Coal Exit, Gas Expansion, and the Energy Trilemma: System Implications of German Energy Policy

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27.03.2026 | Enerday Dresden

FCN | Future Energy Consumer Needs and Behavior

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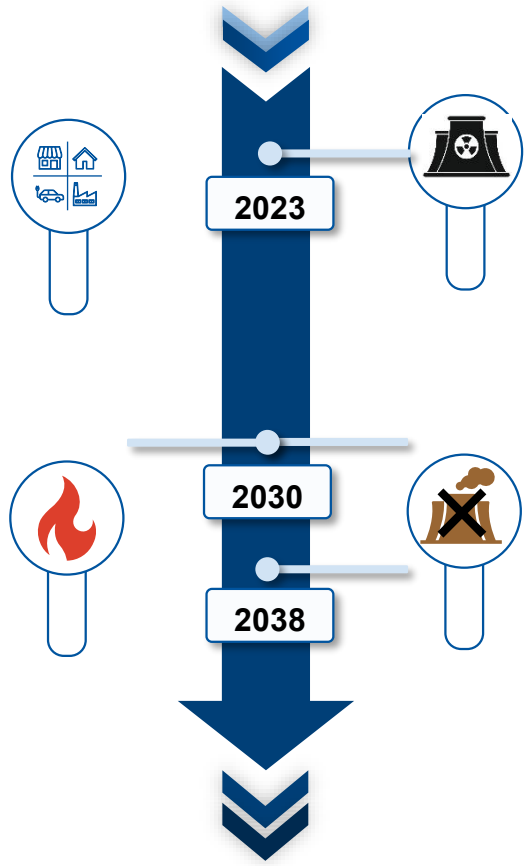
Impact of Coal Phase-Out Timing & Gas Capacity Expansion in Germany

Key Pillars of Germany's Energy Transition Path

Sector Coupling & Expansion of Renewables:
- Electrification of the heating, mobility & industry sector
- Focus on solar PV and wind expansion

Expansion of Gas-Fired Power Plants:
- Flexible gas turbines as backup capacity
- ➢ Controversy: role of natural gas



Nuclear Phase-Out completed
- Driven by safety concerns, energy policy strategy, and public consensus

Coal phase-out:
- **2038:** legally mandated phase-out
- **2030:** political and social discourse

Climate Neutrality by 2045

Is the planned addition of **20 GW** of **gas-fired** power plant capacity by **2030** a necessary condition for maintaining **system stability?**

How will this influence **electricity prices** and the risk of **energy poverty**?

What are the **environmental impacts**?

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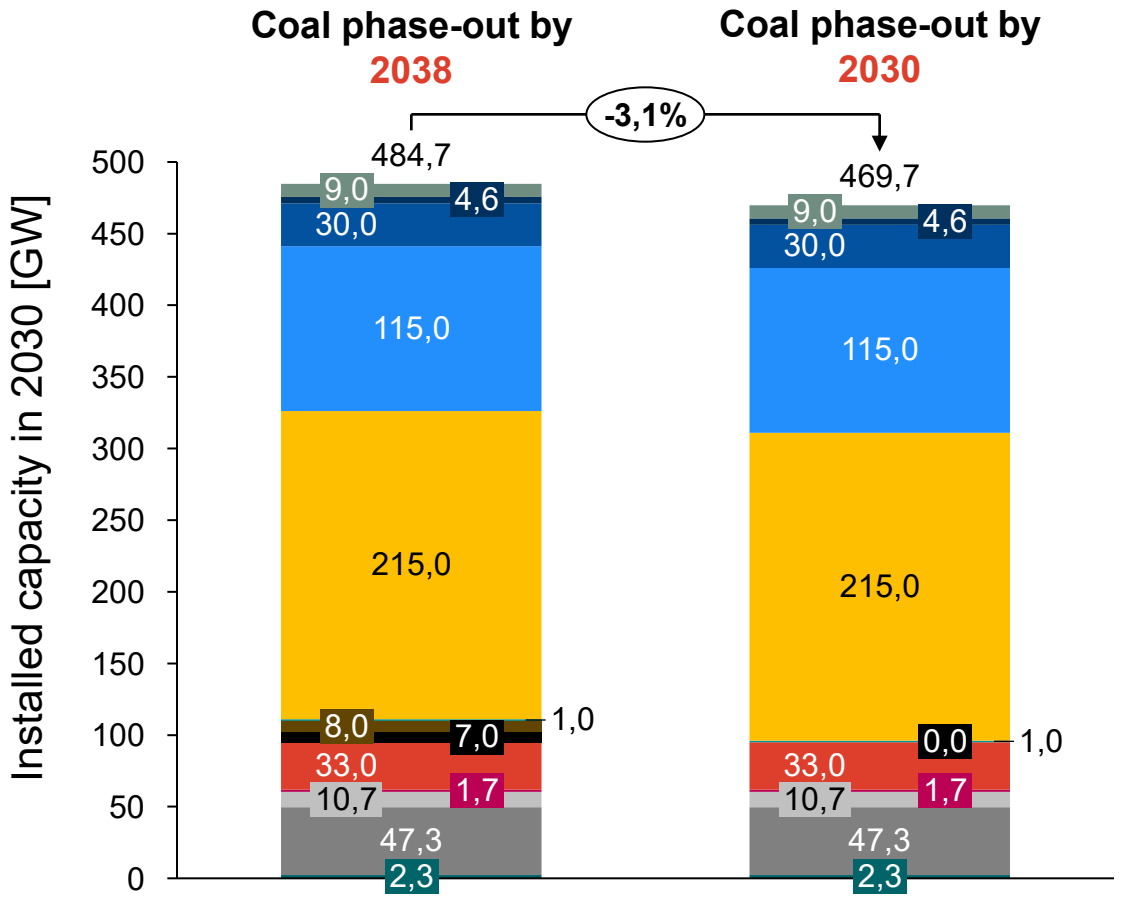
German Electricity Generation Portfolio | Share of Dispatchable Power Plants

Power Plant Portfolio in Germany (2030)

Coal phase-out scenarios and additional strategic substitution measures



\+ Consideration of 2 GW of **reserve capacity** as gas-fired power plants

- Biomass and biogas
- Hydro power
- Wind offshore
- Wind onshore
- Photovoltaics
- Other renewables
- **Lignite**
- **Hard coal**
- Natural gas
- Mineral Oil
- Pumped storage
- Other storages
- Other conventionals

NETZ ENTWICKLUNGS PLAN **STROM**

Planned expansion of gas-fired power plant capacity by **20 GW** by 2030 (German federal government, 04/2025)

Σ 4 power plant portfolio scenarios 2030

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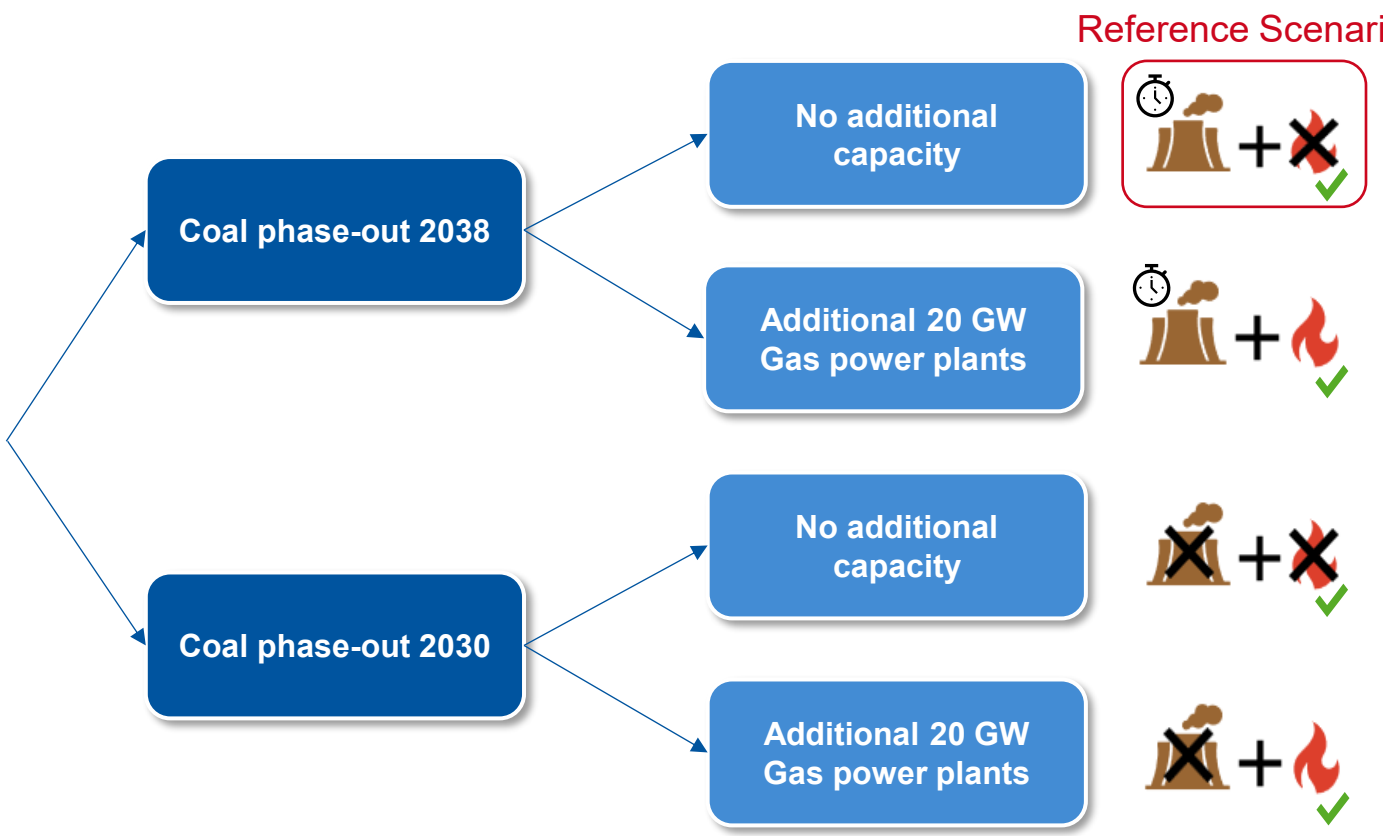
Study Scope | Scenario Overview & Analysis Aspects

Scenario Tree



Consideration of different weather years

Research Aspects

Security of Supply

Impact of portfolio adjustments on risk indicators

Affordability

Price Analysis and Forecasts

Price effects of technology changes

Energy Poverty

Financial burdens and consumption effects through changed retail prices

Climate Impact

Emissions of different electricity generation mixes

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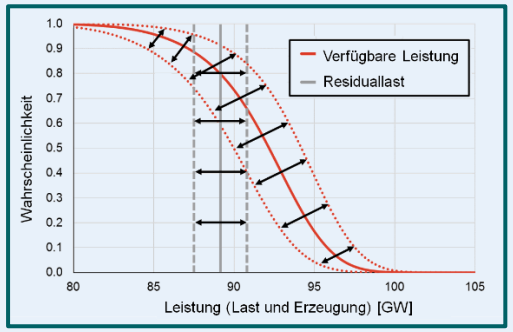
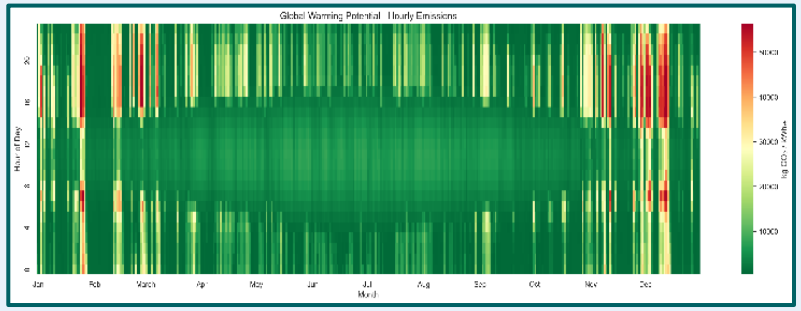
Quantitative Analyses | Applied modelling tools

Security of Supply



- Probabilistic simulative resource adequacy assessment
- Meta-modelling

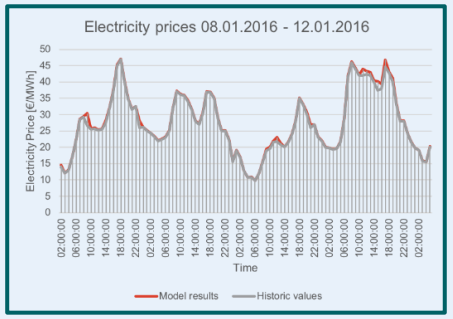
Climate Impact



- Dispatch-based emission modelling
- Multi-dimensional environmental impact categories

Affordability

Price Analysis and Forecasts



- Fundamental modelling of electricity markets
- Economic dispatch for uniform price (pay-as-clear)

Energy Poverty

- Survey-based microsimulations
- Policy-impacted behavior modelling

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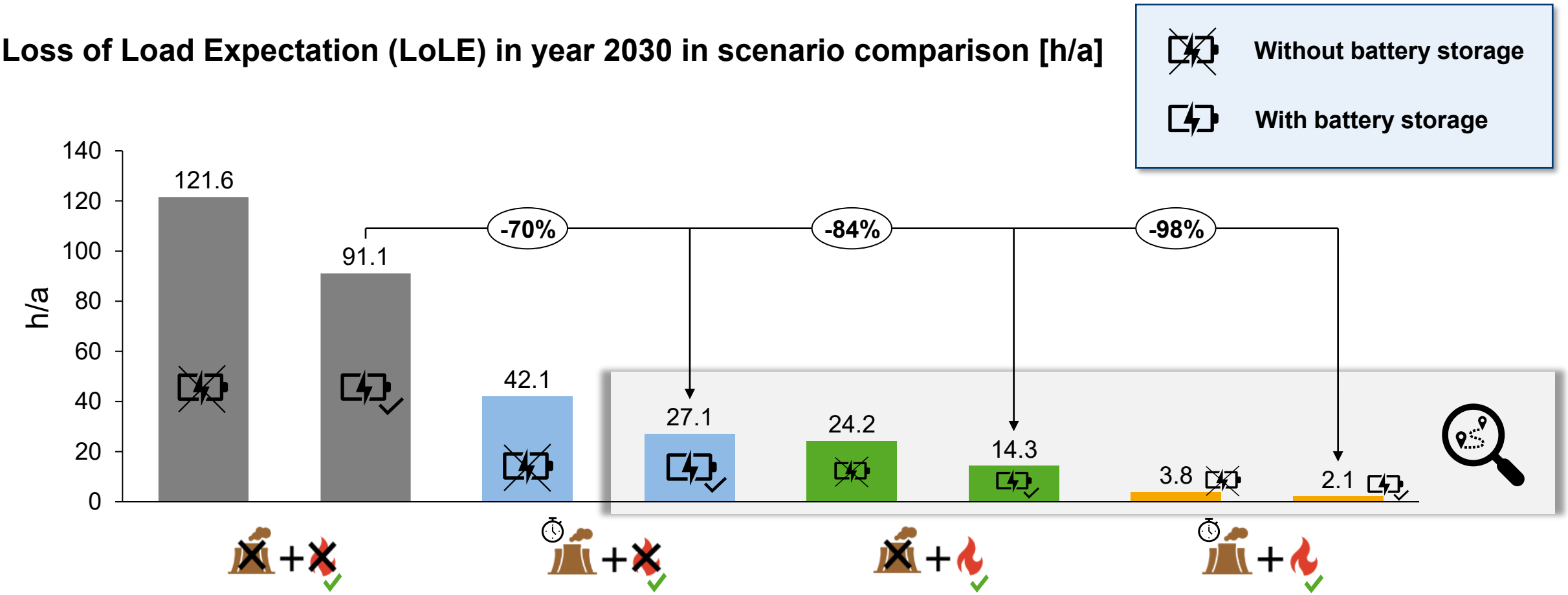
Security of Electricity Supply | Impact of Phase-Outs, Substitution and Flexibility

Loss of Load Expectation (LoLE) in year 2030 in scenario comparison [h/a]



- **Timing** of a coal phase-out is critical to energy security
- Need for **flexibilization** as a measure against loss of load

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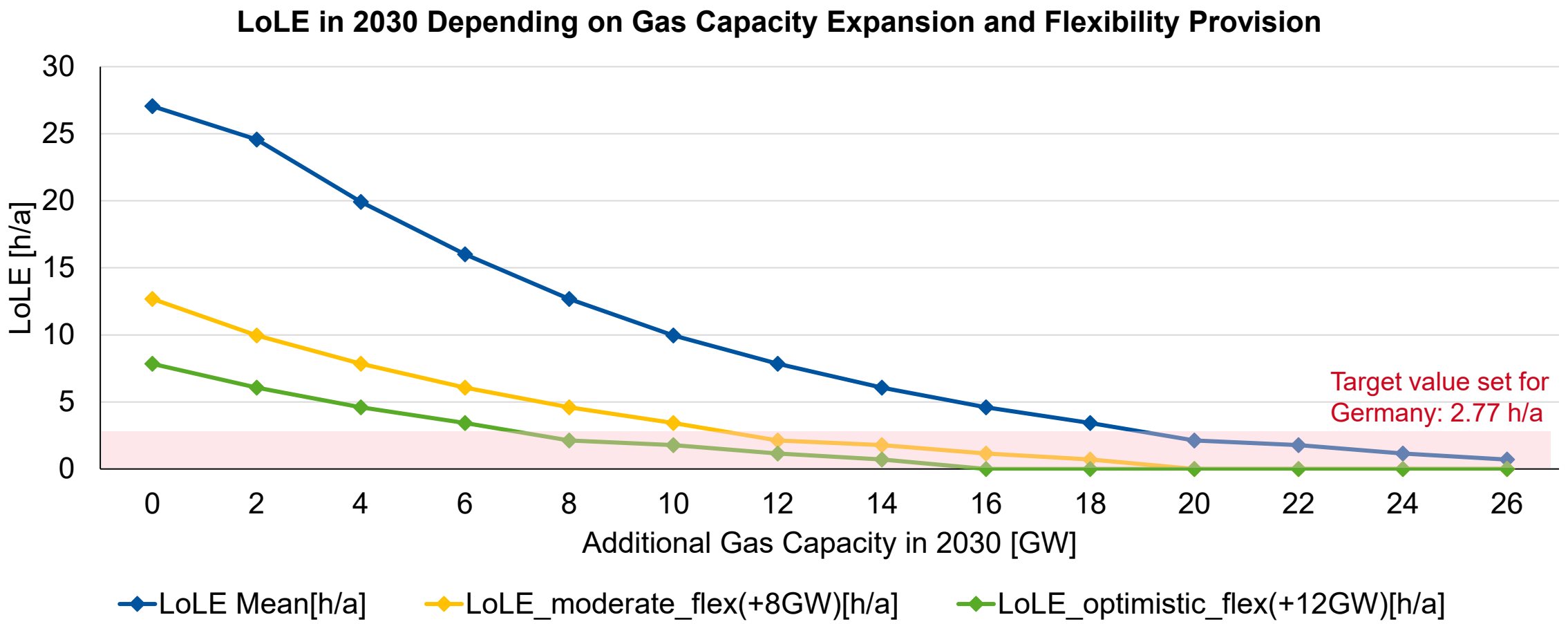
Security of Electricity Supply | Capacity Planning and Reliability Targets



- Availability of **flexible assets** during supply shortages affects need for additional dispatchable power plants

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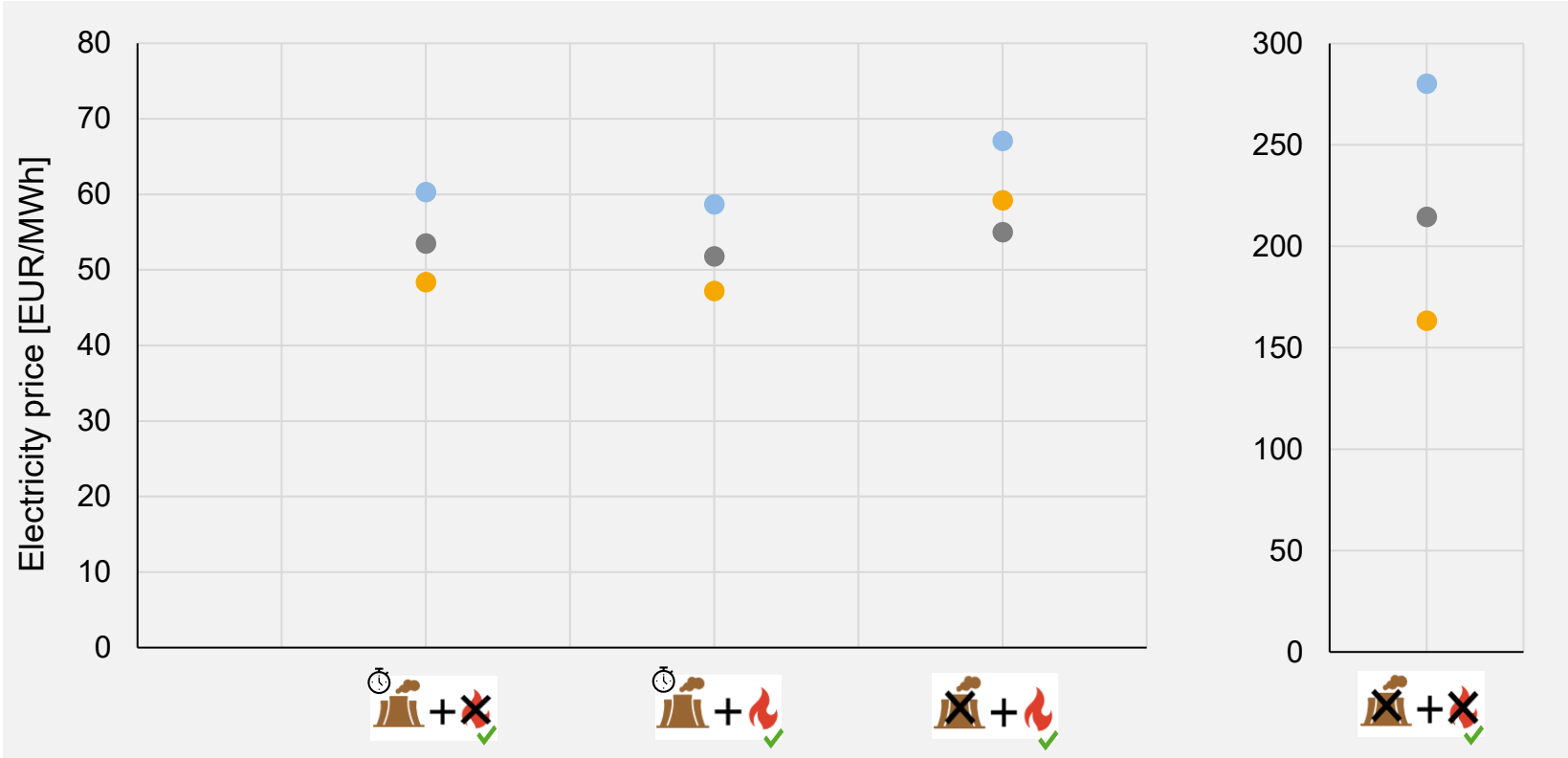
Affordability (Electricity Market) | Price Levels & Weather Effects

Average electricity prices through Merit-Order (Pay-as-clear) in economic dispatch

Weather years

2030

- Reference year: 2004
- Warm year: 2007
- Cold year: 2010



- Weather effects with **larger impact** than portfolio effects
- Dispatchable power plants **stabilize** electricty prices

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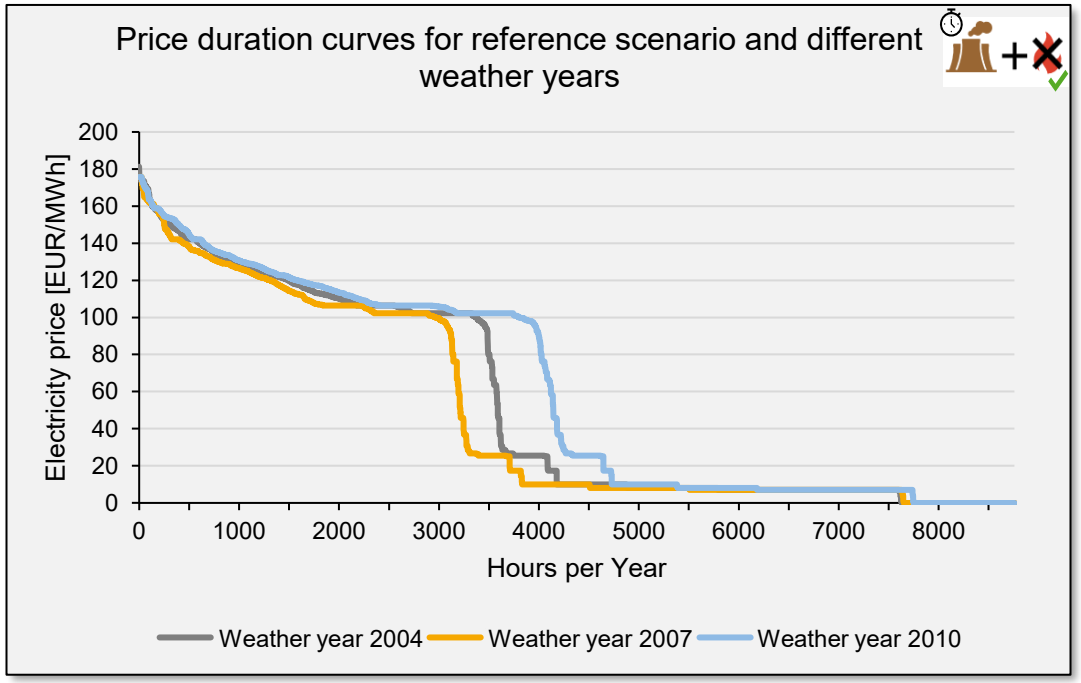
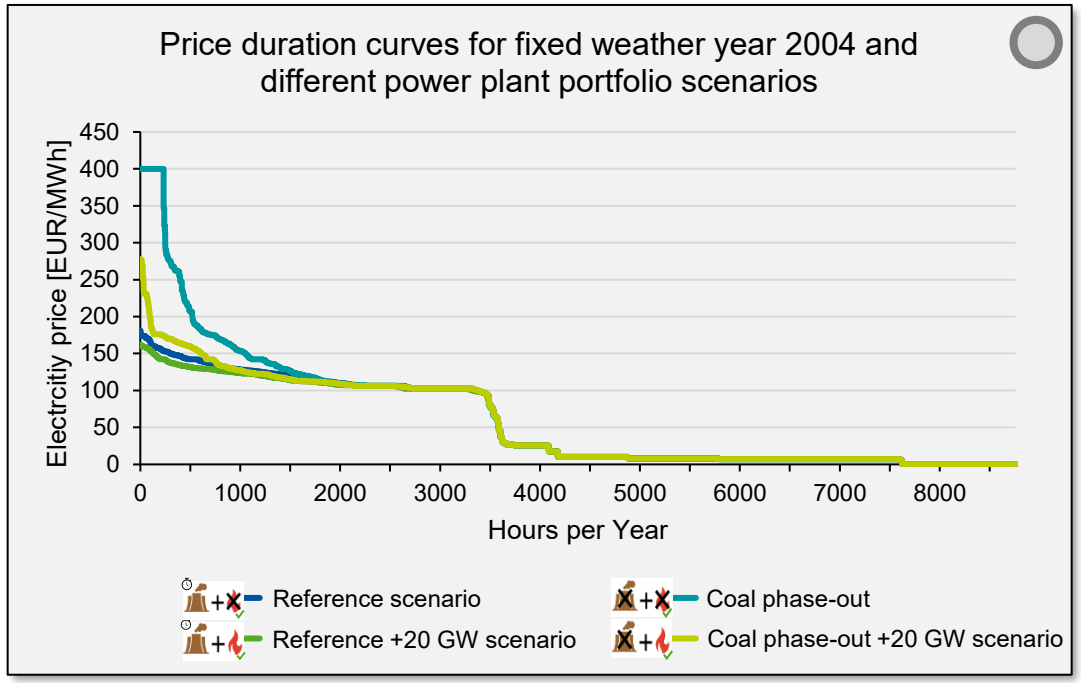
Weather and Portfolio Effects on Price Duration Curves

Weather effects





Portfolio effects

- Weather effects **shift** systematically the **price distributions**
- Scenarios reveal **structural risk** in the price distribution **tails**

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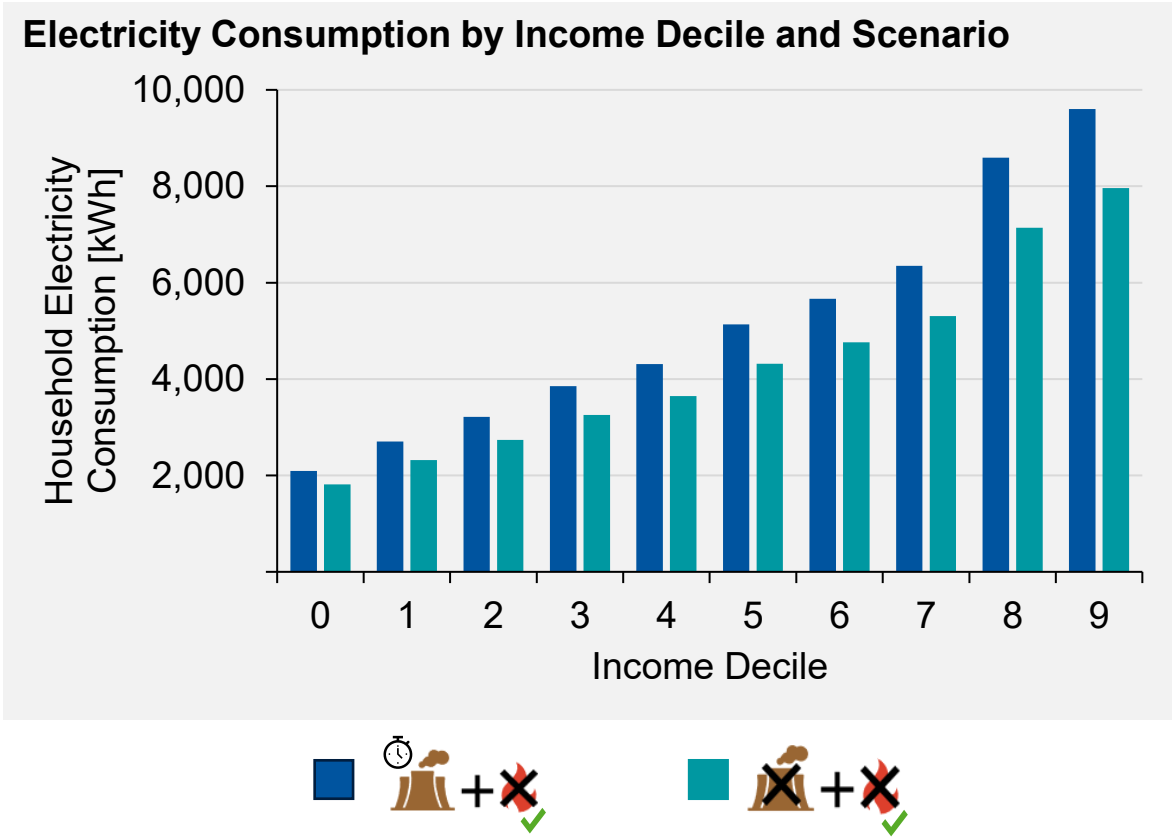
Affordability (Energy Poverty) | Impact on Vulnerable Consumption Groups

Cons. Prices	Household Prices	**0%** (35.7 ct/kWh)	**0%** (35.5 ct/kWh)	**+46%** (51.8 ct/kWh)	**+1%** (35.9 ct/kWh)
At Risk of Poverty	Difference [mn. Households]	**0.0%** (8.65)	**0.0%** (8.66)	**+0.1%** (8.68)	**0.0%** (8.66)
	Relative [%]	**21.0%**	**21.0%**	**21.1%**	**21.0%**
Energy Poverty	Difference [mn. Households]	**0.0%** (3.8 mn.)	**0.0%** (3.8 mn.)	**+0.1%** (3.9 mn.)	**0.0%** (3.8 mn.)
	Relative [%]	**9.3%**	**9.3%**	**9.4%**	**9.3%**



- **Limited impacts** on **poverty** and **energy poverty (Low-Income-High-Cost-Index)**
- Main reason: **Behavioral** adjustments of households (Short-term elasticities)

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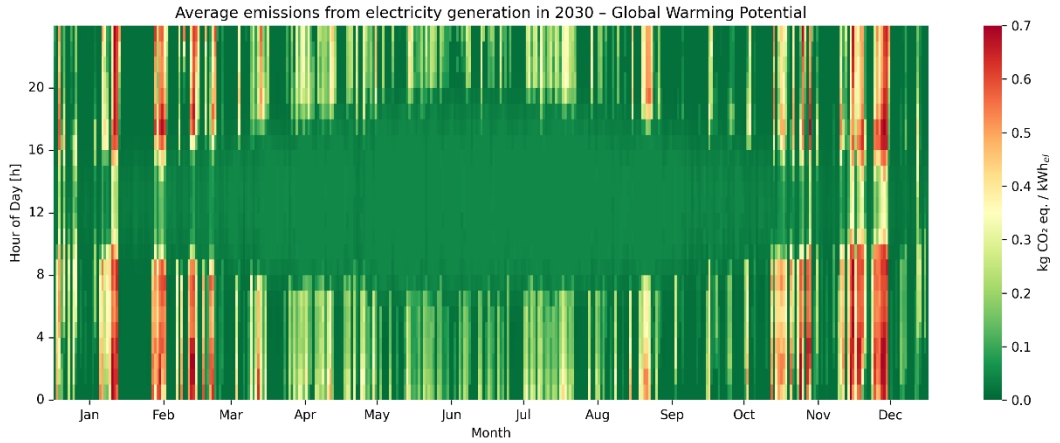
Climate Impact | CO_2 emissions and savings

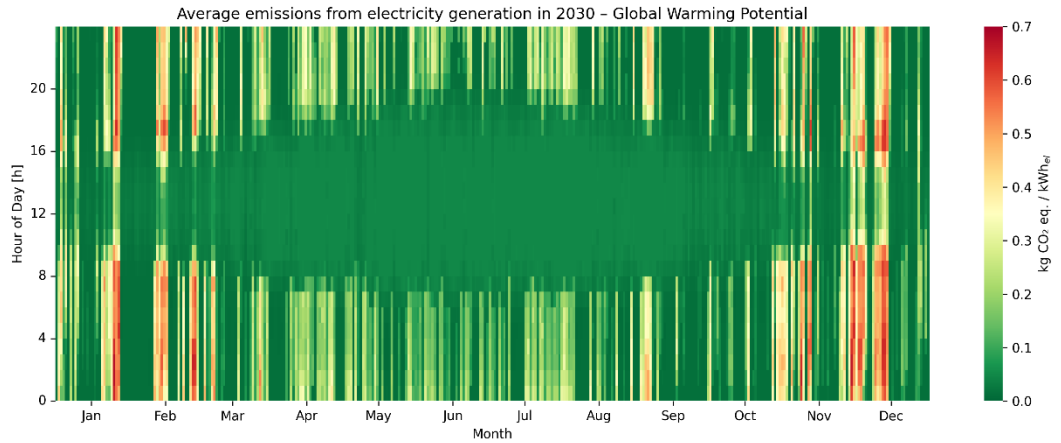
Ref. scenario

~ 64 Mt



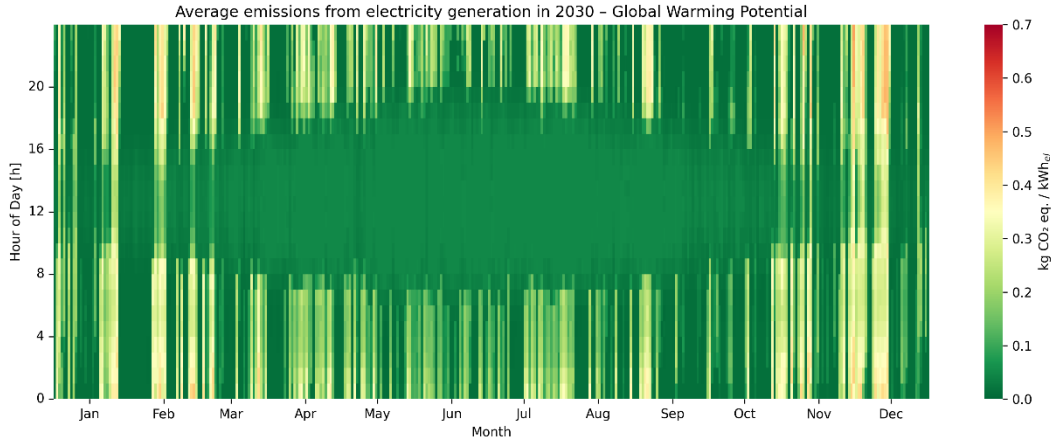
Ref. sc. with 20 GW gas powerplants

↓ ~ 6.8%



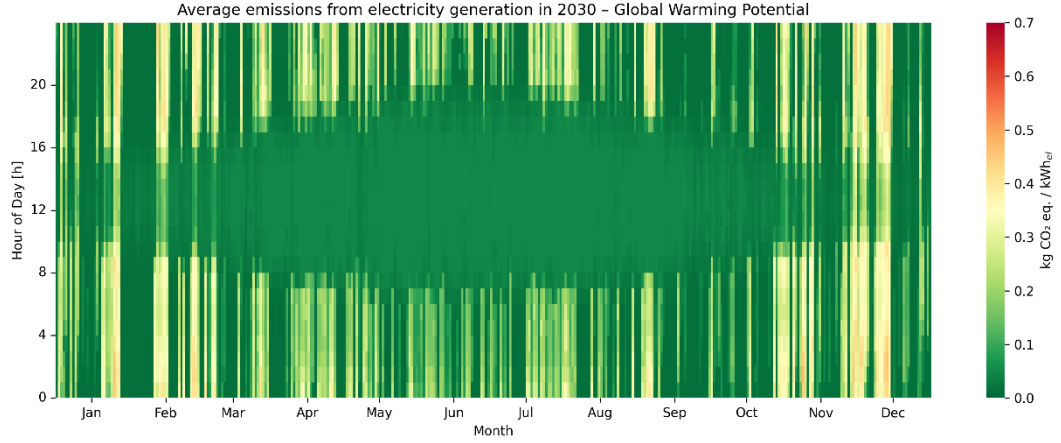
Ref. scenario with coal phase-out

↓ ~ 19.8 %



Ref. sc. with 20 GW gas pp. & coal phase-out

↓ ~ 17.5 %



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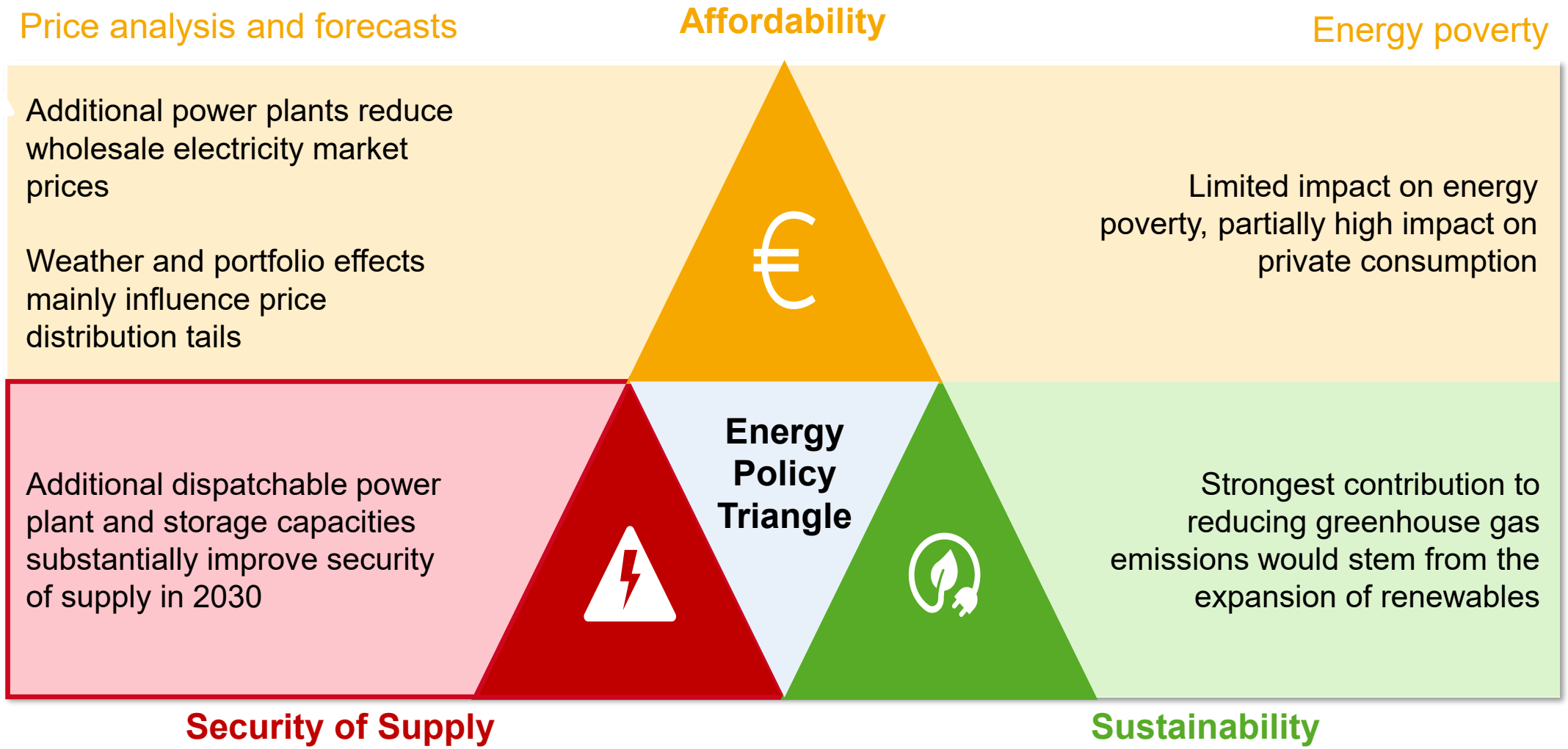
Wrap-Up | Key Insights for German Energy System Planning



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Thank you for your attention!

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