38th LCA Discussion Forum

Integrated Modelling and Analysis of Power and Transportation Systems

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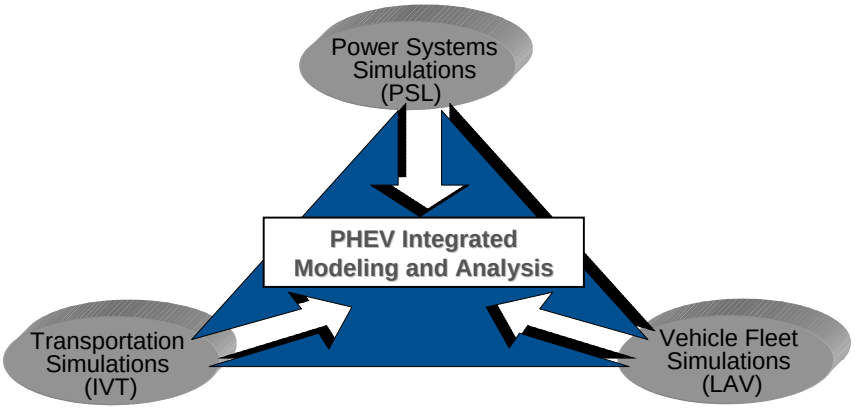
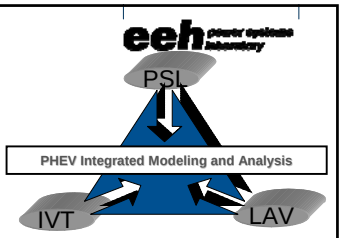
Agenda

- Project Structure
- Modelling of Future Power Systems
- Modelling PHEVs / EVs in Future Power Systems
- Outlook on Integration of Transport and Power Systems
- Impacts of Un- and Controlled Charging on Network and Generation
- Implications for LCA of PHEVs / EVs in the System

Project Structure

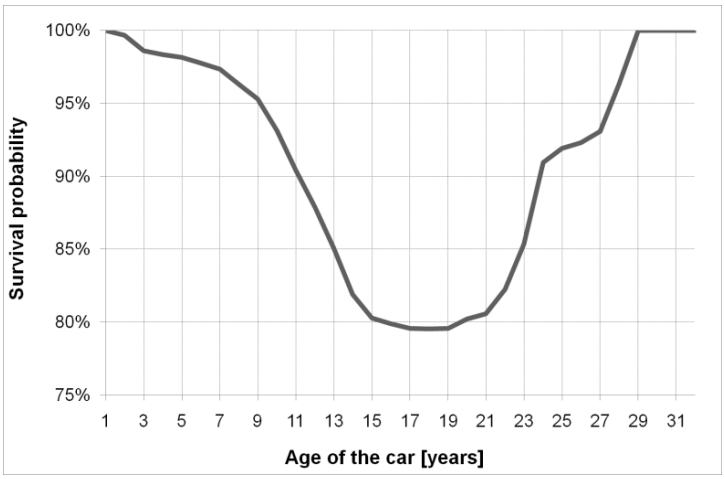


Project Structure



- PSL Expertise and Tasks:
  - Modelling of future power systems including distributed generation
  - Integrating interconnection of multi energy carriers
  - Analysis of technical impacts on network from PHEV integration
- IVT Expertise and Tasks:
  - Modelling and simulation of individual (future) mobility behavior
  - Modelling recharging behavior by individual mobility behavior
  - Considering grid inteactions by changing behavioral mobility plans
- LAV Expertise and Tasks:
  - Modelling the future vehicle fleet (Energy Navigator)
  - Information on primary energy use of fleet, CO_2 emissions and investments

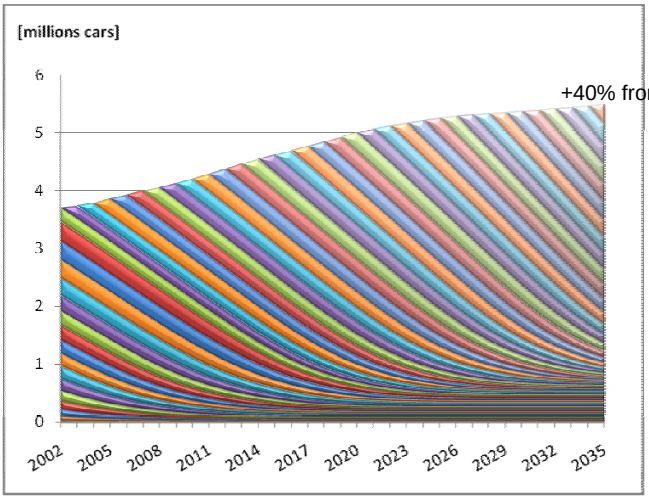
Survival probability of cars



Source: Energy Navigator, ETH-LAV, 2009

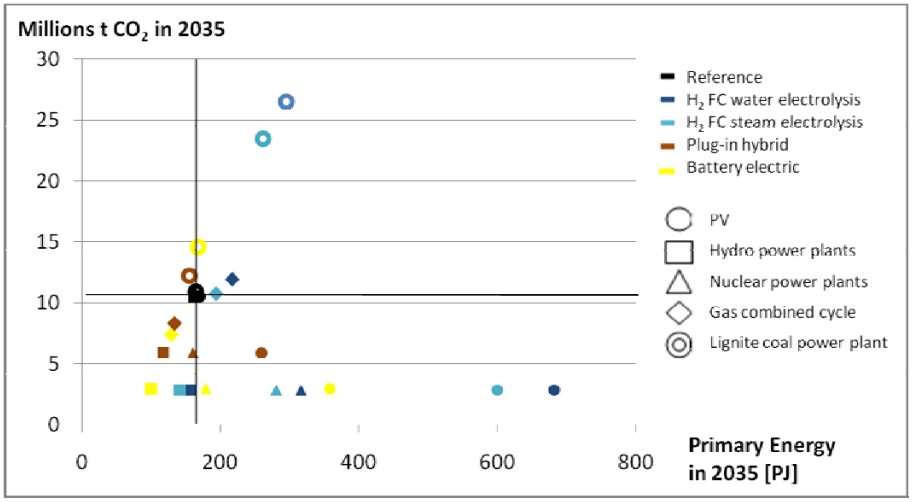
Cars – fleet dynamics

(each colour represents a matriculation year)



Source: Energy Navigator, ETH-LAV, 2008

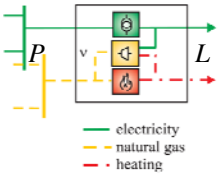
Primary energy demand and CO_2 emissions for different combinations of powertrain and power generation (cars, CH)



Source: Energy Navigator, ETH-LAV, 2008

Modelling of Future Power Systems

Future power systems will face more integration of various energy carriers



$$\begin{bmatrix} L_\alpha \\ L_\beta \\ \vdots \\ L_\omega \end{bmatrix} = \begin{bmatrix} c_{\alpha\alpha} & c_{\beta\alpha} & \cdots & c_{\omega\alpha} \\ c_{\alpha\beta} & c_{\beta\beta} & \cdots & c_{\omega\beta} \\ \vdots & \vdots & \ddots & \vdots \\ c_{\alpha\omega} & c_{\beta\omega} & \cdots & c_{\omega\omega} \end{bmatrix} \begin{bmatrix} P_\alpha \\ P_\beta \\ \vdots \\ P_\omega \end{bmatrix}$$

$\mathbf{L}$ $\mathbf{C}$ $\mathbf{P}$

$$\text{Min} \quad f(\mathbf{P})$$

$$\text{s.t.} \quad \mathbf{L} - \mathbf{C}\mathbf{P} = \mathbf{0}$$

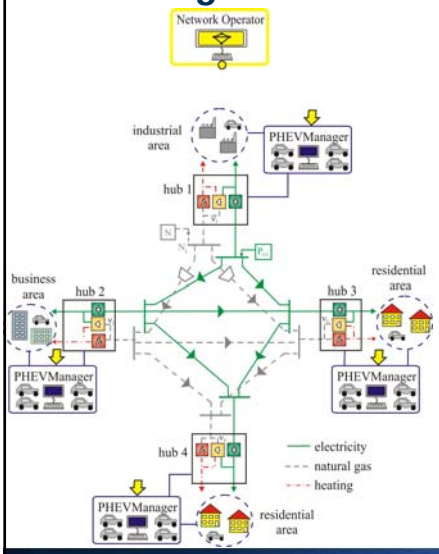
$$\mathbf{P} \le \mathbf{P} \le \overline{\mathbf{P}}$$

$$\underline{\mathbf{P}}_c < \mathbf{N}\mathbf{P} < \overline{\mathbf{P}}_c$$

$$\mathbf{0} \le \mathbf{N} \le \mathbf{1}$$

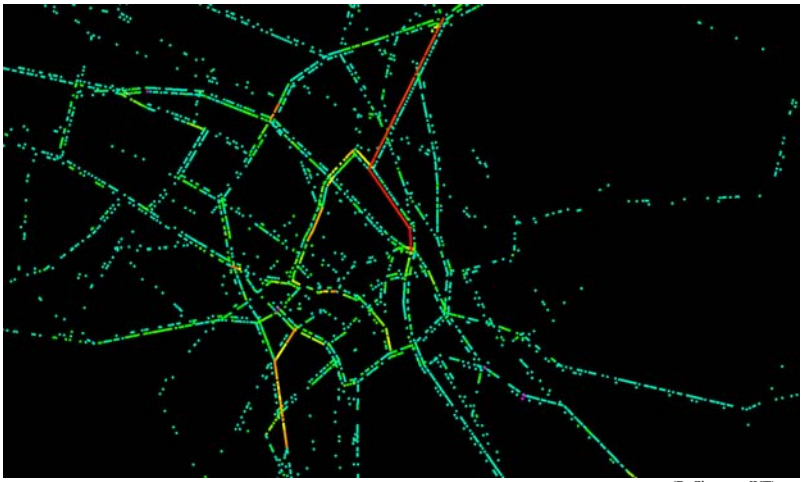
- Entities with inputs (P), output (L), converters (C)
- Converters defined by efficiencies
- Hubs can be optimized by minimizing energy costs using different converters
- Optimization takes technical bounds of converters into account
- Hubs depict possible future energy systems with interconnected multiple energy carriers
- Increased share of distributed generation

Modelling PHEVs / EVs in Future Power Systems



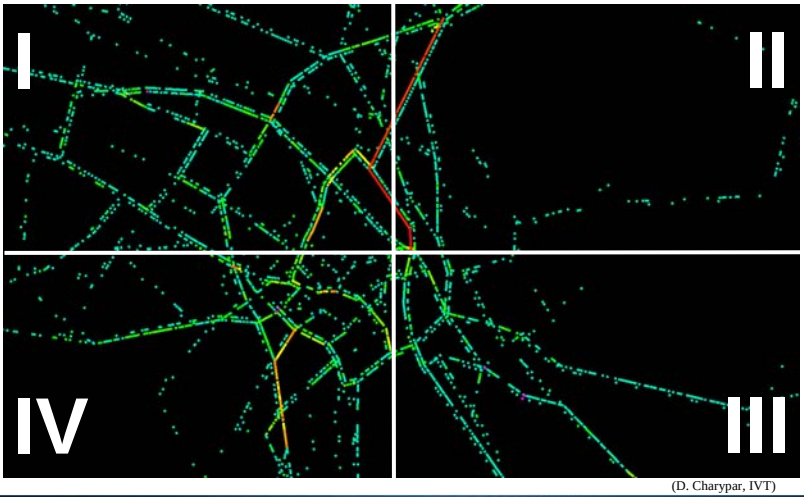
- Hub system can model a city (different areas)
- Connection of areas via electricity, gas lines
- Load curves used for areas (residential, etc.)
- PHEV Manager knows battery state of charge (SOC) and energy valuation
- PHEV Manager aggregates total load from cars (large number of PHEVs)
- PHEV Manager imposes PHEV load on system
- Dispatch results in nodal price signals at hubs
- „Nodal prices“ can be used as an incentive signal to PHEV to charge/not to charge

Outlook on Integration of Transport- and Power Systems



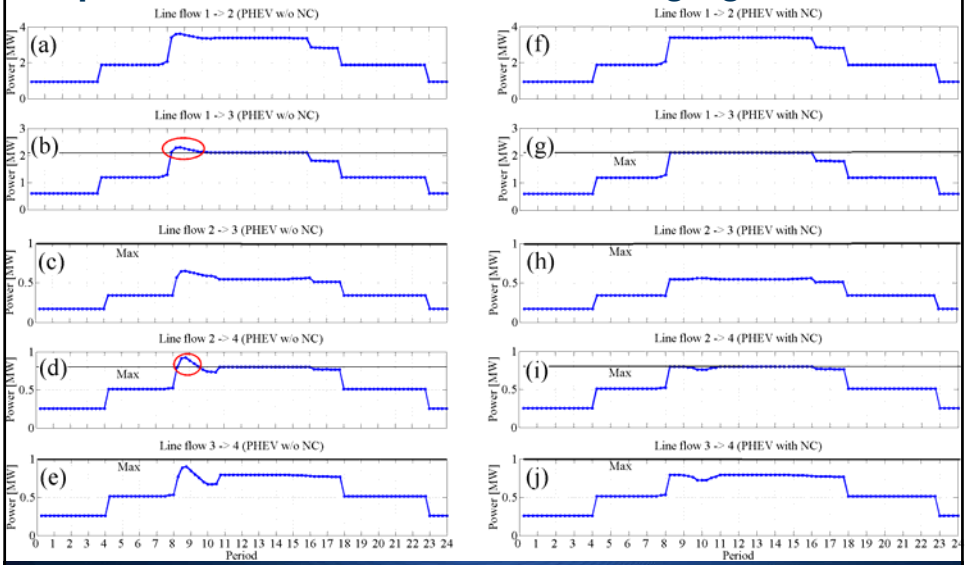
(D. Charypar, IVT)

Outlook on Integration of Transport- and Power Systems

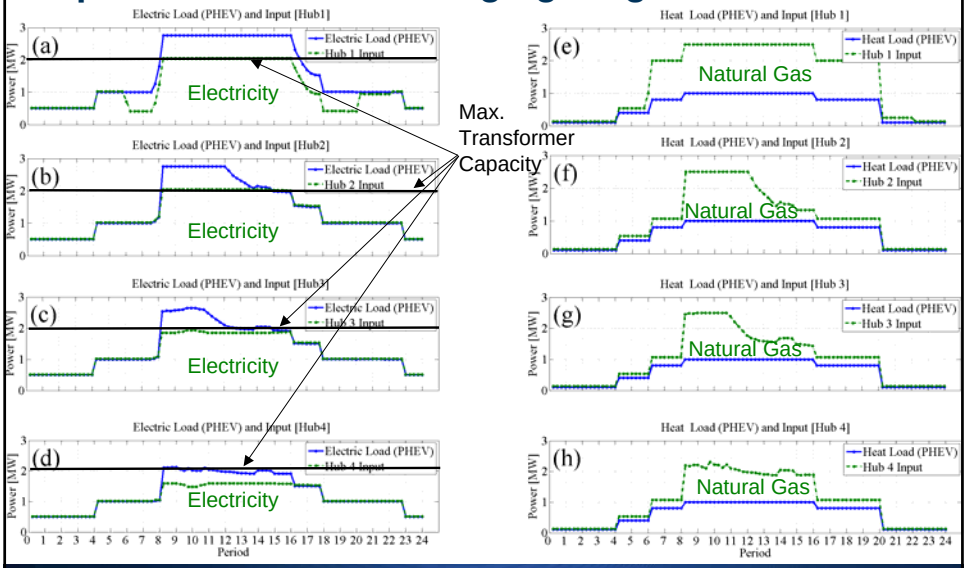


(D. Charypar, IVT)

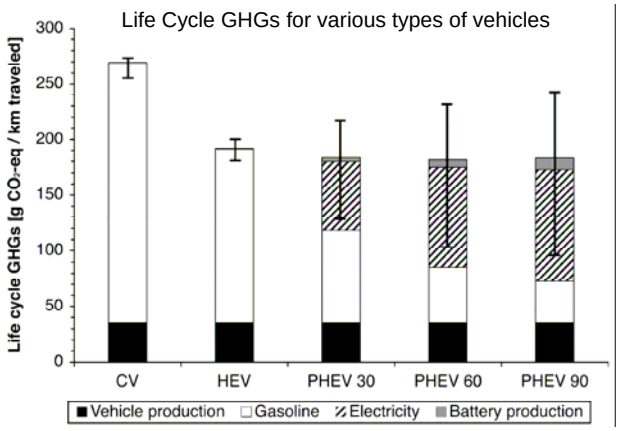
Impacts of Un- and Controlled Charging



Impact of controlled charging on generation



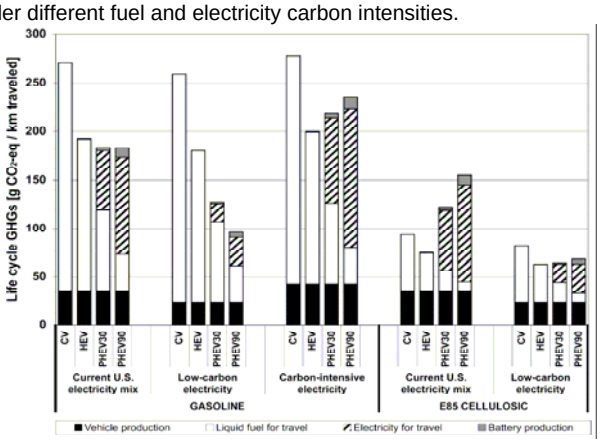
Implications for LCA of PHEVs / EVs in the System



C.Samaras, K. Meisterling: Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy; *Environ. Sci. Technol. 42, pp.* 3170–3176, 2008

Implications for LCA of PHEVs / EVs in the System

Life cycle GHG emissions sensitivity of CVs, HEVs, and PHEVs with 30 and 90 all-electric km ranges under different fuel and electricity carbon intensities.



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Implications for LCA of PHEVs / EVs in the System

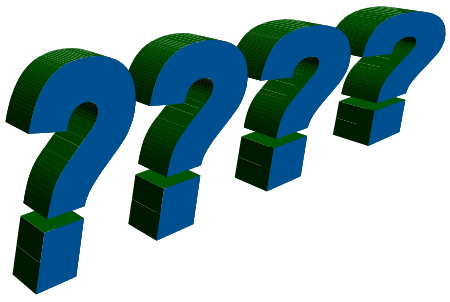
Table 1: Transformer LOL and expected life results

	LOL (normalized)	Expected Life (years)
Without PHEVs, 20 ^{0}C	$7.7588 \cdot 10^{-6}$	353.11
With PHEVs, 20 ^{0}C	$10.6 \cdot 10^{-5}$	25.85
Without PHEVs, 30 ^{0}C	$2.2 \cdot 10^{-5}$	124.3
With PHEVs, 30 ^{0}C	$2.67 \cdot 10^{-4}$	10.25

C.Roe, et al.: Power System Level Impacts of PHEVs, IEEE Proceedings of the 42nd Hawaii International Conference on System Sciences - 2009

Questions to be tackled, may be by LCA…

- Do frequent asset replacements (Transformers) affect efficiency of this technology?
- Does the upgrade of transmission and distribution lines, etc affect the PHEV / EV sustainability?
- Are PHEVs / EVs more sustainable in their production and in their recycling compared to CVs?
- Does distributed generation and interconnection of multi energy carriers affect PHEV LC?
- Can smart grid associated with PHEVs be integrated in LCA?
- Is the roll out of the smart grid expedient considering increased energy consumption in information management, storage, meters, etc. ?



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