CAES
Computer Architectures for Embedded Systems

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- Introduction research group and general scope
- Introduction Project WIEfm
- Optimal district heating supply temperature case Meppel Nieuwveenselanden
- Optimal capacities: renewable generators and storage facilities
- Interesting advantages of district heating systems for integration of renewable energy
Focus of CAES energy group

Energy-autonomous smart micro-grids:
- Modeling and control of energy streams in micro-grids
- TRIANA control methodology for micro-grids based on
  - Prediction
  - Planning
  - Real-time control

Main applications:
- Planning and control of storage and flexibility in micro-grids
- Planning and control of energy streams in buildings
- Measurements and control of power quality in micro-grids

More: www.utwente.nl/energy
Focus of research chair renewable energy
Saxion University of Applied Sciences

1. Bio-based economy and energy from biofuels
2. Smart buildings and energy control
3. Urban energy and integration of renewable energy
smart, integrated energy infrastructure

Wind energy
bio-energy
solar-PV
renewable heat
local/regional renewable energy generation

local/regional energy consumption

Technical and legislative challenges

opportunities

Smart energy control

energy storage

energy system planning

simulation

business models

Large scale profitable

concepts

possibilities
WIEfm: modernizing heat supply in the Euregio
Kom verder. Saxion.

Wärme in der Euregio

WIE®m ist ein deutsch-niederländisches Projekt, das über das INTERREG-V-A-Kooperationsprogramm gefördert wird.

2nd International Conference on Smart Energy Systems and 4th Generation District Heating
27. September - 8:00 bis 28. September - 16:00

2. Expertenworkshop: Wärme aus erneuerbaren Energien
4. Oktober - 13:00 bis 18:00
Case: Smart Grid Meppel Energie
Optimal district heating supply temperature

Assumptions:

- 200 houses
- Existing network designed for 70°C
- Present supply temperature: 80°C
- Joined return: 20-35°C (average: 25°C)
- Specified pipe lengths, diameters and insulation thickness
- Flow calculation available at 70°C

→ Determine the optimal supply temperature
Approach optimal supply temperature

1. Investigate feasibility of decentral temperature boost $\rightarrow$ negative
2. Investigate home heat exchanger transfer limitations

3. Develop models:
   - aggregated heat demand (time series)
   - pumping energy: $P_{\text{pump}}=f(\Phi_{\text{max}}, T_{\text{supply}})$
   - network heat loss: $Q=f(T_{\text{supply}})$

4. Determine optimal supply temperature as cost minimum
5. Develop legionella risk reduction measures

$T_{\text{supply, min}} = 55^\circ\text{C}$
**Optimal supply temperature**

- Apply costs: pumping electricity: €0,15/kWh, heat loss €0,03/kWh
- Energy costs: equivalent full load hours/year: $t_{\text{pump,max}}/8760$

- Practical range: 25-40% for equivalent full load hours
- Include marging of e.g. 5°C to guarantee supply furthest string

**Conclusion:** 60°C
Comments

- Practical experience: less pumping energy than expected → real optimum is at lower temperatures!

- Limitation Meppel case: $T < 55^\circ C$ causes problems for domestic hot water

- Dynamic flow and heat loss calculation to improve design of the district heating system

- Refer to papers by: Atli Benonysson, Henrik Madsen, Jan Hensen.

- Software for dynamic district heating simulation: Termis, Modelica, TRNSYS, Matlab Simulink
Urban energy generation capacities
Optimization principle

- Capacity Constraints
- Cost Optimization Model
- Output: Converter Capacities
- Energy Scheduling Model
- Supply Energy flows

Input: Demand & characteristics
Initial Constraints

More information: refer to upcoming paper related to this conference
Case study: Meppel with bio-fuel boiler & solar PV

- Reference: import (grey) electricity, condensing natural gas boiler per house, natural gas network
- Case:
  - Bio-fuel boiler with thermal storage
  - Supportive: external heat (natural gas boiler)
  - Large scale solar PV for household electric demand with electric storage
- Objective: maximize self consumption, minimize external heat
- Study influence of thermal and electric storage on objective and costs
Dashboard with optimal capacities

- 2.6 kWth per house
- 2.8 kWp per house
- 3 kWh per house
## Results

### Reference:

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<td>Year Totals (kWh)</td>
<td>-576.449</td>
<td>-7.313</td>
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<td>251.799</td>
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**Self consumption of solar PV: 57%**

**Compared to reference: 82% CO2 reduction**

### Case:

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<th>Import-Export</th>
<th>Storage Balance</th>
<th>Total Balance</th>
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**Grid strengthening required**

<table>
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<th>grid peak</th>
<th>export</th>
<th>import</th>
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<tbody>
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<td></td>
<td>0</td>
<td>174</td>
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4 weeks January

Storage alone does not solve grid feed-in peaks
Stand alone Solutions to reduce peak grid feed-in: MPC (smart) charging, flexible device control
Advantage of a district heating network for integration

- Dissipate surplus electricity into district heating network
- Price incentive:
  - Grid feed-in maximum: €0,055/kWh
  - Balance power market: feed-in revenues can be negative!
  - Fuel price wood chips: €0,023/kWh
- Is there a business case?
  - Cheaper connection (uni-directional)
  - No investments in other smart solutions required
  - Less electrical storage
  - More renewable feed-in possible for existing main grid capacity
How does it work?

Peak surplus: 0-1200 kWh/day

Transformer Limit: 174 kW

each area < 1200 kWh

Production prediction

1200 kWh storage

Demand Prediction > 1800 kWh/day
What are the results?

Electricity:
- Household electric demand: -567 MWh
- Cooling electric demand: -8 MWh
- Solar PV production: 584 MWh
- Grid import: 252 MWh
- Grid export: -100 MWh

Grid peaks:
- Export: -174
- Import: 174 kW

Thermal:
- Heat grid demand: -1868 MWh
- Bio-mass boiler production: 1716 MWh
- Electric conversion: 152 MWh

Increased Self consumption from 57% to: 82%

Unstrengthened grid connection

Fuel savings: €3400/y
Case study conclusions

Optimal supply temperature of Meppel district heating system:
- Pumping energy: pipe diameters & flow
- Heat loss: pipe insulation properties
- Minimum costs: 60°C (≈ project limit)
- Opportunity: locally boost low (<55°C) supply temperatures
- Legionella risk prevention for domestic hot water

Optimal capacities of supply system:
- Model for Optimal capacities → generators, storage facilities
- Interaction between demand and renewable generation flows
- Measures to reduce electricity peaks and limit surplus feed-in

Advantage of district heating for system integration:
- Opportunities: direct power to heat to reduce electricity peaks
- Attractive cost savings possible: fuel, grid lay-out & connections
Thank you for your attention!

- More details on: www.utwente.nl/energy
  Electrical and thermal profile generators, PhD publications
  - Online Thesis version expected: may 2017
  - Future work, integrated tool:
    - Optimal capacities
    - Smart control of flexible devices
- Mail: r.p.vanleeuwen@saxion.nl