



# **ELECTRICITY MARKETS, RENEWABLES & THE ENVIRONMENT**

**Reinhard Haas**

Energy Economics Group,  
Vienna University of Technology

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# SURVEY

- 1. Introduction: Historical background**
- 2. How prices come about (theory)**
- 3. Environmental issues: CO<sub>2</sub>-prices**
- 4. How prices developed in Europe**
- 5. Electricity generation costs**
- 6. The role of Renewables**
- 7. Conclusions**

# 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 energy system?**

**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”**

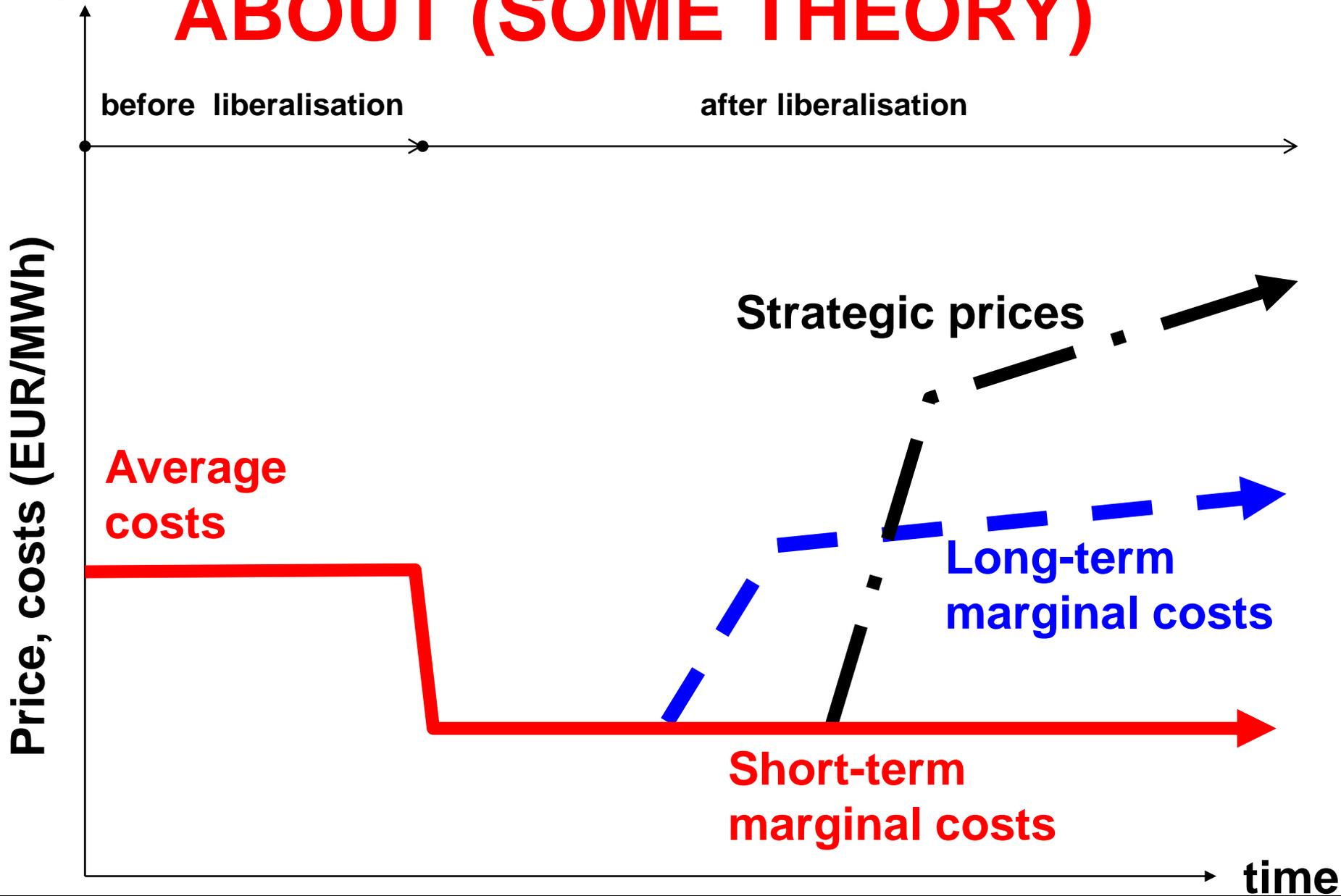
- **Intentions of the EC directive:**

- Competitive markets**

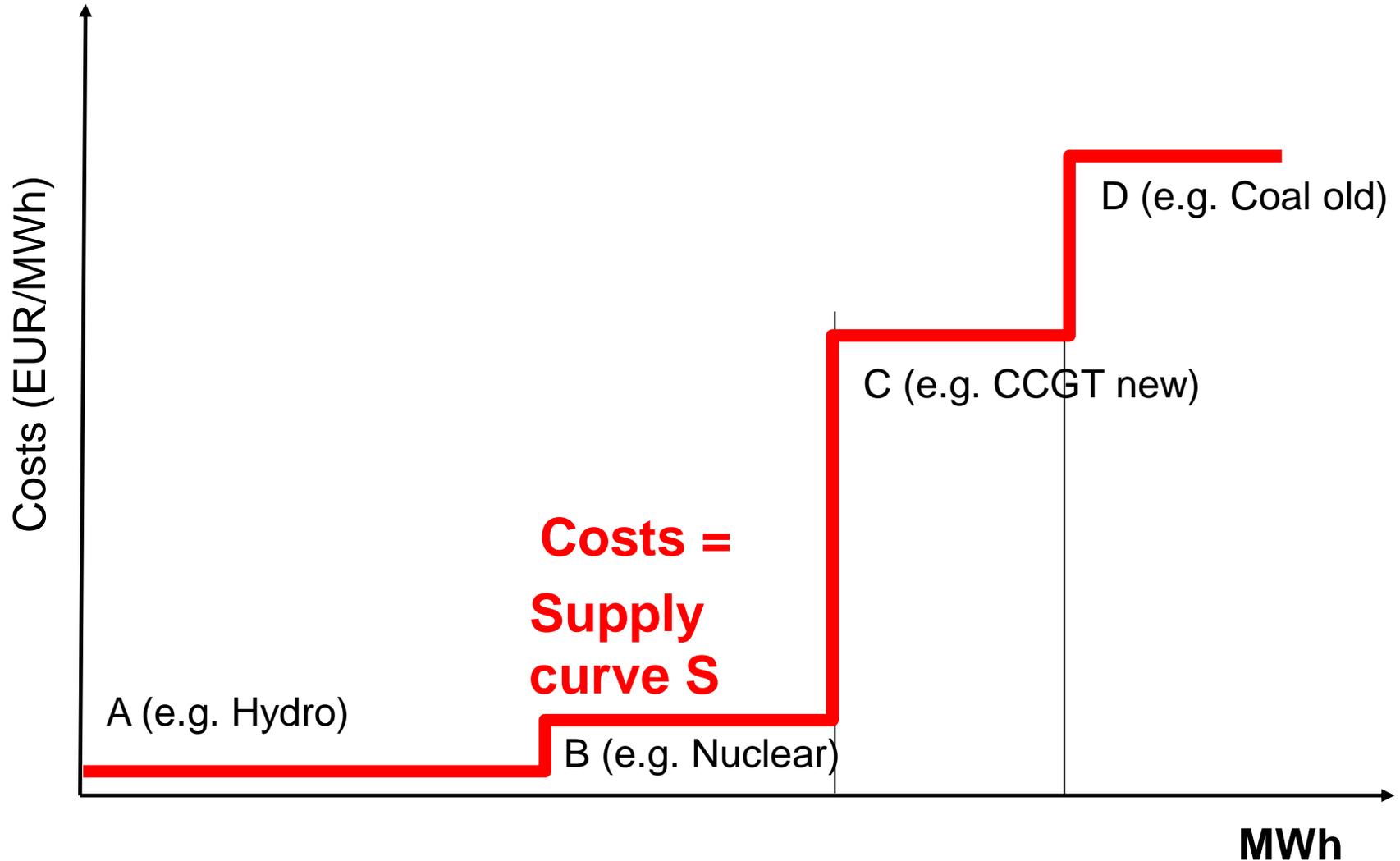
- lower electricity prices**

- more environmentally benign**

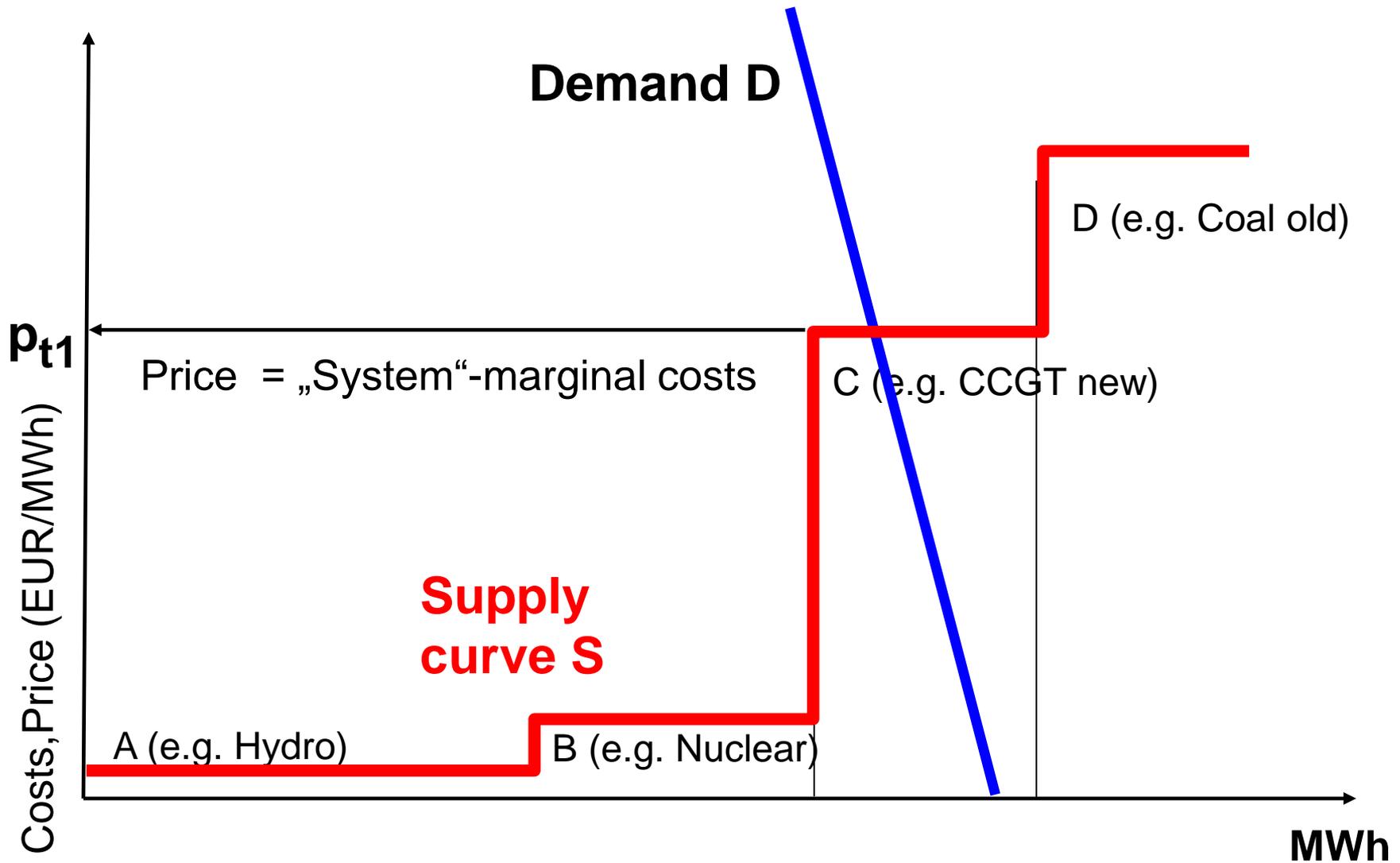
# 2 HOW PRICES COME ABOUT (SOME THEORY)



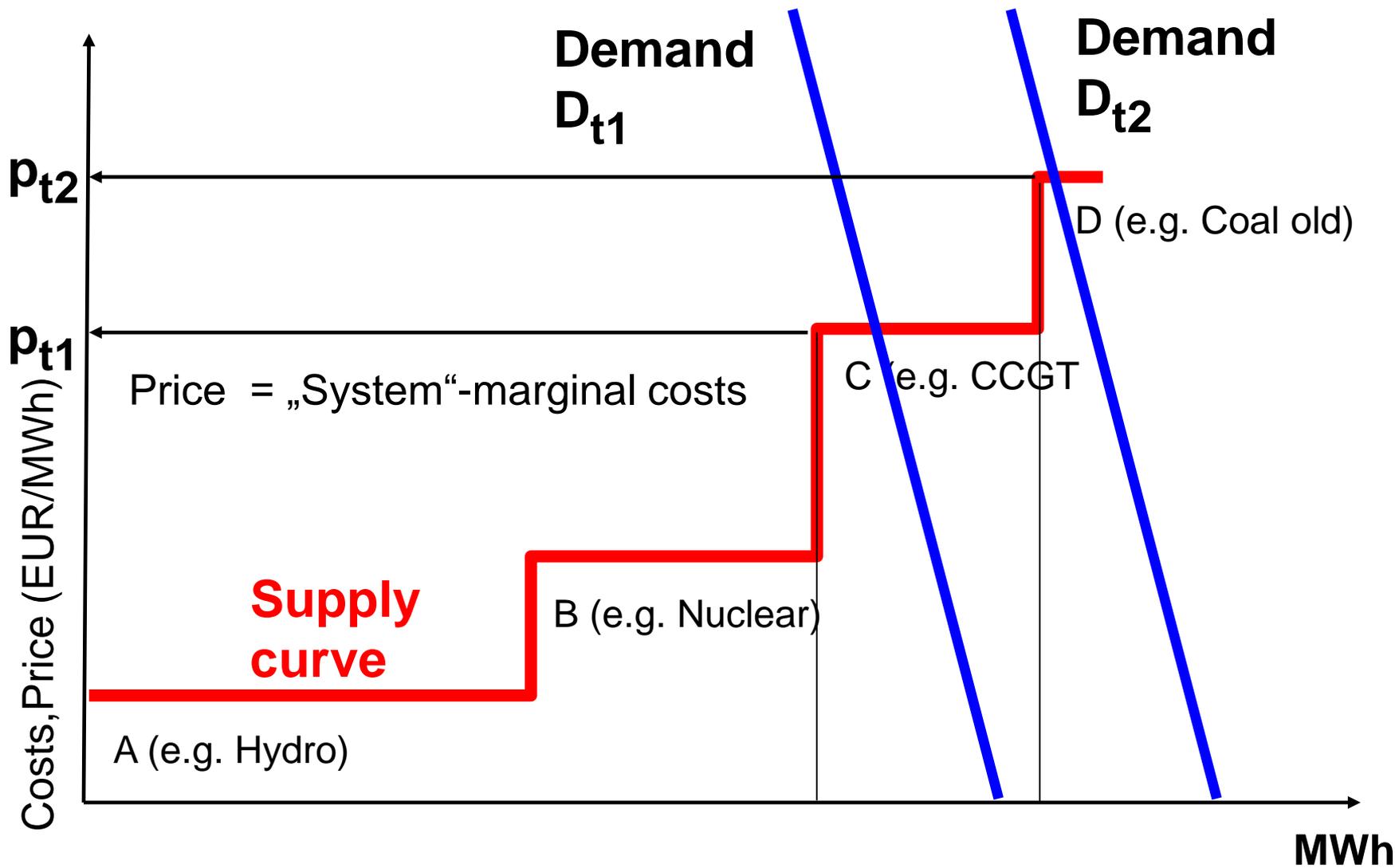
# THE SUPPLY CURVE (SHORT-TERM)



# BASIC PRINCIPLE OF COMPETITION: PRICE = MARGINAL COSTS

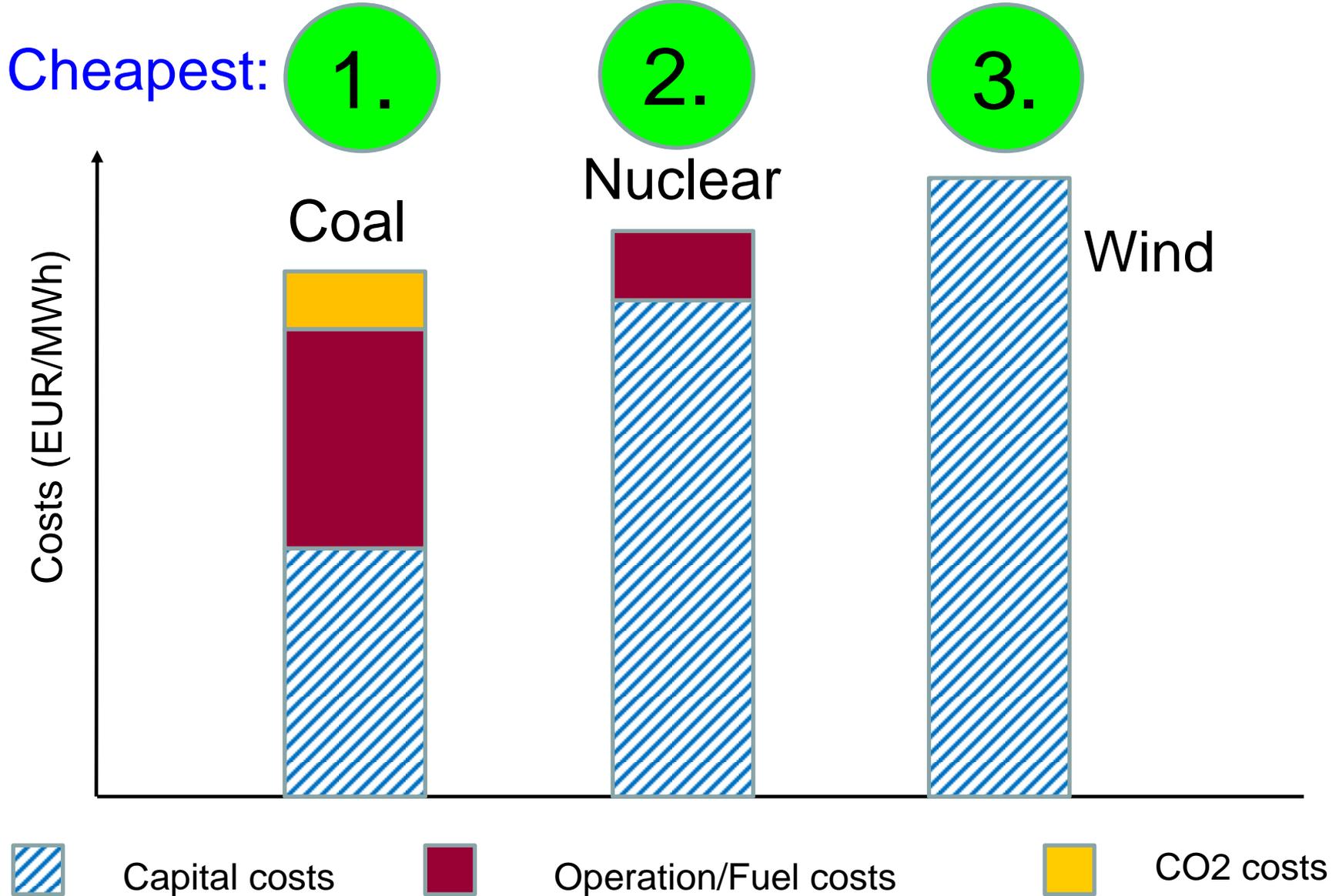


# PRICE = MARGINAL COSTS



**LONG-TERM  
VS  
SHORT-TERM  
MARGINAL COSTS**

# LONG-TERM MARGINAL COSTS



# SHORT-TERM MARGINAL COSTS

Cheapest:

3.

2.

1.

Coal

Nuclear

Wind

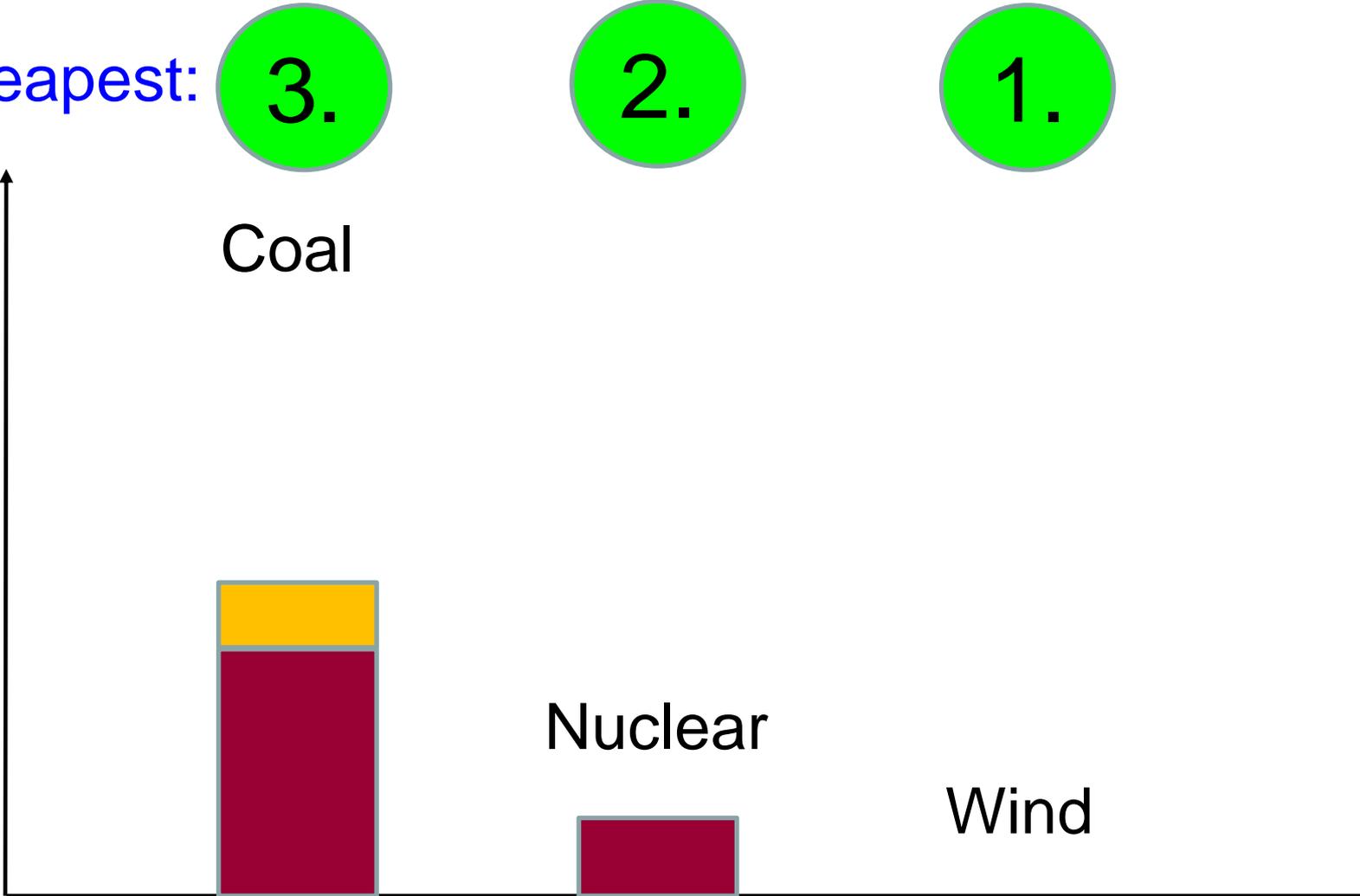
Costs (EUR/MWh)



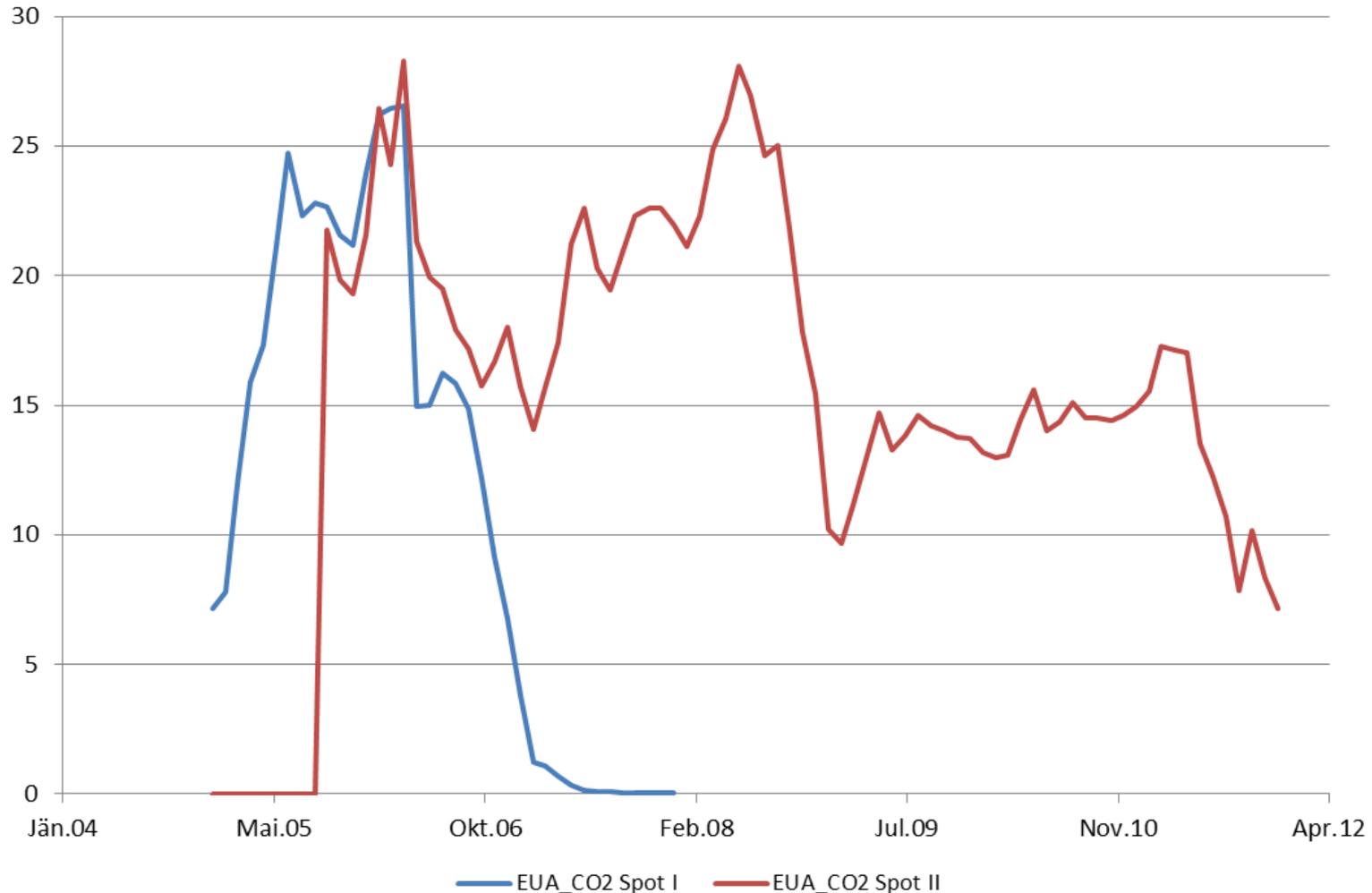
Operation/Fuel costs



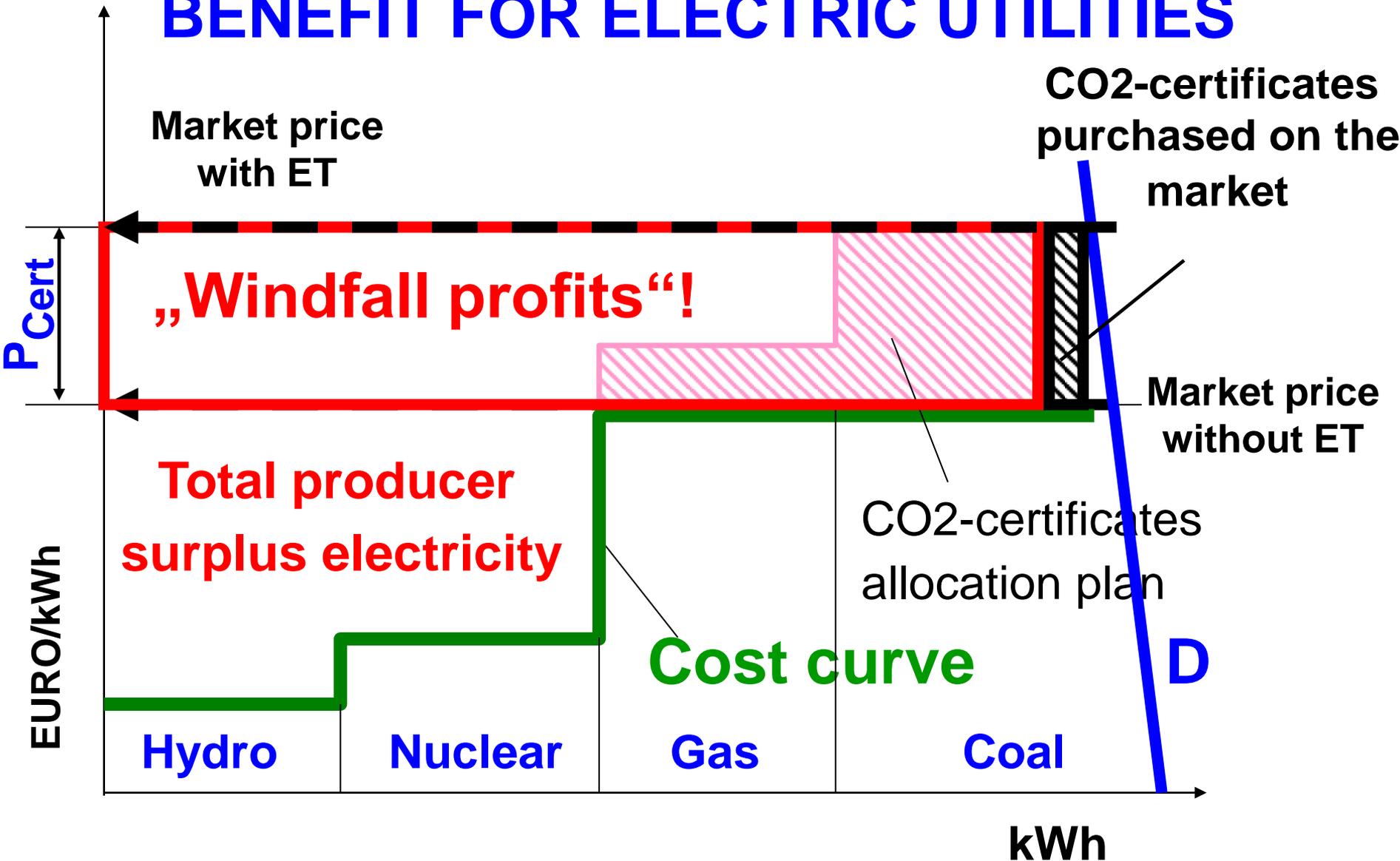
CO2 costs



# 3 ENVIRONMENTAL ASPECTS – THE CO<sub>2</sub>-PRICE

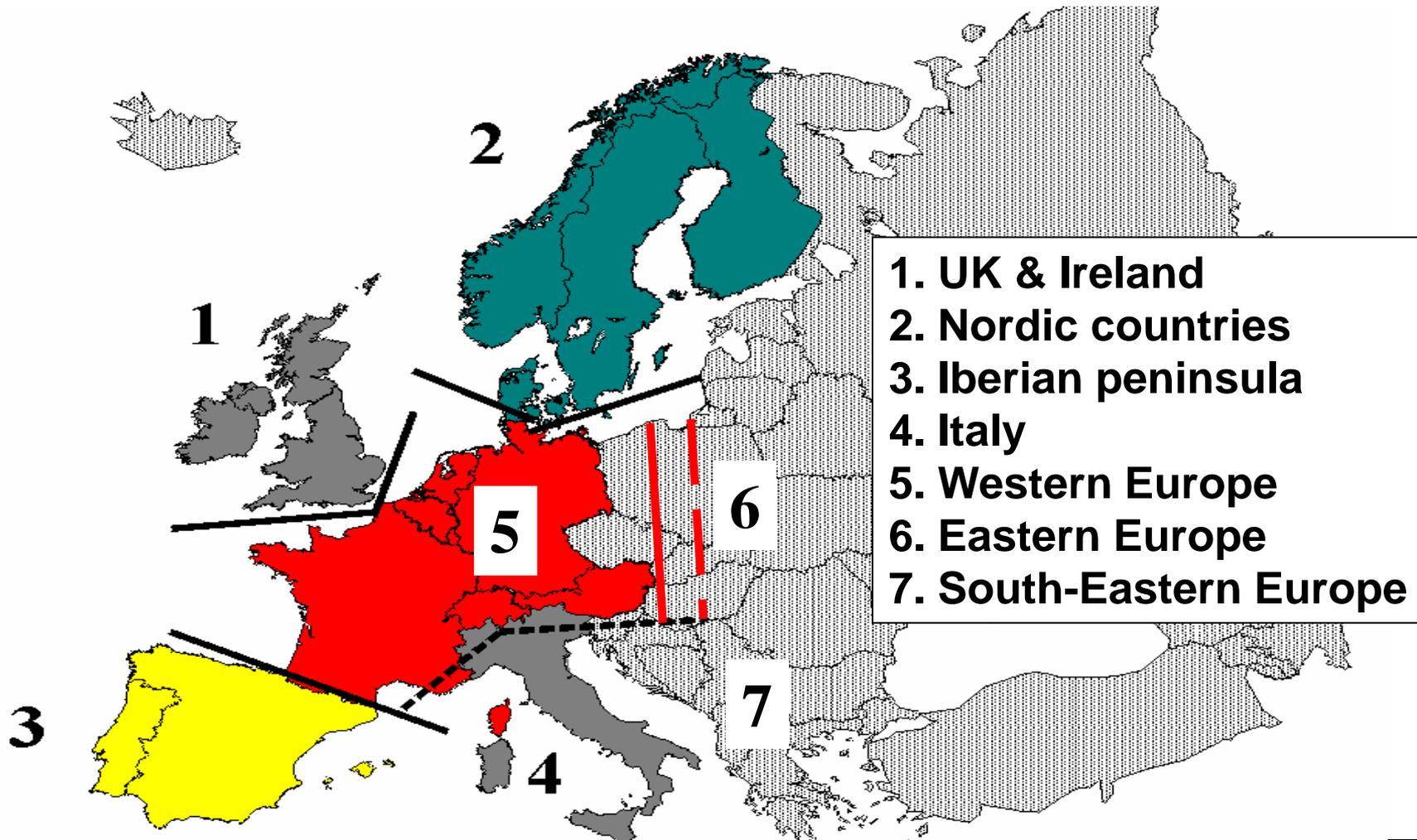


# EMISSION TRADING'S BENEFIT FOR ELECTRIC UTILITIES



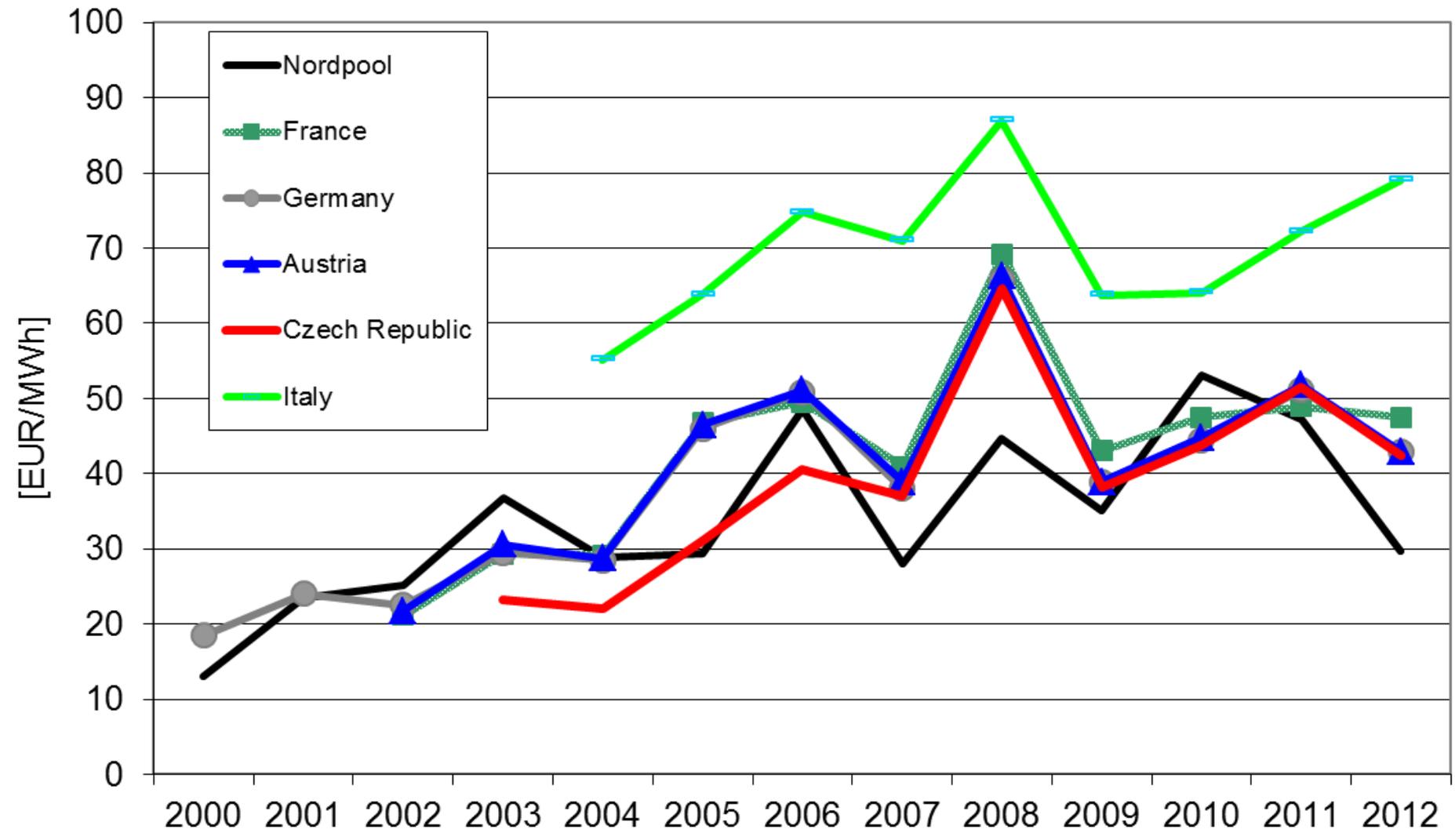
# 4 HOW PRICES DEVELOPED IN EUROPE

## EUROPEAN ELECTRICITY SUB-MARKETS

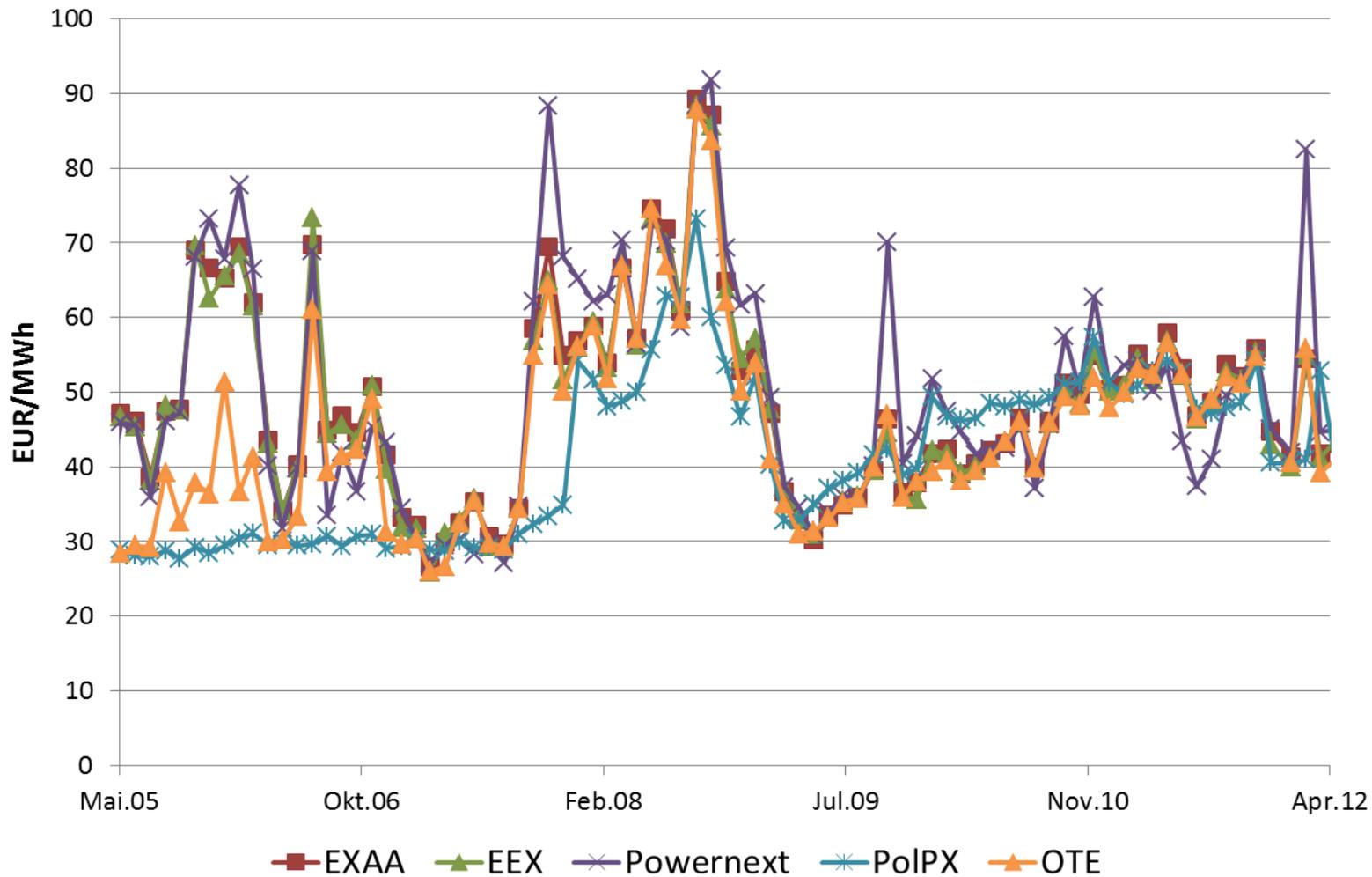




# SPOT MARKET PRICES IN EUROPE

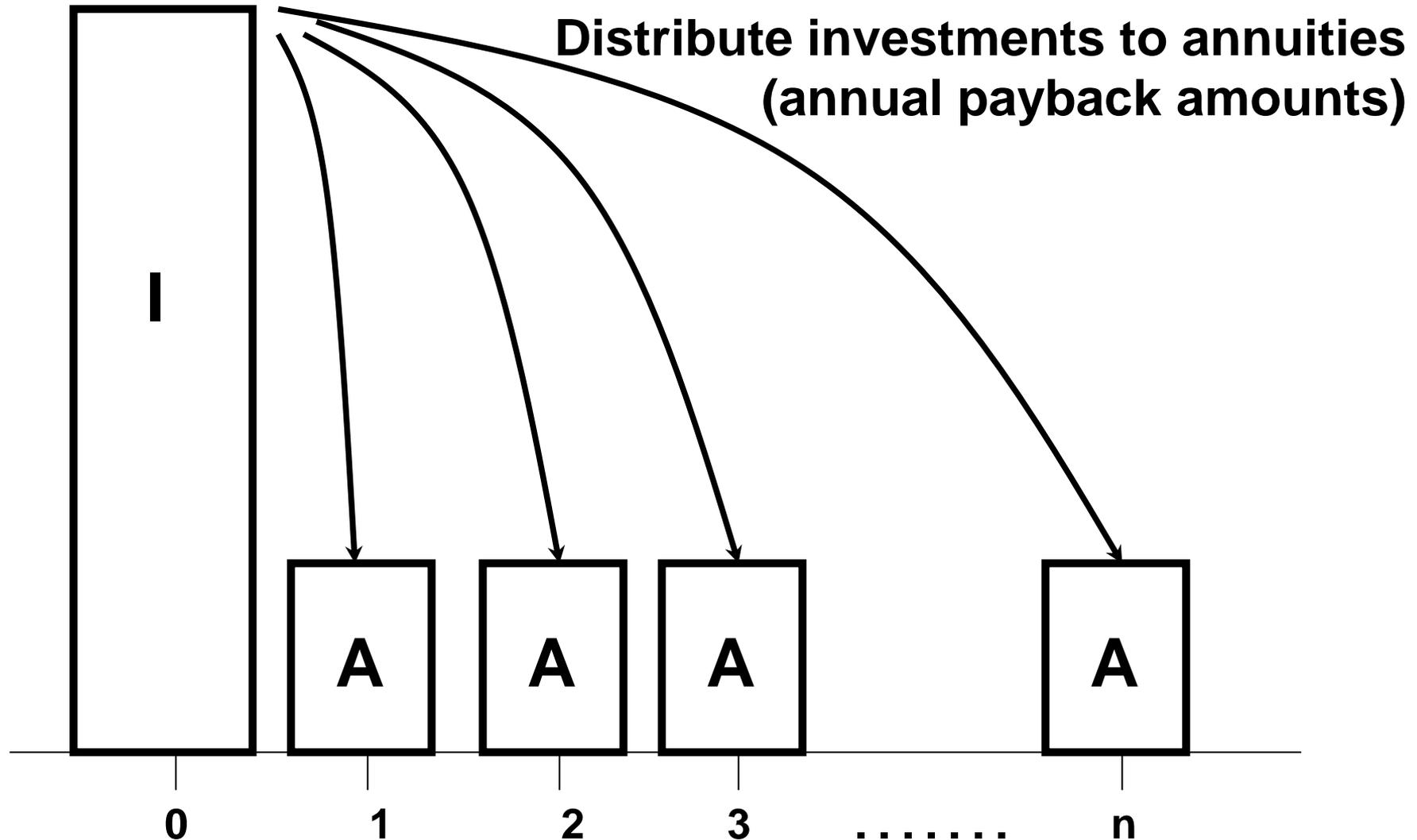


# FRANCE, GERMANY, AUSTRIA, CZECH REPUBLIC, POLAND – ONE CONVERGING MARKET



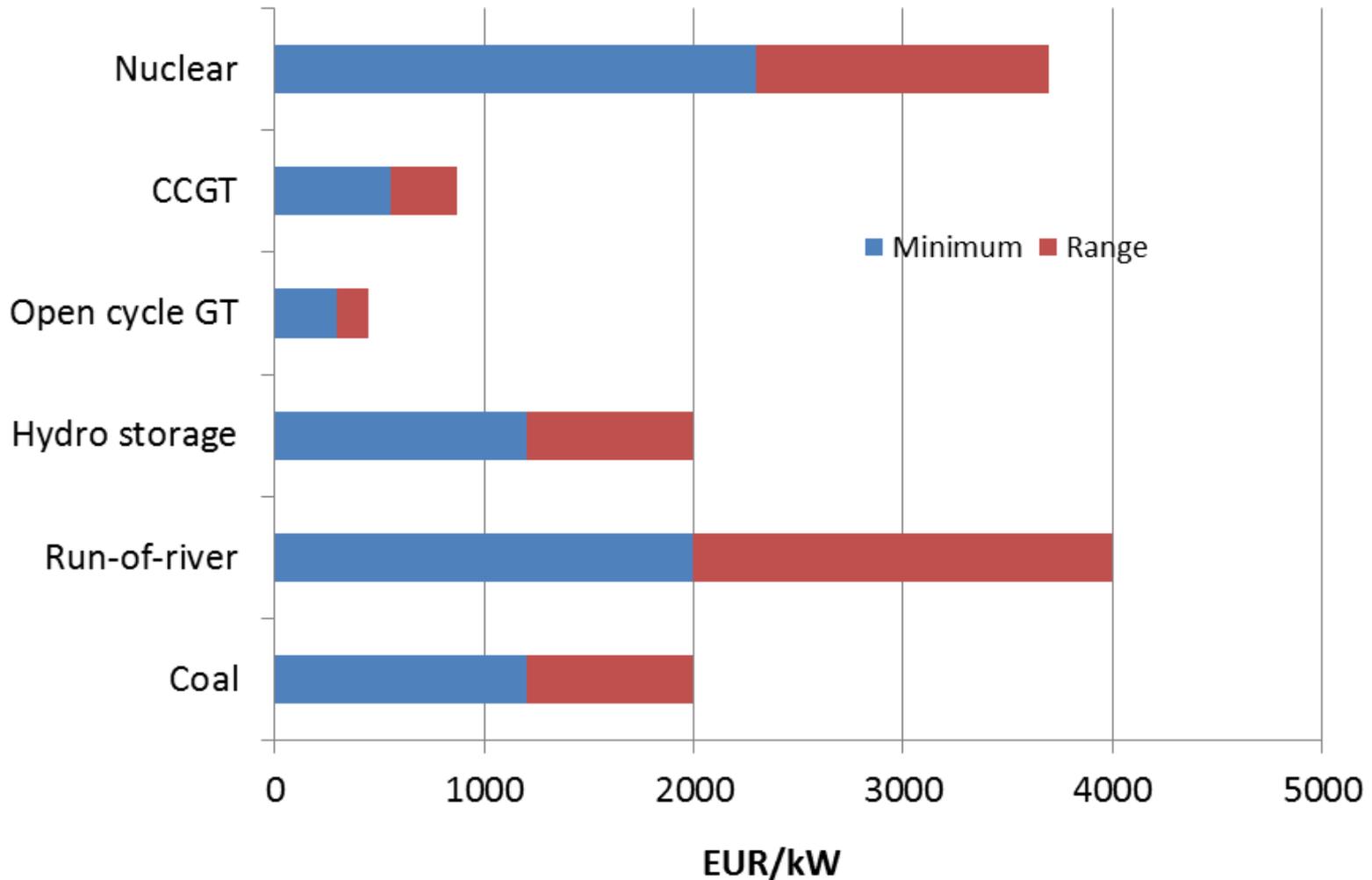
# 5 ELECTRICITY GENERATION COSTS

## ANNUITY METHOD

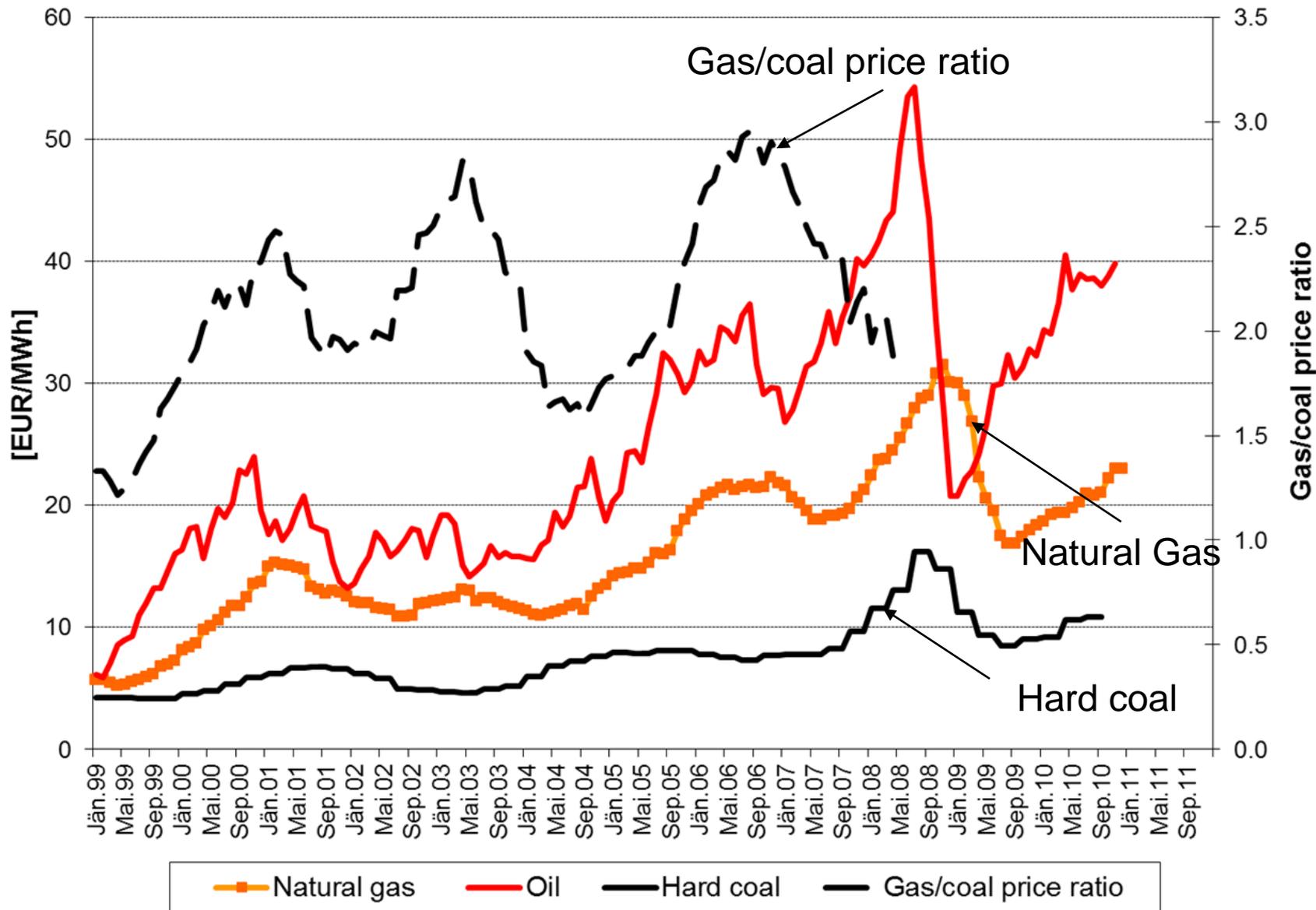


# Investment costs

## Electricity generation Conventional 2012



# FUEL PRICES 1999-2011



# Costs of electricity generation

$$C = C_F + C_V = \frac{I \alpha}{T} + \frac{p_f}{H \eta} + \frac{C_{CO_2} f_{CO_2}}{\eta} \quad \begin{array}{l} \text{cent} \\ \left[ \frac{\text{---}}{\text{kWh}} \right] \end{array}$$

where:

$C$  ... Total costs of electr. Generation (cent per kWh)

$C_F$  ... Fix costs (cent per kWh)

$C_V$  ... Variable costs (cent per kWh)

$I$  .... Investment costs (EUR/kW)

$\alpha$  ... C.R.F. (Capital recovery factor, e.g. 0.1 for 15 years, 5% WACC)

$T$  .... Full load hours (hours per year)

$p_f$  ... Fuel price (cent/kg or m<sup>3</sup>)

$H$  ... Caloric heat content (e.g. 10 kWh per m<sup>3</sup> for gas)

$\eta$  ... Efficiency of power plant

$C_{CO_2}$  ... Price of CO<sub>2</sub> (e.g. 5 EUR/ton Carbon)

$f_{CO_2}$  ... CO<sub>2</sub>-factor of fuel (0.2 kg Carbon/kWh)

# Example: Costs of electricity generation from CCGT

$$C = 1.20 + 4.31 + 0.17 = 5.68 \text{ cent/kWh}$$

I ....Investment costs = 600 EUR/kW

$\alpha$  ... C.R.F. = 0.1 for 15 years and 5% interest rate

T ....Full load hours = 5000 hours per year

$p_f$  ...Fuel price (e.g. 25 cents/m<sup>3</sup> natural gas)

H ...Caloric heat content (e.g. 10 kWh per m<sup>3</sup> for gas)

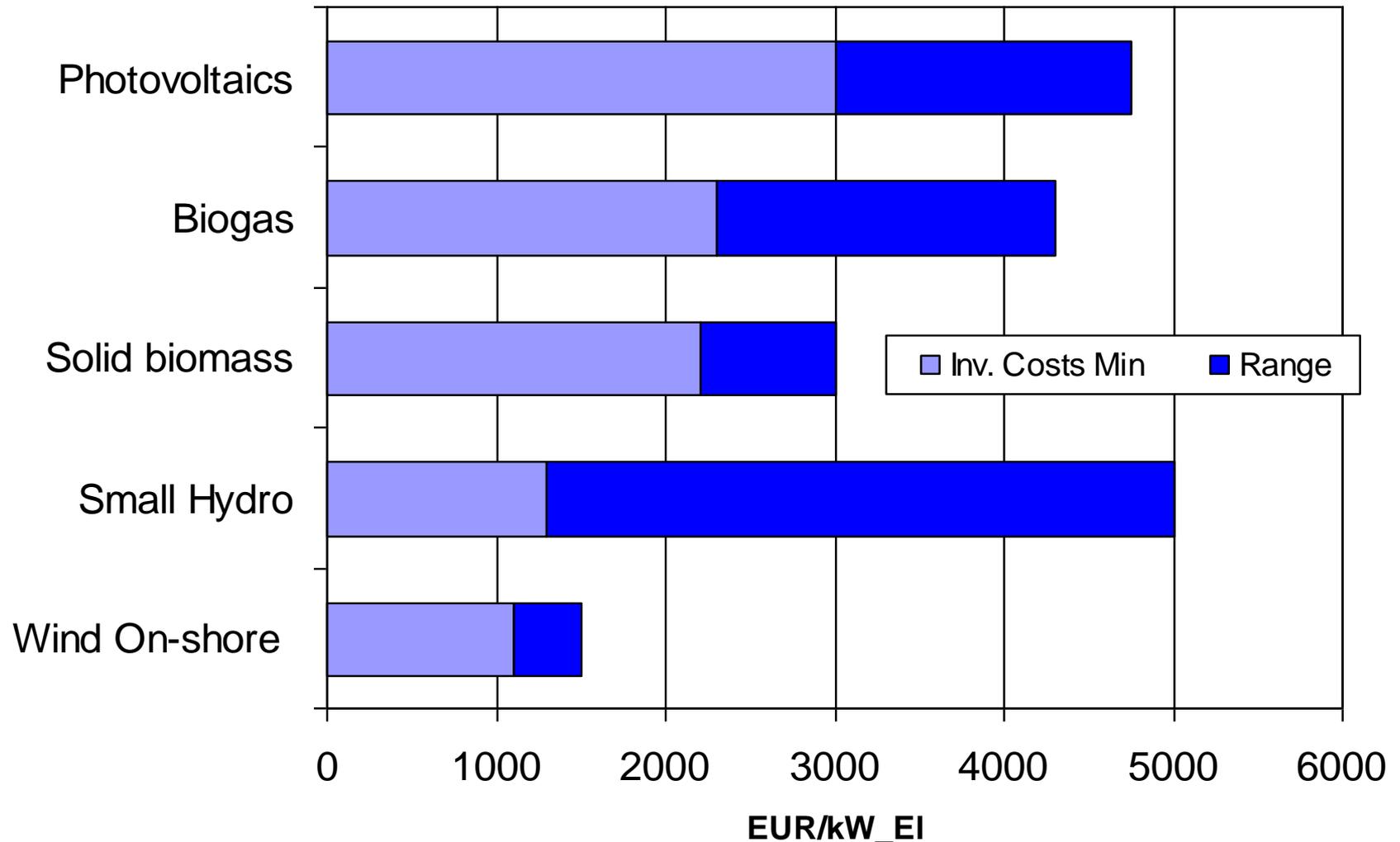
$\eta$  ...Efficiency of CCGT plant = 0.58

$C_{CO_2}$  ...Price of CO<sub>2</sub> (e.g. 5 EUR/ton Carbon)

$f_{CO_2}$  ... CO<sub>2</sub>-factor of fuel (0.2 kg Carbon/kWh)

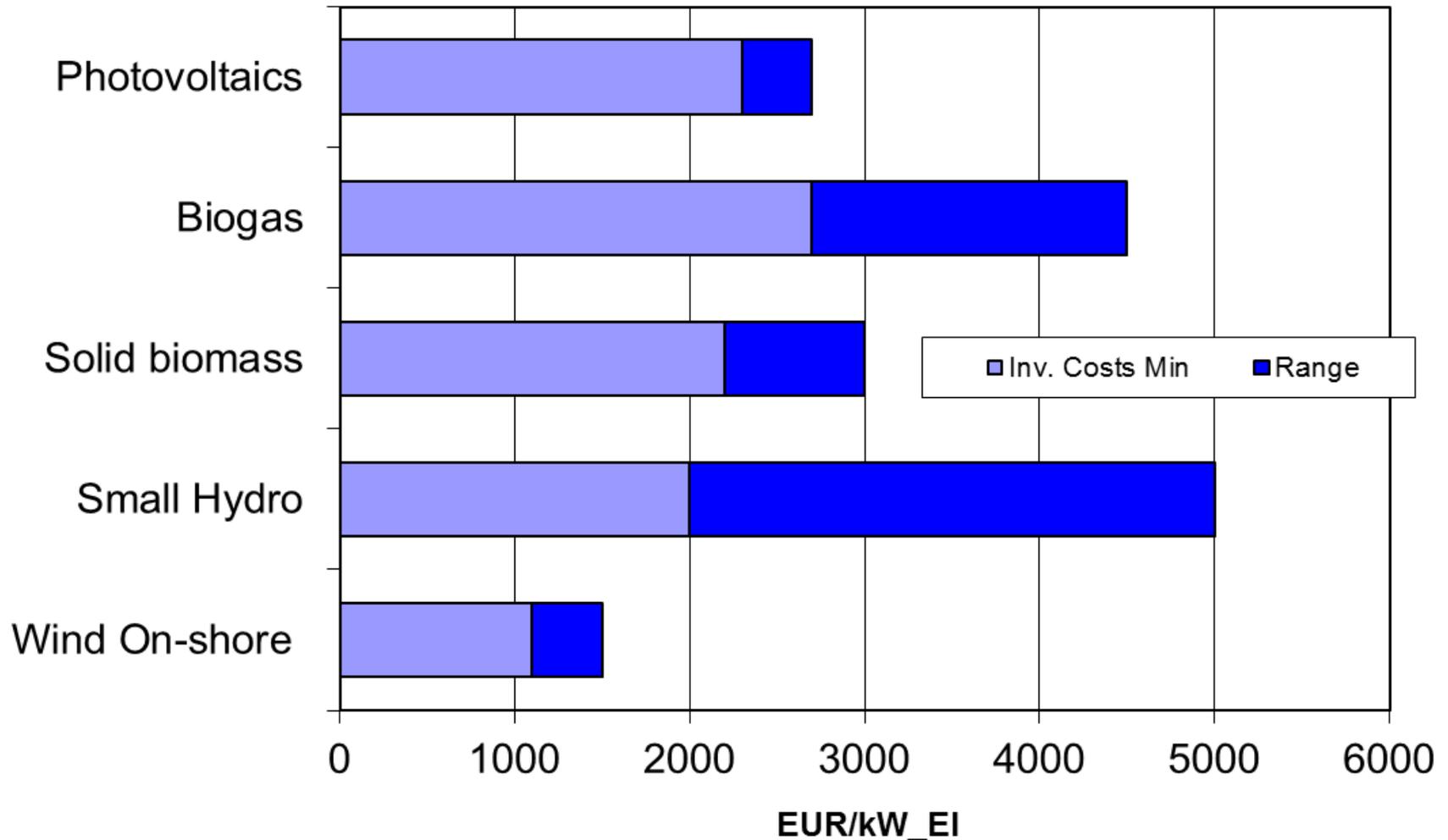
# Investment costs

## Electricity from new renewables 2010



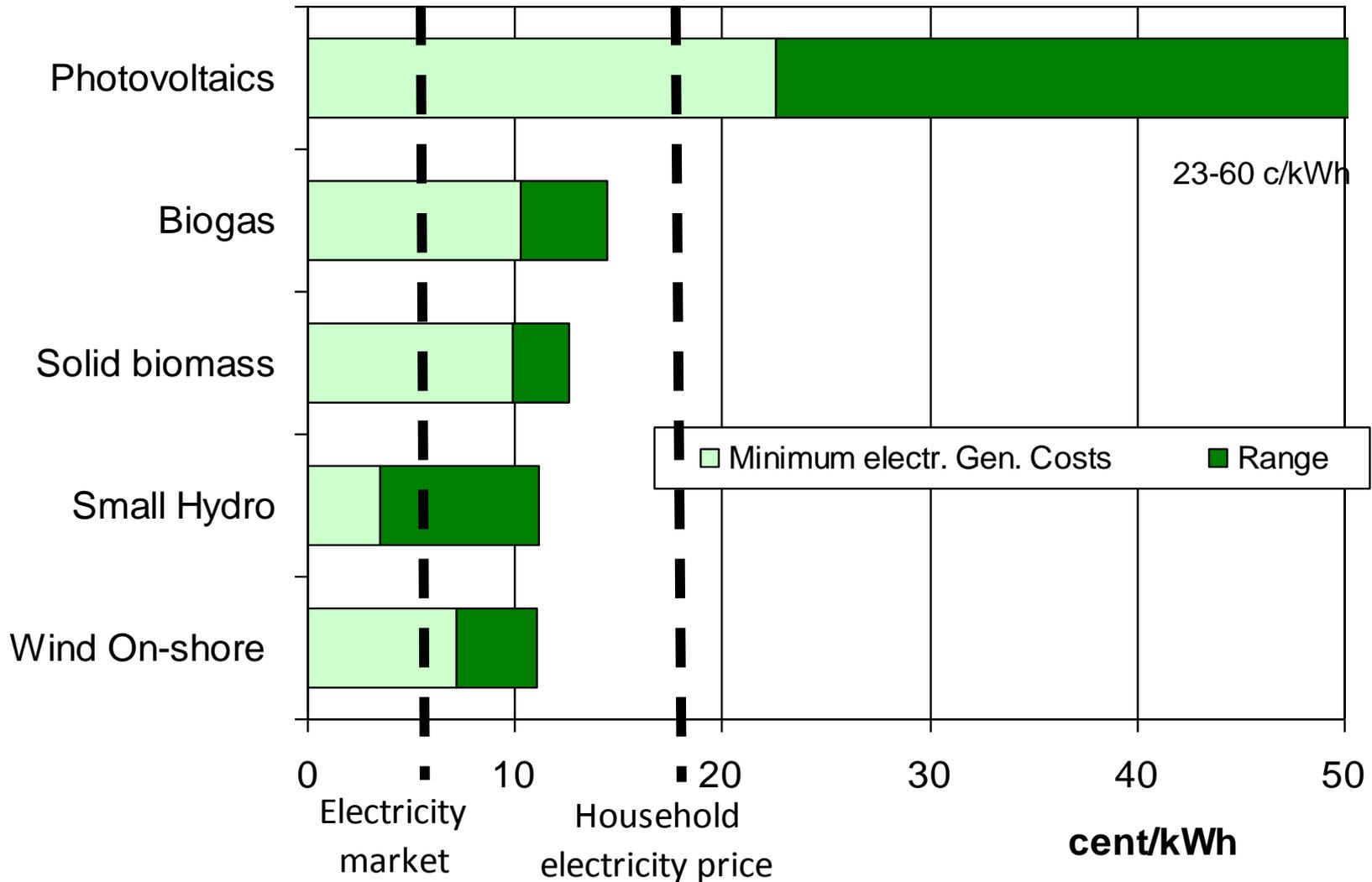
# Investment costs

## Electricity from new renewables 2012



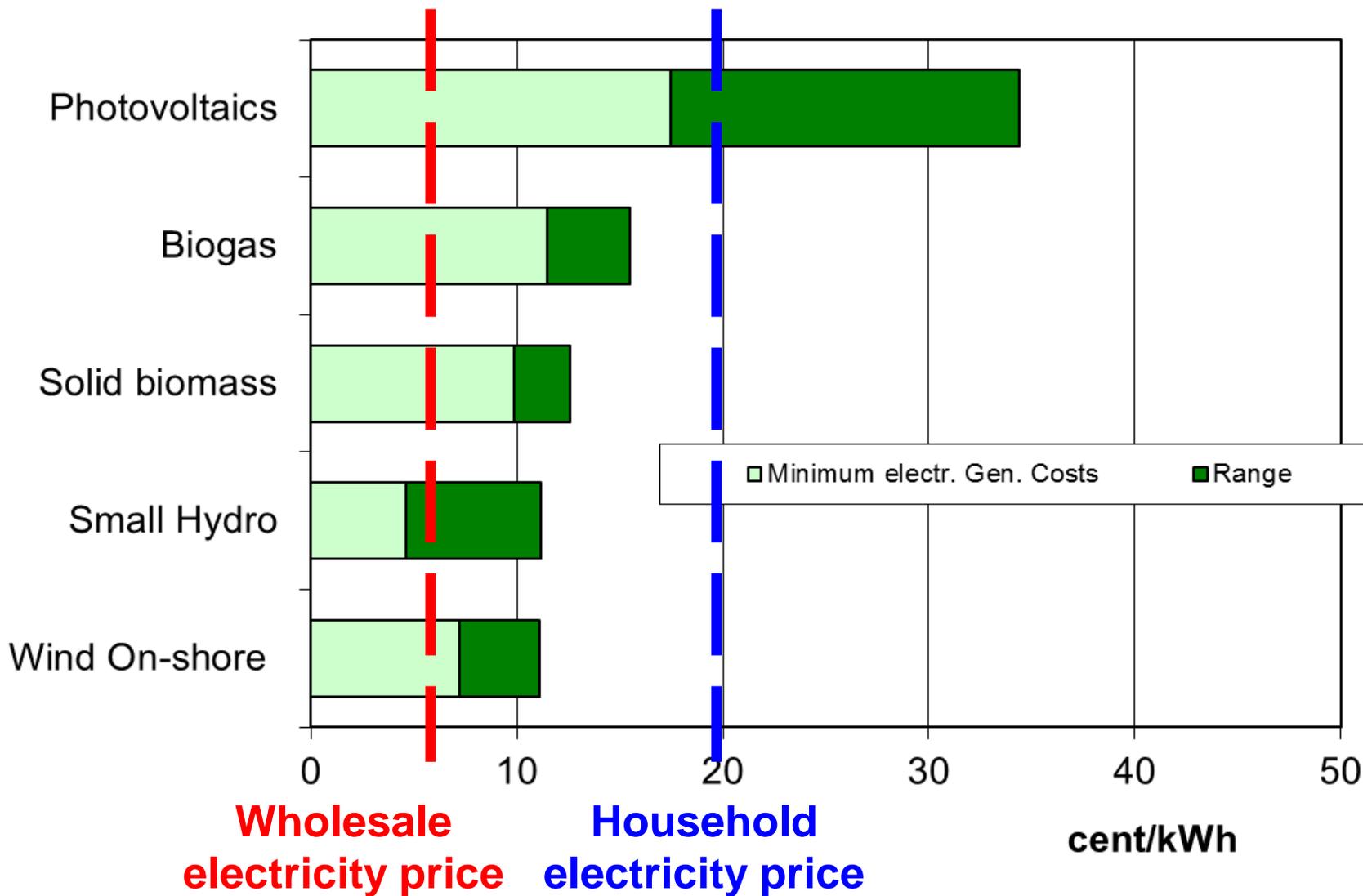
# Generation costs

## Electricity from new renewables 2010

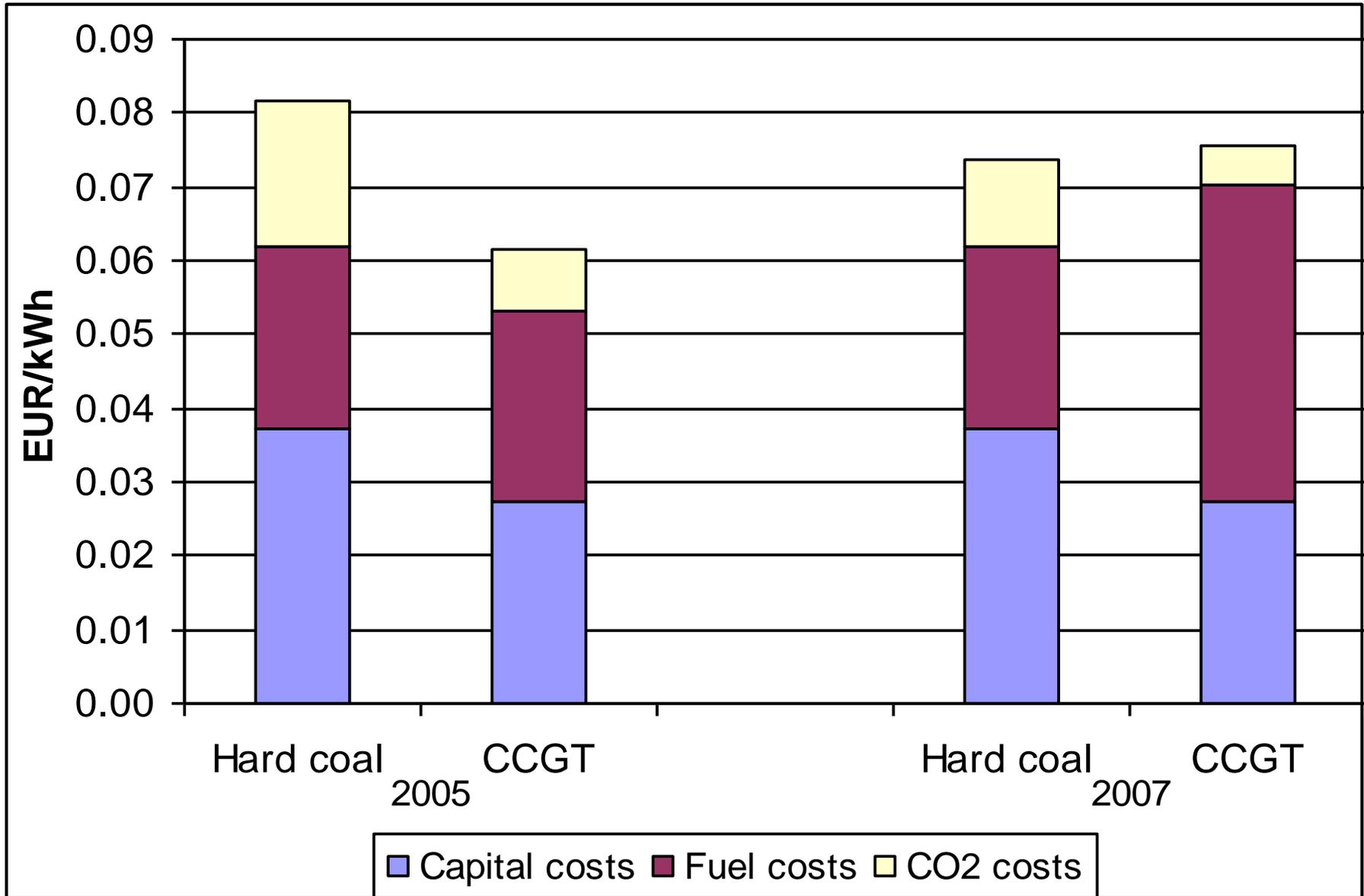


# Generation costs

## Electricity from new renewables 2012



# ELECTRICITY GENERATION COSTS 2005-2007



# THE COSTS OF NUCLEAR SOME RECENT EXAMPLES

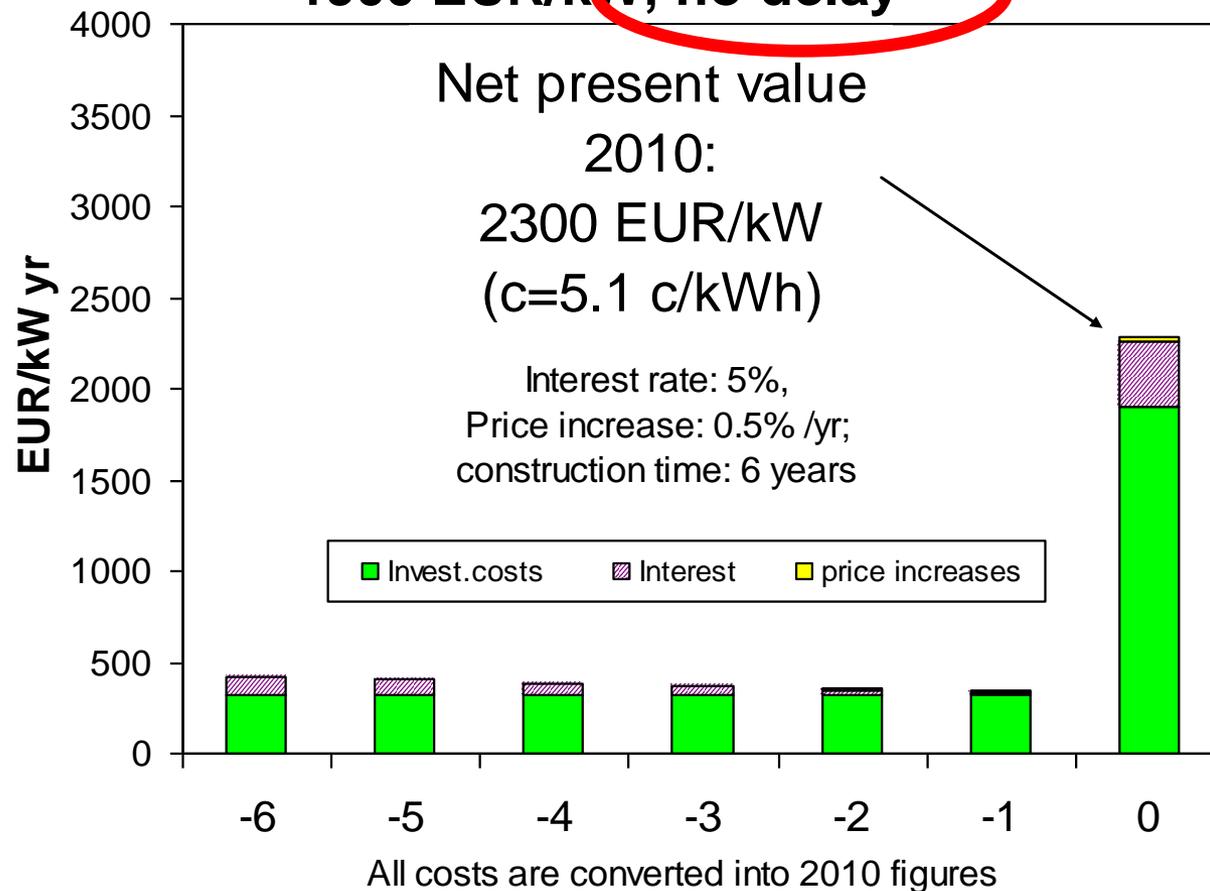
- **Civeau-2 (France): Constructed between 1990 and 2000; 1600 MW**
- **Temelin (CR): Constructed between 1982 and 2005; 1200 MW**
- **Olkiluoto-3 (Finland): Construction started in 2004, now expected to be completed 2013; 1600 MW**
- **Flamanville-3 (France): Construction started in 2006, now expected to be completed 2015; 1600 MW**

- **Interest rate: 8%, depreciation time 25 years;**
- **fuel costs: 9 EUR/MWh up to 2007, slightly increasing afterwards**
- **other O&M costs: 9 EUR/MWh**
- **decommissioning costs: 1.5 EUR/MWh**

**all cost figures are of 2010!**

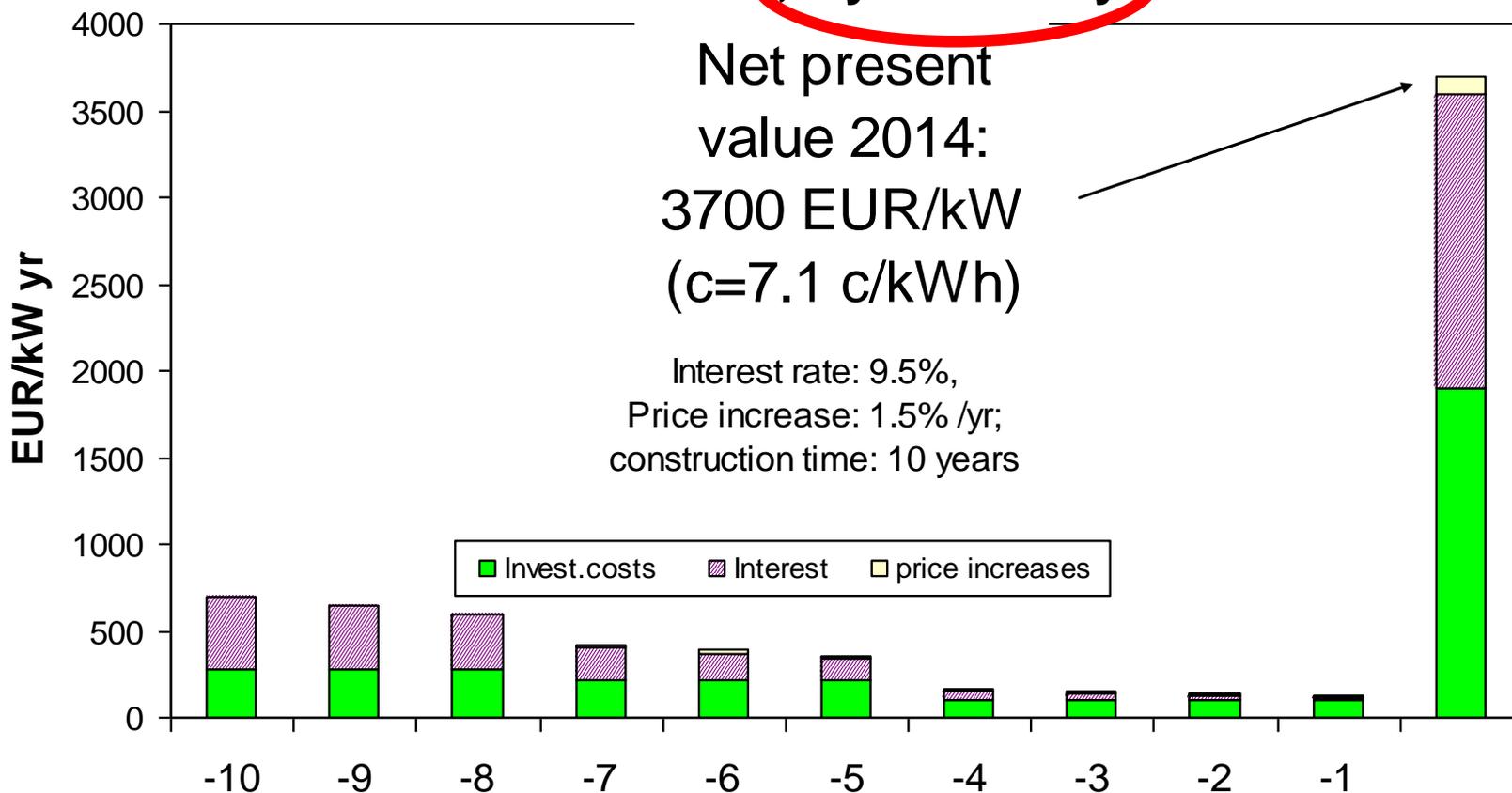
# Impact of construction time on investment costs: Example Olkiluoto

**Olkiluoto: Overnight costs 2004:  
1900 EUR/kW, no delay**



# Impact of construction time on investment costs: Example Olkiluoto

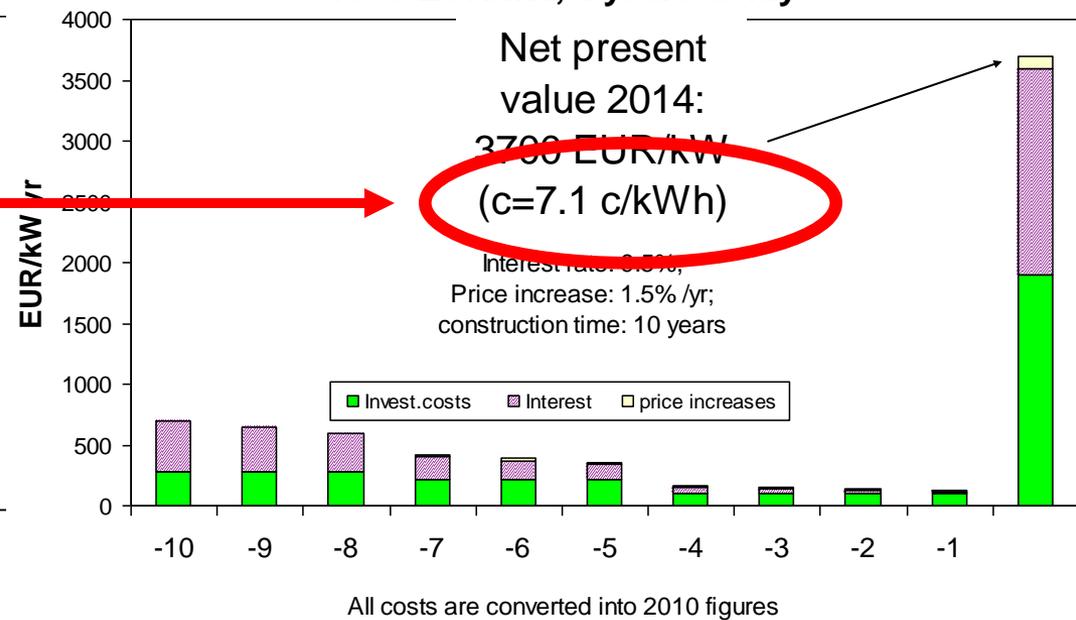
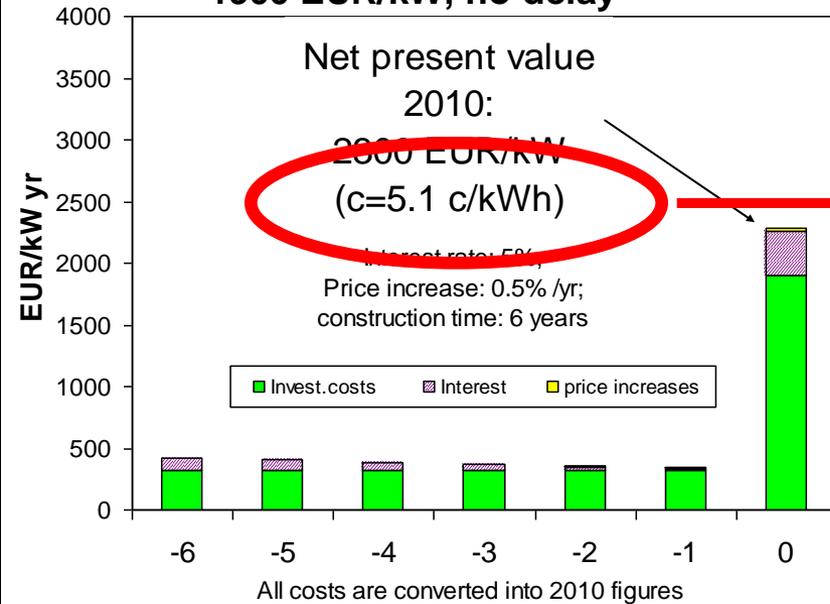
**Olkiluoto: Overnight costs 2004:  
1900 EUR/kW, 4 years delay**



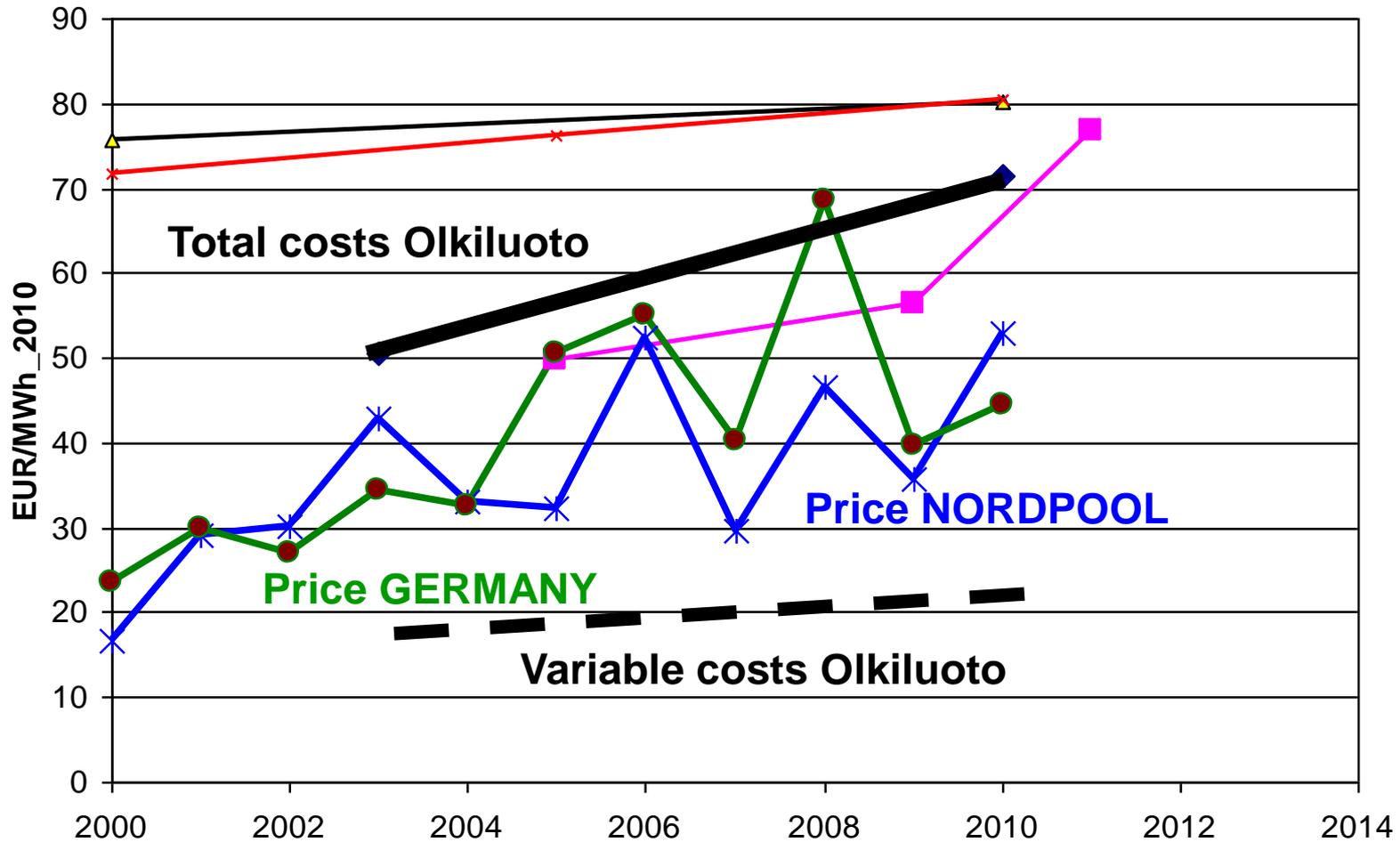
All costs are converted into 2010 figures

**Olkiluoto: Overnight costs 2004:  
1900 EUR/kW, no delay**

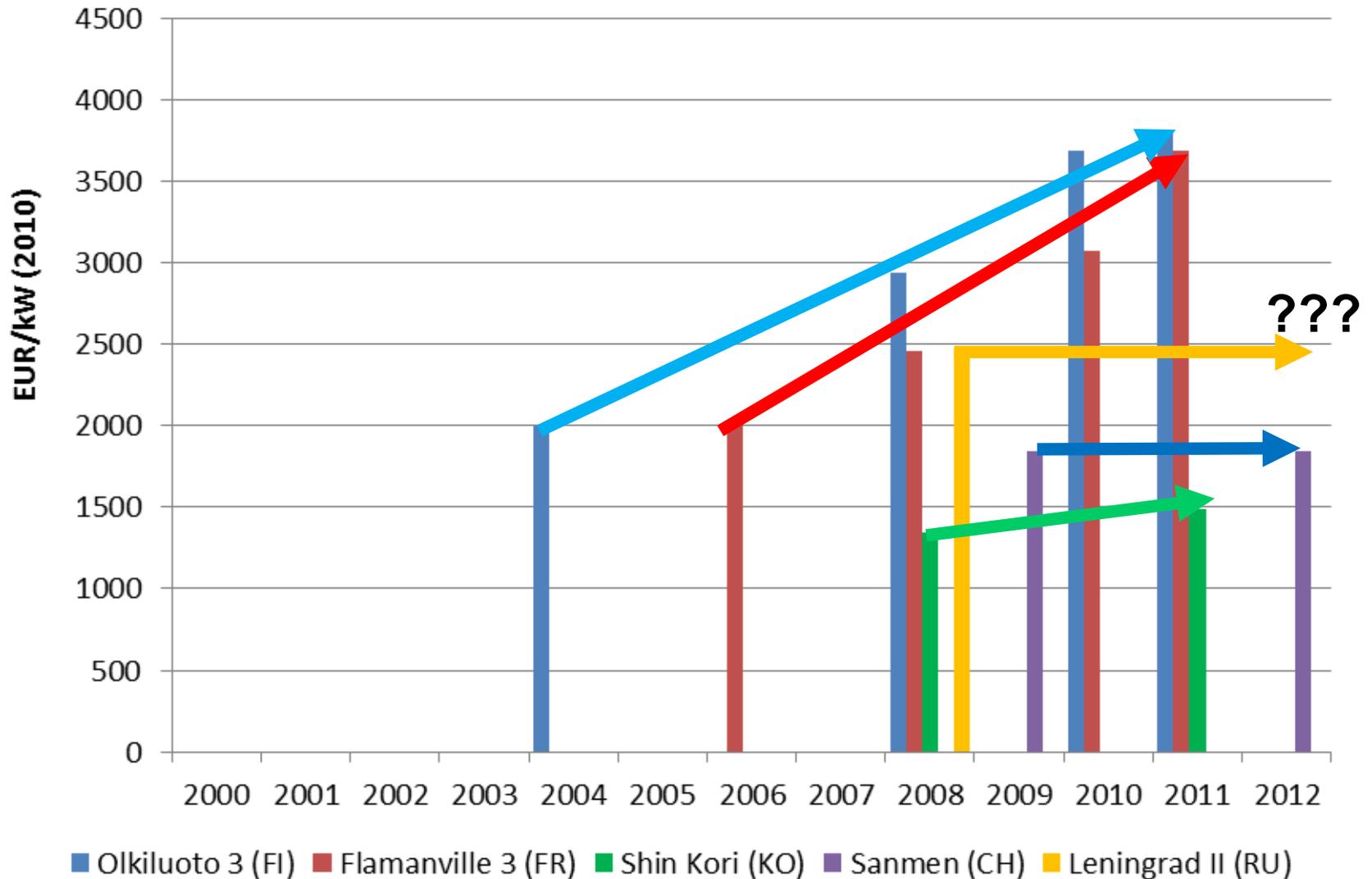
**Olkiluoto: Overnight costs 2004:  
1900 EUR/kW, 4 years delay**



# Total costs vs market prices from 2000



# Investment cost development



# 6. THE ROLE OF RENEWABLES

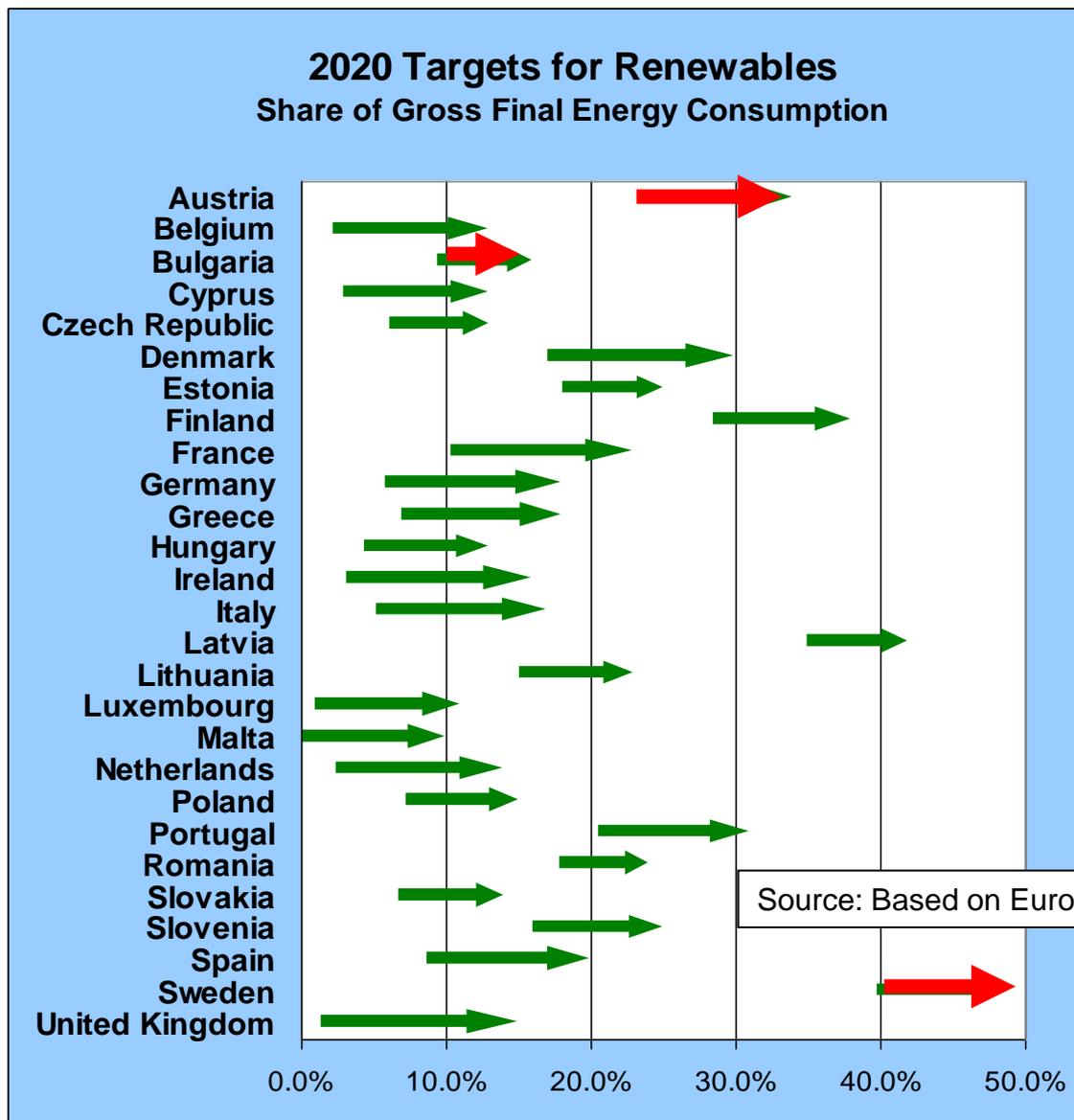
## CORE MOTIVATION:

**Policy targets for an  
INCREASE of RES-E!**

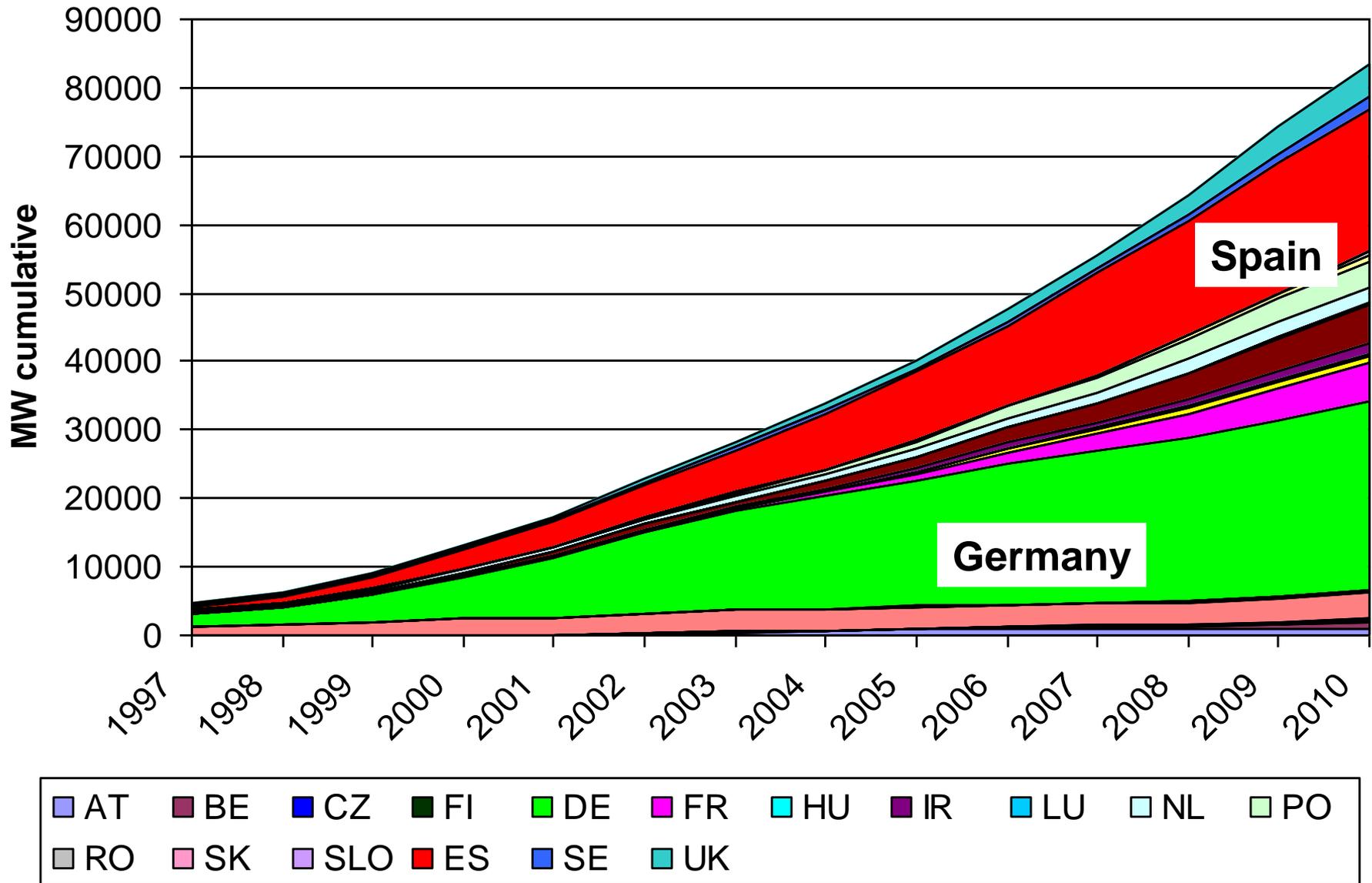
**e.g. 2020/20/20/20 targets**

**RES-E directive: increase share of  
RES-E from 12% 1997 to 22% in 2010)**

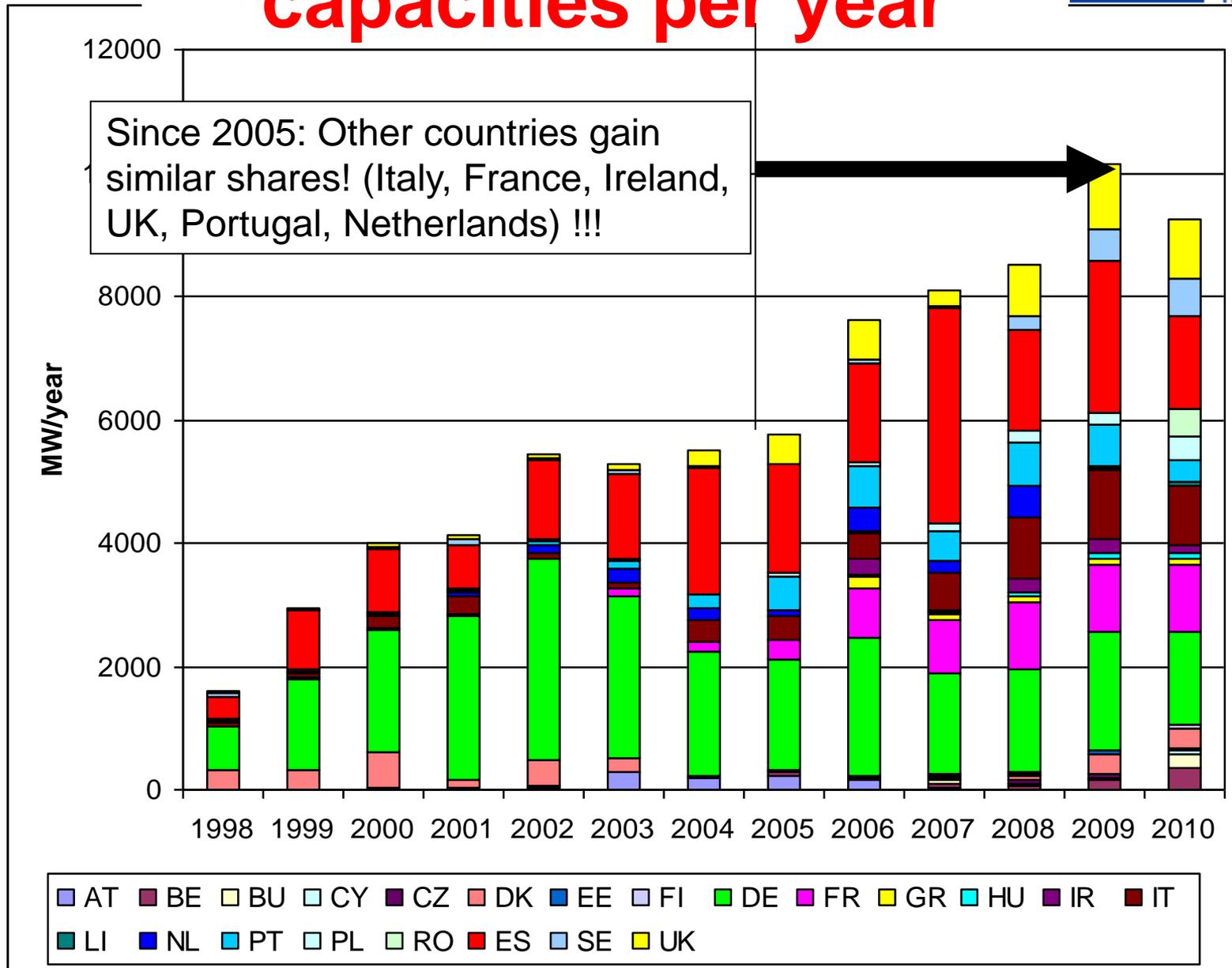
# RES targets for 2020:



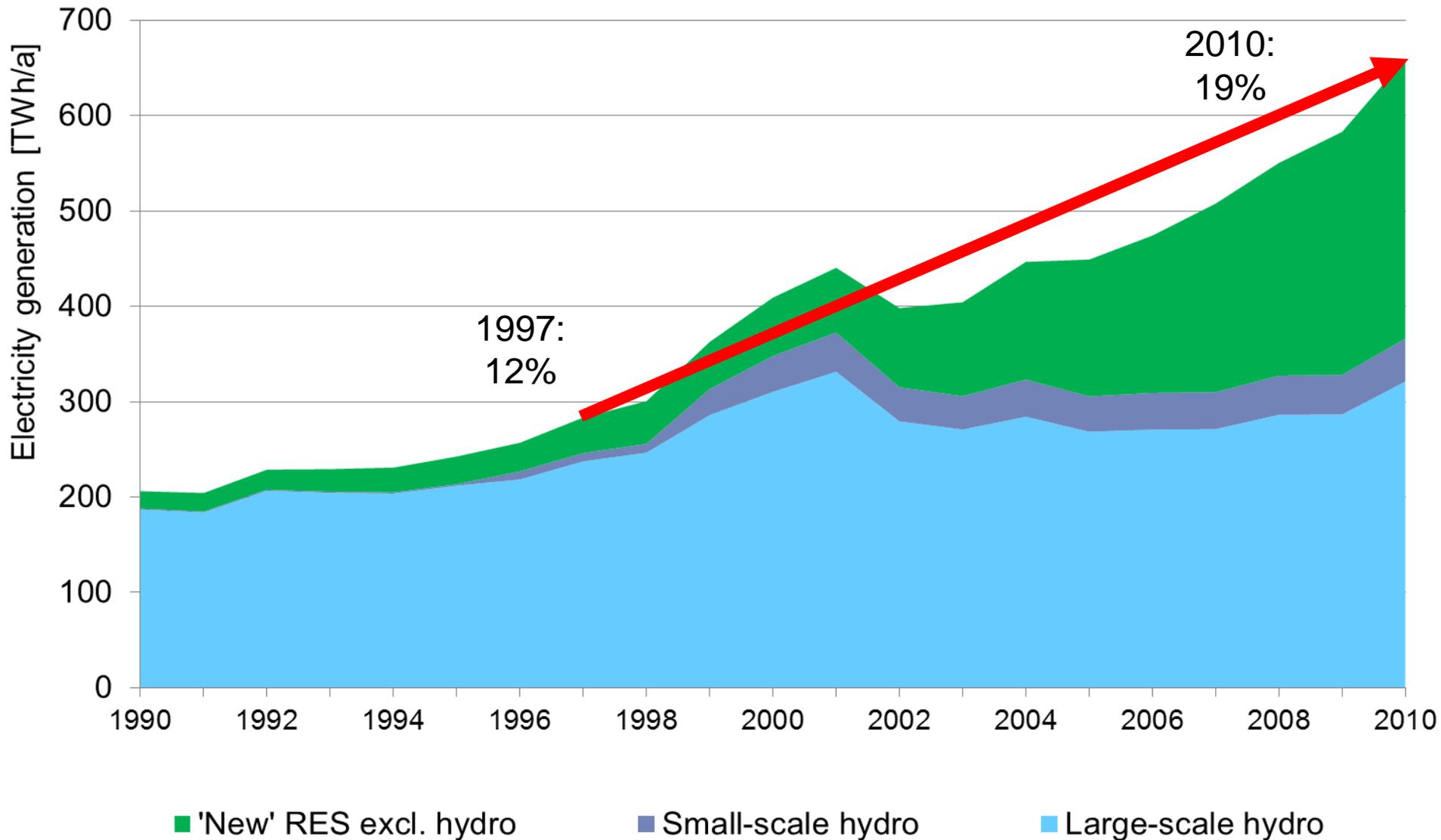
# Wind in EU-27: accumulated capacities



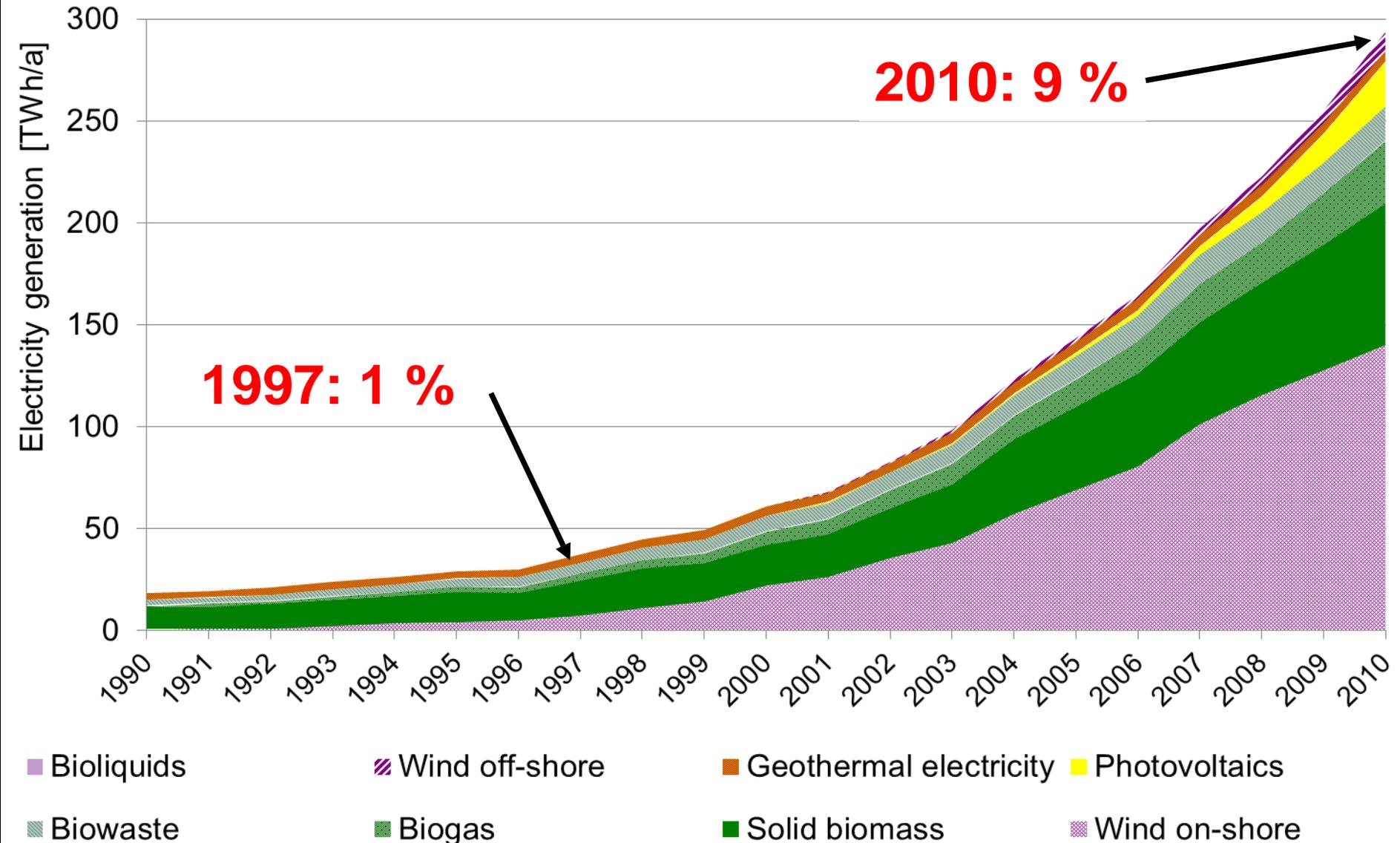
# Wind in EU-27: Installed capacities per year



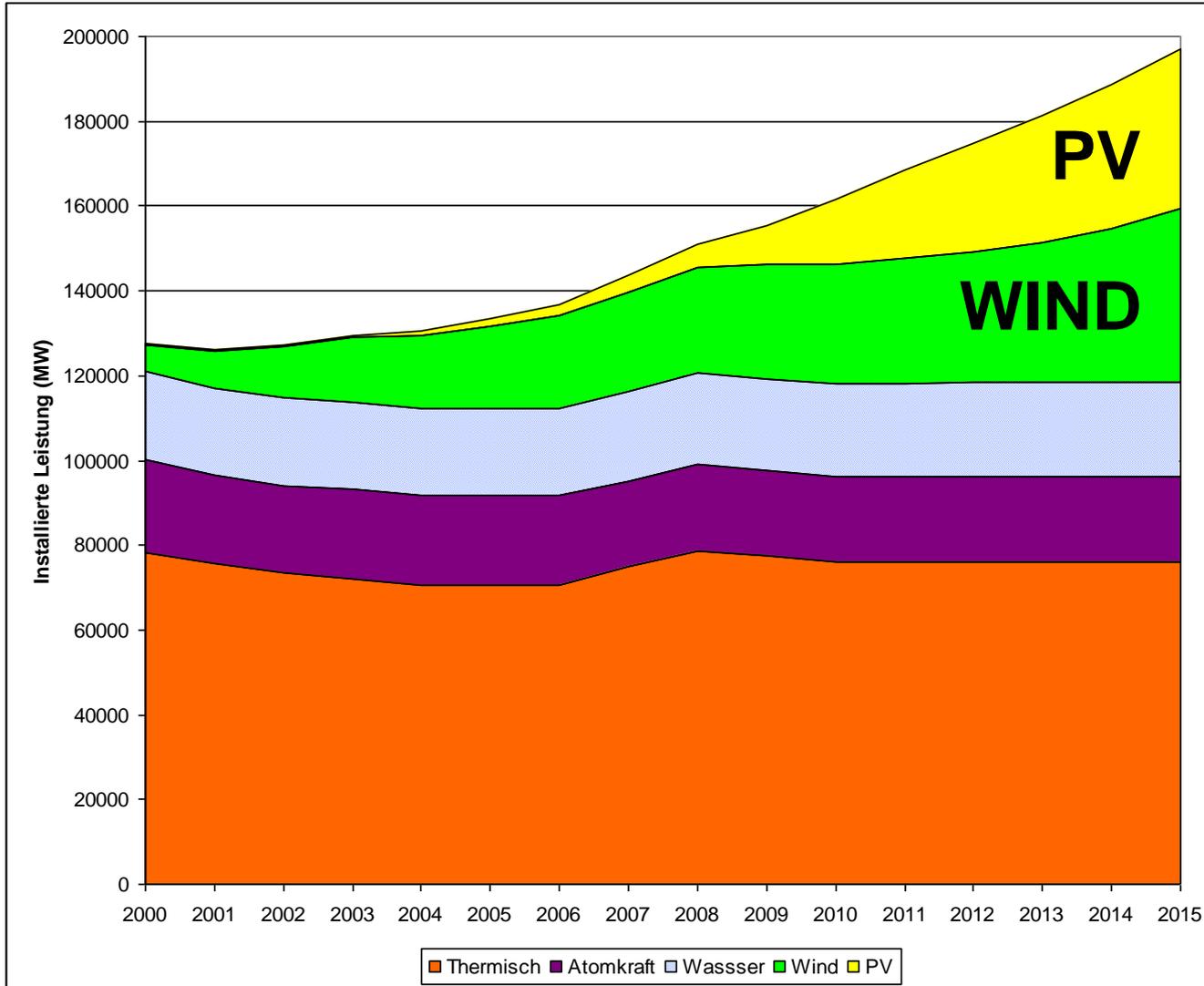
# RES for electricity generation EU-27



# EU-27: Electricity generation from „new“ RES



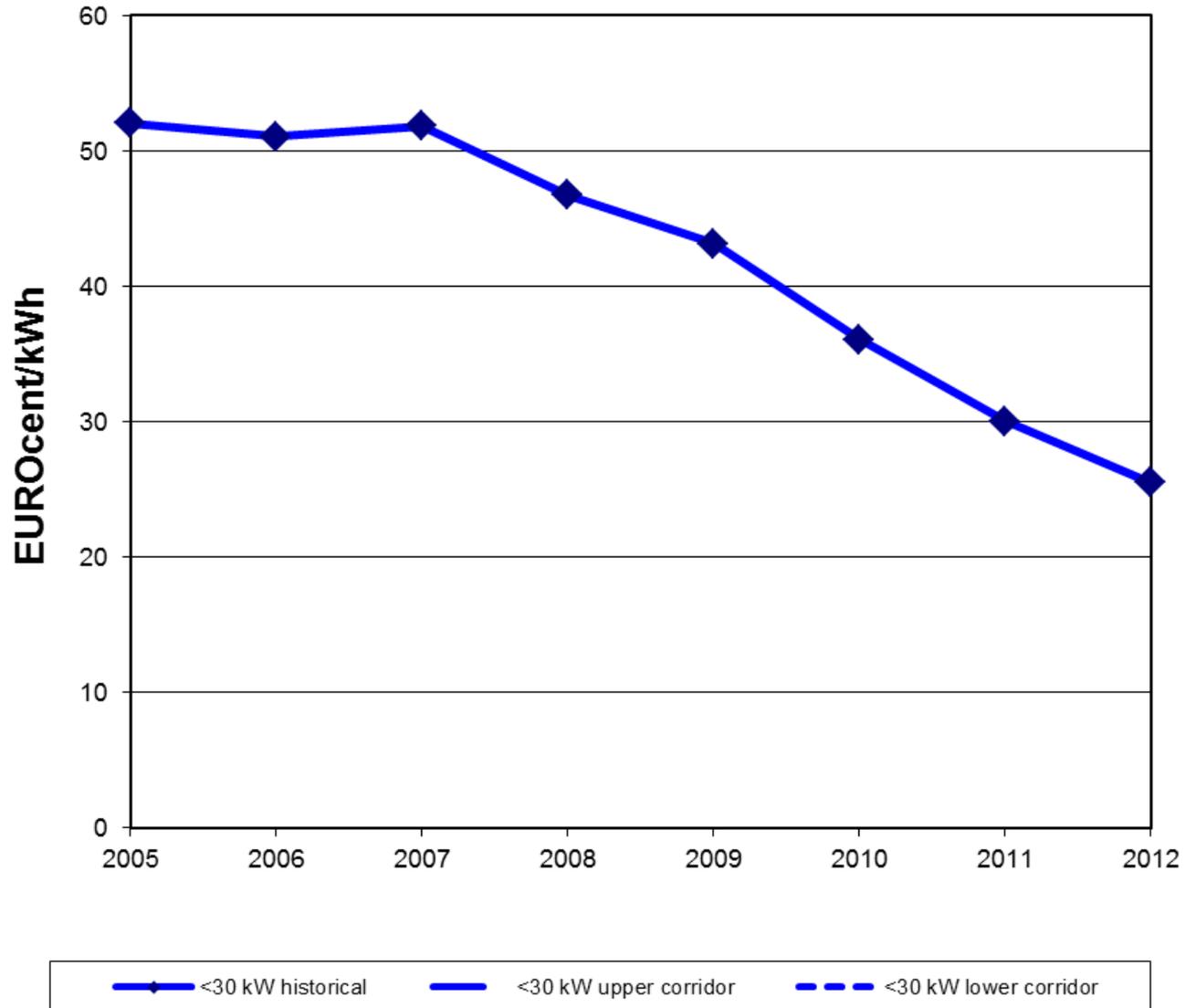
# SINCE 2000: INVESTMENTS MAINLY IN RENEWABLES!



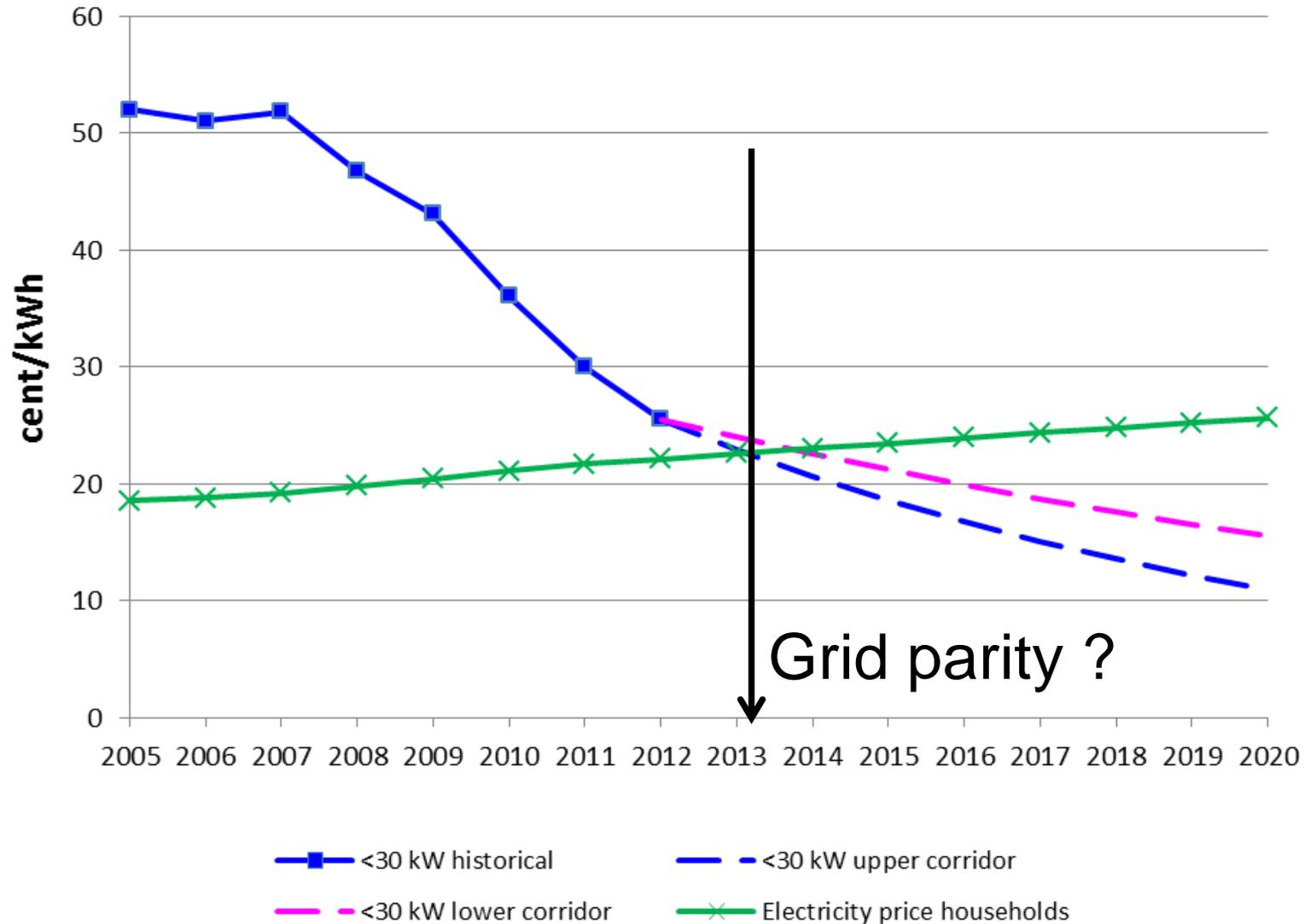
2020: ca.  
25000 MW  
PV



# Development of PV generation costs



# Development of PV generation costs vs household electricity prices



# 7. CONCLUSIONS:

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

# FURTHER INFORMATION:

- **Homepage:**  
**eeg . tuwien . ac . at**
  
- **E-Mail :**  
**Reinhard.Haas @ tuwien . ac . at**