Development of realistic energy demand profiles for estimation of load flexibility of households for the integration of PV generation

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The Research Center for Energy Economics (FfE)

Background

- **Independent institution** dealing with topics related to energy technology and energy economics
- **Research results** can be published **independently from political orientations** or regulations solely based on scientific analytical methods
- Intensive exchange with **industrial partners**, therefore **applied research topics**

Evolution

- Founded 1949 in Karlsruhe
- Moved to Munich in 1969
- Affiliated company: FfE GmbH since 2001

Main features

- Further training for more than 300 scientists
- About 30 theses every year
- More than 30 successful dissertations

Members

- Members from the energy sector, industry, science, administration and private members
- Active exchange of experiences, involvement in a network of knowledge, direct contact to scientific assistants

Research

- Current topics: storage and grids, electric mobility, energy markets, energy efficiency, sustainable heat supply
- Methods: system analyses and simulations, data mining, GIS-models, audits

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Current limitations regarding the usage of top-down load profiles and requirements

Usage of Bottom-Up Model
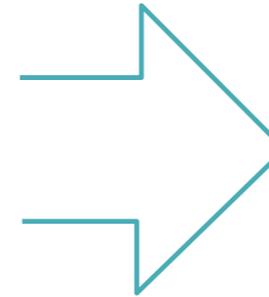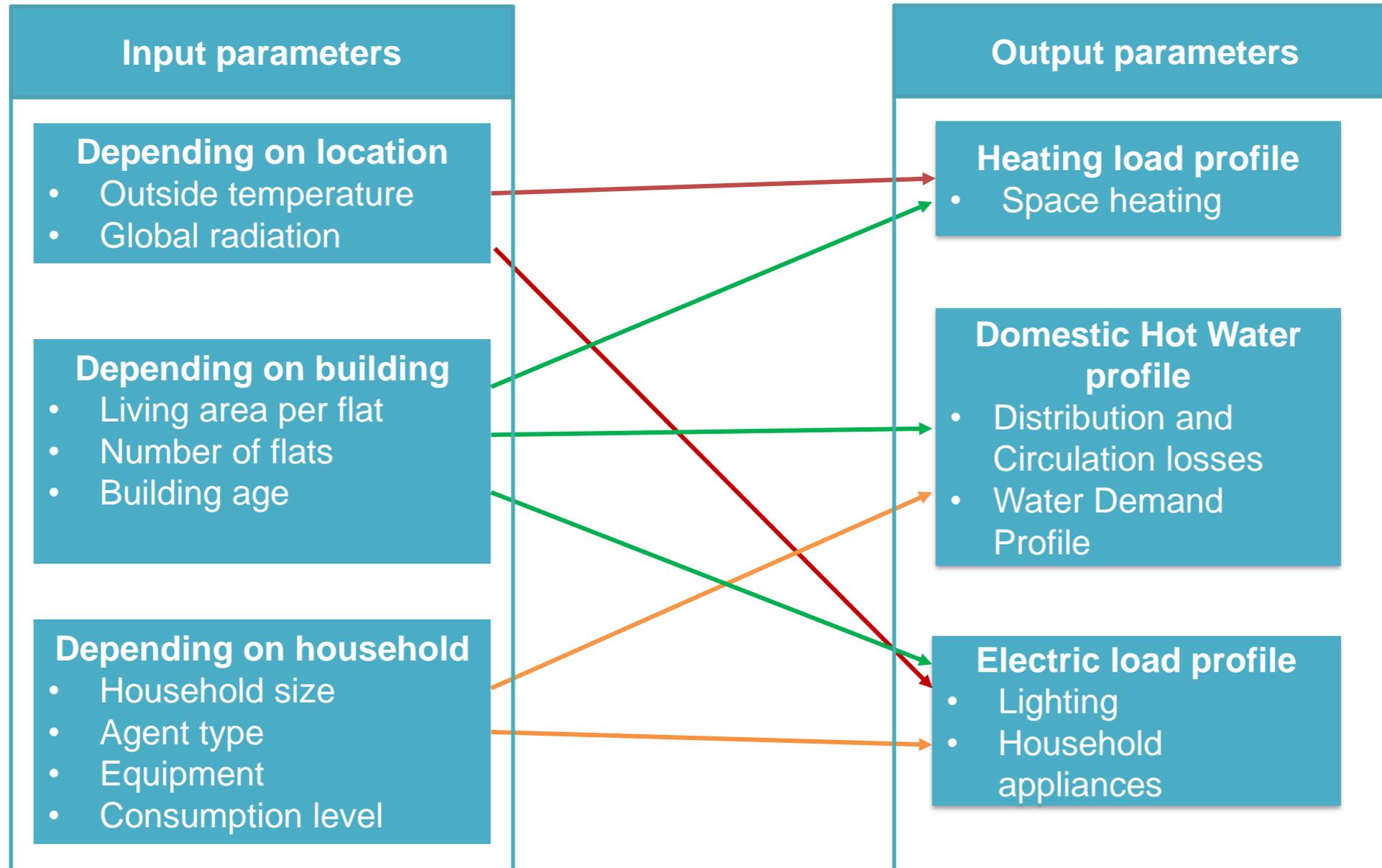
1 Availability

2 Diversity

3 Detailedness

- Real load profiles are usually not available due to lack in data and legal constrain of data measurement

- Individual load profiles have tremendous effect on economic viability of storages for self-consumption but are usually not known for households

- Top-down models neglect load profile per appliance, therefore efficiency change of individual technologies not visible

- No usage of individual data, therefore lower legal constraint in usage

- Implementation of agent types allows evaluation of self consumption per type

- Implementation of technology efficiency levels possible

- Future load profiles can be derived by changing loads of single devices

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Relevant load profiles and the dependencies for their generation in the model

Activity profiles and load profiles per appliance are used to determine the overall agent-based load profile[1]

1 — Definition of data set for activity profiles

- Data of time-spend questionnaire 2012/2013 - Questionnaire of households
- Contains multitude of socio-demographic data (e.g. Occupation)
- Diary entries in steps of 2 x workdays, 1 x weekendday
- Dataset (approx.)
  - 4.700 Households
  - 12.300 People
  - 32.000 Diary entries
  - 165 three digit activity codes

2 — Aggregation of data sets an activity profiles

- Aggregation to relevant agent types
  - Gender (male/female)
  - Occupation (full/part-time, pensioner)
- Aggregation activities relevant for consumption
  - Personal hygiene
  - Cleaning
  - Outdoor activity
  - …
- Definition of activity profiles per agent type
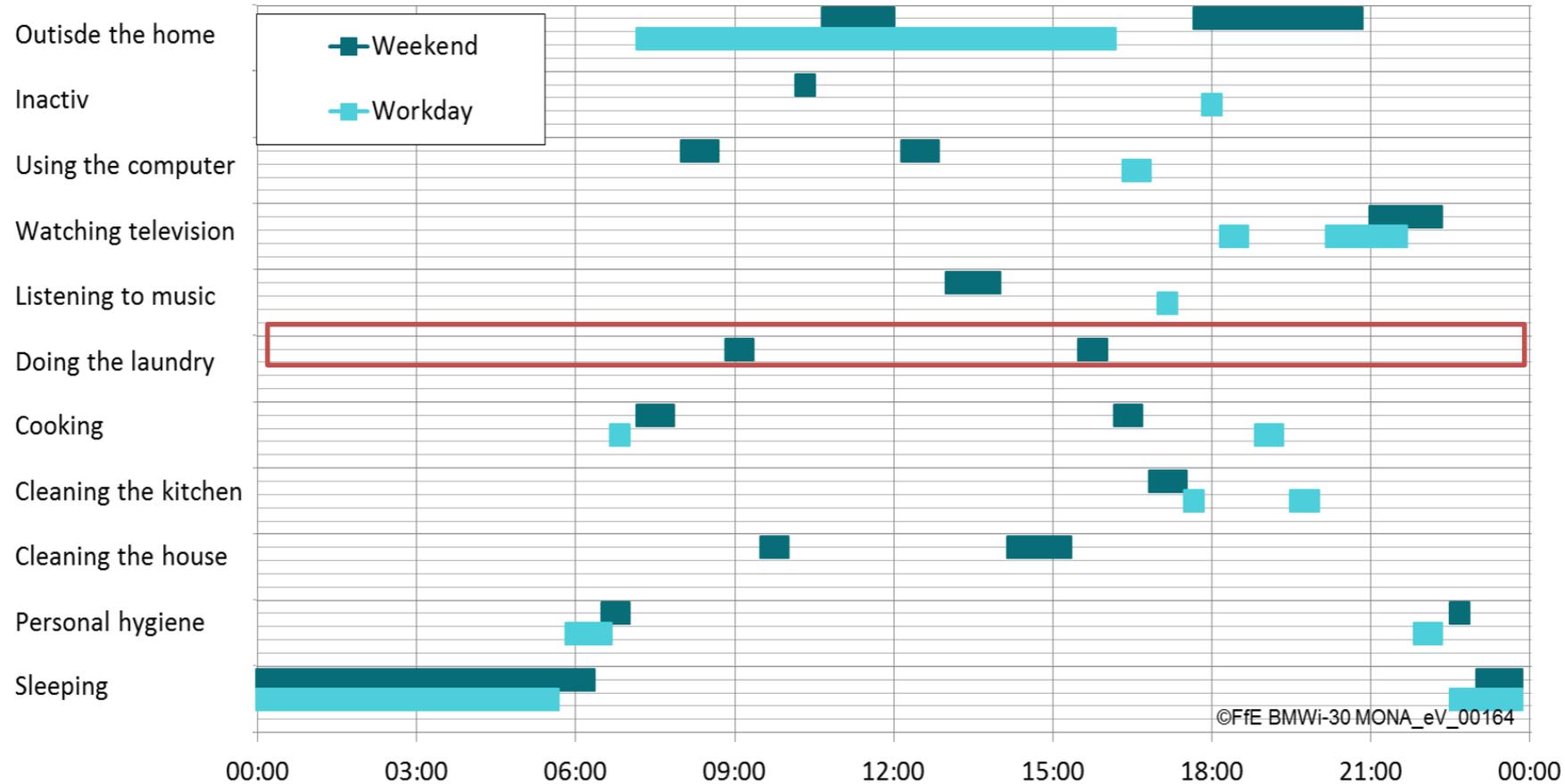
3 — Definition of data for consumption devices

- Loads for different consumption levels integrated
- Heating
  - Standard load profile for gas (BDEW)
- Domestic Hot Water
  - Demand per tapping point: Recknagel 2009 and 2016
  - Losses: own measurements[2]
- Electricity
  - Demand per device: Own measurements on individual devices[3-5]

4 — Validation of profiles

- Aggregation of agent-based load profiles
- Comparison to:
  - Overall Demand
  - Standard load profiles

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Time-use data and activity profiles

Exemplary activity profile generated from the time-spend data


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- ▪ The load profile generator randomizes individual activity profiles
- ➢ E.g. not every time the "coking status" occurs, the relevant devices are turned on

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# Average electric load profiles per appliance for different agent types
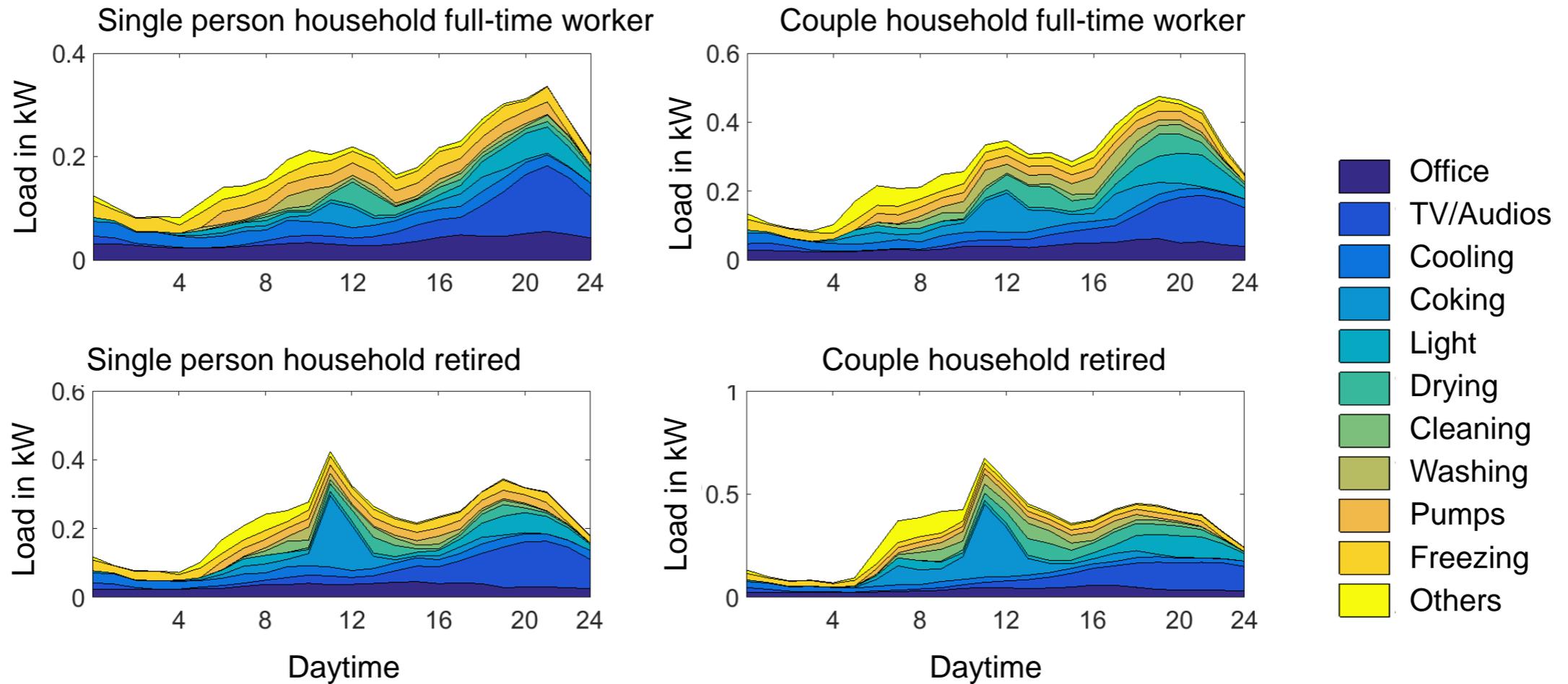
- Electric load profile differentiated between agent types for individual devices
- Here older version, update will be made accessible on the FfE Homepage as soon as available

Lower difference in domestic hot water demand profiles between weekday and holiday for retired people than full-time working people
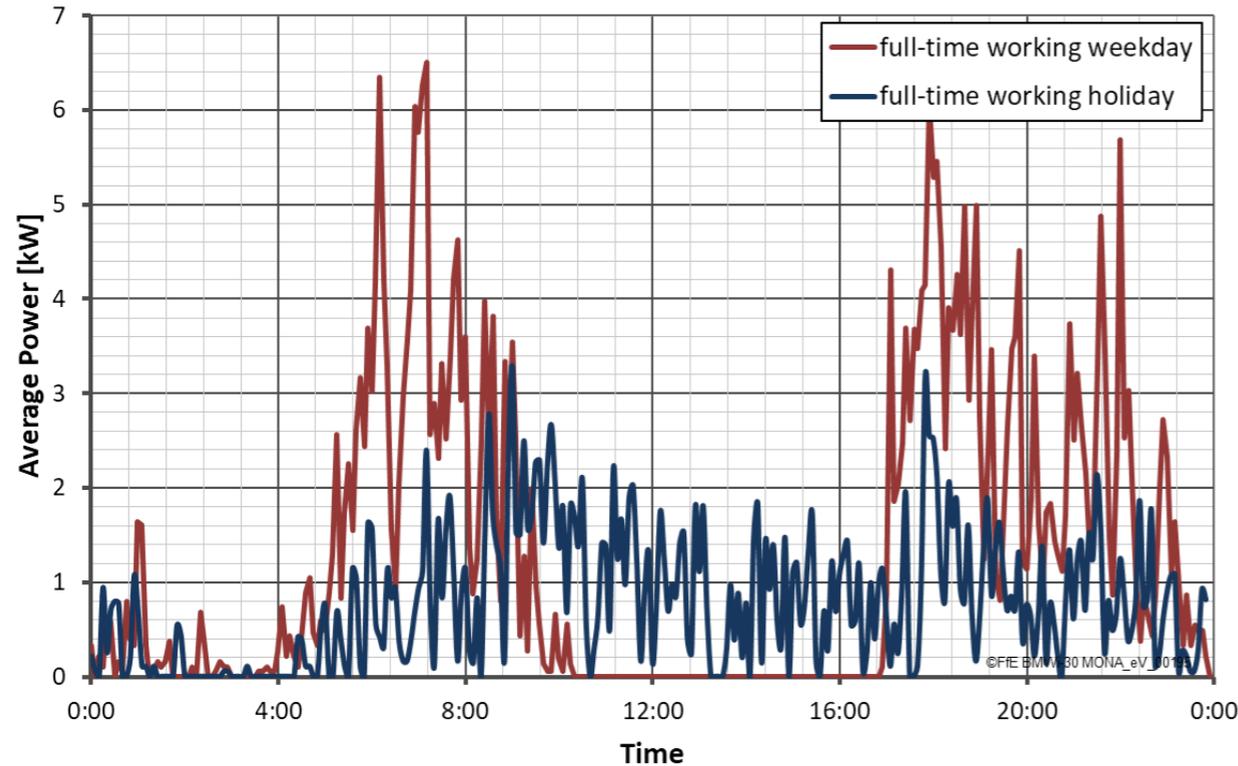
- Here: yearly average load profiles of full-time worker
- On weekdays extreme peak loads in the morning and the evening
- Holidays with less distinct peaks

- Here: yearly average load profiles of retired people
- No distinct difference between weekday and weekend
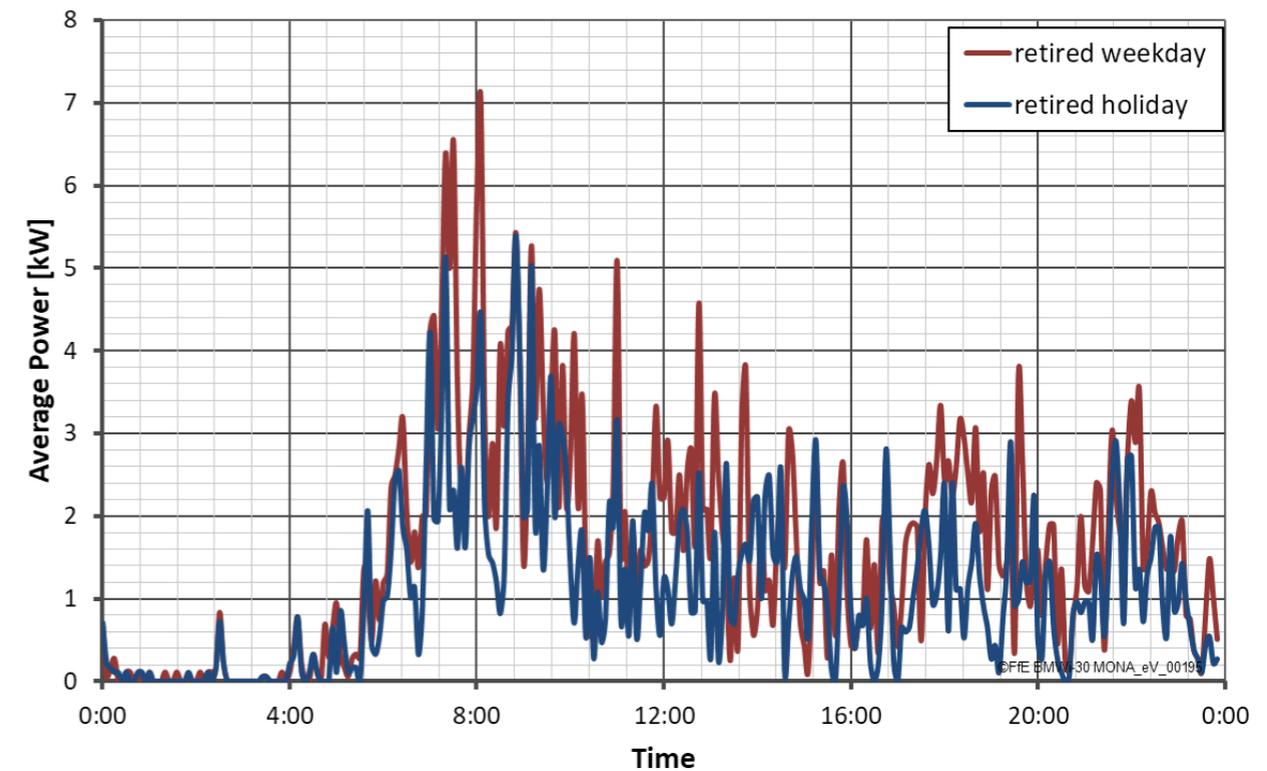
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Input and output parameters for the evaluation of self consumption via flexibilisation of electric and domestic hot water storage[6]

Input parameters

- Amount and occupation of inhabitants
- Energy demand
- Photovoltaic-system
  - Load
  - Orientation
- Storage system (electric and thermal)
  - Storage size
  - Heat generator and storage charging capacity & efficiency
  - Costs for devices
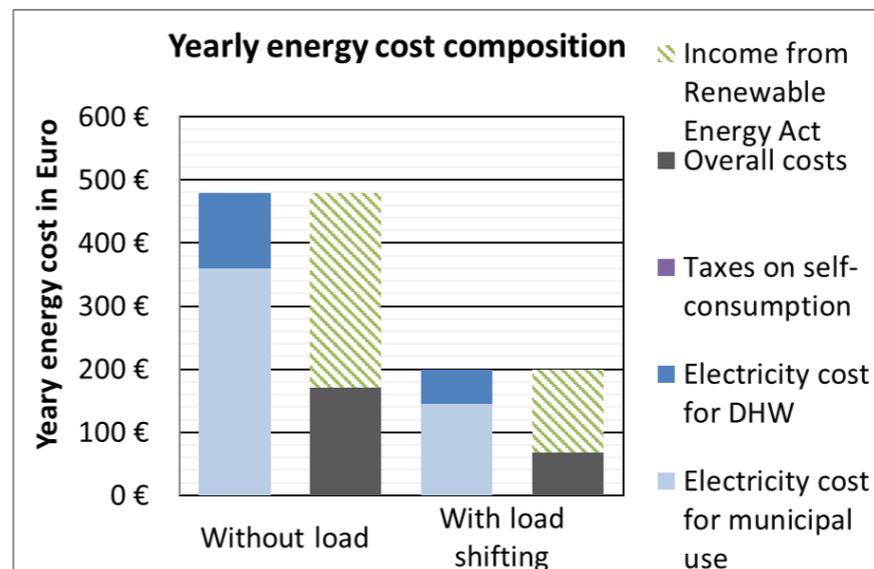- Prices of energy demand
- Definition of reference case

Output parameters
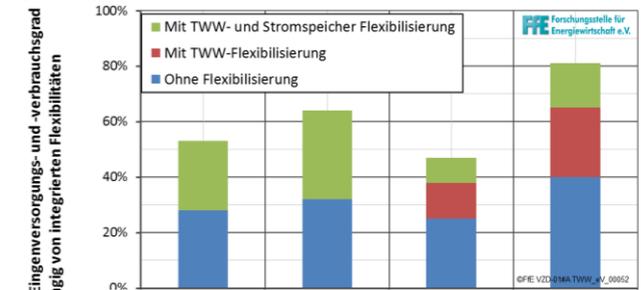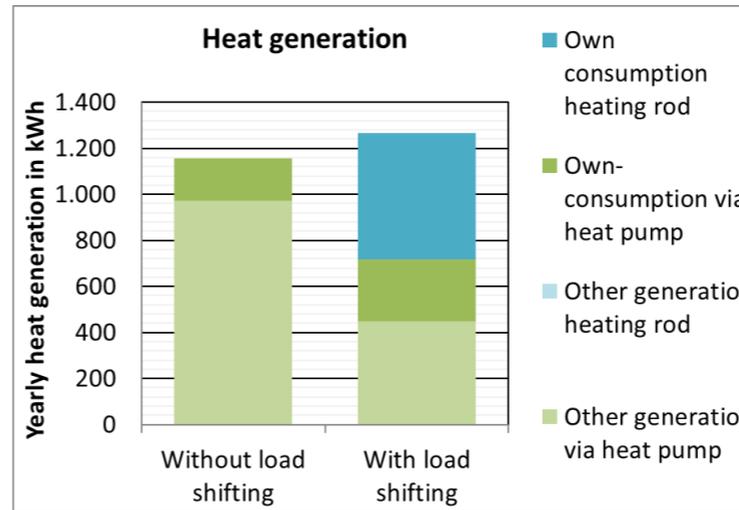
Own-consumption rates
- with and without load shifting
- in- and excluding domestic hot water generation

> Calculations are executed for reference case and self-consumption

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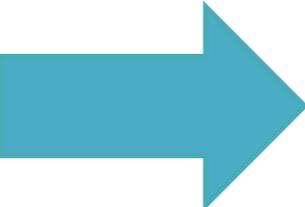
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Parameter for PV-self consumption in exemplary households

- Household with agent types
  a) Two full-time workers
 b) Two retired people

- Generation unit
  - PV-System 3 kWp
  - Orientation south

- Electric storage
  - Capacity 4.3 kWh
  - Maximum charging capacity 2.5 kW

- DHW supply
  - Storage volume 500 l
  - T min = 60 °C, T max = 80 °C
  - Thermal load heat pump 3 kW

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Results for PV-self consumption in exemplary households

- Higher simultaneity between PV generation and consumption of retired people
  - ➢ Higher own consumption without load shifting
- Overall higher demand of retired people
  - ➢ Lower own-consumption with load shifting

Own consumption electricity and DHW

Yearly energy cost savings due to storage utilization
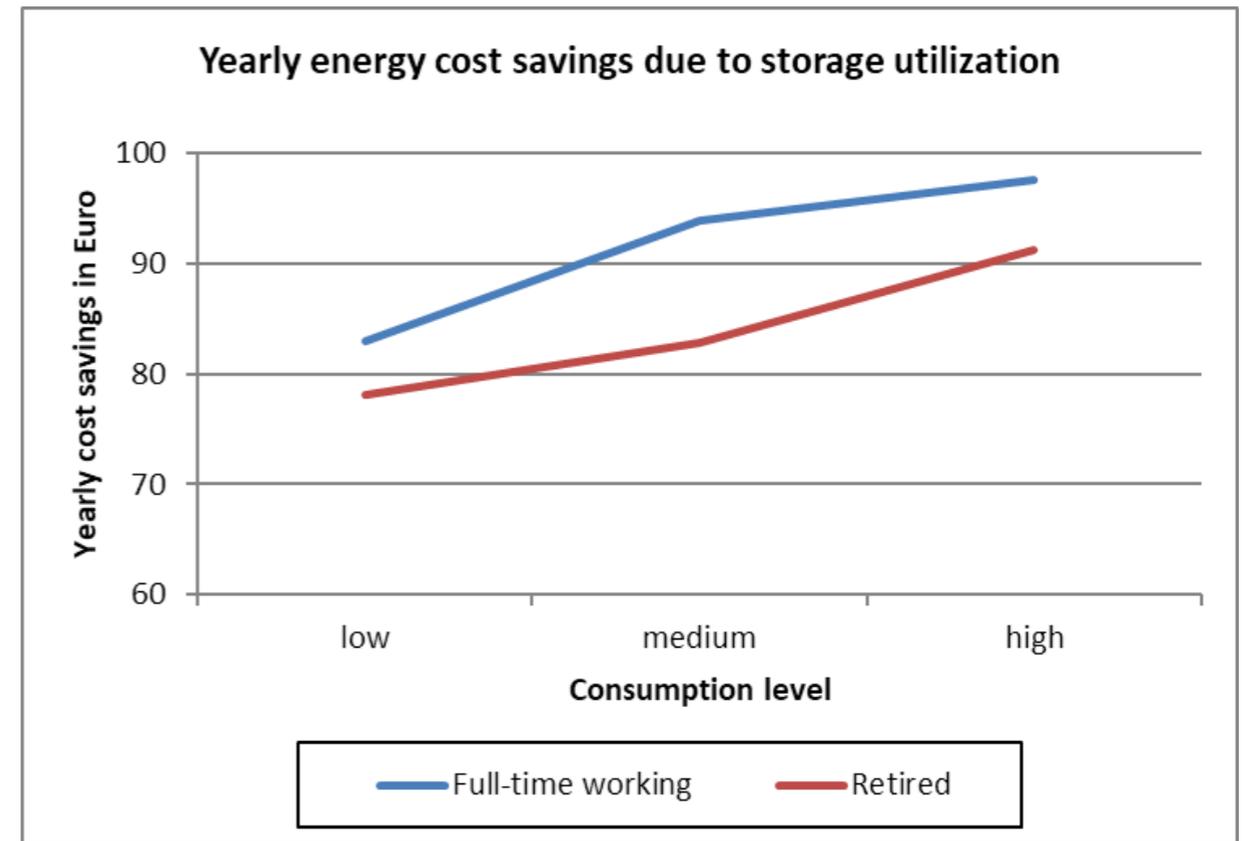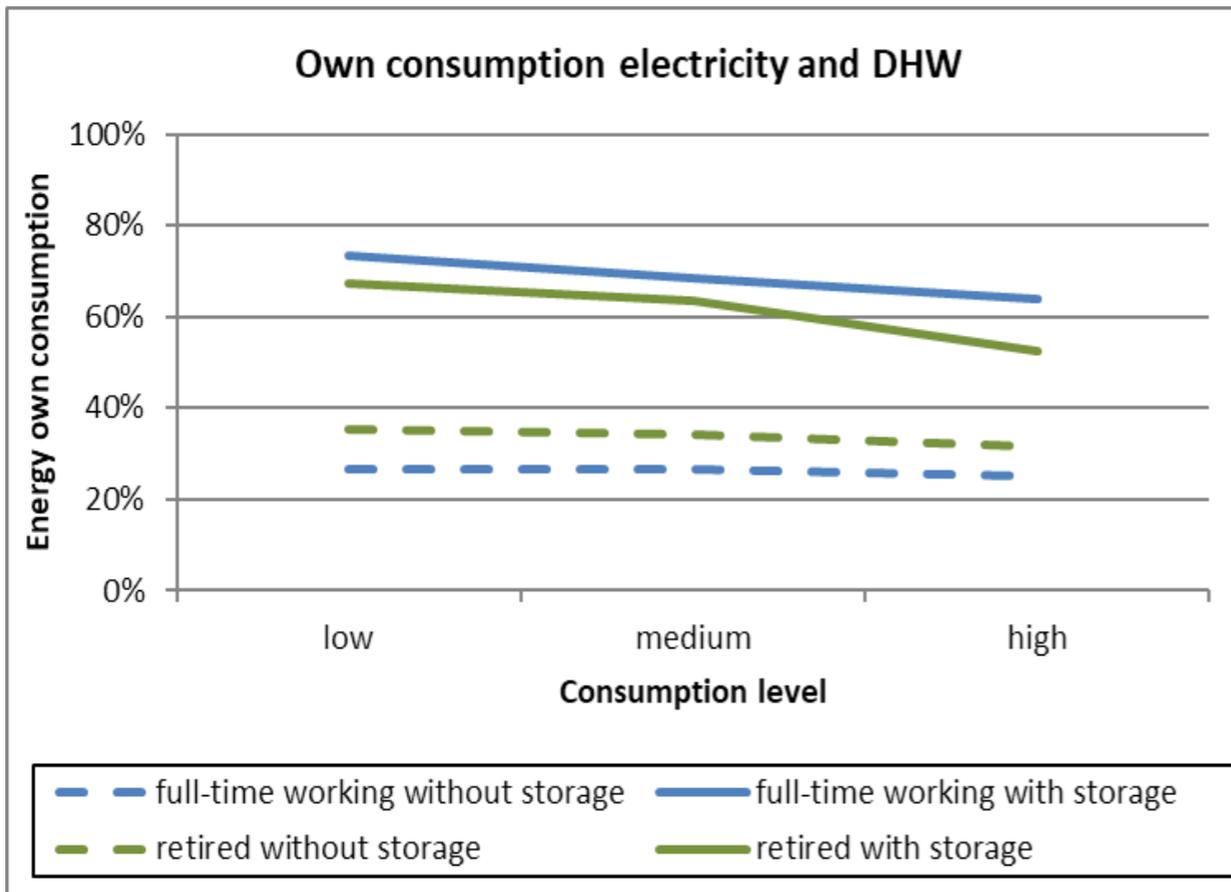
- Cost savings increase with consumption
- For full-time workers cost savings are higher

- ➢ But with set costs own consumption not economically viable

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Conclusion, Outlook and discussion

Methodology for load profiles

- Bottom-up agent-based load profiles meet more criteria than standard load profiles
- Applicability of agents types to different individuals still questionable

→ Include mobility profiles
→ Increase consistency in different load profiles
→ Include regional differentiation in demand
→ Include reactive power and further measured data

Self-consumption

- Increase in self consumption due to load shifting and cost savings differ strongly between agent types
- Parameters like loading capacity and allowed temperatures with strong impact

→ Integration of individual load profiles for assessment of load shifting necessary
→ Due to sector coupling extension of current definition of own-consumption useful

➢ How can households be advised regarding economic viability of self consumption?

➢ Who could be an adequate advisor?

➢ Is it necessary to include grid-relieve in the simplified tool in order to make it interesting for network operators

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Sources and further information

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- [3] C. Lugeder, „Lastverschiebungspotenzial in Privaten Haushalten. München", Research Institute for Energy Economics Forschungsstelle für Energiewirtschaft e.V., 2013.

- [4] C. Lugeder, „Modelling of regional and temporal differentiated load shift potentials of home appliances at community level", Research Institute for Energy Economics Forschungsstelle für Energiewirtschaft e.V., 2014.

- [5]F. Samweber, „Lastverschiebungspotenzial in Niederspannungsnetzen zum Ausgleich der PV-Einspeisung", Research Institute for Energy Economics Forschungsstelle für Energiewirtschaft e.V., 2012.

- [6]Kleinertz, Britta; Dufter, Christa; Greif, Simon; Conrad, Jochen: Energieeinsparpotenziale durch die Optimierung bestehender Trinkwassersysteme - Betrachtung von Mietwohnungen und Einfamilienhäusern mit zentralem und dezentralem System. München: Forschungsstelle für Energiewirtschaft e.V., 2017

What's your opinion on usage of individual load profiles in order to evaluate own-consumption?

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