SUREFIT

SUstainable solutions for affordable REtroFIT of domestic buildings

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Sustainable retrofit solutions for southern European residential buildings

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Study objective

- Evaluate the impact of SUREFIT retrofit technologies on energy consumption and CO_2 emissions of three demo buildings in south Europe

- Analyze the maximum energy conservation and CO_2 emissions reduction with retrofit technologies combinations in different demo buildings

Demo buildings in south Europe

Small apartment building in Athens, Greece

The annual heating degree hours at indoor temperature 15.5 °C are 612.3 °Ch, 467.5 °Ch, and 1577.8 °Ch in Athens, Lisbon and Valladolid.

Social house in Lisbon, Portugal

Terraced house in Valladolid, Spain

Building envelope properties before renovation

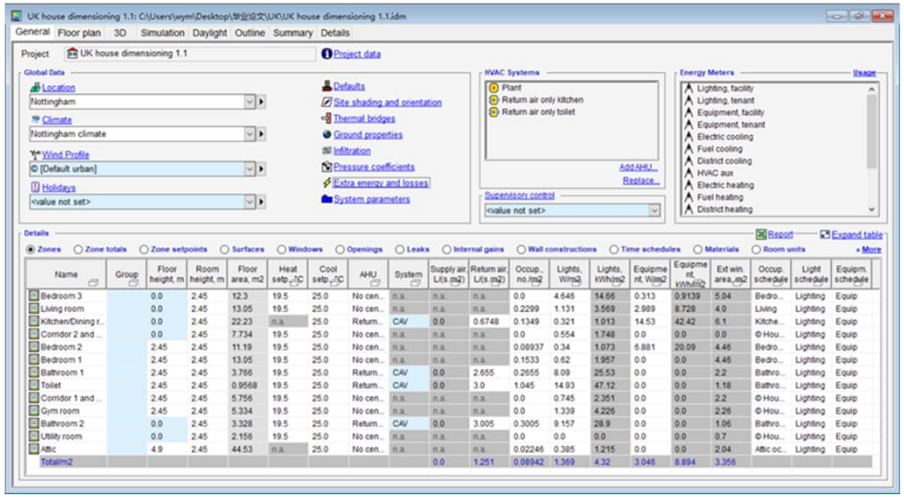
Demo building	Greek apartment building	Portuguese social house	Spanish terraced house
U-values of envelope (W/m^2K)			
External wall	0.7	2.4	1.7
Roof	3.9	3.8	1.6
External floor	3.6	1.0	2.9
External door	1.1	3.6/3.7/3.9	2.2
Windows	5.9/3.0	5.1	5.8/2.8
Infiltration			
Air leakage rate, n_{50} (ACH)	6.7	6.7	6.7

HVAC systems before renovation

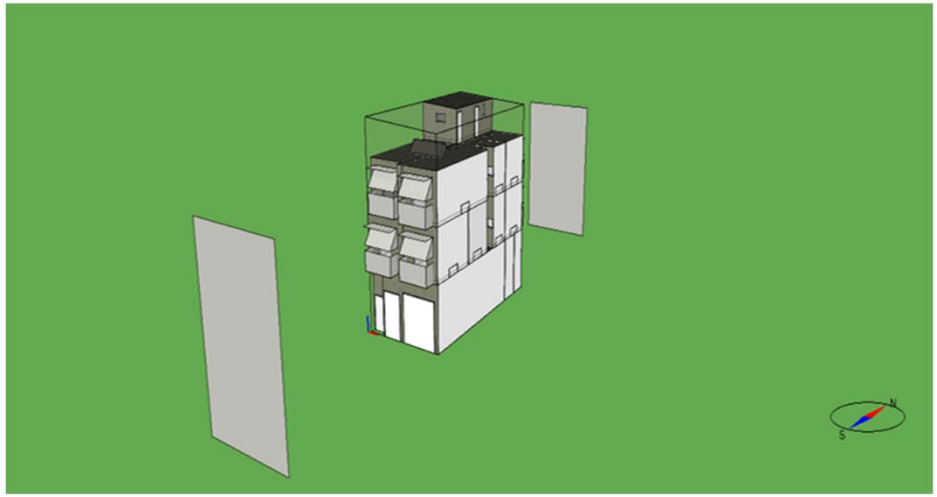
Demo building	Greek apartment building	Portuguese social house	Spanish terraced house
Ventilation system	Natural ventilation	Natural ventilation	Natural ventilation
Space heating system	Oil boiler and water radiators	Portable electric heaters	Gas boiler and water radiators
Heating schedule & setpoint	Intermittent heating: 7-9 am, 7-10 pm from Nov to Mar; setpoint: 20 °C	Intermittent heating: 7-9 am, 7-10 pm from Sep to May; setpoint: 20 °C	Continuous heating with varying setpoint: 2-11 pm, setpoint: 18/20 °C; otherwise, setpoint: 17 °C
Cooling system	Split cooling units	No	No
Cooling schedule & setpoint	Intermittent cooling: 7-12 pm, from Jun to Sep; setpoint: 25 °C	-	-
DHW heating system	Solar collector and boiler	Gas boiler	Gas boiler

Simulation tool

- IDA ICE allows dynamic multi-zone simulations and modelling of building characteristics including geometry, structures and technical systems.
- Output files: building energy consumption, indoor air quality, and thermal comfort



IDA-ICE interface



Building model example in IDA ICE

Purchased and primary energy, CO_2 emissions of demo buildings before renovation

Demo site	Greek apartment building	Portuguese social house	Spanish terraced house
Fuel heating total	36.8	18.3	115.0
Fuel boiler	36.8	18.3	115.0
Electricity total	14.8	97.1	19.4
Equip, Light & HVAC aux	10.3	13.2	19.4
Electric heater	-	83.9	-
Split cooling unit	4.5	-	-
Total purchased energy	51.6	115.4	134.4

Purchased energy (kWh/m^2) of the demo buildings before renovation

	Primary Energy Factors (kWh/kWh)		
	Natural gas	Oil	Electricity
Greece	1.05	1.10	1.79
Portugal	1.00	1.00	1.49
Spain	1.07	-	1.51
	CO_2 Emissions Factors (kg-CO_2/MWh)		
Greece	196	264	572
Portugal	204	267	227
Spain	199	-	190

Primary energy factors & CO_2 emissions factors

Demo site	Greek apartment building	Portuguese social house	Spanish terraced house
Primary energy	67.0	163.0	152.4
CO_2 emissions	18.2	28.3	26.6

Primary energy (kWh/m^2) and CO_2 emissions (kg-CO_2/m^2) of the demo buildings before renovation

Retrofit technologies simulation

U-value: External wall: 1.0 → 0.4, Roof: 3.9 → 0.6

U-value of windows: 3.0/5.9 → 0.6, Efficiency: 3.5%

Thickness: 3.2 cm, Melting temperature: 18-36 °C

Reference building models before renovation

Passive package

Bio-aerogel thermal insulation (Ins)

Bio-aerogel thermal insulation + PV vacuum window (Win)

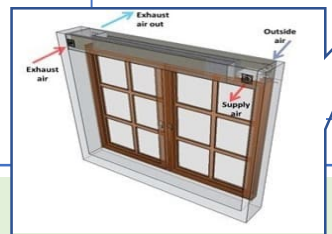
Bio-aerogel thermal insulation + PV vacuum window + Phase change material (PCM)

Ventilation package

Insulating breath membrane (Mem) 50% airtightness improvement

Insulating breath membrane (Mem) 100% airtightness improvement

Insulating breath membrane + Room specific air handling unit with heating recovery (RAHU)



Heat recovery efficiency: 0.76

U-value: External wall: 1.0 → 0.5, Roof: 3.9 → 0.9, Infiltration (ACH, n_{50}): 6.7 → 3.4

Infiltration (ACH, n_{50}): 6.7 → 0.07

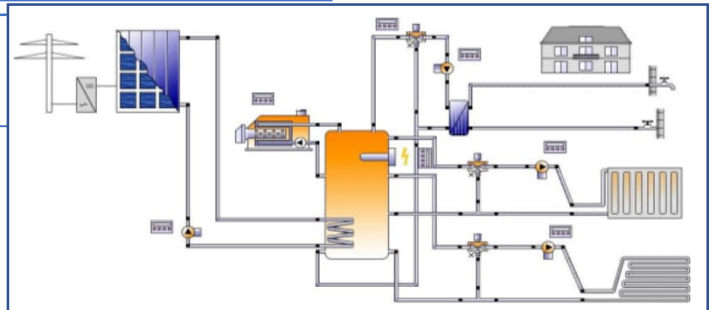
Final Combinations

Scenario 1: Passive + Ventilation + Generation (PV/T)

Scenario 2: Passive + Ventilation + Generation (SAHP)

Generation package

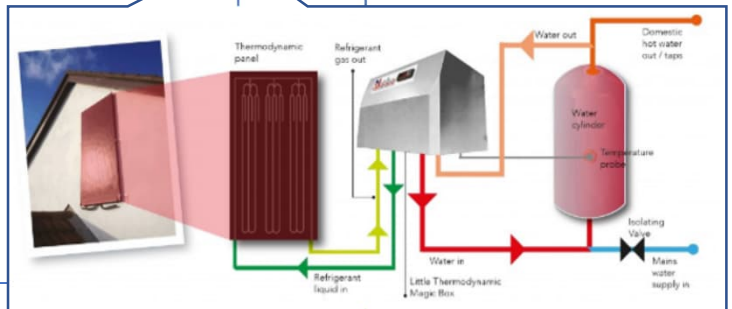
Photovoltaic/Thermal (PV/T) system



Conversion factor of solar thermal: 0.486, Electricity generation efficiency: 0.13

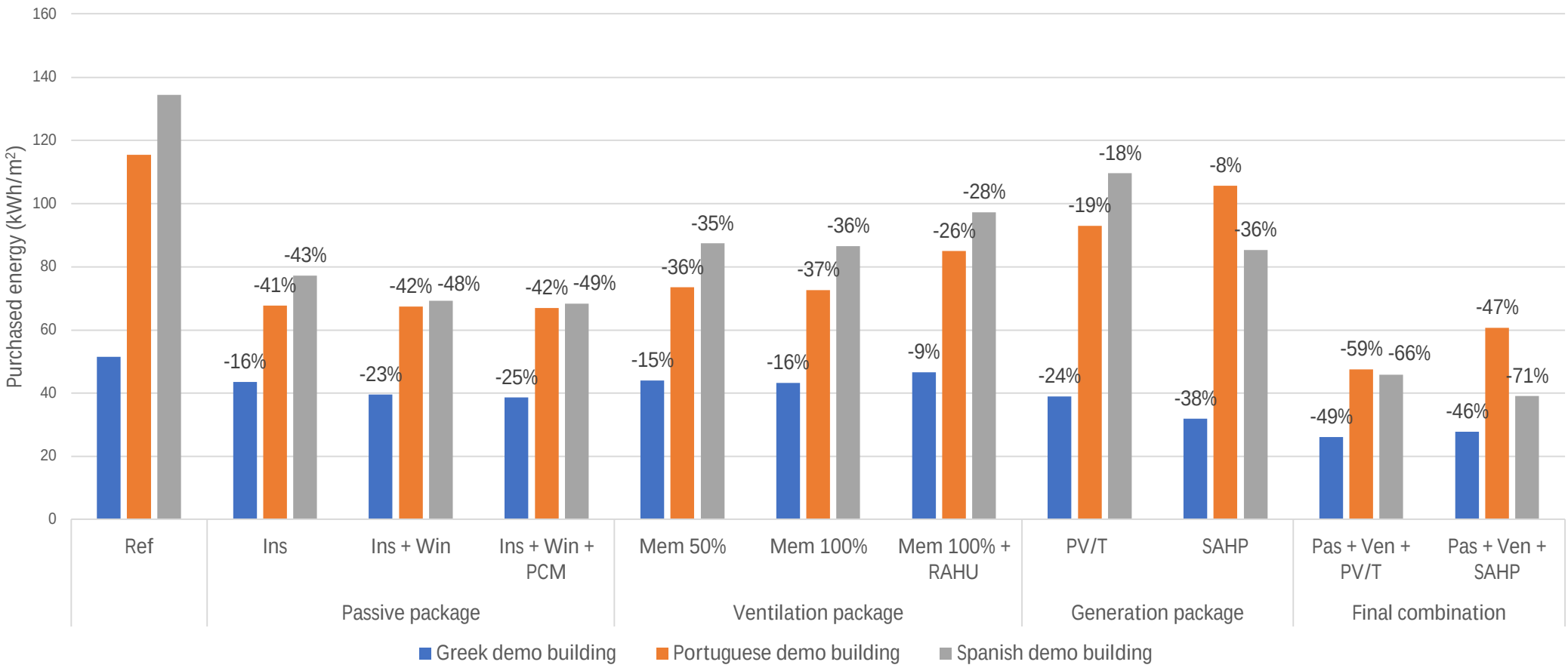
Generation package

Solar assisted heat pump (SAHP)

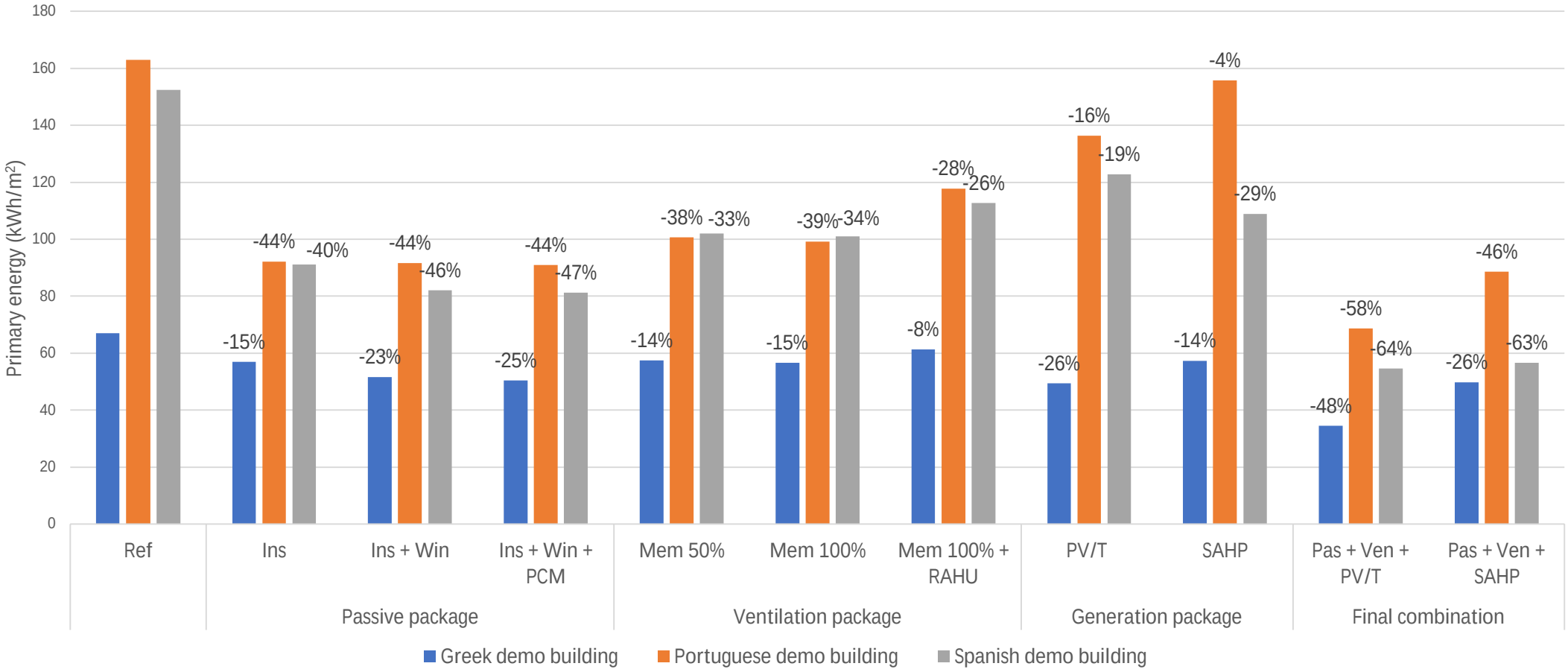


Heating capacity: 11 kW, COP: 4

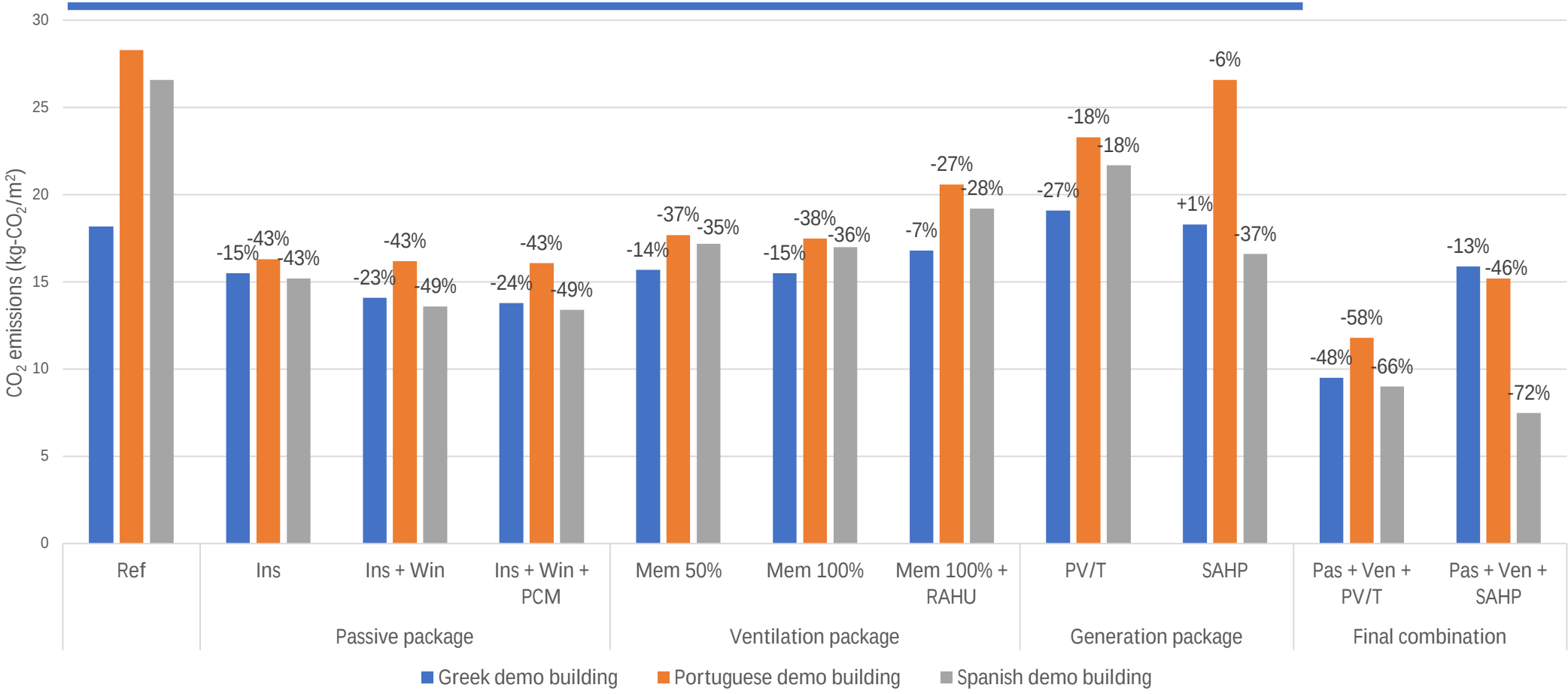
Purchased energy after renovation



Primary energy after renovation



CO_2 emissions after renovation



Conclusion

- Bio-aerogel thermal insulation led to around 15-44% reduction in CO_2 emissions, while the impact of PV vacuum windows and PCM is much smaller (lower than 10%).
- Retrofitting with insulating breath membrane reduced CO_2 emissions by around 15-39%. But to maintain a good IAQ, RAHU is needed, then final reduction is 7-28%.
- Installation of PV/T system or SAHP brought up to 27% or 37% reduction in CO_2 emissions.
- The optimal combination with PV/T system gives 48% and 58% CO_2 emissions reduction in the Greek and Portuguese demo buildings.
- The optimal combination with SAHP reduced CO_2 emissions by 72% in the Spanish demo building.

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Thank you!

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