BASICS OF ENERGY ECONOMICS

Reinhard Haas

Energy Economics Group,
Vienna University of Technology

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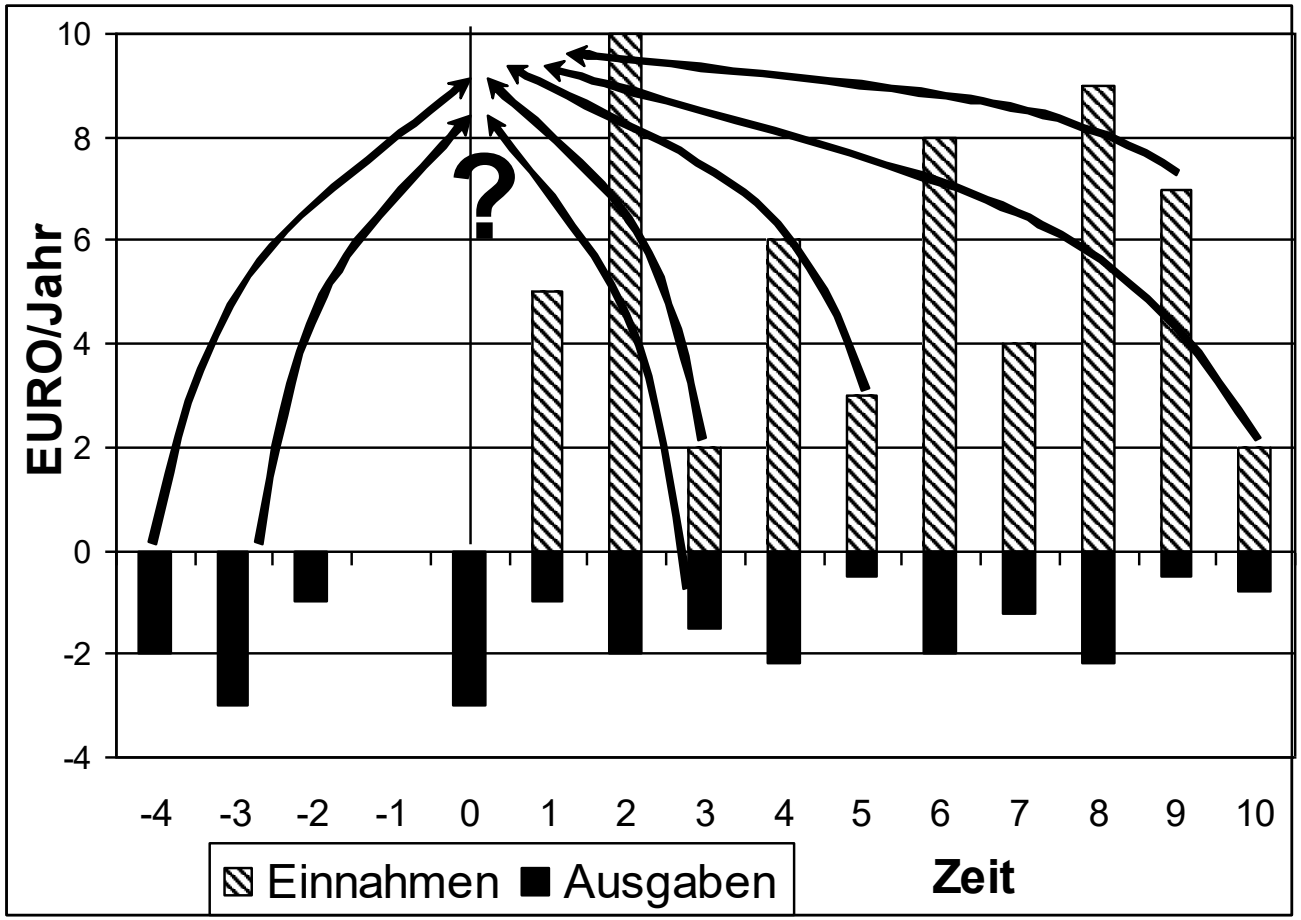
SURVEY

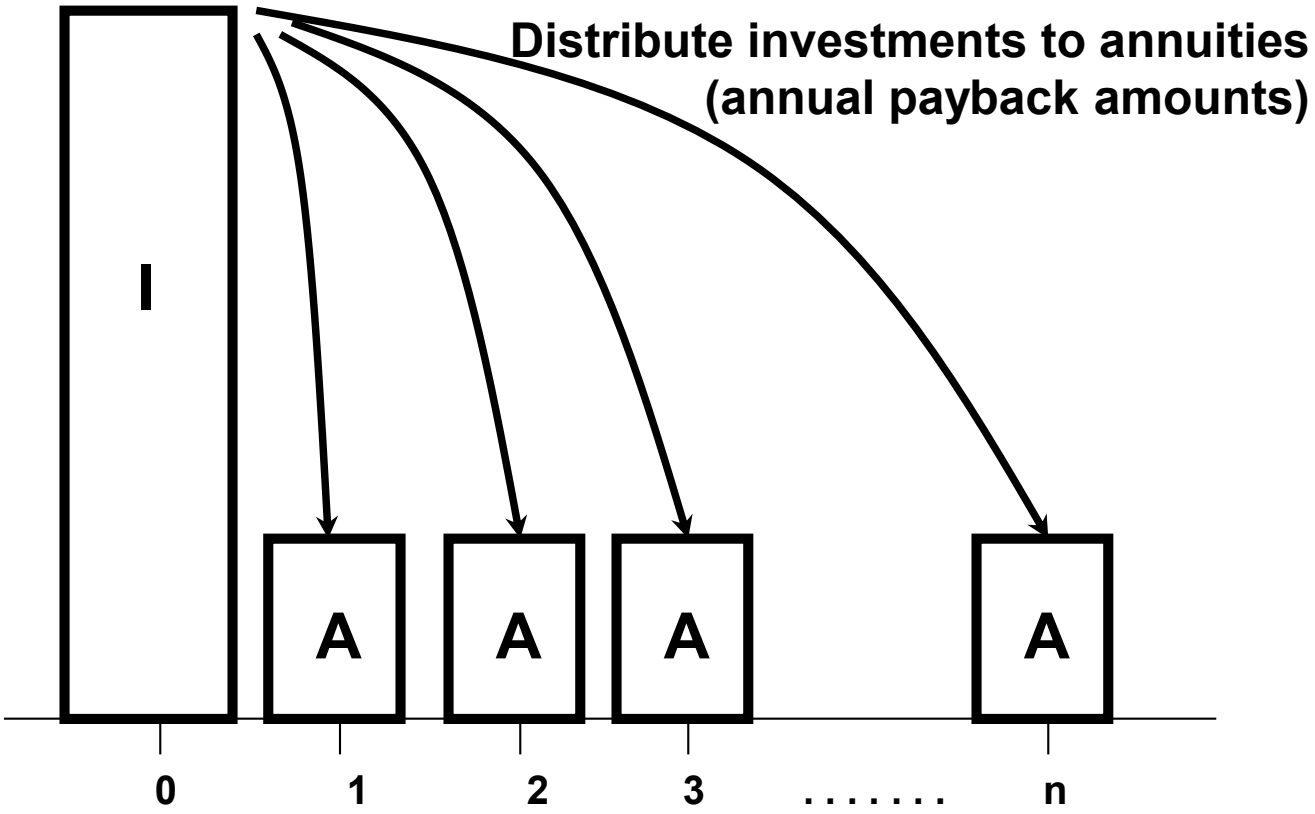
1. The problem
2. Examples
3. Annuities
4. Impact parameters on electricity generation costs
5. Calculation of electricity generation costs
6. Sensitivity analyses

EXAMPLES FROM ENERGY ECONOMICS :

- Power plants
- Heating systems
- Energy saving LED-bulbs
- Building retrofit


10
8
6
4
2
0
-2
-4
EURO/Jahr
?
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
Zeit
Einnahmen
Ausgaben

THE ANNUITY METHOD



Berechnung der Annuität A

$$A = \alpha \; I_0$$

I_0 …Investitionskosten

Capital recovery factor :

$$\alpha = \frac{i \cdot (1+i)^{LT}}{(1+i)^{LT} - 1}$$

i … Zinssatz
LT…life time

Example: i = 5%, LT = 15 years → Capital recovery factor = 0.1

Example:

Investment into a solar-thermal system

9000 EUR

i=5%, LT=15yr;

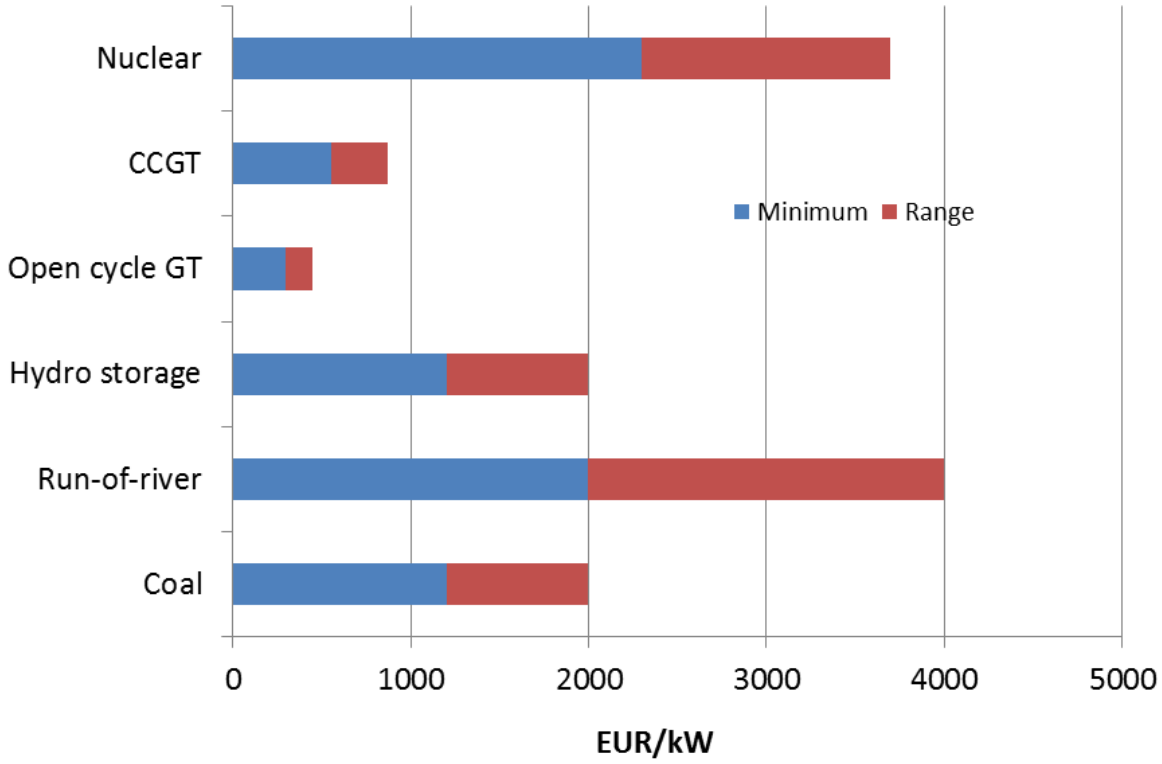
$\alpha = 0.1$

$A = \alpha I_0 = 900$ EUR/year

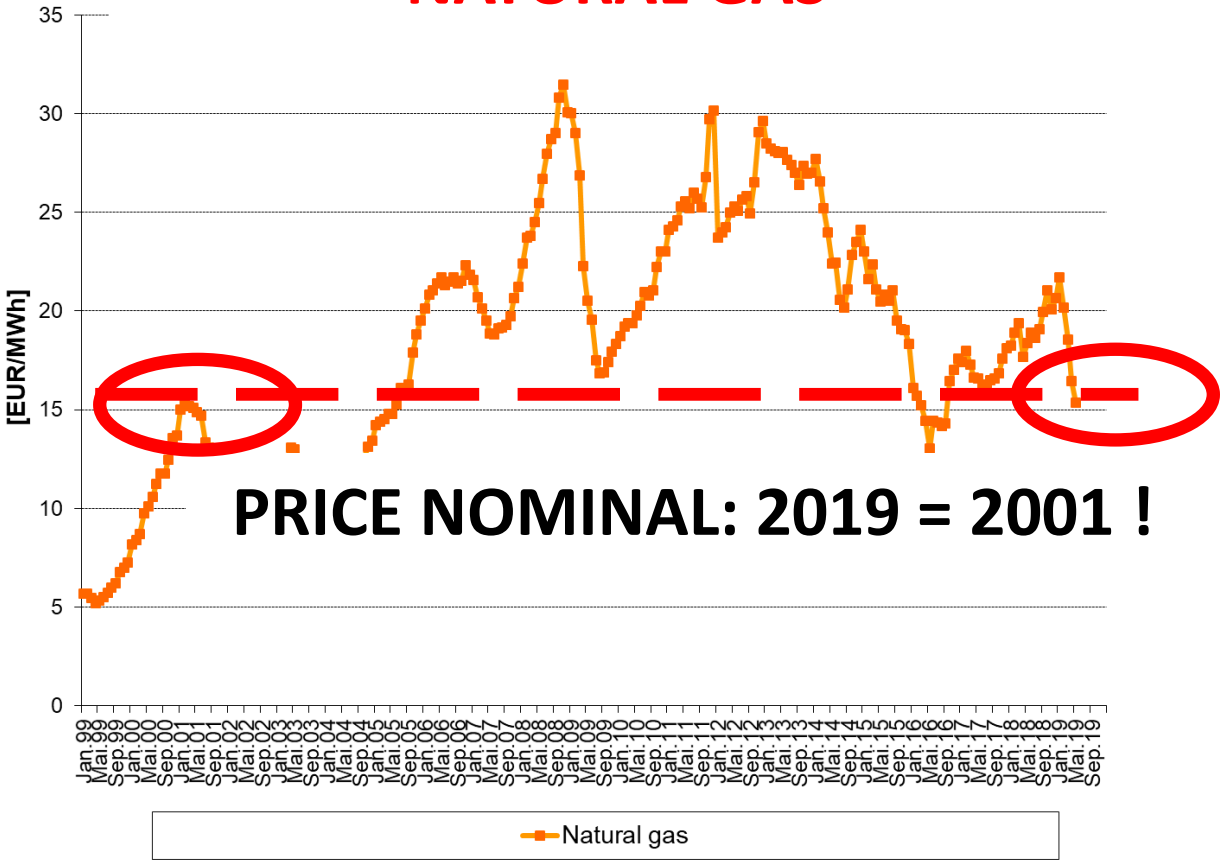
Annual savings: 910 EURO → Investment is economic

Investment costs

Electricity generation Conventional 2018



WHOLESALE MARKET PRICE OF NATURAL GAS

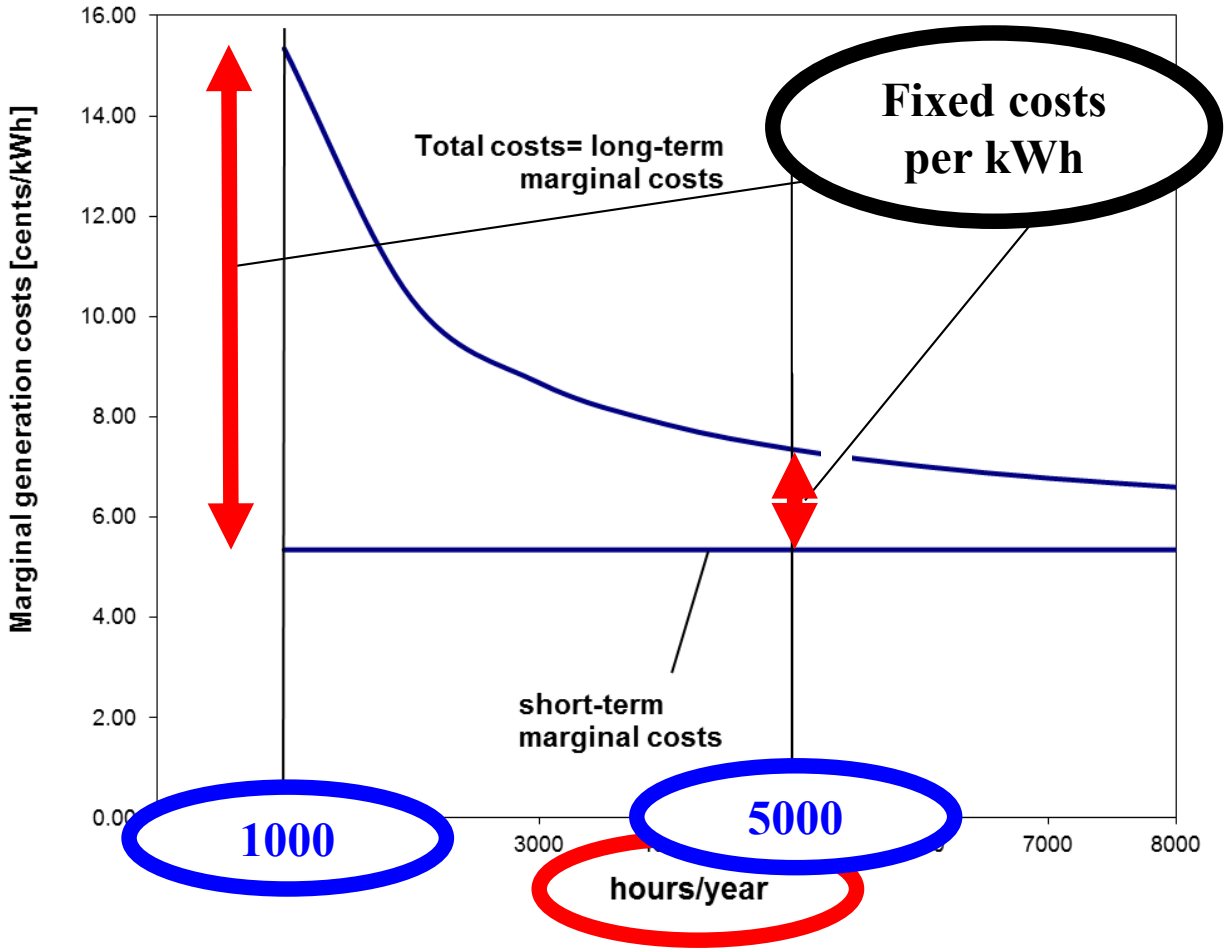


PRICE NOMINAL: 2019 = 2001 !

ENVIRONMENTAL ASPECTS – THE CO2-PRICE

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

Generation costs CCGT



Costs of electricity generation

$$C = C_F + C_V = \frac{I \cdot \alpha + C_{O\&M}}{T} + \frac{p_f}{H \cdot \eta} + \frac{C_{CO_2} \cdot f_{CO_2}}{\eta} \quad \left[\frac{\text{cent}}{\text{kWh}}\right]$$

where:

C …Total costs of electr. Generation (cent per kWh)
C_F …Fix costs (cent per kWh)
C_V … Variable costs (cent per kWh)
$C_{O\&M}$…Operation & maintenance costs (EUR/kW)
I ….Investment costs (EUR/kW)
α … 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 m³)
H …Caloric heat content (e.g. 10 kWh per m³ for gas)
η …Efficiency of power plant
C_{CO2} …Price of CO2 (e.g. 5 EUR/ton Carbon)
f_{CO2} … CO2-factor of fuel (0.2 kg Carbon/kWh)

Example: Costs of electricity generation from CCGT

I ….Investment costs = 600 EUR/kW

α … C.R.F. = 0.1 for 15 years and 5% interest rate

T ….Full load hours = 5000/1000 hours per year

$C_{O\&M}$…Operation & maintenance costs = 20 EUR/kW

p_f …Fuel price (e.g. 25/10 cents/m³ natural gas)

H …Caloric heat content (e.g. 10 kWh per m³ for gas)

η …Efficiency of CCGT plant = 0.58

C_{CO2} …Price of CO2: 25 EUR/ton Carbon)

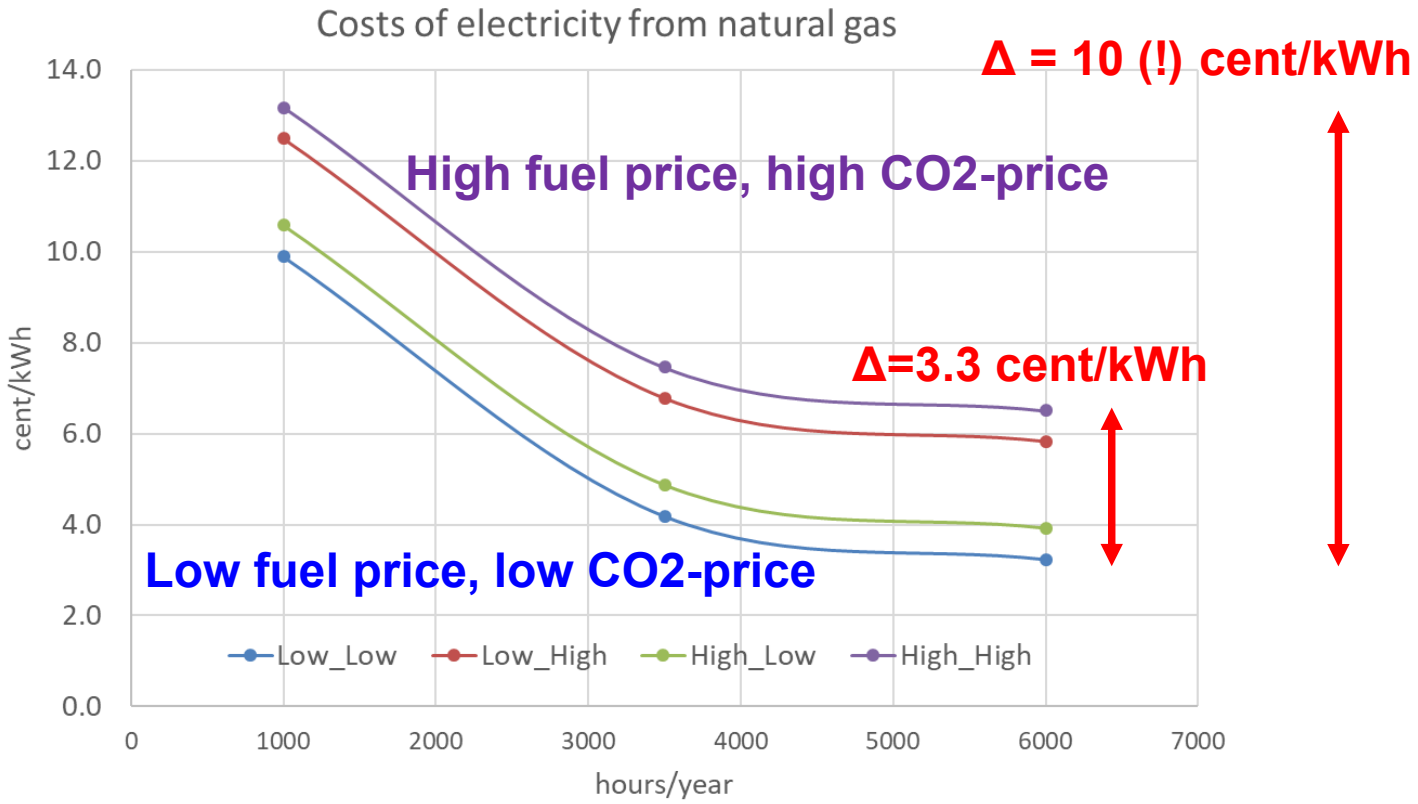
f_{CO2} … CO2-factor of fuel (0.2 kg Carbon/kWh)

$$C = \frac{100 * 600 * 0.1}{5000} + \frac{25}{10 * 0.58} + \frac{25 * 0.2}{0.58} =$$

$$1.19 + 4.3 + 0.9 =$$

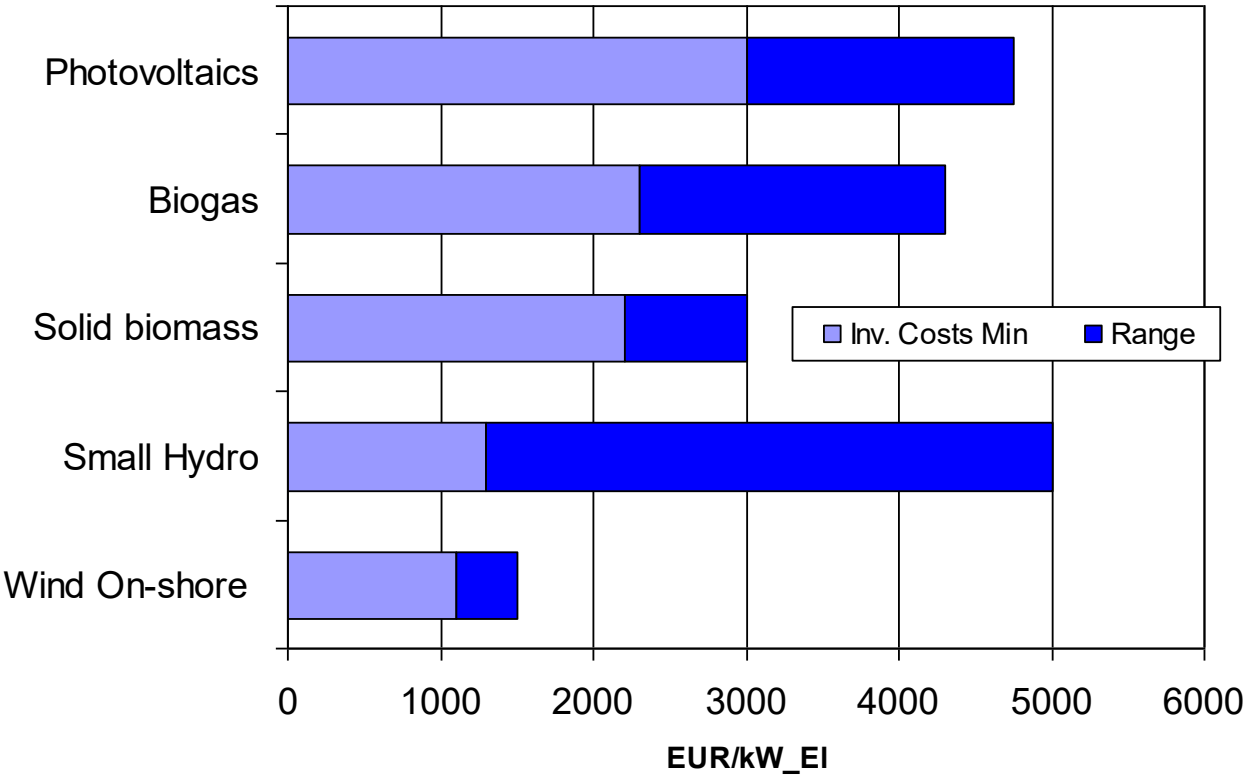
$$= 6.39 \text{ cent/kWh}$$

Example: Costs of electricity generation from CCGT



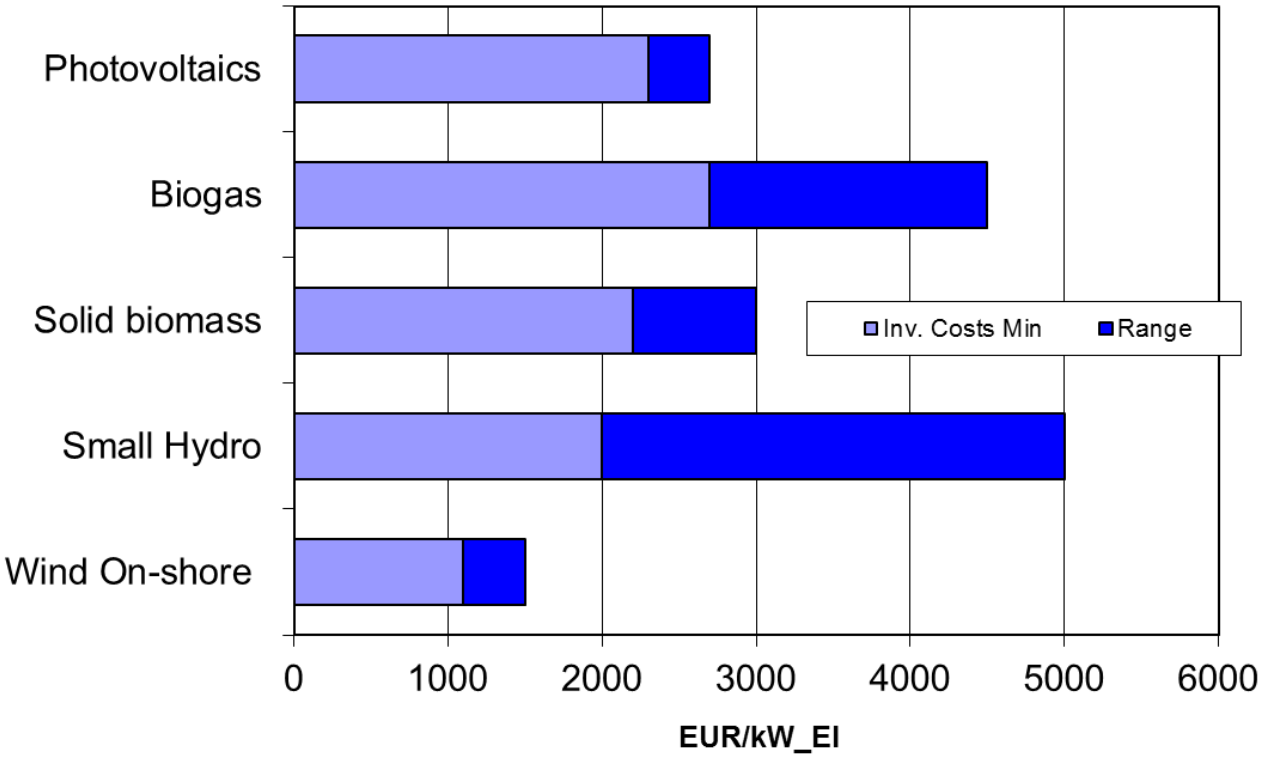
Investment costs

Electricity from new renewables 2010



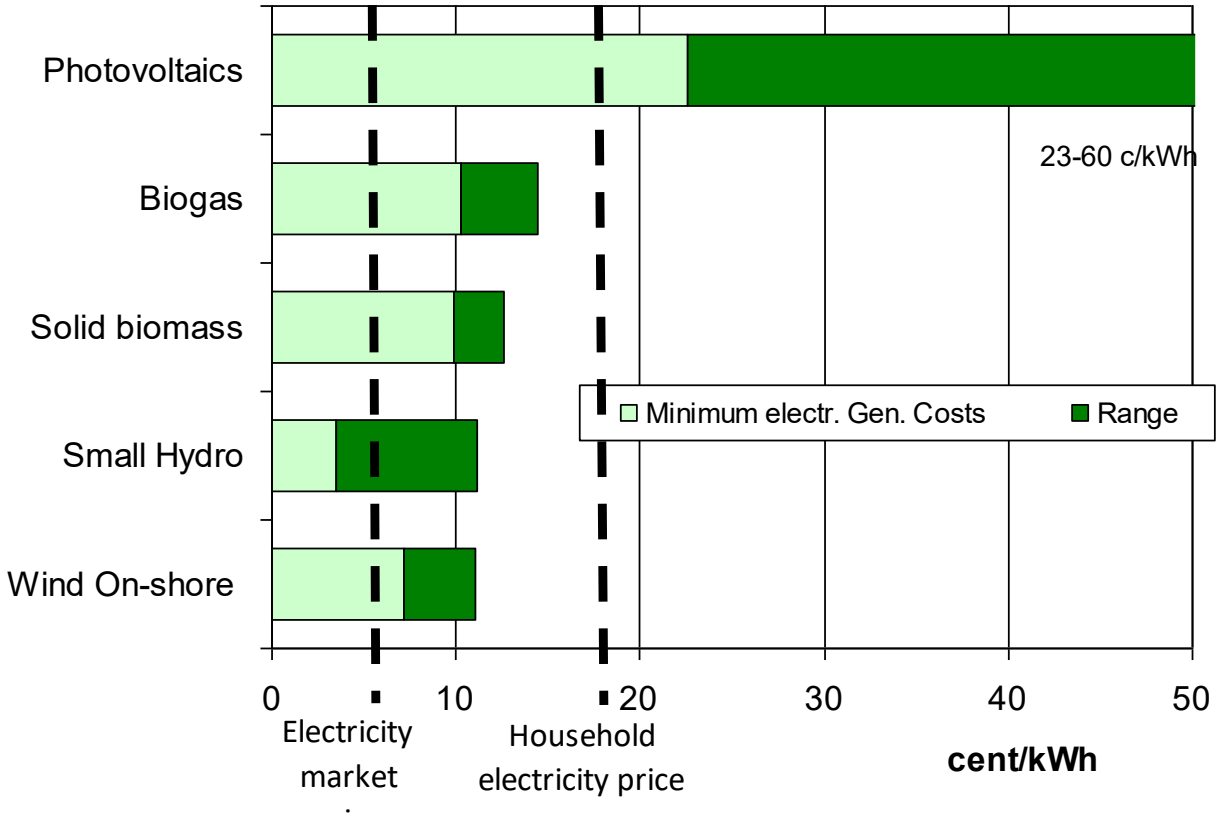
Investment costs

Electricity from new renewables 2018



Generation costs

Electricity from new renewables 2010



What are marginal costs (MC)?

$$MC = C'(X) = dC(x)/dX$$

Marginal costs are the increment of costs due to a generation of one additional unit of kWh

$$P = MC$$

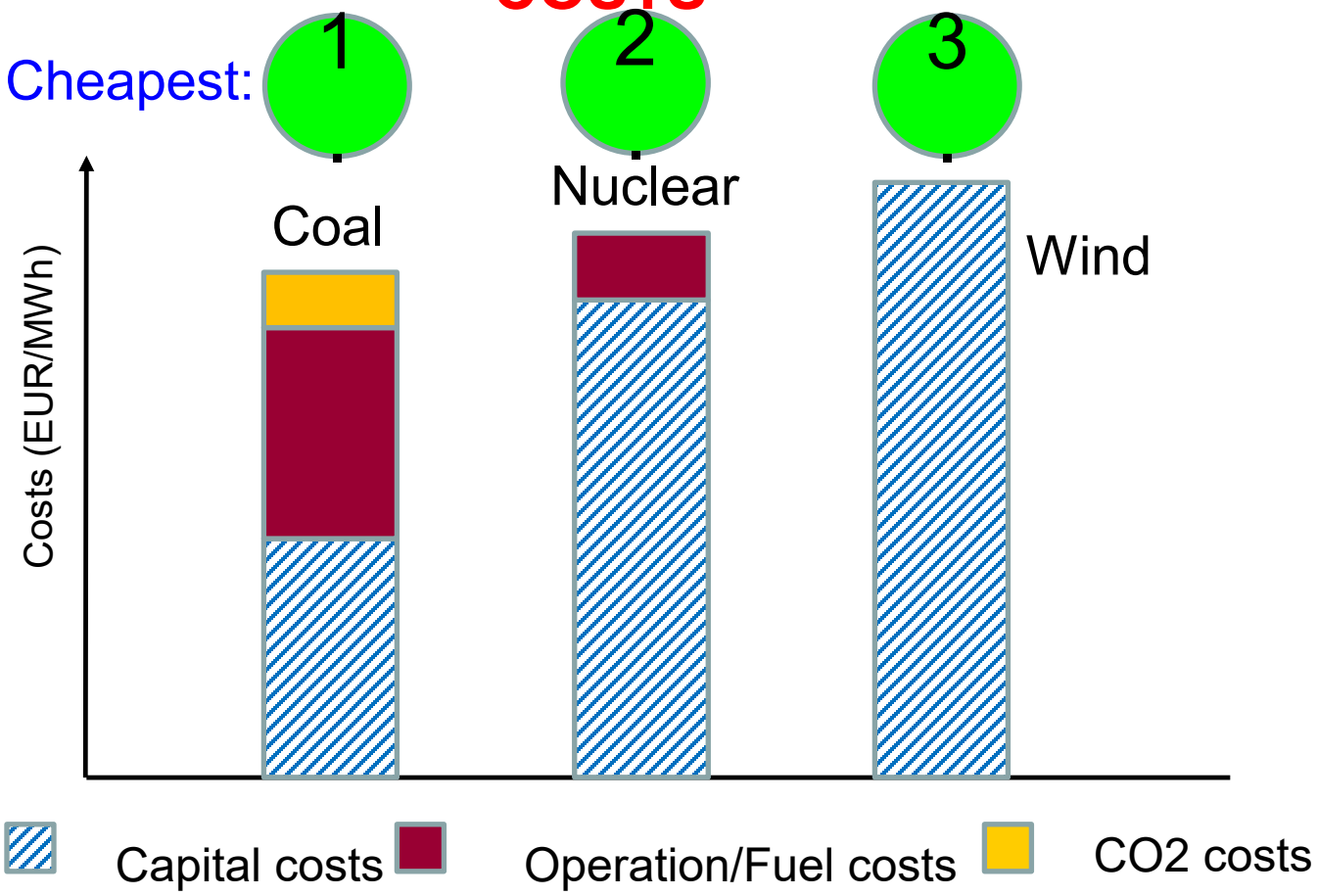
Short-term marginal costs (STMC):

STMC= Fuel costs + CO2 costs

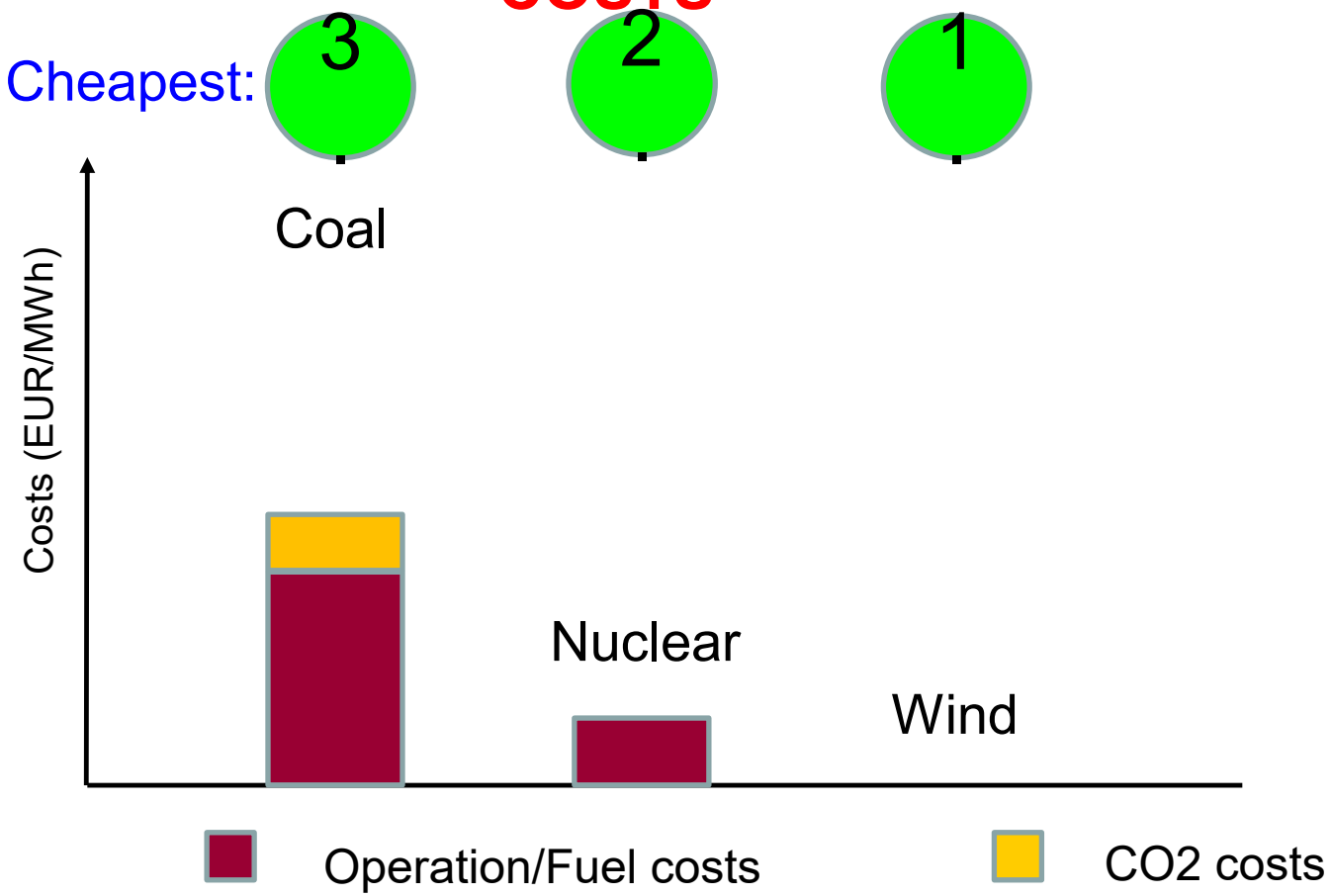
Long-term marginal costs (LTMC):

LTMC= STMC + Capital costs + O&M costs

LONG-TERM MARGINAL COSTS



SHORT-TERM MARGINAL COSTS



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