

## Preferred citation style for this presentation

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Waraich, Rashid A. (2010) Plug-in Hybrid Electric Vehicles and Smart Grid , presentation at *the 2nd MATSim User Meeting*, Zurich, May 2010.

# Plug-in Hybrid Electric Vehicles and Smart Grid

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May 2010

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Swiss Federal Institute of Technology Zurich

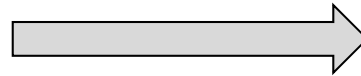
# Future Vehicles?

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## 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]

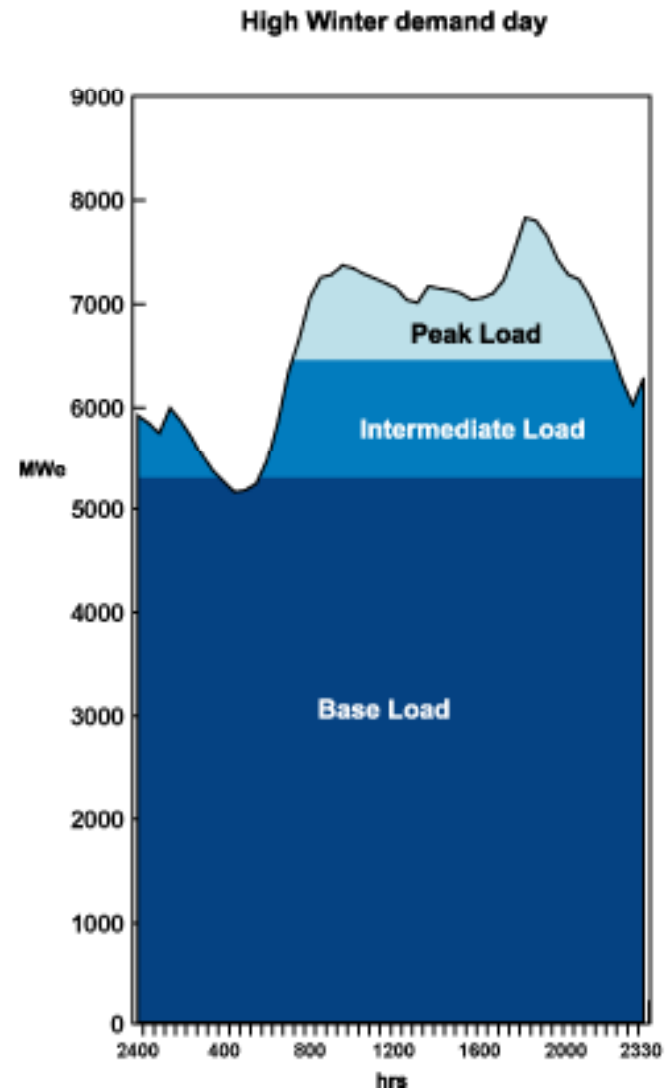
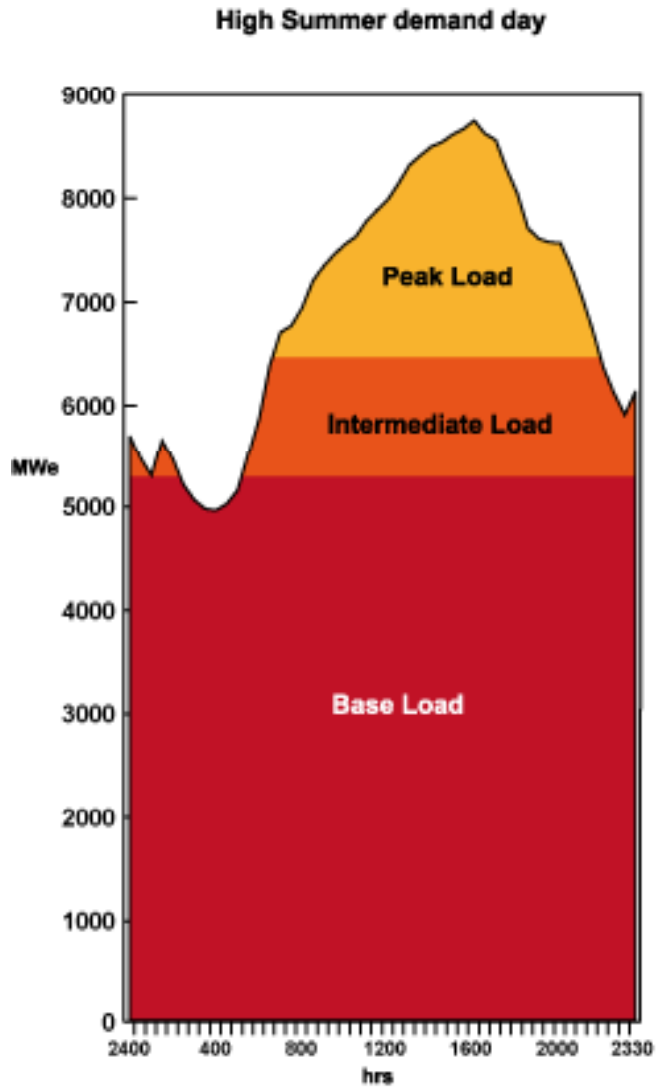
# PHEVs – More Environment-Friendly?

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[all figures from wikipedia.org]

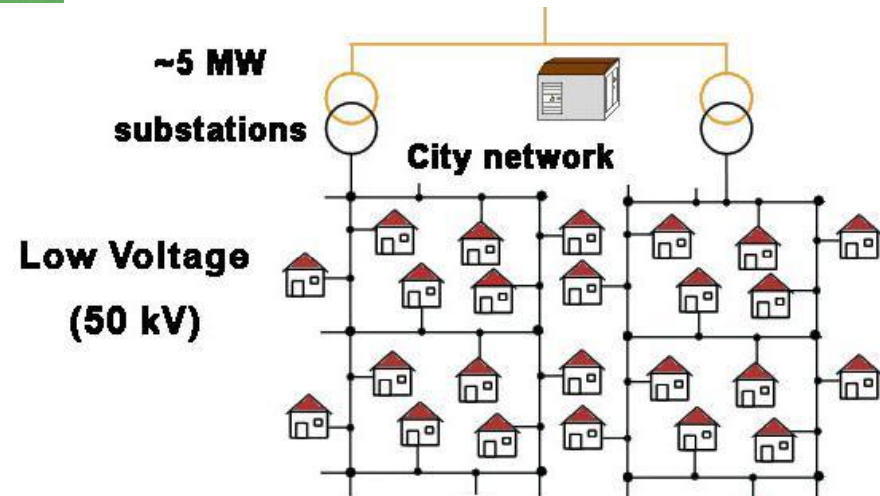
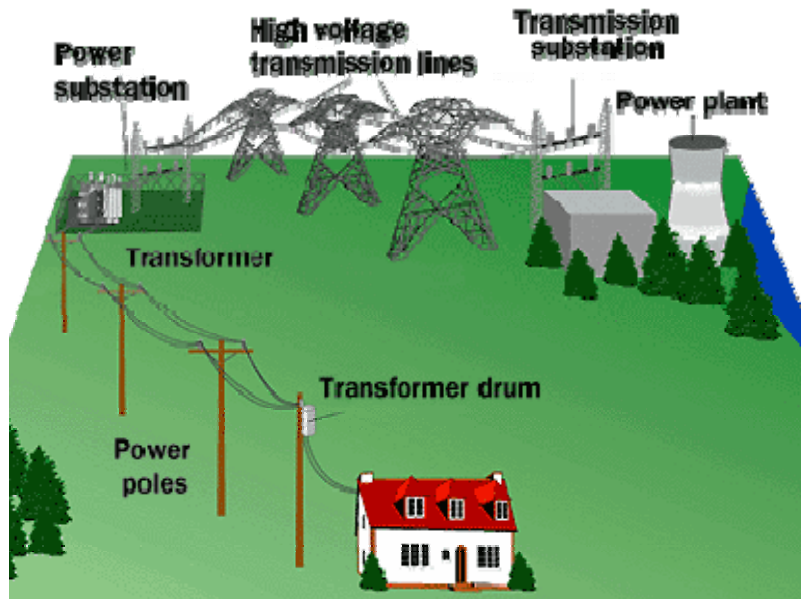
# Load Curves Electricity Grid



Source: [www.world-nuclear.org](http://www.world-nuclear.org)

# Bottlenecks in the Distribution Grid

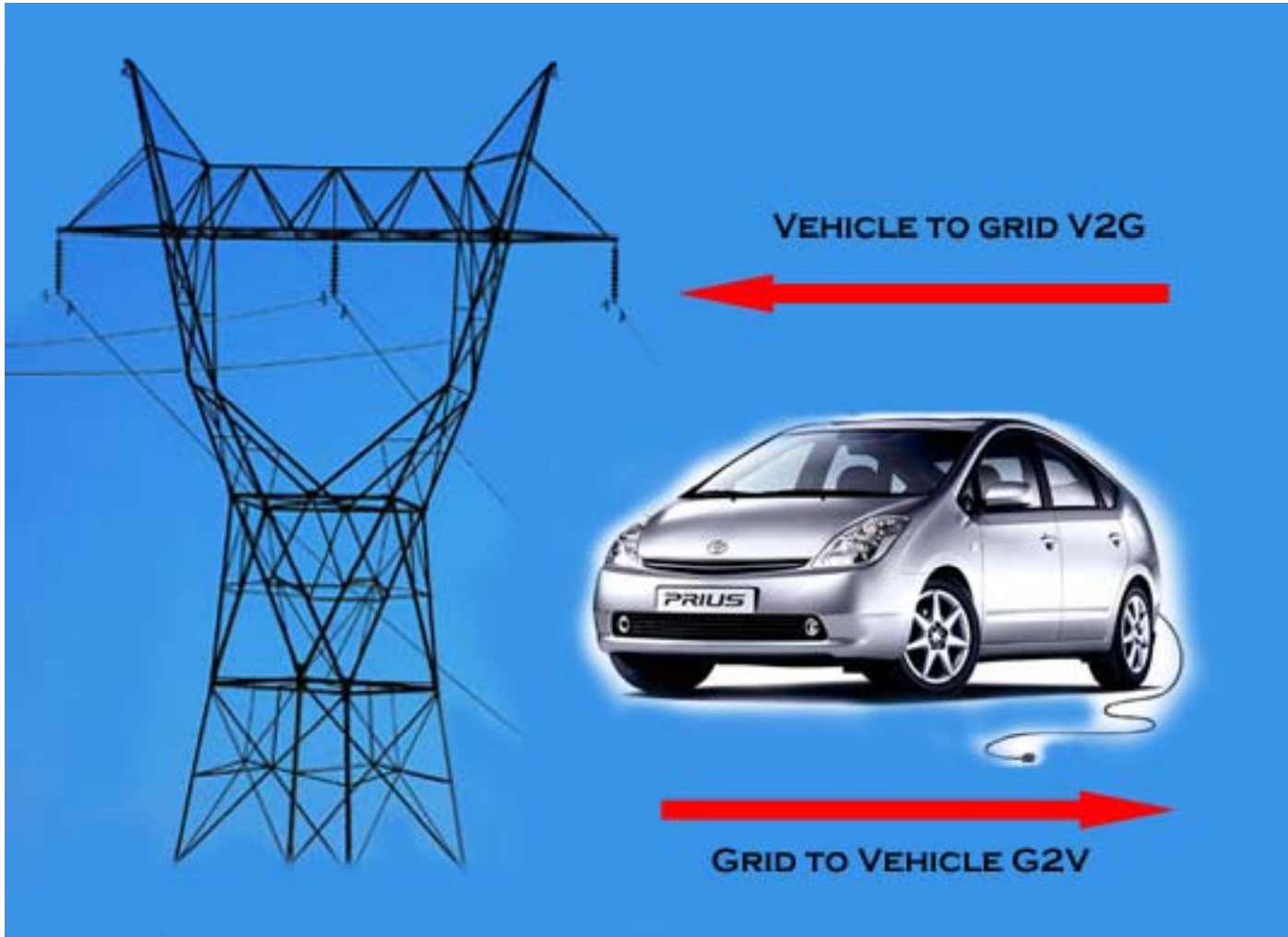
Sources: [www.science.smith.edu](http://www.science.smith.edu) and [wiki.uiowa.edu](http://wiki.uiowa.edu)



# Smart Grid and Vehicle-to-Grid

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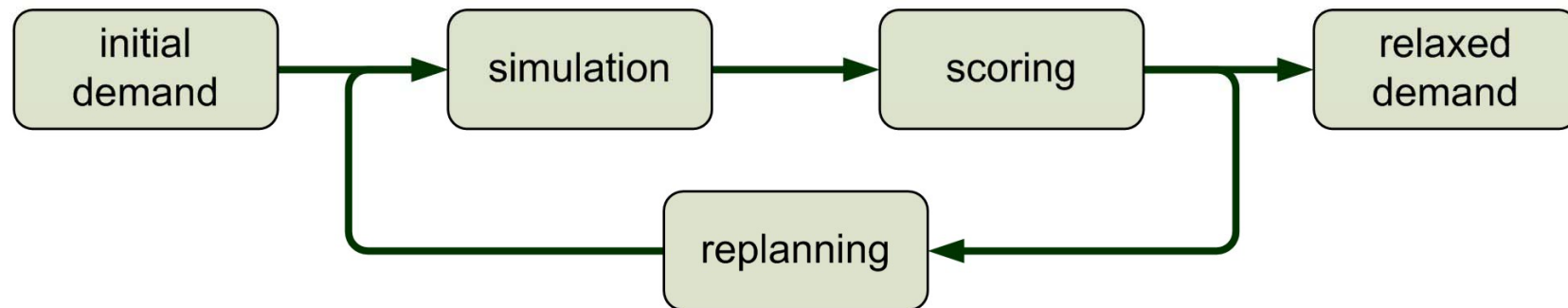
Source: [www.global-greenhouse-warming.com](http://www.global-greenhouse-warming.com)



# Framework based on MATSim

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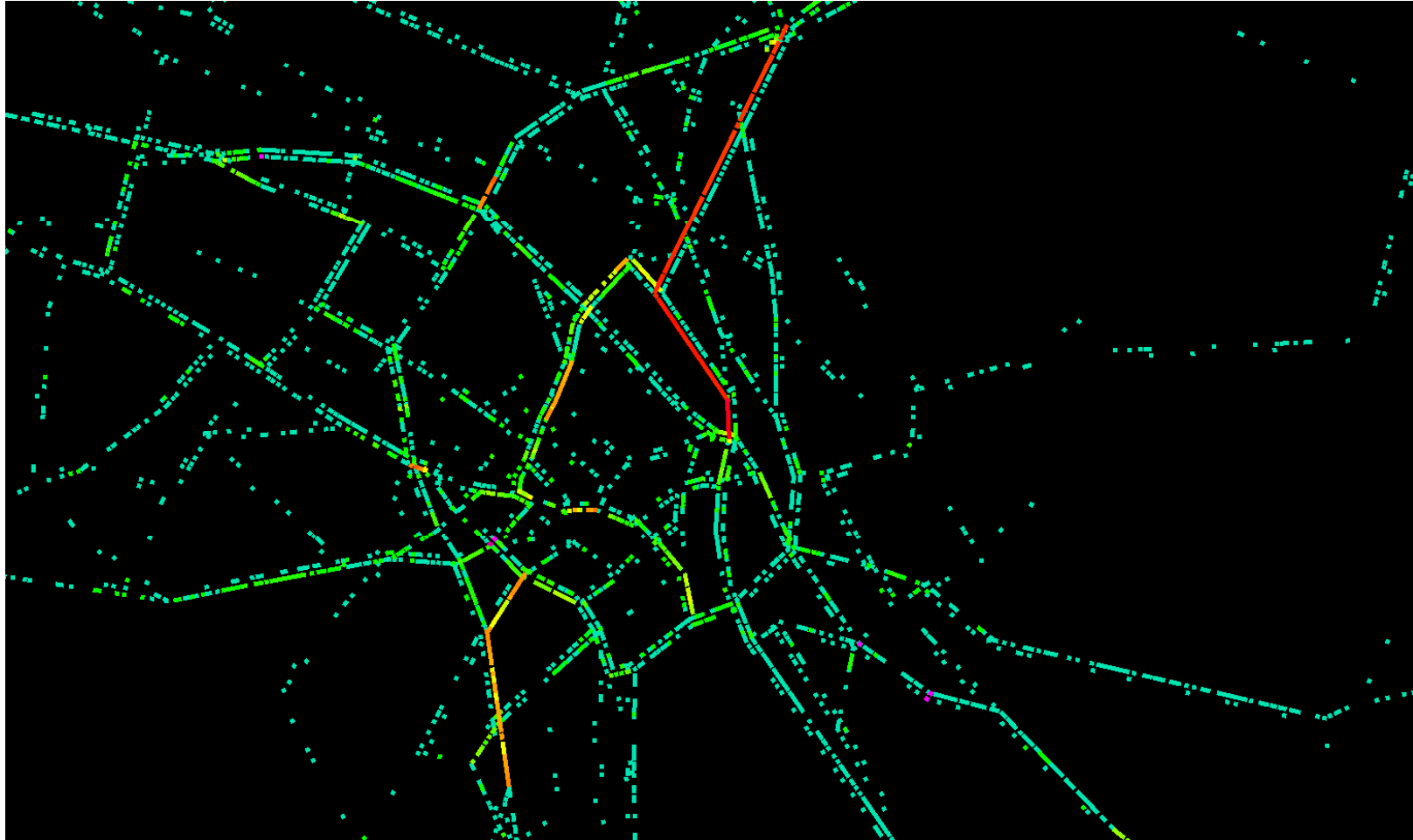
MATSim (Multi-Agent Transport Simulation)





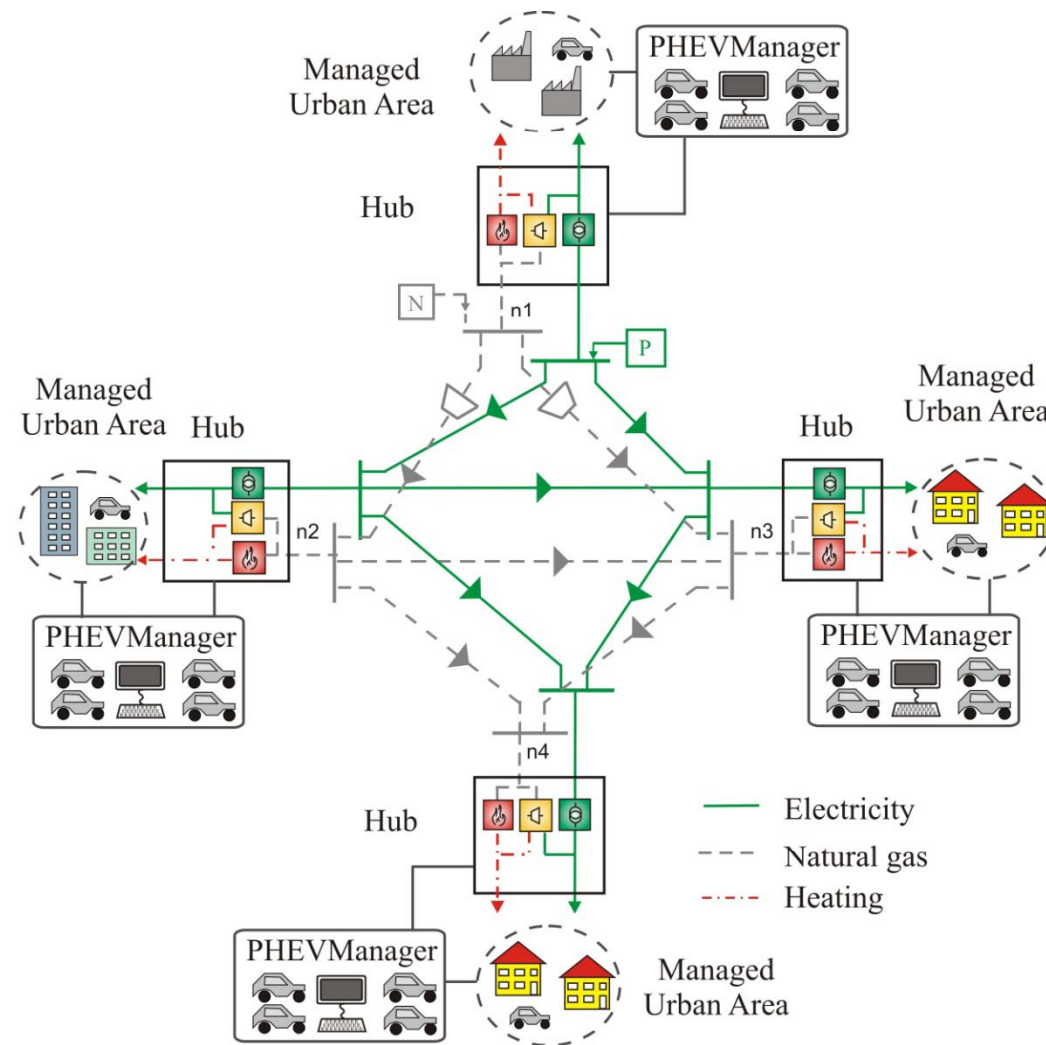
# Traffic Simulation

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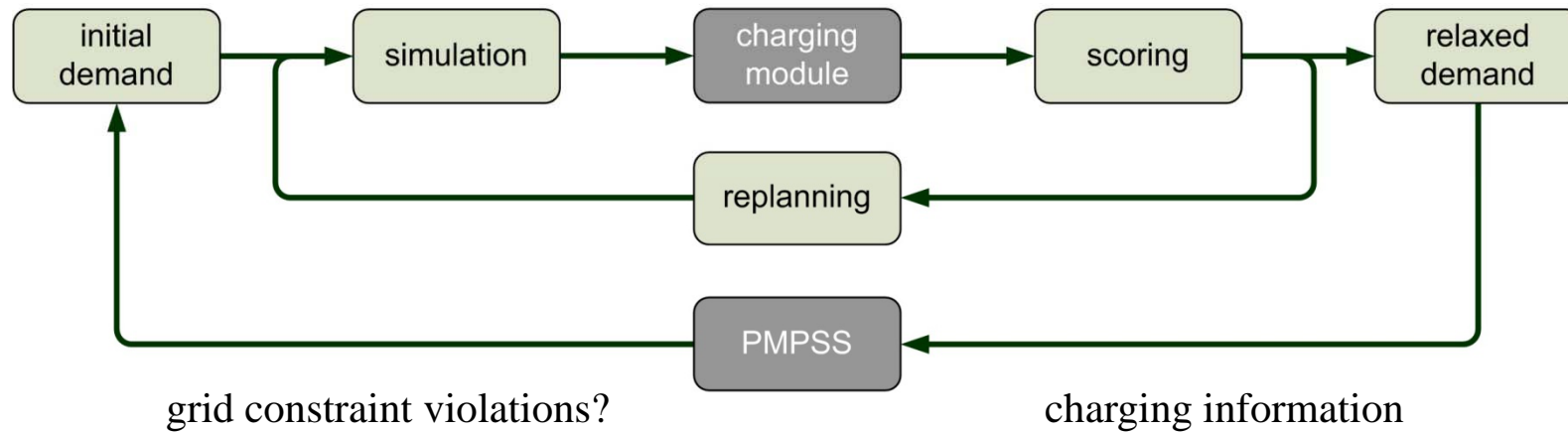
Source: [www.matsim.org](http://www.matsim.org)

# PHEV Management and Power System Simulation (PMPSS)



# Integrating MATSim and PMPSS

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## Technical Background Information

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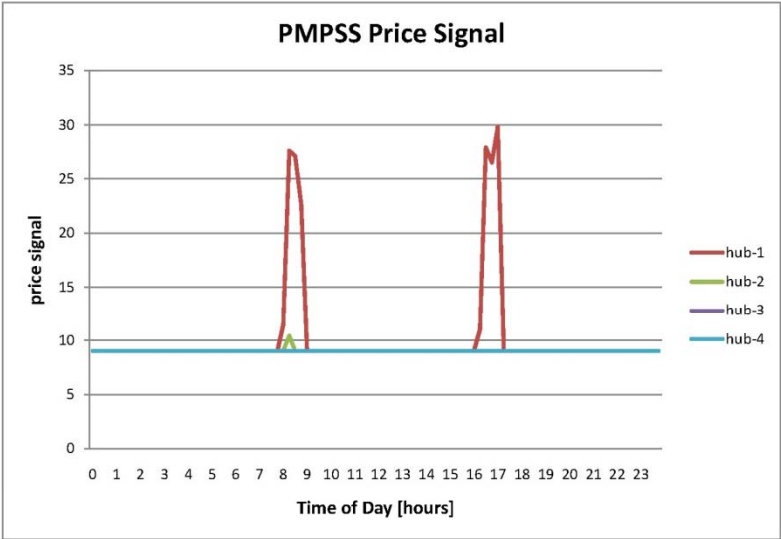
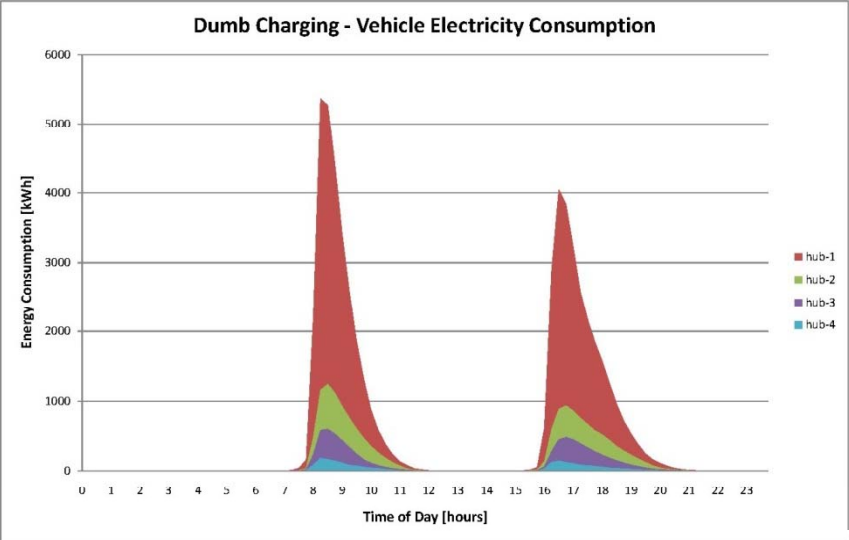
- Energy consumption and „state of charge“ of batteries maintained using event handlers
- Controller listener (between micro-simulation and scoring) introduced for charging module
- Integration: PMPSS implemented in MATLAB, need to invoke it from MATSLab
- Three charging strategies implemented

# Methodology and Simulations

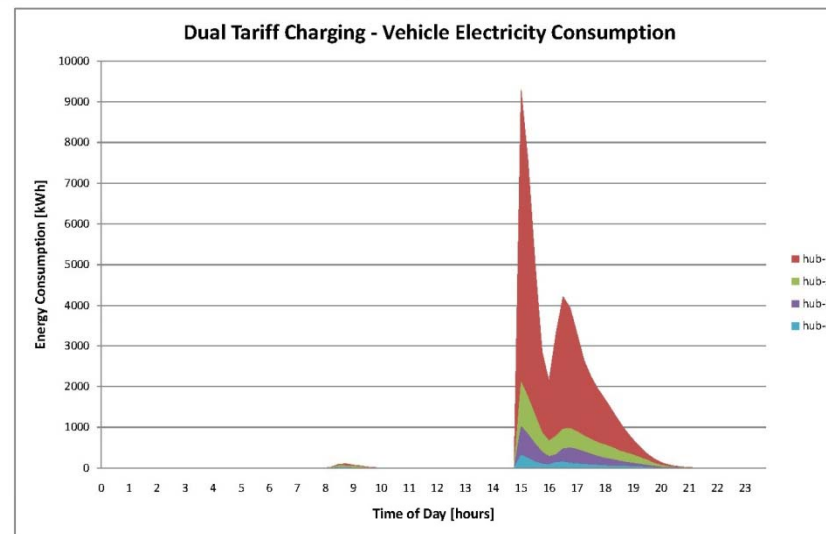
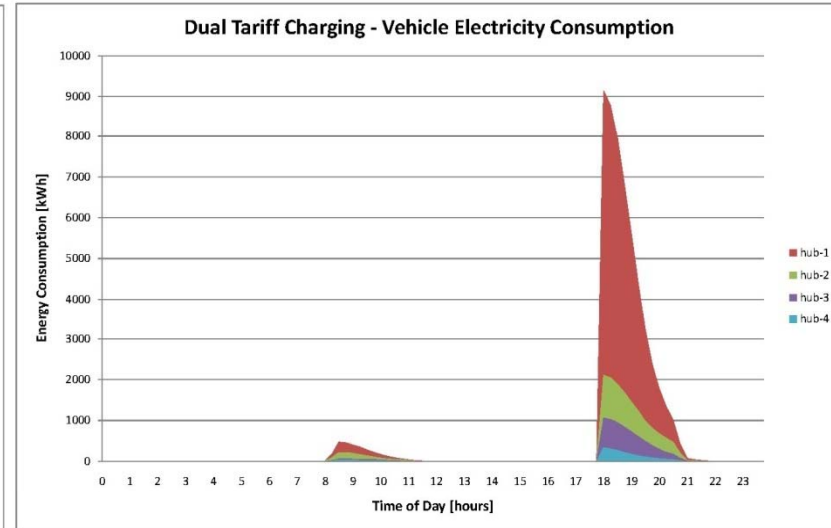
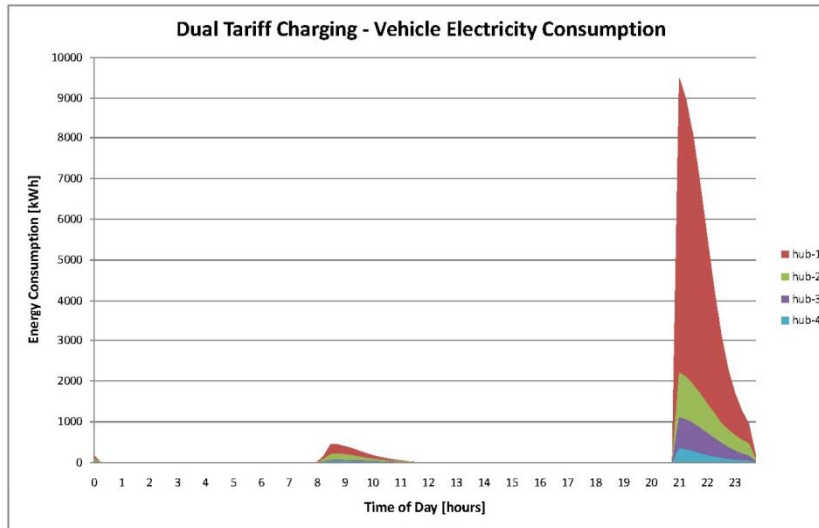
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- Scenario
  - 16'000 agents
  - Berlin network
  - Home-work-home, home-education-home activity chains
  - 4 hubs, base load of a typical western city
  - Plugs available at all activity locations
  - Electricity price cheaper than gasoline
  
- Different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

# Charging upon Arrival

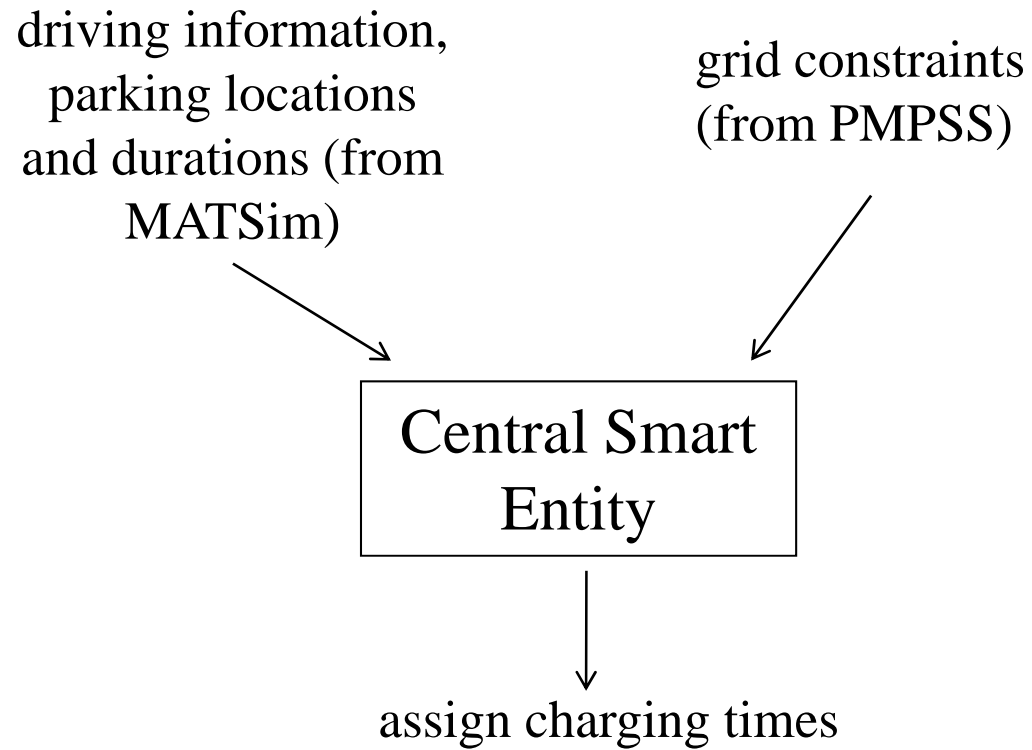


# Dual Tariff Charging



# Centralized Smart Charging

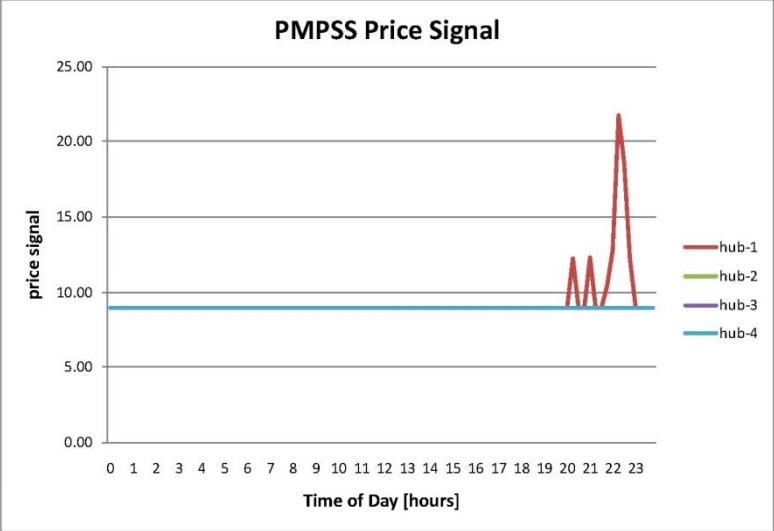
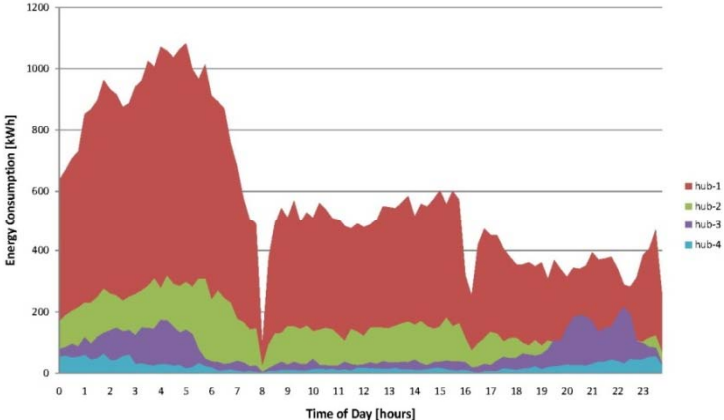
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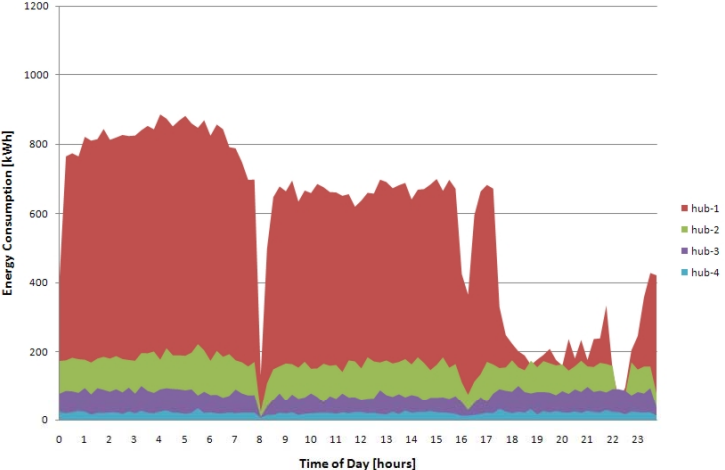


# Centralized Smart Charging

1. Iteration – grid constraints violated

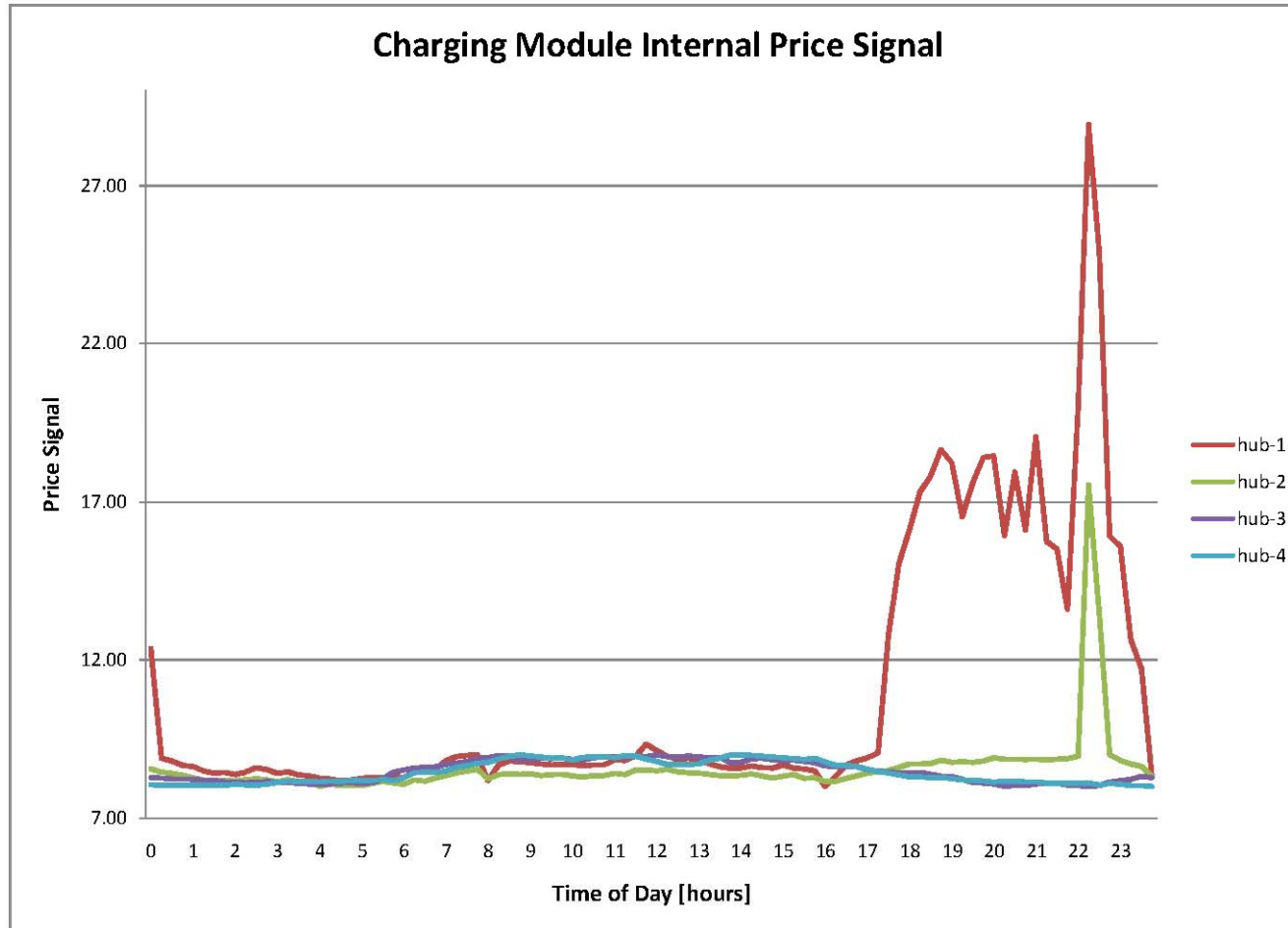


5. Iteration – all vehicles charged successfully



# Technical Detail – Retaining State between Iterations

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## Conclusions and Future Work

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- Framework for investigating PHEVs

In Future:

- Other smart charging schemes
- Privacy