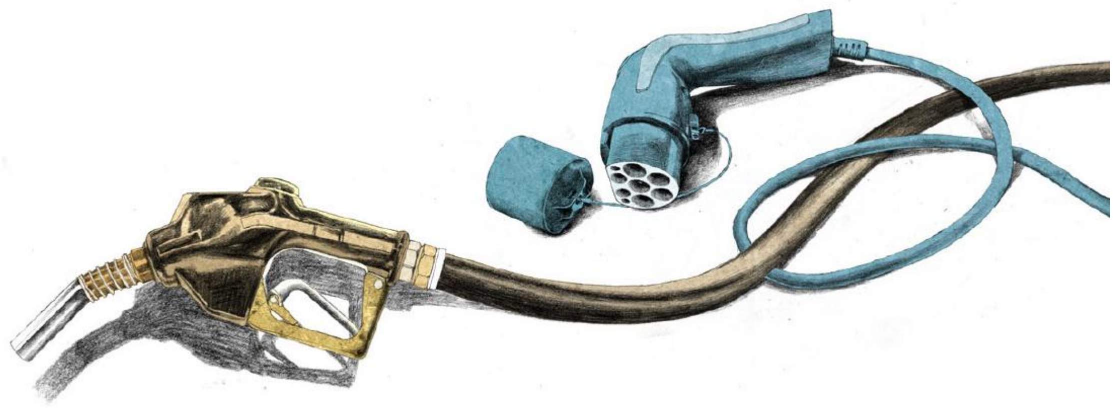
Environmental impacts of electric mobility and interactions with the electricity sector in Germany



4th German-Japanese Environmental Dialogue Forum
Electric Mobility and Smart Grids: Strategies and Technologies

Tokyo, 17 and 18 November 2011

Florian Hacker, Öko-Institut e.V., Berlin

OPTUM research project

- Title: “Optimising the environmental benefits of electric vehicles – An integrated consideration of vehicle use and the electricity sector in Germany”

- Consortium partners: Öko-Institut e.V., ISOE
- Funded by: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
- Duration: 09/2009 – 09/2011
- Overall project value: € 782,760

- Main goals:
  - Market potential of electric vehicles (EVs)
  - Interaction of EVs with electricity market
  - Effect on GHG emissions of German vehicle stock 2010 - 2030

What factors determine the environmental benefits of EVs?

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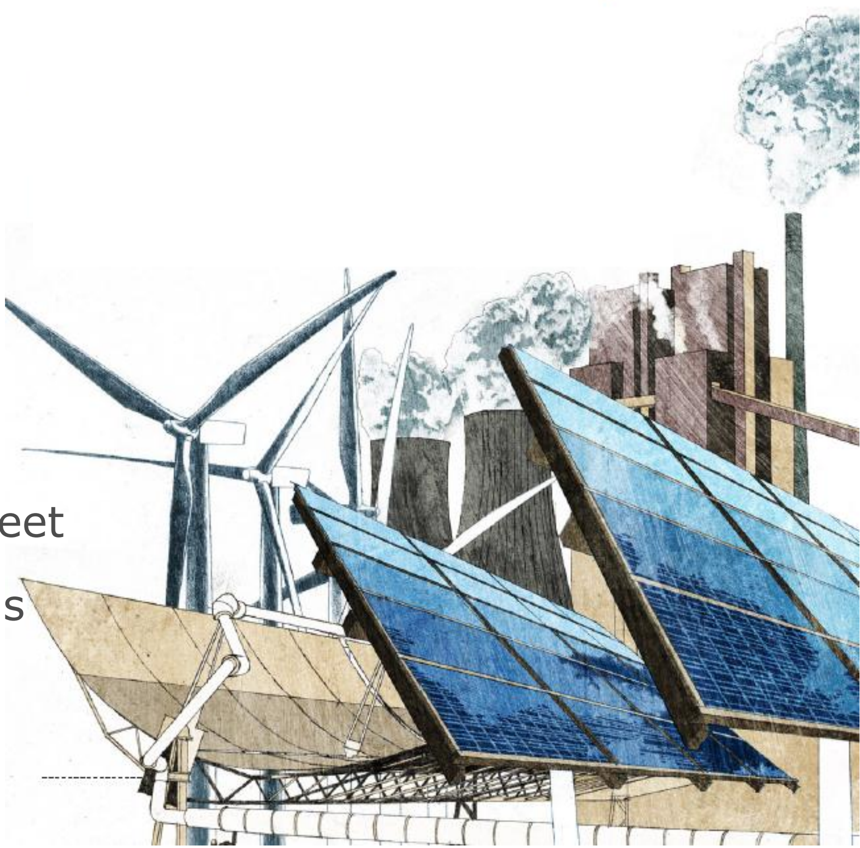
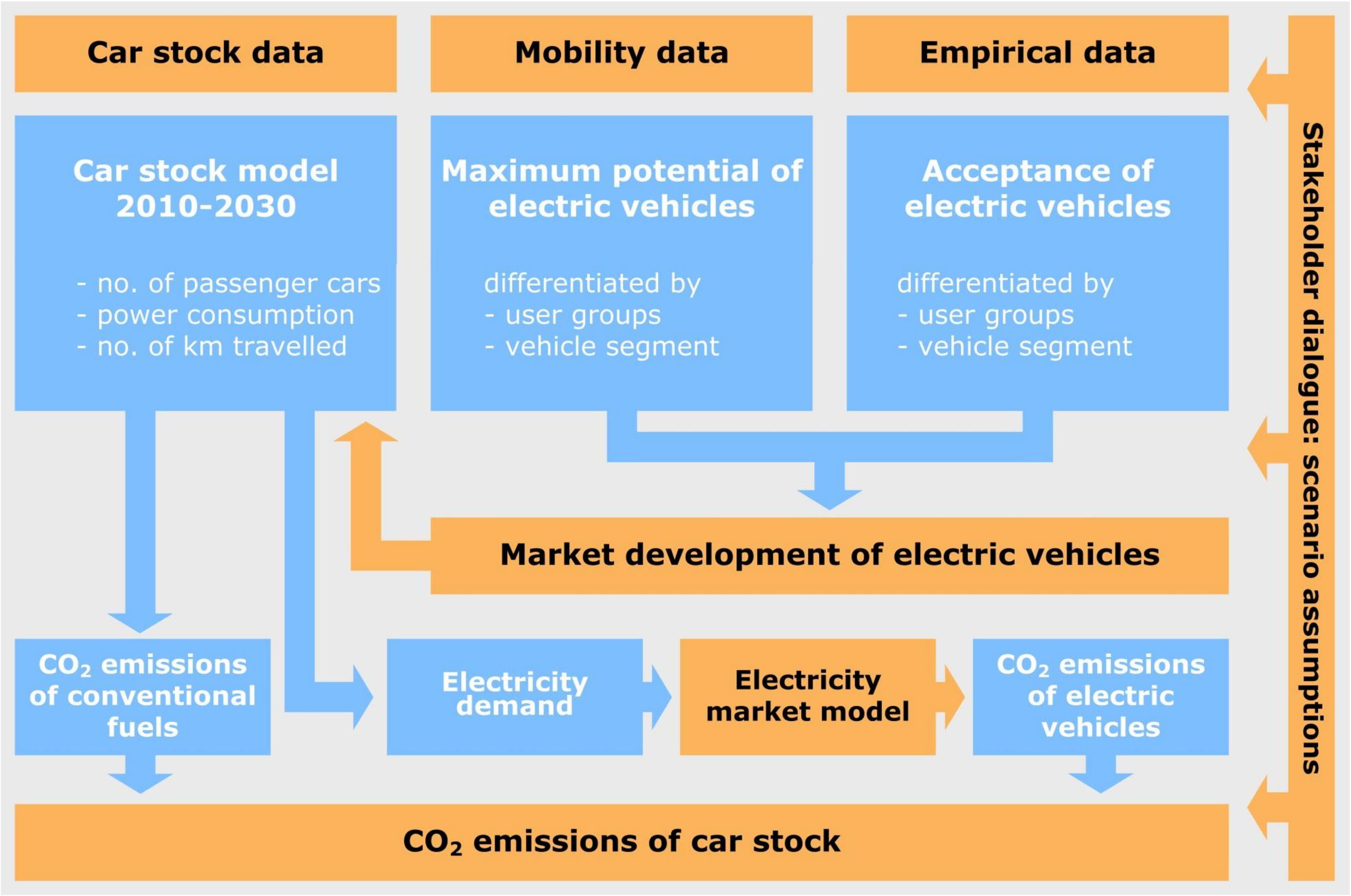
- Starting points:
  - EVs cause no direct emissions
  - GHG balance of EVs is determined by source of electricity generation

- Necessary analytical steps:
  - acceptance of EVs
  - mobility behaviour
  - market potential of EVs
  - interactions with the power plant fleet
  - electricity demand & GHG emissions



Modelling approach OPTUM



Deriving a market scenario

- Definition of scenario assumptions
  - e.g. technology development, energy prices
- Maximum potential of electric vehicles
  - Analysis of current usage profiles and mobility patterns
- Acceptance of electric vehicles
  - User survey (conjoint analysis)
- Consideration of market development
  - Diffusion of technological innovations in automotive sector
- Market scenario for electric vehicles
  - Determining new vehicle entry for 2010-2030
  - Modelling the passenger car fleet for 2010-2030

Electric mobility scenario for 2010-2030

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- Scenario is developed within a series of workshops with representatives from energy sector & transport sector

- Key assumptions:
  - Segments: BEV up to mid-size segment, PHEV in all segments
  - Electric range: BEV 160 km, PHEV 50 km
  - Battery costs: 280 €/kWh (2020), 230€/kWh (2030)
  - Additional efficiency improvements in PHEV, BEV & CV up to 2030
  - Moderate increase in fuel and electricity prices
  - Charging infrastructure: increase in charging points in private and public areas, increase in charging power
  - Mobility behaviour: requirements for passenger car usage remain unchanged

Acceptance of electric vehicles

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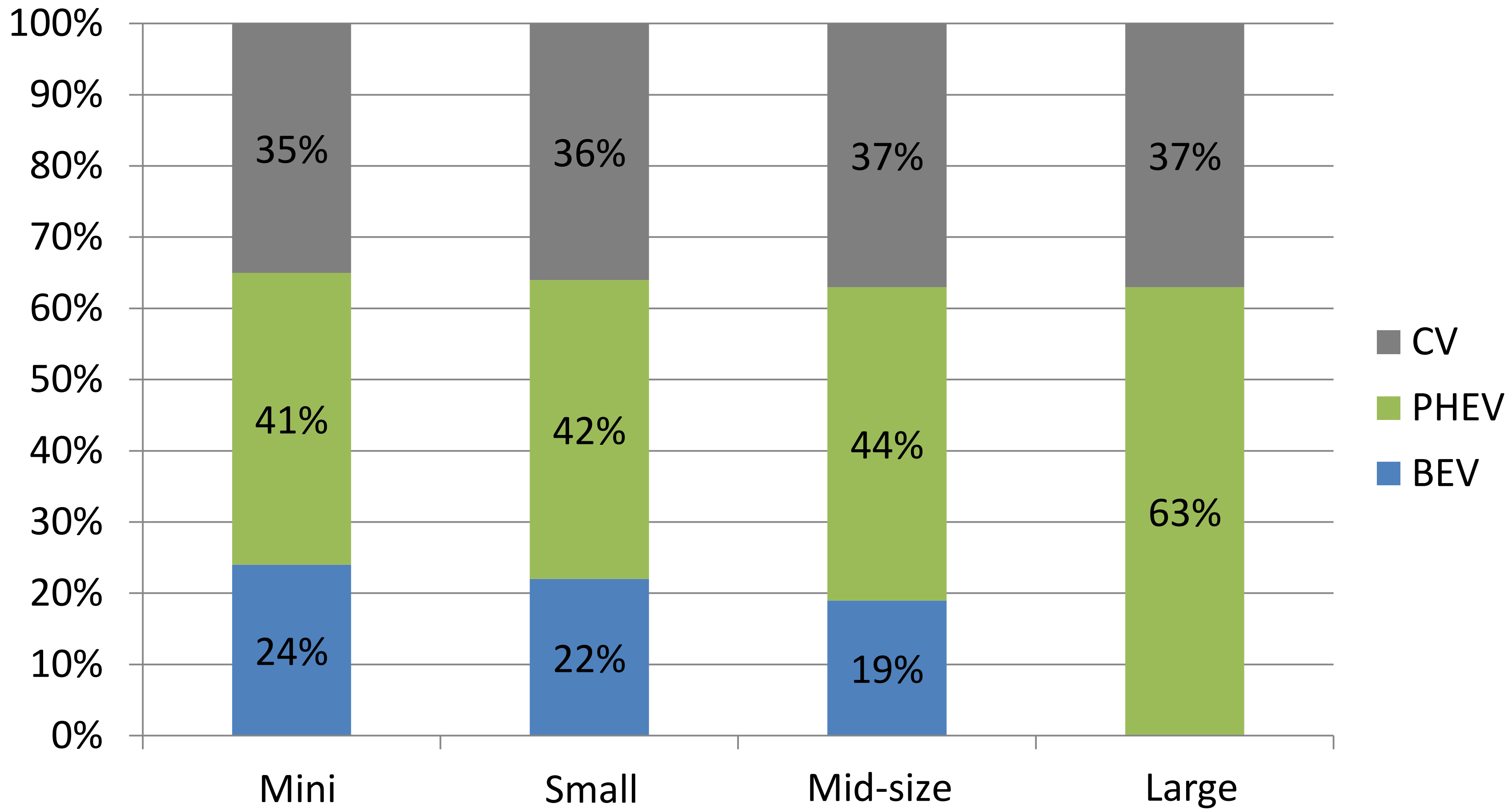
- Methodological approach:
  - Survey of approx. 1,500 new car buyers in Germany
  - Conjoint analysis: Simulation of car purchases based on 8 criteria and 3 propulsion system types
  - Criteria: motor type, performance, purchase costs, fuel and electricity costs, charging time, electric range, CO_2 emissions, parking privileges
  - Motor type: CV, BEV, PHEV
  - Combination of parameters in several simulated cycles
  - Range of example vehicles to choose between

- Purchase decisions are realistically simulated based on a combination of different parameters
- Significance of different parameters is implicitly determined
- Market shares are derived based on different vehicle types

Simulation of vehicle purchase in 2030

Choosing between conventional, battery-electric and plug-in-hybrid vehicles



Source: OPTUM

Results of acceptance analyses

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- Approx. 60 % of users would use electric vehicles, choosing either PHEV or BEV
- Engine type is highly significant – electric motors are regarded as environmentally friendly
- Changes to purchase price have lower effect than expected
- Consumption costs are important factor in choice of vehicle
- Improvements to charging time and electric range lead to significant increase of BEV share – however, almost exclusively at cost of PHEV share
- Highly environmentally conscious people with good local transport connections show a high affinity to BEV
- People without their own parking spaces tend to show a greater interest in electric vehicles

Market scenario for electric vehicles

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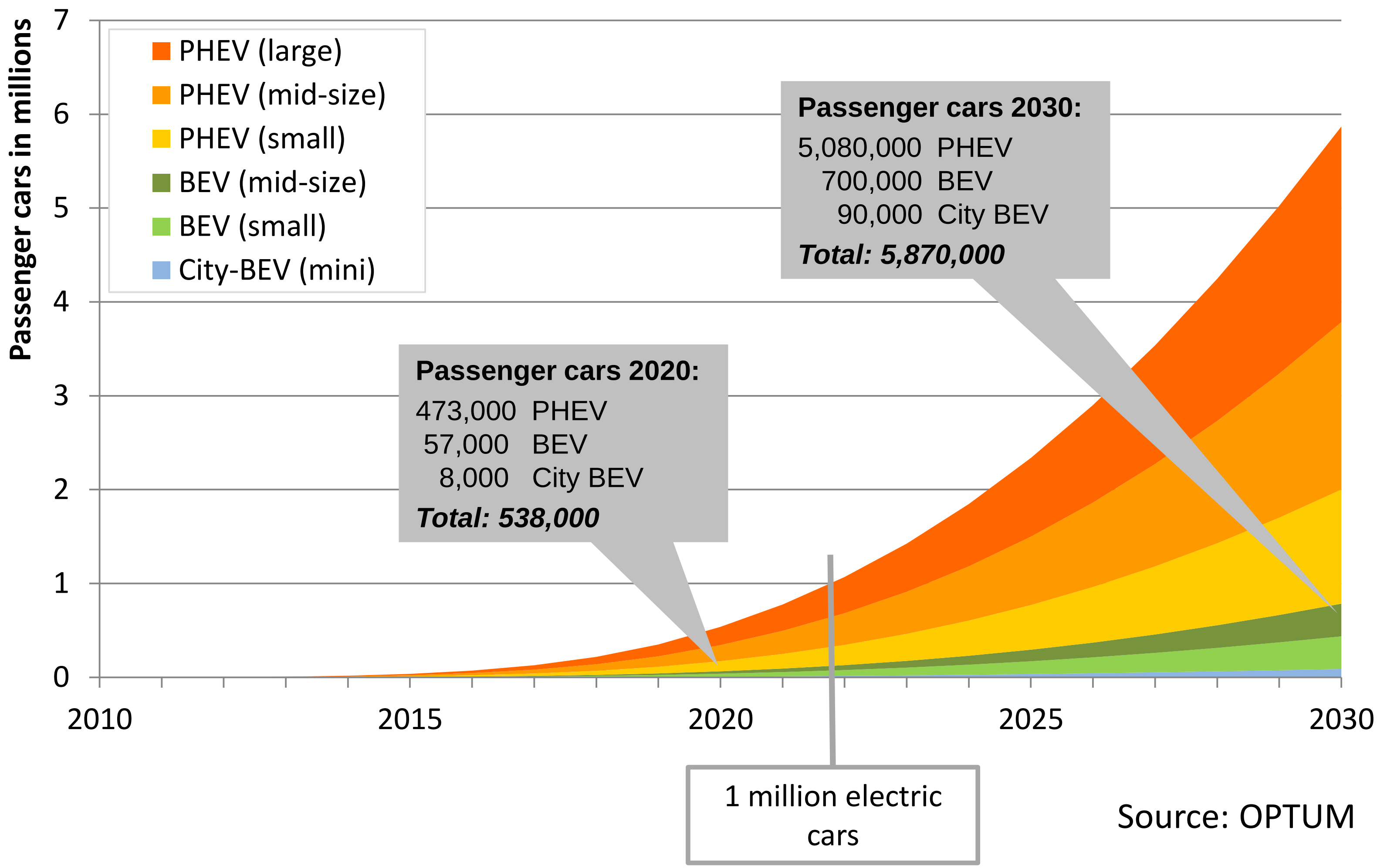
German government targets:
2020: 1 million electric vehicles
2030: 6 million electric vehicles



Source: OPTUM

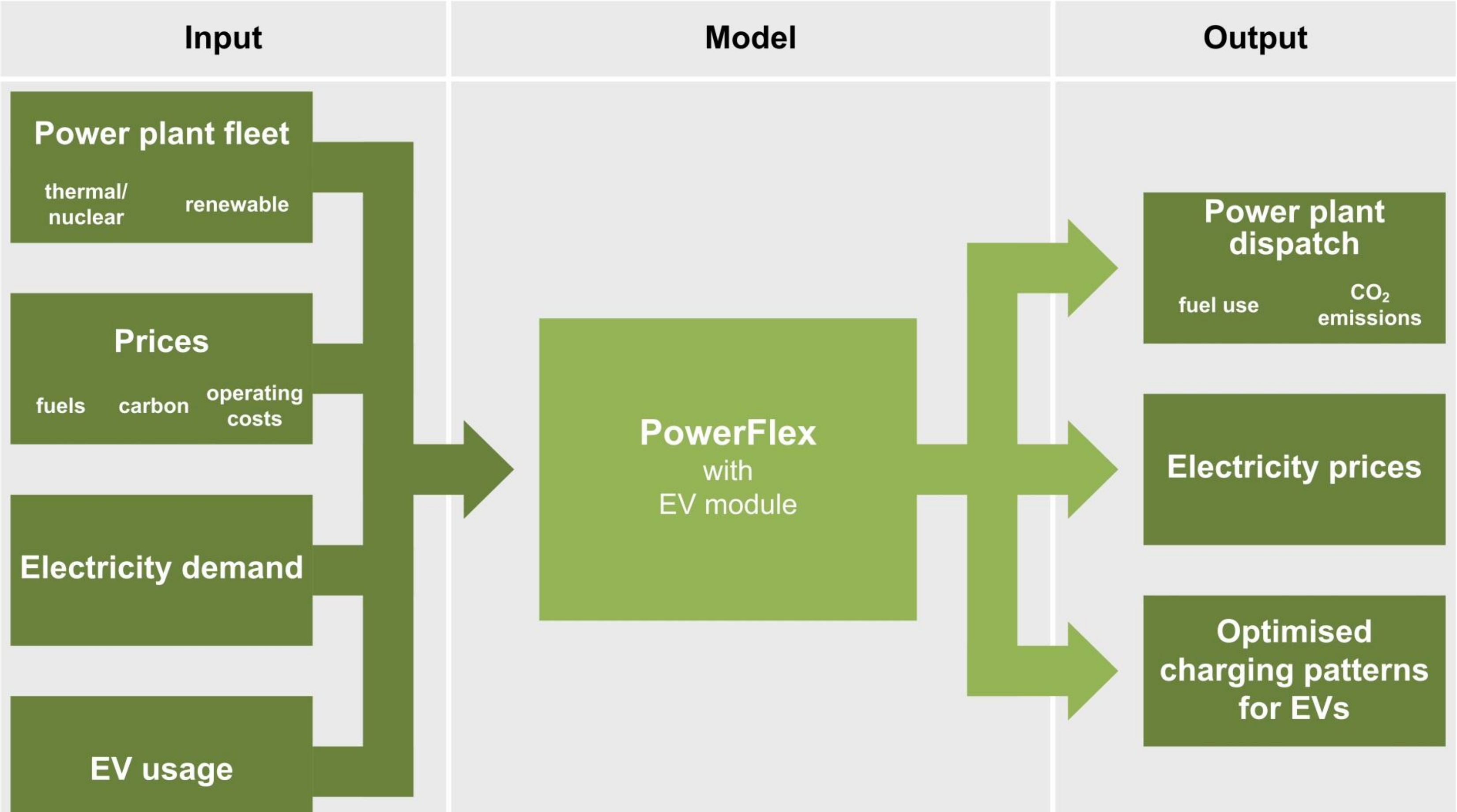
Electricity demand of EVs

- Average annual kilometres travelled:
  - Conventional passenger cars: 13,700 km
  - Important: Annual kilometres travelled for BEV are approx. 40 % lower than for CV
- Electric driving share:
  - (City-)BEV: 100 %
  - PHEV: about 67 %

- Electricity demand profiles for electric vehicles:
  - Electricity demand of BEV and PHEV is simulated in combination with EV fleet based on 60 different vehicle usage profiles
  - Electricity demand profiles take into account necessary minimum battery level and passenger car usage
  - Hourly resolved electricity demand varies depending on assumptions for charging infrastructure and charging patterns of passenger car users
  - Input in POWERFLEX electricity market model is hourly resolved electricity demand

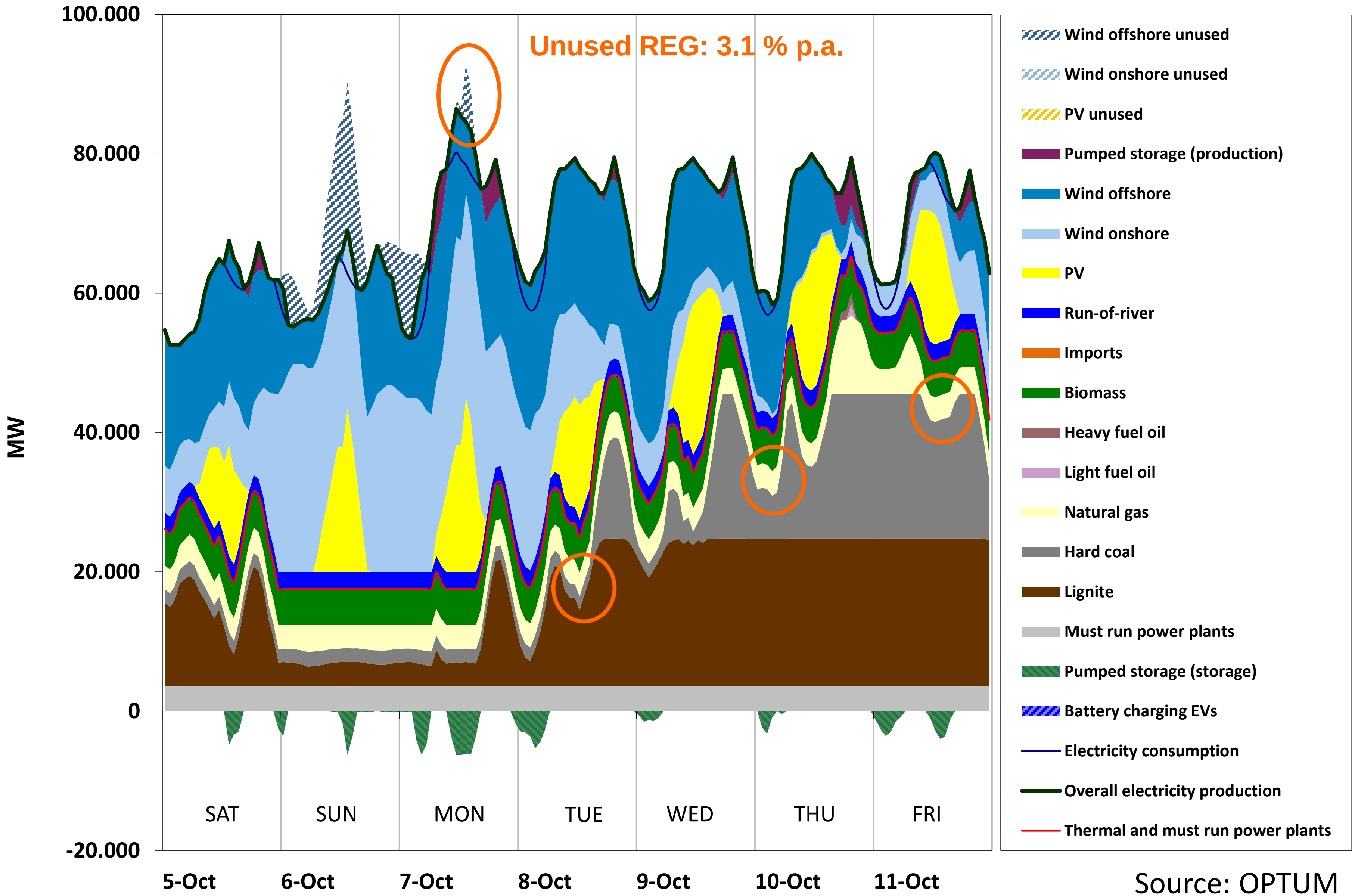
PowerFlex – Functionality of electricity market model

» Optimisation model which minimises objective function of electricity generation costs and determines merit order



Source: OPTUM

German electricity market without EVs in 2030



Source: OPTUM

German electricity market with EVs & load management in 2030

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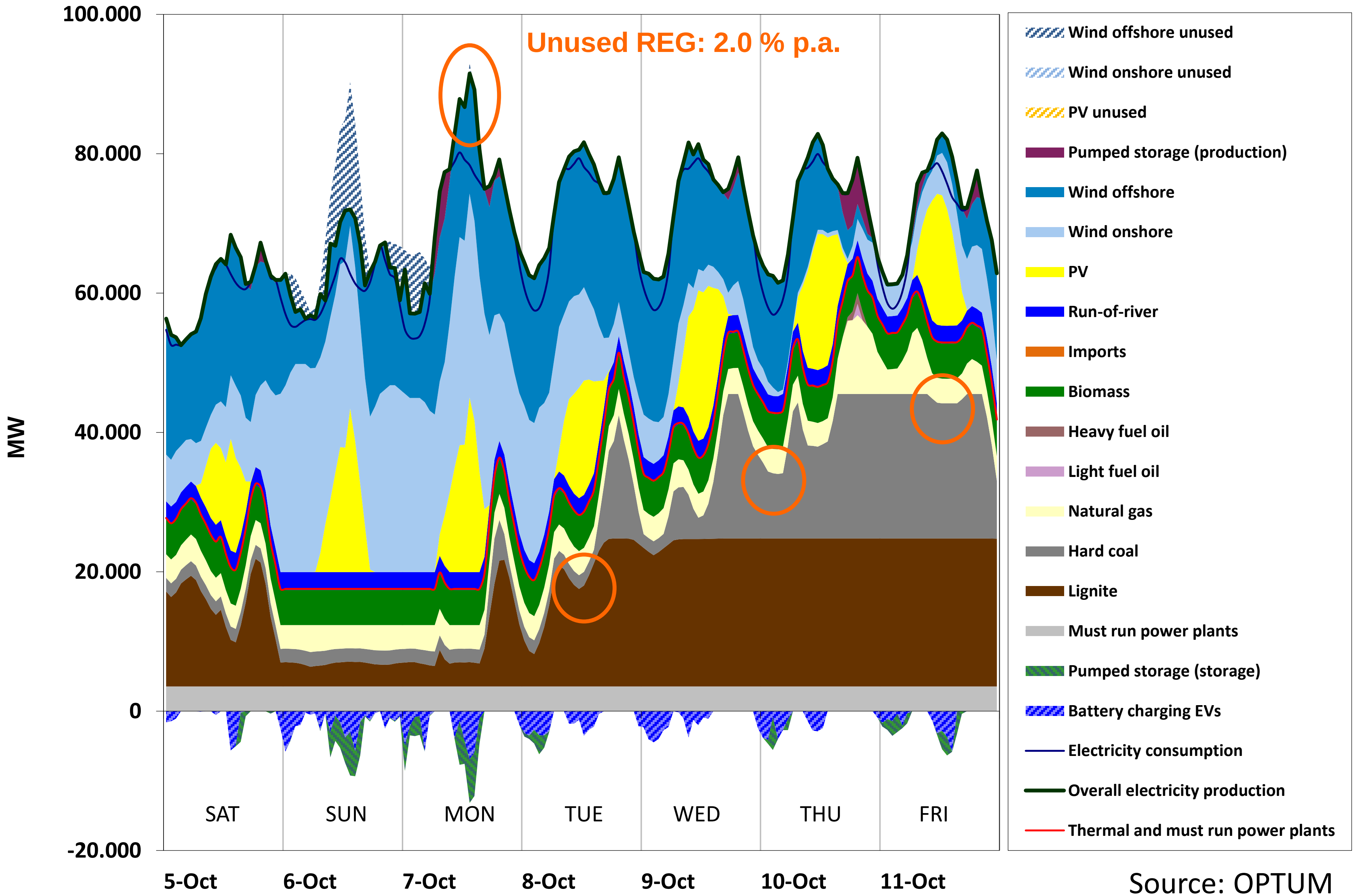

Source: OPTUM

Electricity production for EVs by energy source

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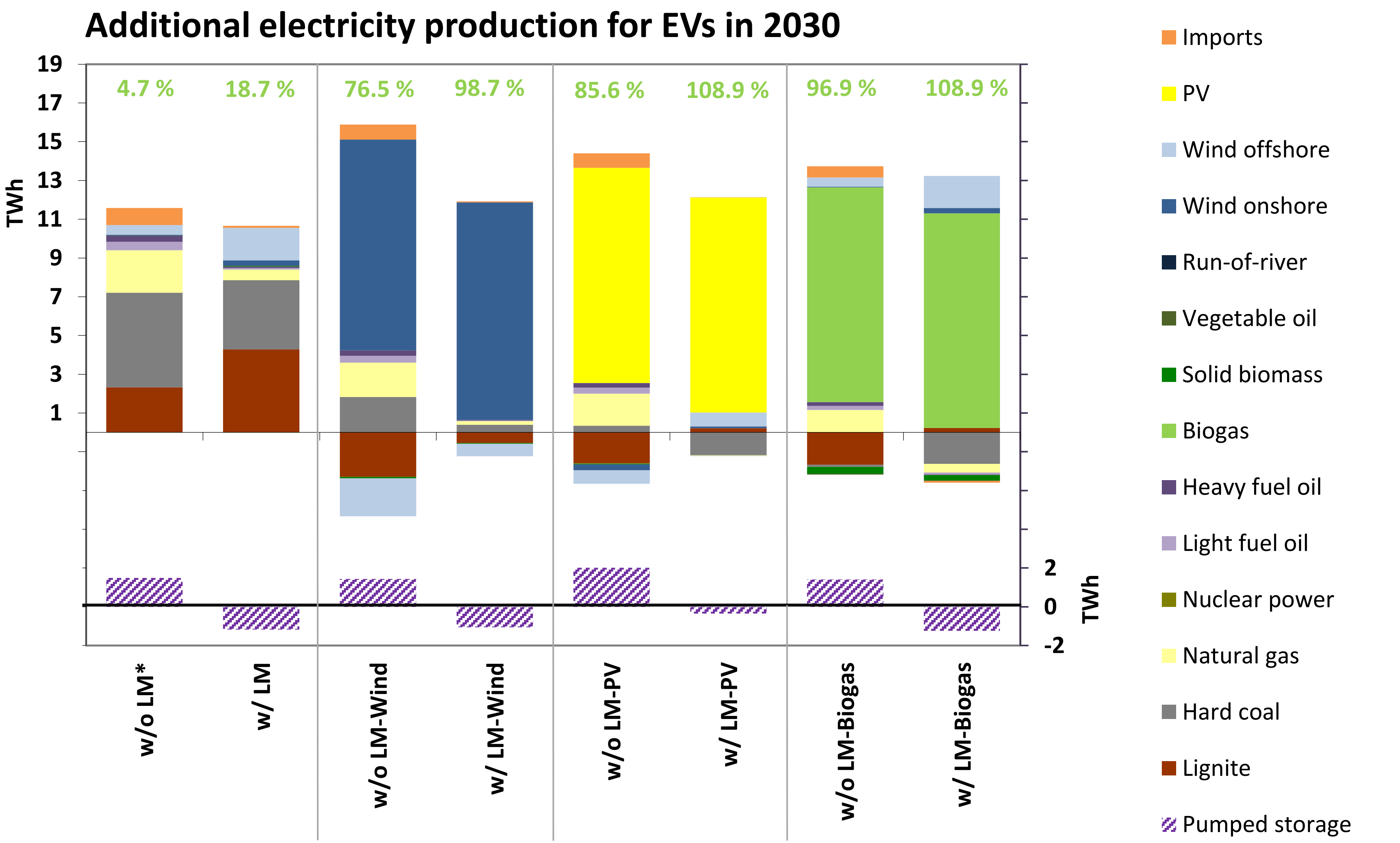
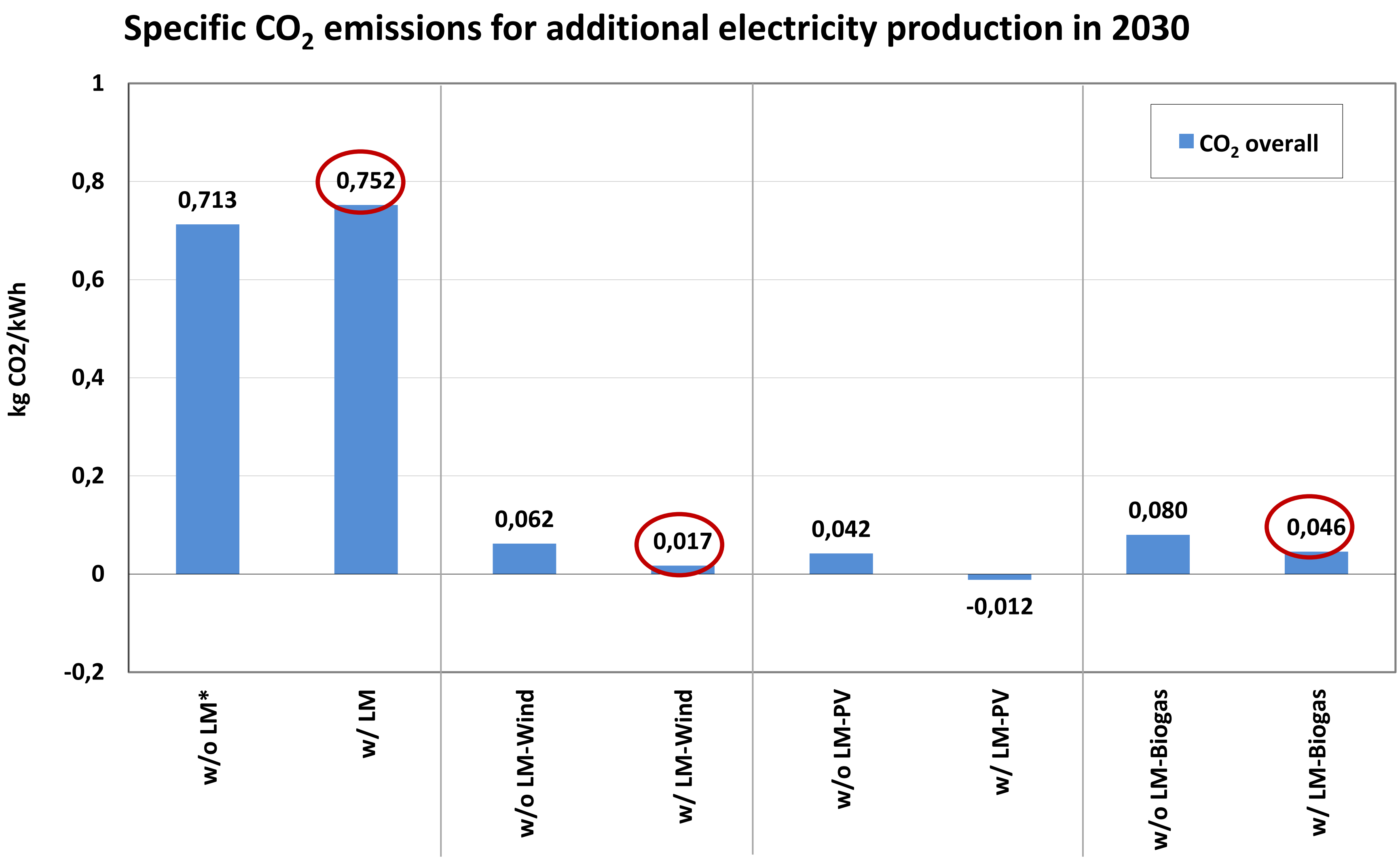


*LM = Load management

Source: OPTUM

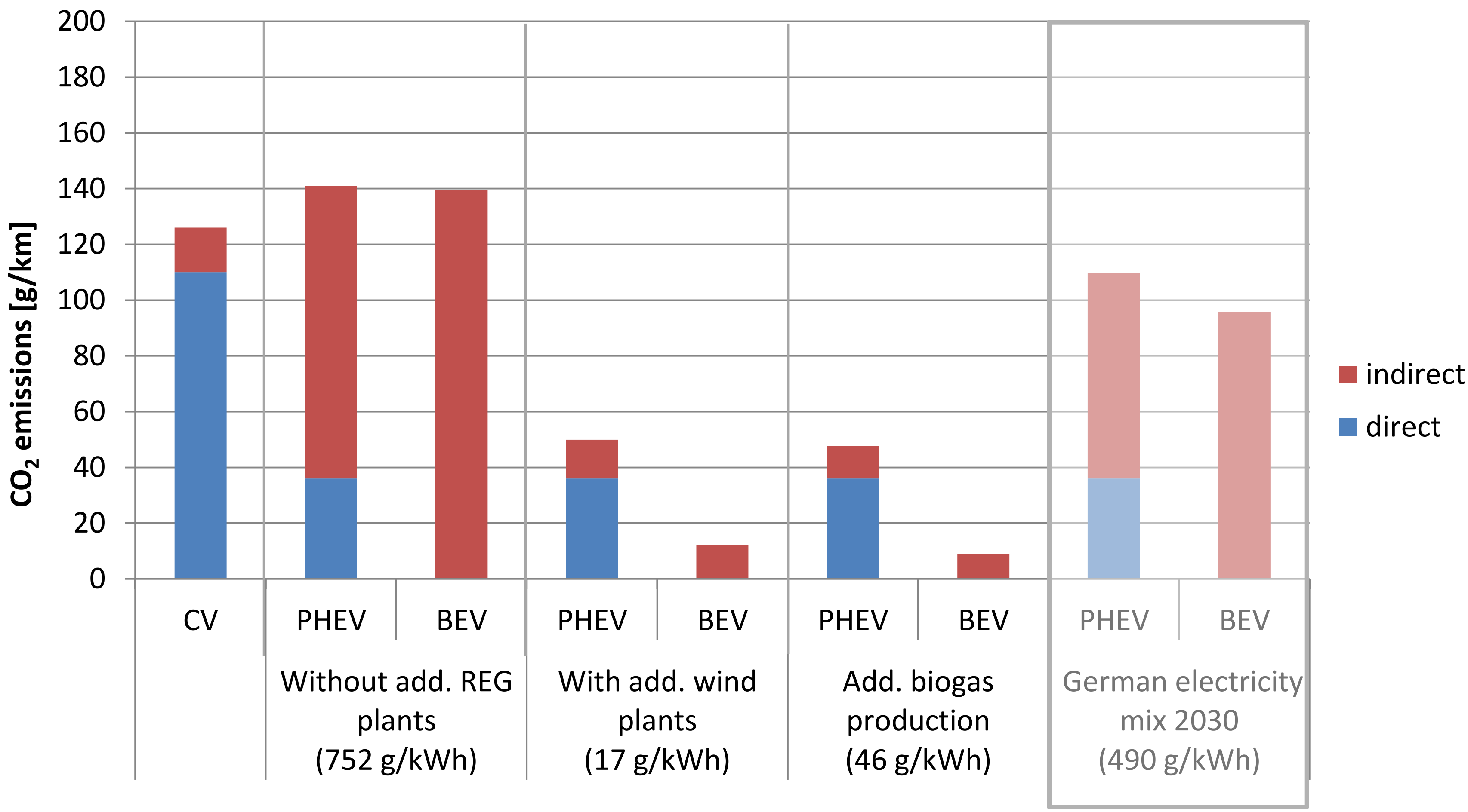
Electricity production for EVs: GHG emissions



*LM = Load management

Source: OPTUM

GHG balance of a mid-size passenger car in 2030



Source: OPTUM

» **Note:** GHG emissions of additional electricity production for EVs are considered

Development of kilometres travelled in Germany

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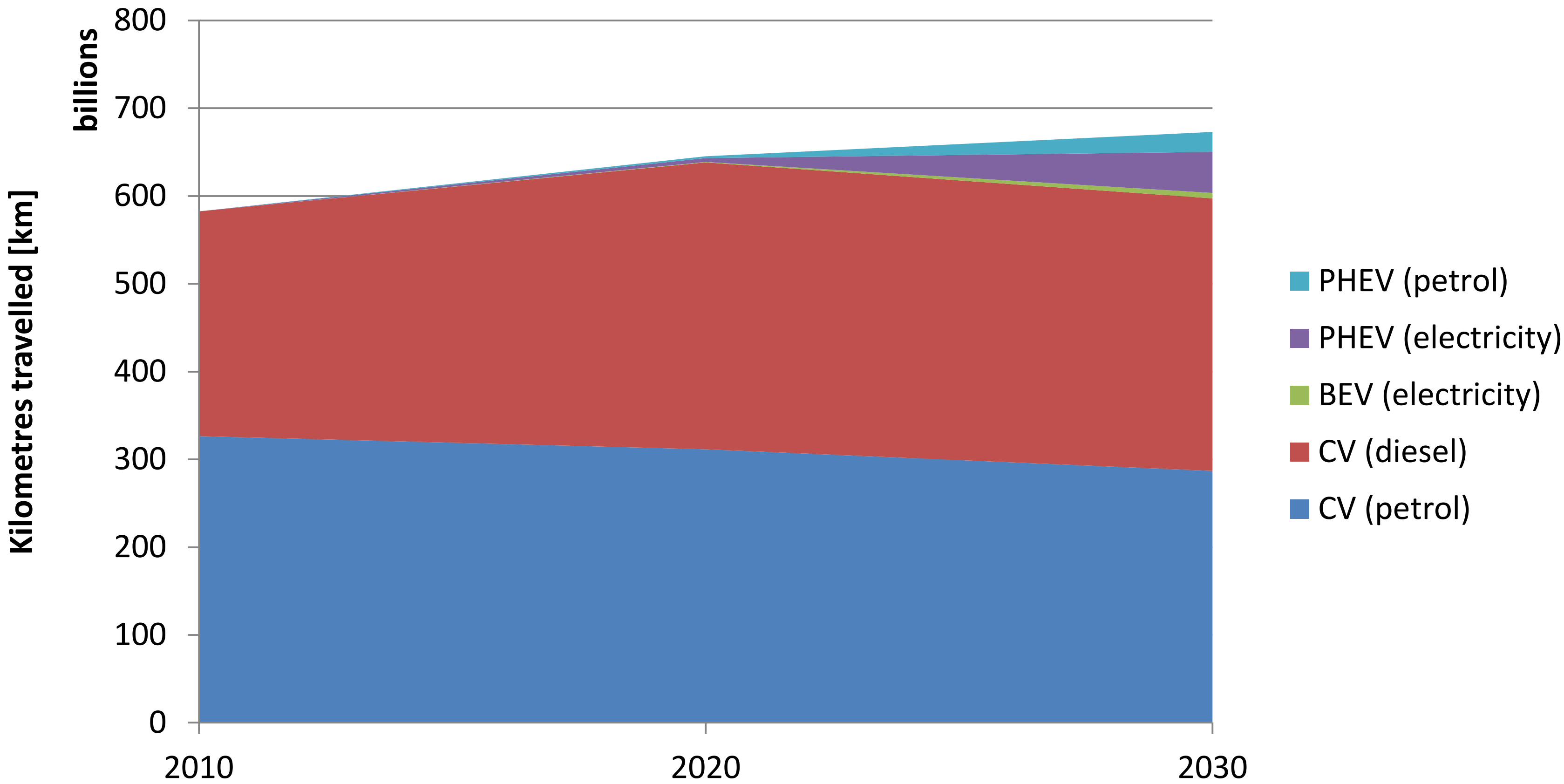
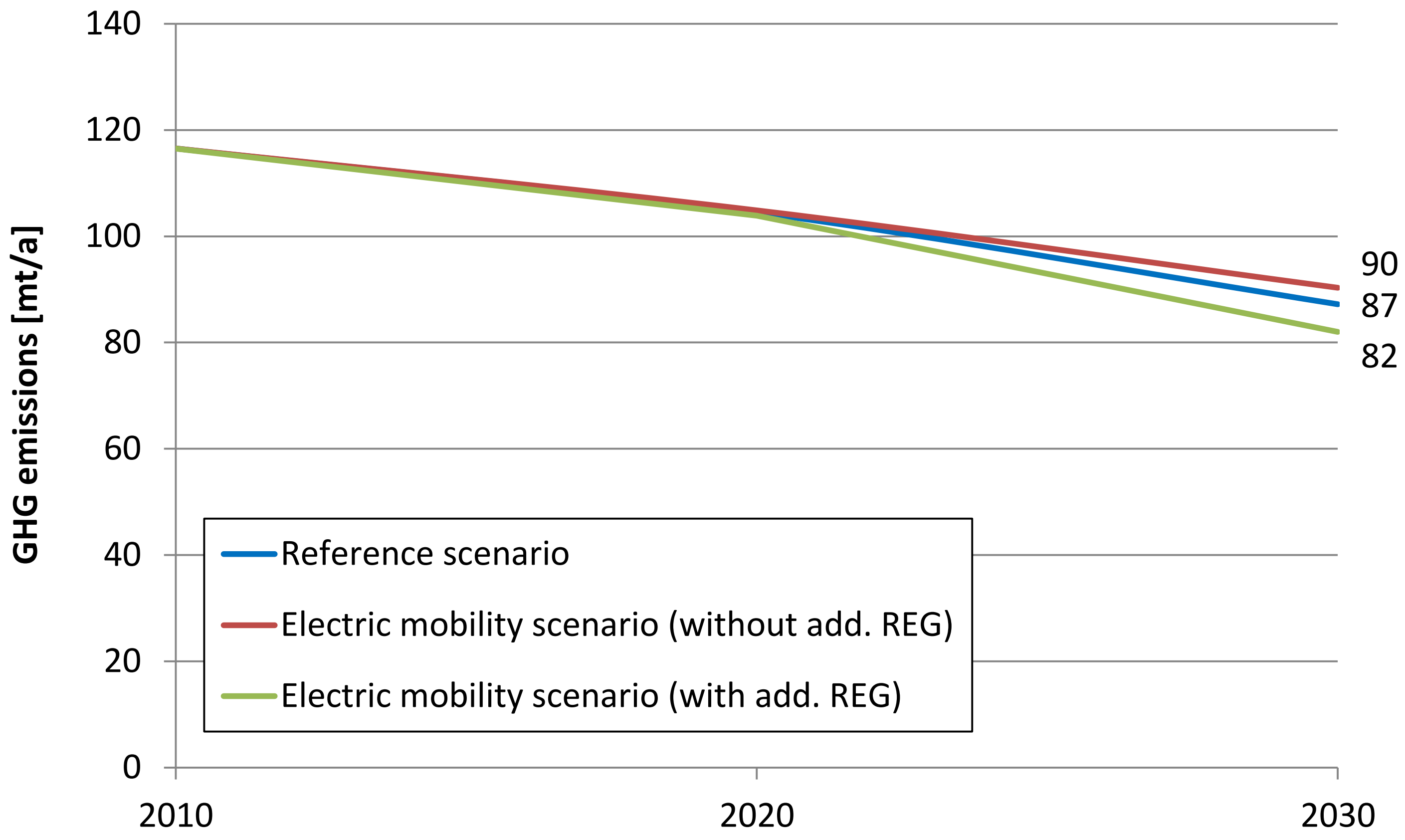


Source: OPTUM

Share of total kilometres travelled in 2030:

- 8 % kilometres travelled with electricity
- 11 % kilometres travelled by BEV & PHEV overall

GHG balance for passenger cars in Germany

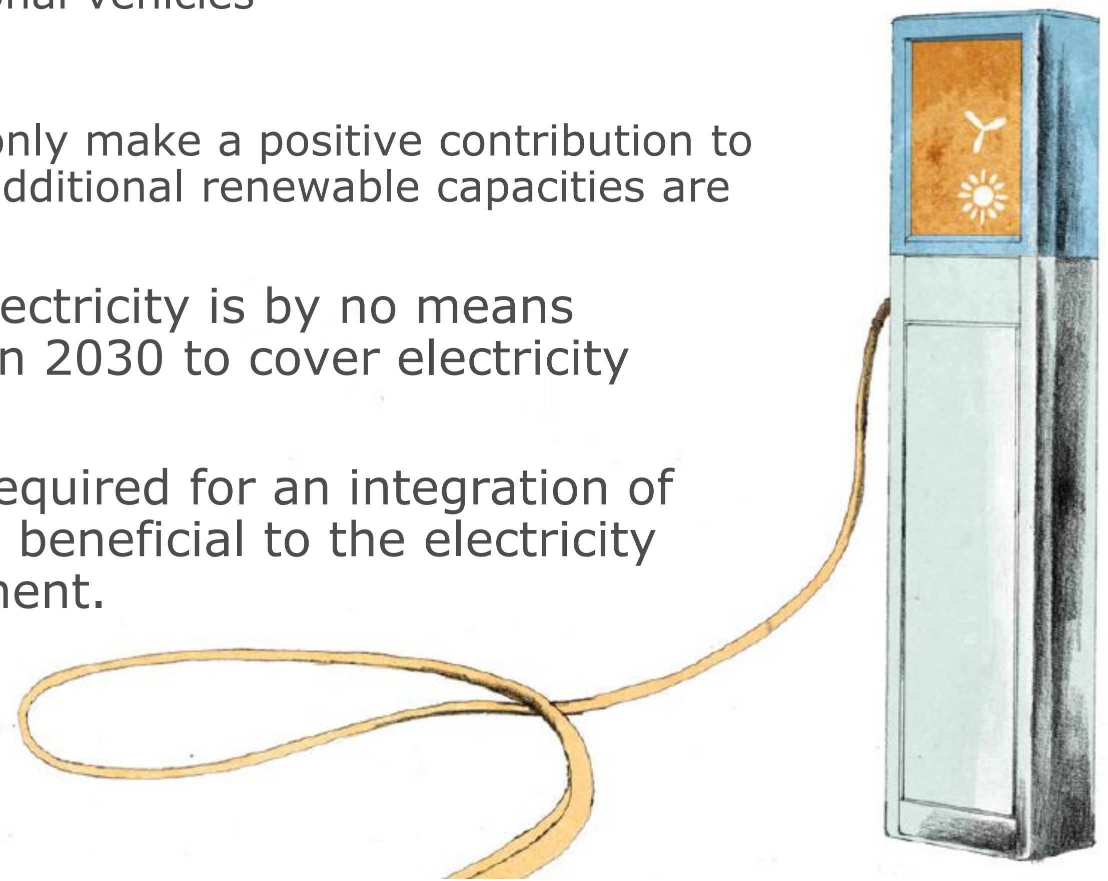


Source: OPTUM

» **Note:** GHG emissions of electric vehicles are determined by the additional electricity production for EVs (see PowerFlex)

Project findings

- Electric vehicles (BEV & PHEV) can have approx. 15 % share of car stock in Germany in 2030
- Scenario without additional REG in 2030:
  - Electric vehicles have similar emission levels to comparable conventional vehicles
- Therefore:
  - Electric vehicles can only make a positive contribution to climate protection if additional renewable capacities are made available.
- “Surplus” renewable electricity is by no means sufficient in Germany in 2030 to cover electricity demand of EVs.
- Load management is required for an integration of electric vehicles that is beneficial to the electricity market & the environment.



Electric mobility as a possible trigger for a change in paradigm?

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- Changed usage characteristics of EVs:
  - Still currently regarded as a barrier to their market success
  - Starting point for new mobility concepts and a changed “mobility culture” of the future?
  - It is conceivable that the effects of electric mobility on future mobility will be much greater.

- Embedding electric vehicles in alternative mobility concepts could have large potentials for a more sustainable transport sector.

- Because: Only a combination of technology, increased renewable power generation and changed mobility behaviour will enable the long-term climate protection targets to be achieved and ensure sustainable mobility in the future.

Thank you for your attention!

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