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# Germany's path towards a nearly climate-neutral residential building stock 2050: Comparison of greenhouse gas mitigation strategies

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# Outline

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- The German governmental energy concept
- Current state of energy efficiency of buildings
- Definition and comparison of strategies
- Results (primary energy, $CO_2$ emissions, costs over strategy)
- Conclusions

# The German governmental energy concept

**Statement of the energy concept:**

*„Energy efficient refurbishment of existing buildings is the central key to modernise energy supply and to the achievement of climate change targets.“*

According to the governmental energy concept, the building sector will play a lead role in reducing primary energy consumption.

By 2050, the sector is prescribed to decrease primary energy demand (non-renewable energy) by 80 % compared to 2008 by:

- reducing heating demand by 20 % until 2020,
- ensuring all **new** buildings are climate neutral by 2020 and
- increasing the thermal retrofit rate from 0.8 % to 2 % per year.

# Current state of energy efficiency of buildings

- Buildings account for about 40 % of final energy consumption and about a third of $CO_2$ emissions. At the same time, there is great potential for saving energy and cutting $CO_2$.
- 68% of Germany's existing residential building stock was built before the first thermal insulation ordinance adopted in 1979.
- 50% of the residential buildings have insufficient insulation and another 30% have only a minor insulated building envelope.
- Around 50% of the heating systems are older than 24 years. The overwhelming majority of heating systems lag behind the state of the art.

# Definition of strategies (time horizon: 2013-2050)

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| Business as Usual | "Governmental" Energy Concept | Gas Innovation Campaign |
|---|---|---|
| ▪ Updating of existing policy instruments for building renovations | ▪ Implementing of building insulation along the German energy concept | ▪ Same policy instruments as in BaU |
| ▪ Building efficiency standards (EnEV 2014, EEWämeG) | ▪ More ambitous requirements of EnEV for existing buildings (2020 and 2030: +30%) | ▪ Efficiency standards (analogous to BaU) |
| ▪ Present rate of energy efficiency refurbishment: 1 %/a, Moderate increase from 2030 to 1.5 %/a in 2050 | ▪ Doubling the rate of energy efficiency refurbishment (from 2015) | ▪ Energy efficiency rate as BaU<br>▪ Increased use of renewable gas |
| ▪ Cycle of refurbishment of heating systems: 25 a | ▪ Cycle of refurbishment of heating systems: 25 a | ▪ Increased use of gas heating systems, cycle of refurbishment: 20 a |

Reference

Focus on:
Heat insulation (without considering renovation cycles)

Fokus on: innovative heating systems and renewable gases (in accordance with renovation cycles)

Project funded by: DVGW *(German Technical and Scientific Association for Gas and Water)

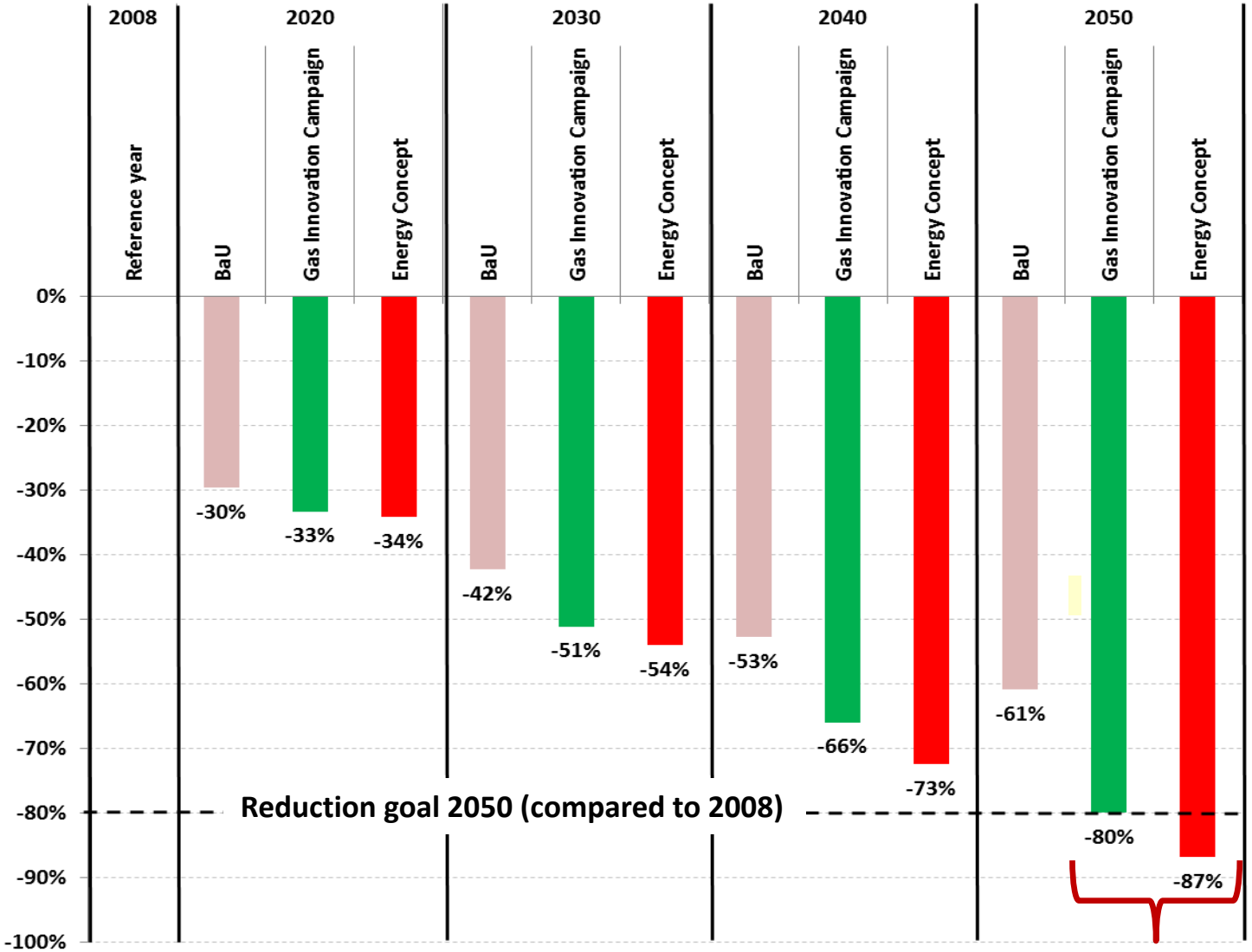
# Comparison of strategies: gas mixtures 2050

- Share of renewable gases (substitution of natural gas) (biogas, SNG from wood/waste and Wind-$H_2$-$CH_4$, PV-$H_2$-$CH_4$):
  - BaU 6 %,
  - Energy concept 30 %,
  - Gas Innovation Campaign 56 %.

- Specific $CO_2$ emissions compared with natural gas can be reduced:
  - BaU 6 %,
  - Energy concept 30 %,
  - Gas Innovation Campaign 47 %.

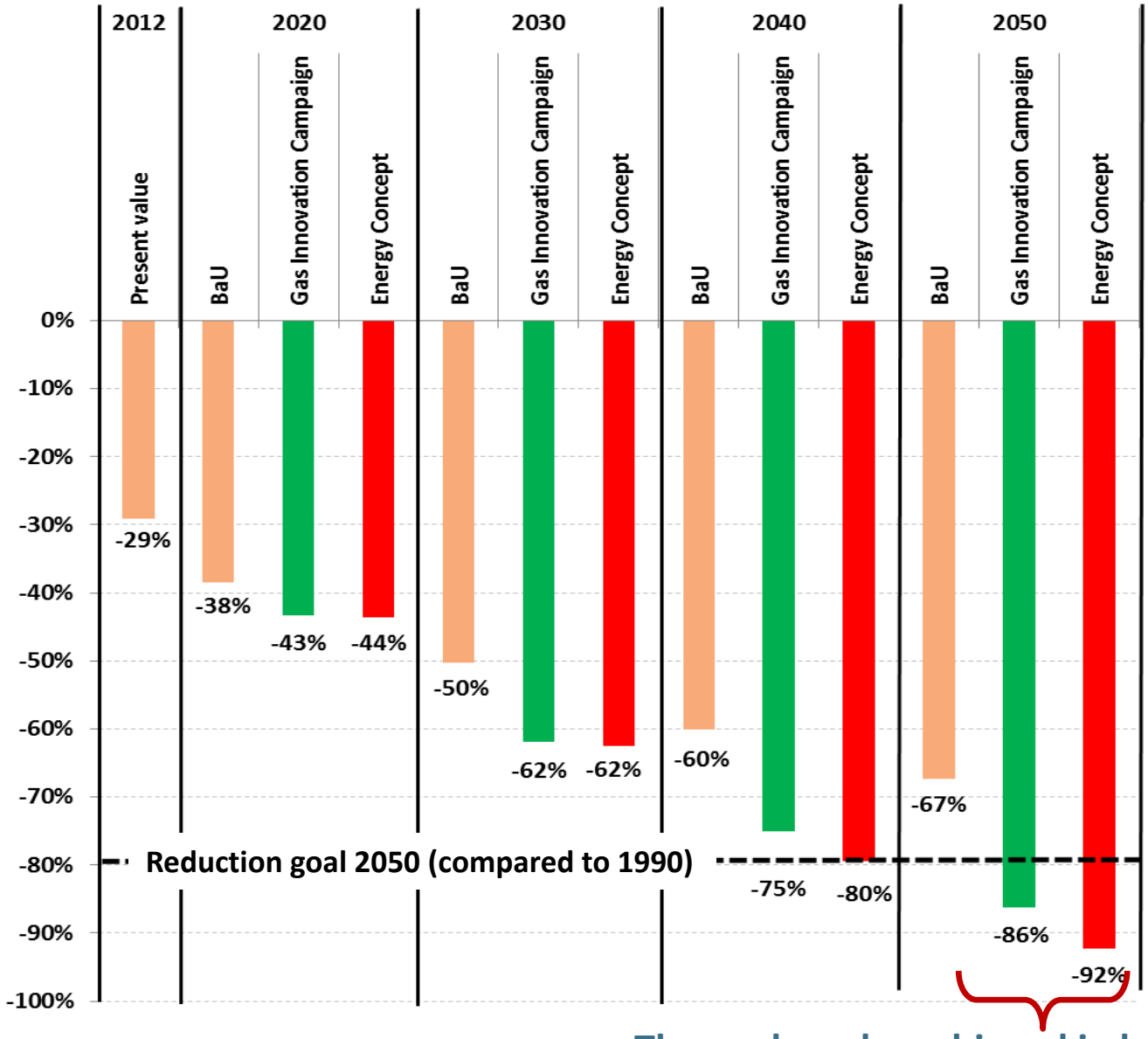
- Gas prices for private households increase from 2013 to 2050:
  - BaU 12 % (9 ct/kWh),
  - Energy concept 23 % (10,5 ct/kWh),
  - Gas Innovation Campaign 53 % (13,5 ct/kWh).

# Results:
# Primary energy consumption of space heating and hot water




**The goal can be achieved in both strategies!**

# Results: Development of $CO_2$ emissions




The goal can be achieved in both strategies!

# Results: Costs over strategy (present value 2013-2050)

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| | BaU | Energy Concept (EC) | | Gas Innovation Campaign (GIC) | |
|---|---|---|---|---|---|
| | absolute values | absolute values | Δ to BaU | absolute values | Δ to BaU |
| ▪ Investment costs (bn €) | **431** | 612 | **181** | 507 | **76** |
| ▪ Fuel costs (bn €) | **832** | 736 | **- 96** | 819 | **- 19** |
| ▪ Revenue micro-chp (bn €) | **10** | 16 | **6** | 65 | **55** |
| ▪ Net costs (bn €) | **1.253** | 1.332 | **80** | 1.260 | **7** |
| ▪ $CO_2$ emissions (incl. micro-chp) (Mio. $tCO_2$) | 2.395 | 1.752 | -643 | 1.788 | -607 |
| ▪ Specific reduction costs (€/$tCO_2$) | | | **124** | | **12** |

➡ The huge difference in specific reduction costs mainly due to lower investment costs in the Gas Innovation Campaign:

- Retrofits in the GIC are in accordance with renovation cycles,
- The EC concerns nearly maximum insulation standards.

# Conclusions

- Primary energy reduction goal of 80% until 2050 (compared to 2008) will be met with both strategies
- Both strategies are ambitious with regard to diffusion:
  - in accordance to renovation cycle or not
- Significant adavantages of the *Gas innovation campaign in terms of specific $CO_2$ reduction costs*
- Heat insulation measures are an important element in both strategies, but less in the *Gas innovation campaign*

→ **Low $CO_2$ reduction costs can be achieved by suitable weightening of all technical measures!**

# Thank you very much for your attention!

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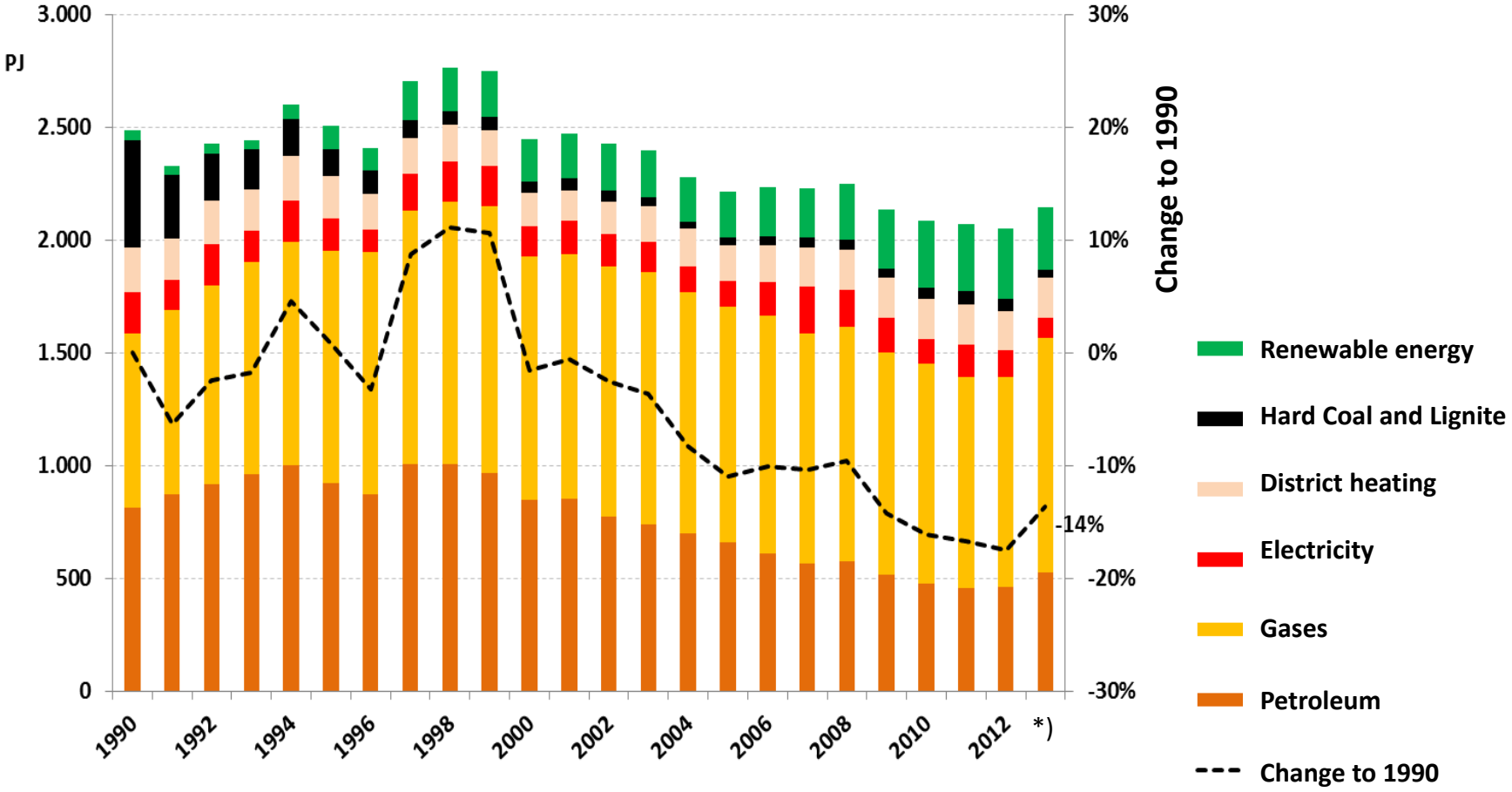
# Appendix (I)

# Final energy: Space heating and hot water

(residential building stock)

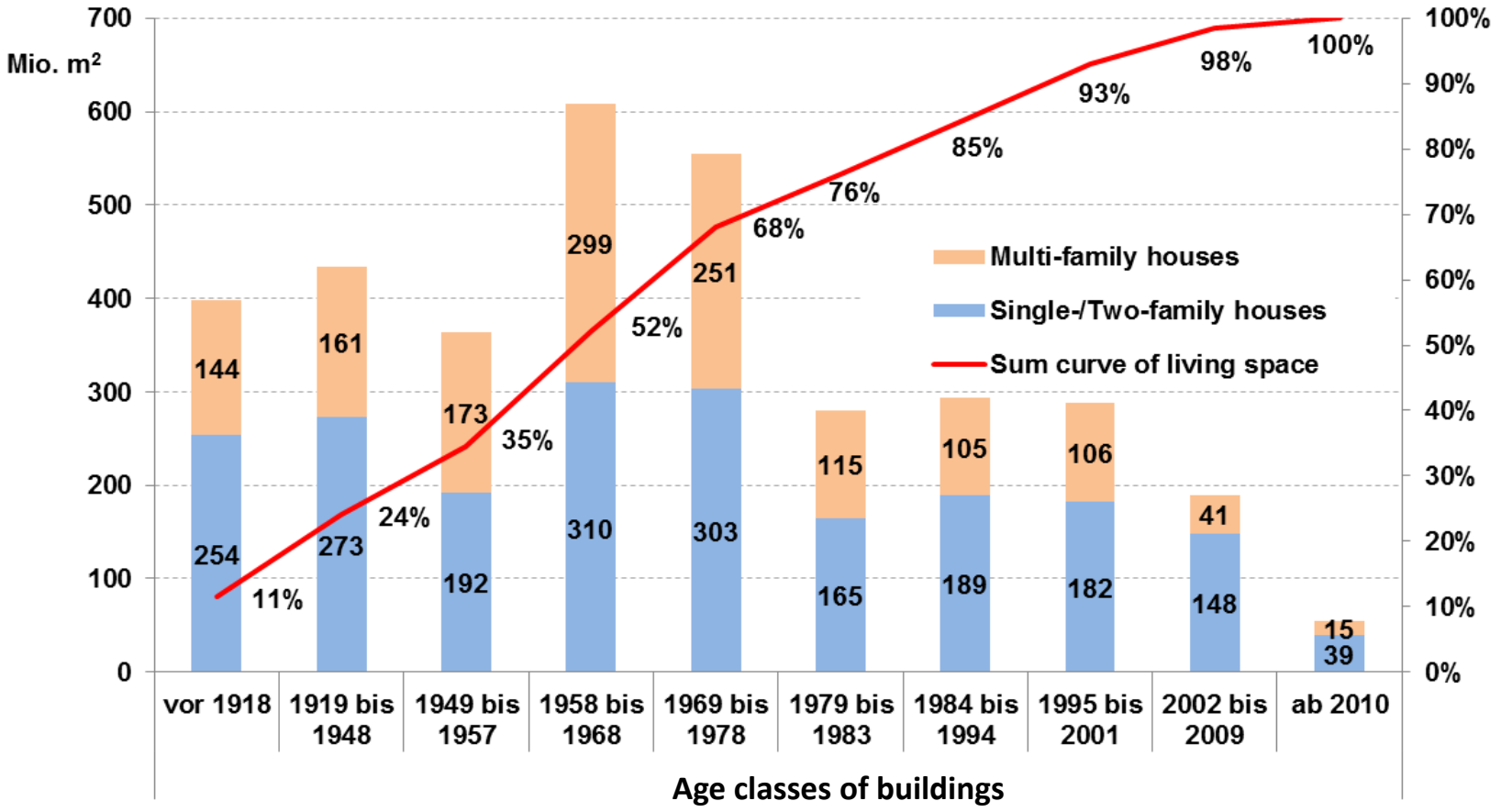



➡ The temperature corrected energy consumption decreased by 2013 compared to 1990 by 14% (2.150 PJ in 2013).

Sources: BMWi (2014), IWU (2014) *) Provisional figures for 2013

# Building stock 2013

## 18.5 Mio. Residential Buildings

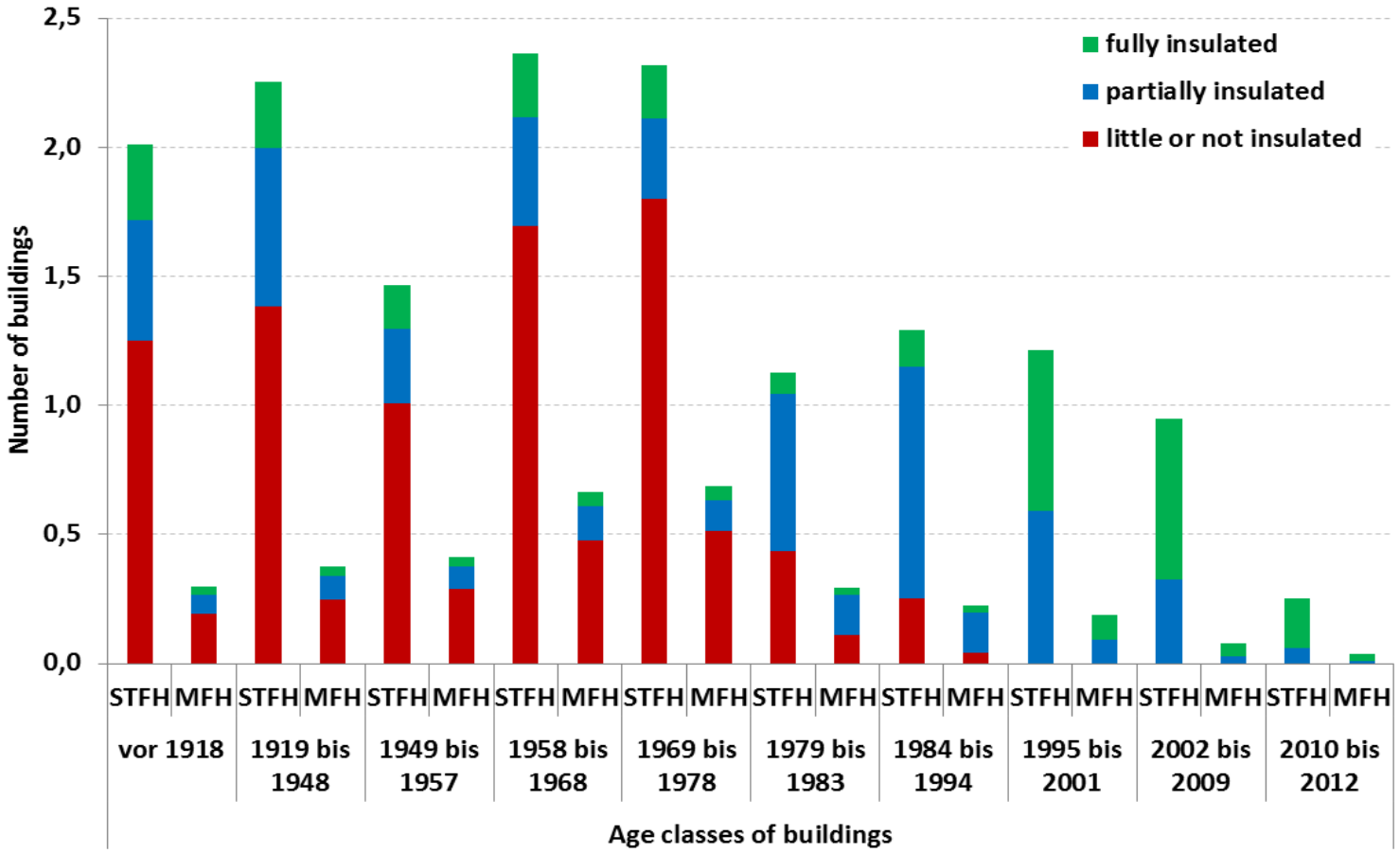



➡ 68% of Germany's existing building stock was built before the first Thermal Insulation Ordinance was adopted in 1979.

Sources: Destatis (2014), IWU (2013), IEK-STE

# Insulation of residential buildings

**2013: 15.4 Single- and Two-Family Houses (STFH), 3.1 Mio. Multi-family houses (MFH)**

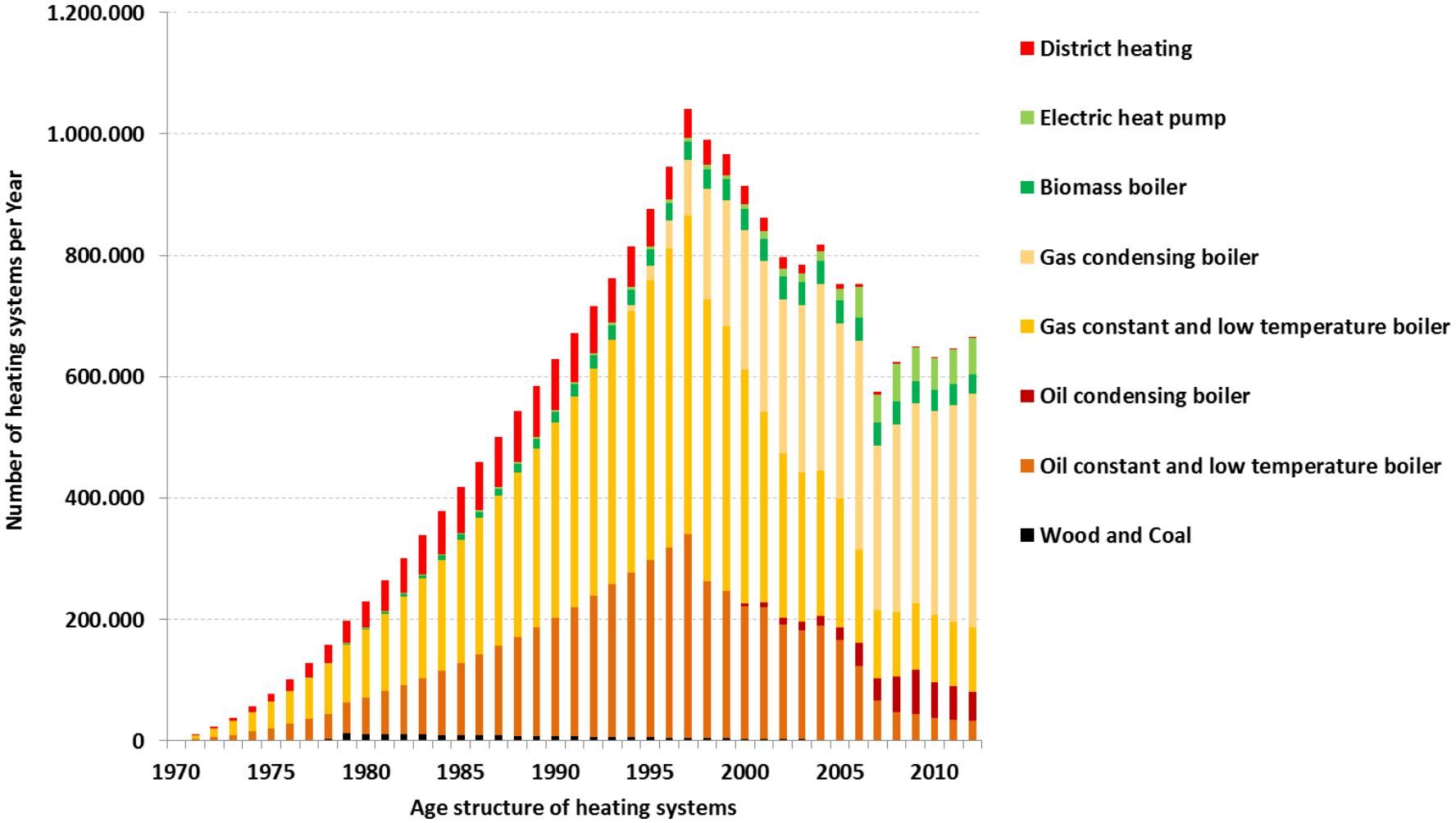



➡ 50% of the residential buildings have insufficient insulation and another 30% have only a little or not insulated building envelope.

Sources: DIEFENBACH et al. (2010), WALBERG et al. (2011), IEK-STE

# Stock of heating systems 2012

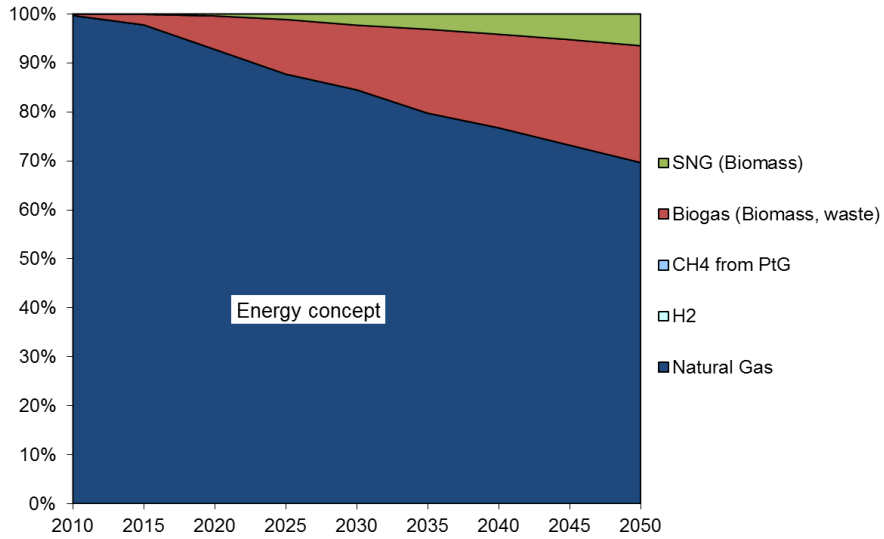
## Total: 23.2 Mio. heating systems

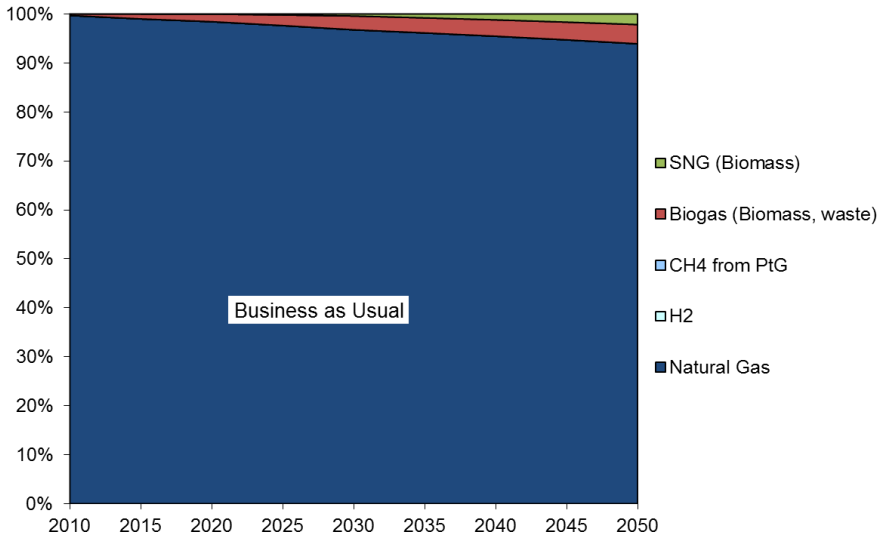


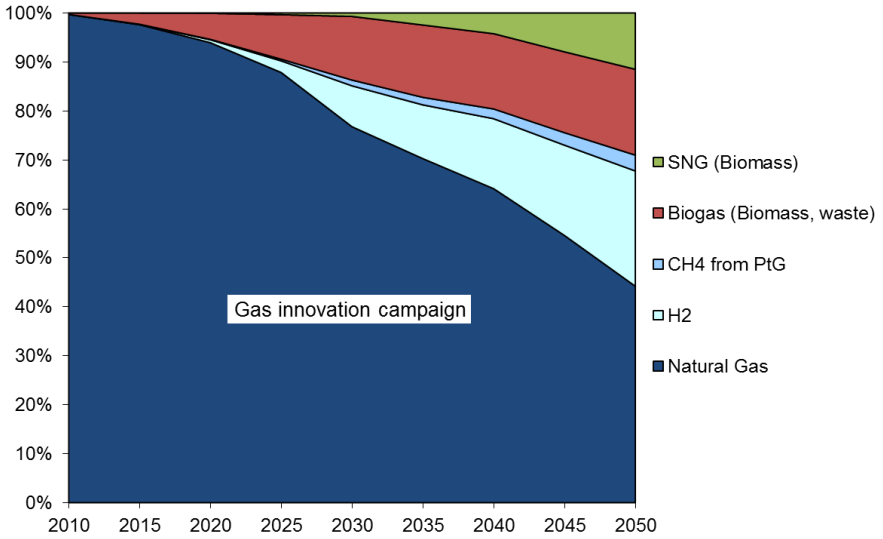

Around 50% of the heating systems are older than 24 years. The overwhelming majority of heating systems lag behind the state of the art.

Sources: ZIV (2013), BDH (2013), DEPV (2013), Shell-BDH (2013), IEK-STE

# Development of gas mixtures in the different scenarios (shares in Vol %)



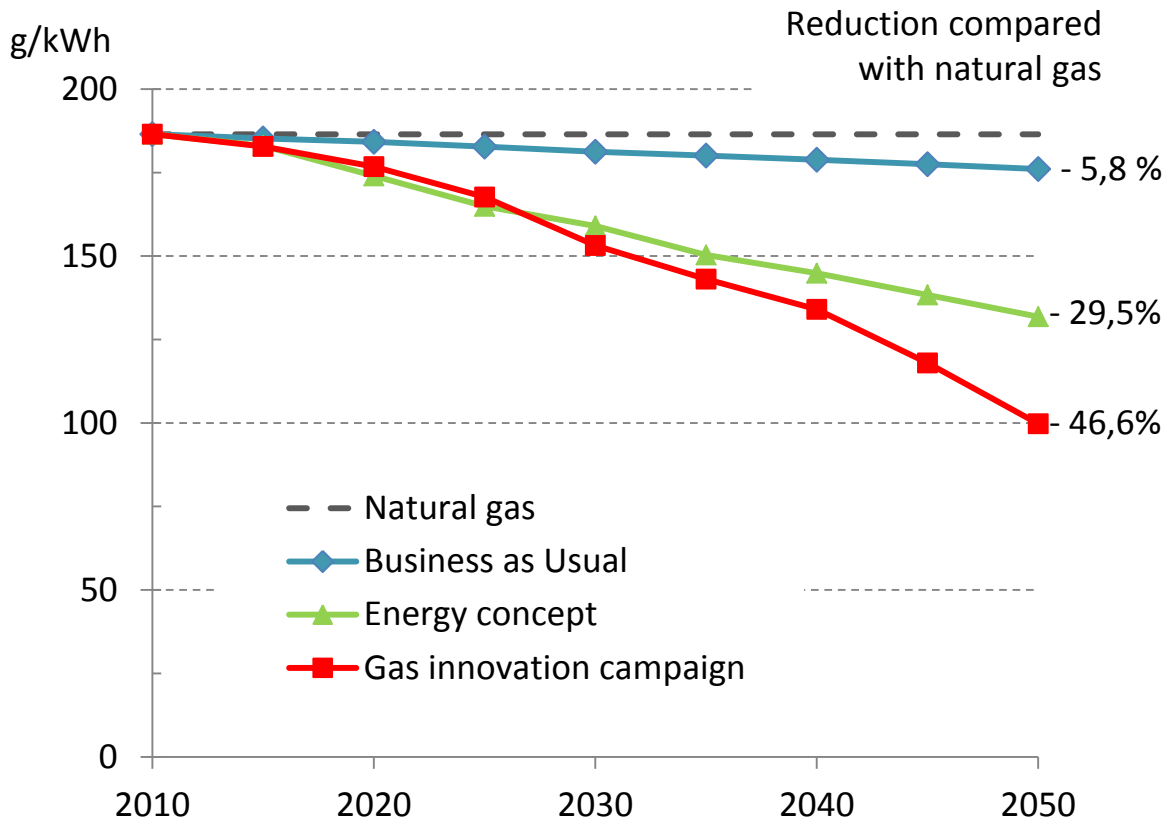




**Share[1)] of rewenable gas within the gas mixture in 2050**

| | |
|---|---|
| BaU: | 6,0% |
| Energy concept: | 30,3% |
| Gas innovation campaign: | 55,8% |

1) Vol-%

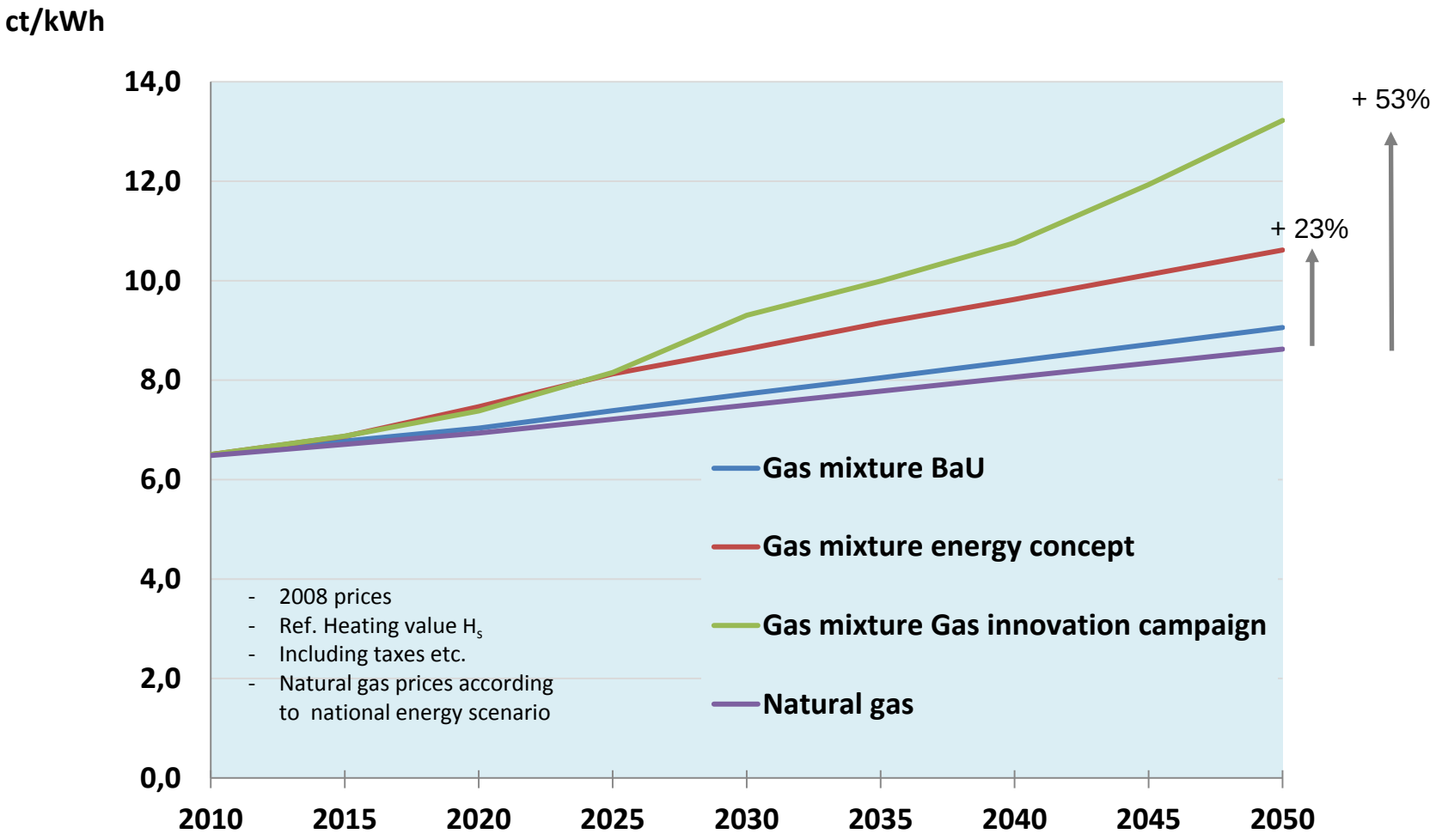
# Development of specific $CO_2$ emissions of gas mixtures



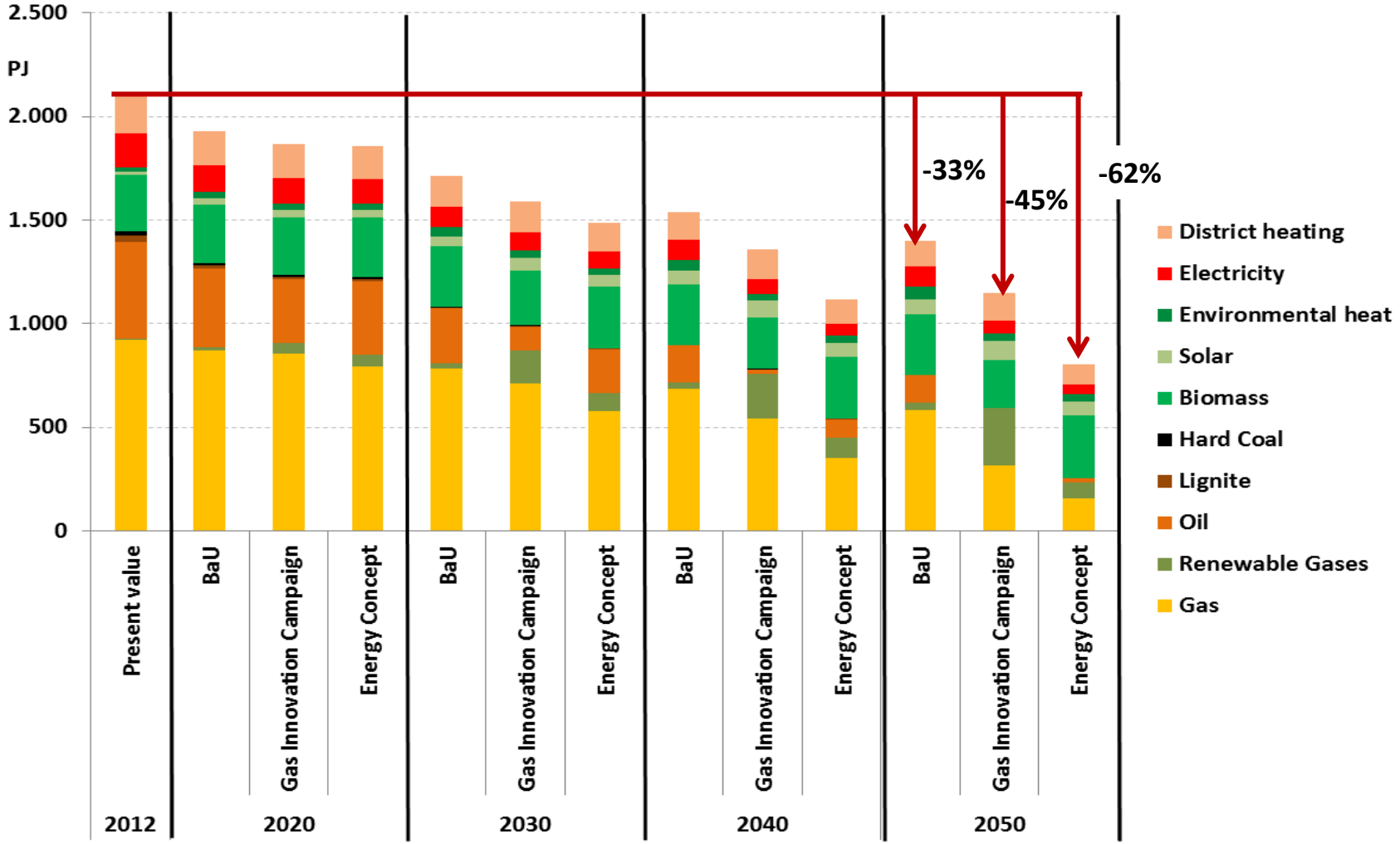

**Reference base:**

- Heating value $H_S$
- direct emissions
- Integration of biogas, SNG from wood/waste and Wind-$H_2$-$CH_4$, PV-$H_2$-$CH_4$

# Gas prices for private households



# Results:
# Final energy consumption of space heating and hot water



# Stock of heating systems

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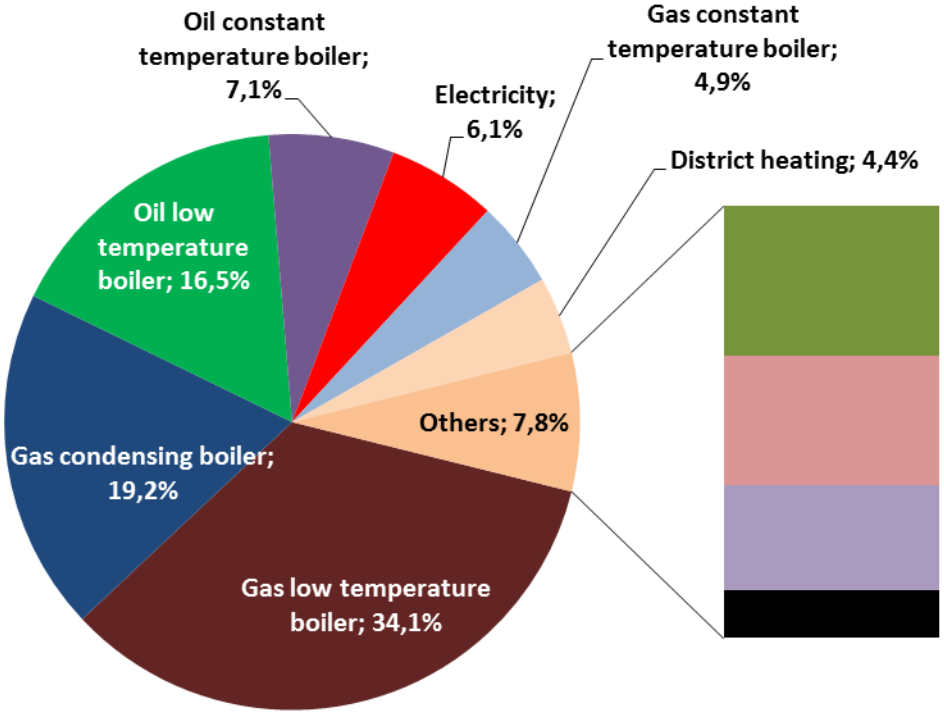
## 2012:

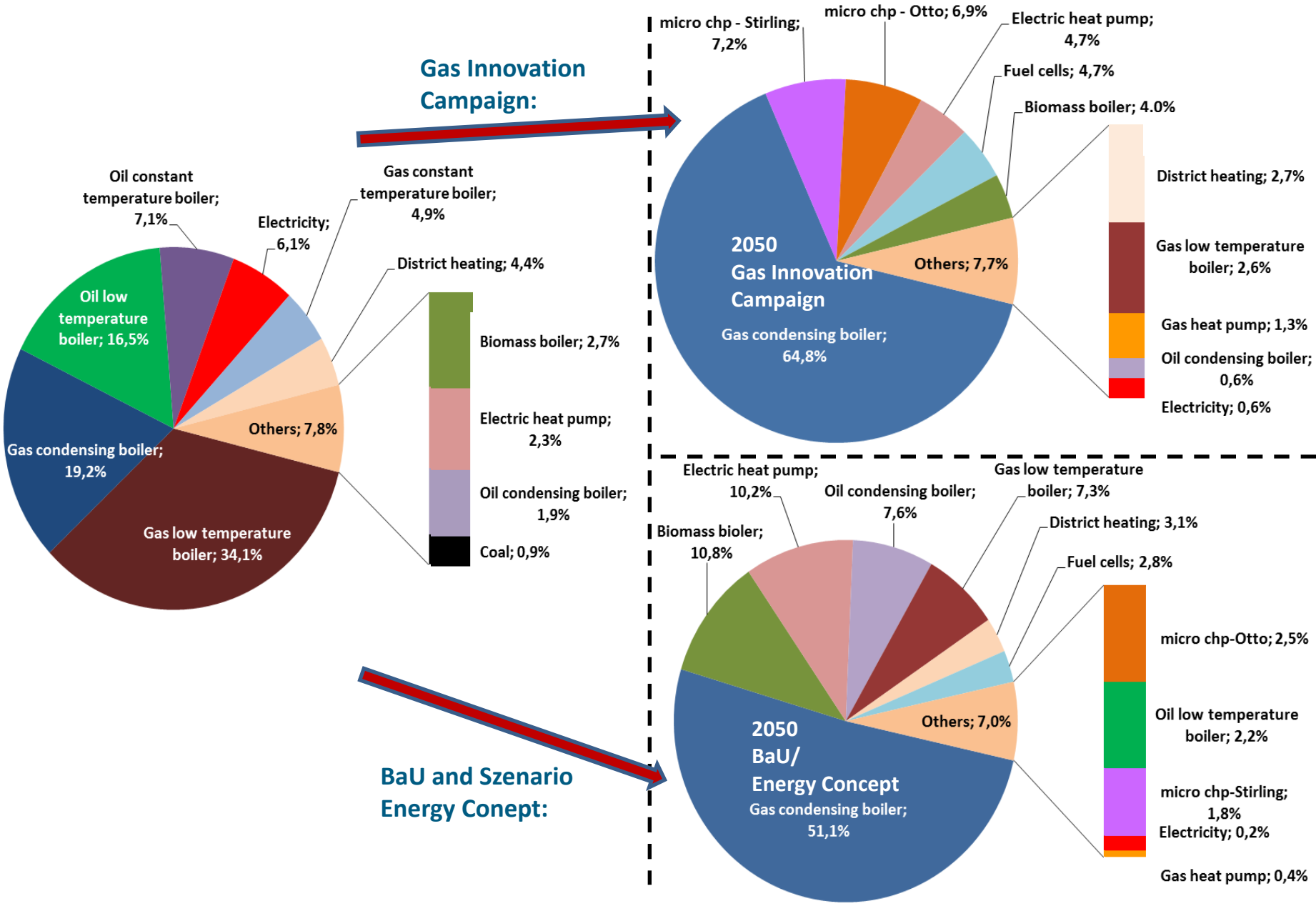



## 2050:

BaU and Szenario Energy Concept ??:

Gas Innovation Campaign ??:

# Stock of heating systems



# Stock of heating systems

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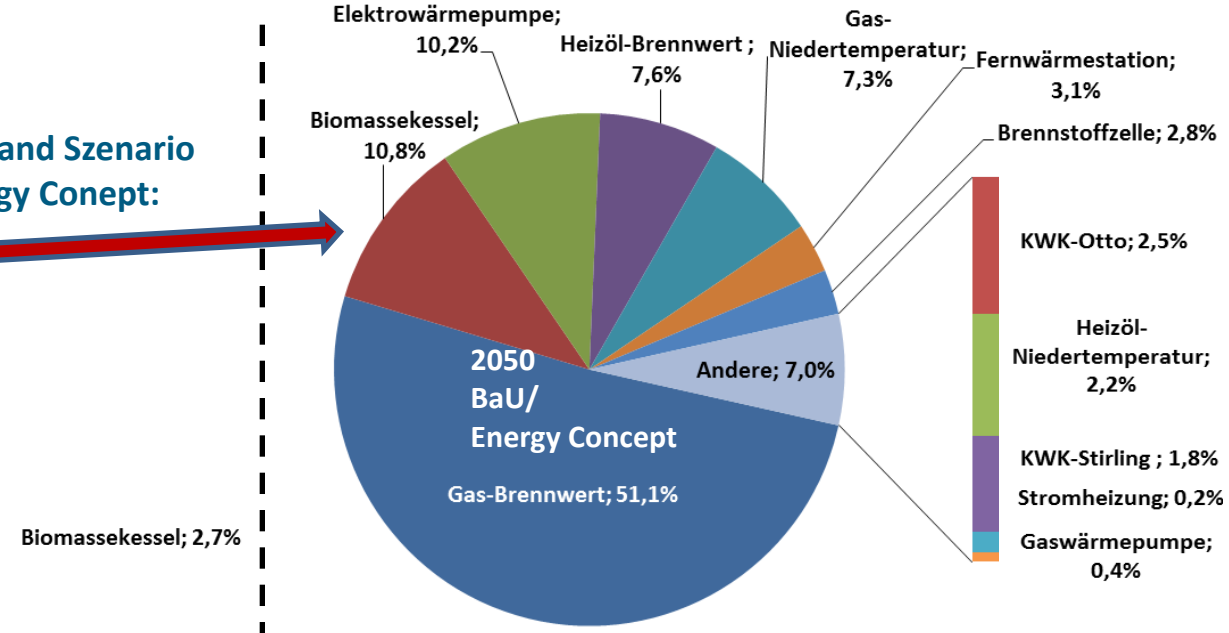
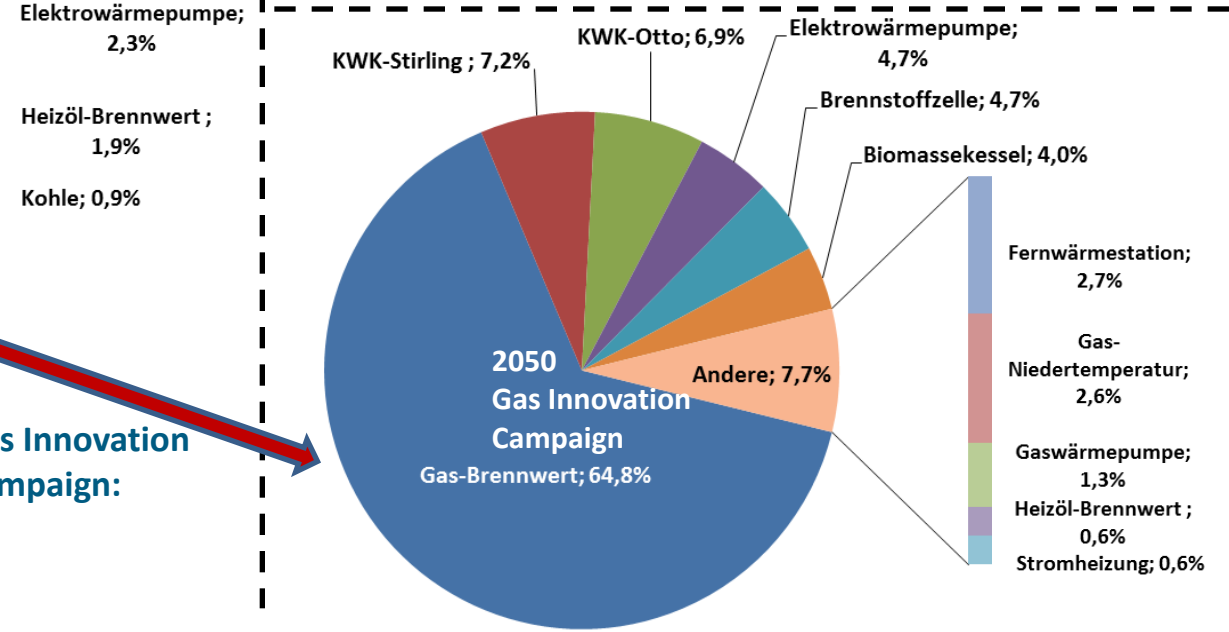
BaU and Szenario Energy Conept:




Gas Innovation Campaign:



# Cumulated investments for building insulation (exisiting building stock), 2013 - 2050

| ($10^9$ €) | Business as Usual (BaU) | Energy concept | Gas innovation campagin |
|---|---|---|---|
| roofs | 40,7 | 97,4 | 52,4 |
| Facades | 41,9 | 103,3 | 54,0 |
| cellars | 5,6 | 11,2 | 7,2 |
| windows | 5,6 | 67,3 | 7,3 |
| *Total* | *93,8* | *279,2* | *120,9* |
| | Cost difference compared with Business as usual | | |
| roofs | | 56,7 | 11,7 |
| facades | | 61,4 | 12 |
| cellar | | 5,6 | 1,6 |
| windows | | 61,7 | 1,6 |
| *Total* | | *185,4* | *27,0* |
| **In 2050:** | 106 kWh/m$^2$ a | 61 kWh/m$^2$ a | 87 kWh/m$^2$ a |

Comparison: Today´s average value (all residential building types): 170 kWh/m$^2$ a

# Components of the gas mixture in 2050

| Gas mixture<br>in % | Business as Usual | German Energy Concept | Gas Innovation Campaign |
|---|---|---|---|
| Natural Gas | 93.94 | 66.31 | 44.21 |
| Natural Gas with Hydogen from wind | 0.00 | 0.00 | 21.88 |
| Natural Gas with Hydrogen from solar | 0.00 | 0.00 | 1.66 |
| Natural Gas with $CH_4$ from wind | 0.00 | 0.00 | 2.82 |
| Natural Gas with $CH_4$ from solar | 0.00 | 0.00 | 0.42 |
| Natural Gas with biogas (waste) | 2.86 | 18.77 | 12.78 |
| Natural Gas with biogas (renewable resources) | 1.05 | 6.98 | 4.75 |
| SNG from wood | 2.15 | 7.94 | 11.48 |
| Total | 100.00 | 100.00 | 100.00 |