Wuppertal Institute
for Climate, Environment
and Energy

The role of NG as an enabler for energy system transformation in Germany

Results of a short study commissioned by Greenpeace Germany e.V.

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Future Energy and Mobility Structures

IGRC Seoul
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Introduction - The Wuppertal Institute

„Research for a sustainable future“

- **Foundation: 1991 under the direction of Prof. Dr. Ernst Ulrich von Weizsäcker**
- **President: Prof. Dr. Uwe Schneidewind**
- **Sustainability: System view ecology – economy – social affairs at regional, national and international level**
- **Interface between science, politics, economy and society**
- **Four interdisciplinary research groups with about 170 employees**
- **approx. 80 – 100 projects per year**
- **Budget 2009: 2.2 billion euros federal promotion by NRW approx. 9 billion euros of funding (UN, EU, ministries, economy, NGOs)**
- **Research Group 1: Future Energy and Mobility Structures**

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Background of the study for Greenpeace Germany

Initial situation:

- Climate protection and energy security require radical restructuring of current energy supply structures in the coming decades
- Renewable energy (RE) is developing very dynamically; e.g. share of gross electricity consumption in Germany: 5.4 % (1999) → 17.0 % (2010),
  Federal Government expects 38.6 % in 2020 („National action plan for renewable energy“ of 4th August 2010)

Challenge for the near future:

- High levels of fluctuating feed electricity sources (wind and PV)
- Coverage of the positive residual load from fossil power plants

Medium- to long- term challenges:

- Full coverage of energy demand with renewable energies
- Absorbing the increase occurring negative residual load through storages and demand side management
- Designing the transitional period and cope the system integration task (including power infrastructure)

The study:

- Identification of the contribution of the energy source of natural gas to solve the requirements described (Bridge to a renewable age)
- Investigation of the supply situation with natural gas and for natural gas substitutes (biogas, LNG, SNG) today and tomorrow

The study

Central questions:

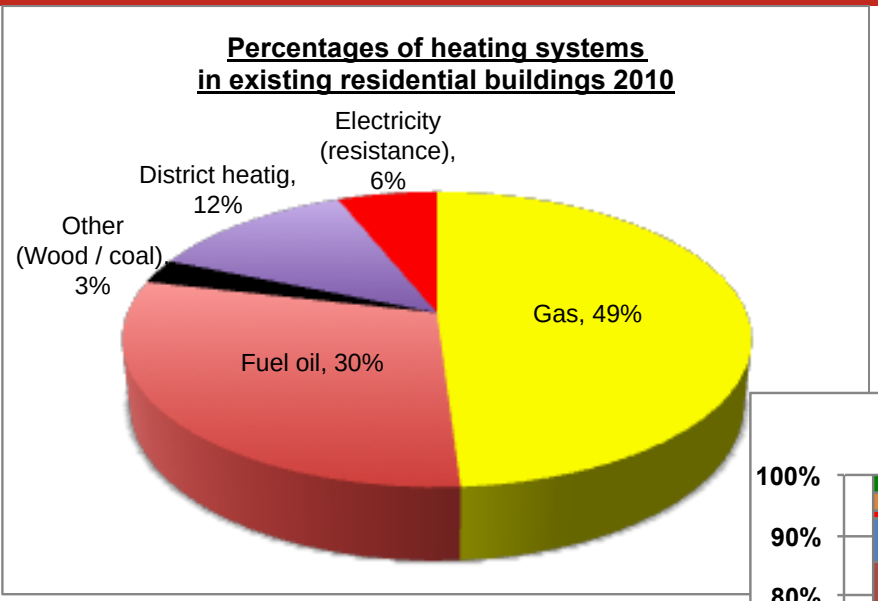
1. What are typical natural gas applications for today and can they be described as sustainable for tomorrow?
2. What is the role of natural gas for the energy supply of today and tomorrow – can natural gas take over the bridge function and help to pave the way towards a fully renewable energy supply?
   Focus presentation: Role of natural gas for the **transition path** in the field of **electricity-** and **heat supply**
3. Where do we get gas from nowadays and what will change in future – do we have to expect higher risks for the energy system?

Content structure:

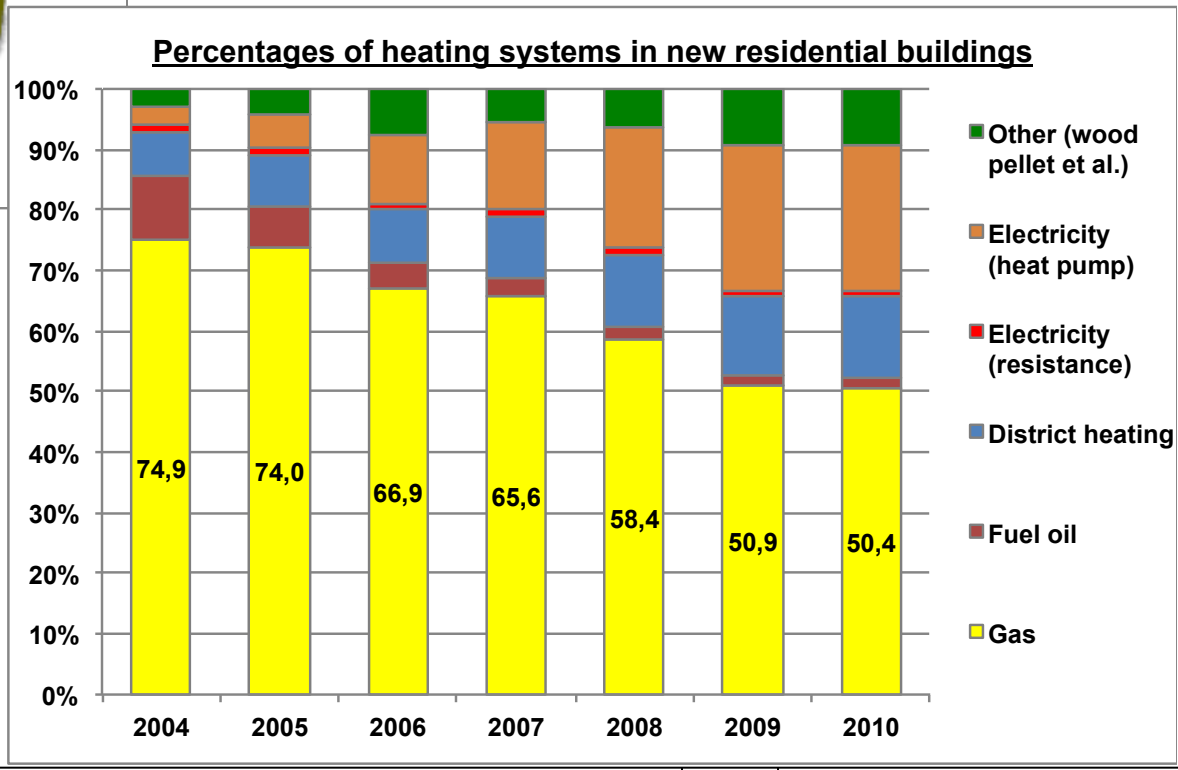
1. **Gas applications** (in heat, electricity and transport)
2. Role of natural gas in **climate change scenarios**
3. **Natural gas supply** today and tomorrow

Natural gas applications in the heating market

Development trends in the German heating market: New and existing residential buildings

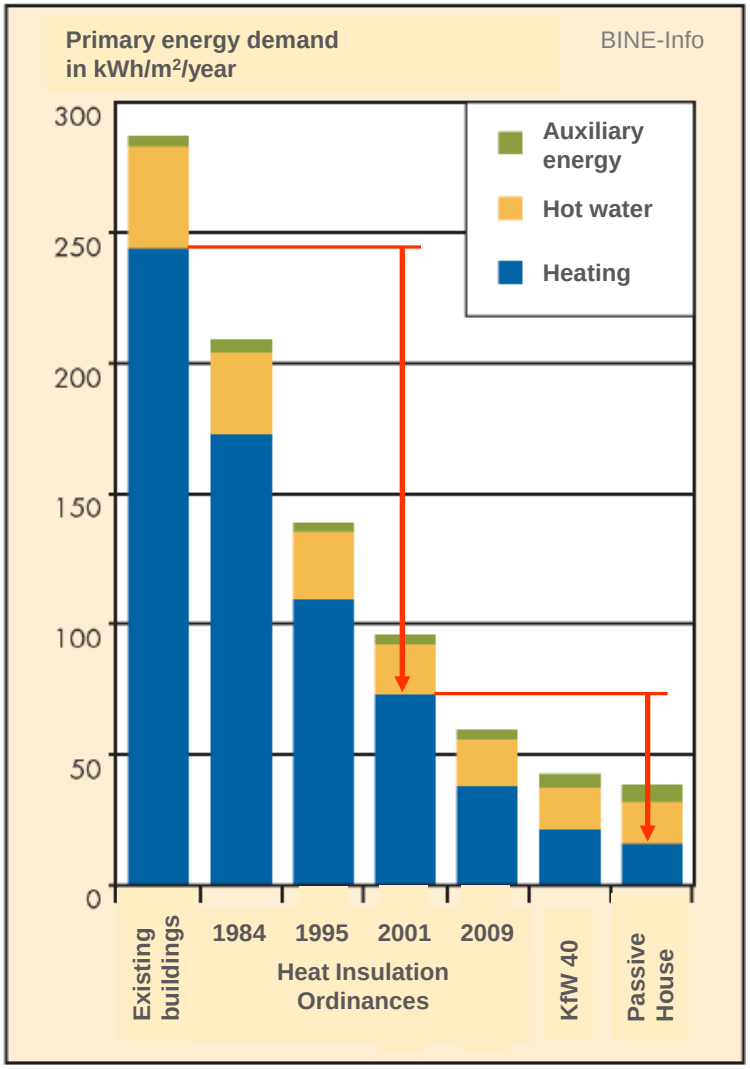


Data: BDEW 2011



Development trends in the heating sector

Deep reduction of specific heat demand through building energy efficiency



Source: BINE 2005, own additions

Modernization according to EnEV 2001 vs. Old buildings

Photo: D. Schüwer

70 instead of
240 kWh/(m²/year)
→ - 71 %

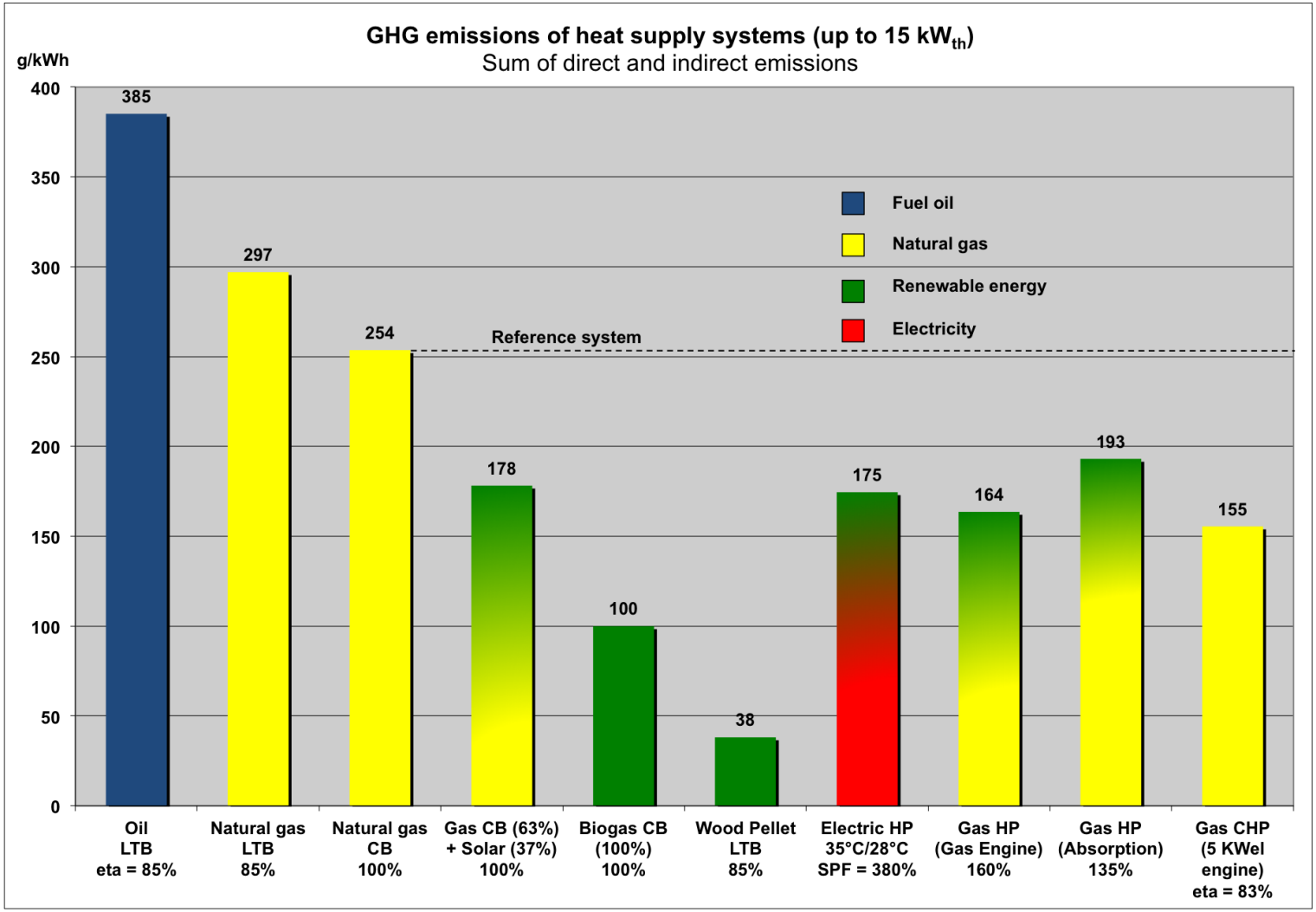
Passive houses vs. EnEV-2001-standard

Photo: Interpane

15 instead of
70 kWh/(m²a)
→ - 79 %

Development trends in the heating sector

Reduction of GHG-emissions (including upstream chains) through innovative heating technologies and renewable heating fuels



RE-shares: 25 to 100 %

GHG-savings vs. reference: 25 to 85 %

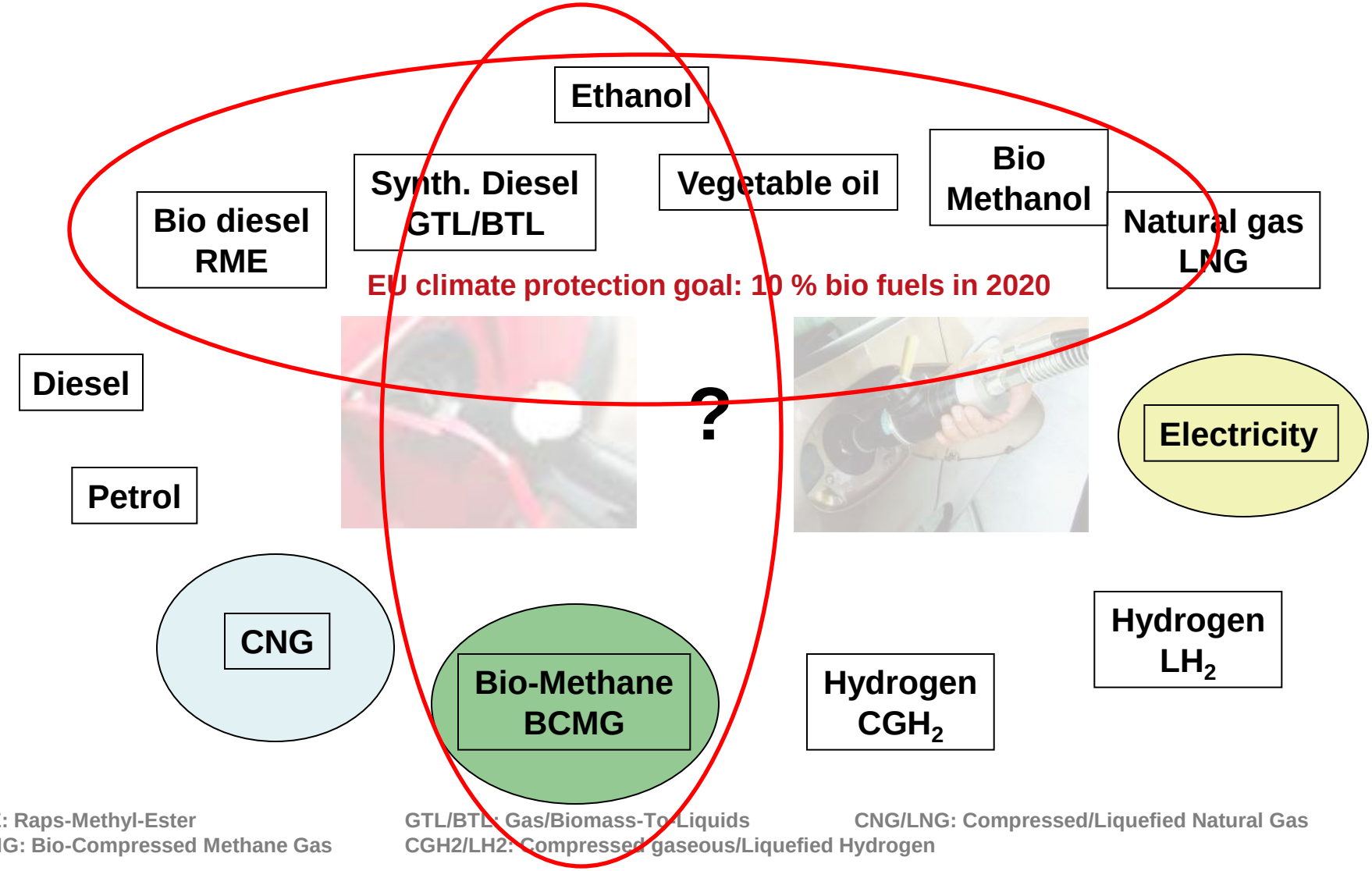
Source: Own calculations with GEMIS 4.2 or 4.4

LTB: Low Temperature Boiler
CHP: Combined Heat and Power
CB: Condensing Boiler
eta: Annual Efficiency
HP: Heat Pump
SPF: Seasonal Performance Factor

Natural gas applications in the transport sector

Natural gas is not the only alternative fuel

What fuels do we want to / will we fill up with in future?



RME: Raps-Methyl-Ester
BCMG: Bio-Compressed Methane Gas

GTL/BTL: Gas/Biomass-To-Liquids
CGH2/LH2: Compressed gaseous/Liquefied Hydrogen

CNG/LNG: Compressed/Liquefied Natural Gas

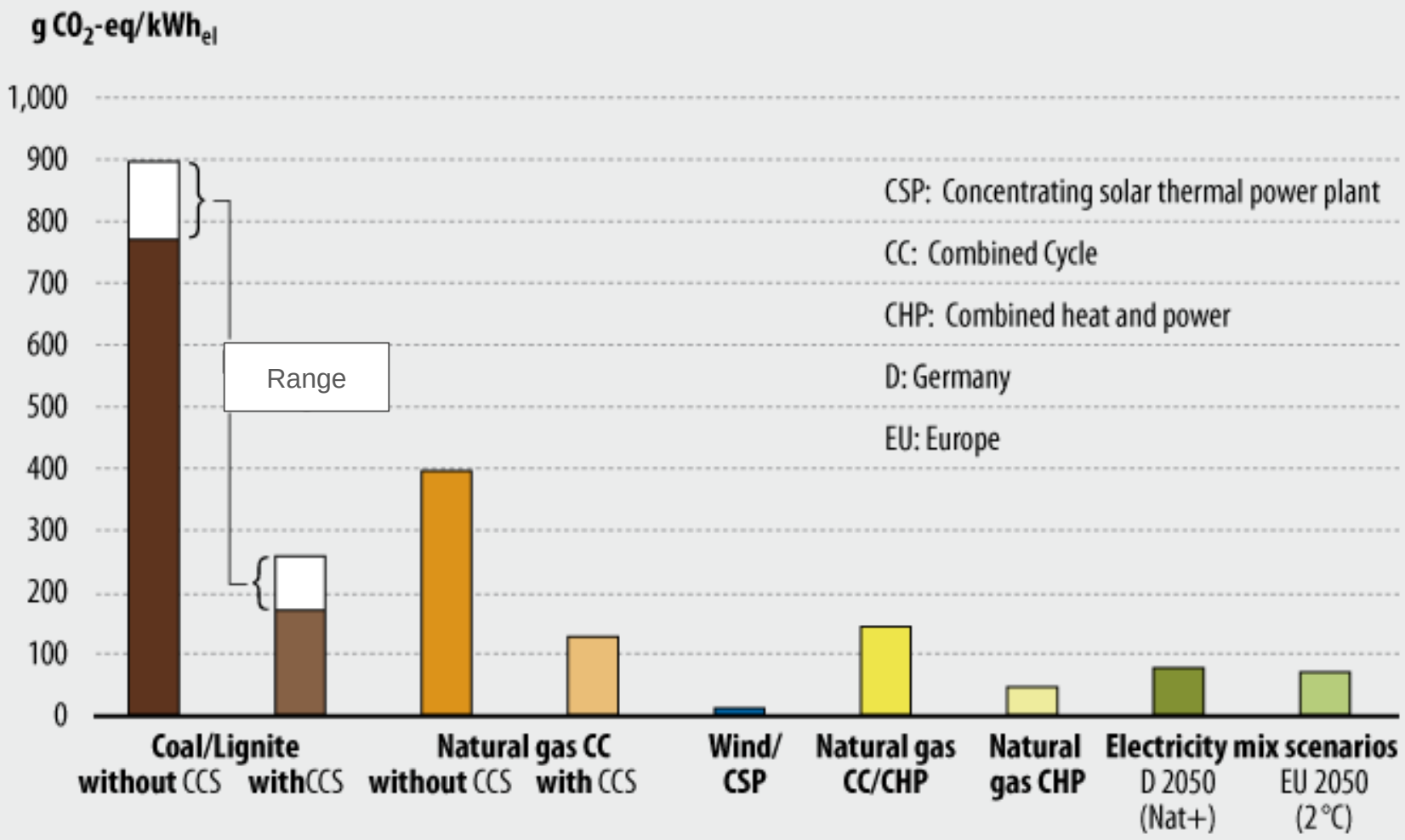
Natural gas in the transport sector: Precursor for gaseous renewable fuels

Strenghts	Weaknesses
Less GHG	New infrastructure (gas stations) needed
Significantly less air pollutants	Lower volumetric energy density and vehicle efficiency→ shorter range → lower customer acceptance
Reduced energy tax rate for natural gas by 2018 → lower fuel costs for the user	Severe and possibly additional tank
Precursor for the use of biogas and possibly renewable hydrogen or RE-methane as fuel	Higher cost of natural gas cars
Contribution to the diversification in the transport sector („Away from oil“)	

Natural gas applications in the electricity sector

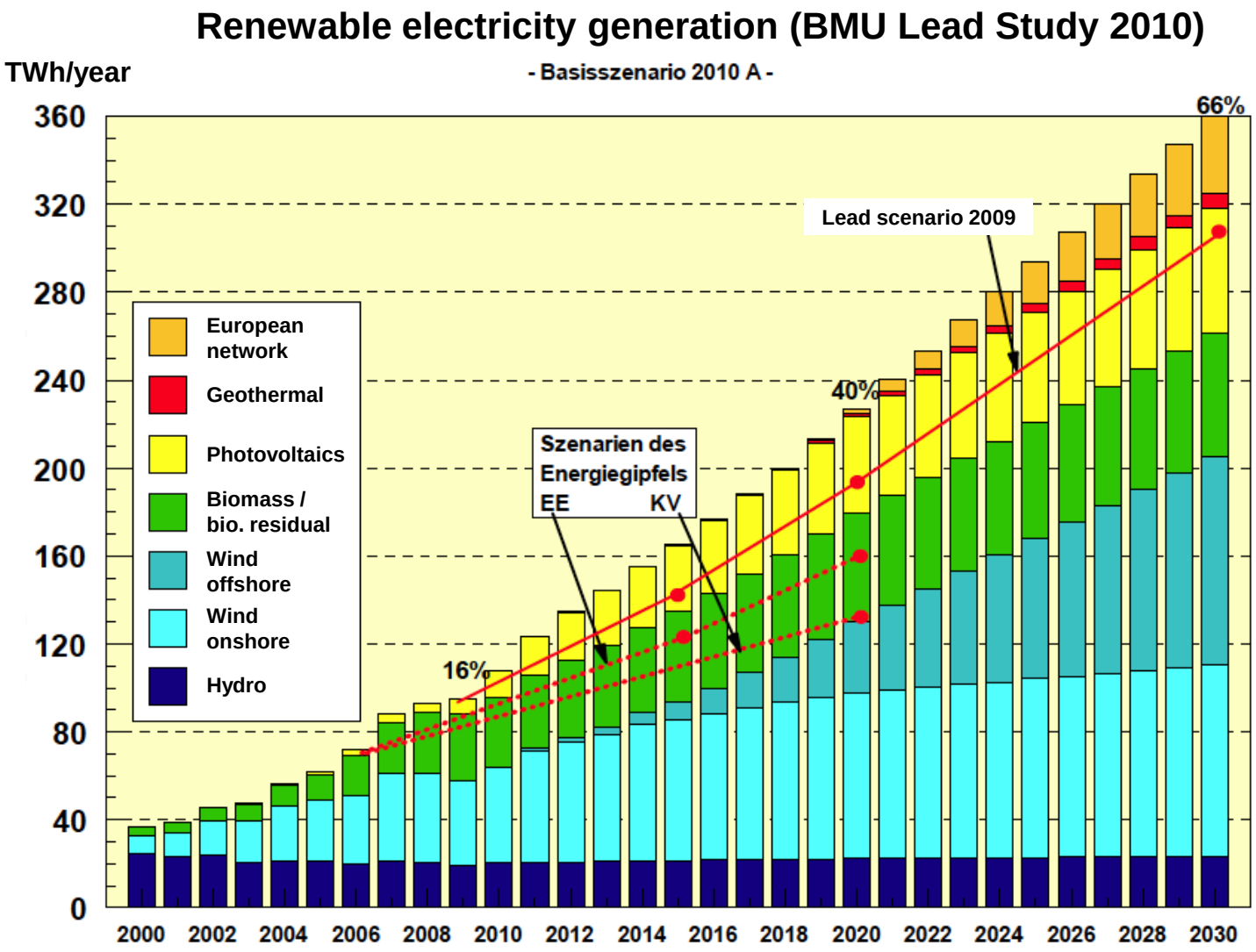
Role of natural gas in the electricity market

Comparison of GHG emissions – gas technologies, available today, meet standards that will only be met by coal-CCS in the future



Natural gas in the electricity market

Electricity generation from renewable energy sources is increasing dramatically - increasing the demands on system integration



Share 2020: 40%
(cf.NAP-draft: 38,6%)

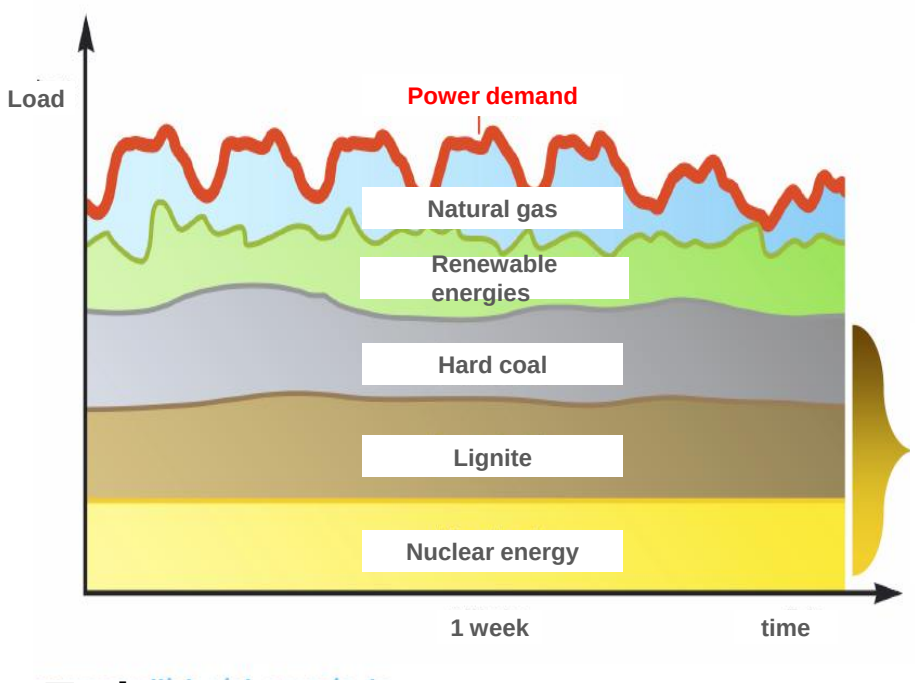
RE capacity 2020:

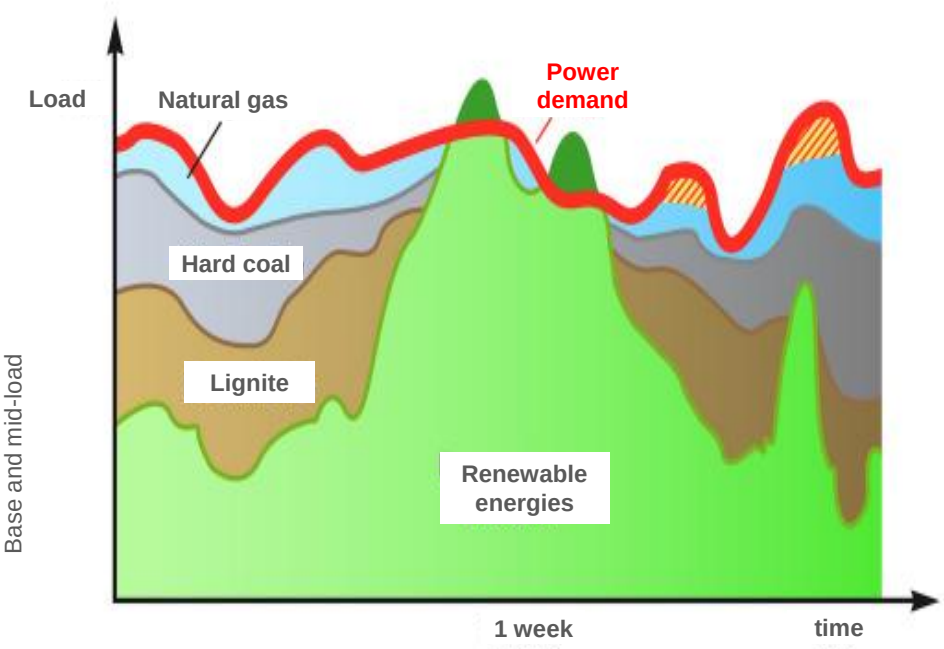
Total:	**112 GW**
Running water:	4,7
Wind country:	35,8
Wind sea:	10,0
Photovoltaic:	51,8
Biomass:	5,3
Biogas:	3,6
Geothermal:	0,3
Import:	0,6

Challenge:
Around 98 GW of fluctuating generation capacity (≈ today´s nuclear-fossil power plant park)

Natural gas in the electricity market

Requirements for power plants in the future energy mix - the challenges are increasing (task: coverage of residual load)





Today:

- Base load / mid-load / peak load
  → based on electricity consumption

Future:

- Renewable + CHP + balancing energy + storage
- → based on wind- /solar power supply and electricity consumption

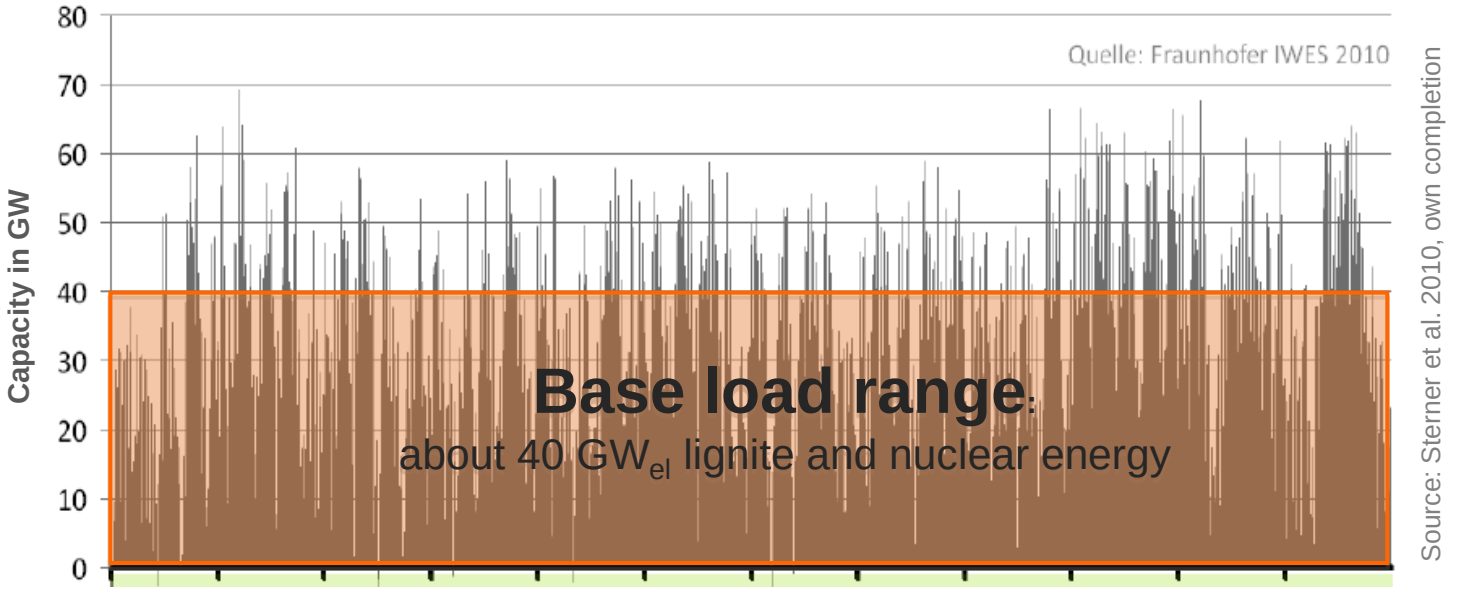
Source: Agentur für Erneuerbare Energien 2009

Natural gas in the electricity market

Fluctuating renewable electricity sources make future base load power plants uneconomical

Residual load (load minus uncontrolled ERE-feeding) during the year

(47% share of renewables in the BEE scenario assumed for the year 2020, weather base year 2007)



Source: Sterner et al. 2010, own completion

System conflict!

Conclusion:

- The present usual basic, intermediate and peak load structures will disappear - this is economically problematic, especially for high fixed cost systems
- The increasing fluctuations require increased power dynamics "bridge fossil power plants"

Natural gas and nuclear energy

Possible contributions of natural gas for a (climate-friendly) accelerated exit out of the use of nuclear energy in Germany

- Stronger utilization of in-use gas power plants
- Recommissioning of plants from the cold reserve
- Additional construction of gas power plants (gas and steam, industrial cogeneration, distributed CHP)
- Renewable Energy (Biogas)
- Compensation measures by gas applications in other sectors (eg. gas heat pump)

Source: Tagesschau

Natural gas in the electricity market
Requirements for power plants in the future energy mix

Strengths of natural gas power plants in the peak load:

- For decades proven highly flexible technology (especially gas turbines)
- Lowest cost of capital within the fossil fuel power plants with relatively high fuel costs→ even possible with a lighter load of economic operation
- Both centralized and decentralized control option („Swarm electricity“ of virtual power plants, decentralized CHP with big heat stores)

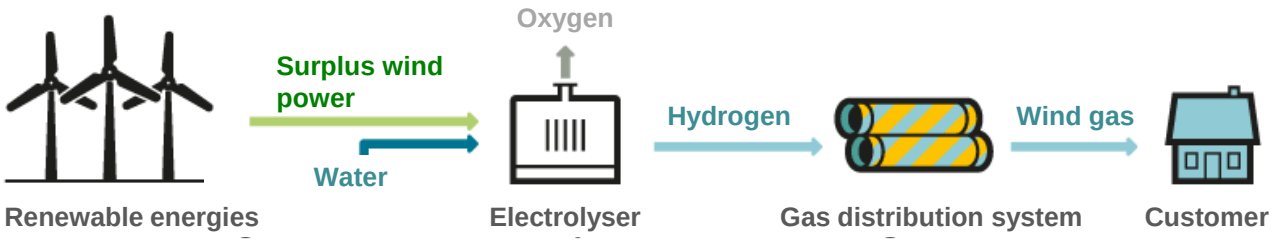
Technological challenge of system integration REG

Hydrogen or natural gas as a chemical energy storage (Surplus electricity generation for electrolysis)

- Increasingly **fluctuating power generation** (wind, solar) requires not only short-term perspective, balancing energy, but also long-term storage
  (week storage, seasonal storage)
- **Capacities** of available systems **are very different**
  - Pumped storage: 0,7 TWh_{el} (range few hours)
  - E-Mobility: 0,45 TWh_{el} (range 6 hours)
    45 billion vehicles per 10 kWh_{el}
  - Gas network: 100 TWh_{el} resp. 200 TWh_{th} (range 2 month)
    Cf. wind power generation in 2009: 27 TWh_{el}
- **Possible utilization of existing infrastructures (H_2-feed gas network)**
  - Full supply of wind power generation in 2009 in form of hydrogen in the gas network equivalent H_2-share of 7,8%
  - Proportionate feed of perspective wind power generation in 2020 (20%) corresponds to the hydrogen content of 4%
- **Full flexibility through Power to Gas (PTG / synthetic methane / methane-RE)**

From the idea to the first marketable offer:

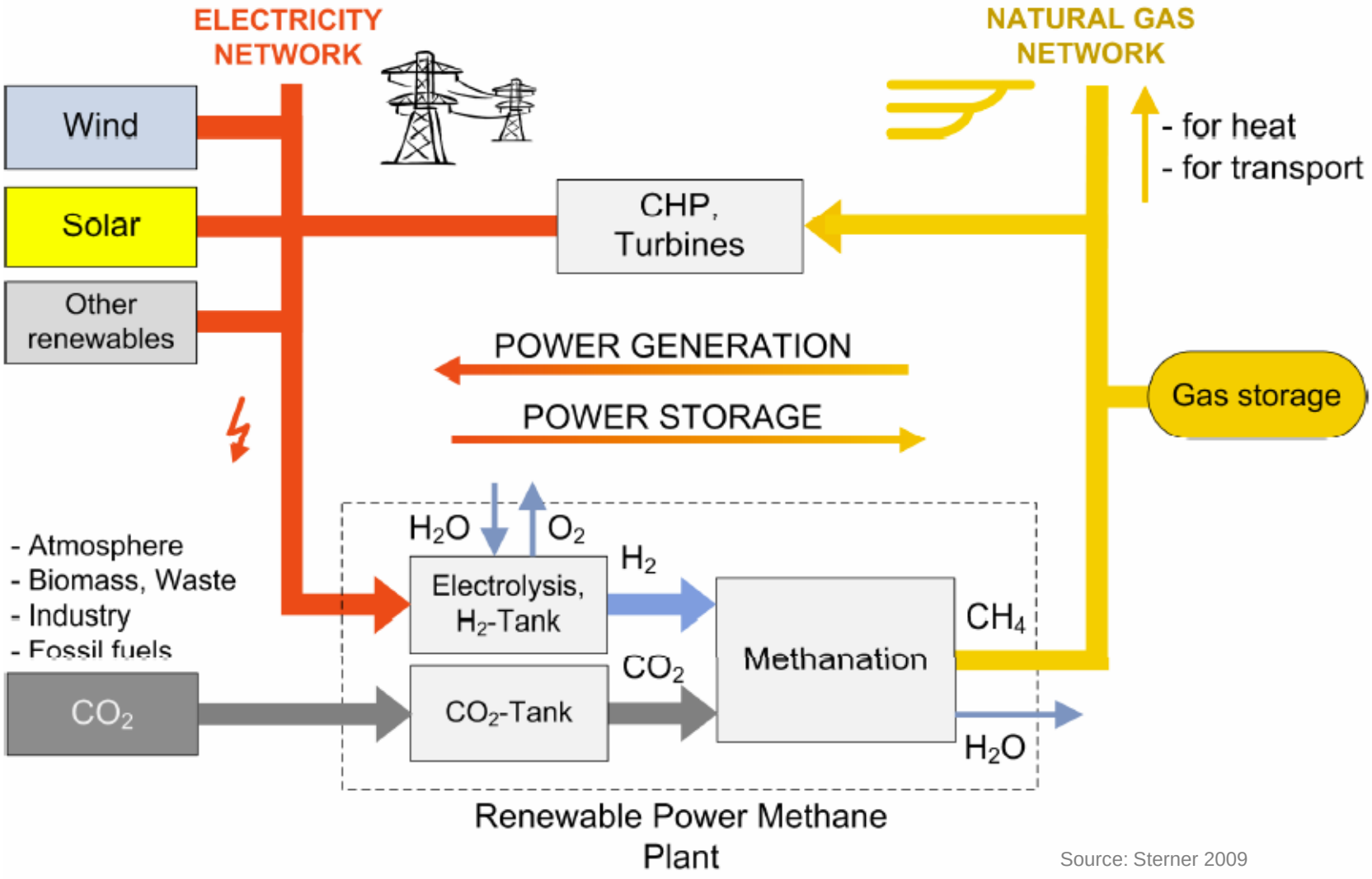
*pro*Windgas of GREENPEACE ENERGY



Source: Greenpeace Energy 2011

Natural gas in the electricity market

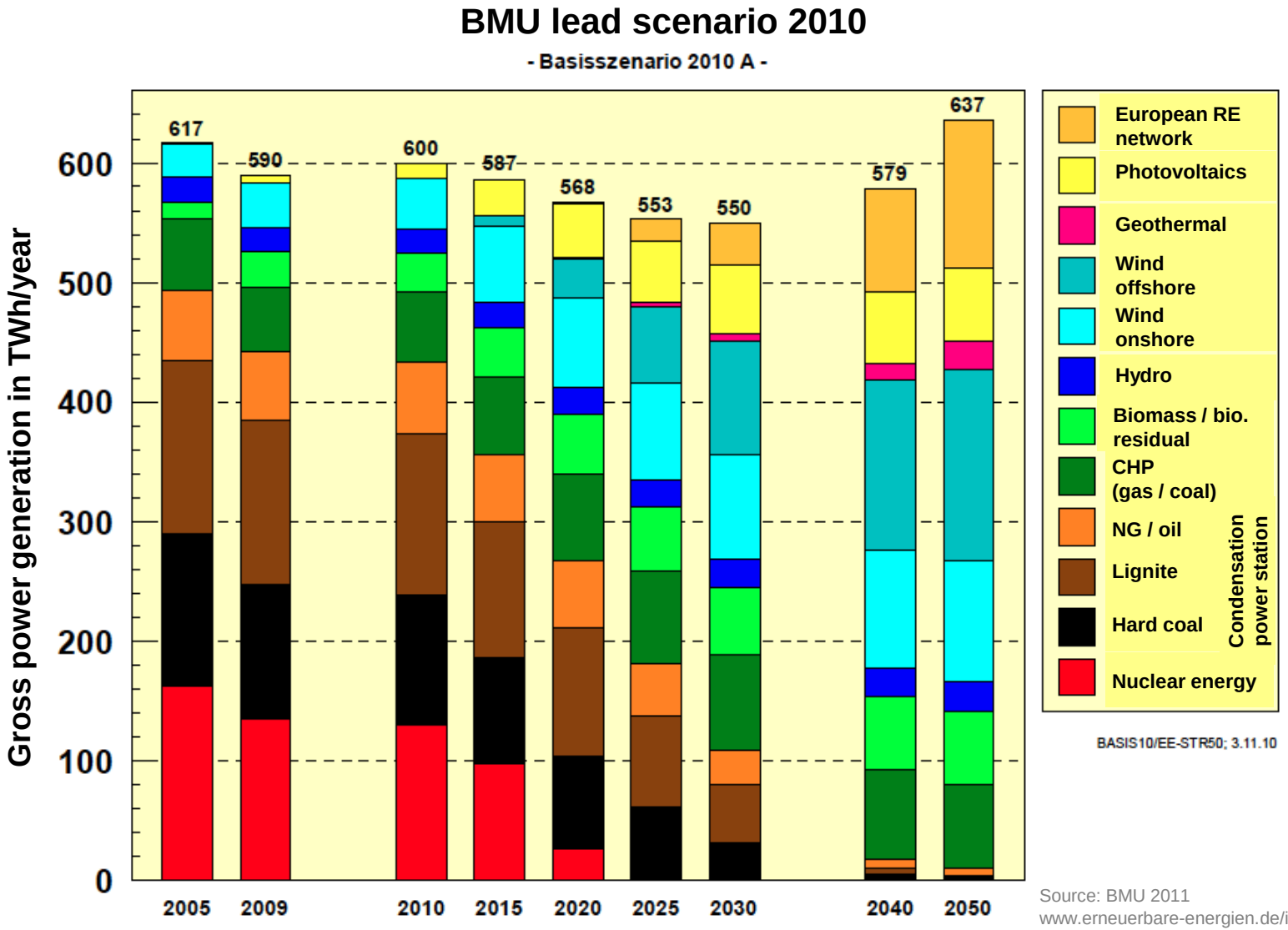
Natural gas as electricity storage (Power to Gas) - RE-Methane as bridge between the electricity- and gas network



Source: Sterner 2009

Role of natural gas in the electricity market

Lead Study 2010 of the Federal Environment Ministry (BMU): Shift to CHP (centralized and decentralized), an important task for the rule energy supply

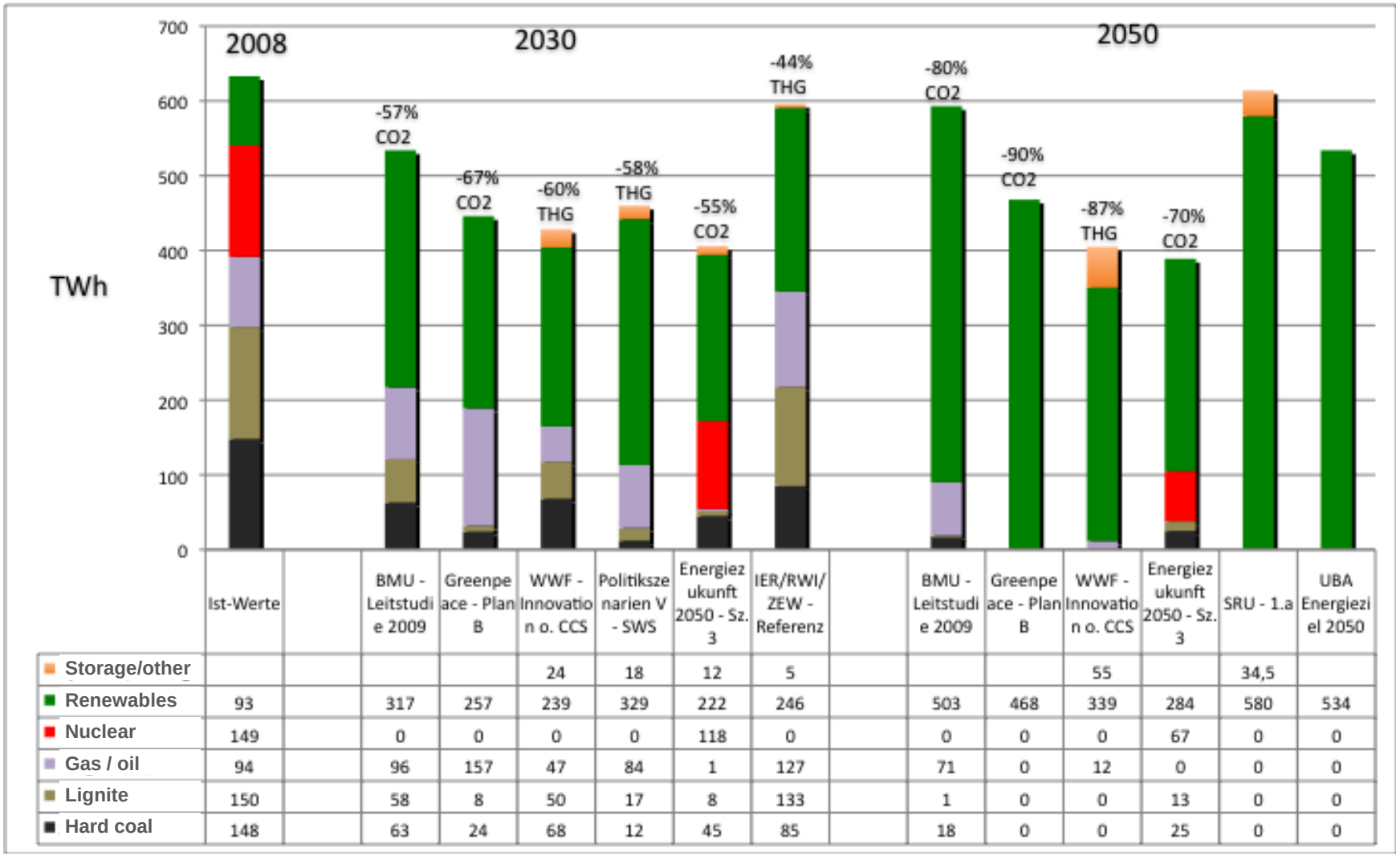


Source: BMU 2011
www.erneuerbare-energien.de/inhalt/47034/4502

Role of natural gas in the electricity market

In the medium term, gas as central fossil fuel on the way to a 100% renewable supply - a robust statement of many scenarios

Power generation mix in 2030 and 2050 for various climate protection scenarios



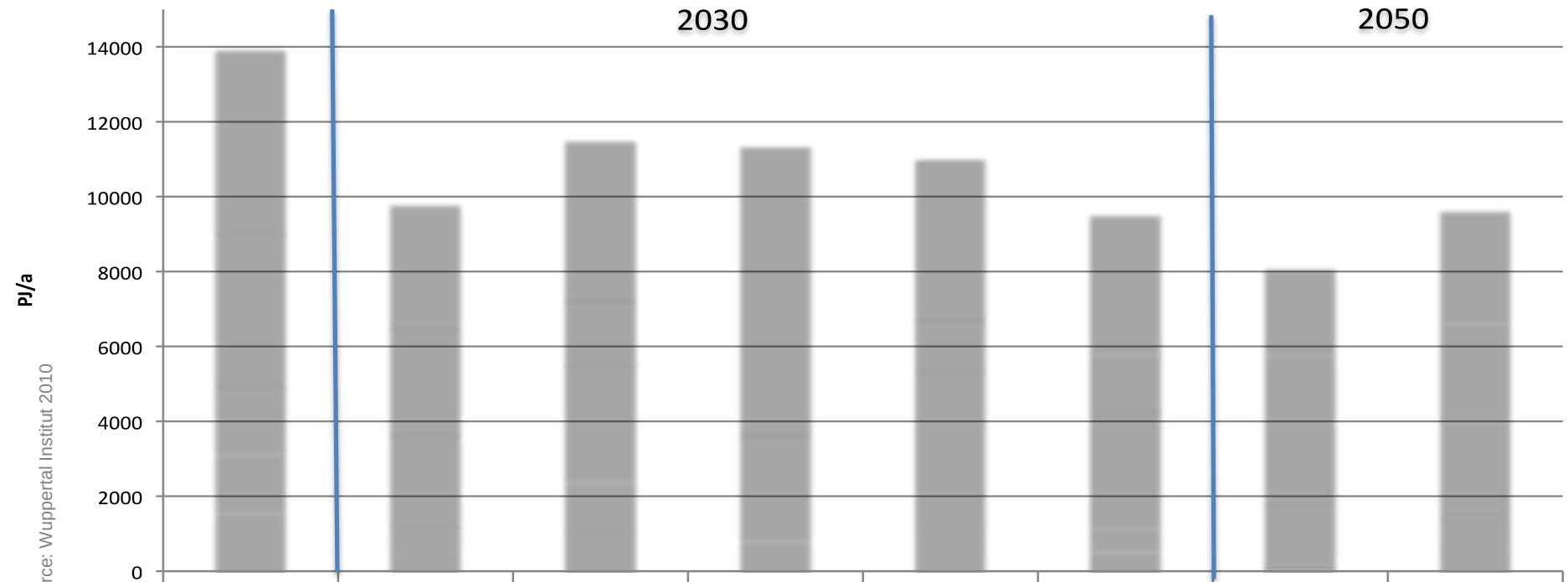
	Ist-Werte		BMU - Leitstudie 2009	Greenpeace - Plan B	WWF - Innovation o. CCS	Politikszenarien V - SWS	Energiezukunft 2050 - Sz. 3	IER/RWI/ZEW - Referenz		BMU - Leitstudie 2009	Greenpeace - Plan B	WWF - Innovation o. CCS	Energiezukunft 2050 - Sz. 3	SRU - 1.a	UBA Energiezieel 2050
Storage/other					24	18	12	5				55		34,5	
Renewables	93		317	257	239	329	222	246		503	468	339	284	580	534
Nuclear	149		0	0	0	0	118	0		0	0	0	67	0	0
Gas / oil	94		96	157	47	84	1	127		71	0	12	0	0	0
Lignite	150		58	8	50	17	8	133		1	0	0	13	0	0
Hard coal	148		63	24	68	12	45	85		18	0	0	25	0	0

Source: Wuppertal Institut 2010

Natural gas in the context of the entire energy system

The role of natural gas for the energy supply of today and tomorrow

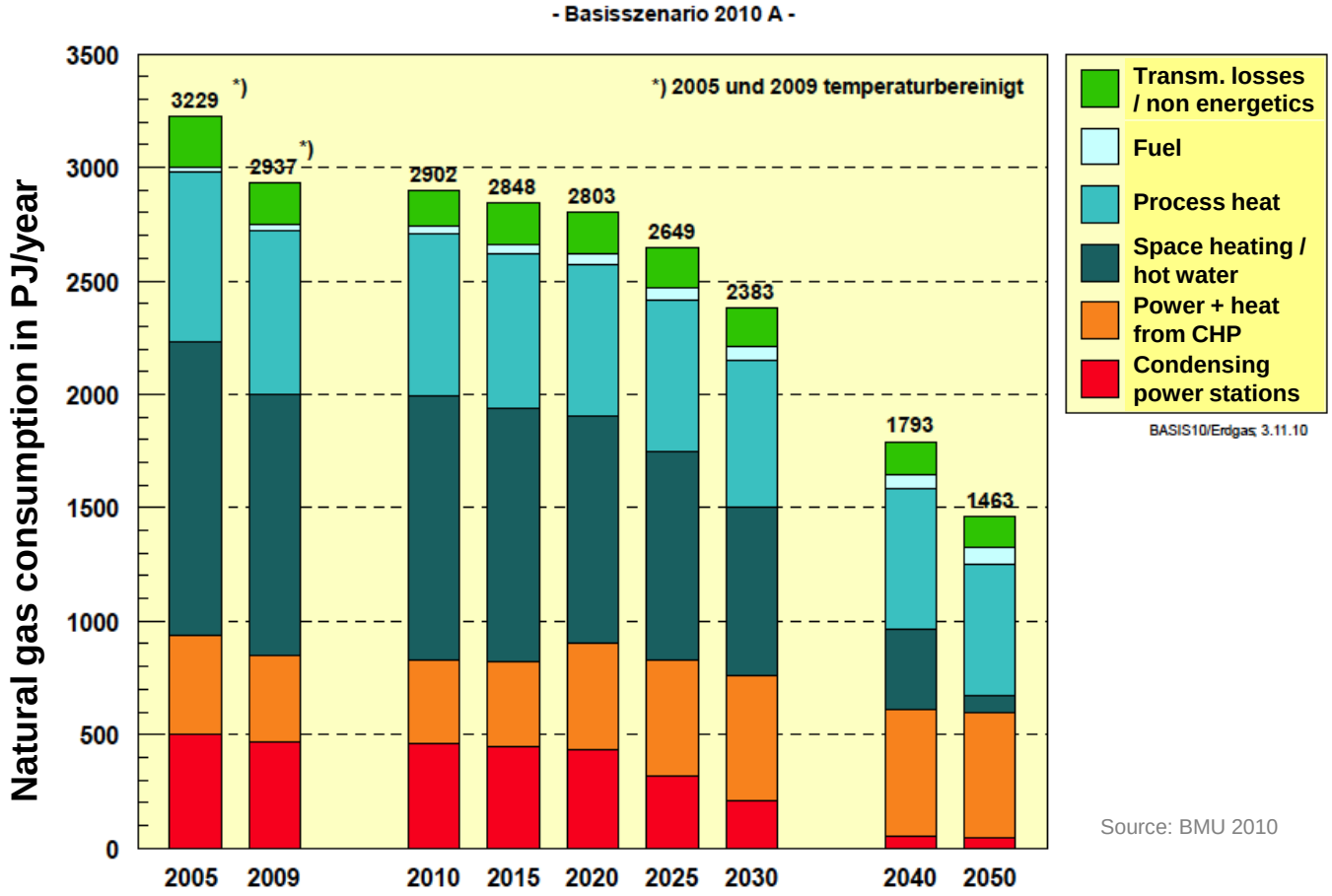
Primary energy use in various studies in 2020 and 2050



	Energiedaten 2008	Leitszenario 2009	RECCS	Politikszenarien V	Energiewirts. Gesamtkonzept 25%	Energiewirts. Gesamtkonzept 40 %	Leitszenario 2009 (2050)	RECCS (2050)
Oil	4868	3300	4246	3279	4277	3714	2305	2987
Renewable	995	2834	1742	4378	1366	1529	4024	2620
Natural gas	3091	2468	3107	2865	4347	3121	1606	2567
Hard coal	1832	714	1330	219	428	598	193	831
Lignite	1554	530	1122	656	657	611	9	669
Nuclear	1632	0	0	0	0	0	0	0
Climate protection targets compared to 1990		- 57%		-47,9%	- 30%	- 50%	- 79,5%	- 75%

Conclusion for natural gas applications in the heating, electricity and transport sectors.

Changes in the absolute natural gas consumption according to a BMU Lead Study 2010



Source: BMU 2010

Conclusion:

Savings in the heating sector can overcompensate for an intensified use of natural gas in the electricity sector.

Conclusions
Natural gas: Bridge to a Renewable Age

Conclusion for the natural gas applications

- **Heat sector**
  Savings of considerable amounts of natural gas through consistent energetic building refurbishment plus use of highly efficient gas applications (condensing solar / decentralized or micro-CHP / gas HP)
  → Margin for displacement of natural gas from the heat into the power sector!

- **Electricity sector**
  Key position through low greenhouse gas emissions, flexible and highly efficient power generation in combined cycle and cogeneration plants as well as central and decentralized provision of system services for the integration of renewable electricity sources
  → Natural gas (not coal or nuclear energy) as a bridge!

- **Transport sector**
  Superordinate importance, however, possibly precursor for a future supply system with gaseous, renewably generated fuels (e.g. hydrogen or synthetic natural gas)

Conclusions
Natural gas: Bridge to a Renewable Age

Conclusion for the provision of natural gas (future supply situation)

Thesis:

- Despite the limited range the natural gas supply in Germany / Europe is secured under an appropriate policy framework with a high probability for the next few decades.

Reasoning:

- High savings in the heating market (up to 80% in the object)
- Alternate supply routes (eg Baltic Sea pipeline) or
- Alternative supply options (LNG, biogas, perspective H_2 shares up about 10% and synthetic methane from renewable electricity surplus)

Conclusion: Natural gas as bridge to a Renewable Age

- Both the consideration of the diverse and flexible gas applications as well as the analysis of key climate change scenarios show: Natural gas is the one fossil fuel that can ideally take over the function of a bridge for a transitional period up to the full supply with renewable energies
- Strategies have to be developed at the political level for the sensible use of natural gas and further reduction in consumption on the demand- as well as on the supply side for further diversification

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Thank you for your attention!

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Download the study „Erdgas: Die Brücke ins regenerative Zeitalter“ (Aug. 2010, German version):
www.wupperinst.org/projekte/proj/index.html?projekt_id=345
www.greenpeace.de/themen/energie/presseerklaerungen/artikel/erdgas_ist_die_brueckentechnologie_fuer_deutschland

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