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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

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Outline

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

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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

Positive Energy District

Energy Efficiency

Buildings retrofits
LCA
Making Cities ISO 52000

Spatial Aspects

No Clear boundaries
Autonomous
Dynamic
Virtual

Economic Aspects

Maximisation cost effectivness
Cost-benefit analysis
No established methodology

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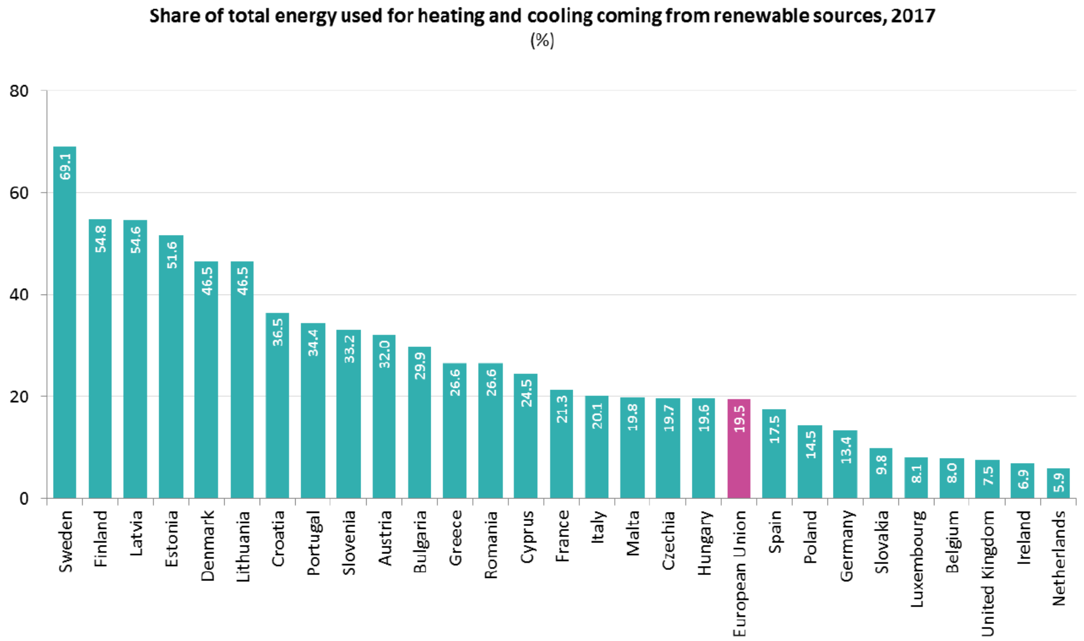
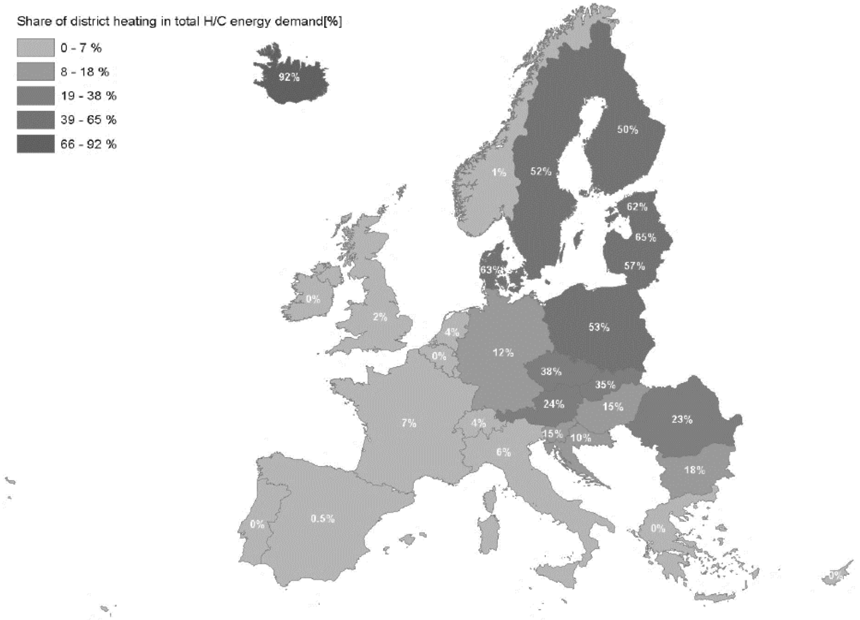
Introduction – Research Question





Source: https://ec.europa.eu/info/news/energy-heating-cooling-renewable-sources-2019-mar-04_en
"Energy for heating / cooling from renewable sources" – Eurostat 2017

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

And only 20% is renewable

Action is obviously needed

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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
Inlet/outlet design temperature of the common indoor distribution systems.

Indoor distribution system typology	Associated building insulation level	Inlet/outlet design temperature
High temperature radiator [2]	Poor	80/60 °C
Radiator[3]	Medium	55/45 °C
Low temperature radiator [4]	Good – NZEB-level (net-zero energy building level)	40/30 °C in apartment buildings. 45/35 °C in detached buildings
Floor heating[5]	Good - NZEB	35 °C/30 °C
Air heating based[6]	Poor – Medium - Good	40–50 °C/30–40 °C

[1] B. Vad *et al.*, "Future Green Buildings," 2016. https://vbn.aau.dk/ws/portalfiles/portal/234005850/Future_Green_Buildings_A_key_to_cost_effective_sustainable_energy_systems_ENGLISH.pdf
[2] V. I. T. Al, "in Smart Cities," no. May, pp. 2–5, 2016.
[3] http://webtool.building-typology.eu/#bm
[4] S. Paiho and F. Reda, "Towards next generation district heating in Finland," *Renew. Sustain. Energy Rev.*, vol. 65, pp. 915–924, 2016, doi: 10.1016/j.rser.2016.07.049.

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

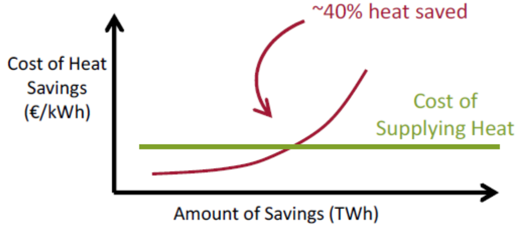

Figure 3: Simplified diagram which shows that energy renovations should only be invested in until the point in which the cost of supplying heat to the building is cheaper than further renovations. In the Danish building stock ~40 of heat demand per square metre should be saved in existing buildings

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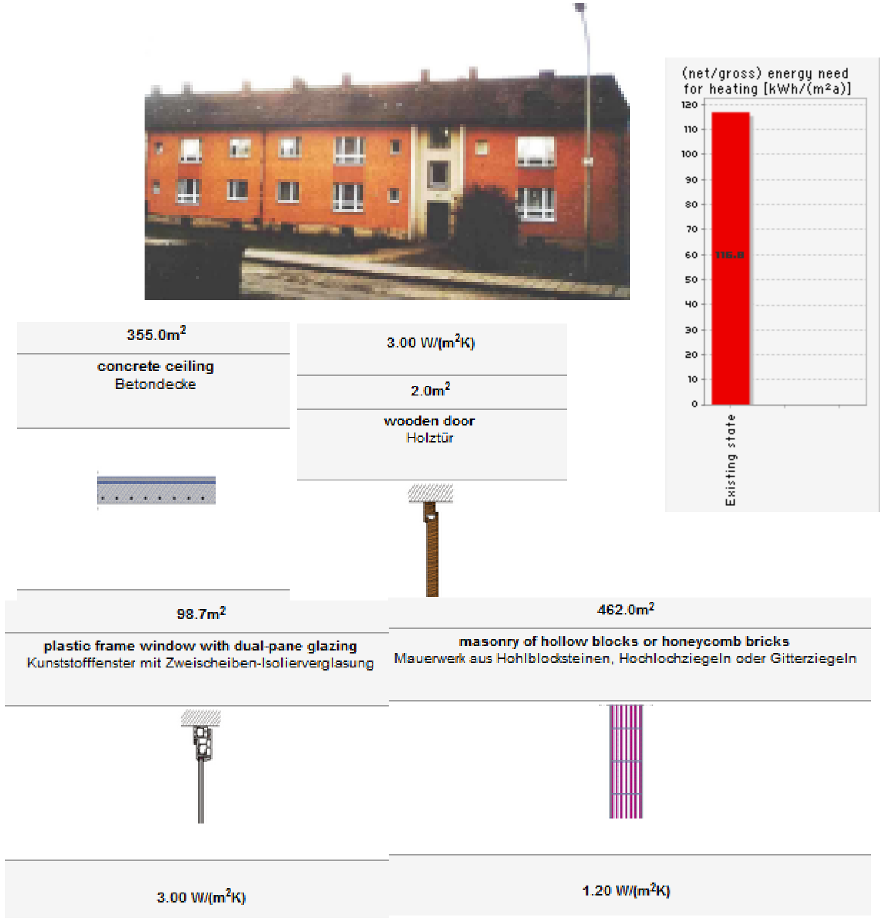
Methodology

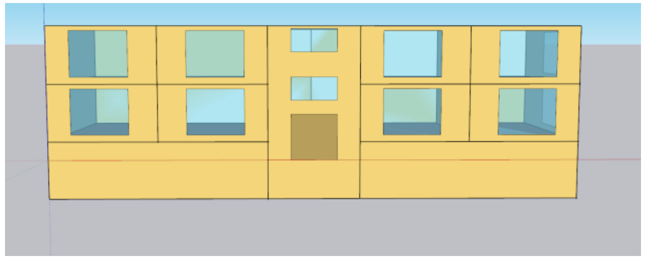
- Dynamic Building Simulation
- OpenStudio/EnergyPlus
- TABULA/episcope
- City: Frankfurt – Griesheim Mitte
- Multi Family House 1945-1957
- Building Renovation/Retrofitting
- Inside temperature 20 °C
- Heating only
- Decrease supply temperature to heating system

Methodology

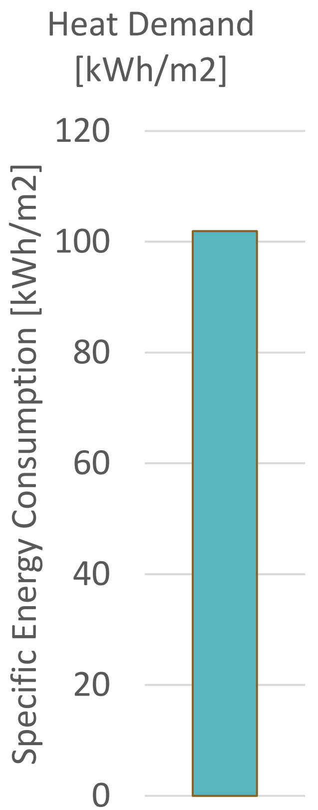
TABULA EPISCOPE



EnergyPlus



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

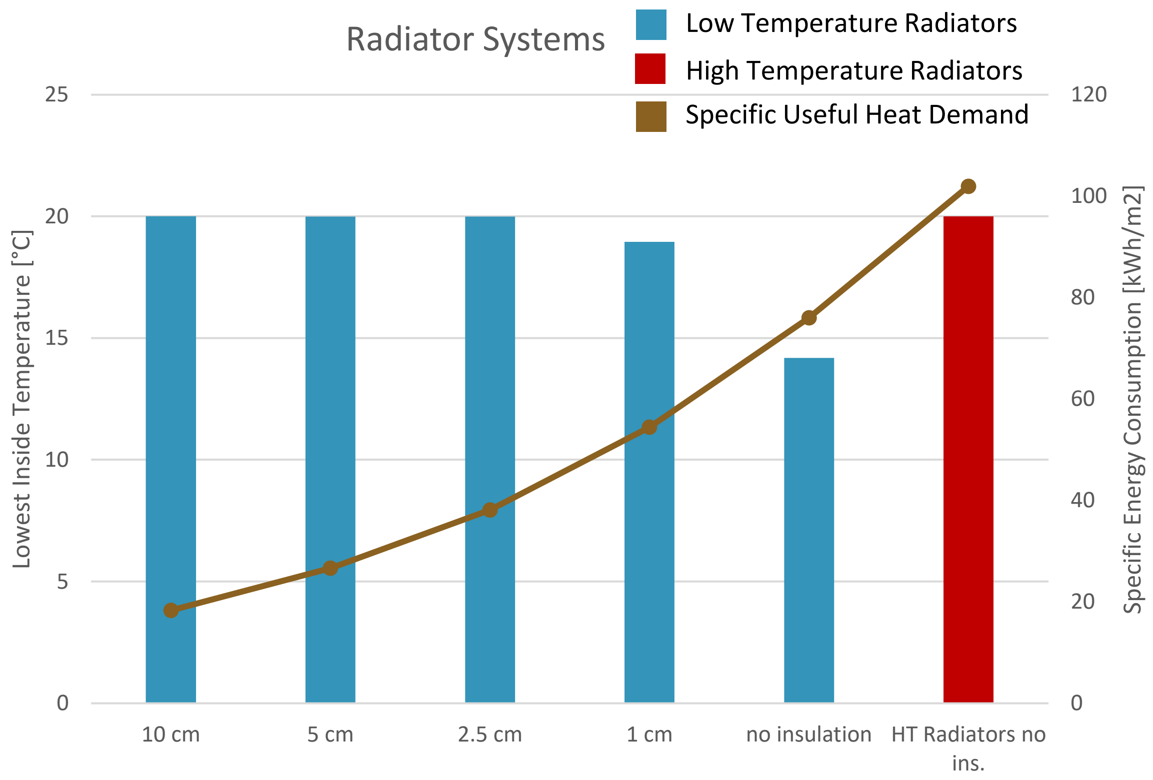


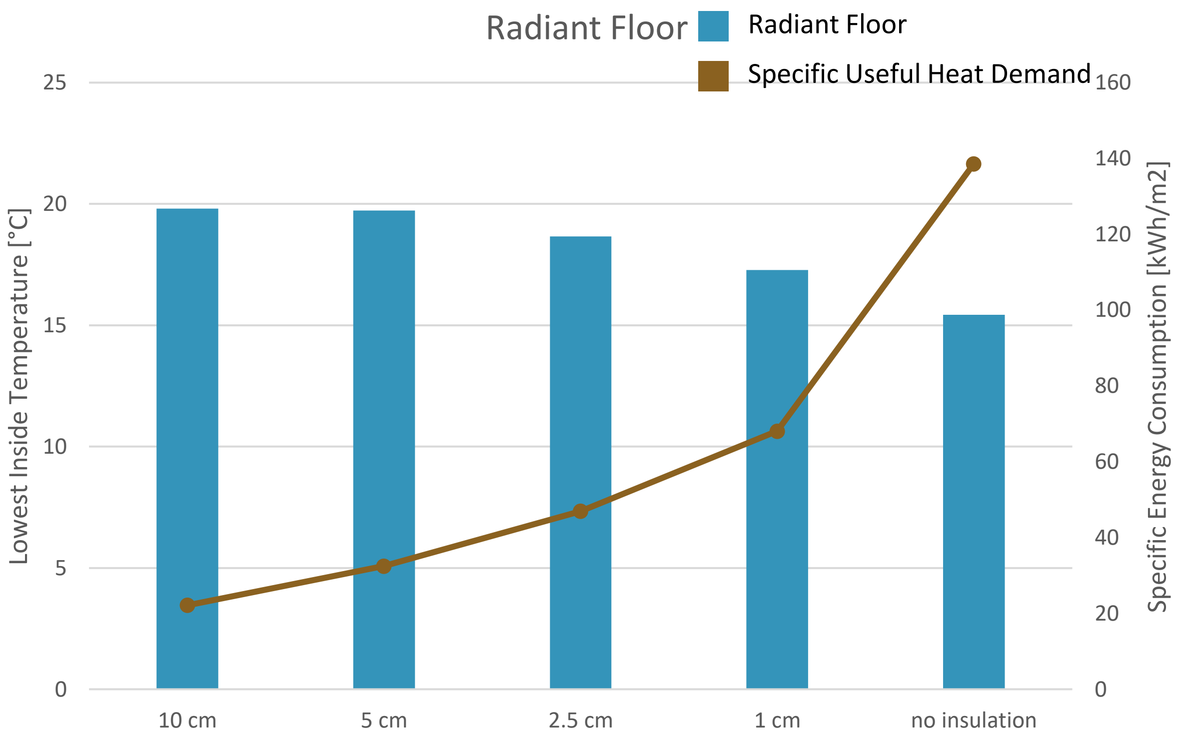
Methodology

- 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





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

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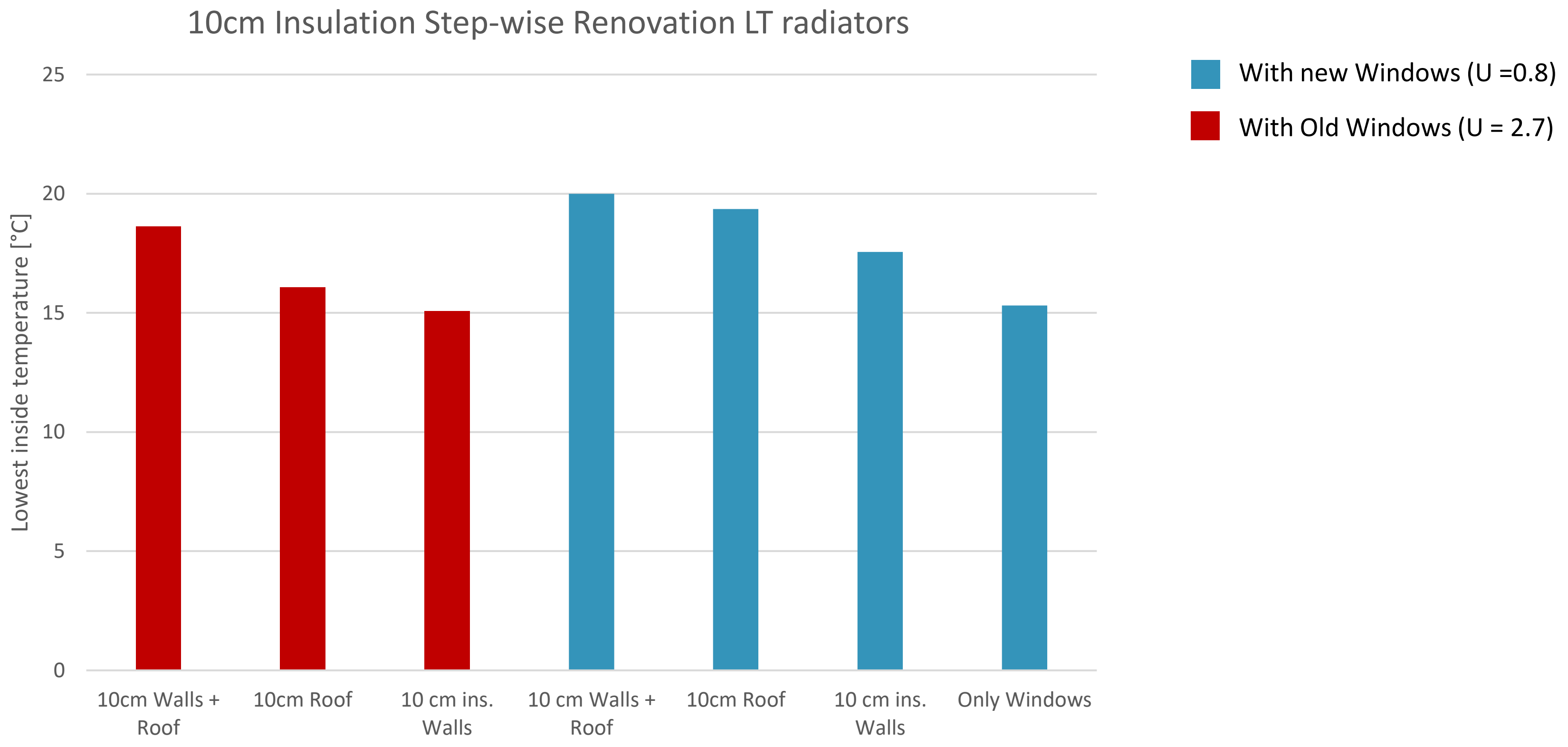

Insulation: Phenolic Foam λ = 0.02 W/(mK)
New Windows U-value= 0.8 W/(m2K)
Old Windows U-Value = 2.7 W/(m2K)

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

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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

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