A Simulation Model for a Smart Home and Vehicle to Building Applications
AGENDA

project constellation

motivation

procedure

results

summary
the problem regarding the greenhouse gas emissions and the scarcity of resources

energy demand shall be reduced and the energy efficiency shall be increased

high-efficiency electrical consumers, innovative heating system in buildings and battery electric vehicles (BEVs) are expected to make its contribution in this challenge

studies show that the majority of future BEV-charging activities will take place at home

for a holistic consideration regarding energy demand and energy efficiency beside the car also the users home has to be considered
energy consumption by application types
- private households germany in 2008 -

- 47% - heating
- 36% - domestic hot water
- 7% - electric domestic appliances
- 8% - information and kommunikation equipment
- 1% - lightening
- 1% - car

Quelle: Arbeitsgemeinschaft Energiebilanzen; BDEW-P Gr “Nutzenergiebilanzen; DIW(Stand: 09/2010)"
energy consumption by energy source
- private households Germany in 2008 -

- electricity: 36%
- natural gas/heating oil: 9%
- gasoline/diesel: 55%
The projects aim:
- Detection of **synergetic effects** by considering both subareas as a **combined holistic system** to reduce the total energy consumption and increase the energy efficiency
- Development of an **operating strategy** which is using the synergetic effects to **minimize the total energy consumption** by a defined and intelligent use of the components
Monthly energy balance of a single-family house an one “BEV”
Thermal energy demand (ca. 24000 kWh/a) of a single-family-house per month
⇒ electrical energy generated by the CHP while covering the thermal energy demand
electrical energy generated by the CHP and the PV system
(CHP 1kW\textsubscript{el}; PV 9kW\textsubscript{peak})
electrical energy generated by the CHP and the PV system

$\Rightarrow$ el. energy demand of one BEV (2 x 20 km / day) and one house
electrical energy generated by the CHP and the PV system
electrical energy generated by the CHP and the PV system
The thermal building model

energy balance:
\[
\frac{dE_{building}}{dt} = dQ_{heat} + dQ_{gain} - dQ_{trans} - dQ_{ventilation}
\]

energy gradient:
\[
m_{building} \cdot c_{building} \cdot \frac{dT_{building}}{dt} = \frac{dE_{building}}{dt}
\]

thermal energy CHP:
\[
dQ_{heat} = m \cdot c_p \cdot (T_{fl} - T_{rl})
\]

internal gains:
\[
dQ_{gain} = 2,1 \frac{Wh}{m^2} \cdot A_{living\space space}
\]

heat losses:
\[
Q_{trans} = \sum_i A_i \cdot U_i \cdot (T_{room} - T_{ambient})
\]

ventilation:
\[
dQ_{ventilation} = 0,3 \cdot V_{building} \cdot c_{air}
\]
The micro-combined and power unit

- manufacturer: Remeha (NL)
- fuel: natural gas
- compact device for wall mounting

- stirling engine
  - linear generator
  - thermal power: 5kW
  - electrical power: 1kW

- integrated additional burner
  - gas-condensing boiler
  - thermal power: 18kW
thermal simulation of a building – 3 days in January temperatures and hating water mass flow
Thermal power output - micro-combined heat and power unit – 3 days in January
electrical power output - micro-combined heat and power unit – 4 days in January
electrical power CHP and building – 4 days in January
electrical power CHP, building and PV system – 4 days in January
electrical power CHP, building, PV system and battery electric vehicle – 4 days in January
electrical power CHP, building, PV system and battery electric vehicle – 4 days in January
electrical power CHP, building, PV system and battery electric vehicle – 3 days in July
electrical power CHP, building, PV system and battery electric vehicle – 3 days in July
model structure – “house” and “BEV”

user behavior

- weather data (temperature)
- nominal-room temperature
- domestic hot water demand

electric load profile

- thermal building model with CHP

- CHP covering of electrical building load

- electrical energy demand - BEV

- thermal energy demand
- room temperature
- fuel quantity

- electric load profile

- user behavior

- model structure – “house” and “BEV”
thank you