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LONG-TERM INVESTMENT DECSIONS FOR PROSUMERS IN MULTI-APARTMENT BUILDINGS

Introduction

- This work aims at assessing the long-term economic viability of shared electricity and heat concepts in multi-apartment buildings.
- Therefore, an optimization model is developed in Matlab with the objective of maximizing the Net-Present-Value (NPV) over a time horizon of 20 years.
- Different scenarios (Table 1) are defined by considering different combinations of renewable electricity and heat concepts (photovoltaic systems, battery storage facilities, heat pumps and conventional renovation) to retrofit an old building.
- By calculating the NPV, the optimal capacities of said renewable electricity and heat concepts are determined as well.
- A ficticious multi-apartment building containing ten residential units (Figure 1), which are allocated real-measured load profiles, are taken as a basis to conduct analyses on.
- Based on the NPV calculated for different scenarios, the optimal long-term investment can be determined.

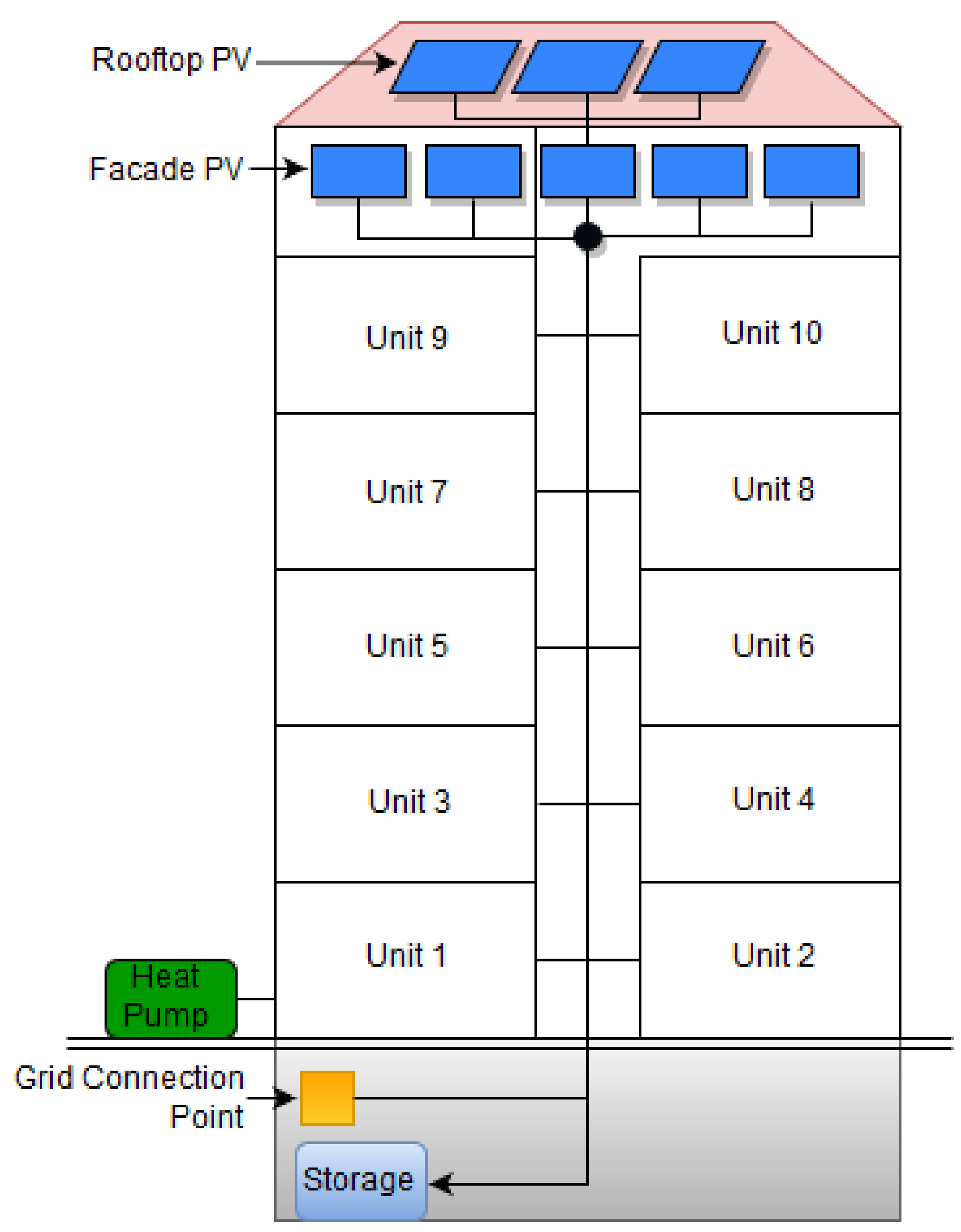


Figure 1: Multi-apartment building

Methodology

$$NPV = \sum_{x=1}^{X} -I_0(x) + \sum_{y=1}^{Y} \frac{E(y) - A(y)}{(1+r)^y}$$

$$E(y) = \sum_{x=1}^{X} \sum_{t=1}^{T} e_{X2G}(x,t,y) * c_{feedin}$$

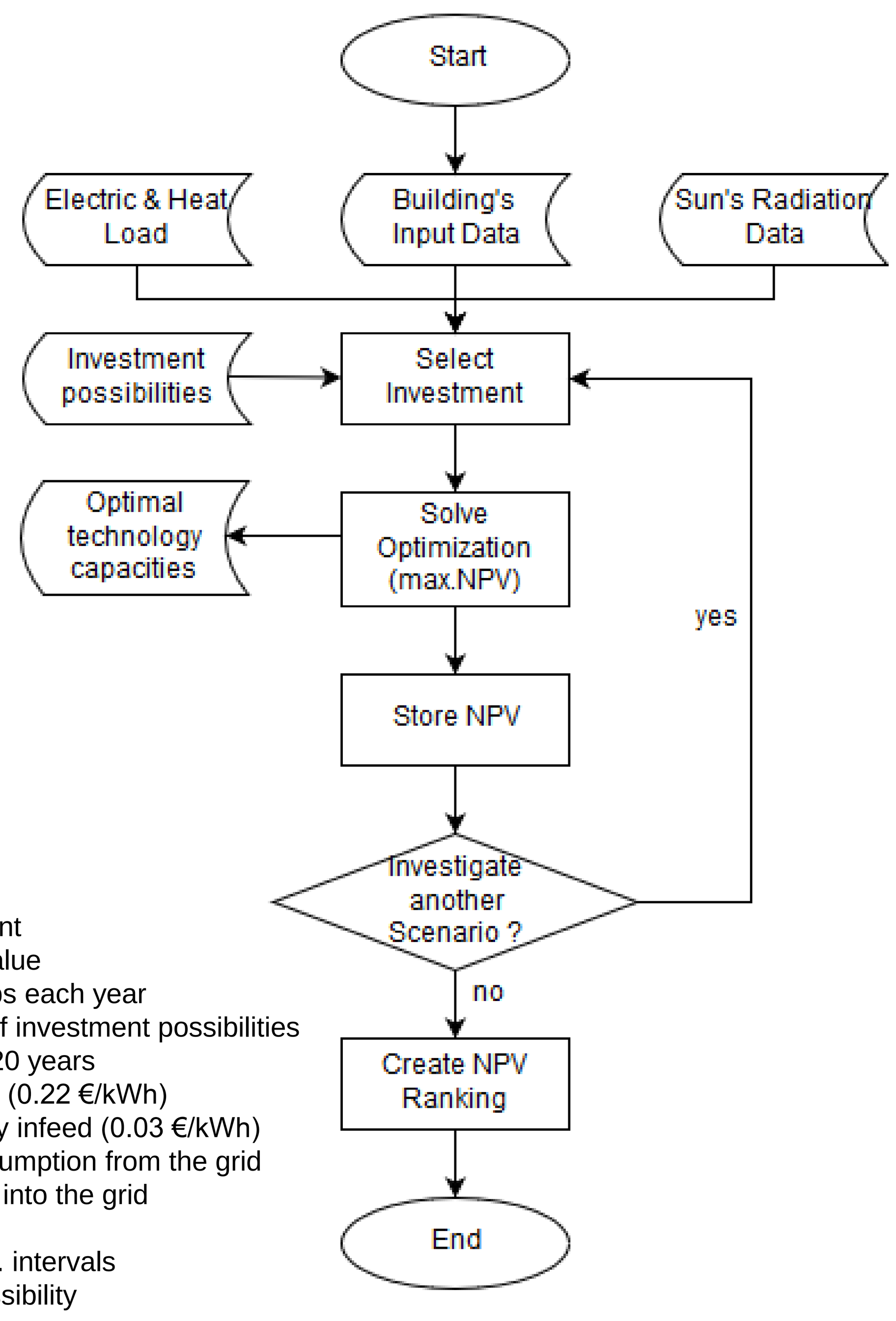
$$A(y) = \sum_{t=1}^{T} e_G(t,y) * c_{elec} + \sum_{x=1}^{X} C_{anno}(x,y)$$

Investment possibilities:

- Photovoltaic System (PV):
  - → Building attached PV (BAPV)
  - → Building integrated PV (BIPV)
    - → Both for rooftop and facade
  - → Shading elements on the facade
- Battery storage facility
- Heat-pump system:
  - → Monovalent operation
  - → Bivalent operation

Nomenclature:

A	Expenses
C_{anno}	Annual costs
E	Income
I_0	Initial Investment
NPV	Net-Present-Value
T	35040 timesteps each year
X	Total number of investment possibilities
Y	Time horizon, 20 years
c_{elec}	Electricity price (0.22 €/kWh)
c_{feedin}	Price for energy infeed (0.03 €/kWh)
e_G	Electricity consumption from the grid
e_{X2G}	Electricity-feed into the grid
r	Rate of return
t	Time in 15-min. intervals
x	Investment possibility
y	Year



Results

Scenario	Rooftop PV	Orientation Roof	Facade PV	Tilt
Scenario 1	Building attached	North / South	-	30°
Scenario 2	Building integrated	North / South	-	30°
Scenario 3	Building attached	East / West	-	30°
Scenario 4	Building integrated	East / West	-	30°
Scenario 5	-	-	Building attached	60°
Scenario 6	-	-	Building attached	90°
Scenario 7	-	-	Building integrated	90°
Scenario 8	Building attached	North / South	-	40°
Scenario 9	Building integrated	North / South	-	40°
Scenario 10	Building attached	East / West	-	40°
Scenario 11	Building integrated	East / West	-	40°

Table 1: Scenario specification

NPV negativ → Electricity/heat consumption leads to expenses → These expenses - in comparison to grid consumption only - can be reduced by investing in different renewable technologies.

The effects of the PV panel tilt and the orientation, BAPV and BIPV systems can be seen in Figures 2 and 3:

→ PV oriented south: A tilt of 40° leads to higher profitability than a tilt of 30° (for the location of Vienna)

→ PV oriented east/west: A tilt of 30° leads to higher profitability than a tilt of 40° (for the location of Vienna)

→ BIPV is always more expensive than BAPV due to unavoidable investments in the building envelope (conventional renovation).

→ In case a PV system is installed, the orientation of choice (if possible) is always south → higher solar irradiance → higher profitability.

Figure 2: NPV comparison, rooftop PV systems

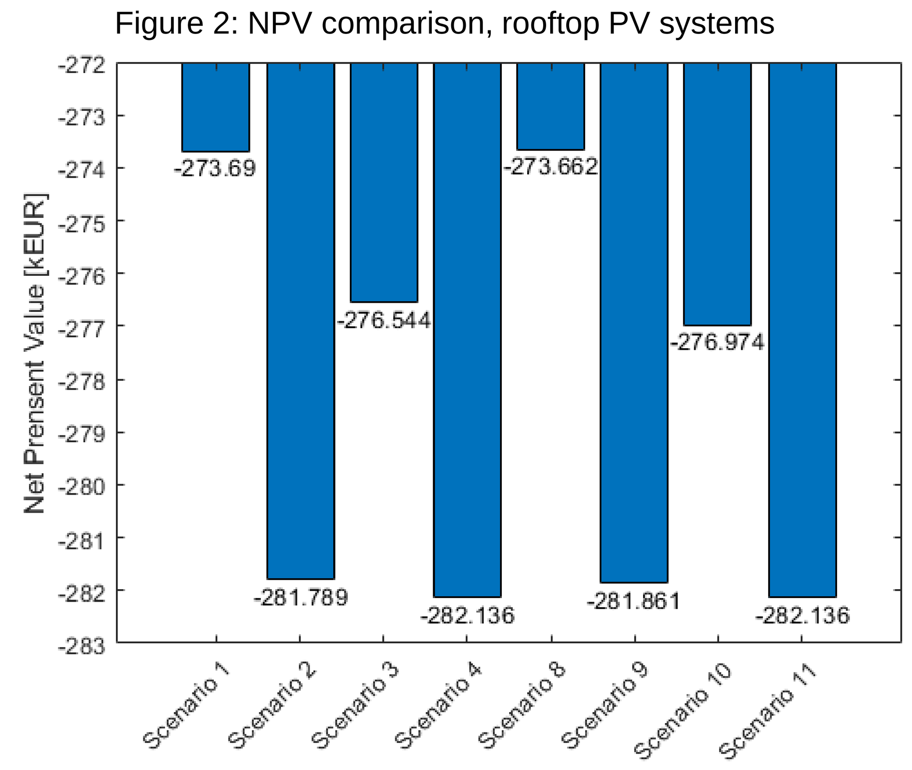
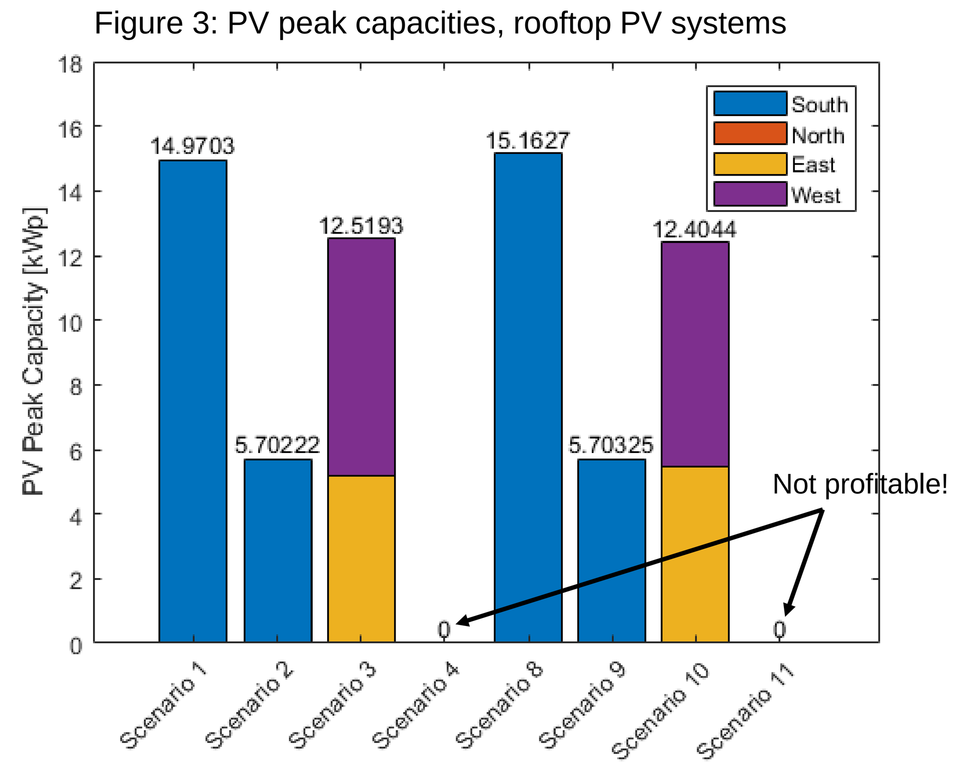


Figure 3: PV peak capacities, rooftop PV systems



All results consider a heat-pump system in bivalent operation mode.

Monovalent heat-pump operation leads to:
→ Rising costs
→ Larger dimensioning of the heat-pump capacity

Figures 4 and 5 provide a comparison of rooftop and facade PV sytems:
→ Implementing PV systems on the roof results in higher profitability than implementing PV panels on the facade. This can be justified by the irradiation angle of the sun.
→ However, using PV panels as shading elements on the facade with a tilt of 60° leads to better results in terms of the NPV compared to the 90° situation.
→ A facade BIPV system is not profitable due to the bad irradiation angle combined with the necessity to include the costs for standard facade retrofitting.

Figure 4: NPV comparison, rooftop/facade PV systems

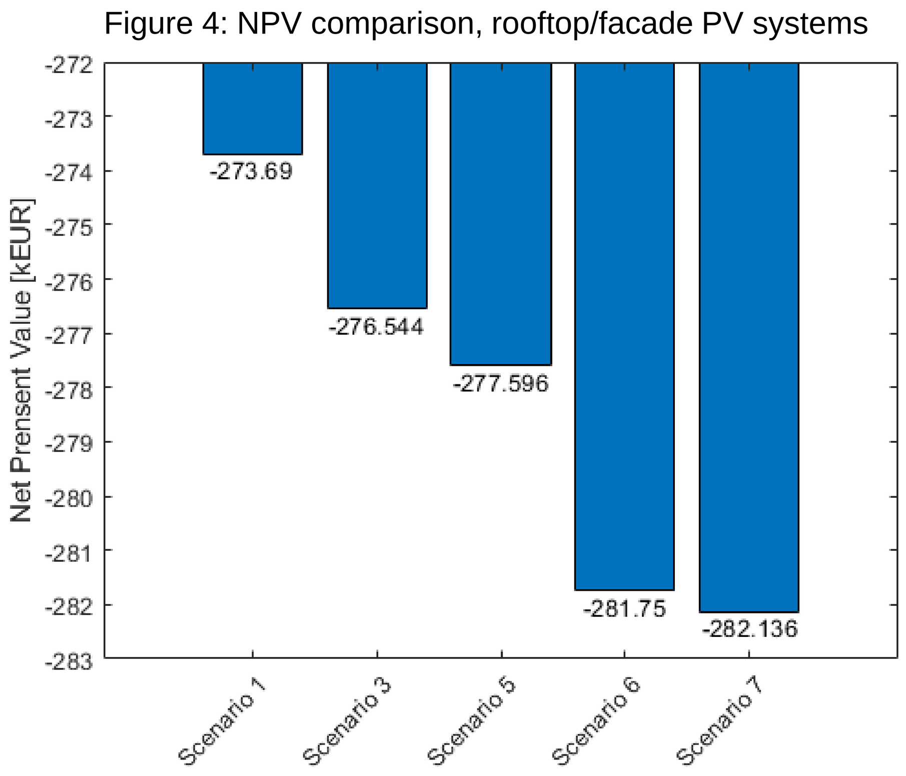
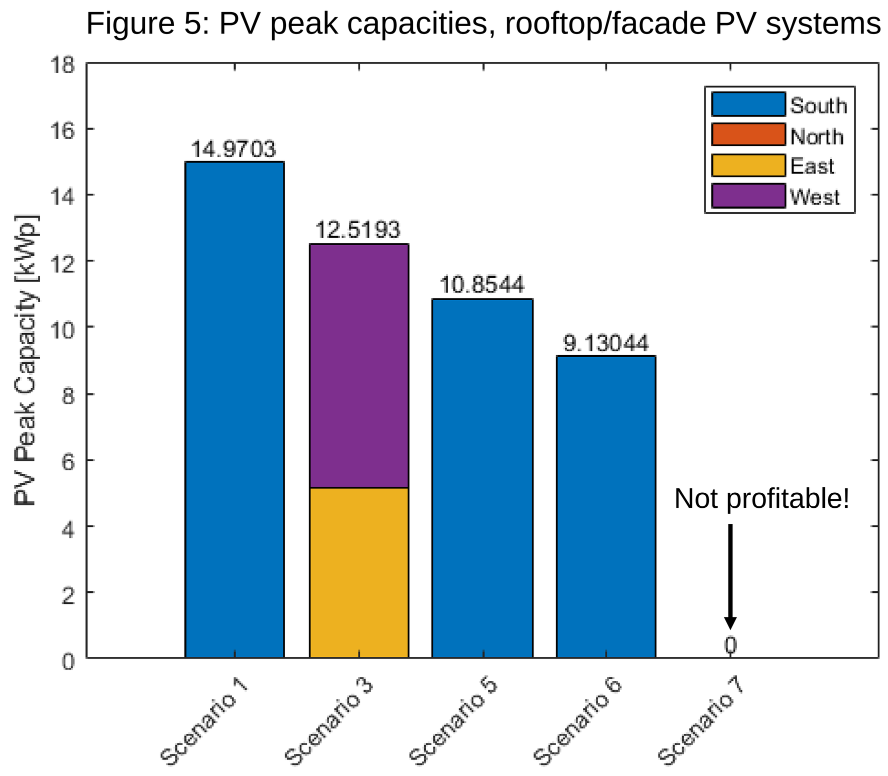


Figure 5: PV peak capacities, rooftop/facade PV systems



Conclusions and Outlook

- The results show that retrofitting an old building with renewable electricity and heat concepts makes perfect sense in long-term: → In most scenarios, the end-users' costs in a time horizon of 20 years can be reduced by investments in PV systems and heat pumps.
- In case roof and facade retrofitting is not necessary per se, implementing BAPV systems is to be preferred over BIPV systems.
- Battery storage facilities don't make a huge difference when aiming at a cost reduction.

- In further research various other heat concepts, like biomass heating, solar thermal systems and CHP systems, will be evaluated in the same context to be used additionally to the heat pump system.
- Furthermore, it will be necessary to spend time on evaluating the economic viability when taking electricity/heat exchange beween buildings within close range into account.
  → Increasement of flexibilities