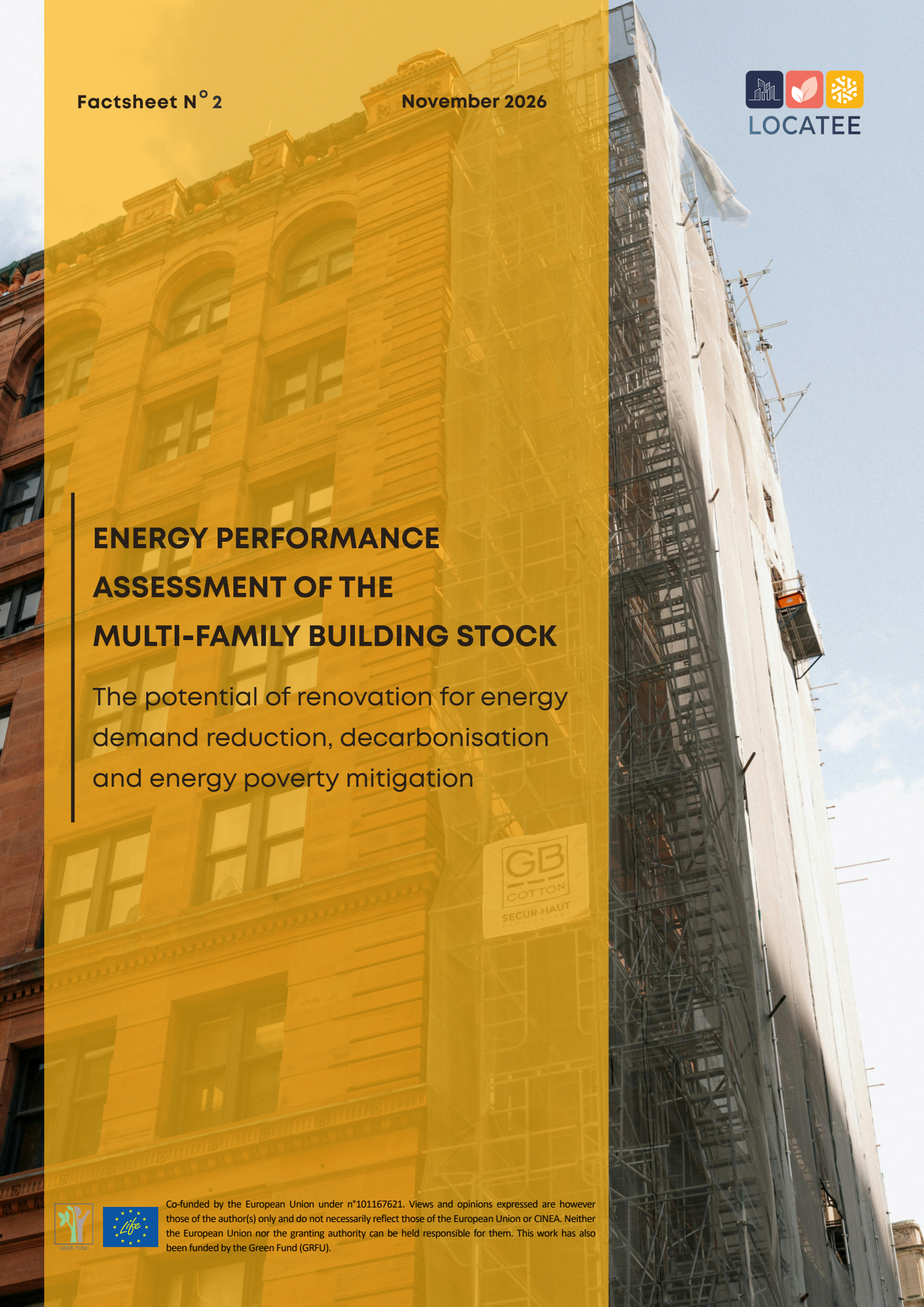
Factsheet N° 2

November 2026

LOCATEE

ENERGY PERFORMANCE ASSESSMENT OF THE MULTI-FAMILY BUILDING STOCK

The potential of renovation for energy demand reduction, decarbonisation and energy poverty mitigation



Co-funded by the European Union under n°101167621. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them. This work has also been funded by the Green Fund (GRFU).

Energy performance assessment of the multi-family building stock

Why this analysis?

LOCATEE Deliverable 3.3 quantifies the impacts of selected renovation and renewable energy measures the energy performance of representative multi-family dwellings in Rumia, Torres Vedras and Piraeus. The analysis links technical performance with investment cost and potential household energy bill reductions, informing municipalities to prioritise interventions to local building conditions and energy poverty vulnerability.



- Representative typologies are grounded in local dwelling stock data, including construction period, EPC class and heating systems.
- The DREEM model simulates baseline energy needs under thermal comfort conditions and tests renovation scenarios.
- Results are compared through potential energy consumption reduction, cost-effectiveness and potential energy bill reductions.

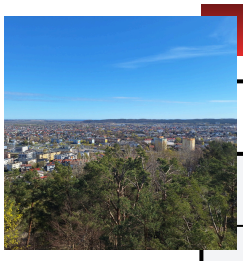
Overview

City of Rumia
Poland
5 typologies
1980 and before / after 1980

City of Torres Vedras
Portugal
10 typologies
Before 1981 / 1981-2000 / 2001-2010

Municipality of Piraeus
Greece
8 typologies
Before 1981 / 1981-2010

Representative dwelling typologies



City of Rumia | Poland

Typology no.	Construction Period	EPC Class	Heating System
PL_1	1980 and before	B	District heating
PL_2	1980 and before	C	Non-condensing gas boiler
PL_3	1980 and before	C	District heating
PL_4	After 1980	B	District heating
PL_5	After 1980	B	Non-condensing gas boiler



City of Torres Vedras | Portugal

Typology no.	Construction Period	EPC Class	Heating System
PT_1	Before 1981	C or D	Electric heaters
PT_2	Before 1981	E or F	Electric heaters
PT_3	1981-2000	C or D	Biomass heat recovery system
PT_4	1981-2000	C or D	Non-condensing gas boiler
PT_5	1981-2000	E or F	Electric heaters
PT_6	1981-2000	E or F	Biomass heat recovery system
PT_7	2001-2010	C or D	Biomass heat recovery system
PT_8	2001-2010	C or D	Non-condensing gas boiler
PT_9	2001-2010	E or F	Electric heaters
PT_10	2001-2010	E or F	Non-condensing gas boiler



City of Piraeus | Greece

Typology no.	Construction Period	EPC Class	Heating System
GR_1	Before 1981	D	Oil boiler
GR_2	Before 1981	F	Oil boiler
GR_3	Before 1981	G	Oil boiler
GR_4	1981-2010	C	Oil boiler
GR_5	1981-2010	C	Non-condensing gas boiler
GR_6	1981-2010	E	Oil boiler
GR_7	1981-2010	G	Oil boiler
GR_8	1981-2010	G	Electric heaters

CORE MESSAGE

The modelling exercise does not point to a single universal renovation package. Heat pumps appear to deliver the strongest overall savings and cost-effectiveness, but dwelling envelope quality, heating systems, fuel prices in each pilot, as well as the household composition (i.e., occupancy and working hours), all influence which intervention could be the most appropriate.

How the DREEM assessment works

1

DWELLING CHARACTERISATION

Construction period, EPC class, dwelling area (m^2), envelope and heating/cooling systems

2

BASELINE SIMULATION

Climate, household composition, appliances and thermal comfort setpoints

3

RENOVATION SCENARIOS APPLICATION

Thermal insulation and windows upgrade, heating system upgrade, heat pump installation and 3 kW_p solar PV installation

4

TECHNICAL/ECONOMIC/ ENVIRONMENTAL IMPACTS COMPARISON

Energy consumption reduction, environmental impact (i.e., carbon emissions reduction), technoeconomic assessment and potential energy bill reduction

DREEM model components



Climate & water

Typical Meteorological Year data provide high-resolution irradiance and temperature conditions for each pilot.



Building envelope

Geometry, construction materials, U-values, thermal resistances/capacities and solar potential are utilised to model the thermal behaviour of each typology.



Energy demand

Bottom-up modelling captures heating, cooling, appliances and occupancy/activity profiles.



Thermal comfort

Predicted Mean Vote (PMV) / Predicted Percentage of Dissatisfaction (PPD)-based comfort benchmarks define indoor temperature requirements.

Renovation scenarios

Scenario	What changes	Applicability
Dwelling envelope improvement	External walls insulation and window upgrade	All typologies for testing the effectiveness of envelope interventions in each pilot
Heat pump installation	Electrification of dwelling heating with a high-efficiency heat pump	All typologies for testing high-efficiency heating systems
Oil to gas boiler upgrade	Transition from an existing oil boiler to a higher-efficiency condensing gas boiler	GR_1-4, GR_6, GR_7 where the existing heating system is an oil boiler or a low-efficiency non-condensing natural gas boiler

Natural gas boiler upgrade	Transition from a lower-efficiency non-condensing gas boiler to a higher-efficiency condensing gas boiler	PL_2, PL_5, PT_4, PT_8, PT_10, GR_5 where the existing heating system is an older lower-efficiency non-condensing gas boiler
Biomass heating system upgrade	Transition from a lower-efficiency biomass heat recovery system to a higher-efficiency one	PT_3, PT_6, PT_7 where the effectiveness of a higher-efficiency biomass heat recovery system needs to be assessed
District heating connection	Replace existing non-condensing gas boiler with local district heating connection	PL_2, PL_5 where the existing heating system is a non-condensing gas boiler and district heating system is available (as it is in Rumia)
Renewable energy production	Installation of a 3 kWp residential solar PV system	All typologies for testing the effectiveness of renewable technologies in each pilot

INTERPRETATION NOTE

EPC classes are not harmonised across Europe. A class with the same letter may reflect different national thresholds. Cross-pilot typology comparisons should therefore focus on modelled energy outcomes and local context rather than EPC classes alone.

City of Rumia

Through the prism of the existing building stock

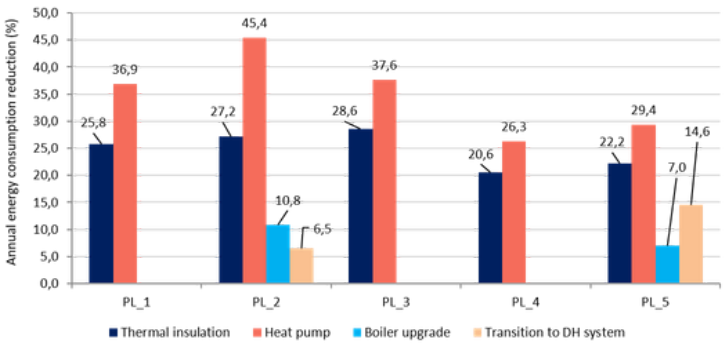
Five representative dwelling typologies capture the city's multi-family dwelling stock across pre-1980 and post-1980 construction periods. The analysis reflects a context where space heating dominates energy use.

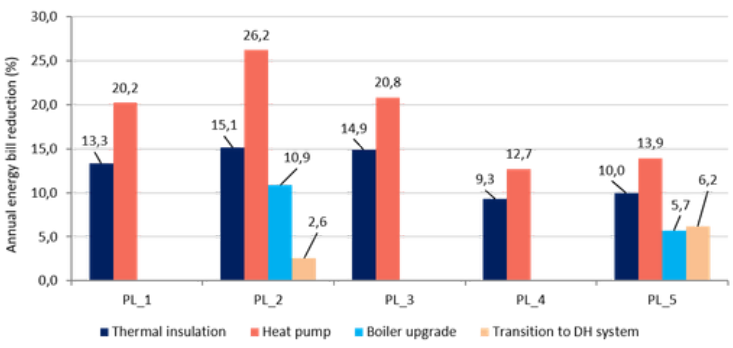
26.3 - 45.4 %
Heat pump energy reduction

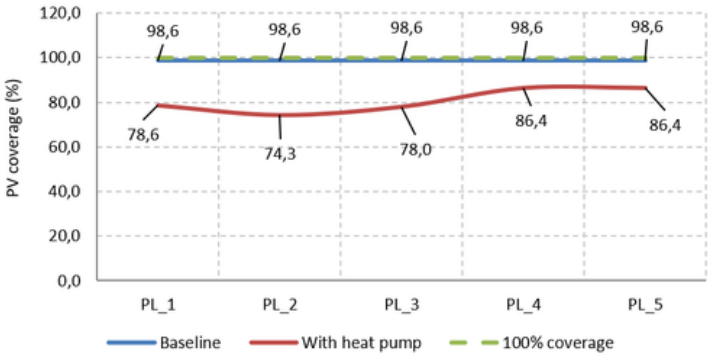
9.3 - 15.1 %
Thermal insulation bill reduction

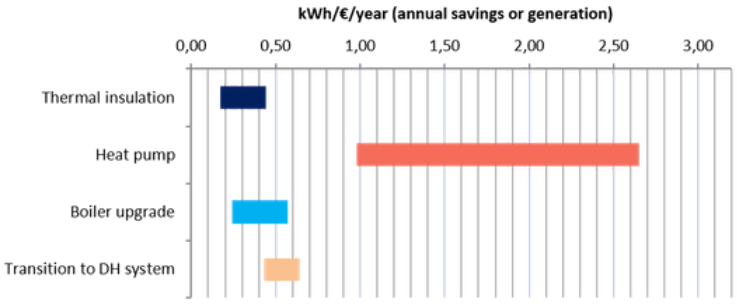
74.3 - 98.6 %
Annual electricity demand coverage by solar PV production

1.71
Solar PV electricity generated (kWh) per € of investment









HIGHLIGHTS

- Heat pumps provide the strongest overall energy savings: 26.3 - 45.4 % lower annual consumption and 12.7 - 26.2 % potential bill reductions.
- Thermal insulation has consistent performance in Rumia, cutting energy demand by 20.6 - 28.6 % and energy bills by 9.3 - 15.1 %, with stronger value in older dwellings.
- Conventional boiler upgrades deliver more limited energy savings (7.0 - 10.8 %).
- Connecting gas-heated typologies to current district heating reduces final energy use by 6.5 - 14.6 % but can increase CO_2 emissions under the present Polish heat supply mix.
- The emissions advantage of heat pumps is currently constrained by the carbon intensity of electricity; this improves as the power system decarbonises.

SOLAR PV CONTRIBUTION

A 3 kW_p PV system produces about 4,017 kWh/year. The share of household demand electricity that can be covered by solar PV ranges from 74.3% to 98.6% across the examined typologies and scenarios. Heat pump installation paired with solar PV has lower coverage because of the electrification of the heating system. PV remains an important complementary measure for increasing household electricity self-sufficiency. Solar PV generation cost-effectiveness: 1.71 kWh/€/year.

INDICATIVE TARGETING LOGIC:

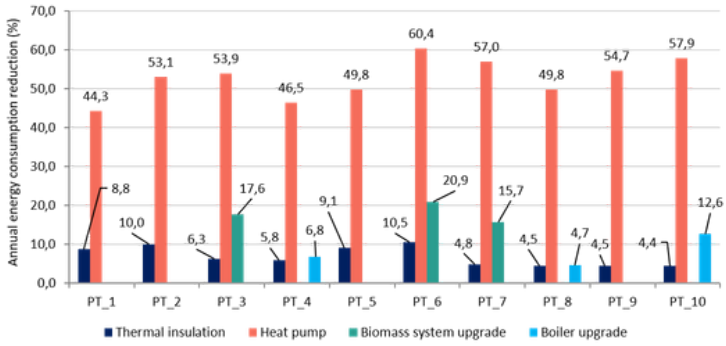
- Prioritise older, higher-demand dwelling typologies for envelope upgrades.
- Coordinate any district heating transition with planned low-carbon district heating investments.

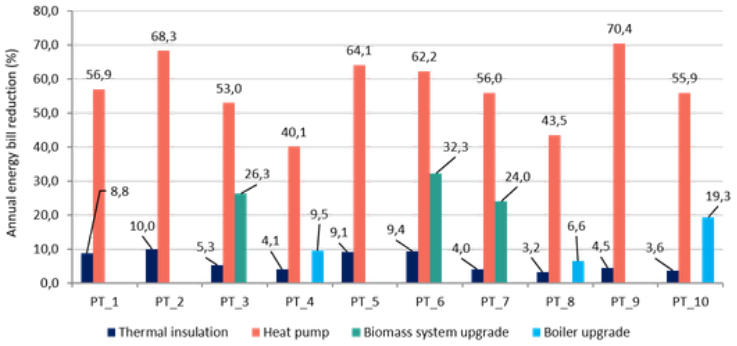
City of Torres Vedras

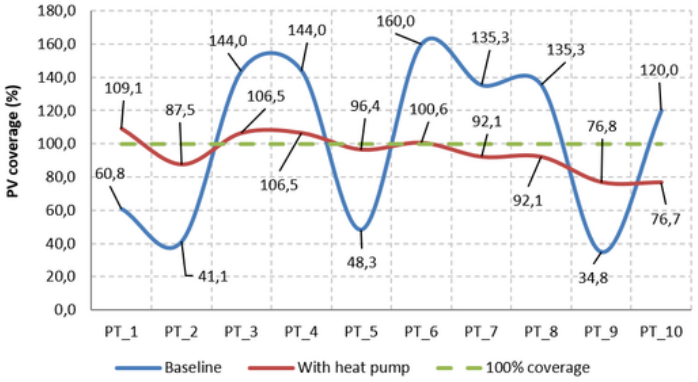
Through the prism of the existing building stock

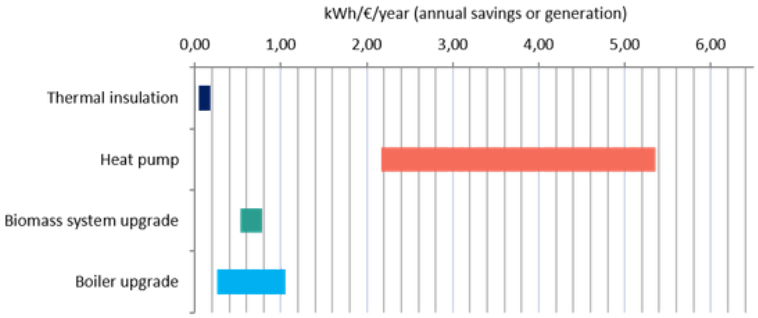
Ten dwelling typologies represent three construction periods and a heterogeneous mix of electricity, gas and biomass heating. This diversity is important for energy poverty policy because low-cost biomass, heating through electric heaters and cooling needs could create different technical and affordability pathways.

44.3 - 60.4 % Heat pump energy reduction	**40.1 - 70.4 %** Thermal insulation bill reduction
34.8 - 160 % Annual electricity demand coverage by solar PV production	**2.16** Solar PV electricity generated (kWh) per € of investment









HIGHLIGHTS

- Heat pumps provide the highest energy savings and emissions reduction across all construction periods, reducing annual energy use by 44.3 - 60.4 % and CO_2 emissions by 44.3 - 83.2 %.
- Potential bill reductions from heat pumps are particularly high (40.1 - 70.4 %), reflecting the technology efficiency improvement and the relatively high cost of electricity used by electric heaters.
- Thermal insulation yields more moderate savings (4.4 - 10.5 %) and has comparatively low cost-effectiveness because of higher investment costs.
- Biomass system upgrades provide an intermediate option where heat pumps are unsuitable: 15.7 - 20.9 % energy savings and 24.0 - 32.3 % bill reductions in applicable typologies.
- Gas boiler upgrades have a lesser impact, with 4.7 - 12.6 % energy savings in the typologies where they apply.

SOLAR PV CONTRIBUTION

A 3 kW_p PV system produces around 6,072 kWh/year. The share of household demand electricity that can be covered by solar PV ranges from 34.8% to 160% across the examined typologies and scenarios. Heat pump installation paired with solar PV has lower coverage because of the electrification of the heating system. PV remains an important complementary measure for increasing household electricity self-sufficiency. Solar PV generation cost-effectiveness: 2.16 kWh/€/year.

INDICATIVE TARGETING LOGIC:

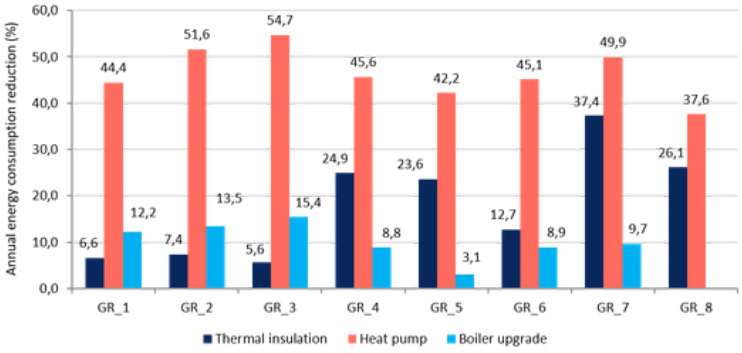
- Prioritise heat pumps in typologies where heating needs are covered with electricity (i.e., electric heaters) that have significant energy demand in the baseline scenario.
- Use efficient biomass as a transitional option where local low-cost fuel access is critical.
- Combine solar PV with heat pumps to further reduce exposure to electricity prices

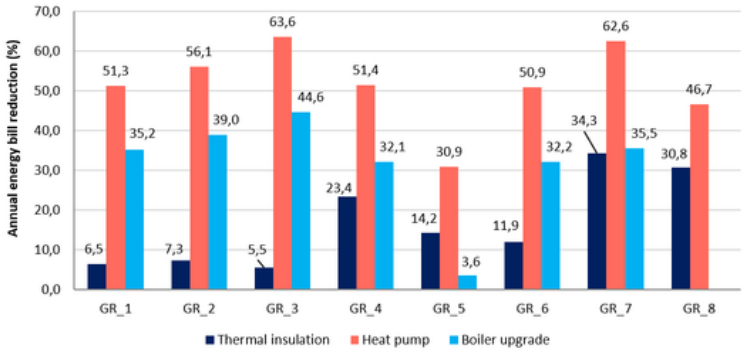
City of Piraeus

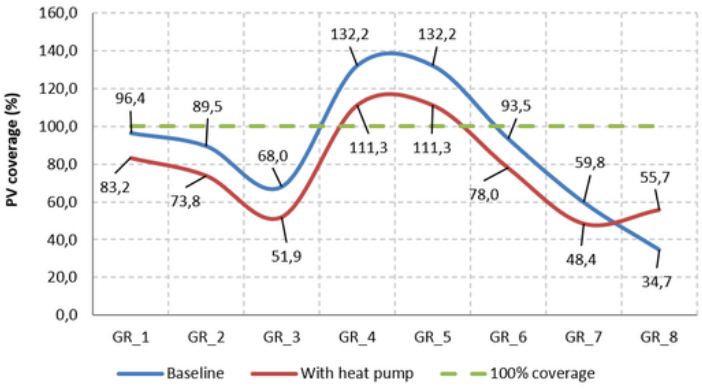
Through the prism of the existing building stock

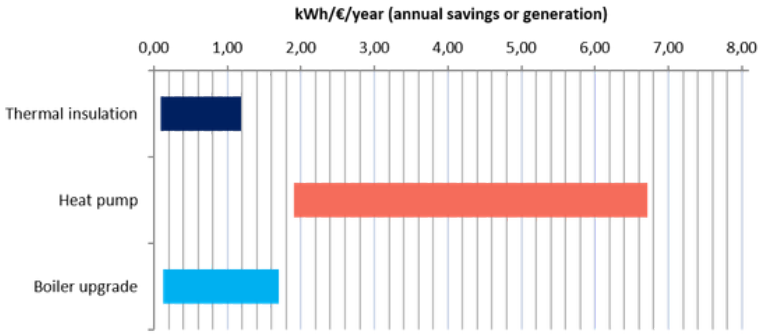
Eight representative dwelling typologies cover pre-1981 and 1981-2010 dwellings, with EPC classes from C to G. About 63.72% of the municipal dwelling stock was built before 1981. Many analysed typologies use oil heating, creating substantial scope for both technology efficiency improvement and fuel switching.

37.6 - 54.7 % Heat pump energy reduction	**30.9 - 63.6 %** Thermal insulation bill reduction
34.7 - 132.2 % Annual electricity demand coverage by solar PV production	**1.90 - 6.72** Solar PV electricity generated (kWh) per € of investment









HIGHLIGHTS

- Heat pumps consistently deliver the largest savings: **37.6 - 54.7%** lower annual energy use, **29.0 - 97.8%** lower CO_2 emissions and **30.9 - 63.6%** potential bill reductions.
- Envelope upgrades are highly typology-dependent (**5.6 - 37.4 %** energy reduction) and become especially effective where windows and walls are not properly insulated.
- Boiler upgrades save **3.1 - 15.4%** of energy. In older oil-heated dwellings, they can generate sizeable bill and emissions reductions because the baseline boilers are inefficient and oil is relatively costly.
- Heat pump cost-effectiveness reaches **6.72 kWh saved per euro** in typology GR_3, the highest value found among the reported pilot typologies.
- The results support prioritising low-EPC, oil-heated dwellings where high energy demand and social vulnerability coincide.

SOLAR PV CONTRIBUTION

A 3 kW_p PV system produces about 5,886 kWh/year. The share of household demand electricity that can be covered by solar PV ranges from 34.7% to 132.2% across the examined typologies and scenarios. Heat pump installation paired with solar PV has lower coverage because of the electrification of the heating system. PV remains an important complementary measure for increasing household electricity self-sufficiency. Solar PV generation cost-effectiveness: 2.10 kWh/€/year.

INDICATIVE TARGETING LOGIC:

- Prioritise heat pumps where oil heating and high energy consumption coincide.
- Use envelope upgrades for poor-performing windows/walls.
- Treat gas boilers mainly as a transitional option where immediate electrification is not feasible.

Cross-pilot insights

CROSS PILOT MESSAGE

- Heat pump installation is the most cost-effective renovation measure across the three pilots, although its impact varies with the efficiency of the existing heating system and the national electricity mix.
- The same intervention can perform differently across pilots because of building envelope characteristics, dwelling size (area), energy prices, solar irradiance and the carbon intensity of energy supply.

HEAT PUMPS	1.71 - 2.16	≥74%
Most cost-effective renovation measure across all three pilots	Solar PV generation cost-effectiveness (kWh/€/year)	Minimum annual electricity demand coverage by solar PV production in Rumia

HEAT PUMPS

- Potential energy savings and bill reductions are greater where existing heating systems have a lower Coefficient of Performance and baseline energy demand is high. For example, transitioning from an oil boiler, a biomass heat recovery system or a non-condensing gas boiler to a heat pump.
- In Torres Vedras and Piraeus, heat pumps also provide noteworthy savings in cooling energy consumption.
- The electricity generation mix strongly influences carbon emission reduction. This limits the present emissions advantage in Rumia.

THERMAL INSULATION

- Cost-effectiveness is limited in all pilots due to high investment costs.
- It is particularly low in Torres Vedras because of higher local prices, which increase investment needs.
- In Piraeus, thermal insulation upgrades show favourable performance in typologies where baseline wall and window thermal transmittance leaves greater scope for improvement.

SOLAR PV



- Solar PV installation has favourable cost-effectiveness for electricity generation in all three pilots, outperforming thermal insulation and gas boiler upgrades.
- Lower solar irradiance reduces PV output in Rumia, yet coverage remains at least 74%. Torres Vedras and Piraeus show a wider range of roughly 30 - 140 % depending on the dwelling typology.
- The report highlights roof/balcony space and approval requirements as relevant barriers in multi-apartment buildings.

POTENTIAL ENERGY BILL EFFECTS



- Heat pump bill reductions are especially important in Torres Vedras, where electric heaters are common, and electricity prices are higher.
- Thermal insulation is more effective in Greece in the cross-pilot bill comparison.
- Gas boiler upgrades show larger potential bill reductions in Greece because heating oil, which is the heating fuel in several typologies' baseline, is more expensive than gas.

From model results to intervention targeting

How the report proposes to move from results to targeting[12]

- Use the model outputs to compare renovation measures and dwelling typologies through investment cost, energy savings, carbon emissions reduction, cost-effectiveness and potential energy bill reduction.
- Combine these technical results with LOCATEE energy poverty vulnerability mapping so that high-potential dwelling typologies can be located where social vulnerability and higher energy poverty levels exist.

COMPARE MEASURES AND TYPOLOGIES:

Identify which renovation options deliver the strongest technical, environmental and affordability outcomes for each representative dwelling typology.

IDENTIFY HIGH-POTENTIAL CASES:

Use the results to identify the most cost-effective measures and the dwelling typologies with the highest potential for improvement.

COMBINATION WITH VULNERABILITY MAPPING:

Combine the modelling results with LOCATEE vulnerability mapping to identify buildings and areas where analysed typologies overlap with social vulnerability and higher energy poverty levels.

SUPPORT HOUSEHOLD/BUILDING MATCHING

Integrate the combined outcomes into the Energy Poverty Monitoring System of LOCATEE to support matching of impactful, cost-effective measures with vulnerable households, buildings and districts.

[1] The absolute bill reduction values are based on a theoretical baseline in which households maintain thermal comfort for a significant part of the day. This may not reflect households experiencing hidden energy poverty.

[2] The report recommends using reduction percentages cautiously when estimating impacts for energy poor households, because actual savings may differ and rebound effects can change post-renovation consumption.

Implications for energy poverty mitigation and local policy

DELIVERABLE 3.3
POLICY MESSAGE

- The modelling results can help municipalities prioritise renovation measures and dwelling typologies that jointly support energy efficiency, decarbonisation and energy poverty mitigation, particularly where public funding is limited.
- Their value increases when combined with LOCATEE vulnerability mapping, enabling a more socially just allocation of support to buildings and dwellings where social, energy and structural vulnerabilities overlap.

STRATEGIC PLANNING



- Integrate the analysis into Sustainable Energy and Climate Action Plans (SECAPs), building renovation plans and regional or local energy poverty mitigation plans.
- Use the generated evidence to contribute to national targets under National Building Renovation Plans and Social Climate Plans.

FUNDING AND PROGRAMME DESIGN



- Use the results to inform local support instruments for private multi-apartment building renovation and improve resource efficiency under constrained public budgets.
- The report highlights the relevance of upcoming Social Climate Fund support for targeted building renovation.

LOCAL DELIVERY AND ADVICE



- Strengthen renovation programmes during design, deployment and monitoring.
- Inform local support points and one-stop shops so citizens can identify measures that are appropriate for their dwelling typology.
- Support local associations and other stakeholders pursuing the same energy poverty and renovation goals.

BARRIERS AND INCLUSION



- Revise support schemes to address split incentives, limited access to finance, lack of information and administrative burdens.
- Account for participation, inclusion and engagement difficulties that are particularly relevant for citizens experiencing energy poverty.

The role of the LOCATEE toolkit

Through integration into the LOCATEE Energy Poverty Monitoring System, the combined modelling and vulnerability evidence can identify buildings and districts at the nexus of social, energy and structural vulnerabilities and support the matching of the most cost-effective and impactful measures with the most vulnerable households and districts.

LOCATEE

Scan here to access Deliverable 3.3

Stay in Touch

https://ibs.org.pl/en/research/locatee-local-authorities-tackling-energy-poverty-in-private-multi-apartment-buildings/

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