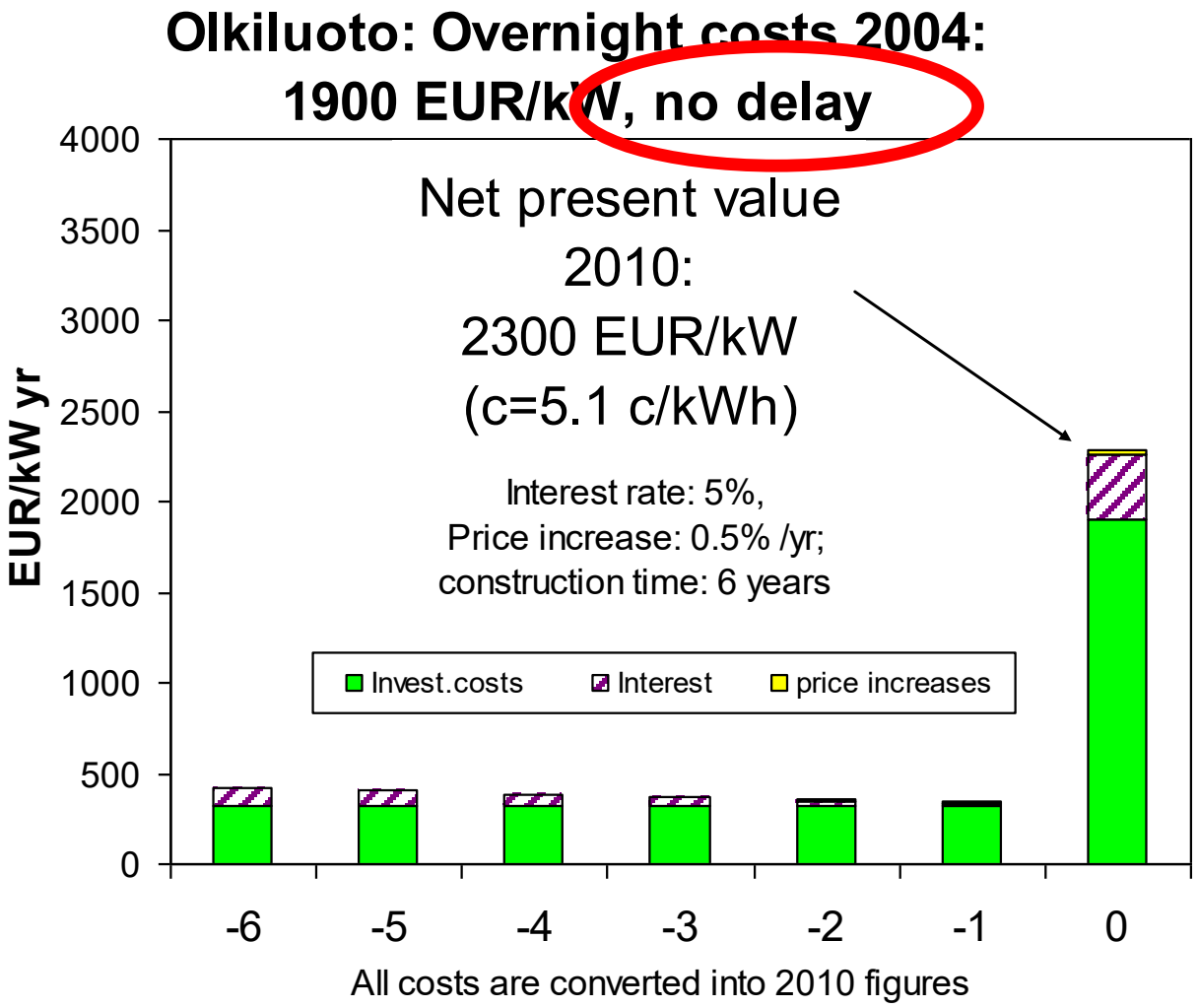
- Flamanville-3 (France): Construction started in 2006, now expected to be completed 2019 (originally: 2011); 1600 MW

- Hinkley point (UK): Construction start expected in 2022, 1600 MW

Construction times



Impact of construction time on investment costs: Example Olkiluoto



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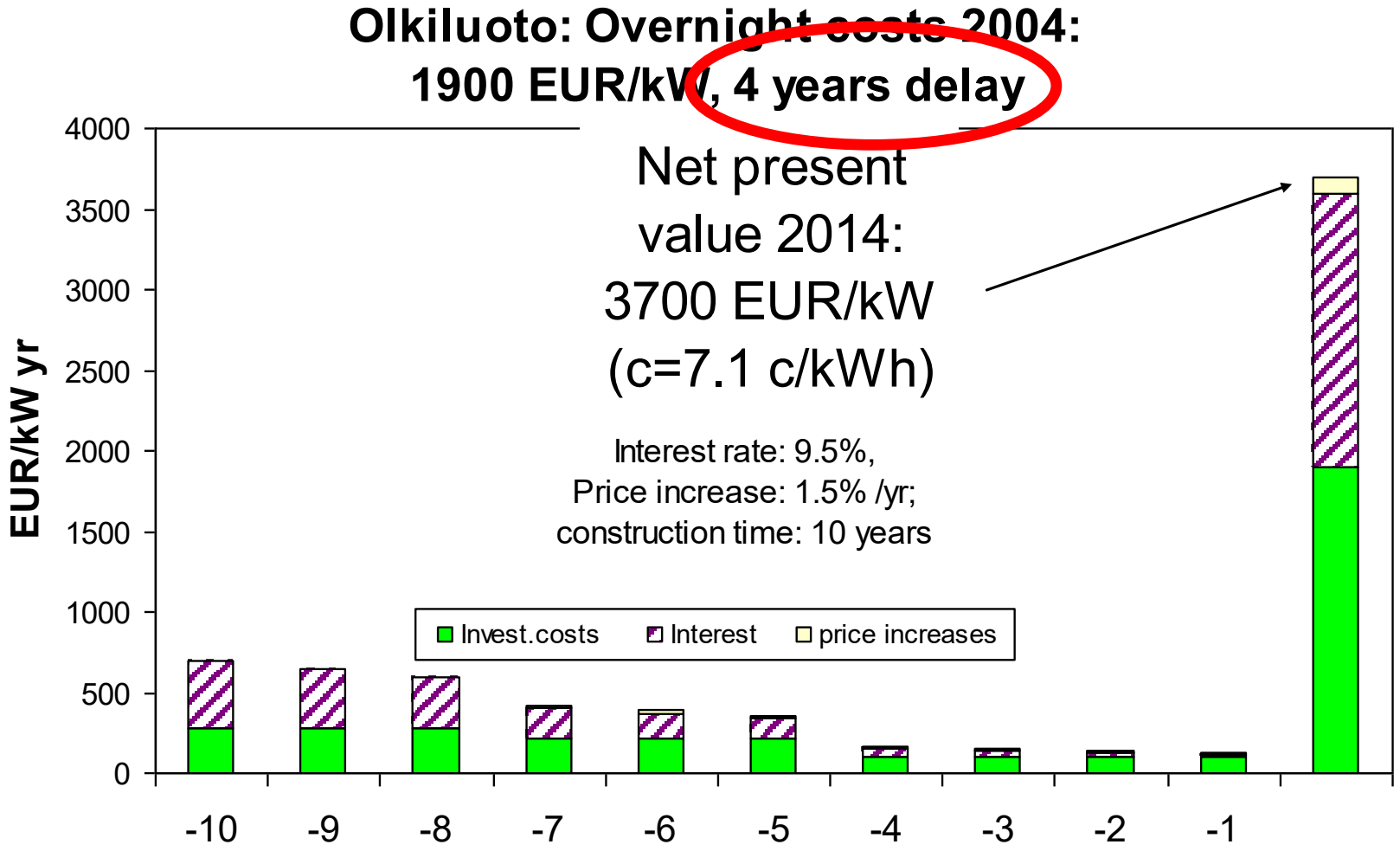
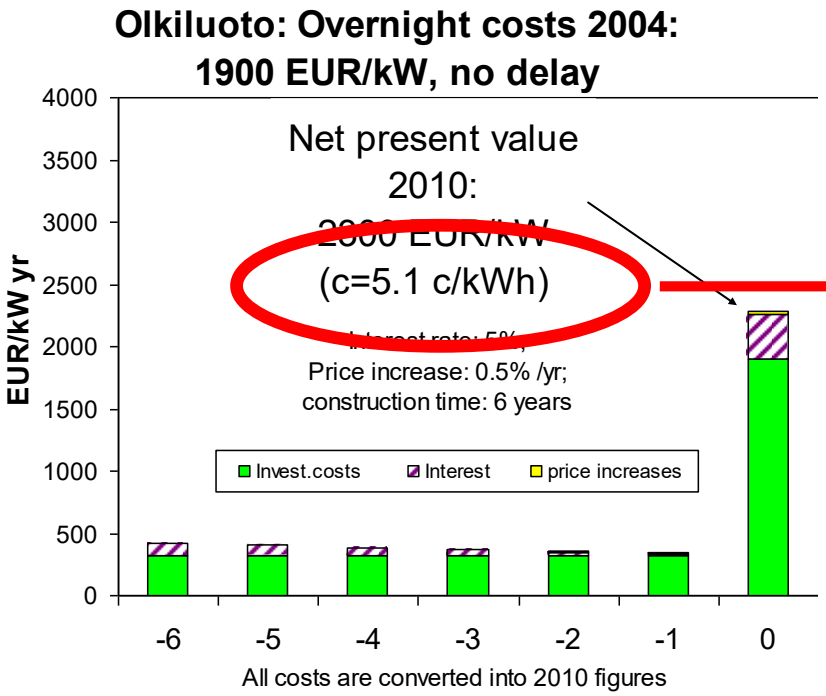
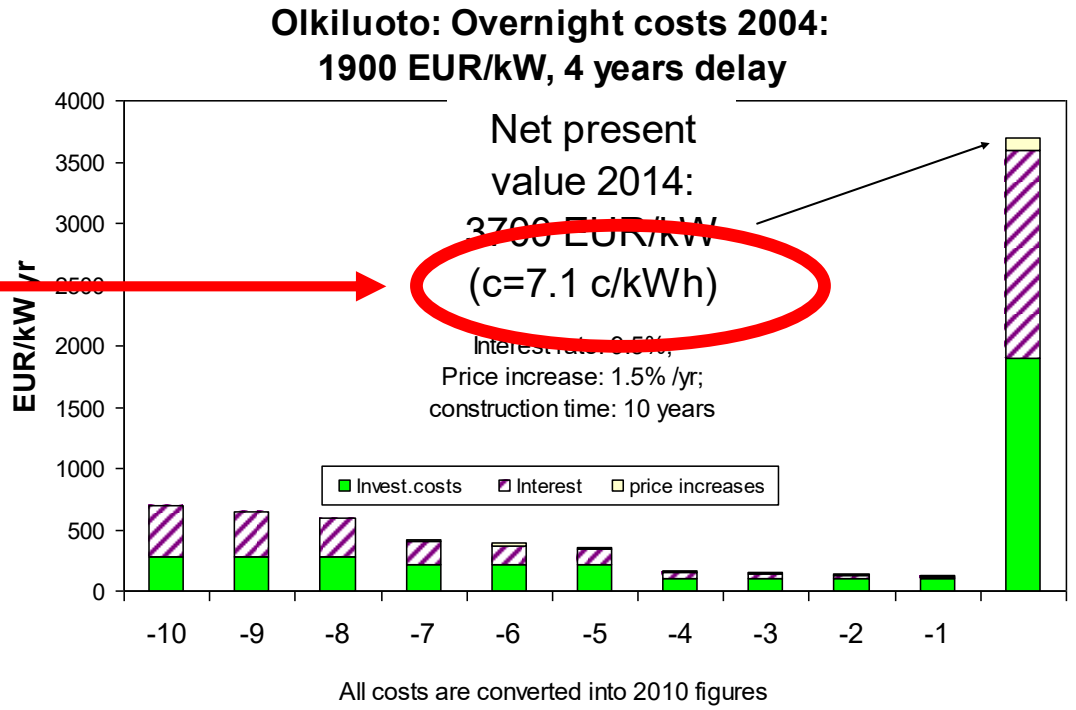
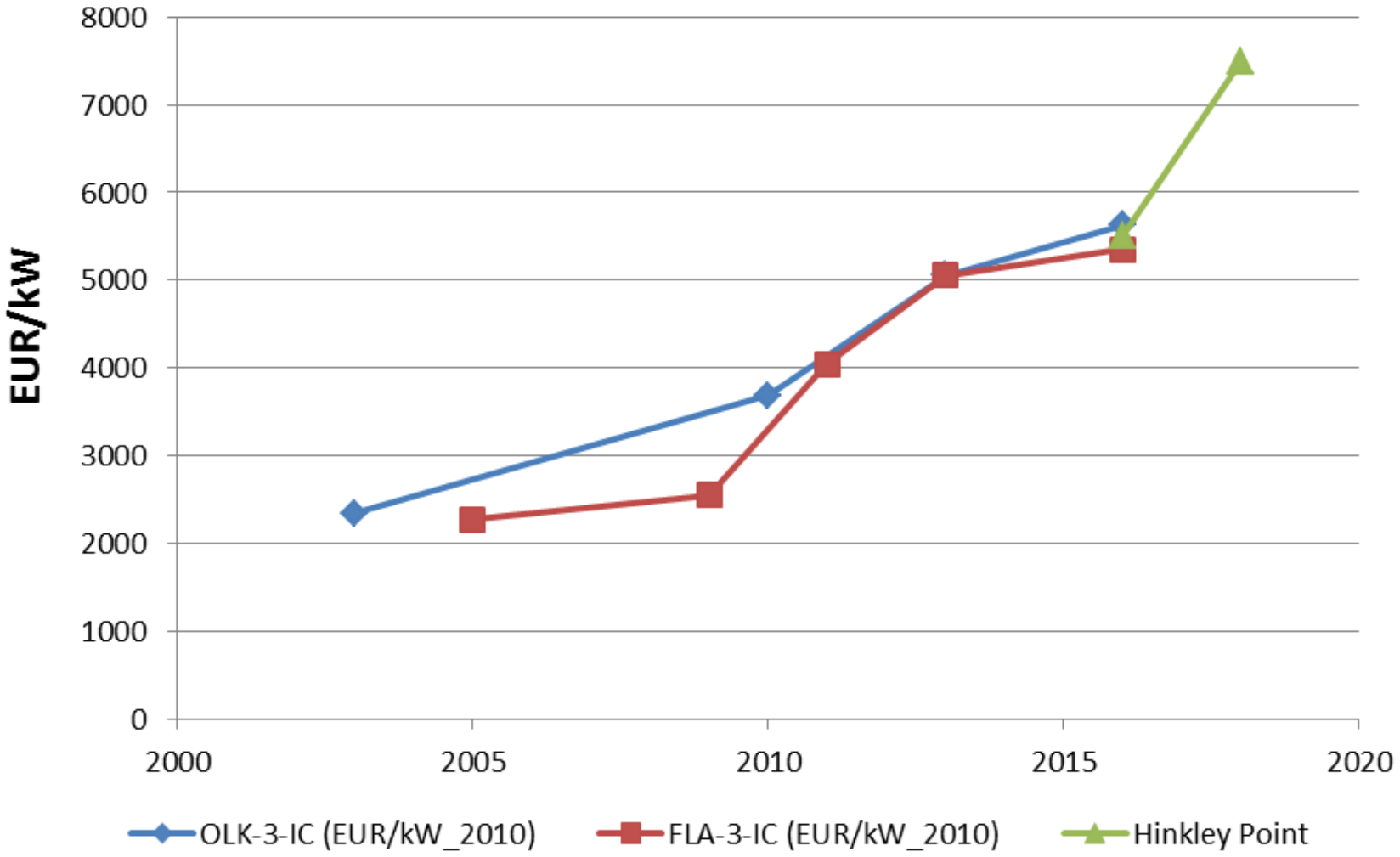


All costs are converted into 2010 figures


Olkiluoto: Overnight costs 2004:
1900 EUR/kW, no delay
Net present value
2010:
(c=5.1 c/kWh)
Price increase: 0.5% /yr;
construction time: 6 years
Invest.costs
Interest
price increases
EUR/kW yr
4000
3500
3000
2500
2000
1500
1000
500
0
-6
-5
-4
-3
-2
-1
0
All costs are converted into 2010 figures

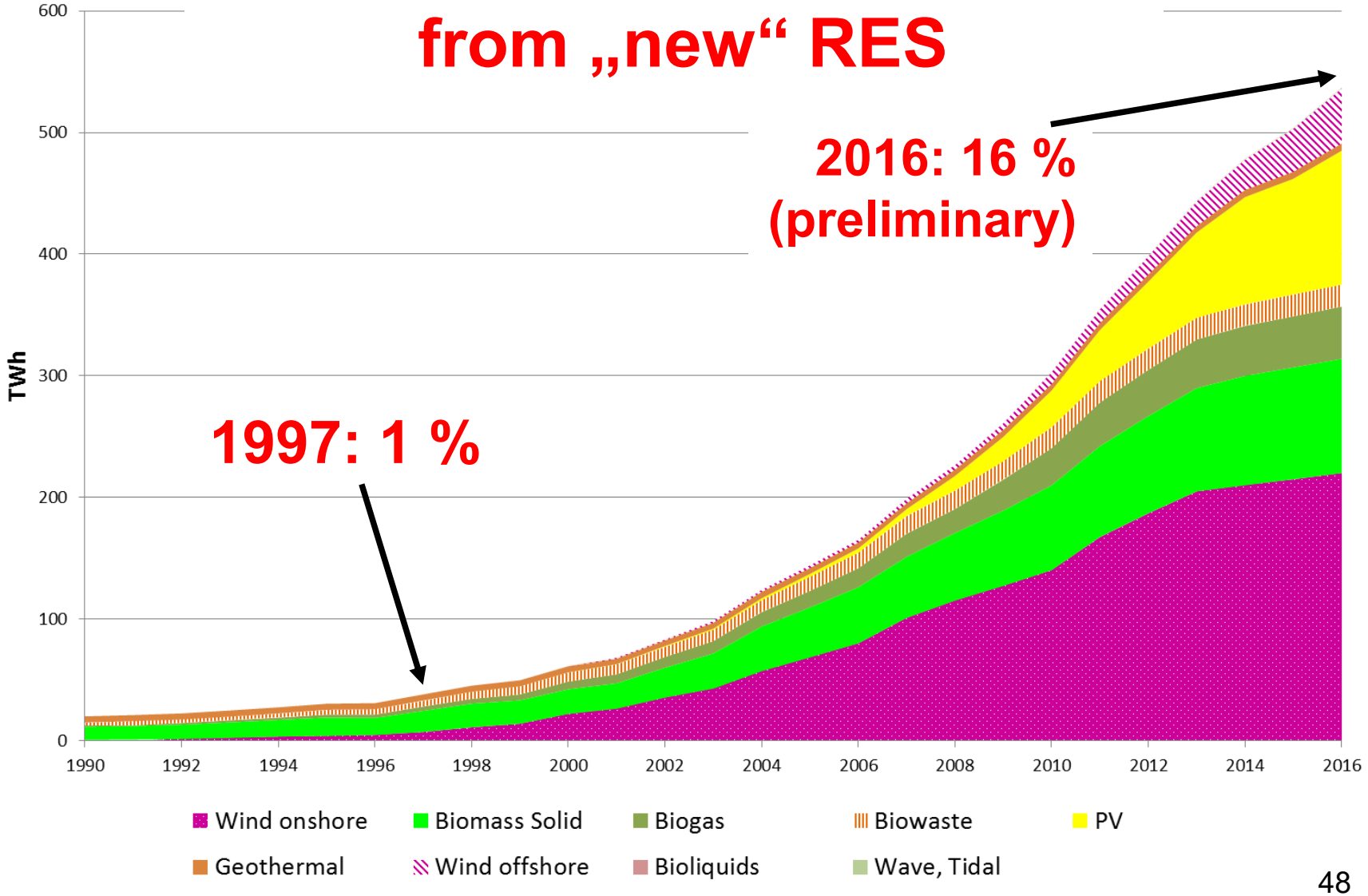

Olkiluoto: Overnight costs 2004:
1900 EUR/kW, 4 years delay
Net present
value 2014:
(c=7.1 c/kWh)
Price increase: 1.5% /yr;
construction time: 10 years
Invest.costs
Interest
price increases
EUR/kW yr
4000
3500
3000
2500
2000
1500
1000
500
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
All costs are converted into 2010 figures

Investment cost development Olkiluoto 3 vs Flamanville 3 vs HP



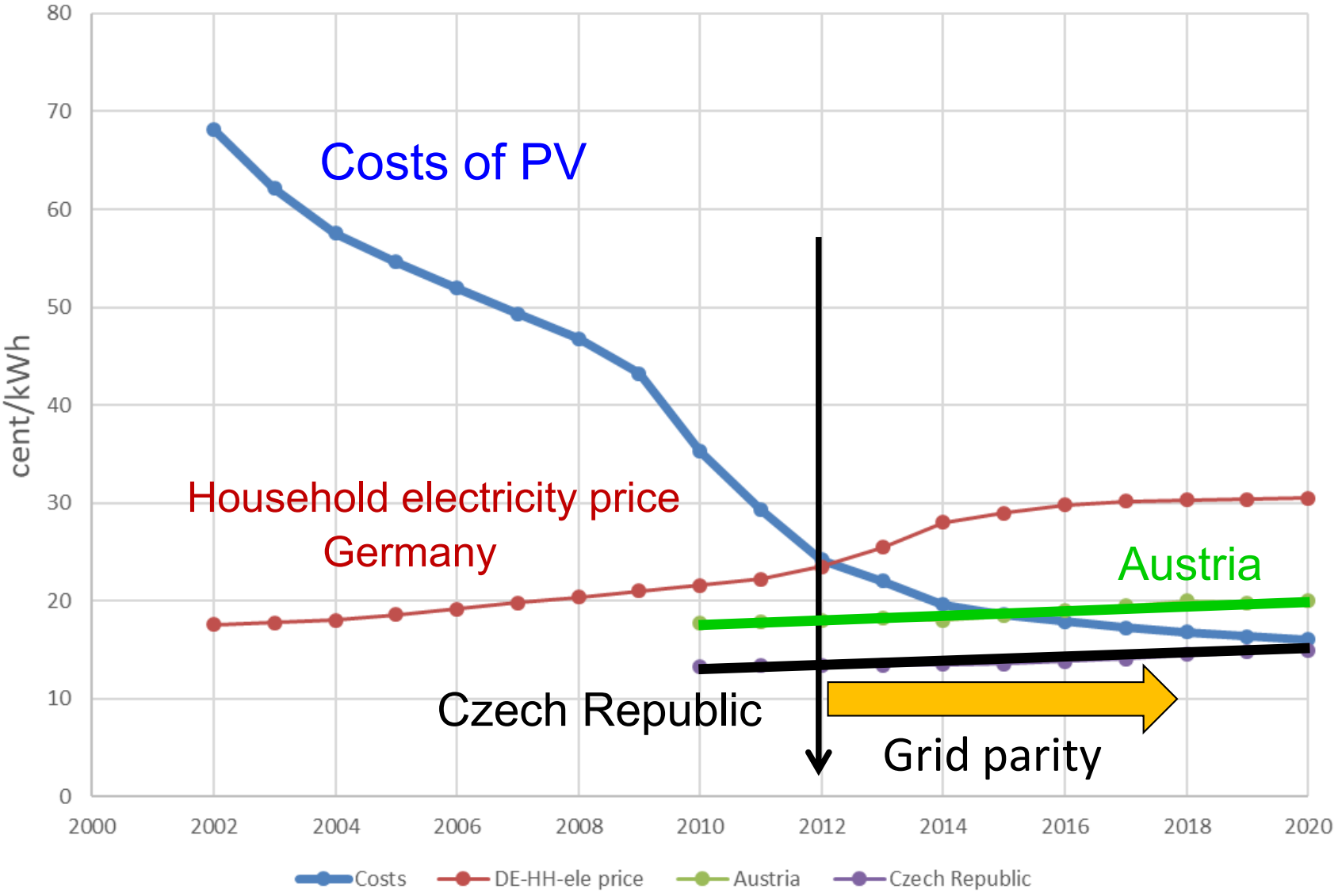
7. THE ROLE OF RENEWABLES

EU-28: Electricity generation from „new“ RES

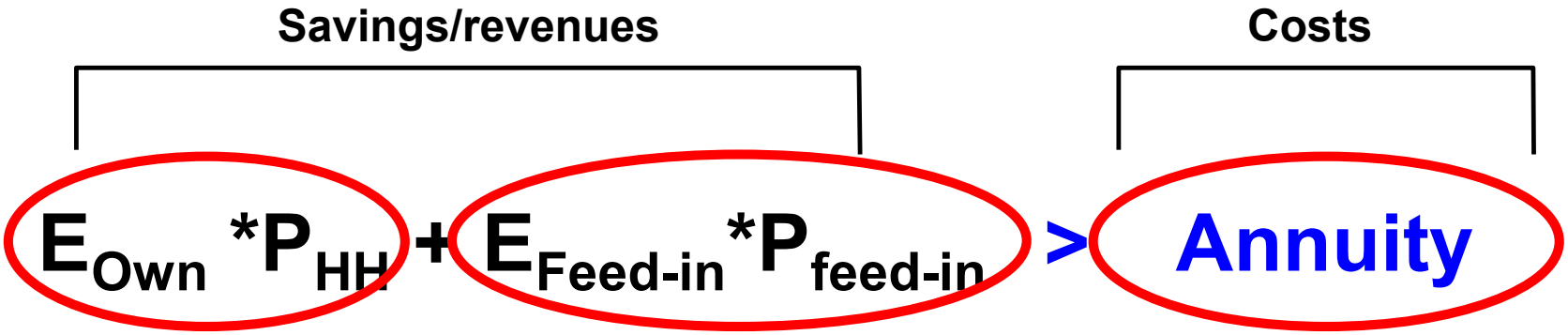


Source: EUROSTAT, own estimations

Grid parity: PV-costs and household electricity prices



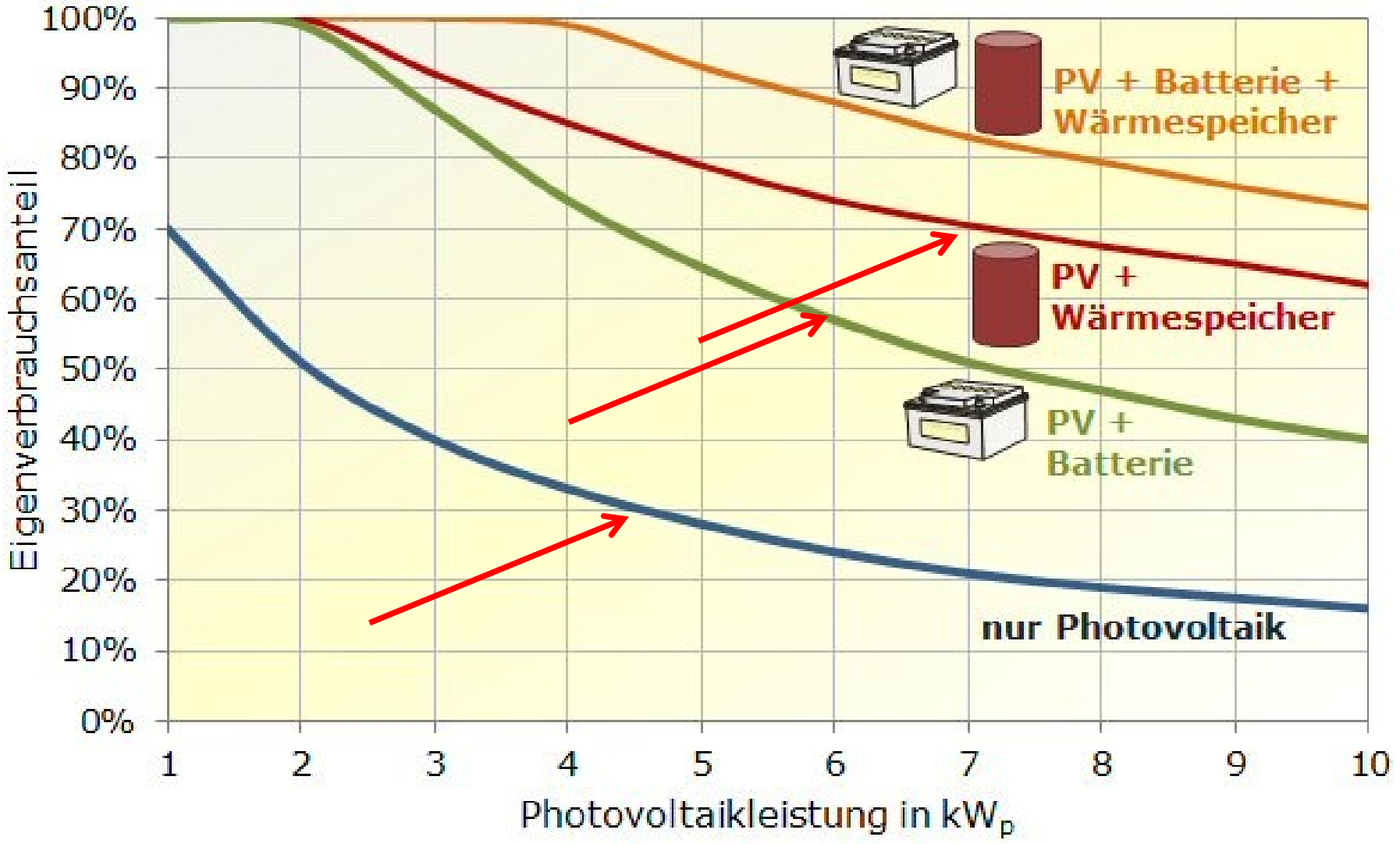
Assessment of Grid Parity



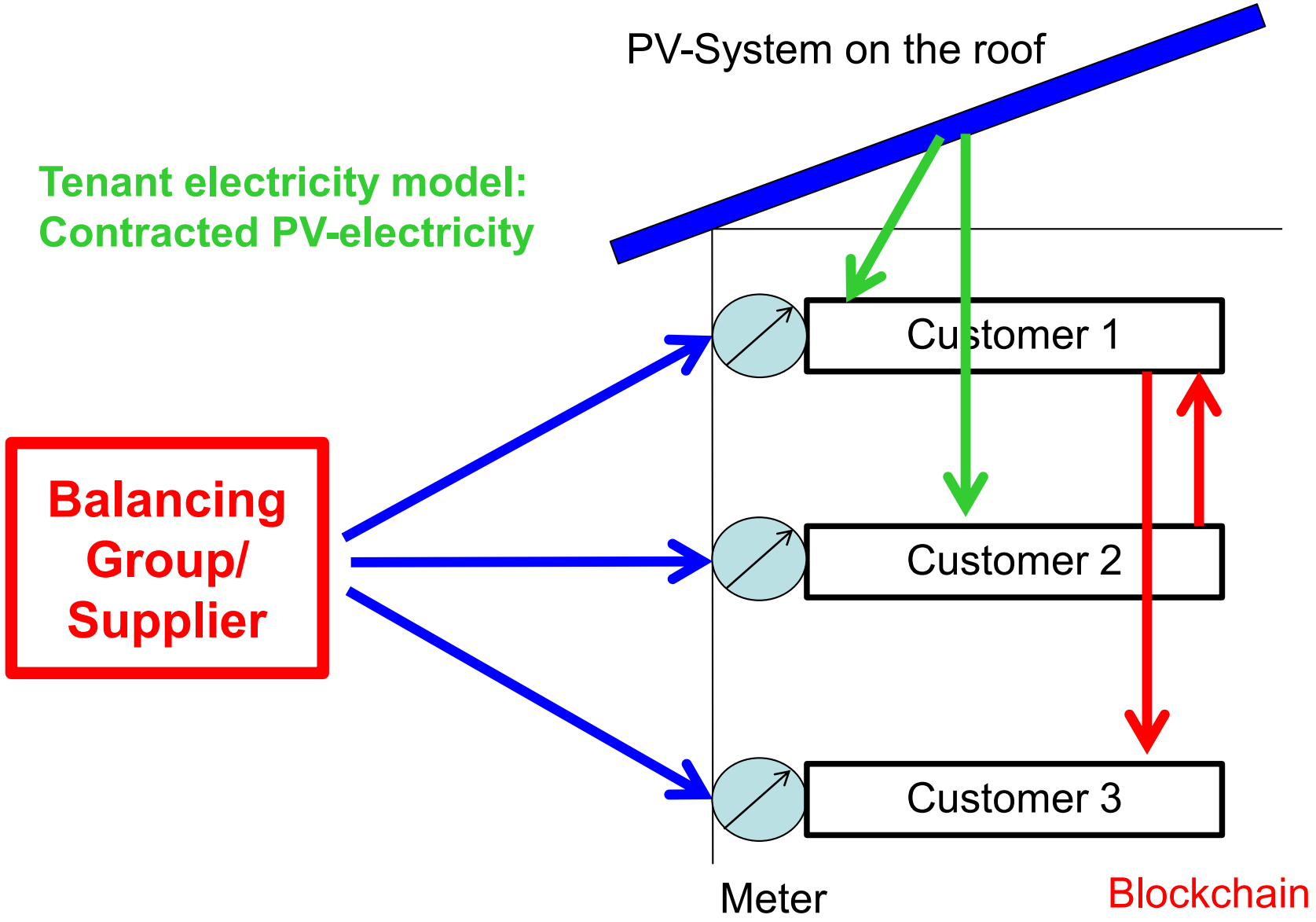
Grid parity term

Subsidy still necessary?

Share of own consumption



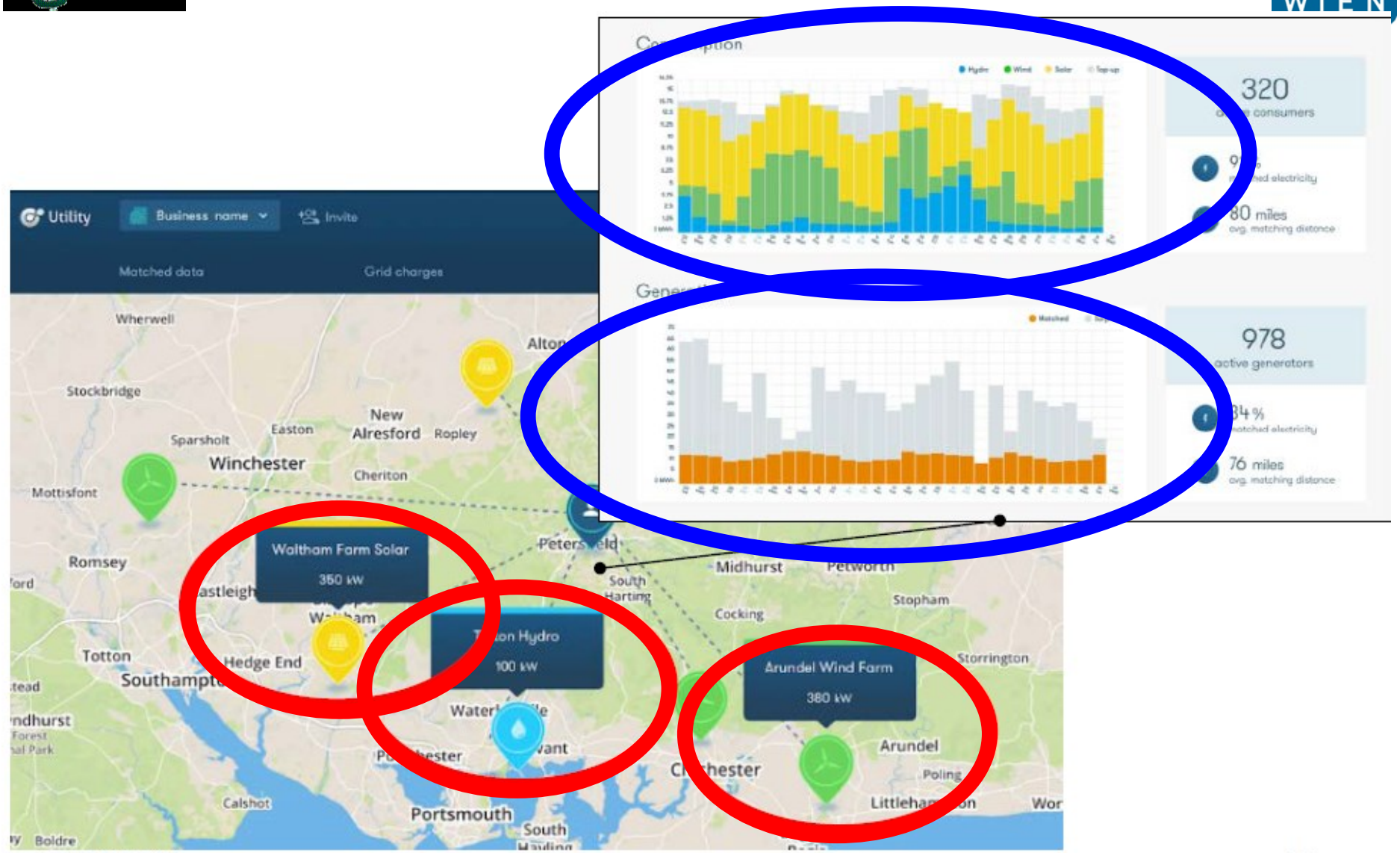
Tenant electricity model and Blockchain



Promotion of decentralized PV in Czech Republic

- Program is opened for family houses and blocks of flats
- Currently 3rd call for family houses includes:
  - PV systems for power: *below 10 kWp,
    * should be connected to the grid
  - Systems with and without batteries with utilization of excess electricity for hot water or general own use are subsidized
  - Generated power should be used on site of generation at least by 70%

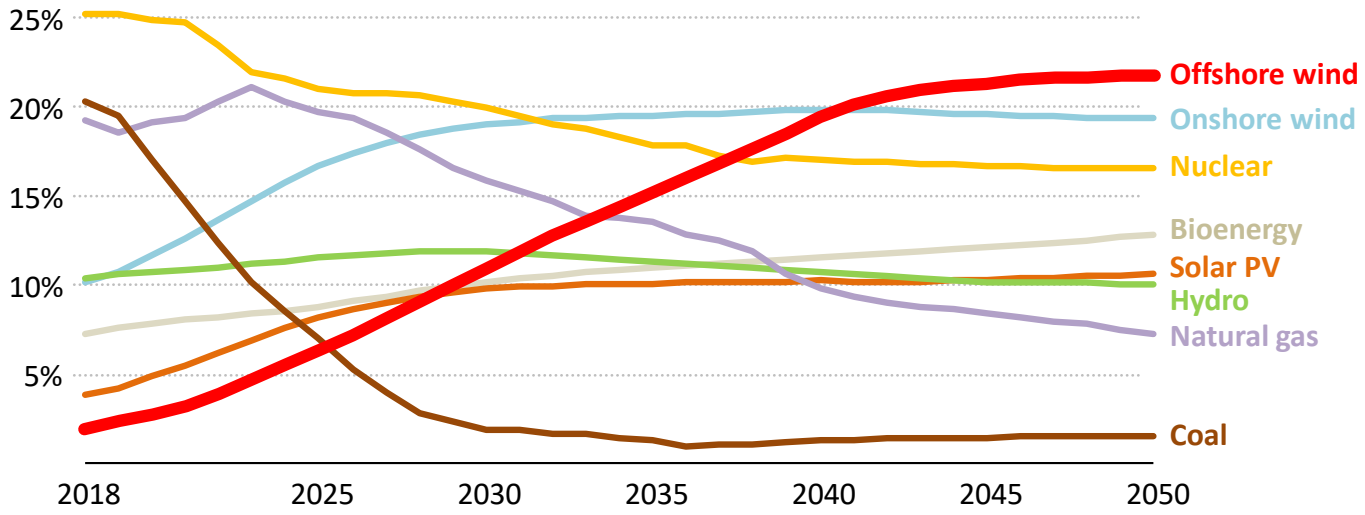
Peer-to-peer



Source: piclo.co.uk

A carbon neutral Europe puts offshore wind in front

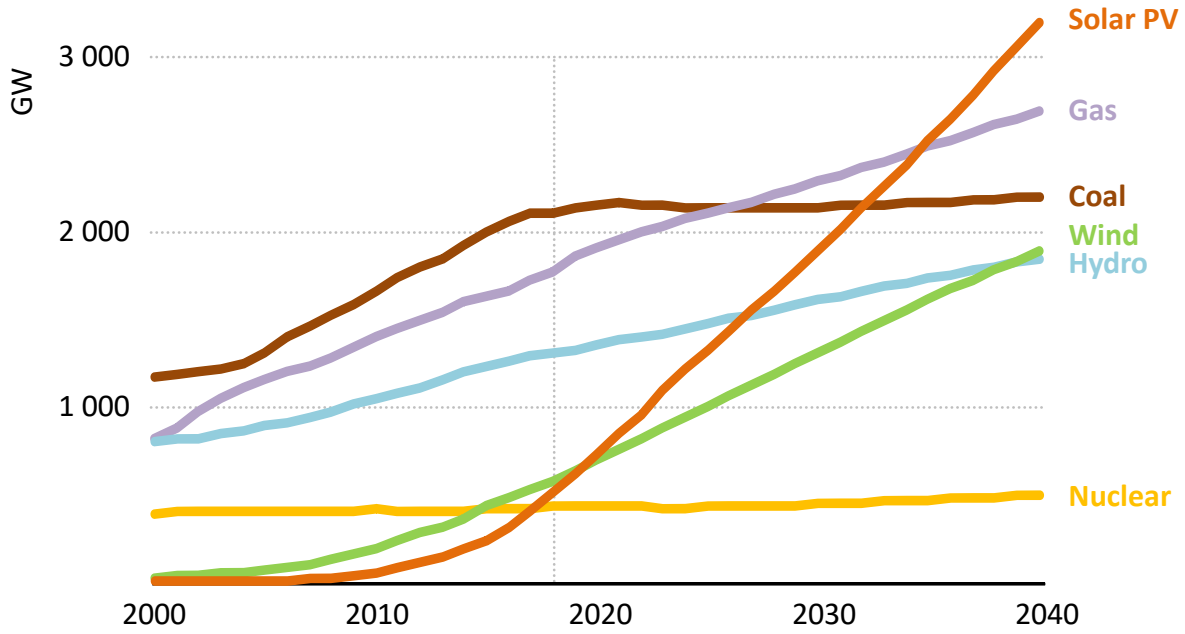
Shares of electricity generation by technology in the European Union, Sustainable Development Scenario



Offshore wind is set to become the largest source of electricity in the European Union by 2040, complementing other renewables towards a fully decarbonised power system

ar PV projects are taking off

Global power capacity by source in the Stated Policies Scenario



The power mix is being re-shaped by the rise of renewables and natural gas. In 2040, renewables account for nearly half of total electricity generation.

8. CONCLUSIONS:

- Markets are in a period of transition towards volatility;
- Nuclear: long lead time, uncertain costs → high promises, low fullfilments;
- Renewables: next very interesting phase: after PV-Grid parity!
- More details: Summer school

Example: Costs of electricity generation from CCGT

6000 h/yr:

Low fuel & CO2-price:

C = 1.0 + 0.33 + 1.72 +0.17 = 3.22 cent/kWh

High fuel & CO2-price:

C = 1.0 + 0.33 + 4.31 +0.86 = 6.50 cent/kWh

1000 h/yr:

Low fuel & CO2-price:

C = 6.0 + 2.0 + 1.72 +0.17 = 9.89 cent/kWh

High fuel & CO2-price:

C = 6.0 + 2.0 + 4.31 +0.86 = 13.17 cent/kWh