TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Presentation of Electricity Market Model by TU Vienna

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DEFINE, Kick-Off, June 14-15, 2012

HiREPS Modell

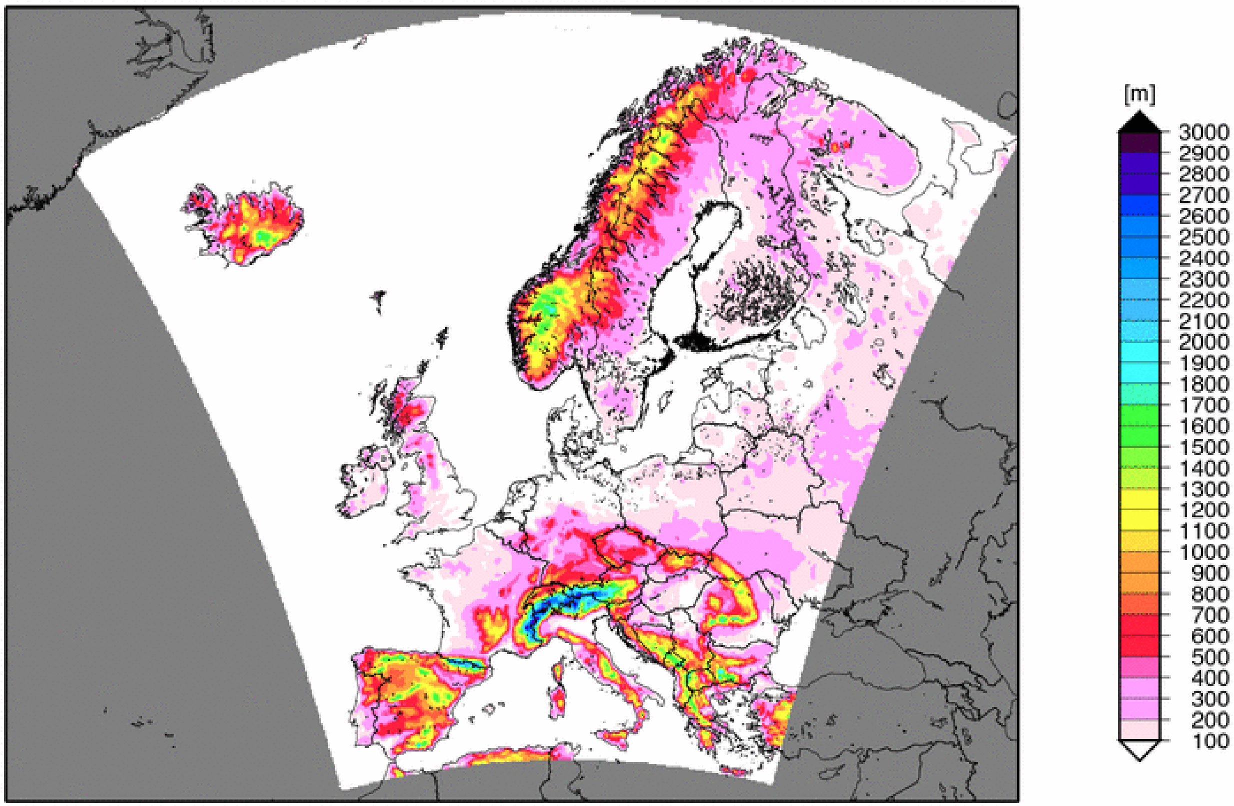
Methodological Approach Ansatz:

Testing of the future power system with the weather of the past (hydro, solar, wind).

Hourly unit commitment optimization and capacity expansion planning

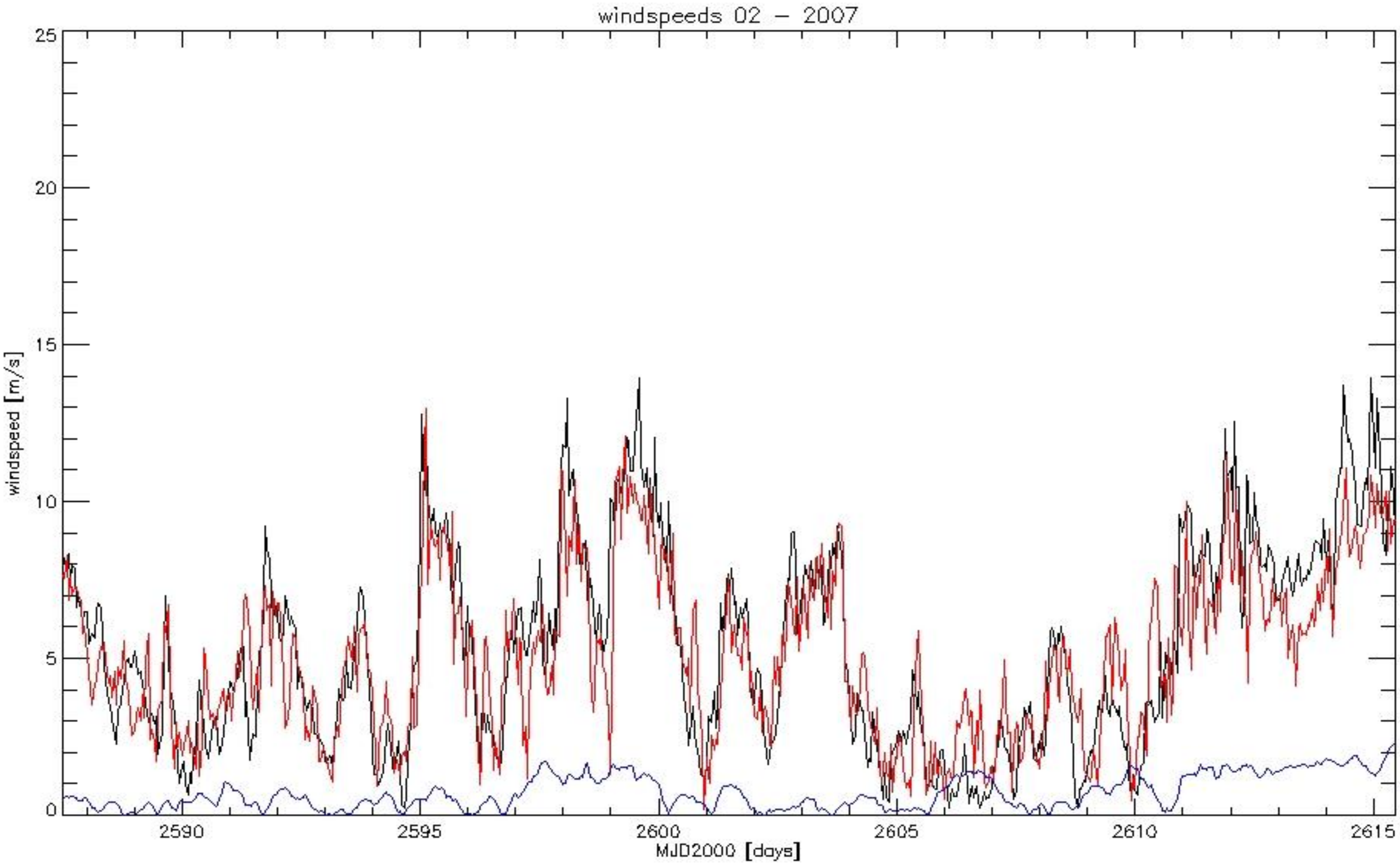
Solar und wind data:

Data of numerical weather model → 10 km spatial resolution, hourly data, for 2001-2010



Test:

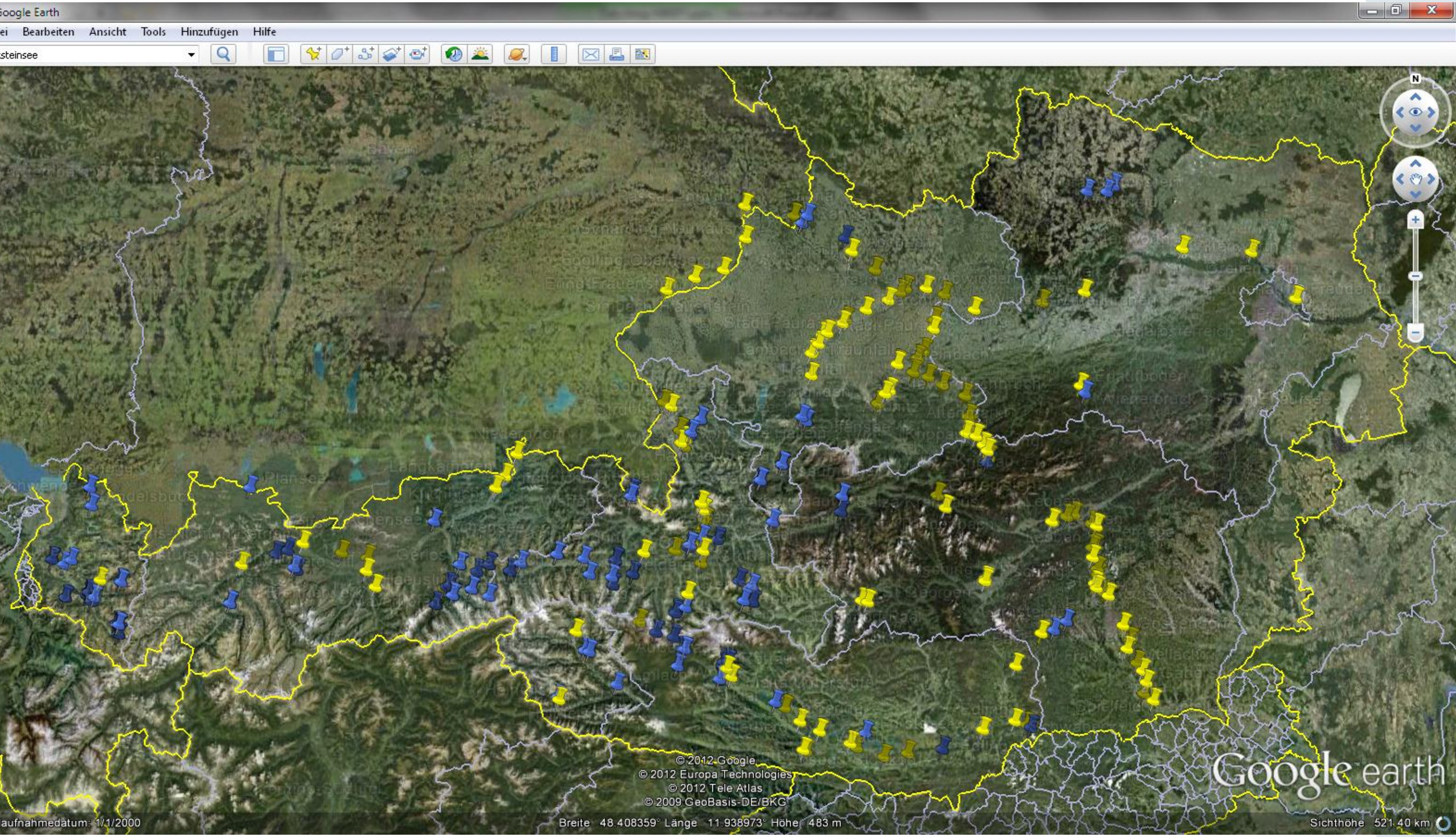
Numerical weather model (black) vs 100m wind mast in Karlsruhe (rot)

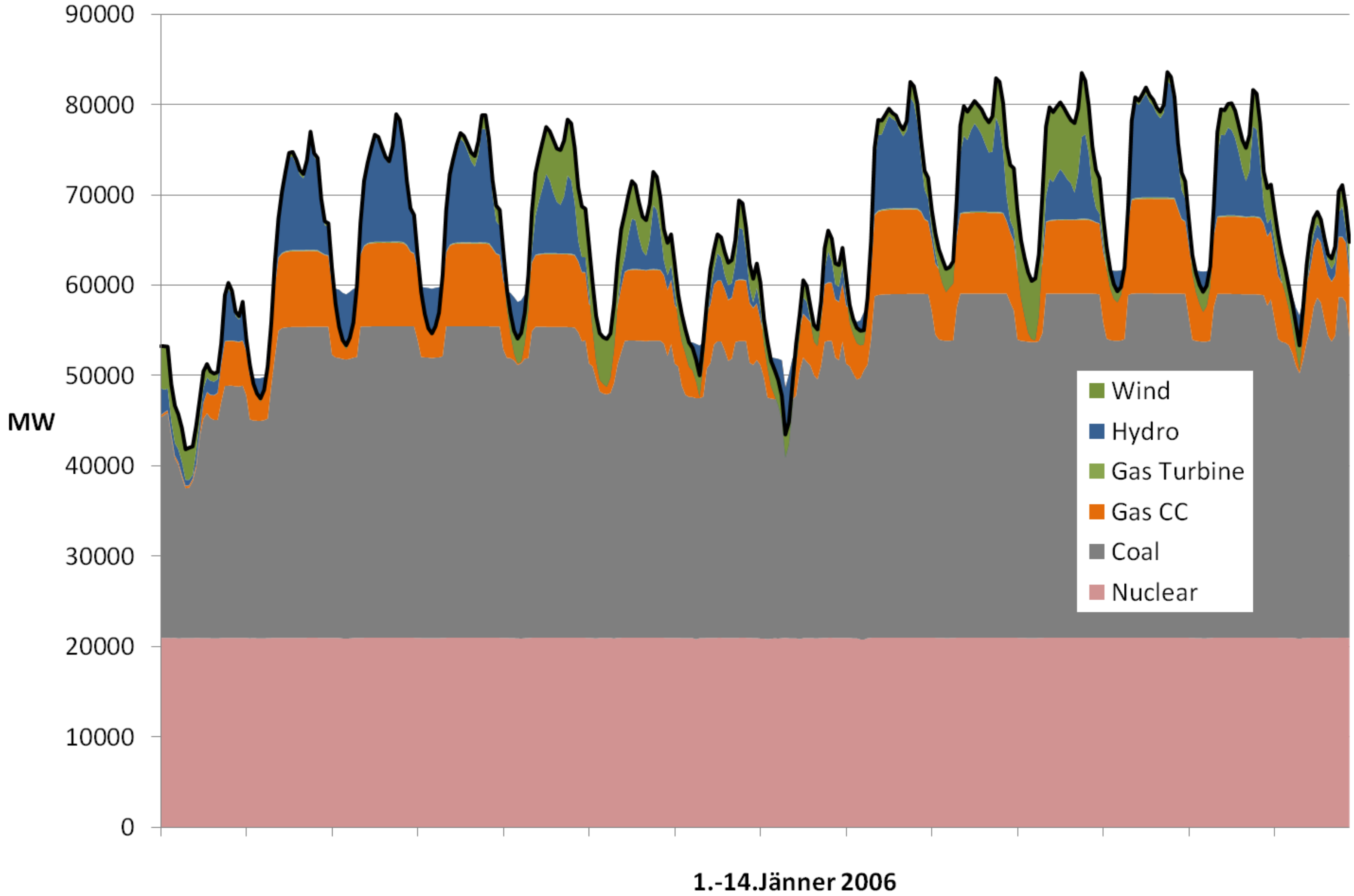


HiREPS

Detailed hourly unit commitment optimization and simulation:

- hydro power
- thermal power
- wind und solar
- Load flow
- Define: electromobility


Google Earth
Bearbeiten
Ansicht
Tools
Hinzufügen
Hilfe
© 2012 Google
© 2012 Europa Technologies
© 2012 Tele Atlas
© 2009 GeoBasis-DE/BKG
Breite 48.408359° Länge 11.938973° Höhe 483 m
Sichthöhe 521.40 km
Google earth


90000
80000
70000
60000
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Hydro
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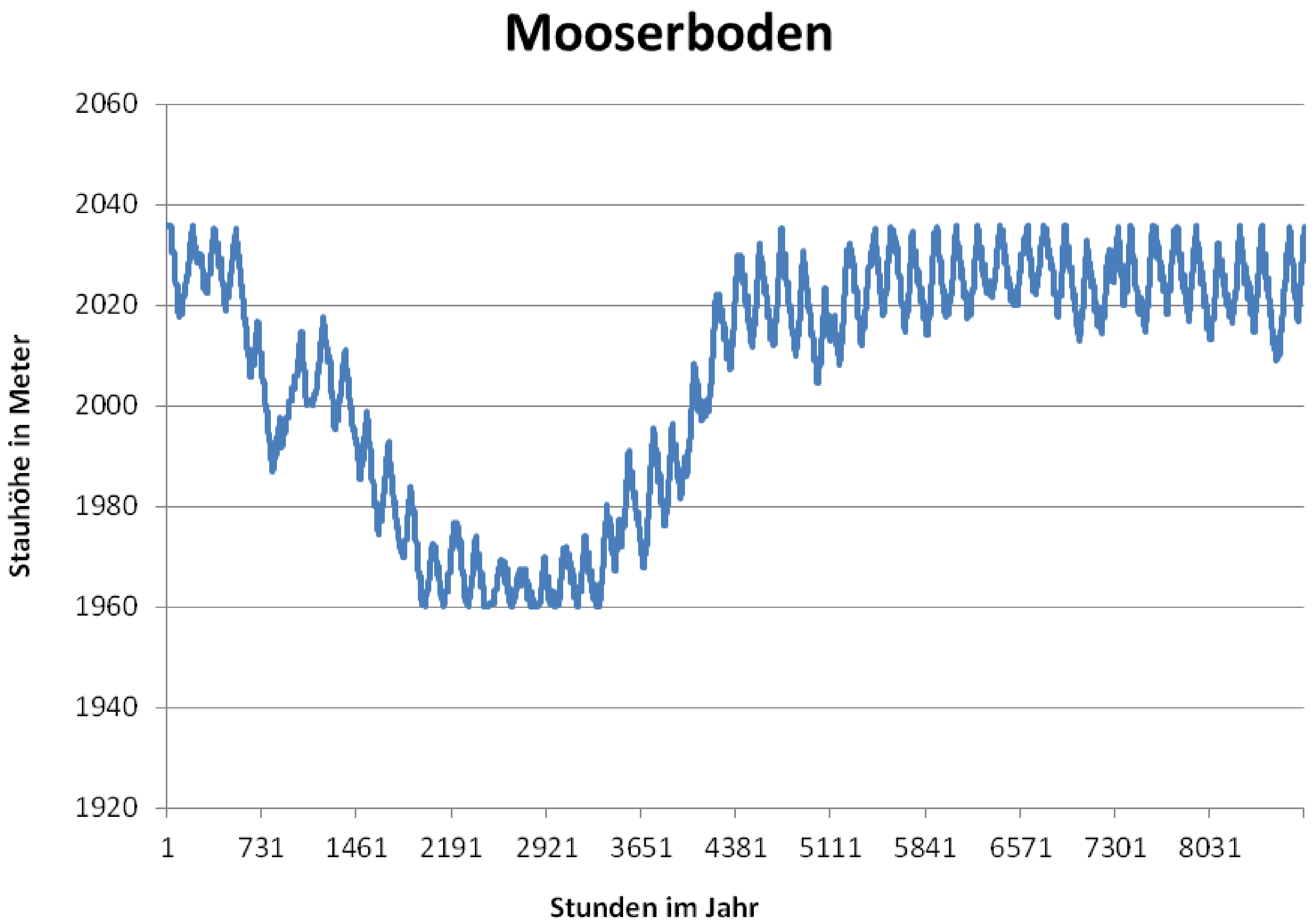
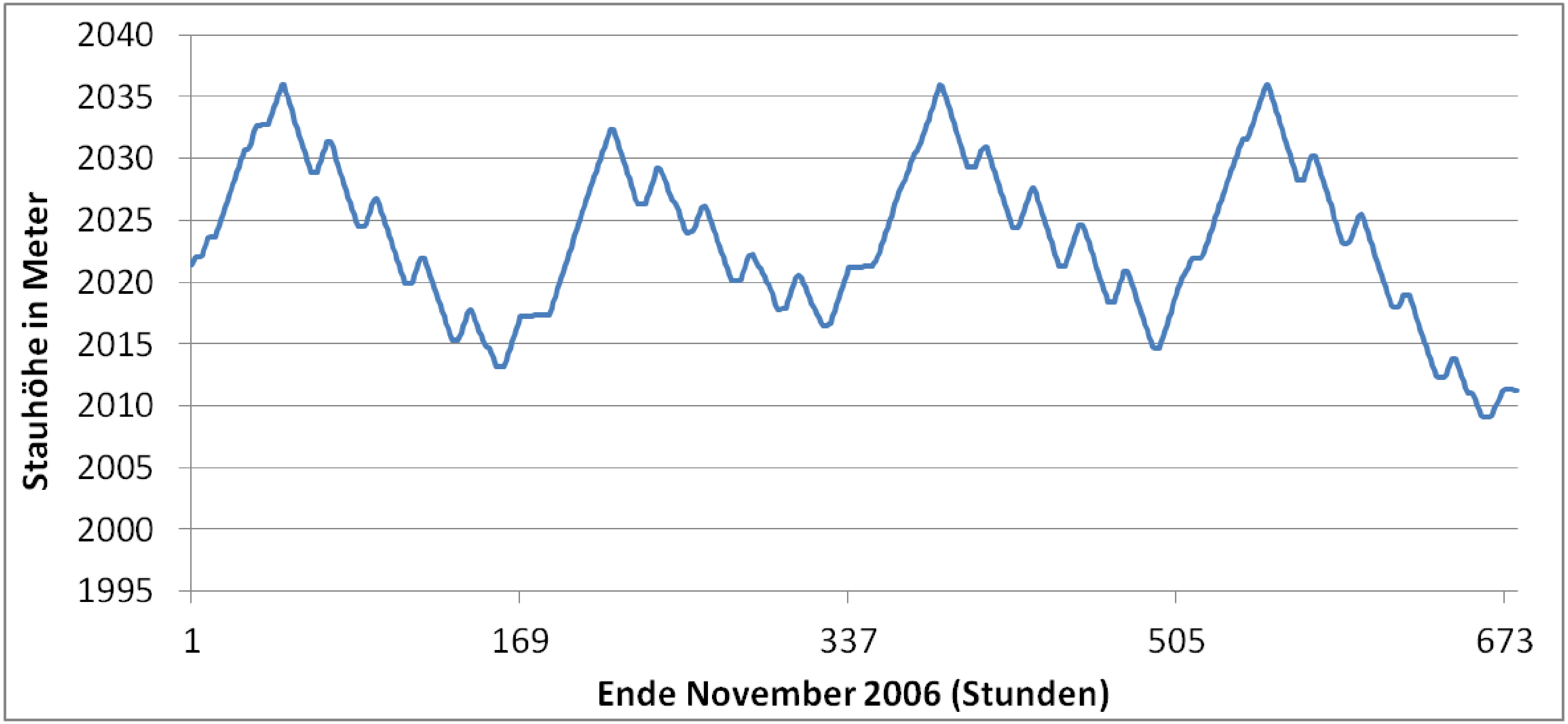
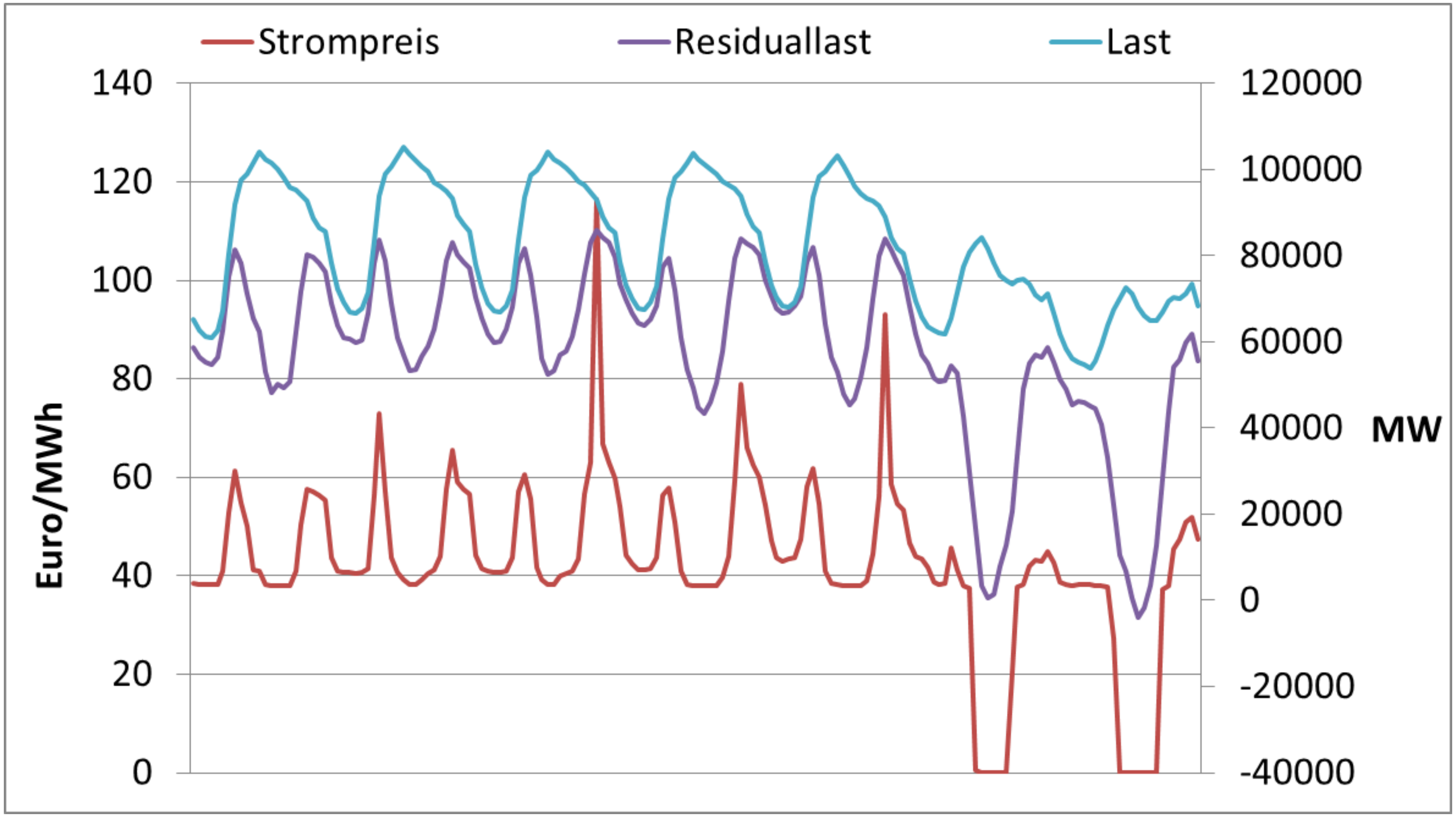
Coal
Nuclear
1.-14.Jänner 2006


Mooserboden
Stauhöhe in Meter
2060
2040
2020
2000
1980
1960
1940
1920
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
Stunden im Jahr

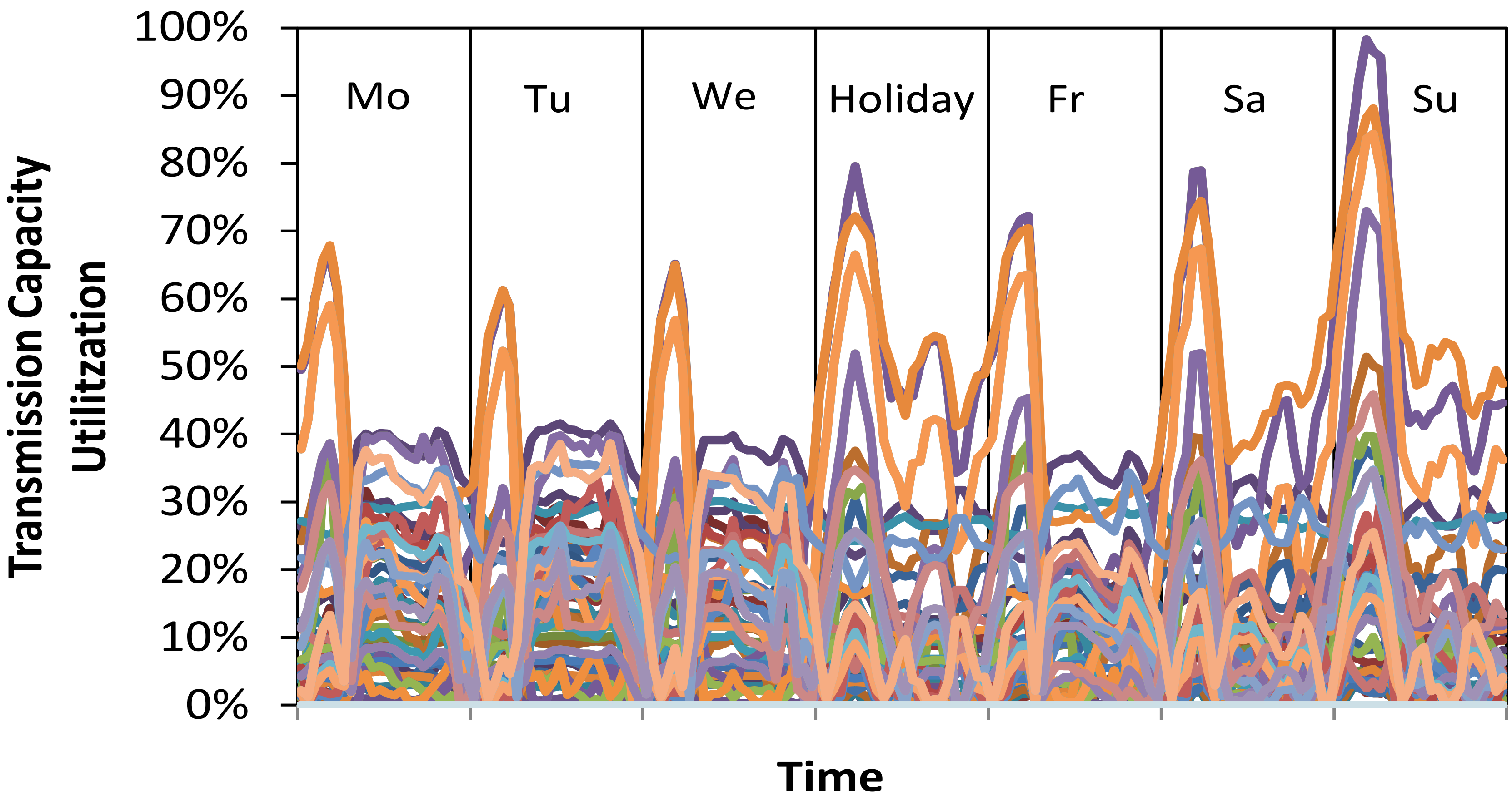
Mooserboden- Sommer



- Example Szenario: Total 23% of demand supplied by solar u. wind (presently 9%) in Austria and Germany



Combined unit commitment optimization and load flow calculation: 23.-29.10.2006



Generation of EV load profiles, developing charging strategies and analyzing the effects on the low voltage grid

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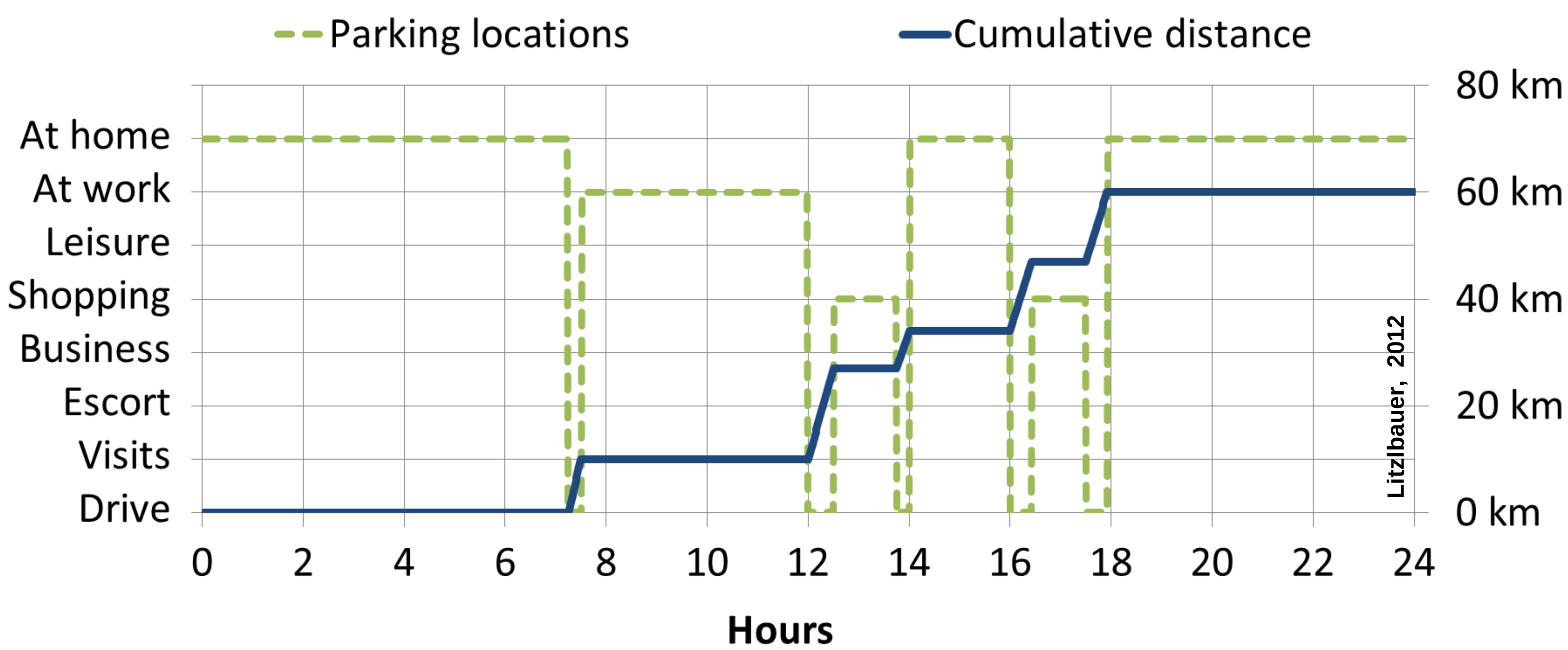
DEFINE, Kick-Off, June 14-15, 2012

Travel survey data

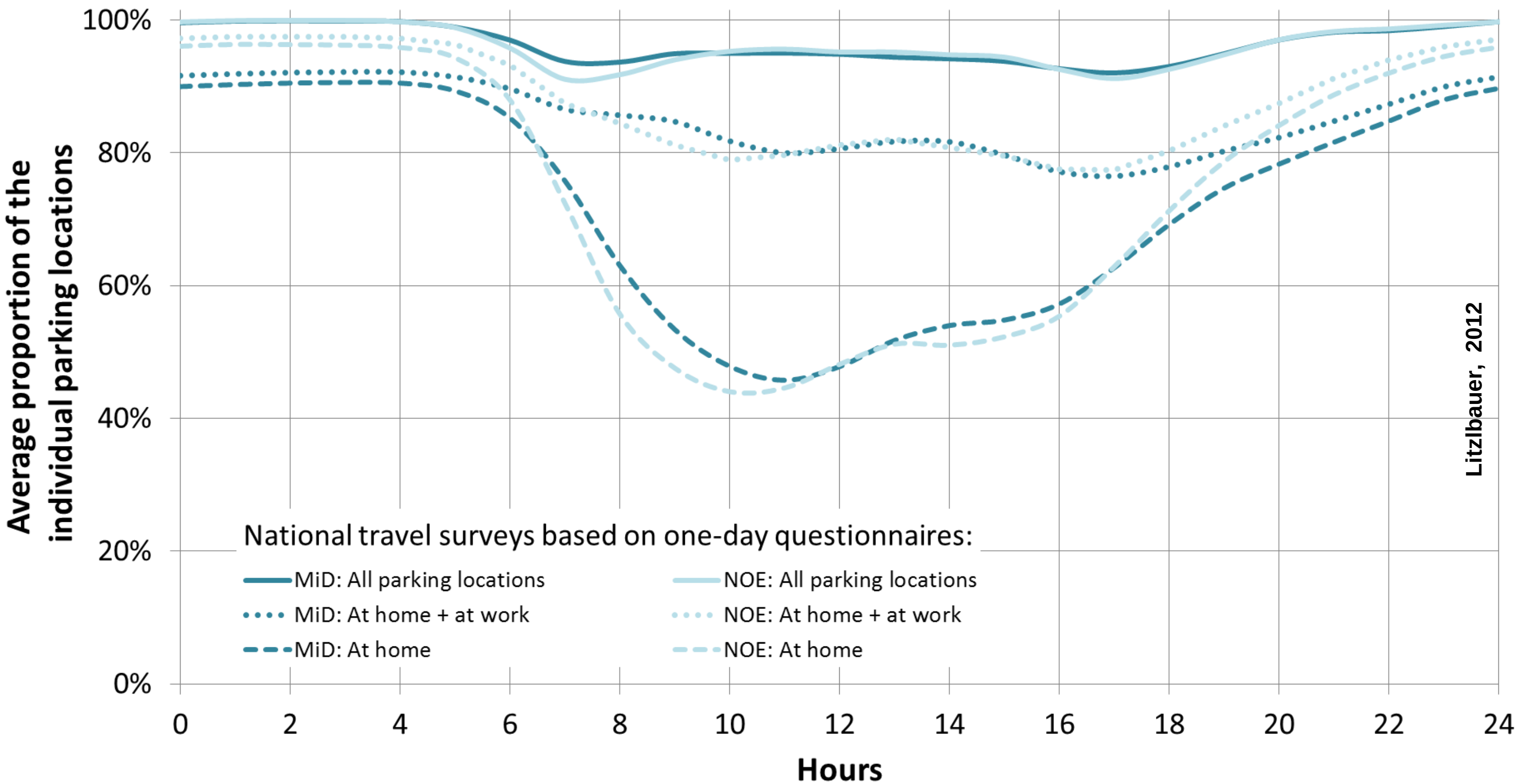
National travel survey – MiD 2008:

- Germany in the year 2008
- Based on one-day questionnaires
- Including weekdays and weekend
- Motorized individual transport
- About 21.000 vehicles extracted

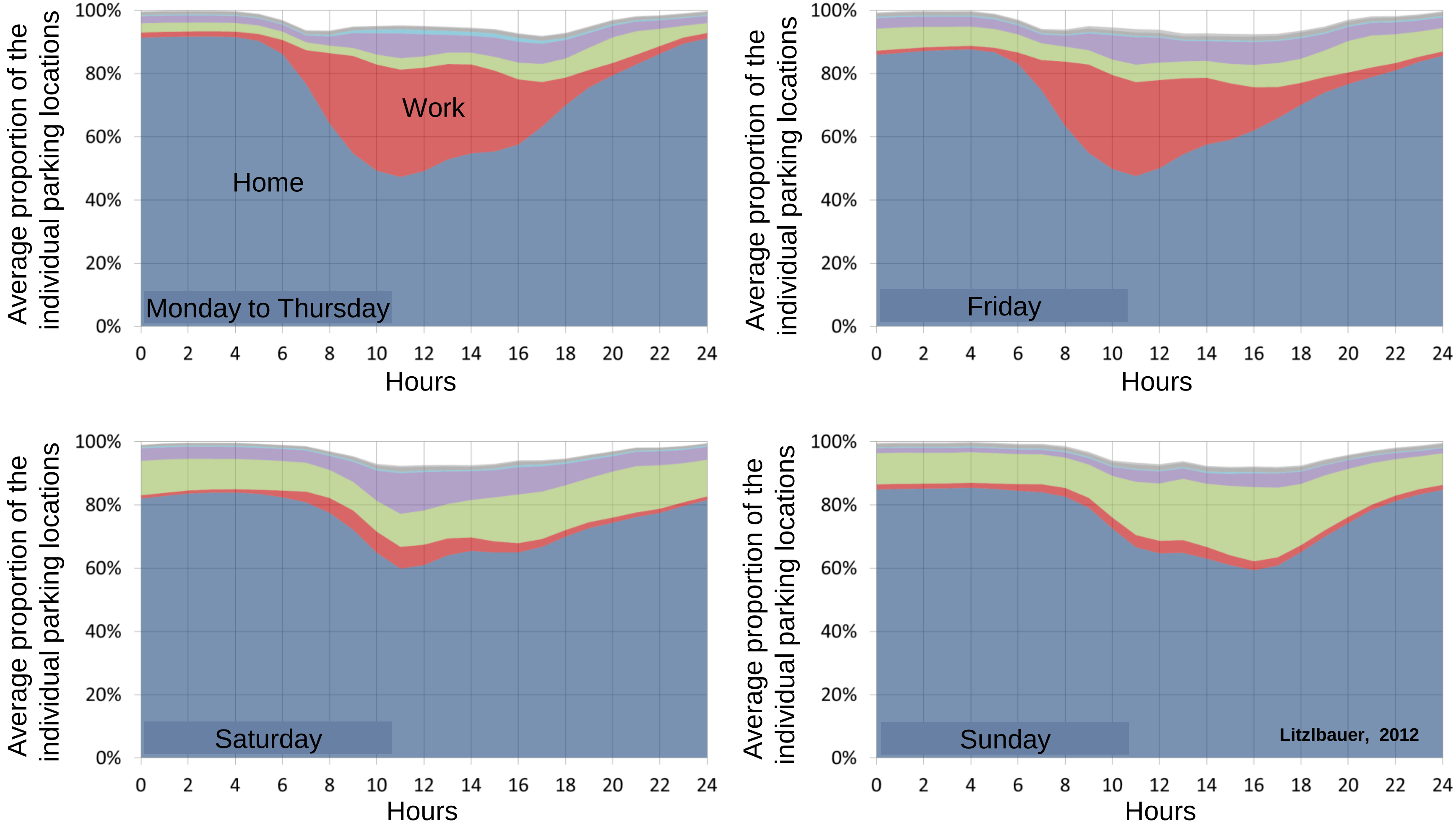


Distribution of parking locations

- About 90% of all vehicles park at home in the night and max. 35% park at work between 10:00 and 10:30 am.
- The next common parking locations are „Leisure“ and „Visiting friends“. However, they never achieve individually a proportion over 7%.

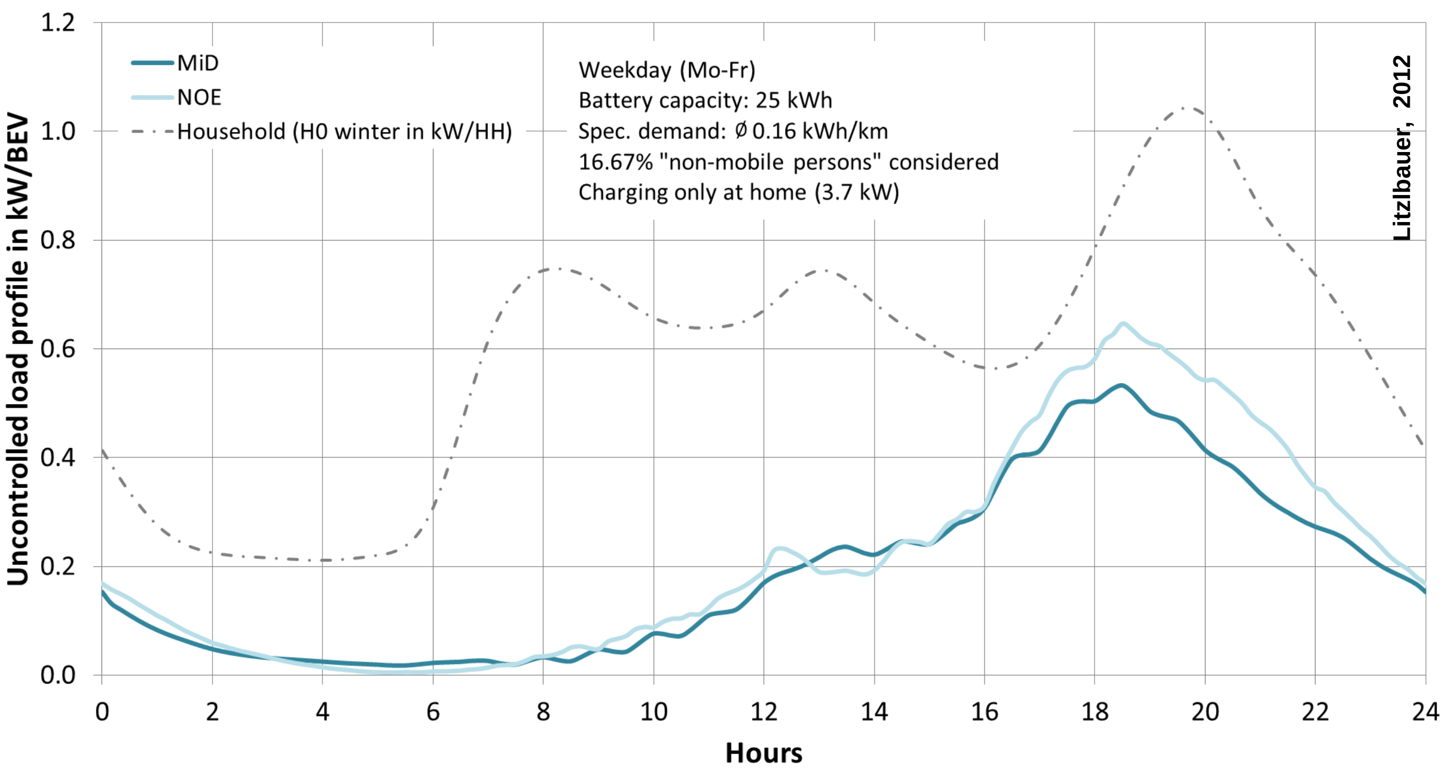


Differences between Mo-Th, Fr, Sa and Su



Uncontrolled charging profiles

- Charging starts immediately after arriving at home with 3.7 kW.
- The peak of the total load profile occurs at around 6:30 p.m. and is about 0.60 kW / BEV.
- This case would lead to a significant increase of peak load in the distribution grid in the evening.



Charging strategies and grid analysis

To prevent overloading:

- Expanding the charging infrastructure (e.g. at work)
- Using controlled charging

The choice of the energy source plays an important role ▪▪▪▶

PV-based charging strategy:

- Cover the charging demand by using photovoltaic
- Locally and at the same time
- The charge events must be shifted from evening to midday

Effects on the distribution grid:

- Load flow analysis: e.g. MATLAB <=> PSS SINCAL
- Dynamic model: Adjusting the charging strategy when grid problems occur (power, voltage)
- Using distribution grid models from other research projects

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Participation of EVs on the control energy markets in Austrian control area (APG)

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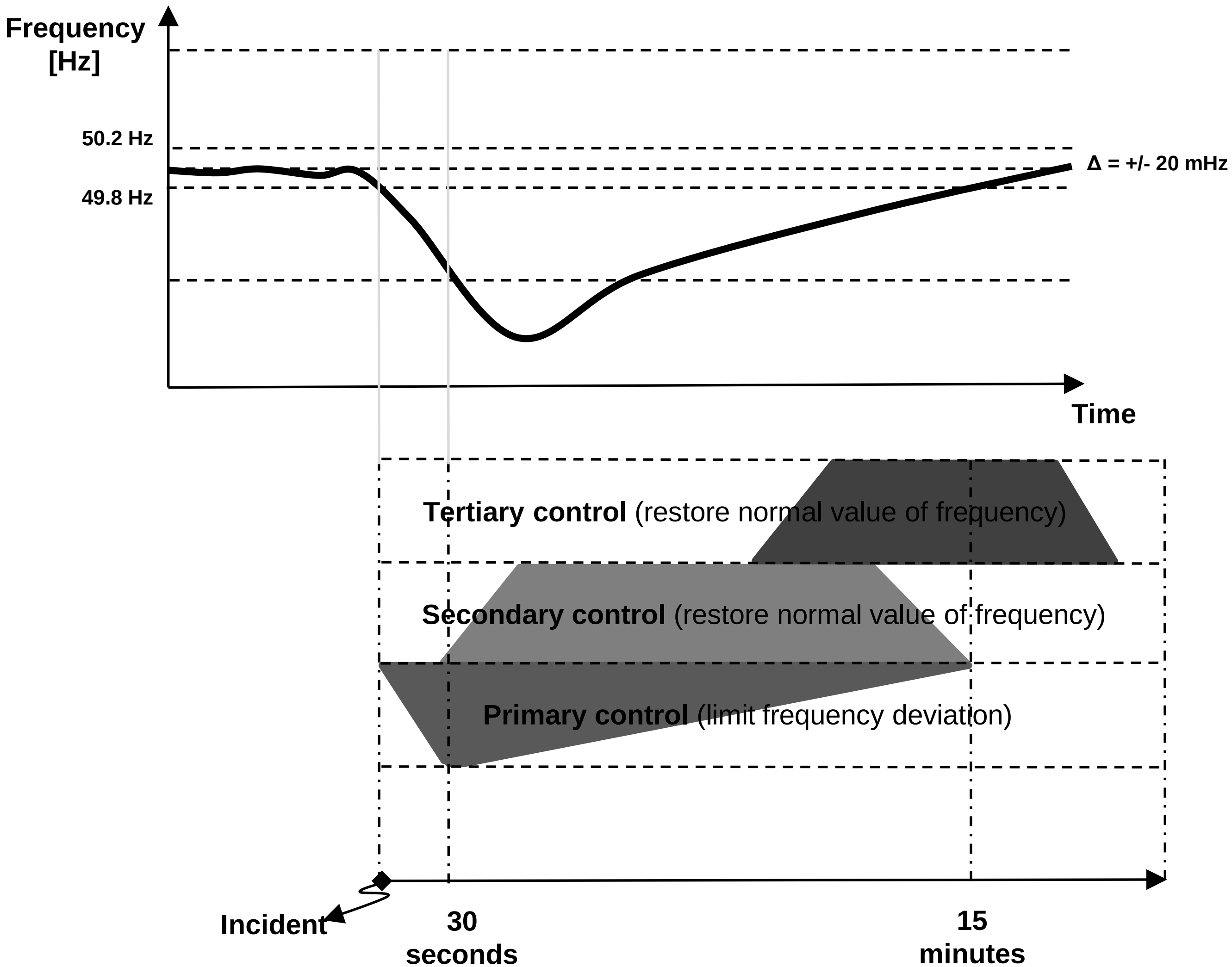
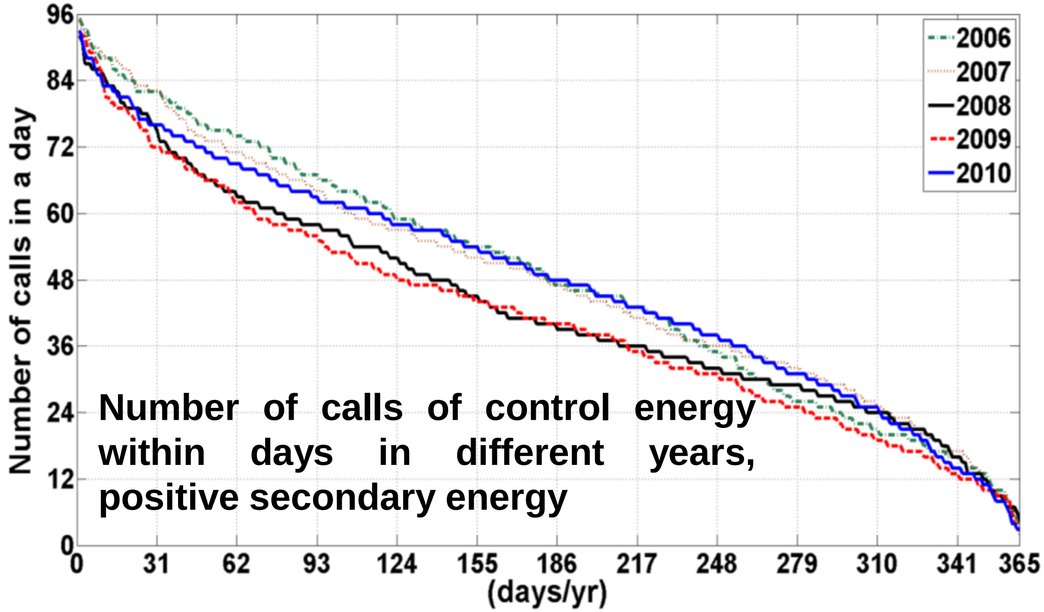
DEFINE, Kick-Off, June 14-15, 2012

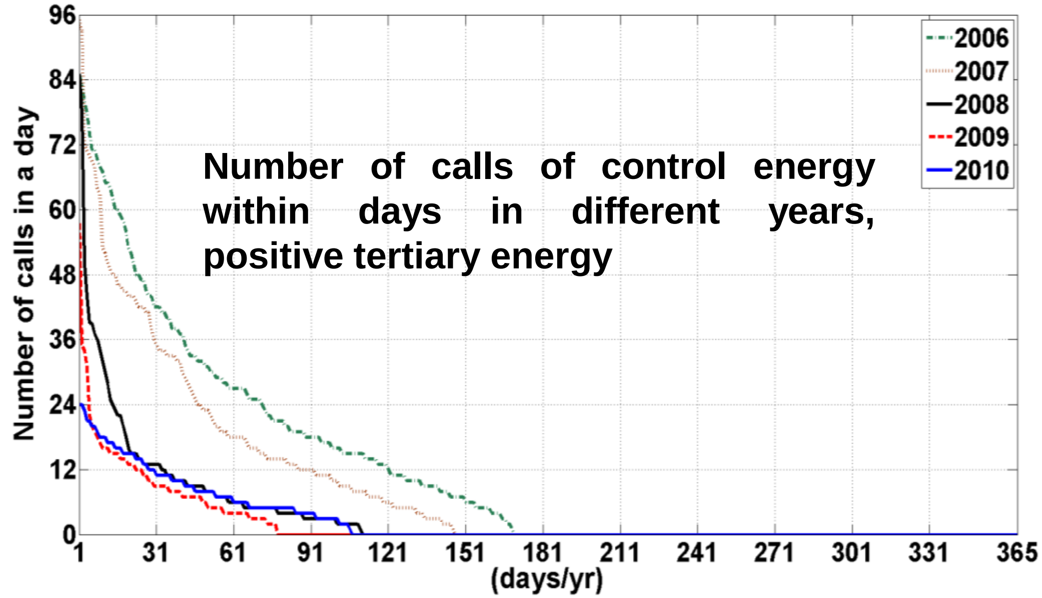
Control energy (retrieval of control reserve)



[1] Own description
[2] Marvin Steinböck: „Integration of electric vehicles in a smart grids platform: The case of Austria“, master thesis, Supervisor: R. Haas, R. Rezania, Technical University of Vienna, Department of Energy Economics Group, April 2011

Called control energy in APG

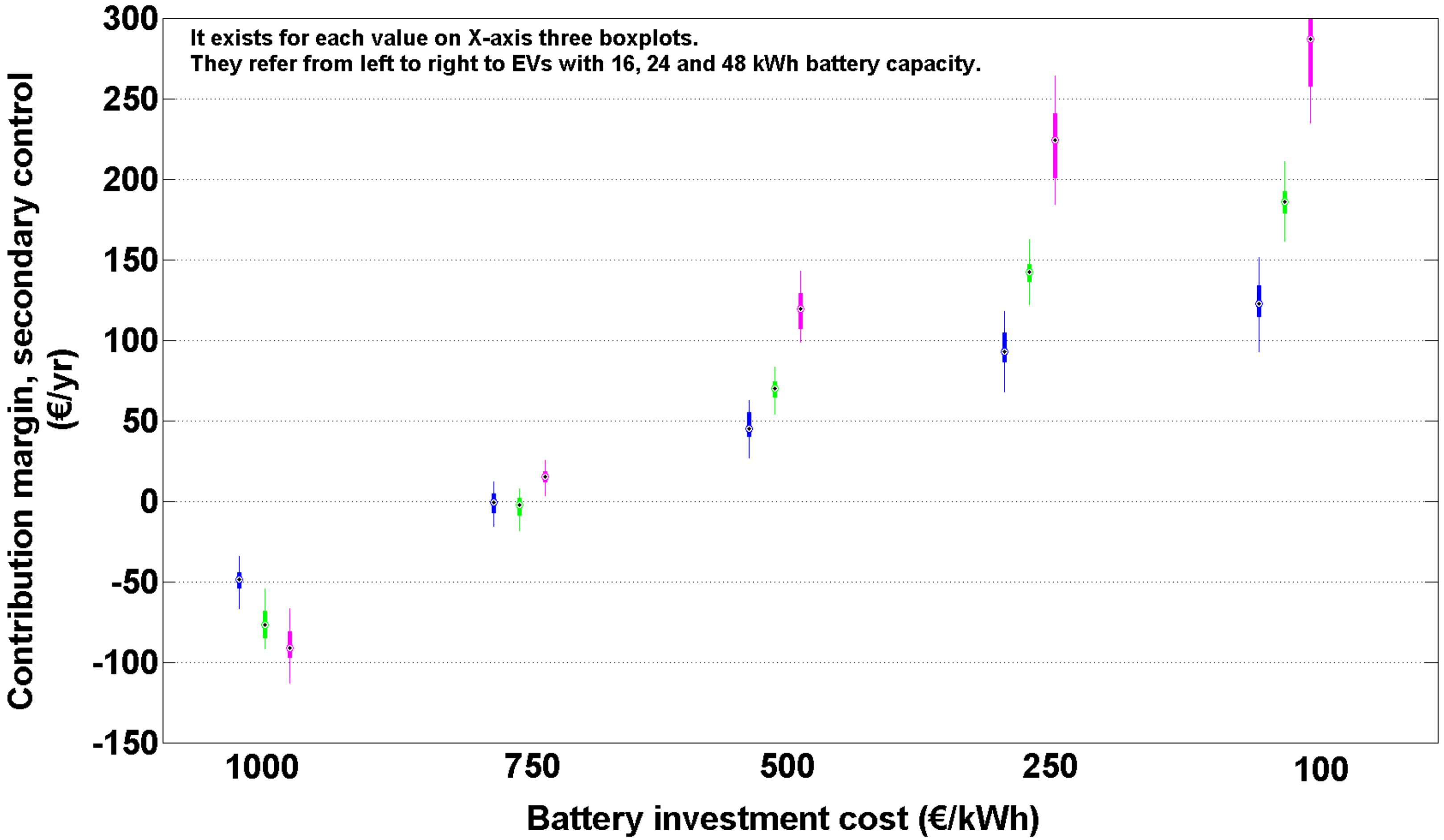




Assessment of V2G/ G2V use cases

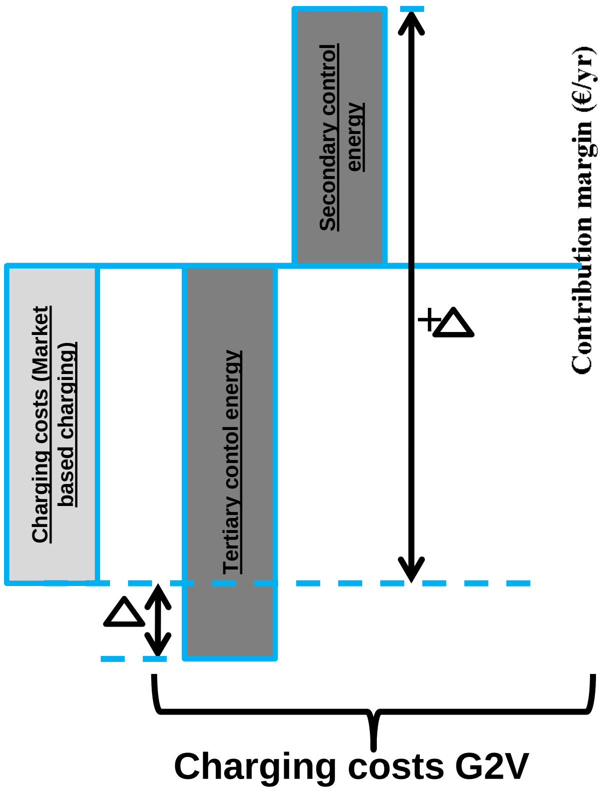
- Definition of different EV- categories with various battery capacities and the associated driving patterns
- Using a main charging strategy: Cost optimum charging of vehicles
- Simulation of control energy demand in Austrian power grid based on historical data
- Battery characteristics such as charging pattern and degradation due to discharging based on laboratory experiences
- Calculation/ Estimation of development of energy and power prices in control energy market as well as the energy exchange market for 2020

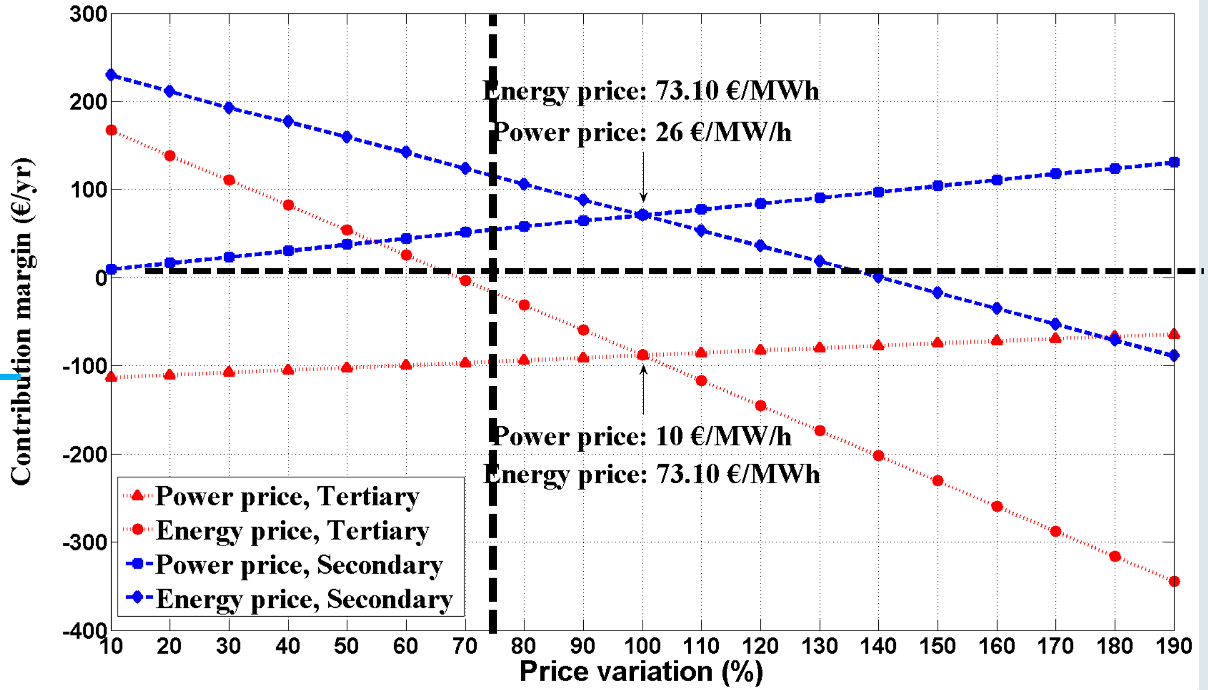
Provision of positive control energy (V2G)



<u>Positive secondary control energy</u>

Negative tertiary and secondary control energy





In Comparison with other studies/papers

Sources	Analyzed region	Participated market	Net Profit €/Month/Vehicle	Regulation power	Battery/ Vehicle constraints
Kempton and Tomic 2005	USA	Regulation up and down	**112-165**	10-15 kW	Electric drive vehicles
Tomic and Kempton 2007	USA, Four different control areas	Regulation down (Th!nk City) Regulation down and up (Toyota RAV4)	**4.3 – 43 (Th!nk City) 6 – 64 (Toyota RAV4)**	6.6 kW	100 Th!nk City vehicles (Nicd) ,252 Toyota RAV4 (NiMH)
Larsen et.al. 2008	Denmark	Secondary and Tertiary control	**6 – 160**	power: 2 kW, 20 kW, 20 kW	EDV: Capacity: 5 kWh, 5 kWh, 20 kWh,
Camus et.al. 2009	Portugal	Secondary and Tertiary control	**18**	3.5 kW	Plug-in Hybrid and electric vehicles
Andresson et.al. 2010	Sweden/ Germany	Control energy market	**30 – 80 (Germany, coal fired power plants) -19 – 7 (Sweden, Hydro power plants)**	3.5 kW	Plug-in hybrid EV (10 kWh , Maximum depth of discharge 20 %) Charging and discharging efficiency are 94 %.
V2G-Strategies 2011	Austria	Secondary and Tertiary control	**-7.32 – 63.94**	10.5	Electric Vehicles (16 kWh, 24 kWh, 48 kWh)

Conclusion

- Participation of Evs in Austrian control energy markets
  - The calculation of G2V and V2G contribution margins doesn’t consider the main costs like communication infrastructure, aggregator’s energy management system and V2G inverter. Therefore, an economic realization of V2G (G2V) concepts (participation on the control energy market in Austria) with a maximum margin from -7.32 to 63.94 €/vehicle/month can hardly be recommended.
  - The G2V application for participation on the negative secondary control market has a better economic potential compared to the V2G application. The reasons lie in a higher number of control energy calls and non-existing battery degradation costs.

Rezania, R., Prüggler, W.: Business models for the integration of electric vehicles into the Austrian energy system, Peer reviewed paper, 9th international conference on European Energy Market (EEM12), Florence, Italy, May 2012

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