Science Centre
North Rhine-Westphalia
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and Technology

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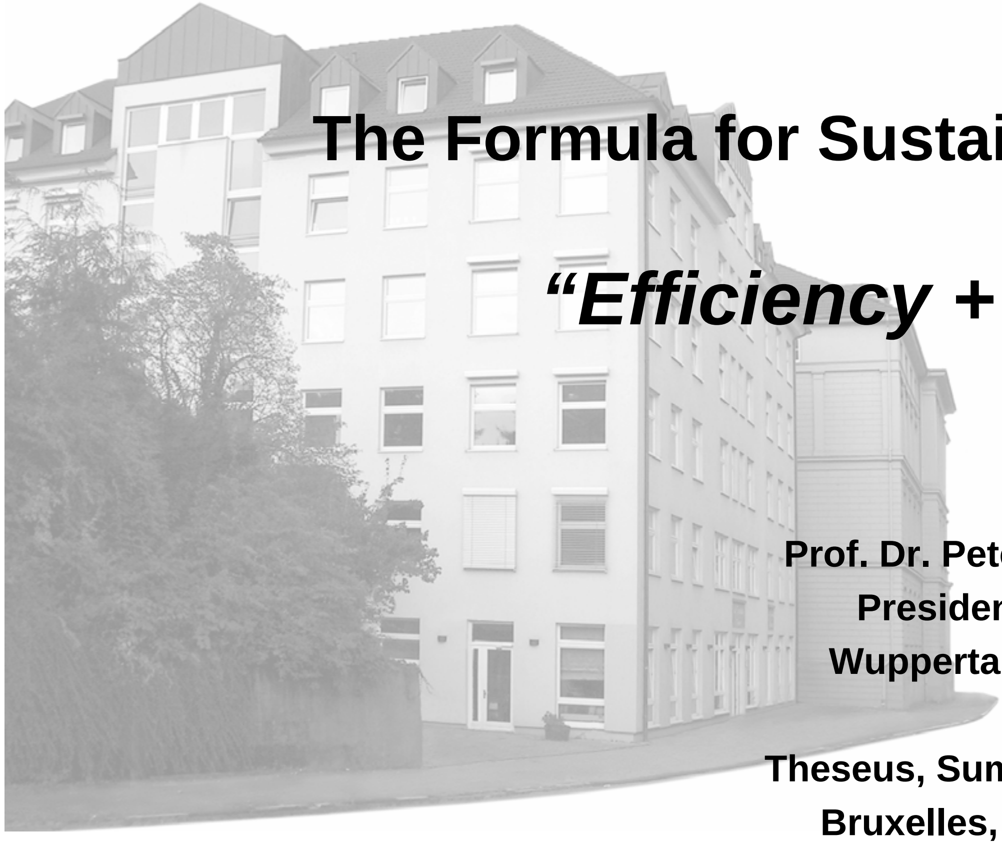
Wuppertal Institute for
Climate, Environment and
Energy



The Formula for Sustainable Energy Systems:

“Efficiency + Renewables”

Prof. Dr. Peter Hennicke
President of the
Wuppertal Institute

Theseus, Summer School,
Bruxelles, 5. 7. 2007

Wuppertal Institute
Legal and financial status

- Established in 1991
- Legal form: Ltd., Non-Profit-Organisation;
- Ownership: State of North Rhine-Westphalia
- **Offices**: Berlin Office and „UNEP/ Wuppertal Institute Centre on Sustainable Consumption and Production“ (CSCP)
- Staff: 140 members from all disciplines
- Projects: 80-100 projects per year
- Budget 2006:
  - 2.3 m. Euro basic funds from the state of North Rhine-Westphalia
  - 7 m. Euro of third party funds (UN, EU, Ministries, Private Sector, NGOs)

Mission
Application-oriented Sustainability Research

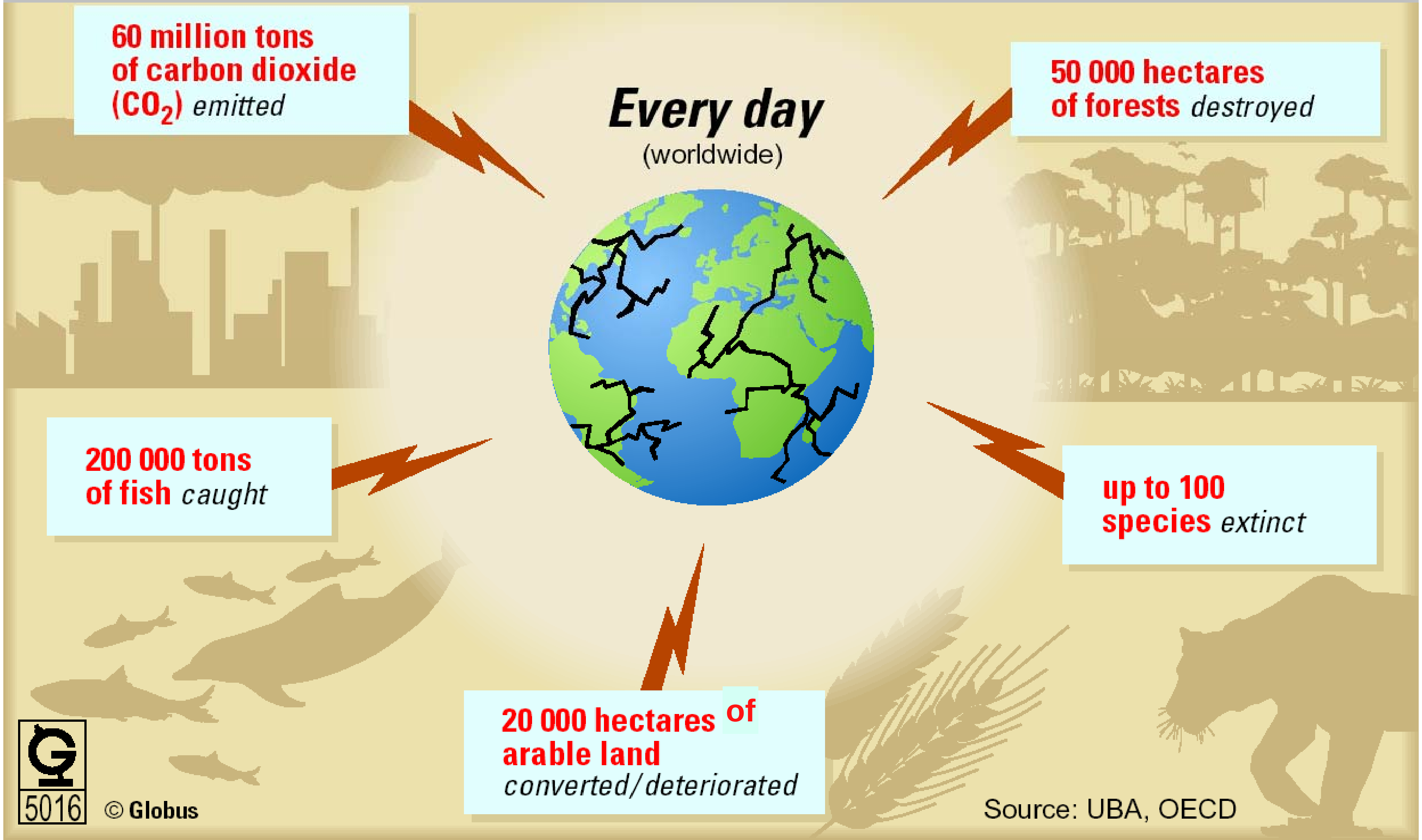
- The WI explores and develops models, strategies and instruments to support a sustainable development at local, national and international levels.
- Sustainability research at the WI focuses on ecology and its relation to economy and society.
- Our research analyses and initiates technological and social innovations that decouple economic growth from nature use and wealth.

Overview and thesis

1. **At the crossroads**: **Pessimism,** because of alarming unsustainable **trends**. **Optimism**, owing to a growing variety of promising **projects** and **innovations**
2. **The implementation gap**: Scaling up what we already know to do and speeding up the dissemination of good practices and lessons learned (The „Wedges Concept“)
3. **Reducing uncertainty**: Focussing on a “robust technological corridor”to sustainable energy systems: rational use of energy, combined heat/cold and power production and renewables
4. **Many open questions on nuclear, CCS and hydrogen** (risky; expensive; late; public acceptance, commercially not available)
5. **A sustainable world energy strategy needs (at least):** doubling energy efficiency increase (2% p.a.) plus diversifying, greening and decentralizing energy supply
6. **The key for climate mitigation:** Integration of renewables and efficiency on the strategic and project level to buy down the costs of renewables
7. **Macroeconomic benefits** of sustainable energy systems (e.g. jobs, competitiveness, security of supply, less energy import dependency) compared to BAU

Unsustainable Trends

Unsustainable Trends: The Daily Toll



Climate change

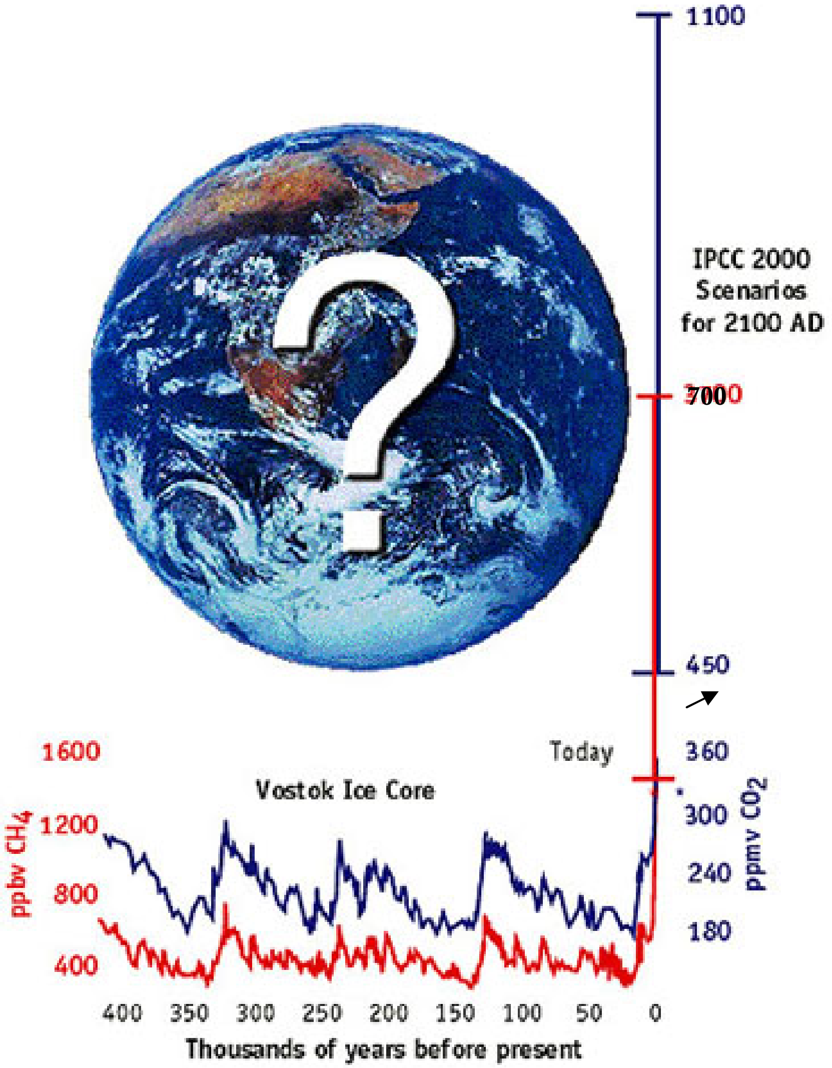

APRIL 3, 2006
www.time.com AOL Keyword: TIME
SPECIAL REPORT GLOBAL WARMING
TIME
BE WORRIED. BE VERY WORRIED.
Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well
EARTH AT THE TIPPING POINT
HOW IT THREATENS YOUR HEALTH
HOW CHINA & INDIA CAN HELP SAVE THE WORLD—OR DESTROY IT
THE CLIMATE CRUSADERS
THE CLIMATE INSTITUTE TOP TEN TIPPING POINTS ON CLIMATE CHANGE

Würthle & Sohn, August 1898

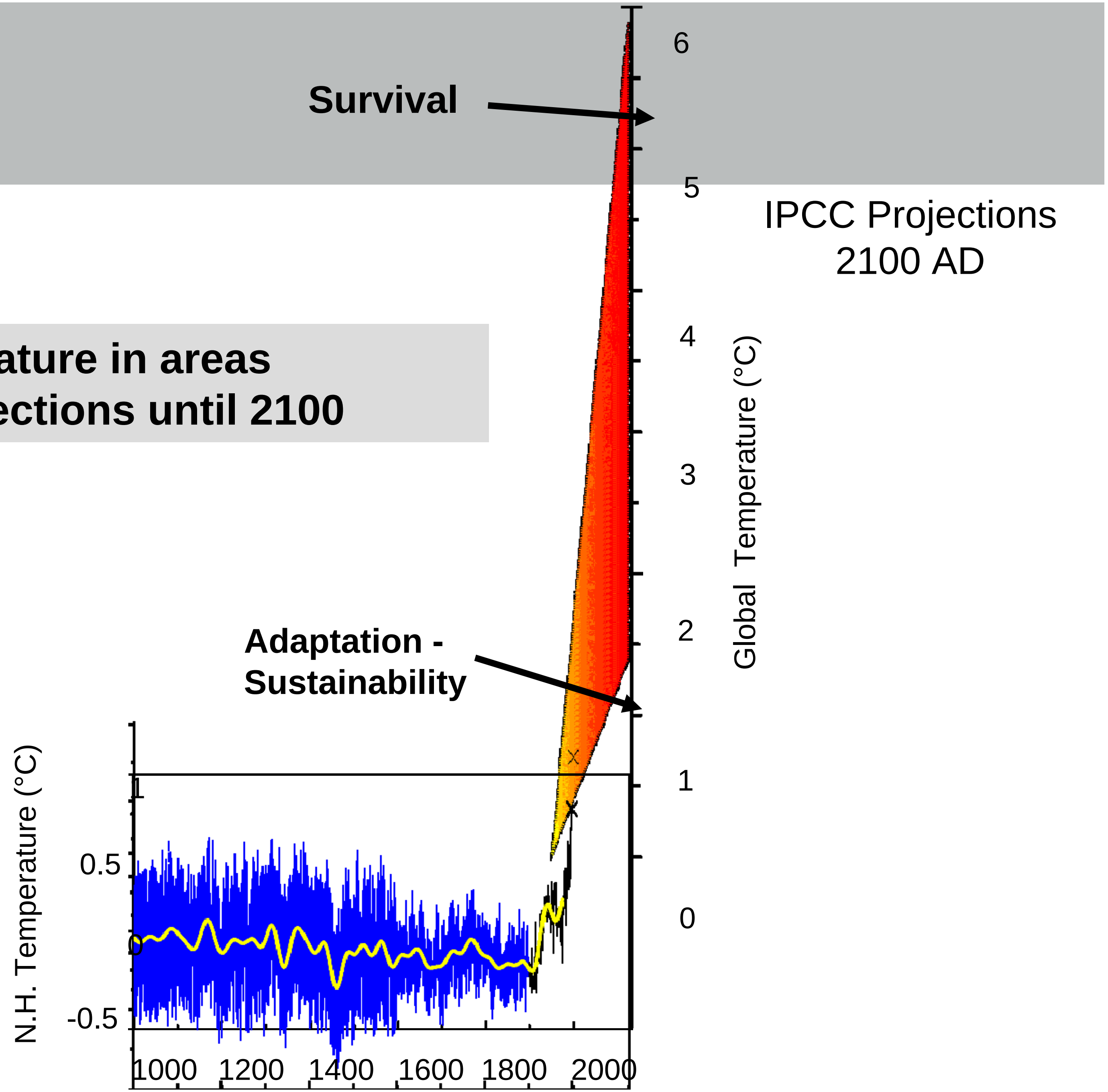
The heat is on: Vernagt Glacier in Austria

http://files.alpenverein.at/download/1076670171156_18_gletscherberichte2003.pdf

CO_2-concentration in the past and in the future



Range of temperature in areas within IPPC Projections until 2100



Quelle: Steffen et al. 2003

Unsustainable Trends:
Current $C0_2$- Emissions compared to IPCC-SRES

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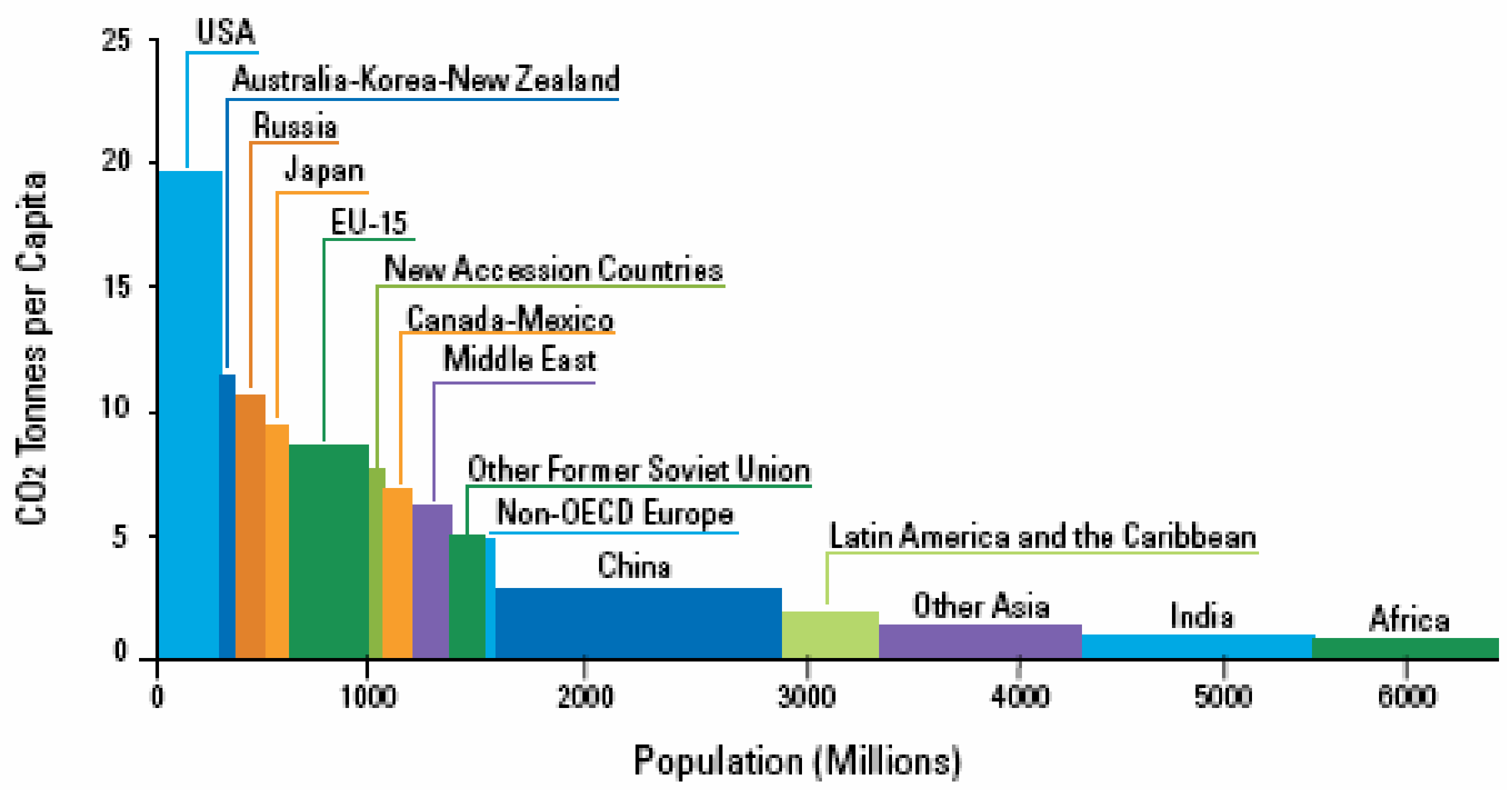
benötigt.

Per capita CO_2 Emissions, Population & Total Emissions, 2003



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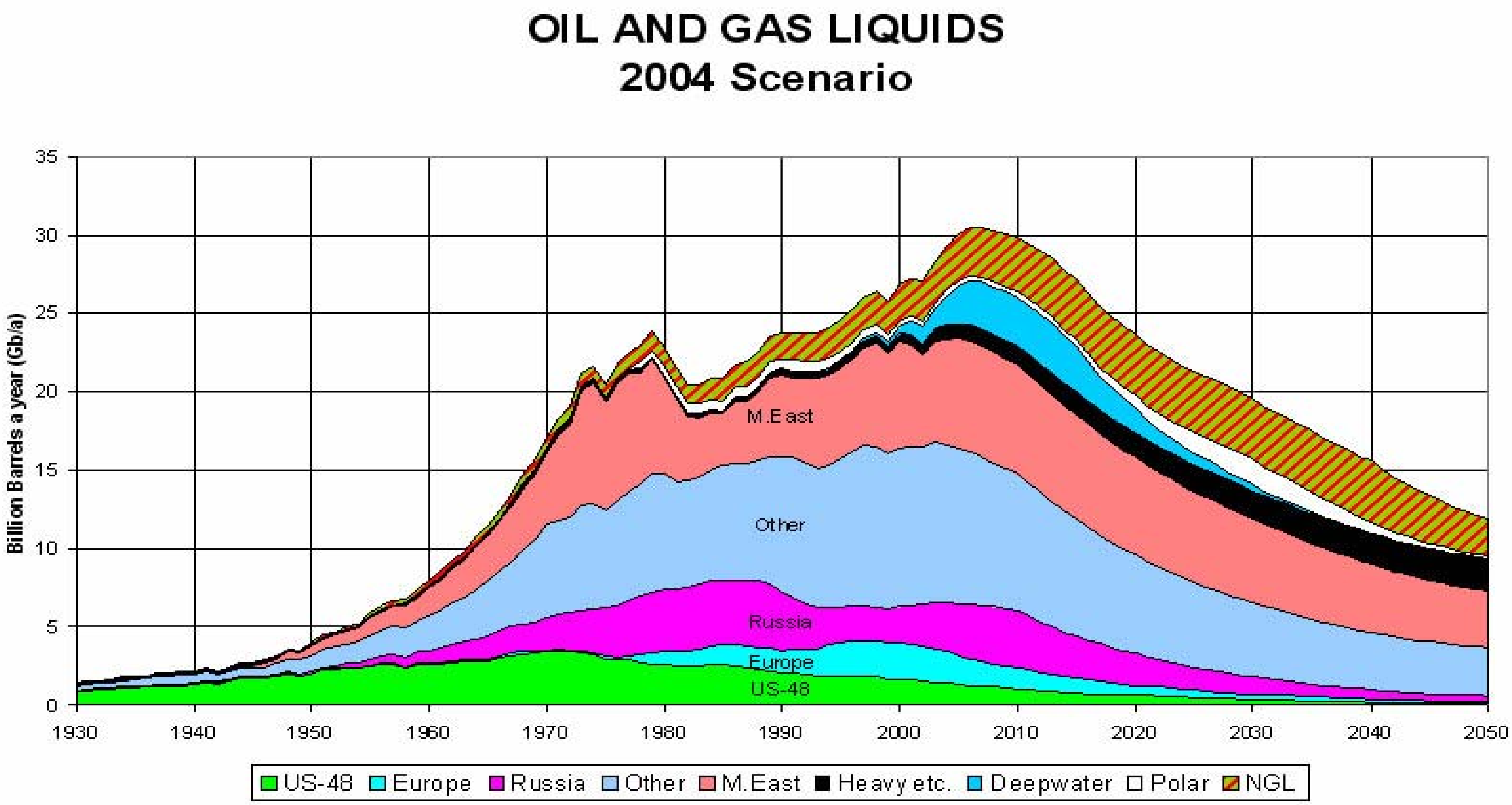
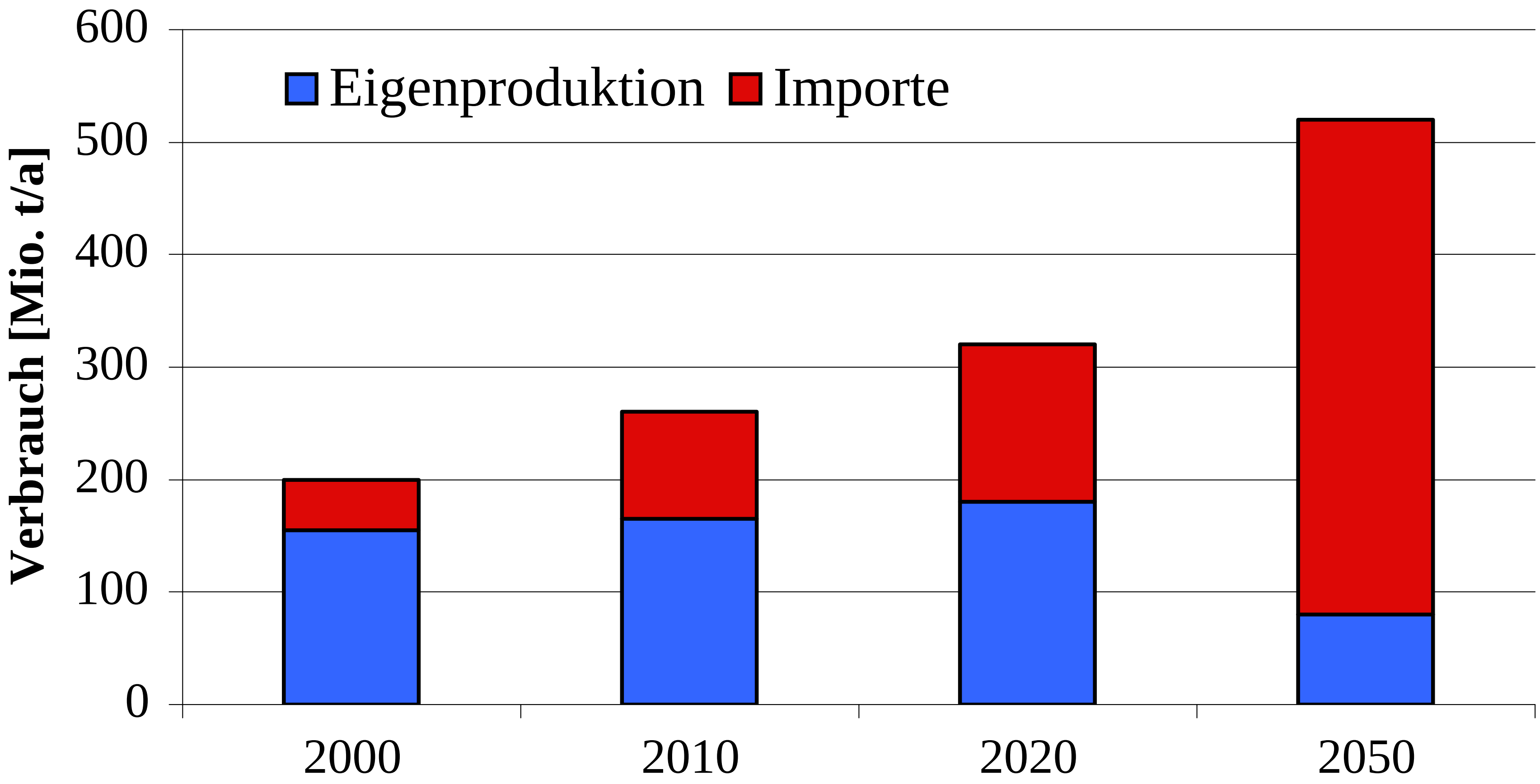
Resource conflicts

Maximum of Global Oil Production before 2010?
The ASPO Scenario 2004



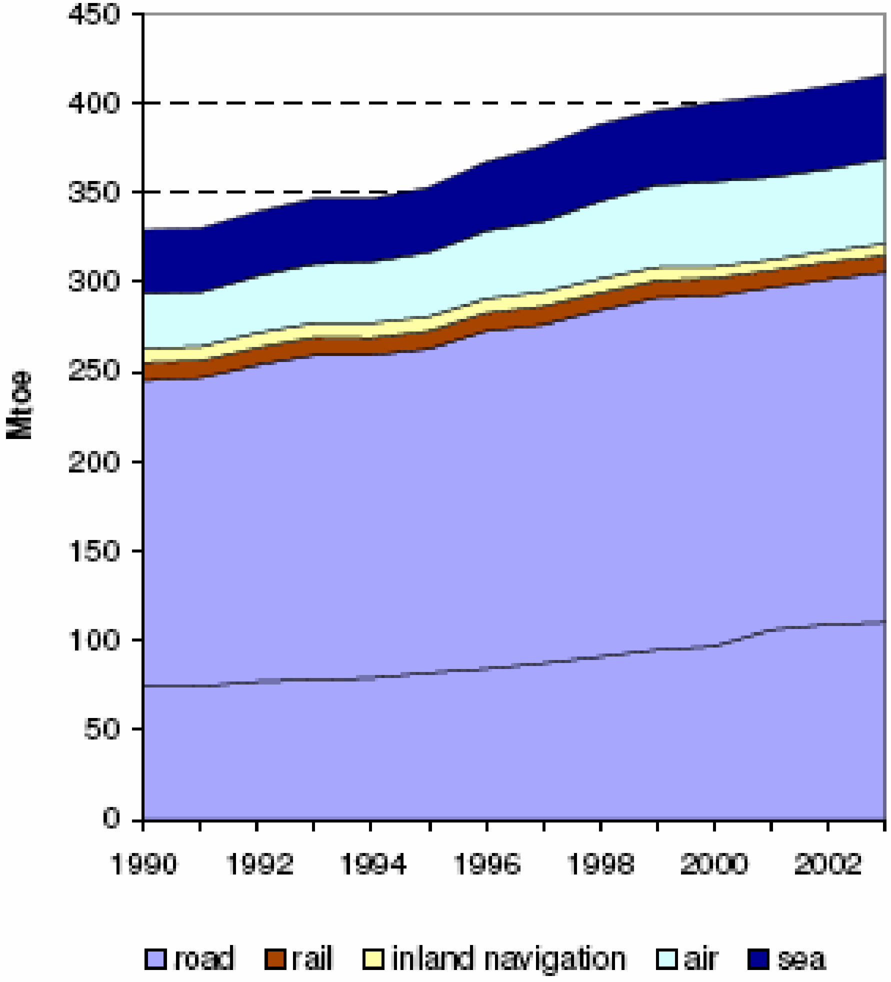
source: The Association for the Study of Peak Oil&Gas (ASPO): Oil and Gas Liquids 2004 Scenario, updated by Colin J. Campbell, 2004-05-15, in: www.peakoil.net, Recherche v. 08.07.2004

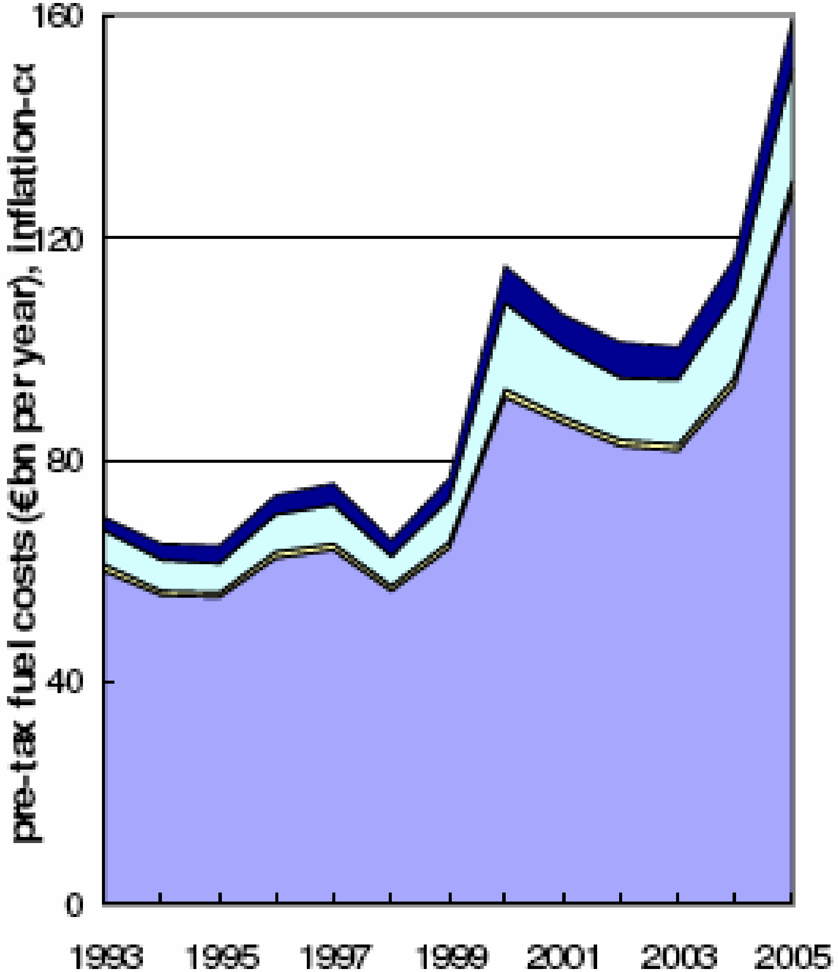
China: Domestic oil production and imports, 2000 - 2050



Internationale Energie-Agentur, 2000

Final energy consumption in transport from 1990 to 2003 in the EEA30 (EU25 plus Norway, Iceland, Bulgaria, Romania and Turkey) and the cost of the fuel (pretaxes, inflation-corrected, Euro of 2005)





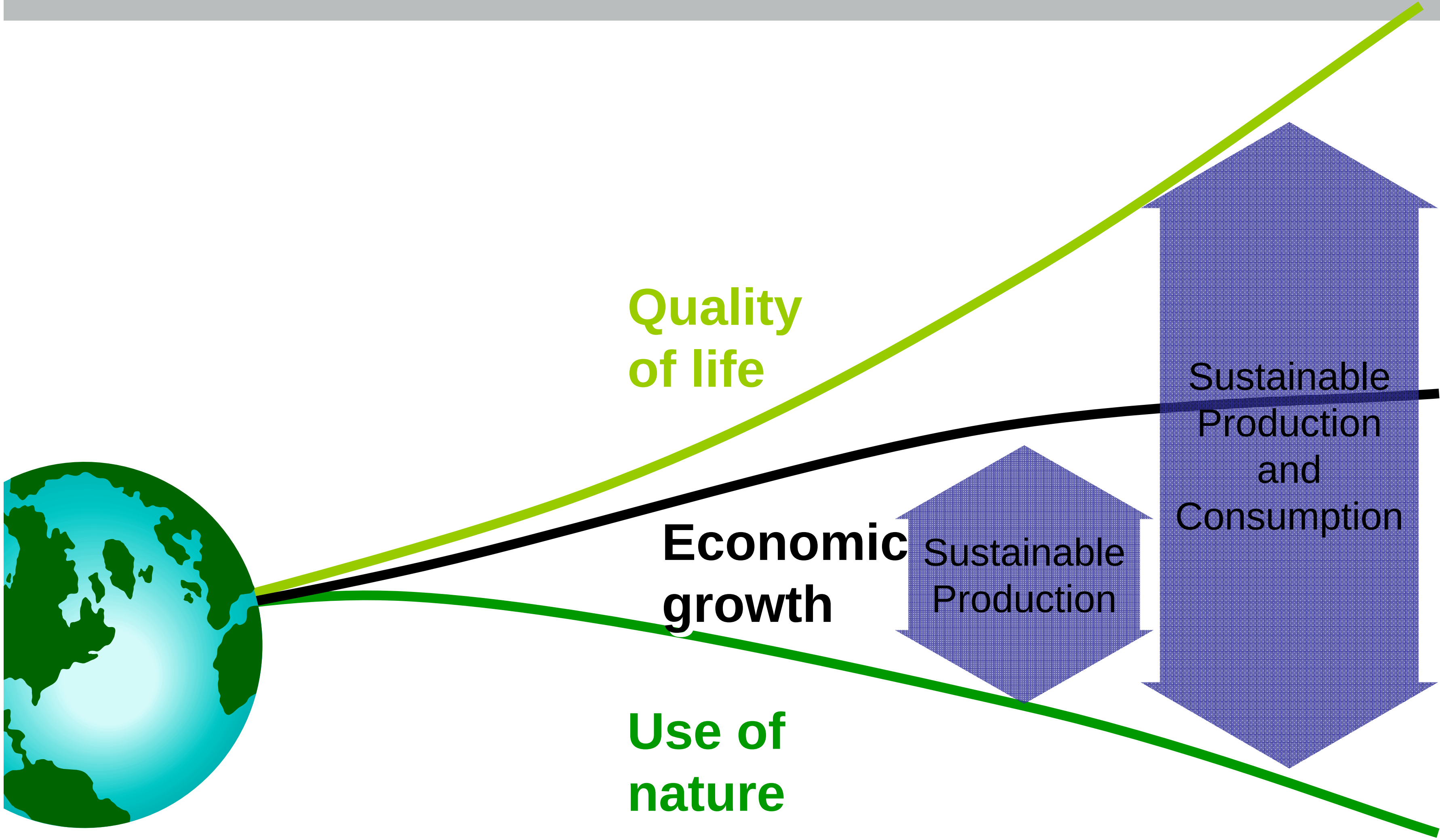
Quelle: EEA-fact sheet in the Oil Bulletin, 2005

A necessary condition for sustainable development:

Decoupling economic growth

from the use of nature

The Challenge:
Absolute decoupling of qualitiy of life from use of nature



Relative decoupling of GDP, energy und $C0_2$ ¡as a first step, but not sufficient for sustainable energy systems!

Zur Anzeige wird der QuickTime™
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Climate protection is necessary but not sufficient: Criteria and goals for sustainable energy systems

- **Access to energy services for all** and fair partnerships with developing countries
- C**onservation of resources and protection** of environment, climate and health
- **Social acceptability** now and in accordance with the needs of later generations
- **Low risks** and contribution to mitigate international conflicts
- **Cost-effectiveness** (including external costs)
- **Industrialized countries (IC) should take the lead**: To reduce **global** CO_2**-** emissions by 50% up to 2050 a reduction target of 80% for IC is necessary.

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 75%, but increase well-being (e.g. Swiss „2000 W/cap society“)
- Establish **sustainable consumption and production patterns**: Eco-efficiency, service orientation,life style changes, „qualitative“ growth...

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:

- Built sustainable energy systems on **„three robust green pilars“: RUE+CHP+REN**
- **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

The power of technology diffusion - a challenge for implementation: How can we make it happen in time?

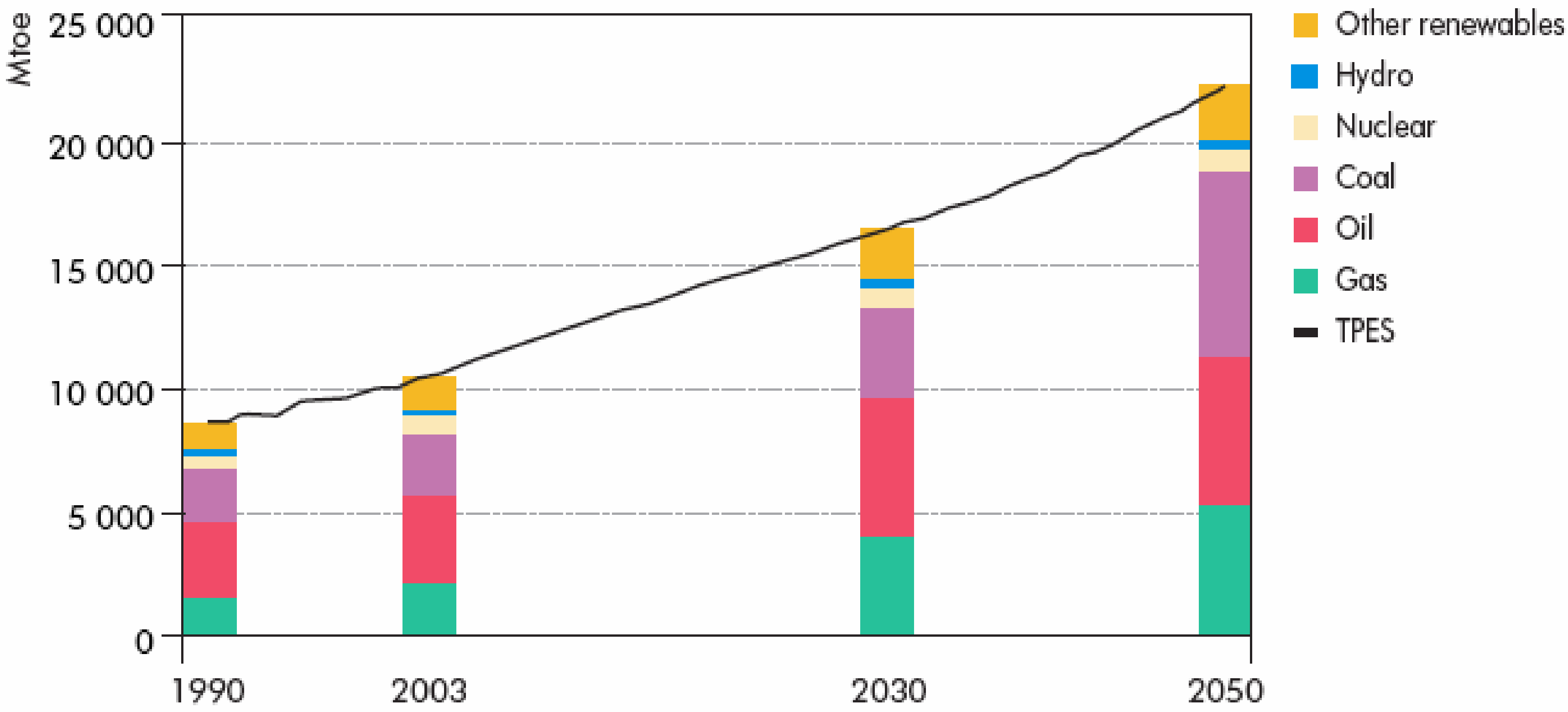
„Humanity can solve the carbon and climate

problem in the first half of this century **simply by**

scaling up what we already know to do".

(Pacala/ Socolow 2004)

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

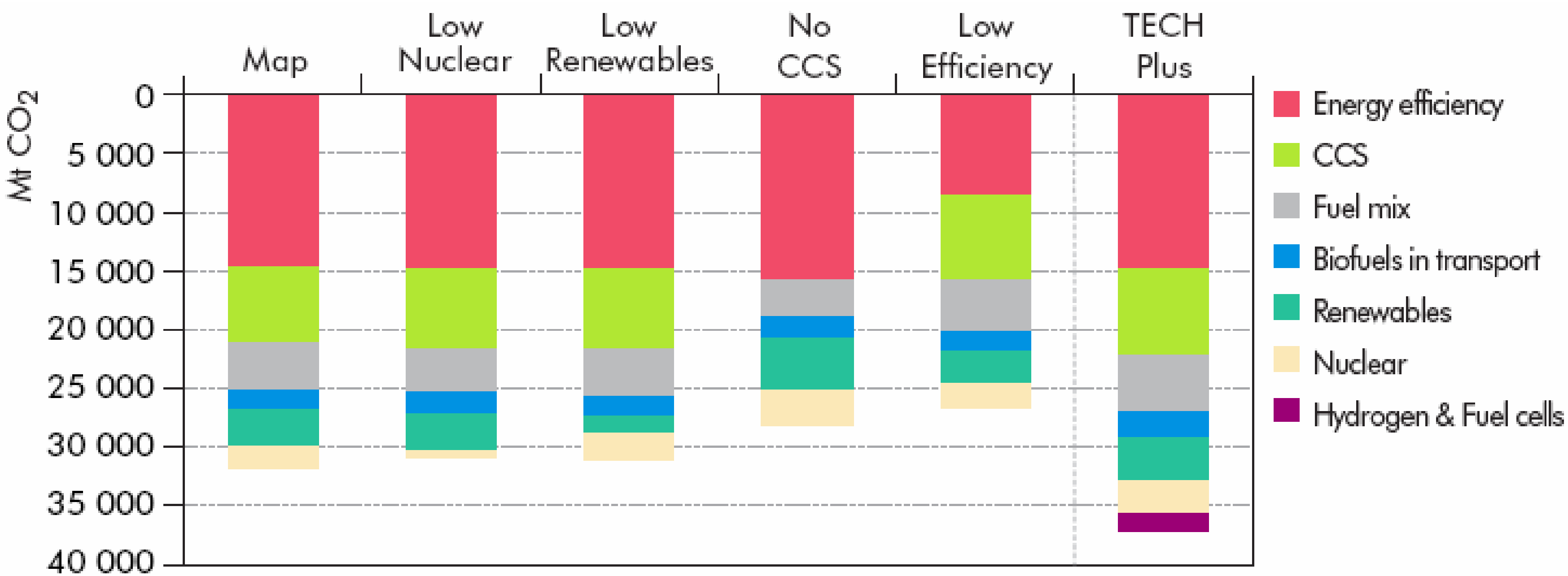


Key point

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

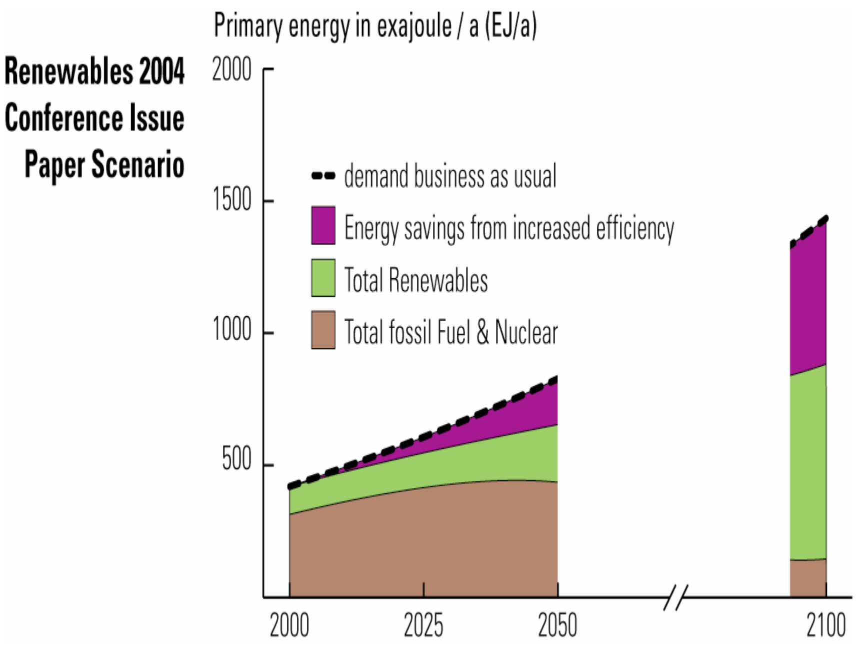
CO_2 emission reductions by contribution factor in the ACT and TECH - Plus scenarios

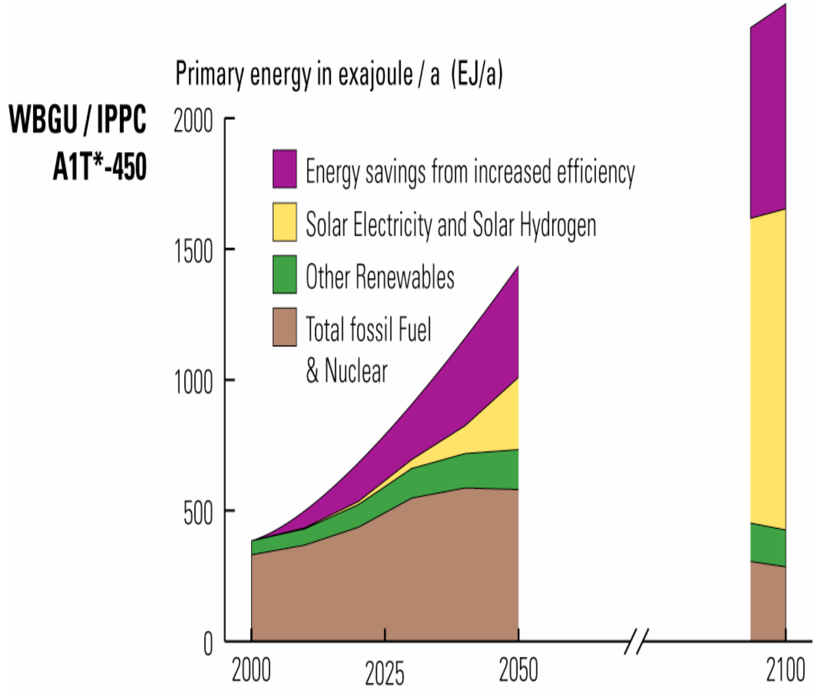
reduction below Baseline Scenario in 2050

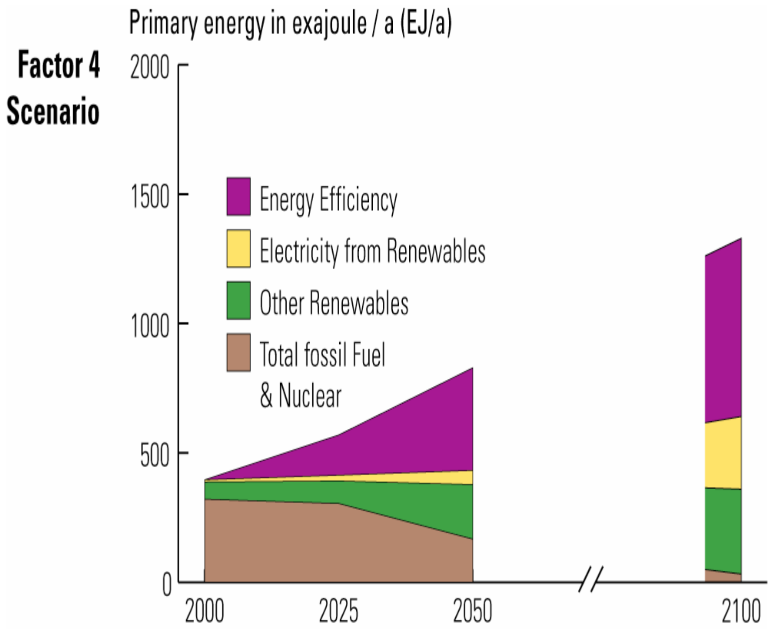


Key point

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







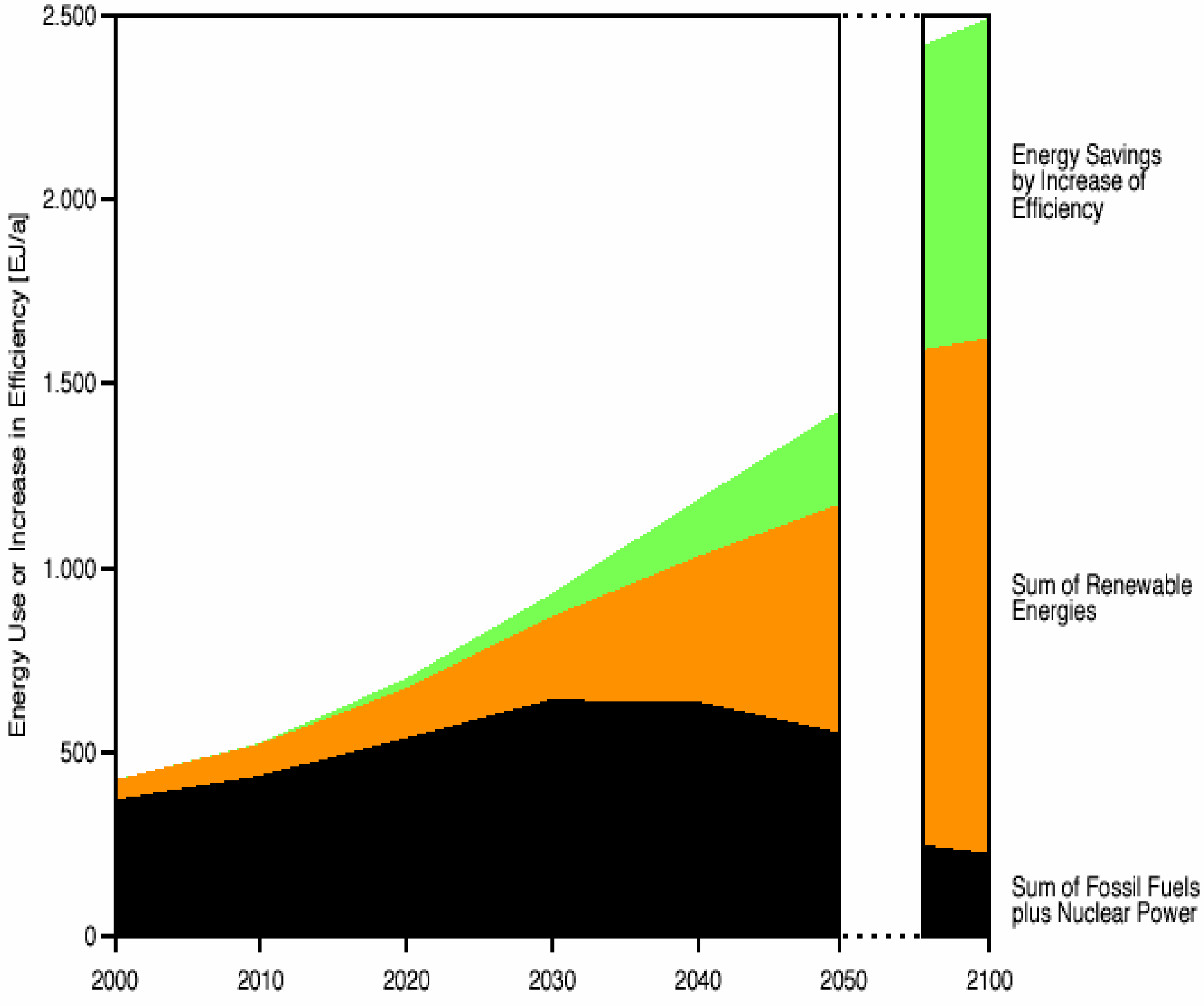
The contribution of energy efficiency (purple bar; compared to Reference Case), renewables and $C0_2$-sequestration (WBGU) in three recent world scenarios of sustainable energy systems

WBGU Sustainability Scenario: Increased Energy Productivity

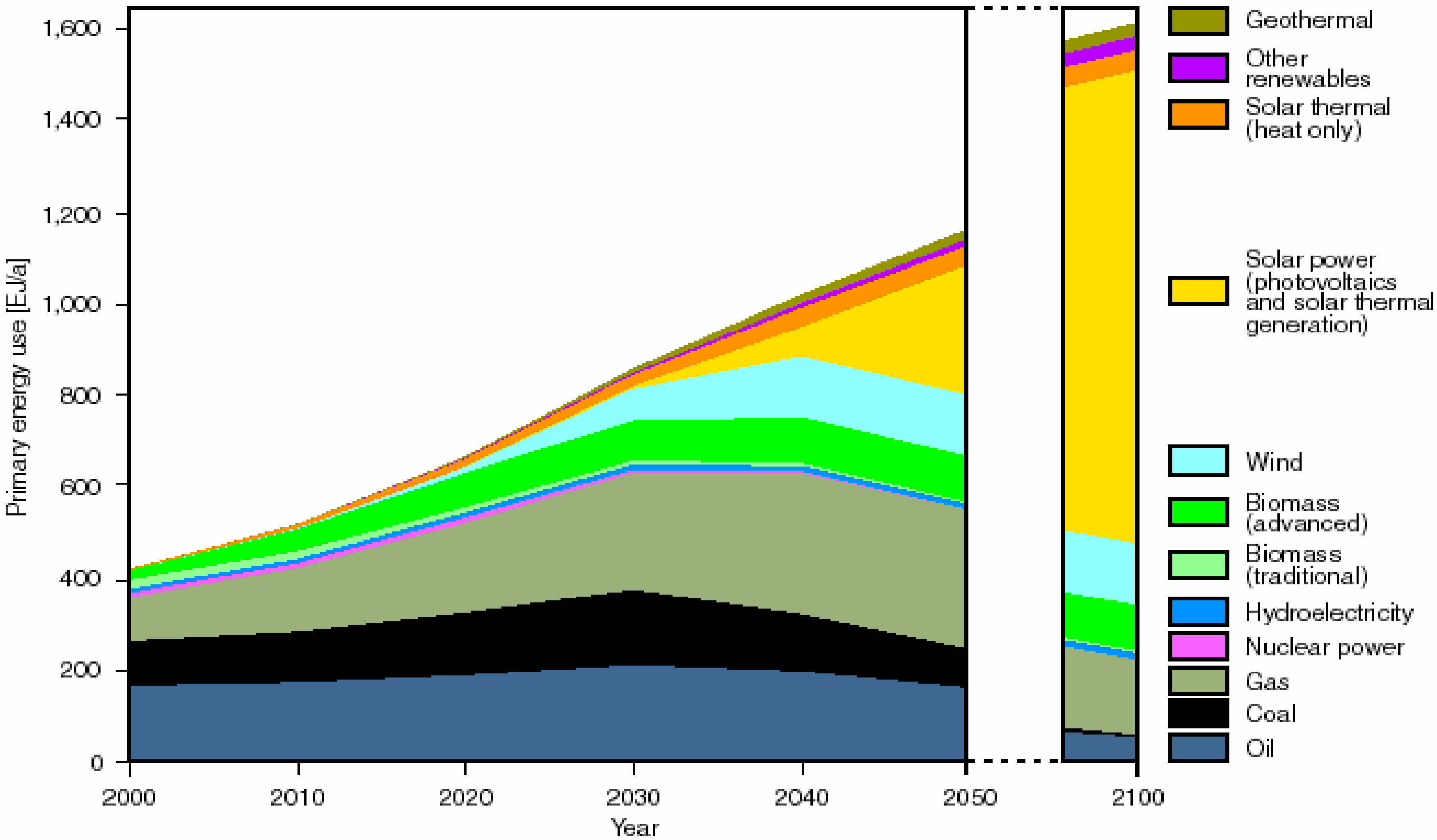
WBGU: 1,6% p.a.
(historically: 1%)

Productivity
Increase:
„Factor 3“
by 2050

Remark:
2% p.a.efficiency increase
has been demonstated
by the Wuppertal-Scenario



WBGU/IPCC A1T*-Path: Global Energy Mix

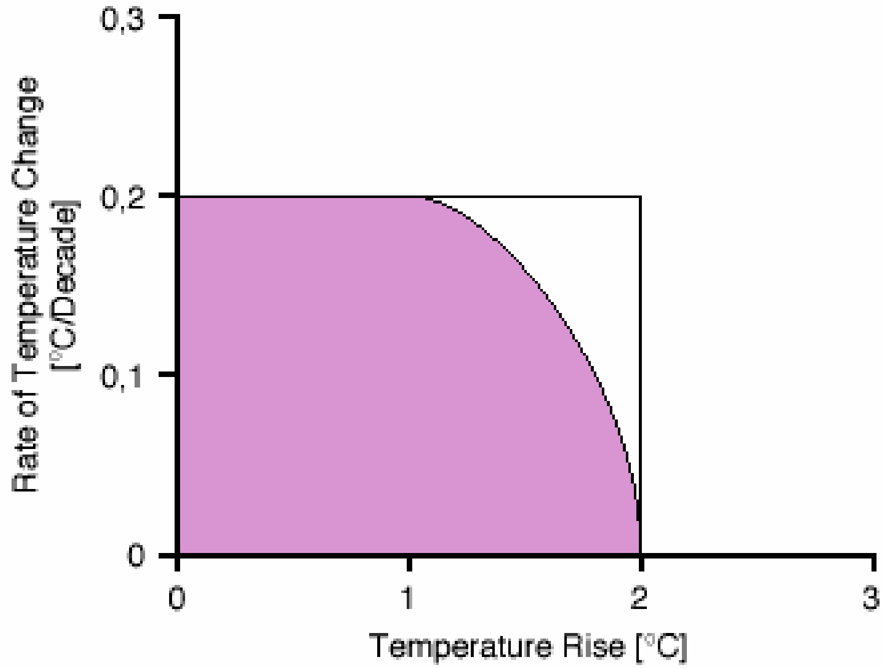


“Tolerabel Window” and Results of the WBGU-Sustainabilty Scenario

WBGU

- Keeping Climate Change within the „Tolerable Window“ is possible
- Reducing $C0_2$ by about 50% globally and 80% in ICs (using $C0_2$-sequestration)
- Phasing out nuclear up to 2050, using $C0_2$-sequestration
- Raising living standards in all developing countries
- Being the „Least Cost Option“ compared to IPCC-SRES-Scenarios

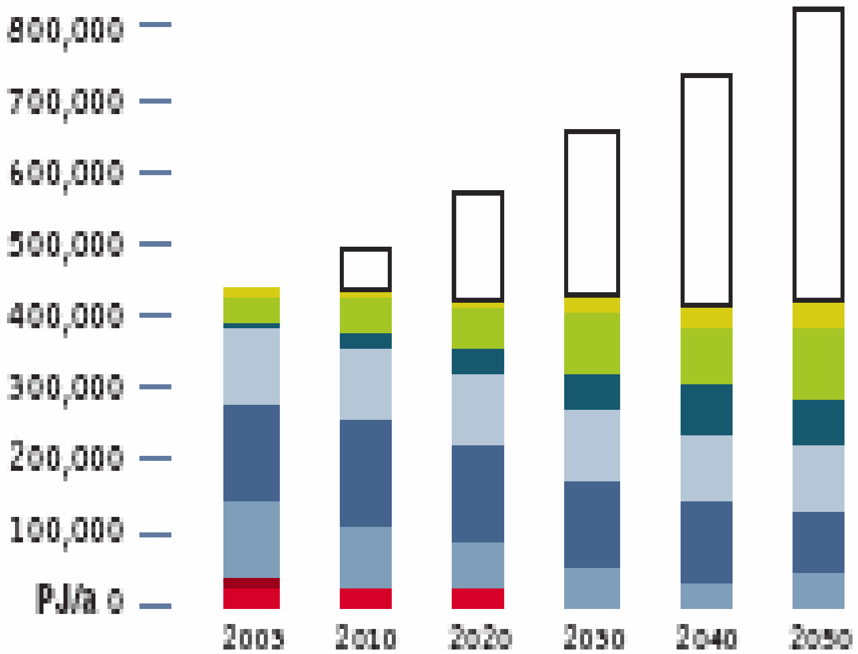
„Tolerable Window“:
Temperature change
2^0C and <0.2^0C/decade



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

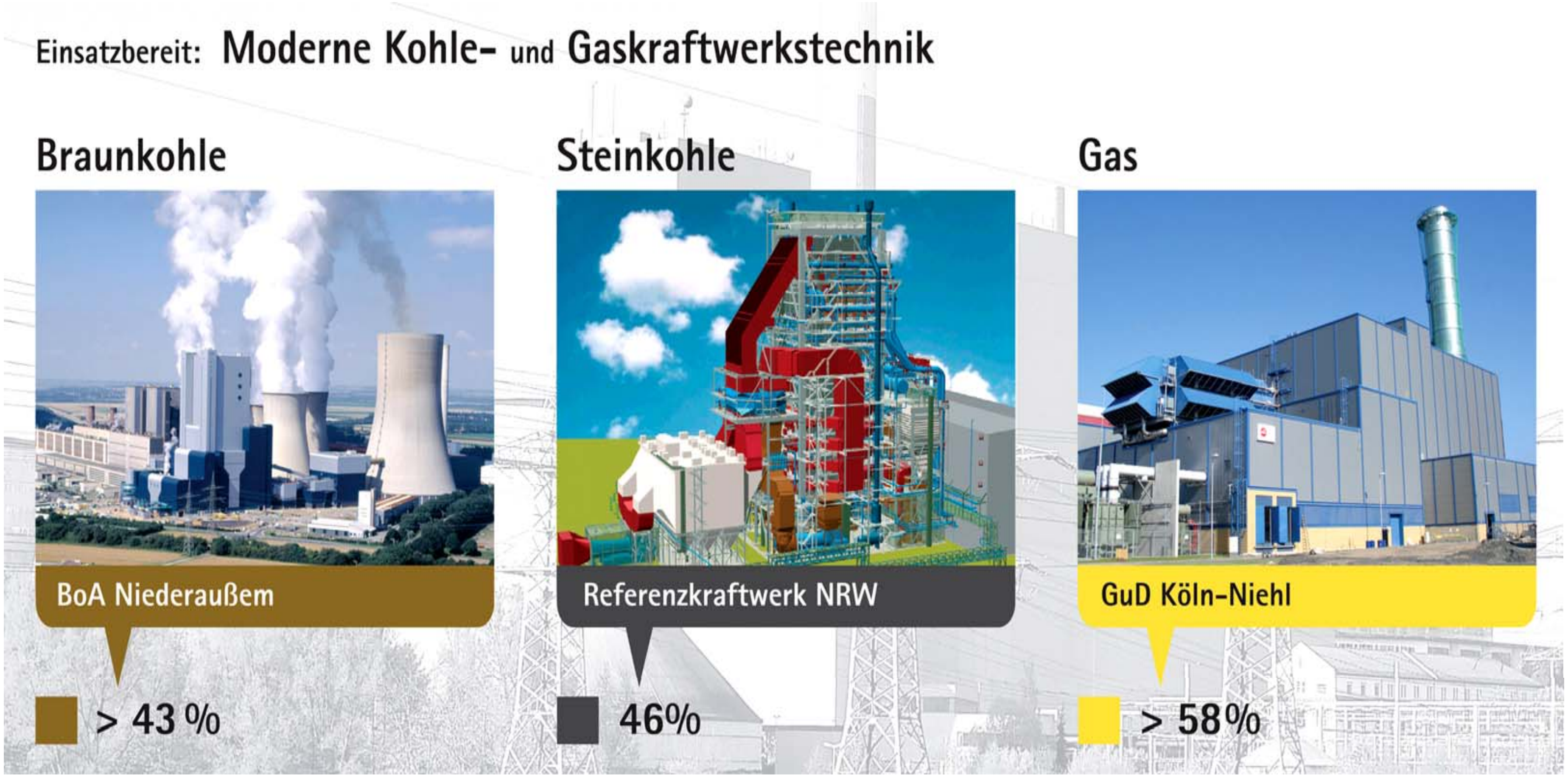
•Expansion of CHP (gas; biomass); biomass mainly unsed for stationary use

•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

Carbon capture and storage (CCS) and nuclear: Promising options?

Efficiency
State of the art of fossil fired power plants



Power plant with and without carbon capture and storage (CCS; example for lignite)

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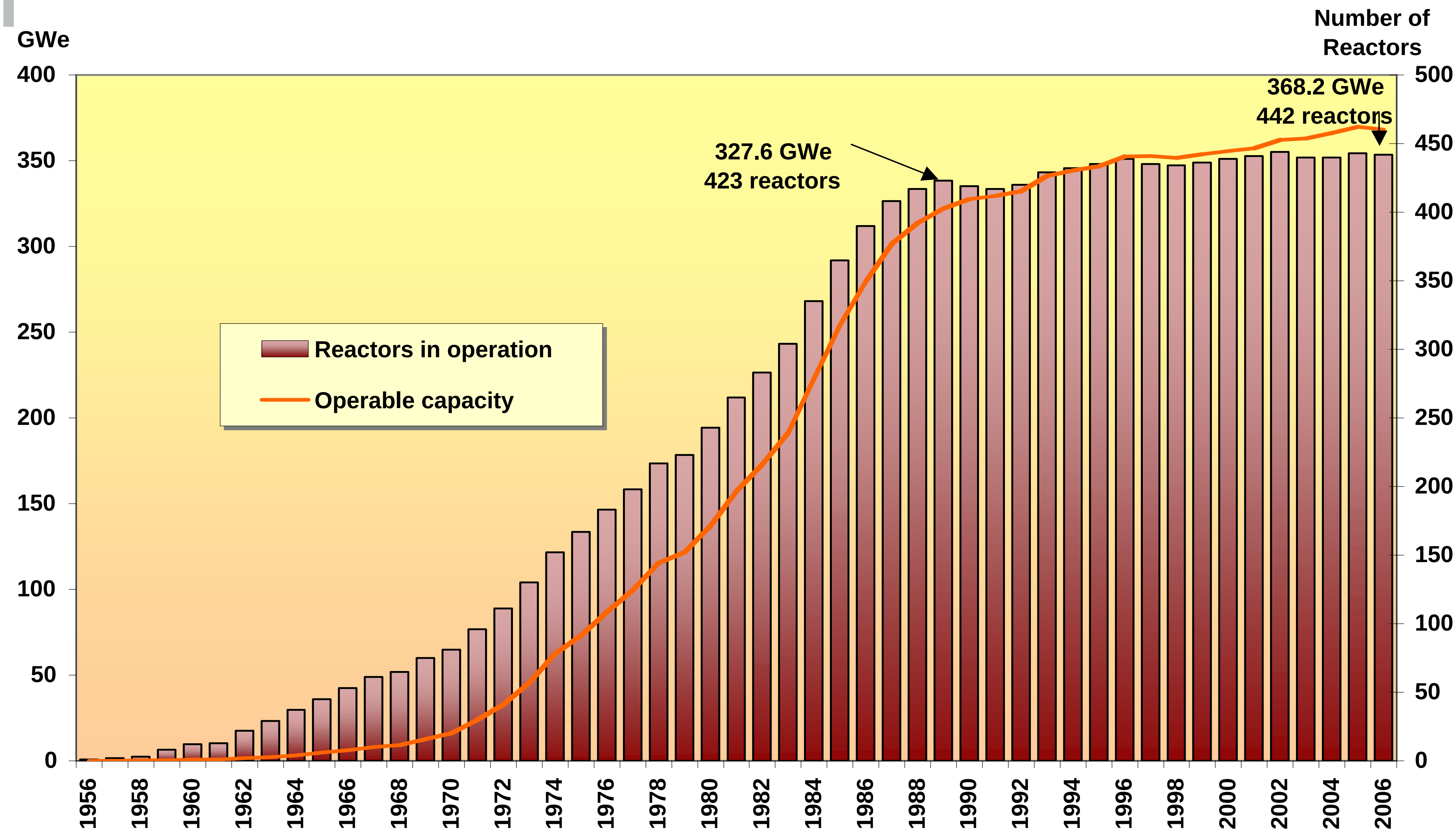
Quelle: Ewers/ Renzerbrink, VGB Power Tech 4/2005

Nuclear Reactors & Net Operating Capacity in the World

in GW, from 1956 to May 2006



Source : IAEA PRIS, MSC

Worldwide new electrical generating capacity: Decentralized (28 GW) vs. nuclear (4.7 GW) in 2004 (forecast 2010: ca. 70 GW vs. 0.5 GW!)

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Centralized power□s competitors on a consistent accounting basis. Levelised cost of delivered electricity or end-use efficiency

(at 2,75¢/kWh delivery cost for remote sources; source: Lovins/2006; based on MIT 2003).

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Facts and projections on wordwide decentralized vs. centra-lized (nuclear) electricity capacity and efficiency gains

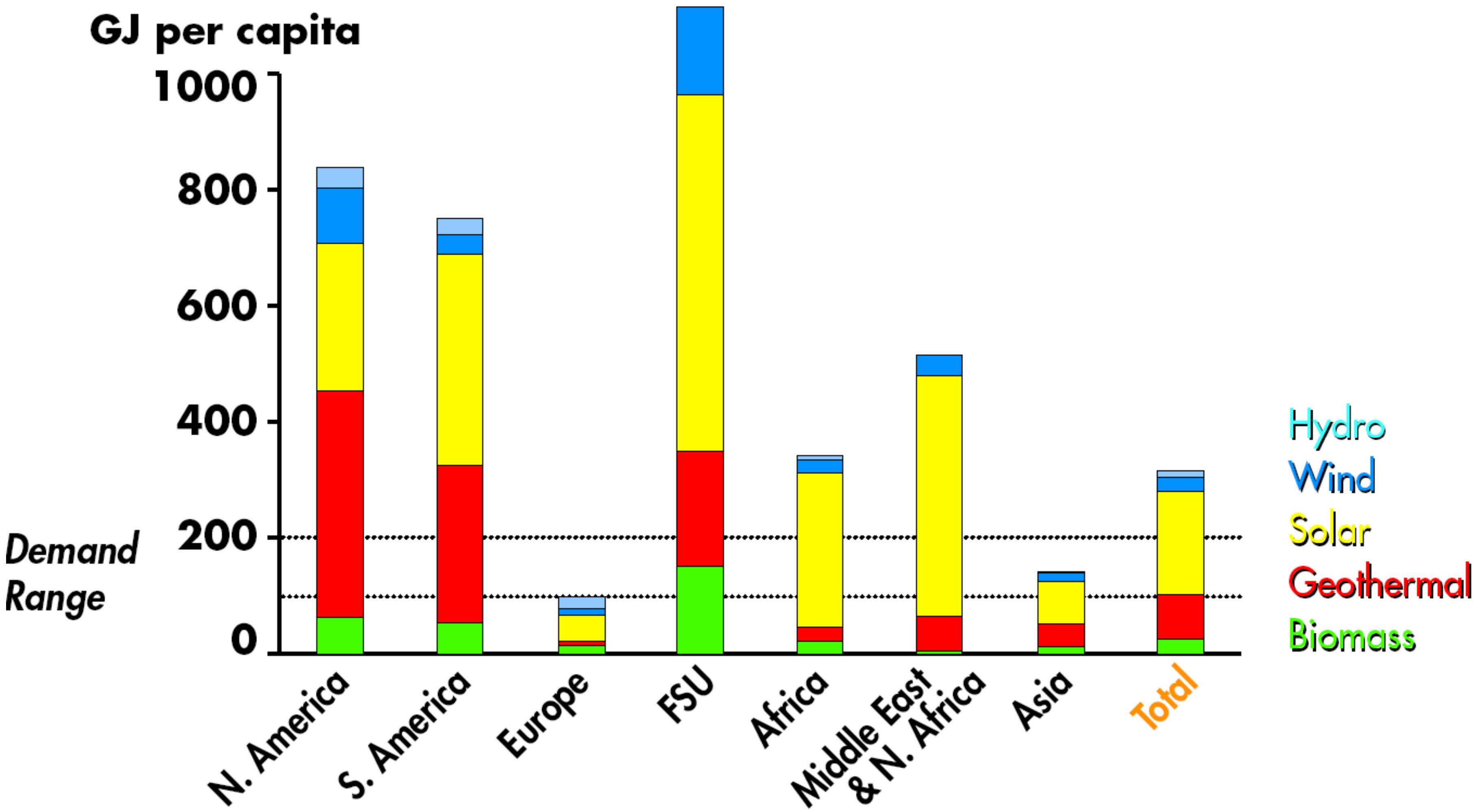
- In 2004 low- and no-carbon decentralizend sources of electricity (28 GW) added worldwide 5.9 as much capacity p.a. as nuclear (4.7 GW); in 2010 it could be 65-87GW to 0.48 GW
- Efficiency gains plus decentralized sources add 10x as much capacity p.a. as nuclear power
- Nuclear is an inherently limited climate protection option: it makes only electricity and it`s too big for small countries, the slowest option to deploy, (without subsidies) the most costly and financially risky technology, least accepted in society and vulnerable to terrorist attacks and proliferation: „Since nuclear power is unnecessary and uneconomic, we needn't debate whether it`s safe" (Lovins 2006, p.18)
- **Comparative costs** (MIT 2003; levelized 2004 US$; including 2.75c/kwh delivery costs;$100/t carbon tax):

  - nuclear: 9.77 c/kWh (decreasing to 7.15 c/kWh?)
  - coal: 9.66 c/kWh (without tax: 7.15 c/kWh)
  - combined cycle: 7.78 - 9.77c/kWh (depending on gas prices; without tax: 6.73-8.61 c/kWh)
  - wind: 7.51 - 8.01 c/kWh (1.0 c/kWh reduction expected in 2012)
  - end-use efficiency: 1c/kWh up to 5c/kWh (suboptimal business programs); average: 2- 4c/kW
- Opportunity costs: Instead of spending 10c to displace 1 kWh coal-fired electricity/$C0_2$ by nuclear we get: 1.2-1.7 kWh wind, 0.9 -1.7kWh gas fired industrial cogeneration; 10 kWh end-use efficiency
- Opportunity costs and climate protection: „nuclear power saves half as much carbon per dollar as windpower and traditional cogeneration, half to a ninth as much as innovative cogeneration, and a tenth as much as end-use efficiency" (Lovins, 2006, p.15)

Policy can create huge lead markets

for energy efficiency and renewables

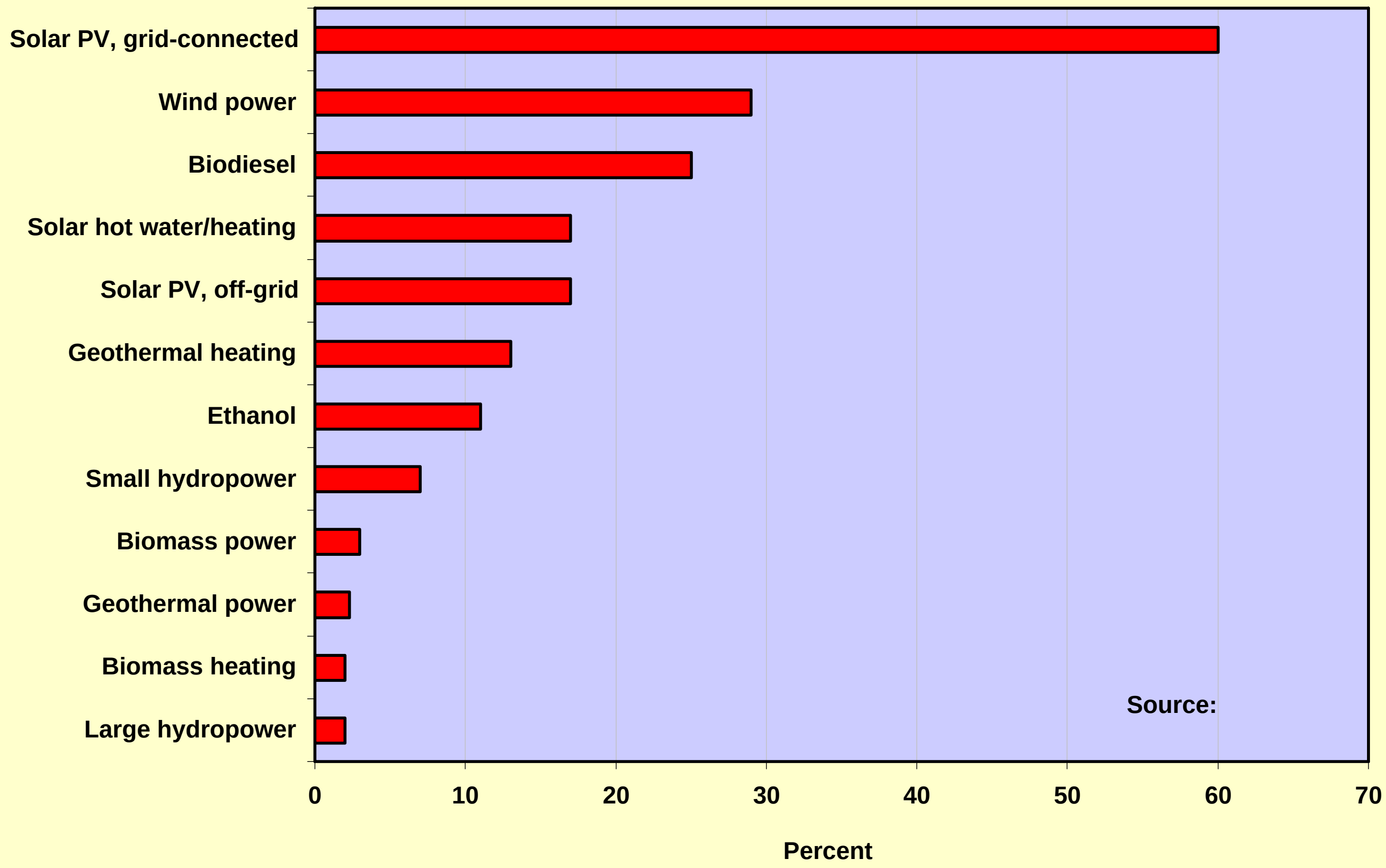
Renewable Resources are Adequate to Meet all Energy Needs



Source: adapted from UN 2000, WEC 1994, and ABB 1998. Figures based on 10 billion people.

Shell International Ltd.

Average Annual Growth Rates of Renewable Energy Capacity, 2000-2004



Increase of renewables 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

A business opportunity
(Cited from BP 2007)

- Society is increasingly demanding environmental solutions
- Material opportunities now exist
- Technologies have matured and are becoming economic
- BP has distinctive capabilities
- This is an inflexion point

The bp alternative energy businesses

Solar power

Wind power

Hydrogen power

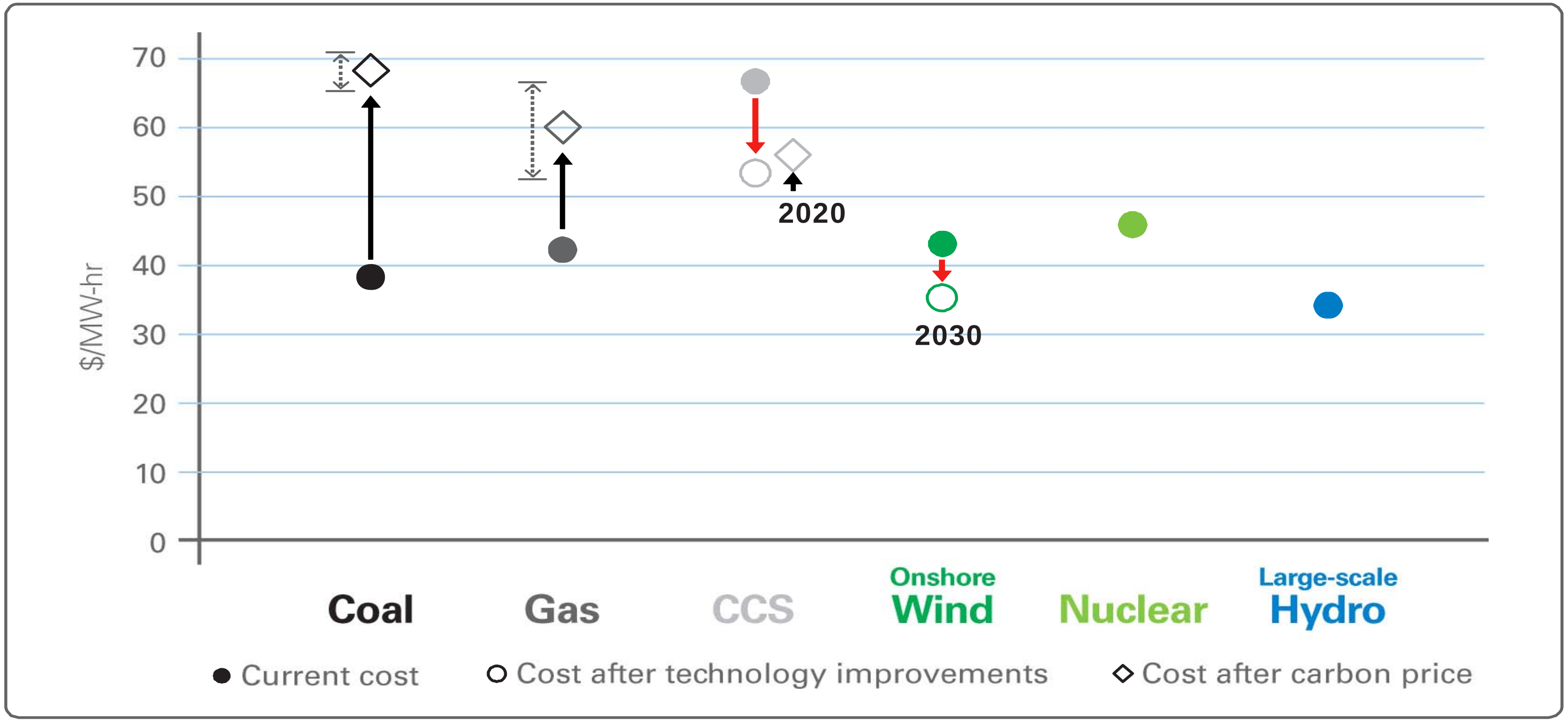
Gas-fired power

Wind
(Cited from BP 2007)

- We will build 550 MW in 2007 with projects in Colorado, Texas, North Dakota and California.
- We have a 40 MW project under construction in Maharashtra, India with our partner Suzlon Energy
- Secured options for 4250 MW of turbines over the following 5 years through a strategic deal with Clipper Wind Power
- Have acquired a 15 GW development portfolio in the USA.
- Looking to develop further projects in India and China
- In Europe our focus will be on offshore wind

Increasing suite of low carbon power options are available
(Source: BP 2007)

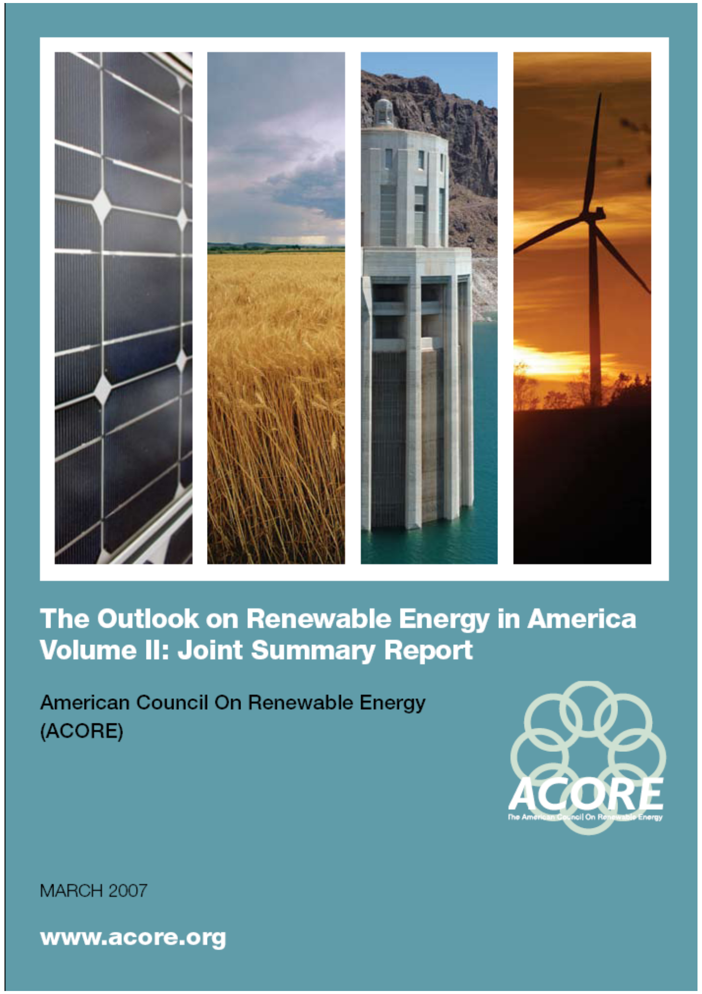
- Accelerated deployment reduces costs of low-carbon technologies
- As the chart shows, pricing carbon dramatically shifts the picture



Source: IEA Technology Perspectives 2006, IEA World Energy Outlook 2006, Booz Allen/BP analysis
Note: All data from lower bound of sources' reported ranges. Coal and gas power price varies due to fuel prices, predicted range shown on chart. No coal CCS plants currently in operation; earliest operational plant in 2010. All costs are for wholesale generation.

American Council On Renewable Energy (ACORE): Joint Outlook on Renewables in America

To be released May 1, 2007



Technically Feasibly Renewable Electricity by 2025:

Wind Power	248 GW
Solar Energy and Power	164 GW
Water Power	23 GW
Geothermal Energy and Power	100 GW
Biomass energy, fuels and Power	100 GW
Total Renewable Electricity	635 GW

Market Trends and Perspectives for „Clean Energy“
(Clean Edge, March 2005)

- **1.Projected world markets for „Clean Energy“ (2004 to 2014)**

- **Wind Power:**8 to 48,1 (US $ Billions)
- **Solar PV:** 7.2 to 39.2 (US $ Billions)
- **Fuel Cells:** 0.9 to 15.1 (US $ Billions)

- **2. Up coming „Clean Energy Markets“**

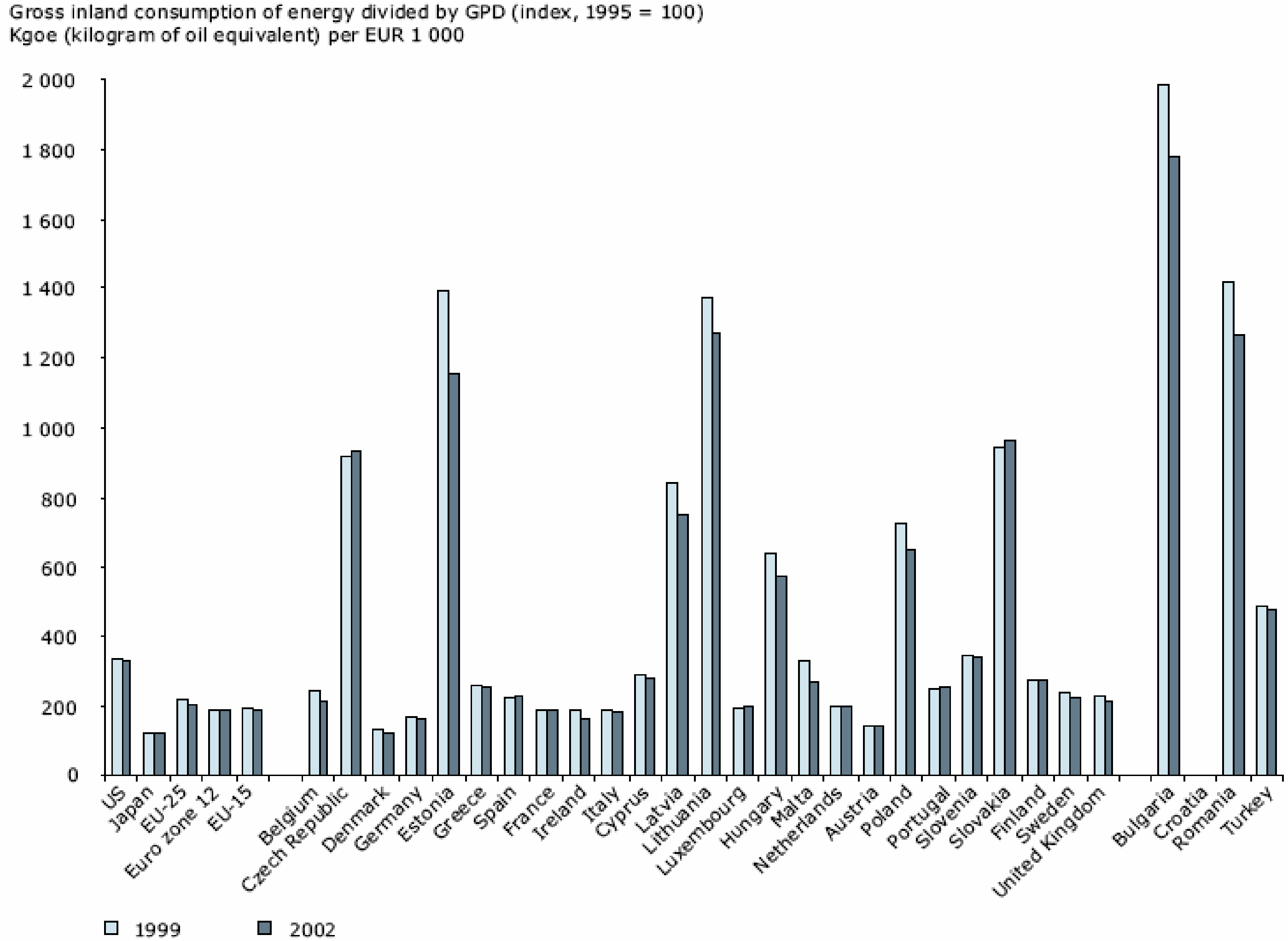
- **Biofuels** (e.g. biogas, biodiesel, ethanol, long term:BTL (driven by oil prices/ security of oil supply e.g. in countries like Brasil, US, EU, India)
- **Energy Efficiency** („Efficiency is back on the spotlight“; driven by private companies like General Electric and countries like China, EU and US states like California)
- **Concentrated Solar Power (CSP)** („after a standstill of more than a decade“; 1000MW initiative of US DOE; many plans in the „Solar Belt“ (e.g. Spain, Northern Africa, Middle East; EU-MENA Study)
- **Green Buildings** (e.g driven bei US Green Building Council and LEED-Standard „Leadership in Energy and Envionmental Design“; „leap frogging“ in rapidly growing economies like in e.g. China, India))

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

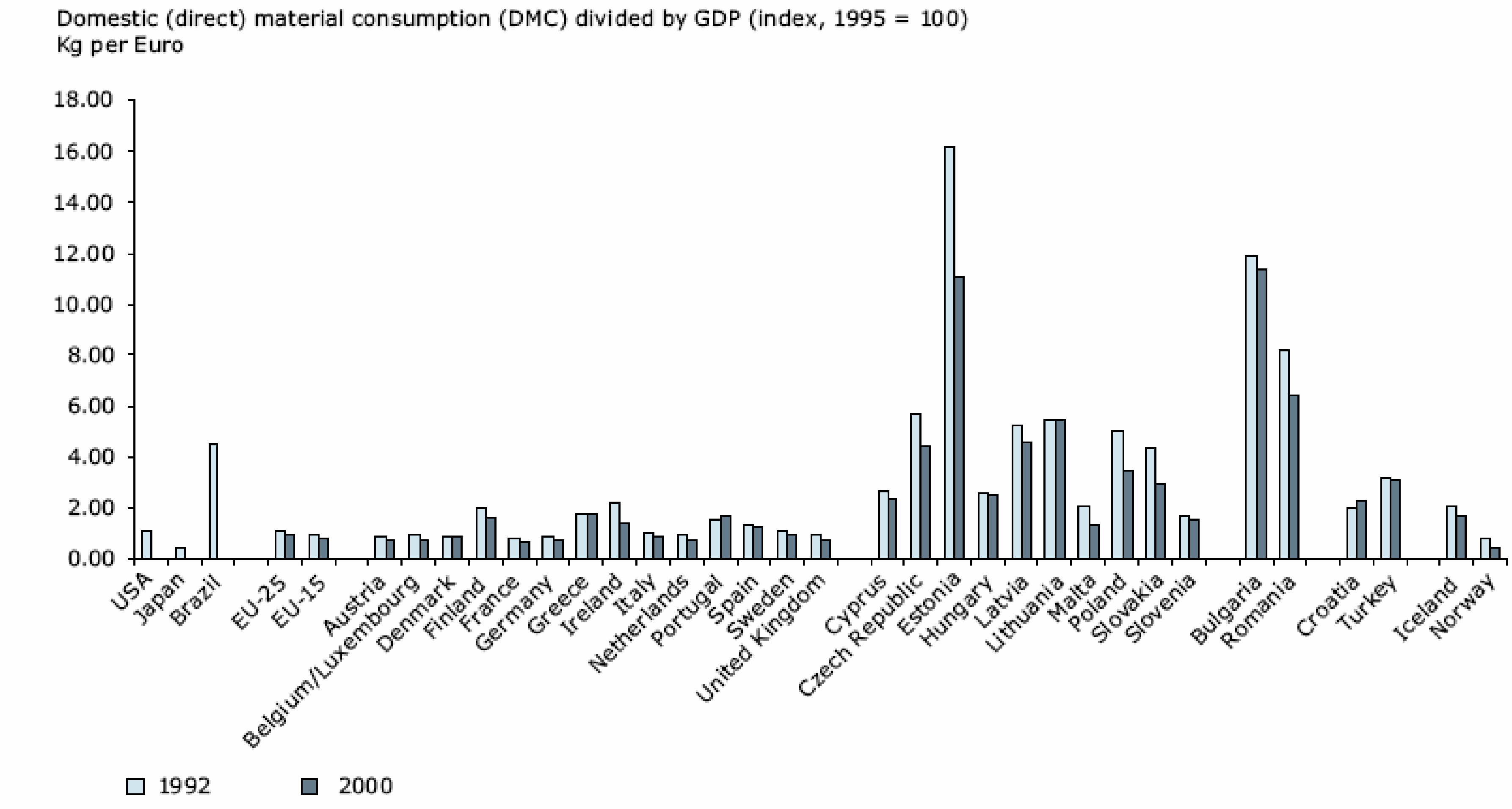
(EU Accession Countries: about 4x higher than EU15!)

Different energy intensities: A huge potential for worldwide "leap frogging" by advanced energy efficiency technologies



Source: Eurostat (2005): Structural indicators — online (http://europa.eu.int/comm/eurostat/newcronos/reference/display.do?screen =detailref&language=en&product=EU_strind&root=EU_strind/strind/enviro/en020).

Material intensity of European economies:
East European Countries a factor 4 higher than EU15



Sources: Wuppertal Institute, 2005; Eurostat, 2004; van der Voet *et al.*,2004.

EU-25 :

Challenges and Sustainability Scenarios

Overview: New Energy Scenarios for the EU 25
(Study of Wuppertal Institute on behalf of the European Parliament, September 2006)

Background:
- The end of cheap fossil energy and growing import dependency
- Targets for Climate Stabilisation (e.g. < 2^{o} C; - 80% CO_2 in 2050)
- Window of opportunity in restructuring the EU electricity sector

Task of the study:
- Analysis of import dependency,robust technology trends, GHG-emissions and investment costs up to 2030

Methodology
- Accounting model of the EU25 energy system
  - Detailled analysis of the power sector and CHP production
  - Bottom up modelling of energy demand by sector and energy carrier
- Baseline compatible with recent DG TREN scenario

Five Energy Scenarios for the EU 25 up to 2030

(Study of Wuppertal Institute on behalf of the European Parliament, September 2006)

BAU: **Baseline scenario (BAU)**
(compatible with the new DG-TREN baseline scenario)

N+: **+25% nuclear capacity** in 2030 vs. new baseline
(+ CCS)

N-: **-25% nuclear capacity** in 2030 vs. new baseline
(76 GW nuclear capacity in 2030)

EE: 50% increase in **energy efficiency** on a primary energy level vs. BAU by 2030

RE: >30% **RES** by 2030 (includes + 75% energy efficiency)

Estimates of energy saving potential in EU 25 up to 2020

(EU-Baseline Scenario and Wuppertal Institute 2005;
EU Action Plan for Energy Efficiency 19.10.2006)

Sector	Energy consumption (Mtoe) 2005	Energy Consumption (Mtoe) 2020 (Business as usual)	Energy Saving Potential 2020 (Mtoe)	Full Energy Saving Potential 2020 (%)
Households (residential)	280	338	91	27%
Commercial buildings (Tertiary)	157	211	63	30%
Transport	332	405	105	26%
Manufacturing Industry	297	382	95	25%

Comparison of the EU25 scenarios: results for 2030

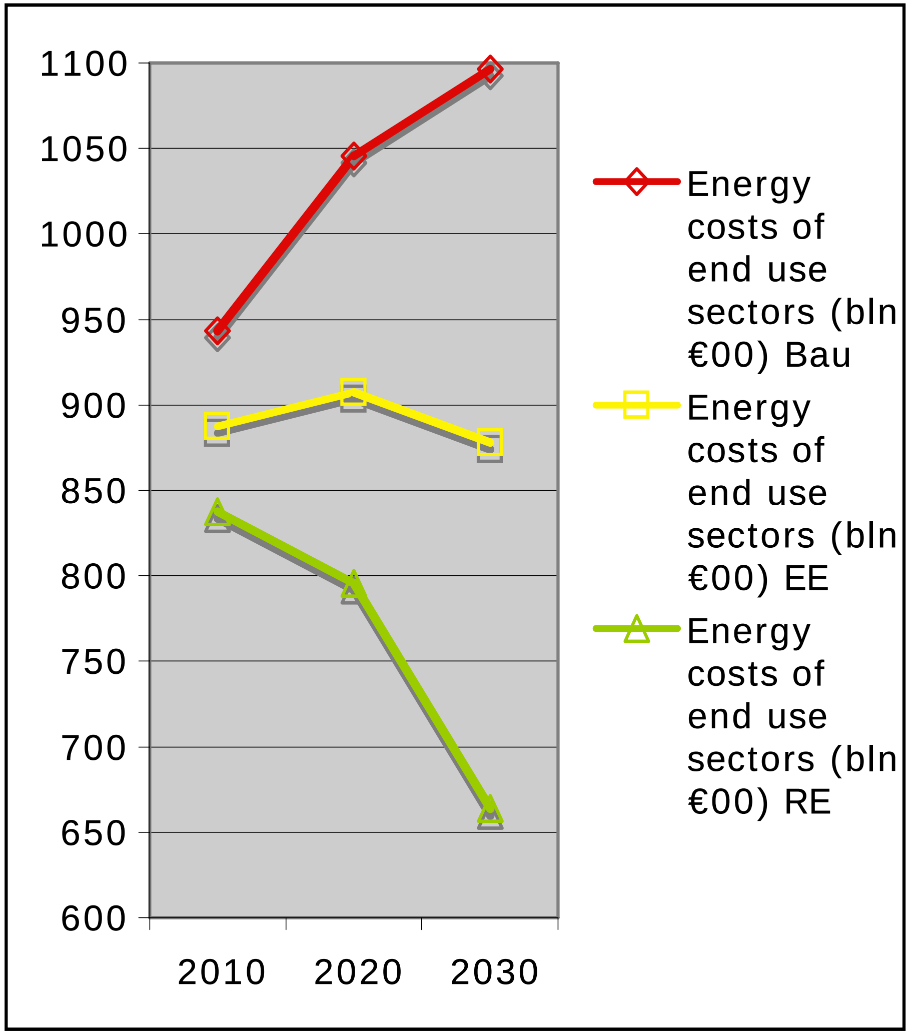
Scenario	CO_2 emissions (% Δ 1990)	Primary energy demand (% Δ 1990)	Import dependency	Nuclear share of electricity generation	RES share of PE demand	Energy efficiency growth rate (2000 - 2030)
BAU	+4.7%	+14.6%	64.8%	18.7%	12.2%	1.5%/year
N+ (+CCS)	+1.9%	+16.4%	62.7%	23.6%	12.0%	(<) BAU
N-	+6.6%	+12.2%	66.5%	13.8%	12.4%	(>) BAU
EE	-18.8%	-8.2%	59.8%	15.7%	15.0%	2.2%/year
RE	-45.1%	-20.1%	49.1%	16.4%	31.4%	2.7%/year

Source: own calculations, Wuppertal Institute

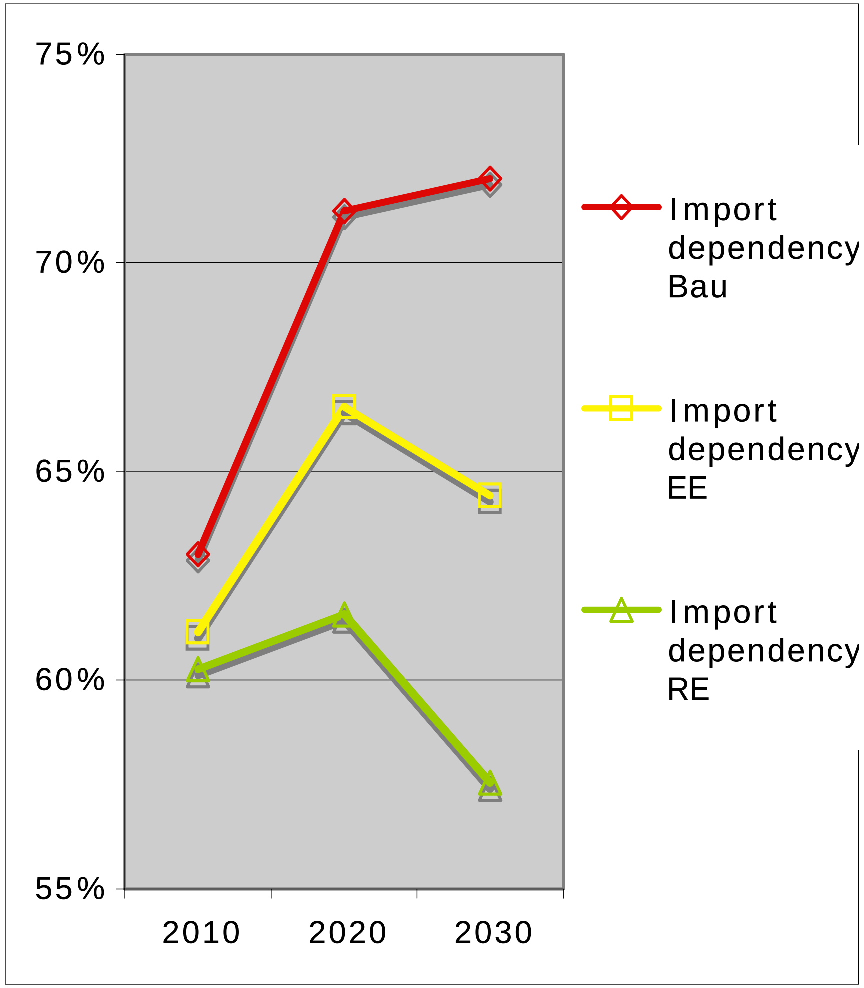
„From a technical point of view, the recently proposed Commission objective of a 20% overall improvement in energy efficiency in Europe by 2020 could be easily achievable. A long run target of (say) a 50% improvement in European energy end use-efficiency by mid-century should be agreeed“. EU DG Research, Transition to a sustainable energy system for Europe, EUR 22396, Bruxelles 2006

EU25 scenario results -
Energy costs of end use sectors (bln €)

- Increasing energy costs in BAU
- Relative constant energy costs in EE
- Decreasing energy costs in RE



Scenario results: import dependency



- Increasing import dependency in BAU
- Decreasing import dependency in RE and EE after 2020

Results of the first European Energy-Delphi-Survey up to 2030

- *„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...*

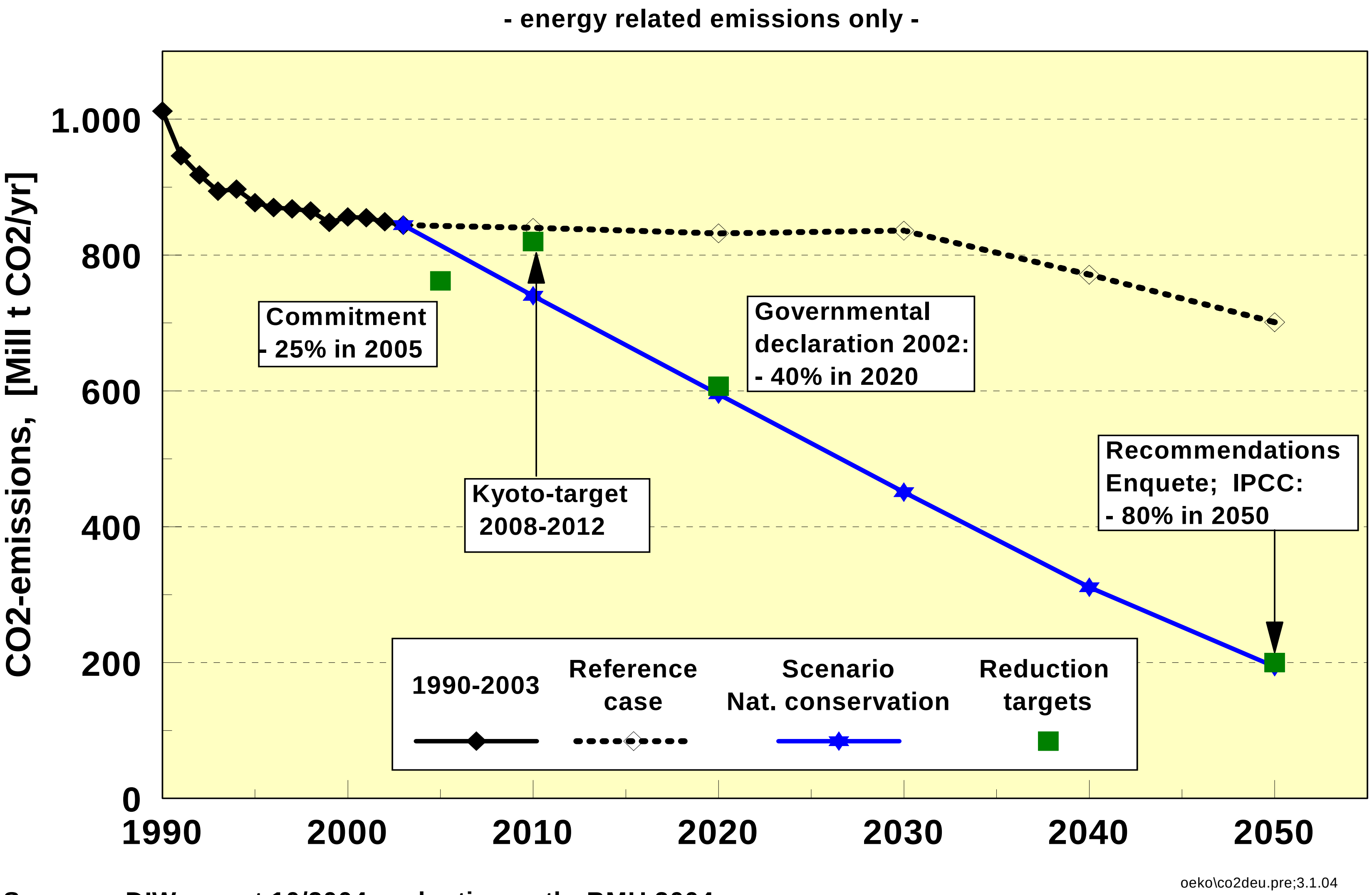
- *A number of Delphi comments point to the apparent contradiction between the high share of funding for nuclear research, especially **fusion**, and the meagre positive impacts anticipated over the next 35 years...*

- *The respondents generally rated the anticipated **impacts of $C0_2$ sequestration** as rather low in relation to the uncertainties connected with the technology“.(IZT 2004)*

German Sustainable Energy Scenarios:

80% $C0_2$-reduction (2050) and nuclear phase out (2025) are technically and economically feasible

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



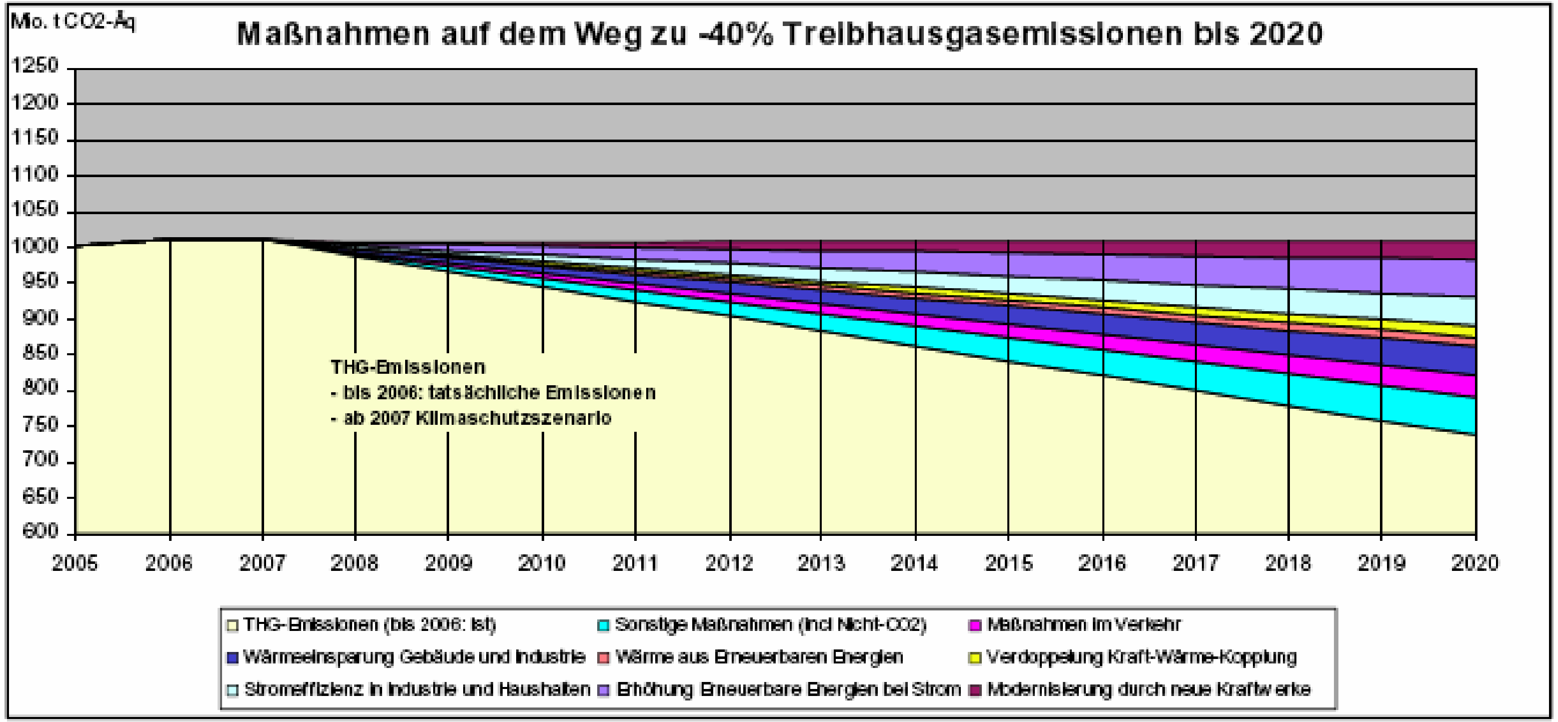
Sources: DIW-report 10/2004; reduction path: BMU 2004

Status and targets of German Energy and Climate Policy (up to 4 / 2007)

- Status quo: 18.5 % $C0_2$ reduction in 2003 compared to 2000, but reduction rates have drastically slowed down since the mid 90s
- **Kyoto targe**t: 21% $C0_2$ reduction up to 2008-12; additional activities in the residential and transportation sector are needed
- Increase of the **share of renewables** to 12,5% (2010) and 20% (2020)
- Double **energy and resource productivity** by 2020 compared to 2000
- **40% $C0_2$ reduction by 2020** provided all other EU member states achieve 30%
- **80% $C0_2$ reduction by 2050 in Germany**; temperature rise not more than 2 degrees Celsius (corresponds to 450ppm; 50% $C0_2$-reduction by 2050 globally)
- E**U counci**l:“Industrialised countries are to bring down their greenhouse gas emission by 15 to 30 % by the year 2020 and by 60 to 80 % by 2050 as against baseline levels of 1990“.

New decision of the German Government (26.4.2007) to reduce GHG by 40% up to 2020 with eight targeted policies and measures

(- 270 million tonnes of GHG comp. 1990)

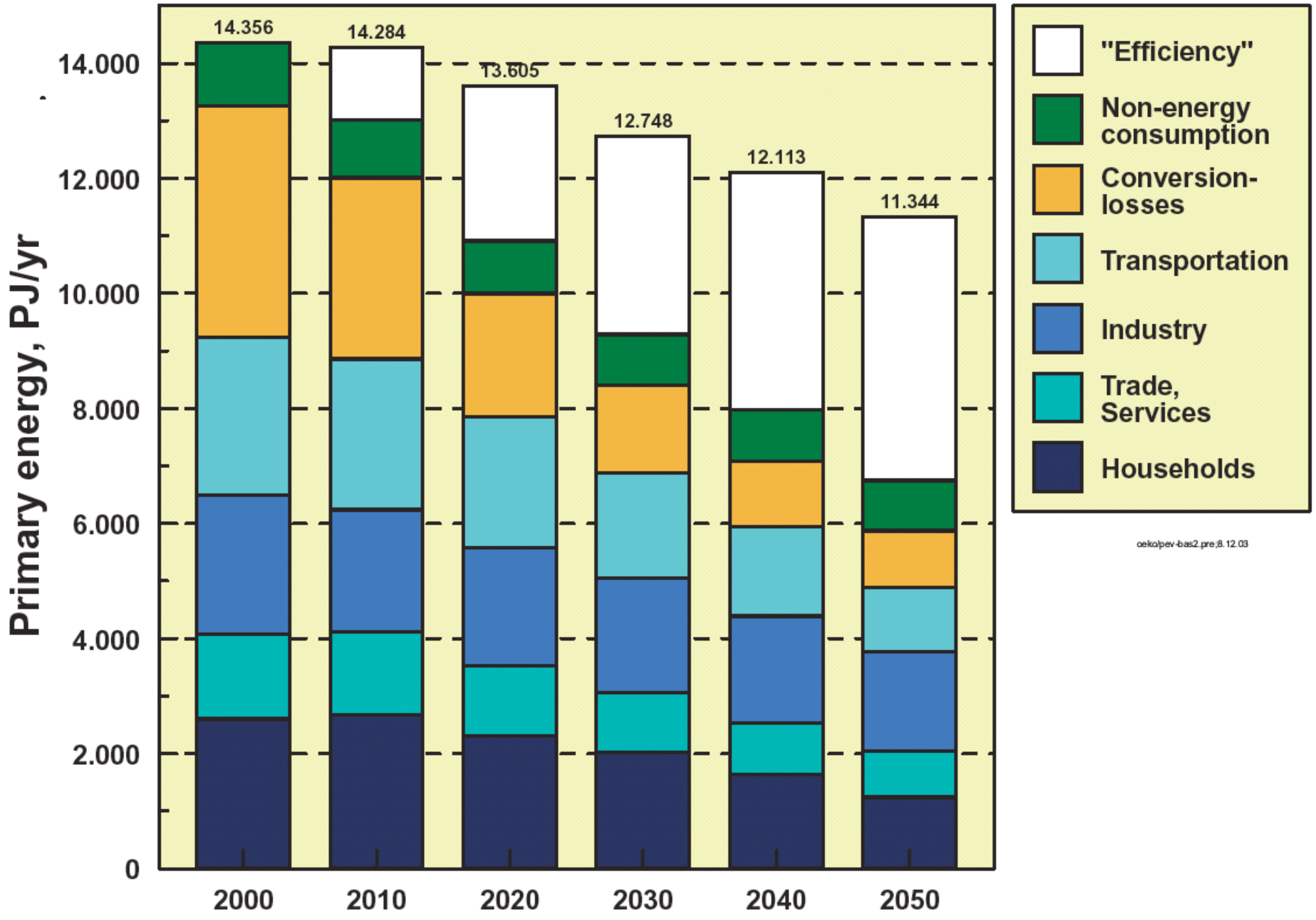


Ist-Situation: Treibhausgasemissionen: 1990: 1.228 Mio. t CO_{2e} 2006: ca. 1.007 Mio t. Ziel 2020 (-40% gg. 1990): 737 Mio. t

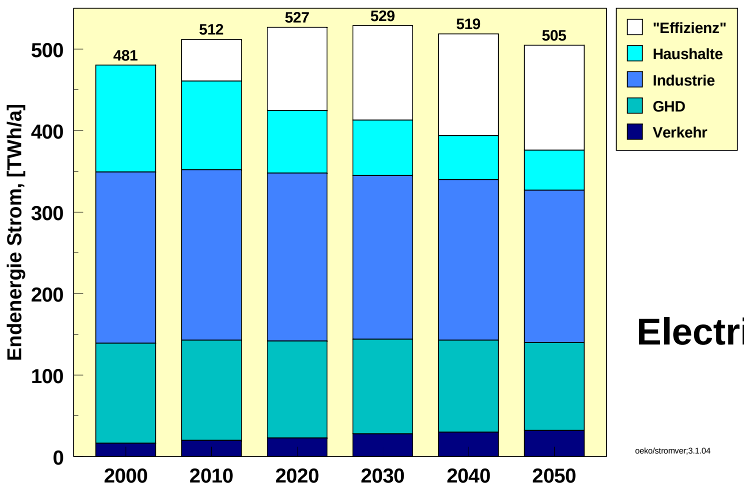
Maßnahmenkatalog zur Reduktion der Treibhausgasemissionen um 270 Mio. t bis 2020 gegenüber Ende 2006:

1. Reduktion des Stromverbrauchs um 11 % durch massive Steigerung der Energieeffizienz im Strombereich: 40 Mio. t
2. Erneuerung des Kraftwerksparks durch effizientere Kraftwerke: 30 Mio. t
3. Steigerung der Stromerzeugung durch erneuerbaren Energien auf über 27%: 55 Mio. t
4. Verdoppelung der effizienten Nutzung der Kraft-Wärme-Kopplung auf 25%: 20 Mio. t
5. Reduktion des Energieverbrauchs durch Gebäudesanierung, effiziente Heizungsanlagen und in der Produktion: 41 Mio. t
6. Steigerung der erneuerbaren Energien im Wärmesektor auf 14%: 14 Mio. t
7. Steigerung der Effizienz im Verkehr und Steigerung der Biokraftstoffe auf 17%: 30 Mio. t
8. Reduktion der Emissionen von Methan, Lachgas und F-Gasen: 40 Mio. t

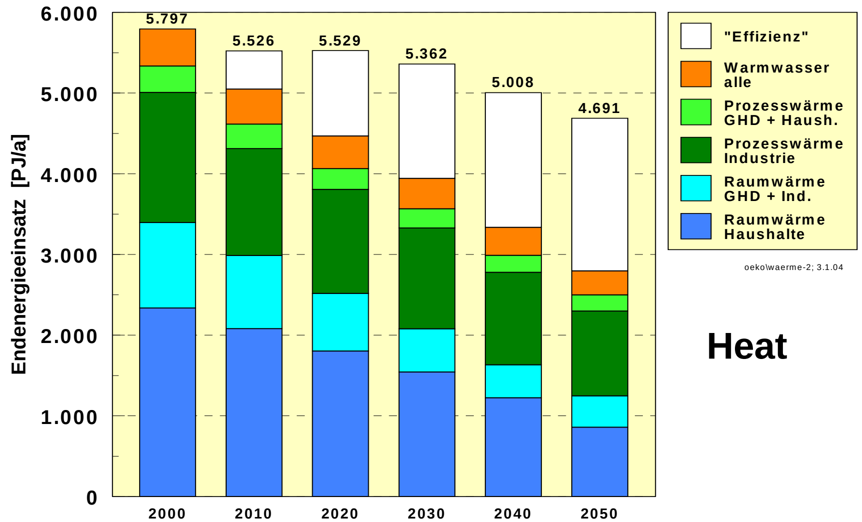
Decoupling GDP-growth (1.5% p.a.) from energy: The role of sectoral energy efficiency in a German sustainable energy system



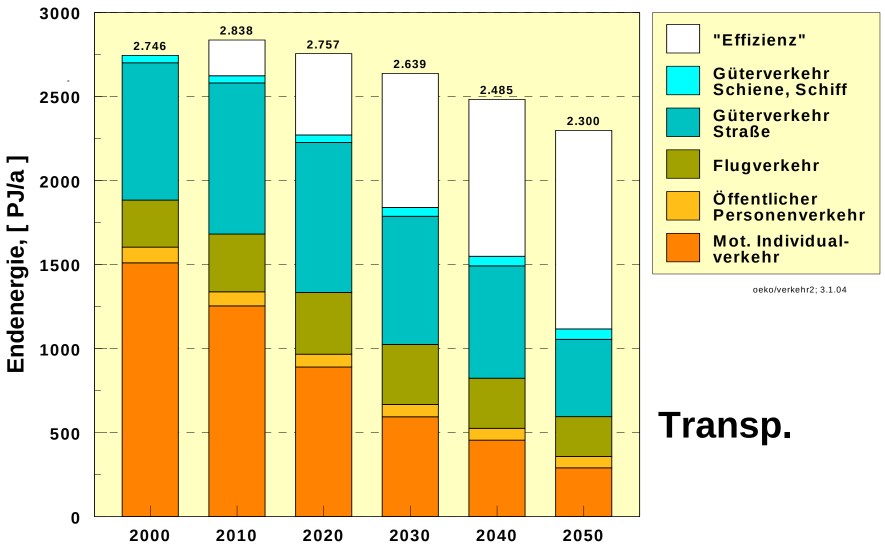
The role of efficiency within a German sustainble energy system



Electricity



Heat



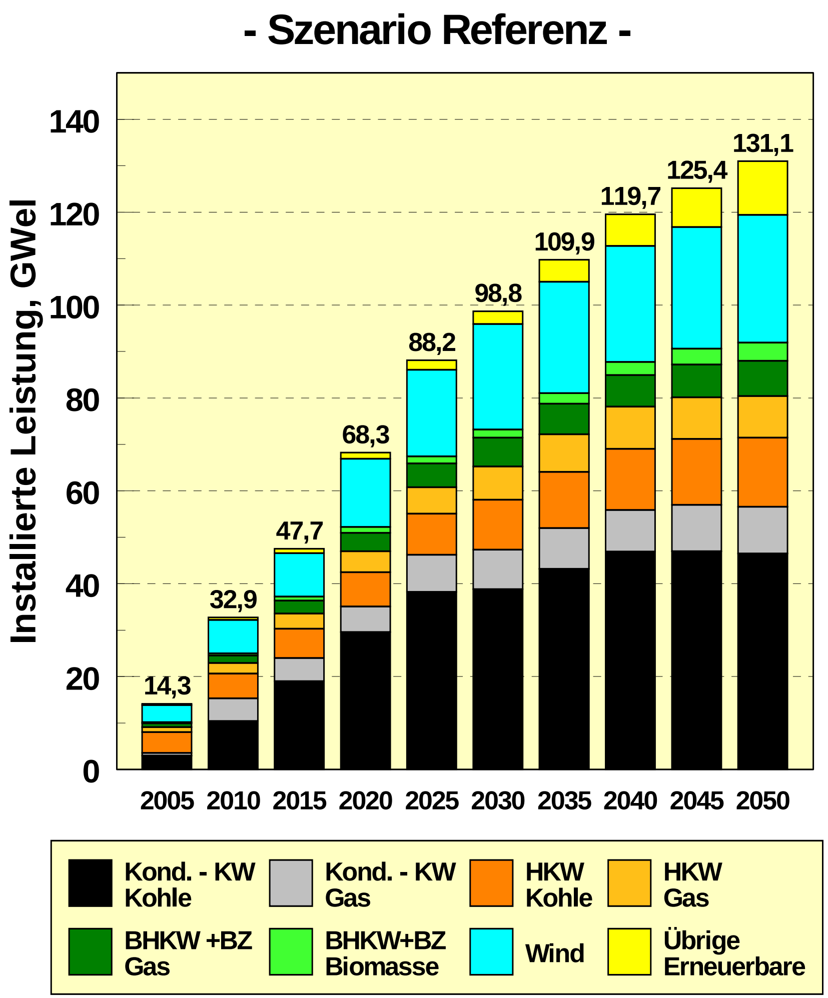
Transp.

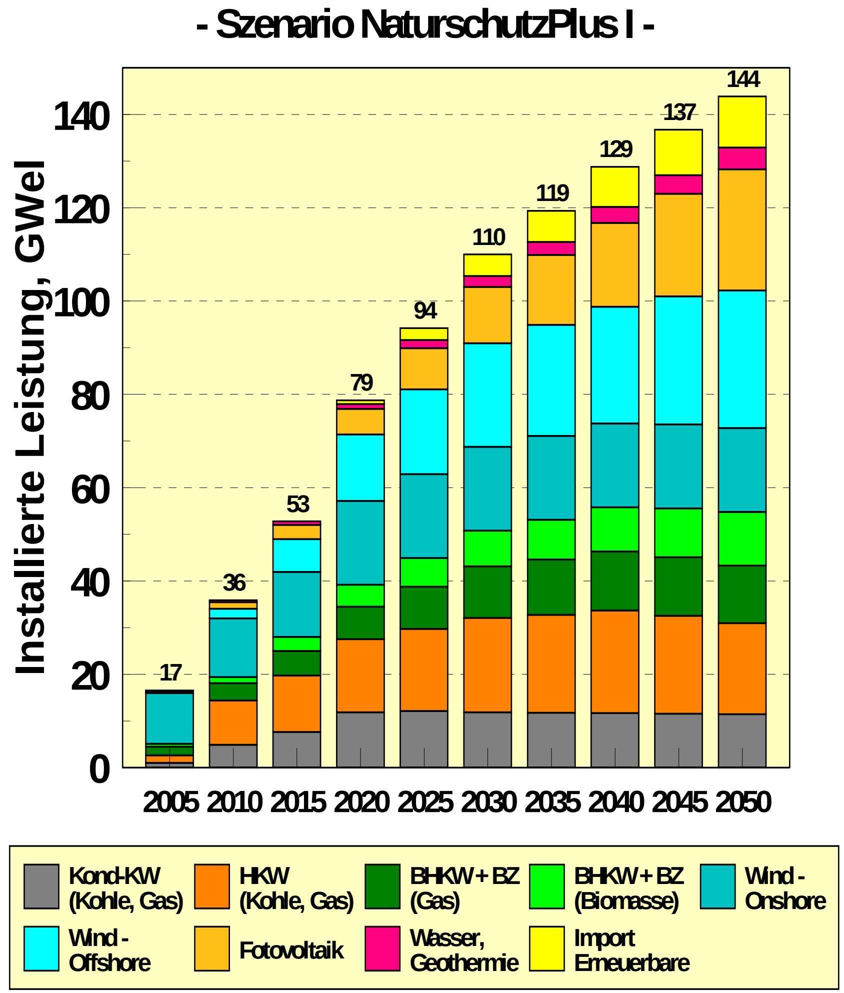
„Efficiency“compared to Ref.: (in % to 2000)

Electr.	=	- 450 PJ	(26%)
Heat	=	- 1680 PJ	(36%)
Transp.	=	- 1170 PJ	(41%)
Final Energy	=	- 3300 PJ	(36%)

Technical and Non-Technical Solutions to Reduce CO_2 emissions

Installed power capacity compared to reference case in a German sustainable energy system





REN from 6% (2000) to 19 % (2050)

REN from 6% (2000) to 68% (2050)

Integrating energy efficiency and renewables: German final Energy Structure in the Sectors Electricity, Heat, Fuels

Scenario „Environmental ProtectionPlus I“ by the German Federal Ministry of Environment

„Efficiency“ to REF

Convent. liquid fuels

Convent. fossil fuels

Convent. electricity

RE-Hydrogen

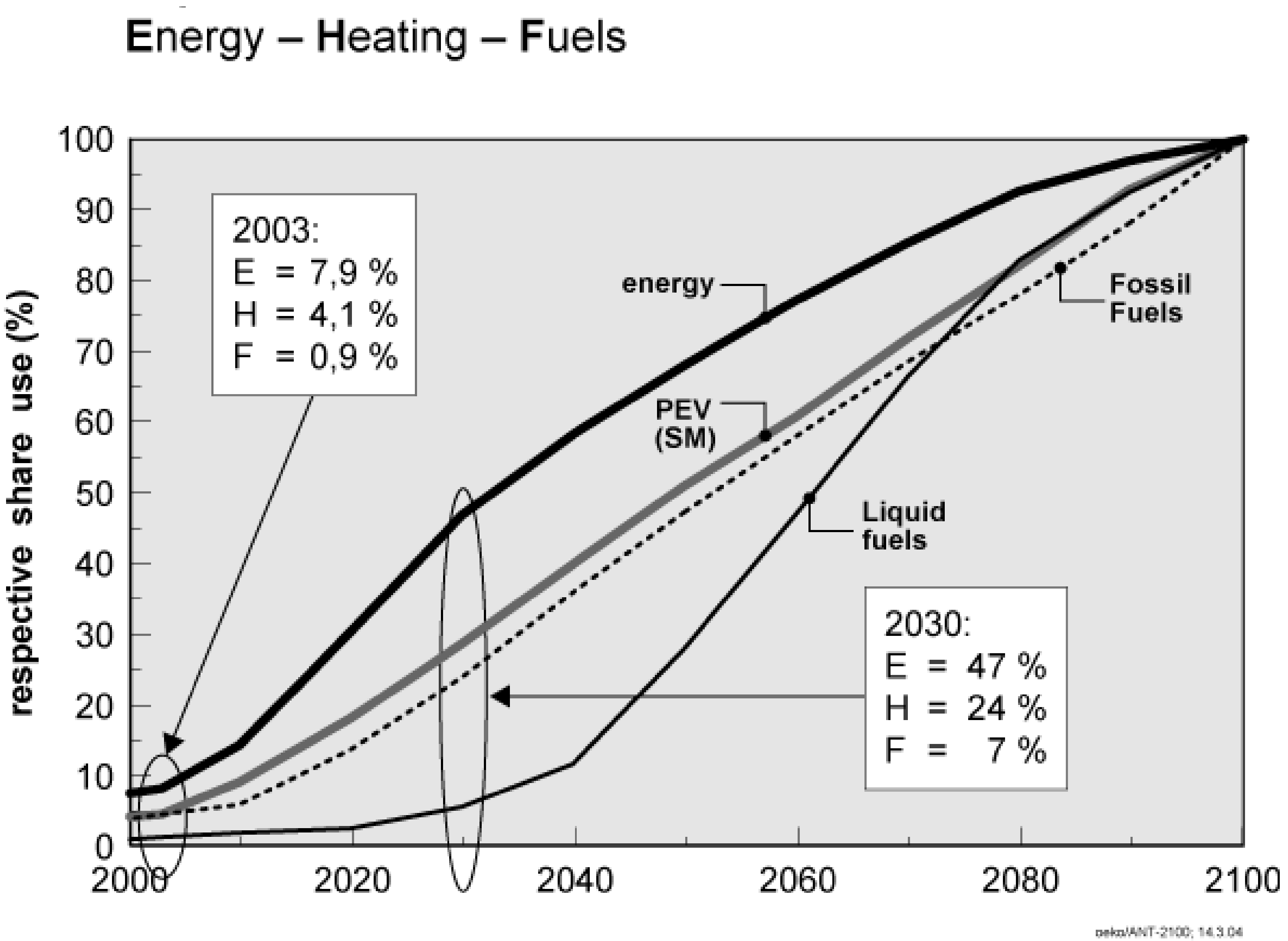
Biogenous fuels

RE-Heat, direct

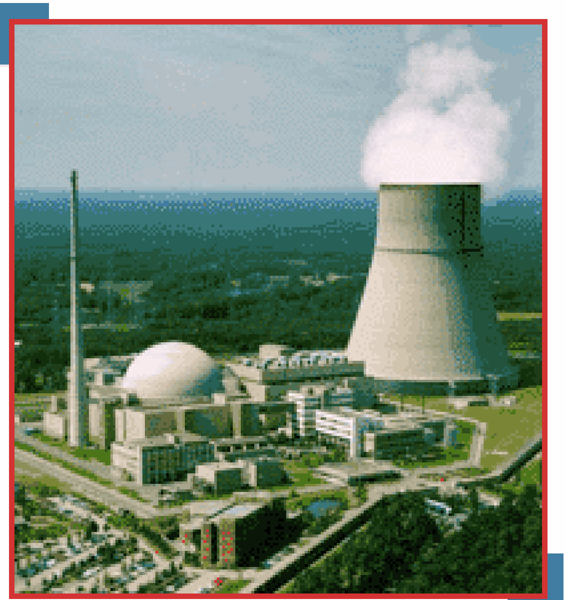
RE-Electricity direct

(Nitsch 2004)

Strategic „Implementation Order“ of Renewables towards a Sustainable German Energy System: First electricity (E), then heat (H), then transportation (F)



Targets for nuclear phase out



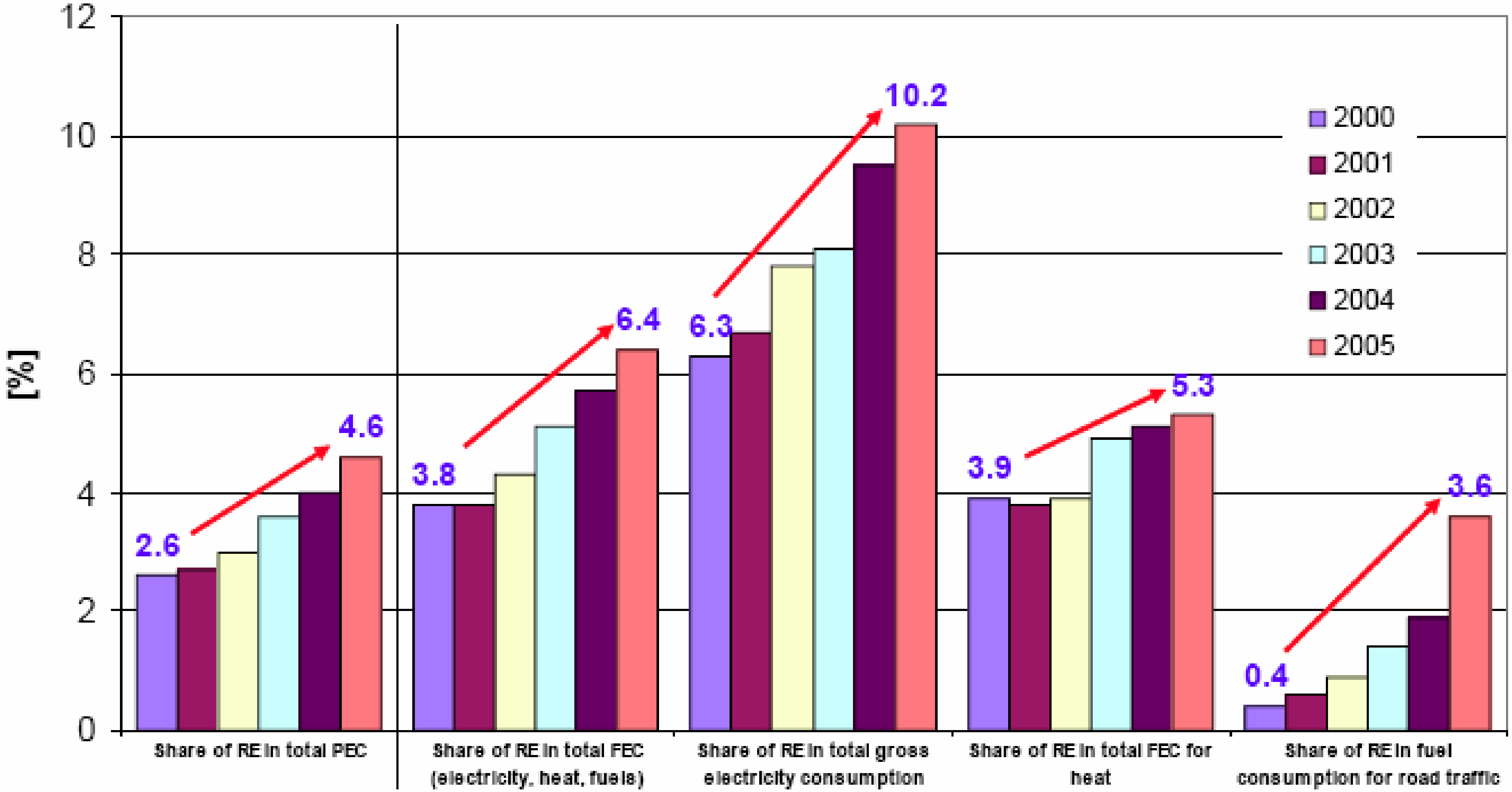
Facts and Agreements:

- 19 nuclear power plants
- Electricity generation: 164,8 TWh
- **Limitation** of the further electricity generation

  to 2.623 TWh (from 01.01.2000)
- Commitment for each nuclear power plant to stop electricity generation after **32 years** of operation
- Opportunity to **change generation budgets** from one plant to an other one
- **Prohibition for reprocessing** of nuclear waste
- **Use of intermediate stores** while decisions on how to come to a final disposal are on the way
- **The last nuclear power plant will end time of operation between 2020 and 2025**

Development of renewable energies in Germany

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety



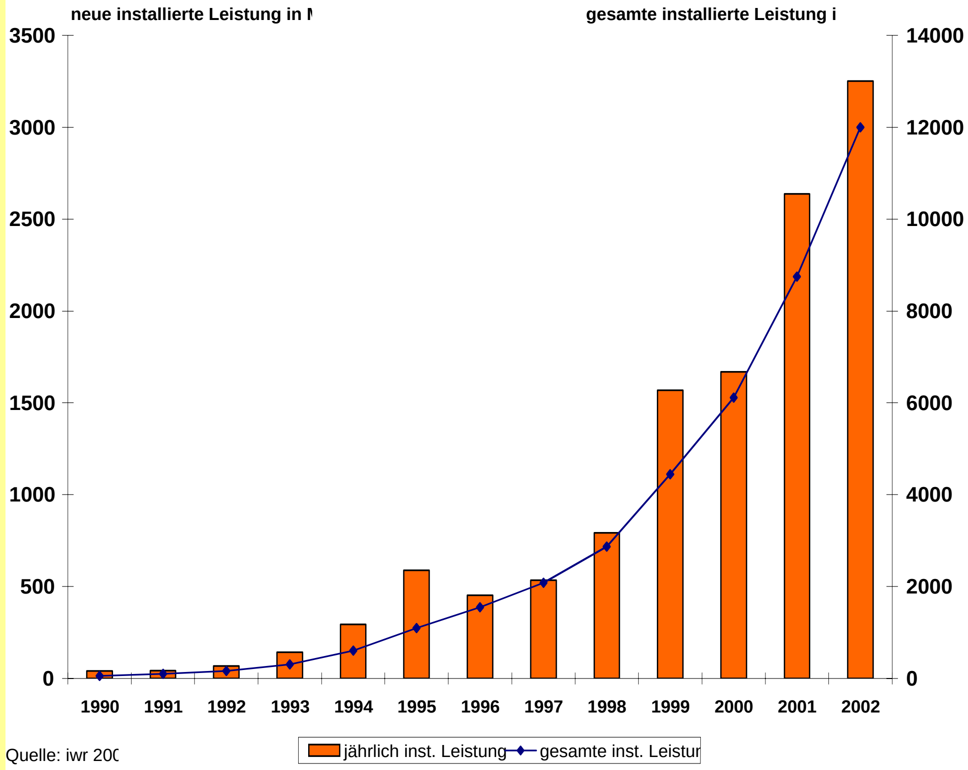
Sources: BMU publication "Renewable energy sources in figures - national and international development", Status: May 2006; from 2003 new data taken into consideration from the Act on Energy Statistics (Energiestatistikgesetz - EnStatG)

PEC: Primary energy consumption; FEC: Final energy consumption

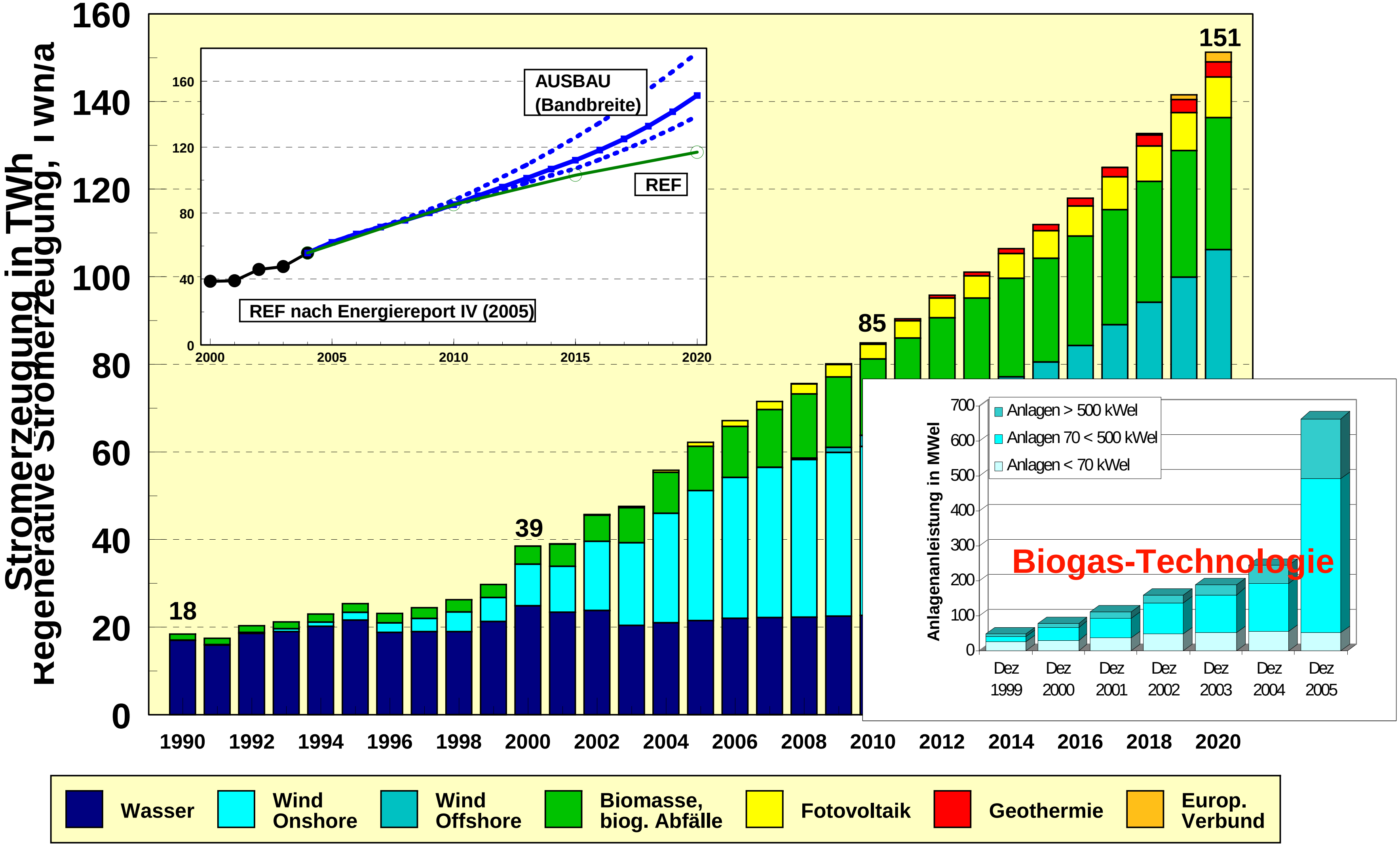
The German Renewable Energy Sources Act: Incentives to create a domestic wind power sector of 18.5 GW in 10 years!

- Wind power capacity: more the 18.5 GW
- Subsidizes a mix of renewables to reduce costs by learning effects
- Obligation and fixed remunerations for electricity from renewables
- Incentives for cost reductions
- Financed by consumers - no additional tax or public budget
- Debate on “over-subsidizing” (e.g. wind power)

Development of wind energy in Germany



Development of renewables in Germany:
More dynamic than expected!



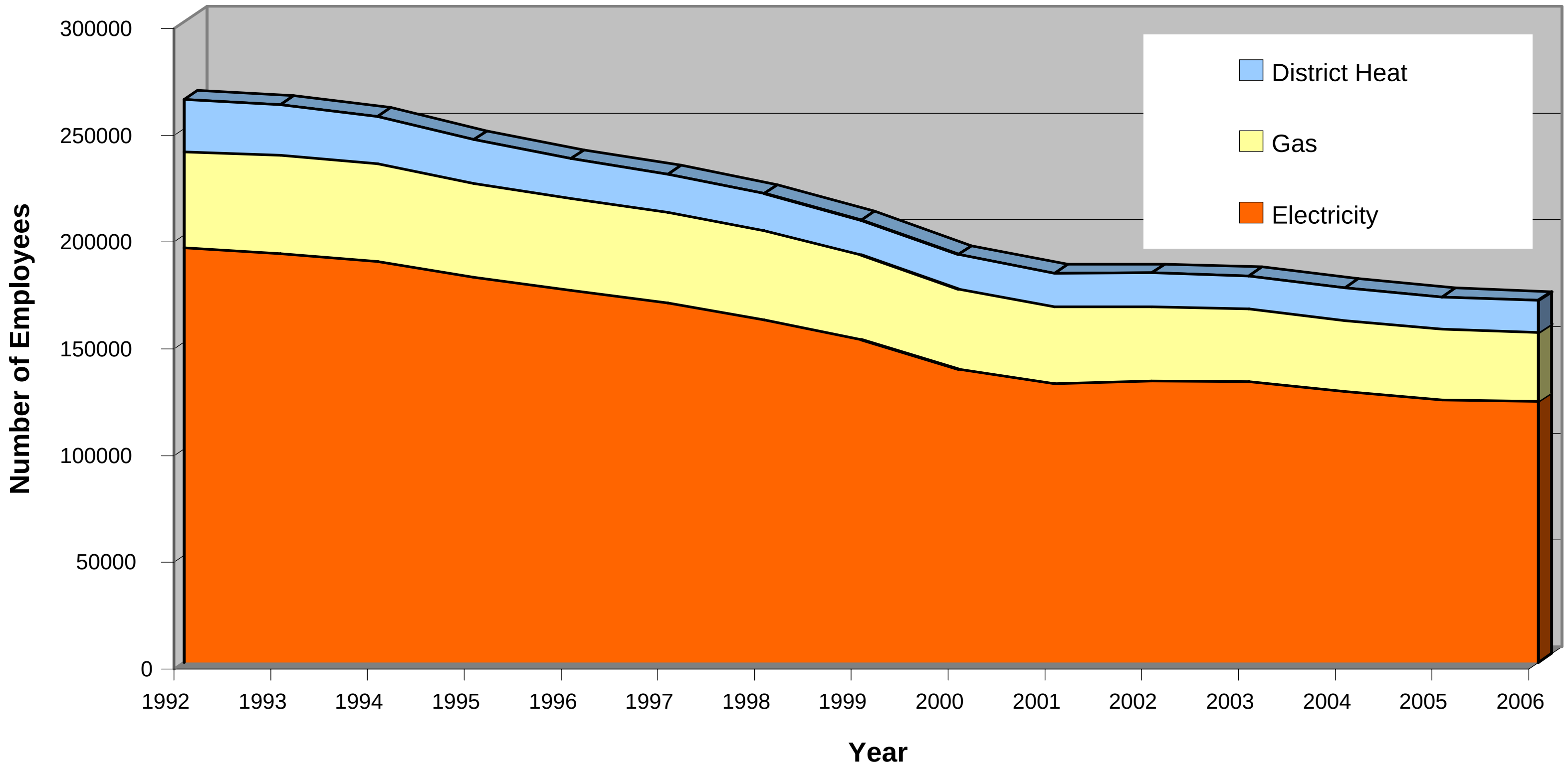
oeko/projekt2020/str20var; 28.11.05

Development of monthly payments of each German household for the Renewables Energy Sources Act
(compare: ca 7 Euro/month for „stand by"- consumption; UBA 24/2006)

Zur Anzeige wird der QuickTime™
Dekompressor „TIFF (LZW)"
benötigt.

Zur Anzeige wird der QuickTime™
Dekompressor „TIFF (LZW)"
benötigt.

Development of jobs in German energy industry 1992-2006: - 35.7%
Sold quantities of Electricity+Gas+District Heat (PJ) 1992-2005: + 18.3%



Source:
German Federal
Statistical Office

The impact of

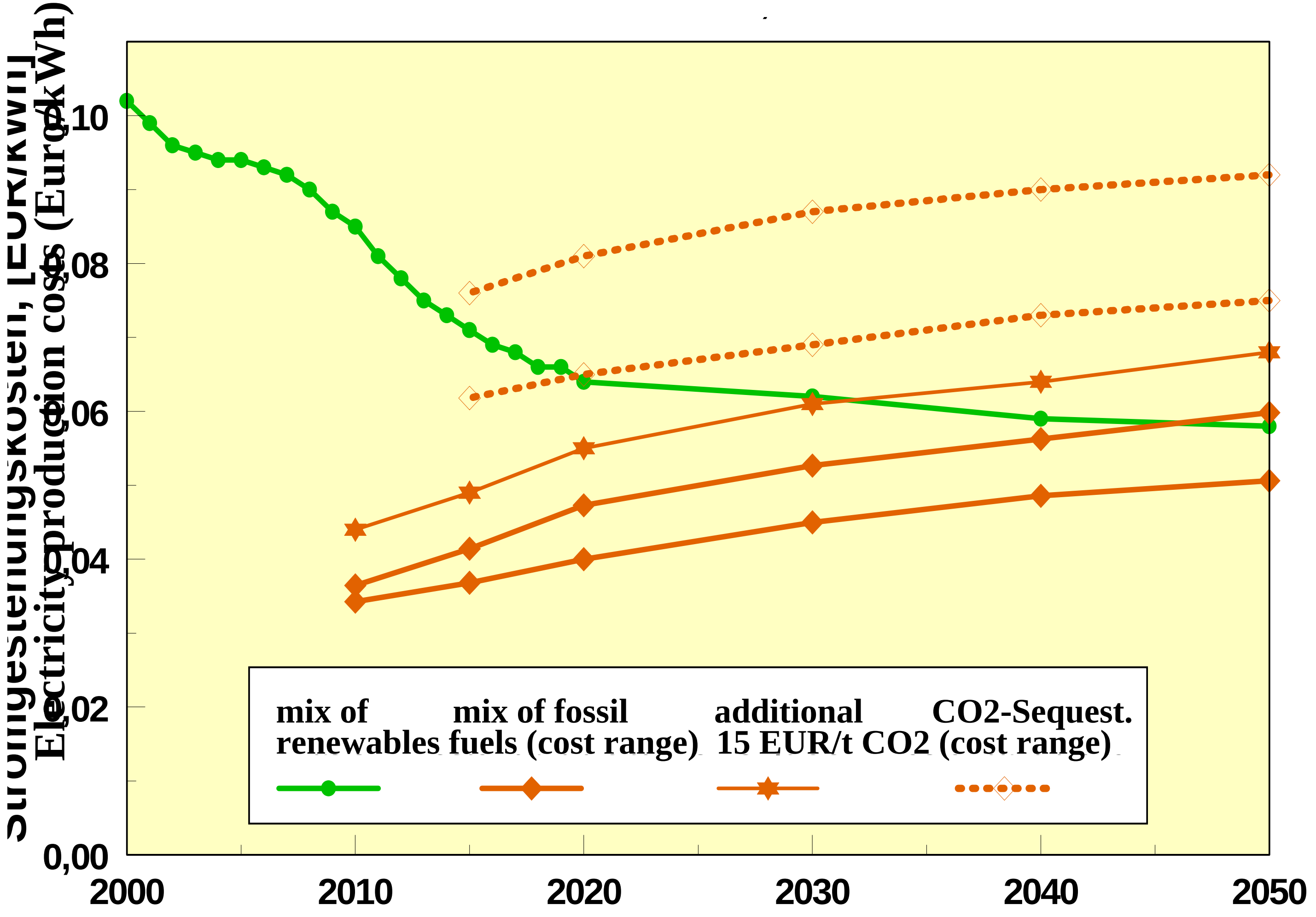
- **direct price competition** and cost pressure from **deregulation** (EU/national)
- **technical restructuring**
- pressure from **shareholders** (fiscal crises of municipalities, global financial markets)

Low number of jobs in new fossil power plants

VGB study on model coal-fired power plant in the State of North Rhine-Westphalia	RKW NRW - reference case of a new **coal-fired** power plant [600 MW el.]	New **gas-fired** power plant [800 MW el.]	**IGCC** reference case [600 MW el.]
Employees / year during operation	70	35	100

Municipality of Wiesbaden, Germany	New **coal-fired** power plant [750 MW el.]	**New decentralised co-generation** [750 MW el.]
Employees / year during operation	100	375

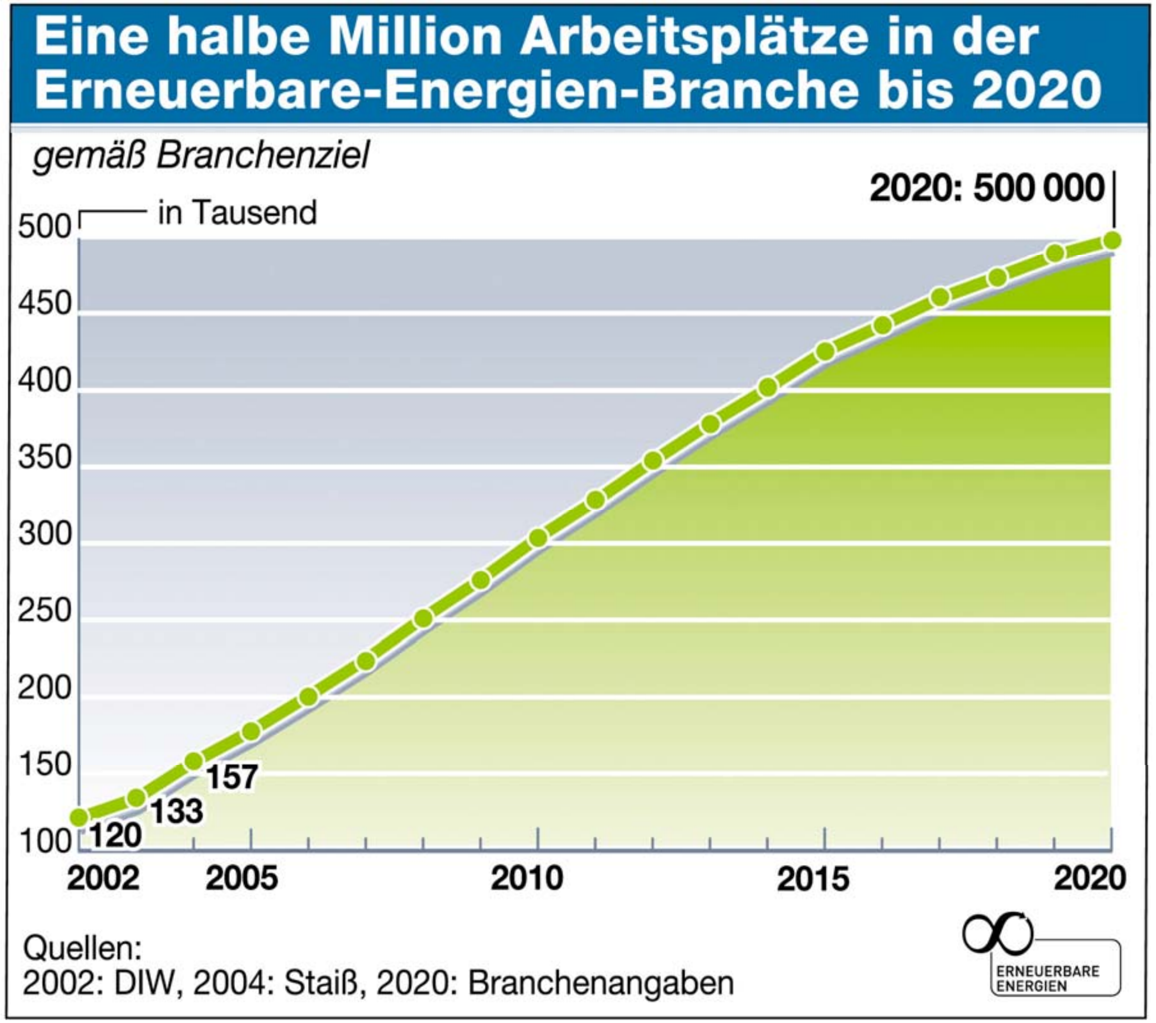
Comparison of electricity costs of new powerplants
- fossil mix 50% coal, 50% natural gas -



oeko/kost-kw.pre; 15.09.03

Development of investments for renewables up to 2020

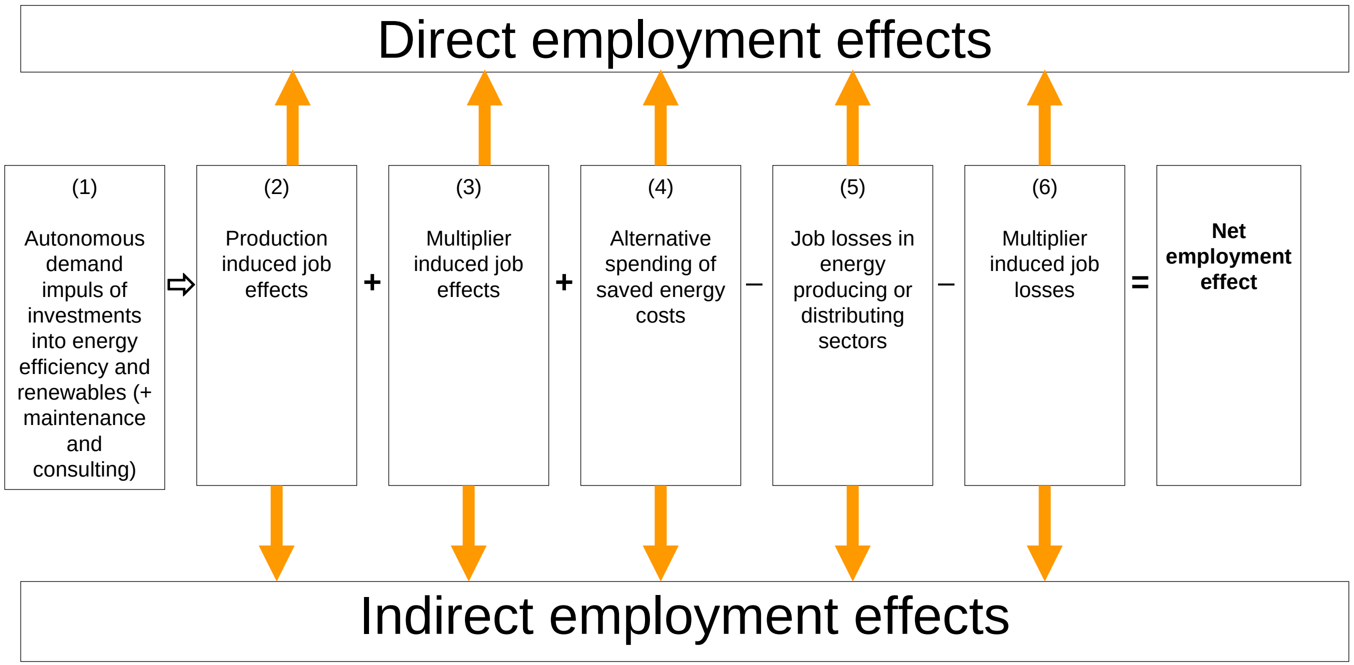
500.000 new jobs in the renewables energy sector up to 2020



Specific *net* employment effects per petajoule (PJ) saved

Study	**DIW 1993**	**CE 1995**	**ISI/DIW 1994**	**Ledergeber et al 1986**	**Öko-Institut 1996**
Scenario	Forced environment protection	Climate protection	Climate protection	Nuclear Phase out	Sustainable Energy
Country	D	NL	D	CH	D
Projection periode	2000	2005	2020	2020	2020
Net jobs / PJ in comparison to reference case	98 jobs/PJ	58 Jobs/PJ	32 Jobs/PJ	56 jobs/PJ	104 jobs/PJ

Macroeconomic employment effects



Net Impact: Do renewables create jobs? - Mixed results

- ZEW 1997 (O. Hohmeyer): **106 person-years / PJ net employment** for renewables in Germany by 2010
- EU study MITRE 2004: between **+ 1.4 Mio.** (BAU) and **+ 2.5 Mio.** („advanced renewable strategy“) full-time jobs in 2020 in **EU-15,** of which 27-29% are „skilled employment“
- Bremer Energie Institut 2004: **Negative long-term employment impact of fostering renewables in Germany** because of higher costs of renewables compared to other energy carriers („**budget effect**“ - income effect)
- EWI / IE / RWI 2004: + 33,000 full-time jobs in 2004, **-6.000 full-time jobs in 2010**
- ZSW / DLR / DIW / GWS 2006: **+ 70,000 person-years** net employment impact of advanced renewable strategy compared to BAU development by 2020

Does energy efficiency create jobs? - Clear evidence

Rule of thumb

for net impact

based on results from

several studies in

Germany:

about

100 person-years / PJ

end-use energy saved

Energy Efficiency:
The largest, quickest and
most cost-effective resource

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

Lessons learned
from German long term Energy Scenarios (up to 2050)

- **80% $C0_2$ reduction** up to 2050 is technically and economically **feasible** with different technological options on the supply side
- 60-75% of $C0_2$-reductions must and can be realized **by energy efficiency**
- **Risk minimisation** - climate protection plus nuclear phase out - can be financed with reasonable additional costs
- **Challenges for implementation**:

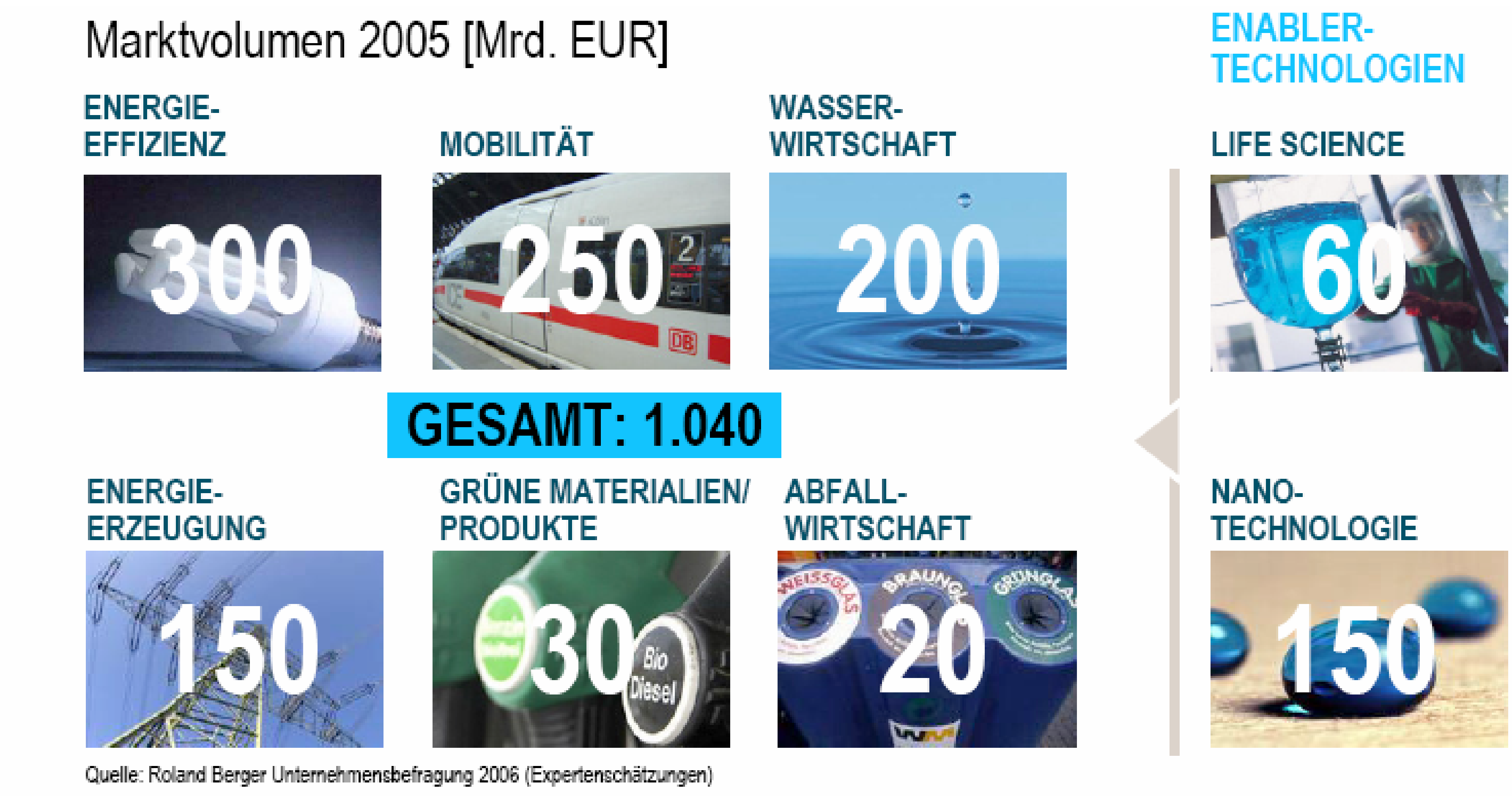
➢ Discussion on **life time extension** of nuclear power plants
➢ **Too much coal power plants:** ETS not functioning up to now
➢ Opposition against **higher costs** of renewables
➢ **No consensus** on sector and target group specific **policy mixes** to support renewables, combined heat and power (CHP) and highly efficient vehicles

➢ **Key: Strategic initiative for fostering energy efficiency (3% p.a.) needed!**

Efficiency Potential in Germany

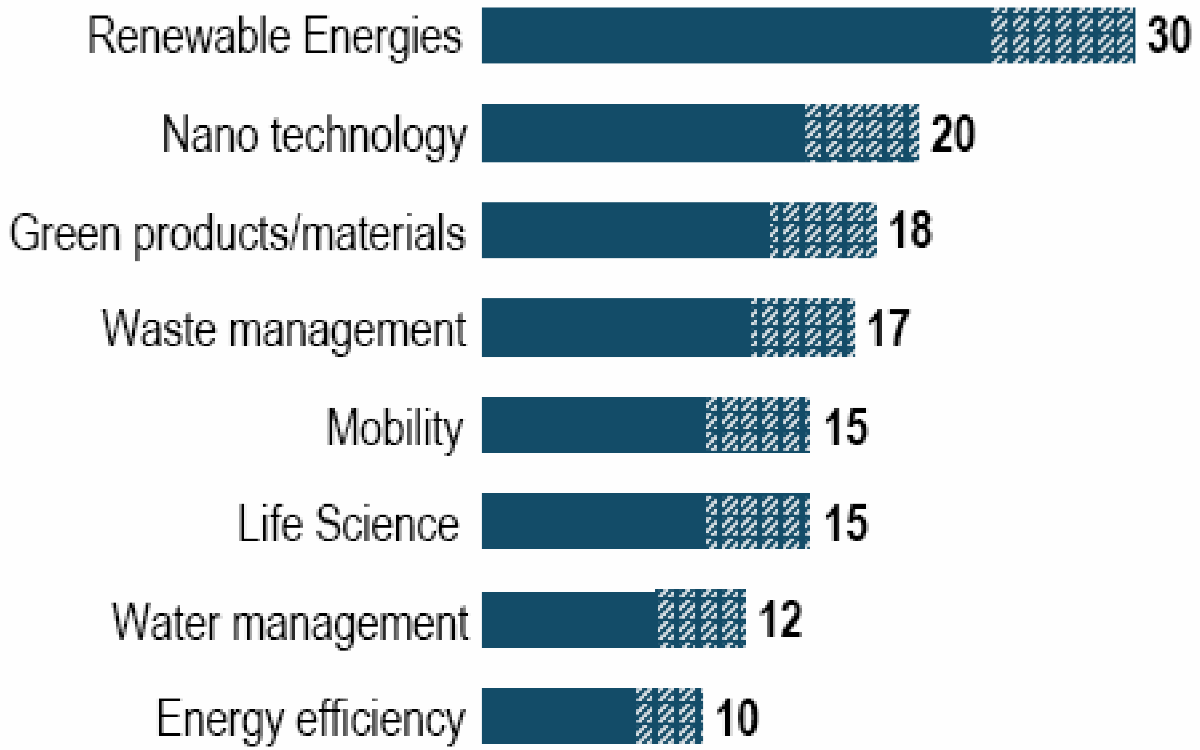
▪ **Technical Potential:**	Up to 45% of primary energy = 70 billion Euro/a reduction of total energy bill
▪ **Cost-effective Potential:**	About 30% within the electricity sector
▪ **Employment effect:**	370 jobs per 1 TWh saved 500.000 jobs with implementation of total technical potential

World market for environmentally benign technologies: promising lead markets! (preliminary expert estimate, Roland Berger 2006)



...and expansion rates are considerably high

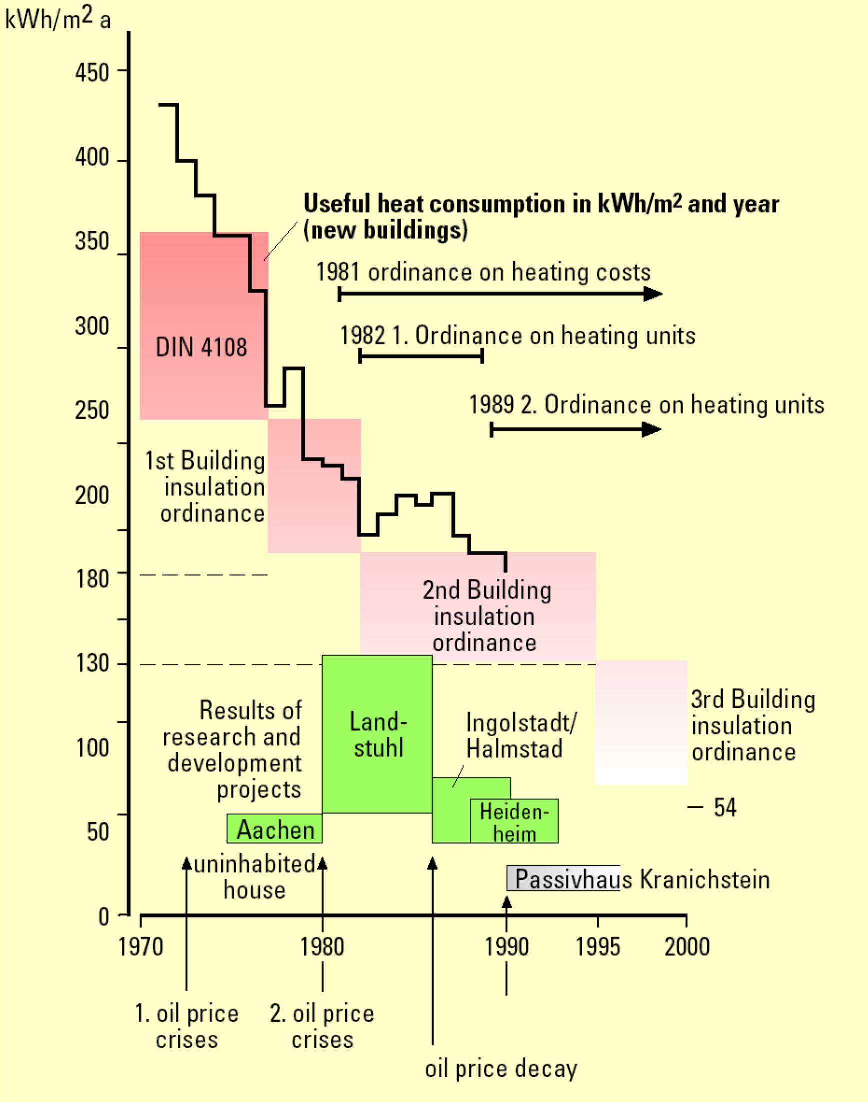
Growth of different markets for environment technology worldwide 2005 [%]



Quelle: Roland Berger Unternehmensbefragung 2006 (Expertenschätzungen)

Roland Berger Strategy Consultants

The “silent efficiency revolution”: Development of useful heat consumption in *new* buildings in Germany



„Passive house“ office building that needs almost no heating and cooling

High efficiency ‚Factor 4‘ circulation pump

- Uses 5 to 20 W instead of 40 to 80 W for current technology
- Product is on Swiss and German market
- Potential for saving: up to 1 % of all electricity in the EU
- Market penetration programmes needed

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**

The updated EU energy label for refrigerators (2004)

Two new classes A+ and A++ introduced

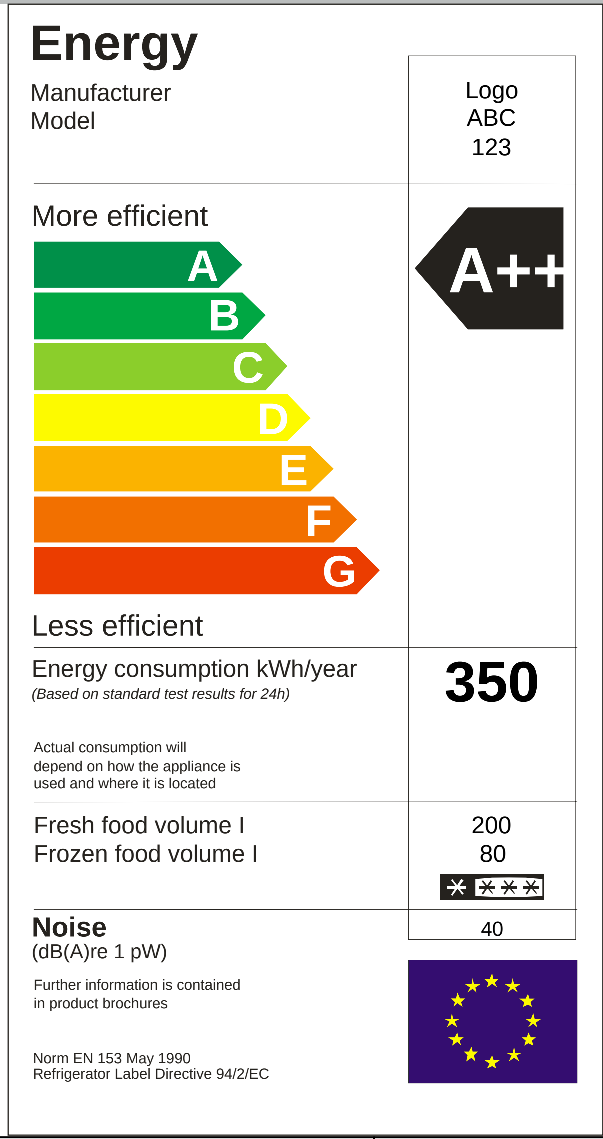
A+ needs 25 % less energy than A

A++ needs 45 % less energy than A

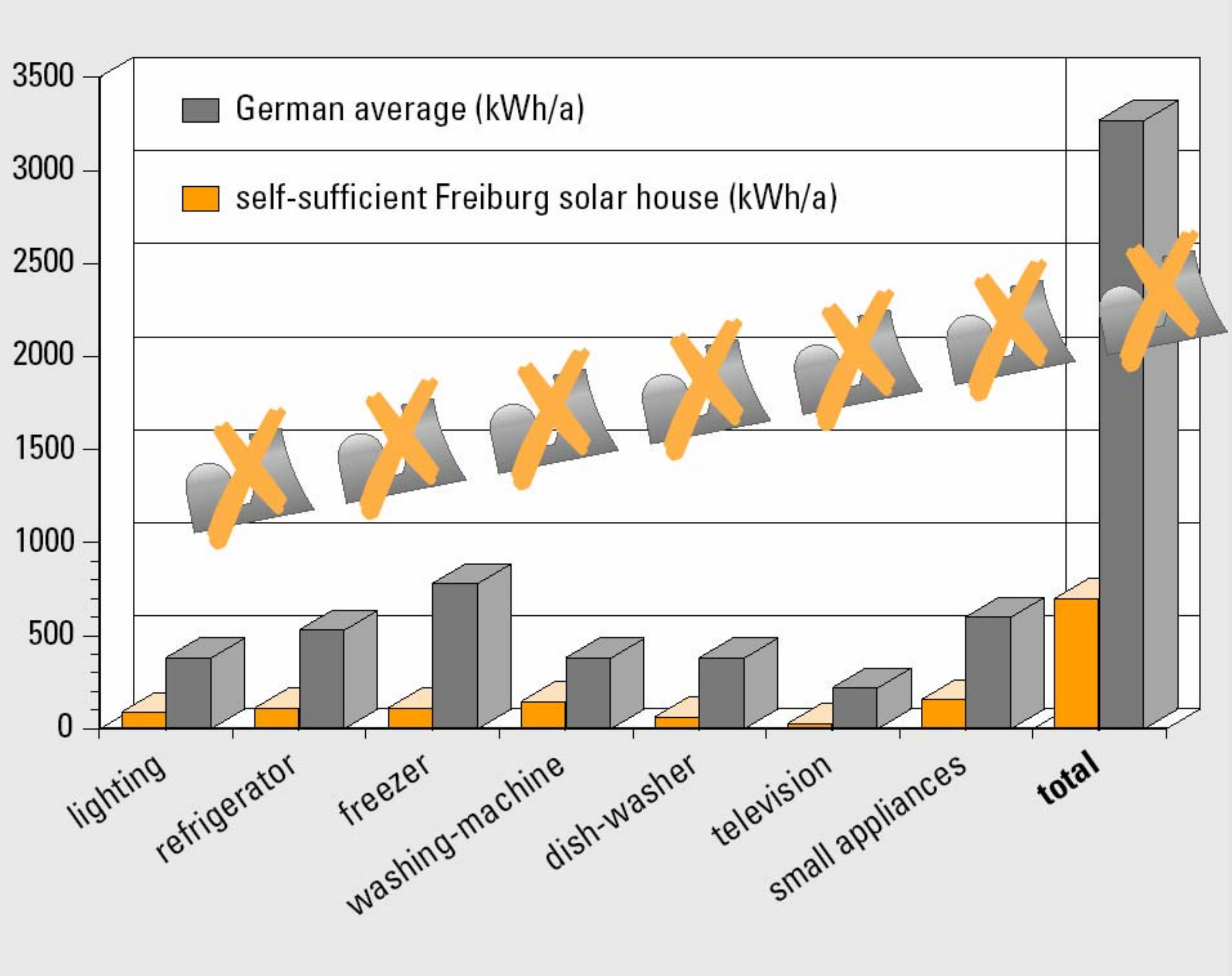
Almost 900 A+ and A++ appliances on market

Award winner of Energy+ project: 300 l fridge-freezer with only 140 kWh/year

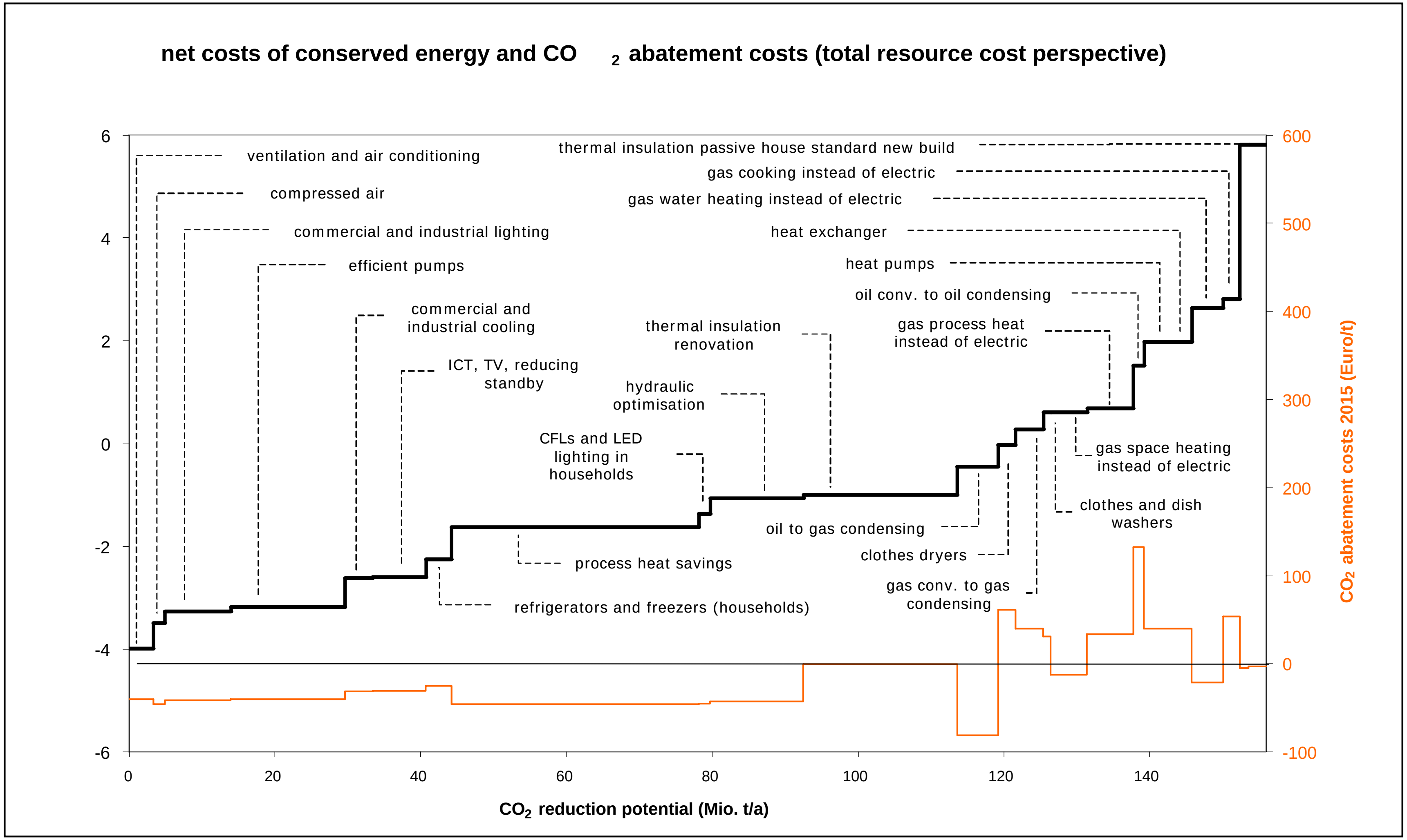
Mandatory energy labelling also for clothes washers and dryers, dish washers, ovens, household lamps



“Factor 5” less: Electricity consumption of the Freiburg solar house compared to average (7x1000MW power plants less if transferred to every German household)

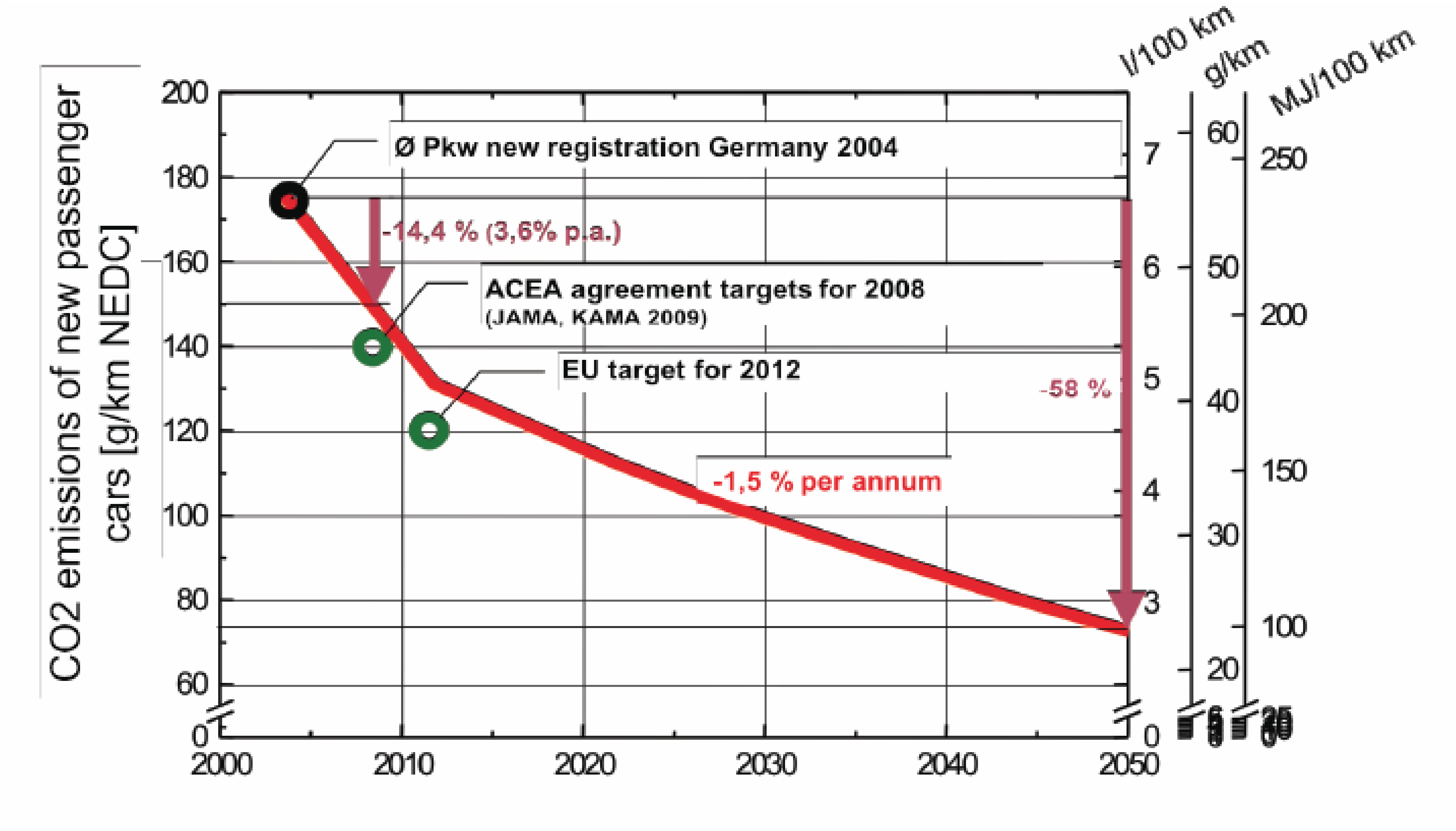


120 mio t of CO_2 can be avoided in the German electricity sector with a profit or with zero net costs with 70 technical options
(up to 2015; study of WI on behalf of E.ON 2006)



Net costs of conserved energy=additional costs of advanced technology less long-run avoided system costs

Average CO_2-emissions of new cars in Germany and EU: Far away from agreed targets and the „car of the future“



Identify and reduce market barriers and market failures!

Information deficits

- missing information tools e.g. for “life cycle analysis;
  false incentives by subsidized energy prices

Split markets

- no functioning competition between energy efficiency and energy supply
- marginal costs of “NEGAwatts” are lower than “MEGAWatts”, but “hidden”

Asymmetrical market power for power generation (“David-Goliath positions”)

- no fair “level playing field”: Using grids as “natural monopolies”
- dumping prices of great utilities against newcomers/independent producers

Different requirements for return on investment (’pay back gap’)

- Electricity suppliers: 15 years, industry: 2 – 3 years, households: 1 year

“Perverse” public budgeting: Separation of running costs and investments

Investor/user dilemma/split incentives

- e.g. rented building sector

A paradigm shift in energy policy is needed: A policy mix to overcome target group specific barriers and to foster the diffusion of 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, launch**
- **Motivation, information, energy analyses, labelling, training**
- **Products and production standards (mandatory/ voluntary)**
- **Launch by procurement, bundeling of demands ect.**
- **A stimulating framework for energy efficiency programme and services**
- **Energy efficiency funds on the national and regional level**
- **EU-directive on energy efficiency** (1 % additional increase of energy efficiency p.a.)

Integrated market transformation programme

Manufacturers → Planers, Installers, Retailers → Building,Equip-ment owners, Final users ← Energy- (Service) Companies

A breakthrough for efficiency policies in EU25: The EU-directive on energy efficiency and energy services

Establishes indicative energy efficiency targets for all EU-Member States:

a) Increase of average energy efficiency **each year** by 1% in addition to trend

b) Public Sector should set good examples: 1.5% p.a. more (by procurement)

c) Retail suppliers/distributors should offer efficiency programmes (e.g.DSM, audits)

d) Energy efficiency funds can be established

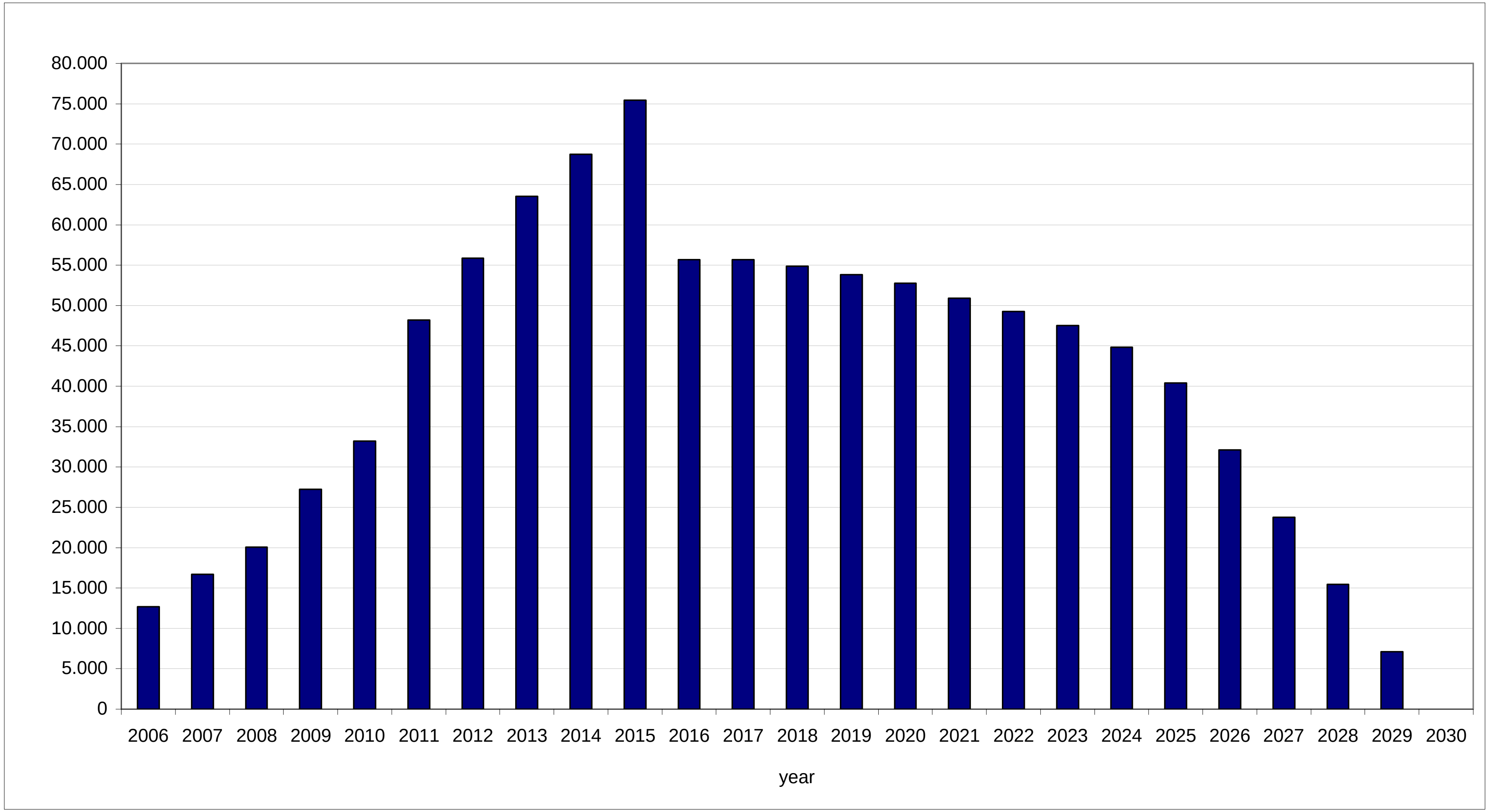
Proposal for a federal German energy efficieny fund

- **Financing** by ‘Public Benefit Charge’ (charge on electricity/gas prices) according to the Danish or English example or from auctioning ETS:
  - Charge: 0.13 Cent/kWh_{th} and 0.25 Cent/kWh_{el} for residential and 0.02 Cent/kWh_{th} und 0.07 Cent/kWh_{el} for commercial/industrial sector
  - Total Fund: 1.0 - 1.3 Billion Euro/a for 12 model programmes
- Invite **tenders from all actors (including utilities)** for energy saving projects or DSM programs
- **Evaluation** of the impacts according to international standards
- **Total savings from 12 programs** :15 % by 2015 compared to baseline forecast

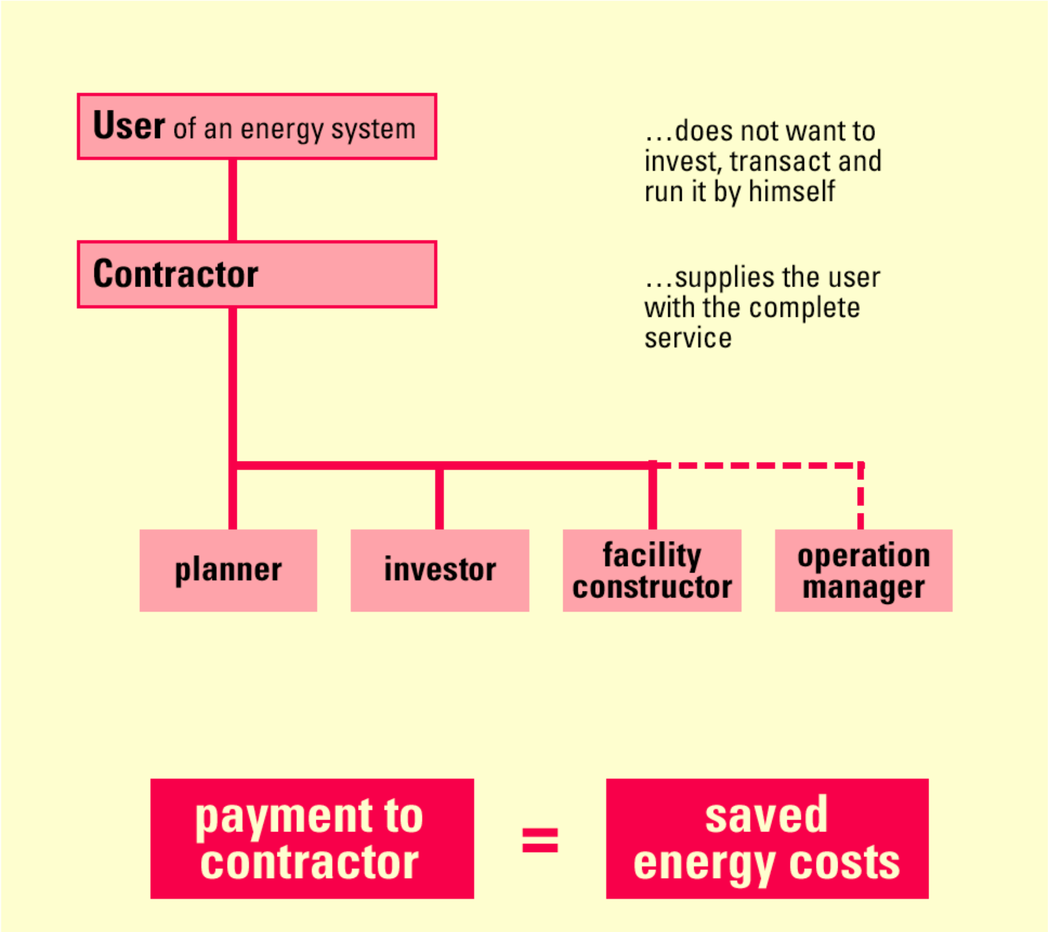
Results of 12 model programmes by 2015

- **Saved electricity 74 TWh/a** (compared to reference case)
- **Saved heat energy 102 TWh/a** (compared to ref.)
- **70 mill. tonnes of CO_2-reduction/a** (compared to ref.)
- **Benefit/cost relationship** from a societal perspective: **1,31**
- **Net employment effect:** about 75,000 jobs by 2015

Example: About 1,000,000 person-years of jobs gained over time from 12 programmes of an Energy Saving Funds in Germany proposed by Wuppertal Institute



Energy Performance Contracting (Third Party Financing)



Wiehl: Lighting Contracting and Energy Management

Object:

School Centre Wiehl-Bielstein with sports hall, schwimming pool, classrooms, teacher rooms and side rooms

New Installation:

Lighting Installation with dimmers which is controlled depending on daylight and presence of persons

Lighting Contracting:

Through renovation of the lighting installation, electricity consumption was reduced by 25 to 30%.

Costs for Modernising the Lighting Installation: approxy 175,000 Euro

Economic Efficiency:
Electricity consumed previously:

540,000 kWh in 1998 (62,500 Euro)

subsequently:
400,000 kWh/a (35,000 Euro)

Reduction in CO2 emissions by over 50%

The „Eco-Profit-Movement“: From the City of Graz (A) to mor than 50 cities in Germany

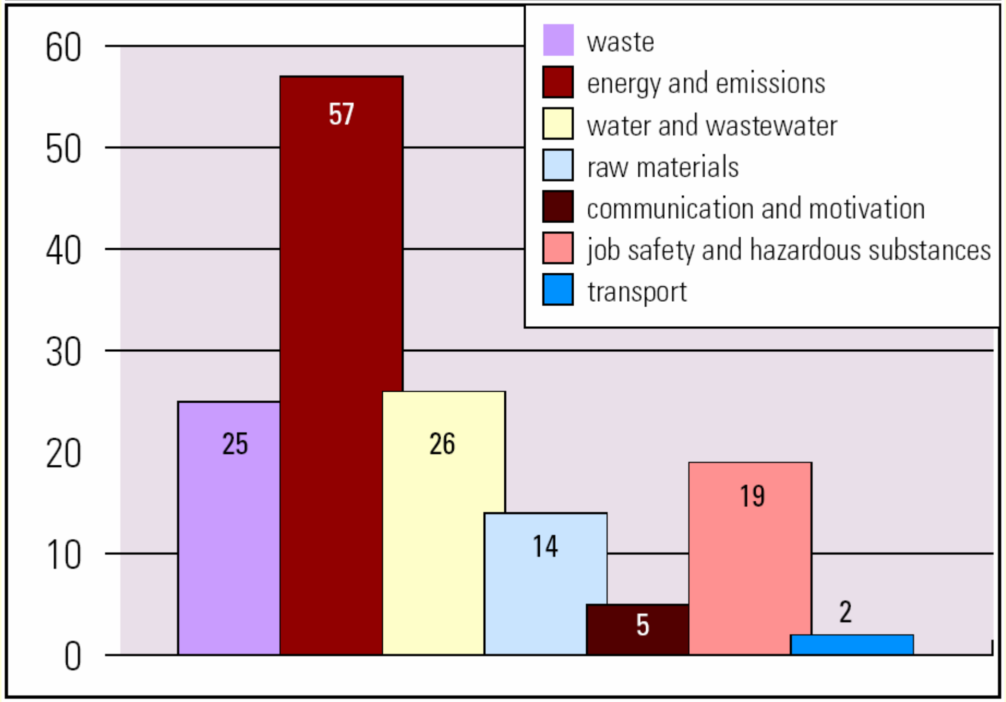
- Net work between municipalities and SMEs, based on a series of workshops
- Involving environmental authorities, local academia and consultants
- Enabling SMEs via education programmes
- Dissemination to other SMEs, cities and countries

„Eco-Profit"-Network for SMEs in „Bergisches Städte-Dreieck" (incl. Wuppertal) 2001/2002

Annual savings and investments of 123 measures of 24 participating companies

Amortisation category	Savings in €/a	Investments in €
Measures without investment	250.000	0
< 1 year	282.000	135.000
1–3 years	101.000	141.000
> 3 years	44.000	322.000
Economically not assessable	0	142.000
Total	**677.000**	**740.000**

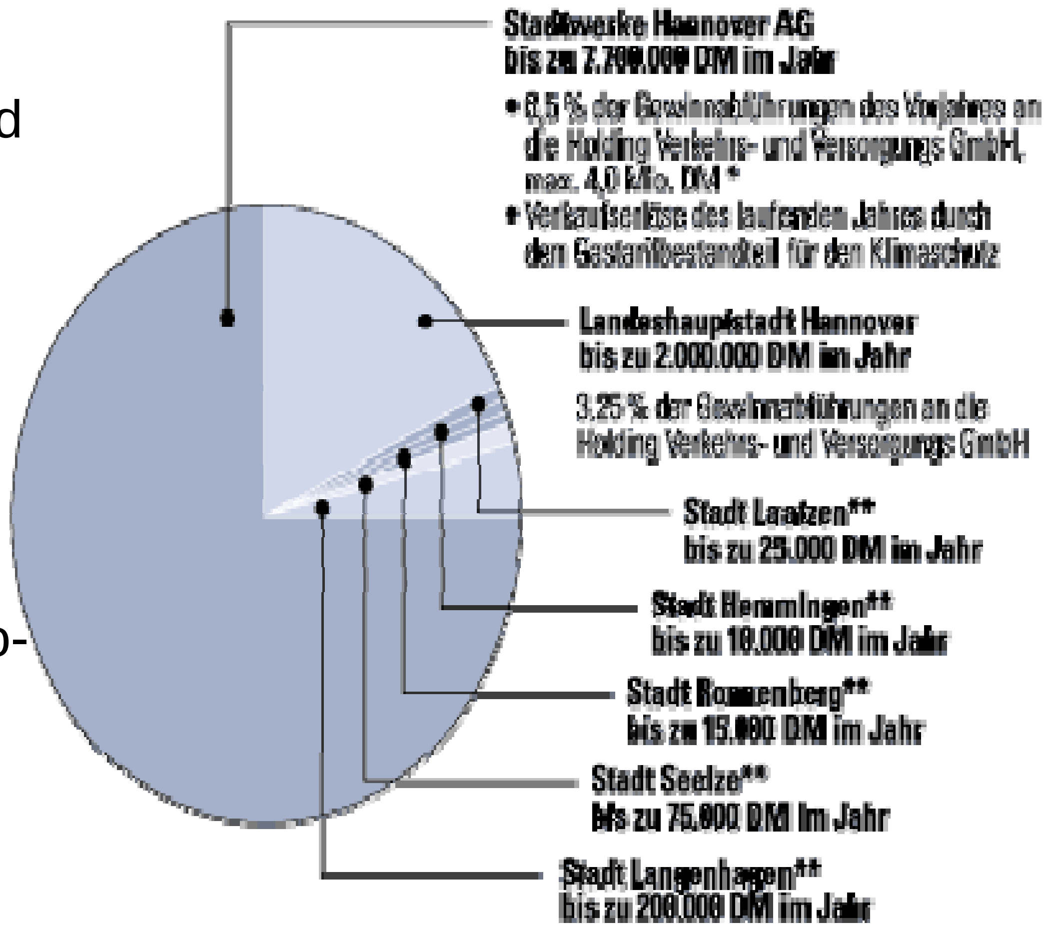
Breakdown of measures by environmental fields



The success story of a regional Energy Efficiency Fund: „proKlima“/Hannover

The municipal utility of Hannover und local governments finance a fund up to **5 Mill Euro/a**

a) to provide incentives to citizens and utility customers
b) to increase customer loyality
c) to create local markets for energy efficiency (e.g. retro-fitting buildings) and for renewables and
d) to create jobs



Linking energy efficiency and renewables - an example

Solar&Save projects in schools in NRW

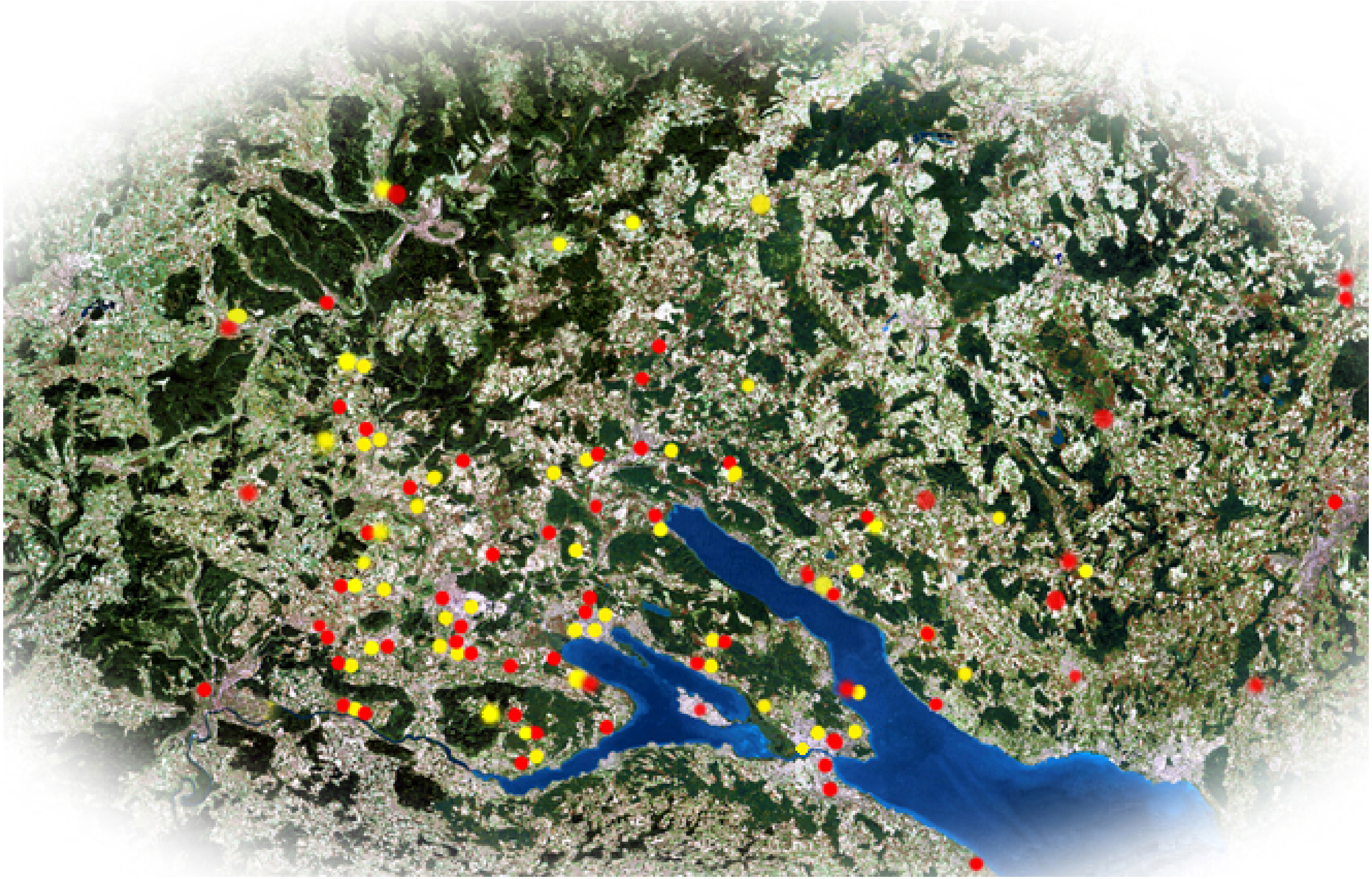
- Objective
  - Test „Citizen Contracting“ concept;
  - Combination of energy savings (50% and more) and solar energy (PV)
- Approach
  - Four pilot projects:
  - Ltd. Co. with capital from (students, parents, teachers & local citizens;
  - Contracts with local governments (14 to 20 years): pay-back from saved energy costs and feed-in law for PV electricity
- Results
  - Total investment ca. 3 million Euro;
  - Citizens‘ capital ca. 2 million Euro;
  - Target rate of return 5 to 6 %

Good examples: Solarcomplex AG





- founded in 2000 as a limited company of 20 citizens
- target: 100% renewables in the region „Hegau“ at the Bodensee up to 2030
- Activities: solar, biogas/district heating, hydro
- financed by citizens capital
- political frame conditions: German Renewable Resources Law
- today > 200 active members (AG)
- investments up to 2006: ~ 23 Mio Euro



Region and activities of Solarcomplex around the Bodensee

Citizens financed solar power plants ~ 3 MW
Area ~ 30.000 qm
Investment ~ 15 Mio. Euro
Electricity ~ 3 Mio. kWh / a
CO_2 reduction ~ 1.800 t / a

Energy Efficiency Potentials in Developing Countries

Agriculture	
Agriculture Tractors up to 35% Irrigation up to 85% Soil cultivation up to 70%	**Transportation** Persons and goods 10 - 35 %
Buildings Industry, Production 50 - 60 % Private 50 - 70 %	**Industry** Steel-Cement- Chemicals 25 - 50 % Pulp and Paper - Oil 30 - 40 % Steam - Electrical Drives 20 - 50 %

Quelle: UNDP, 2000

Energy intensive industries (cement, steel, paper):
Share of energy costs up to 20 - 30 % of total production costs

→ **Energy efficiency is the key for cost reduction!**

→ **General barrier: subsidized energy prices!**

Metro Mexico City: A feasibility study for a possible model project for efficient lighting in Megacities

(Source: WISIONS/SEPS;Dieter Seifried/ö-quadrat 2005)

Metro Mexico City: Inefficient lighting

(Source: Dieter Seifried/ö-quadrat 2005)

- **Status:**

➢ Old and inefficient lighting system

➢ 160.000 lamps

➢ 8.000 h/a of use

➢ Electricity consumption 160.000 MWh/a

➢ Electricity costs: 14 million US$/a

Metro Mexico City: Results of the feasibility study

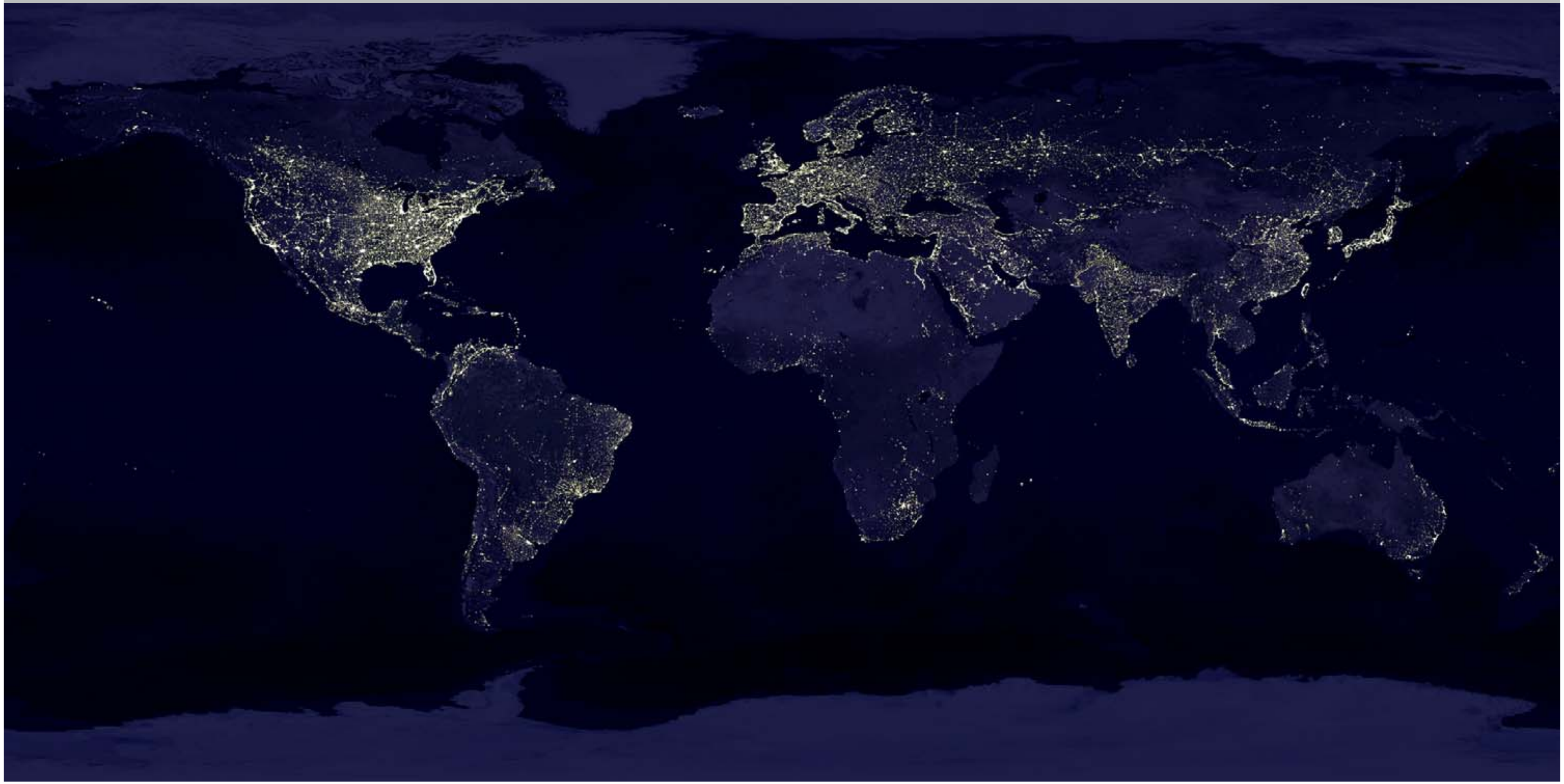
(Source: Dieter Seifried/ö-quadrat 2005)

- **Results of retrofitting the lighting system:**

- Energy sayings about 50% (80.000 MWh/a)
- Better lighting quality in the stations
- Emissions reduction : 50.000 tons of $C0_2$/a
- Less costs for maintenance after retrofitting
- Pay back time: about 3 years

- **Main obstacle: Awareness rising and contractor is needed!**

LED+Solar: Alternatives to Fuel-based Lighting in Rural Areas of Developing Countries



Source: Evan Mills, LBL, USA 2006

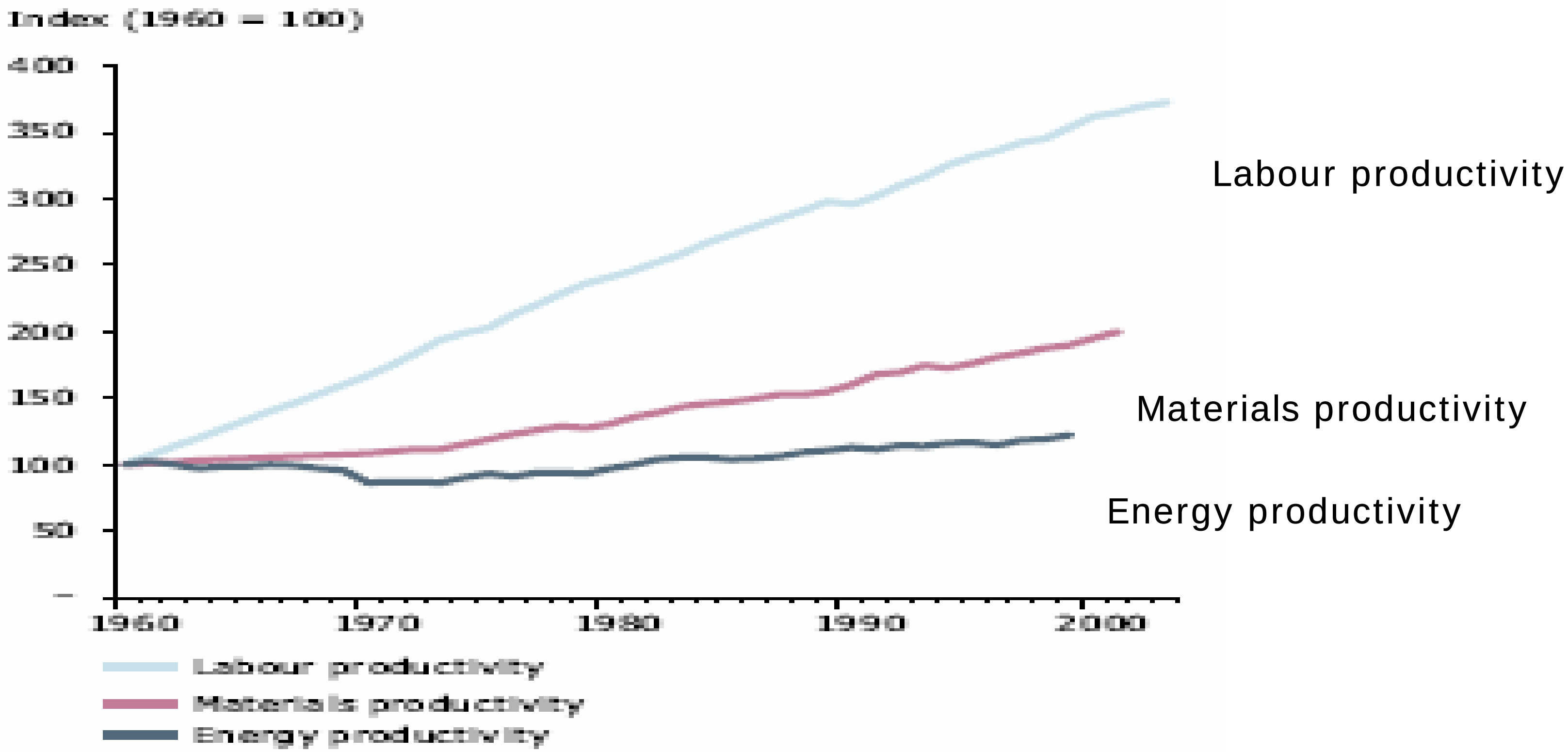
“The 93,000,000 mile extension cord”

million points of light

BETTERENERGYSYSTEMS Ltd.

SOLIO
plug into the sun

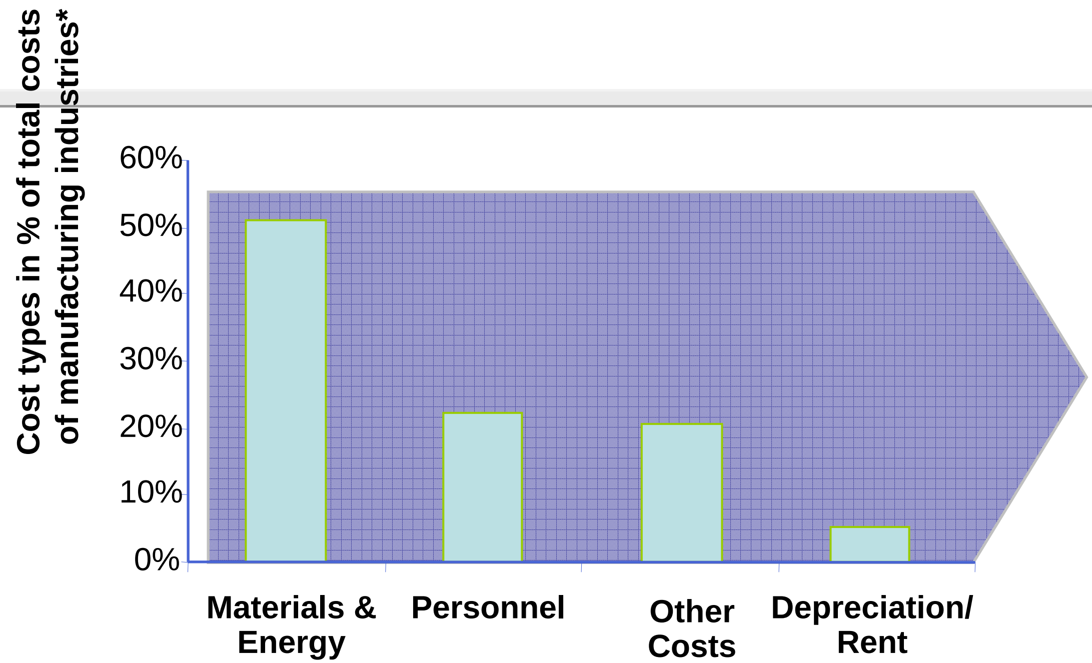
A new direction of technical progress - raise resource productivity: "Make tons and kilowatthours redundant not people" (EU 15; 1960 to 2002)



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: 51% of total costs of industry. Materials throughput causes a further 21%.
- Starting point: Impulse programme "Materials Efficiency"

Factor 2-3 : 1

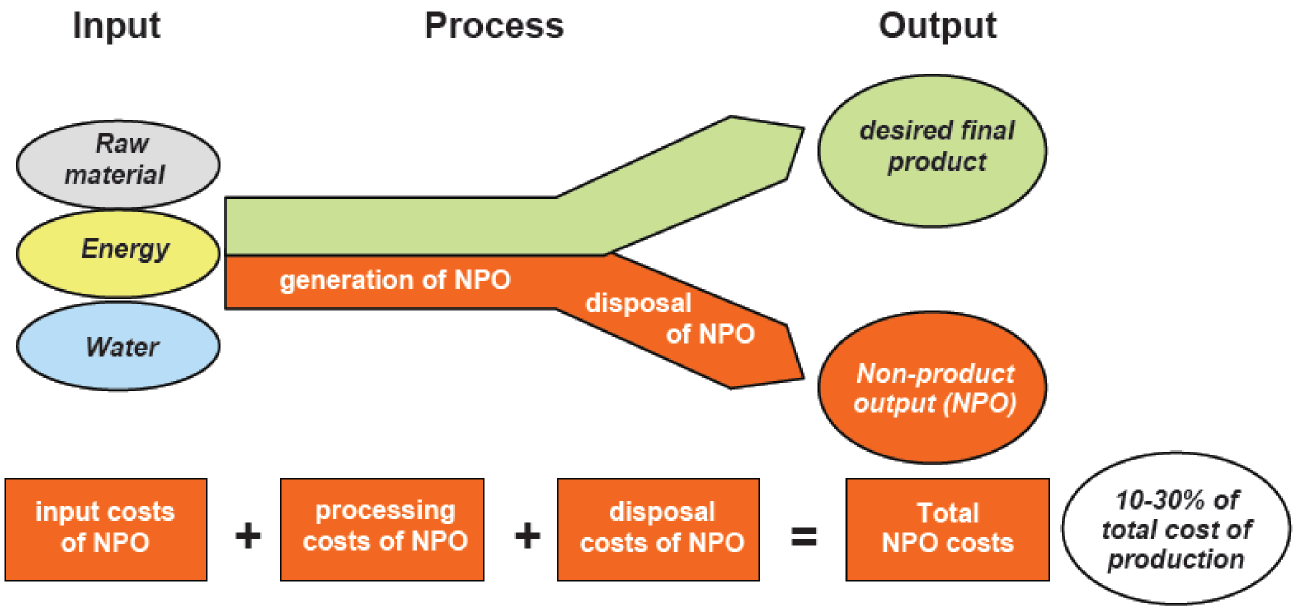
Cost Factor: Personnel

- Personnel costs: 23% of total costs of industry.
- Starting point: Agenda 2010

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

Source: Fischer, ADL, 2003

Non Product Output (NPO) concept helps to identify untapped savings and resource efficiency potentials



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

An Assumed 10%-Reduction in Life-Cycle Costs Through More Material Efficiency Results in Considerable Economic Win-Win Effects

Benefit to private enterprise
130* b/a more turnover

- New products and business fields, cost reduction
- Strengthening SME in global competitiveness

Benefit to labour market
800,000* jobs

- More turnover creates additional jobs
- Focusing on “materials” vs. “personnel” curbs pressure on labour costs

Benefit to public budgets
relief of 45* b/a

- Reduced expenditure (material costs, social insurance)
- Increased revenue (tax revenue through growth and more jobs)

* = provisional values if 50% of the potential available today is realised and the job creation effects are not cancelled out by additional wage increases.

Source: Fischer, ADL, 2003

Why is there an efficiency and implementation gap?

Cause	Structural short comings
costs underestimate..	Management often is not aware of impacts of materials inefficiency. Cost accounting systems are not suited to show LCA cost impacts
cost reduction = lay offs	Cost reduction is considered equivalent to reducing jobs and wages - in the extreme, human capital is reduced at the "expense" of future innovations
Incentives not conveyed in ..	Internal incentive systems tend to blend out cost impacts of materials inefficiency (e.g. In purchasing, production management, distribution)
… and between companies	2 billion €/a could be saved alone by using more cost effective motors and motor controls*. Product & real estate developers experience lack of client LCA-valuation
lack of know-how	University students typically graduate with inadequate knowledge of the state of the art in their field for improving materials efficiency
obstacles to contracting	Low degree of modularization of production systems (see logistics). Insufficiently established measuring and contracting standards

* Estimate of the German Association of the Electronics Industry

The German „Impulse Programme Material Efficiency“

(Pilotphase: 2005-2009)

- **Government target**: Raise resource and energy productivity by a factor of 2 (1990-2020)
- **Overall economic goal**: Reduction of material and energy costs in the manufacturing industry and public sector
  - ➢ Cost savings, new business fields, increased employment and competitiveness
  - ➢ Minimization of resource use, residues, waste and emissions
- Pre feasibility study identified potentials, priority sectors for pilots (see: www.wupperinst.org)
- “German Material Efficiency Agency” established; kick-off conference with Trade Unions (IG Metall) in August 2006
- In the future: Implementing a broad scale “Impulse Programme” (e.g. integrating R&D, pilots, dissemination, market deployment)?

A Program for Growth of Material Productivity: The "Aachen" Scenario

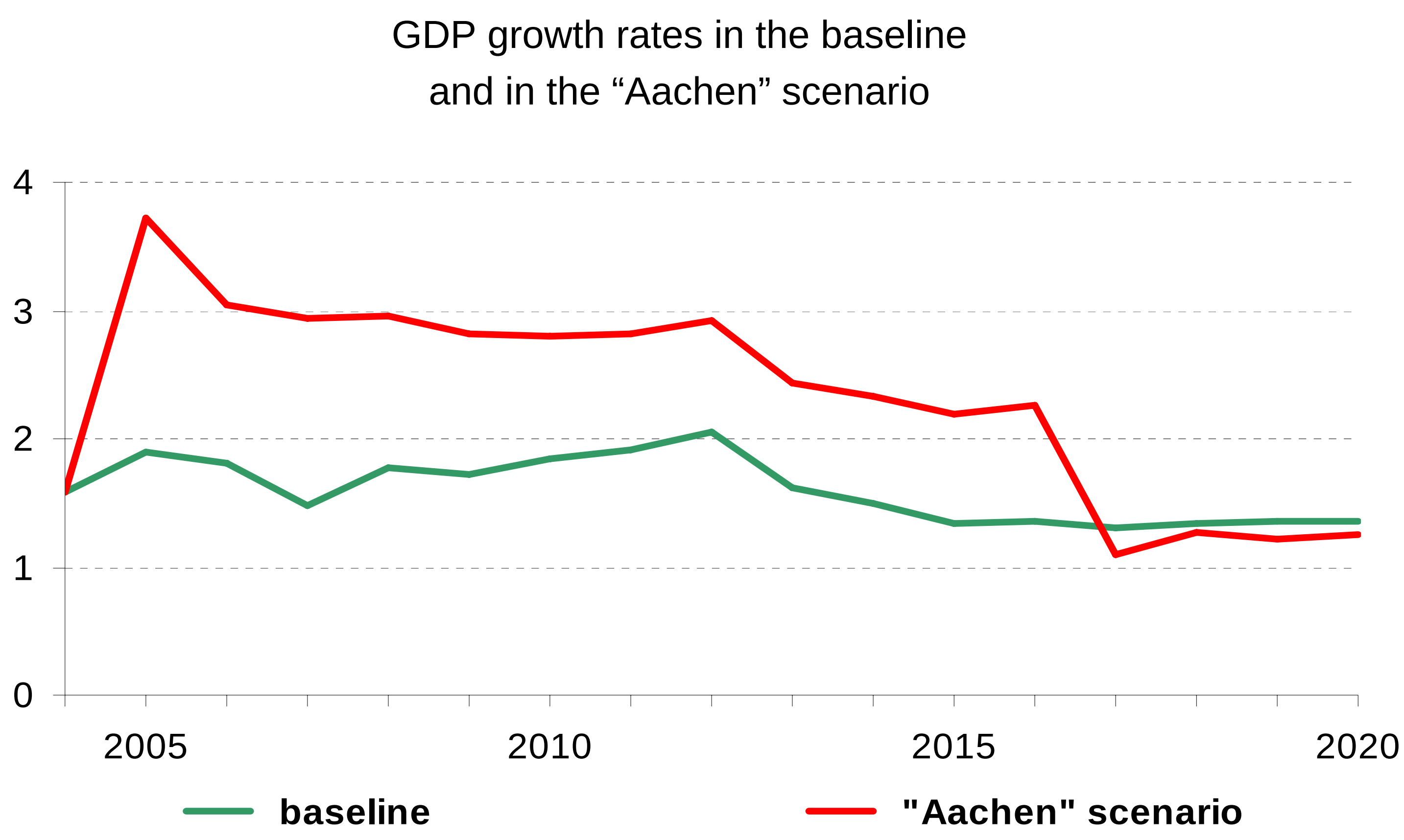
- Research work induced and sponsored by the Aachen foundation "Kathy Beys"

- Assumptions, based on consulting experience of A. D. Little and others:

  - 20 % reduction of material and energy costs of manufacturing sectors, construction and public administration in 11 years (linearly from 2005 to 2016),

  - one third of the additional costs are consulting costs, two third are capital costs.

A Program for Growth of Material Productivity: The “Aachen” Scenario GDP - growth rate expands by 1 point per year



Further results of the „Aachener Scenario“

At the end of the simulation periode (2020):

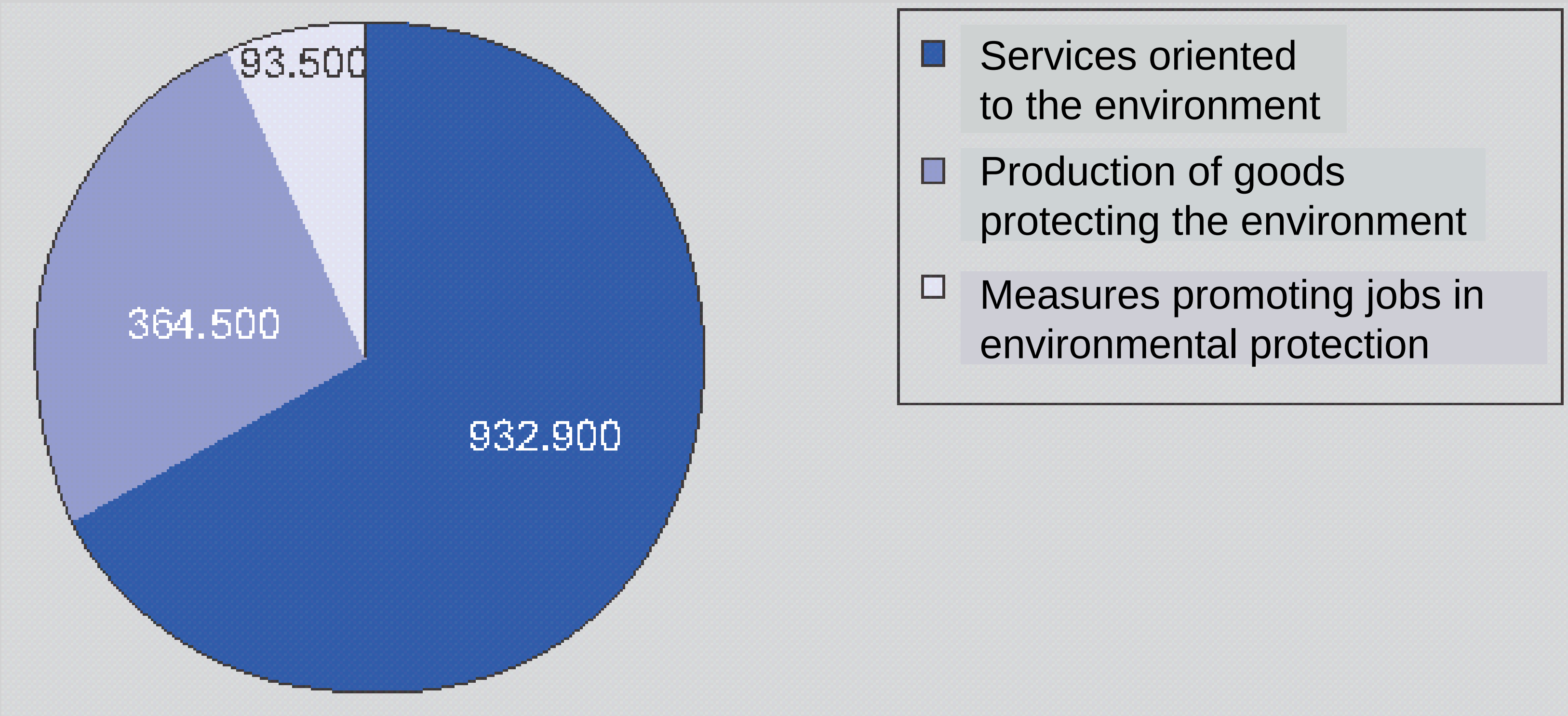
▪ Additional employment:	+ 1,000,000 jobs
▪ Additional business revenues:	+120 bn Euros
▪ Additional increase of economic growth:	+ 1% per annum

- Harvesting first mover advantages of competitiveness
- Reducing import dependency of strategic resources
- Contributing to geostrategic risk minimisation
- Approaching the official German goal („doubling resource productivity in 2020“)

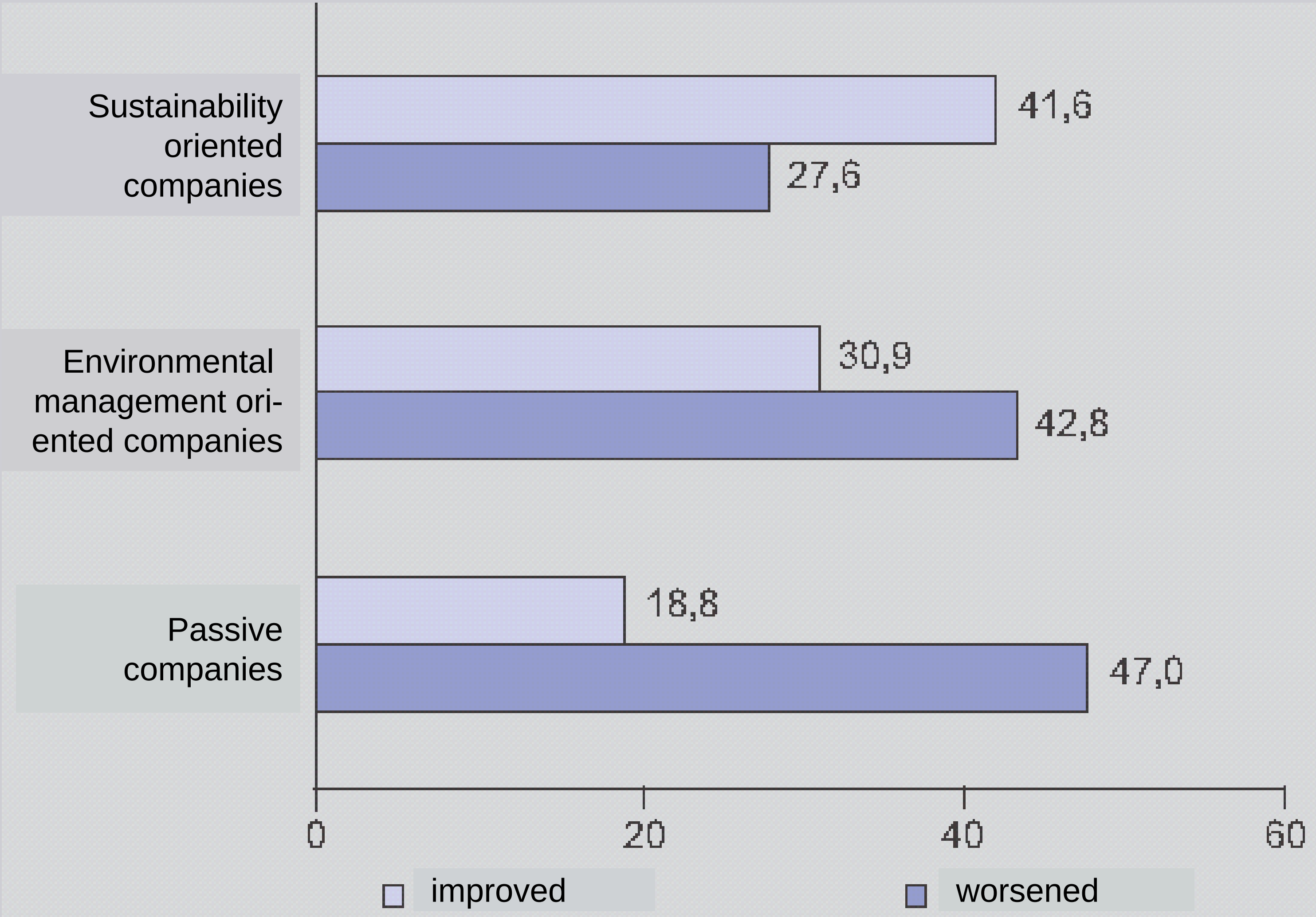
Typical features of the German „Impulsprogramme Material Efficiency"

- **“Sustainable Structural Change“:** Impulses for nature saving and labour augmenting technical progress
- **“A new type of investment programme“:** Target group and growth oriented support for the supply and demand side - neither neoliberal nor Keynesian!
- Pillar for an **„ Ecological Industrial Policy“ (**„New Deal“: Minister Gabriel): Integrated Programme of Rsearch&Development&Qualification& Demonstration
- **„Consensur of labour and capital“:** Cost reduction, without pressure on labour costs + increased competitiveness
- **„High self financing effect for public budgets“:** Reducing barriers for innovations, dissemination of good practice and learning effects

Persons employed in Germany in environmental protection



Assessment of the competitive situation of German companies in the last two years (in %)



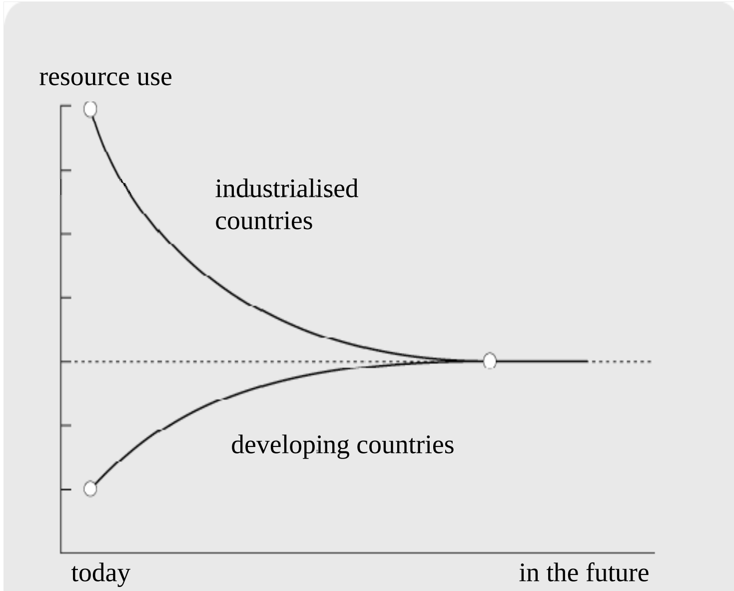
Life styles, happiness, visions...

The Vision of a „2000W 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.

Increasing purchasing power in developing countries: Copying unsustainable consumption patterns of the industrialized countries?

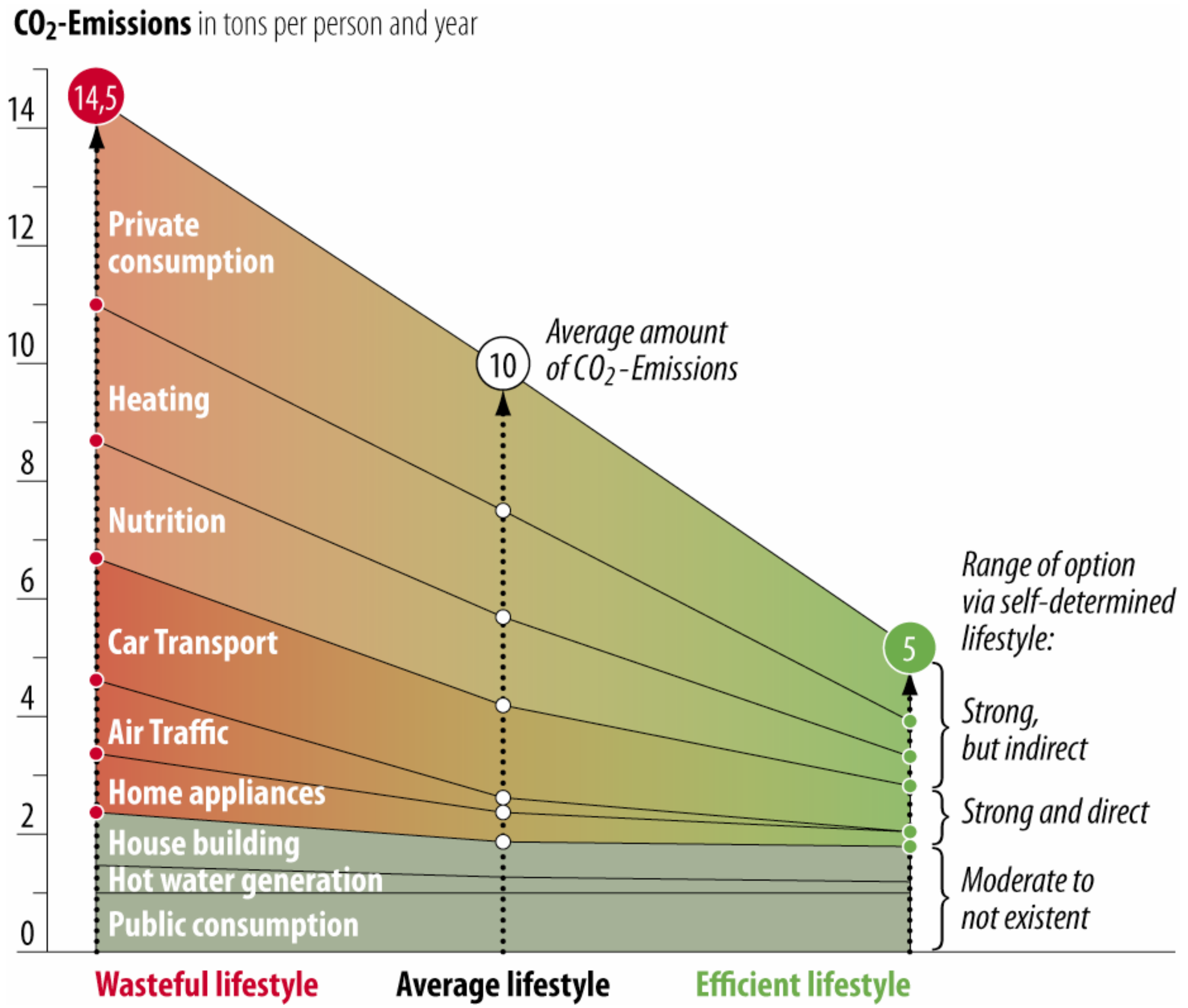
The share of worldwide “consumer classes” (CC >7000 USD yearly nominal income) will raise from 1,7bn to 2bn in 2015

→ especially in transition countries large backlog demand:

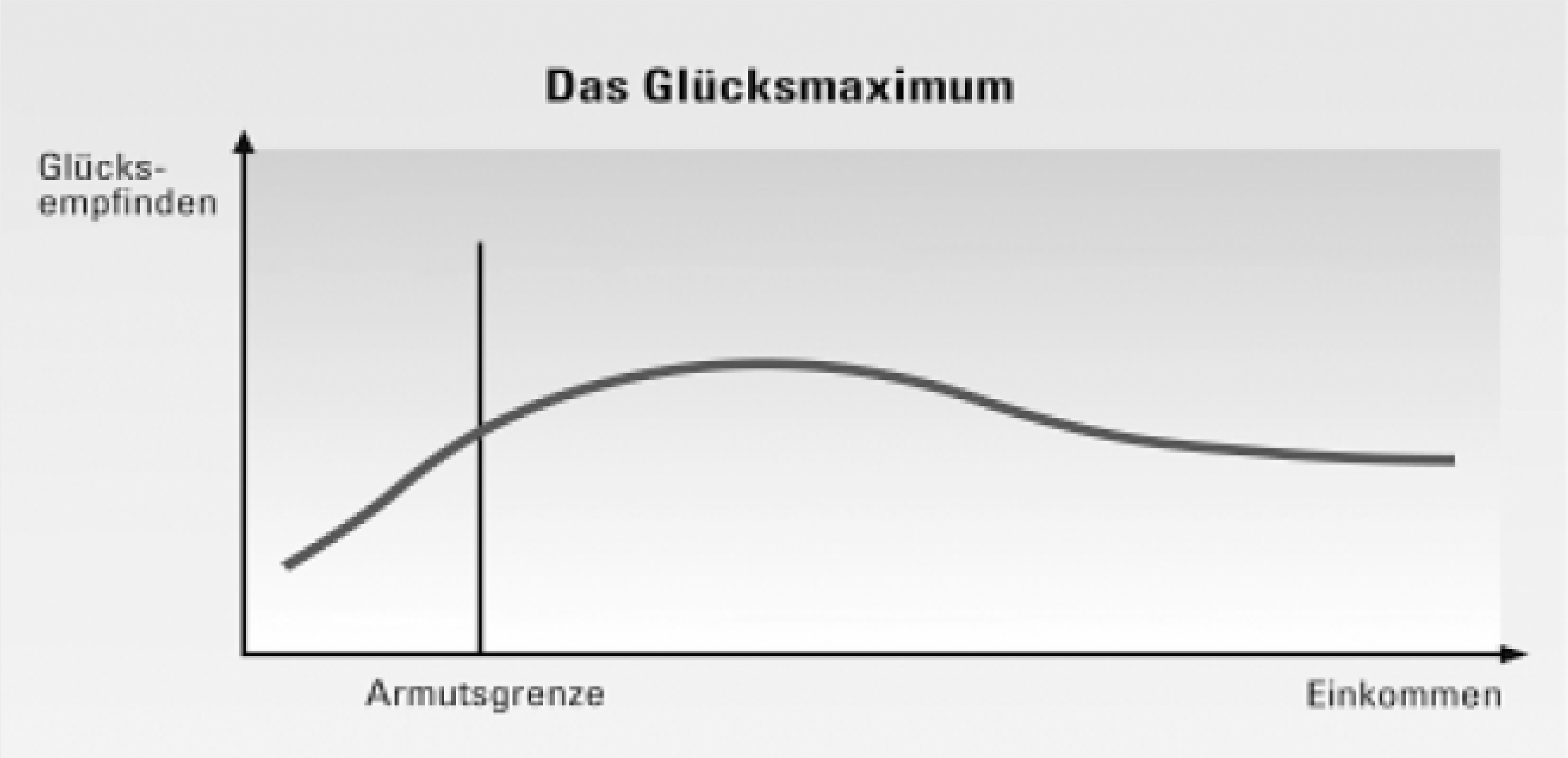
Country	Members of CC 2002 (in millions)	Share of total population in the given country (in %)
USA	242,5	84
China	**239,8**	**19**
India	**121,9**	**12**
Japan	120,7	95
Germany	76,3	92
Russian Federation	**61,3**	**43**
Brasil	**57,8**	**33**

Source: Bentley 2003: Leading consumer classes in countries, 2002

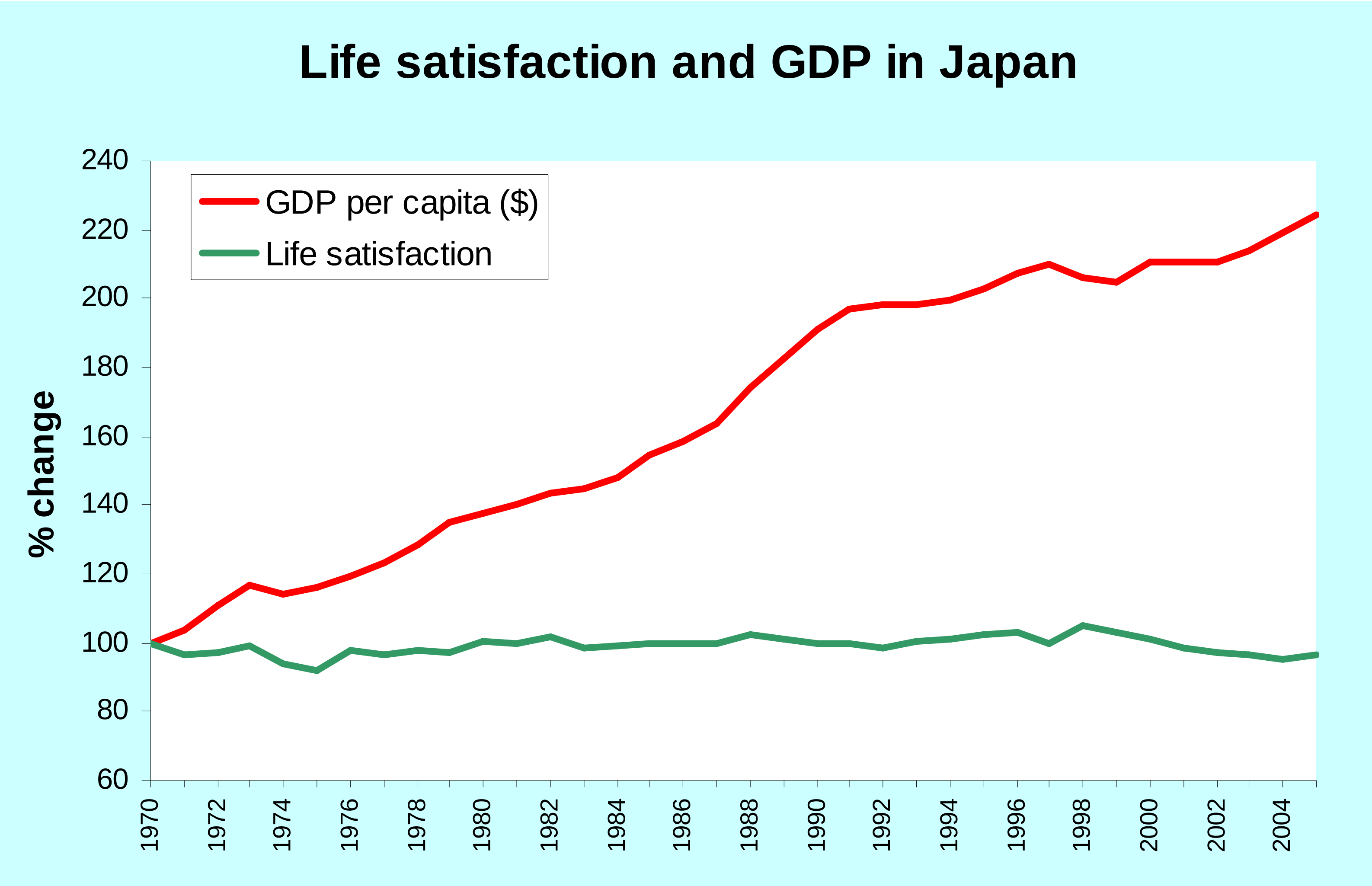
„European Lifestyle“: Scope of different consumption patterns to reduce $C0_2$ in EU 25 (WI 2007)



Does a growing income increase happiness?



Decoupling of GDP and Life Satisfaction: A social debate on sustainable patterns of consumption is needed in the North.



Prof. Joergen Noergard:

„It may not be cost-effective

to save the world,

but it will be worthwhile anyhow“

Wissenschaftszentrum Nordrhein-Westfalen

Institut Arbeit und Technik

Kulturwissenschaftliches Institut

Wuppertal Institut für Klima, Umwelt, Energie GmbH

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