Energy and Sustainability

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Content

- **The concept of sustainable development: What does it mean for the energy system and how can it be measured?**
- **A comparison of various electricity supply options with regard to sustainability**
- **Energy Systems Alternatives: Four Scenarios**

The Brundtland Commission ‘s Definition of Sustainable Development

"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

It’s “a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs.”

The challenge is to simultaneously help to deliver economic prosperity, to reduce and eliminate poverty, to provide environmental quality and social equity and to maintain the natural foundations of life in spite of a growing global population.

"Sustainable development": What does it mean for the energy sector

- Scientific fundamentals
- Sustainability and the use of finite *(non-renewable)* resources
- Sustainability and the economic principle

➢ Scientific fundamentals

- Second law of thermodynamics => Life and development of economical and cultural achievements require a permanent input of workable energy and material.
- Growing knowledge (*Gestaltungsfähigkeit*) and the connected possible technological progress create the base for preserving and expanding the abilities of future generations.
- Environmental pollution results from the release of substances into the environment, not from the energy degradation.

Sustainability and the use of finite *(non-renewable)* resources

- Can the use of finite resources (e.g. Oil and Coal) be consistent with the principles of sustainability?
- Supply of energy service requires the use of workable energy, but also the use of non-energetic resources and materials.
- Use of finite resources require a compensation
=> the expansion of resource quantities available technically and economically.
- State of technology determines the technological-economical available base *(potential)* of raw materials and energy.

➢ Sustainability and the economic principle

- Prudent use of scarce resources represents a key aspect of sustainability.

- Also the general economic principle targets at minimising the use of resources.

  => Costs and prices are a measure for usage of resources.

- Costs can only be a measure for relative sustainability of energy systems, if all costs (including the usage of the environment) are considered.

  => Internalisation of external costs (Getting prices right).

Sustainable energy supply: management rules (1/2)

1. Use of renewable resources must not exceed their rate of regeneration.

2. Use of non-renewable energy carriers and raw materials requires a compensation for future generations. This compensation requires the extension of the technical-economical accessable resource base.

3. Emissions of substances into the environment shall not exceed the absorption capacity respectively the ability for assimilation of the natural environment.

4. Hazards and risks for human health and environment from energy provision have to fall below natural hazards and risks avoided by use of energy.

Sustainable energy supply: rules for orientation and activities (2/2)

5. The supply of energy services shall be carried out with the possibly lowest total costs (private plus external costs). Total costs represent a useful measure for the usage of scarce resources. Therefore they are an indicator for relative sustainability of technologies and systems for supplying energy services.
6. Research and development are the basis for improving efficiencies for usage of resources, for limiting energy caused environmental impacts and for expanding the technical-economical energy-basis for future generations.

Indicators for sustainability (1/2)

Dimension	Scope	Indicator	Unit per unit of Energy
Ecological	Usage of resources	Consumption of finite energy resources	J resp. kWh
		Consumption for raw-materials, e.g. copper, bauxite, iron	kg
	Influence on climate	Greenhouse gas potential (GHG)	kg CO_2 – equivalent
	Acidification / Eutrophication	Potential for acidification	kg SO_2 -equ.
		Potential for eutrophication	kg PO_4^{3-} -equ.
	Waste	Waste (non-radio-active)	kg
		Radioactive waste	m^3

Indicators for sustainability (2/2)

Dimension	Scope	Indicator	Unit per unit of Energy
Social	Adverse health effects	Public health-risks	YOLL (years of life lost)
		Occupational health-risks	YOLL
Economical	Costs	Microeconomic costs	€
		External costs	€
		Total costs	€

- **Sustainability of electricity supply options: A comparative assessment**

Reference Electricity Production Technologies

	Technology	Power installed	Efficiency	Life
Coal (43 %)	Pulverised Fuel Firing	600 MW	43.0 %	35 a
Lignite (40 %)	Pulverised Fuel Firing	800 MW	40.1 %	35 a
Gas CC (57.6 %)	Combined-cycle	777.5 MW	57.6 %	35 a
Nuclear (PWR)	PWR	1375 MW	34 %	40 a
PV (poly) (amorphous)	poly-crystalline amorphous	5 kW 5 kW	9.5 % [1)] 4.5 % [1)]	25 a 25 a
Wind (4.5 / 5.5 m/s) [2)]	horizontal axis wind energy conv.	1 MW	—	20 a
Hydro (3.1 MW)	Run-of-River	3.1 MW	90 %	60 a

1) System-efficiency
2) Average windspeed p.a.

Source: Marheineke 2002

Cumulative energy requirements (CER) and energy payback periods (EPP)

		CER (without fuel) [kWh_{Prim} / kWh_{el}]	EPP [months]
Coal	(43 %)	0.29	3.6
Lignite	(40 %)	0.17	2.7
Gas CC	(57.6 %)	0.17	0.8
Nuclear (PWR, ult.waste dispo.)		0.07	2.9
PV (5 kW)	amorphous poly	0.62 0.94	71 107
Wind (1 MW)	5.5 m/s 4.5 m/s	0.08 0.18	7.3 16.4
Hydro	(3.1 MW)	0.05	13.7

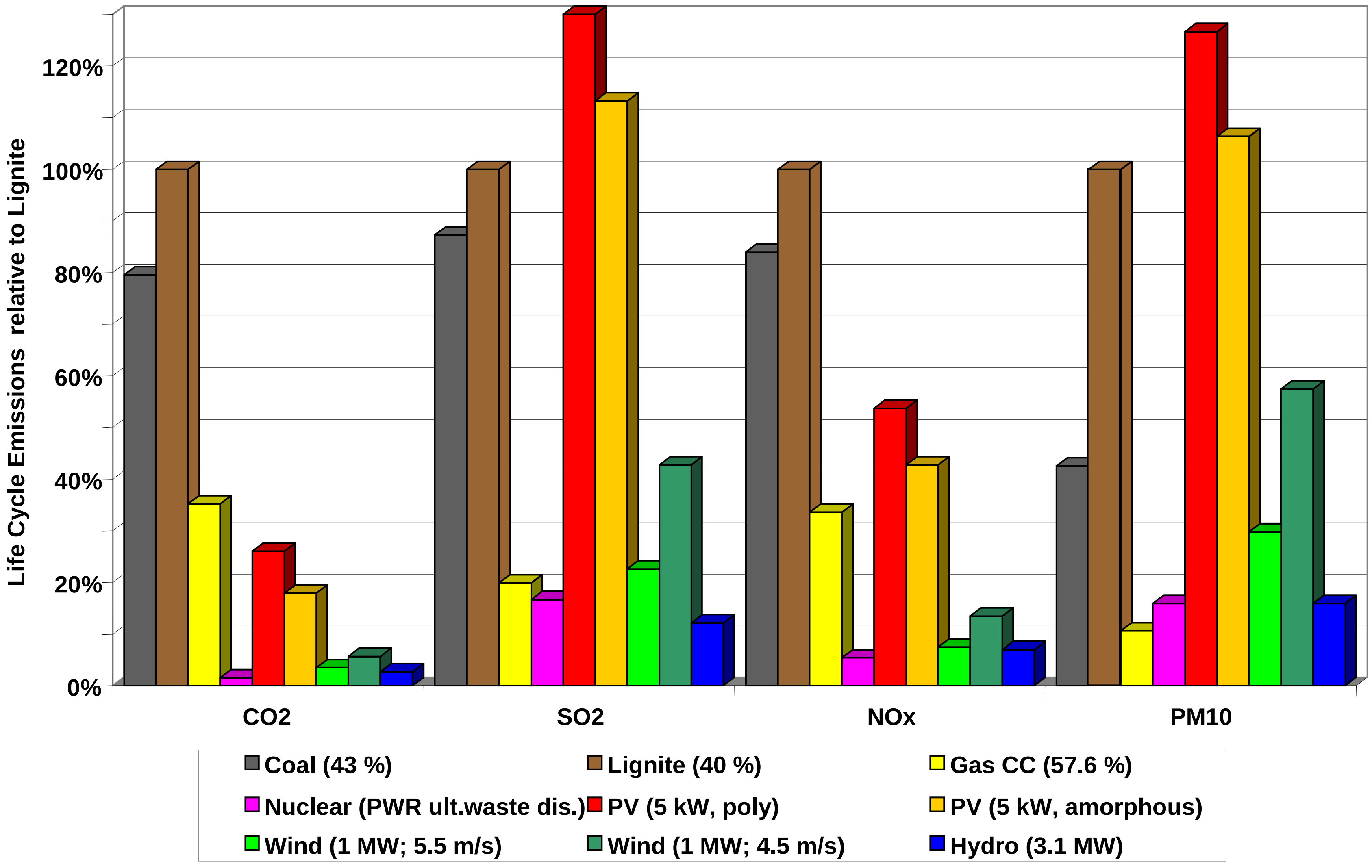
Source: Marheineke 2002

Total life cycle raw material requirements

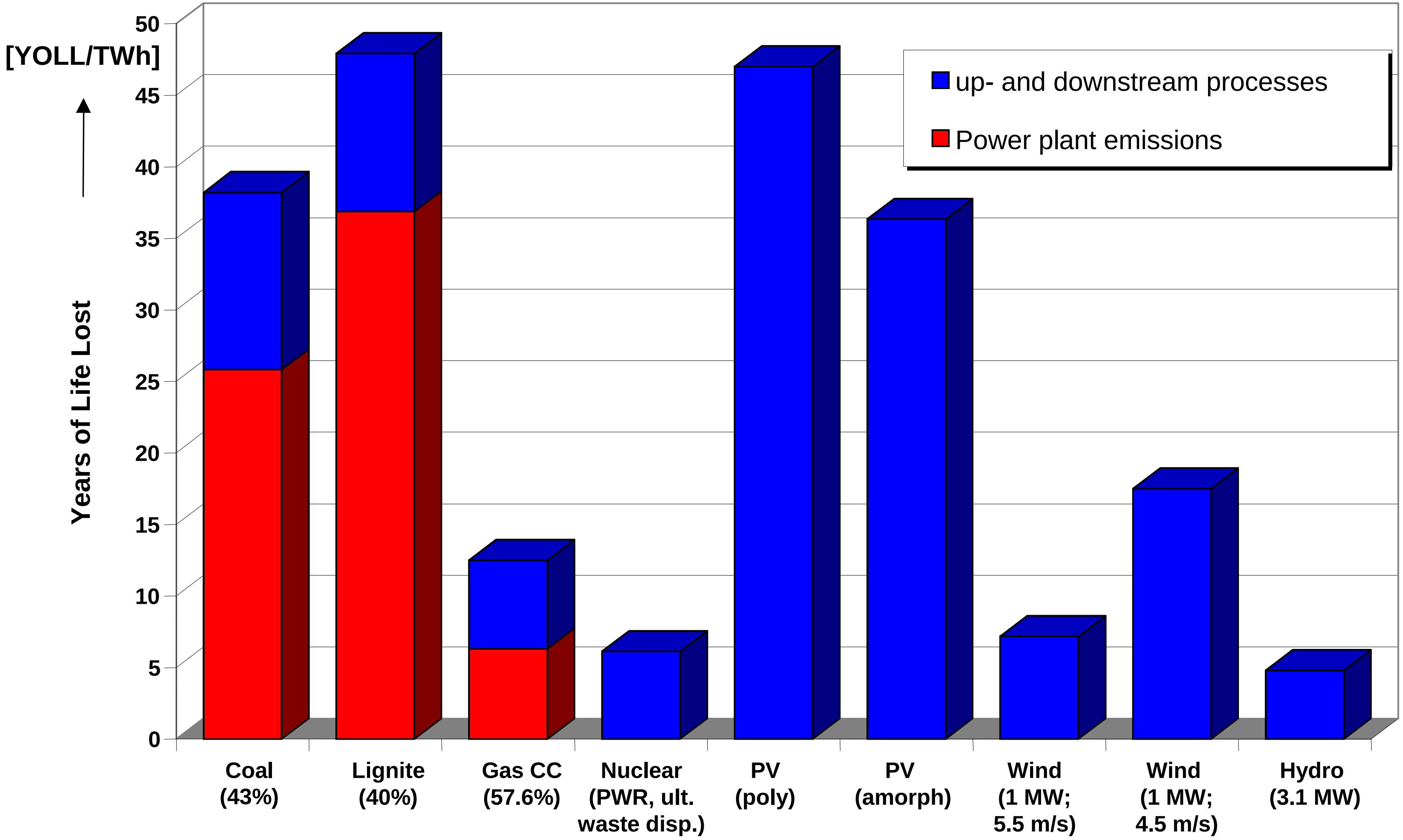
	Iron [kg / GWh_{el}]	Copper [kg / GWh_{el}]	Bauxite [kg / GWh_{el}]
Coal (43 %)	2308	2	20
Lignite (40 %)	2104	8	19
Gas CC (57.6 %)	969	3	15
Nuclear (PWR, ult. waste dispo.)	445	6	27
PV (5 kW) poly	6708	251	2100
PV (5 kW) amorph	8153	338	2818
Wind (1 MW) 5.5 m/s	5405	66	54
Wind (1 MW) 4.5 m/s	10659	141	110
Hydro (3.1 MW)	2430	5	10

Source: Marheineke 2002

Life Cycle Emissions



Health Risks

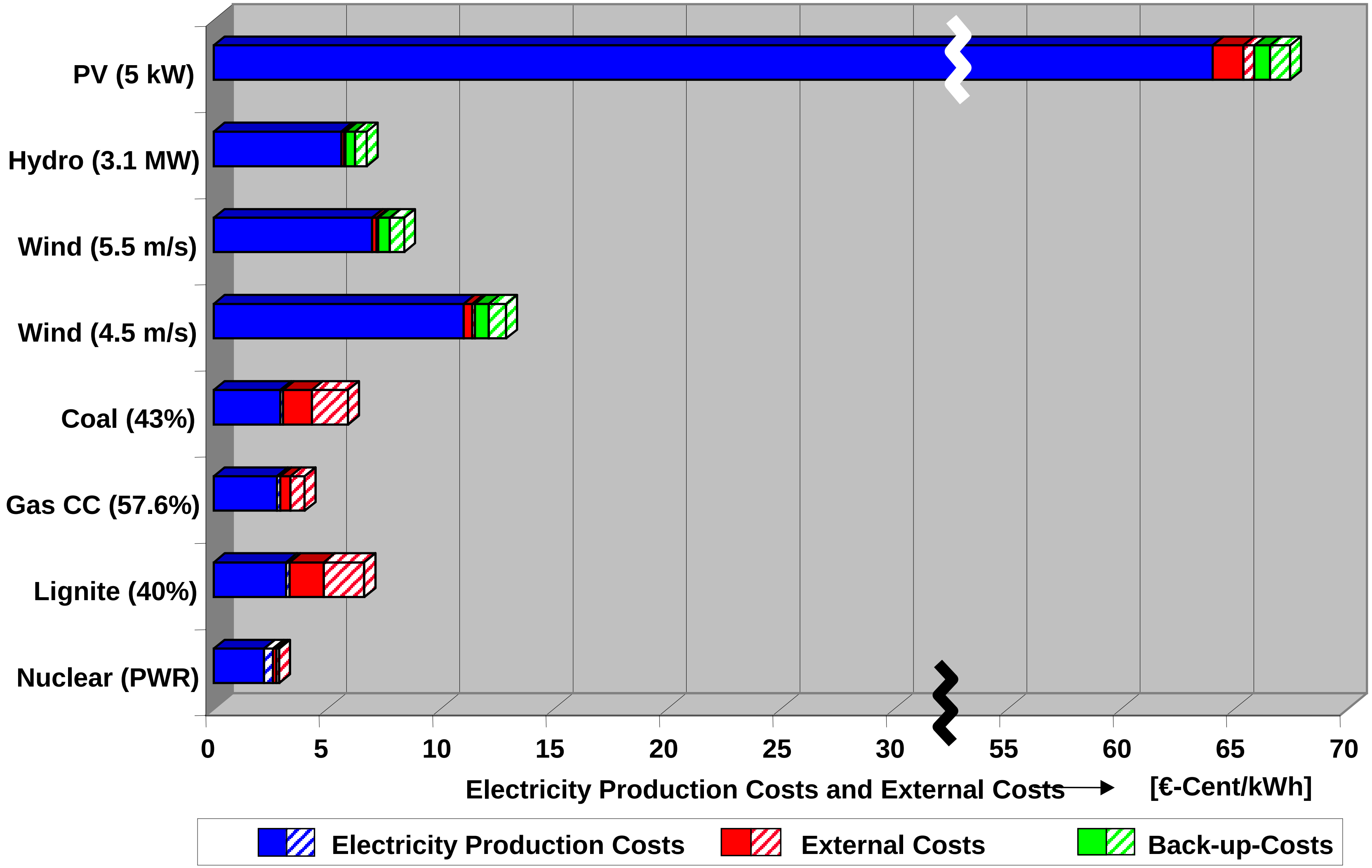


External Costs

[€-Cent/kWh]	Coal (43 %)	Lignite (40 %)	Gas CC (57.6 %)	Nuclear (PWR)	PV (5 kW; amorph - poly)	Wind (1 MW; 5.5 - 4.5 m/s)	Hydro (3,1 MW)
Damage Costs[1]							
Health Effects	0,53	0,66	0,17	0,1 - 0,17[3]	0,52 - 0,66	0,11 - 0,20	0,07
Agriculture	0,031	0,032	0,015	0,004	0,025 - 0,028	0,004 - 0,008	0,003
Material	0,013	0,015	0,004	0,001	0,010 - 0,014	0,002 - 0,004	0,001
Glob. Warming	0,23	0,257	0,091	0,004	0,050 - 0,072	0,01- 0,016	0,008
Abatement Costs[2]							
Acid., Eutroph.	0,47	0,55	0,15	0,06	0,42 - 0,56	0,08 - 0,15	0,05
Glob. Warming	1,82	2,04	0,72	0,03	0,40 - 0,57	0,08 - 0,13	0,06
Total	**1,27 - 2,87**	**1,51 - 3,29**	**0,43 - 1,06**	**0,17 - 0,27**	**1,02 - 1,83**	**0,20 - 0,49**	**0,13 - 0,19**

1) Rate of Social Time Preference 3%/a, except radiological risks of nuclear energy (0%/a)
2) according to standard-price-approach
3) ultimate waste disposal compared to nuclear fuel reprocessing

Total Costs of Electricity Production



- **Energy System Developments with respect to Sustainability**

Perspectives on the development of the energy supply in Germany

Reference scenario (REF)

- extrapolation of present energy policy
- phasing-out of nuclear energy
- no targets for climate protection

Preference for renewable energy sources (PEE)

- share of renewable energy sources of net electric power consumption rises to 30%
- phasing-out of nuclear energy
- no CO_2-sequestration

GG-reduction targets:
2010: -21%
2020: -35%
2030: -50%

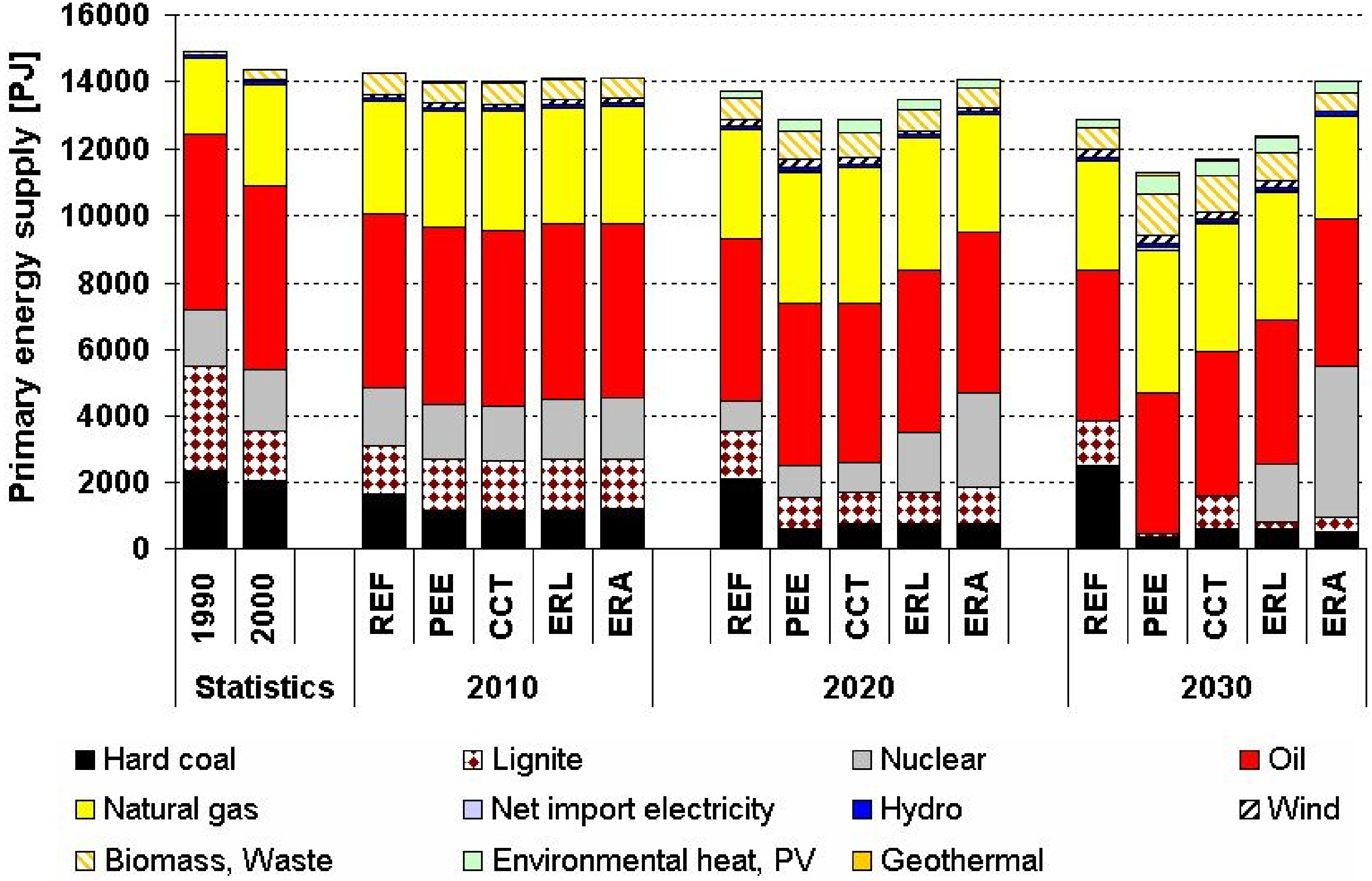
Clean Coal Technologies (CCT)

- CO_2-sequestration and disposal allowed
- phasing-out of nuclear energy

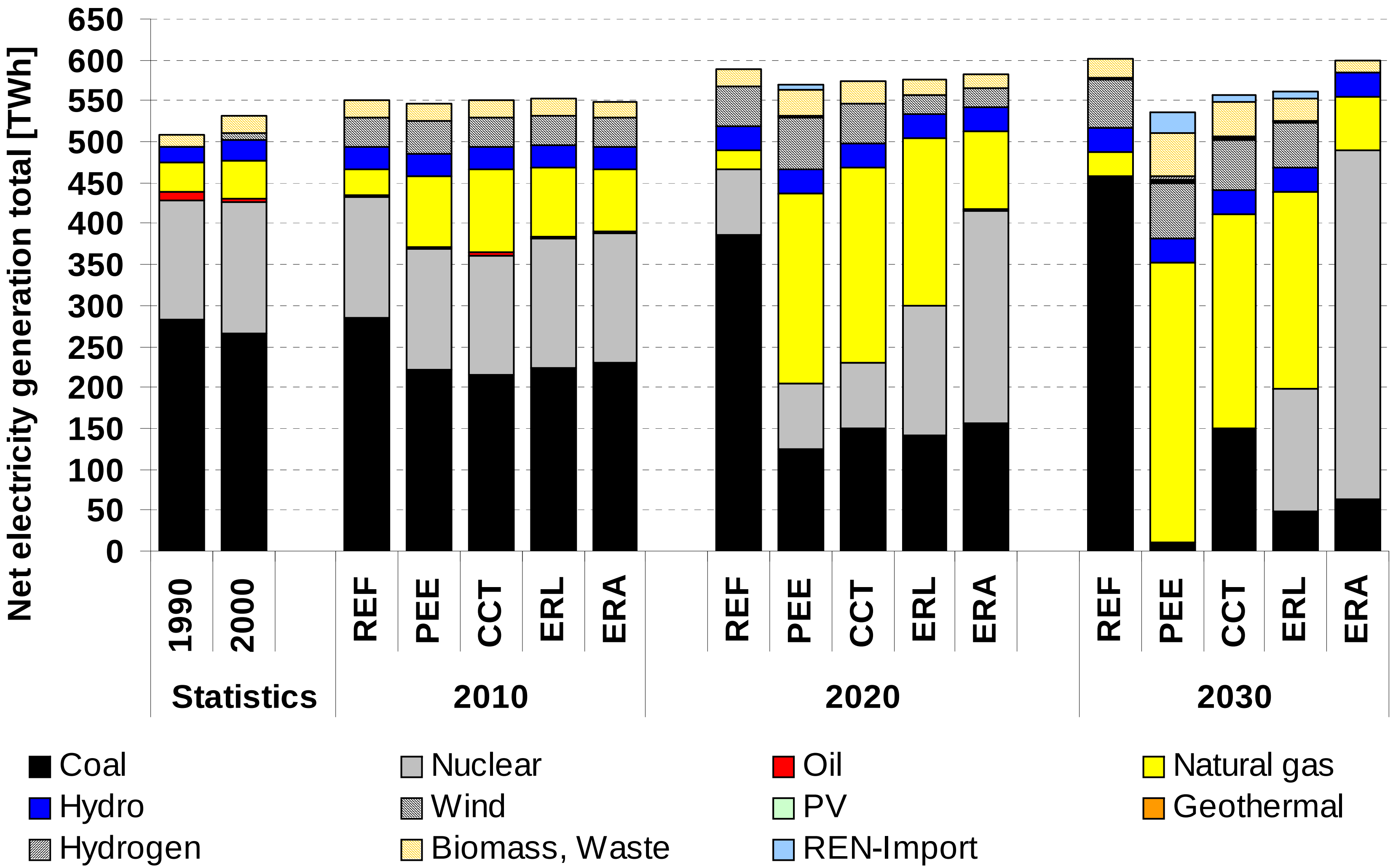
Efficient utilisation of resources

- cost efficient attainability of reduction targets
- nuclear energy: extension of operation time **(ERL)**
- nuclear energy: expansion possible **(ERA)**

Development of total primary energy supply



Development of electricity production structures



Cost implications

Scenario	cumulated reduction costs to 2030 [bn. $Euro_{00}$]	marginal reduction costs in 2030 [$Euro_{00}$/t]	average electricity production costs in 2030 [€-$Cent_{00}$/kWh]
Reference scenario (REF)			**3,6**
Preference for renewable energy sources (PEE)	**110**	**79**	**5,5**
Clean Coal Technologies (CCT)	**86**	**57**	**5,0**
Efficient utilisation of resources, extension of operation time (ERL)	**-30**	**42**	**3,8**
Efficient utilisation of resources, expansion (ERA)	**-113**	**27**	**2,5**

We must consider our planet to be on loan from our children, rather than being a gift from our ancestors. (...) As caretakers of our common future, we have the responsibility to seek scientifically sound policies, nationally as well as internationally. If the long-term viability of humanity is to be ensured, we have no other choice.

Go Harlem Brundtland


Thank you very much for
your attention!