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Plug-in Hybrid Electric Vehicles and Smart Grid: Investigations Based on a Micro-Simulation

Rashid Waraich

IVT
ETH
Zurich

December 2009

 Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

ETH

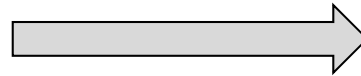
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Future Vehicles?

Hybrid Vehicles



Toyota Prius



Bigger batteries and
el. plug added

Plug-in-Hybrid Electric Vehicles (PHEV)



Chevrolet Volt



Opel Ampera

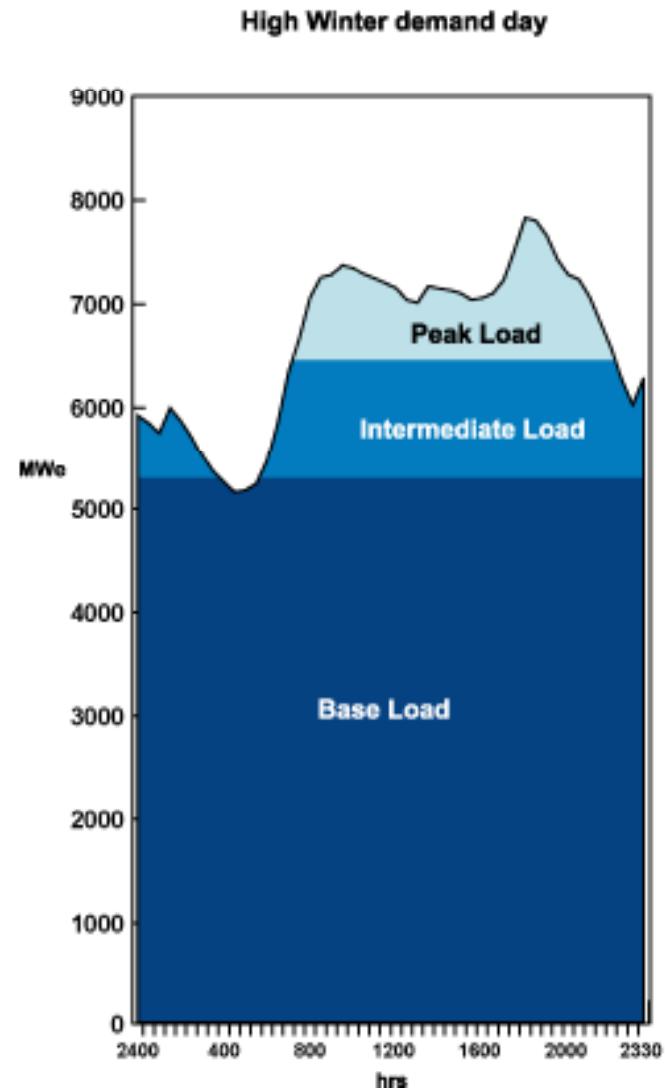
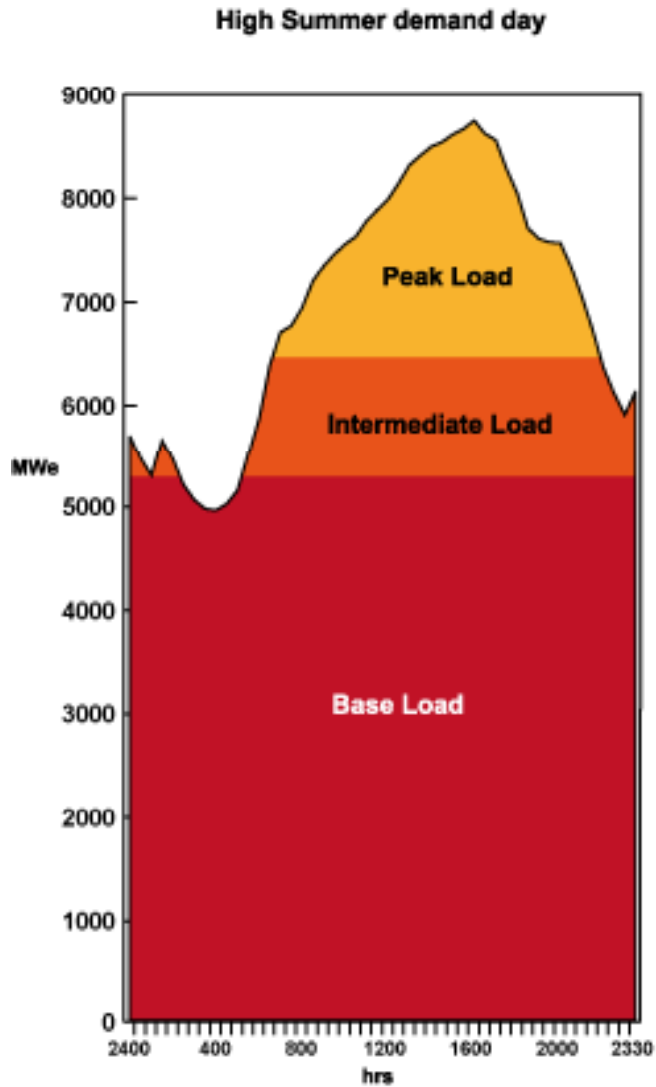
[all figures from wikipedia.org]

PHEVs – More Environment-Friendly?



[all figures from wikipedia.org]

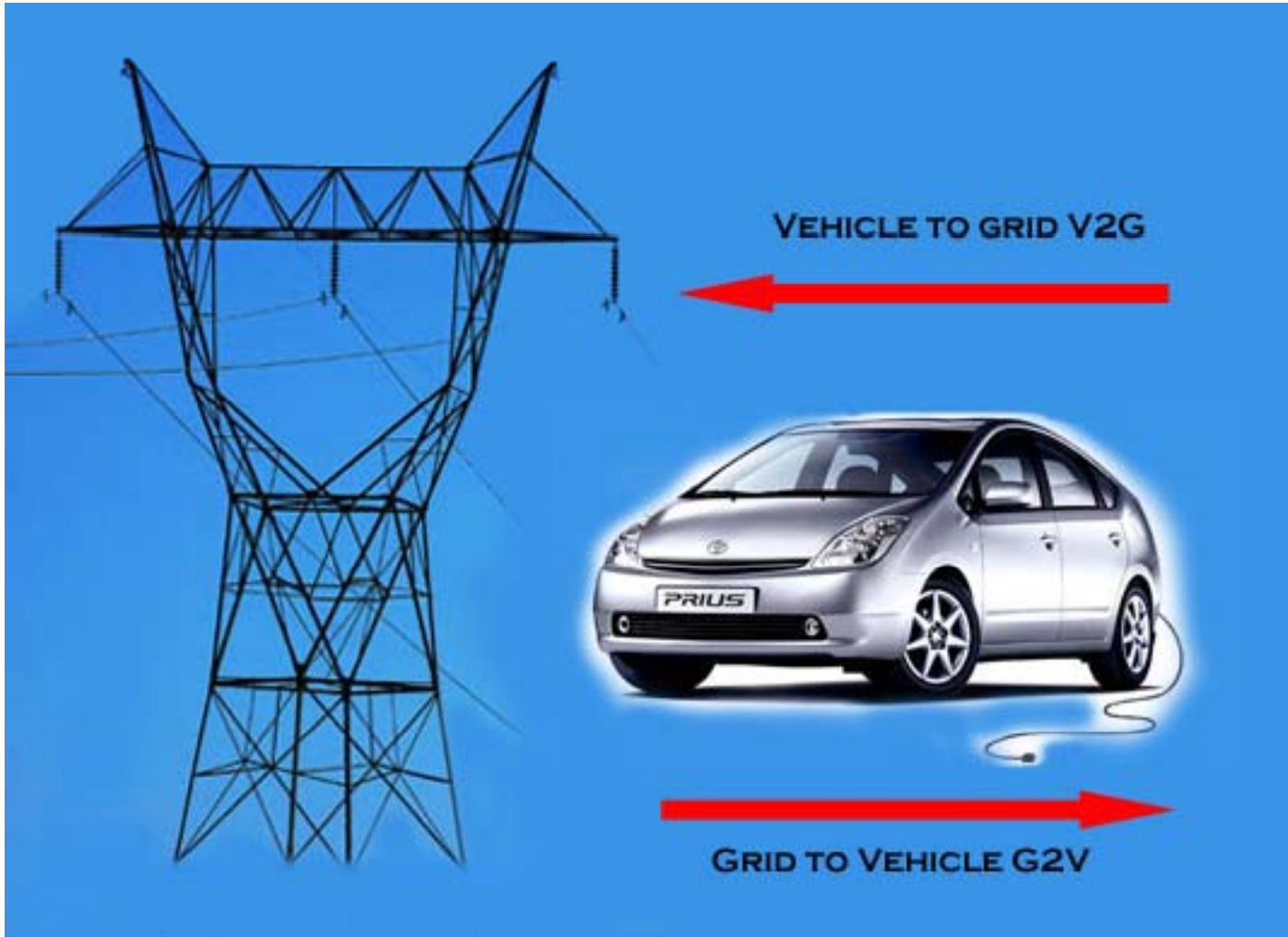
Load Curves Electricity Grid



Source: www.world-nuclear.org

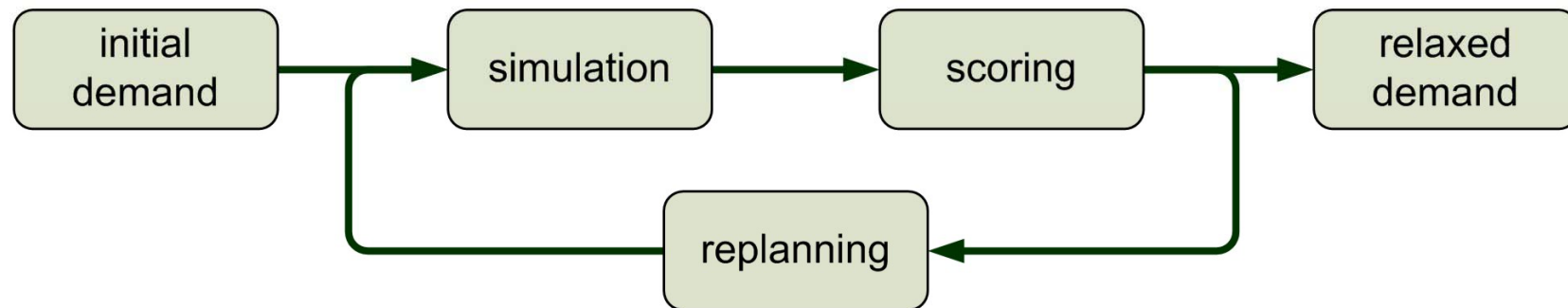
Smart Grid and Vehicle-to-Grid

Source: www.global-greenhouse-warming.com

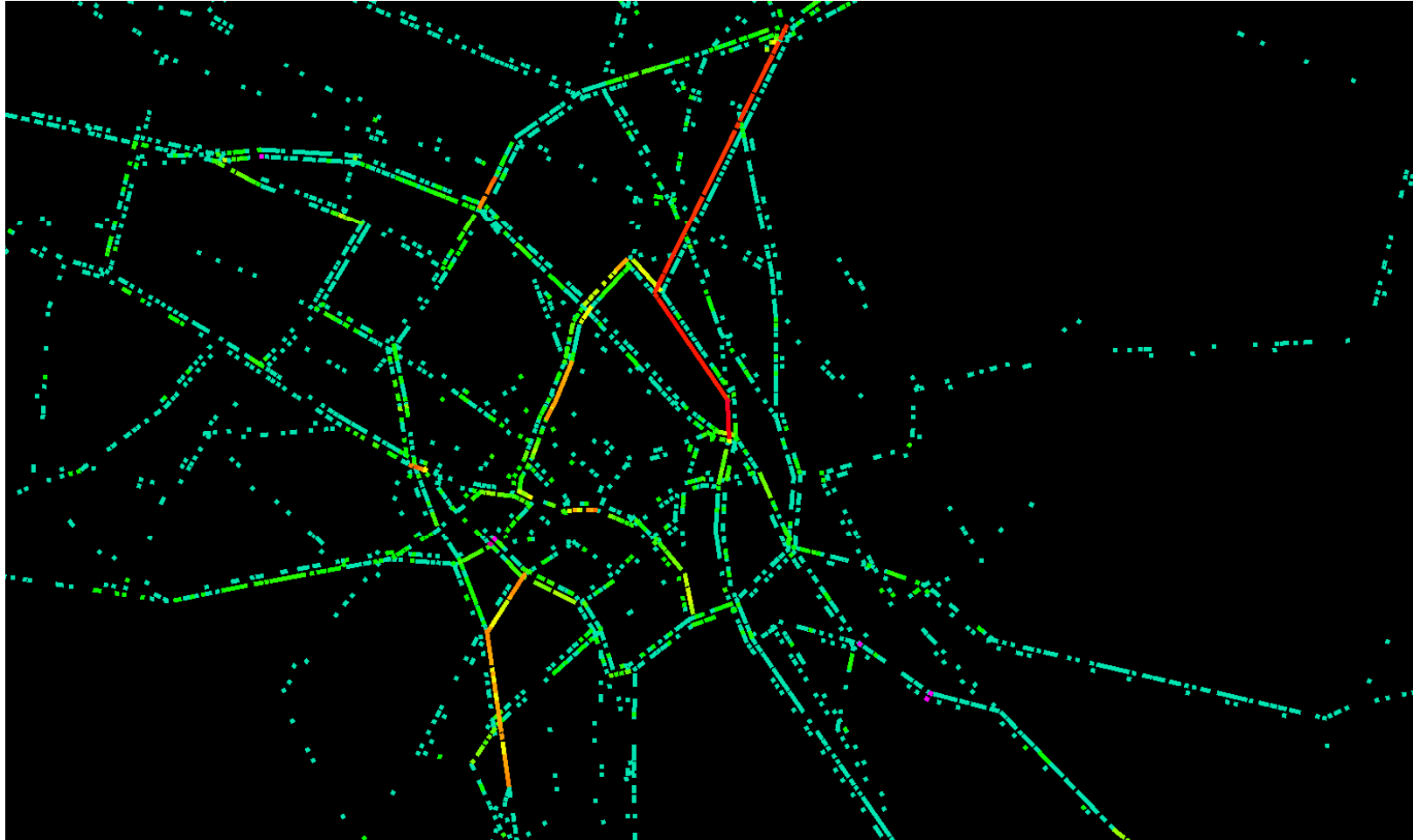


Framework based on MATSim

MATSim (Multi-Agent Transport Simulation)



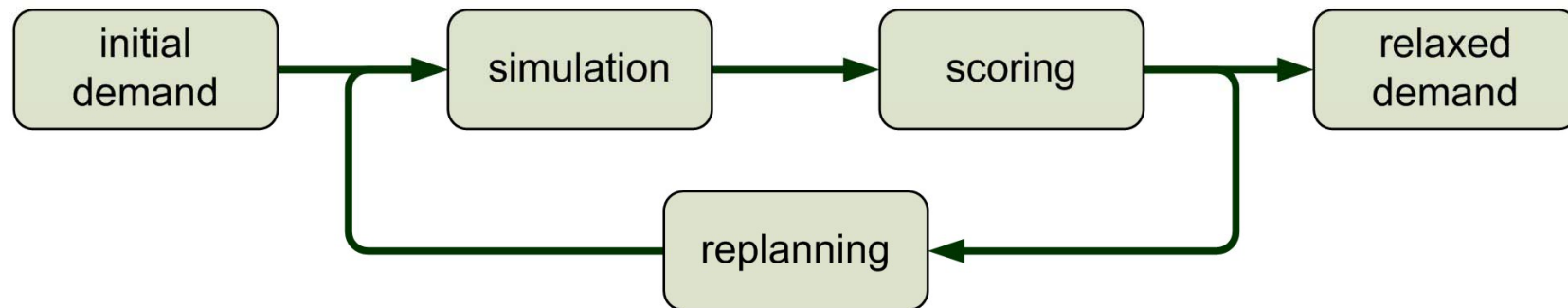
Traffic Simulation



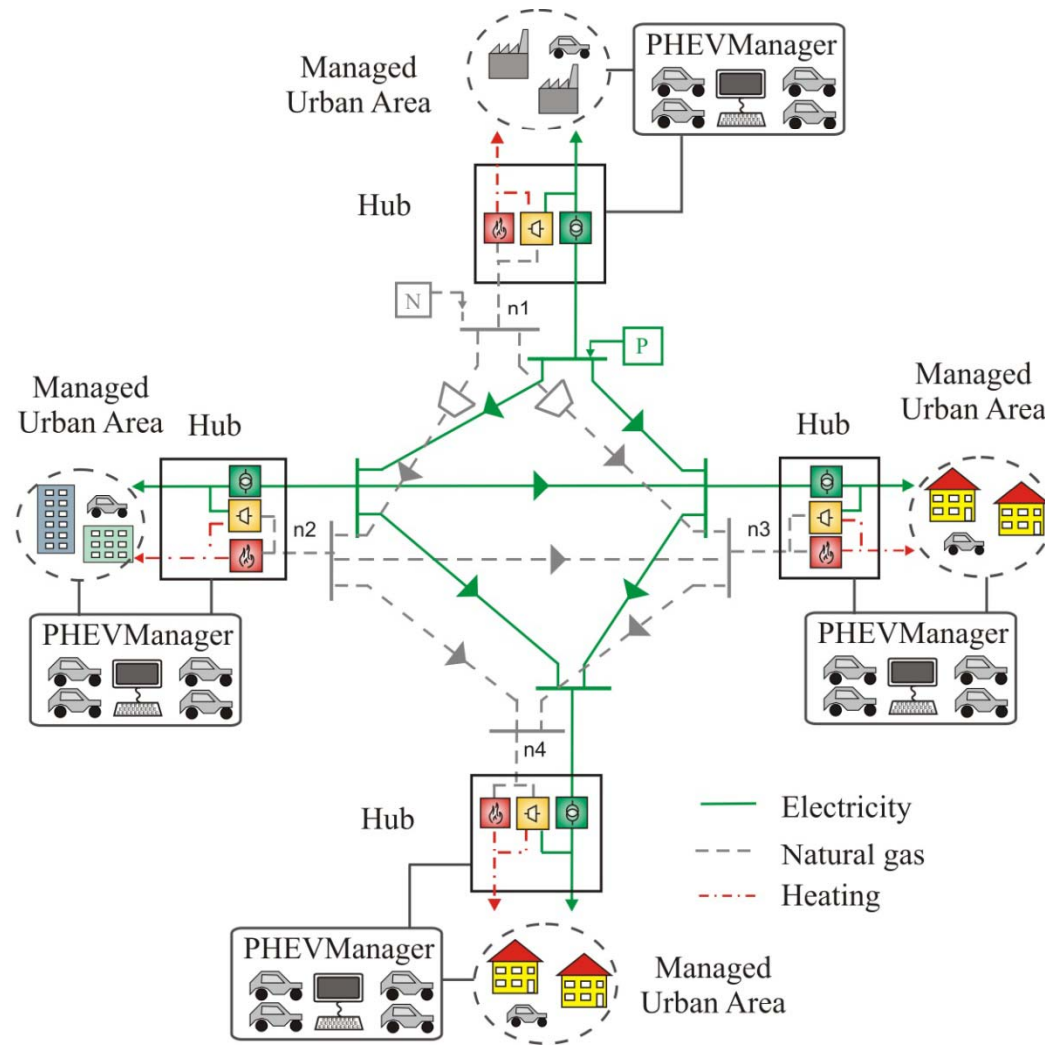
Source: www.matsim.org

Framework based on MATSim

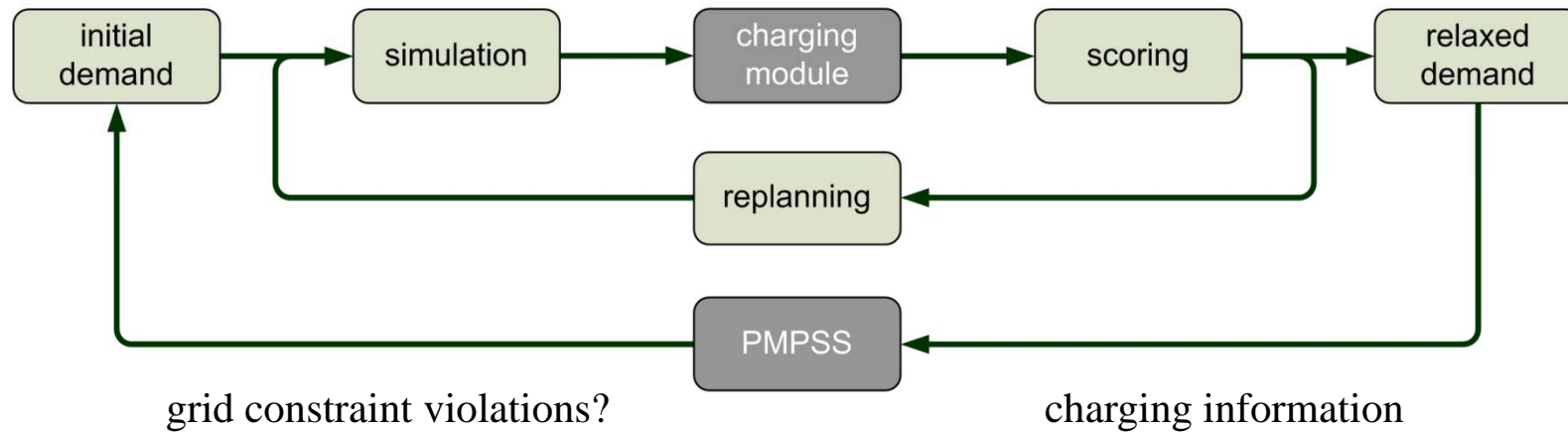
MATSim (Multi-Agent Transport Simulation)



PHEV Management and Power System Simulation (PMPSS)



Integrating MATSim and PMPSS

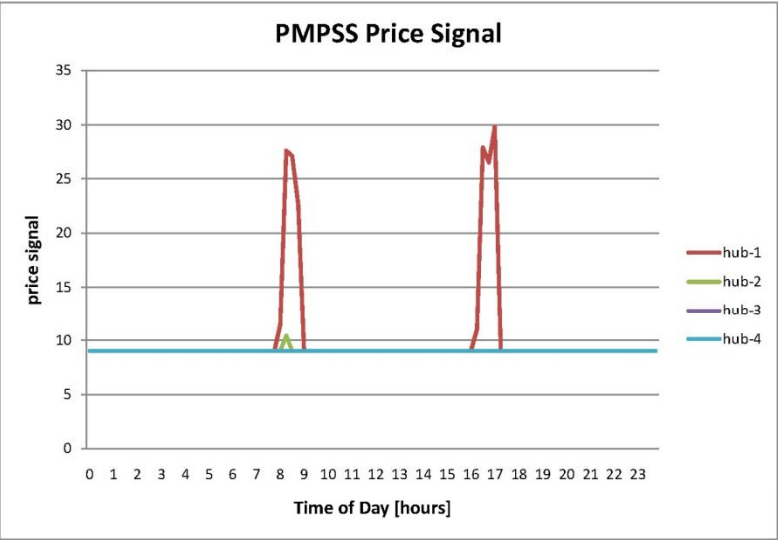
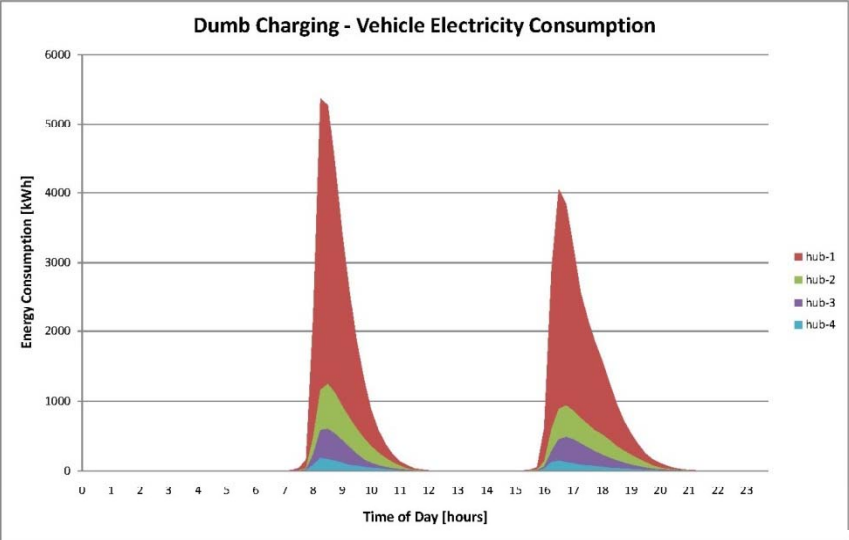


Methodology and Simulations

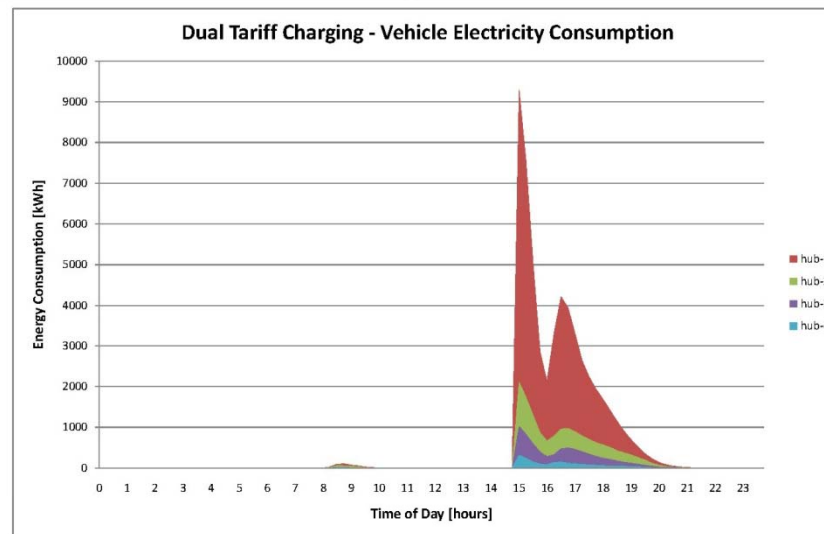
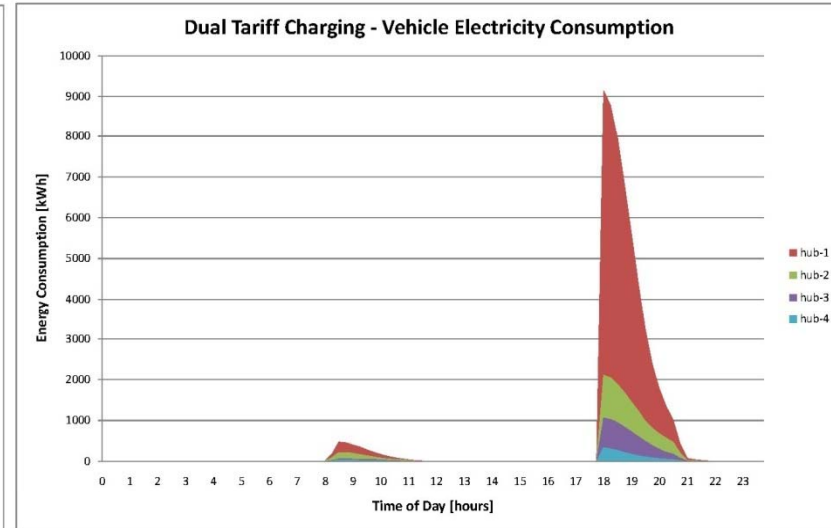
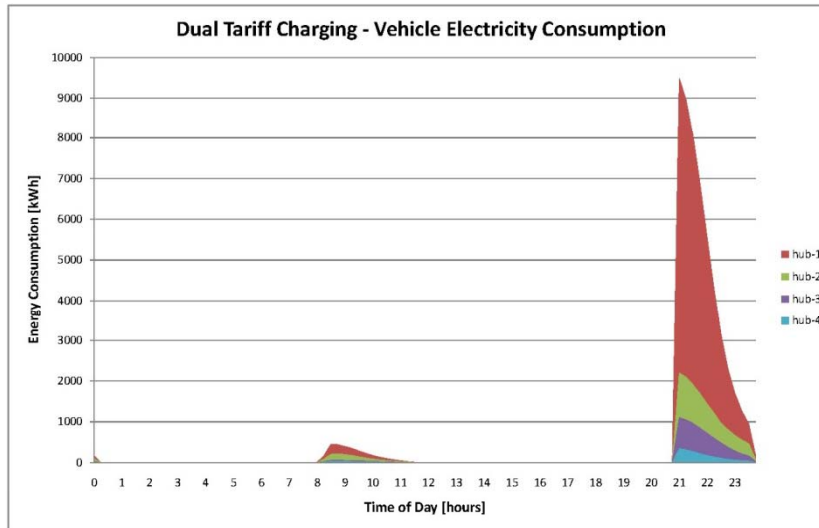
- Scenario
 - 16'000 agents
 - Berlin network
 - Home-work-home, home-education-home activity chains
 - 4 hubs, base load of a typical western city
 - Plugs available at all activity locations
 - Electricity price cheaper than gasoline

- Different charging schemes and policies tried simulated

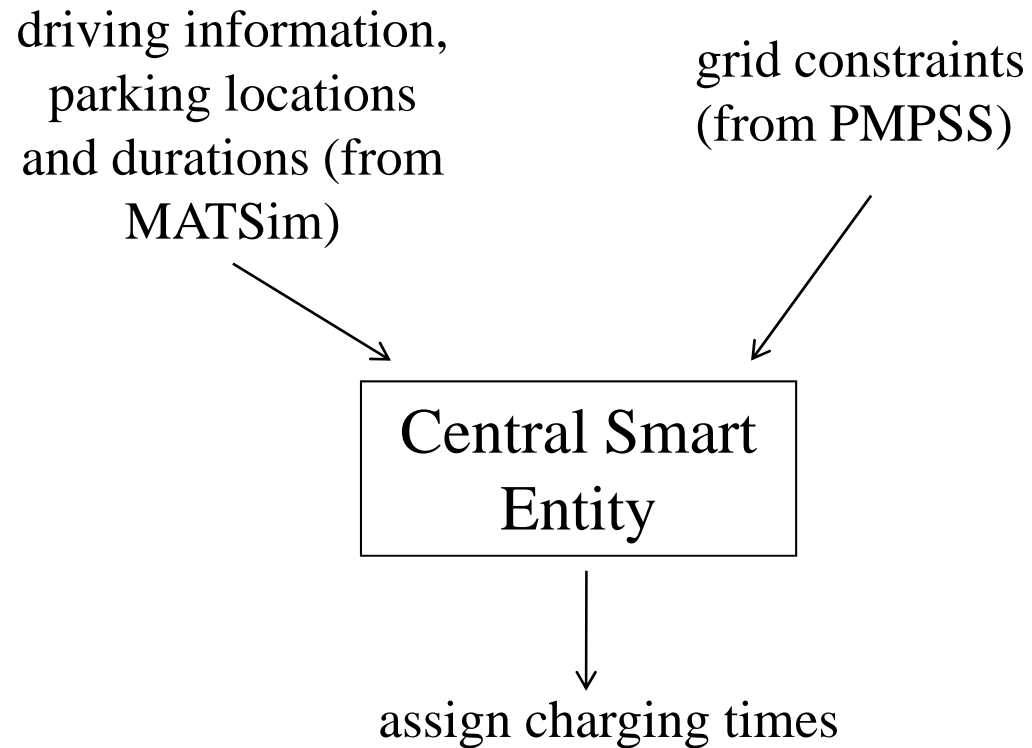
Charging upon Arrival



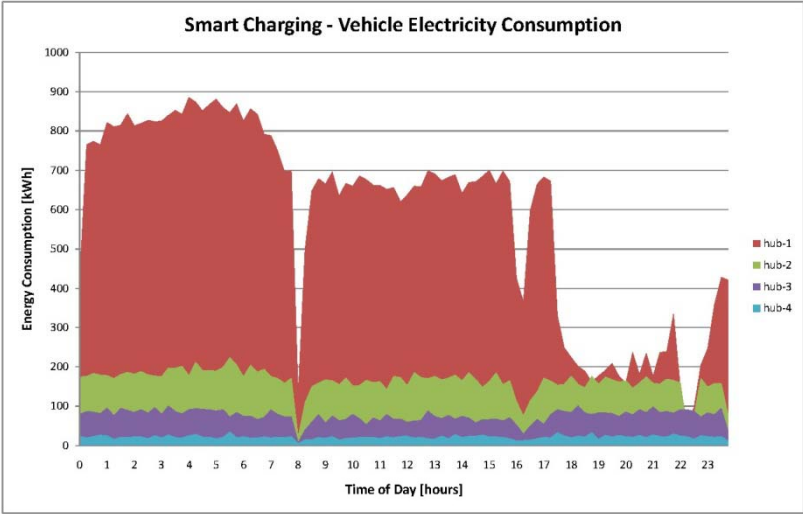
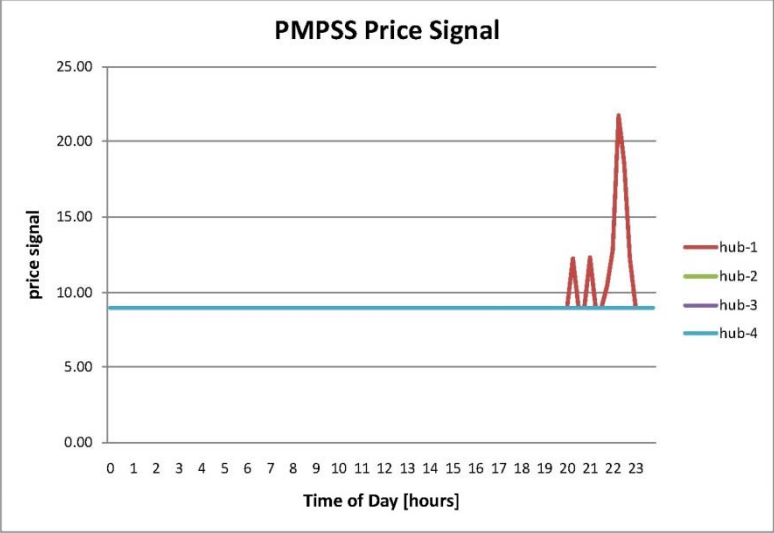
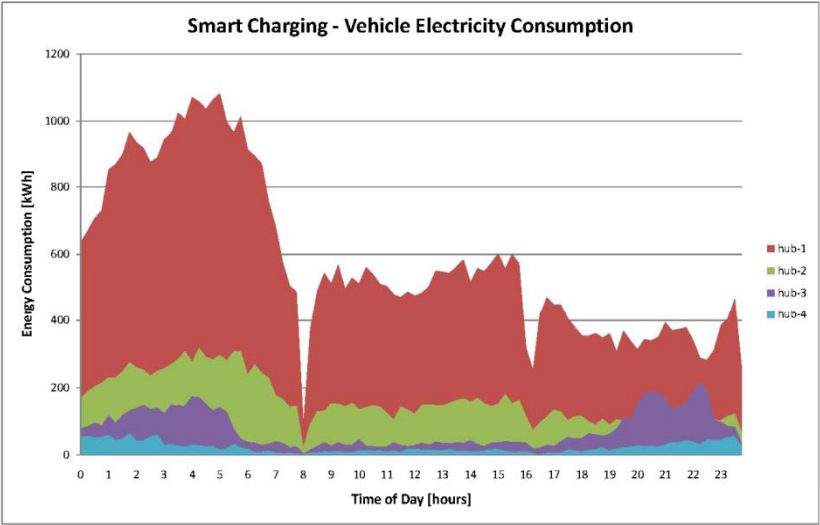
Dual Tariff Charging



Centralized Smart Charging



Centralized Smart Charging



Conclusions and Future Work

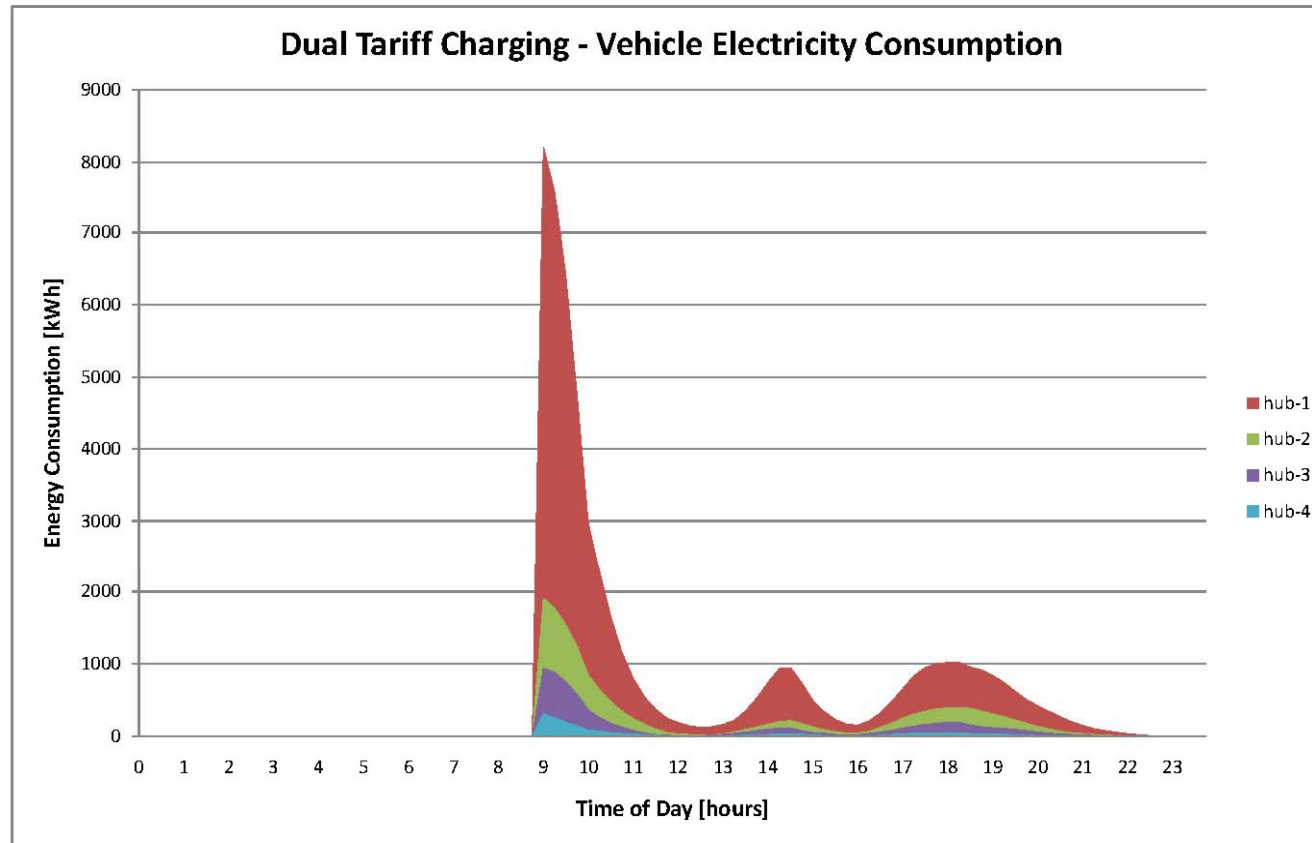
- Framework for investigating PHEVs

In Future:

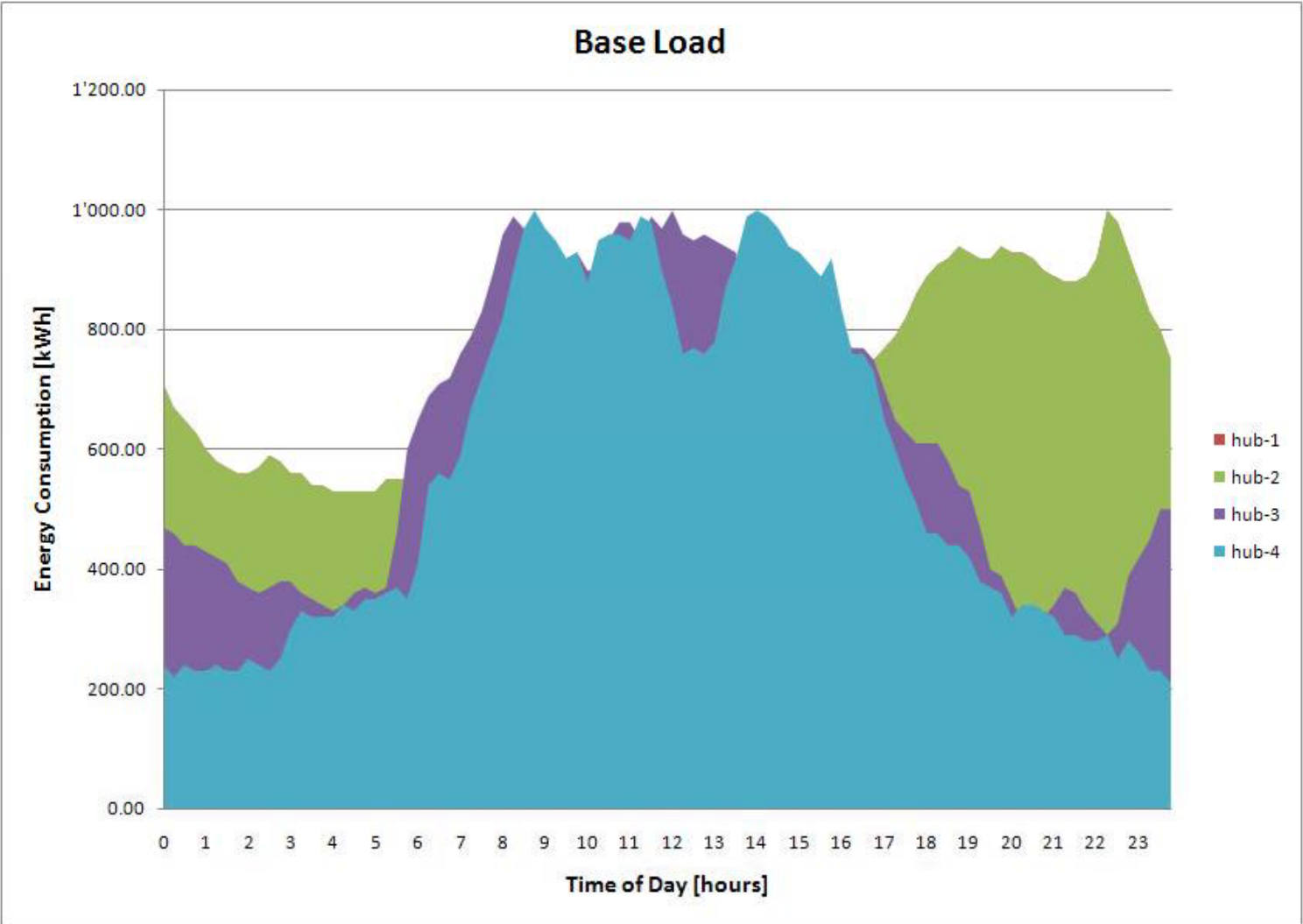
- Other smart charging schemes
- Privacy

Questions?

Excessively High Charging Price During the Night



Base Load



The Automotive Evolution

Conventional Vehicles (CVs)

only gasoline

Battery Electric Vehicles (BEVs)

electricity

Hybrid Electric Vehicles (HEVs)

only gasoline, but better fuel economy

e.g. Toyota Prius

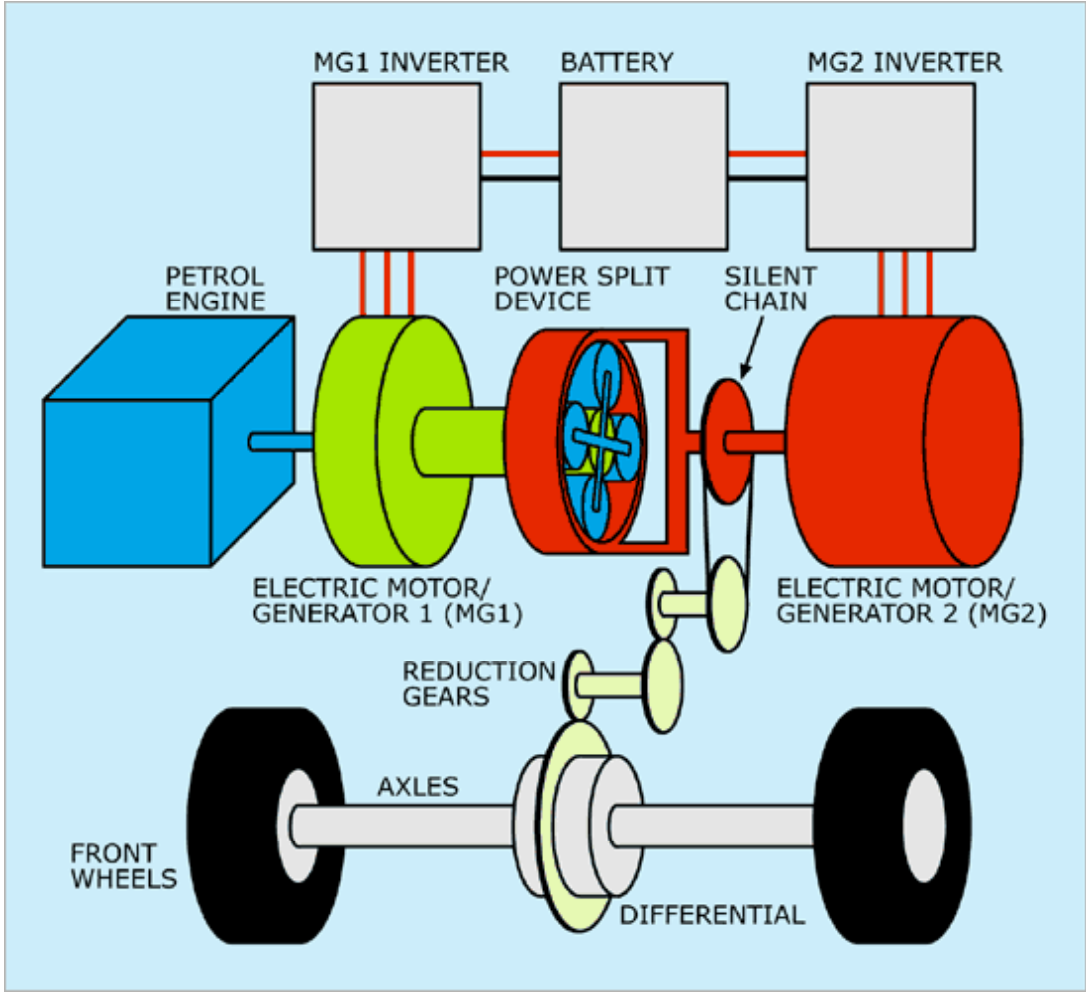
Plug-in Hybrid Electric Vehicles (PHEVs)

gasoline and electricity



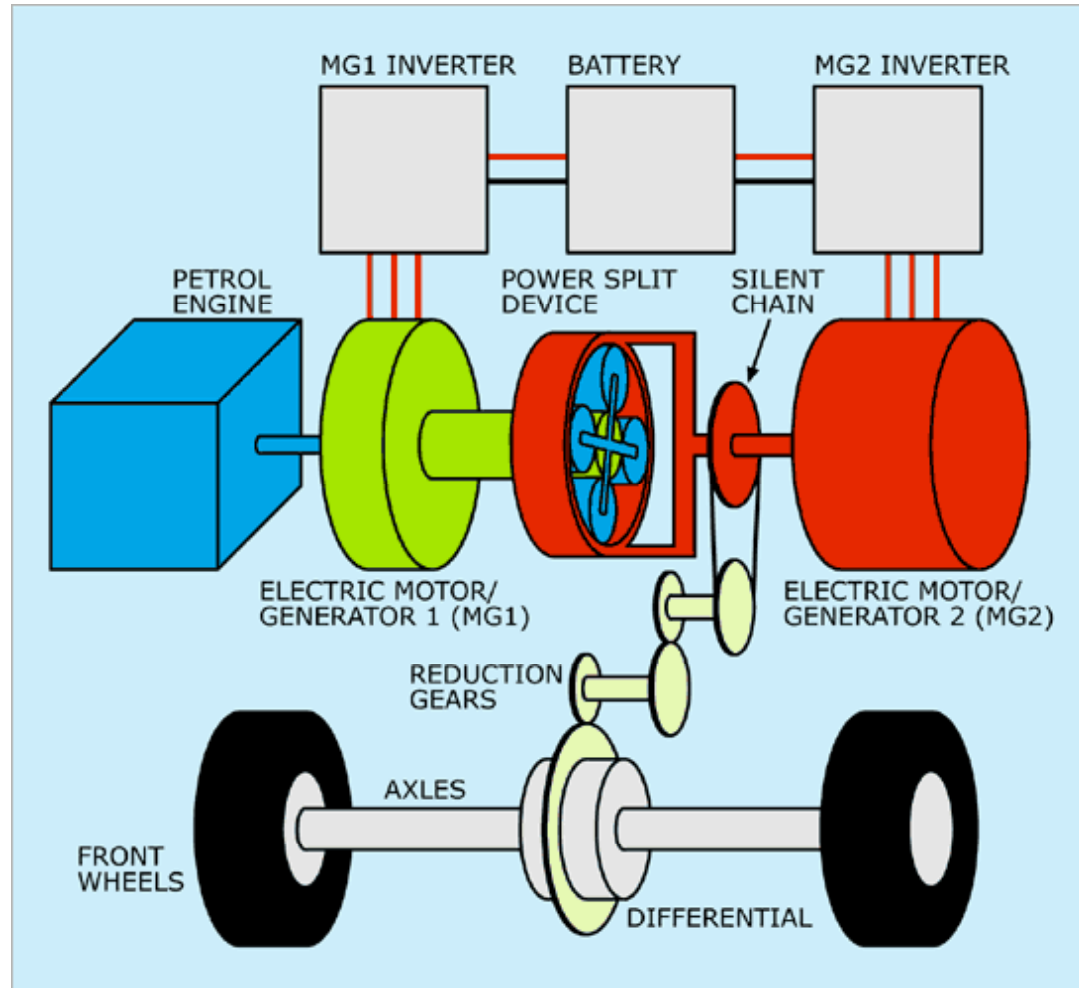
[www.wikipedia.org]

Hybrid Electric Vehicle (e.g. Toyota Prius)



[www.cleangreencar.co.nz]

Plug-in Hybrid Electric Vehicle (PHEV)



[www.cleangreencar.co.nz]

The Automotive Evolution (cont.)

- Increasing battery size
- Decreasing use of gasoline

CVs

HEVs

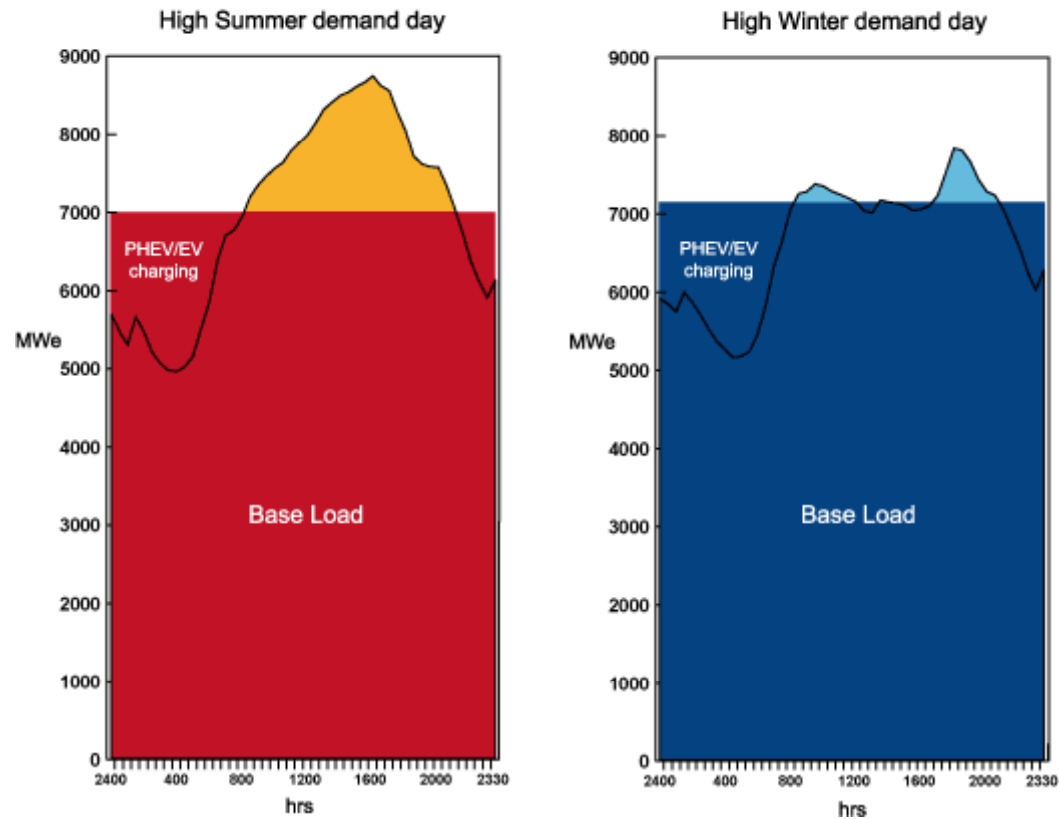
PHEVs

BEVs

Load Curves Electricity Grid (cont.)

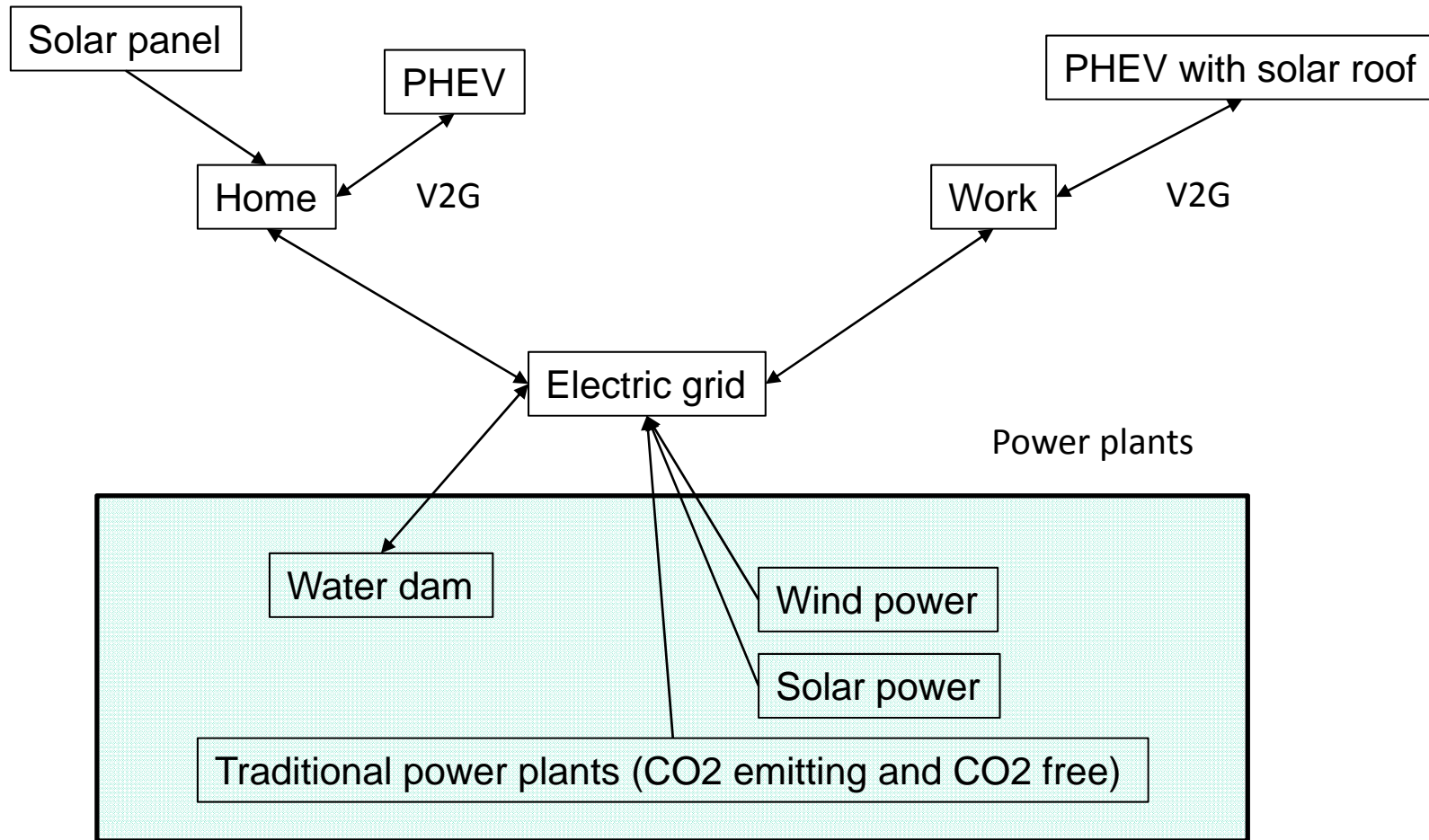
- Smart grid

Load Curves For Typical Electricity Grid



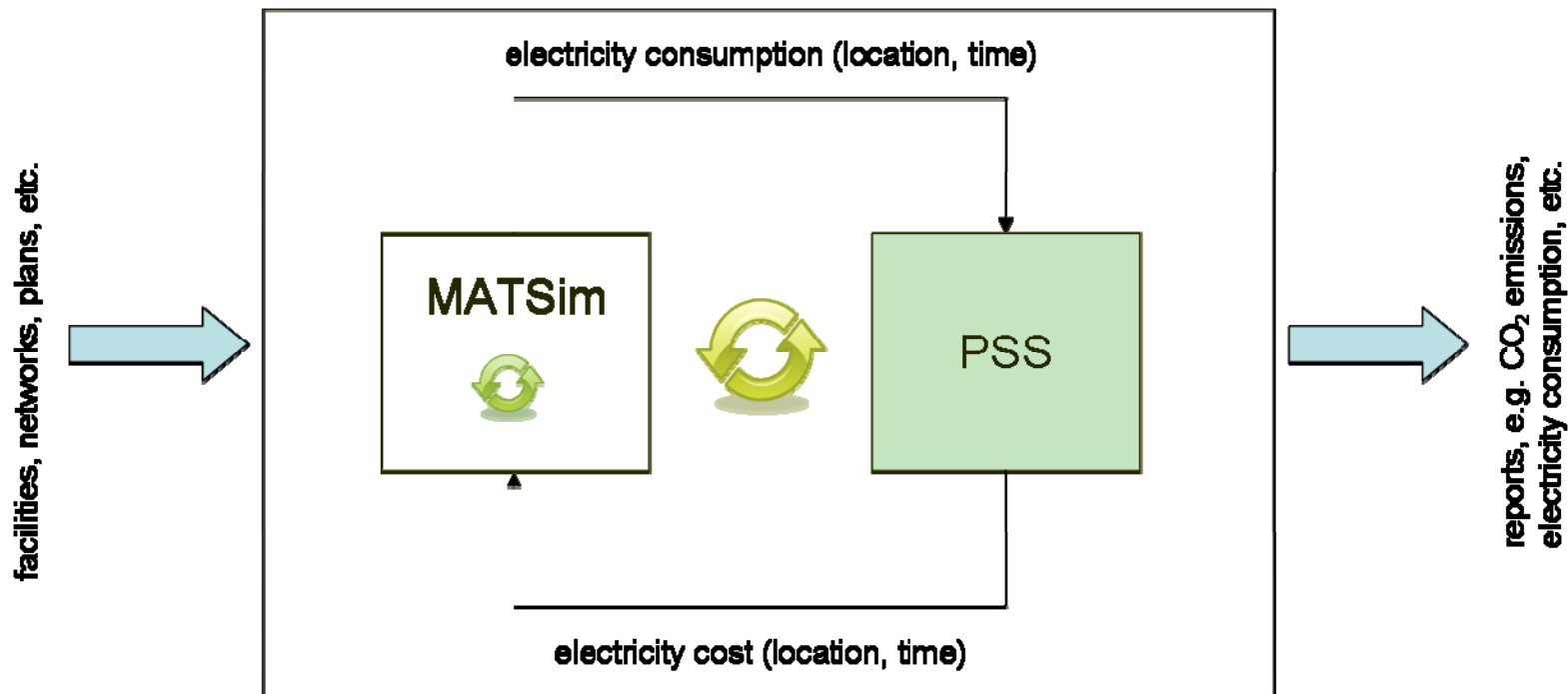
[www.world-nuclear.org]

Simulating PHEVs on top of MATSim



Current State of Projects

- Together with Power Systems Laboratory (PSL) and Aerothermochemistry and Combustion Systems Laboratory (LAV) at ETH Zurich.
- Integration of MATSim and Power System Simulation



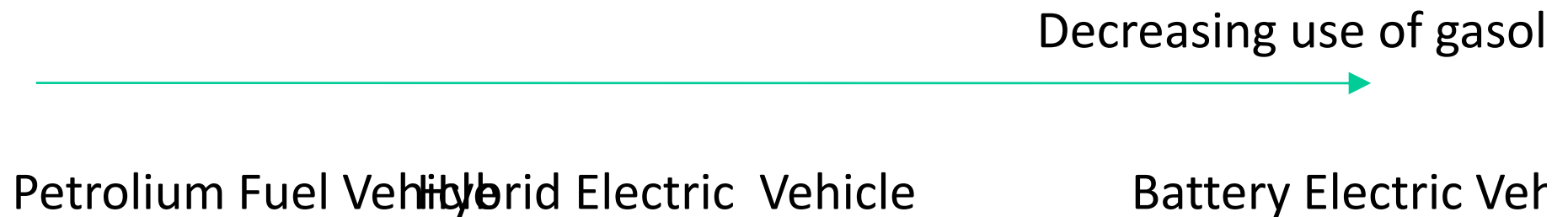
Plug-in Hybrid Electric Vehicles

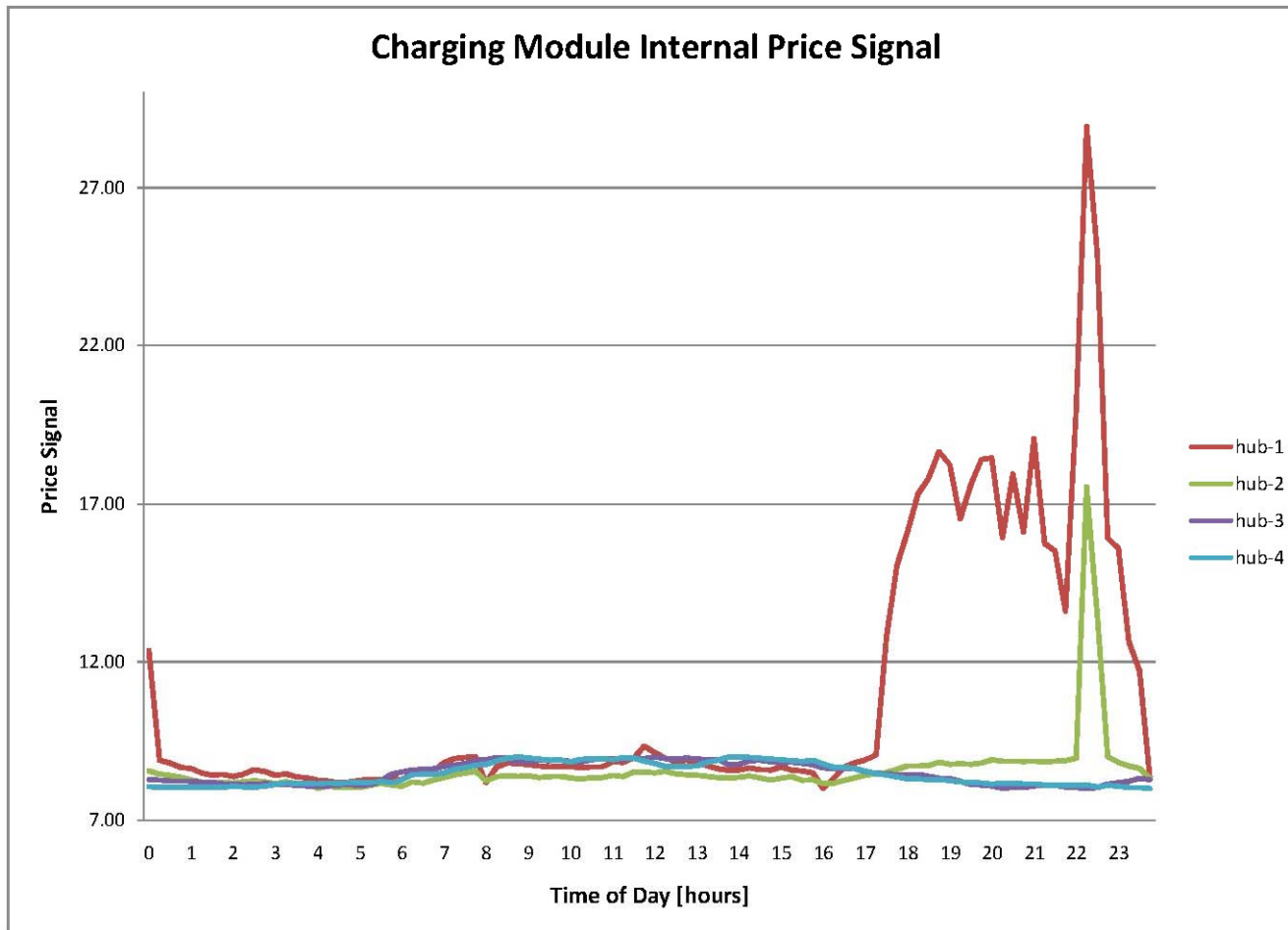
Have big batteries for electric drive

Can be charged using usual plug at home

Run both on electricity and gasoline

Mass production announced by several major car vendors





Electric Grid Load Curves (Peak Load)

Source: www.wikipedia.org - adpated

