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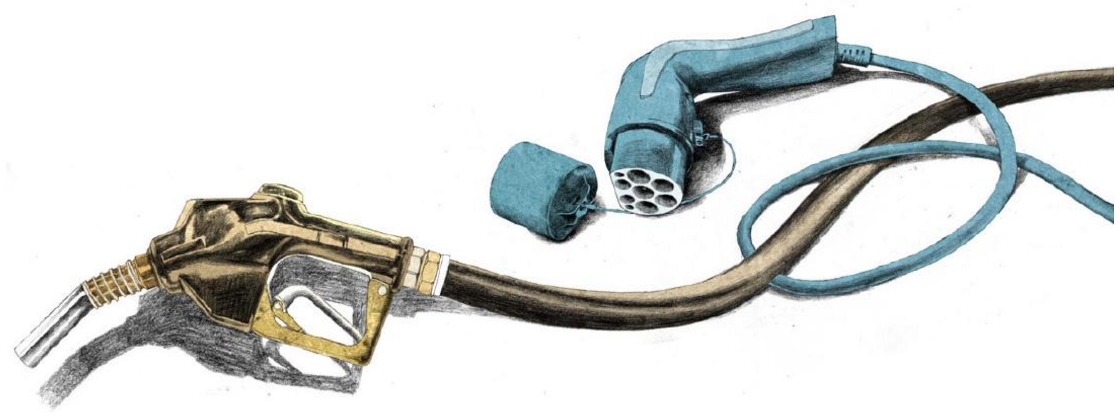
Environmental Impact Assessment of Electro Mobility in Germany (OPTUM)



Kick-off meeting at Kempinski Hotel, Beijing

8 May 2013

Florian Hacker / Peter Kasten, Oeko-Institut e.V., Berlin

(presented by Christian Hochfeld, GIZ)

Oeko-Institut

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Oeko-Institut is a leading European research and consultancy institute based in Germany which is working for a sustainable future.

- Founded in 1977, non-profit association
- Offices in Freiburg, Darmstadt and Berlin
- More than 145 staff, including 100 researchers
- More than 300 national and international projects per year
- Clients: European Union, ministries, industrial companies, non-governmental organisations
- Annual turnover: approx. 12 million Euro
- **More information on our website: www.oeko.de**

OPTUM research project

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- Title: "Optimising the environmental benefits of electric vehicles – An integrated consideration of vehicle use and the electricity sector in Germany"
- Consortium partners: Oeko-Institut e.V., ISOE
- Funded by: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
- Duration: 09/2009 – 09/2011
- 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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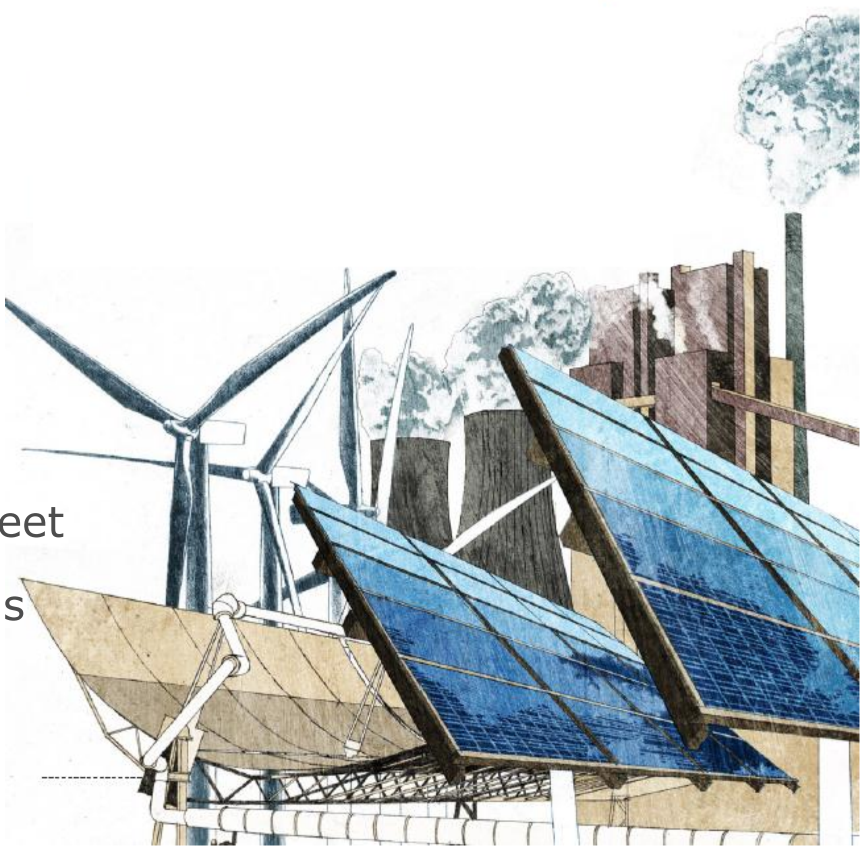
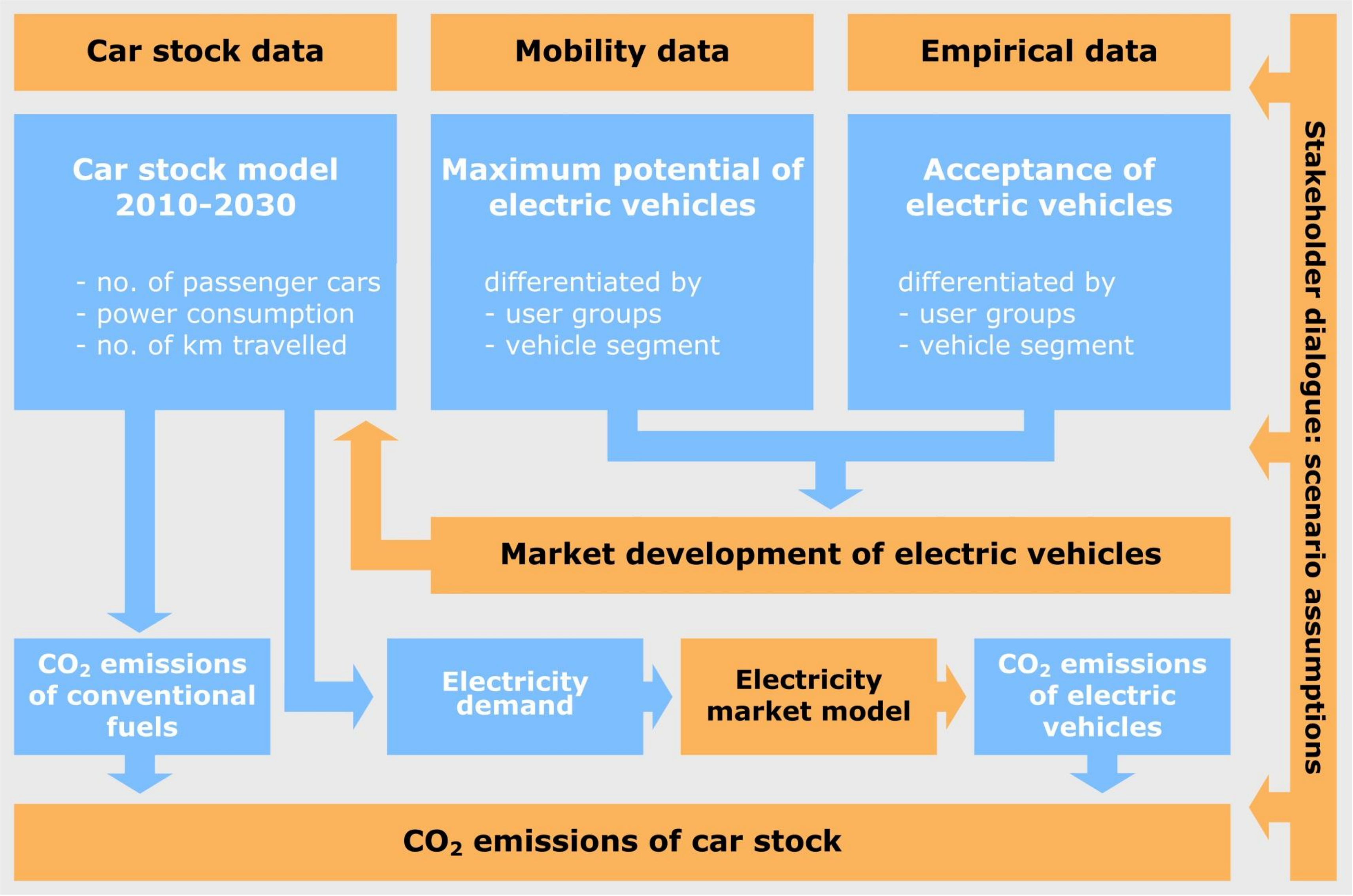
- Starting points:
  - EVs cause no direct emissions
  - GHG balance of EVs is determined by source of electricity generation
- Necessary analytical steps:
  - acceptance of EVs
  - mobility behaviour
  - market potential of EVs
  - interactions with the power plant fleet
  - electricity demand & GHG 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: City BEV 100 km, 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

Mobility survey: “Mobility in Germany 2008”

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- Data set for derivation of maximal potential and car usage profiles

- Representative survey regarding the mobility behaviour of German households
  - ~77,000 people, ~26,000 households
  - All members of a household are included
  - Surveyed on random days over an entire year
  - All journeys on specific day are covered (means of transport, distance, time of day, purpose)
  - Additional information on car ownership, social demographics and region type

- Transformed into car usage data set
  - Weekly car usage profiles
  - Day-to-day mobility behaviour
  - Data cleansing

Maximum potential of electric vehicles (modelling approach)

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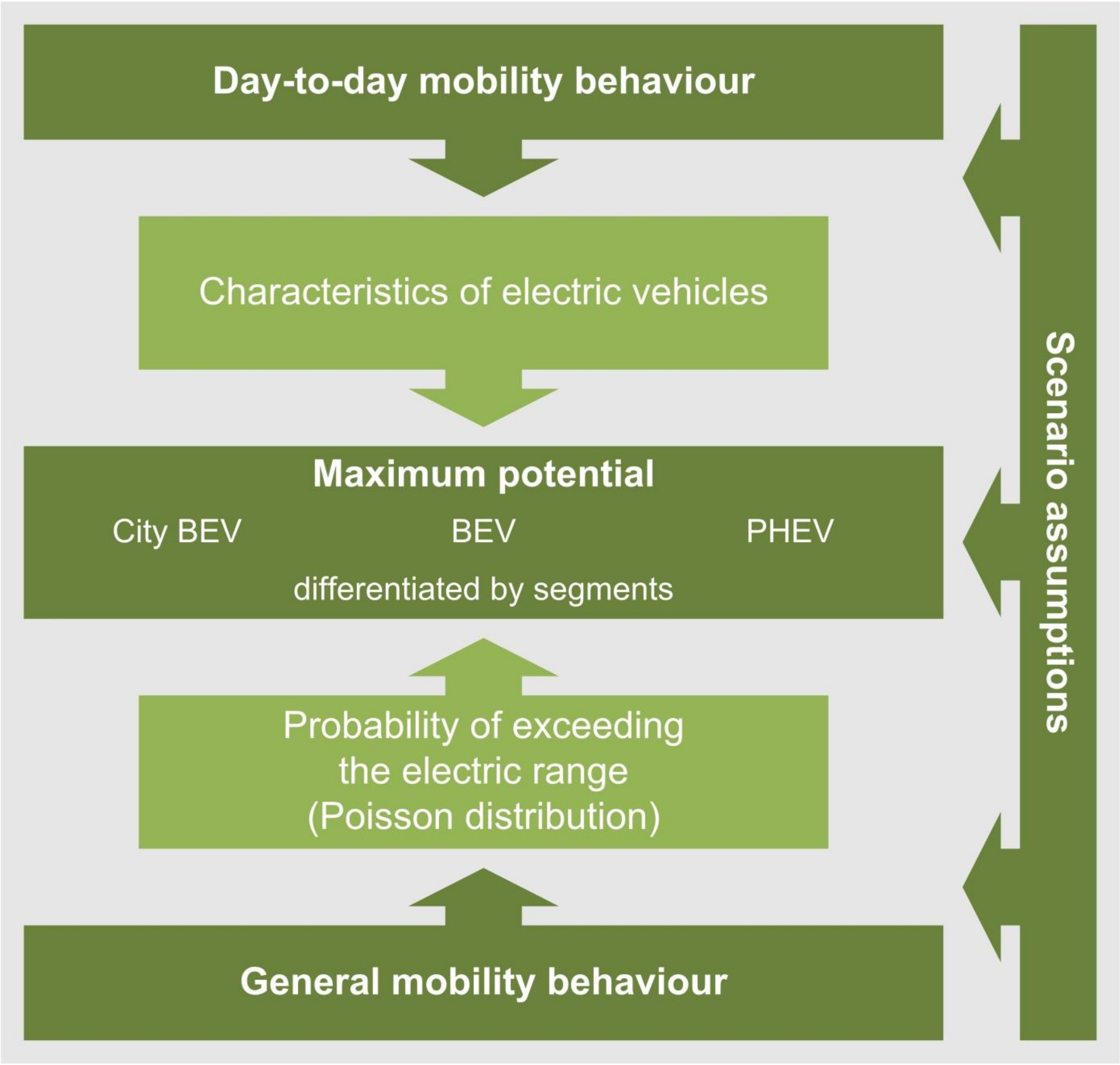
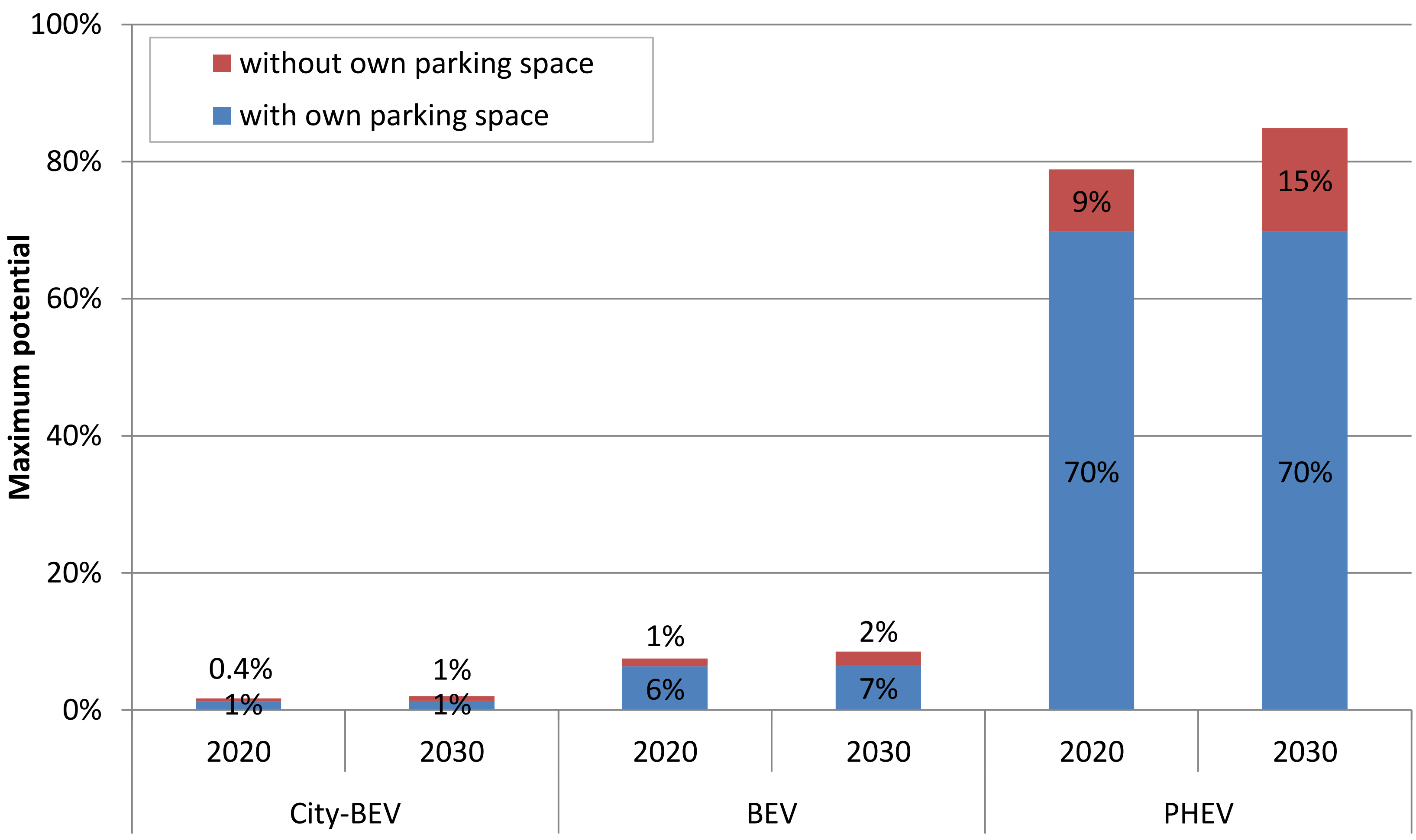


Maximum potential of electric vehicles



Source: OPTUM

Maximum potential of electric vehicles

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- Day-to-day mobility behaviour is not a general barrier to EV use
- Limitation factors for City BEV & BEV:
  - Such cars are not available in all car segments
  - Long distance journeys
  - City BEV requires a second car in household
  - High probability of exceeding electric range of BEV (~ 86 % with more than 8 long distance journeys)
  - Limited charging infrastructure in public spaces
- Limitation factors for PHEV:
  - Limited charging infrastructure in public spaces
- Increase of maximum potential from 2020 to 2030 is based on more public charging stations (scenario assumption)

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

Example of Conjoint Task (CAPI)

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Wenn das Ihre einzigen Optionen sind, welches Fahrzeug wählen Sie?

Motor	Verbrennungsmotor	Plug-In-Hybrid	Elektromotor
Leistung	120 kW/ 165 PS	120 kW/ 165 PS	90 kW/ 120 PS
CO_2	100 g/km	50 g/km	5 g/km
Anschaffungskosten	24.000 €	29.000 €	35.000 €
Kraftstoffkosten	12 €/100 km	8 €/100 km	4 €/100 km
Reichweite pro Ladung			200 km
Ladedauer			8 Stunden
Privilegien			Kostenfreie für Elektroautos reservierte Parkplätze in Innenstädten

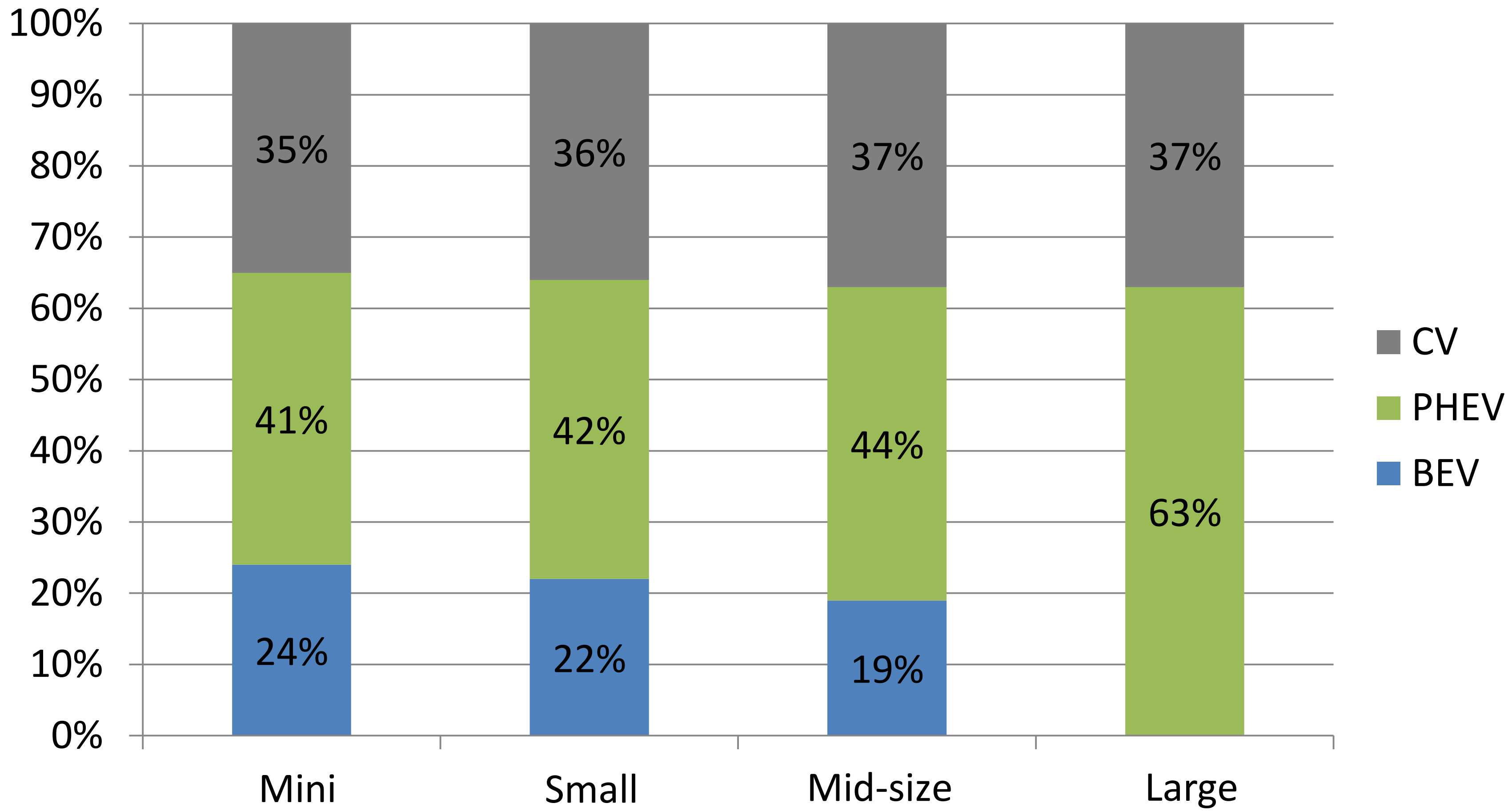
Mit Blick auf das, was Sie über den Automarkt wissen: Würden Sie dieses Fahrzeug, das Sie hier ausgesucht haben, tatsächlich kaufen?

- Ja
- Nein

Source: OPTUM

Simulation of vehicle purchase in 2030

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



Source: OPTUM

Results of acceptance analyses

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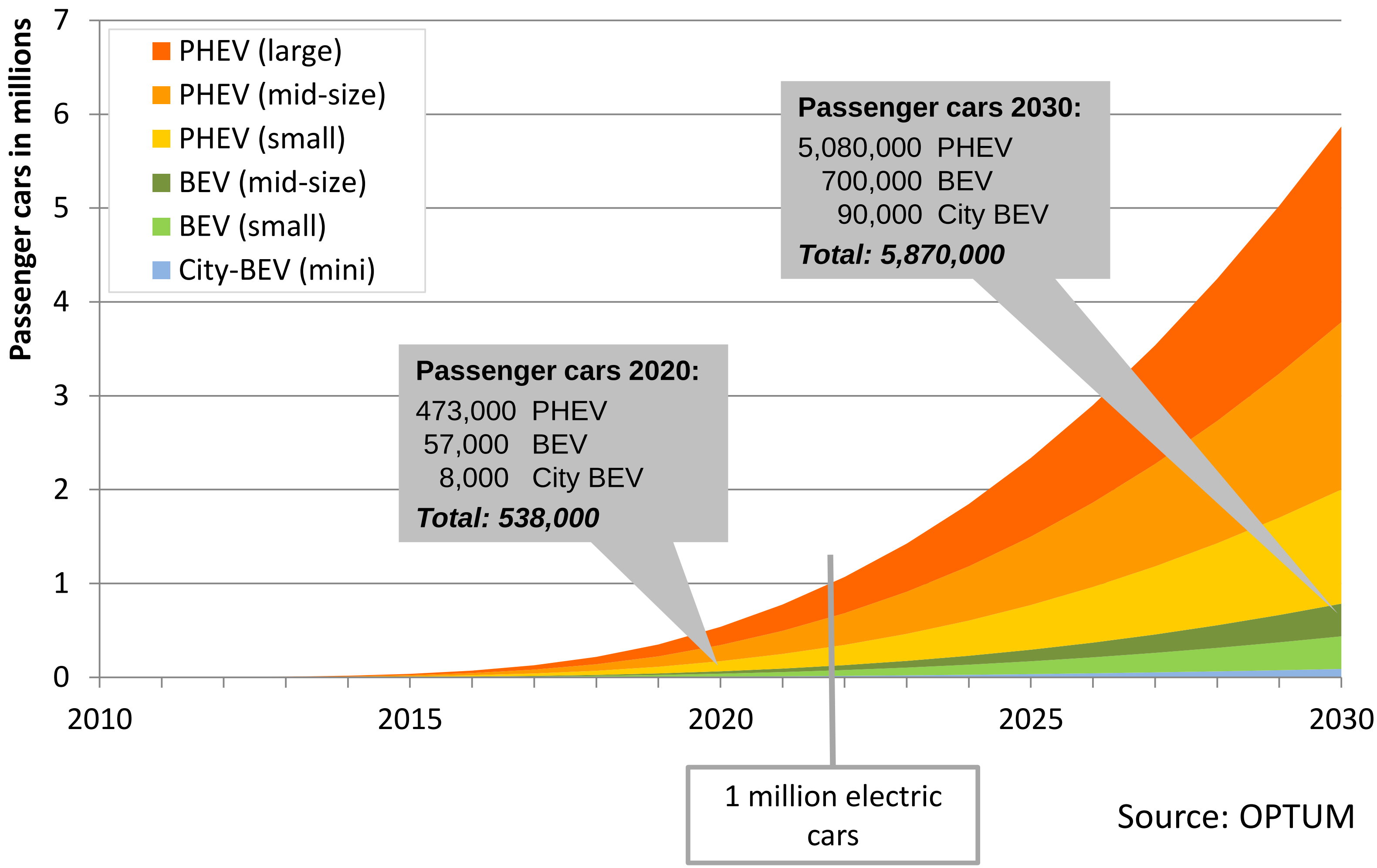
German government targets:
2020: 1 million electric vehicles
2030: 6 million electric vehicles



Source: OPTUM

Electricity demand of EVs

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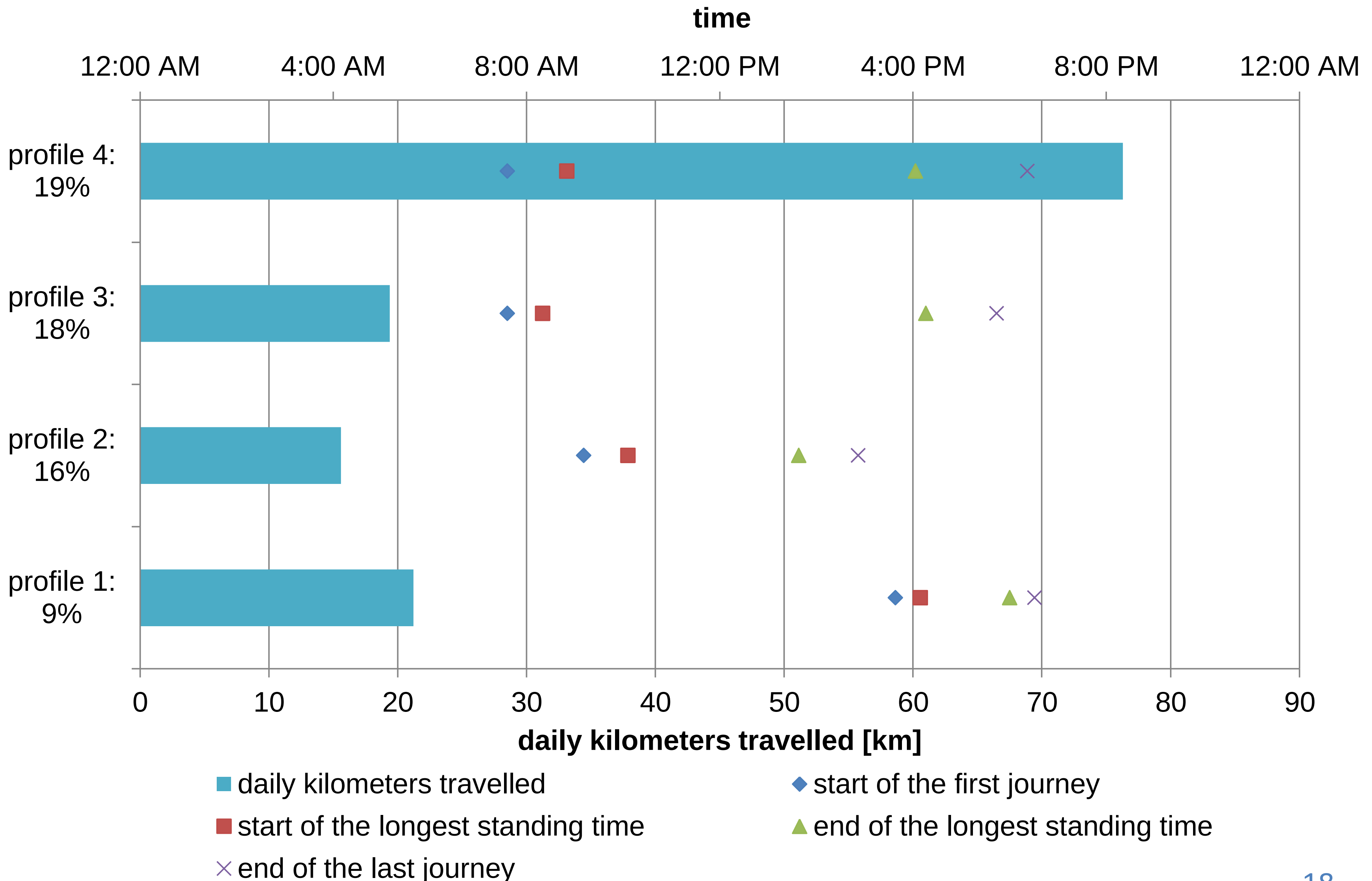
- Average annual mileage:
  - Conventional passenger cars: 13,700 km
  - Important: Annual mileage for BEV is approx. 40 % lower than for CV
- Electric driving share:
  - (City-)BEV: 100 %
  - PHEV: about 67 %

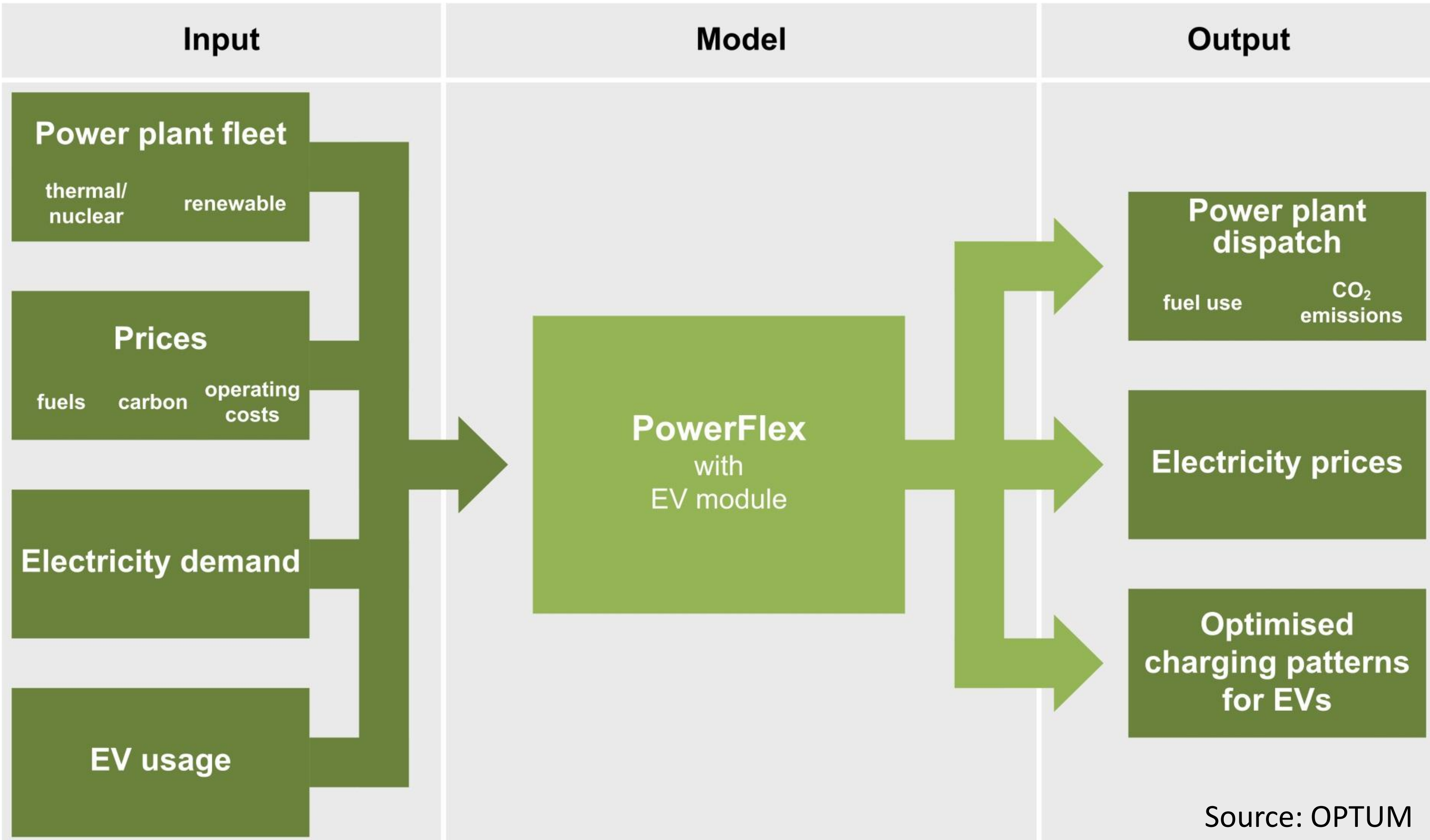
- Electricity demand profiles for electric vehicles:
  - Electricity demand of BEV and PHEV is simulated in combination with EV fleet based on 60 different car usage profiles (derived from MiD 2008)
  - Electricity demand profiles take into account necessary minimum battery level and passenger car usage
  - 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

Car usage profiles – weekdays



PowerFlex – Functionality of electricity market model

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



German electricity market without EVs in 2030

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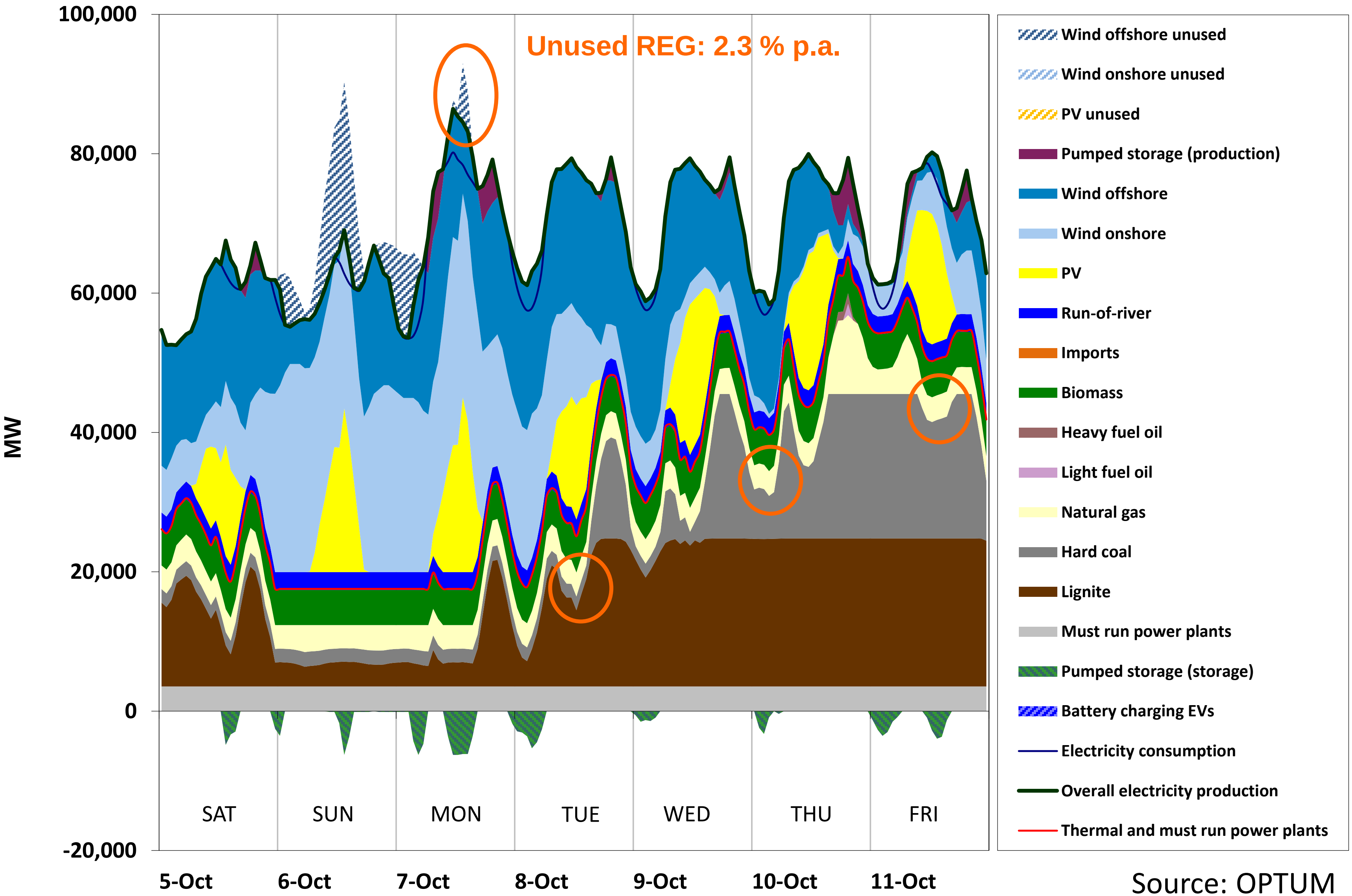
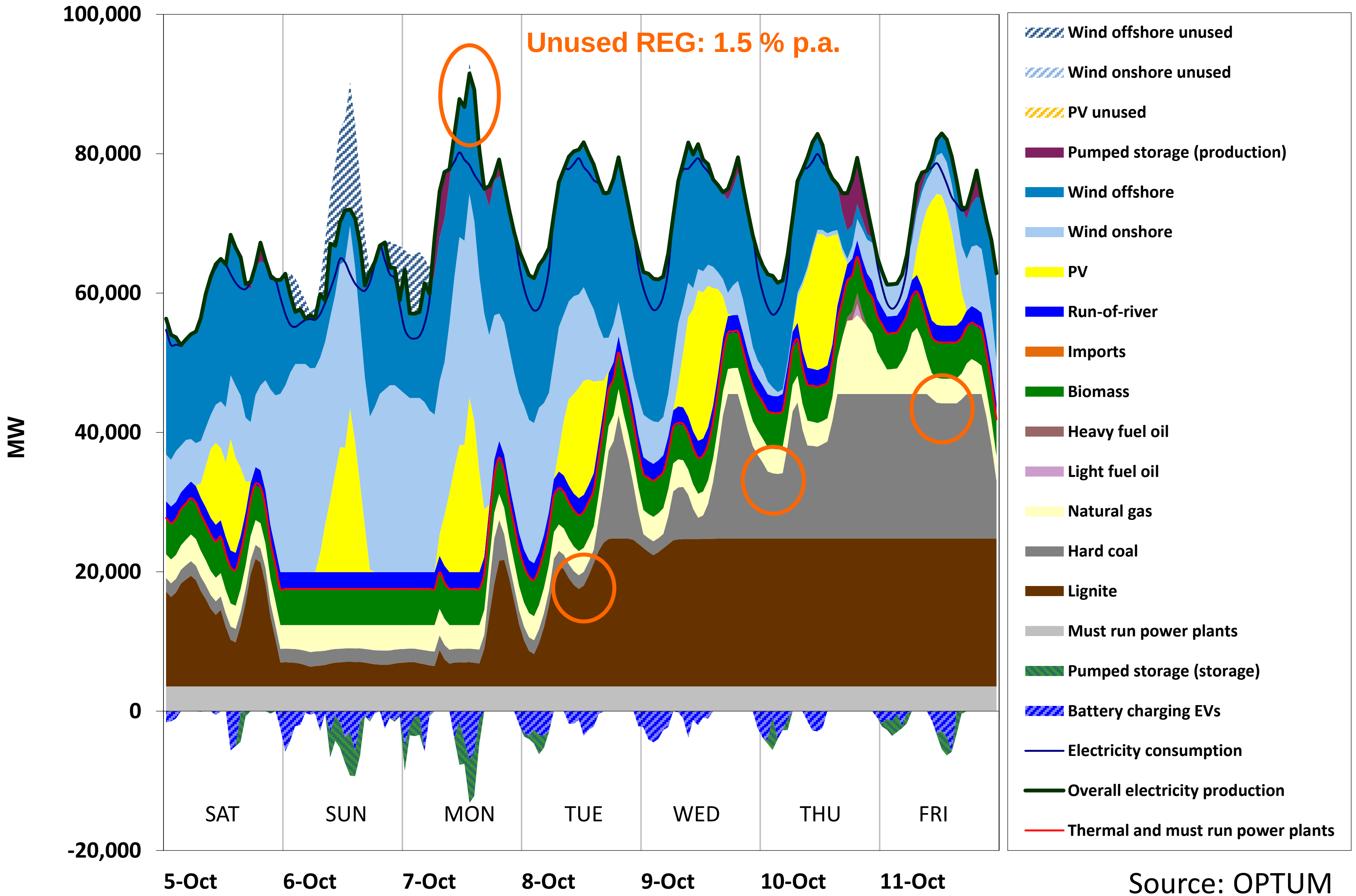


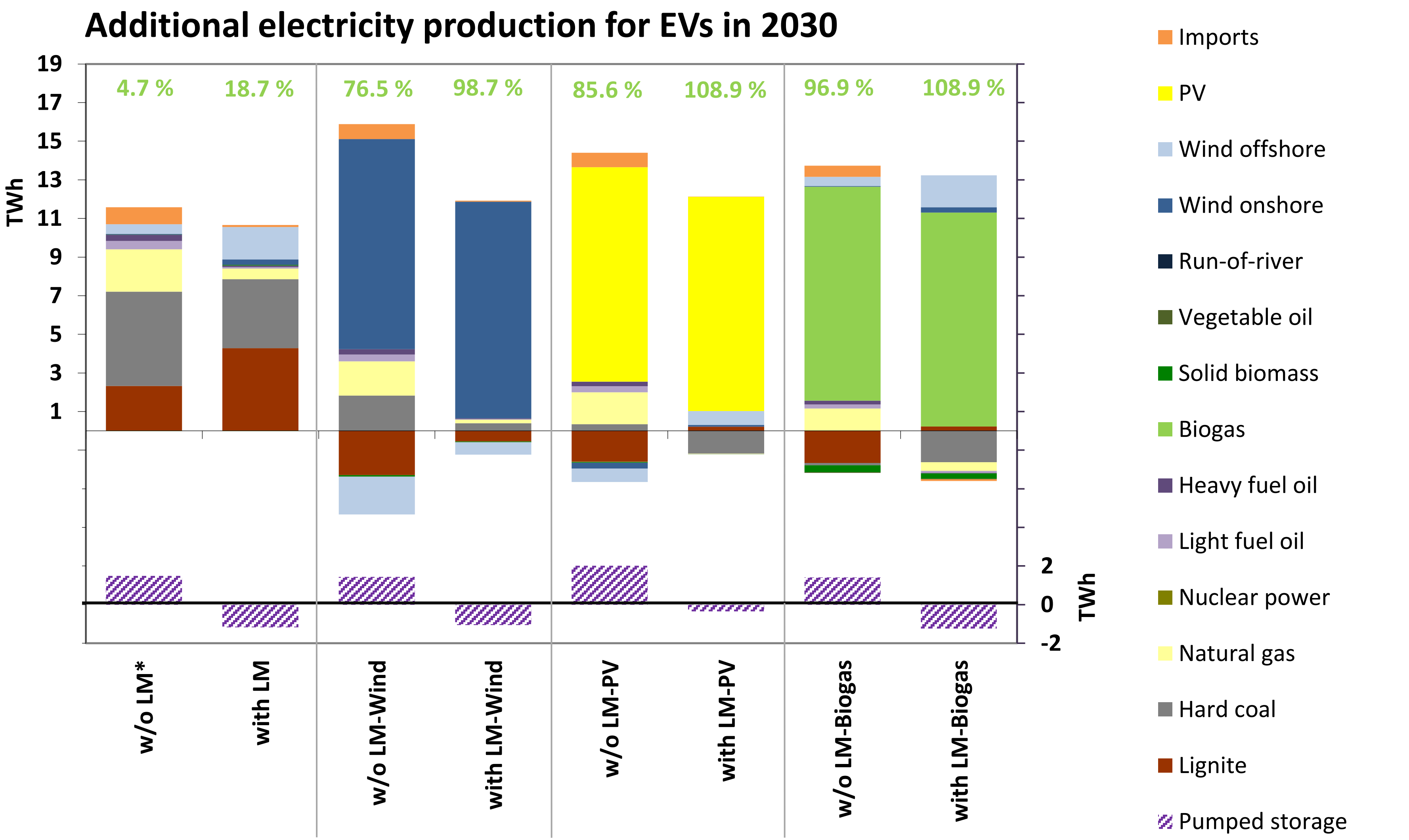
Source: OPTUM

German electricity market with EVs & *with* load management in 2030



Source: OPTUM

Electricity production for EVs by energy source

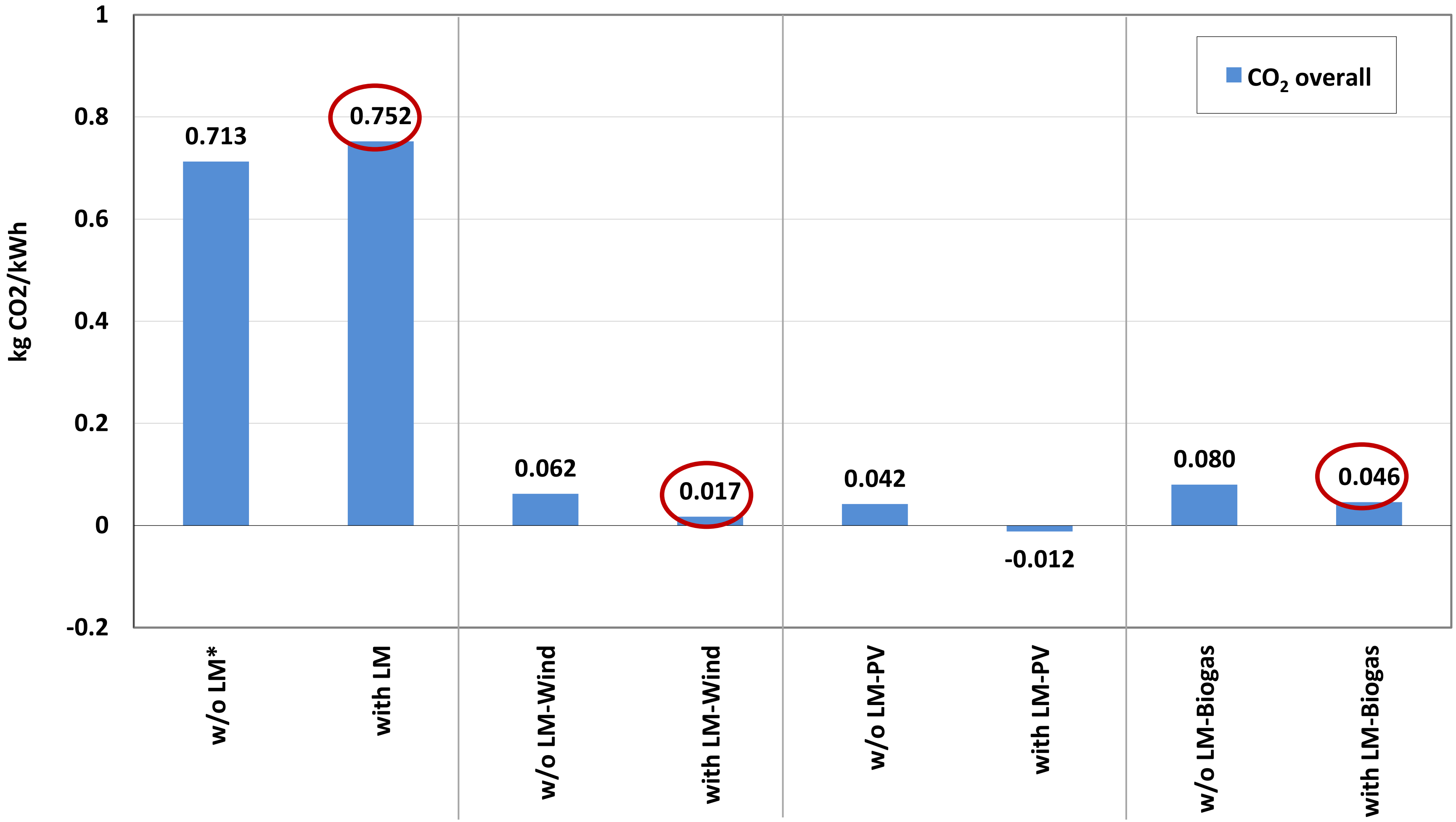


*LM = Load management

Source: OPTUM

Electricity production for EVs: GHG emissions

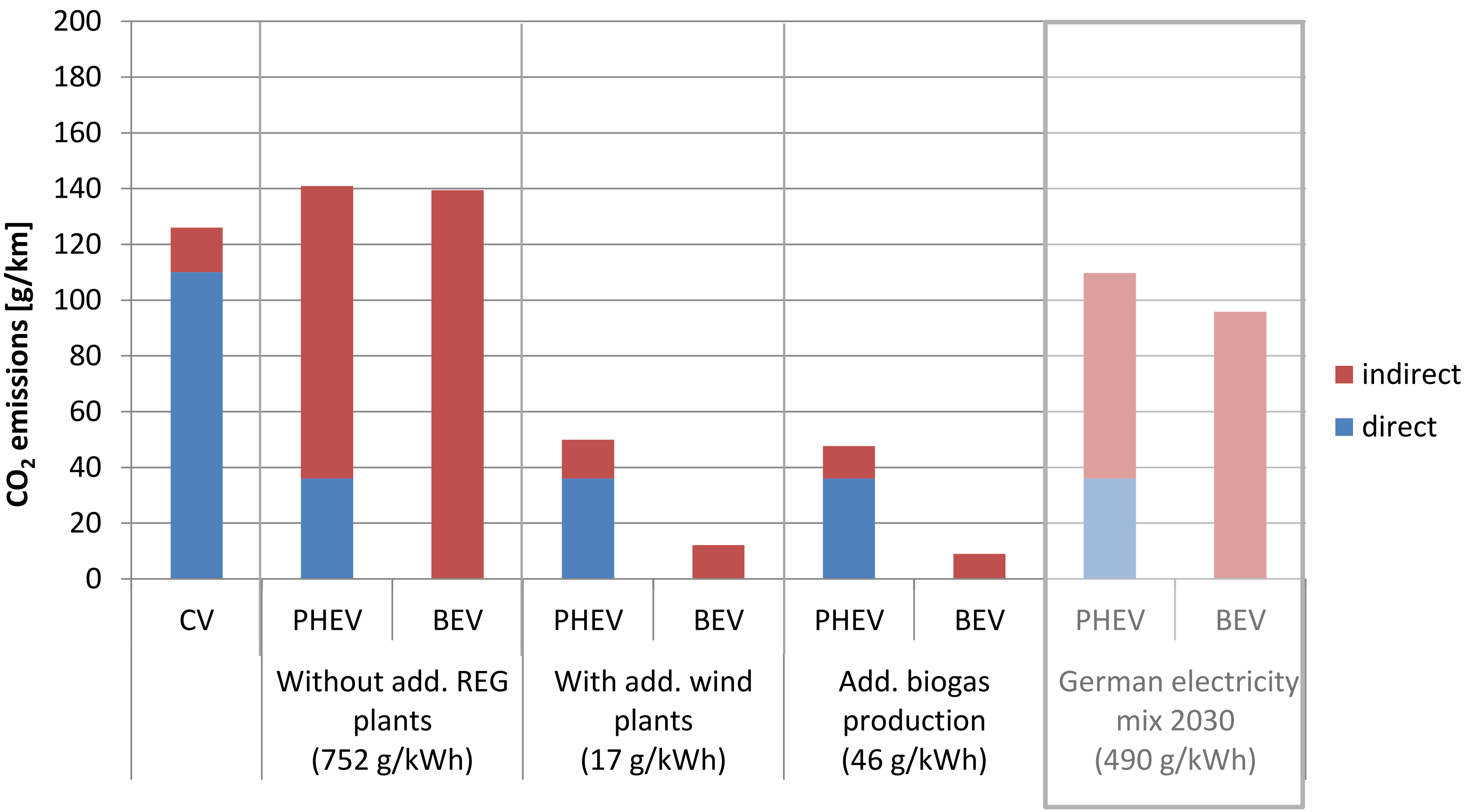
Specific CO_2 emissions for additional electricity production in 2030



*LM = Load management

Source: OPTUM

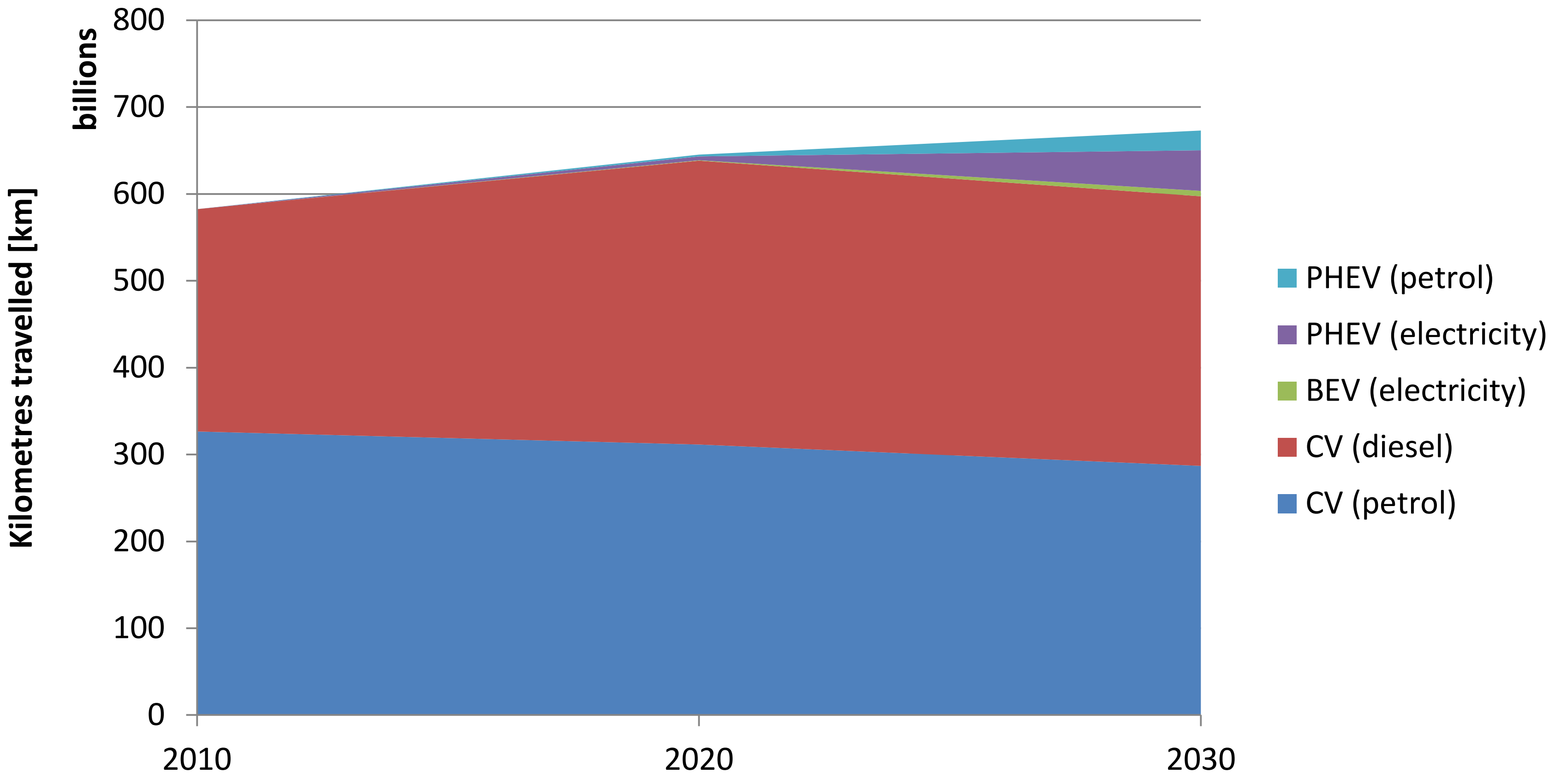
GHG balance of a mid-size passenger car in 2030



Source: OPTUM

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

Development of kilometres travelled in Germany

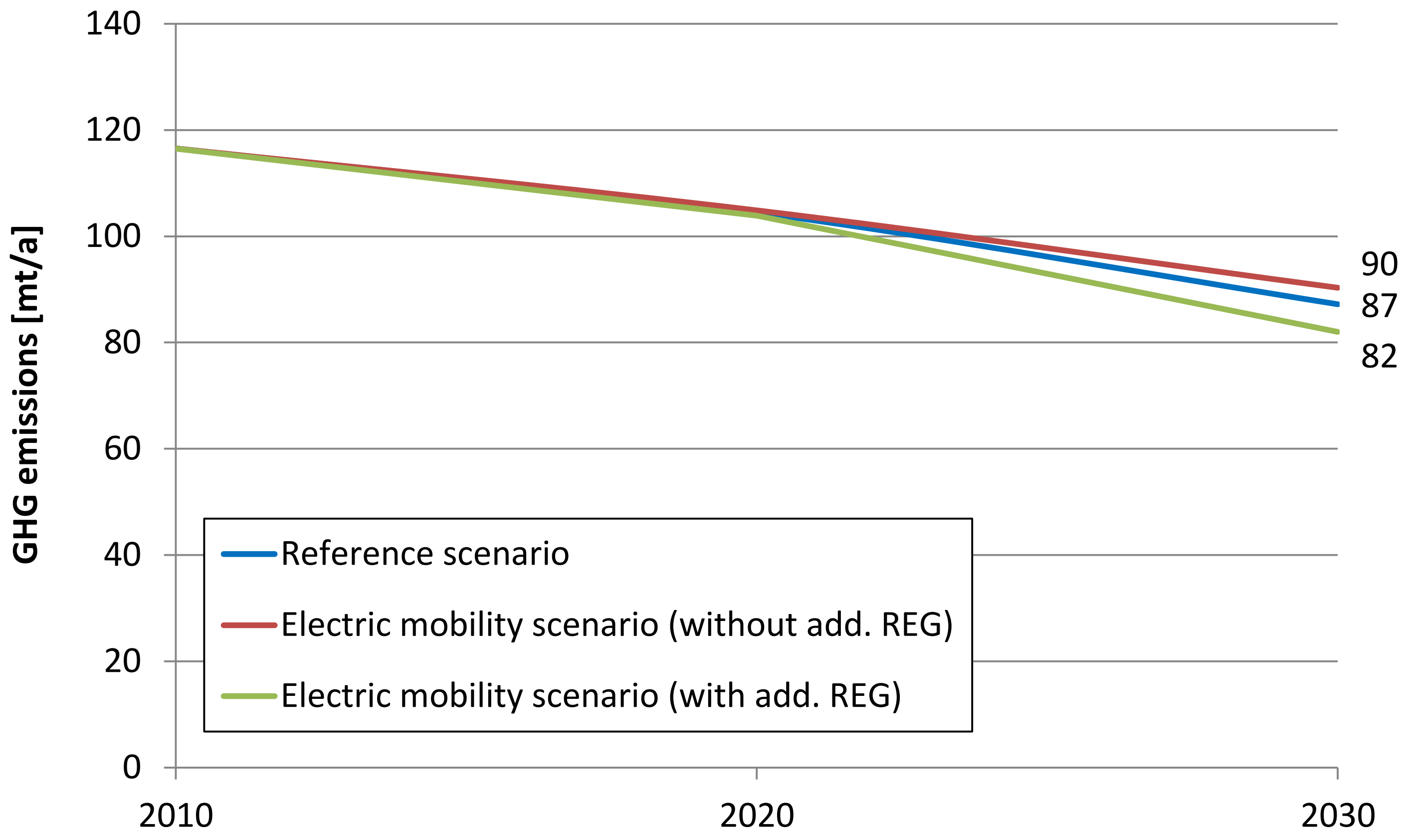


Source: OPTUM

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

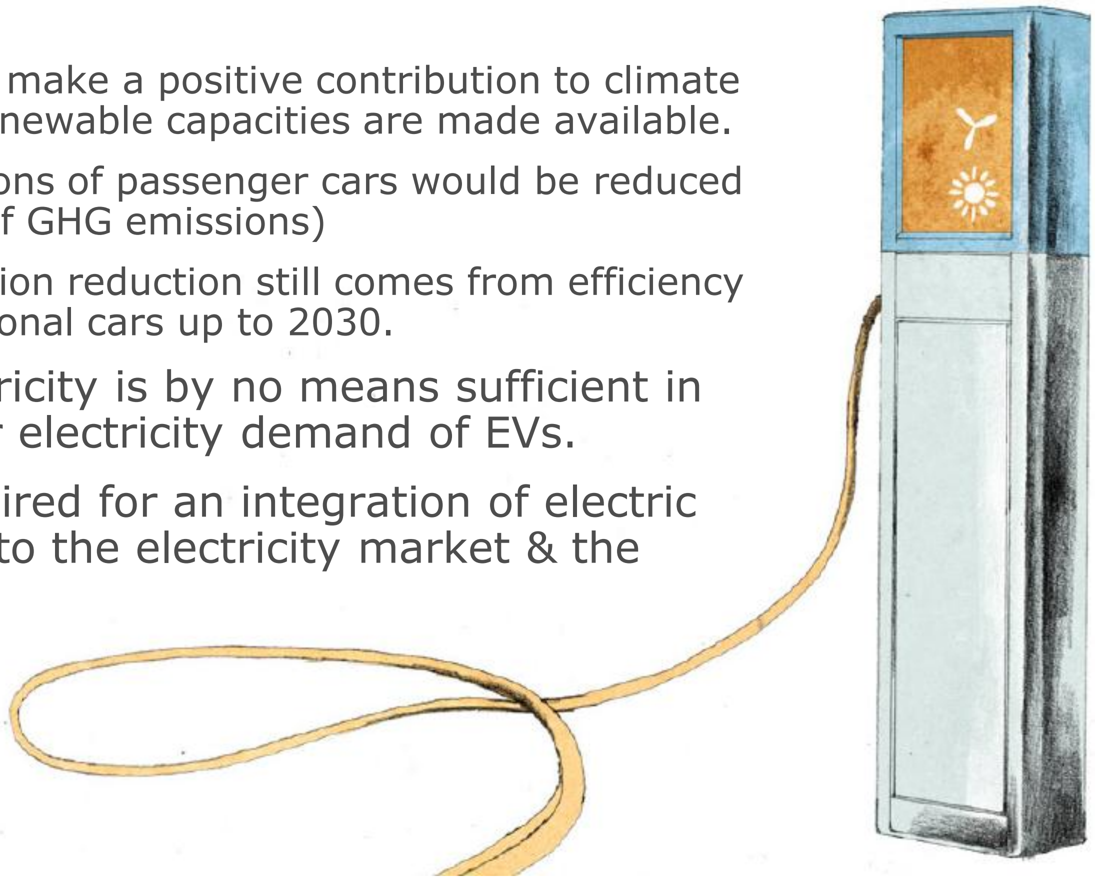


Source: OPTUM

» **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.
  - In this case: GHG emissions of passenger cars would be reduced by 5.2 Mt in 2030 (6 % of GHG emissions)
  - But: main share of emission reduction still comes from efficiency improvement of conventional cars up to 2030.
- “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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