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The contribution of PEV to greenhouse gas mitigation

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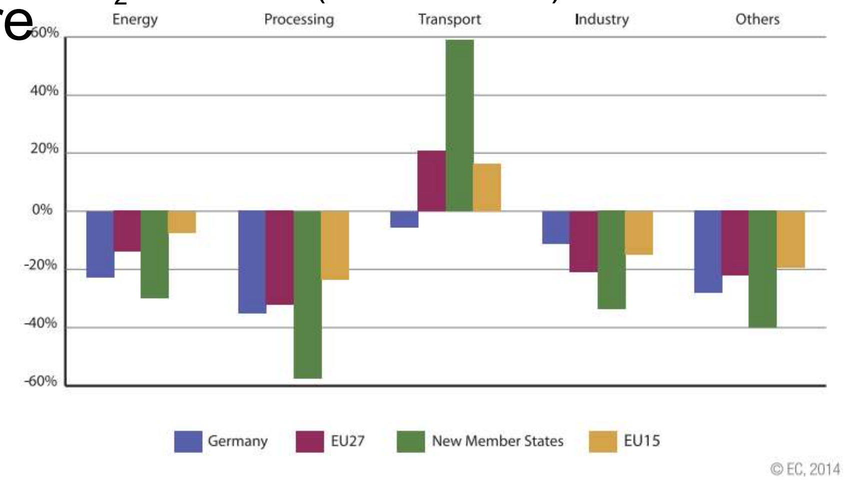
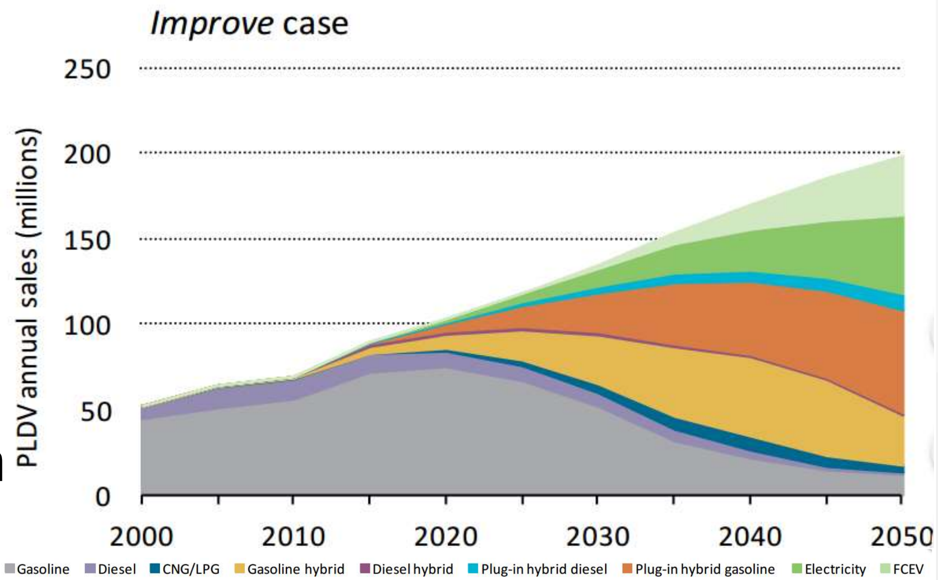
Motivation

- Limited carbon capacity of our atmosphere
- Transport's share on CO_2 em. is ≈ 23%
- Opposing **trend** from empirical GHG emissions and targets for most countries
- Smog in **mega cities**
- Increasing oil demand and **oil dependency** of many countries and the transport sector in particular
- Fast increasing global **car fleet**
- More and more **stringent standards**
- Energy transition in **electricity system**

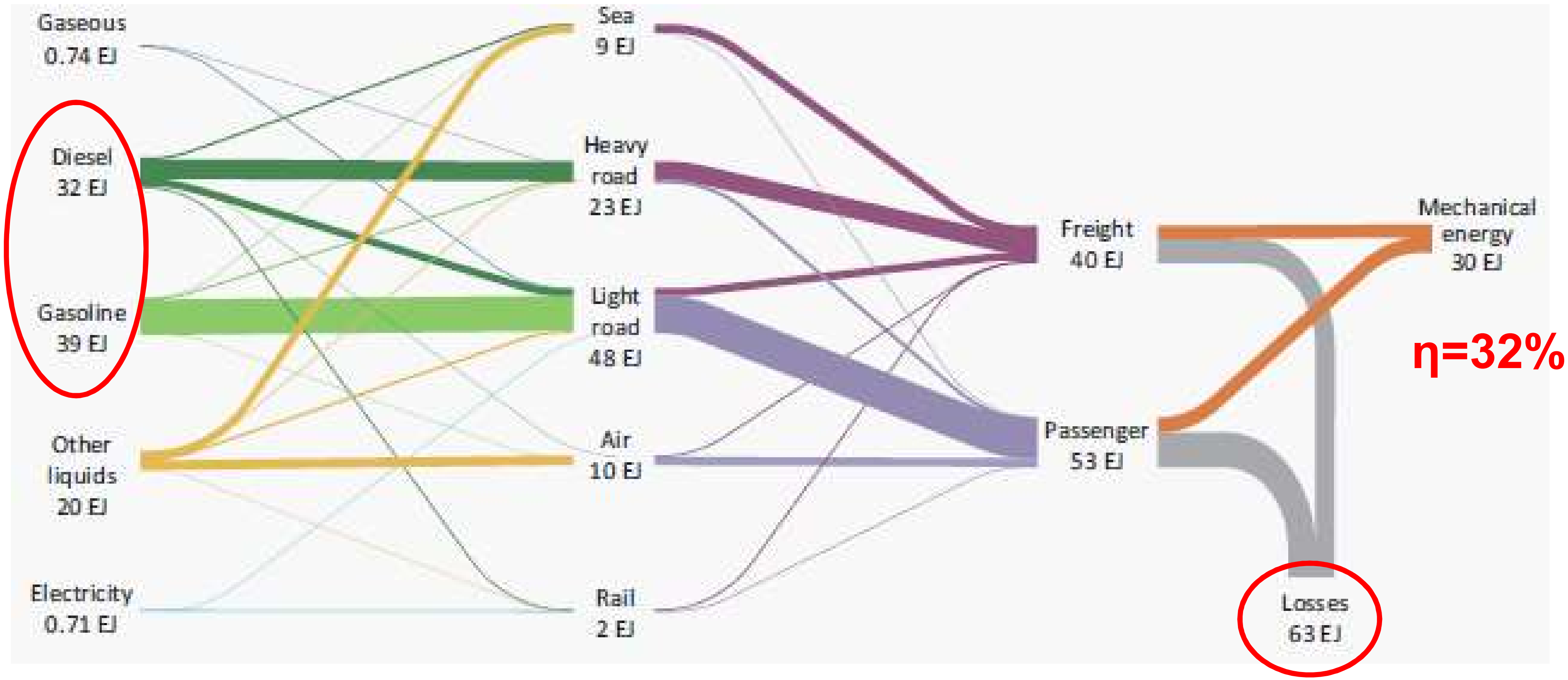
CO_2 emissions (1990 vs 2010)





Creutzig, F.; Jochem, P.; Edelenbosch, O.Y.; Mattauch, L.; Vuuren D.P.v.; McCollum, D.; Minx, J. (2015), Transport – a roadblock to climate change mitigation?, Science (Policy Forum) 350 (6263), 911-912

Oil dependency and inefficiencies of transport



Oil dependency = 0.77%

IEA, 2012, ETP2012

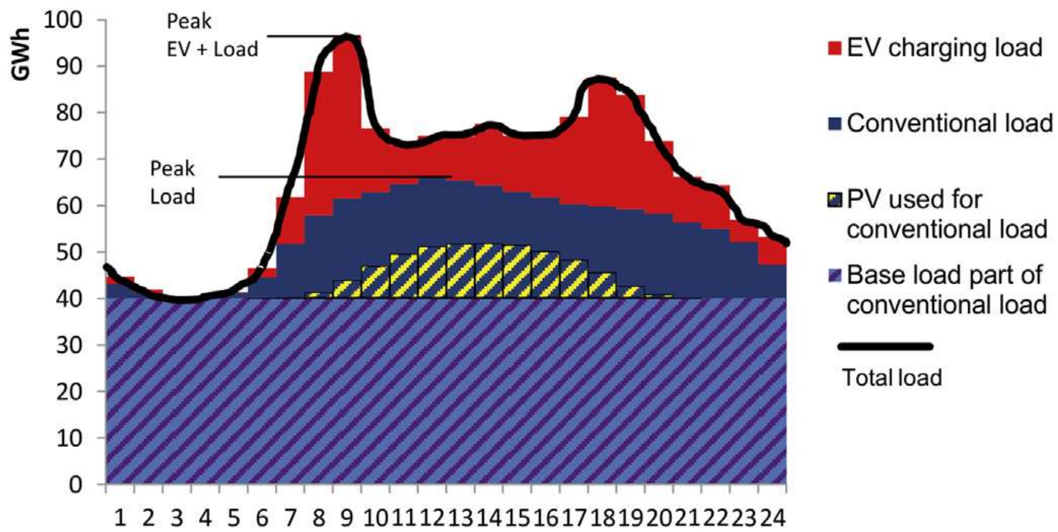
Electricity demand by electric vehicles (PEV)

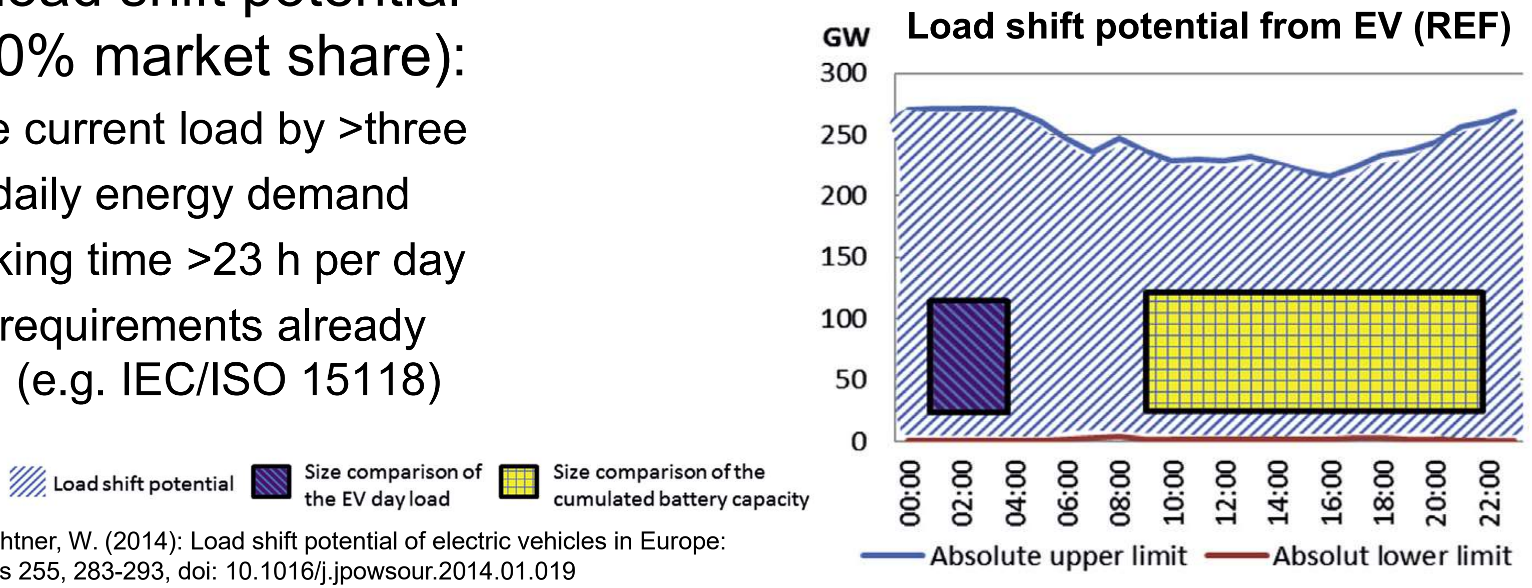
100% market share of EV would …

- increase electricity demand only by about 20%
- but might more than double national load

→ There is a urgent need for controlled charging

- The <u>technical</u> load shift potential is very high (10% market share):
  - Can increase current load by >three
  - Can double daily energy demand
  - Average parking time >23 h per day
  - All technical requirements already implemented (e.g. IEC/ISO 15118)

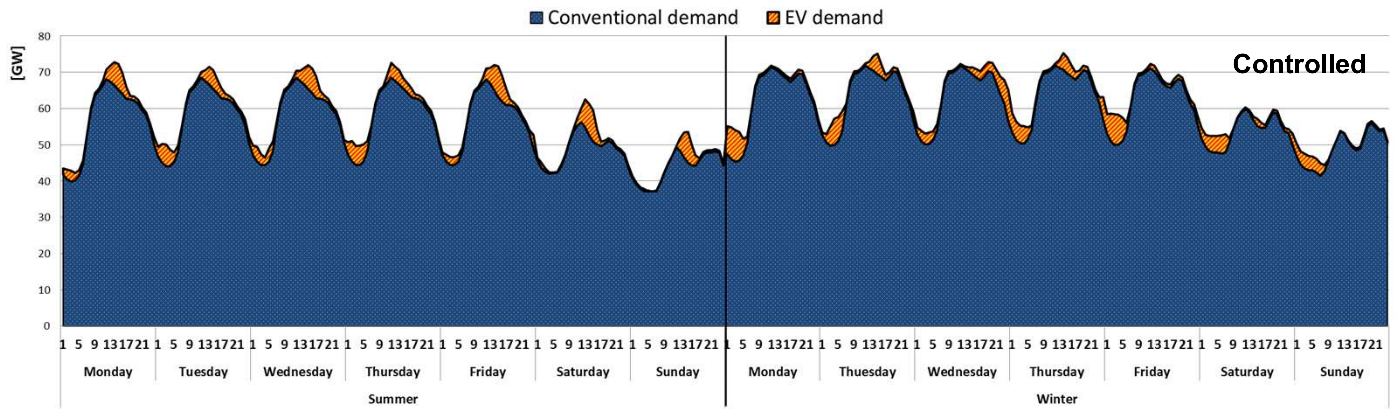


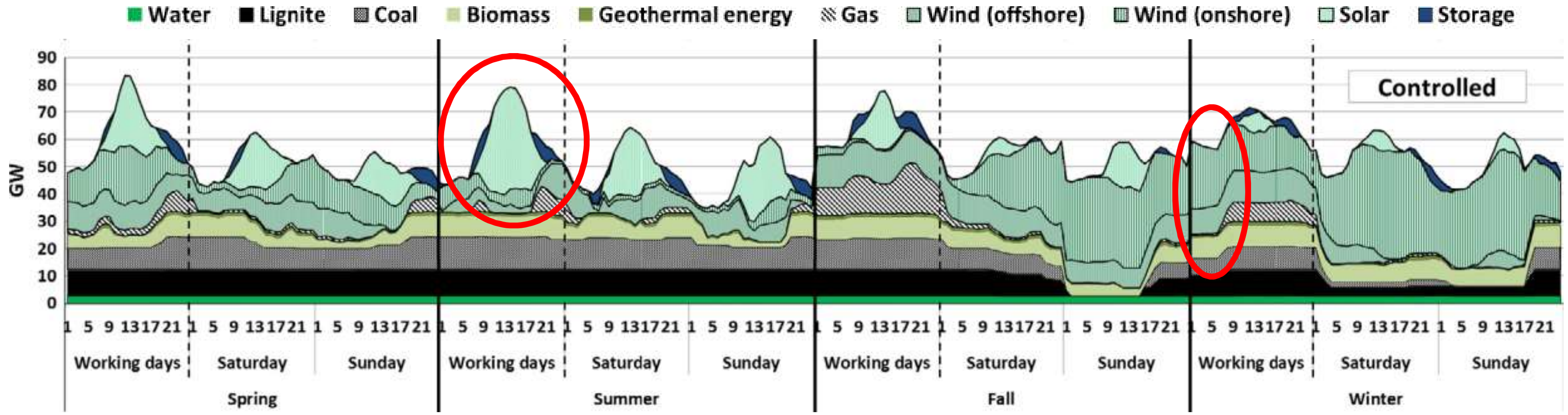


Babrowski, S.; Heinrichs, H.; Jochem, P.; Fichtner, W. (2014): Load shift potential of electric vehicles in Europe: chances and limits, Journal of Power Sources 255, 283-293, doi: 10.1016/j.jpowsour.2014.01.019

Synergies with the energy transition in EU & D

- E.g.: Germany, 12% PEV market share, 2030





- Instantaneous (controlled) charging has little impact on the electricity generation by conventional power plants.

Jochem, P.; Babrowski, S.; Fichtner, W. (2015): Assessing CO_2 Emissions of Electric Vehicles in Germany in 2030, Transportation Research A: Policy and Practice 78, 68-83, doi: 10.1016/j.tra.2015.05.007.

Results

Measuring the CO_2 emissions from PEV:

- Annual average mix (1):
  D_{2030}: 58 g/km,
  $Sweden_{2010}$: 6 g/km (≈ 0.3 l/100km or ≈ 1000 MPG)
- Weighted average annual mix (2):
  D_{2030}(controlled charging): 50 g/km (≈2.3 l/100km or ≈110 MPG)
- Marginal mix (3): D_{2030}(instantaneous charging):
  110 g/km (≈4.8 l/100km or ≈ 50 MPG)
- "Policy mix" (balancing emissions e.g. EU-ETS): 0 g/km

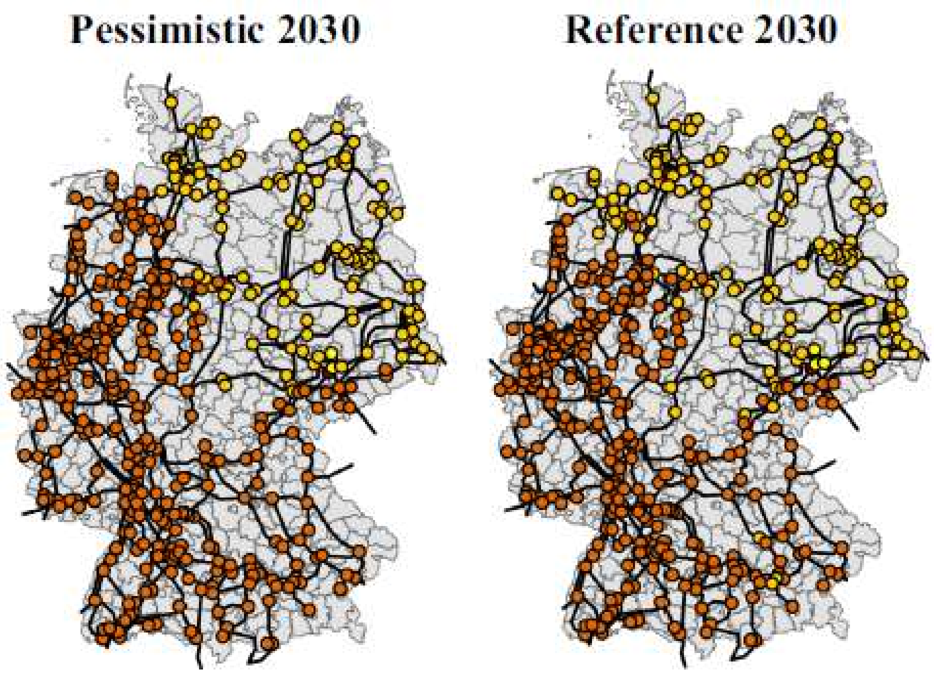
→ Energy transition will help to cut down GHG emissions from PEV

Jochem, P.; Babrowski, S.; Fichtner, W. (2015): Assessing CO_2 Emissions of Electric Vehicles in Germany in 2030, Transportation Research A: Policy and Practice 78, 68-83, doi: 10.1016/j.tra.2015.05.007

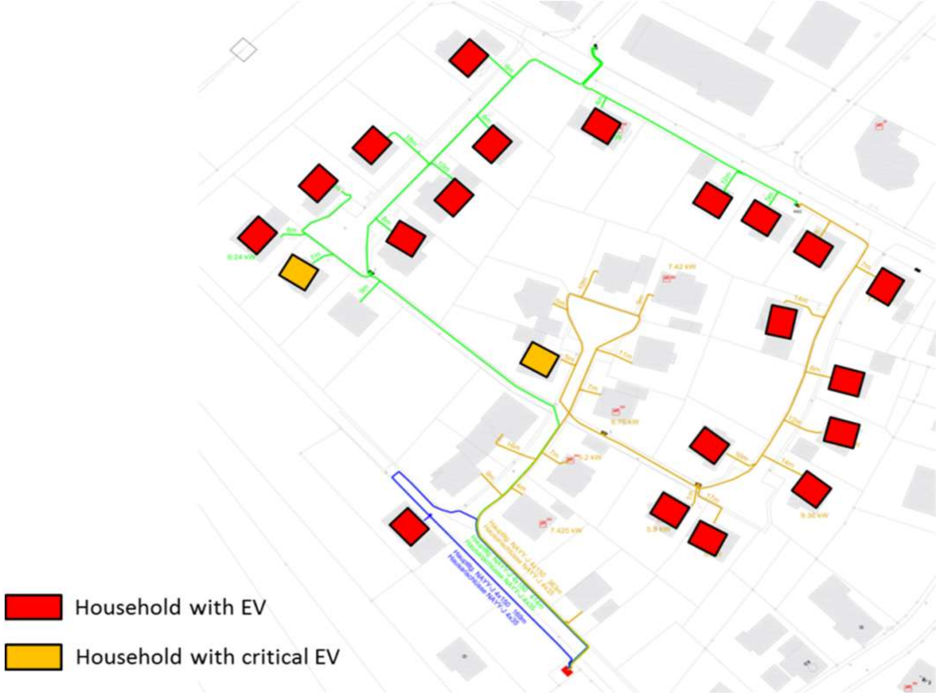
Impact on different power grid levels (GER, 2030)

- There is hardly any effect on the transport grid level
- The distribution grid is more vulnerable (depending on grid structure, current load, charging rate of EV, scheduling of charging, etc.)

Impact on the German transport grid in 2030



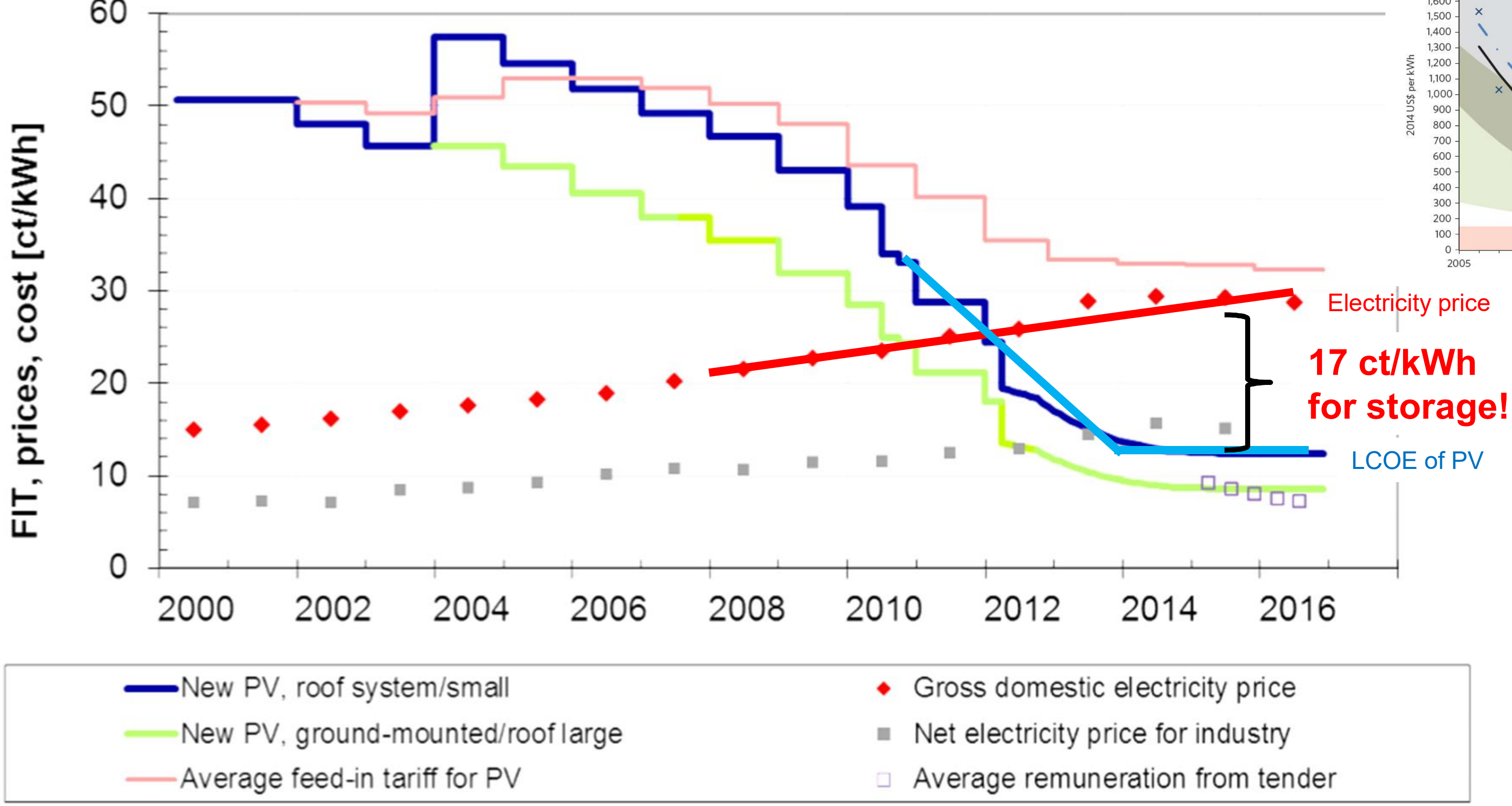
Impact on an example distribution grid

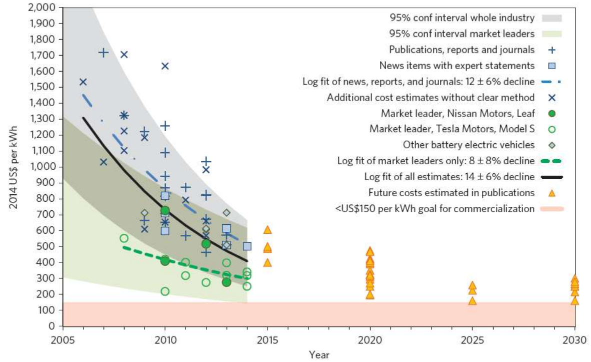


Heinrichs, H.; Jochem, P. (accepted), Long-term impacts of battery electric vehicles on the German electricity system, European Physical Journal Special Topics
EVREST (2014), Deliverable 4.1, project report, www.evrest-project .org

Second use of mobile storages

- There is a high need for storages in the future electricity system
- Locally battery storages in combination with photovoltaics are already profitable in Germany.



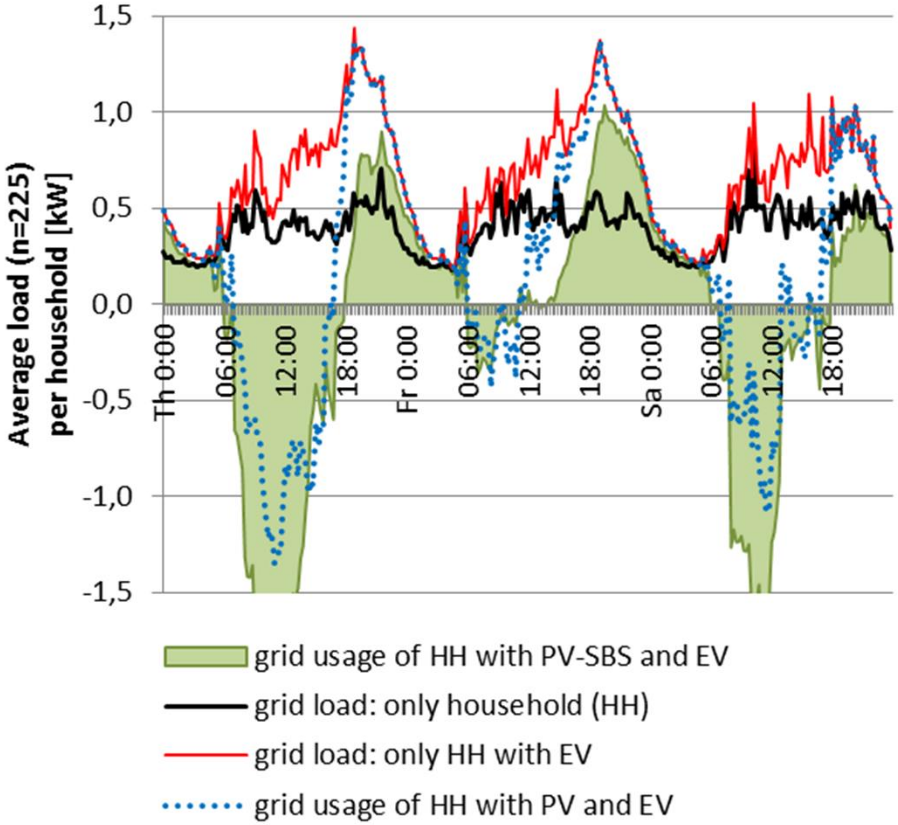


Nykvist, B. and M. Nilsson (2015), Rapidly falling costs of battery packs for electric vehicles, Nature Climate Change 5,329–332(2015), doi:10.1038/nclimate2564

Kaschub, T.; Jochem, P.; Fichtner, W. (2016): Solar energy storage in German households: profitability, load changes, and flexibility, Energy Policy 98, 520-532, doi: 10.1016/j.enpol.2016.09.017

Fhg-ISE (2016), Recent Facts about Photovoltaics in Germany, Freiburg, https://www.ise.fraunhofer.de/en/publications/veroeffentlichungen-pdf-dateien-en/studien-und-konzeptpapiere/recent-facts-about-photovoltaics-in-germany.pdf.

We expect a significant impact from stationary storages on decentral electricity supply

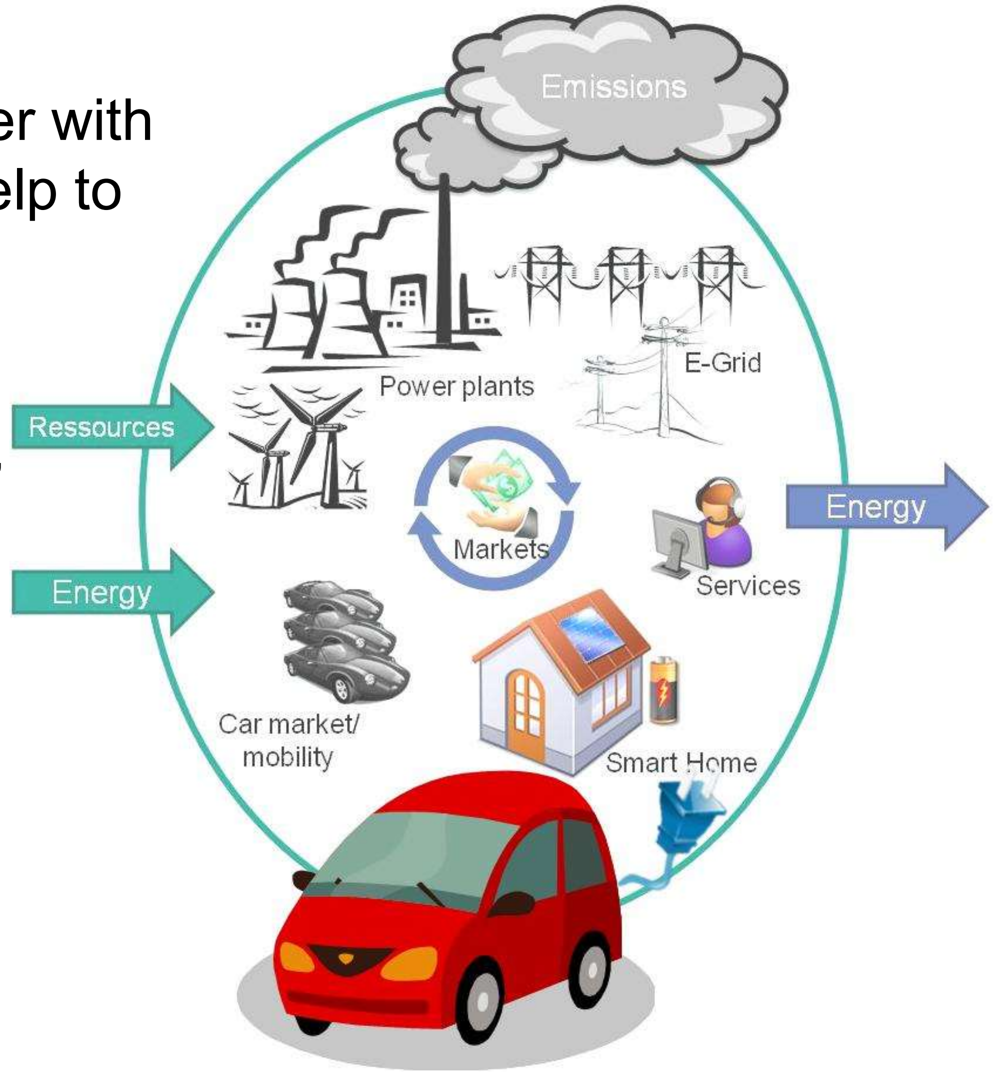


- Electricity demand turns to net electricity supply
- New market players balances decentral electricity exchange (→ new services in smart grids)

Kaschub, T.; Jochem, P.; Fichtner, W. (2016): Solar energy storage in German households: profitability, load changes, and flexibility, Energy Policy 98, 520-532, doi: 10.1016/j.enpol.2016.09.017.

Hypotheses

- **Controlled** (**V1G**!) charging together with (second use) stationary batteries help to accelerate the energy transition.
- **Politics** should …
  - force 100% V1G ready PEV
  - force utilities to generate "EV electricity" only from renewables.
- There is a high potential for **new market players** in the smart grid.
- Automated control (charging + autonomous cars) increases **user acceptance**.
- In **developing countries** these synergies are still limited.



Recent papers

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- Ensslen, A.; Schücking, M.; Jochem, P.; Steffens, H.; Fichtner, W.; Wollersheim, O.; Stella, K. (2017): Empirical Carbon Dioxide Emissions of Electric Vehicles in a French-German Commuter Fleet Test, Journal of Cleaner Production 142, 263-278, doi: 10.1016/j.jclepro.2016.06.087.
- Jochem, P.; Brendel, C.; Reuter, M.; Fichtner, W.; Nickel, S. (2016): Optimizing the allocation of fast charging infrastructure for electric vehicles along the German Autobahn, Journal of Business Economics 86(5), 513-535, doi: 10.1007/s11573-015-0781-5.
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- Ketelaer, T.; Kaschub, T.; Jochem, P.; Fichtner, W. (2014): The potential of carbon dioxide emission reductions in German commercial transport by electric vehicles, International Journal of Environmental Science and Technology 11(8), 2169-2184, doi: 10.1007/s13762-014-0631-y.
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