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TAMPERE UNIVERSITY OF TECHNOLOGY

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sgem
Smart Grids and Energy Markets

Modelling loads and responses in SGEM (Smart grids and Energy Markets), WT 4.2

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Modelling loads and responses in SGEM

Content of this potpourri presentation

- Development of load models and network calculation
  Contact: antti.mutanen at tut.fi

- Models of load responses
  Contact: pekka.koponen at vtt.fi

- A new approach to load profiles: the use of building blocks
  Contact: goran.koreneff at vtt.fi

- Load modelling using integrated data sets
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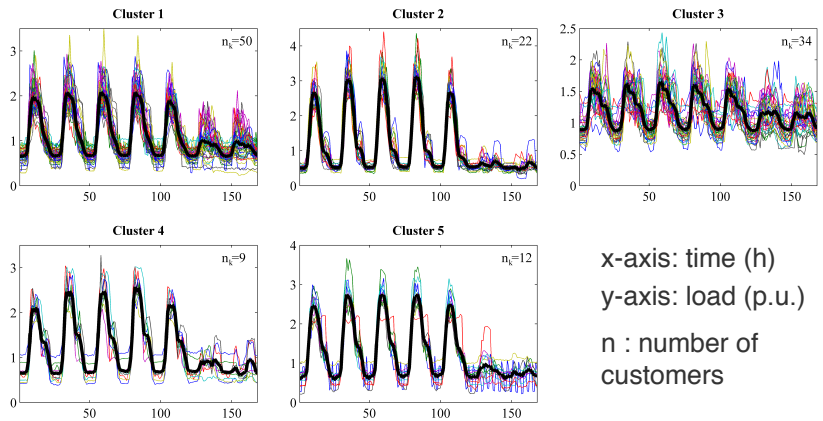
Research partners of this SGEM task have long periods of hourly AMR-measurement data from well over 20 000 meters and in addition weather data, building data etc.

Original AMR-measurement data is strictly confidential. Legislation regarding customer privacy and electricity markets must not be compromised.

Development of load models and network calculation

- Our aim is to improve distribution network analysis accuracy by developing more accurate load models.
- AMR meters provide huge amounts of measurement data that can be used in load research.
- So far we have developed a clustering based load modelling method that:
  - Groups customers into similarly behaving customer groups and forms customer group specific load profiles.
  - Detects abnormally behaving customers and forms individual load profiles for them.
  - Calculates temperature dependency parameters for the load profiles
  - Keeps load profiles up-to-date by updating them whenever needed.



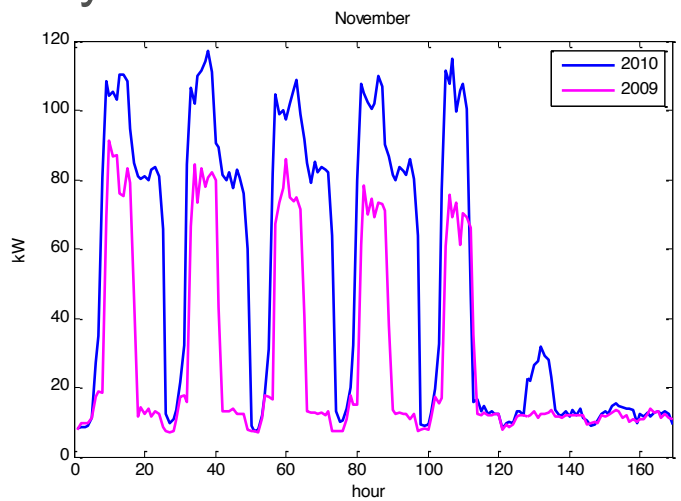
x-axis: time (h)
y-axis: load (p.u.)
n : number of customers

Clusters for customers belonging to public administration subgroup.

Development of load models and network calculation

Ongoing & upcoming research topics

- What is the effect of new AMR-based cluster profiles on the distribution network calculation accuracy.
- How to detect changes in customer behaviour and take the changes into account in load profiling (see figure below for an example of changed customer behaviour).
- How does demand response, price elasticity and customer level micro generation change the loads.
    - How these changes can be detected and modelled with the help of AMR measurements.
    - What effects these changes have on distribution network states.

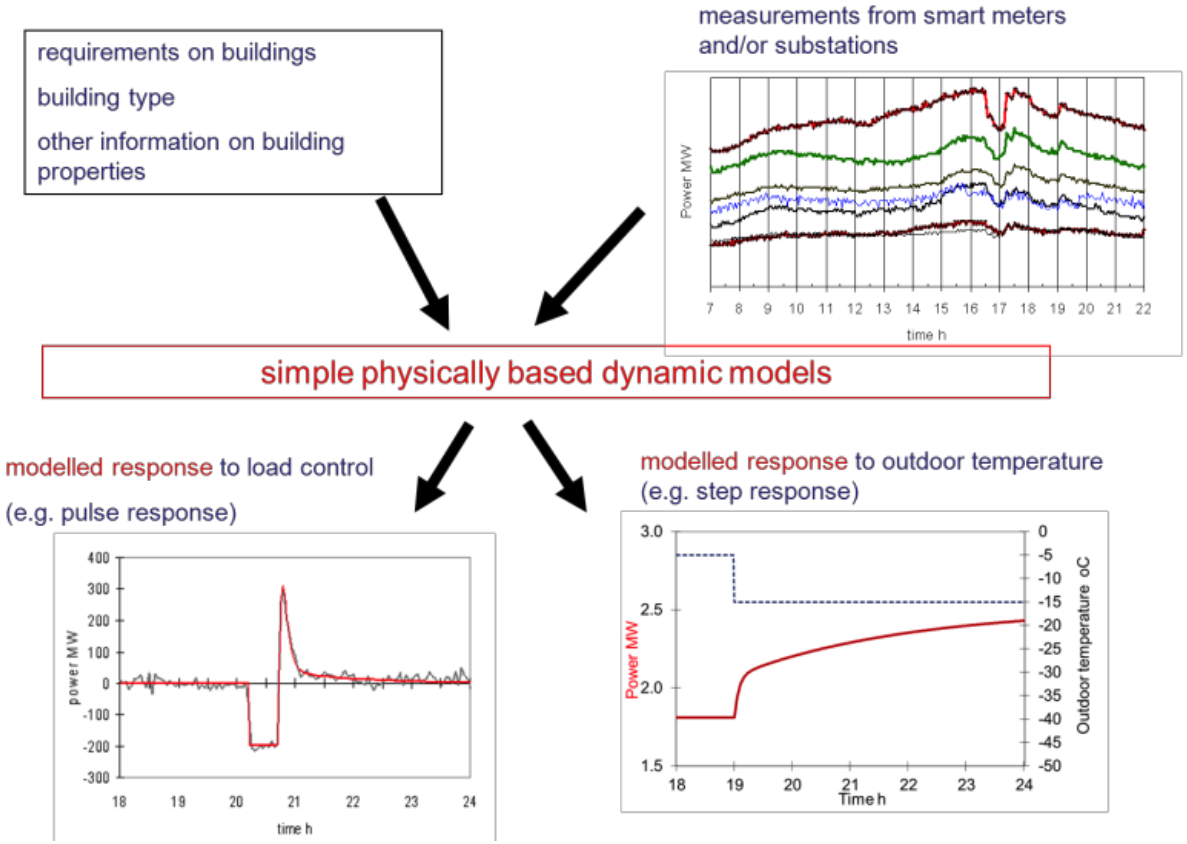


Models of load responses

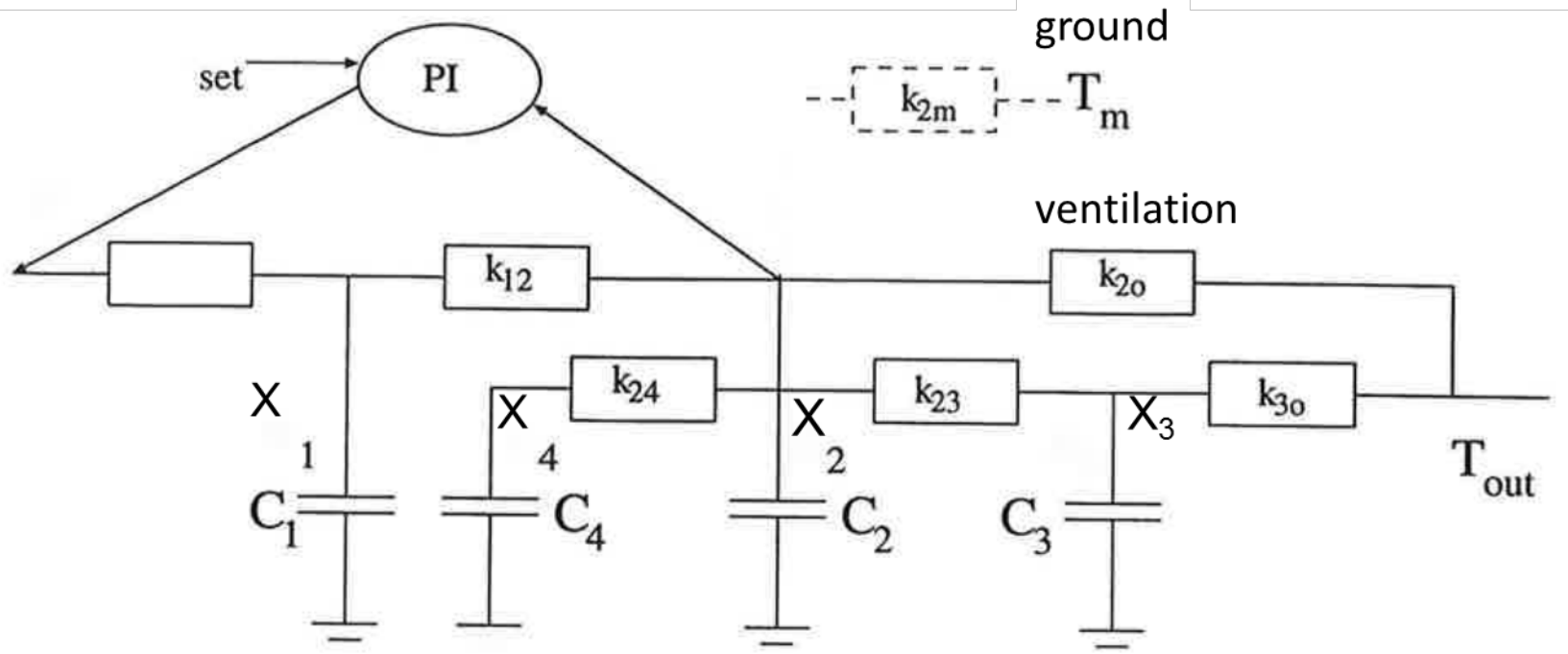
- For short term forecasting and optimisation of responses to control actions and weather variations.
- It is important for the market and the grid to accurately know the responses of demand.
- Does not fit with the traditional customer type specific load models, but is in line with the consumption type based load forecasting approach (=the building blocks approach).
- Purely measurement based models require too long measurement periods, cannot forecast new situations and their adaptation to the changes in the loads is slow => Partially physically based models are applied.

Models of load responses for forecasting and optimisation

to control actions and temperature variations based on measurements from substations, smart meters and weather + building data



An example of a simple physically based model

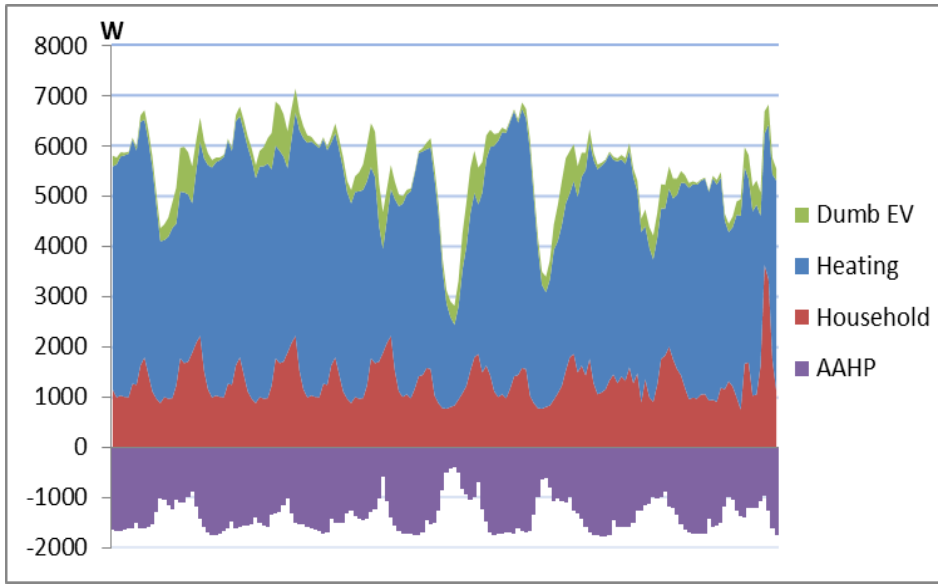


heating element, heat storage, indoor air, walls, outdoor air

Load profiles, especially for one or two family houses

Electricity use may be a sum of very differently behaving large part loads, some

- are very time and day but not temperature dependent (household electricity, DHW)
- are very temperature dependent (el.heating, heat pumps)
- affect or even diminish other loads (PV, solar heat, air heat pumps)
- are mobile or might be very flexible (EV)
- Part loads scale differently



- => we would need thousands of load profiles, none of which would be good

Load profile building blocks

THE MAIN IDEA

- Divide the load into feasible and more easily managed part loads
- Only the largest part load chunks, which also benefit the most from being treated separately
- For building blocks, models can be used instead of measurements
- The basic load, household electricity, should however be based on good and clean measurements
- Easy to add new building blocks

An example:

Customer load =

+ household electricity

+ DHW

- solar heat panel (=savings)

+ direct electric heating

- AAHP in electric heated house (=savings)

+ AAHP during the summer

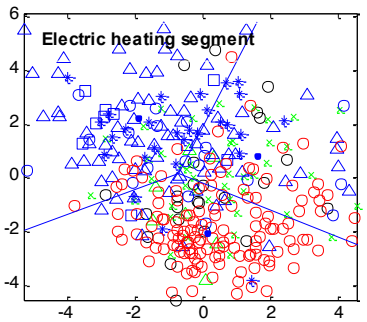
+ EV without smart charging

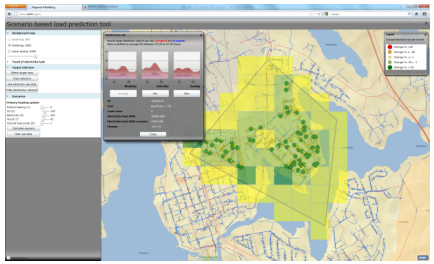
+ sauna 3 times/week

Load modelling using integrated data sets

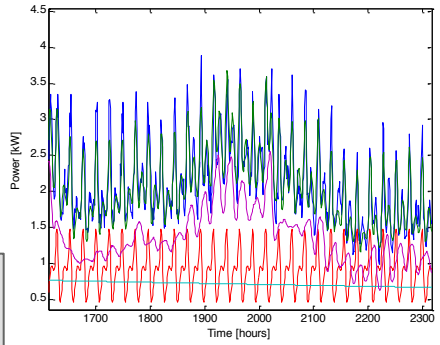
- Focus on applying advanced computational methods (data mining, machine learning, evoluationary algorithms) using integrated datasets
  - smart meter data (AMR)
  - meteorogical data, building information, socioeconomics etc.
- Combining the methods with other approaches (load profiling, building blocks, dynamic response models)
- Main objectives of modelling:
  - recognition of consumption type and heating solutions of customers from the data using clustering and classification
  - disaggregation, modelling and forecasting of controllable heating loads
  - spatiotemporal modelling of loads using geographic data sets
    - modelling of regional heating loads (DR potential)
    - regional analysis and mapping of future EV adoption potential based on traffic and socioeconomical statistics (250 m*250 m)

Load modelling using integrated data sets





Scenario tool for modelling spatial loads in heating system scenarios



Load modelling tools (WP6)

Predictive load models

Clustering and classification of customers

Recognition of heating solution of customer

Combining to building block & dynamic response model (VTT)

Data integration (WP6)

CIM
Data semantics
Ontologies

Model identification, fitting and validation

GIS

Socio-economic (Tike) 250x250m

Building data (VTJ) ~20 000 buildings

Smart meter data (AMR) ~4500 customers

Meteorology (FMI) ~30 met.stations

Modelling temperature dependence