Wuppertal Institute
for Climate, Environment
and Energy

Tools for energy planning

- overview and examples -

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Vice President

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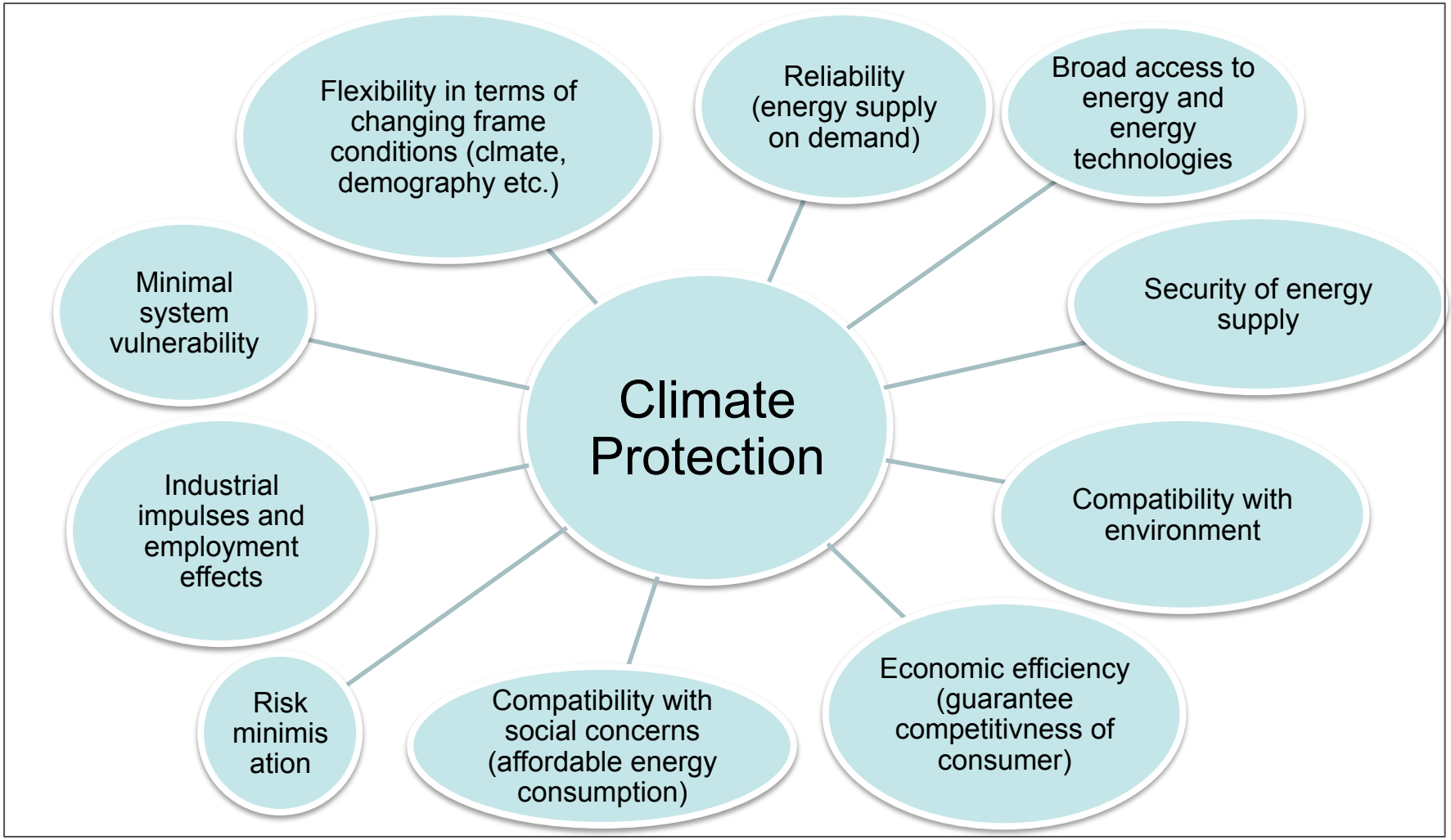
Overview

- **Introduction – important challenges for the energy industry**
- **Energy scenarios as supporting tool for dealing with future uncertainties and identification of future opportunities**
  - ✓ General philosophy
  - ✓ Methodologies
  - ✓ Limitations
  - ✓ Follow up questions and impact analysis
  - ✓ Selected examples

Huge and complex challenges for the energy future – avoid trade off‘s, look for synergies



Huge and complex challenges for the energy future – avoid trade off's, look for synergies

Consider competing goals

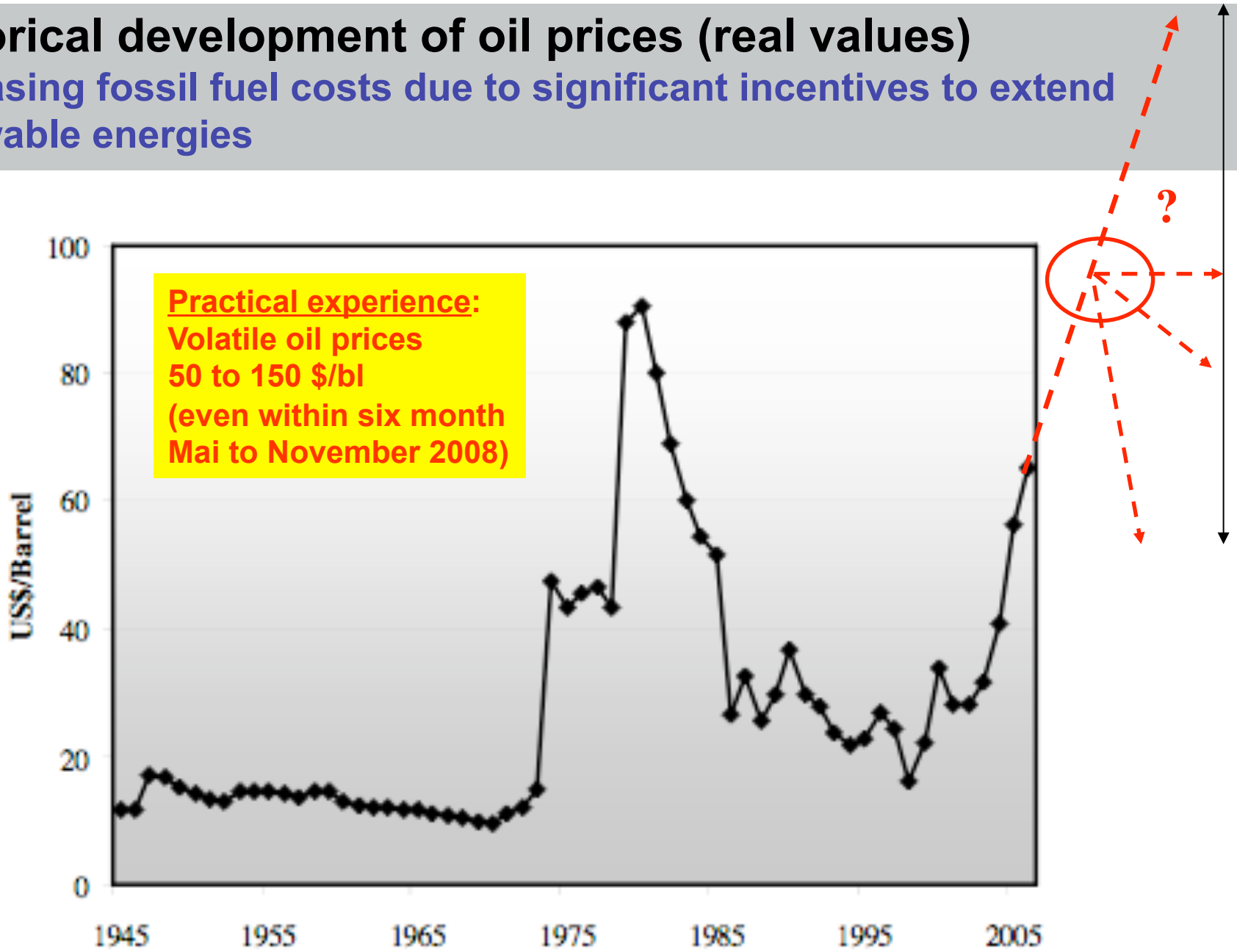
Quino, Der große Quino, dtv 1466

➔ **cross sectoral, integrated perspective requested instead of looking for a partial optimum**

➔ **Don't focus on the wolf if there might be other dangerous animals around**

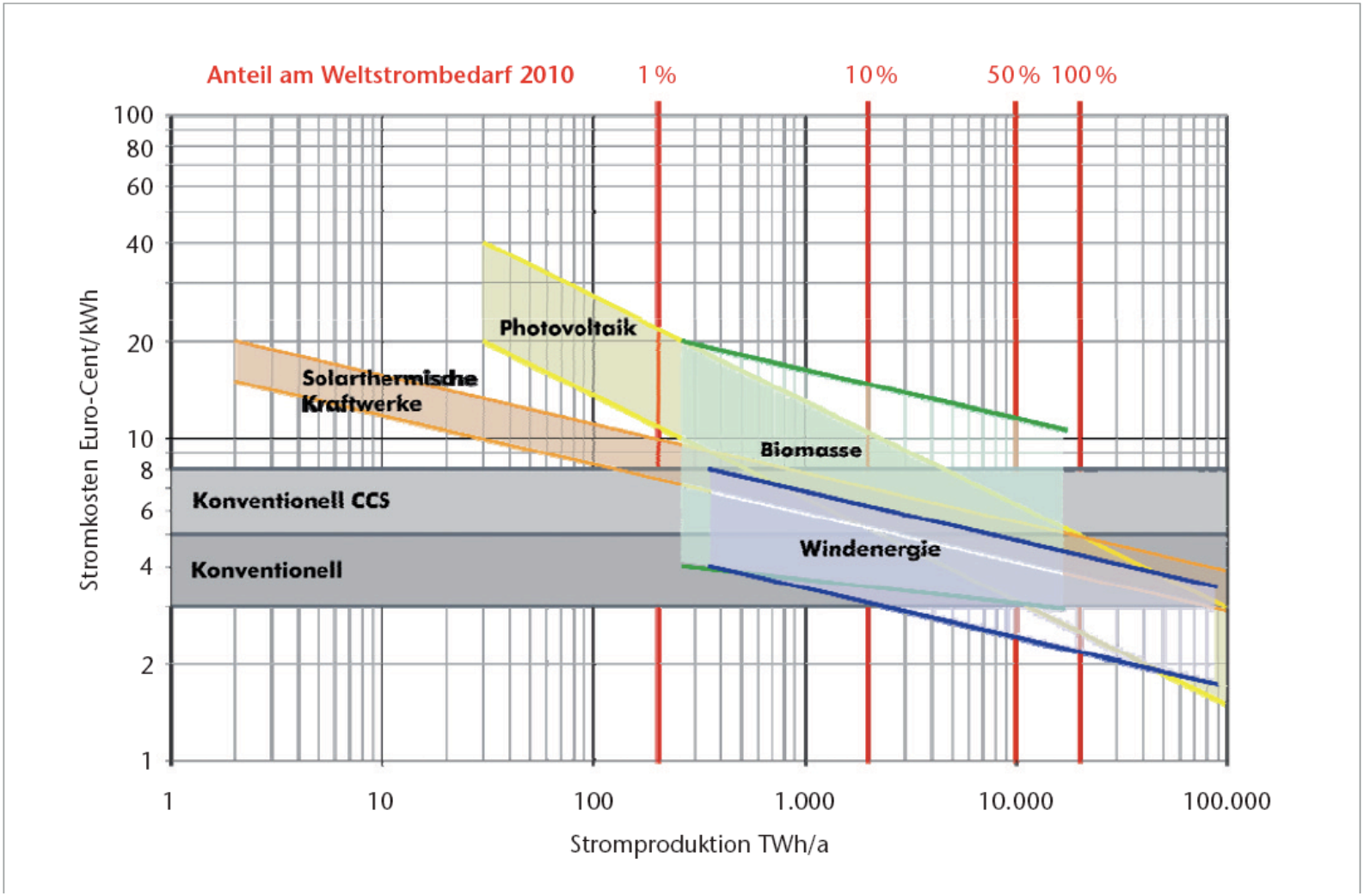
Historical development of oil prices (real values)

Increasing fossil fuel costs due to significant incentives to extend renewable energies



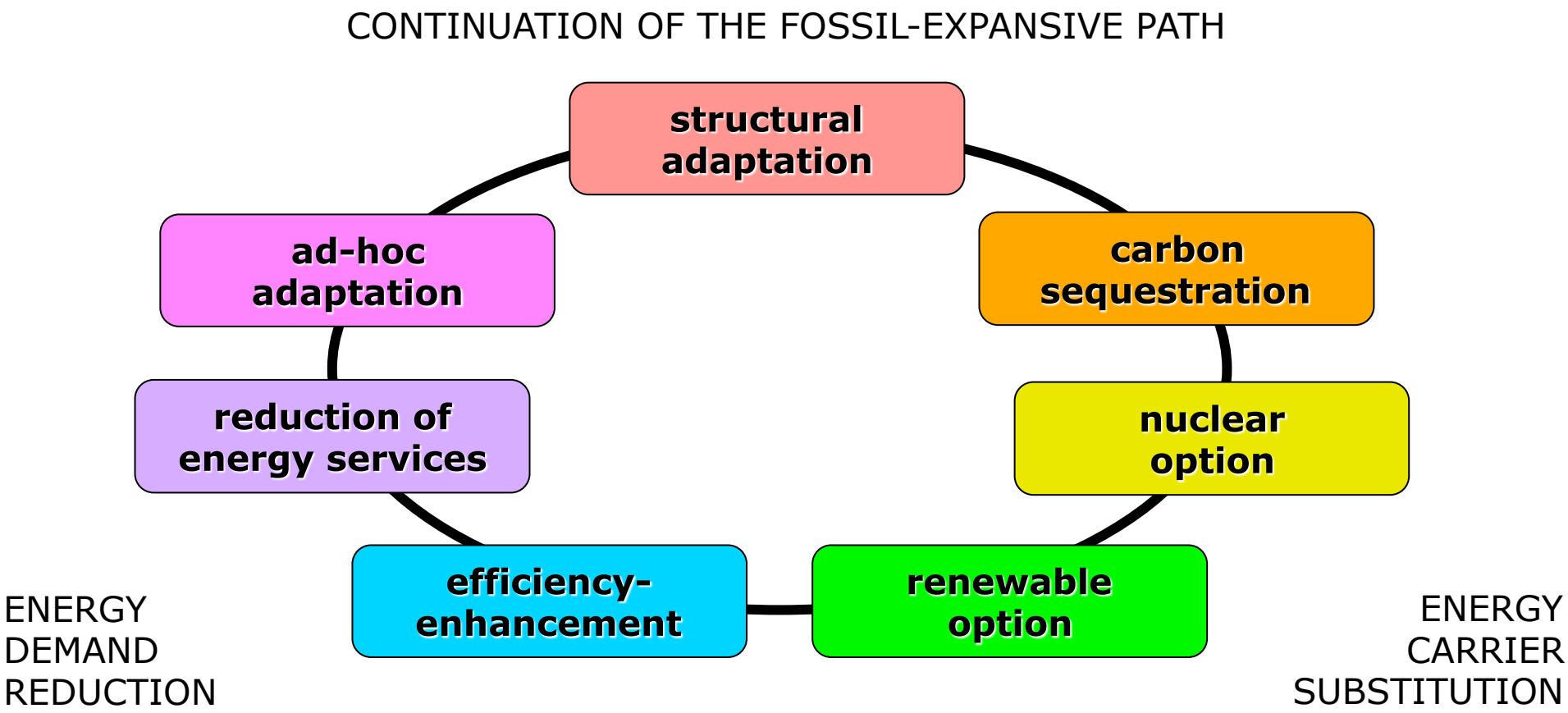
Future uncertainties

Illustrative example – expected learning effects power plant technologies



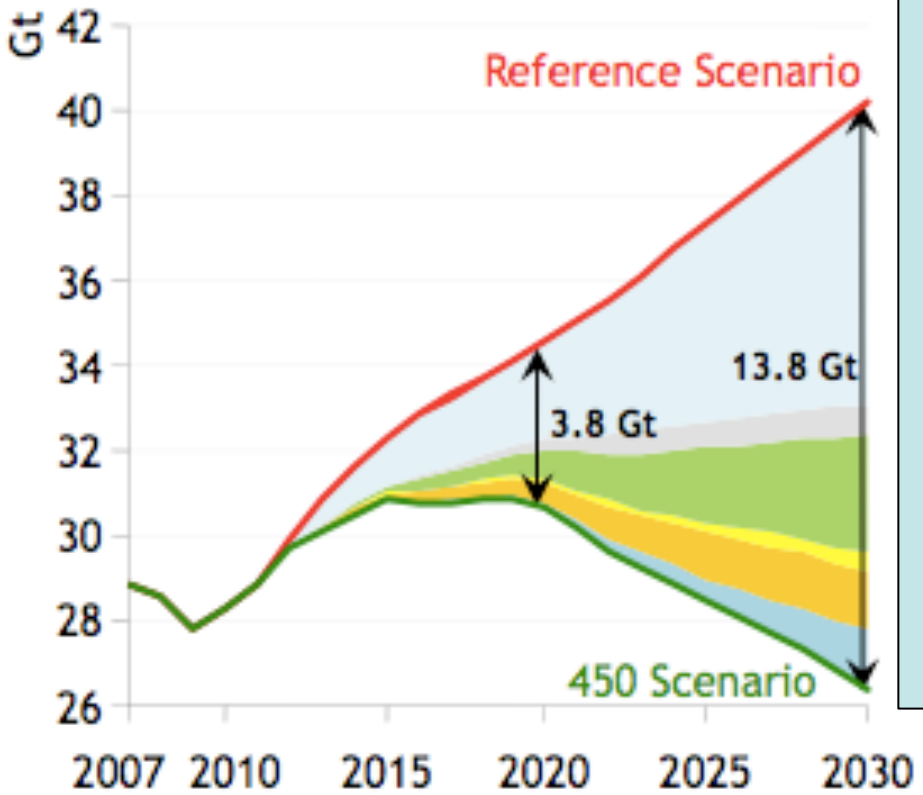
What are the options for climate protection and adaptation?

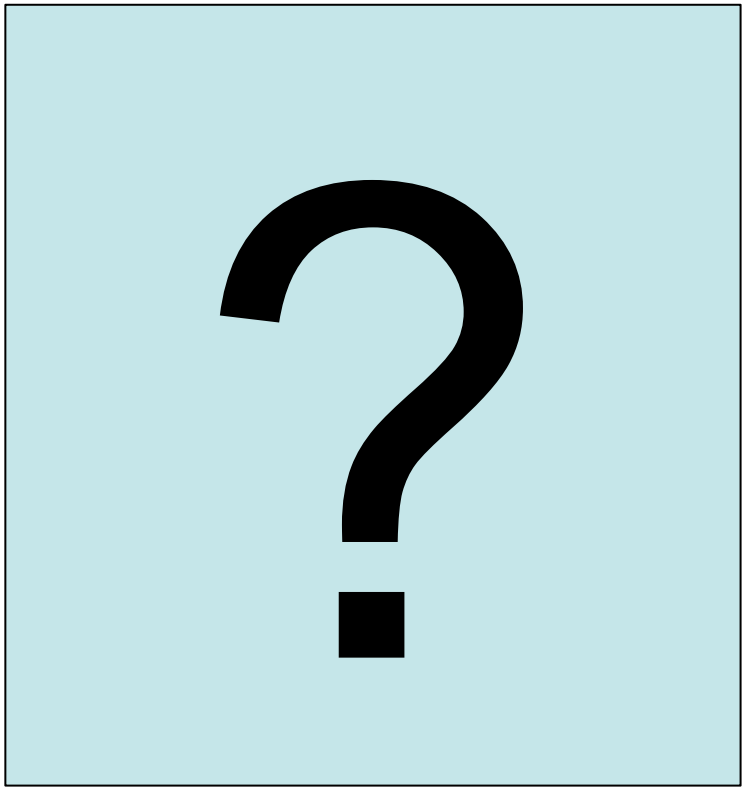
There is no silver bullet – a combination of technologies has to solve the problems



Energy system perspectives

How the energy system is developing?





Energy system perspectives

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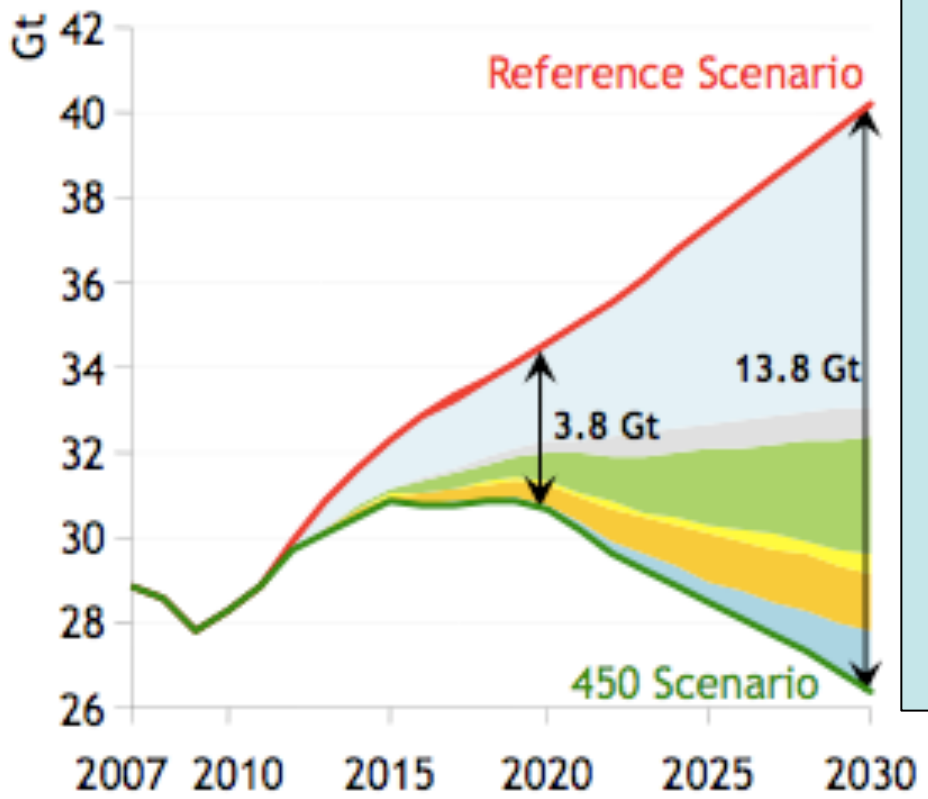

Use energy scenarios to define and discuss orientation marks and to help politicians to shape the energy future

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Philosophy of Wuppertal Institutes Scenario Work

- Scenarios are quite different from predictions
- Scenarios are asking “what happens if ….”
- Scenarios are based on a consistent set of assumptions which should be outlined transparently
- Scenarios are necessary
  - to pick up future uncertainties
  - to identify the corresponding range of possible future paths (including the branching points)
  - to describe the major impacts and dangers of those paths
  - to deal with new challenges and significant changes of crucial frame conditions
  - to gain more experience about the manifold interactions in the system
  - to enable an elaborate discussion about suitable policy and technology strategies following defined targets

  ➔ For policy makers it is worthwhile to present set of different scenarios to mark the decision range

  ➔ Scenarios should include a broad spectrum of opinions and expert views from different stakeholders (e.g. via interviews)

For what for instance scenarios can be applied? I

- **Policy context**
  - ✓ Identification of suitable key aspects and strategies for an integrated energy and climate policy
  - ✓ Starting point for a public and political debate on different energy future paths
  - ✓ Identification of robust strategies (orientation knowledge)
- **Industry and Enterprises**
  - Identification of future business opportunities (future markets) and market potential assessment
  - Improved planning and investment reliability through considering and assessing future uncertainties
- **Identification of technology needs and gaps**
  - ✓ Identification of entrepreneurial opportunities
  - ✓ Determination of R&D priorities

For what for instance scenarios can be applied? II

Selected projects of the Wuppertal Institute

- **1990: Parliamentary Enquete Commission "Protection of the Earth"**
  - Setting of a long term target: -80% GHG by 2050
  - Prof. Hennicke was member of that commission
- **1995: WI flagship study: Sustainable Germany**
  - Groundbreaking study for German sustainability discussion
  - Mainly qualitative recommendations on "basic needs"
  - Quantitative scenario analysis for 2050 (cross sectoral and problem perspective)
- **2006-2009: Long low carbon scenarios for the EU (WWF, EU Commission)**
- **2000: Long term energy scenarios for Germany (Fed. Environmental Agency)**
- **2002: Parliamentary Enquete Commission "Sustainable Energy Future"**
  - Prof. Hennicke & Dr. Lehmann were members of that commission
  - Quantitative energy scenarios for Germany: -80% GHG by 2050; competing analysis WI vs. IER (lead by Manfred Fischedick)

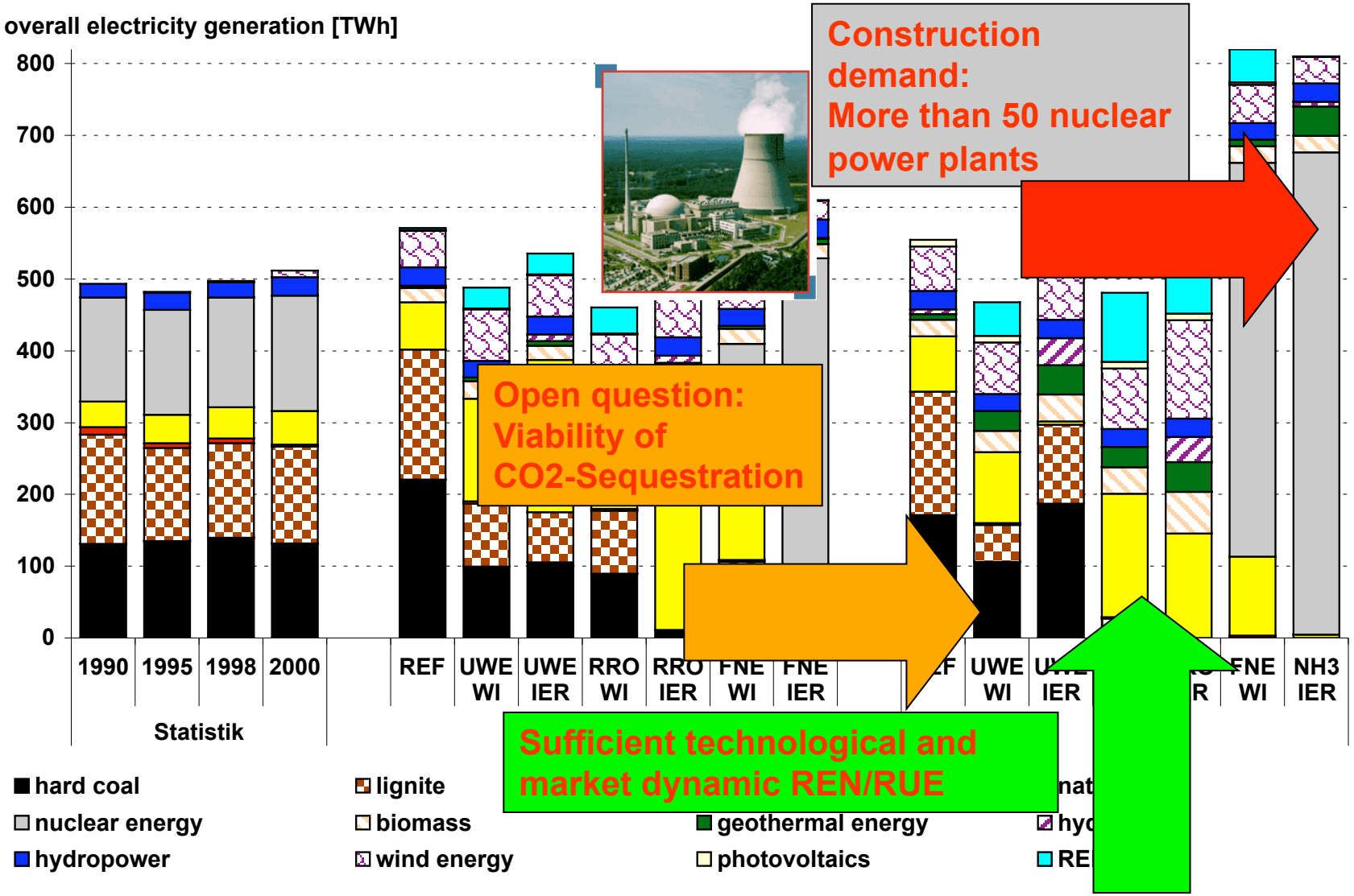
For what for instance scenarios can be applied? III

Selected projects of the Wuppertal Institute

- **2004 - 2006: Ecologically optimised expansion of renwable energies**
  - Quantitative energy scenarios for Germany: -80% GHG by 2050, with DLR
  - Basic studies for the annual “Leitstudie 2050” of German MOE
- **2008: Pathways to a carbon free Munich 2058**
  - Commissioned by Siemens as part of their sustainable urban infrastructures project
- **2009 and ongoing: Low Carbon Region/City Concepts**
  - Pre study for “low carbon Alpes region”
  - Pre study “Sustainable Ruhr Valley”
  - Low Carbon infrastructures for cities (e.g. Düsseldorf)
- **2010 (intended): Low Carbon Cities in Germany and China**
  - Concepts studies and organisation of experience exchange (sister city concept)

Range of possible future paths – German Long Term Energy Scenario

Different pathways for 80 % GHG reduction compared to 1990 by 2050 – make results explicit



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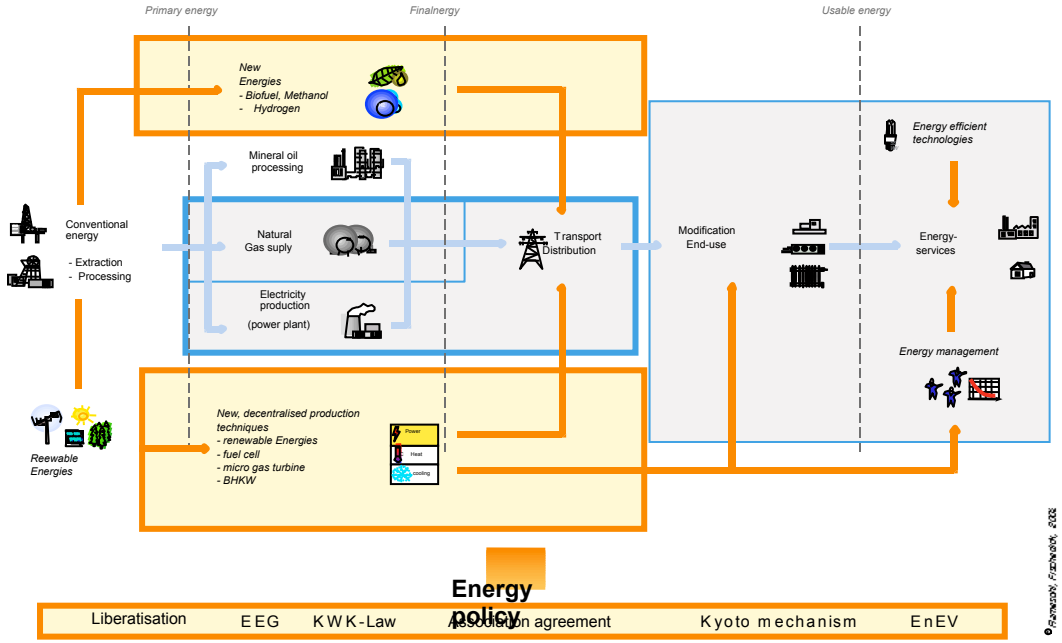
Methodological approach of bottom up scenario modelling

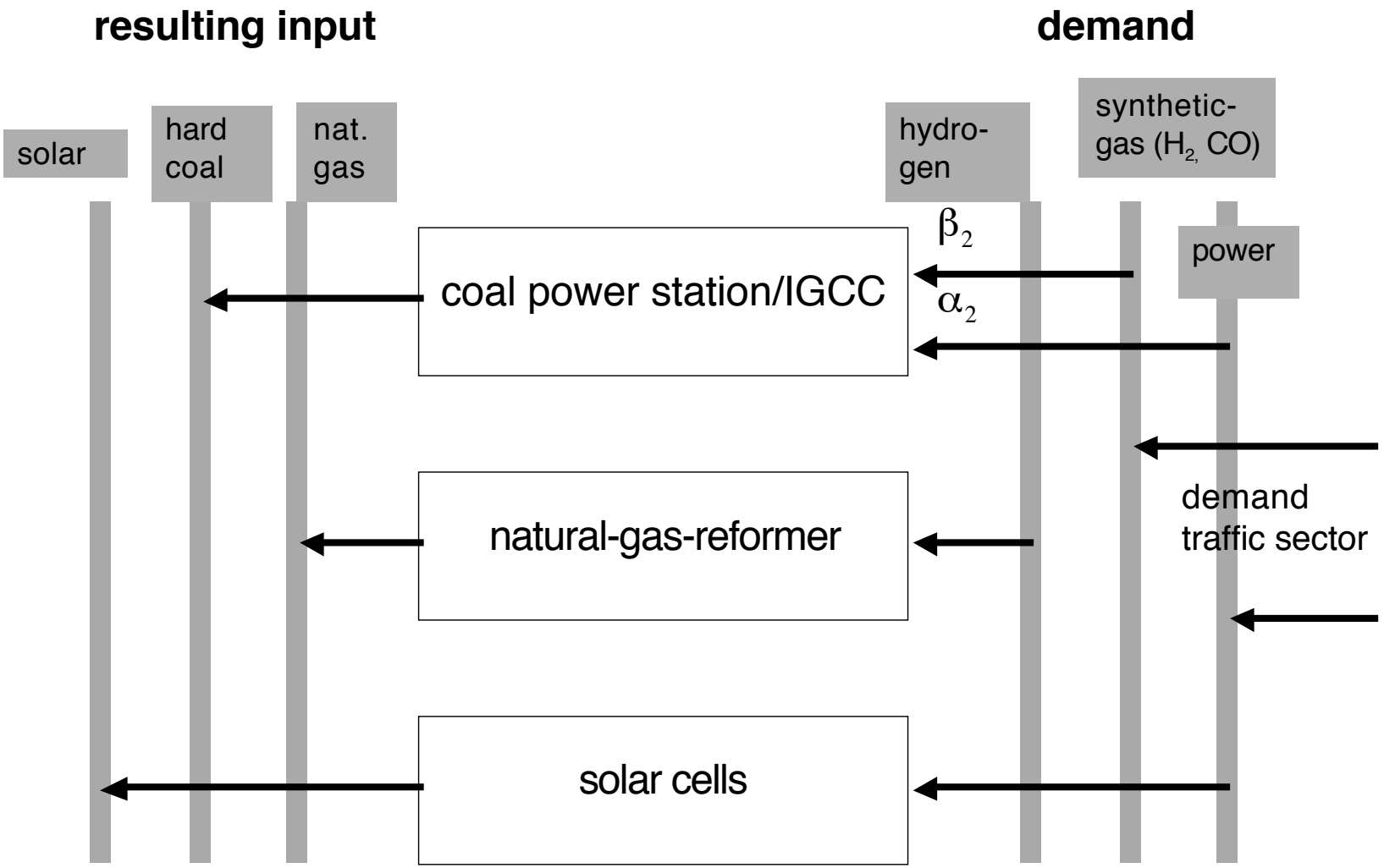
Energy system modelling

- Bottom-up oriented technological energy modelling (from energy service demand to primary energy exploitation technology)
- Detailed technological analysis of the energy systems
  - Supply side
  - Demand side (high disaggregation level considered)
- Simulation approach (determination of market shares via expert knowledge)
- RES as technological, simplified picture of the real energy system (RES: Reference Energy System)



Bottom up Energy System Modelling

Reference Energy System (RES)



Bottom up Energy system Modelling
Characteristics of simulation approach

Criteria for determination of market shares

- General scenario philosophy
- Distinguished driving forces (technology status, market, society, government etc.)
- Costs
  - from national perspective
  - from individual perspective
- Market barriers
- Available policy measures for overcoming barriers
- Expected opposition against implementation of suitable policies
- Continuity principles for development processes (e.g. market introduction and penetration path of new technologies) - avoiding structural breaks

The result is not the optimum from the mathematical point of view but may be a more realistic solution

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Limitations of scenario analysis

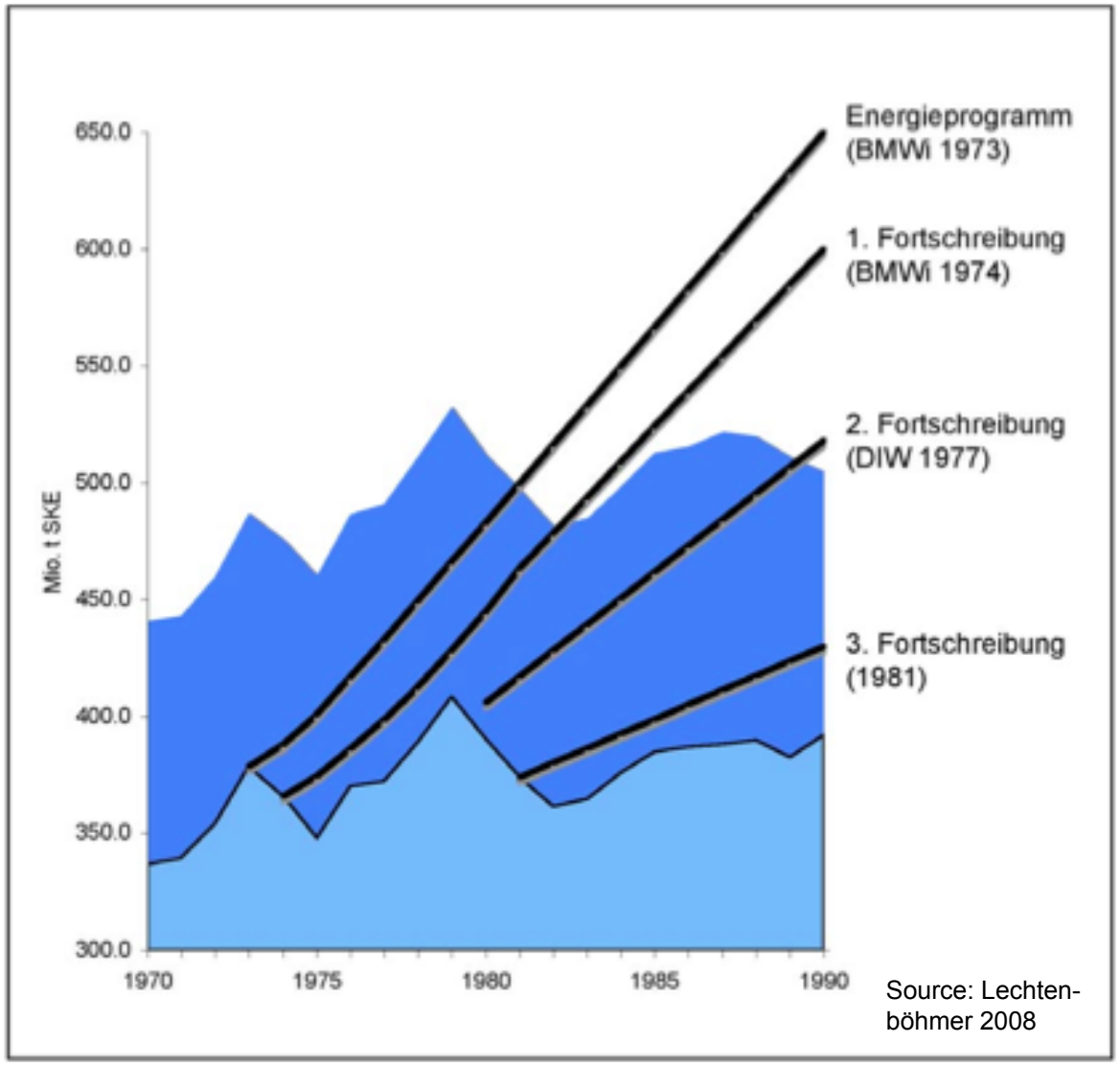
How to deal with future uncertainties – scenarios do not predict the future but can help to assess the scope of possible futures

Predictions (prognosis) are difficult, in particular if they deal with future aspects

(Winston Churchill)

Limitations of scenario analysis

Scenarios can not foreseen massive and sudden structural changes (e.g. oil price crises)

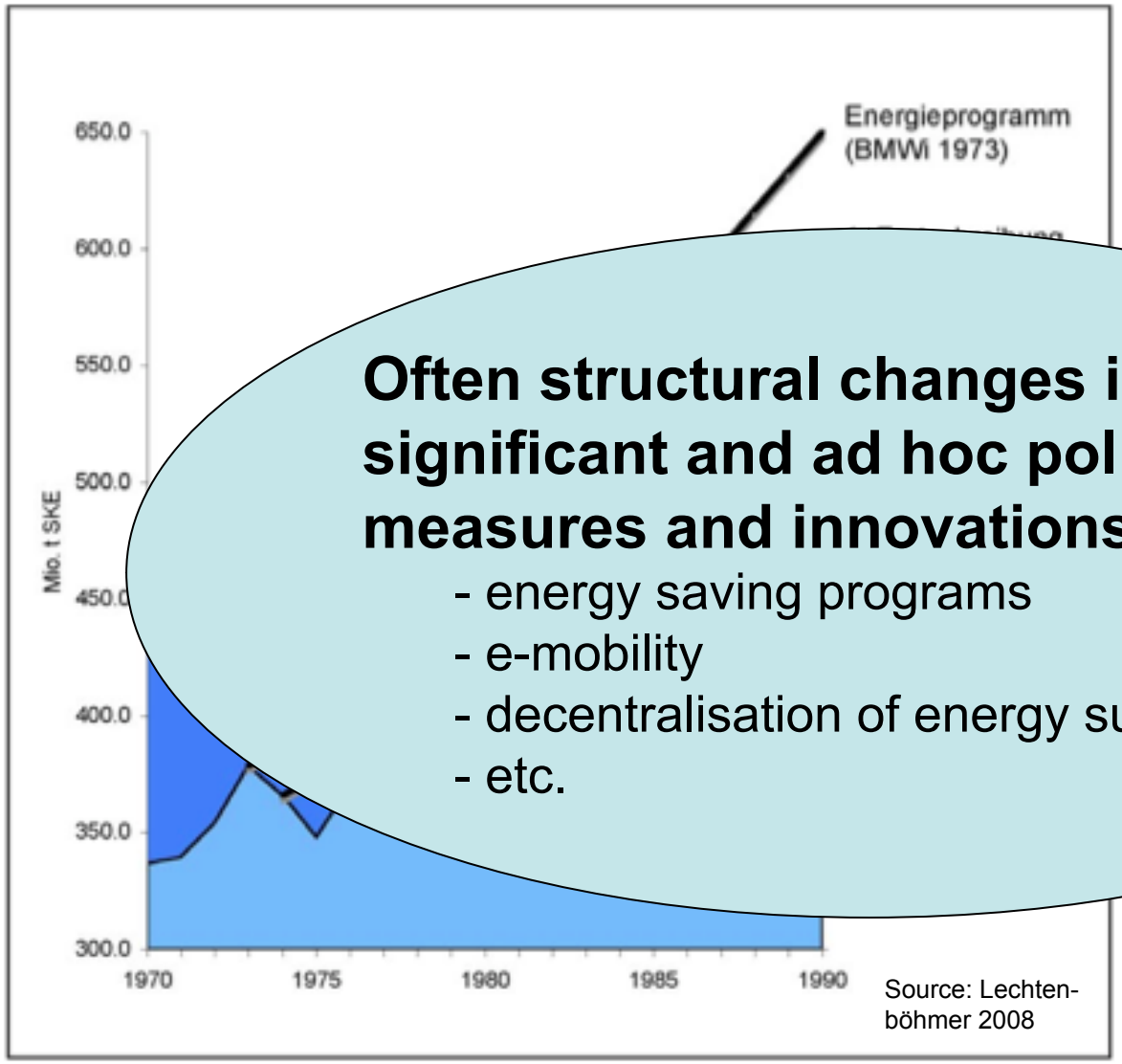


Source: Lechten-böhmer 2008

- Forecasts by MoE
- Significantly and constantly overestimated future demand
- Examples of projections on purpose (e.g. Germany) – structural effect of possible oil price crises have not been considered

Limitations of scenario analysis

Scenarios can not foreseen massive and sudden structural changes (e.g. oil price crises)



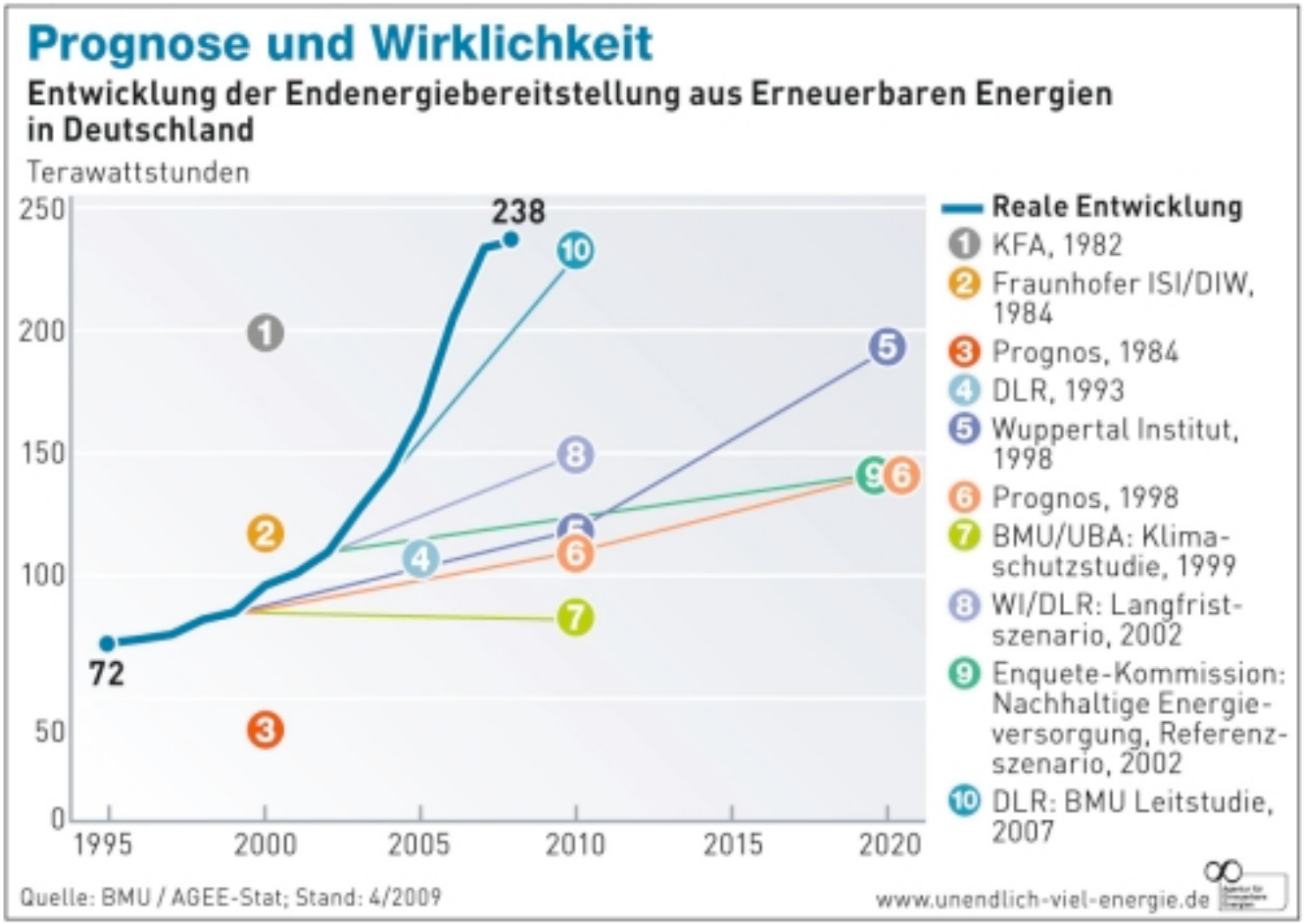
Often structural changes initiate significant and ad hoc policy measures and innovations?

- energy saving programs
- e-mobility
- decentralisation of energy supply
- etc.

- Forecasts by MoE
- Significantly and constantly overestimated
  future demand

Scenarios and reality

As a result of policy measures and unexpected technology developments reality can be faster than scenarios expect



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Follow up questions and impact analysis

Energy scenarios can not reply to all questions

- **How climate protection future fit with other goals related to the energy sector: Sustainable Development is more as "Low Carbon"?**
  - identification of trade offs
  - cross problem/sectoral analysis (sustainability scenarios)
- **What are the impacts of the climate protection future from a broader integrative perspective?**
- **How "low carbon structures" can be shaped and implemented?**
  - What are the concrete tasks within the transition process?
  - Which kind of social and cultural impacts can be expected and have to be considered?
  - Which role consumer behaviour does play?
  - How necessary modifications can be communicated?
  - How suitable policies and instruments can be shaped supporting the transition process?

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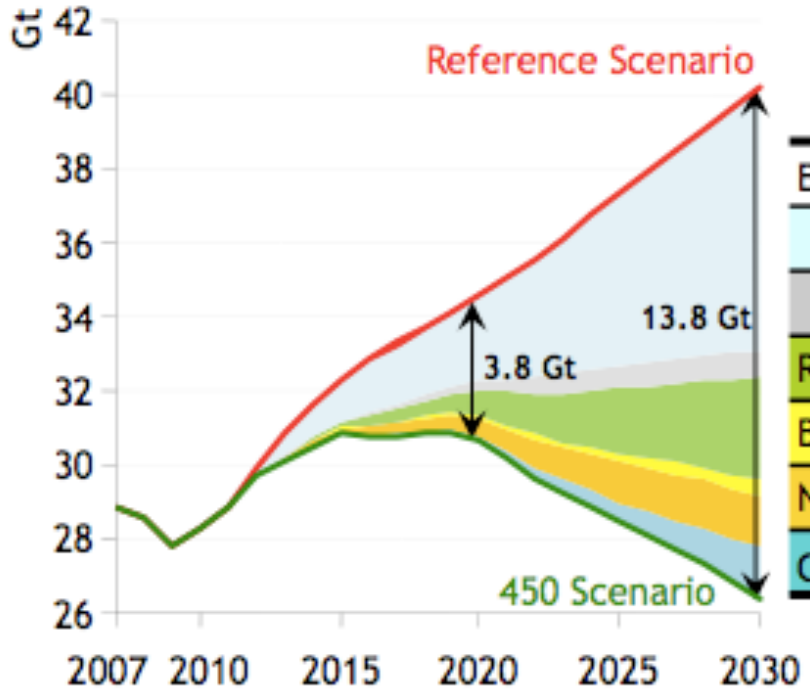
Global Energy and Climate Scenarios

CO_2-Mitigation scenario (450 ppm CO_{2eq} scenario to achieve 2° target)

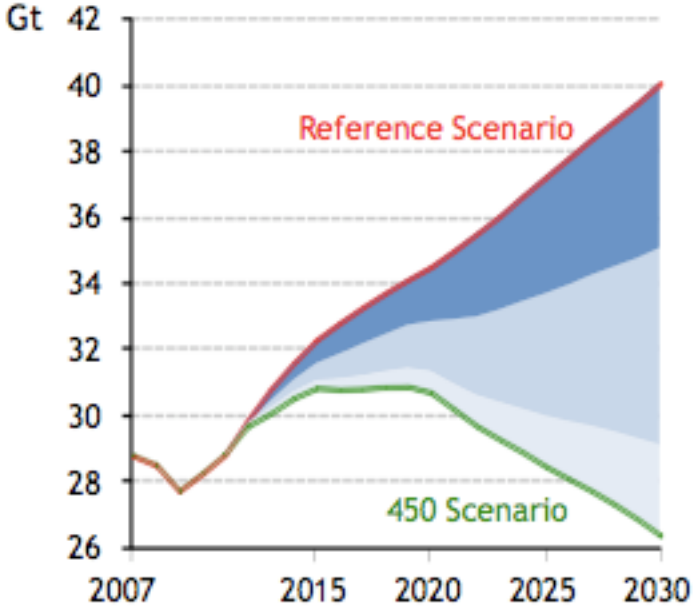
Main strategy elements energy efficiency and renewables



Share of abatement %	2020	2030
Efficiency	65	57
End-use	59	52
Power plants	6	5
Renewables	18	20
Biofuels	1	3
Nuclear	13	10
CCS	3	10

Global climate protection strategy

CO_2-reduction requirements related to world regions



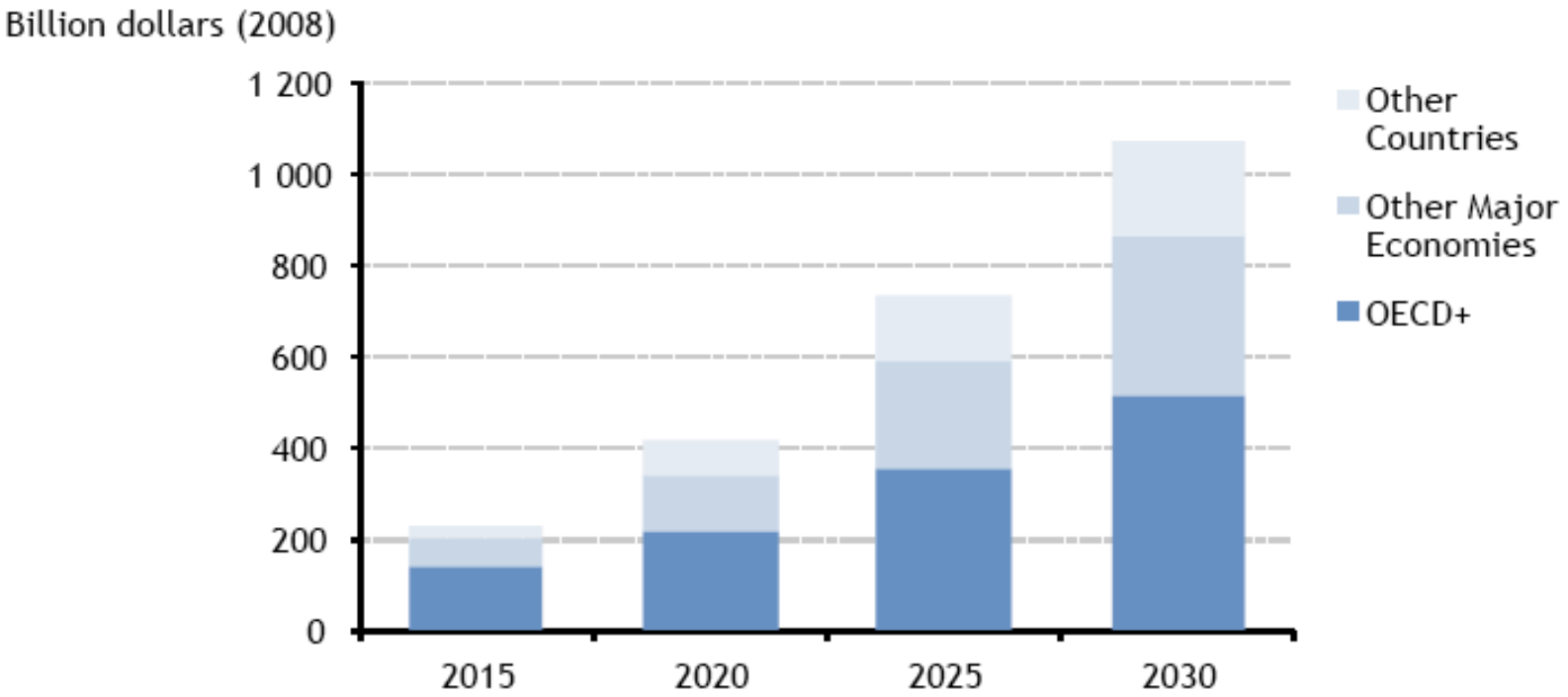
	Abatement 2020	Abatement 2030
Total (MtCO2)	3 850	13 840
OECD+	43%	36%
Other Major Economies	40%	43%
Other Countries	16%	19%

Of which the US comprises about half

Of which China comprises about three quarters

Global climate protection strategy

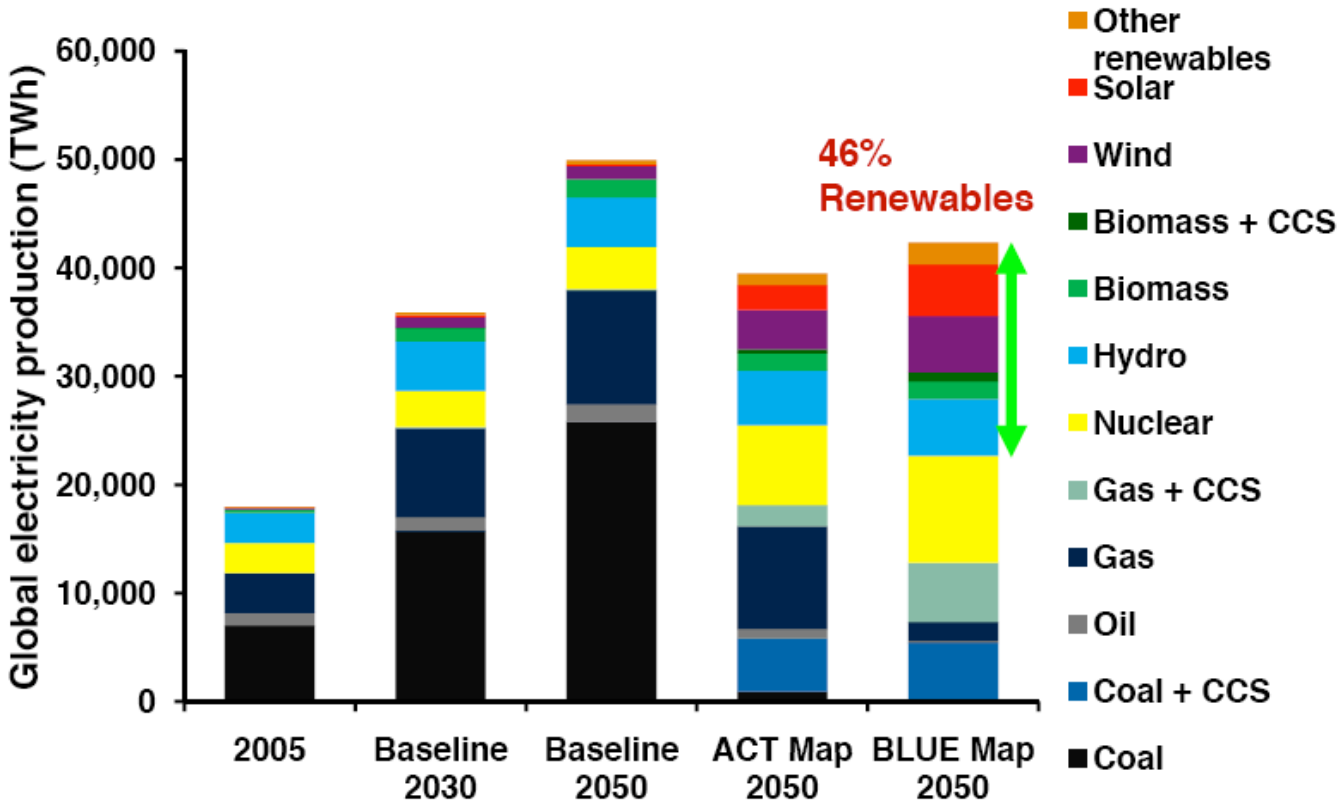
Additional investments compared to BAU in different world regions



The 450 Scenario sees $10 trillion of additional investment to the Reference Scenario, costing 0.5% of GDP in 2020 and 1.1% of GDP in 2030

Descriptive results of scenario analysis

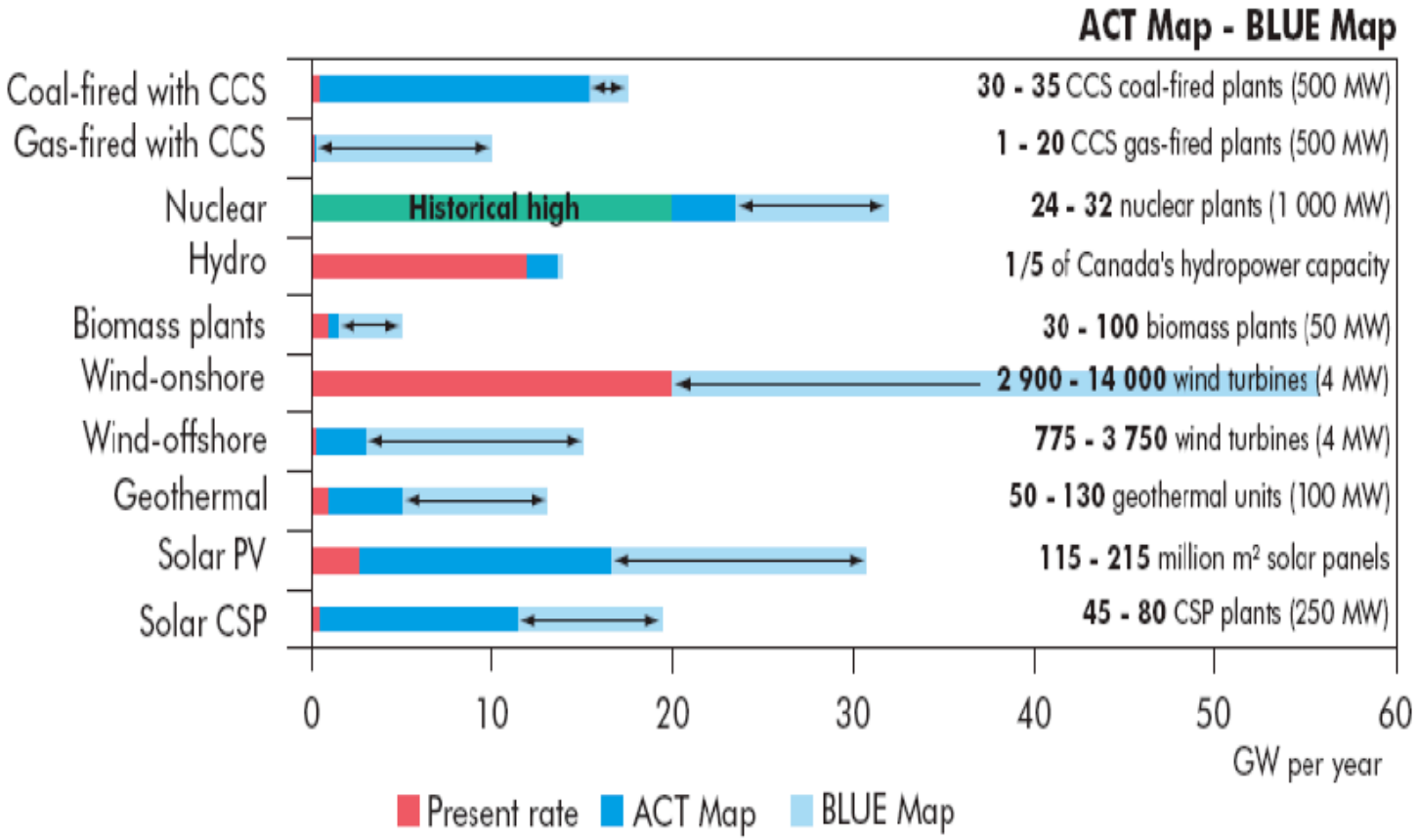
Electricity generation mix



In support of the G8 Plan of Action

Descriptive results of scenario analysis

Average Annual Capacity Additions (2010 – 2050)

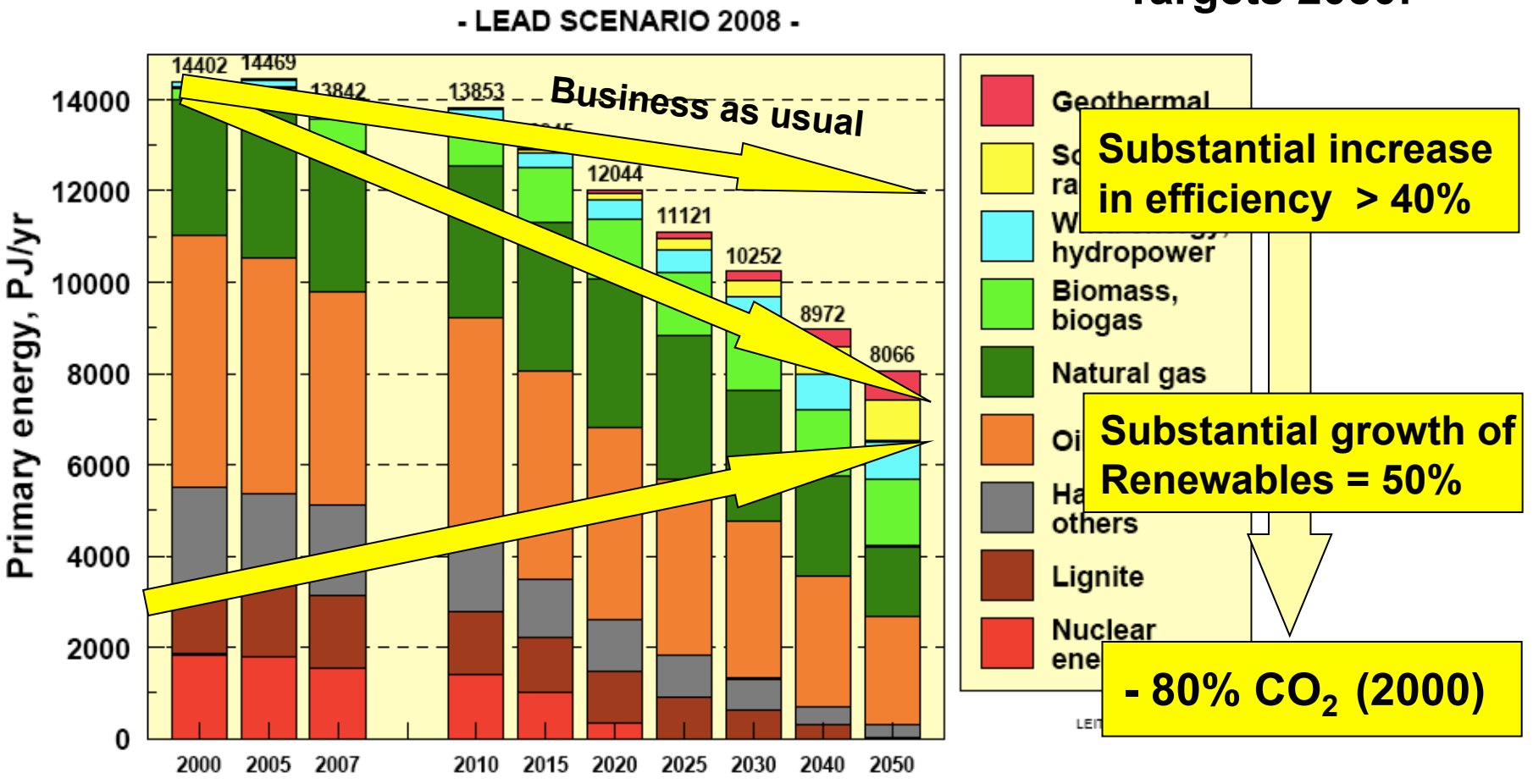


In support of the G8 Plan of Action

Long term energy scenarios in Germany

Lead Scenario for the German Ministry for Environment: Climate protection based on renewable energies and energy efficiency improvement

Primary energy demand in PJ



Targets 2050:

Substantial increase in efficiency > 40%

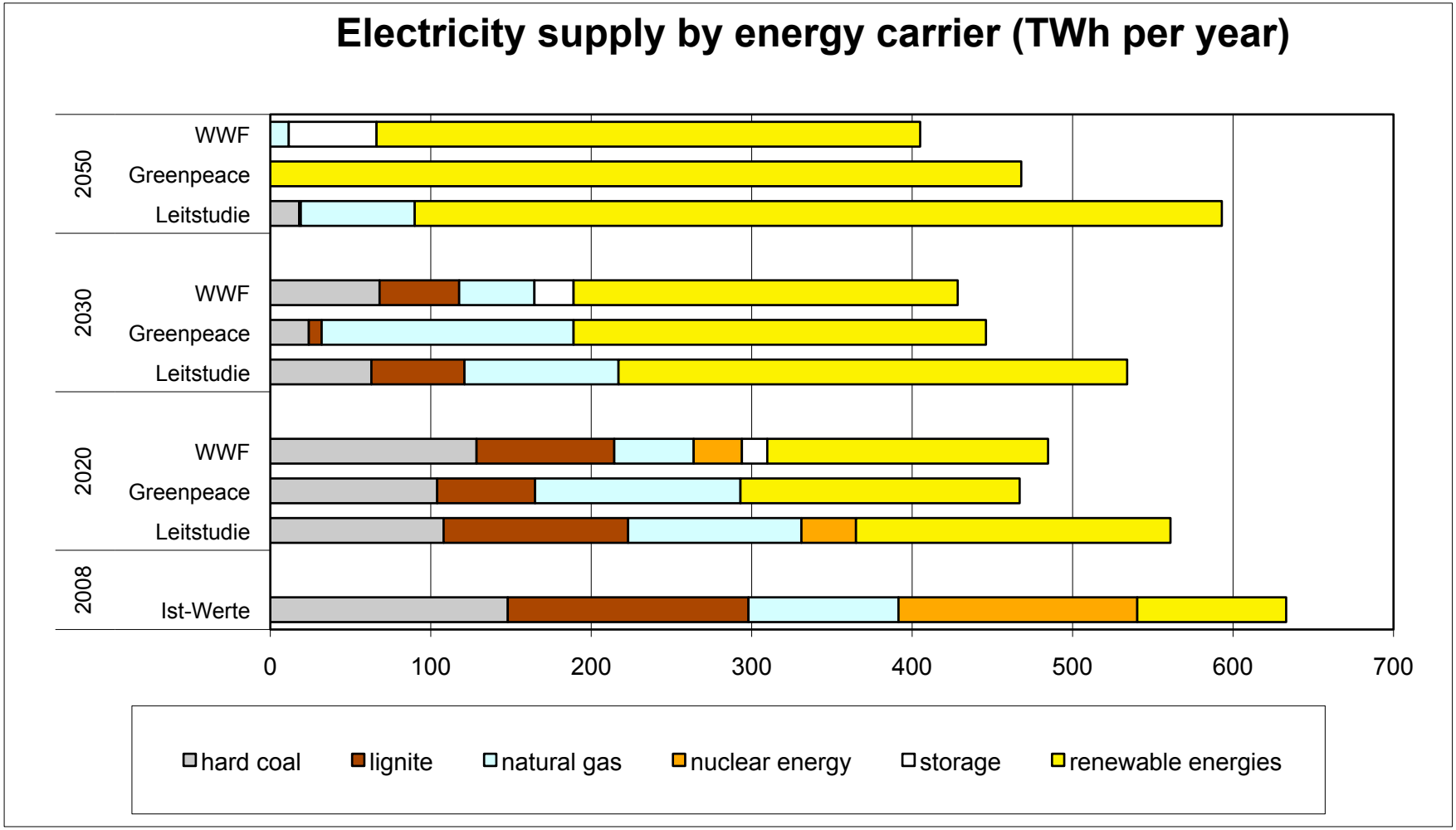
Substantial growth of Renewables = 50%

- 80% CO_2 (2000)

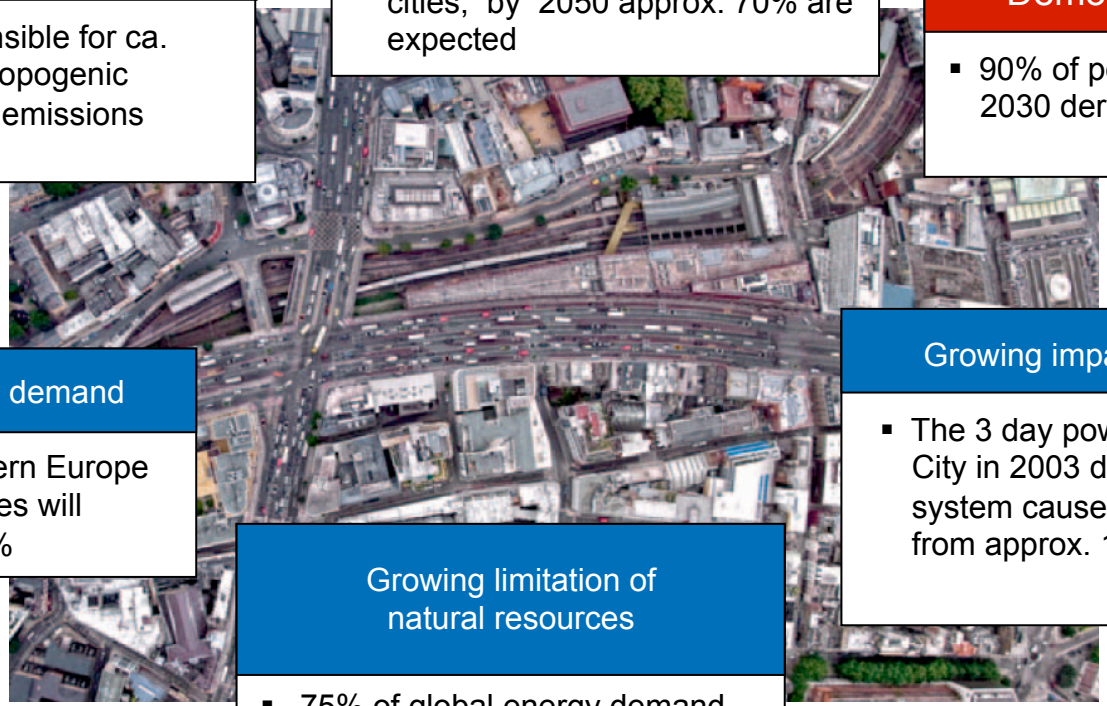
Efficiency method; actual values are not temperature-adjusted

Long term mitigation scenario perspective for Germany

Power generation



Cities have to deal with many challenges on the way to a sustainable deveplopment



Urbanization

- Since 2007 more than 50% of the world population lives in cities, by 2050 approx. 70% are expected

Climate Change

- Cities are responsible for ca. 80% of the anthropogenic greenhouse gas emissions

Demographical change

- 90% of population growth until 2030 derives from cities

Growing mobilty demand

- By 2010 in Western Europe traffic jams in cities will increase by 188%

Growing impacts on the infrastructure

- The 3 day power shortage in New York City in 2003 due to overheating the system caused an economic damage from approx. 1 Mrd. US Dollar

Growing limitation of natural resources

- 75% of global energy demand comes from cities

Scenario application on the city level - sustainable Urban infrastructure on behalf of Siemens

Munich 2058 – Pathways to a Carbon Free Future

- **Blueprint for the restructuring of cities**
  - 50% of the worlds population lives in cities, but they consume more than 70% of the energy
  - cities are determining nodes of ressource use and core to the solution
  - 50% of cities of 2050 are still to be built
  - 50% have been already built (including infrastructural backbones)
- **Project goals:**
  - Technology matrix (100 local technologies for a CO_2 free future)
  - Scenario analysis „Vision Munich 2058“

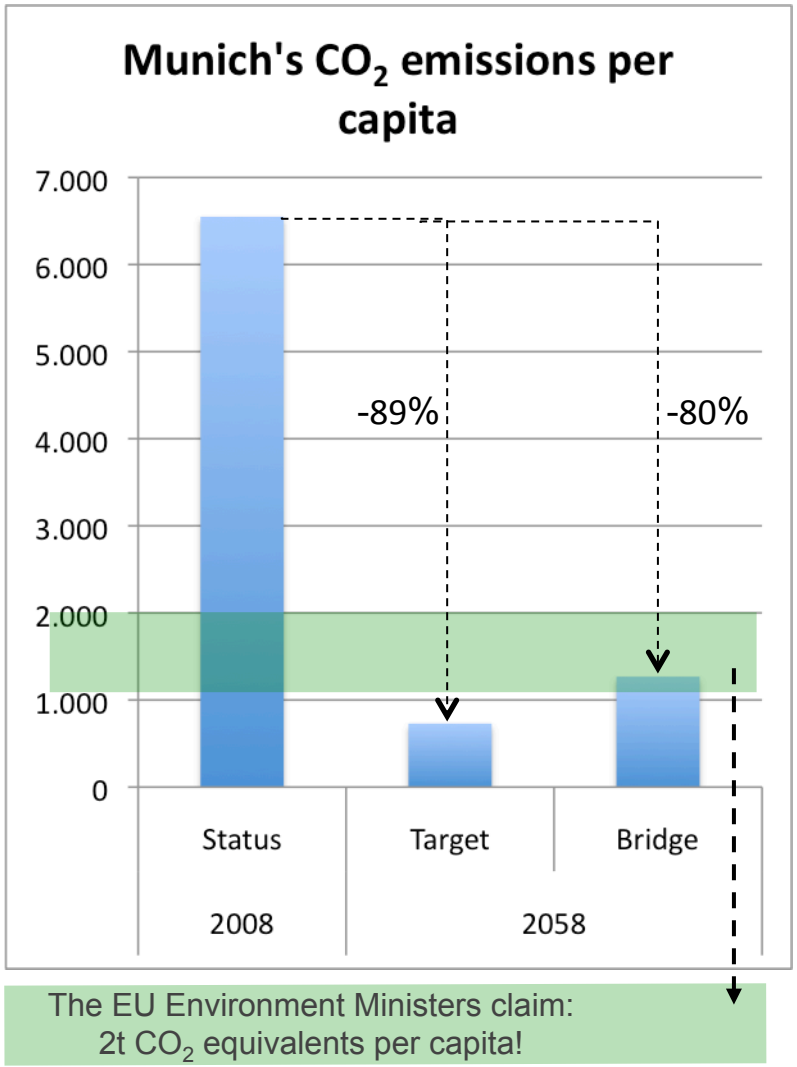
    Scenarios (Target & Bridge): 750 / 1300 kg CO_2/cap
  - Pilot district „CO_2 free“ by 2038
  - ***Future oriented technology portfolio for manufacturer***
  - ***Economic chances of being a low carbon frontrunner***

Example Munich:
Two pathways to a carbon free city

- We analysed the period up to 2058 (the cities 900 anniversary)
- As ambitious climate protection goal orientation on the EU decisions took place: The EU Environment Ministers target: 2t CO_2 equivalents per capita!
- We described two different ways cutting down $CO_{2,eq}$ emissions to 2 tons per capita annually

750 kgs
in the „Target“ Scenario (more ambitious target)

1.300 kgs
in the „Bridge“ Scenario (corresponds to 2 t CO_{2eq}/ a



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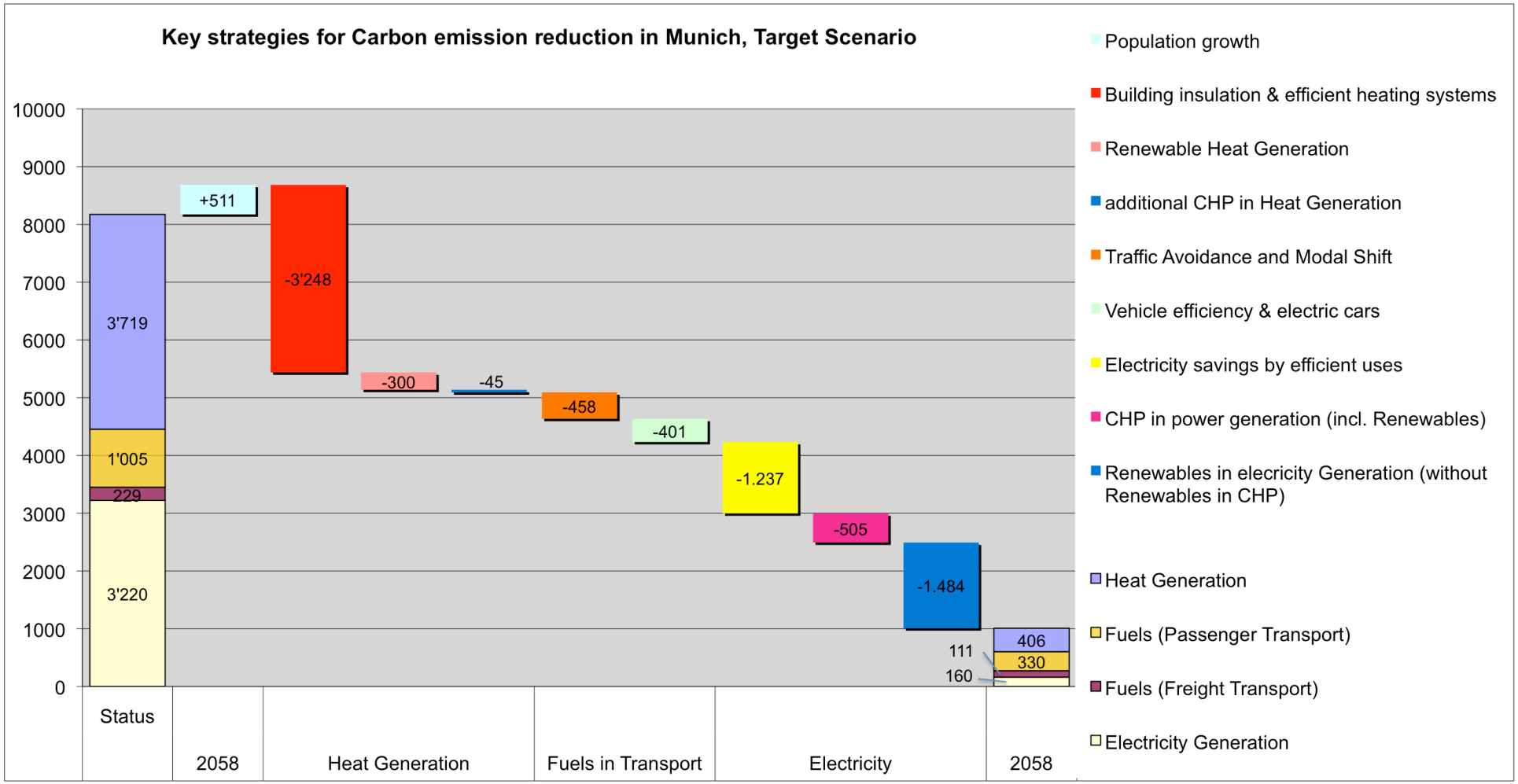
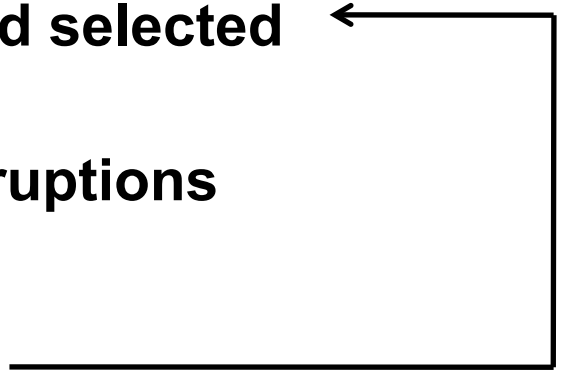
Munich 2058: Key strategies for 90% CO2 reduction



Outlook and summary: Scenario analysis – how to approach (a practical guide in 9 steps)

- Analysis of the problem (achievement of climate protection target)
- Analysis of the environment and the determining aspects/ variables
- Assumptions about Business as Usual (BAU) development
- Consistency check and definition of alternative future paths
- Scenario writing (definition of storyline and selected strategies)
- Identification and analysis of possible disruptions
- Impact analysis
- Re-Formulation of scenario if necessary
- Identification and implementation of measures based on scenario analysis



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Vielen Dank für Ihre Aufmerksamkeit

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