A PROPOSED PATHWAY TO FUTURE-PROOF CURRENT BUILDING STOCK FOR UPCOMING 4TH GENERATION DISTRICT HEATING IN THE SCOPE OF POSITIVE ENERGY DISTRICTS

Luca Casamassima, Pietro Zambelli, Lukas Kranzl, Reinhard Haas
Outline

• Introduction
  – Positive Energy Districts
  – Research Question
• Methodology
• Results
• Further work
Introduction - Positive Energy Districts

Energy Balance
- Primary Energy
- Positive over year
- Includes public services

Environment
- Net Zero GHG
- No PM account
- SOx (Opt)
- NOx (Opt)

Social Aspects
- Energy Poverty
- Local Participation
- Marginalised Group
- Distributed Benefits
- Distributed Burdens

Spatial Aspects
- No Clear boundaries
- Autonomous
- Dynamic
- Virtual

Energy Efficiency
- Buildings retrofits
- LCA
- Making Cities ISO 52000

Economic Aspects
- Maximisation cost effectiveness
- Cost-benefit analysis
- No established methodology
Introduction – Research Question

And only 20% is renewable
Action is obviously needed

Share of total energy used for heating and cooling coming from renewable sources, 2017

"Energy for heating / cooling from renewable sources" – Eurostat 2017

And only 20% is renewable
Action is obviously needed

Source: "Mapping and analyses of the current and future (2020-2030) heating/cooling fuel deployment (fossil/ renewables)
The European Commission. Directorate-General for Energy
Introduction – Research Question

• Research question
  • What are the technical requirements from a building point of view to be connected to 4th generation district heating, for the existing buildings and under different climate conditions?
• Technically and economically viable measures ways for building renovation and retrofitting
  • 4th generation district heating
  • Appropriate thermal comfort
• Costs of transition

Table 1

<table>
<thead>
<tr>
<th>Indoor distribution system typology</th>
<th>Associated building insulation level</th>
<th>Inlet/outlet design temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperature radiator [2]</td>
<td>Poor</td>
<td>80/60 °C</td>
</tr>
<tr>
<td>Low temperature radiator [4]</td>
<td>Medium</td>
<td>55/45 °C</td>
</tr>
<tr>
<td>Air heating based [6]</td>
<td>Poor – Medium - Good</td>
<td>35 °C/30 °C</td>
</tr>
</tbody>
</table>

References:
Introduction – Research Question

• Some examples current building-stock
  – DK -> 132 kWh/m²/year [1]
  – UK (Nottingham) 110 – 225 kWh/m² (est.) [2]
  – AT -> 135 kWh/m² [3]

• Aim: 80 kWh/m²/year [1]

• Difficult to understand whether thermal comfort is achieved

• Difficult to know which measures to take

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https://vbn.aau.dk/ws/portalfiles/portal/234005850/Future_Green_Buildings_A_key_to_cost_effective_sustainable_energy_systems_ENGLISH.pdf


Methodology

- Dynamic Building Simulation
- OpenStudio/EnergyPlus
- TABULA/episcope
- City: Frankfurt – Griesheim Mitte
- Multi Family House 1945-1957
- Building Renovation/Retrofitting
- Inside temperature 20 °C
- Heating only
- Decrease supply temperature to heating system
Methodology

<table>
<thead>
<tr>
<th>Name</th>
<th>Tabula u-value [w/(m²K)]</th>
<th>E+ U-Value [w/(m²K)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Roof</td>
<td>1.08</td>
<td>1.185</td>
</tr>
<tr>
<td>Masonry of hollow blocks/honeycomb bricks</td>
<td>1.2</td>
<td>1.47</td>
</tr>
<tr>
<td>Concrete ceiling</td>
<td>1.33</td>
<td>1.41</td>
</tr>
<tr>
<td>Plastic frame window w. dual-pane glazing</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>wooden door</td>
<td>3</td>
<td>2.495</td>
</tr>
</tbody>
</table>
Methodology

• Model calculation
  – Windows thermal bridges
  – Solar gains
  – Wind effect
  – Soil heat exchange
  – Supply Temperature 45°C
  – High Temperature radiators
  – High Temperature radiators supplied with 45 °C
  – Radiant floor

• Model Limitations
  – No domestic hot water
  – No internal gains
  – Simplified thermostat schedules (const. 20 °C)
  – Radiant floor control not optimal
Results

Radiator Systems

- Low Temperature Radiators
- High Temperature Radiators
- Specific Useful Heat Demand

Radiant Floor

- Radiant Floor
- Specific Useful Heat Demand

Insulation: Phenolic Foam $\lambda = 0.02$ W/(mK)
New Windows $U$-value = 0.8 W/(m²K)
Old Windows $U$-Value = 2.7 W/(m²K)
Results

10cm Insulation Step-wise Renovation LT radiators

Lowest inside temperature [°C]

- With new Windows (U = 0.8)
- With Old Windows (U = 2.7)

Insulation: Phenolic Foam $\lambda = 0.02$ W/(mK)
New Windows U-value $= 0.8$ W/(m2K)
Old Windows U-Value $= 2.7$ W/(m2K)
Conclusion

- Current building stock not ready for low supply temperature
- Impossible to achieve thermal comfort with low supply temperature
- Step-wise renovations possible
- At least 5 cm insulation when supplying HT radiators with 45 °C
- At least 5 cm insulation for radiant floor
Future Work

• Study in Mediterranean Climate
• Increase building typologies
• Increase indoor distribution system typologies
• Increase insulation thickness
• Include renovation costs
• Expand simulation to district level with heat grid
THANK YOU FOR YOUR ATTENTION

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