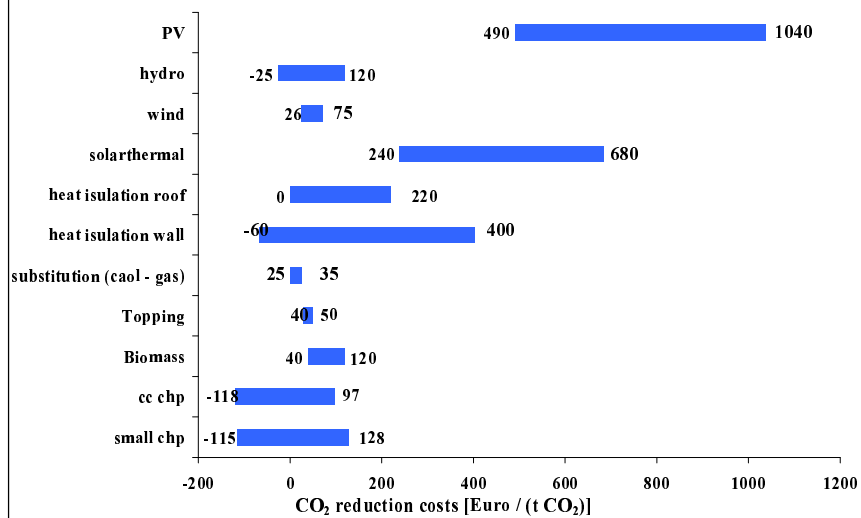
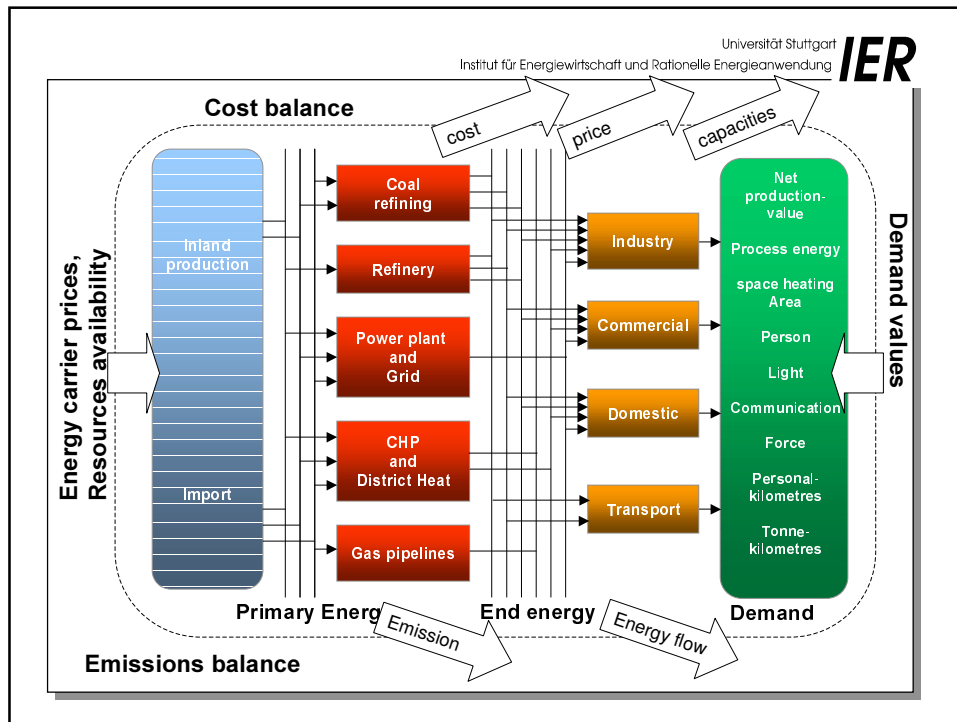


## Sustainable energy supply in Germany – scenario analysis with different CO<sub>2</sub> certificate prices

24.06.2003  
International Energy Workshop,  
Laxenburg  
Markus Blesl, Uwe Remme, Ulrich Fahl

### Comparison of CO<sub>2</sub>-reduction cost for different technologies in Germany





- Universität Stuttgart  
Institut für Energiewirtschaft und Rationelle Energieanwendung **IER**
- ### TIMES-D2
- Two regional model (West + East Germany)
  - Approx. 135 conversion technologies per region
  - Approx. 85 transport technologies per region
  - Approx. 120 residential technologies per region
  - Approx. 90 commercial technologies per region
  - Approx. 90 industrial technologies per region
  - Time horizon 1990-2030, 5 year periods
  - Six time segments per year
  - 17 sectors per region

**Socio-economic assumptions for the Scenarios**

<b>Population</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2020</b>	<b>2030</b>
Inhabitant in Mio.	82,2	82,2	82,1	80,8	77,9
<b>Gross domestic production</b>					
GDP per head (Euro)	24611	27019	29695	35668	42182
<b>Changes p.a.</b>	<b>2005/2000</b>	<b>2010/2005</b>	<b>2020/2010</b>	<b>2030/2020</b>	<b>2050/2030</b>
GDP (Mrd. Euro)	1,9%	1,9%	1,7%	1,3%	1,0%
GDP per capita (Euro)	1,9%	1,9%	1,8%	1,7%	1,7%
<b>Living space</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2020</b>	<b>2030</b>
Detached house (Mio m <sup>2</sup> )	1880	2016	2155	2425	2493
Multiple house (Mio m <sup>2</sup> )	1428	1505	1578	1717	1738
Sum	3308	3521	3733	4142	4231
Living space per capita (m <sup>2</sup> )	40,2	42,8	45,5	51,3	54,3
<b>Traffic</b>					
Personnel traffic, Mrd Pkm	968,1	1034	1090,7	1138,2	1139,1
Goods traffic, Mrd tkm	483,1	544,3	607,4	732,4	839,2
<b>Energy prices (Euro/GJ)</b>					
Crude oil	2,81	3,18	3,56	4,31	5,06
Gas	2,15	2,50	2,84	3,52	4,20
Hard Coal	1,36	1,40	1,43	1,59	1,76

**Policy Measures**

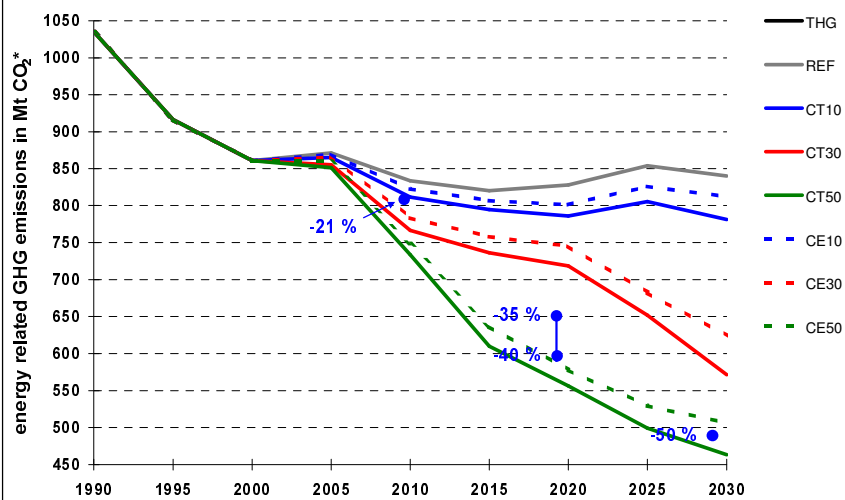
- Phase-out of nuclear energy
- Use of domestic hard coal will decline (1120 PJ in 2000 => 200 PJ in 2030)
- Use of domestic lignite
- Subsidies for renewable energy sources and CHP
- Efficiency improvement programme for buildings
- Self commitment of German car industry to reduce specific fuel consumption
- Starting from year 2007 stronger legislative measures concerning maximum SO<sub>2</sub> and NO<sub>x</sub> emissions for conversion technologies exist

**Scenario definition**

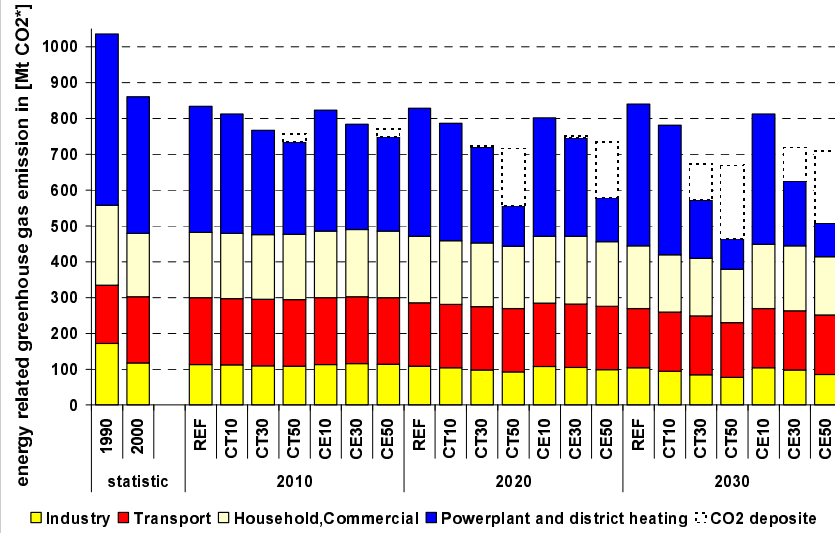
- Reference case (REF)
  - Scenarios with different CO<sub>2</sub> certificate prices between 5 and 50 Euro per t CO<sub>2</sub> in 2010, after 2010 increasing 4 % per year
    - Certificate prices for the total energy system (CT)
    - Certificate prices only for the electricity production (CE)
- (CT30 Certificate price for the total energy system of 30 Euro /t CO<sub>2</sub>)

4%	2005	2010	2015	2020	2025	2030
CT10	0,00	10,00	12,17	14,80	18,01	21,91
CT30	0,00	30,00	36,50	44,41	54,03	65,73

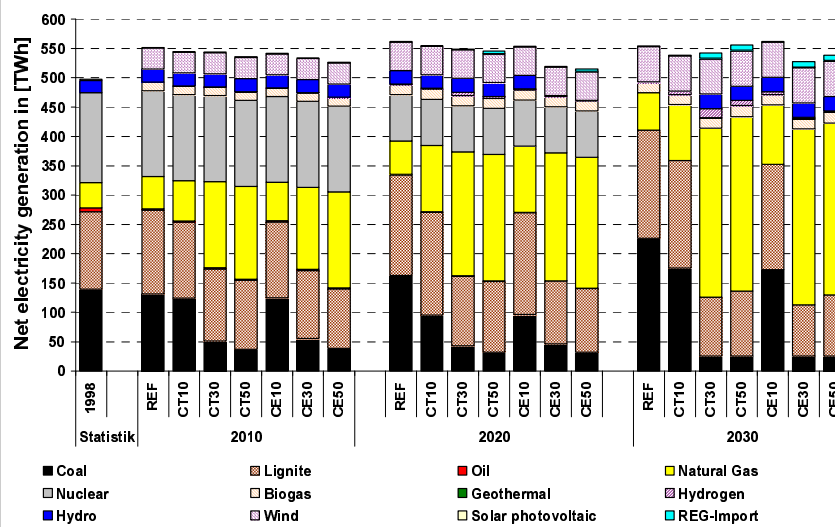
**Energy related greenhouse gas emissions in Germany in Mio. t CO<sub>2</sub>\***



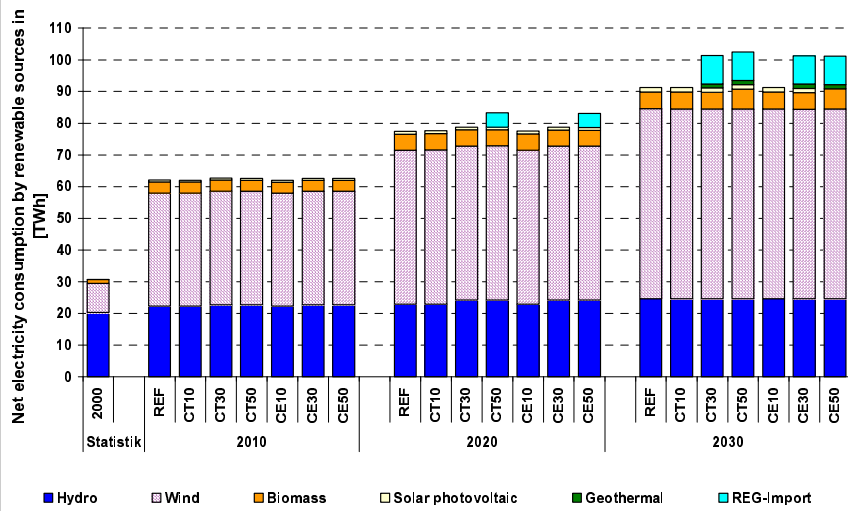
### Energy related greenhouse gas emissions by sectors in Germany



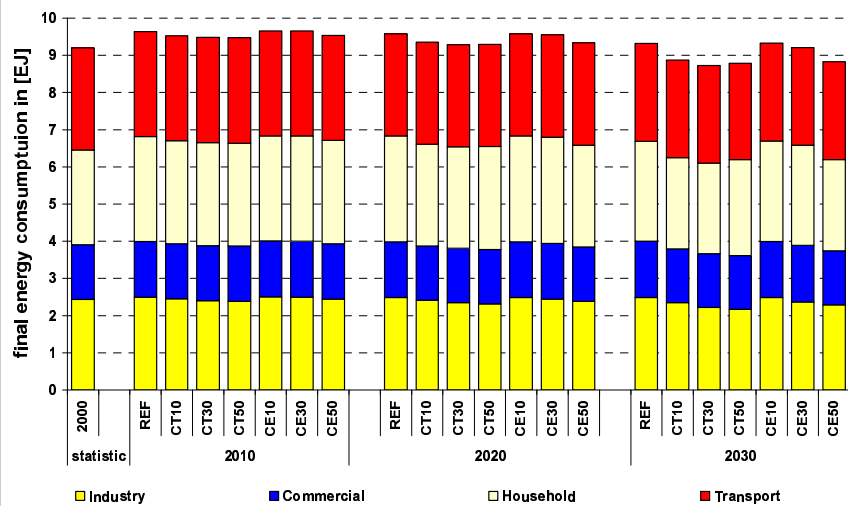
### Net electricity generation by energy carrier in Germany in TWh



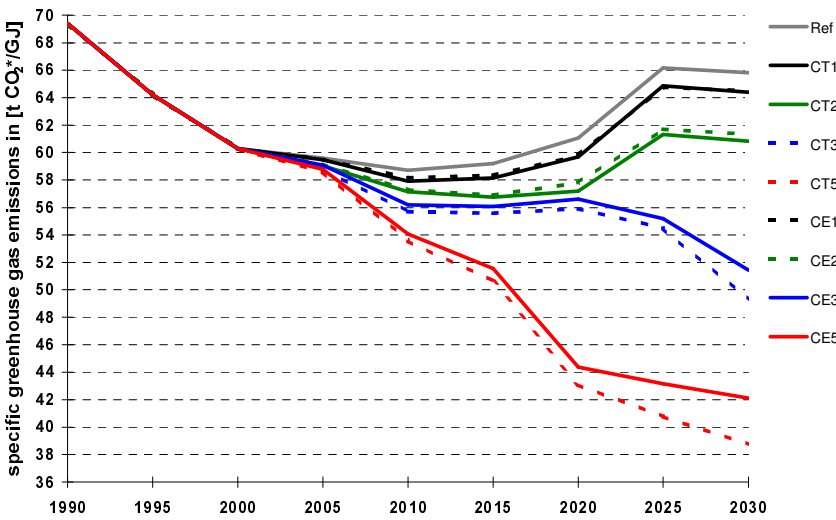
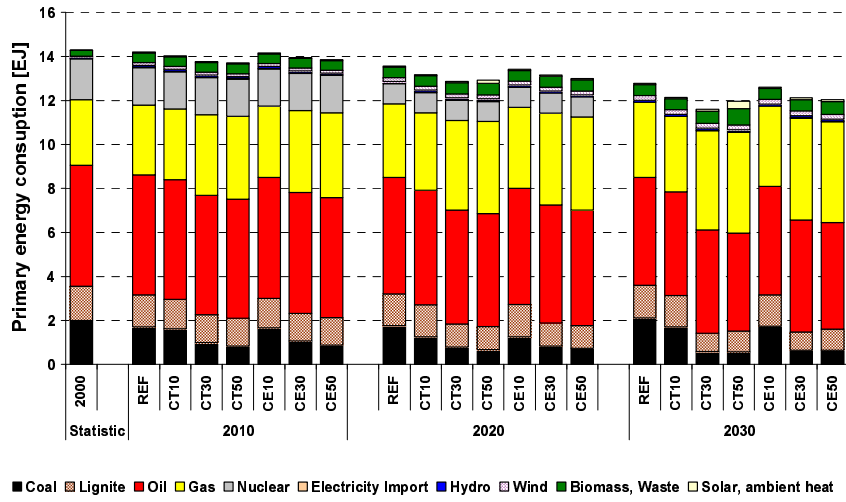
### Net electricity generation by renewable sources in Germany in TWh



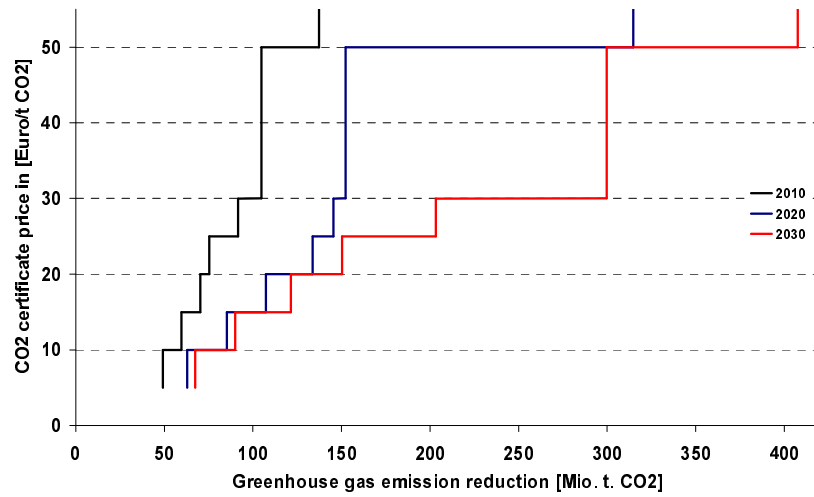
### Final energy consumption by sector in Germany in EJ



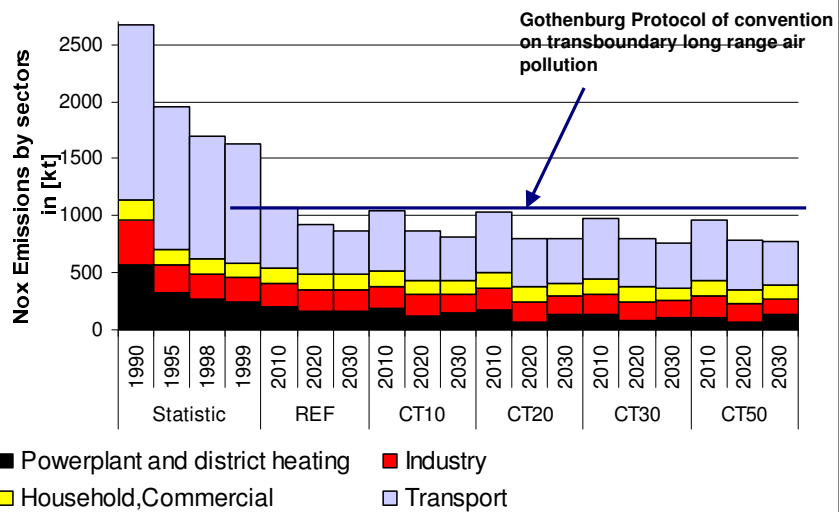
**Primary energy consumption by energy carrier in Germany in EJ**



**Energy related greenhouse gas emissions reduction depending on the certificate price in Germany**

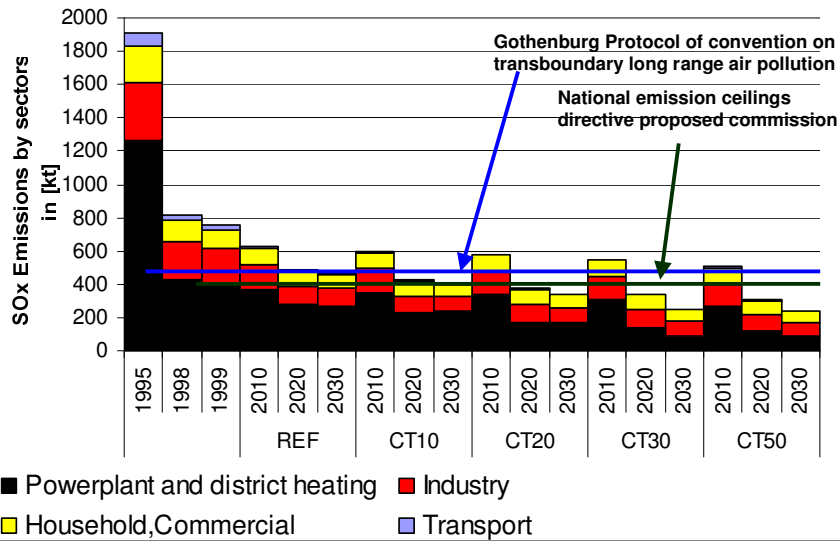


**NO<sub>x</sub>-Emissions by sector for the different scenarios**





### SO<sub>x</sub>-Emissions by sector for the different scenarios



### Considered monetary values for the external costs

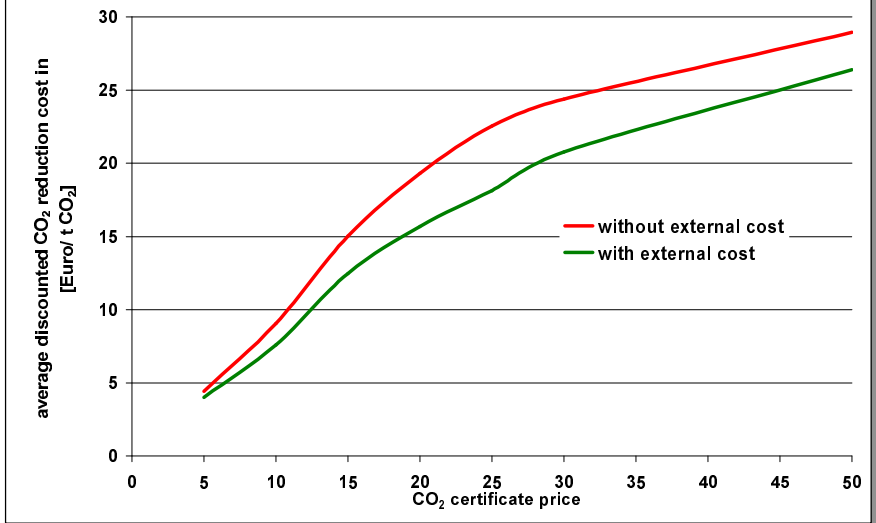
#### For fossil conversion technologies and transport

Cost per t of pollutant	NOX		SOX		particulates	
	stationär	mobil	stationär	mobil	stationär	mobil
	2920	6200	4980	3174	9850	65241

#### For special conversion technologies

	mEuro/kWh
Fuel Cells	3
Nuclear	5
Wind	1
Hydro	1
biomass	3
PV	1

**Comparison between the average of the discounted CO<sub>2</sub> reduction cost with and without taking the external cost into account (ex post)**



**Conclusions**

- **Germany can achieve the Kyoto targets with given CO<sub>2</sub> certificate prices for the whole energy system of 10 €/t CO<sub>2</sub>.**
- **Germany has also with certificate prices lower than 30 €/t CO<sub>2</sub> costs problems to achieve the national emission targets for air pollutants from the European commission.**
- **CO<sub>2</sub> certificates should be applied to the entire energy system to avoid leakage effects.**
- **CO<sub>2</sub> certificates can be used to realise hidden benefits and to realise a sustainable energy supply system in Germany.**