sccer mobility

Swiss Competence Center for Energy Research
Efficient Technologies and Systems for Mobility

In Zusammenarbeit mit der KTI

Energie
Swiss Competence Centers for Energy Research

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Kommission für Technologie und Innovation KTI

Capacity Area B2: Integrated Assessment

Stefan Hirschberg et al.
Paul Scherrer Institut

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Goals and overview

Research teams, their competences and responsibilities

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Integrated Assessment of Mobility Systems (CA B2)

- **Goals**:
  1. **Inter-disciplinary assessment** of transportation sector, including advanced technologies for all passenger and freight modes; covering environmental, economic and social effects.
  2. **A long-term perspective** to develop a roadmap for future Swiss mobility with reduced emissions and energy demand, and to gain policy insights.
  3. **Increasing stakeholder** awareness of issues including infrastructure development, resource allocation, risks and energy security.

- **Academic Partners**:

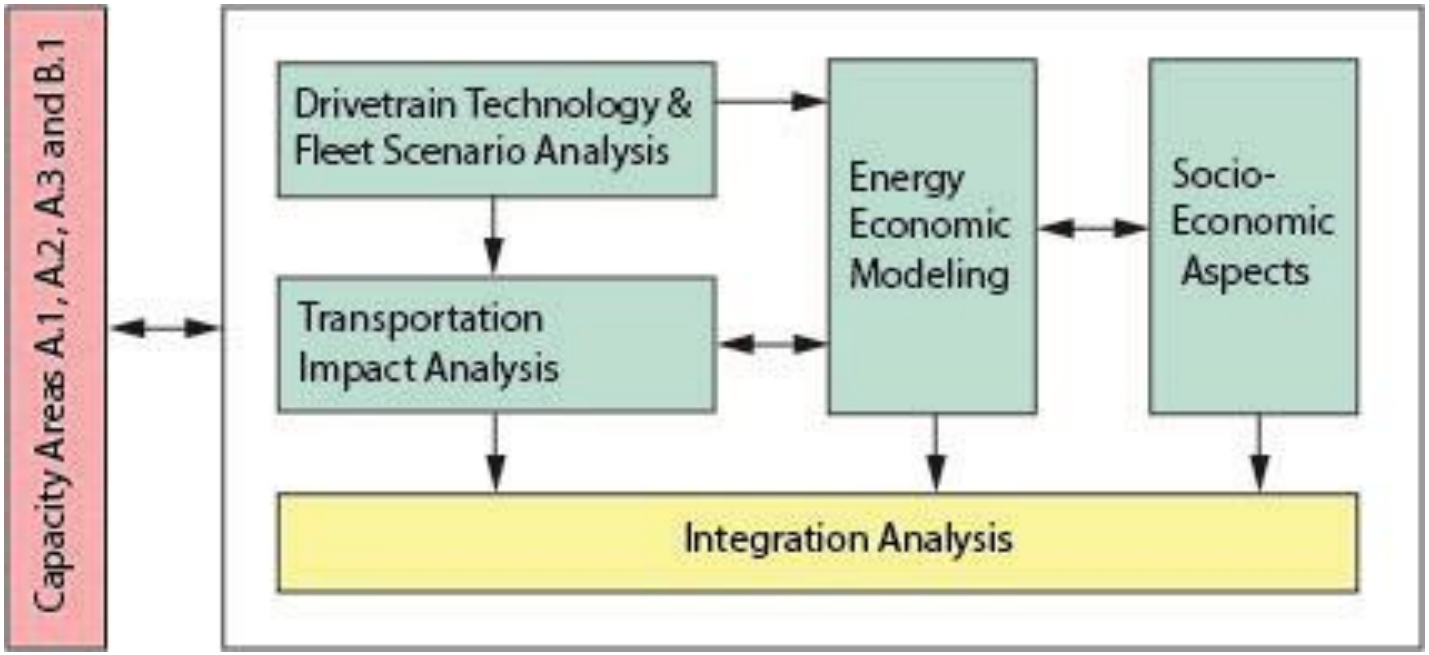
ETHZ-LAV LAV Laboratorium für Aerothermochemie und Verbrennungssysteme Aerothermochemistry and Combustion Systems Laboratory

SUPSI University of Applied Sciences and Arts of Southern Switzerland SUPSI

PSI-LEA PAUL SCHERRER INSTITUT PSI

ZHAW Zurich University of Applied Sciences zhaw School of Engineering INE Institute of Sustainable Development

Integrated Assessment of Mobility Systems (CA B2)



Methods and Tools:

Vehicle Simulation, Life Cycle Assessment, Impact Pathway Approach, Comparative Risk Assessment, Learning Curves, Partial Equilibrium Modeling, Cost-Benefit Analysis, Multi-Criteria Decision Analysis, Living Labs.

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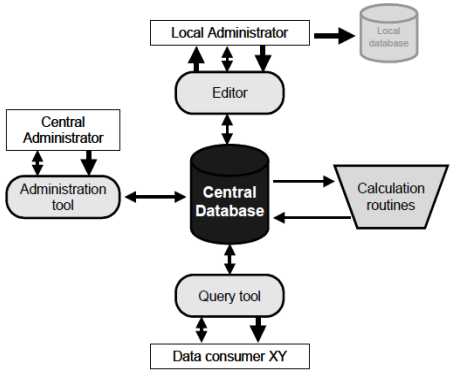
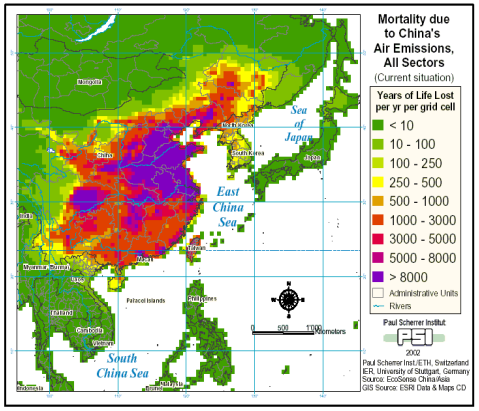
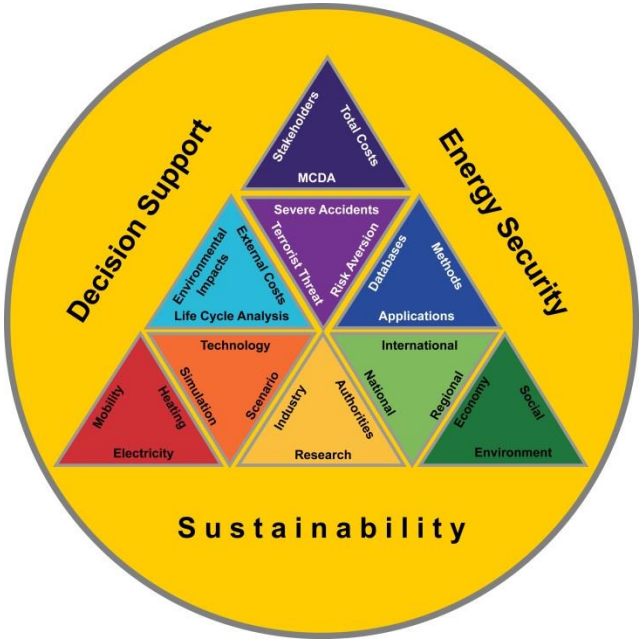
Methods, Models, Databases

ecoinvent (LCA) database

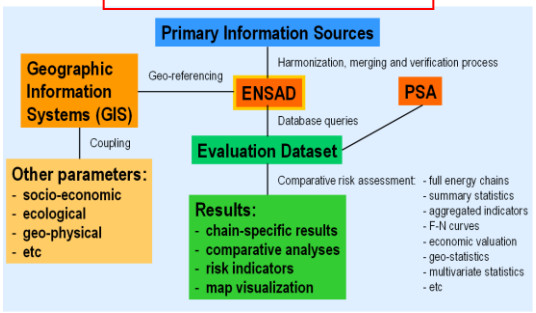


impact pathway approach

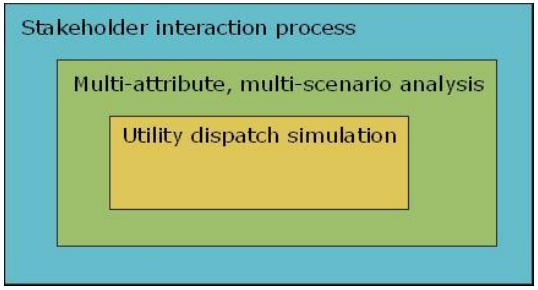




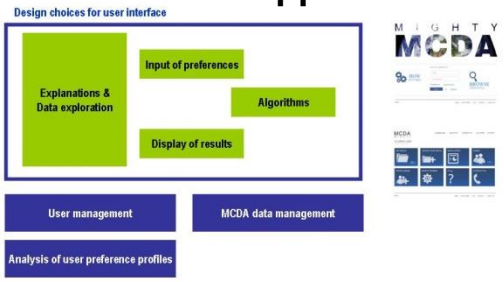
risk assessment



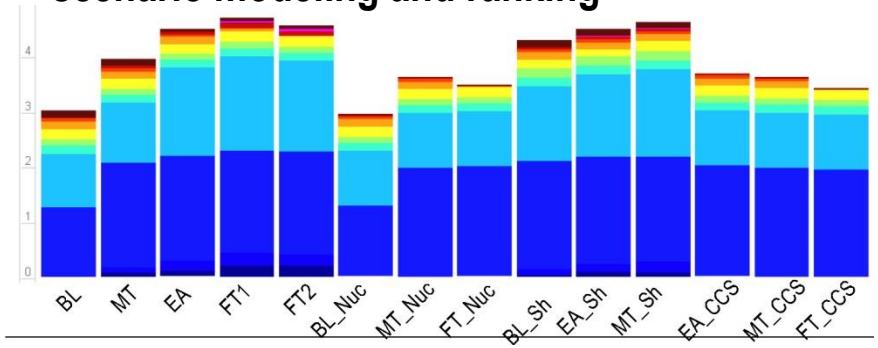
electric sector simulation



flexible decision-support tools



scenario modeling and ranking



Technology Assessment & Energy Economics

Life Cycle Assessment (LCA): Evaluation of environmental burdens (including energy supply chain)

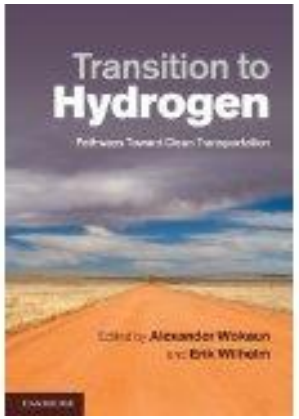
Economic Assessment: Internal & external costs

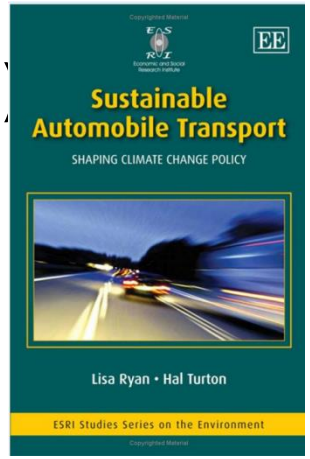
Risk Assessment: Accidents in transport system and associated energy chains

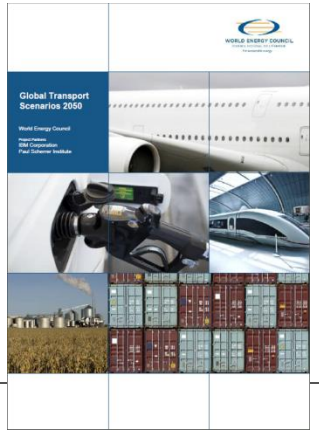
Energy-economic modeling (based on least-cost optimisation)

- Analysis of mobility scenarios with energy sector interactions

Integration



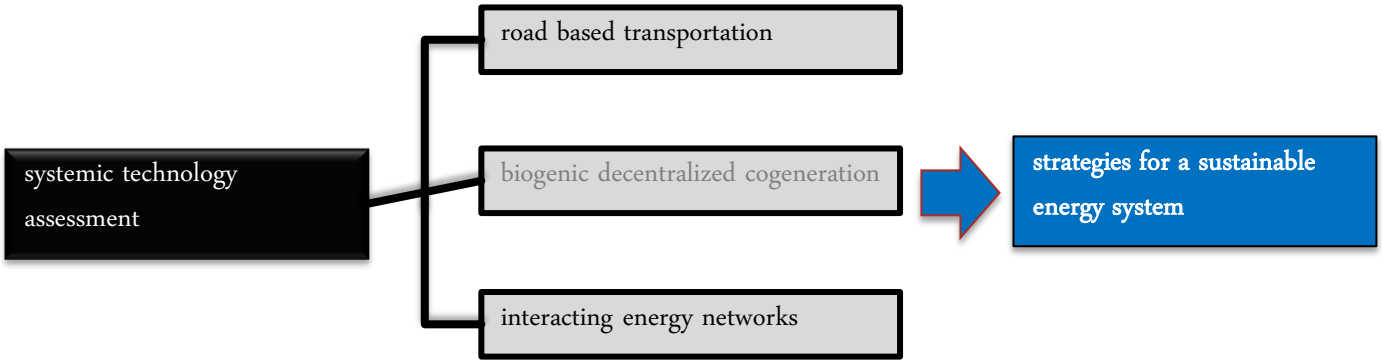




LAV's energy systems group

LAV: Aerothermochemistry and Combustion Systems Laboratory

- Research activities:
  1. Fundamentals of chemically reactive systems
  2. Combustion based energy conversion technology → low-carbon, near-zero pollutant emission
  3. **Energy systems research → interacting energy networks and conversion devices**
- Activities in energy systems research



- Researchers involved in CA-B2

Prof. Konstantinos **Boulouchos**
Head of LAV & SCCER mobility

Gil **Georges**
Head of Energy Systems Group

Fabrizio **Noembrini**
Senior Researcher

Activities within B2

- Competences
  - Internal combustion engine technology
  - Vehicle and powertrain modeling and simulation
  - Modeling non-propulsive loads and usage patterns
- Focus: energy demand of heavy-duty transportation

  (no specific milestones in 2014)

- ZHAW - Institute of Sustainable Development
  - Multidisciplinary research
  - Research on transport and energy systems; risk management & technology assessment
  - European and Swiss research projects, SCCER 5 and SCCER 6
  - System analysis and future oriented research on transport and mobility :
    - Future trends in transport and system transformation
    - Socio-economic development and mobility behaviour
    - New technologies and transport concepts
    - Innovation and decision making
- Persons involved in SCCER 6
  - Merja Hoppe: PhD in Economic Geography
  - Alberto Castro: PhD in Civil Engineering

Approach

- Trends in mobility and frame conditions for transport reveal future challenges if no intervention is undertaken
- A transformation of the mobility system is needed to adapt to the change and to reach the goal of energy transition
- Results will guide decision makers to deal with the change, support and shape the transformation process

SUPSI-ISAAC research group in SCCER Mobility

- Roman Rudel, Head of institute

- Francesca Cellina, Senior researcher

- Research assistant, under selection

Main competences

- Participatory decision-making and decision support systems (DSS) for natural resource management
- Transitions studies and diffusion of innovation
- Applications in energy, land, transportation decision-making processes and in water and forest resource management

Capacity Area B2:
Integrated Assessment of Mobility Systems

Topic B2.4: Socio-Economic Aspects

- **Objectives:**
  - Transition analysis of the mobility system in an integrative way, adopting a bottom-up approach (stakeholder analysis and "living lab" experiments)
  - Identification of recommendations to favour and support system transitions
- **Tasks:**
  - Analysis of options and barriers to the transformation of the mobility system.
  - Focus on:
    - potential of new technologies
    - trends in factors affecting energy demand (socio-economic and cultural aspects, land-use, infrastructures and accessibility)
    - behaviour change and demand side management strategies
- Collaboration with SCCER "FURIES" (Future Swiss electrical infrastructure)






How to achieve major changes in mobility behaviour?

It is not only a matter of technology:
transition and changes are hindered by psychological and behavioural barriers

LIVING LAB

A socio-technical and actor-centered approach:
real-life users
explore, experience and evaluate innovation in complex, real-world settings

An open learning process and a co-evolutionary perspective between innovation and its users

A deeper and more effective understanding of the phaenomena

A powerful decision-support system for the definition of new policies and regulations



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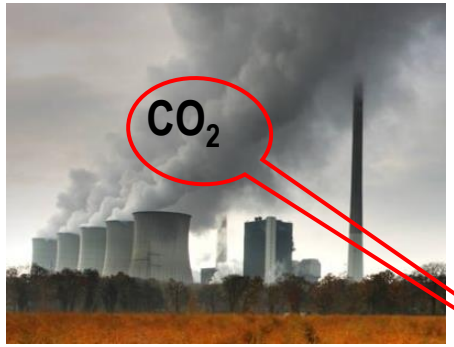
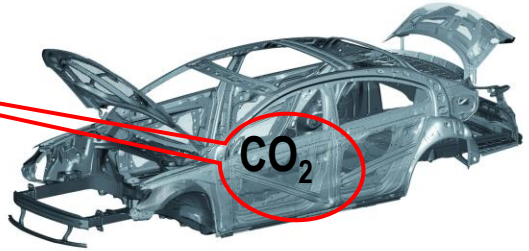
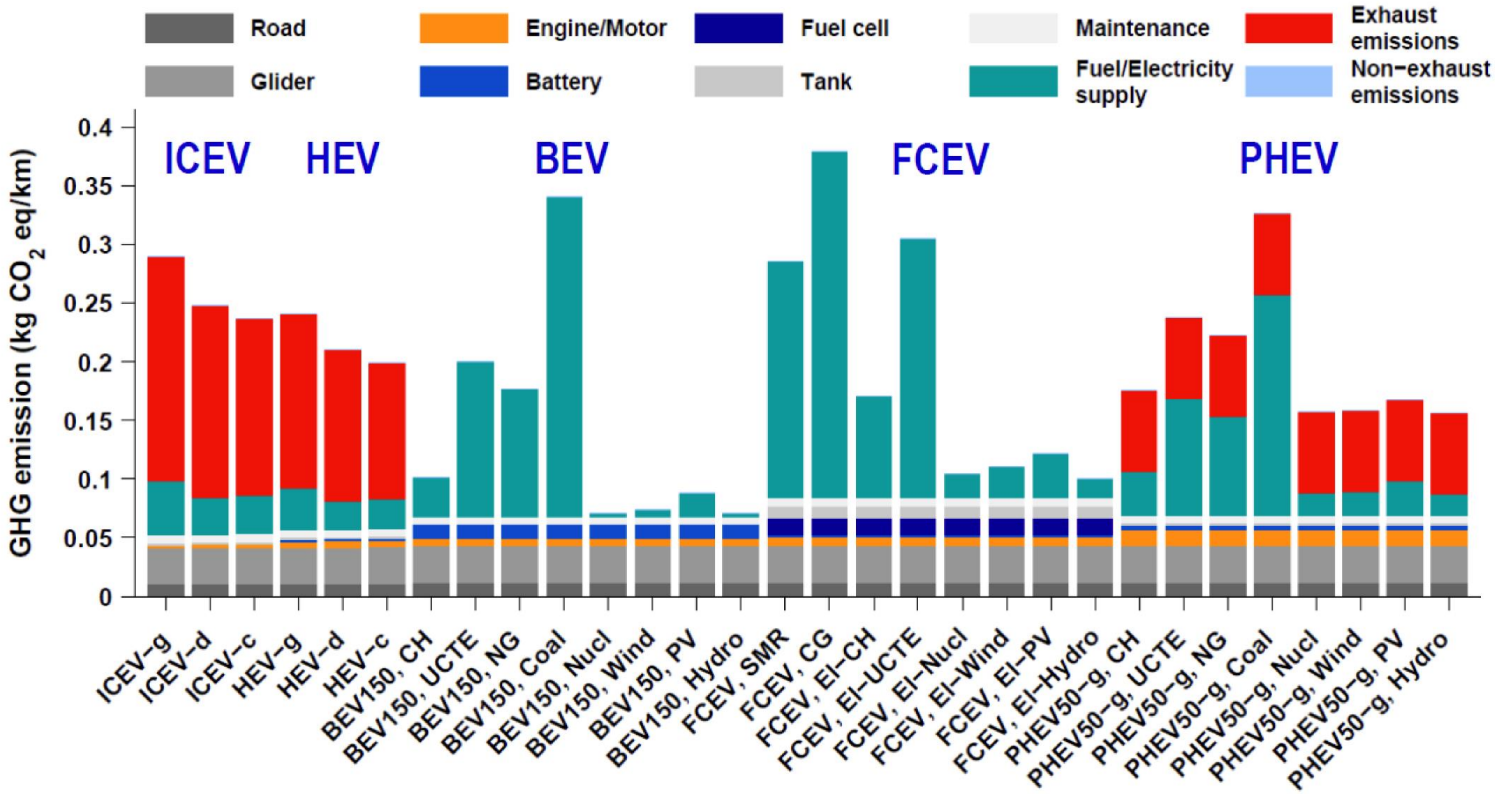




Well-to-Wheel GHG Emissions: Midsize car, 2012



Drivetrains

ICEV-g: Internal Combustion Engine Vehicle (gasoline)
HEV-g: Hybrid Electric Vehicle (gasoline)
BEVx: Battery Electric Vehicle, x km range
PHEVx-g: Plug-in Hybrid Electric Vehicle (gasoline) , x km range
FCEV: Fuel Cell Electric Vehicle

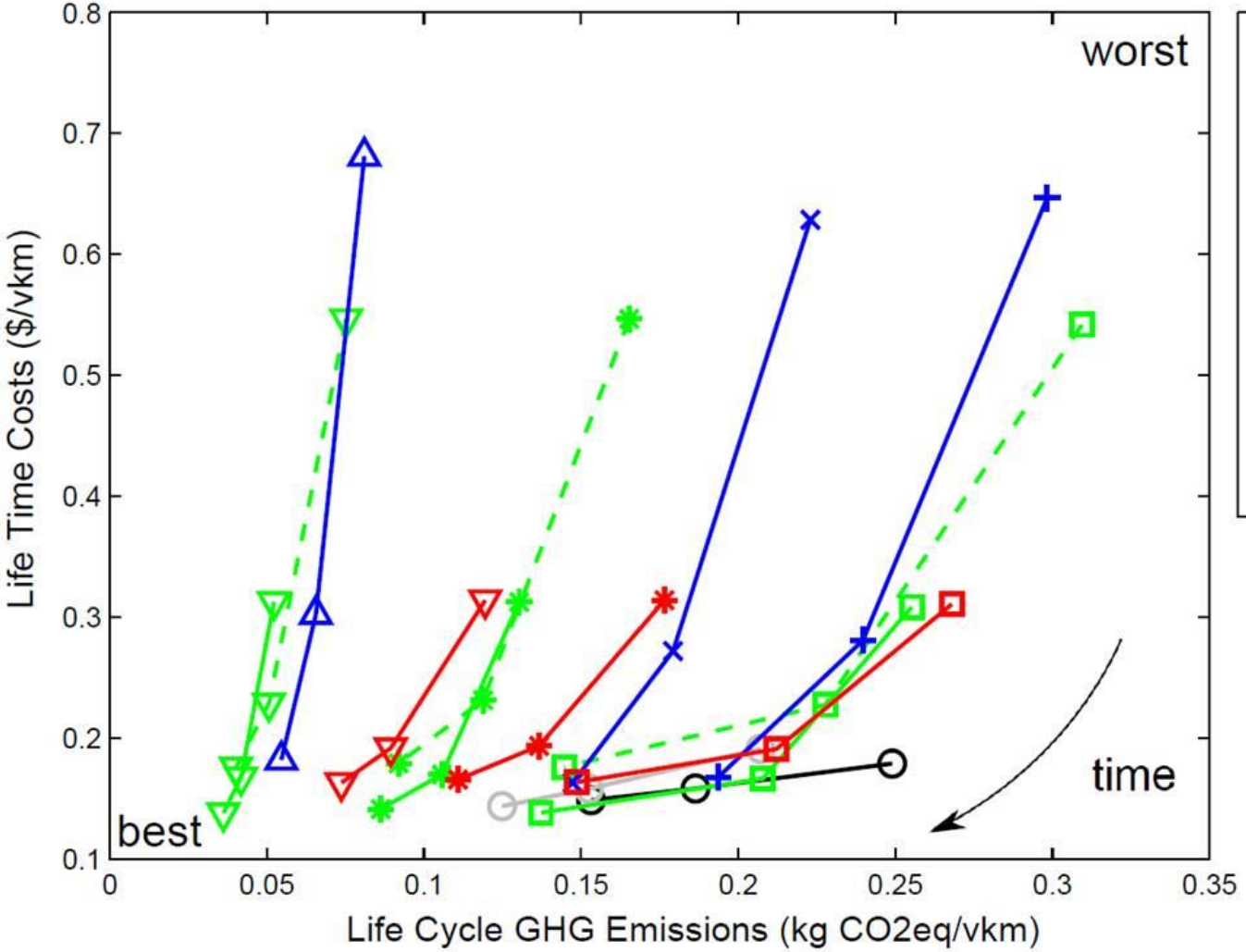
Electricity Production

CH: Swiss electricity mix
UCTE: European electricity mix
NG: Natural gas power plant
Coal: Coal power plant
Nucl: Nuclear energy
PV: Photovoltaics
Hydro: Hydro power

Hydrogen Production

SMR: Steam methane reforming
CG: Coal gasification
El-CH: Electrolysis (Swiss mix)
El-UCTE: Electrolysis (European mix)
El-Nucl: Electrolysis (Nuclear power)
El-Wind: Electrolysis (Wind power)
El-PV: Electrolysis (PV power)
El-Hydro: Electrolysis (Hydro power)

Prospective Technology Advancements



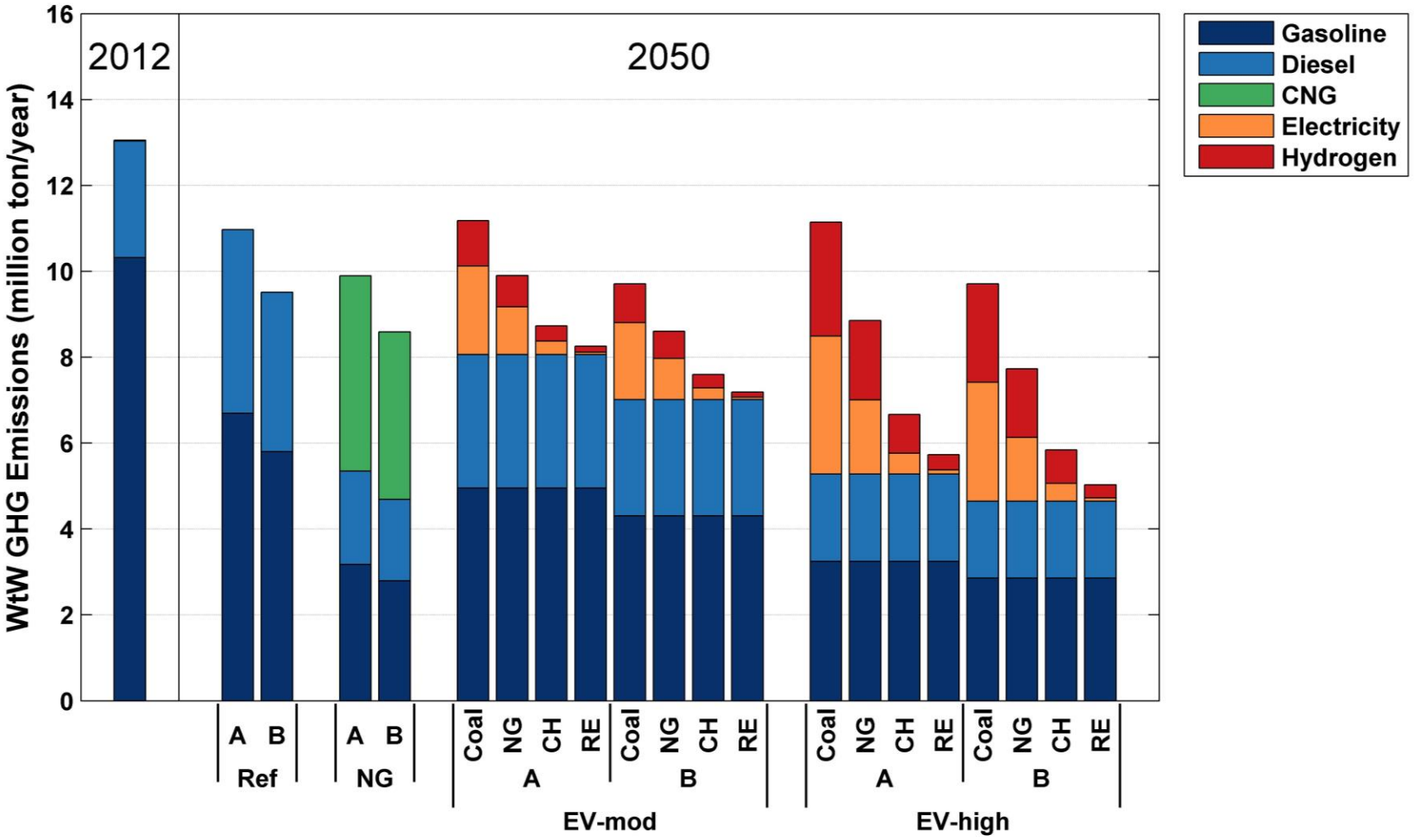
- ICEV-g
- HEV-g
- BEV-150, NGCC
- BEV-400, NGCC
- BEV-150, Coal
- BEV-400, Coal
- BEV-150, Wind
- BEV-400, Wind
- FCEV, SMR
- FCEV, CG
- FCEV, EI-Wind
- PHEV-g, NGCC
- PHEV-g, Coal
- PHEV-g, Wind

Acronyms

ICEV-g: Internal Combustion Engine Vehicle, gasoline fueled
HEV-g: Hybrid Electric Vehicle, gasoline fueled
BEV-150/400: Battery Electric Vehicle with 150/400km range
FCEV: Fuel Cell Electric Vehicle
PHEV-g: Plug-in Hybrid Electric Vehicle, gasoline fueled
NGCC: Electricity from Natural Gas Combined Cycle power plant

Well-to-Wheel GHG Emissions: Scenario Comparison

Fleet Travel Distance 2030/50: 64.5/67.5bn vkm (Baseline scenario)



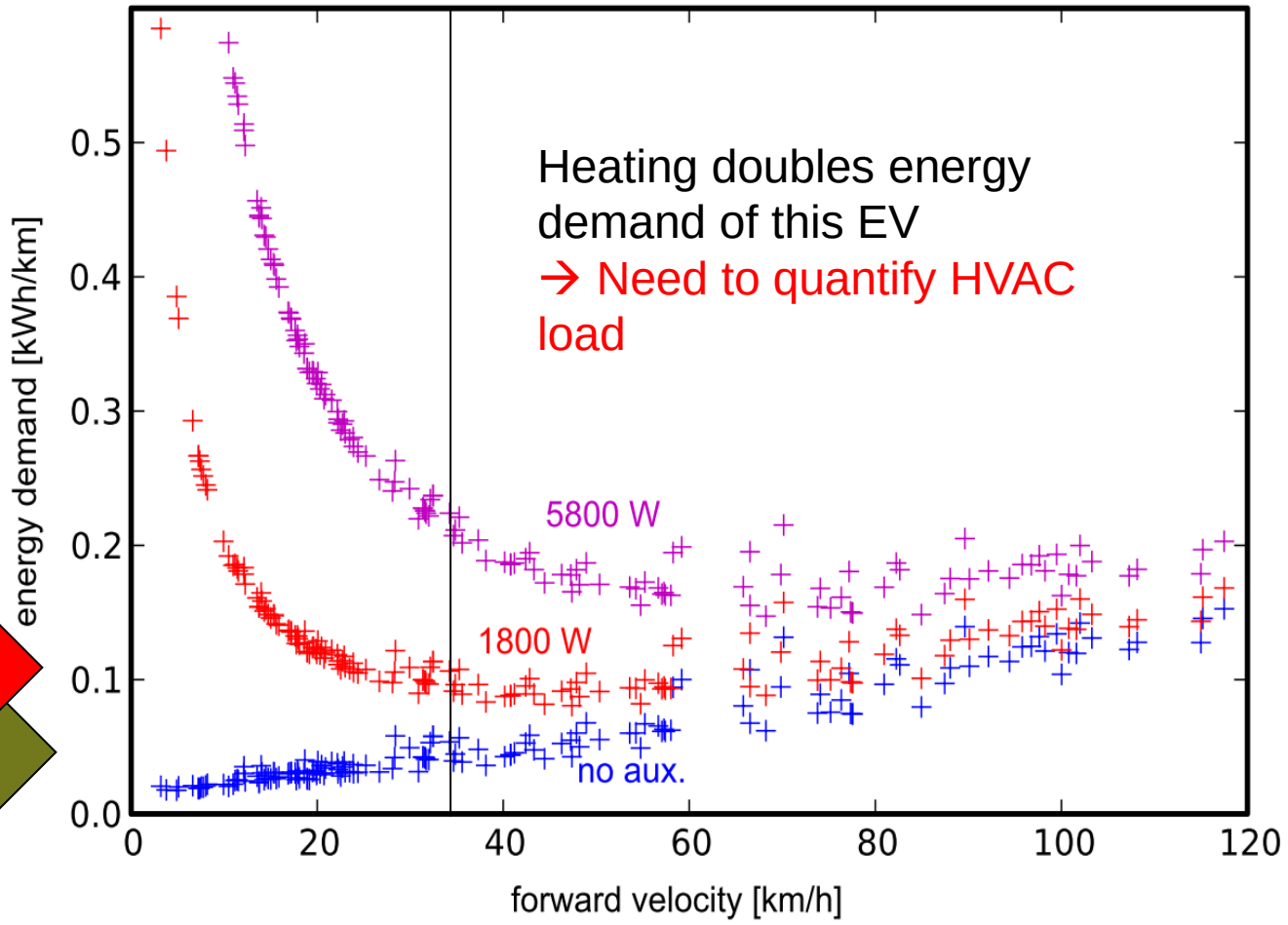
Results: energy demand of EVs

Assuming a small to mid-size passenger car, a 80 kW electric machine (modeled using ADVISOR) and the Tremblay battery model

Prop. + 1.8 kW + 4 kW heating

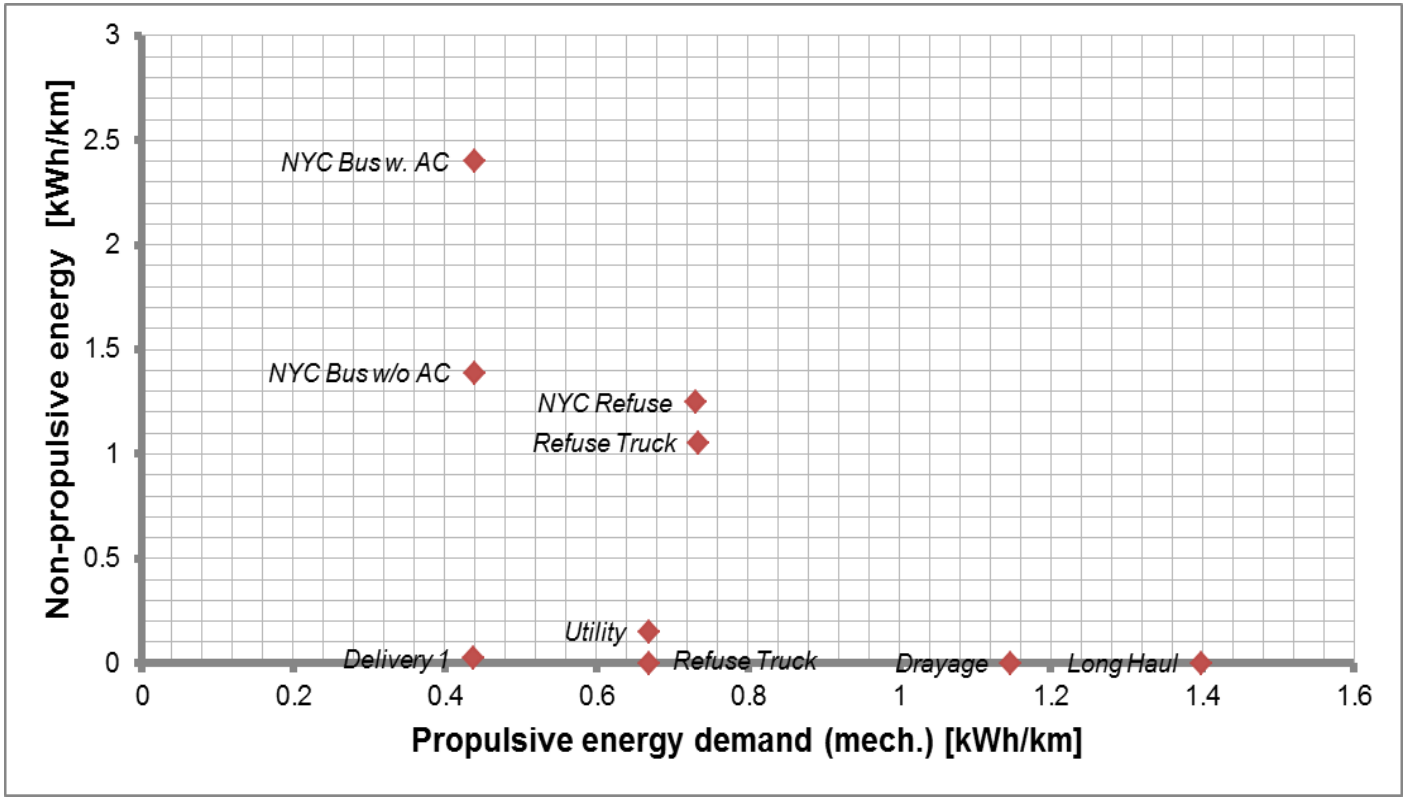
Prop. + 1.8 kW

Propulsive load



Source: Investigation of the propulsive and non-propulsive loads in passenger cars with emphasis on electric mobility, G. Georges, ETH-Diss Nr. 22057

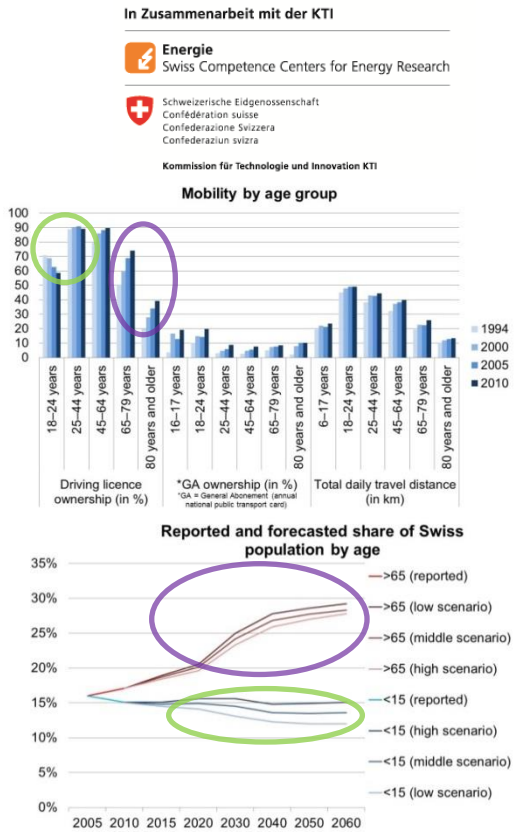
Preliminary results w.r.t. heavy duty vehicles

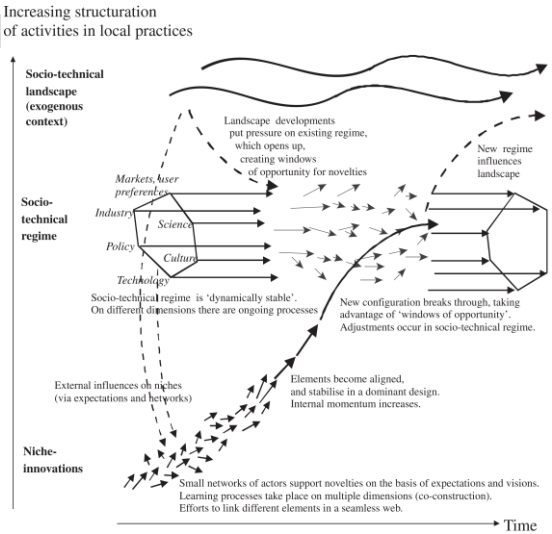


- Freight transport → little to no non-propulsive load
- Passenger transportation → possibly very high AC / heating load
- Special vehicles → variable behavior (compactor in waste disposal truck)

Provisional results

- Trend:
  - Change of mobility (behaviour) with peak car of youth and more mobility of aged groups
- Complementary fields are analysed to support the transformation of Swiss mobility at different levels:
  - Macro-level: a Model of Multiple-Level Perspective is used to analyse the Swiss mobility context and develop solutions for transformation on the system level
  - Meso-level: Socio-economic development will be addressed to disseminate transformation strategies
  - Micro-level: Psychology research can reveal how individuals behaviour and authorities decisions could support the transformation process

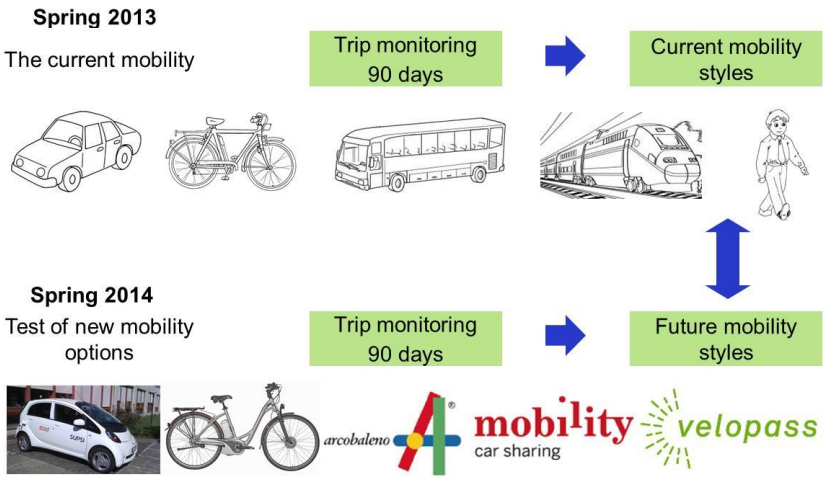




Ongoing activities: the *e-mobiliTI* living lab

- Is it true that main barriers to the use of electric vehicles are psychological and can be removed by experience?
- Does the availability of an electric vehicle imply pure substitution between conventional and electric vehicles?
- And does it act as a leverage for a wider transformation of the mobility styles?

- The living lab is run in the Lugano area
- Sixteen families (thirty persons) are involved
- Their trips are monitored via a smartphone application, developed on purpose
- They test, for three months, electric cars and bikes, season tickets for public transport, Publibike and Mobility tickets
- Analyses are based on automatic quantitative data and on focus groups and interviews



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Regionalized LCA

- Process locations can be point, linear, or areal

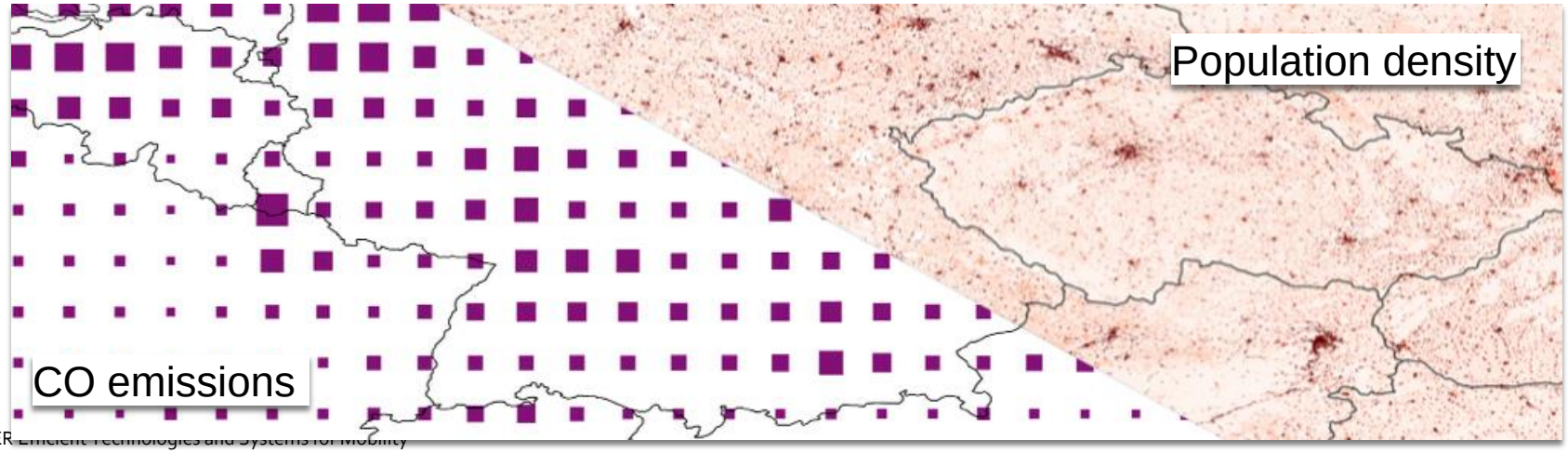
Point sources | Transport routes | Background processes

- Comprehensive methodology for entire supply chain

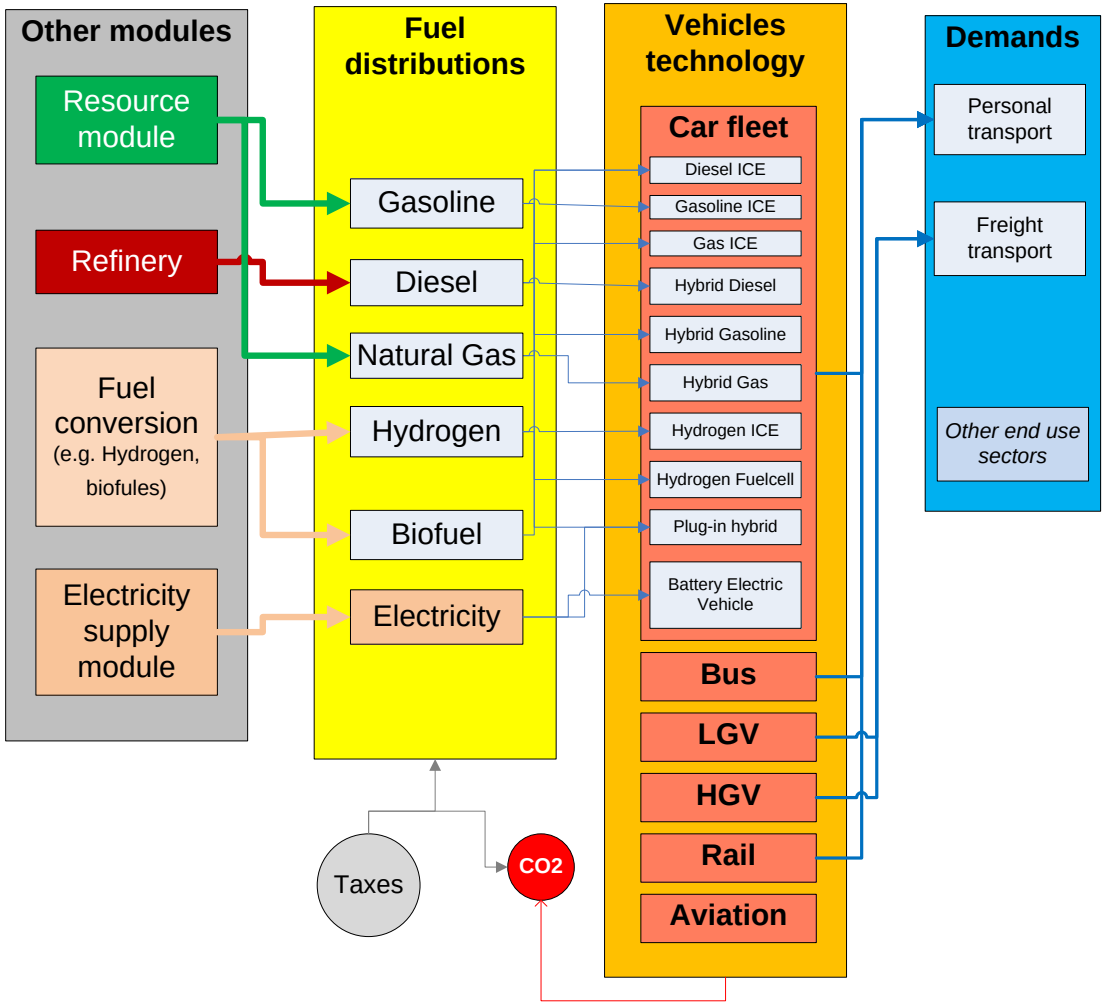
$$h = [BA^{-1}f] \circ [MN_{GL}GLR]^T$$

Inventory | Impact Assessment

- Can combine with site-specific analysis
- Estimate emissions intensities with proxy data



Energy-economic Modeling: Transport Module



Outlook

- Heavy-duty road transportation vehicles
  - Characterization → energy demand & usage patterns
    - Freight transport: *long-haul & short-haul trucks*
    - Passenger transport: *small and large urban busses, motor-coaches*
    - Specialized vehicles: *waste collection vehicles, cooling trucks, cleaning vehicles, …*
  - Propulsion technology assessment
    - Potentials for drivetrain hybridization and electrification
    - Reducing auxiliary loads through electrification
    - Options for including infrastructure (e.g. electrified bus line)

Perspectives

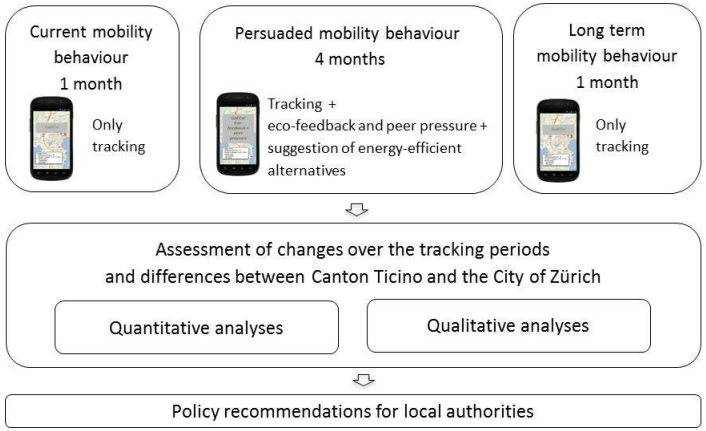
- Analysis of mobility under system perspective including economy, socio-economy and land use with their interlinks
- Interpretation of trends taking into account influencing factors and foresight of future impact
- Theories from different field of study (psychology, social research…) will be applied on transport at different levels to support the transformation of the system – including mobility behavior and decision making in policy and planning
- Conclusions will be translated in recommendations for energy transition in Switzerland

Future activities: the *GoEco!* living lab *(with ETHZ, CA B.1)*

Can eco-feedback information and social interaction (social comparison and peer pressure) be effective triggers to:

- foster changes in personal mobility behaviour?
- facilitate the long-term challenge to reduce private motorized transport?
- promote a transition to more energy efficient mobility options, such as vehicle-sharing, intermodal use of means of transport, public transportation and slow mobility?

- The living lab is run in Zürich and in Lugano
- Eight hundred persons are involved
- Their trips are monitored via a smartphone application, developed on purpose, which:
  - tracks their trips
  - suggests alternative, low-impact modal options
  - provides them with feedback on mobility behaviour
  - creates a virtual community, setting up a *gamification* rewarding scheme
- Analyses are based on automatic quantitative data and on focus groups and interviews



B2 Posters

Gil Georges (ETHZ-LAV)
Systemic Technology Assessment in Electric Mobility

Brian Cox et al. (PSI-LAV)
Environmental and Cost Comparison of Personal Transportation Powertrains

Merja Hoppe and Alberto Castro (ZHAW)
Transformation of Mobility – Context Perspective

Roman Rudel and Francesca Cellina
e-mobiliTi – A living Lab to Investigate the Transition towards Electric Mobility

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Thank you for your attention!