How to integrate feed-in tariffs in energy system models – the case of Germany

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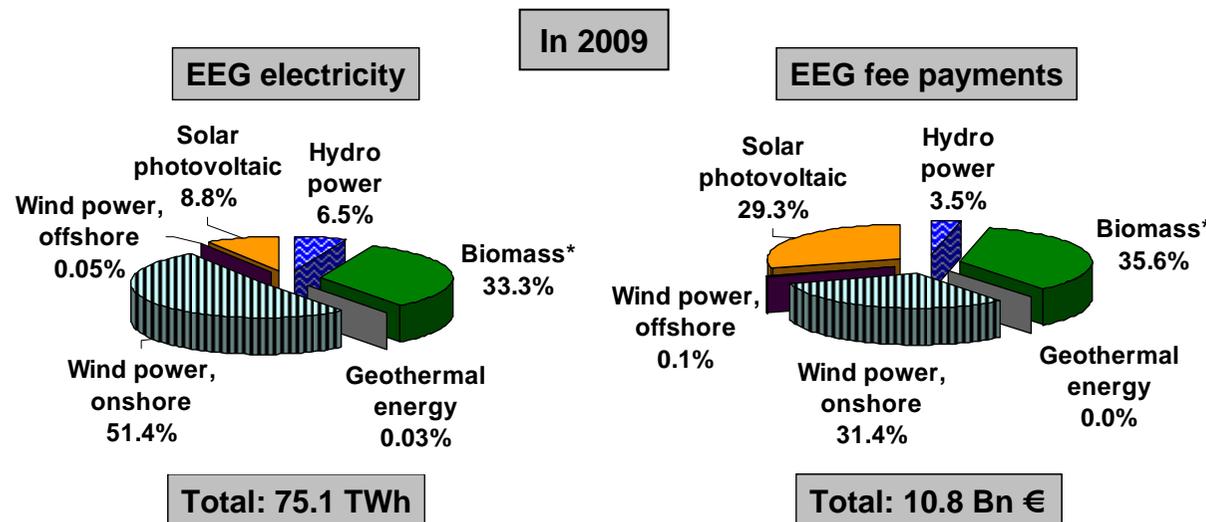July 6-8, 2011

Agenda

1. Introduction & background information

2. Model characteristics & methodology

3. Results of the scenario analysis

4. Conclusion

1. Introduction and background information

- **Ambitious targets for the expansion of renewable energies**
  Europe: 20 % of gross final energy consumption in 2020
  Germany: 35 % (2020) & 80 % (2050) of gross electricity consumption

- **Different policy instruments for the promotion of renewable electricity**
  Mainly feed-in tariffs/premiums, green certificates, tendering procedures

- **Germany: Renewable Energy Sources Act (EEG)**

In 2009

EEG electricity

Solar photovoltaic 8.8%
Hydro power 6.5%
Wind power, offshore 0.05%
Biomass* 33.3%
Wind power, onshore 51.4%
Geothermal energy 0.03%

Total: 75.1 TWh

EEG fee payments

Solar photovoltaic 29.3%
Hydro power 3.5%
Biomass* 35.6%
Wind power, offshore 0.1%
Wind power, onshore 31.4%
Geothermal energy 0.0%

Total: 10.8 Bn €

- Introduced in 2000
- Tariffs depend on energy source and plant size, annual degression
- Usually paid over a period of 20 years
- 2009: 16,4% of gross electricity consumption in Germany covered by RE

Average tariffs (ct/kWh)					
Hydro power	7.8	Wind power, offshore	15.0	Geothermal energy	19.8
Wind power, onshore	8.8	Biomass*	15.4	Solar photovoltaic	48.0

* incl. gas from landfills, mines and sewage treatment plants

Source: ÜNB (2010)

TIMES-D model characteristics

- Based on the model generator TIMES, developed in the Energy Technology Systems Analysis Programme (ETSAP) of the IEA

- Technology oriented bottom-up energy system model with perfect foresight

- Linear optimization model, minimization of total system costs to meet the exogenously set sectoral energy demands

- Modeling of the German energy system with detailed representation of the demand sectors (industry, residential, commercial/agriculture and transport), public & industrial electricity and heat production, refineries and other fuel conversion, exchange processes with neighboring countries

- Model horizon 2000 – 2050, 32 time slices

- Assumptions on energy prices, resource availability, potentials of renewable energy sources

- Emissions of greenhouse gases and other air pollutants

2. Modeling approach

So far: In energy system analyses the effect of support systems for renewable electricity are often only accounted for in an indirect way, by exogenously setting minimum volumes for the electricity produced from renewable sources. The effects on electricity prices and demand are often neglected.

Objective: Integrating the German feed-in tariff system into TIMES-D by

- Explicitly modeling the tariffs (to account for the effects on the generation side)
- Including the levy on electricity prices (to account for the effects on the demand side)

Advantages:

- Flexible representation of the EEG system
- Evaluation of the effects of changing scenario settings on the support system
- Evaluation of interactions with other policy measures

Assumption: Modeling horizon to 2030, EEG is maintained in this period

Modeling of the tariffs

To display the tariffs, the TIMES parameters to model subsidies are used.

Special features of the EEG:

- Tariffs are paid over a limited period of time (usually 20 years).
- Tariffs remain constant in nominal terms during the payment period resulting in a gradual decline in real terms.
- Tariffs for newly installed plants are subject to an annual degression.

$\rightarrow$ The impact of the EEG on the competitiveness of the renewable electricity generation depends substantially on these features.

Solution:

- To model the annual degression, the process parameters are defined as depending on the vintage year, not the model year.
- To model the limitation of the payment period as well as the tariff reduction caused by inflation, a SHAPE curve is used.

Modeling of the demand side

The additional costs of the feed-in tariff system are financed through a levy on retail electricity prices, **the EEG apportionment**:

EEG app. = (Ø-EEG tariff – Ø-wholesale electricity price) * EEG quota

Exemption: the apportionment is restricted to a maximum of **0.05 ct/kWh** for manufacturing enterprises and rail operators with comparatively high electricity consumption in order to prevent endangering their international or intermodal competitiveness.

But: the EEG apportionment depends on model results

→ **Iterative process** of several model runs to adjust EEG payments and the EEG apportionment to one another

3. Scenario analysis: Overview

Variation of

- Support system for renewable electricity

- Integration of the EU Emissions Trading System

- Operation time of nuclear power plants

	Support system for renewable electricity	Integration of the ETS	Nuclear power plants
EEG+ETS	EEG	YES	Phase out until 2022
EEG_only	EEG	NO	Phase out until 2022
ETS_only	None	YES	Phase out until 2022
NO_instrument	None	NO	Phase out until 2022
EEG_NUC44	EEG	YES	44 years*
EEG_NUC60	EEG	YES	60 years
RE_quota	Quota System	YES	Phase out until 2022

* According to the Energy Concept of the German government from September 2010
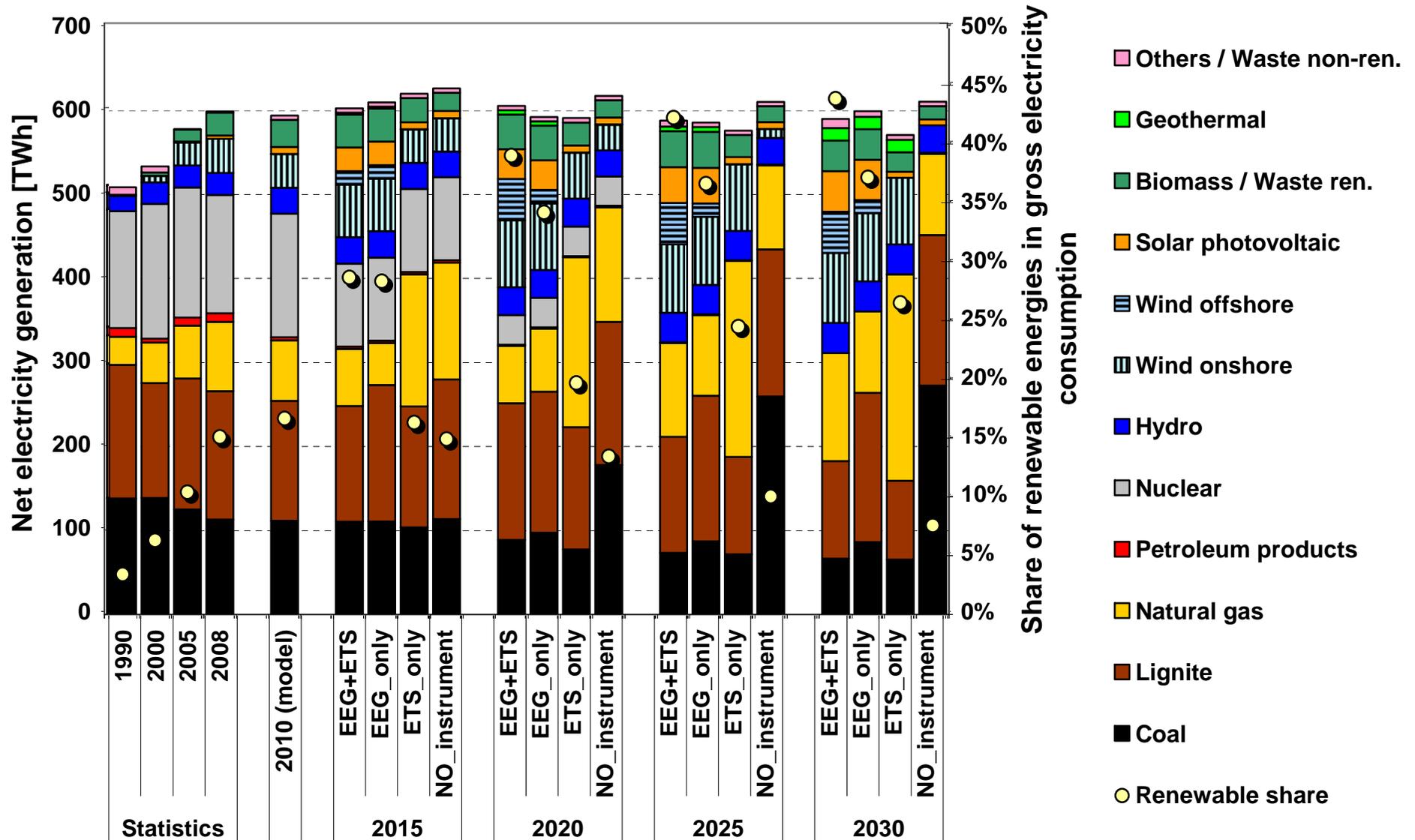
Key socio-economic scenario assumptions

	Unit	2010	2020	2030
Population	M	81.7	81.4	79.7
Gross Domestic Product	Bn €$_{2000}$	2248	2526	2784
Crude oil price (OPEC Reference Basket)	US\$$_{2007}$/bbl	74	87	100
	US\$/bbl	77	117	169
Fuel prices (power plants)				
Natural gas	€$_{2007}$/GJ	6.66	8.27	9.09
Hard coal	€$_{2007}$/GJ	2.96	2.79	3.03
Lignite	€$_{2007}$/GJ	0.96	0.96	0.96

Based on: Energieprognose 2009 (IER, RWI, ZEW 2010)

Interaction between EEG and ETS

EEG electricity generation and cost side

Legend:
- Geothermal (direct marketing)
- Geothermal (EEG)
- Biomass** (direct marketing)
- Biomass** (EEG)
- Photovoltaics (direct marketing)
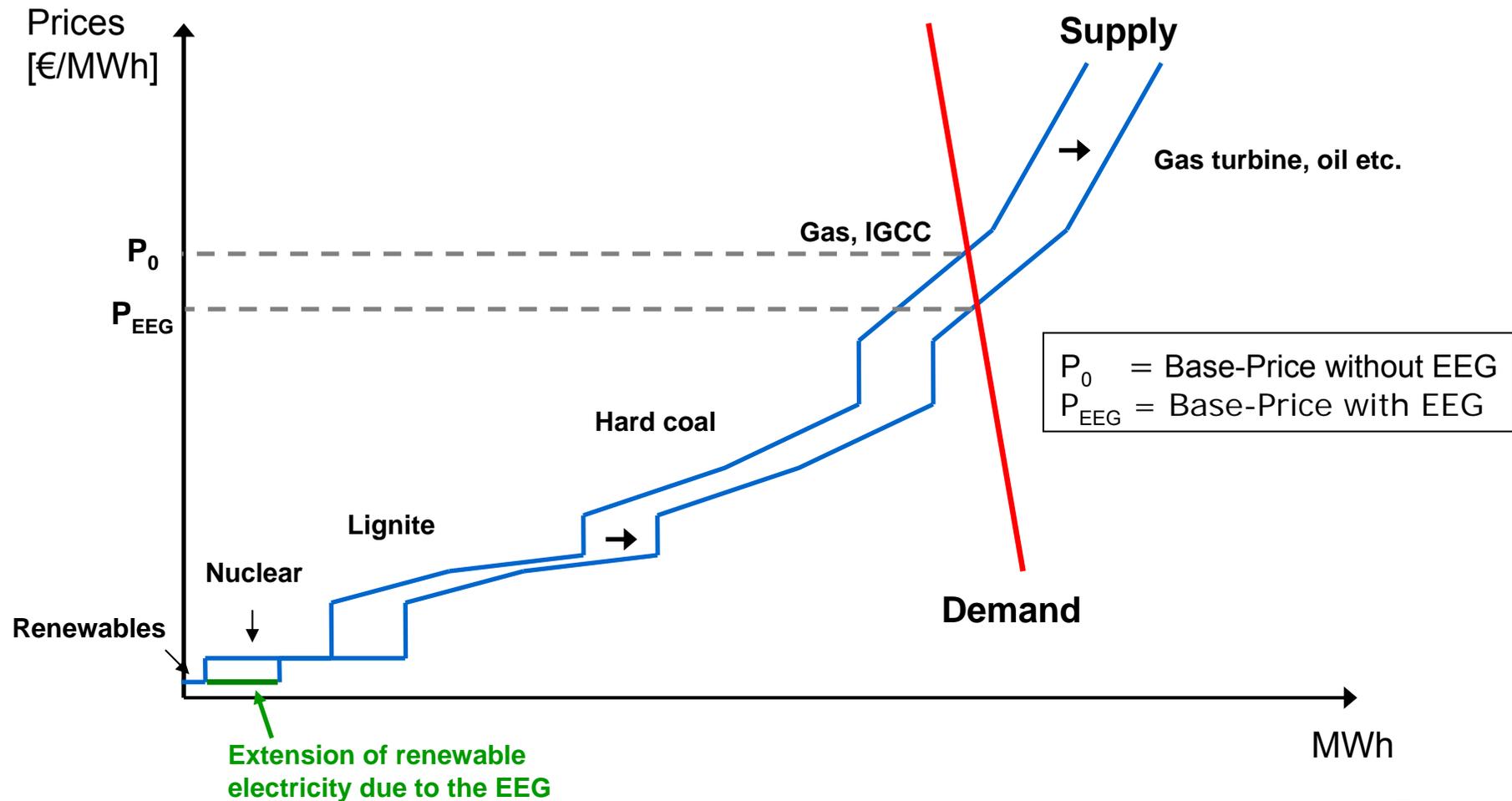- Photovoltaics (EEG)
- Wind, offshore (direct marketing)
- Wind, offshore (EEG)
- Wind, onshore (direct marketing)
- Wind, onshore (EEG)
- Hydro* (direct marketing)
- Hydro* (EEG)

* Excl. pump storage
** Incl. Sewage and landfill gas
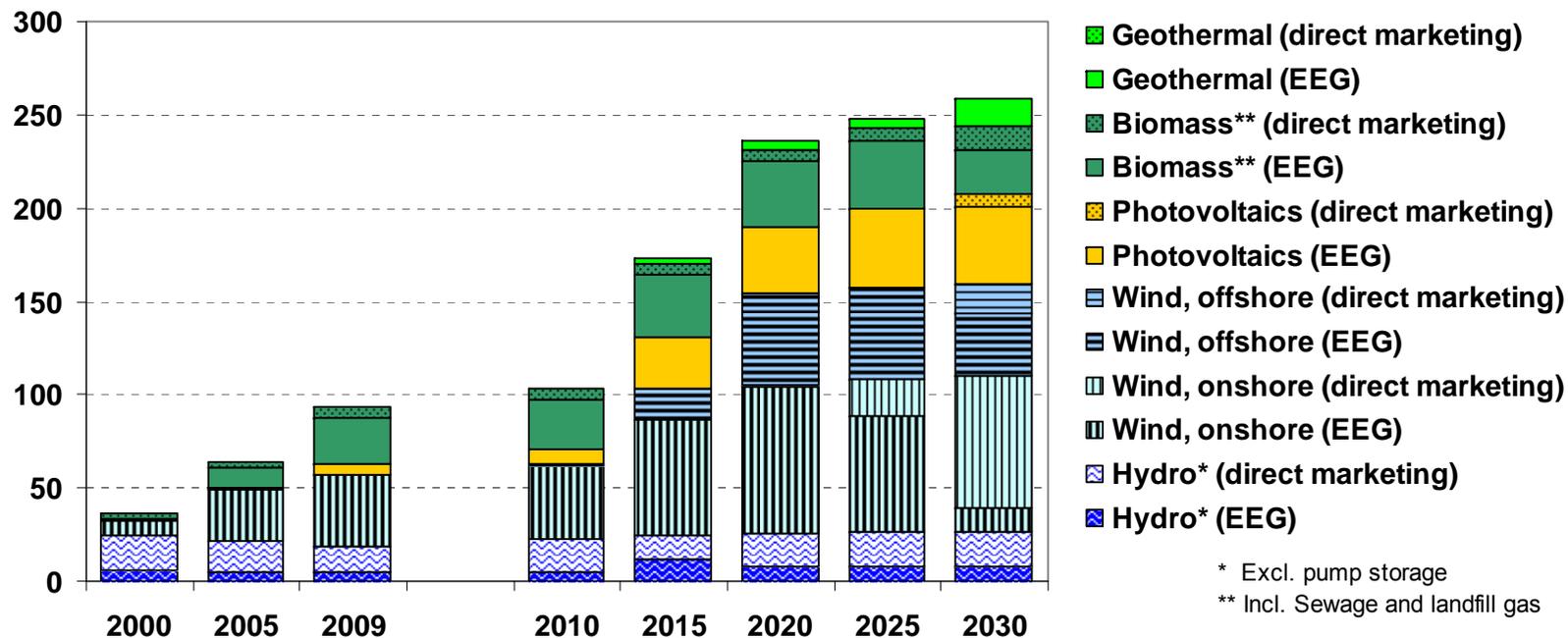
		2009	2015	2020	2025	2030
Renewable electricity	TWh	95	173	236	248	259
EEG electricity	TWh	75	154	212	203	135
EEG payments	Bn €$_{2007}$/a	10.5	25.1	26.9	22.5	13.1
EEG differential cost	Bn €$_{2007}$/a	-	17.4	12.0	9.3	3.6
EEG apportionment	€ct$_{2007}$/kWh	1.3	4.4	5.2	3.5	1.8
Effect on electricity prices*	€ct$_{2007}$/kWh	-	3.4	1.4	1.9	0.1

* Difference in household electricity prices in the scenario EEG+ETS compared to scenario ETS_only

Merit-order effect: electricity price reduction through the extension of renewable electricity

Prices [€/MWh]

Supply

Gas turbine, oil etc.

Gas, IGCC

P_0

P_{EEG}

P_0 = Base-Price without EEG
P_{EEG} = Base-Price with EEG

Hard coal

Lignite

Nuclear

Demand

Renewables

Extension of renewable electricity due to the EEG

MWh

Author's design based on Teske (2008)

Effects on final electricity consumption

- Electricity consumption for consumers that pay the full EEG apportionment decreases

- Electricity consumption in the energy intensive industry (with the reduced apportionment) increases slightly

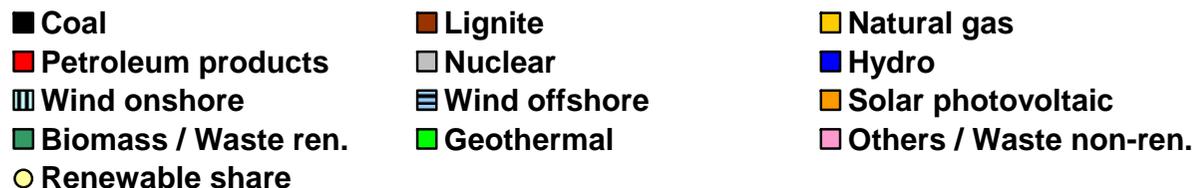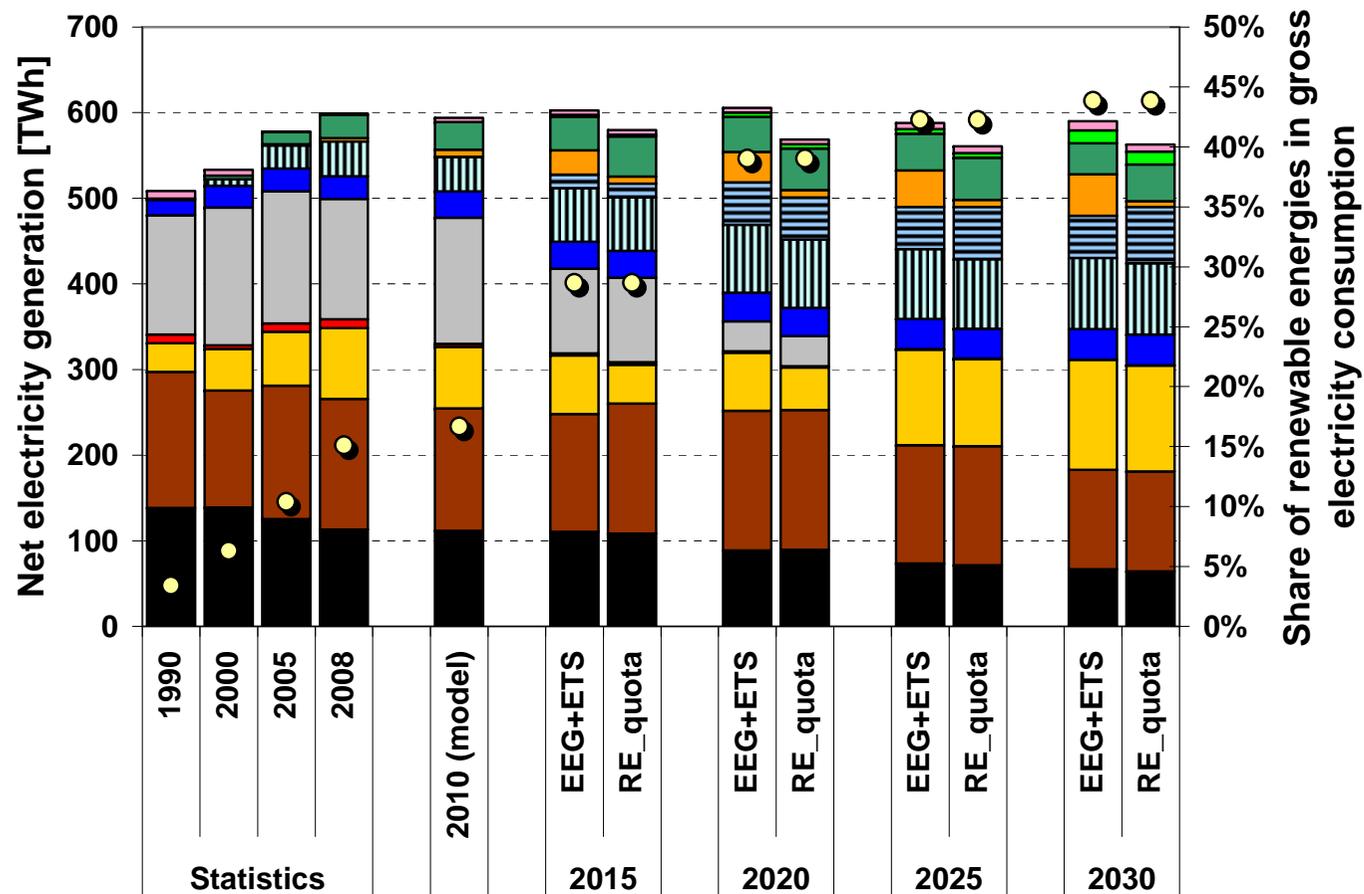|	2015		2020		2025		2030	
	EEG+ ETS	ETS_ only	EEG+ ETS	ETS_ only	EEG+ ETS	ETS_ only	EEG+ ETS	ETS_ only
Industry	240	240	251	246	248	245	248	247
Tertiary Sector*	158	165	141	143	137	139	136	137
Residential	131	143	126	133	121	127	122	121
Transportation	23	23	25	25	28	28	31	31
Sum	**552**	**571**	**543**	**547**	**534**	**538**	**537**	**535**

*incl. agriculture

Impact of different operation times for nuclear energy
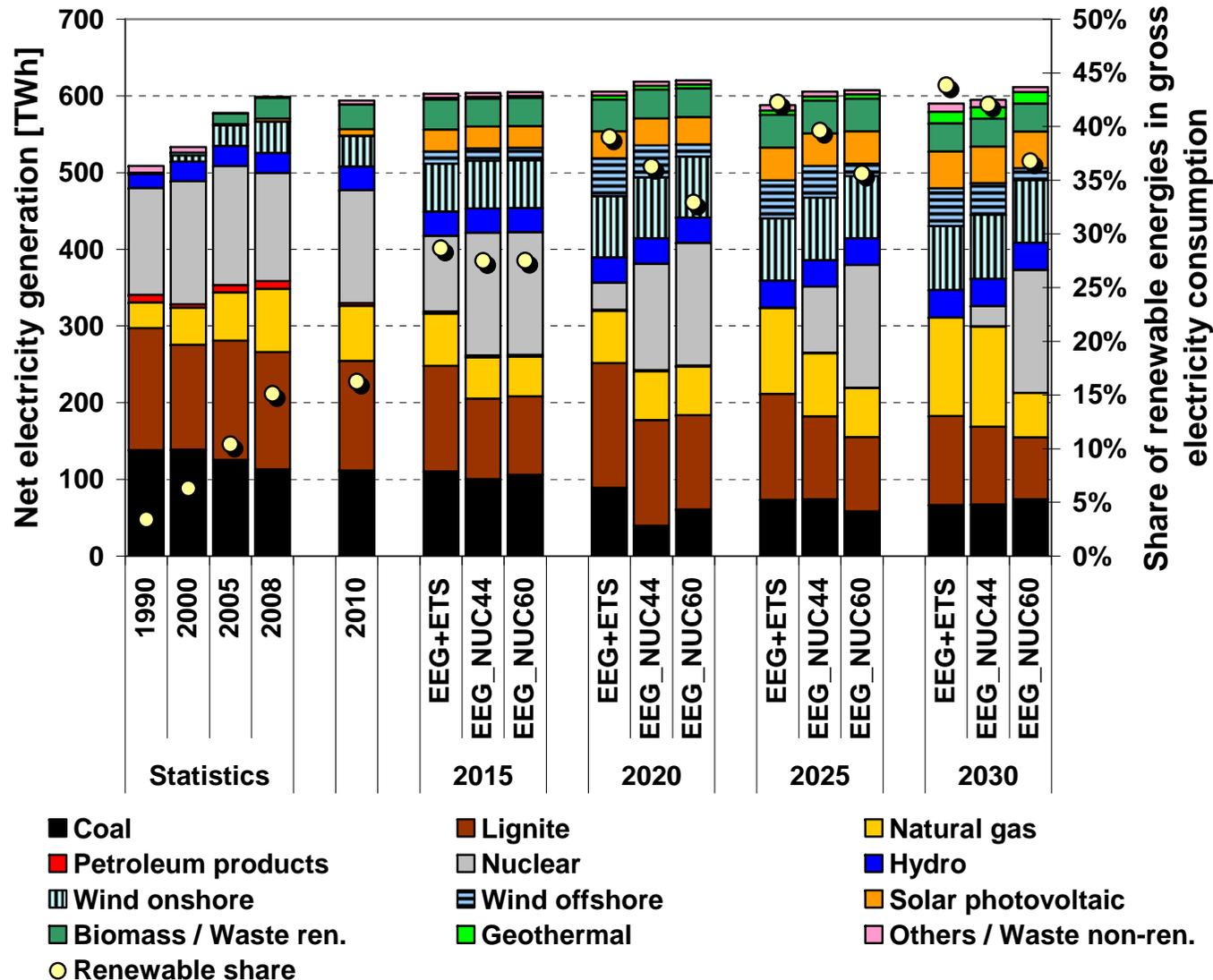
No significant effects on the extension of renewable electricity in Germany in the case of operation times of 44 years, slightly dampening effect in the case of operation times of 60 years

Legend:
- ■ Coal
- ■ Lignite
- ■ Natural gas
- ■ Petroleum products
- ■ Nuclear
- ■ Hydro
- ▥ Wind onshore
- ▤ Wind offshore
- ■ Solar photovoltaic
- ■ Biomass / Waste ren.
- ■ Geothermal
- ▨ Others / Waste non-ren.
- ○ Renewable share

Comparison with a quota system

With quota system

- Less heteroge-neous structure of renewable electri-city production

- Slightly lower energy system costs

- considerably higher electricity prices

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- ■ Coal
- ■ Lignite
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4. Conclusion

- With the help of the EEG the renewable electricity generation rises substantially in Germany

- EEG payments and the EEG apportionment increase strongly until 2020

- Due to the merit-order effect, the impact on electricity prices is less pronounced

- The effect of the EEG on electricity demand is relatively small

- The expansion of renewable electricity is not the most cost efficient CO_2-abatement strategy for Germany

- Longer operation times for the existing nuclear power plants in Germany do not hamper the development of the renewable electricity production significantly

- A fixed quota system leads to a less heterogeneous structure of renewable electricity production, slightly lower energy system costs, but considerably higher electricity prices

Thank you for your attention!

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