Local energy planning for commercial areas: what role for the Energy Efficiency First principle?

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enefirst.

Agenda

01 | Background
Why is there a need for model-based assessments on commercial areas in the EU?

02 | Methodology
Scenarios, model, input data

Q&A Session

03 | Results
Building retrofits do pay off, but there are limitations

04 | Discussion
Why the results should be interpreted with caution

Background

Why is there a need for model-based assessments on commercial areas in the EU?

Societal relevance

- Services sector represents 13.4% of EU final energy use
- Energy Efficinecy First principle
- Renovation wave strategy
- EPBD revision proposal
- EED revision proposal

Local relevance

- Need for identifying opportunities to improve performance of buildings at neighbourhood scale
- Options include building retrofits, on-site resources, DHC, demand response, and others

Scientific relevance

- Need for reliable models to assist optimisation of local system design and operation
- Requires detailed description of spatiotemporal patterns of building demand and resource availability

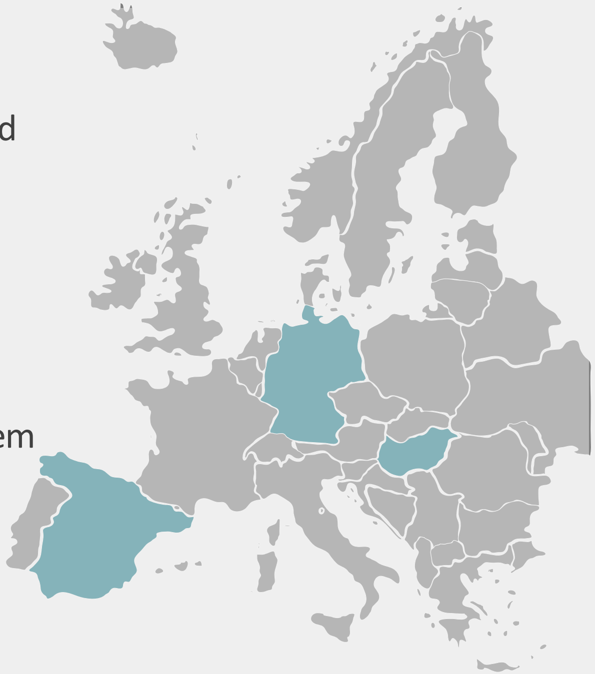
What's the objective of this case study?

Objective

Explore trade-offs and synergies between building retrofits and energy supply options in commercial areas

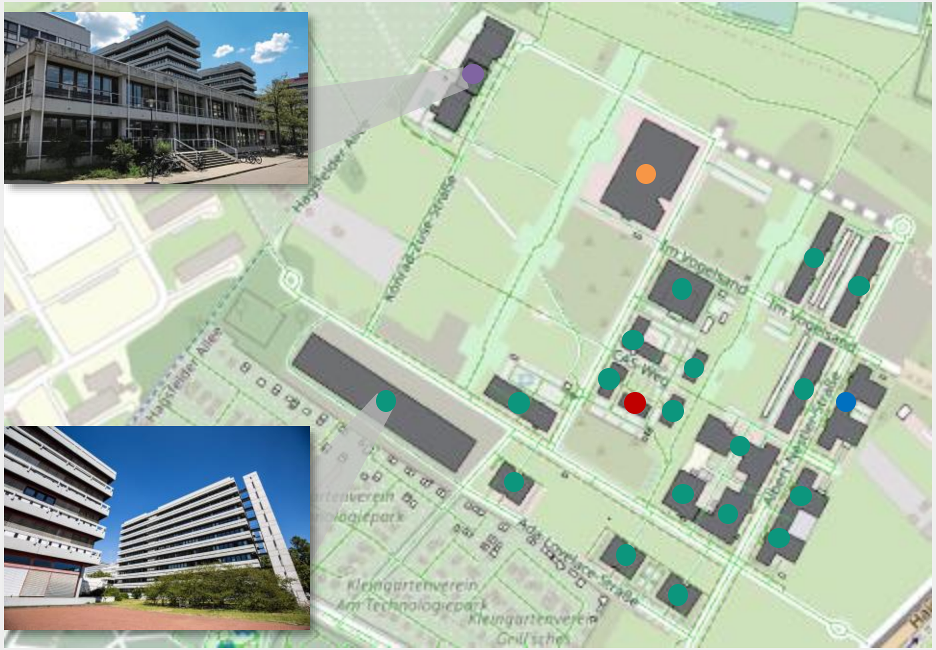
Key characteristics

- One archetypical commercial area in three EU countries
- Inspired by real-life buildings and topography
- Use of open-source modelling software for analysing system technology configurations and their cost-effectiveness
- Hourly resolution of system operation



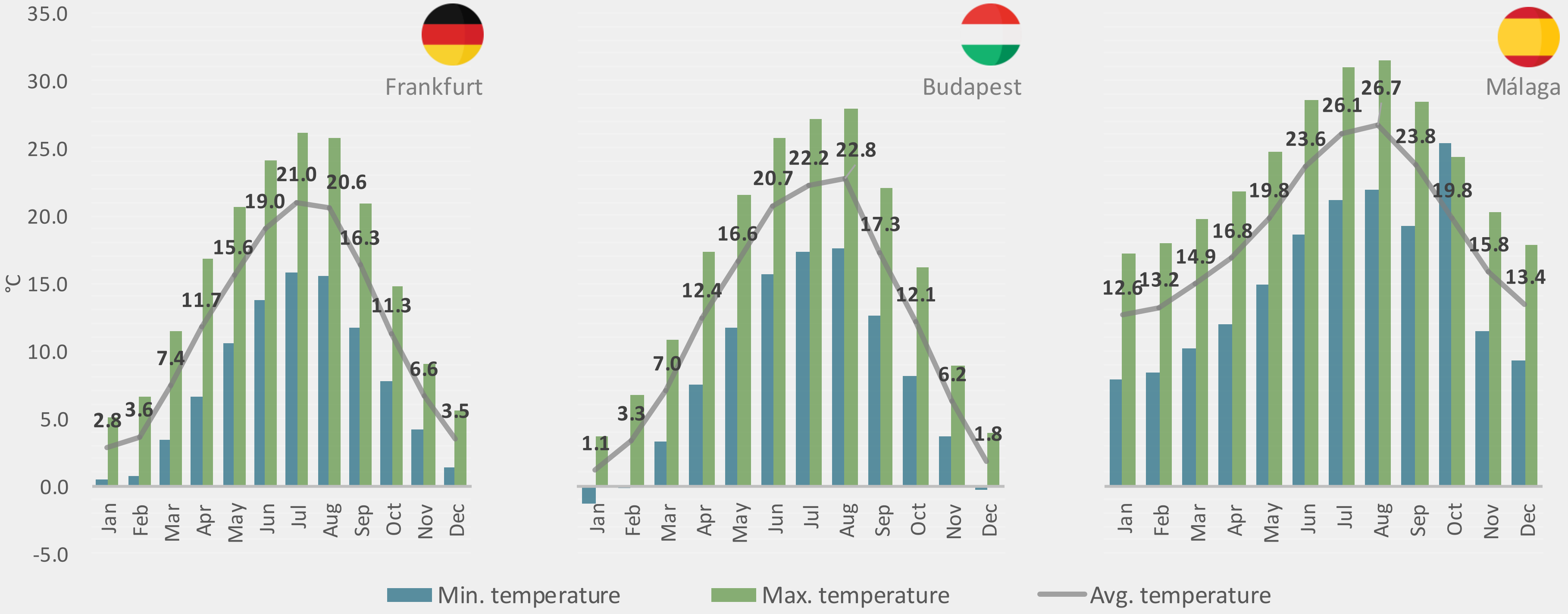
Methodology

One archetype office park is examined in all three countries



No.	Type	Conditioned floor area (m² | %)	Gross floor area (m² | %)
#1	Office	25948 m² | 24.2%	37972 m² | 23%
#2	Lab	11955 m² | 11.2%	19438 m² | 11.8%
#3	Office	8653 m² | 8.1%	14070 m² | 8.5%
#4	School	6647 m² | 6.2%	10808 m² | 6.5%
#5	Canteen	6571 m² | 6.1%	10017 m² | 6.1%
#6	Office	4878 m² | 4.6%	6798 m² | 4.1%
#7	Office	4876 m² | 4.5%	6795 m² | 4.1%
#8	Office	4456 m² | 4.2%	6793 m² | 4.1%
#9	Office	4855 m² | 4.5%	6767 m² | 4.1%
#10	Office	4327 m² | 4%	6596 m² | 4%
#11	Office	4212 m² | 3.9%	6420 m² | 3.9%
#12	Office	3209 m² | 3%	5870 m² | 3.6%
#13	Office	3259 m² | 3%	5299 m² | 3.2%
#14	Office	2690 m² | 2.5%	4375 m² | 2.6%
#15	Office	2655 m² | 2.5%	4317 m² | 2.6%
#16	Office	2606 m² | 2.4%	4237 m² | 2.6%
#17	Office	1758 m² | 1.6%	2859 m² | 1.7%
#18	Office	1060 m² | 1%	1723 m² | 1%
#19	Office	888 m² | 0.8%	1444 m² | 0.9%
#20	Server room	844 m² | 0.8%	1373 m² | 0.8%
#21	Office	839 m² | 0.8%	1364 m² | 0.8%
		107186 m² | 100%	165337 m² | 100%

We consider buildings in three climate zones



Source: meteostat.net | Average climate 1991 – 2020

The following scenarios are defined

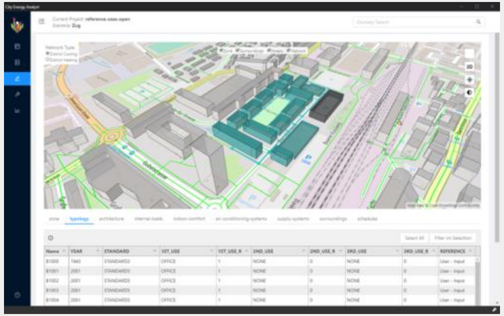
Retrofit measures by building component | U-value

	Scenario	Roof	Wall	Floor	Windows
DE	DE_Existing	Concrete ceiling with 5 cm insulation 0.51 W/(m²K)	Concrete panels 1.10 W/(m²K)	Concrete base with 2 cm insulation 0.77 W/(m²K)	Plastic frame with double glazing 3.00 W/(m²K)
	DE_Standard	+12 cm insulation 0.19 W/(m²K)	+12 cm insulation 0.23 W/(m²K)	+8cm insulation 0.28 W/(m²K)	Double glazing, argon filled, low emissivity 1.30 W/(m²K)
	DE_Advanced	+30 cm insulation 0.09 W/(m²K)	+24 cm insulation 0.13 W/(m²K)	+12 cm insulation 0.21 W/(m²K)	Triple glazing, argon filled, low emissivity 0.80 W/(m²K)
ES	ES_Existing	Wooden joints 1.92 W/(m²K)	Cavity wall 1.33 W/(m²K)	Wooden joints 1.13 W/(m²K)	Single glazing 5.70 W/(m²K)
	ES_Standard	+2 cm insulation and gravel 0.60 W/(m²K)	+3 cm insulation 0.64 W/(m²K)	No improvement 1.13 W/(m²K)	Double glazing 1.84 W/(m²K)
	ES_Advanced	+6 cm insulation and greenery 0.15 W/(m²K)	+5 cm insulation 0.42 W/(m²K)	No improvement 1.13 W/(m²K)	Triple glazing 0.80 W/(m²K)
HU	HU_Existing	Concrete ceiling 0.44 W/(m²K)	Concrete panels 0.70 W/(m²K)	Concrete base 0.48 W/(m²K)	Wooden frame with double glazing 2.50 W/(m²K)
	HU_Standard	+10 cm insulation 0.21 W/(m²K)	+5 cm insulation 0.37 W/(m²K)	+10 cm insulation 0.24 W/(m²K)	Double glazing, argon filled, low emissivity 1.60 W/(m²K)
	HU_Advanced	+24 cm insulation 0.12 W/(m²K)	+16 cm insulation 0.18 W/(m²K)	+20 cm insulation 0.16 W/(m²K)	Triple glazing, argon filled, low emissivity 1.00 W/(m²K)

Source: TABULA building typology

The City Energy Analyst (CEA) tool is used to model the scenarios

City Energy Analyst



Key features

- Data helper
- Urban solar radiation
- Renewable energy assessment
- Dynamic demand forecast
- Multi-objective optimisation
- Mapping & visualisation

Input data is compiled from various sources

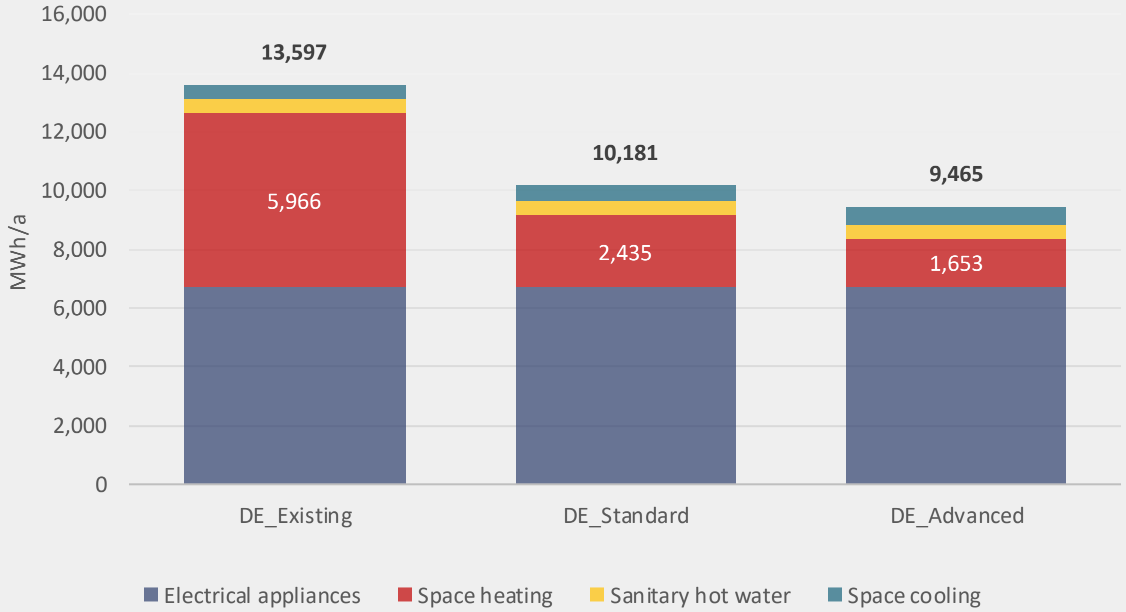
Input data	Source
Building properties	TABULA project
Building retrofit cost	ENTRANZE project
Weather	Meteostat.net
Technology cost	RES-H project; DEA Technology Catalogue
Energy carrier prices	Eurostat; ENEFIRST project
GHG emission intensities	ENEFIRST project

Q&A Session

Results


Morris Charts
Line Chart
Area Chart
Bar Chart
Donut Chart
Sparkline Charts
Line Chart
Bar Chart
Pie Chart
Easy Pie Charts
25%
50%
75%
100%

Final energy demand



Final energy demand by end-use in DE [MWh/a]

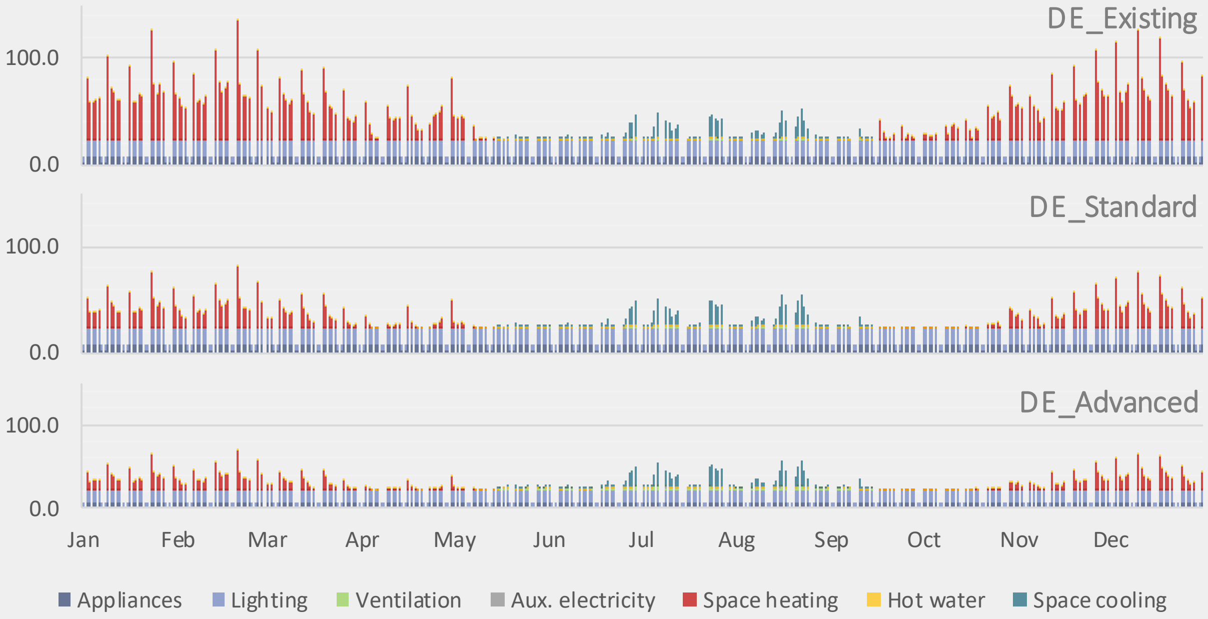
Results

- Building retrofits reduce space heating demand by -59.2% (*DE_Standard*) and -72.3% (*DE_Advanced*)
- Space cooling demand slightly increases due to internal gains

Key message

According to the bottom-up model, thermal retrofits lead to significant reductions in final energy demand for buildings

District load curve



Load curve by end-use [MWh/d]

Results

- Peak load on 20 Feb with outdoor temperature of -4.5°C
- Peak load reduced from 138.2 (*DE_Existing*) to 82.0 (*DE_Standard*) and 70.9 MWh/d (*DE_Advanced*)

Key message

Building retrofits reduce peak demand and thus the capacities needed on the supply side

District heating network layout

District heating network layout at nominal operating conditions

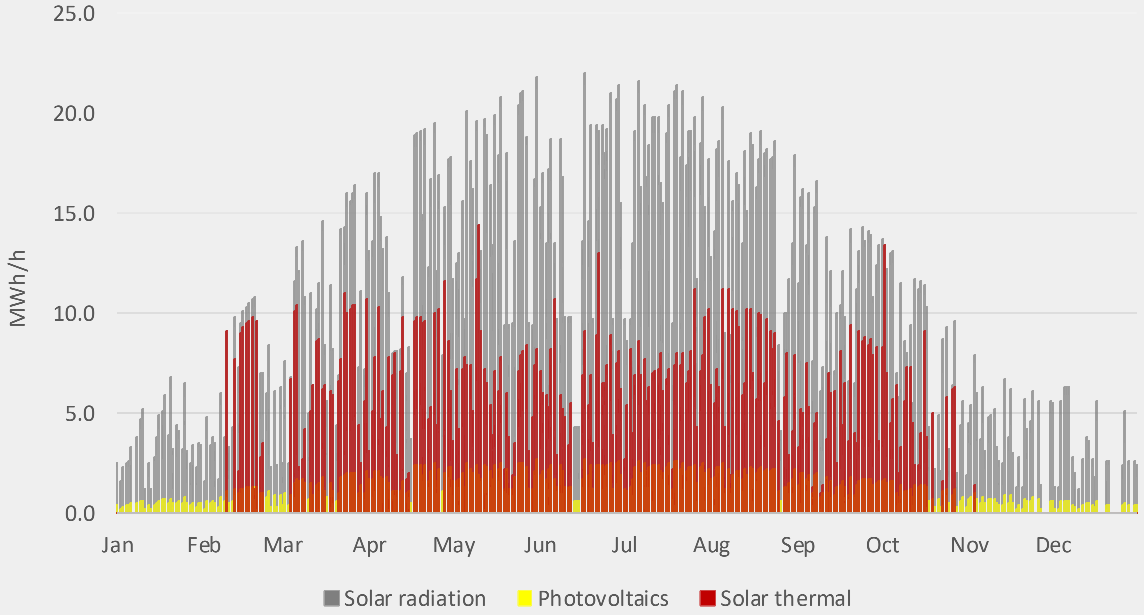
Results

- CEA model computes potential layout of network with minimum spanning tree
- trench length 0.7–103.5 [m]
- mass flow rate 3.3–96.3 [kg/s]
- peak velocity 1.8–2.5 [m/s]

Key message

According to the simulation, a thermal hydraulic network is technically feasible for all buildings in the area

Solar generation potentials



Technical generation potentials for solar technologies [MWh/h]

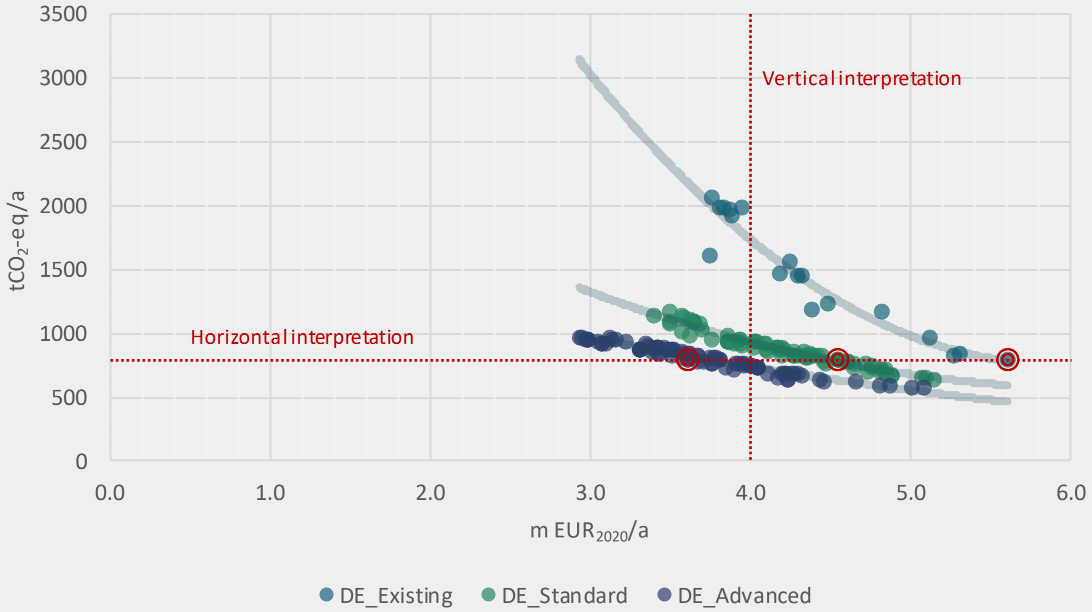
Results

- Total space available (roofs) = 24,487 m² (= 156 x 156 m)
- Solar radiation = 24,263 MWh/a
- Technical potential = 3,301 (photovoltaics); 6,469 (solar thermal) MWh/a

Key message

Different technically viable solar technologies compete for limited roof space in the neighbourhood

Possible supply system configurations



Comparison of Pareto-frontiers for supply configurations [m EUR_{2020}/a vs. tCO_2-eq/a]

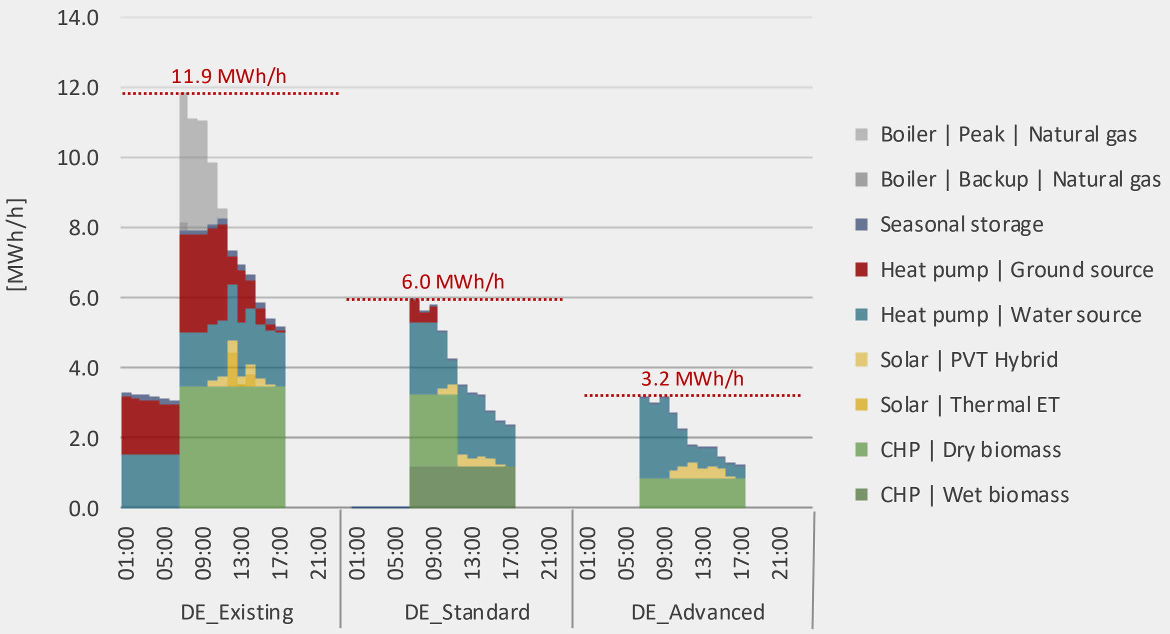
Results

- Vertically: higher levels of GHG reduction for same level of cost
- Horizontally: reduced cost for same level of GHG reduction
- GHG 574.6 – 2,074.7 tCO_2-eq/a
- Cost 2.9 – 5.6 m EUR_{2020}/a

Key message

In each scenario, buildings can be supplied by a variety of technically feasible technology configurations.

Heat dispatch



Dispatch curve for heating plants on 20 Feb 2022

Results

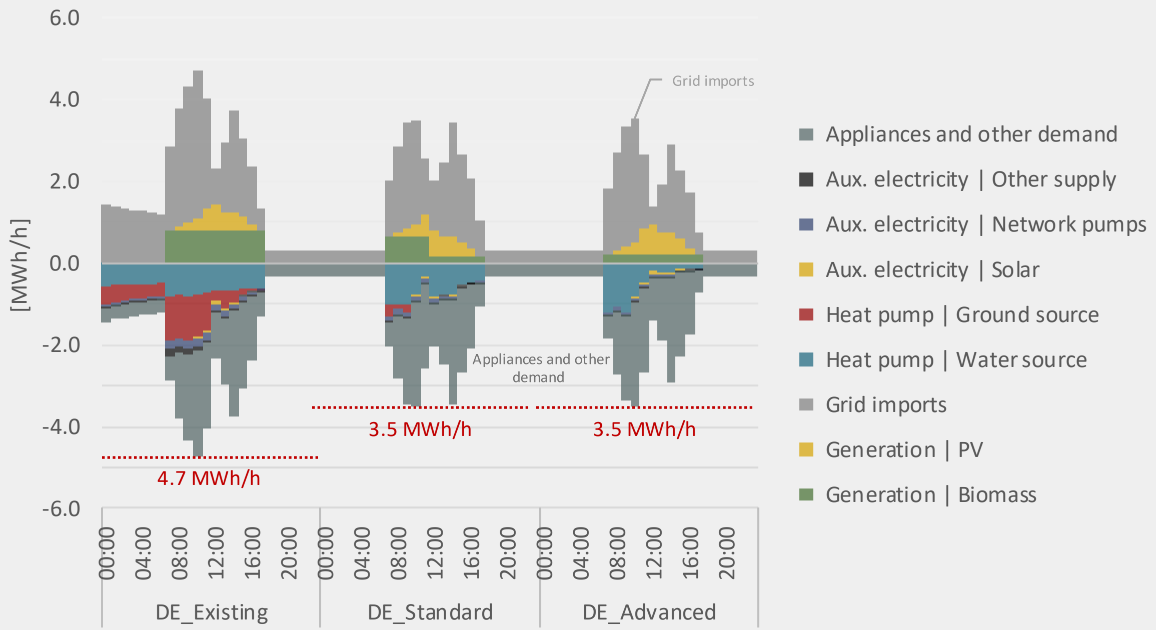
- Base load covered by biomass CHPs; peaks served by natural gas boilers
- Peak thermal load reduces by -49.5% (DE_Standard) and -73.4% (DE_Advanced)

Key message

Building retrofits reduce district heating peak load and alter the composition of cost-effective technologies

Thermal ET = Evacuated tube solar thermal collector; PVT Hybrid = Photovoltaic-thermal panel

Electrical dispatch & load



Dispatch curve for electricity generators and load on 20 Feb 2022

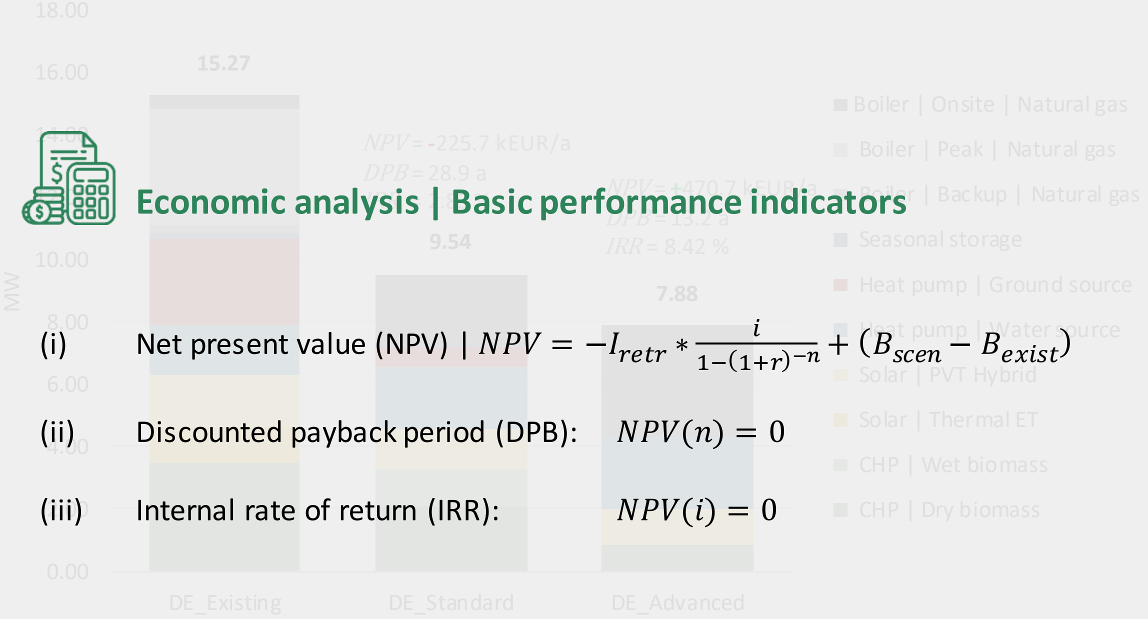
Results

- Peak electrical load reduces by -25.7% in DE_Standard and DE_Advanced
- Stable load for appliances (2.6 MWh/h)
- Var. load for DH network pumps (0.22–0.08 MWh/h)

Key message

Building retrofits do not only reduce thermal load in district heating networks, but also electrical load

Installed capacities



Installed heat generation capacities by technology [MW]

Economic analysis | Basic performance indicators

(i) Net present value (NPV) | $NPV = -I_{retr} * \frac{i}{1-(1+r)^{-n}} + (B_{scen} - B_{exist})$

(ii) Discounted payback period (DPB): $NPV(n) = 0$

(iii) Internal rate of return (IRR): $NPV(i) = 0$

Results

- Heat generation capacity reduces by 37.5% (DE_Standard) and 48.4% (DE_Advanced)
- Onsite natural gas boilers significant technology in DE_Advanced (3.5 MW)
- DE_Standard not cost-effective

Key message

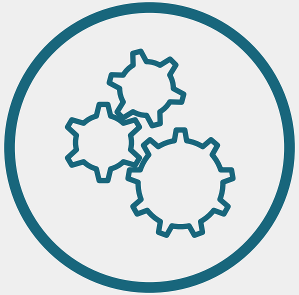
An advanced building retrofit is the most cost-effective option for meeting local energy demand while reaching equivalent GHG reductions

Discussion of the model-based results

Three reasons why the results should be interpreted with caution

Parameter uncertainties

- ❑ Learning rates & technology cost
- ❑ Energy carrier prices
- ❑ Climate conditions
- ❑ ...



Model capabilities

- ❑ No power network modelling
- ❑ No direct rebound effects
- ❑ No demand response

Cost/benefit accounting

- ❑ Search & information cost
- ❑ Comfort gains
- ❑ Reduced air pollution
- ❑ Real estate value
- ❑ Local employment
- ❑ ...

Key findings

- **Local planning for low-carbon energy systems involves a trade-off between saving and supplying energy.** Building retrofits reduce the magnitude of energy needed, thus also the generation capacities and the overall cost for energy supply. However, retrofits involve significant capital expenditures.
- **There is clear scope for Energy Efficiency First in local energy planning for commercial areas.** Deep renovations can be more cost-efficient in meeting equivalent greenhouse gas reductions than light renovations or strategies focusing exclusively on supply side investment.
- **Energy Efficiency First should not be equated with end-use energy efficiency.** Heat pumps, cogeneration and efficient district heating overall are a key requirement for achieving significant greenhouse gas reductions in commercial areas. Supply-side energy efficiency is key.
- **As with every model-based analysis, these results should be taken with caution.** The problem is not only uncertainties, but also the capabilities of the model setup as well as conceptual issues in counting costs and benefits.

Coming up in eηefirst...

D3.3 | Is there need for the Energy Efficiency First principle in the European building sector and its energy supply?

D3.4 | What's the role of Multiple Impacts in implementing the Energy Efficiency First principle?

D3.5 | How does the Energy Efficiency First principle perform in a local context?

Q&A Session