Perspectives of electric vehicles in a supply system with a high share of renewable energy sources

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Project “Perspectives of electric vehicles in a supply system with a high share of renewable energy sources”

DLR Institute of Vehicle Concepts

Fraunhofer ISE Institut Solare Energiesysteme

IFHT Institut für Hochspannungstechnik RWTH Aachen

DLR Institute of Technical Thermodynamics

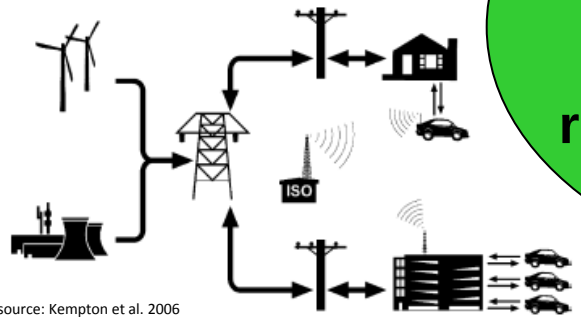
Vehicle technologies, market development, electricity demand

Grid integration, effects and measures

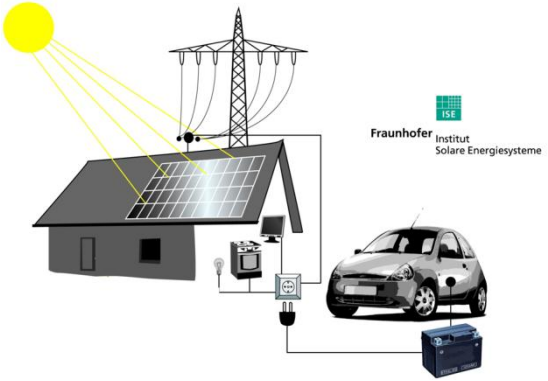
Optimised renewable power generation incl. electric vehicles

Political and financial framework conditions

Perspectives of electric/hybrid vehicles in a supply system with a high share of renewable energy sources



source: Kempton et al. 2006



03/2009 to 07/2012

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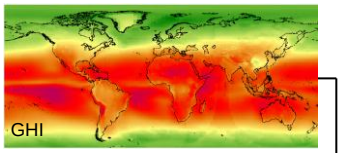
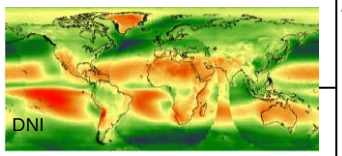
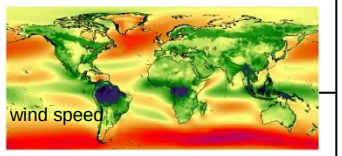
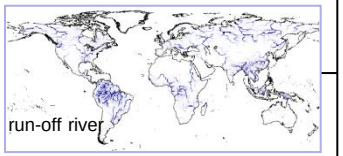
Energy-economical perspective: role of electromobility in the energy system: new demand & option for load balancing/storage

Renewable potentials/ installed capacities for electricity generation









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High voltage DC: Interregional long-distance electricity transport

Main grid: based on todays AC-Grid (Europe)

Scenario analysis with REMix model

Cost minimising, temporally & spatially resolved

Model

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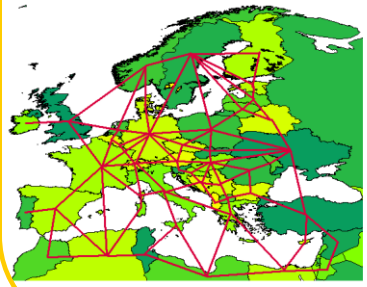
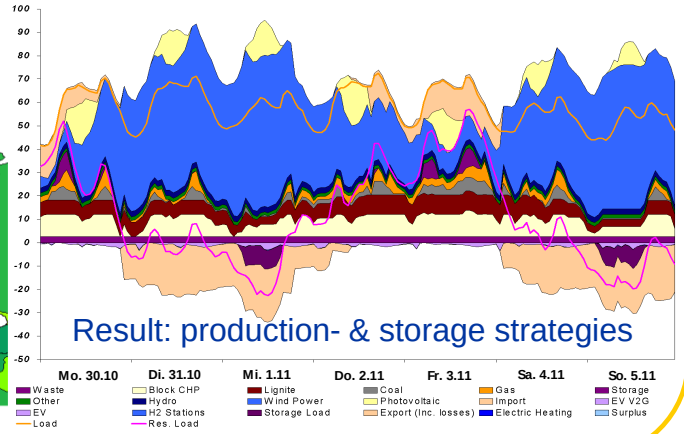




Conventional power plants: nuclear, coal natural gas

Electricity storage: Pumped-storage Compressed air Hydrogen

Demand side management Industry & households Increase in energy efficiency

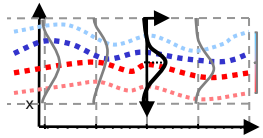
Electricity demand

Heat demand (CHP)

Flexible management:
- heat storage
- peak burner/el.-heater

Electric vehicles (EV)

BEV/hybrids: charging strategy, hourly battery capacity of the fleet on the grid.



FCEV: flexible on-site H_2 generation

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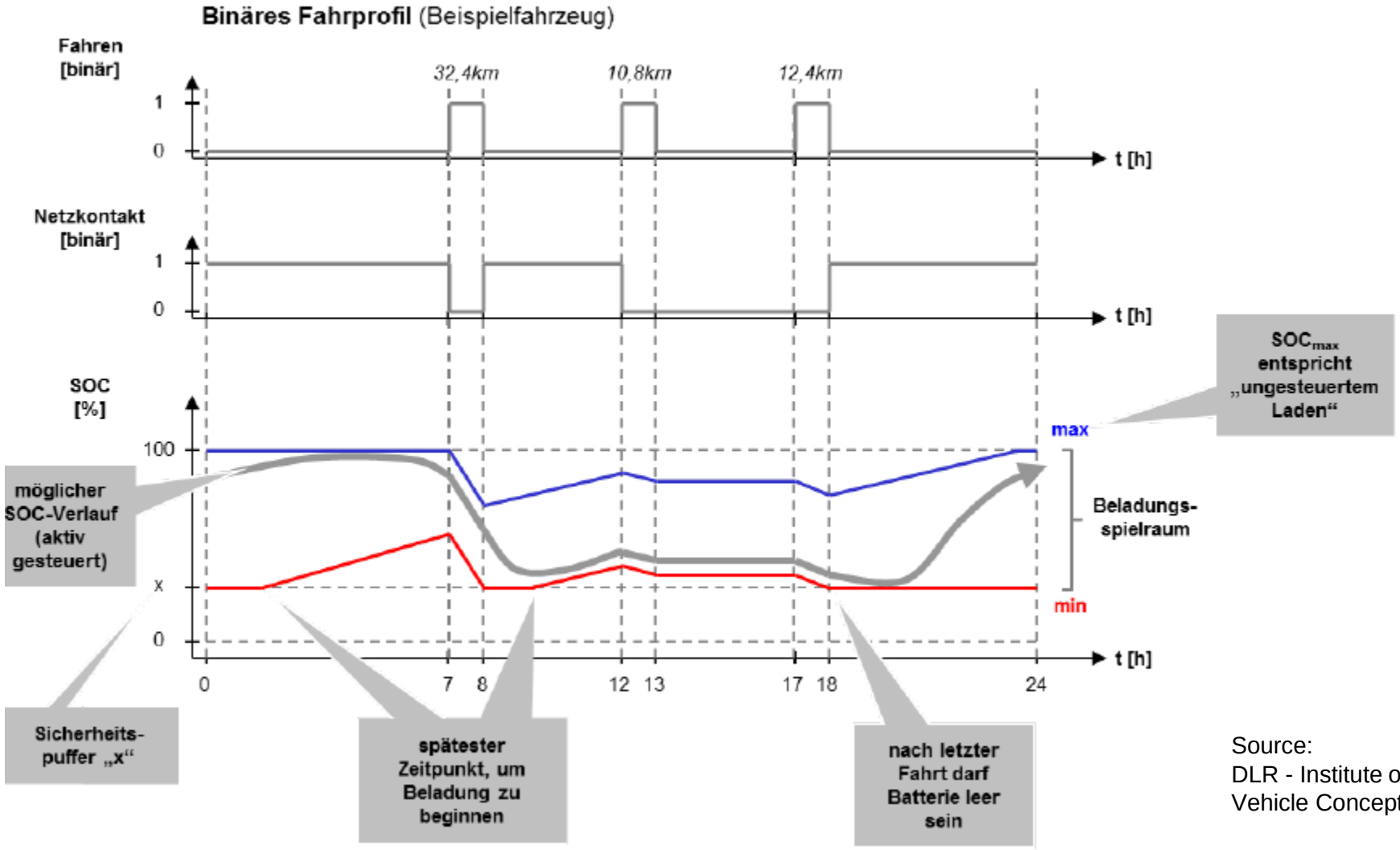
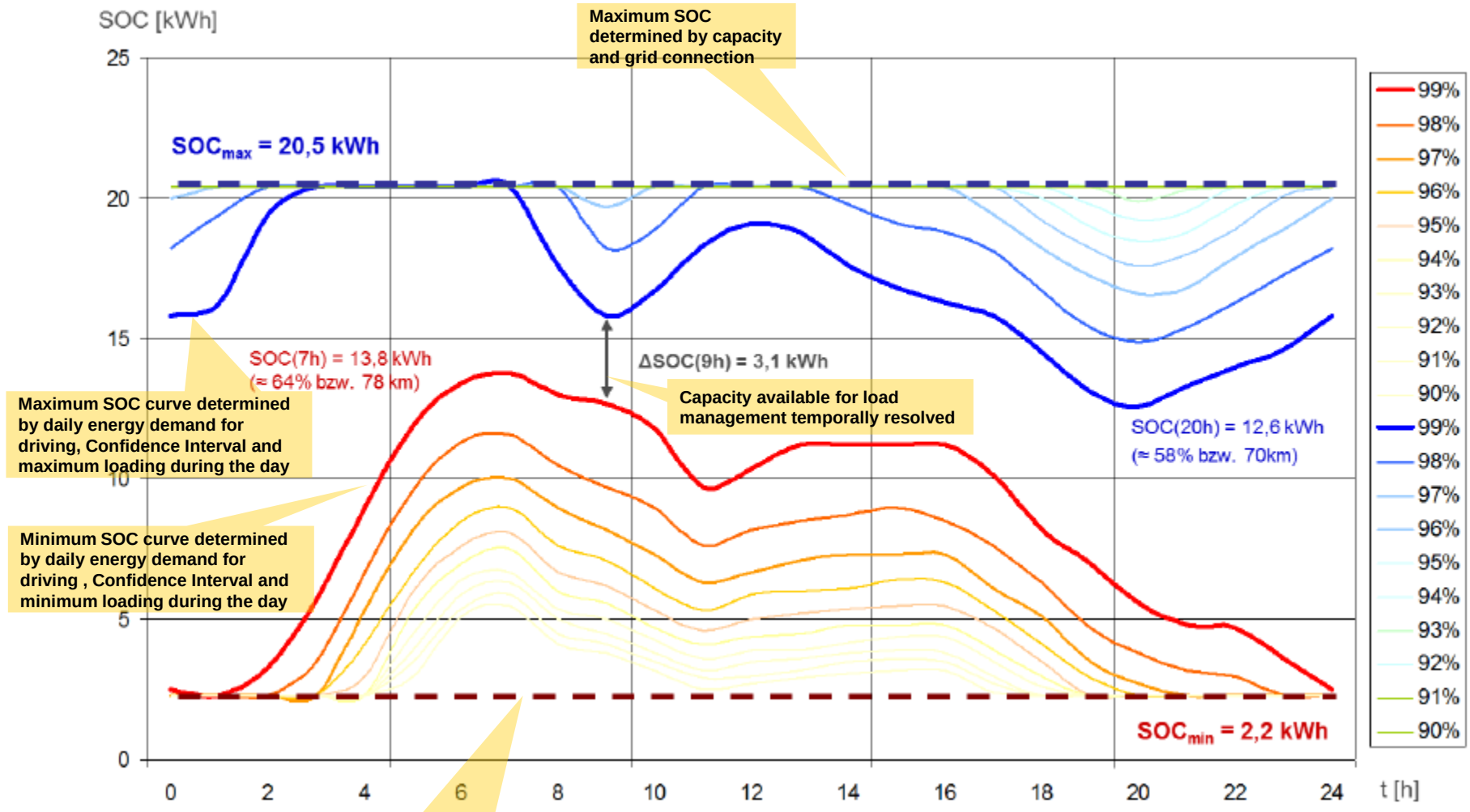
Modeling of the „large battery“ made up of vehicles

binary daily driving pattern with maximal and minimum loading of the battery



Source:
DLR - Institute of Vehicle Concepts

Statistical evaluation of 17‘868 empirical measured real world driving patterns (MiD 2008) ► hourly battery “capacity” of the fleet on the grid



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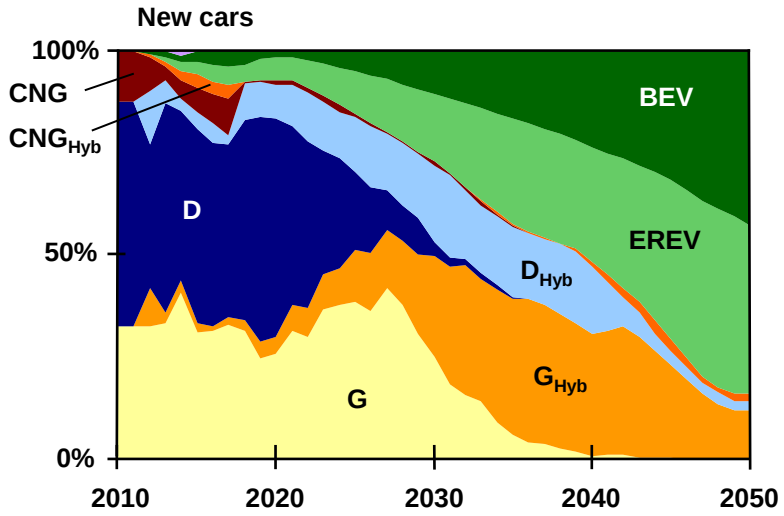
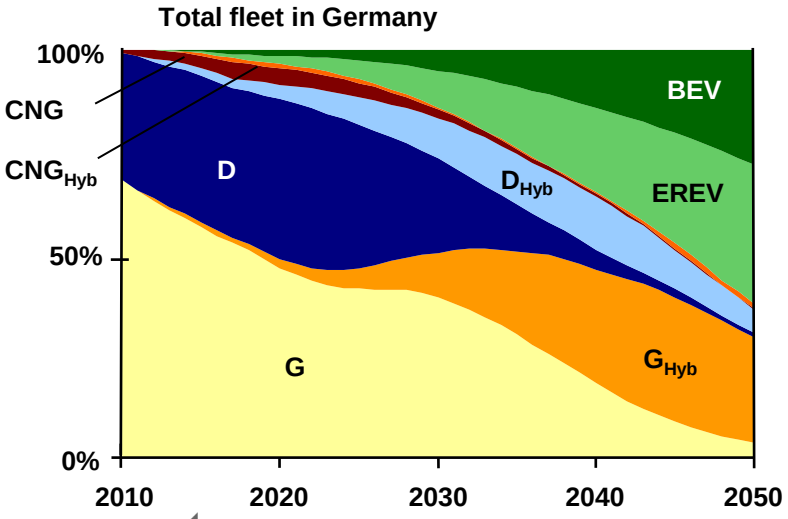
Scenario for EV success in Germany – new PC and PC fleet development – fleet modelling based on the total costs of ownership approach



- Conventional vehicles will be substituted by their hybrid variants
- If reduced tax for CNG cars will be phased-out in 2018, CNG will be squeezed out of the market
- Due to the assumed learning rates alternative vehicles will be implemented in the vehicle market
- Fuel cells are not successfull in this scenario depending on cost assumptions



- The change of the total fleet takes place with time delay
- In 2050 still conventional vehicles are existing in the fleet
- The share of vehicles with electric drive train (BEV & EREV) reach more than 50% in 2050. The sceanrios reaches about 1 million EV in 2020 and about 5 millions in 2030.

Vehicle categories:G: gasoline, D: diesel, CNG: natural gas, Hyb: hybrids w/o plug-in, EREV: plug-in range-extender, BEV: battery electric vehicle, FCV: fuel cell vehicle, source: **DLR-FK with VECTOR21 model**

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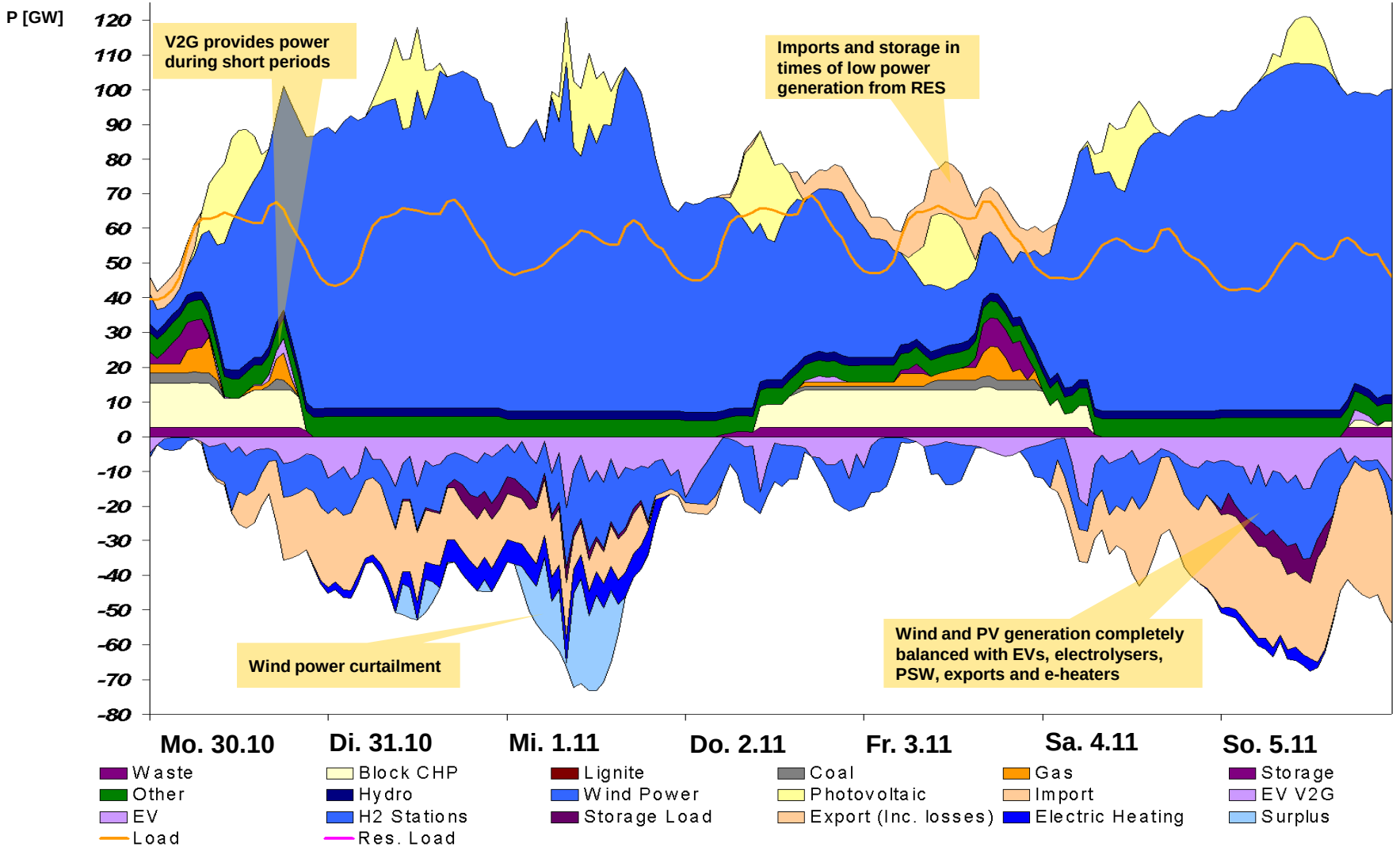
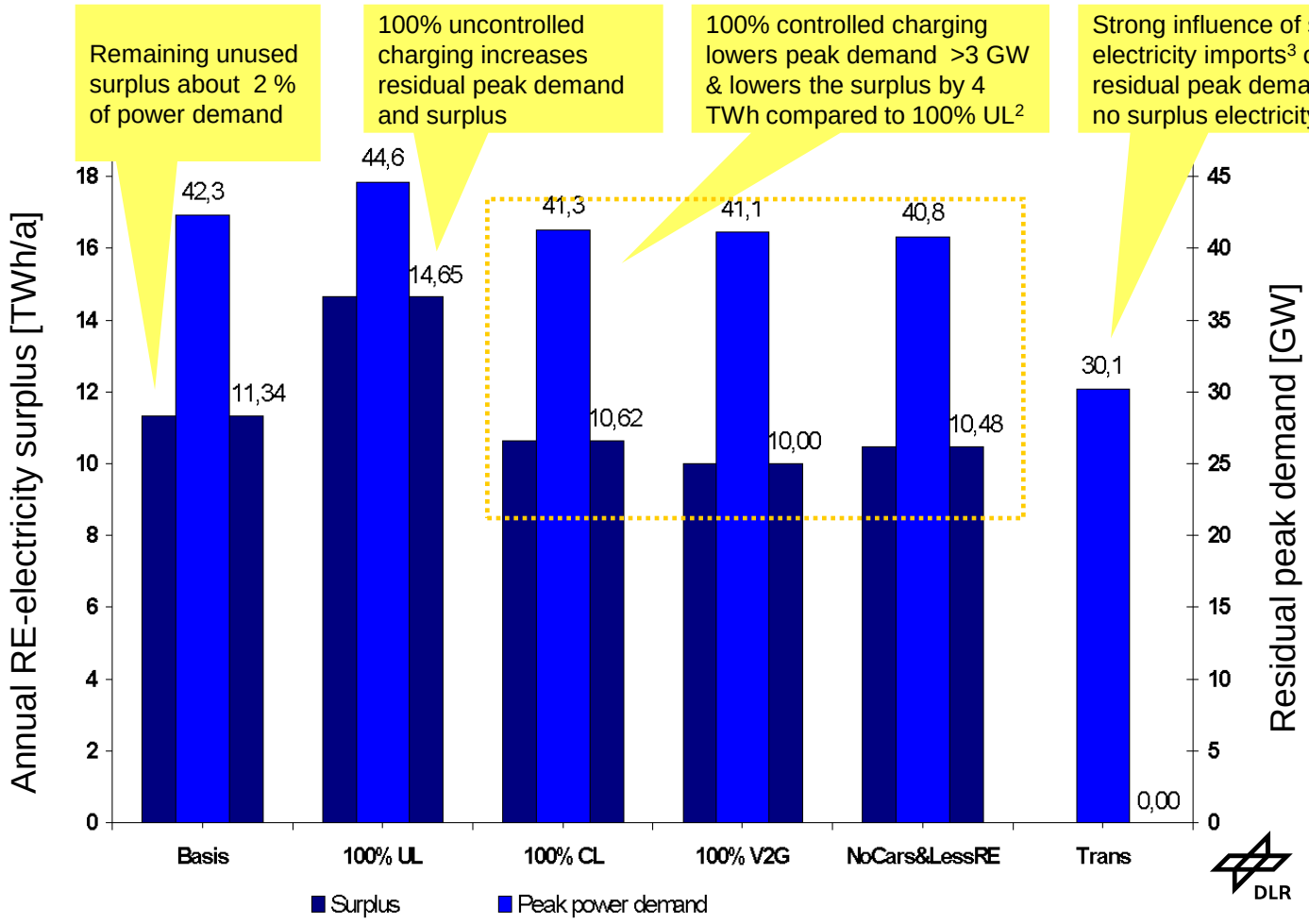
Demand coverage - week with high wind power volatility - Fall 2050 (R2006)

(scenario: local use of RES, 27 Mio. EVs, H_2 through onsite electrolysis[1], RE share 87% DE & 80% EU)



1. EVs consuming 53,5 TWh/a (40% uncontrolled loading (UL), 40% controlled loading (CL), 20% V2G), 85 TWh/a for H_2 electrolysis with 4000 flh

Results for power supply system in 2050: „Basis“scenario: 27 Mio. EV (53,5 TWh/a) (40% controlled charging, 20% V2G); 87%/80% RE share electricity in D/EU; 57 TWh H_2 generation for Transport in D; no electricity imports



1 average of 5% hours of the year with the highest loads

2 refer to electricity generated by additional RE capacities to cover the demand of EVs

3 >15% of demand in Germany

source: Prospects for electric/ hybrid vehicles in a power supply system dominated by decentralized, renewable energy sources. Final report by DLR Stuttgart/FhG ISE Freiburg/IfHT RWTH Aachen, FGH Aachen. July 2012

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Main Results: prospects of electric vehicles in a supply system with high shares of renewable energy (Germany 87% in 2050, high fluctuating share)

- The simulation of economically optimised operation/use of
  - controllable/flexible generation capacities, storage capacities (pumped storage),
  - power transfer capacities in the (expanded) European transmission grid and
  - the controlled loading of vehicle batteries in Germany in 2050

  shows a **significant potential for peak shaving and use of „excess“ power**

- **Electric vehicles** in a „successful“ fleet scenario and entirely **with controlled loading** are able to reduce the **residual peak load by ~3 GW and use ~4 TWh** excess electricity compared to uncontrolled loading. The total excess power that was used by vehicle batteries in some hours of the year were up to 20 GW.

- I.e. **electro-mobility using renewable energy** (total annual demand generated by additional RE capacities) could be realised in Germany by controlled loading without negative impacts on the power supply system (in terms of residual peak load, excess electricity and CO_2 emissions)

- However, load balancing potentials of flexible cogeneration plants (with heat storage & electric heater), power transfer between generation & demand centres in Europe and solar power import appeared to be **much higher than the EV potential**

Main Results: cost effects of electric vehicles in a supply system with high shares of renewable energy (Germany 87% in 2050, high fluctuating share)

- **Scenario without EV vs. scenario with 27 Mio. EV + 60% controlled loading**

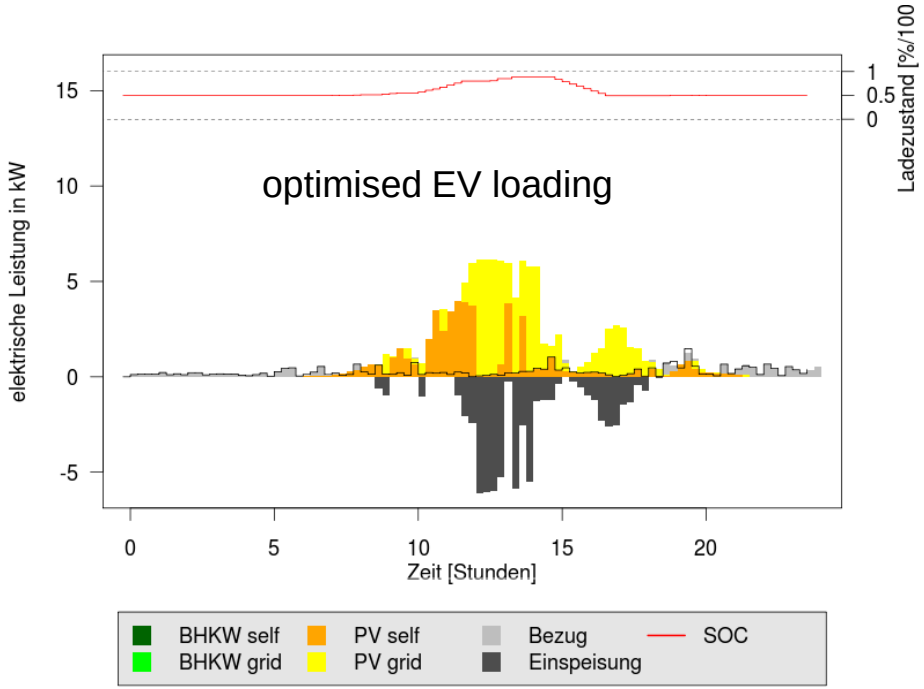
  - 53,5 TWh/a more consumption, ~20 GW more installed RE in 2050
    but significant lower final energy demand and CO_2 emission in transportation
  - total power generation costs **increase by 8%**

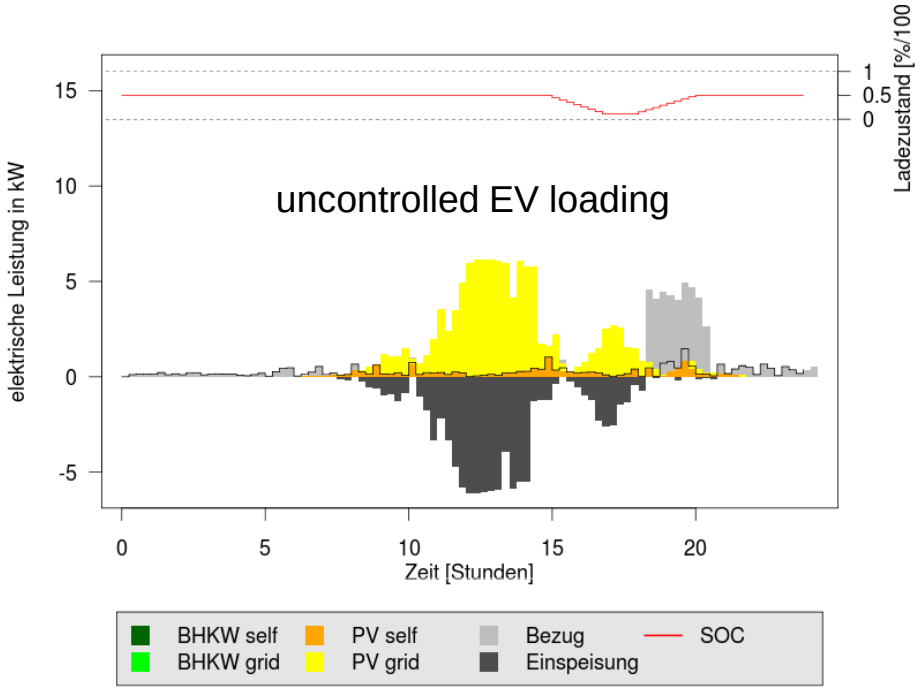
- **Scenario with 27 Mio. EV and uncontrolled vs. 100% controlled loading**

  - ~3 GW less back-up PP and ~4 TWh less power generation required
  - total power generation costs **decrease by 3%**

Results single house with EV + PV: Electrical load and power generation for a summer day in Germany, single house with PV (7 kW_p) with optimised operation (left) resp. uncontrolled loading (right); maximal loading capacity EV 3.7 kW

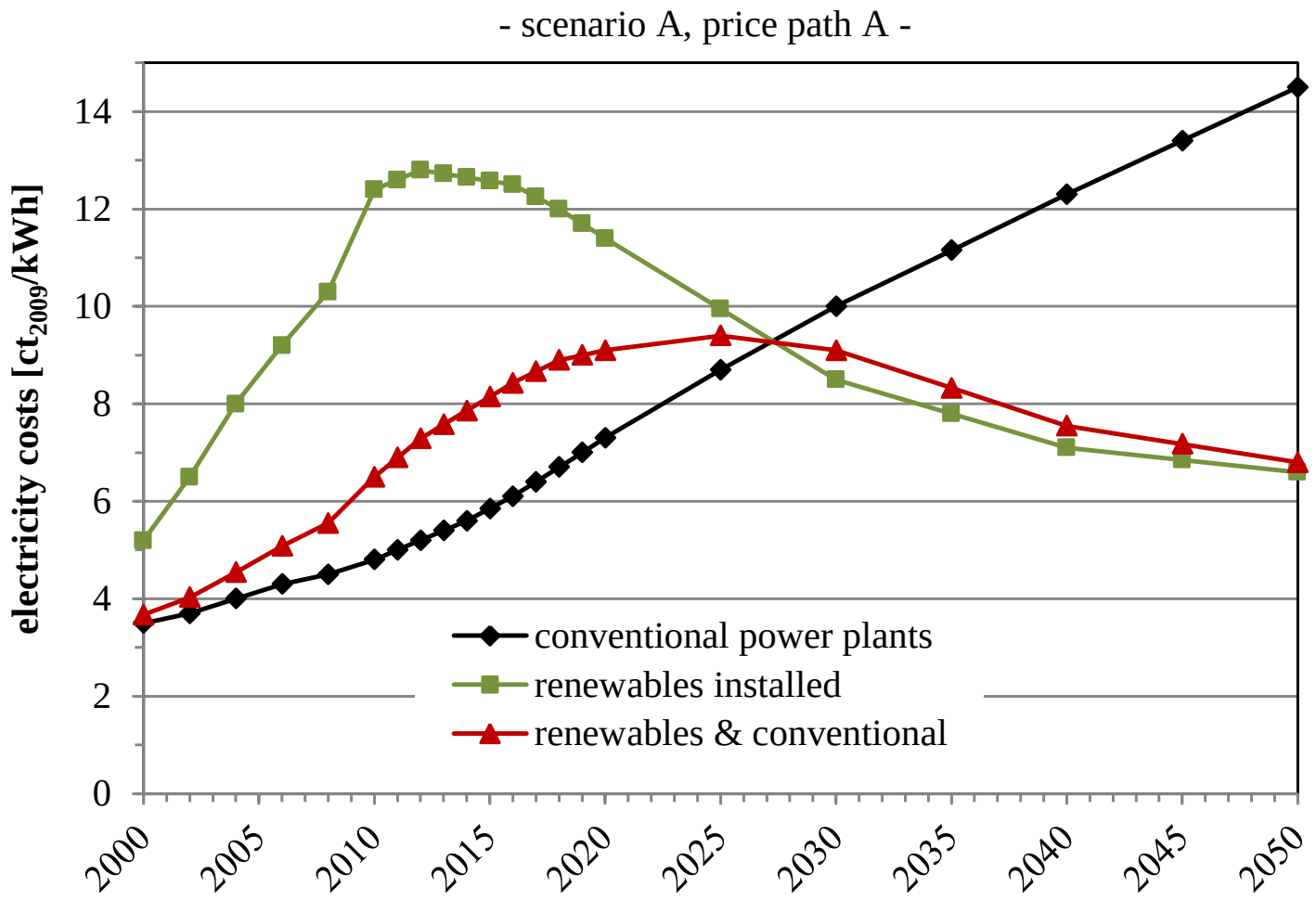
- Optimised loading of EV increases own used share of electricity from PV and reduces electricity demand from the grid
- However, due to limited battery capacity PV feed-in starts at noontime, therefore PV generation peaks can not be avoided





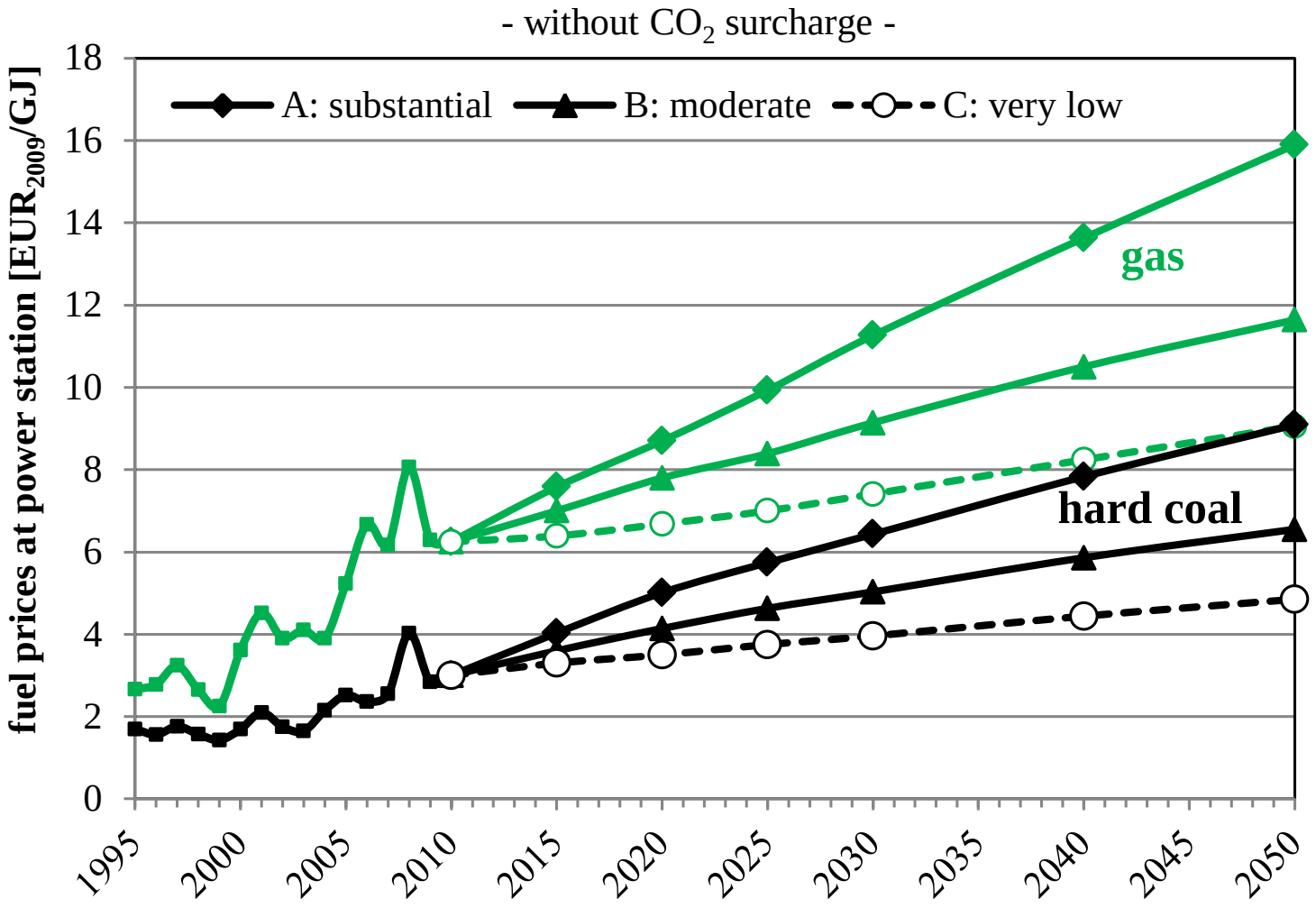
Source: FhG ISE Freiburg

Cost effects of RES deployment: scenario for Germany up to 2050, RE share in power generation up to ~85%, compared to fossil generation scenario (fossil fuel price path A = significant increase, CO_2 costs up to 75 €/t)



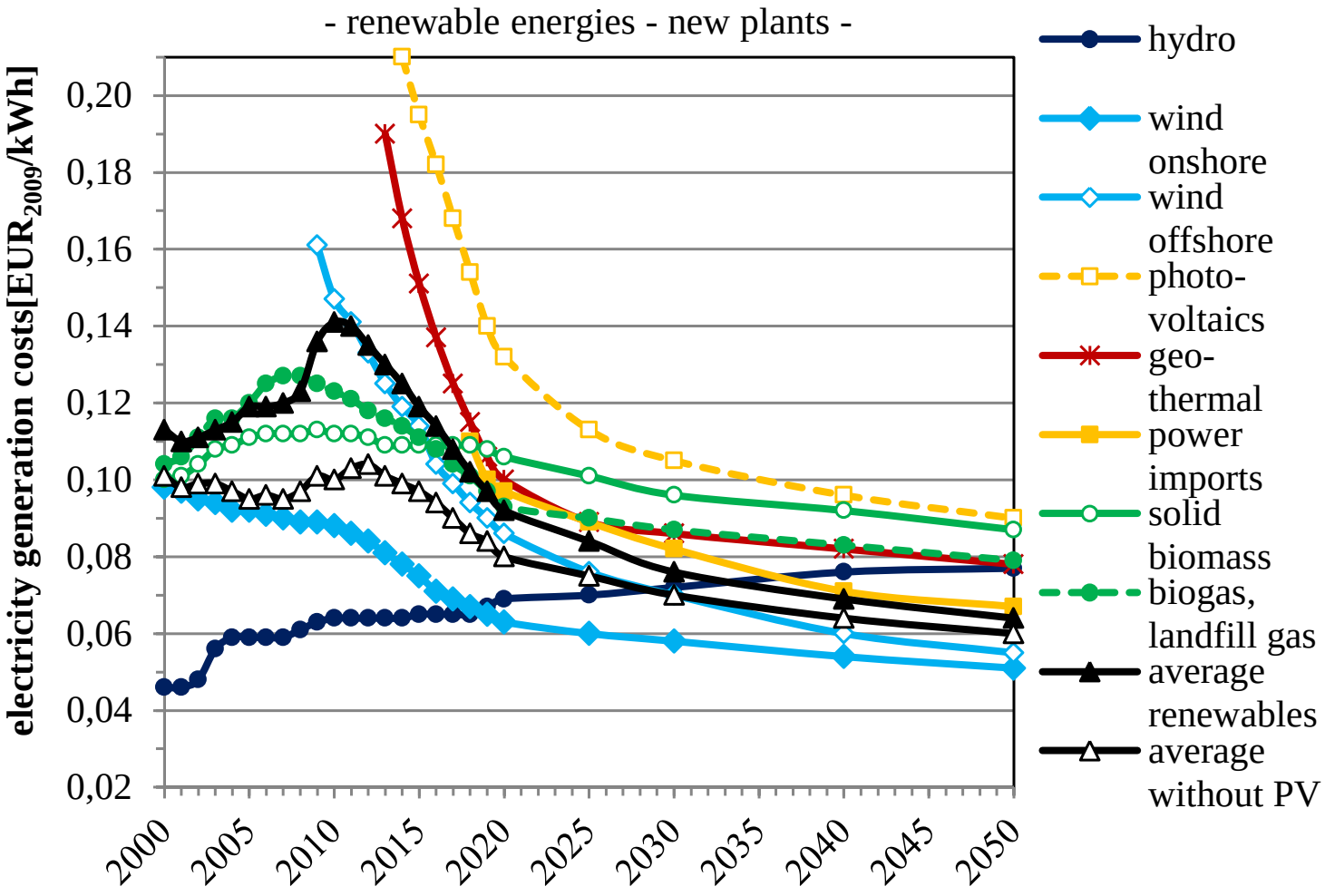
Source: Long term scenarios and strategies for the deployment of renewable energies in Germany, DLR 2012

Price paths assumed: 3 scenarios up to 2050



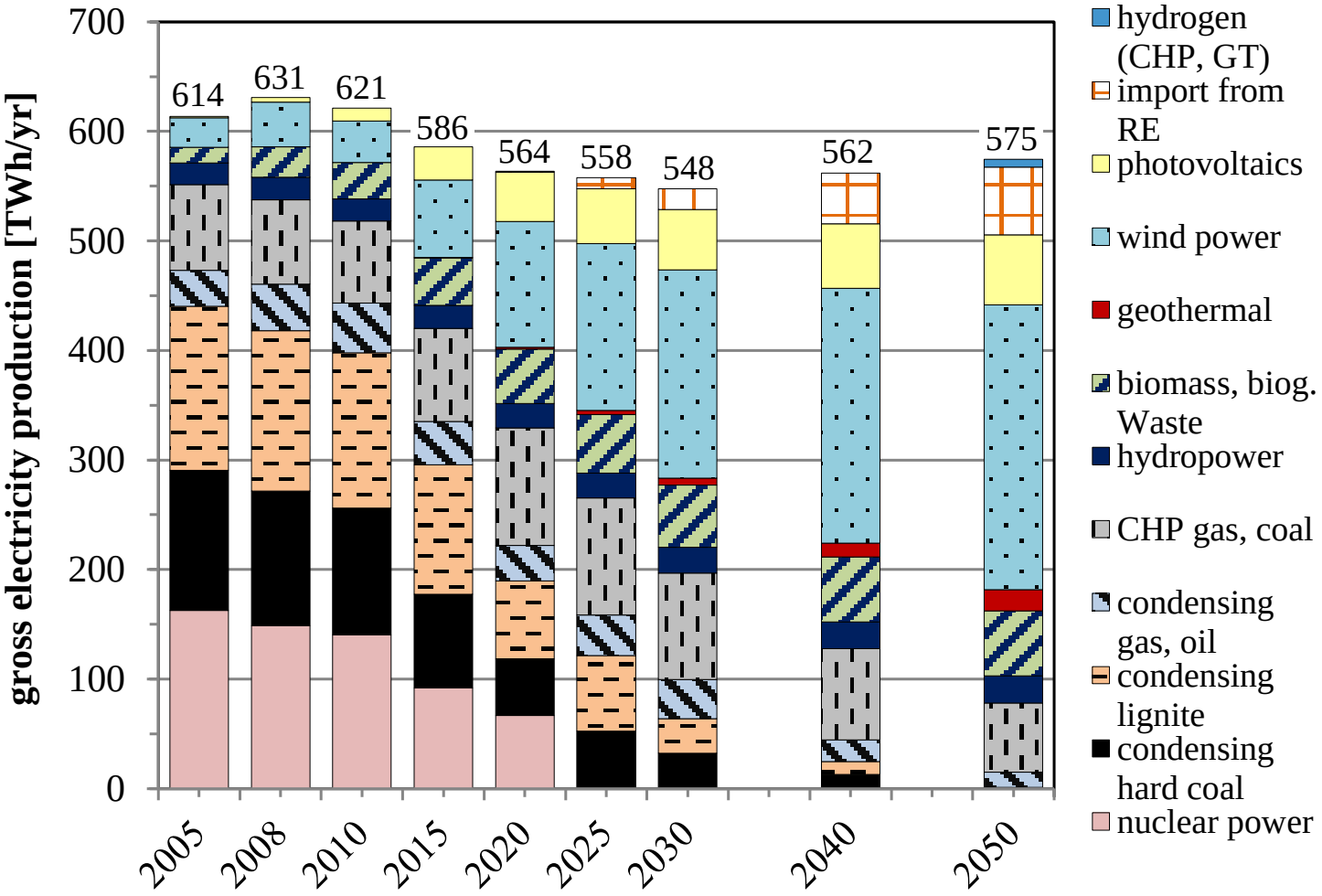
Source: Long term scenarios and strategies for the deployment of renewable energies in Germany, DLR 2012

Development paths RE technologies assumed:
scenario based on (own and external) expert judges up to 2050



Source: Long term scenarios and strategies for the deployment of renewable energies in Germany, DLR 2012

Transformation of the electricity supply system: scenario for Germany up to 2050, RE share in power generation up to ~85%



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