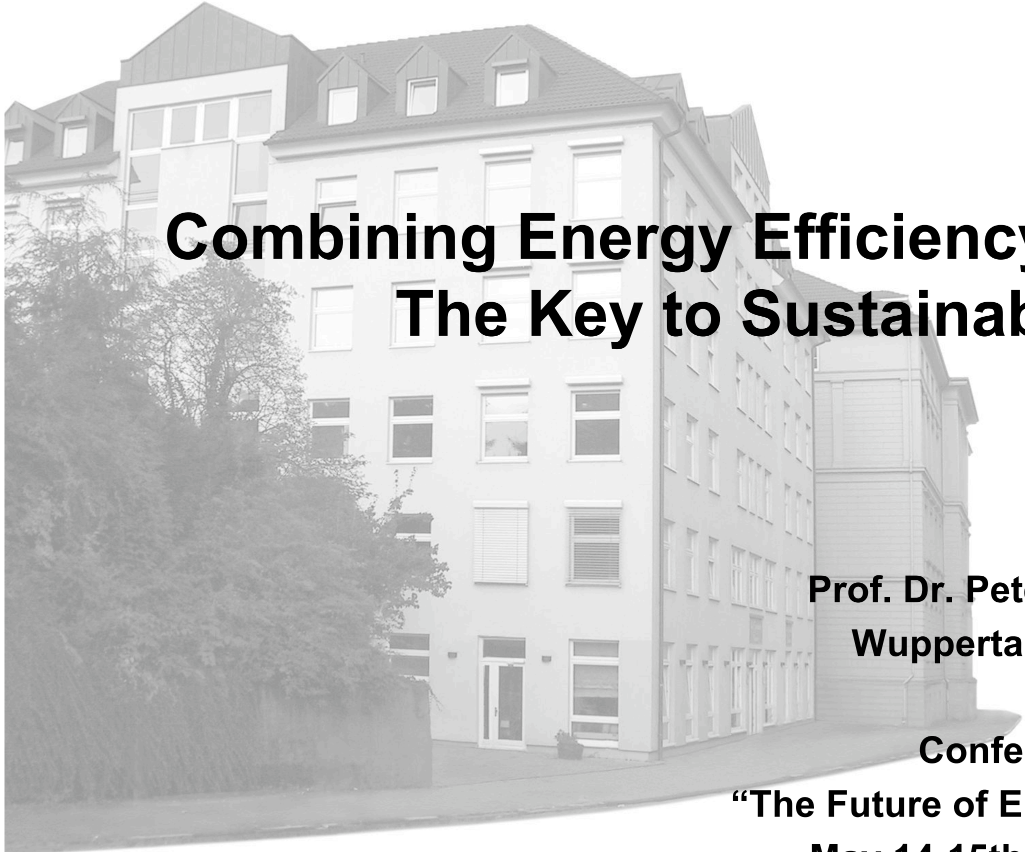
Wuppertal Institute
for Climate, Environment
and Energy



Combining Energy Efficiency and Renewable Energies: The Key to Sustainable Energy Systems

Prof. Dr. Peter Hennicke
Wuppertal Institute

Conference
“The Future of Energy in Egypt”,
May 14-15th, Cairo 2008

Thesis and Overview

1. **At the crossroads**: **Pessimism** because of **unsustainable trends** (e.g.climate change; resource wars) - **optimism** due to a growing number of good practice **projects** and **innovations**

2. **Closing the implementation gap**: "Scaling up what we already know to do" (Pacala/Socolov) - speeding up the dissemination of advanced mitigation technologies and good policies

3. **The key** for sustainable energy systems: Focussing on a **"robust technological corridor"** with "three green pillars": more efficient use of energy, co-/trigeneration and renewables

4. **„The future will be decentralized" (Siemens)**: Technology and competition driven power plant parks will **converge** worldwide - they will be „cleaner, leaner and greener"

5. **A combined „energy efficiency + renewables initiative"** is needed, it includes:

- **A vision** (Convergence and reduction to „2000 Watt per capita societies" in OECD countries / Swiss concept),
- **Quantified targets** (efficiency increase of 3 % p.a.in OECD countries; 3x20% EU-goal up tp 2020)
- **An innovative policy mix** and a supporting framework to create **markets for energy services**
- **The „Revival of the NEGAWatts"** (e.g. „Energy efficiency power plants"/ DSM; ESCOs; Energy Efficiency Funds)

Mitigation urgently needed

Characteristics of stabilization scenarios

Stabilization level (ppm CO_2-eq)	Global mean temp. increase at equilibrium (ºC)	Year CO_2 needs to peak	Year CO_2 emissions back at 2000 level	Reduction in 2050 CO_2 emissions compared to 2000
445 – 490	**2.0 – 2.4**	**2000 - 2015**	**2000- 2030**	**-85 to -50**
490 – 535	2.4 – 2.8	2000 - 2020	2000- 2040	-60 to -30
535 – 590	2.8 – 3.2	2010 - 2030	2020- 2060	-30 to +5
590 – 710	3.2 – 4.0	2020 - 2060	2050- 2100	+10 to +60
710 – 855	4.0 – 4.9	2050 - 2080		+25 to +85
855 – 1130	4.9 – 6.1	2060 - 2090		+90 to +140

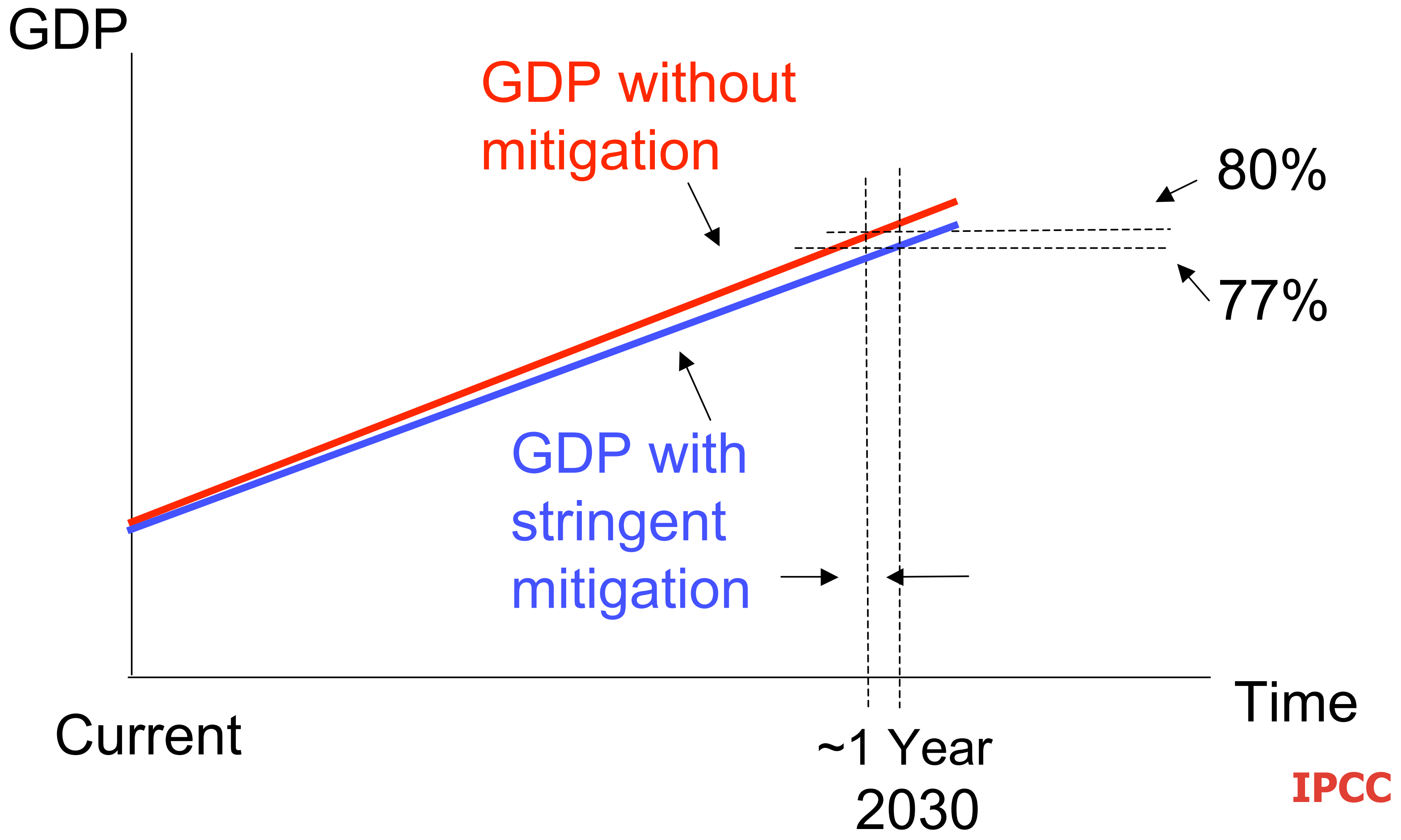
Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels

[1] The best estimate of climate sensitivity is 3ºC [WG 1 SPM].
[2] Note that global mean temperature at equilibrium is different from expected global mean temperature at the time of stabilization of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilisation of GHG concentrations occurs between 2100 and 2150.
[3] Ranges correspond to the 15^{th} to 85^{th} percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios.

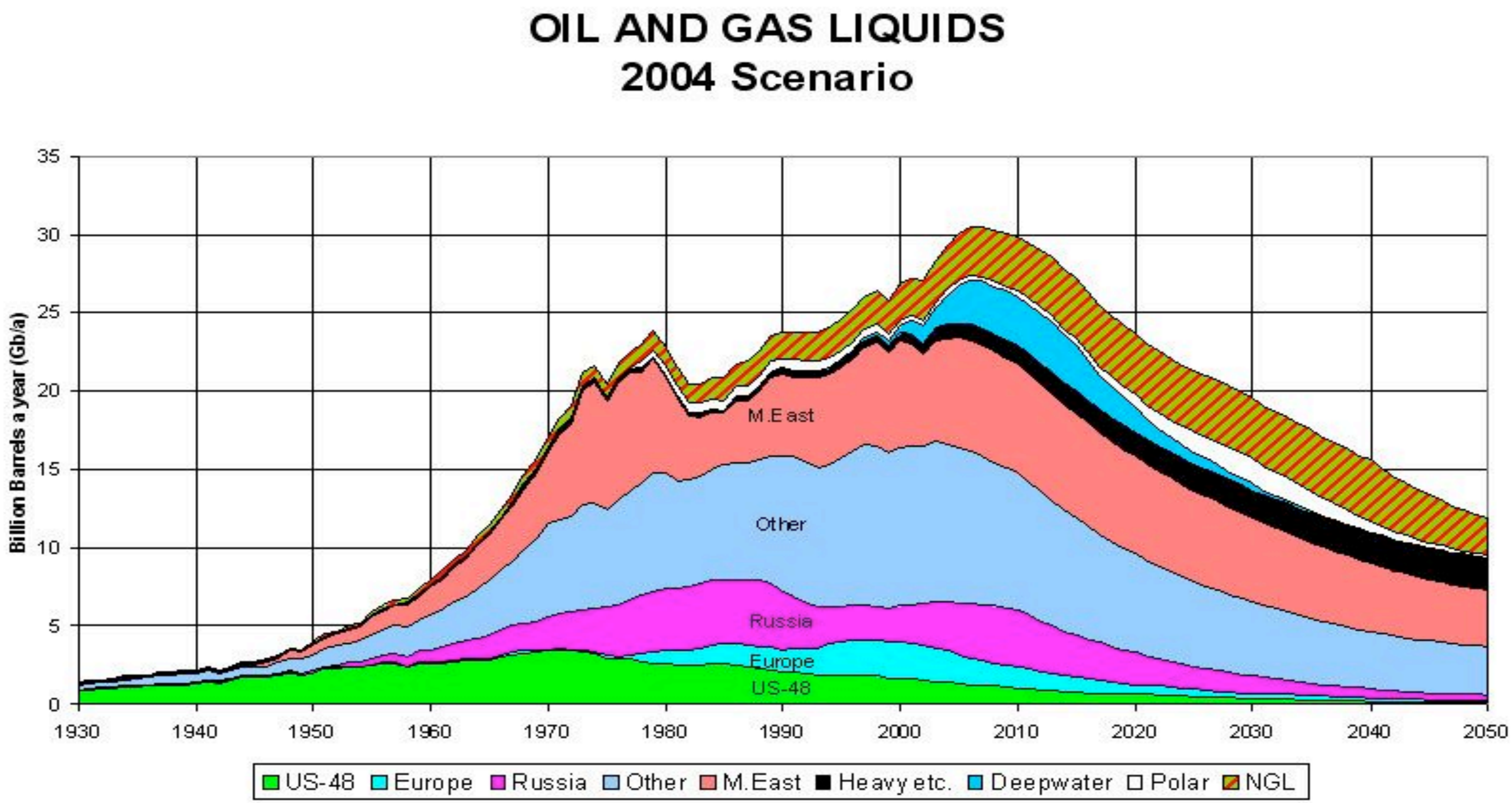
IPCC

Stringent mtigation pays:
IPCC calculates maximum 3% costs of GDP -
World GDP delayed only one year in 2030!

Illustration of costs numbers

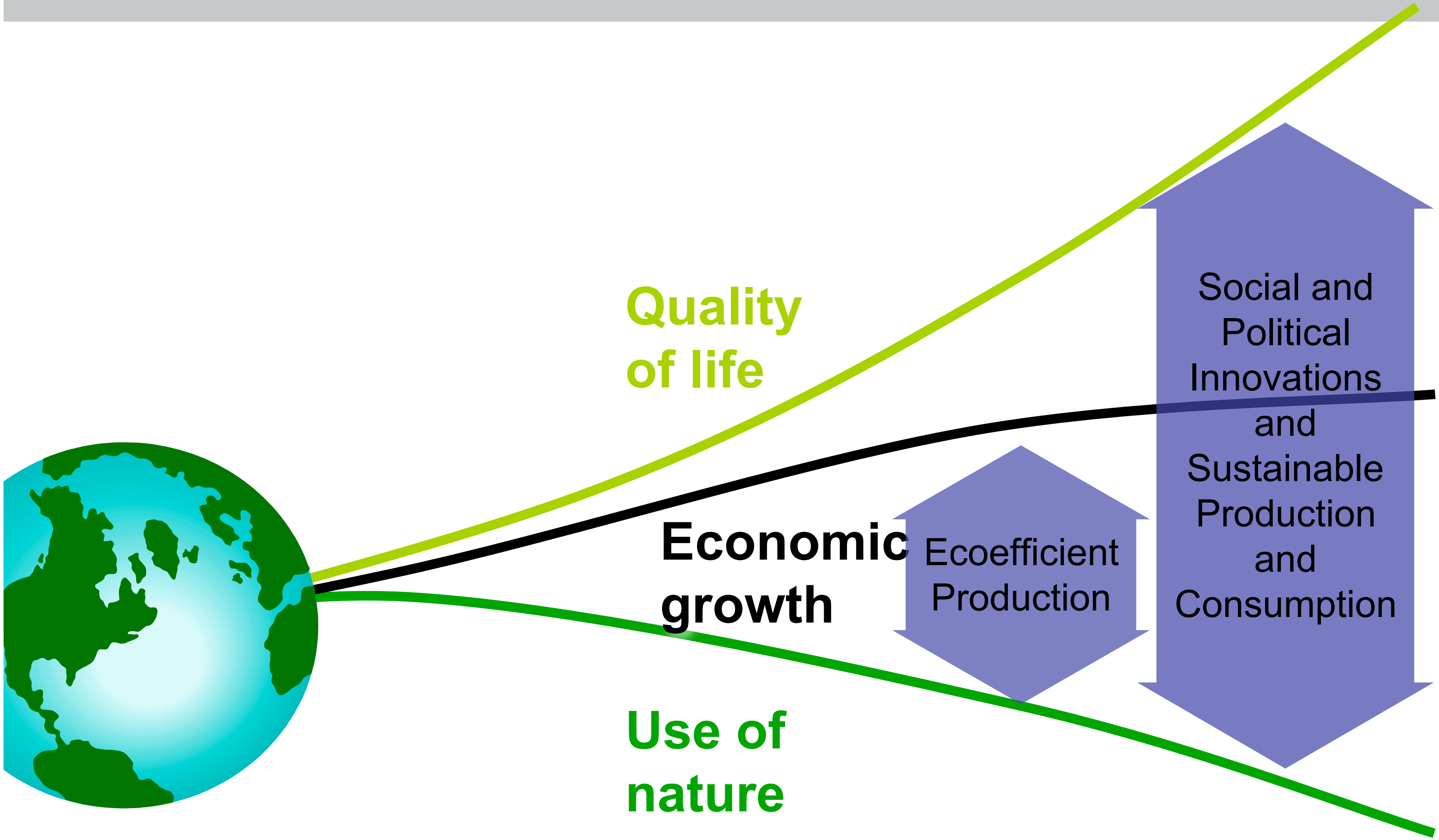


Maximum of Global Oil Production around 2010 ?
Oil Price of 200$/b „very probable“ (Goldman Sachs 5/2008)?
The ASPO Scenario 2004



source: The Association for the Study of Peak Oil&Gas (ASPO): Oil and Gas Liquids 2004 Scenario, updated by Colin J. Campbell, 2004-05-15, in: www.peakoil.net, Recherche v. 08.07.2004

The Challenge:
Absolute decoupling of the quality of life from the use of nature



Sustainable Energy Systems:
Common, but differentiated challenges for IC and DC

Industrialized Countries (IC)

- **Absolut decoupling** of primary energy and GDP growth; reduce per cap energy consumption by 50-75%, but increase of well-being (e.g. „2000 W/cap society“)
- Establish **sustainable consumption and production patterns**: Eco-efficiency, service orientation, life style changes, ecological modernisation,....

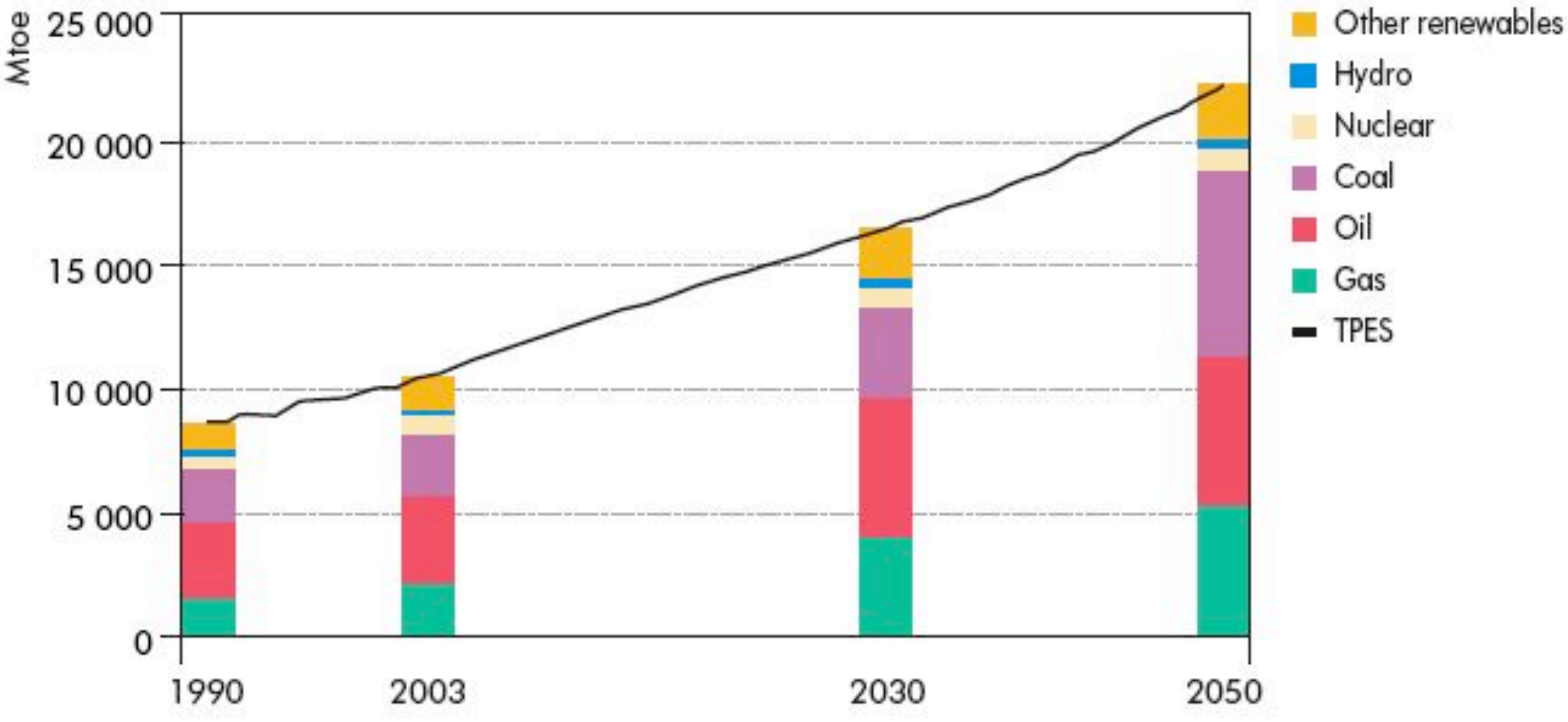
Developing Countries (DC)

- **Relative decoupling:** Reduce **growth rates** of energy consumption by more efficient use; increase living standards, alleviate poverty, foster rural electrification
- Combine advanced end use efficiency with renewables **("leap frogging)**

Common challenges:

- **Avoid lock-in into outdated and inefficient technologies:** The reference should be the sustainable common future and not the unsustainable past
- **Foster Institutional change**: decentralisation,liberalisation,democratisation
- Raise **resource productivity** by integrating material + energy efficiency

IEA 2006: World primary energy supply in the (non sustainable) Baseline Scenario (IEA, Energy Technology Perspectives, Paris 2006)

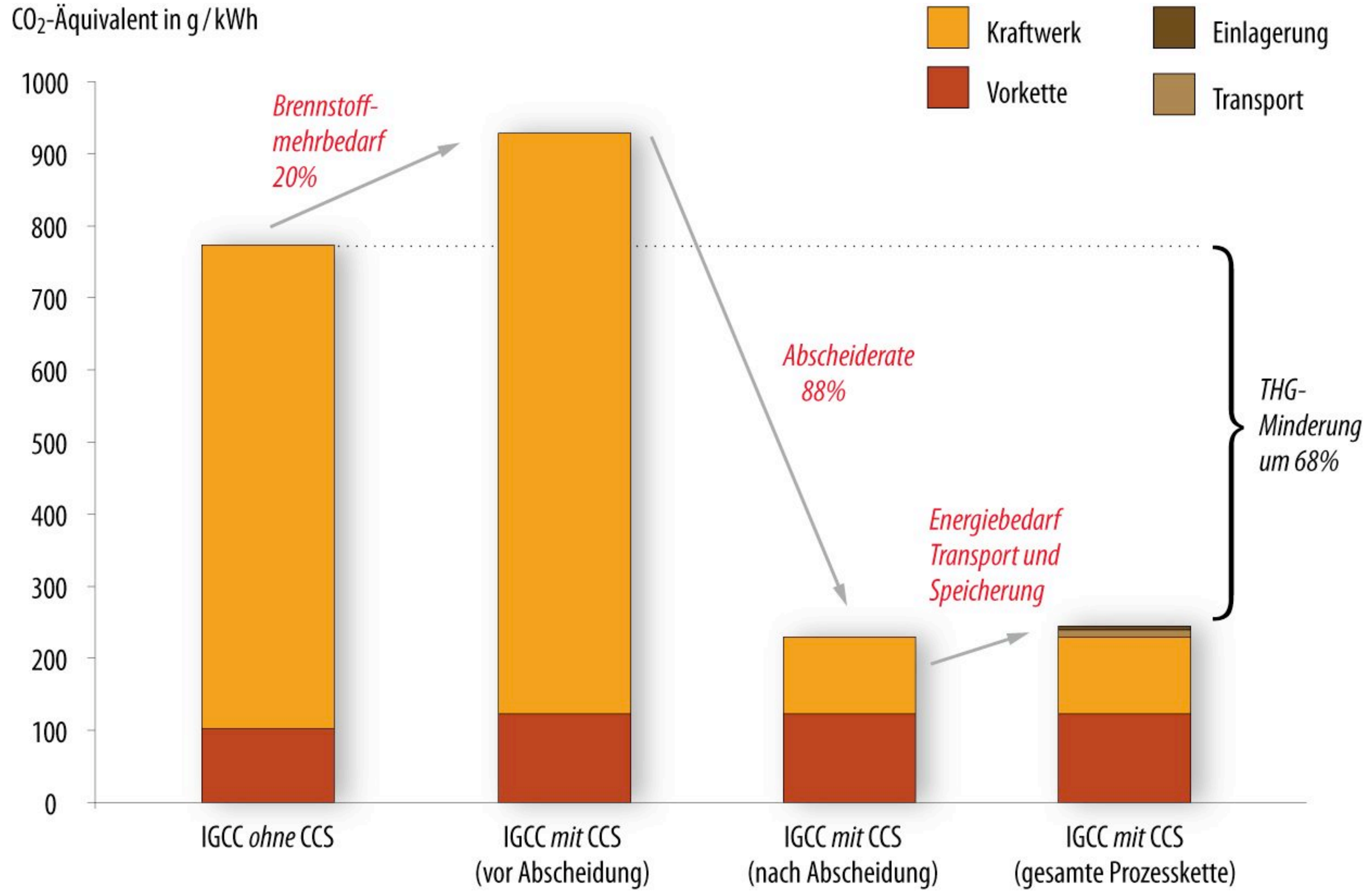


Key point

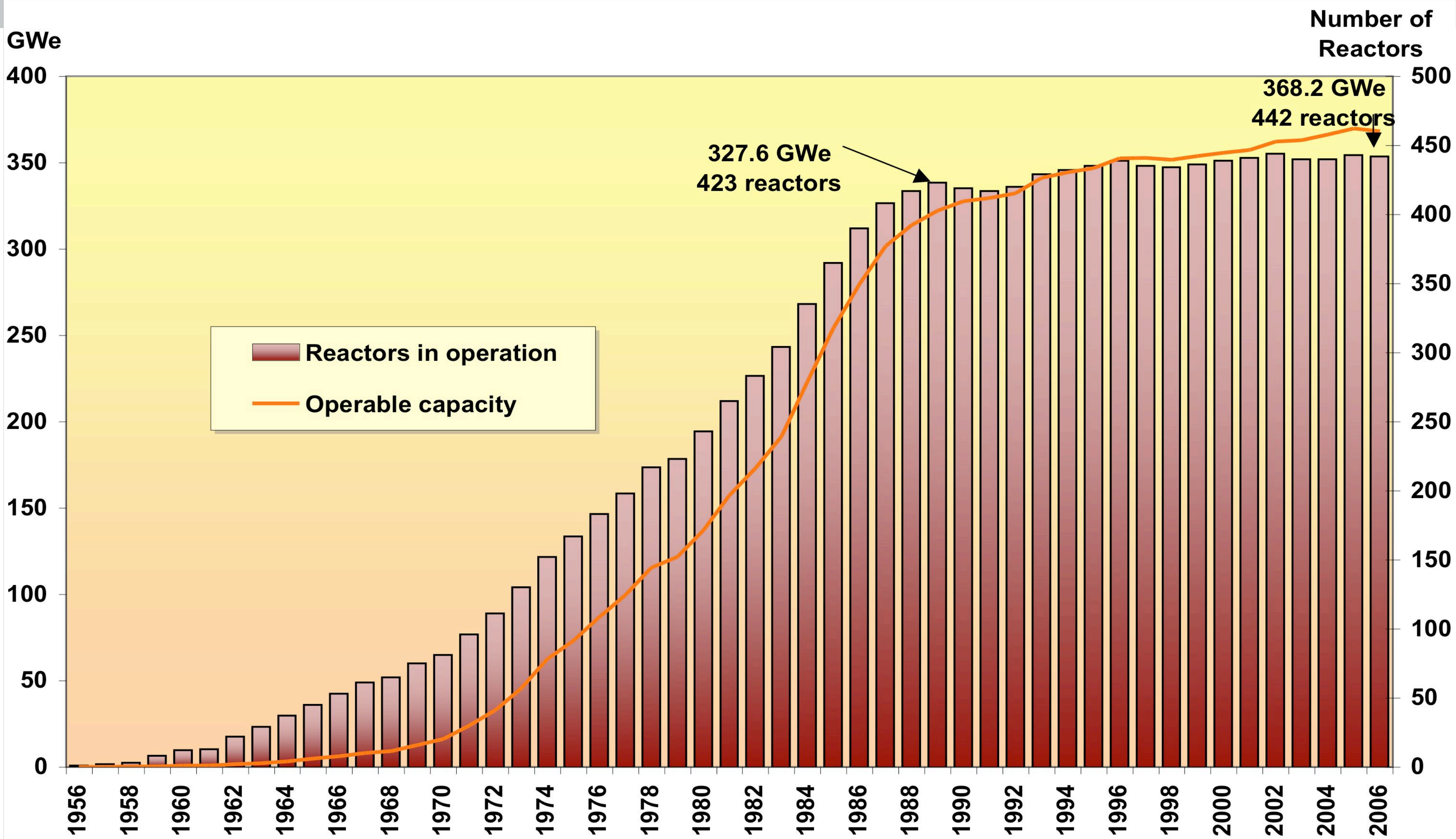
Primary energy use more than doubles between 2003 and 2050, with a very high reliance on coal.

Only "*Cleaner*" Coal with CCS: About 70% avoided GHG-emissions

(hard coal IGCC; reduction of efficiency: 50% to 42%)



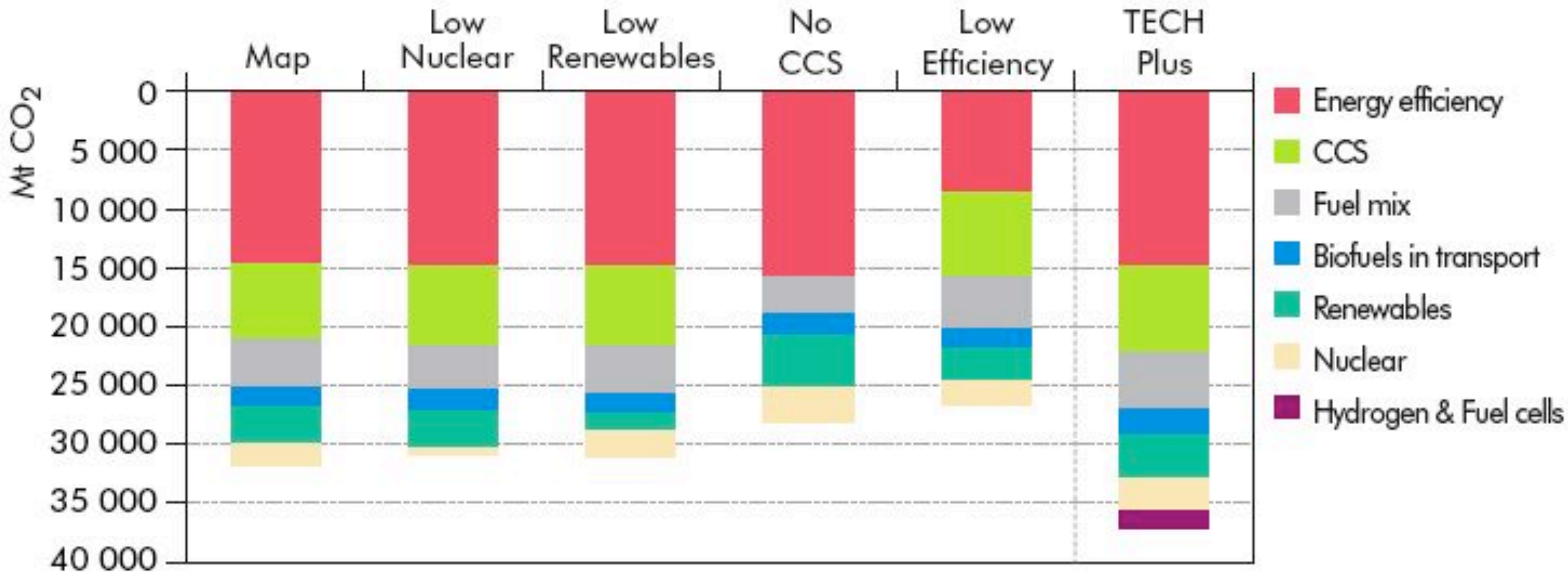
Nuclear Reactors & Net Operating Capacity in the World
in Gwe, from 1956 to May 2006



Source : IAEA PRIS, MSC

Energy efficiency is the most promising CO_2 reduction option within the Energy Technology Perspectives Scenarios of the IEA

reduction below Baseline Scenario in 2050



Key point

Energy efficiency plays the most important role in CO_2 emission reductions, accounting for up to 53% of total CO_2 emission reductions.

Source: IEA 2006

To foster diffusion of advanced technologies is crucial:
How can we make it happen in time?

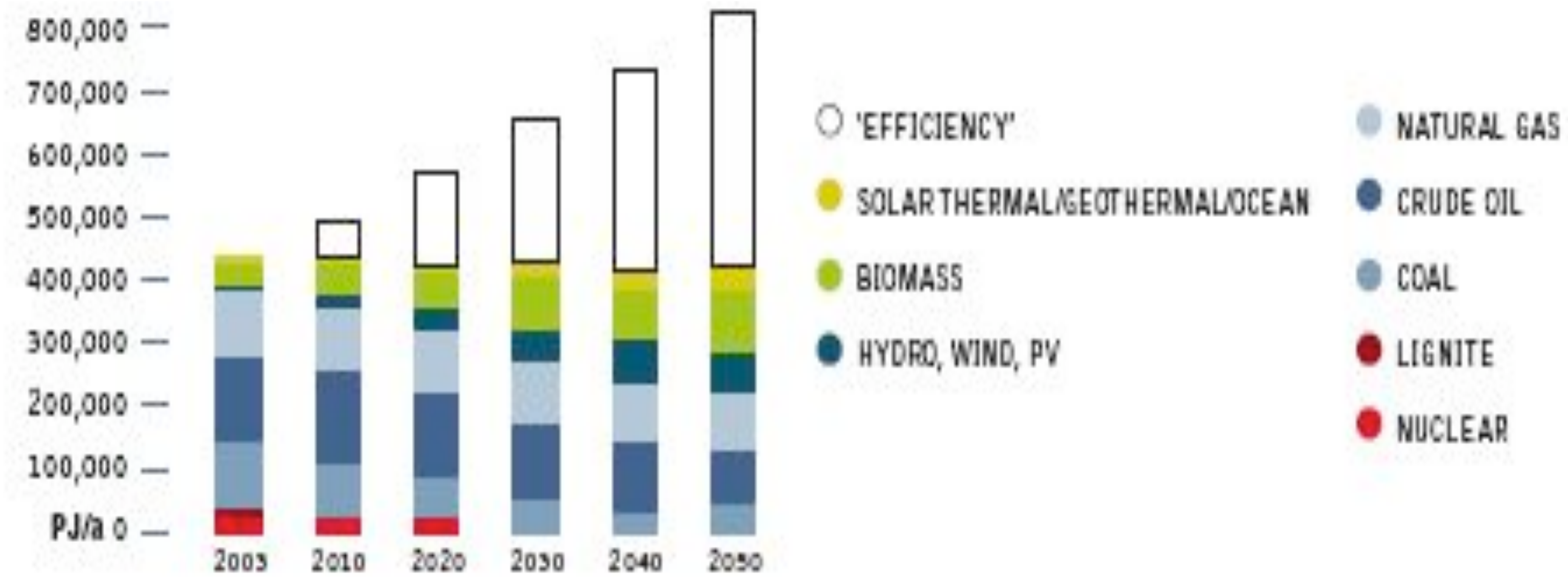
„Humanity can solve the carbon and climate problem in the first half of this century **simply by scaling up** what we already know to do“.

(Pacala/ Socolow 2004
Princeton University, USA)

Primary energy under the "energy (r) evolution scenario

(Source: DLR (Ger); Ecofys (NL) on behalf of Greenpeace and Europ.Renewable Energy Council, 2007)

("EFFICIENCY" = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



Results in 2050:

- **Nearly halving primary energy consumption**: 422 EJ instead of 810 EJ (BAU)
- **Share of renewables:** 70% (electricity) and 65% (heat); phasing out nuclear
- **Expansion of CHP** (gas; biomass); biomass mainly unsed for stationary use
- **50% $C0_2$-reduction** from 23 bn t/a (2003) to 11,5 bn t/a
- **Reducing total electricity costs** from $ 4,300bn by on third

Long-term global scenario of the German Advisory Council on Global Change (WBGU)

WBGU

Basis for WBGU exemplary path:
A1T-450-scenario (IPCC-Post-SRES-scenario, IIASA, MESSAGE-Model)

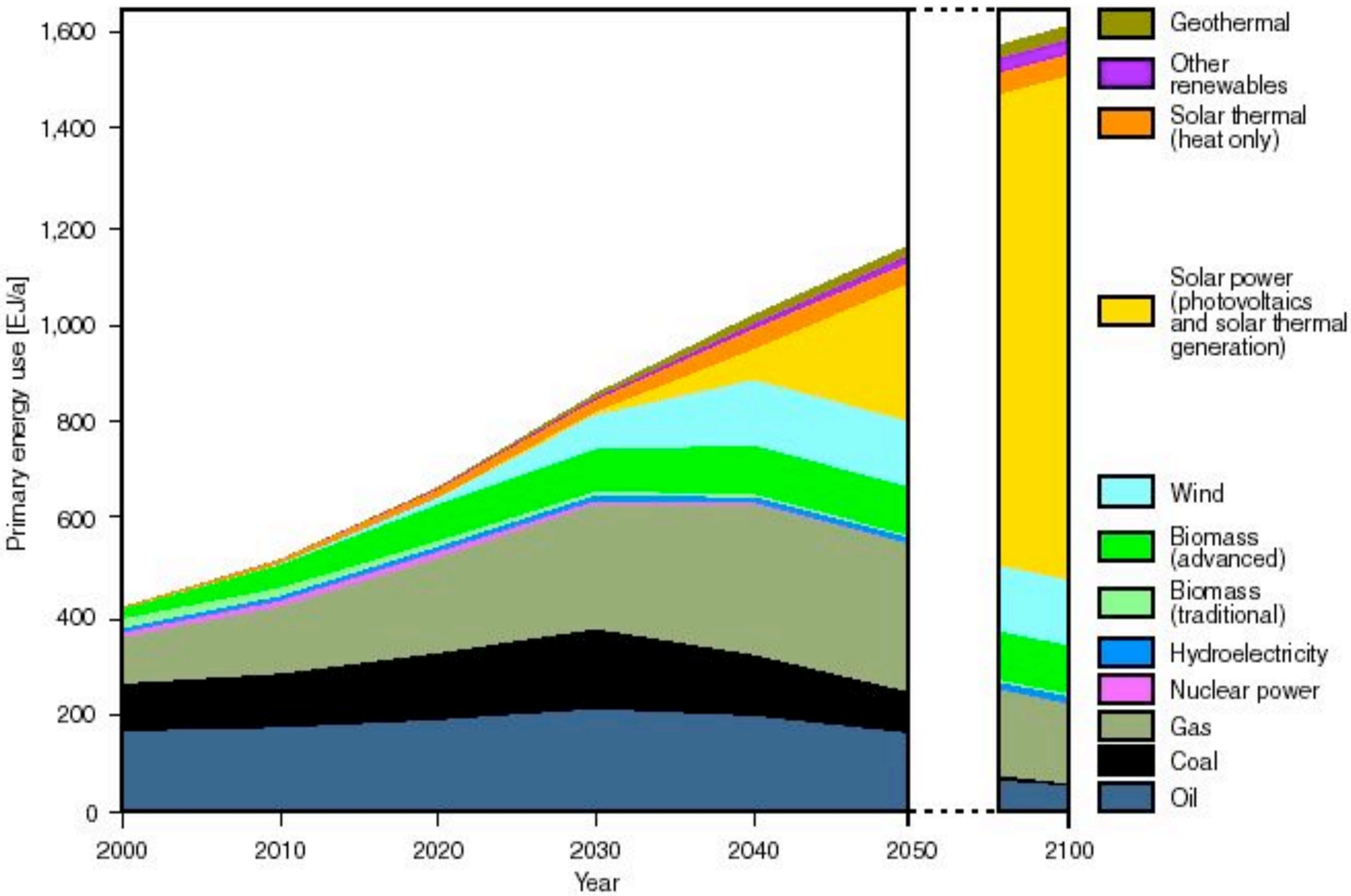
A high economic growth

1 economic and social convergence, globalisation
cooperation between regions

T dynamical technological development
towards non-fossile energy sources

450 CO_2-stabilisation concentration in ppmv

WBGU Exemplary Path: Global Energy Mix



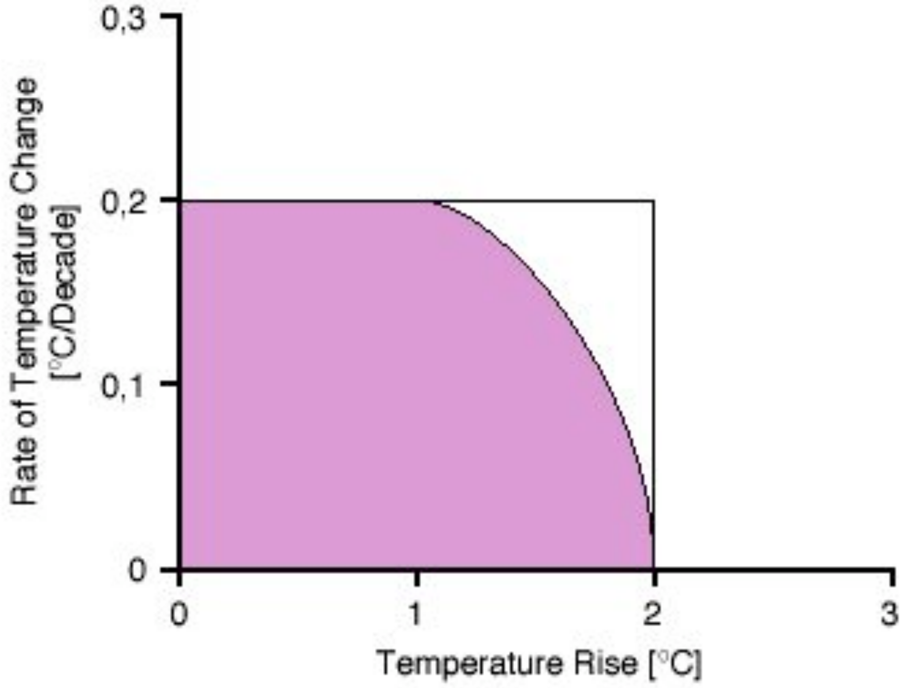
“Tolerabel Window” and Results of the WBGU-Sustainabilty Scenario

WBGU

▪

- •Keeping Climate Change within the „Tolerable Window“
- •Reducing $C0_2$ by about 50% globally and 80% in ICs
- •Phasing out nuclear up to 2050; CCS needed
- •Raising living standards in all developing countries
- •Being the „Least Cost Option“ compared to IPCC-SRES-Scenarios

Tolerable Window:
Temperature change:
2^0C and <0.2^0C/decade



Results of the first European Energy-Delphi-Survey (2005)

▪An international Dephi survey revealed the following results concerning the future of the European Energy Systems up to 2030 *(IZT, 2007)*

▪*„The 670 experts gave those technologies the **highest priority** which could reduce the energy consumption" (**„increase of energy efficiency"**).*

▪ *A clear trend to a **decentralized energy system** and to implementing **more energy storage capacity** was identified.*

▪ ***Nuclear energy** was controversial among the experts...*

▪*A number of Delphi commments point to the apparent contradiction between the high share of funding for nuclear research, especially **fusion**, and the meagre positive impacts anticipated over the next 35 years...The crucial issue in the case of nuclear **fission** is public acceptance related...to the unsolved problem of waste management and the risks from political instability, terrorism and war,*

▪*The **impacts of $C0_2$ sequestration** were rated as rather low in relation to the uncertainties connected with the technology".*

Comparison of energy intensities: a huge potential for leap frogging

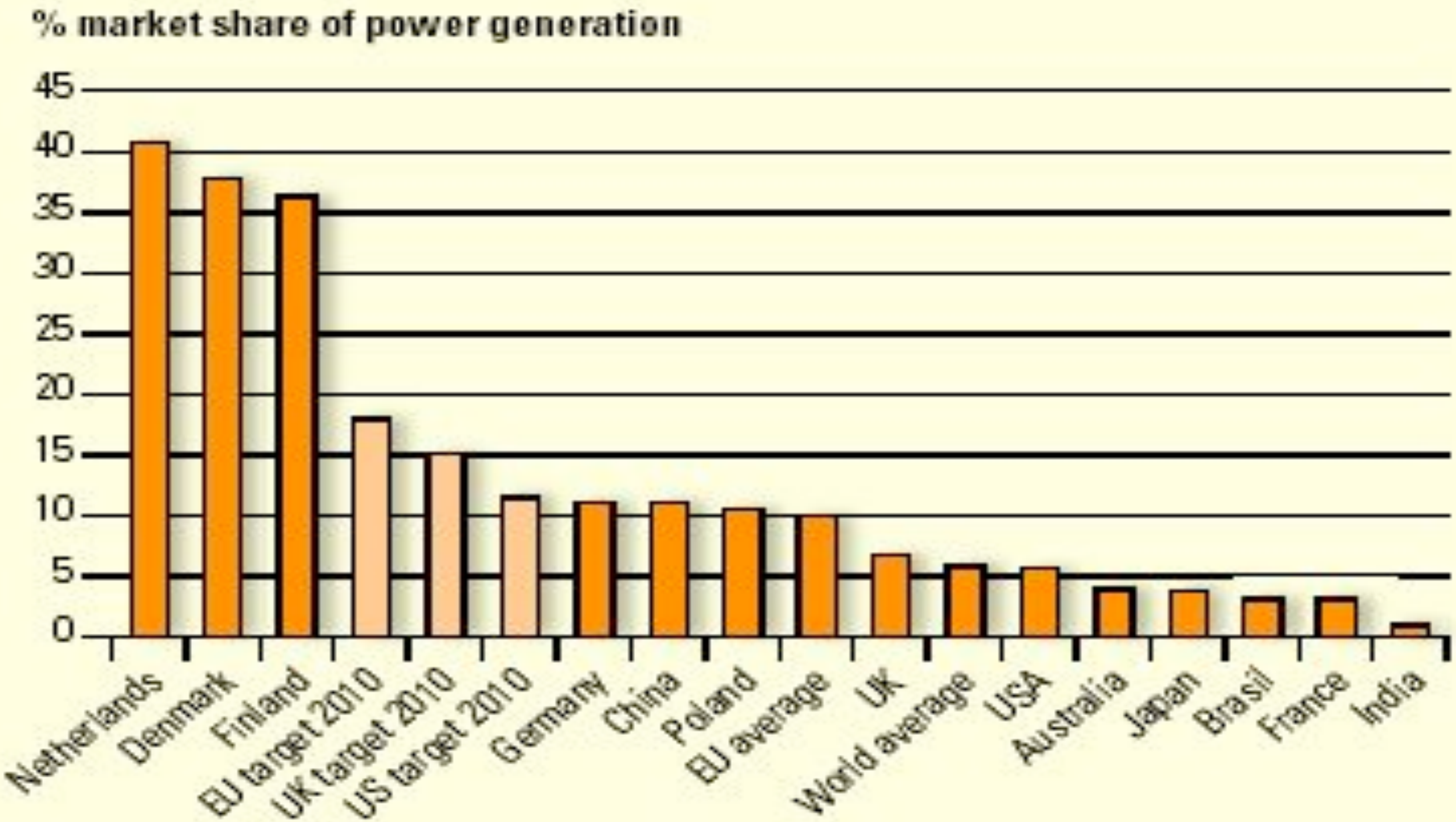
(Primary Energy/GNP (1996) in kg SKE per 1000 DM)

Japan	101
Europe	200
USA	306
China	1171
Former SU	1777
Russia	1817

(EU Accession Countries: about 4x higher than EU15!)

Source: RWE 2002

A potential for "leap frogging" around the world: Many untapped options for co-/trigeneration!



▪ Source: Literature List of Wuppertal Institute

Increase of renewables is often unterestimated: The case of China

- **World Energy Outlook 2003 (IEA)**
  - **New capacities: + *2,3 GW* up to 2010 (without small hydro)**

- **International Action Plan (Target 2010: > + *60 GW*)**
  - **Hydro (50 GW)**
  - **Wind (4 GW)**
  - **Biomass (6 GW)**
  - **Solar (450 MW)**

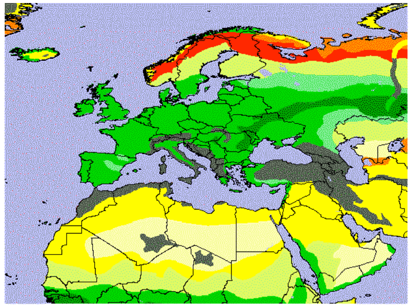
Committment for 2020: + *121 GW (about 12% of total power capacity)*

but also: 1) ca. 2 nuclear power plants/a

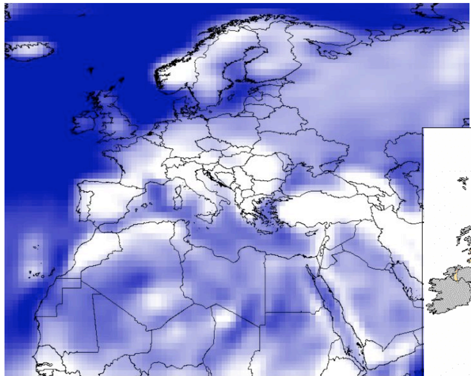
2) ca. 20 GW coal/a

Renewable Energy Resource Mapping : Typical Yield in million $kWh_{el}/km^2/y$

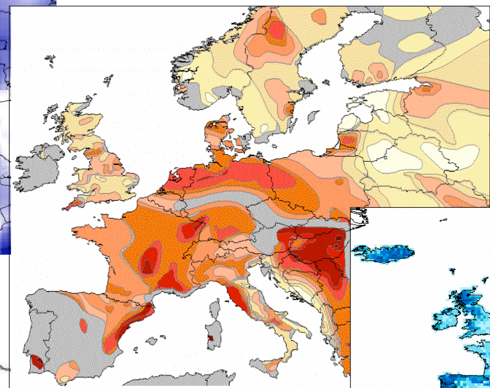
Biomass (1)



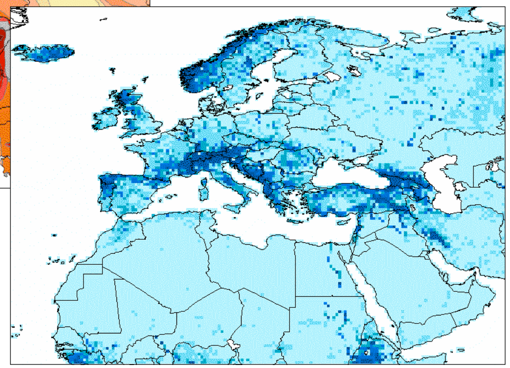
Wind Energy (30)

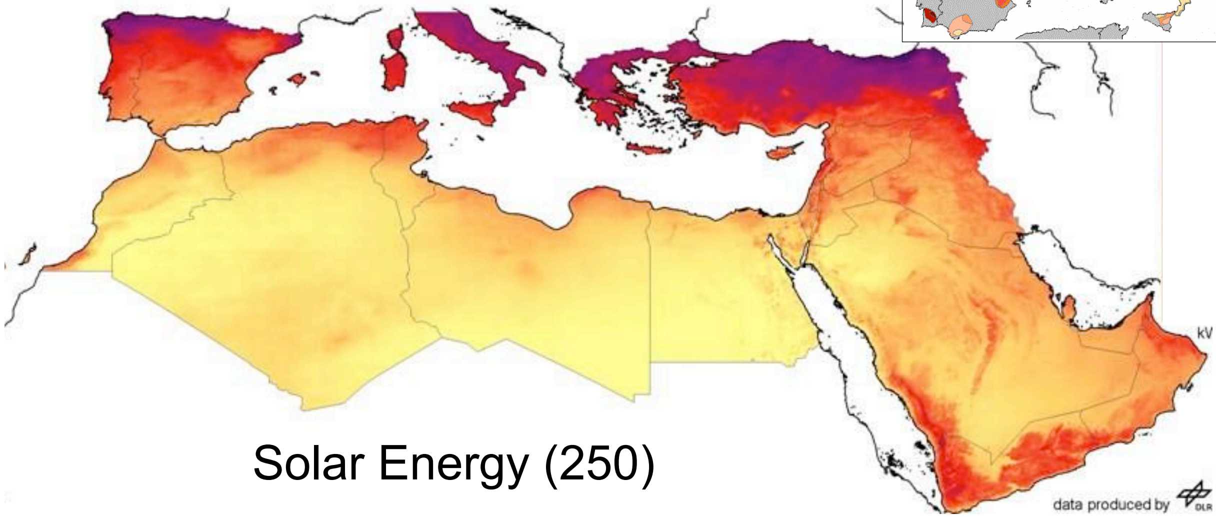


Geothermal Energy (1)



Hydropower (30)





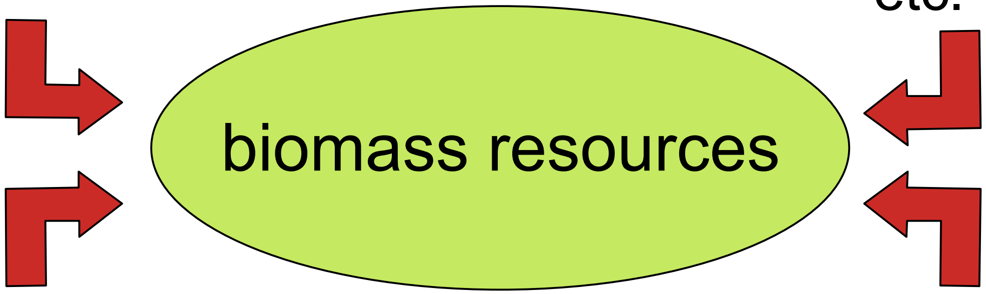
Solar Energy (250)

Competition for food, raw materials and mobile/stationary biofuels - with limited biomass resources

industrial resources
- textile industry
- chemical/pharmacy
- automobile industry
- etc.

Biofuels
- Ethanol and Bio-Diesel
- **Hydrogen**
- BTL (Sunfuel)
- etc.

Ecological agriculture



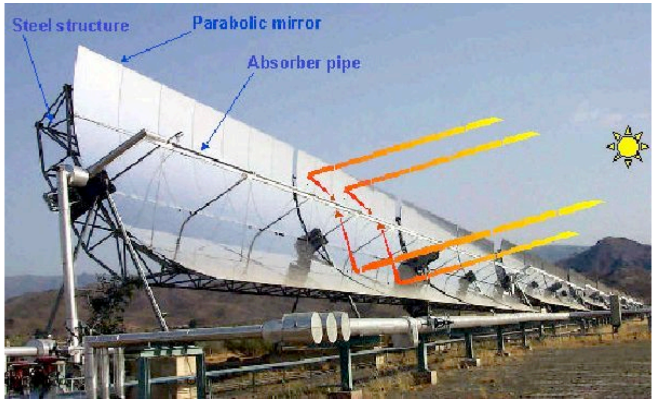
Landscape protected areas

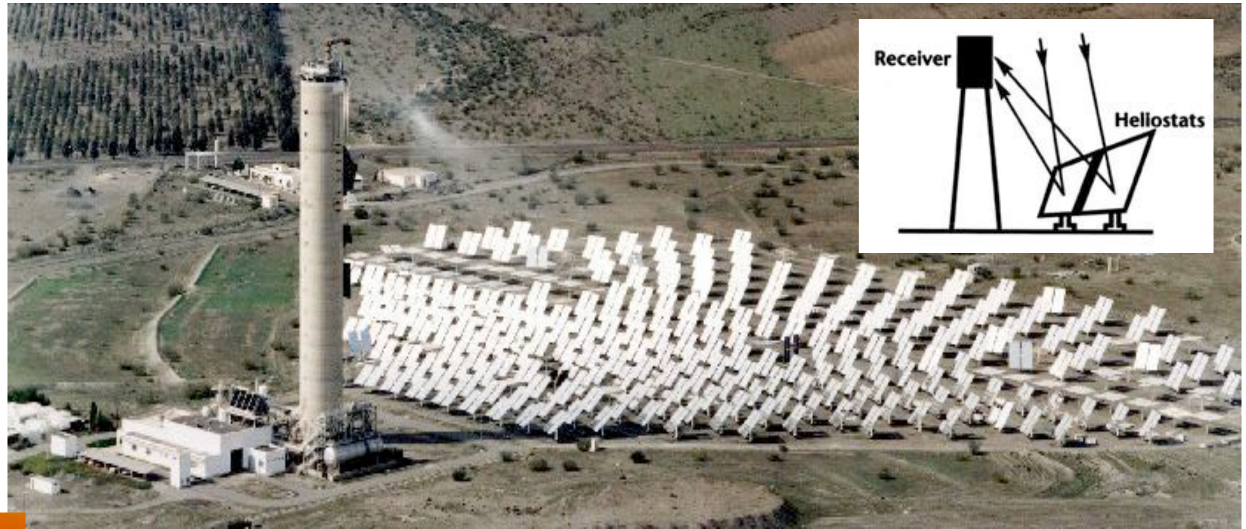
electricity supply
- condensating power plants, co-firing
- co- and trigeneration
- innovative gasification plants

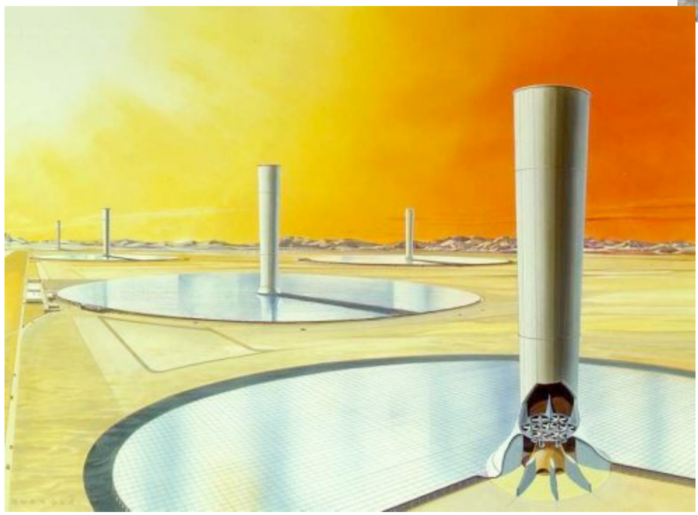
heat supply
- pellet heating systems
- district heating
- etc.

⇨ **Detailed energy system analysis, science based priorities and longterm strategies are needed!**

Options for global renewable energy supply
Concentrated Solar Power (CSP)





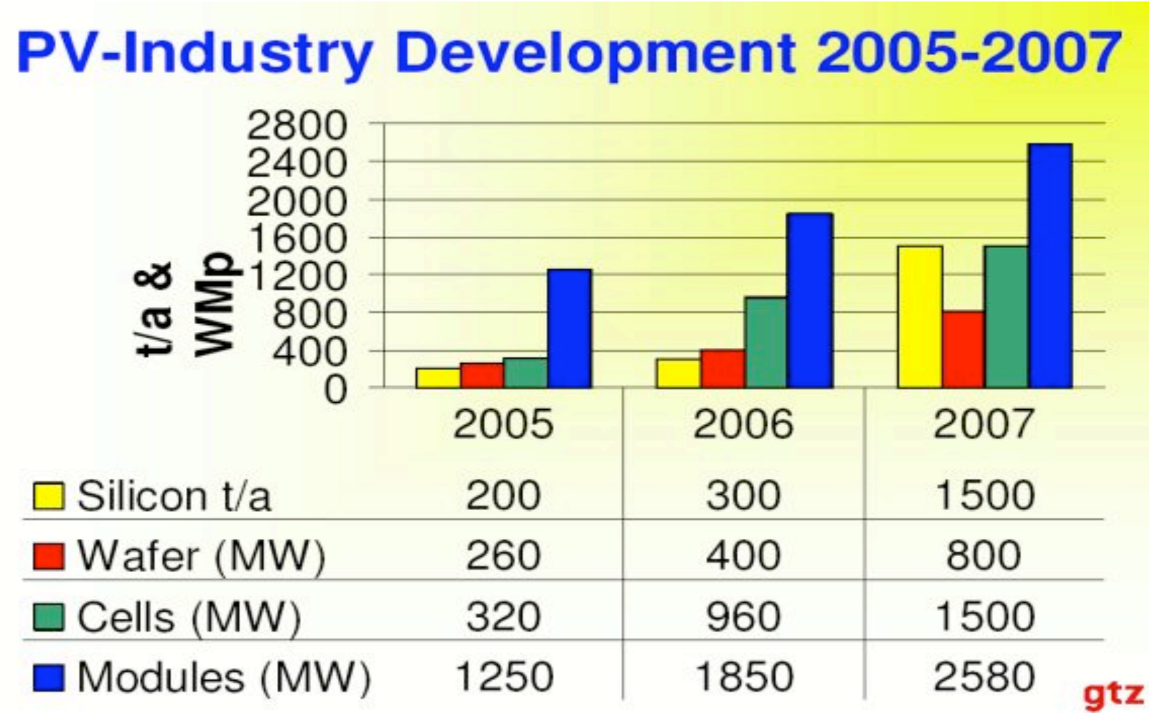


Rapid PV-Development 2005-2007
„PV competitive in 5-10 years“
(Photon Consult 2007)

The growth of China`s production capacities is tremendous.
Today, China is Nr.3; in a few years China will be Nr.1.

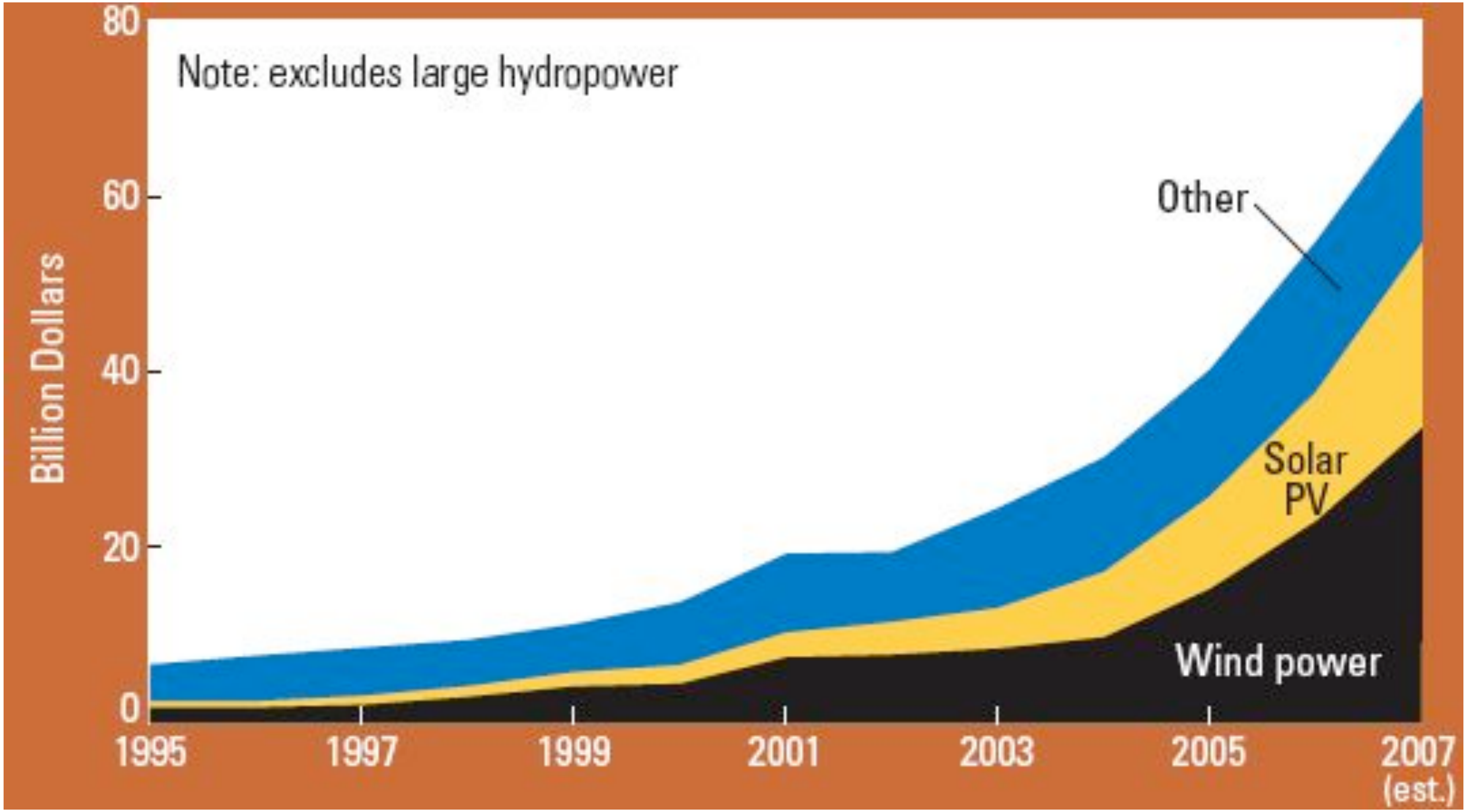
For comparison:
In 2006 world production capacities had been about 2500 MW; China 400 MW, exporting to Europe

Greatest World Producers::
- Sharp (Japan)
- Q-Cells (Gerrnany)
- Kyocera (Japan)
- Suntech (China)

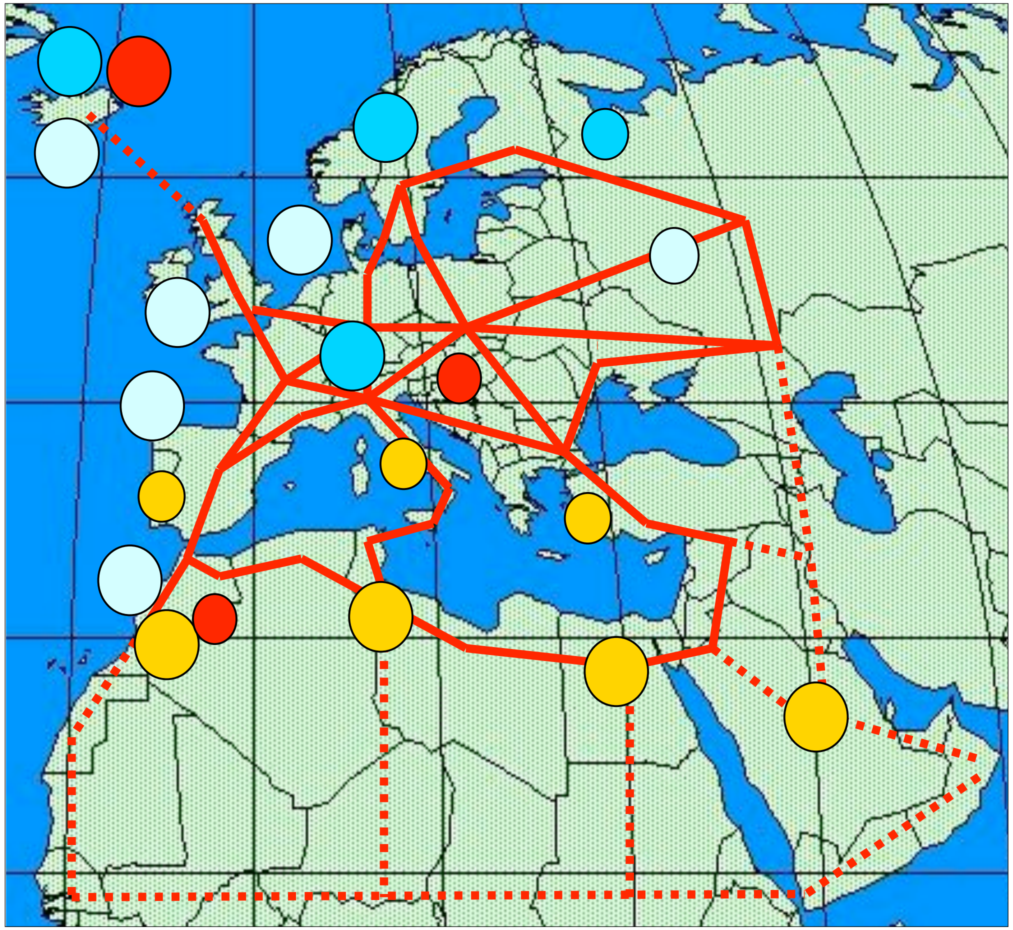


Quelle: Frank Haugwitz, gtz, 2007

Annual Investment in New Renewable Energy Capacity, 1995-2007
(Ren21, Status Report 2007)



Perspectives of cooperation: Mutual benefits from utilizing renewables within supraregional and trans-European systems.



Solar

Wind

Hydro

Geothermal

EURO-MED

possible further inter-connections

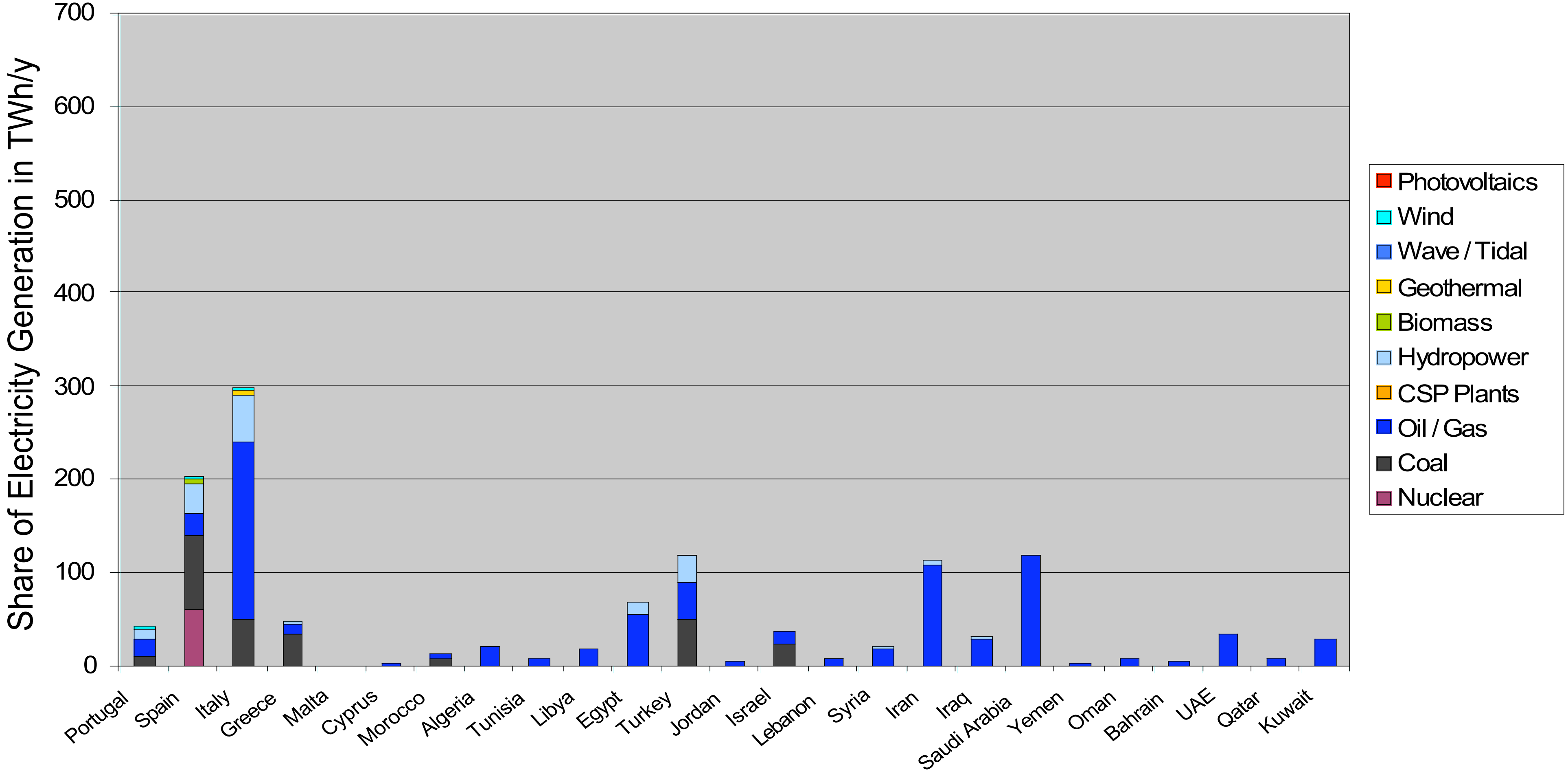
Technical potential of electricity from CSP in North Africa: 1.360.000 TWh = 100 x world electricity demand!

Status of electricity generation in MENA-Region/MED-CSP Project

Source: DLR/Trieb 2005

DLR

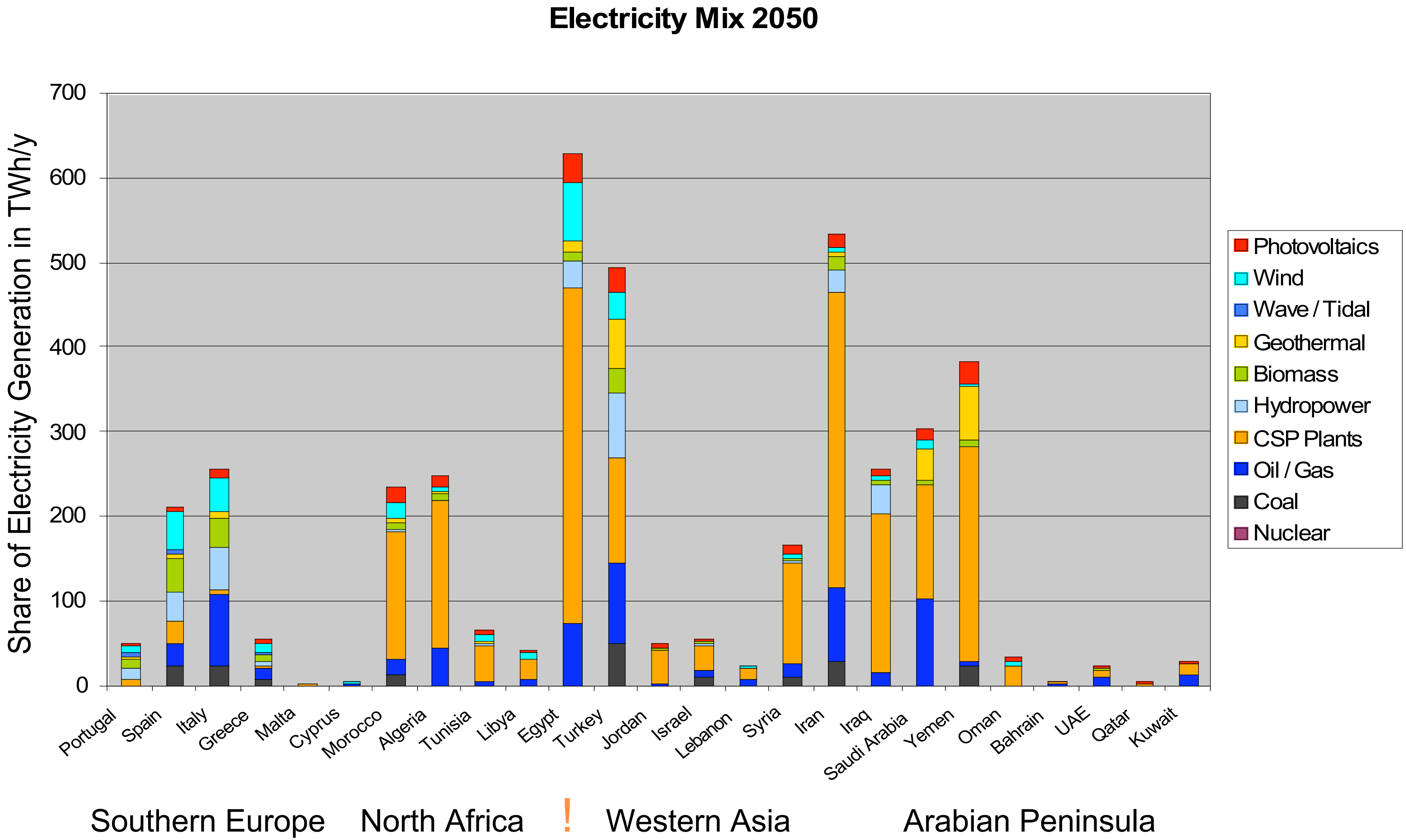
Electricity Mix 2000



Southern Europe North Africa ! Western Asia Arabian Peninsula

Share for electricity generation in a long term Cooperation Scenario in MENA-Region/Med-SCP Project

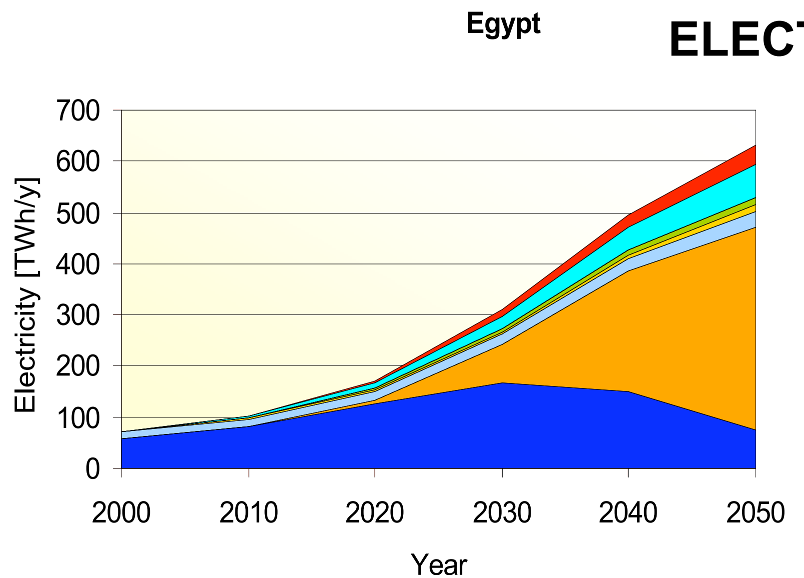
Source: DLR/Trieb 2005

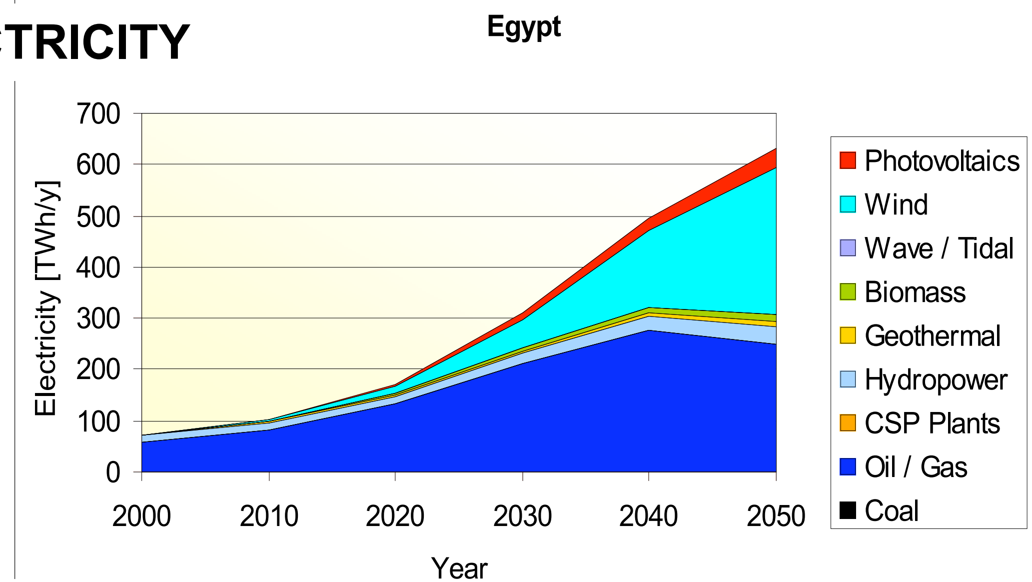


Scenario MED-CSP Scenario “Wind”

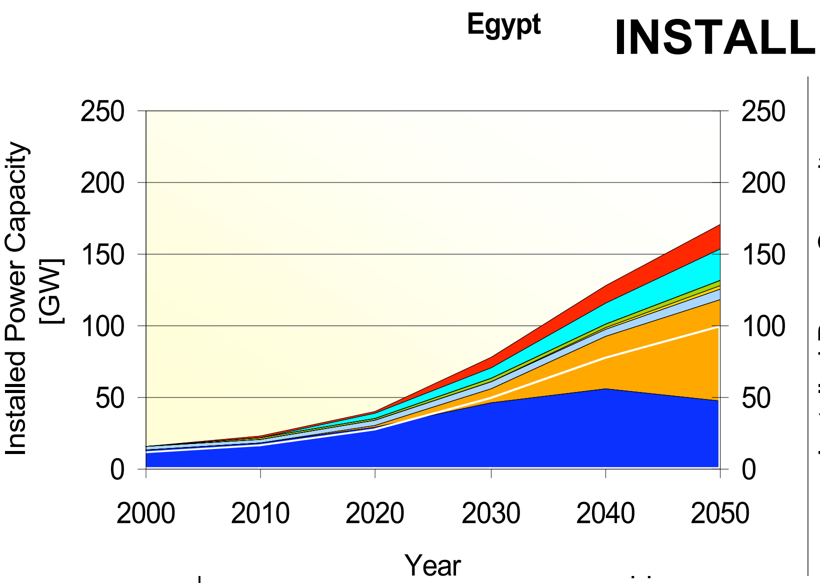
Source: DLR/Trieb 2005

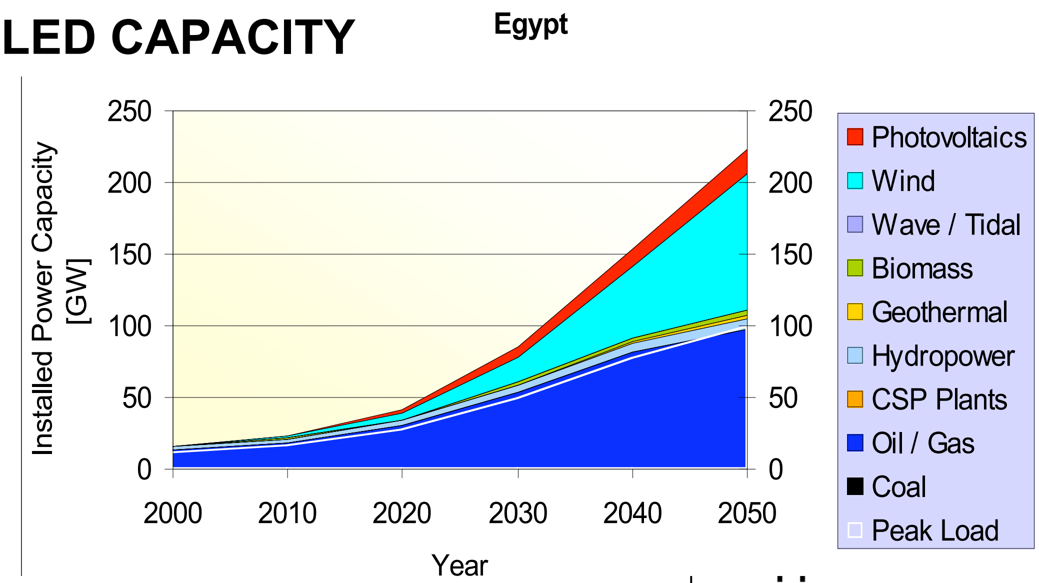
ELECTRICITY





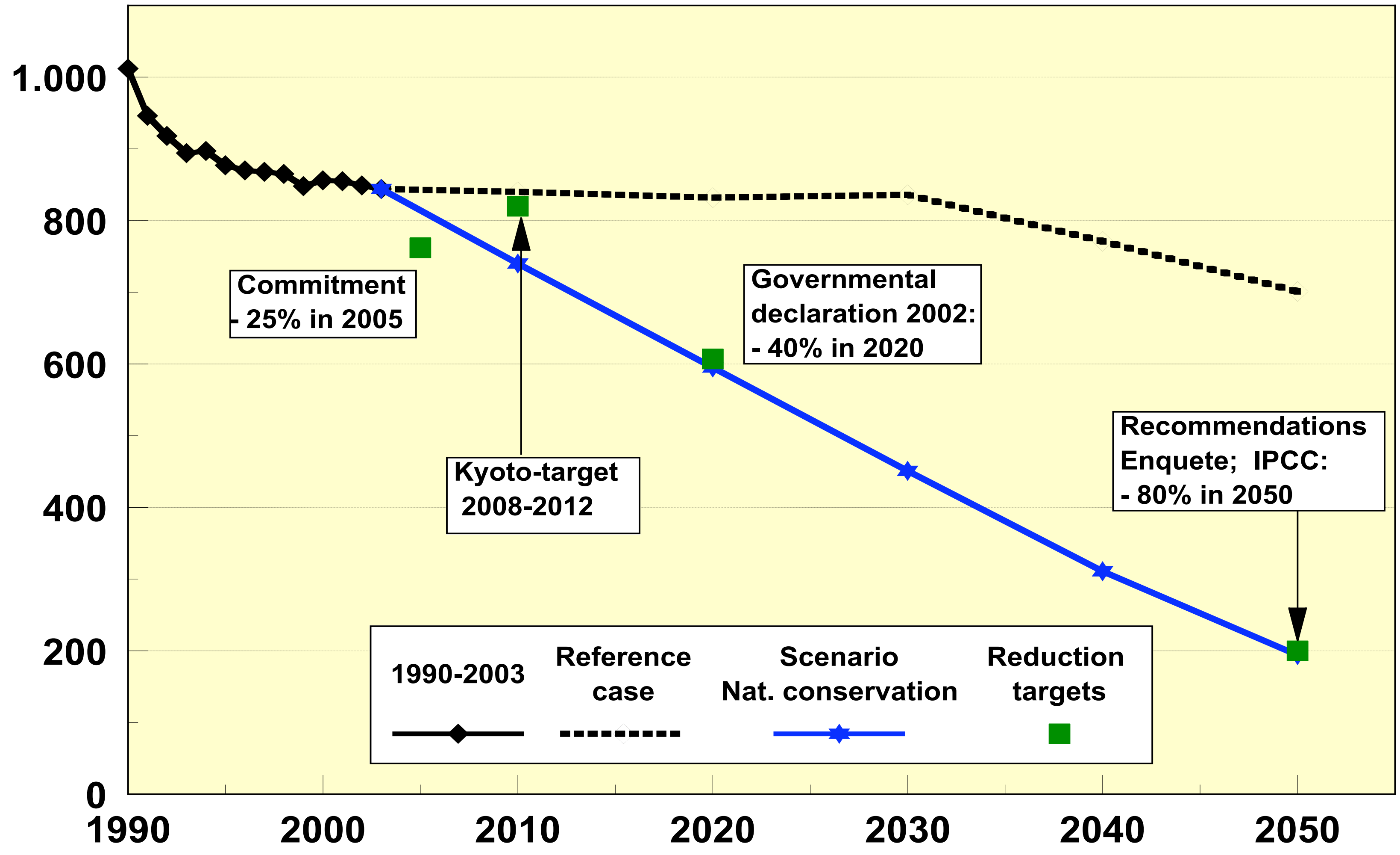
INSTALLED CAPACITY





How can Germany contribute to climate mitigation?
CO_2-reduction path in a German sustainable energy system

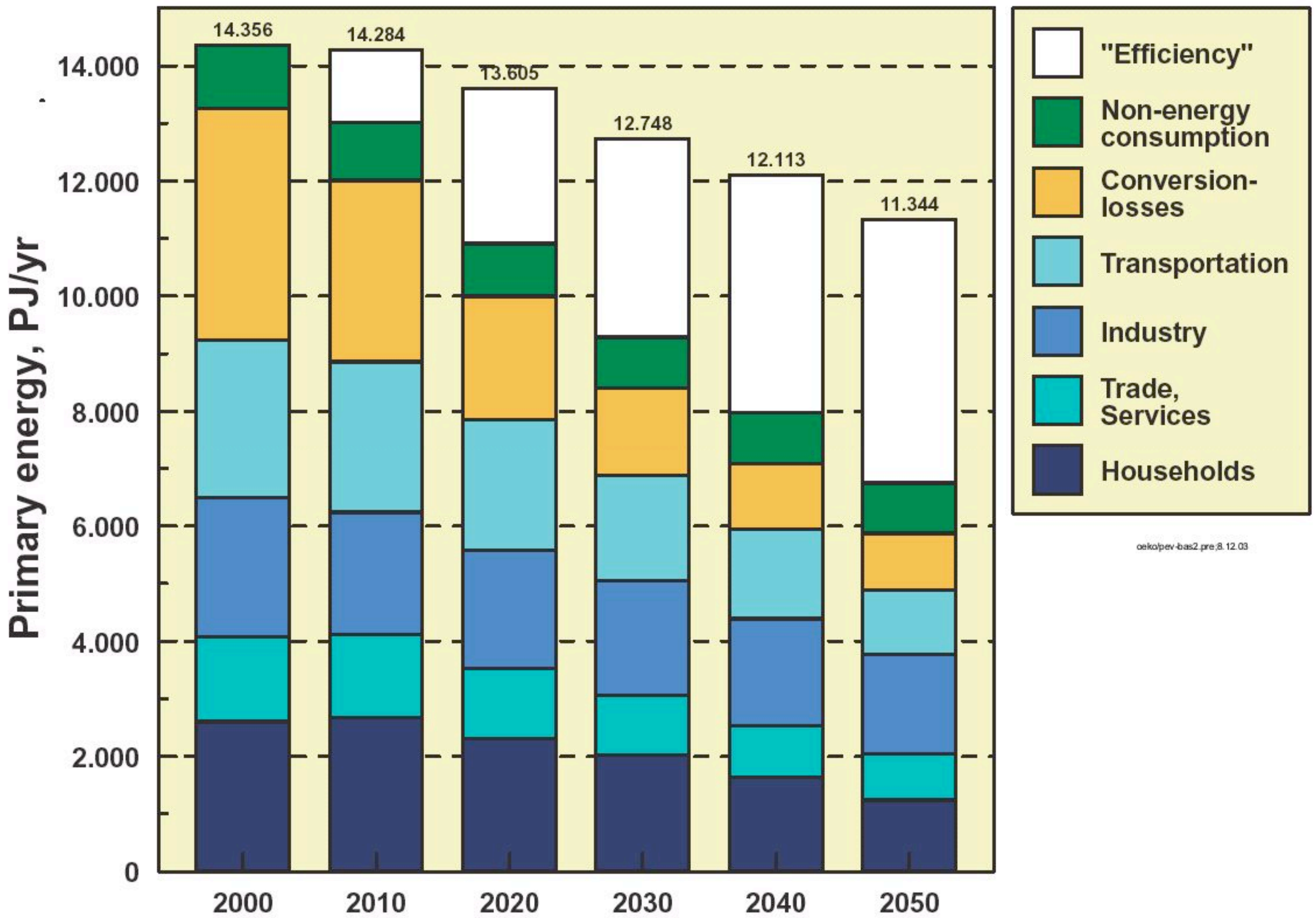
- energy related emissions only -



Sources: DIW-report 10/2004; reduction path: BMU 2004

Decoupling GDP-growth (1.5% p.a.) from energy: Integrating energy efficiency and renewables in a German sustainable energy system

Source: BMU 2007



Economic and job impacts of a German sustainable energy system (80% $C0_2$-reduction; nuclear phase out by 2025)

Additional cost (cumulative: 2000 to 2050; compared to reference case) Annual additional cost in average	201 billion Euro 3,8 billion Euro/a
Additional costs per capita	**48 Euro/capita**

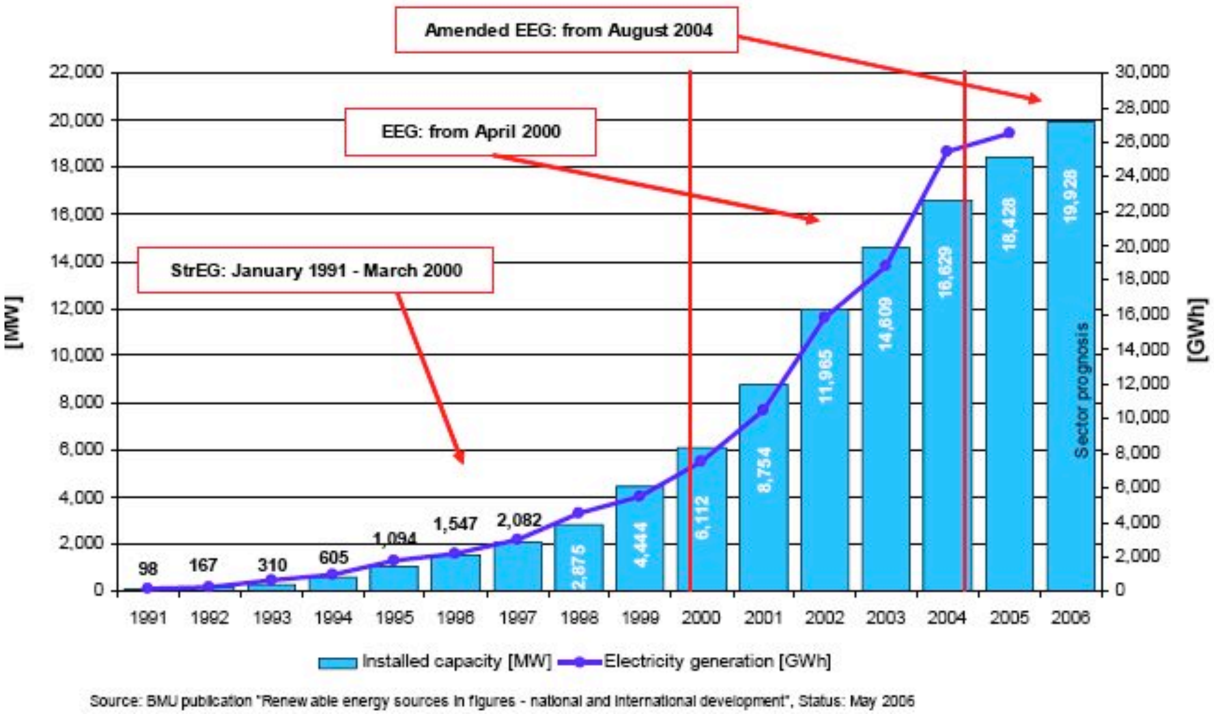
• significant **(net) employment effects** (change of jobs):

- renewable energies: + 250.000 to 350.000
- building industry: + 85.000 to 200.000
- coal and nuclear industry: **-** 100.000

The German Renewable Energy Sources Act: Incentives to create a domestic wind power sector of 22.3 GW (12/2007) in 15 years!

- Wind power capacity: more the 22,3 GW
- Subsidizes a mix of renewables to reduce costs by learning effects
- Obligation and fixed renumerations for electricity from renewables
- Incentives for cost reductions
- Financed by consumers - no additional tax or public budget
- Debate on "over-subsidizing" (e.g. wind and solar power)

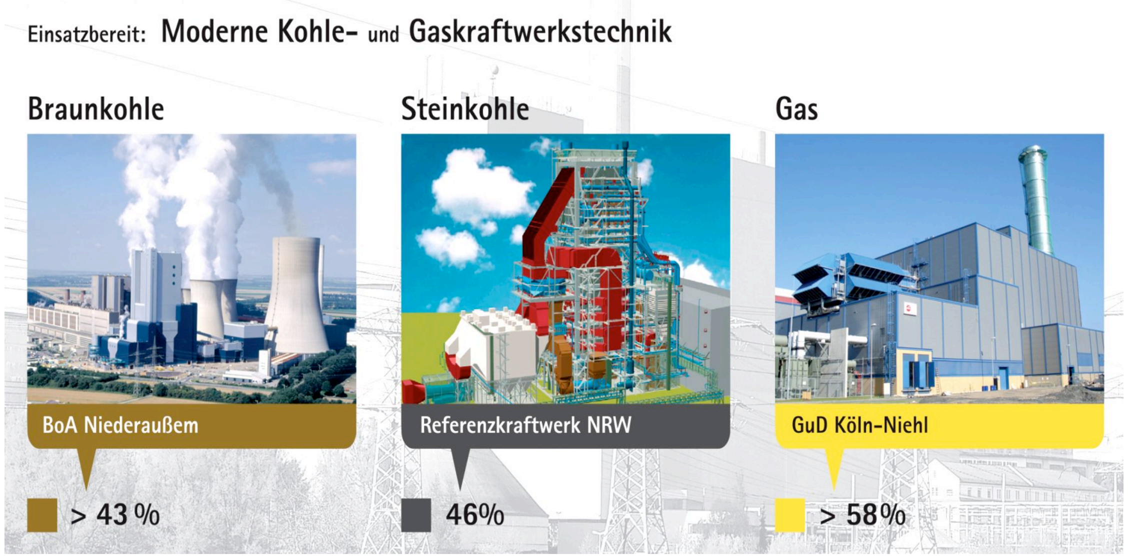
Development of wind energy in Germany



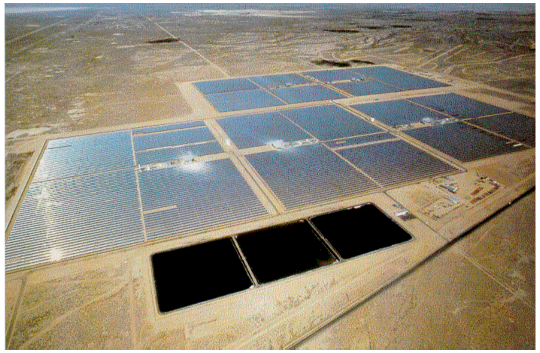
Investment in electricity supply system in Germany (2006 - 2012): At the crossroads to a new energy system?

More investments into renewables than into conventional power plants!

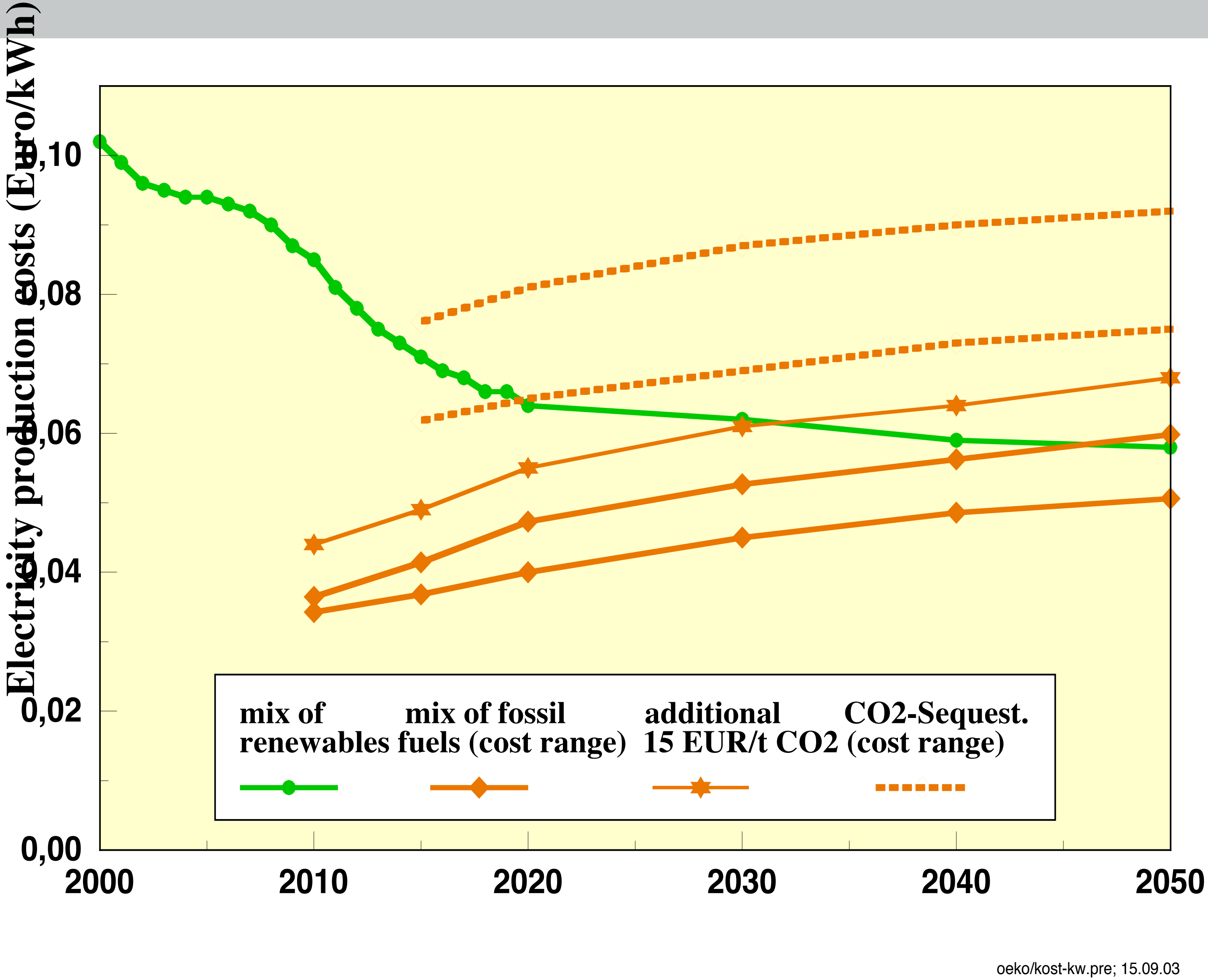
- Investment in conventional (fossil) power plants and transmission system:
  ca. 30 Bill. Euro



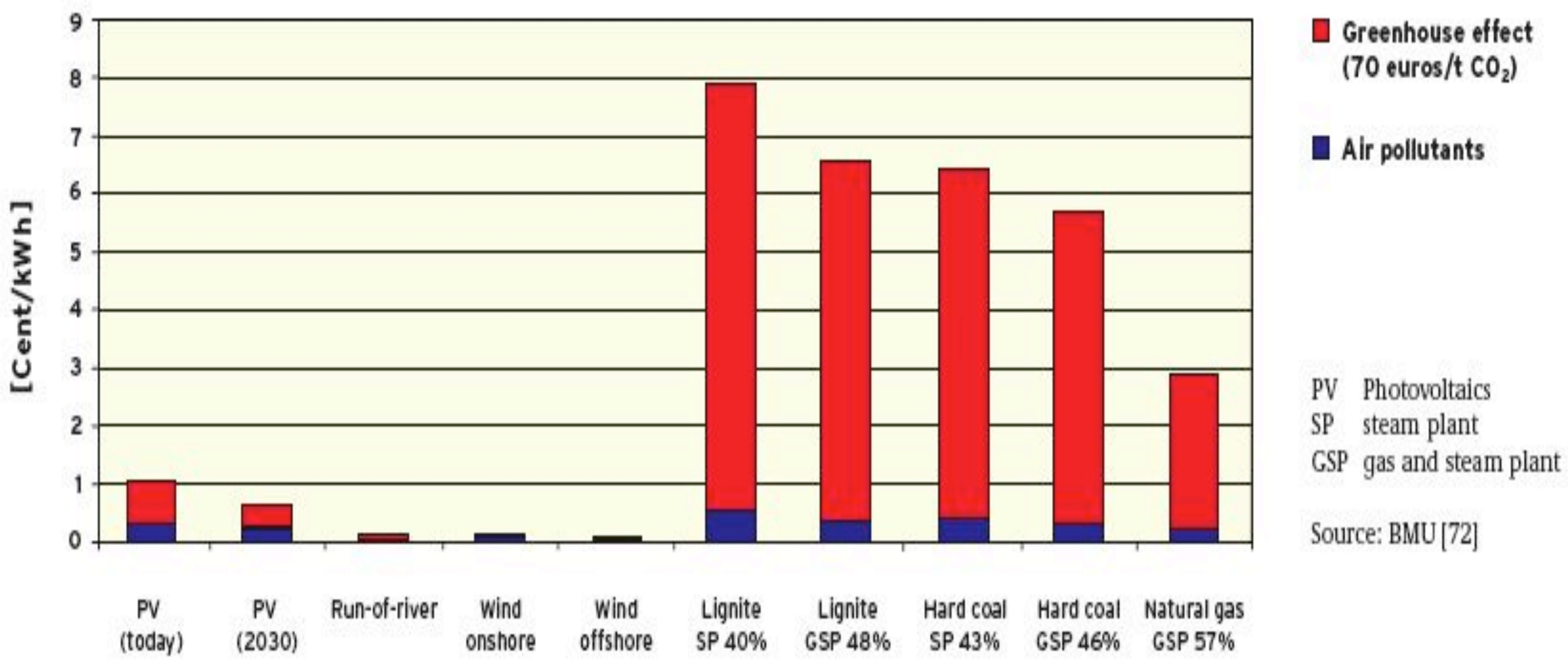
- Investment in renewable energy technologies:
  33 to 40 Bill. Euro



Comparison of electricity costs of new power plants: Decreasing from renewables - increasing from fossil/nuclear

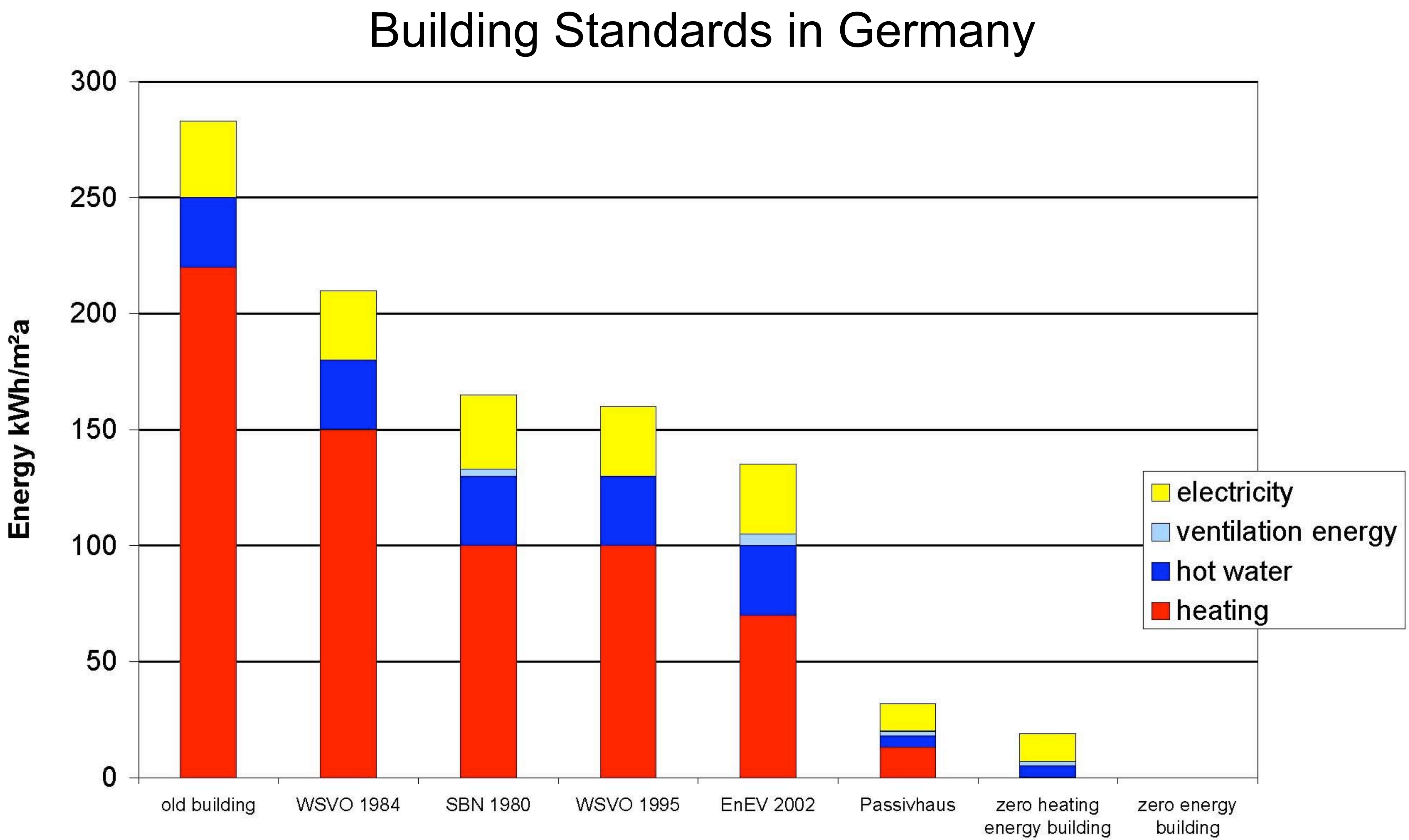


External costs of electricity generation for various options;
for nuclear highly controversial (2 - 100 cts/kWh)



Efficiency Potential in Germany

- **Technical Potential:** Up to 45% of primary energy = 70-90 billion Euro/a reduction of total energy bill
- **Cost-effective Potential:** About 30% within the electricity sector
- **Employment effect:** 370 jobs per 1 TWh saved
  500.000 jobs with implementation of total technical potential


Building Standards in Germany
Energy kWh/m²a
300
250
200
150
100
50
0
old building
WSVO 1984
SBN 1980
WSVO 1995
EnEV 2002
Passivhaus
zero heating energy building
zero energy building
electricity
ventilation energy
hot water
heating

Examples for multifamily passive houses in Hamburg

(Reinig 2007)

Selected data on passive houses in Germany:

Ca. 8.000 passive houses in Germany (2007); very cost effective over live time (additional costs: +8%; energy costs: - factor 4)

ca. 95 % new buildings

ca. 2,3 % old buildings

ca. 1,5 % extension of old buildings

ca. 1,7 % apartment buildings

ca. 2,6 % business, service and administations buildings

Examples for offices with passive house standard in Germany
(Reinig 2007)

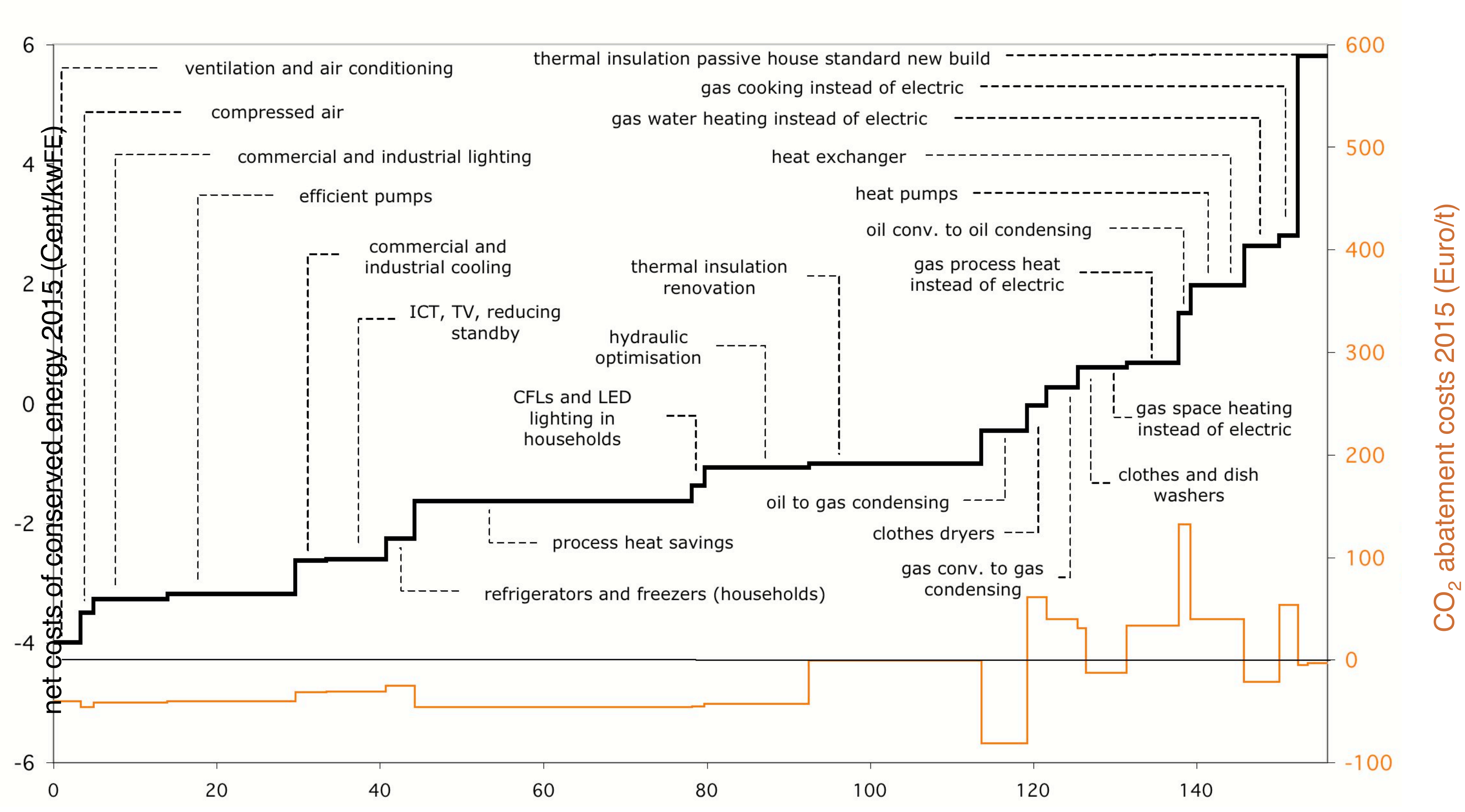
The future of buildings: „Plus energy“ („Plusenergiehaus“®) estate and office building („solar ship“) in Freiburg/ Germany

(Rolf Disch, 2006)

70 cost-effective technical options to save electricity (or switch to gas): 120 Mio t CO_2 can be avoided in Germany with no net costs!

(Study of Wuppertal Institute on behalf of E.ON, 2006)

net costs of conserved energy and CO_2 abatement costs (total resource cost perspective)



CO_2 reduction potential (Mio. t/a)

Potentials and benefits of electricity savings in German Trade, Commerce,Services: Study of Wuppertal Institute on behalf of E.ON 2006

Technology or end-use area	CO_2 reduction potential [t/a]	Final energy savings [TWh/ year]	Net benefit for society [Mio. Euro/year]	Net benefit for custom ers [Mio. Euro/ year]	Pay-back time for custom er [years]	IRR for custo-mer [%]	
TRADE, COMMERCE, AND SERVICES							
Air conditioning of mobile phone base stations	880,631	1	61	116	0.9	376.0%	
Reduced standby electricity consumption in ICT's	2,403,365	4	77	204	1.8	53.2%	*
Pumps	3,638,068	6	175	374	2.2	51.7%	*
Indoor lighting	6,115,493	9	325	656	2.7	61.2%	
Ventilation and air conditioning	1,504,589	2	72	136	3.2	44.7%	*
Cooling / freezing	2,528,431	4	90	210	3.9	31.0%	
Process heat (substitution, fuel savings)	5,461,394	19	168	211	5.1	21.9%	
Cooking (substituting electricity by gas)	411,380	1	6	33	6.5	18.7%	
Street lighting and traffic signal lighting	584,071	1	0	21	6.9	14.8%	
Hot water (substituting electricity by gas)	305,926	1	-6	15	9.6	12.8%	*
Heat recovery	1,155,030	5	39	20	10.6	11.5%	
Thermal insulation + exchange of gas/oil boilers	3,616,294	26	198	104	13.1	37.3%	*
Total	**28,604,671**	**78**	**1,204**	**2,099**			

The „efficiency revolution“ for appliances: The new EU A++Standard

- **E.g. Energy+ fridge-freezers** that use only 140 kWh/year (300 l)
- **A++: 45% less electricity than A**

Example: Energy saving opportunities for lighting

- An achievable energy saving of up to 40% on all the lighting currently installed globally would save:

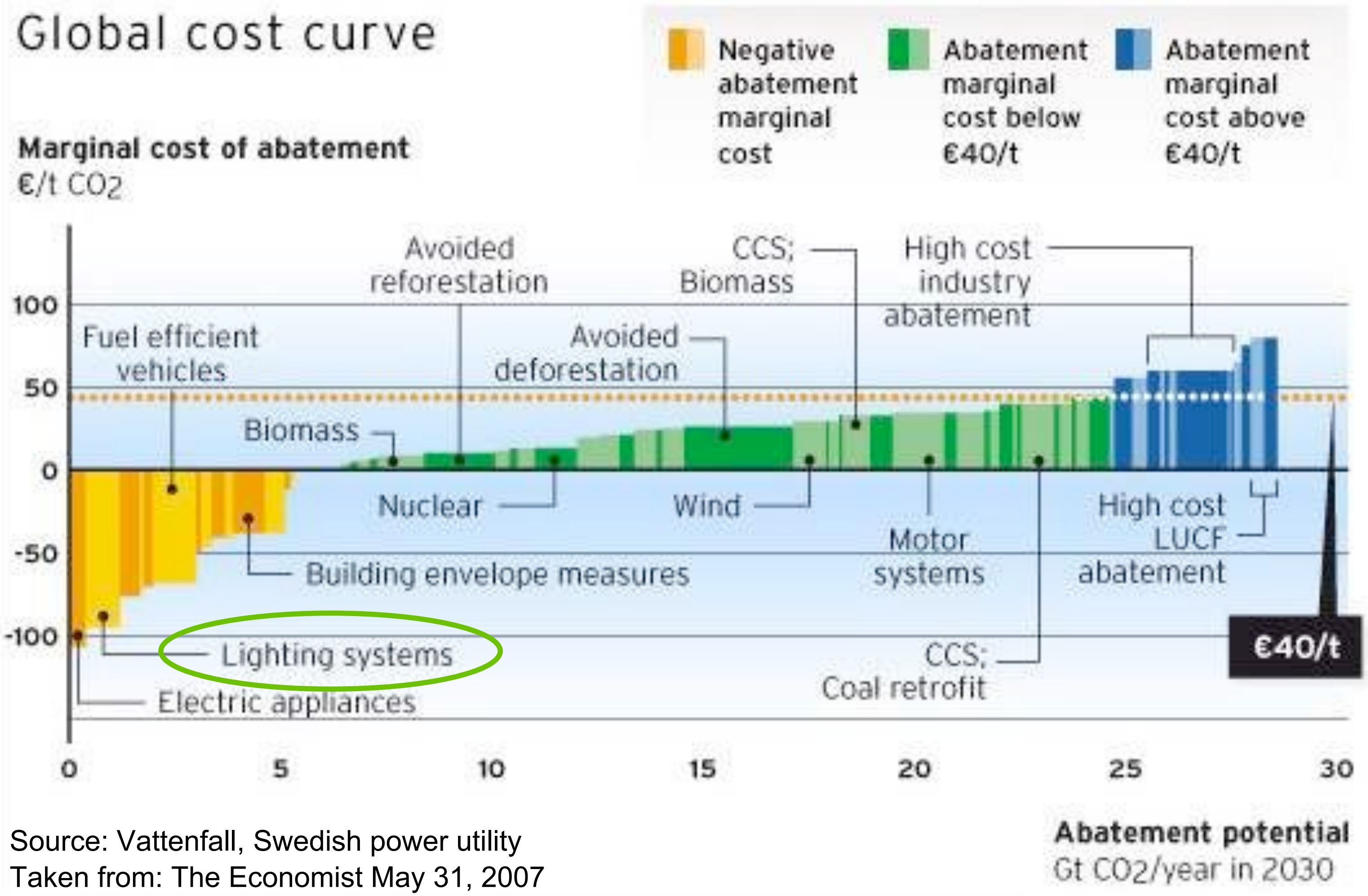
- EUR 106 billion in energy costs per year
- This equates to:

555 million tonnes of CO_2 per year

1.5 billion barrels of oil per year

Annual output of 530 medium sized power stations @ 2TWh/yr

Appliances, buildings and lighting among most economic ways to cut CO_2



Source: Vattenfall, Swedish power utility
Taken from: The Economist May 31, 2007

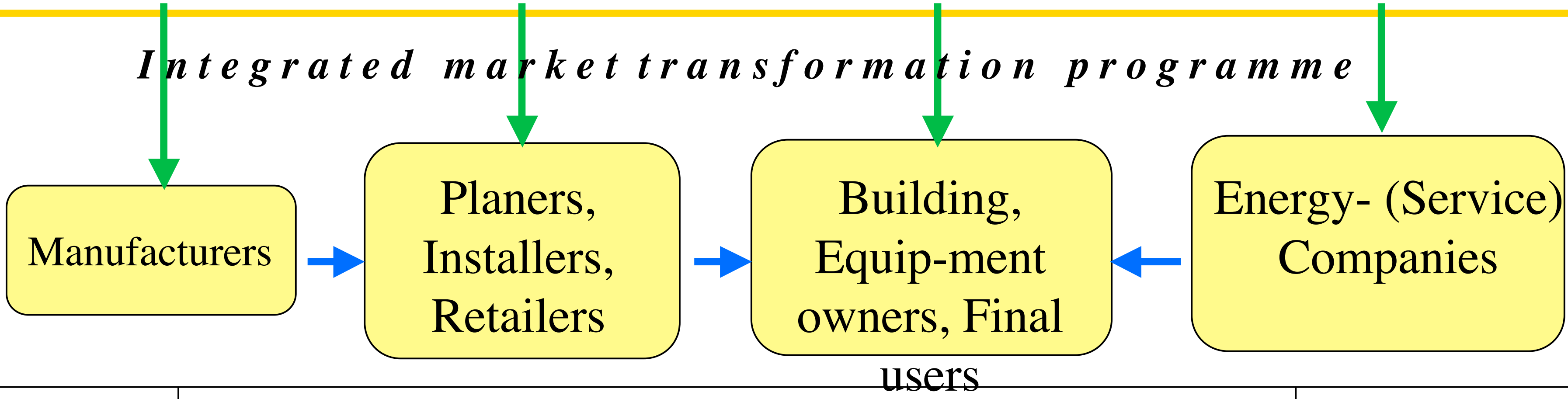
A Paradigm Shift is Needed:
A Policy Mix to Overcome Target Group Specific Barriers and to Foster Climate Mitigation and Efficiency Technologies!

Energy tax,
subsidy reform

Price structure,
costs oriented prices

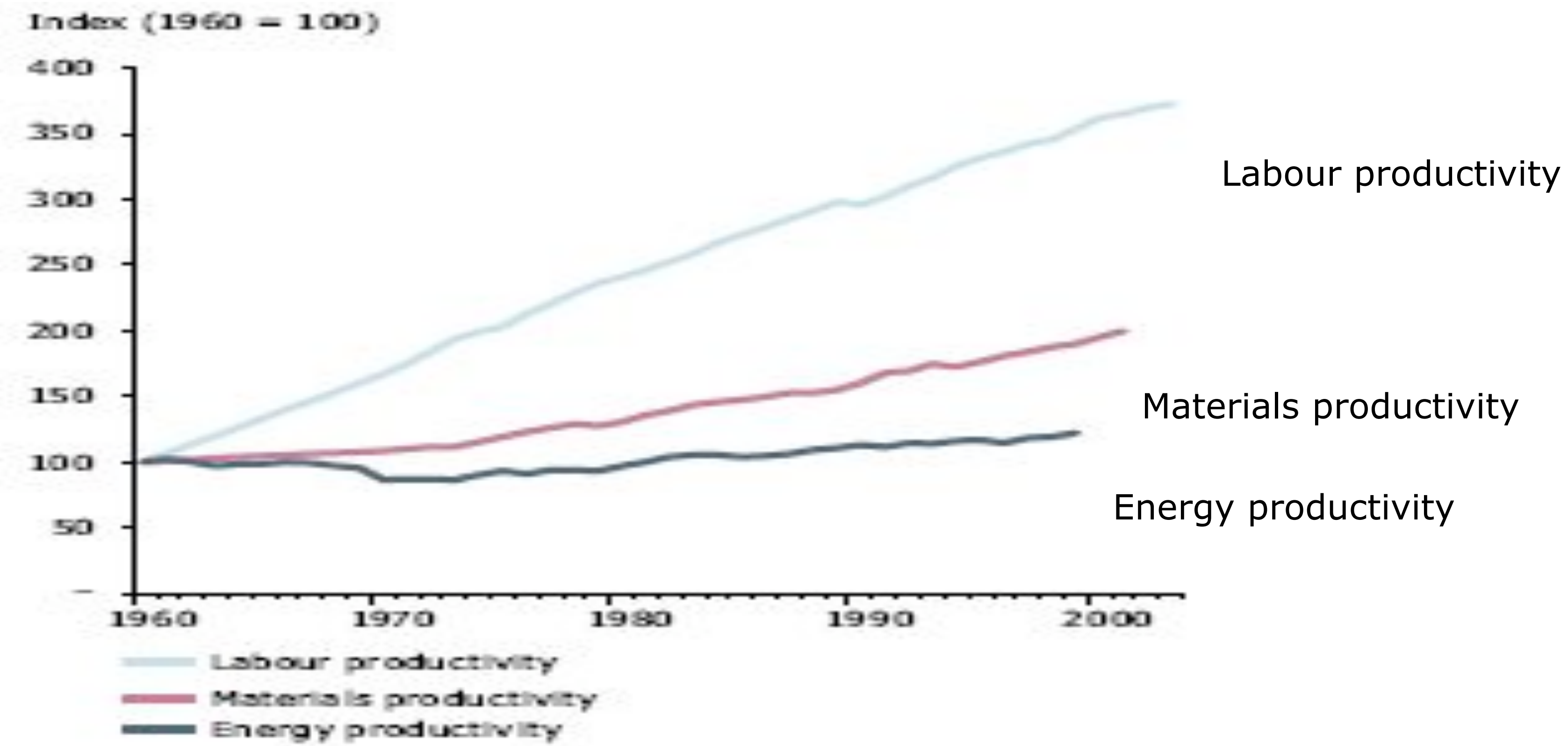
Emission trading, JI, CDM

- **Incentives and support** (financial, organisational) :for investments, R&D, demonstration, pilots
- **Campaigning**: Motivation, information, energy audits, training
- **Efficiency standards/labelling**: for products and production (mandatory/ voluntary; "Top Runner ")
- **Foster public procurement,** bundling of demands etc.
- **Stimulate ESCOs , Contracting/ Third Party Financing** (about 600 in Germany)
- **Establish Energy Efficiency Funds**: on the national, regional and local level (e.g.ProKlima/Hanover)
- **EU-directive on energy efficiency** (target: **1 % additional** increase of energy efficiency p.a.)



A new direction of technical progress - raise resource productivity: ”Make tons and kilowatthours redundant not people”

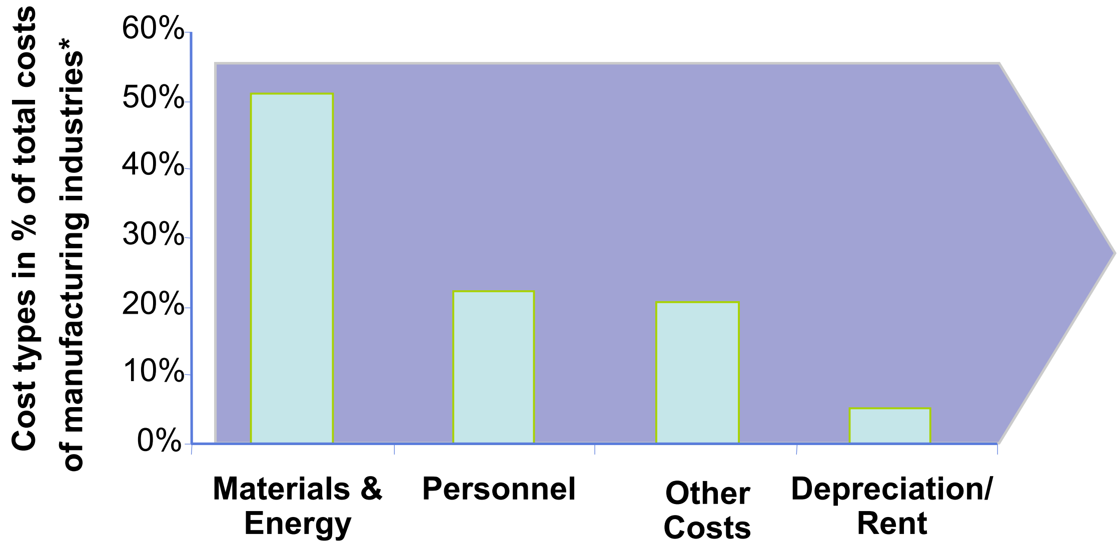
(EU 15; 1960 to 2002)



Note: Labour productivity: GDP per annual working hours (1999 USD (converted at EKS PPPs) per hour); material productivity: GDP per domestic material consumption (DMC) (EUR per kg); energy productivity: GDP per total primary energy supply (TPES) (thousand 1995 USD per toe).

Sources: Groningen Growth and Development Centre and The Conference Board, Total Economy Database, 2004; EUROSTAT/IFF, 2004; IEA, 2001; Federal Statistical Office, 2003.

Materials are a Central Factor in the Life-Cycle Costs of Industrial Products. Cutting these Costs Increases Competitiveness and Growth



Cost Factor: Materials & Energy

- Material costs: up to 50% of total costs of industry, far more than wage cost
- Starting point: Impulse programme “Materials Efficiency”/ a “Win-Win”-Strategy

Factor 2-3 : 1

Cost Factor: Personnel

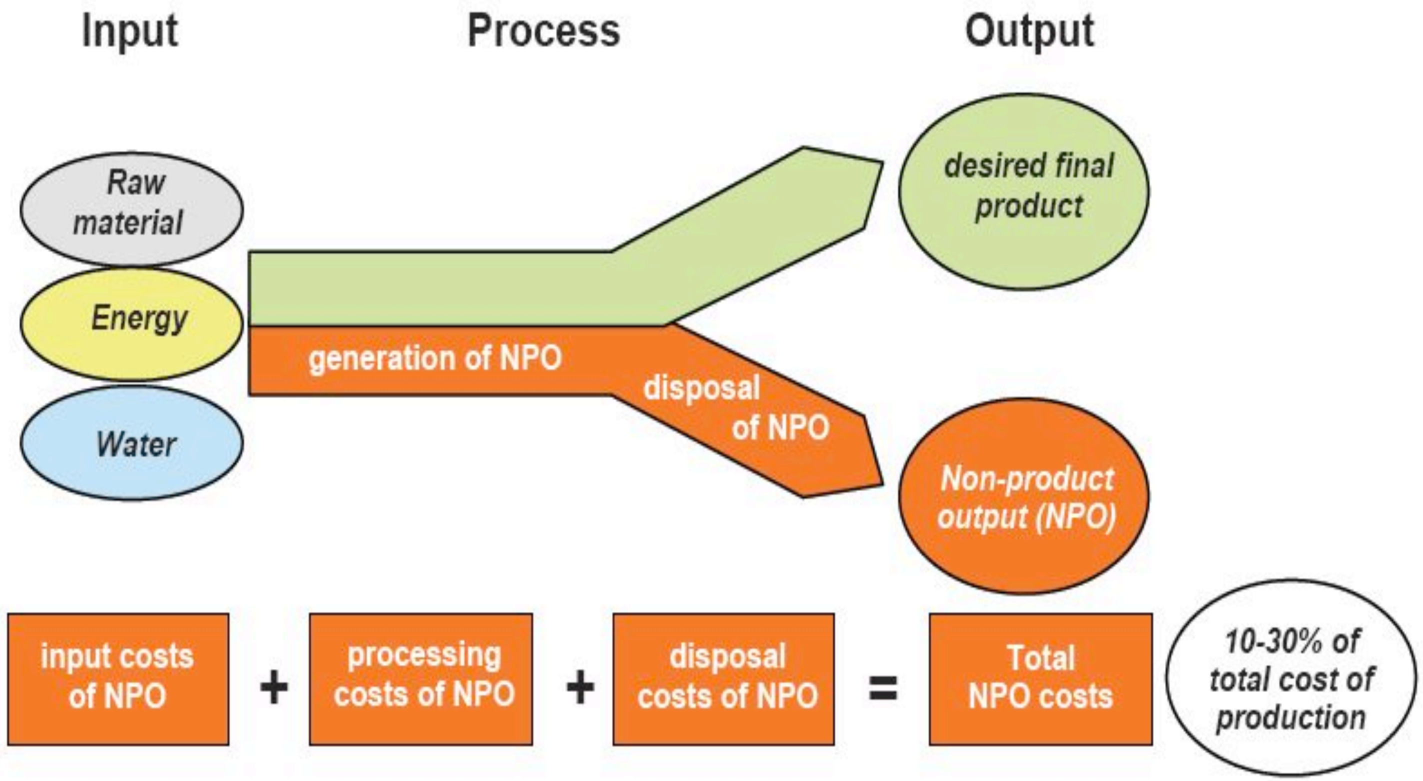
- Personnel costs: 23% of total costs of industry.
- Agenda 2010: strong pressure on wages and many conflicts

* Federal Statistical Office, Cost Structure of Manufacturing Industries, 1999

Source: Fischer, ADL, 2003

Non Product Output (NPO) concept for enterprises: To identify untapped resource efficiency potentials and cost savings





NPO = all raw materials, energy, and water which are used in the production process creating costs and no added value.

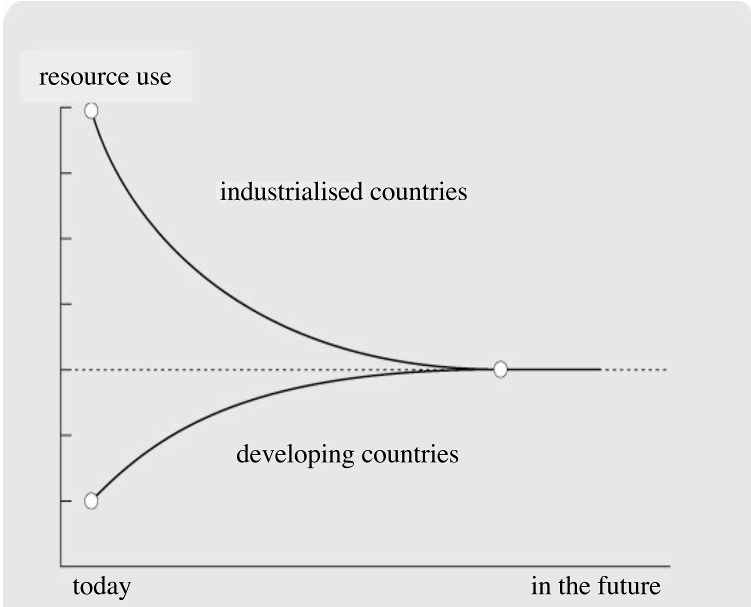
Estimated total avoidable costs for NPO in Germany: 180 bn Euros/a!

Source: Kürzinger/GtZ 2006

World market for environment technologies ("GreenTech"): promising lead markets! (expert estimate, Roland Berger 2006)

The Vision of a „2000 W per Capita Society“.
Results of the R&D initiative of Swiss Research Institutes
(Swiss „White Book for R&D of energy-efficient technologies“, March 2004)

- **A „2000W per Capita Society“** in OECD-countries is feasible; 2000W/cap (= 65 GJ/cap) corresponds to **1/3 of today`s European per capita energy use;**
- **World average** in the last two decades (=70 GJ/cap): The future convergence value?
- Enabling a GDP/cap growth of 2/3 up to 2050, the „2000W per Capita Society“ **implies a factor 4 to 5 increase of energy and material efficiency**
- Needed: **change of innovation systems**, exploitation of **long re-investment cycles**, **sustainable patterns** of consumption and production



Industrialized countries reduce their resource use more than it increases in developing countries.

Convergence value should be compatible with the carrying capacity of the biosphere.

Wuppertal Institute
for Climate, Environment
and Energy

Thank you for your attention!

Have you visited our website?
http://www.wupperinst.org