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Energy Efficient Refurbishment of existing buildings: A multiple case study of Multi Storey Residential Building

EPISCOPE – EU, IEE Project

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General Information

- Three case studies for Multi Storey Residential Buildings, in Cyprus.
- Representative of the National Residential building stock typologies.
- Exemplary of three different chronological periods
- Buildings are located in two different coastal areas
- The building typologies were developed on early stages of the IEE Episcope Project.

Methodology

- Building typology identification
- Chronological Division: prior 1980, 1981-2006, after 2007.
- The existing buildings ' design, construction characteristics and their electromechanical systems were recorded and studied.
- Energy targeted refurbishment scenarios and technics for Energy Conservation savings were analysed and compared
- Simulations were carried out using the Tabula.xls tool, which calculates
 - Primary energy demand,
 - Energy use for heating and domestic hot water,
 - CO₂ emissions,
 - RES integration,
 - Heat losses and gains and
 - Operational cost.

Multiple case studies







Multi Storey Residential Building (MSRB01) Chronological period: 1980

Multi Storey Residential Building (MSRB02) Chronological period: 1981-2006

Multi Storey Residential Building (MSRB03) Chronological period: 2007 and after

REFURBISHMENT STRATEGIES FOR BUILDINGS CONSTRUCTED PRIOR 1980 AND 1981-2006 CHRONOLOGICAL PERIODS.

- Adding thermal insulation on the building envelope to meet the National minimum energy requirements for the building envelope (EPDB Directive 2010).
- Replacement, maintenance and thermal insulation of the existing heating and domestic hot water systems.
- Replacement of the single glazing with double glazing.

REFURBISHMENT STRATEGIES FOR BUILDINGS BUILT AFTER 2007 (to raise an EPC* Category class)

- Increasing the thickness of thermal insulation of the already thermally insulated building envelope.
- Retaining the existing heating and hot water system. *Energy Performance Certificate

Multi Storey Residential Building 01 (MSRB01) Before 1980

- Built in the late 1970's
- Coastal Area, Limassol
- O Total Area: 2185m²
- Heated living Volume: 10464m³
- Number of storeys: 8, Number of apartments: 23,
- No thermal insulation on floor slab, on roof flab, external walls,
- Siingle glazed wooden frame windows.
- Constant temperature oil boiler with storage tank, old inefficient electric element for hot water, no thermal insulation, no maintenance.
- O CO₂ emissions 0.0495t
- O Operating Cost 28 €/m²a







Heat losses and space heating for MSRB01, [kWh/(m²a)]

Multi Storey Residential Building 02 (MSRB02) 1981-2006

• Built in 2006

- Costal Area, Limassol
- O Total Area: 1120m2
- O Heated living Volume: 3360m3
- Number of Storeys: 4, Number of apartments: 8
- No thermal insulation on floor slab, on roof flab, on external walls,
- Single glazed aluminium frame windows.

• Constant temperature oil boiler with storage tank, no thermal insulation, solar collectors and back up electric element for domestic hot water, well maintained

CO2 emissions 0.045t

Operating Cost 25 €/m²a



- Heat losses and space heating for MSRB02, [kWh/(m²a)]
 - Ventilation losses
 Transmition losses roof
 Transmition losses floor
 - Transmission losses wall



Energy Consumption for MSRB02, [kWh/(m²a)]



Multi Storey Residential Building 03 (MSRB03) After 2007

- Built in the 2008
- O Costal area, Larnaca
- Total Area: 1350m²
- Heated living Volume : 5989m³
- Number of Storeys: 3, Number of apartments: 14
- Thermally insulated floor slab, roof flab, external walls,
- Double glazed aluminium frame windows.

• Constant temperature natural gas boiler with storage tank, thermal insulation, solar collectors and back up electric element for hot water, well maintained.

- CO₂ emissions 0.013t
- Operating Cost 5.8 €/m²a

Heat losses and space heating for MSRB03, [kWh/(m²a)]



- Ventilation losses
- Transmition losses roof
- Transmition losses floor
- Transmission losses wall





Energy Consumption for MSRB03, [kWh/(m²a)]

Comparing the Buildings Existing Condition

- MSRB01, MSRB02, MSRB03 coastal areas.
- MSRB01 and MSRB02 have the same U-Values
- MSRB01 higher usable solar heat load than MSRB02; less thermal energy demand.
- MSRB01 old electric element and no solar collectors for hot water.
- MSRB02 and MSRB03 have solar collectors and a back up electric element for domestic hot water.
- MSRB03 according to EPDB requirements, new natural gas boiler with solar collectors for domestic hot water.

Energy Demand for the existing Multi Storey Residential Buildings kWh/(m²a)



Energy Conservation Measures Standard refurbishment scenario MSRB01 and MSRB02

- Applying the national minimum requirements for energy performance of buildings (European EPBD Directive)
 - Adding 50mm thermal insulation (expanded polystyrene) on roof slab.
 - Adding 30mm thermal insulation (expanded polystyrene) on external walls.
 - Replacement of single with double glazed aluminium frame windows.
- Replacement the of the old heating system with a new oil, constant temperature boiler, a new electric element for hot water
- MSRB02 retained the existing solar collectors for hot water



Energy Conservation Measures Standard refurbishment scenario MSRB03

- To raise the building an EPC Category class
 - Adding 50mm thermal insulation (expanded polystyrene) on roof slab.
 - Adding 40mm thermal insulation (expanded polystyrene) on external walls.
 - Replacement of double glazed aluminium frame windows with low-e windows.
- Retaining the existing heating and domestic hot water system
- Limited savings; less to save on an already insulated house that has a new heating and domestic hot water systems.

Primary energy Demand: $kWh/(m^2a)$ CO_2 emissions: tonnes Operational Cost: ϵ/m^2a



Savings % for MSRB03

Primary Energy Demand Existing Condition Vs. Refurbishment

«Wh/m²a

Comparison of Primary Energy Demand for the existing Multi Storey Residential Buildings and the reduction achieved by applying the energy targeted refurbishment scenarios.

- The MSRB01 has a saving of 105kWh/m2a
- The MSRB02 has a saving of 70.3kWh/m2a
- The MSRB03 10.5kWh/m2a



Primary Energy Demand for the existing and refurbishment scenarios

Operational Cost €/m2 & Payback Period

Existing Condition Vs. Refurbishment scenario



Cost & Payback Period/years

		MSRB01	MSRB02	MSRB03
	Installation & construction cost	€127,135	€95,885	€64,048
	Payback Period/ years	3.5	4.5	66.6

- MSRB01 has the highest savings, this is due the higher impact of thermal insulation on its large, exposed surface area. The replacement of the oldest heating and hot water system was more beneficial.
- MSRB02 savings are due to the introduction of the thermal insulation. The replacement of heating system was also beneficial. It already had solar collectors for hot water(no extra saving).
- MSRB03 has the lowest savings, it already meets the EPDB standards and the extra cost of thermal insulation does not justify the resulting savings. Very high pay-back period.

CONCLUSIONS

- Classification of Residential building typologies can be an excellent tool to perform scenario analysis for energy conservation measures.
- Buildings constructed prior to 2006 can benefit the most with targeted energy retrofitting scenarios on the building envelope and the existing heating supply system. They can have average savings of:
 - **o** 48% in Primary Energy Demand, of
 - 44.25% reduction in CO₂ emissions and
 - 47% savings in operational cost
- The payback period for using the above retrofitting scenarios is between 3.5 4.5 years, for buildings constructed before the enforcement of the EPBD.
- It is not cost effective to increase the thickness of insulation to an already well thermally insulated building.
- Further studies are needed between the calculated and the actual energy consumption.
- More detailed techno-economic studies are required to examine the cost effectiveness and pay back period of each refurbishment scenario.



Thank you for the attention.