Energetic and Economic assessment of a hybrid system designed for a multi-family house

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Outline

- Aim of the work
- Methodology
- Results
- Conclusion

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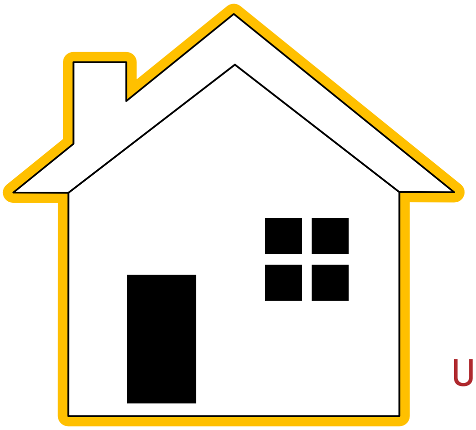
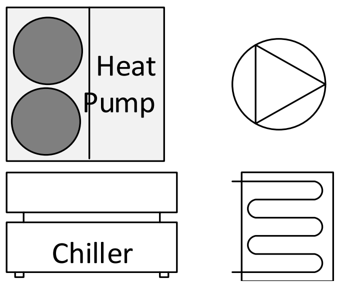
Aim of the work

Energy demand limitation

Aim of the work





Use high efficiency systems

Energy demand limitation

Aim of the work

Analysis of different passive and active solutions for refurbishment of existing residential buildings, by means of <u>model-based calculation</u> through:

- <u>Energy evaluation</u>
- <u>Economic evaluation</u>

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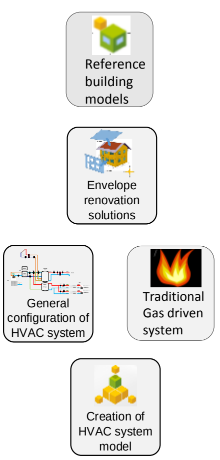
Methodology

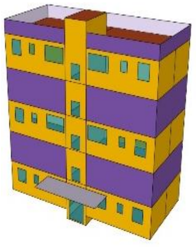


- Definition of reference buildings before renovation
- Definition of passive solutions aimed to reach two energy levels (15, 70 kWh/m^{2}y of heating demand)
- Implementation of different HVAC systems: hybrid systems or reference systems
- Evaluation of the Energy and Economic performance of the whole system (building + HVAC system)

Methodology

Building Model:

- 5 floors
- 2 dwellings per floor
- 50 m²/dwelling

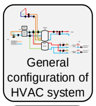


Passive solutions:

- Envelope insulation
- New windows
- Mechanical ventilation

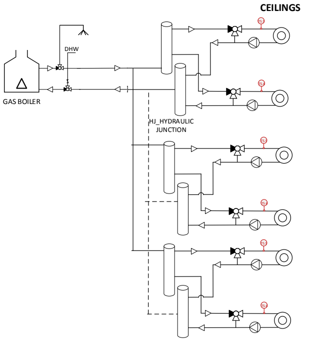
	EL	Reference Building Heating Demand	Renovated Building Heating Demand	Reduction
		[kWh/m²y]	[kWh/m²y]	[%]
Rome	15	108	13.3	88
Rome	70	108	69.1	36
Stuttgart	15	193	16.1	91
Stuttgart	70	193	78.3	59
Stockholm	15	119	15.0	87
Stockholm	70	119	73.1	39

Institute for Renewable Energy

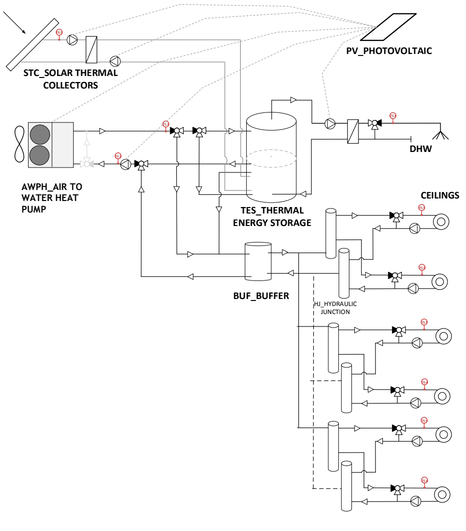


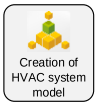
Methodology

Reference case



Hybrid System





Methodology

Analysed configurations

Case Name	STC Area	STC tilt angle	PV Area	PV tilt angle
[-]	[m²]	[°]	[m²]	[°]
Base Case	-	-	-	-
AWHP	-	-	-	-
AWHP+PV	-	-	24	30
AWHP+STC18	18	30	-	-
AWHP+STC28	28	30	-	-
AWHP+STC18+PV	18	30	24	30
AWHP+STC28+PV	28	30	24	30

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    - Seasonal Performance Factor
    - Renewable Energy Fraction
    - Primary Energy
    - Total retrofit investment cost
    - Total annualized cost of energy
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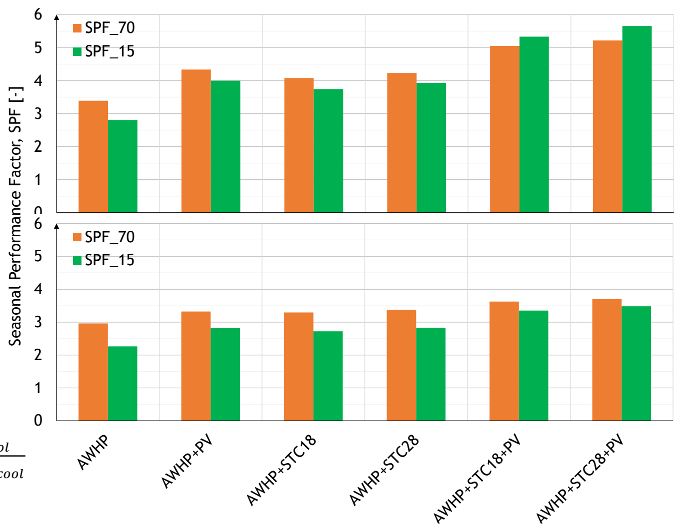
Results – Seasonal Performance Factor

Rome 15-70 kWh/m²y

Stockholm 15-70 kWh/m²y



$$SPF = \frac{Q_{heat} + Q_{DHW} + Q_{cool}}{EL_{heat} + EL_{DHW} + EL_{cool}}$$

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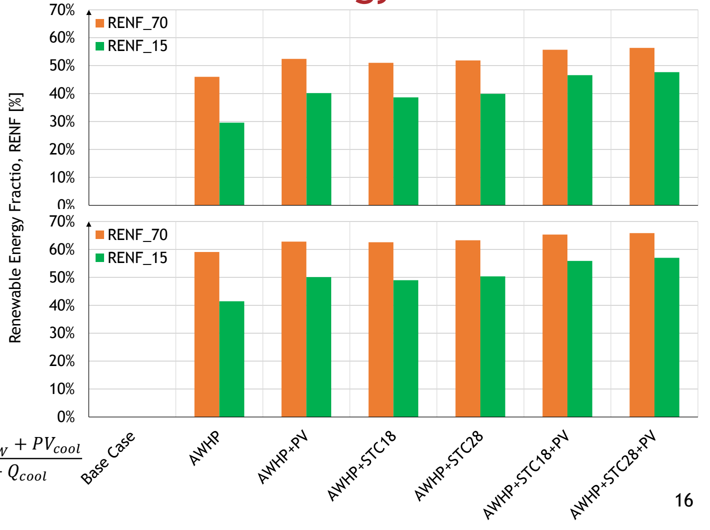
Results – Renewable Energy Fraction

Rome

15-70 kWh/m²y

Stockholm

15-70 kWh/m²y



$$RENF_{tot} = \frac{Q_{REN\,heat} + Q_{REN\,DHW} + PV_{cool}}{Q_{heat} + Q_{DHW} + Q_{cool}}$$

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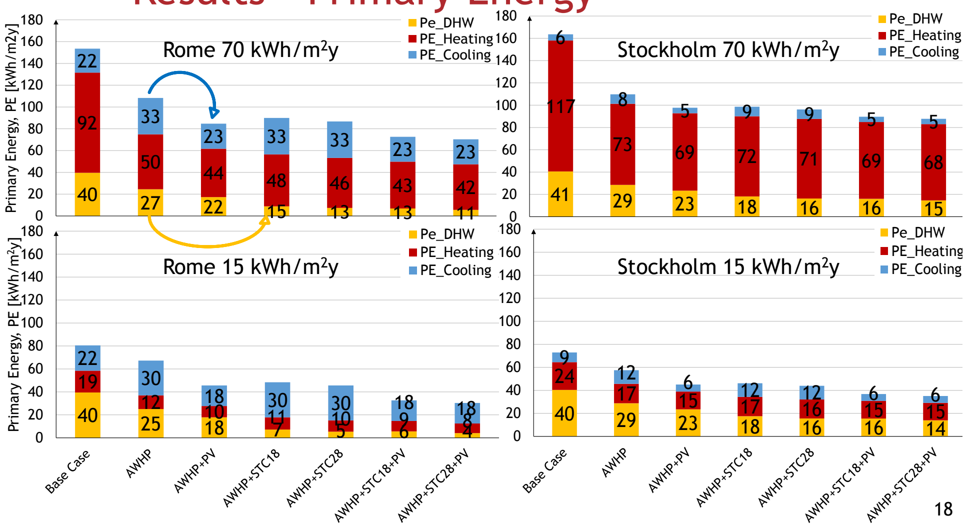
Results – Primary Energy



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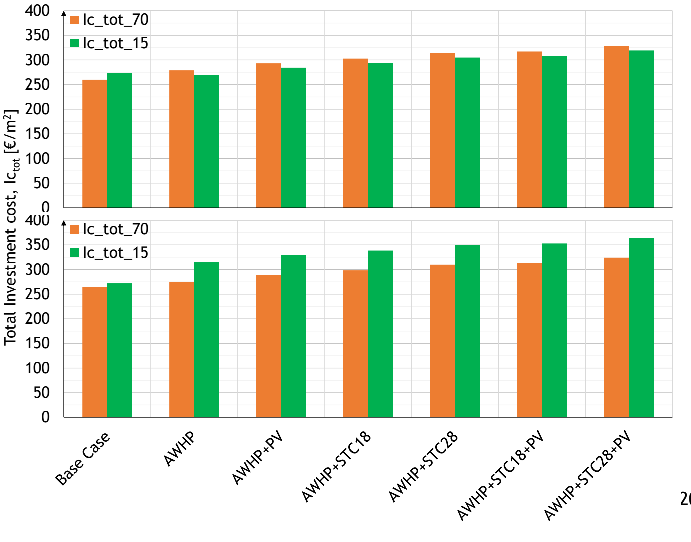
Results – Total retrofit investment cost [€/m²]

Rome

15-70 kWh/m²y

Stockholm

15-70 kWh/m²y



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Results – Total annualized cost of energy [€/m²y]

$$TC = (I_0 + C_{r_N}) + C_{m_N} + C_{fe_N} \quad [€/m^2y]$$

$I_0 + C_{r_N}$ Total annualized retrofit investment cost [€/m²y]

C_{fe_N} Total annualized final energy cost [€/m²y]

C_{m_N} Total annualized maintenance cost [€/m²y]

The annualized costs have been calculated over a period of 30 years

iNSPiRe project, Deliverable 6.3a - Performance of the Studied Systemic Renovation Packages - Method, 2016

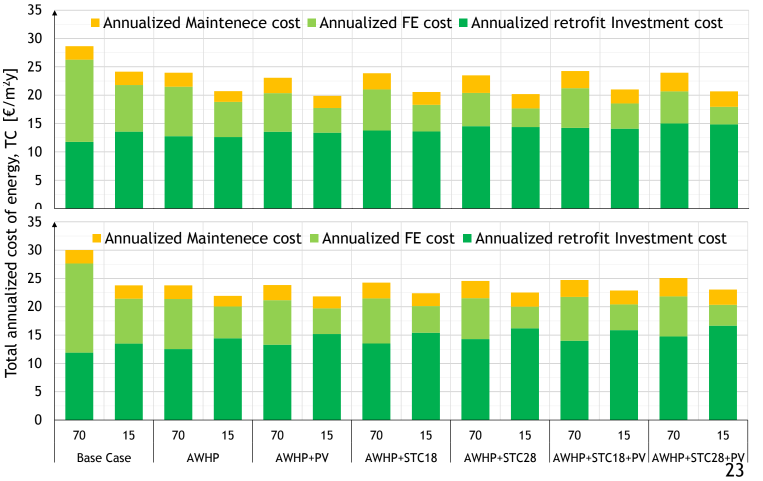
Results – Total annualized cost of energy [€/m²y]

Rome

15-70 kWh/m^{2}y

Stockholm

15-70 kWh/m^{2}y



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Conclusion

- A reduction of PE consumption can be obtained applying passive and active solutions to the existing cases
- Among the active solutions, hybrid systems, i.e. heat pump technologies, coupled with solar thermal collectors and/or PV, represent a solution for the PE consumption reduction

Conclusion

- All the hybrid systems solutions outperform energetically the reference case even without solar technologies
- In warmer climates, RENF can reach 56% while in colder climates, it reaches 67%
- PV energy is mainly exploited to cover the cooling load, therefore it has more influence in warmer climates
- Solar collectors are mainly exploited for the DHW production. An increase of 35% of the field area slightly improve the PE reduction (13% in Rome)

Conclusion

- Total annualized energy cost in the hybrid system solutions are lower than in the reference case
- The improvement of passive solutions leads an increase of investment cost but lower final energy costs with an overall lower total annualized cost of energy
- The increase of investment cost due to the solar technologies is balanced by reduced final energy cost with a final comparable total annualized cost of energy

Thank you for the attention

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Total annualized cost of energy [€/m²y]

$$TC = (I_0 + C_{r_N}) + C_{m_N} + C_{fe_N} \quad [€/m^2y]$$

$I_0 + C_{r_N}$	Total annualized retrofit investment cost [€/m²y]
C_{fe_N}	Total annualized final energy cost years [€/m²y]
C_{m_N}	Total annualized maintenance cost [€/m²y]

The annualized have been calculated over a period of 30 years

Total annualized cost of energy [€/m²y]

Total annualized final energy cost years

$$C_{fe,N} = \sum_{j=1}^{N} C_{fe} \cdot (1 + i_e)^j$$

Total annualized maintenance cost

$$C_{m,N} = \sum_{j=1}^{N} C_m \cdot (1 + i)^j$$

Total annualized retrofit investment cost $(I_0 + C_{r_N})$

$$C_{r,0,N} = \sum_{j=0}^{n} C_{r,0}^{(j)} = I_0 \frac{1 - (1+i)^{\tau \cdot n}}{1 - (1+i)^{\tau}} \qquad RV_0 = \frac{RV}{(1+i)^N} = I_0 (1+i)^{\tau \cdot n - 1} \left(1 - \frac{\tau \cdot n - 30}{\tau}\right)$$

$C_{r,N} = C_{r,0,N} - RV_0$ *Total annualized net replacement cost*

Total annualized cost of energy [€/m²y]