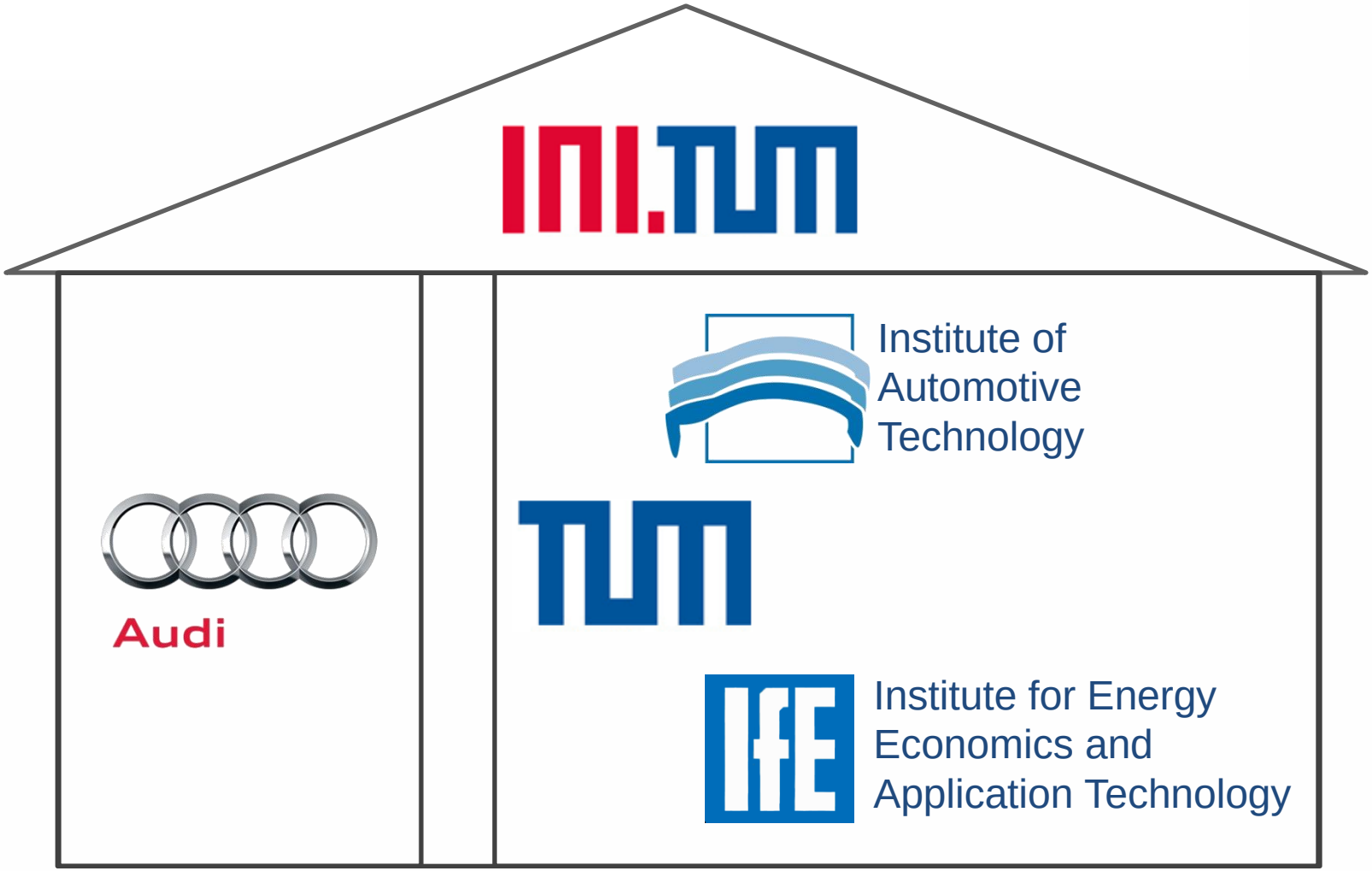
A Simulation Model for a Smart Home and Vehicle to Building Applications

AGENDA

- project constellation
- motivation
- procedure
- results
- summary


Audi
Institute of Automotive Technology
Institute for Energy Economics and Application Technology

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**

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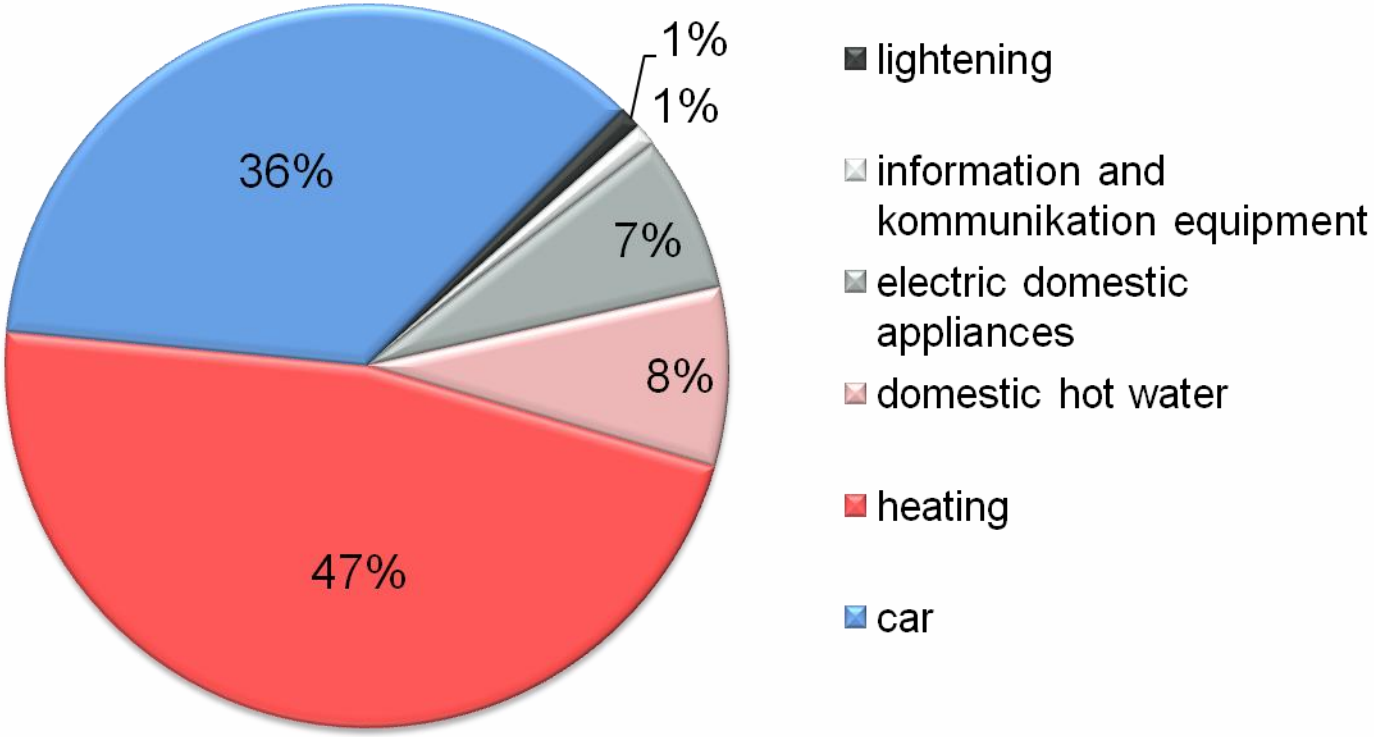
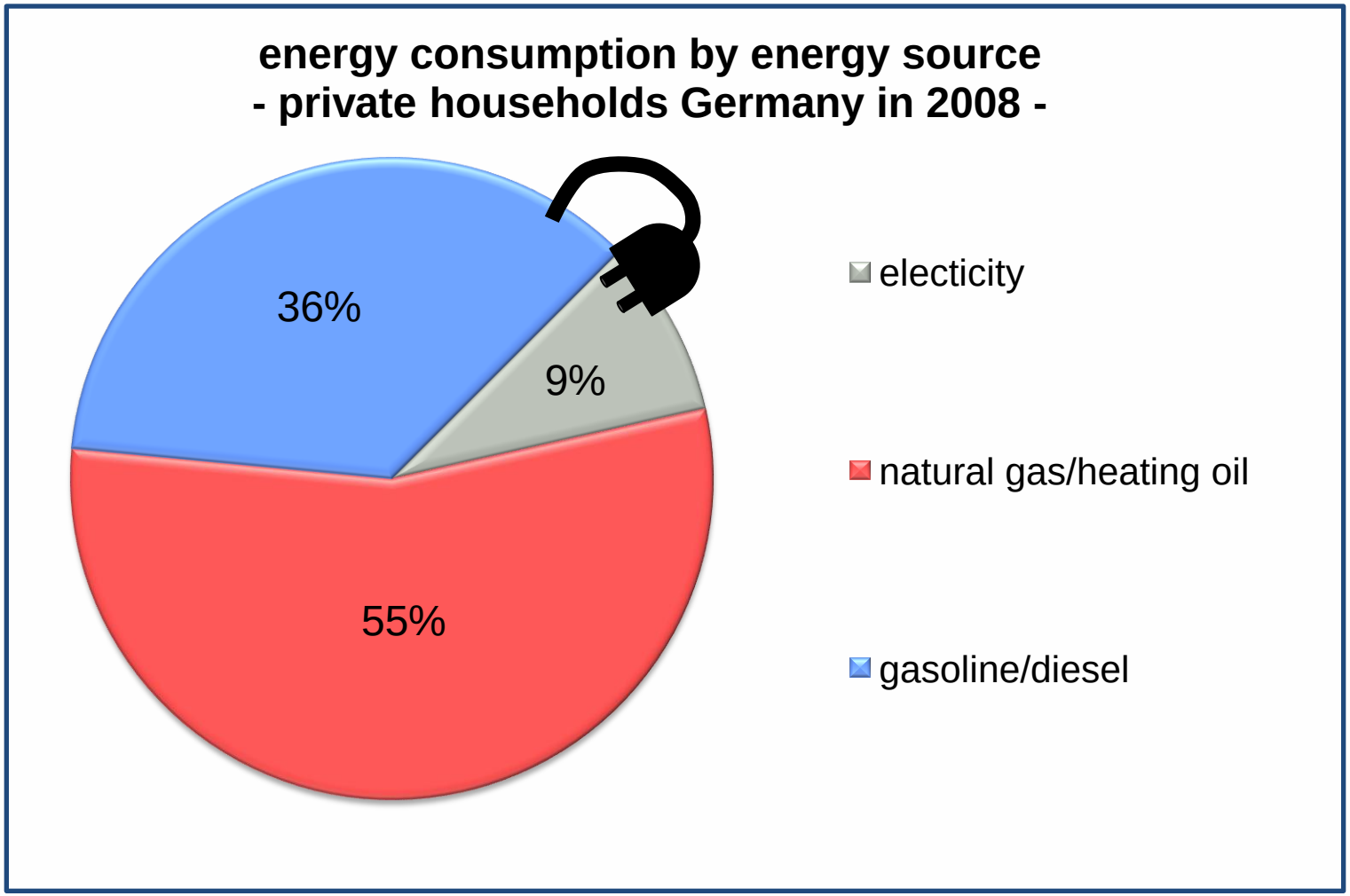
for a holistic consideration regarding energy demand and energy efficiency beside the **car** also the users home has to be **considered**

energy consumption by application types - private househoulds germany in 2008 -

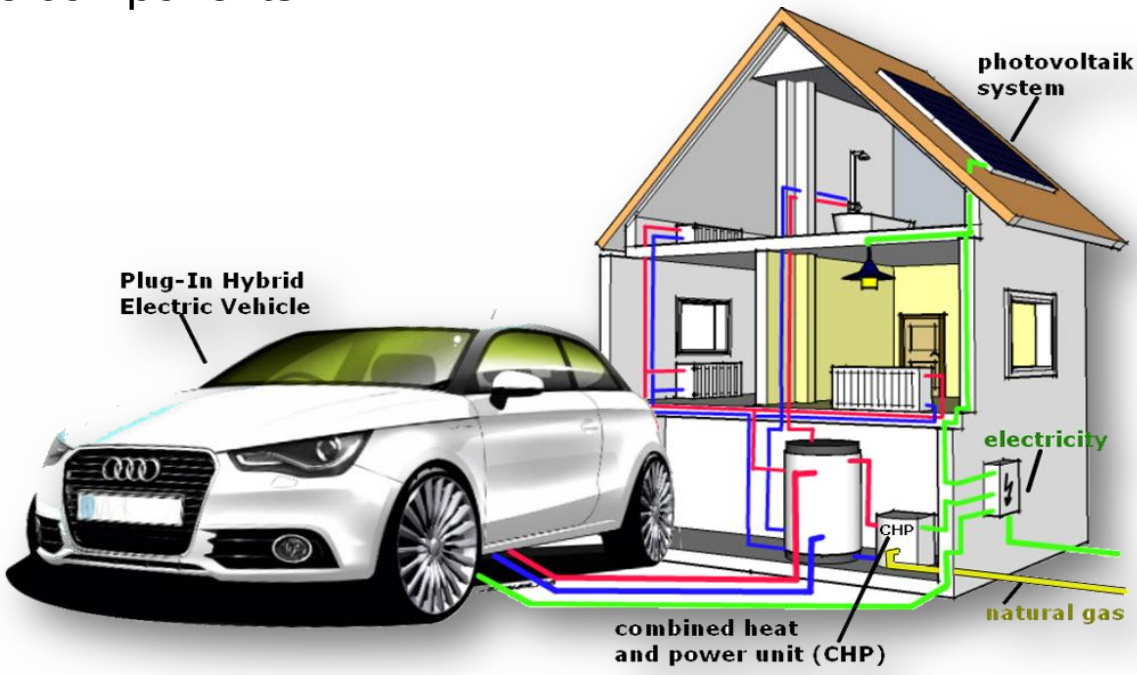


Quelle: Arbeitsgemeinschaft Energiebilanzen; BDEW-P Gr “Nutzenergiebilanzen; DIW(Stand: 09/2010)“

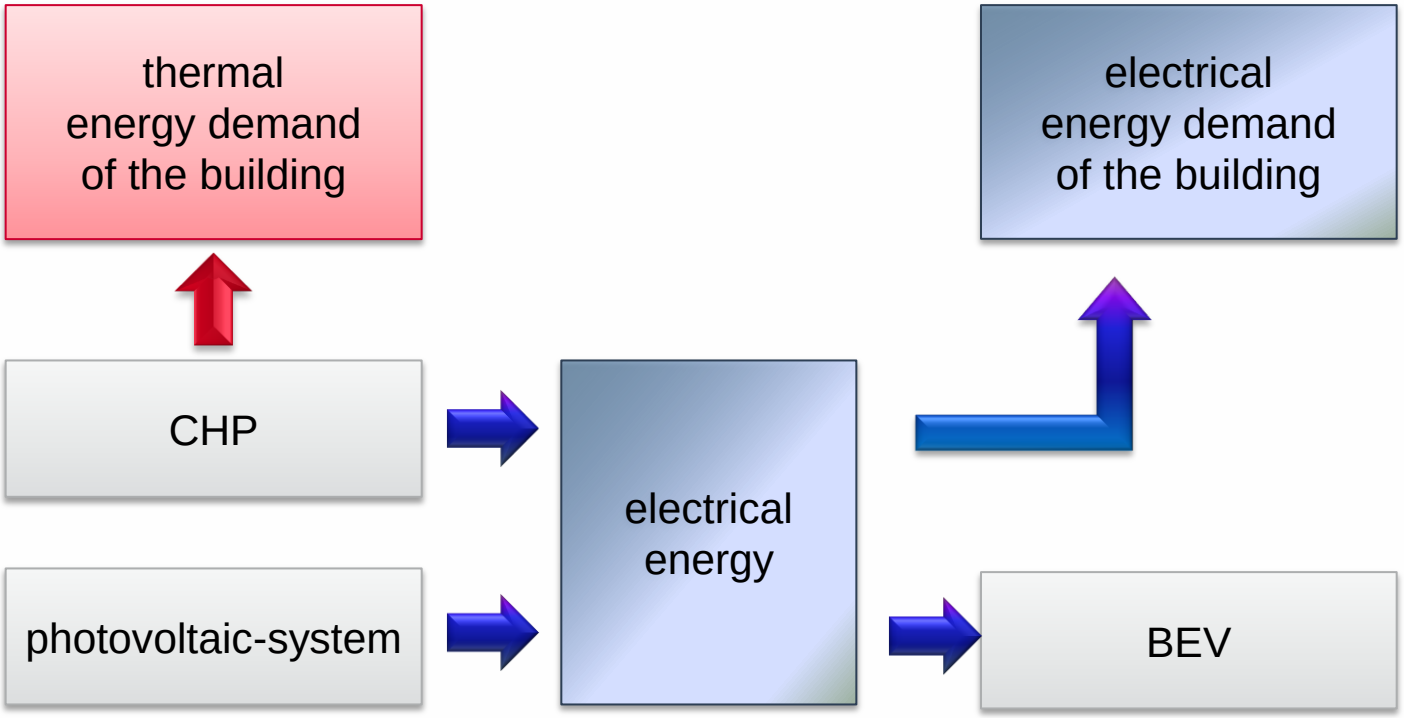

energy consumption by energy source
- private households Germany in 2008 -
36%
9%
55%
electicity
natural gas/heating oil
gasoline/diesel

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

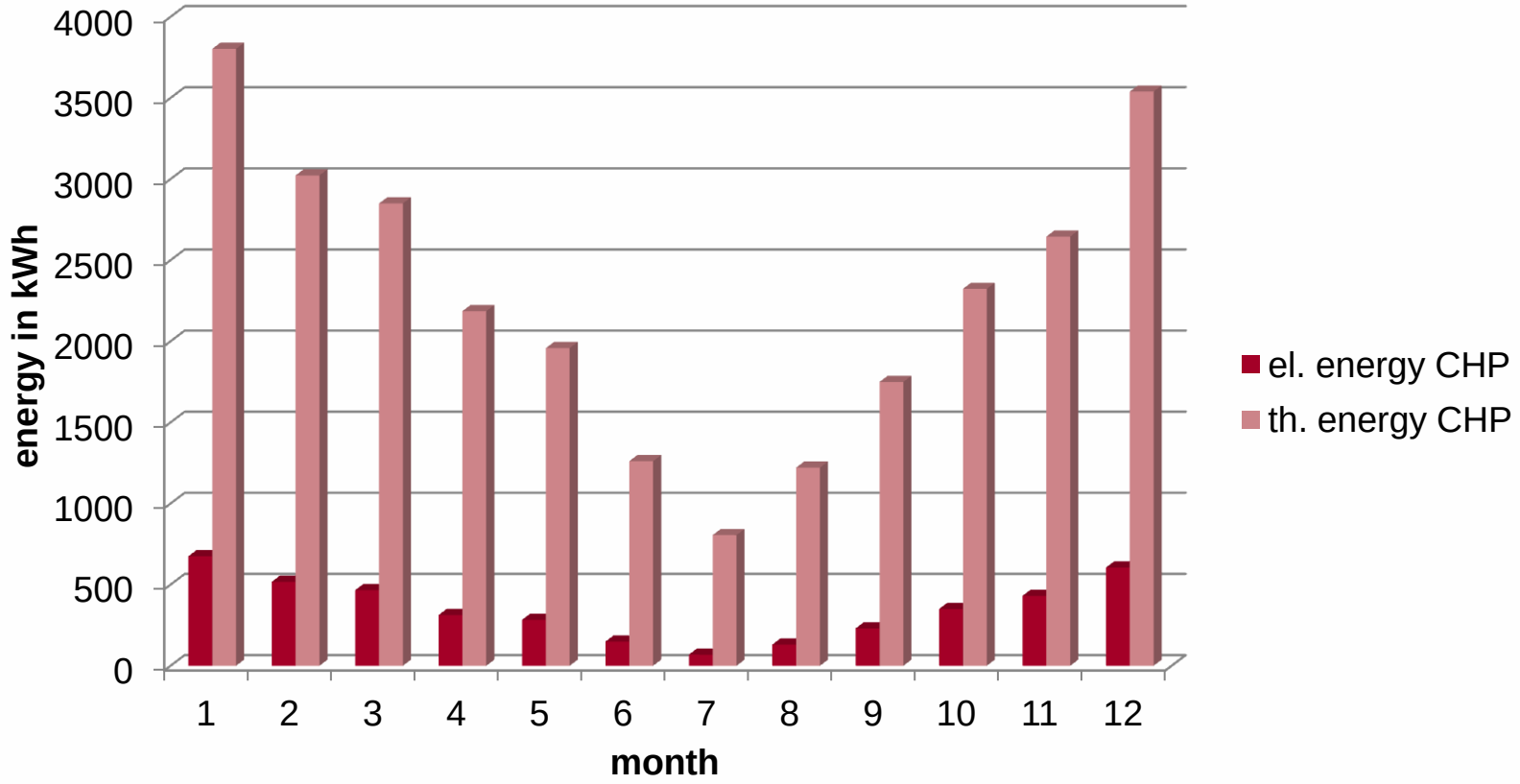


Monthly energy balance of a single-family house an one “BEV”

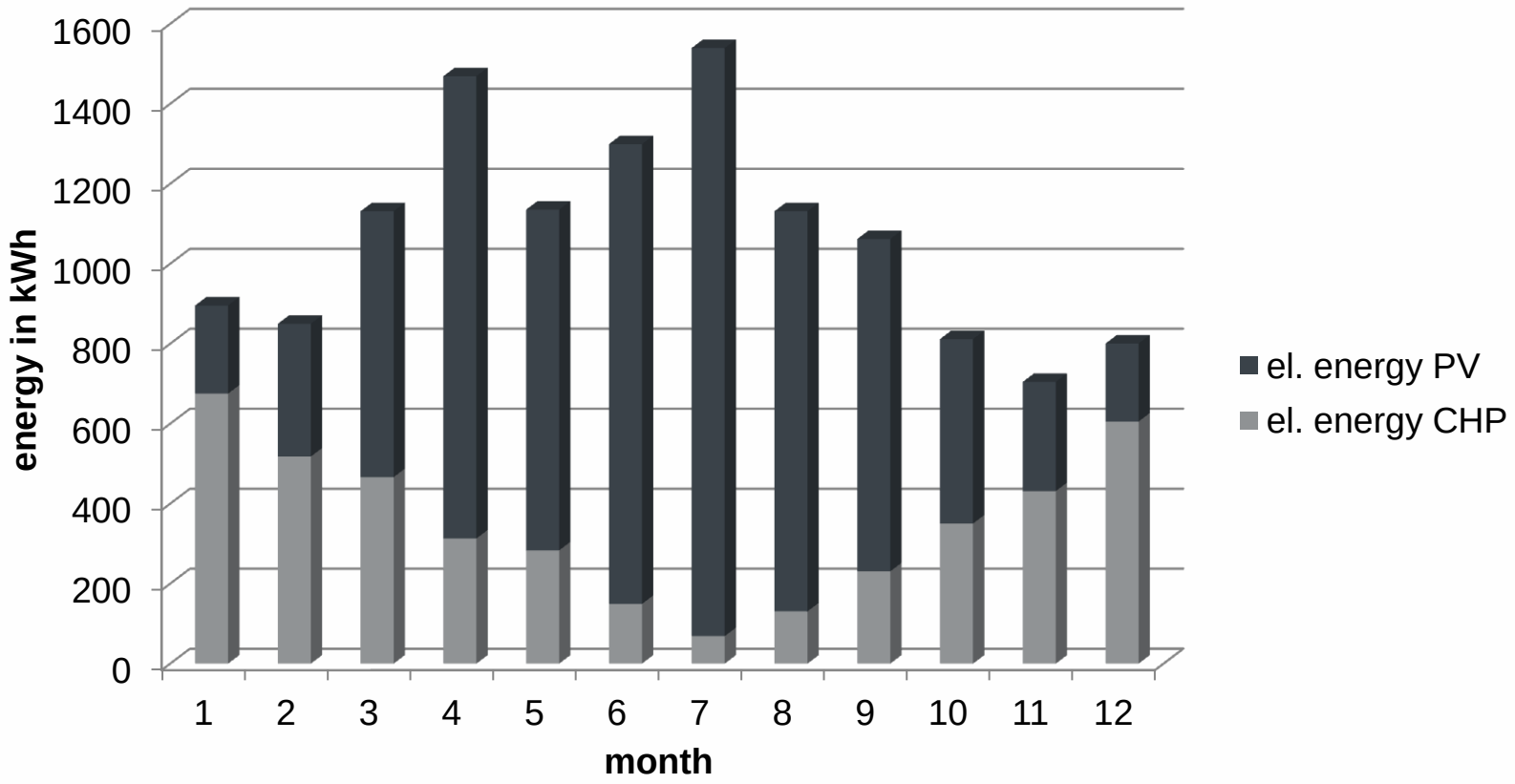


Thermal energy demand (ca. 24000 kWh/a) of a single-family-house per month

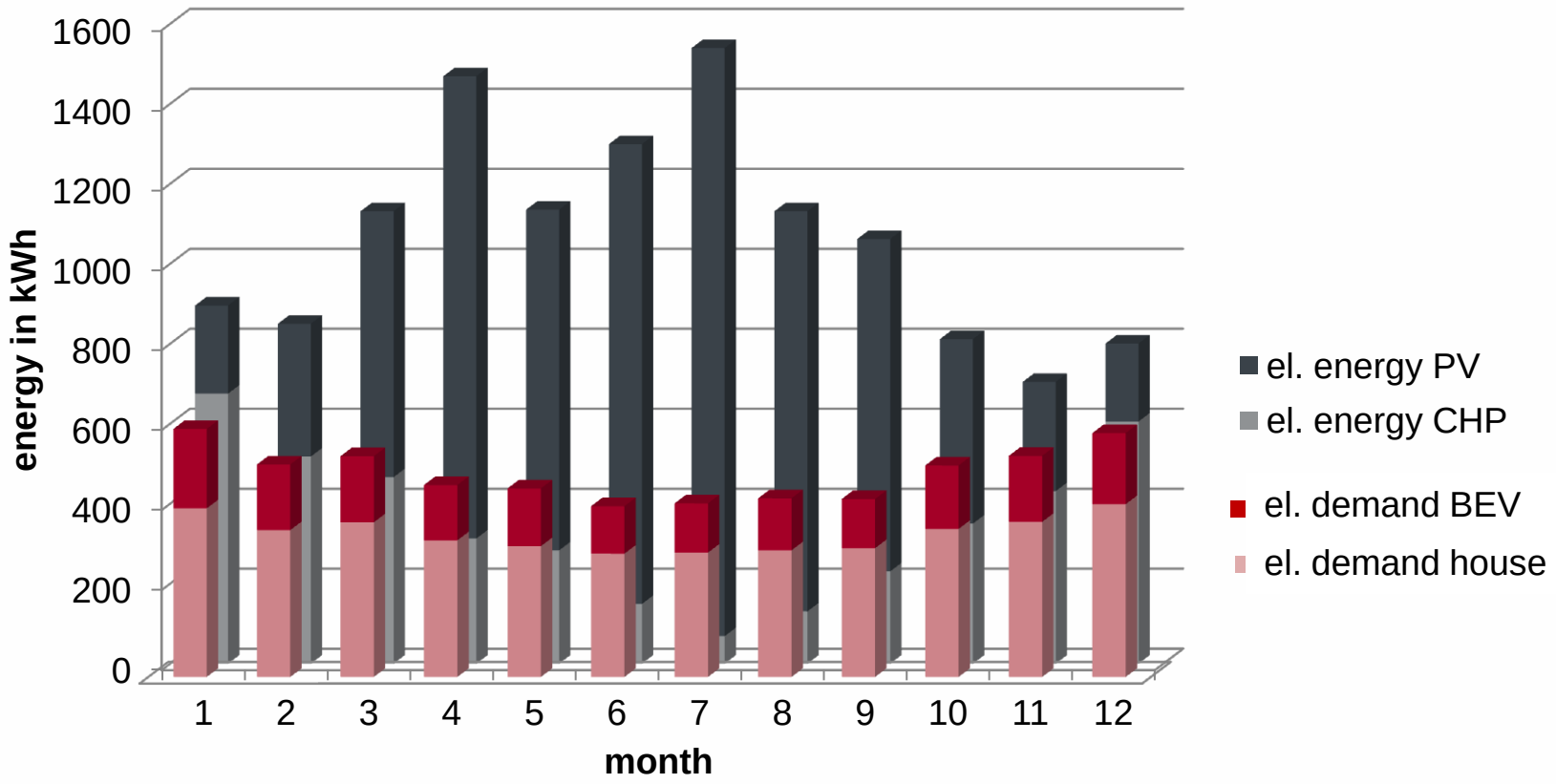
⇒ electrical energy generated by the CHP while covering the thermal energy demand



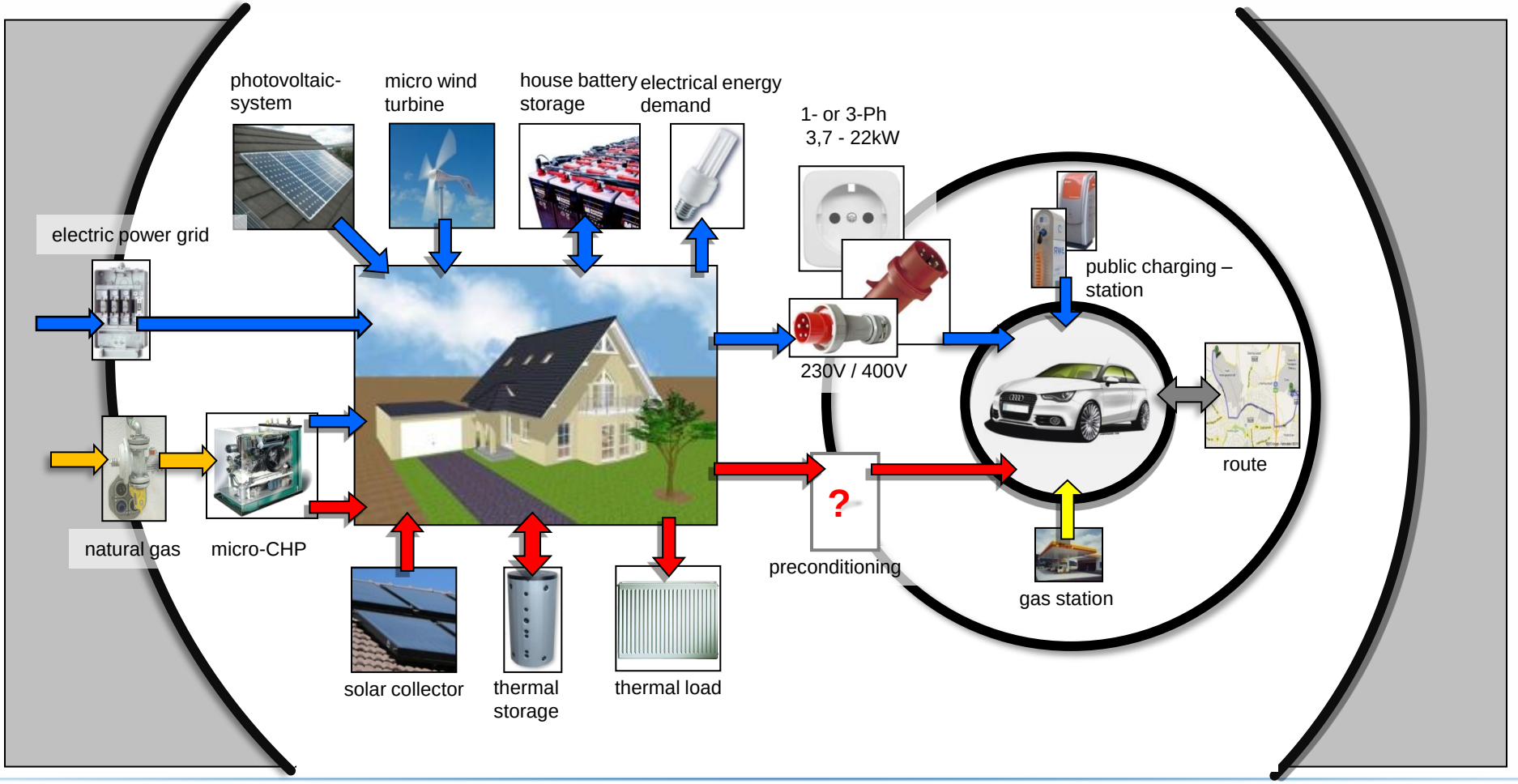
electrical energy generated by the CHP and the PV system (CHP 1kW$_{el}$; PV 9kW$_{peak}$)



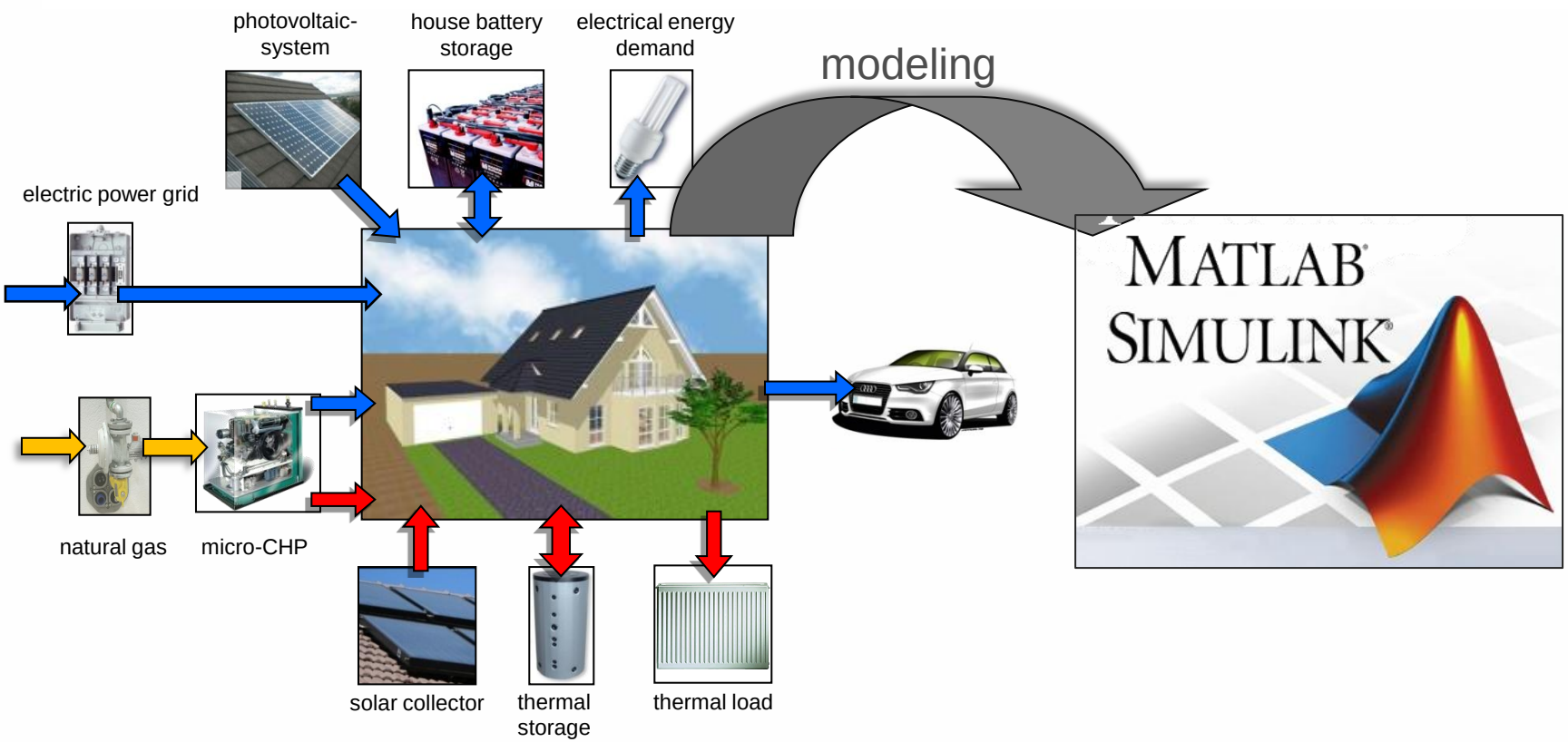
electrical energy generated by the CHP and the PV system
=> el. energy demand of one BEV (2 x 20 km / day) and one house



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:

$$dQ_{heat} = \dot{m} \cdot c_p \cdot (T_{fl} - T_{rl})$$

internal gains:

$$dQ_{gain} = 2{,}1 \frac{Wh}{m^2} \cdot A_{livingspace}$$

heat losses:

$$Q_{trans} = \sum_i A_i \cdot U_i \cdot (T_{room} - T_{ambient})$$

ventilation:

$$dQ_{ventilation} = 0{,}3 \cdot V_{building} \cdot c_{air}$$

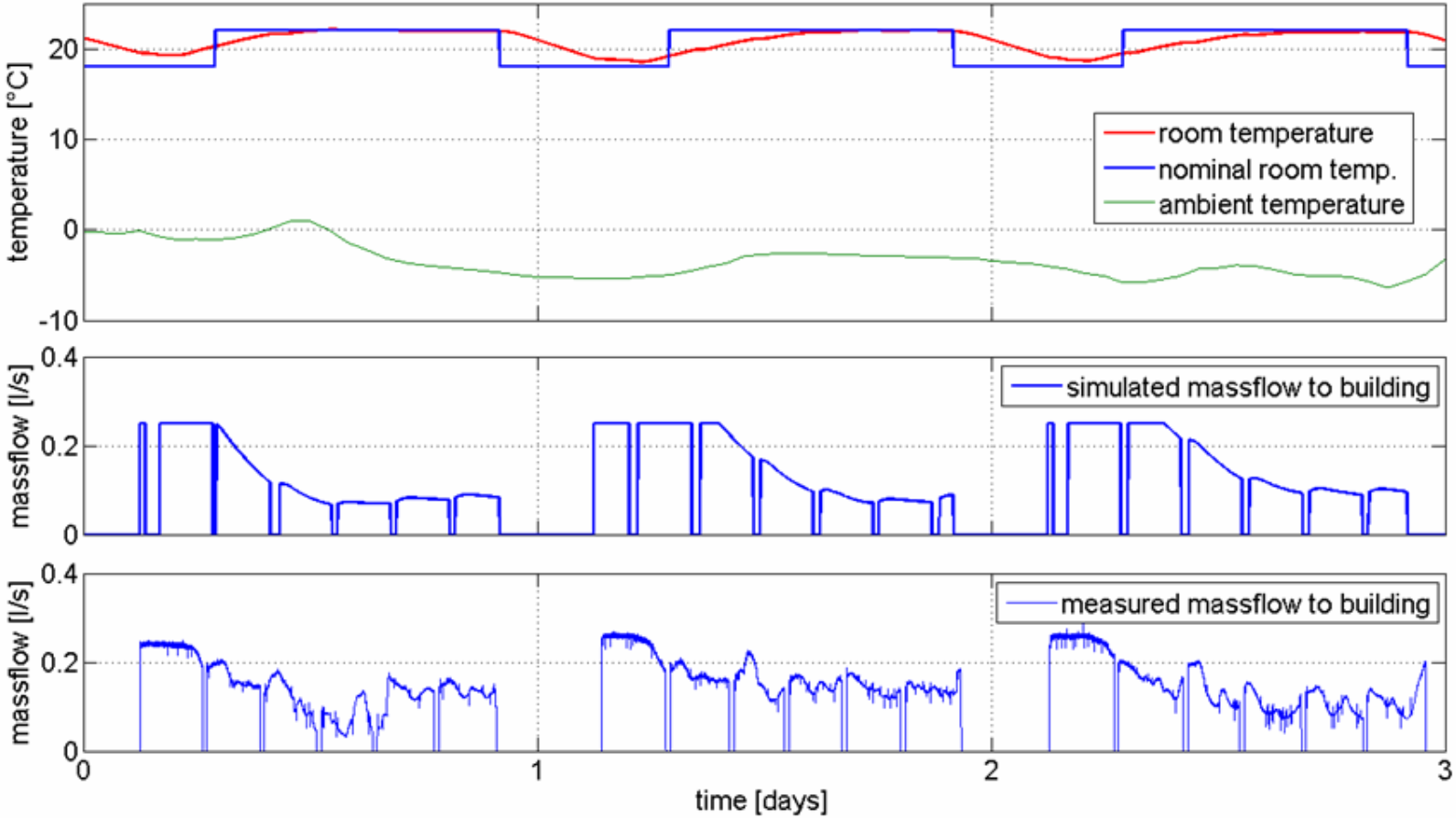
The micro-combined and power unit

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

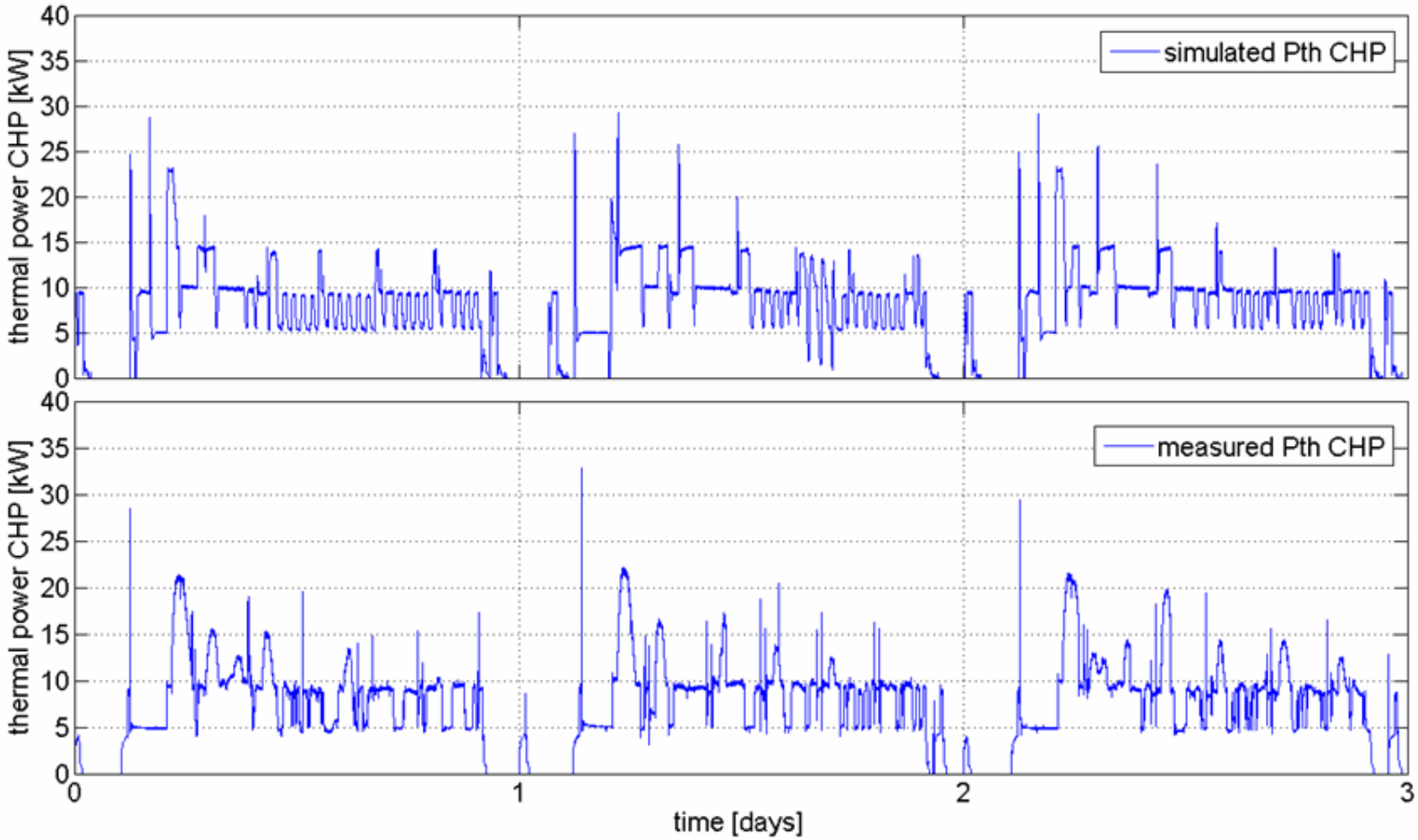
- stirling engine
  - linear generator
  - thermal power: 5kW
  - electrical power: 1kW

- integrated additional burner
  - gas-condensing boiler
  - thermal power: 18kW

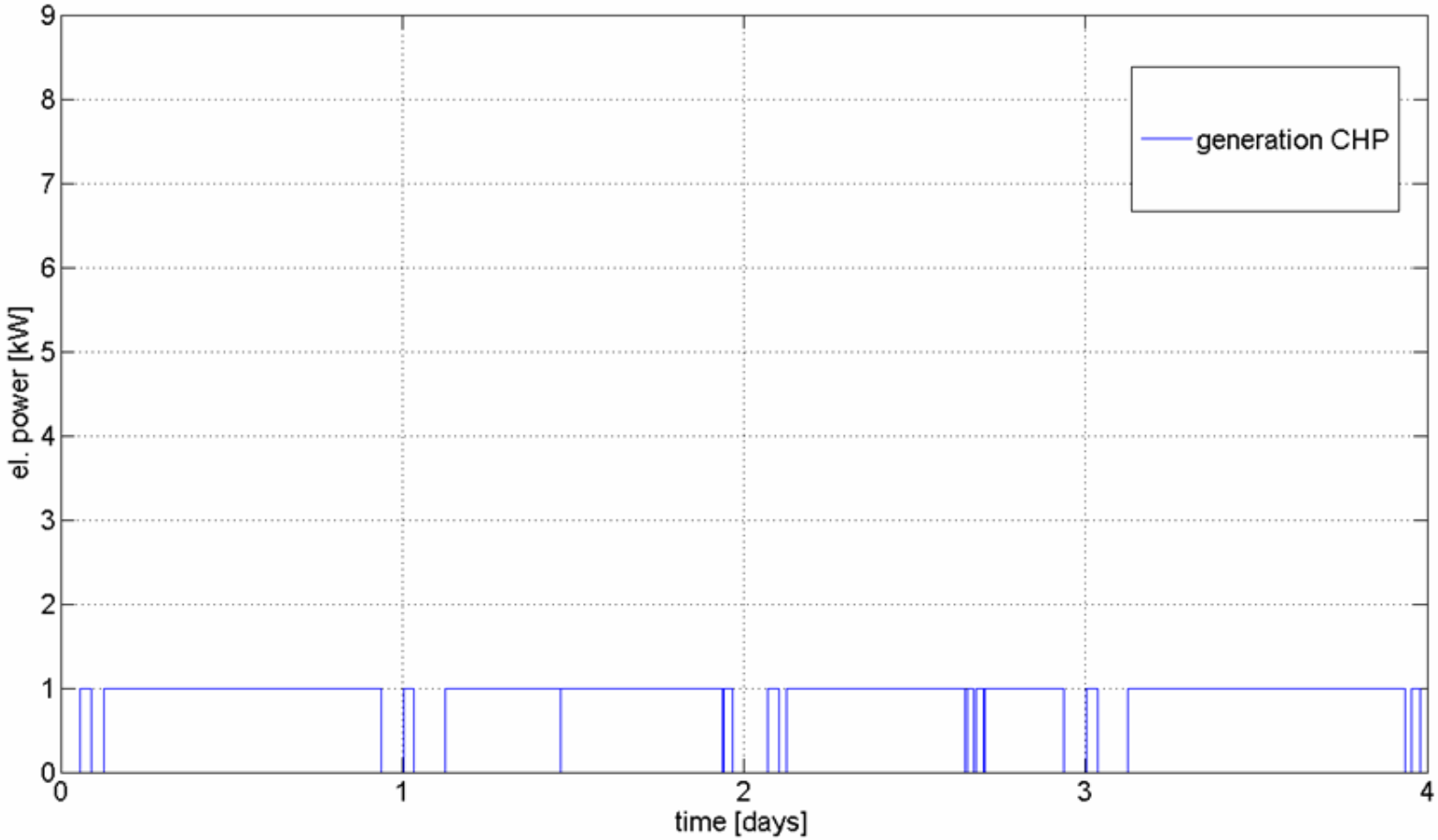
thermal simulation of a building – 3 days in January temperatures and hating water mass flow



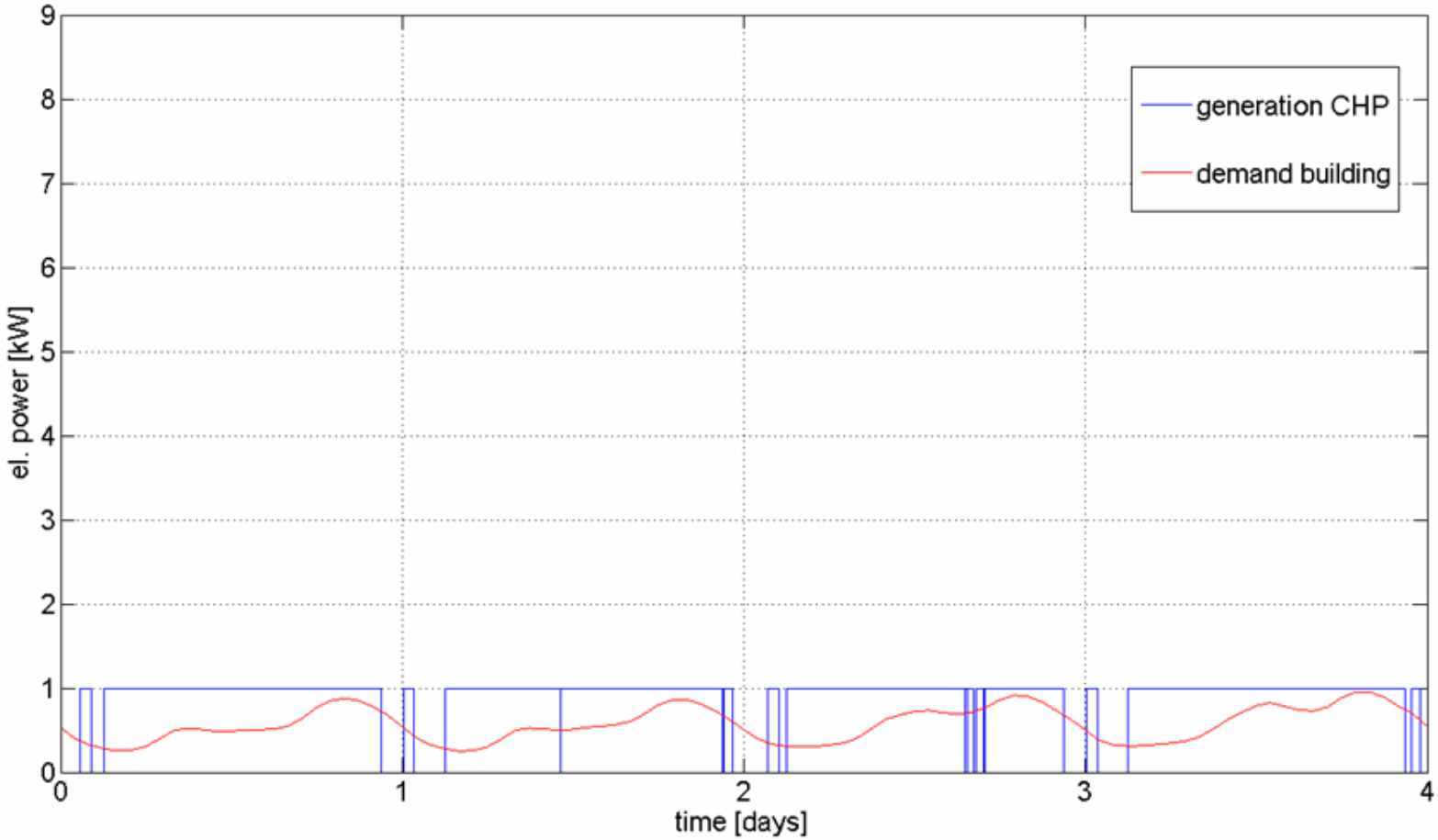
Thermal power output - micro-combined heat and power unit – 3 days in January



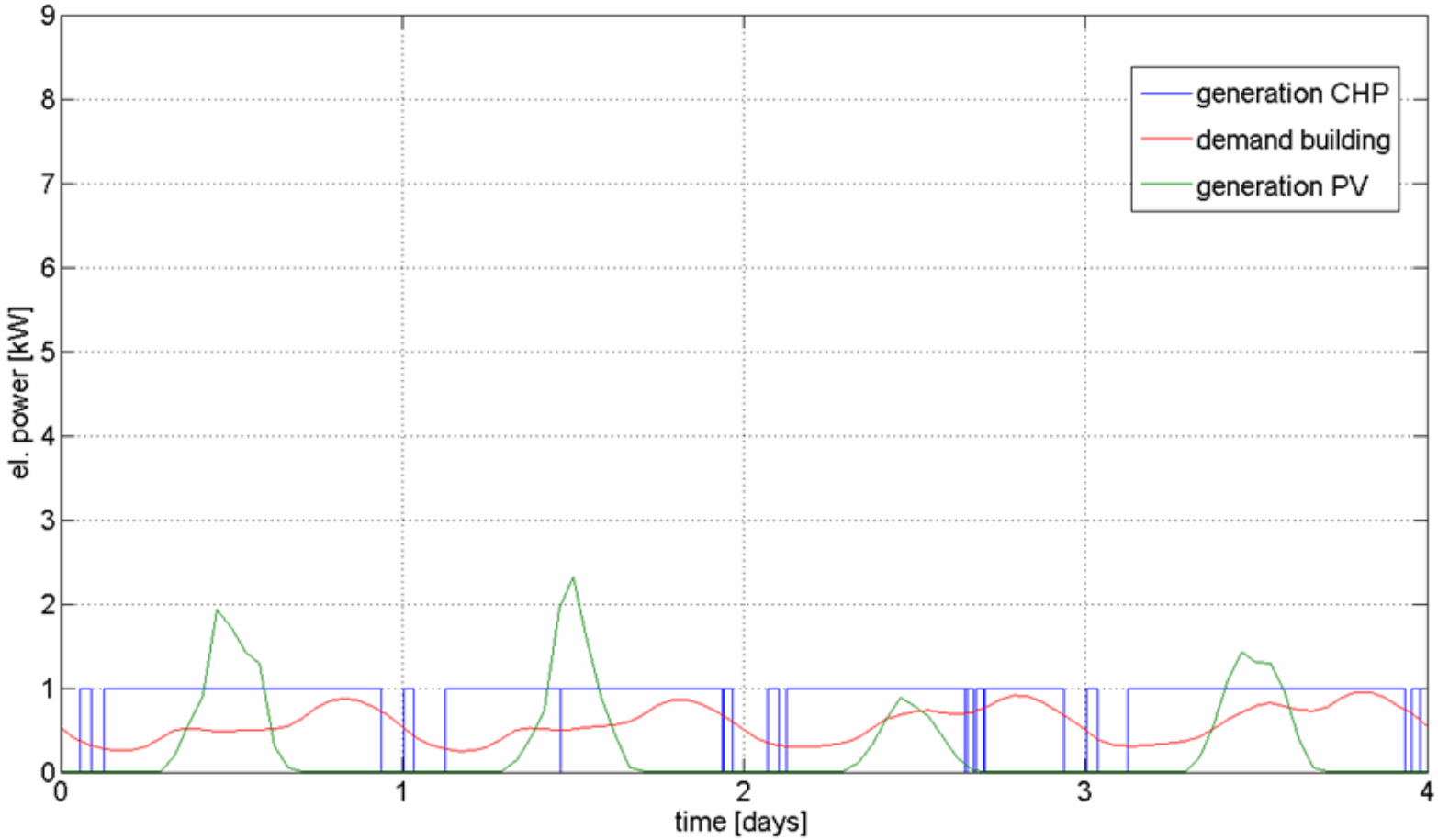
electrical power output - micro-combined heat and power unit – 4 days in January



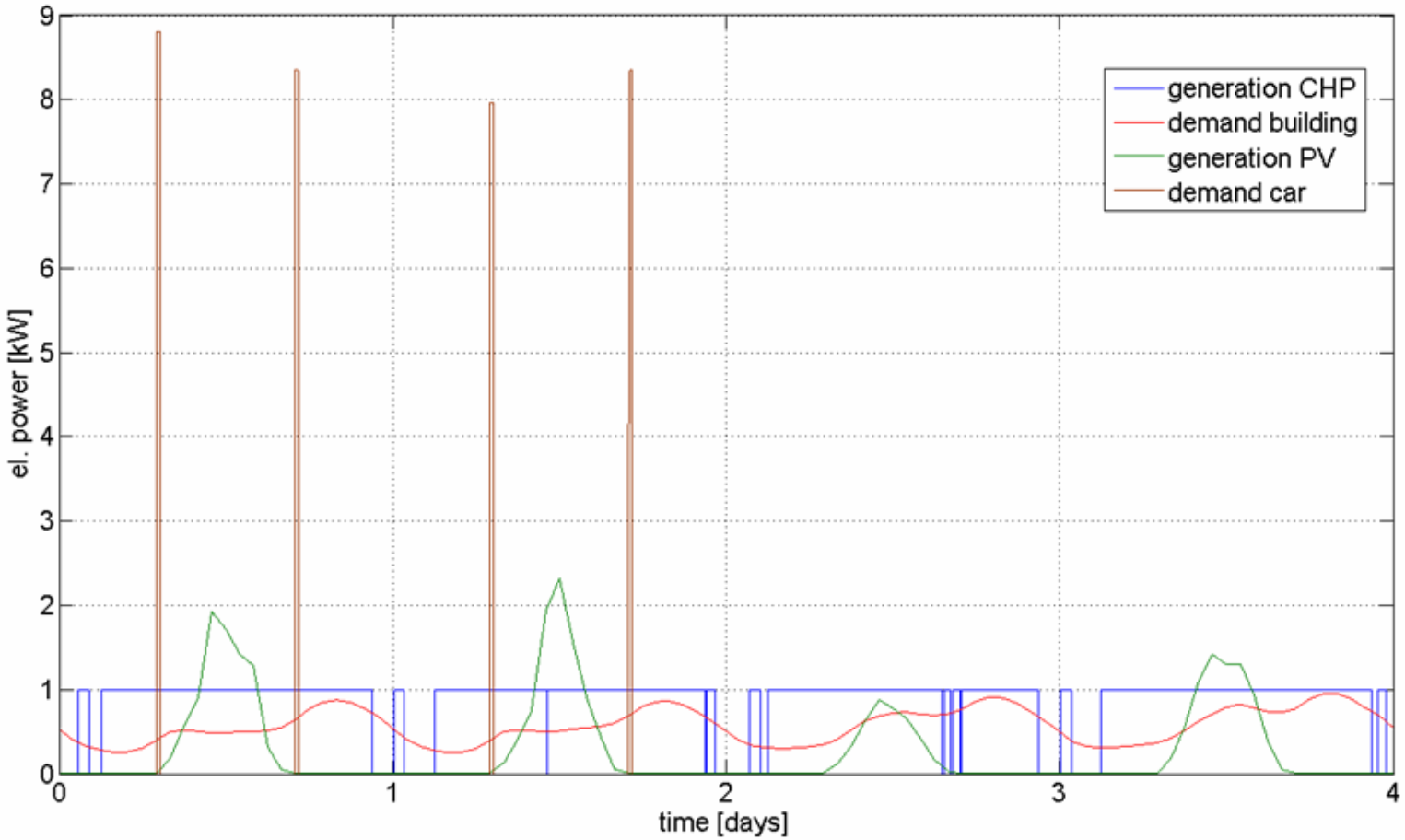
electrical power CHP and building – 4 days in January



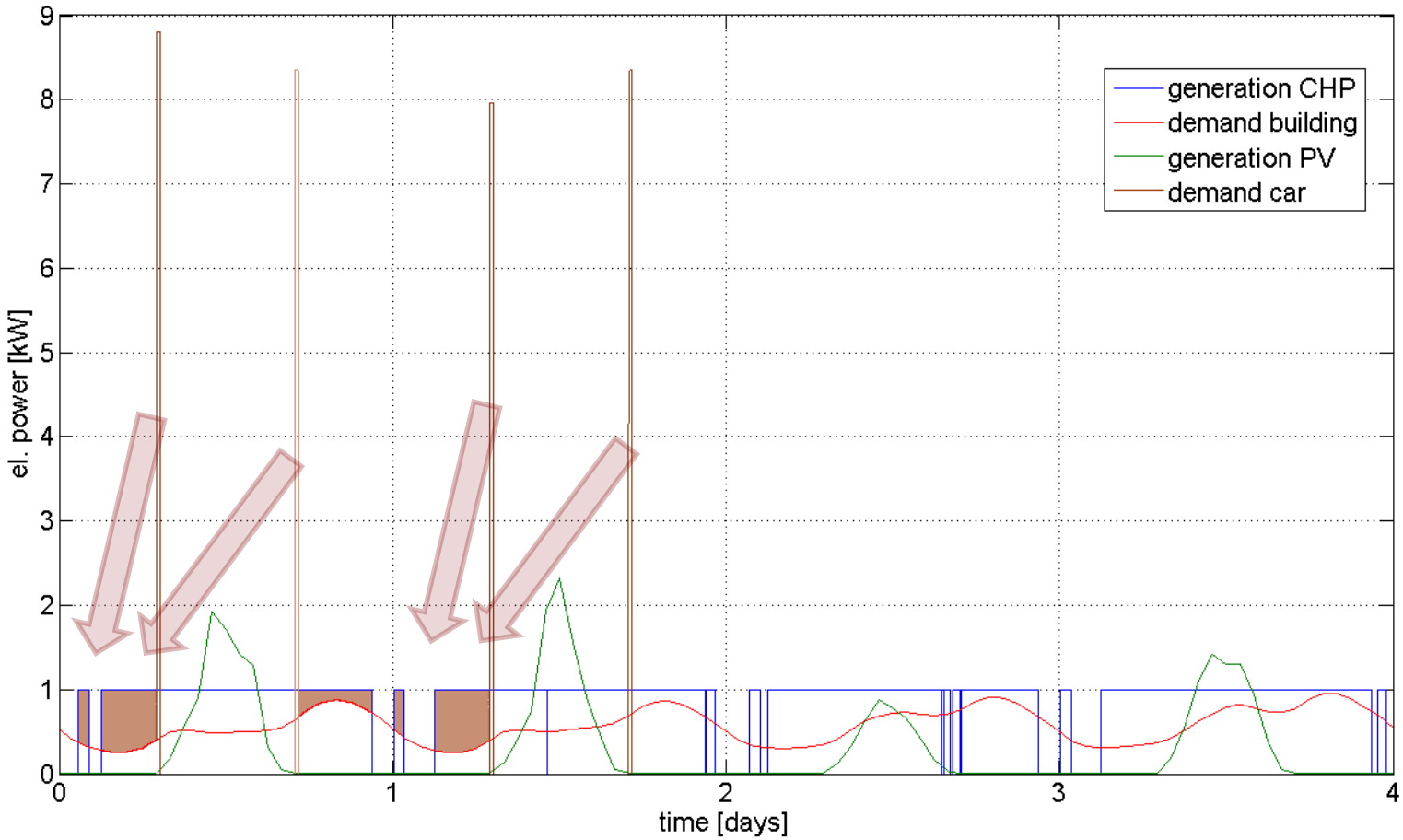
electrical power CHP, building and PV system – 4 days in January



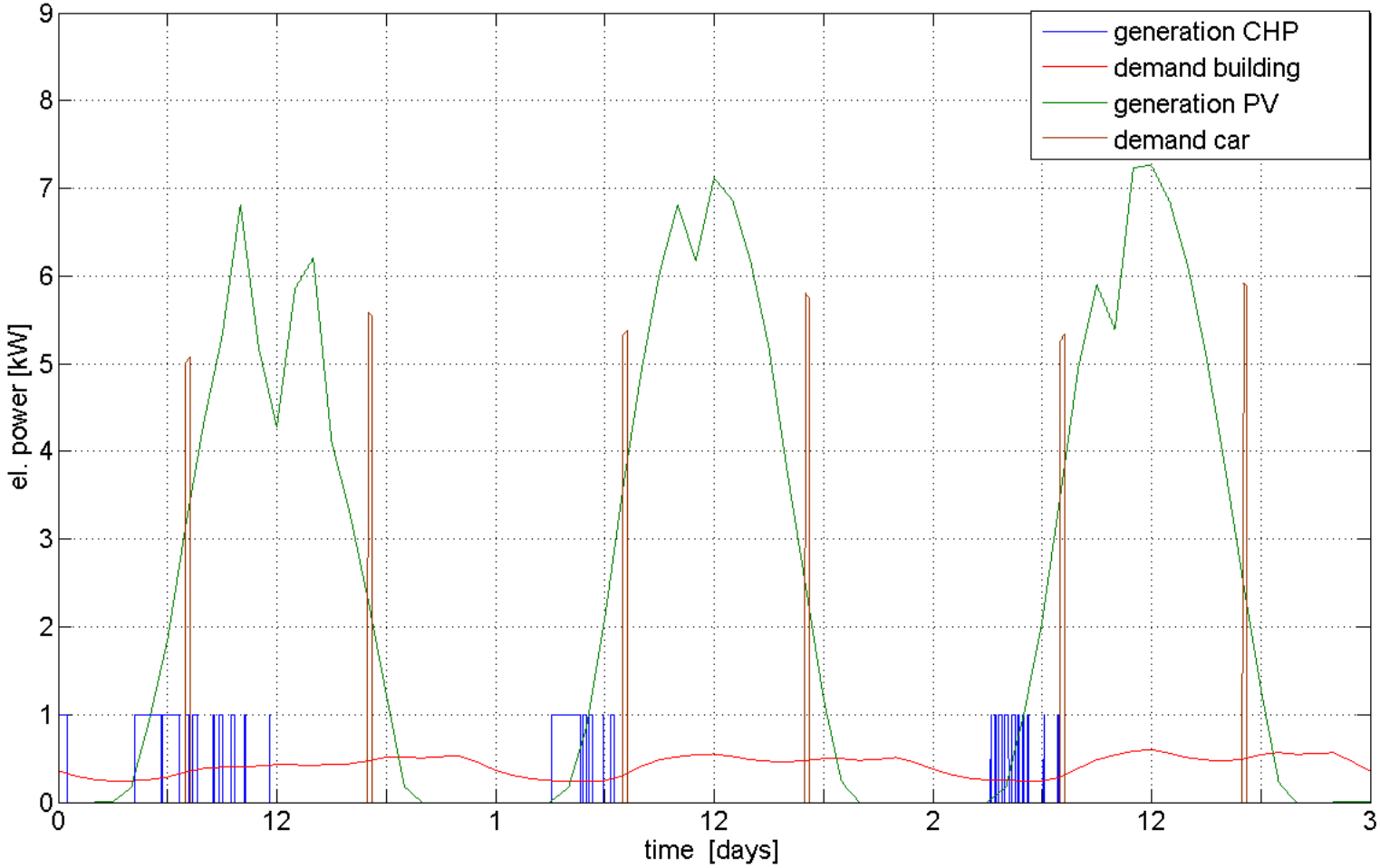
electrical power CHP, building, PV system and battery electric vehicle – 4 days in January



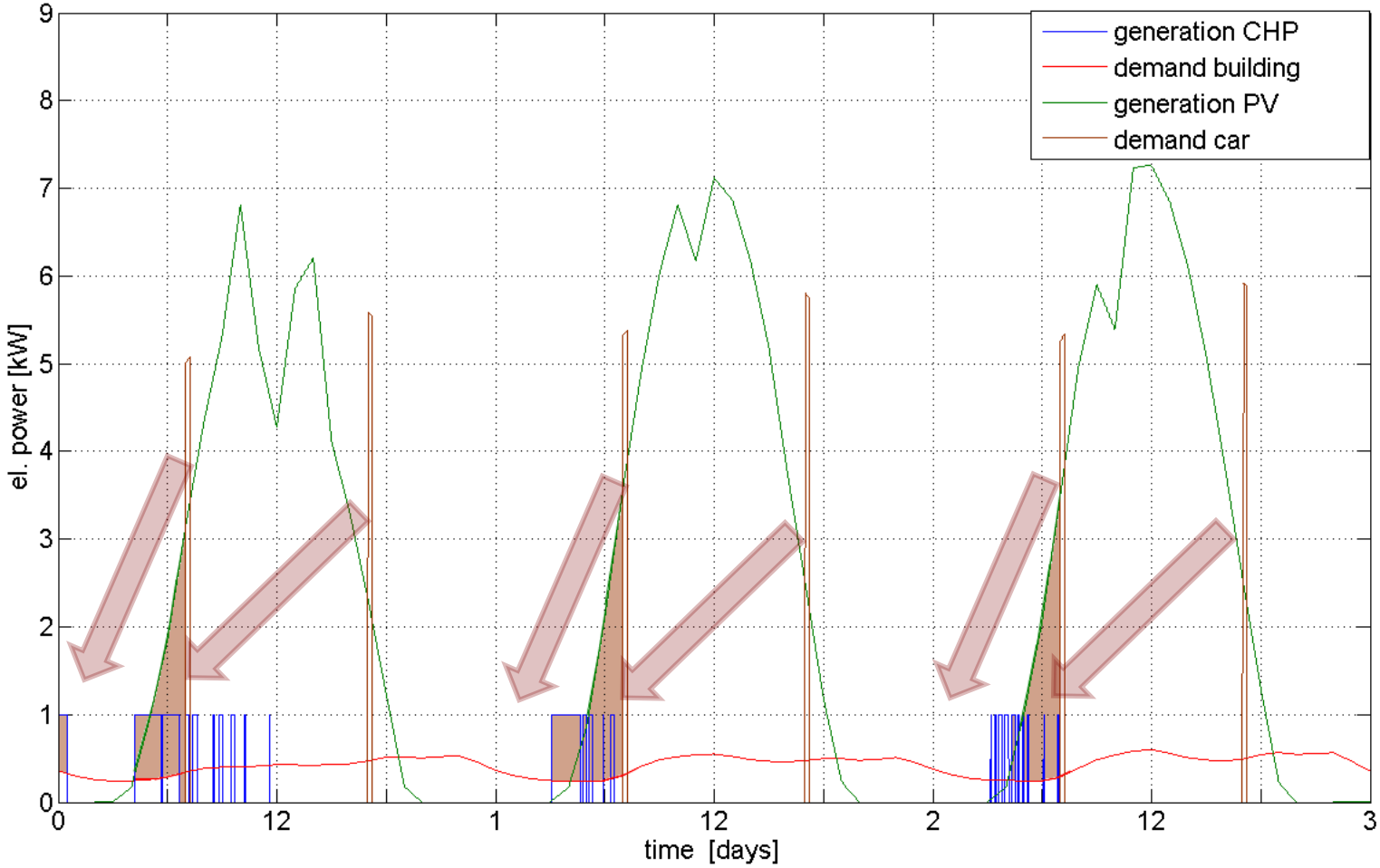
electrical power CHP, building, PV system and battery electric vehicle – 4 days in January



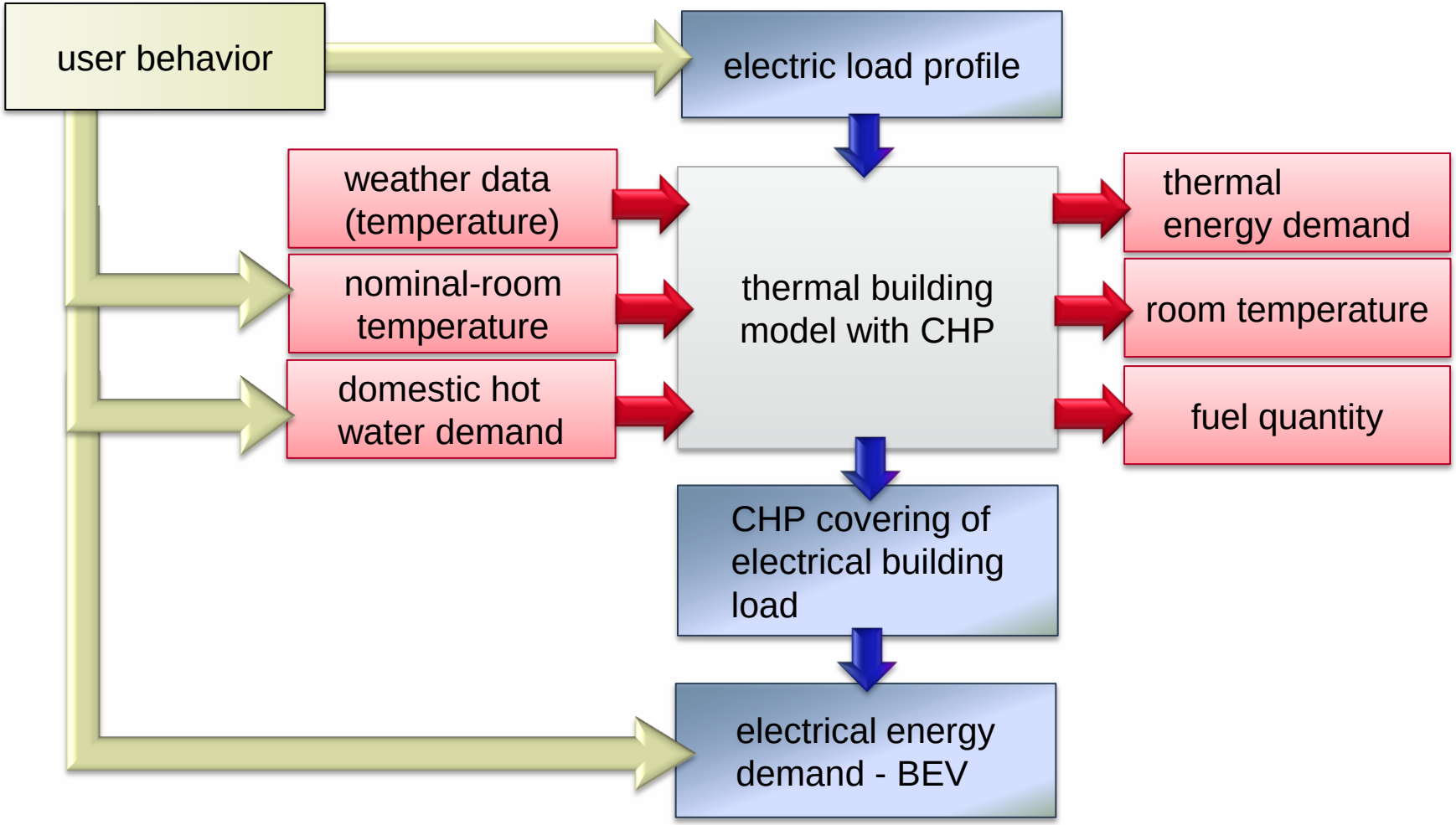
electrical power CHP, building, PV system and battery electric vehicle – 3 days in July



electrical power CHP, building, PV system and battery electric vehicle – 3 days in July



model structure – “house” and “BEV”



thank you