Perspectives of electric vehicles in Germany: customer suitability & renewable energy integration

EVS 25, Shenzhen, 09.11.2010

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To the work presented:

- Work based on the ongoing research project "Perspectives of Electric Vehicles with high Share of distributed and renewable Energy Sources" (End due 2011)
- Financed by the Federal Ministry of Economics and Technology

Bundesministerium für Wirtschaft und Technologie

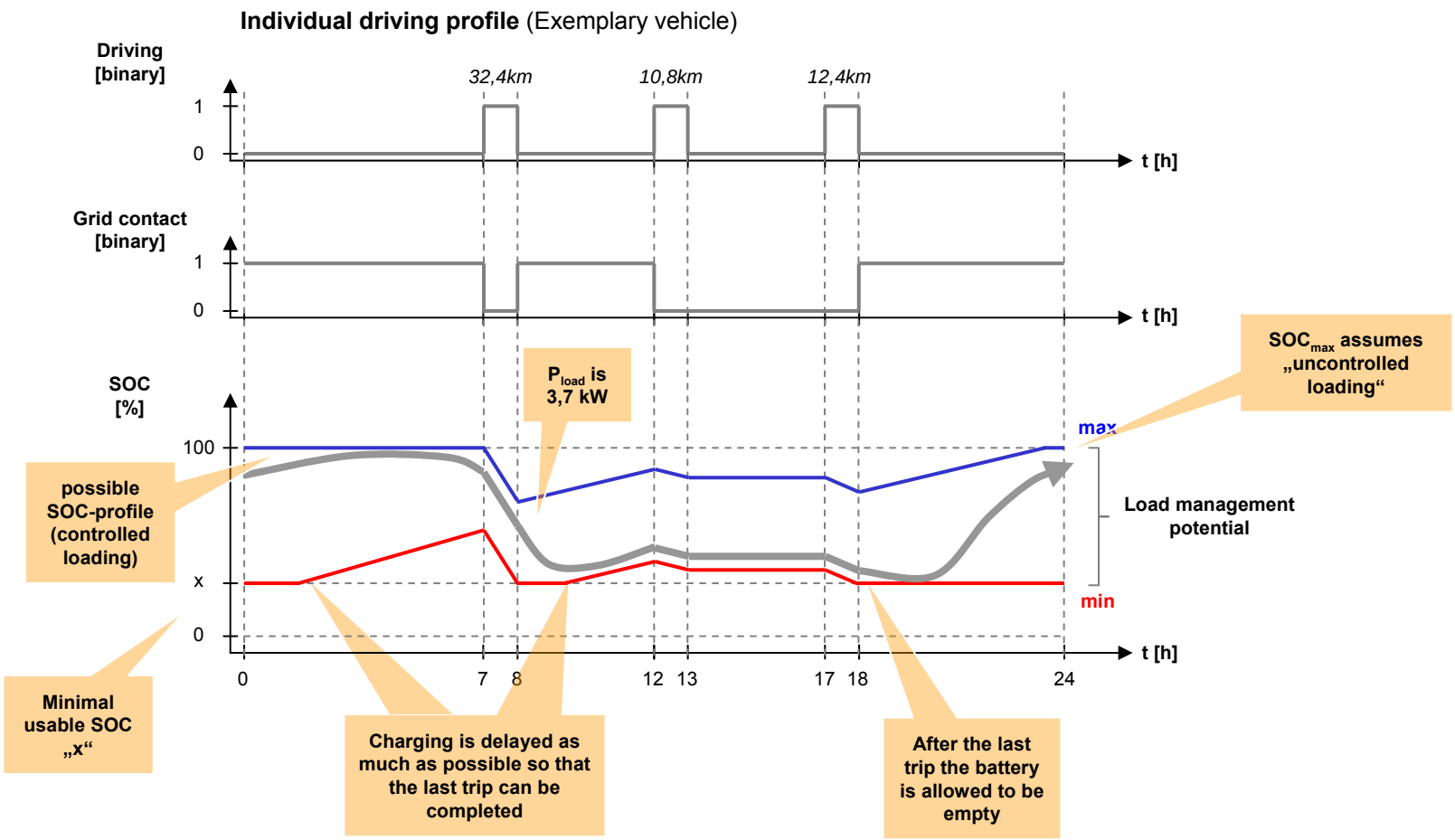
- Project partner:

DLR Institute of Technical Thermodynamics	Coordination Power gen. technologies, potentials and scenarios Political and economical framework	Impact on the power system
Fraunhofer ISE	Battery and loading technology Integration in house level & in distribution grids	
DLR Institute of Vehicle Concepts	Vehicle technology & user driving profiles Market penetration of different vehicle concepts	Model of the EV fleet
IFHT & FGH	Power transmission technologies Impact in the medium and high voltage network	

Presented In this work

Individual daily driving profiles

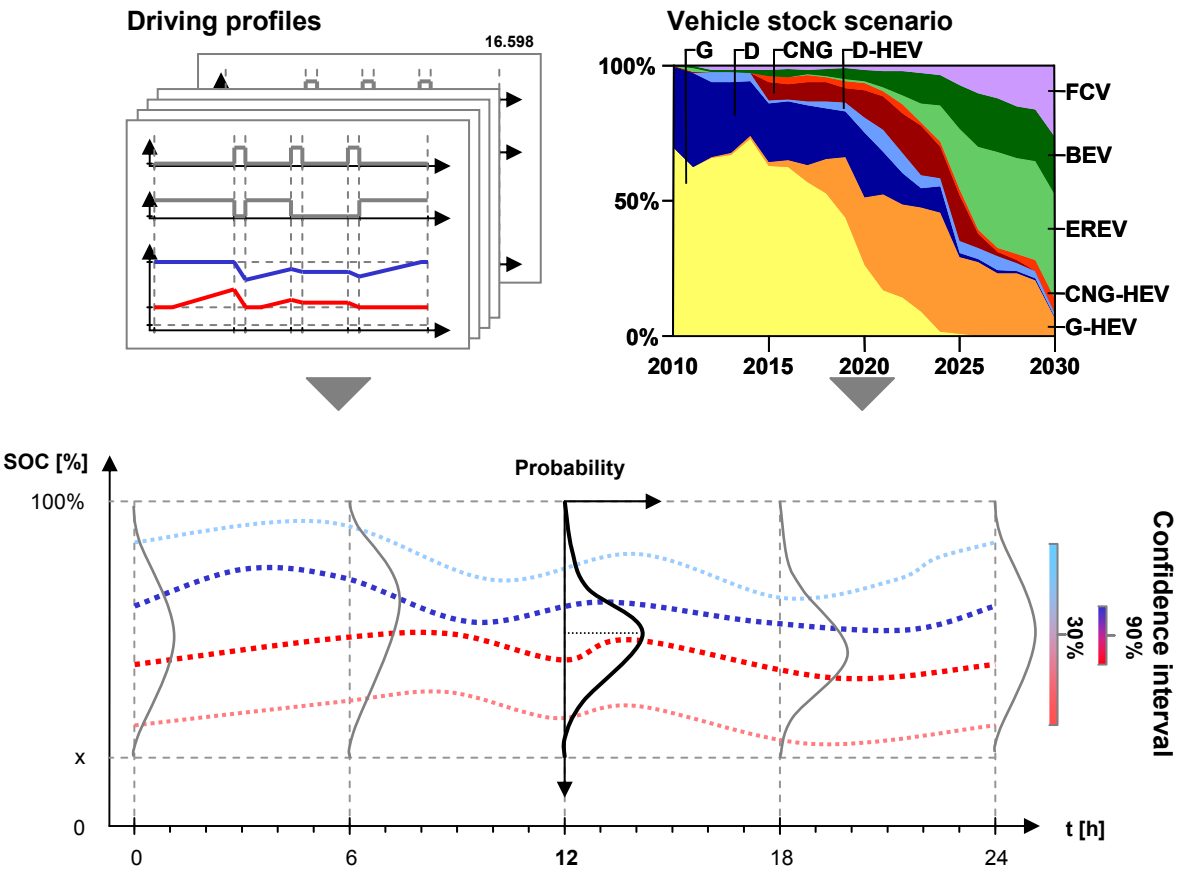
Calculation of the loading state's limits of each vehicle and profile



Source: DLR Institute of Vehicle Concepts

SOC-Profiles of the electric vehicle fleet

Calculation of the load management potential of the EV fleet



Source: DLR Institute of Vehicle Concepts (DLR-FK)

User profiles

- Based on the survey "Mobility in Germany"
- Modeling of the power consumption of electric vehicles
- Determination of the maximal and minimal charging state of the battery

Vehicle stock scenario

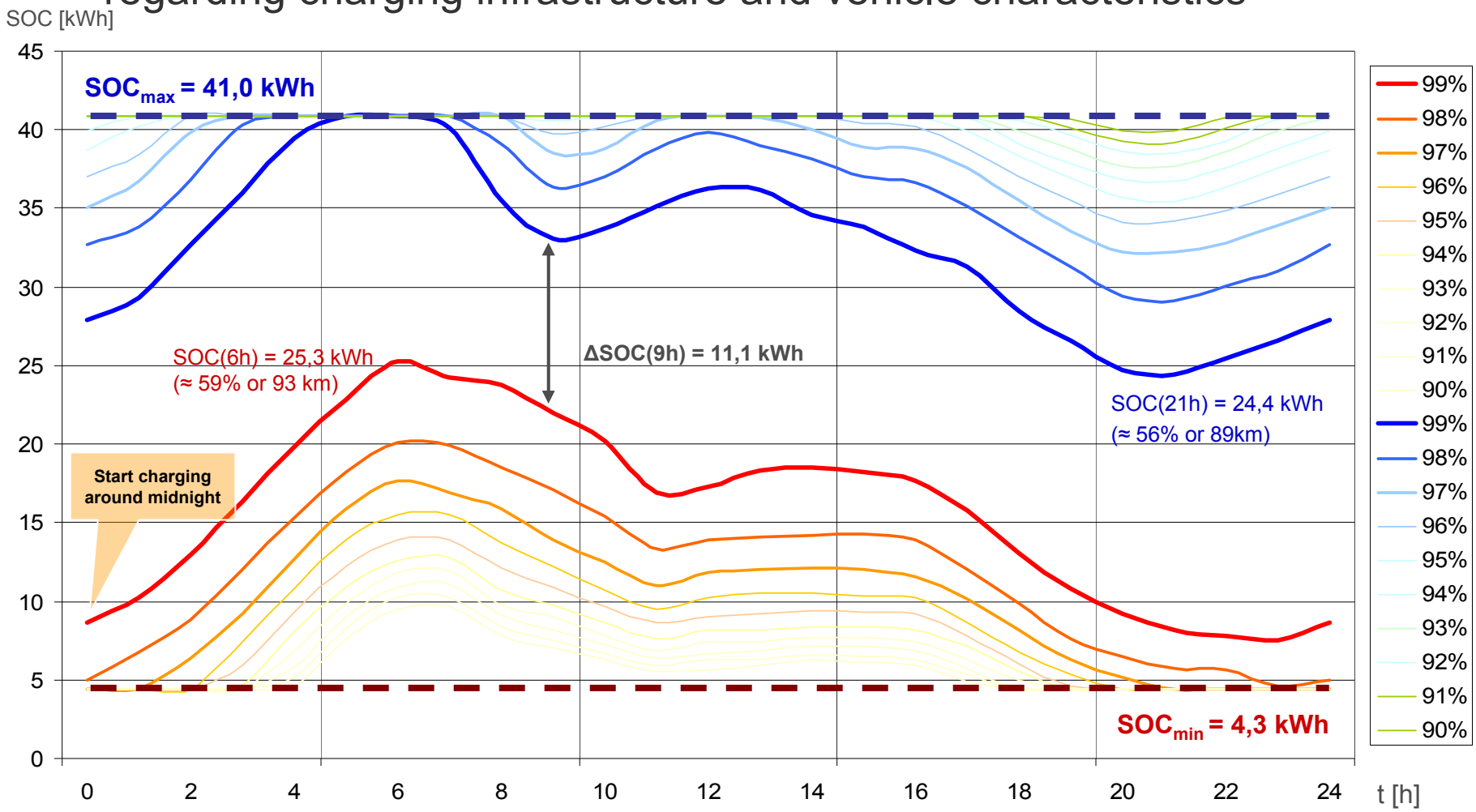
- Scenarios calculated with *VECTOR21* (DLR-FK) considering different vehicle concepts, customer groups, and cost developments

Aggregated profiles

- Calculated applying confidence intervals on the single profiles
- Robust results due to the high significance level (99%)

Load management potential of electric vehicles

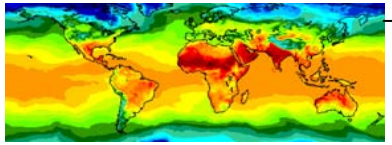
~75% from the profiles suitable for EVs with the assumptions made regarding charging infrastructure and vehicle characteristics

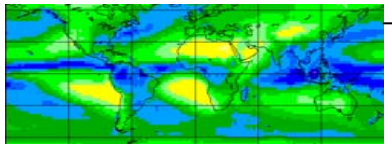


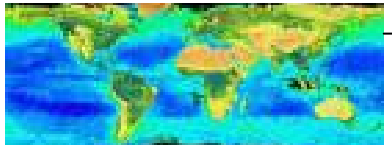
Source: DLR Institute of Vehicle Concepts, medium sized battery electric vehicles displayed

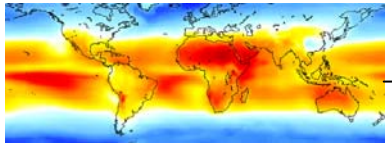
Inventory of RES

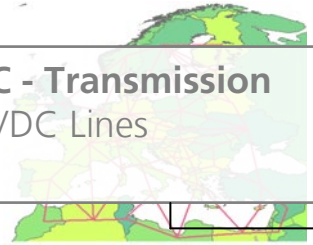
(GIS, C)



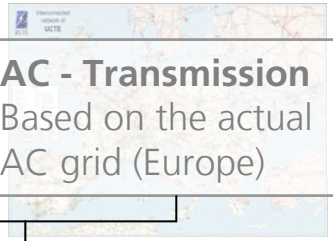








DC - Transmission
HVDC Lines



AC - Transmission
Based on the actual AC grid (Europe)

Power demand

Heat demand

Optimizations Model
Linear programming
(GAMS)

Electric vehicles

- Uncontrolled loading
- Controlled loading
- Controlled loading bidirectional

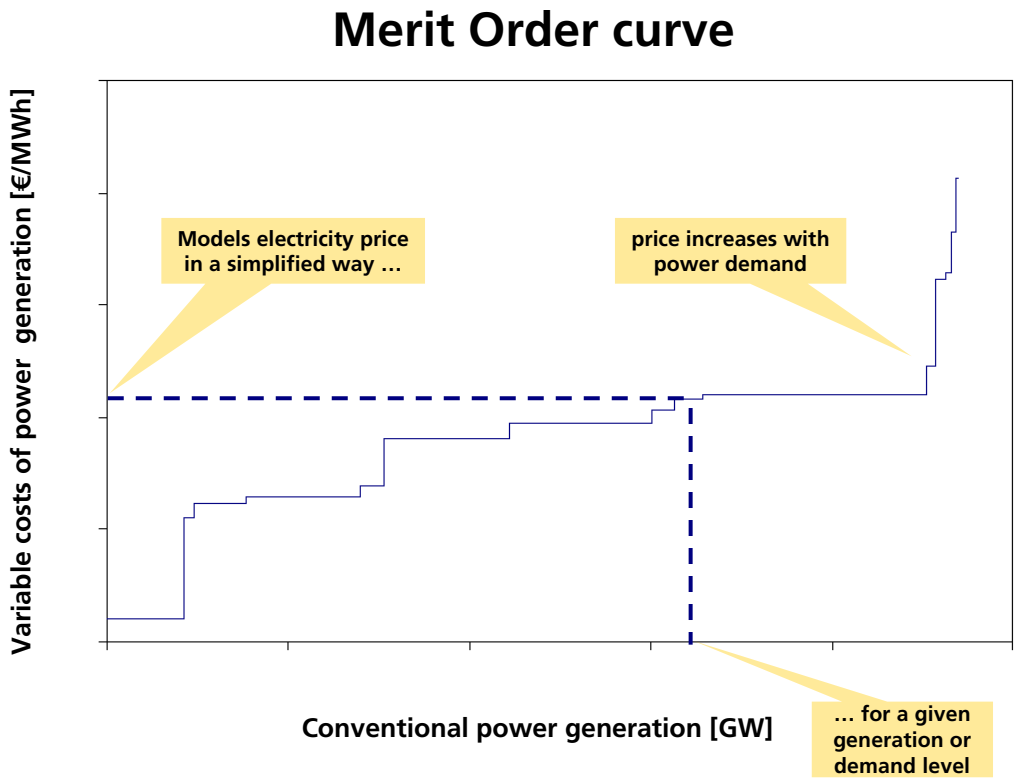
Conventional generation
Nuclear, Coal
CCGT, Gas

Storage
Pumped Stor.
CAES
Hydrogen

Load Management
Increase in system-efficiency

(Fields in grey haven't been used in this work)

Modeling of conventional power plants



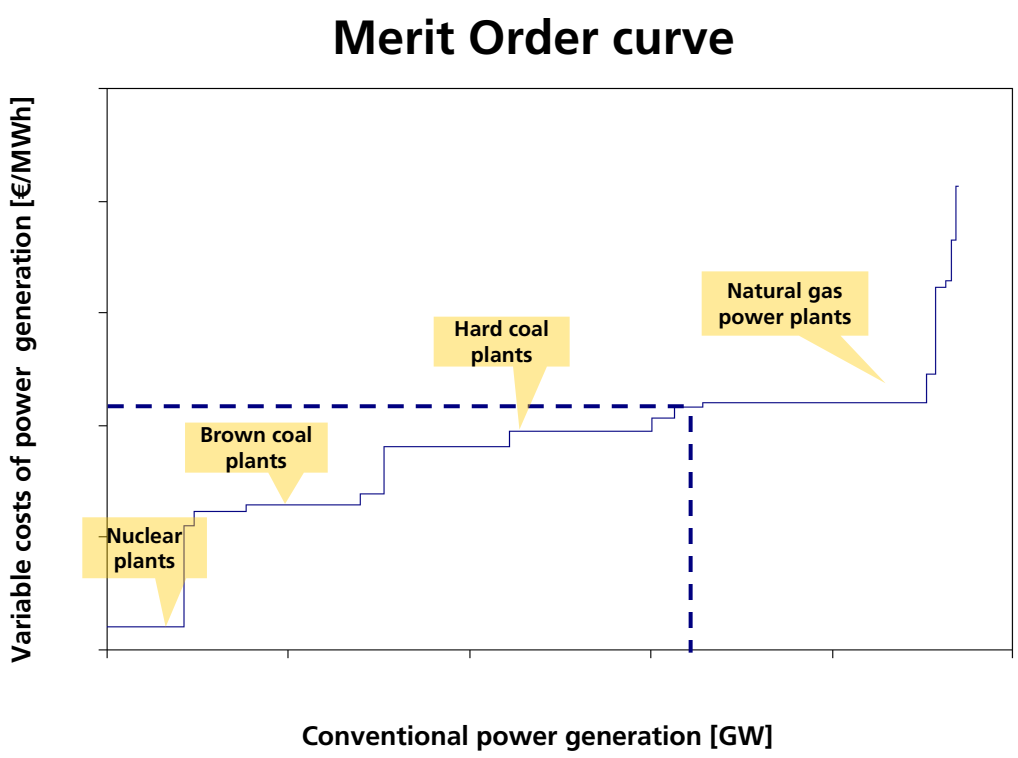
Power plant data

- Considering present power plants as well as those approved or in approval process

Power generation costs

- Take into account:
  - Year of construction
  - Year of decommissioning
  - Development of fuel costs and CO_2 certificate prices

Modeling of conventional power plants



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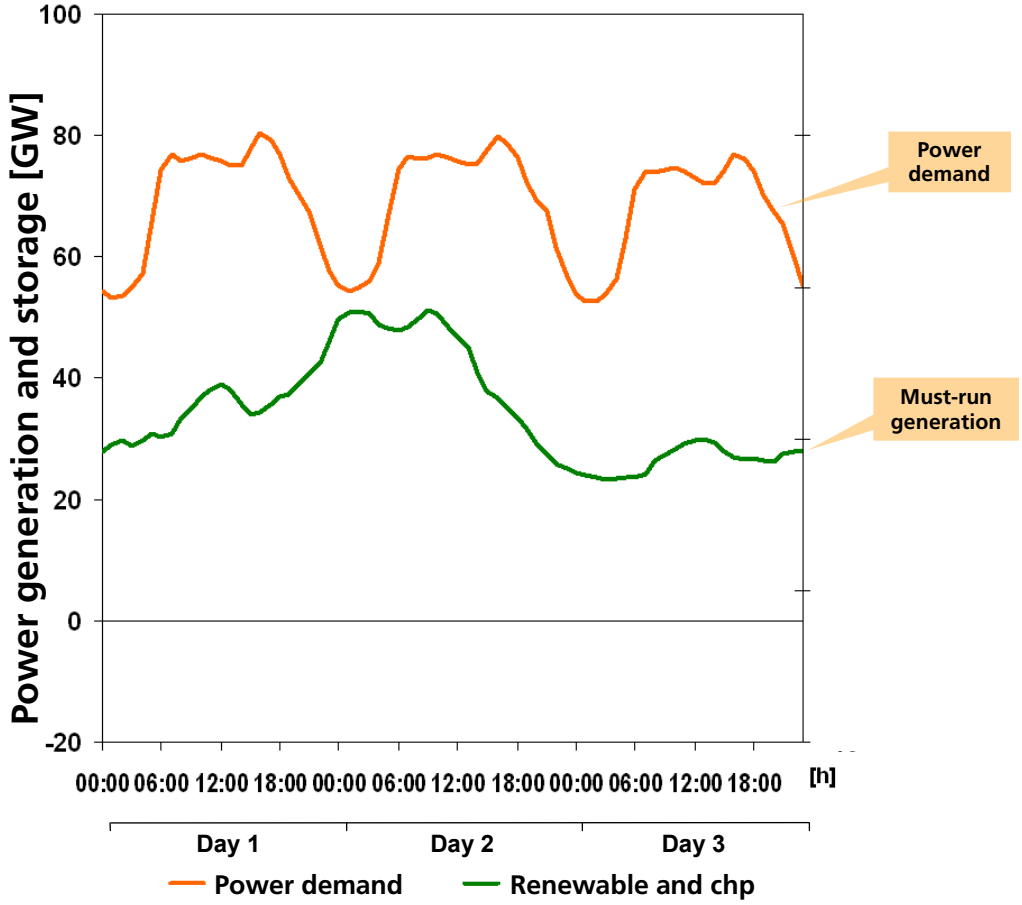
Controlled loading of EVs with small wind variations
Exemplary results for 2030, 30% EVs (12 Million)



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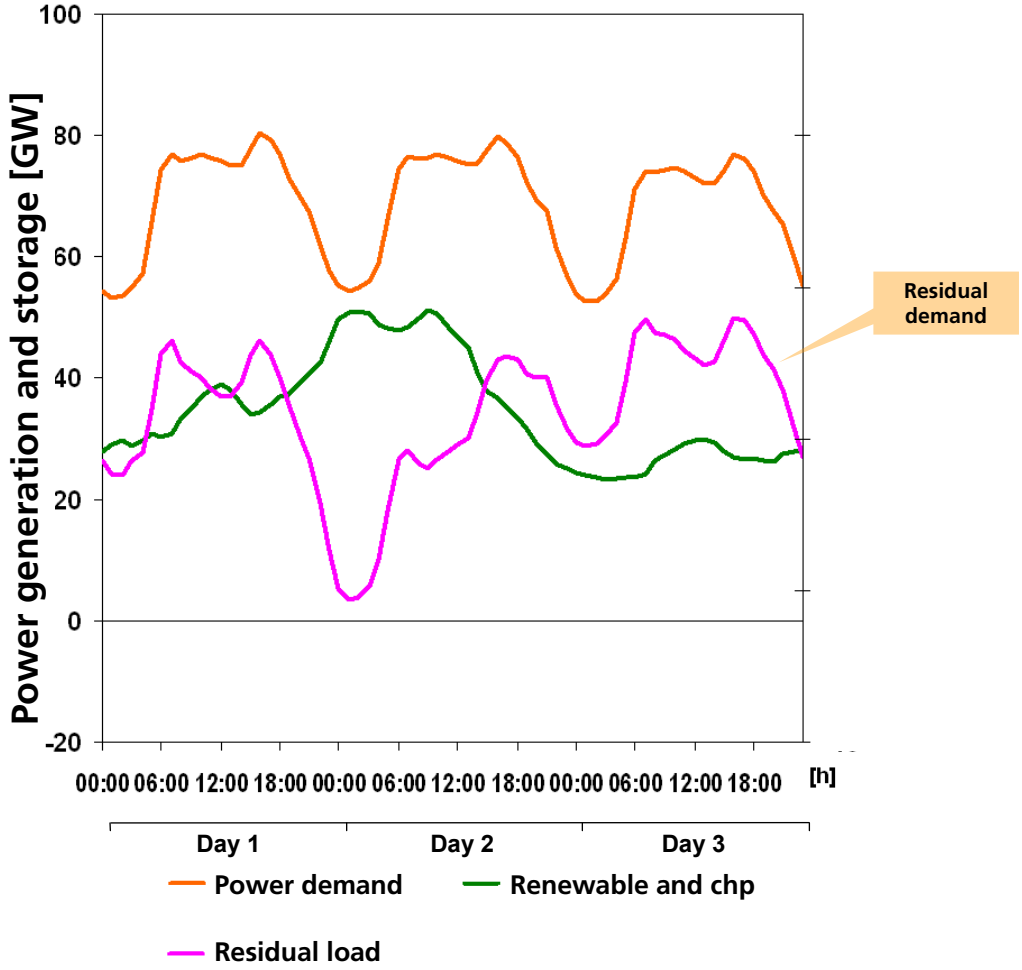

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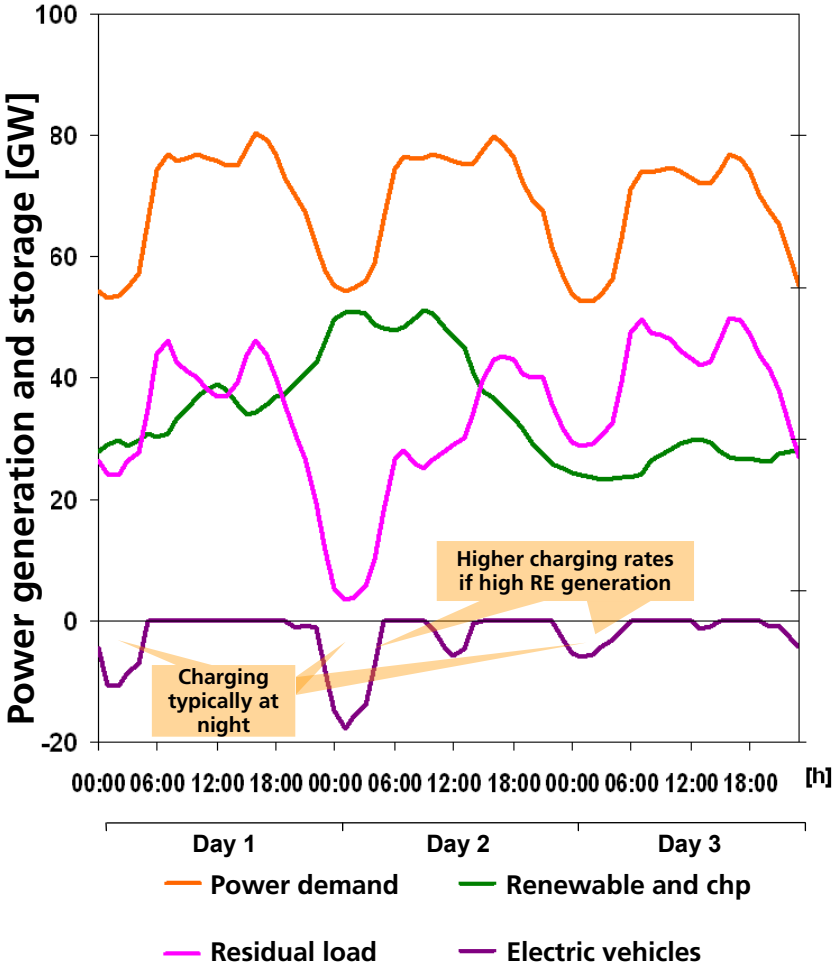

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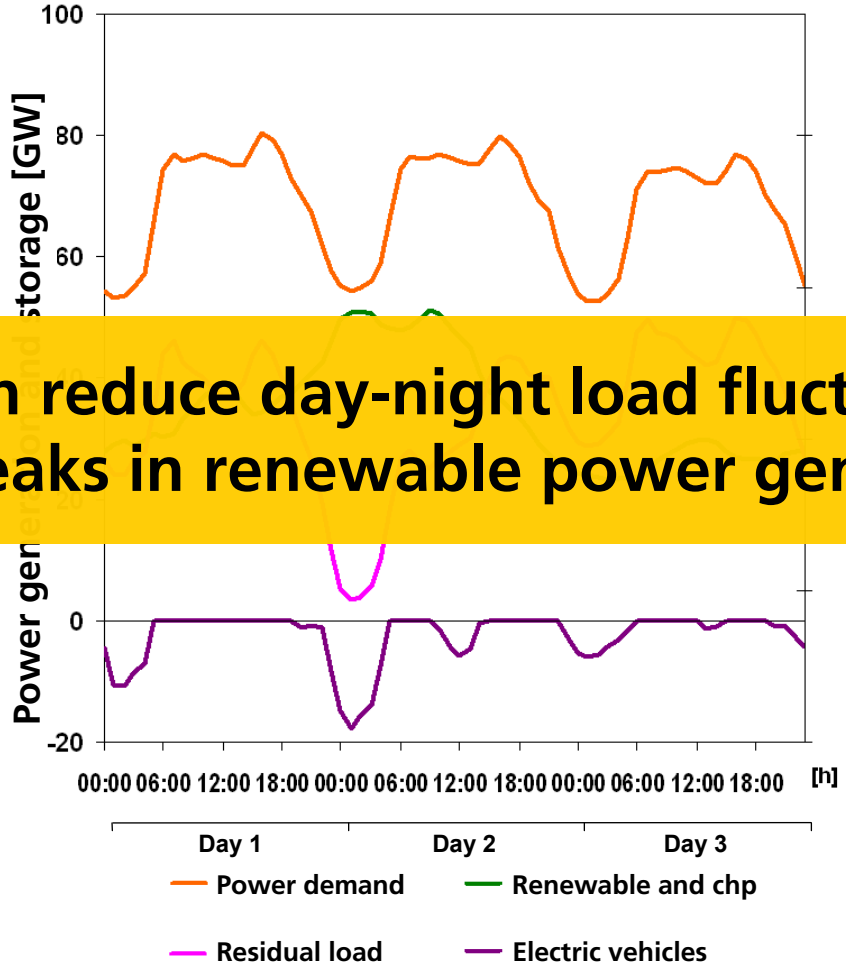

EVs can reduce day-night load fluctuations and peaks in renewable power generation

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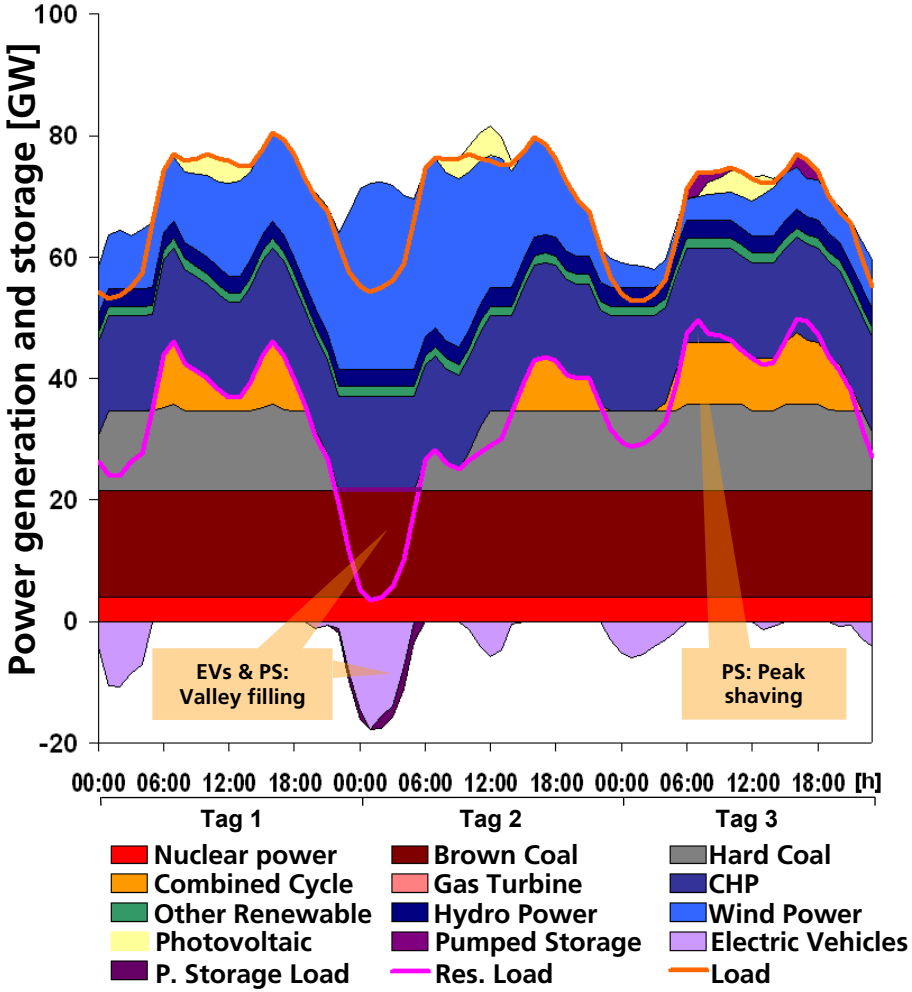

Analysis of the residual load

- Coverage depending on merit order
- Peak shaving with storage plants
- Valley filling with EVs and storage plants
  - Get lower electricity prices
  - Increases generation from coal plants
  - Causes higher CO_2 emissions

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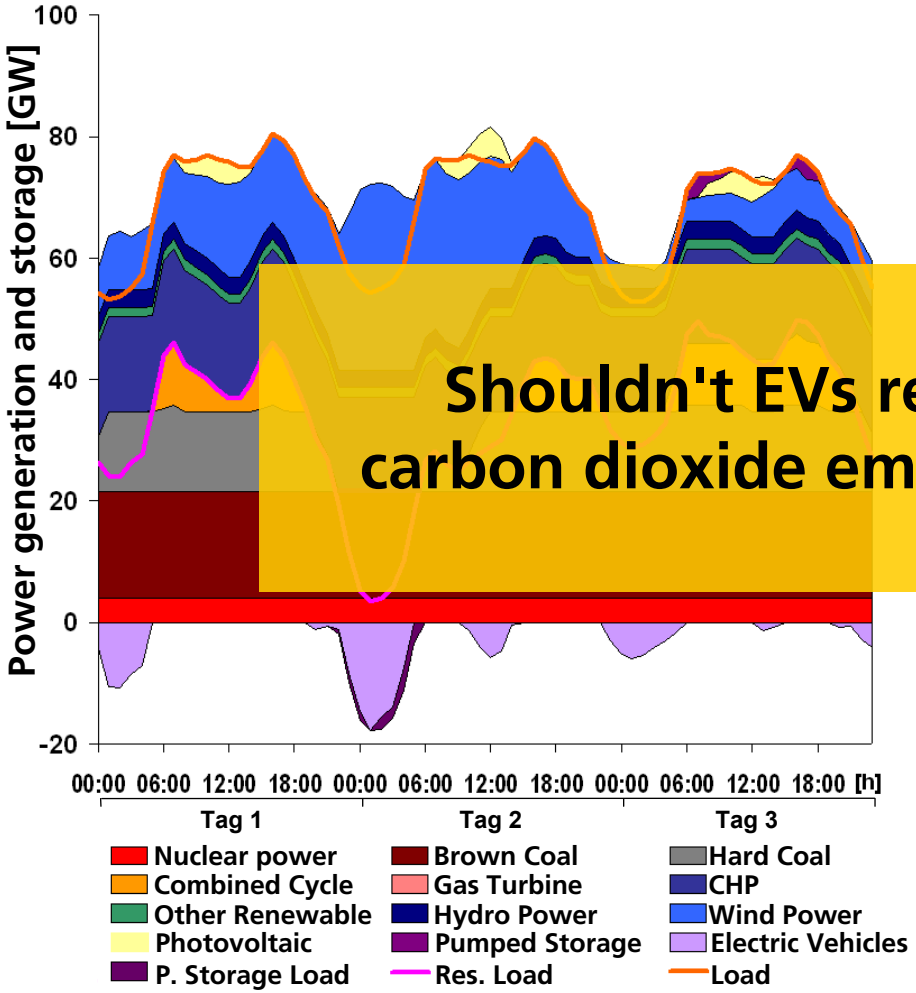

Shouldn't EVs reduce carbon dioxide emissions??

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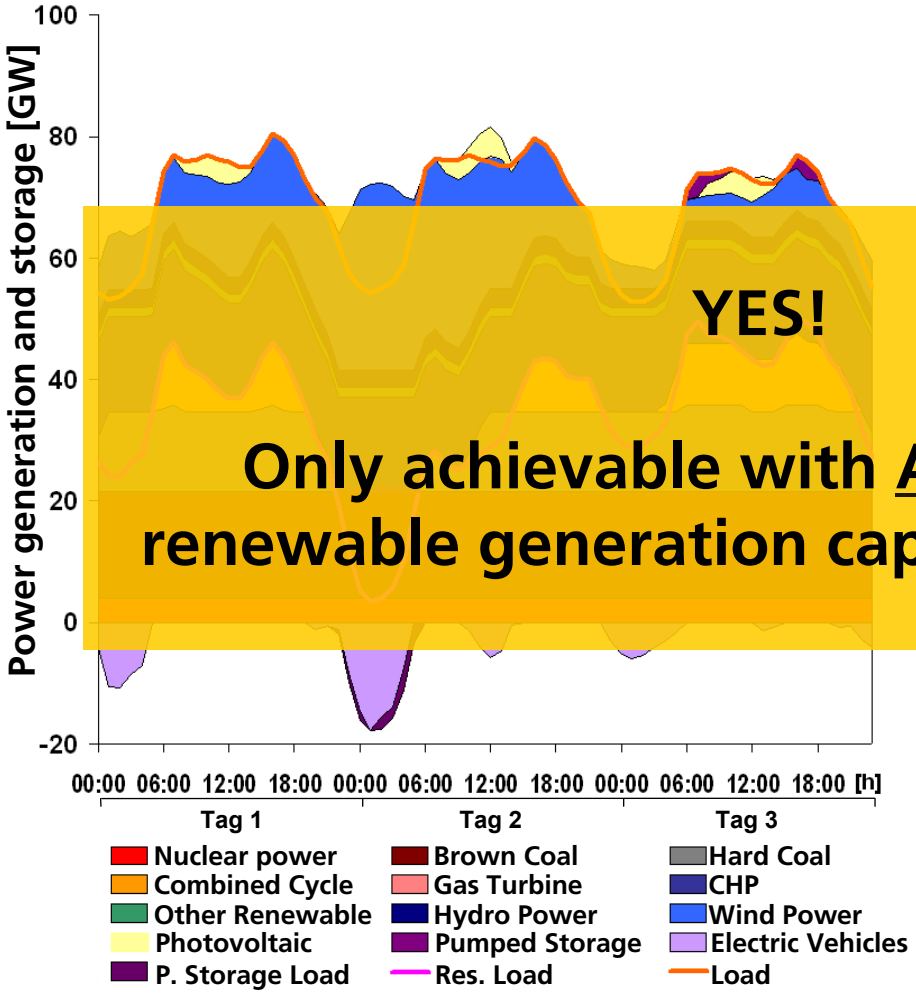


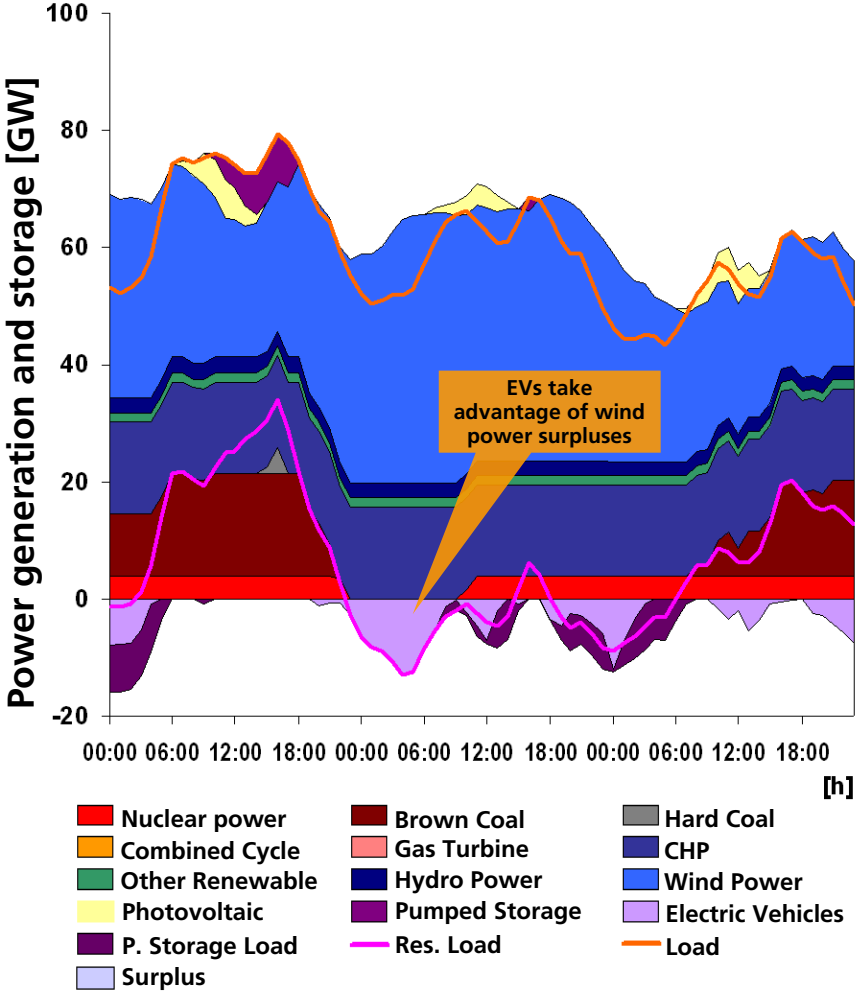
YES!

Only achievable with <u>ADDITIONAL</u> renewable generation capacities <u>for EVs</u>!!

Analysis of the residual load

- Coverage depending on merit order
- Peak shaving with storage plants
- Shifting with EVs and storage plants
- Get lower electricity prices
- Increases generation from coal plants
- Causes higher CO_2 emissions

Controlled loading of EVs with high wind generation
Exemplary results for 2030, 30% EVs (12 Million)



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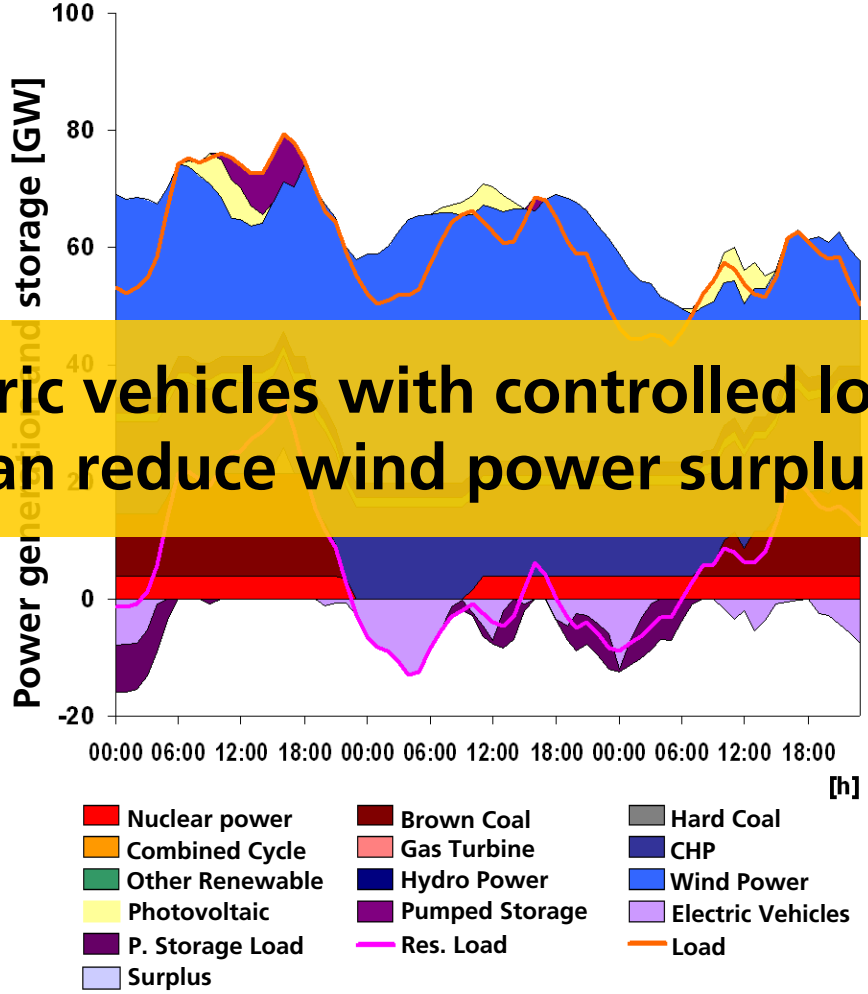
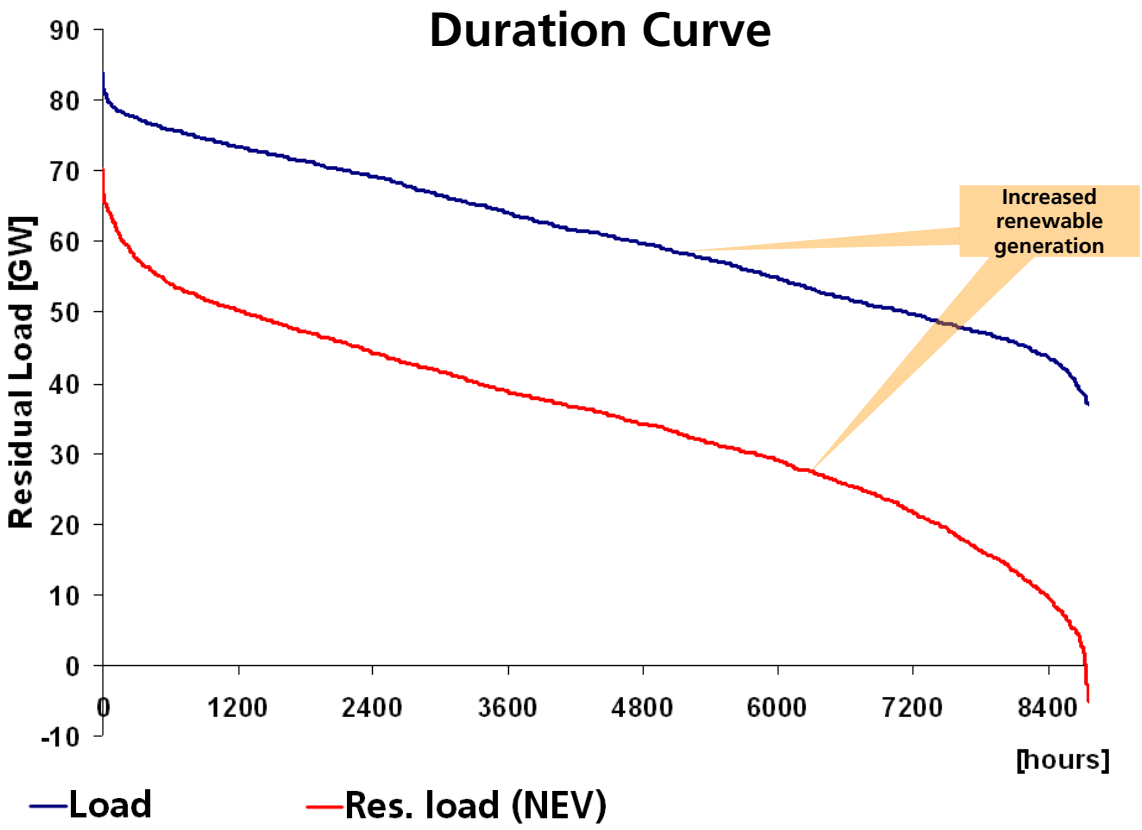


Electric vehicles with controlled loading can reduce wind power surpluses

Power plants' utilization for different loading strategies Exemplary results for 2030, 30% EVs (12 Million)



Residual Load: Power demand minus power generation from intermittent renewable energy sources (wind, solar and water power without storage)
(NEV: without electric vehicles, CL: EVs with controlled loading, UL: EVs with uncontrolled loading)

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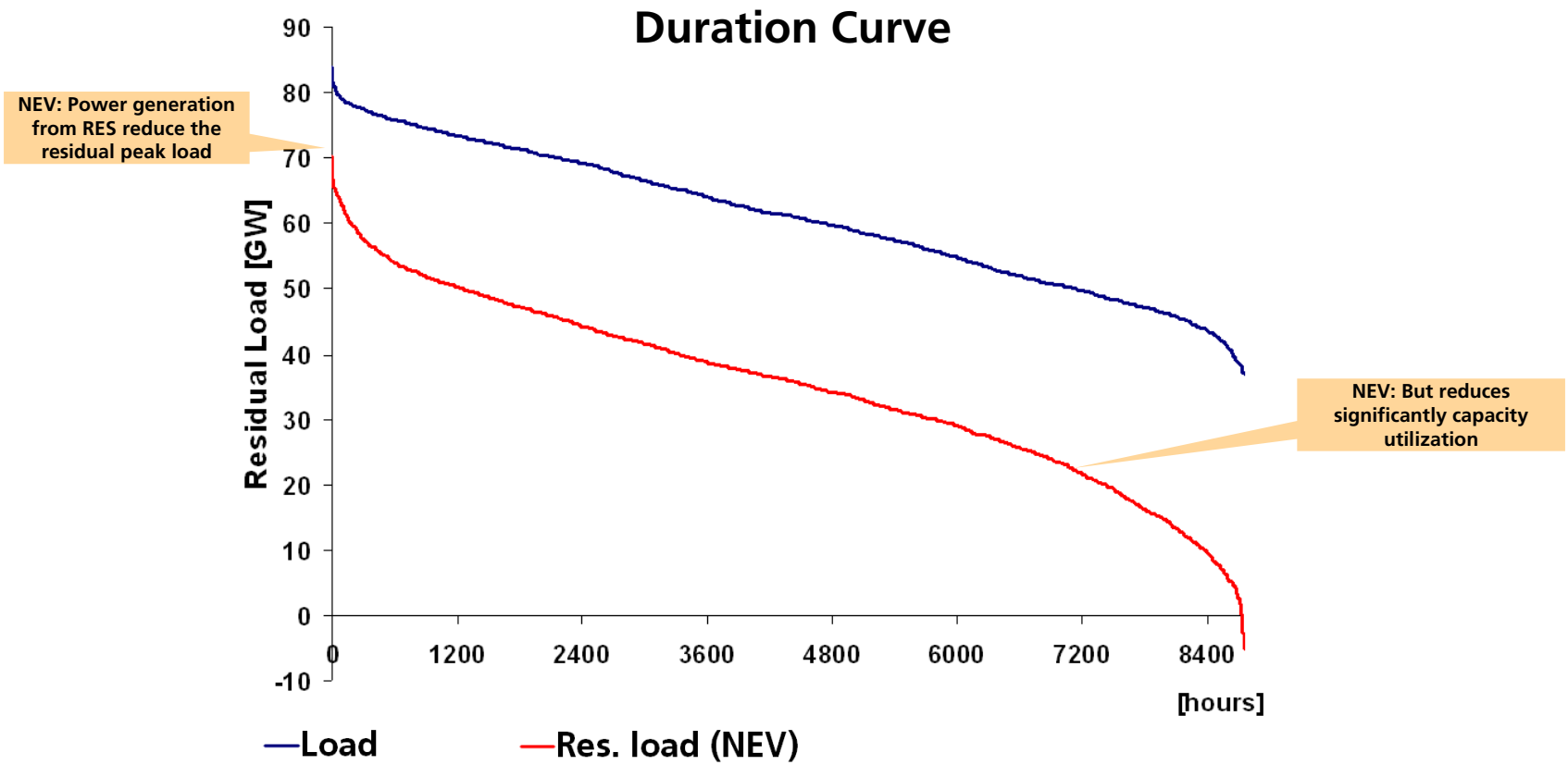

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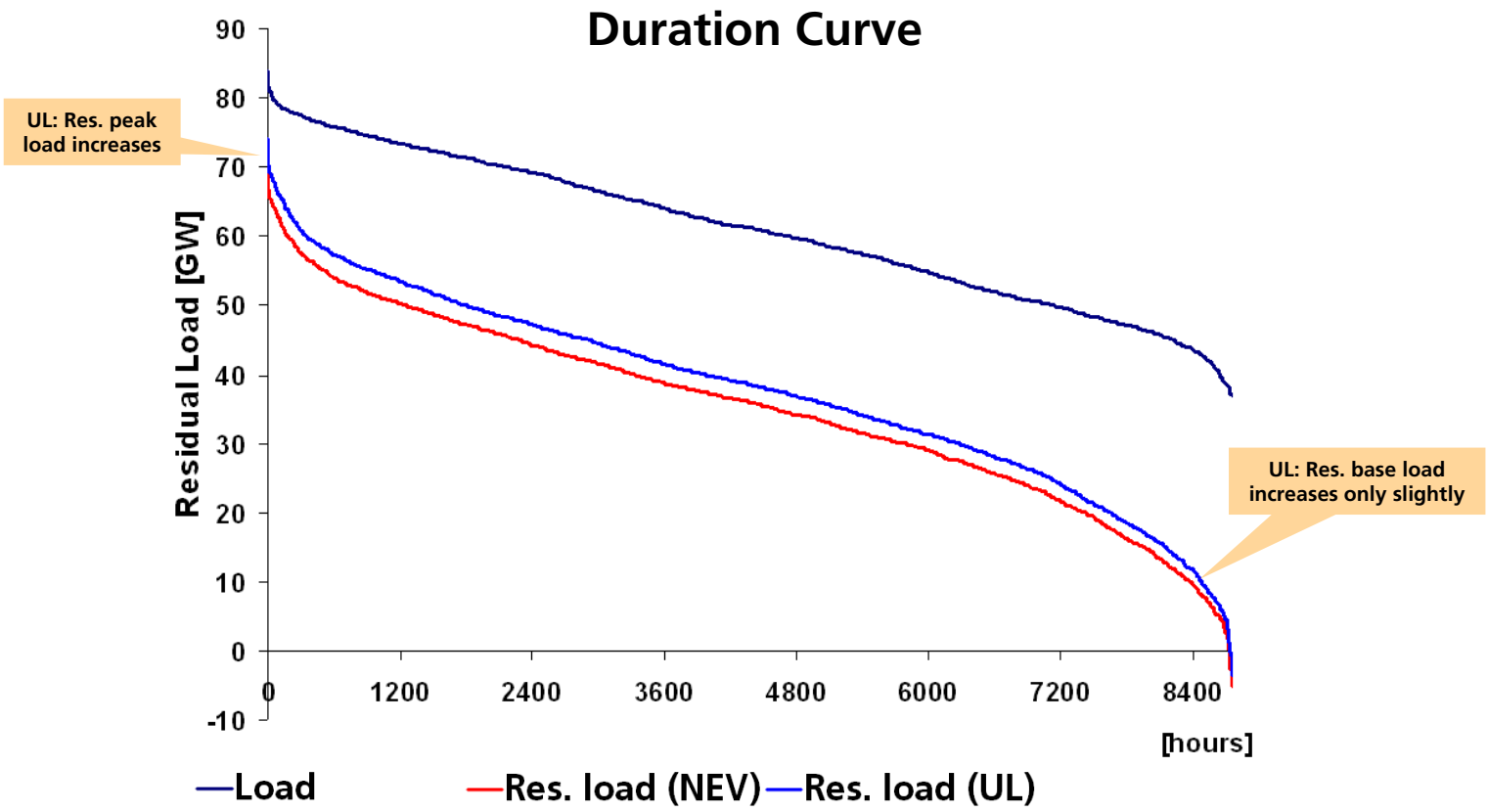

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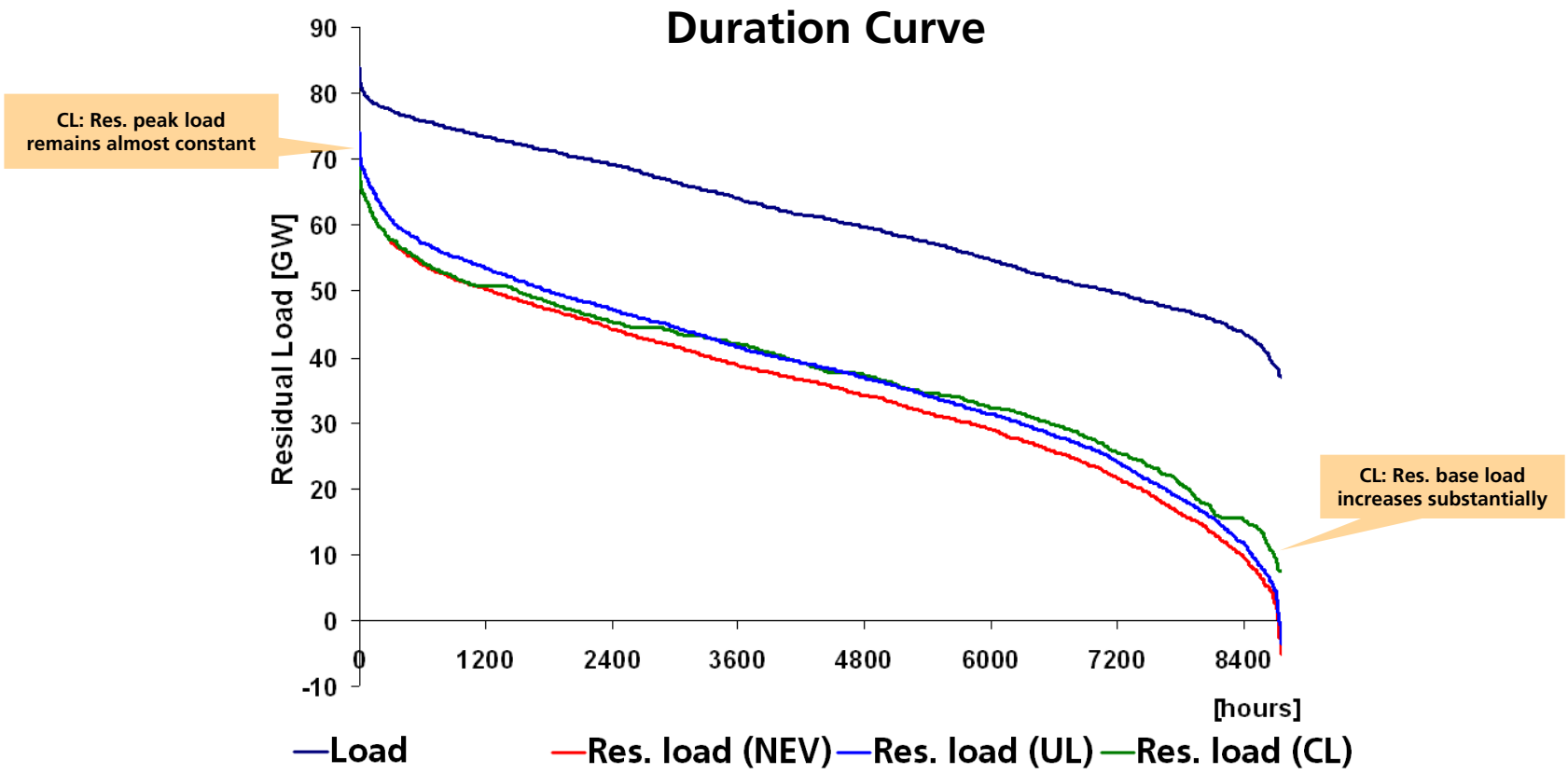

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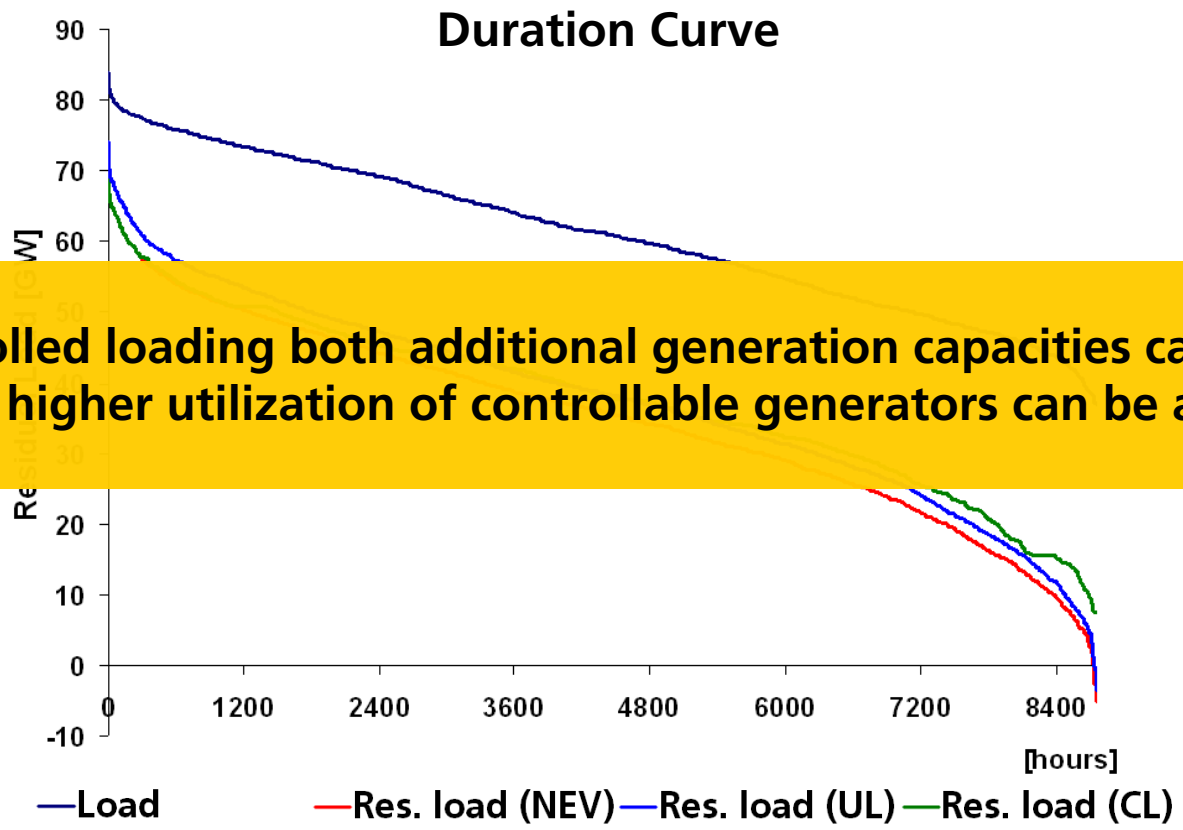


With controlled loading both additional generation capacities can be avoided, and a higher utilization of controllable generators can be achieved

Residual Load: Power demand minus power generation from intermittent renewable energy sources (wind, solar and water power)
(NEV: without electric vehicles, CL: EVs with controlled loading, UL: EVs with uncontrolled loading)

Summary

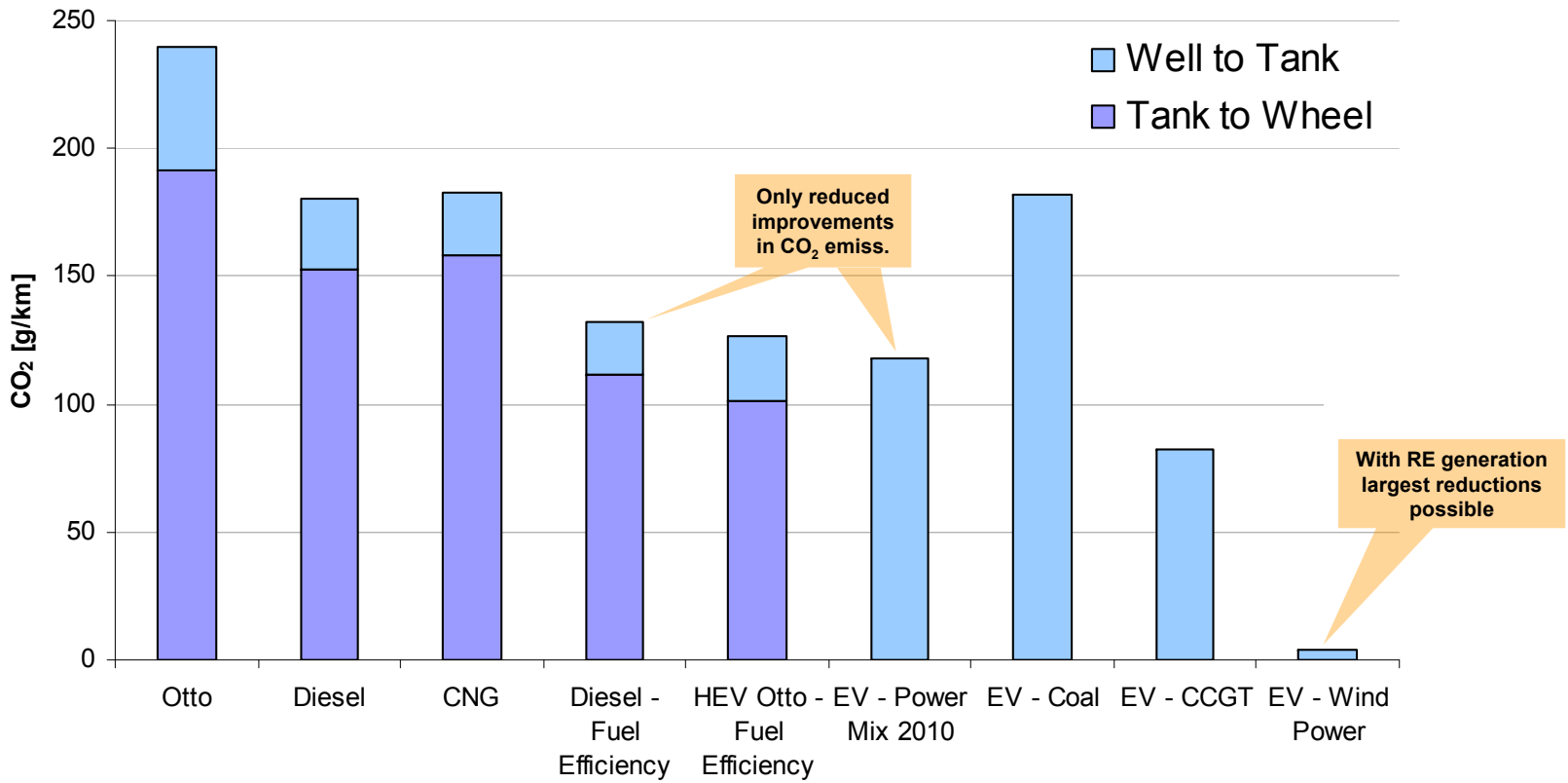
- The analysis of the EVs' driving profiles show that:
  - Some have to start the charging process around midnight
  - Battery requirements are the highest in the morning around 6 am
  - The battery level is lowest in the evening around 20 pm
  - Load management is most limited in the morning around 9 am
- The results also show that a load management strategy for EVs presents many advantages:
  - Lower generation capacity requirements if compared to uncontrolled load.
  - A better integration of intermittent renewable generation
  - A higher utilization of conventional power plants, what improves economics, but also causes higher carbon dioxide emissions
- Additional renewable generation capacities will have to be built <u>for EVs</u> to achieve a sustainable and low carbon electromobility

Thank you for your attention!

contact: diego.lucadetena@dlr.de

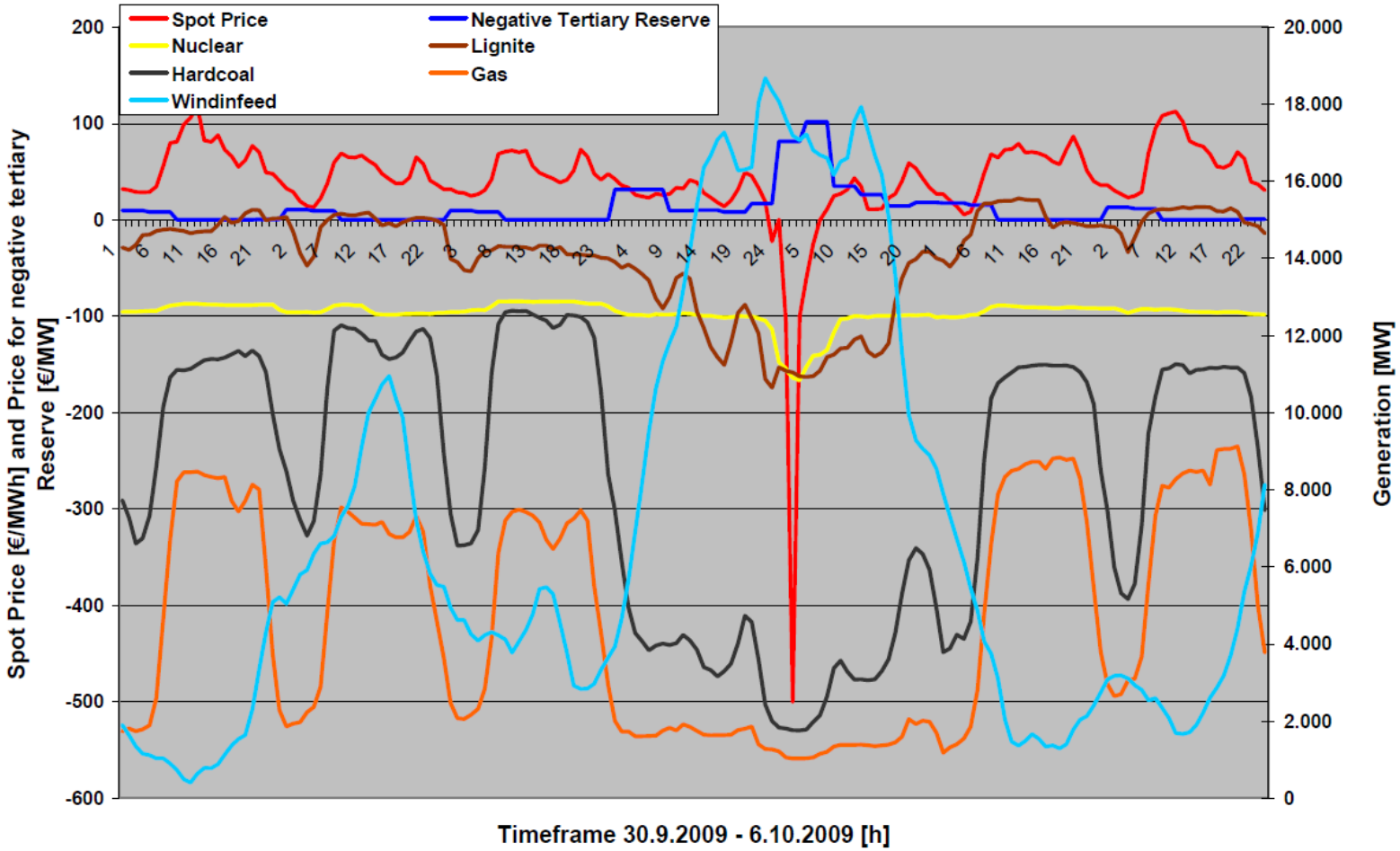
Back up

Comparison of the CO_2 emissions of different vehicle concepts



Back up

Figure 5: Power market on October 4th 2009



Source: Nicolosi, Marco. "*Wind Power Integration, negative Prices and Power System Flexibility - An Empirical Analysis of extreme Events in Germany*". EWI Working Paper, No. 10/01.

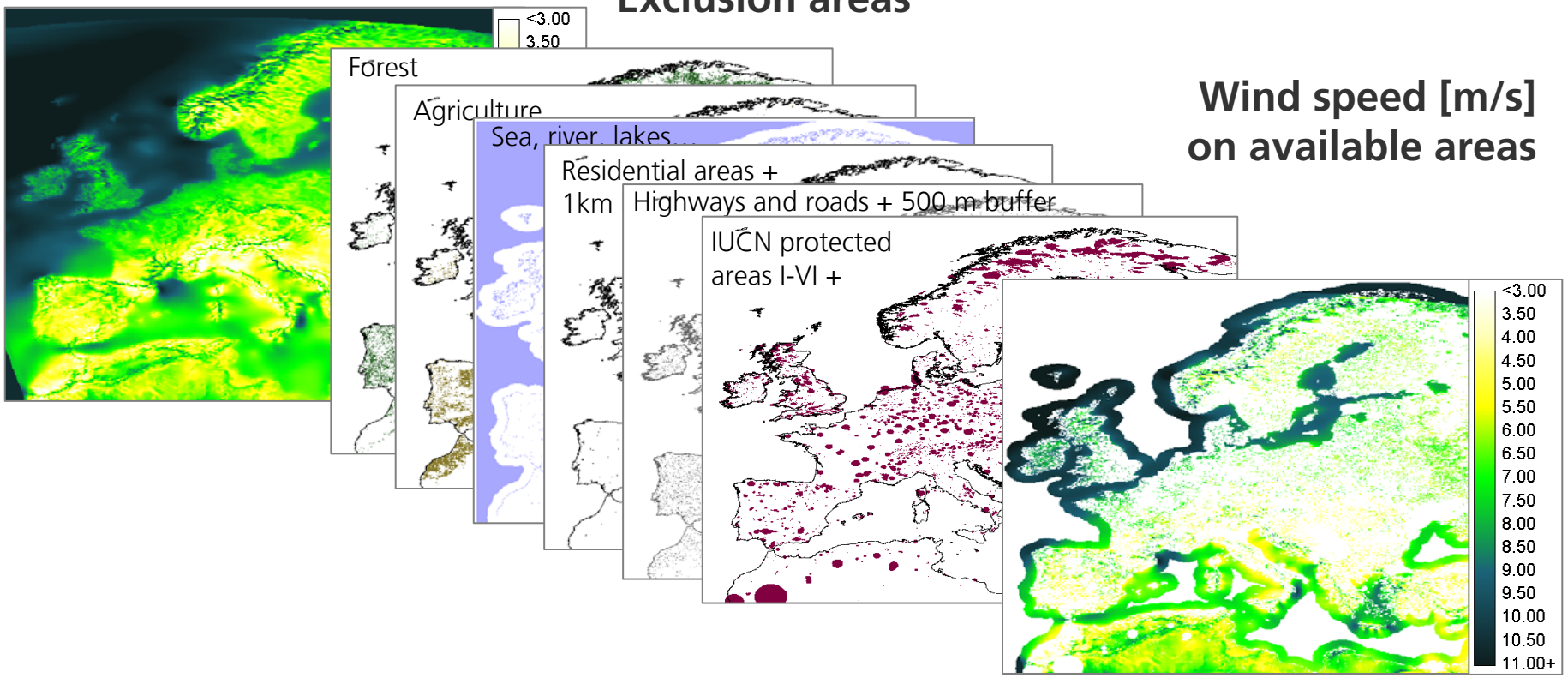
Back up

Inventory of potentials from renewable energy sources

Methodology for wind energy exemplary presented

Wind speed [m/s]

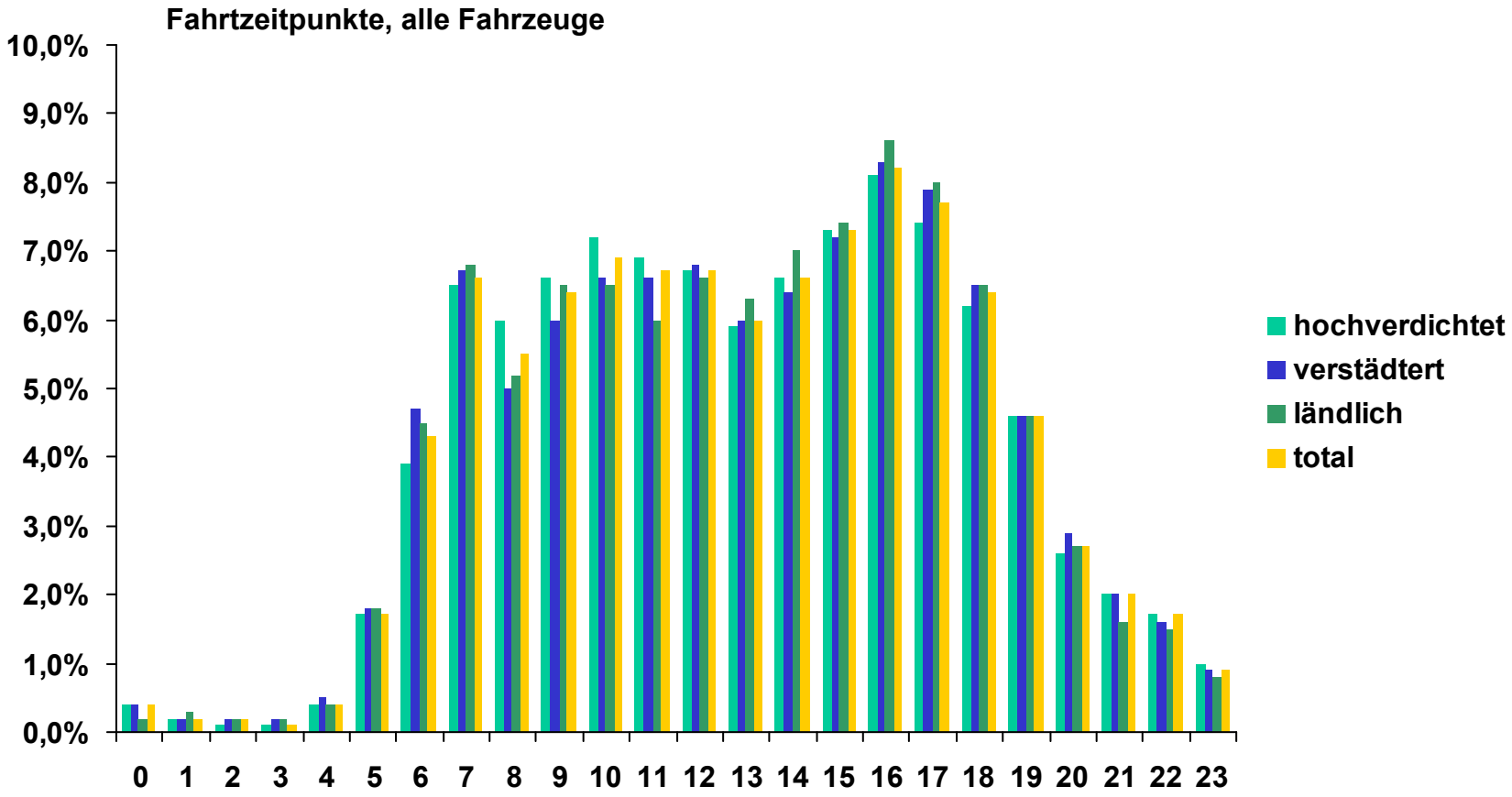
Exclusion areas



Wind speed [m/s] on available areas

Back up

Fahrprofile - Agglomerationsräume



Keine signifikanten Unterschiede

Stichprobenumfang: n = 17863
Quelle: MiD 2002, eigene Darstellung