TECHNISCHE UNIVERSITÄT WIEN

Energy Economics Group

Equitable decarbonization of heat supply in residential multi-apartment buildings

Optimal subsidy allocation between the property owner and tenants

43th IAEE International Conference, Tokyo, 31.07-04.08.2022

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03.08.2022

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This work has received funding from the European Union's Horizon 2020 research and innovation programme undere grant No. 835896

Todays' agenda

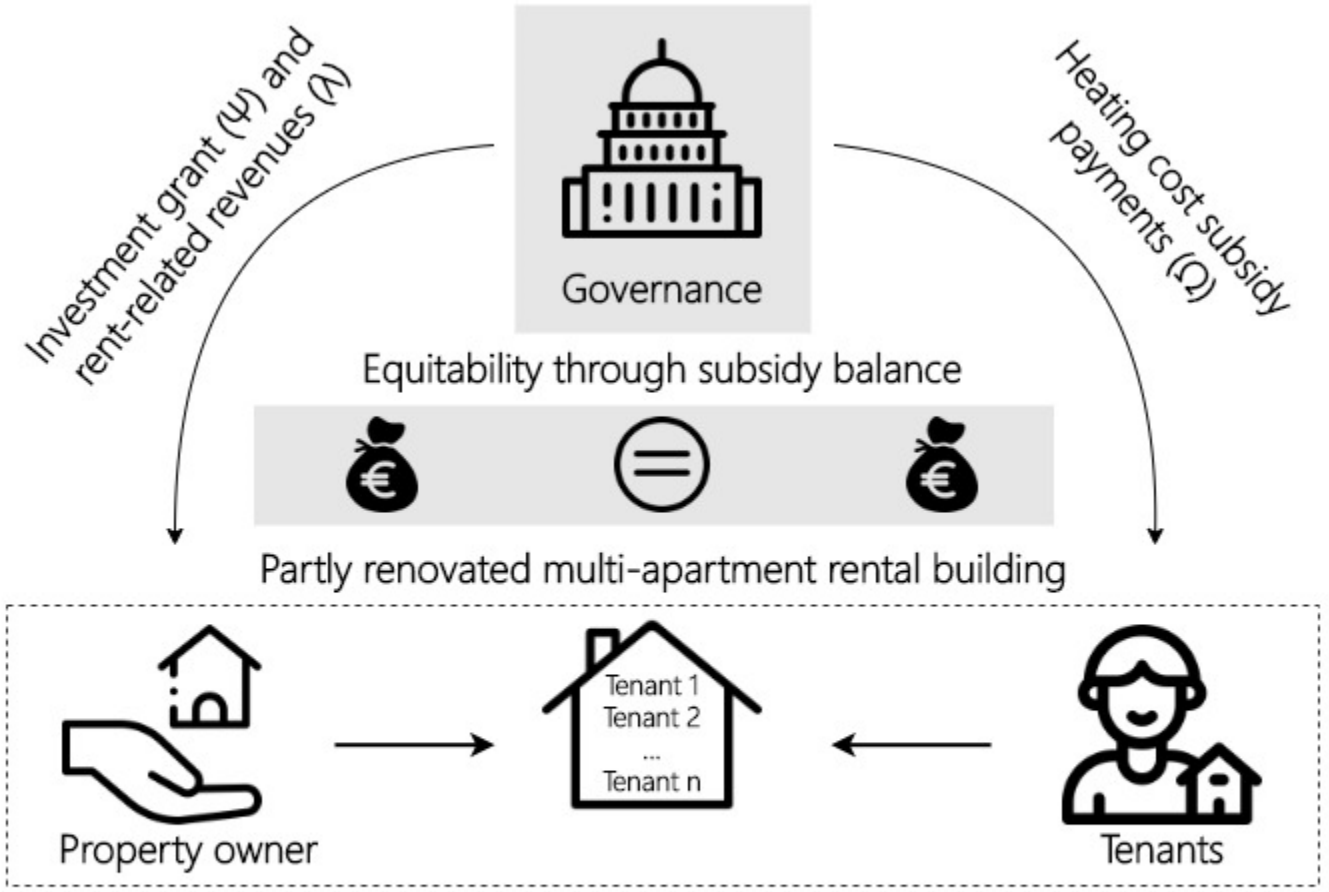
- Background and motivation
- Methodology
- Case study set up and scenarios
- Results
- Conclusions and outlook

Background and motivation

- *Fit for 55* package by the European Commission outlines the pathway until 2030 to reduce greenhouse gas emissions by 55%
- Need for energy justice with the manner of "no one left behind"
- The residential building sector calls for particular attention
  - High shares of fossil fuels in the provision of heat service needs
  - Inefficient ways of delivering heat demand caused by low standards of both building stock and heating devices
  - Complex building ownership structures and the property owner/tenant nexus in rented apartments or dwellings
- Buildings are responsible for 40% of EU energy consumption and 36% of the greenhouse gas emissions in 2021
- 75% of EU's buildings are energy inefficient and 35% are older than 50 years

Source: European Commission, Energy performance of buildings directive

Sketch of the approach



- Interest rate (i_l)
- Investment and construction costs

- Number of tenants (n)
- Energy prices (p)
- Initial rent price (r), etc.

- Interest rate (i_t)
- Heat demand (d)
- Rented area, etc.

Mathematical formulation of the model

Equation	Type	Short description
$\min_x \underbrace{\Psi}_{Inv.\,grant} + \underbrace{\sum_y \sum_m \frac{n}{(1+i_g)^y} * \Omega_{y,m}}_{Subsidy\ payment}$	Objective function	Minimize governance's total costs including investment grant (Ψ) and subsidy payment (Ω)
$\underbrace{\Psi + n * \sum_y \sum_m \frac{a * r_{y,m}}{(1+i_g)^y}}_{property\ owner\ financial\ support} = \underbrace{n * \sum_y \sum_m \frac{\Omega_{y,m}}{(1+i_g)^y}}_{tenants\ financial\ support}$	Equality constraint	Financial support parity between property owner and all tenants at the multi-apartment building level

Zwickl-Bernhard, S., Auer, H. (2022). Equitable decarbonization of heat supply in residential multi-apartment buildings: Optimal subsidy allocation between the property owner and tenants. *Energy and Buildings*, forthcoming.

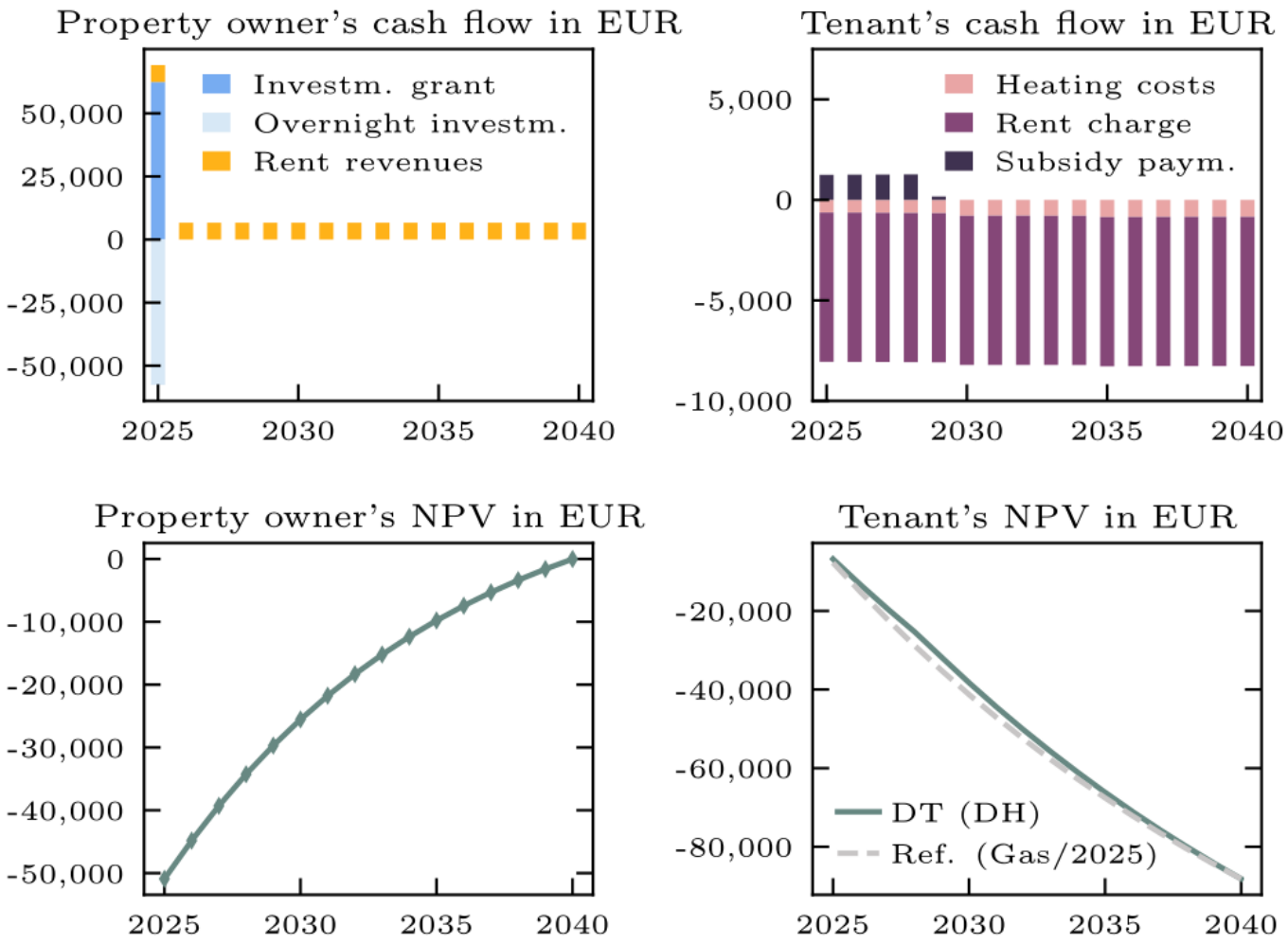
Case study set-up and scenario description

- Partially renovated and natural gas-fired heating system in an old building (privately owned) in Vienna, Austria
- Multi-apartment building (including all dwellings) is privately owned by the property owner
- The decarbonization of the existing heating system can be realized by a connection to district heating or the installation of an air-sourced heat pump
- Energy and CO_2 prices from European decarbonization scenarios in line with the remaining European CO_2 budget of the 1.5/2.0°C climate target[1]

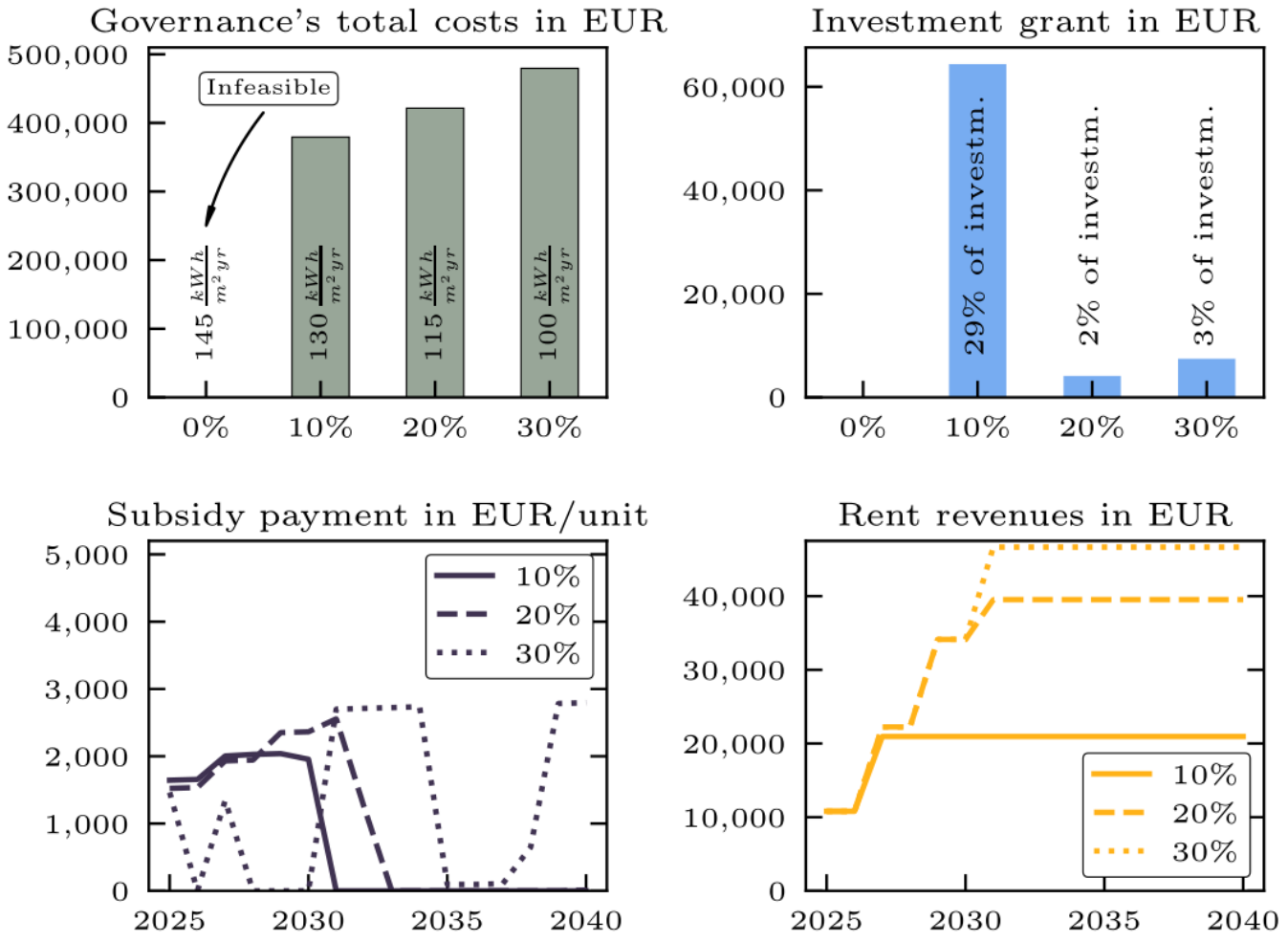
Symbol	Variable	Unit	Value
n	Number of tenants	-	30
i_g	Governance's interest rate	%	3
i_l	Property owner's interest rate	%	10
i_t	Tenant's interest rate	%	5
q	Heat demand (per dwelling)	kWh	8620
$\hat{d}$	Peak heat demand (per dwelling)	kW	5
c_{alt}	Heat pump|Investment costs	EUR/kW	1000
c_{con}	Heat pump|Construction costs (per dwelling)	EUR	1000
c_{alt}	District heating|Investment costs	EUR/kW	320
c_{con}	District heating|Construction costs (per dwelling)	EUR	2000
$\bar{r}$	Initial rent price	EUR/m^2	10
ρ	Maximum rent charge adjustment (ρ)	%	10
a	Rented area (per dwelling)	m^2	60

[1]Results from the Horizon 2020 project openENTRANCE (https://openentrance.eu/)

Results (1/4) – District Heating



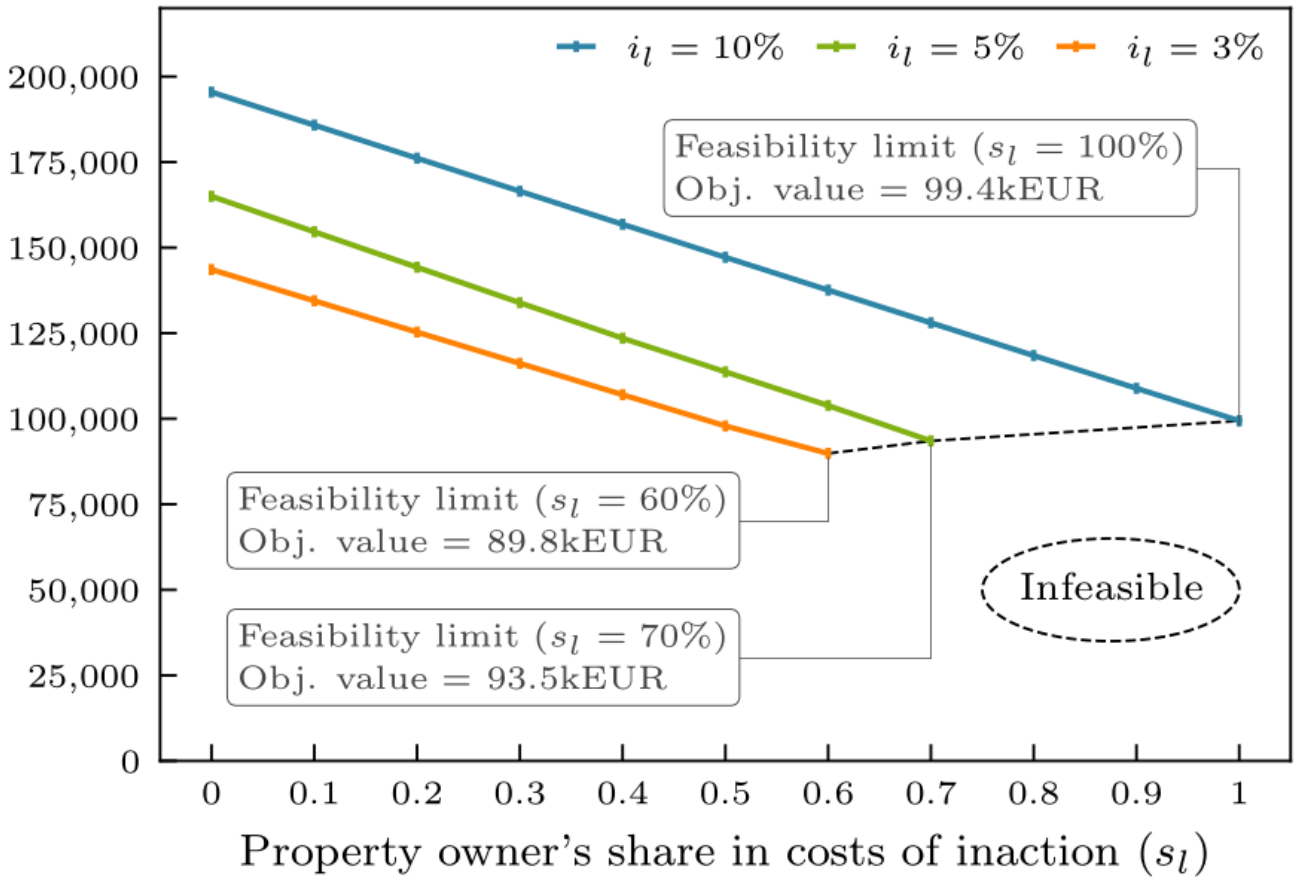
Results (2/4) – Heat Pump



Results (3/4) – Allocation of opportunity costs

	Rel. allocation of opportunity costs			Objective value	
Brief summary	Governance	Property owner	Tenant	Absolute in EUR	Rel. change in % from GD (DH)
Equally	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	146.6	-25%
Property owner & tenant	0	$\frac{1}{2}$	$\frac{1}{2}$	129.0	-34%
Property owner	0	1	0	99.7	-49%
Governance & tenant	$\frac{1}{2}$	0	$\frac{1}{2}$	183.8	-6%
GD (DH) from Sec. 3.3.3 (Governance)	1	0	0	195.5	-

Results (4/4) – Varying property owner's interest rate



Conclusions and outlook

- Rapid and equitable decarbonization of the heat sector in buildings is an indispensable cornerstone in a sustainable society
- Special attention is needed for the rented buildings sector since an investment decision is in the property owner's hands
- A fair and equitable switch to a sustainable heat system is possible but with massive public subsidy payments
- Heat pump alternative is not competitive in supplying heat service needs in partly renovated old buildings (equitability constraint)
- Allocating the costs of inaction between the governance, the property owner, and the tenants is an important lever and can reduce the required subsidy payments
- Future work: active/passive building renovation measures as a necessary precondition for subsidy payments; tenant's diversification within the building (e.g., different willingness to pay to contribute to CO_2 mitigation)

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