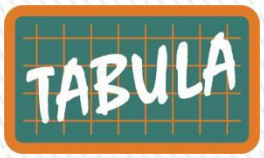


World Renewable Energy Congress, 3-8 August 2014 London UK

Energy Efficient Refurbishment of existing buildings: A multiple case study of Terraced Family Housing

EPISCOPE – EU, IEE Project.

Prof. Arch. Despina Serghides

Prof. Despina Serghides, Negar Sabuhi, Marina Markides, Martha Katafygiotou, Theoni Koutra

Department of Environmental Science and Technology

Cyprus University of Technology

General Information

- Three case studies for Terraced Family Houses, in Cyprus.
- Representative of the National Residential building stock typologies.
- The building typologies were developed on earlier stages of the IEE Episcope Project.
- Buildings are located in a mountainous area, inland and costal area.

Methodology

- Chronological Division: before 1980, 1981-2006, after 2007
- The existing buildings' design, construction characteristics and their electromechanical system were recorded and studied.
- Refurbishment strategies for Energy Conservation and savings were analysed.
- Simulations with Tabula.xls tool, which calculates
  - Primary energy demand,
  - Energy use for heating and domestic hot water,
  - CO_2 emissions,
  - RES integration,
  - Heat losses and gains and
  - Operational cost.

Multiple case studies

Terraced Family House (TFH01)
Chronological period: 1980

Terraced Family House (TFH02)
Chronological period: 1981-2006

Terraced Family House (TFH03)
Chronological period: 2007-Now

REFURBISHMENT STRATEGIES FOR DWELLING BUILT BEFORE 1980 AND 1981-2006 CHRONOLOGICAL PERIODS.

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

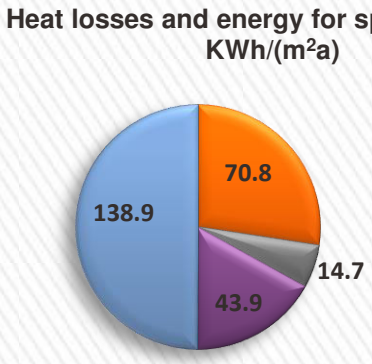
REFURBISHMENT STRATEGIES FOR DWELLING BUILT AFTER 2007

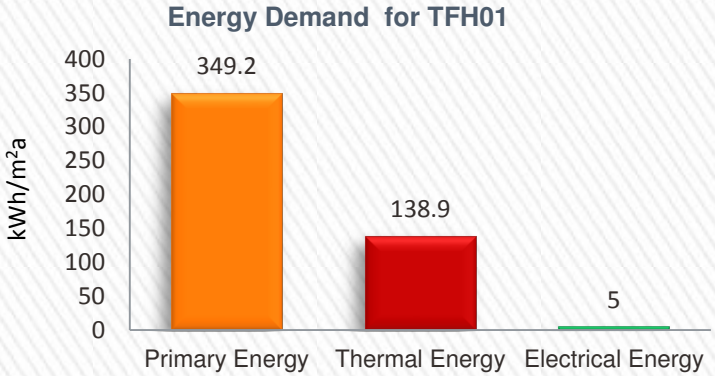
- Adding thermal insulation on the building envelope elements.
- Retaining the existing heating and domestic hot water system.

Terrace Family House 01 (TFH01)

Before 1980

- Built in the late 1970's
- Mountainous area, Platres- Troodos (1951m Height)
- Total Area: 120m^2
- Heated living Volume: 720m^3
- Not thermally insulated (floor slab, roof flab, external walls), single glazed wooden frame windows.
- Constant temperature oil boiler with storage tank, old inefficient electric element for domestic hot water, no solar collectors no thermal insulation, no maintenance.
- CO_2 emissions 0.085t
- Operating Cost 45.9 €/m^{2}a

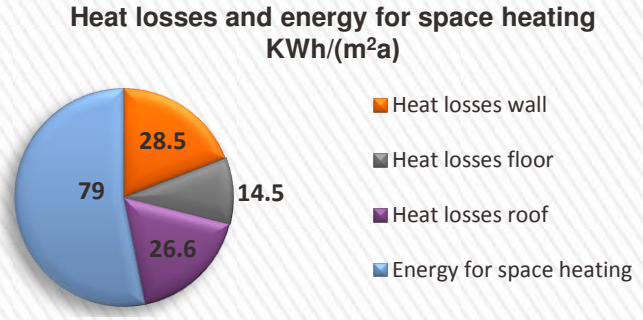


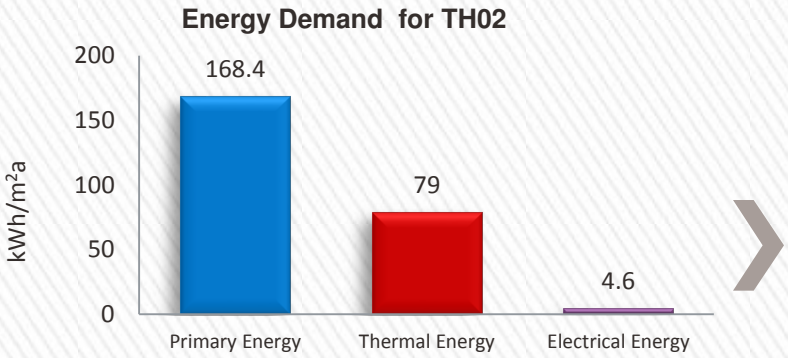


Terrace Family House 02 (TFH02)

1981-2006

- Built in the late 1990's
- Inland, Nicosia
- Total Area: 124m^2
- Heated living Volume: 744m^3
- Not thermally insulated (floor slab, roof flab, 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.
- **CO_2 emissions 0.04t**
- **Operating Cost 23.3 €/m^{2}a**

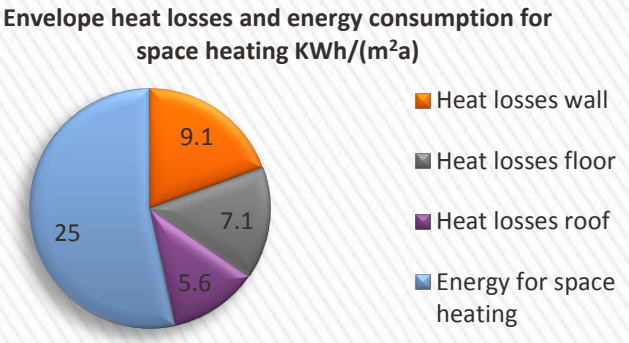


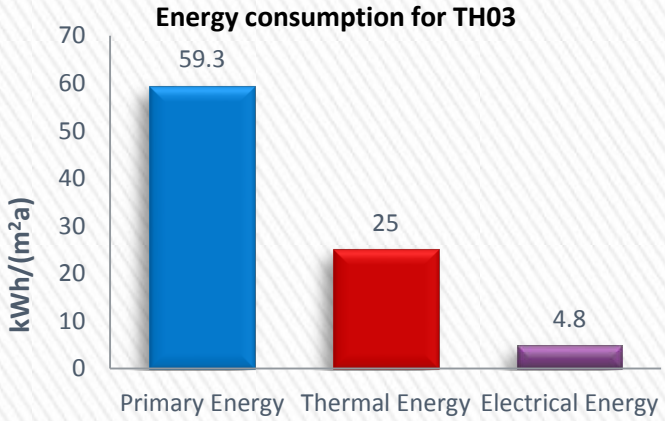


Terrace Family House 03 (TFH03)

After 2007

- Built in the 2012
- Costal area, Limassol
- Total Area: 226.1m^2
- Heated living Volume : 1356.6m^3
- 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 domestic hot water, well maintained.
- CO_2 emissions 0.01t
- Operating Cost 4.9 €/m^2



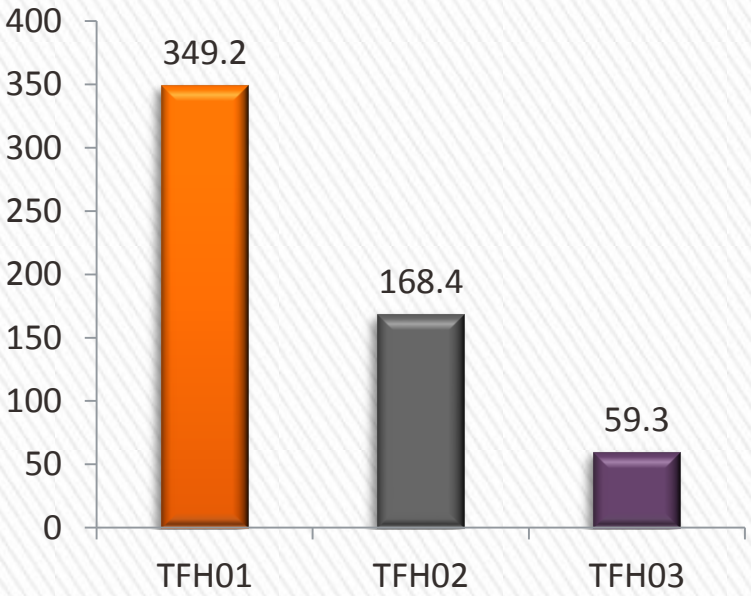


Comparing the Houses

Existing Condition

- TFH01 mountainous, TFH02 inland, TFH03 coastal area.
- TFH01 due to the location higher heating demands
- TFH01 old oil boiler and electric element and no solar collectors for domestic hot water.
- TFH01 and TFH02 have the same U-Values and oil boilers for the heating.
- TFH02 and TFH03 have solar collectors and a back up electric element for domestic hot water.
- TFH03 complies with EPDB requirements, new natural gas boiler.

Primary Energy Demand for the existing Terraced Family Houses kWh/(m^2a)



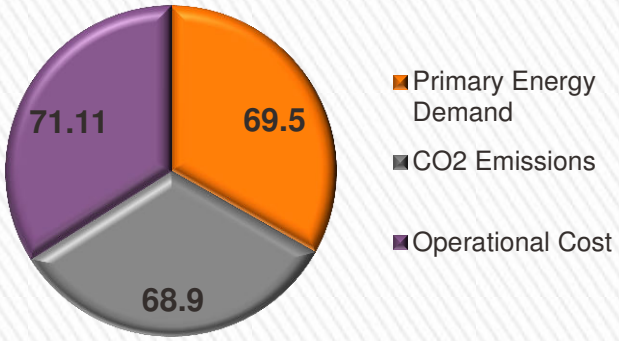
Energy Conservation Measures

Standard refurbishment scenario

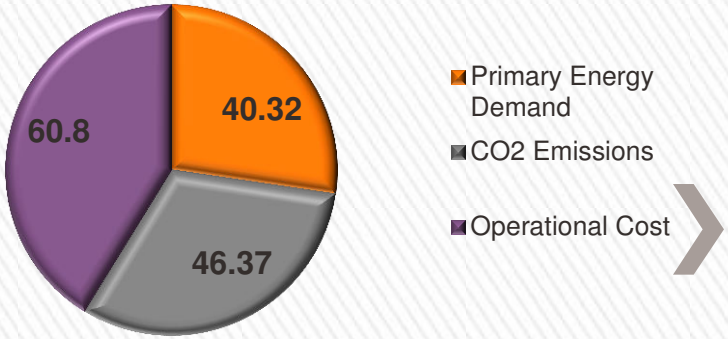
TFH01 and TFH02

- Complying with the European EPBD Directive (minimum national requirements for energy performance of buildings).
- 50mm thermal insulation (expanded polystyrene) on roof slab.
- 30mm thermal insulation (expanded polystyrene) on external walls.
- Replacement of single with double glazed aluminium frame windows.
- Thermal insulation & maintenance of the existing heating system and hot water system

Savings % for TFH01



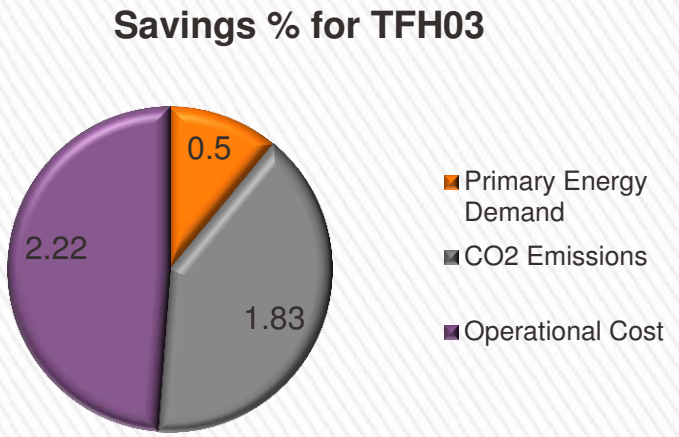
Savings % for TFH02



Energy Conservation Measures

Standard refurbishment scenario TFH03

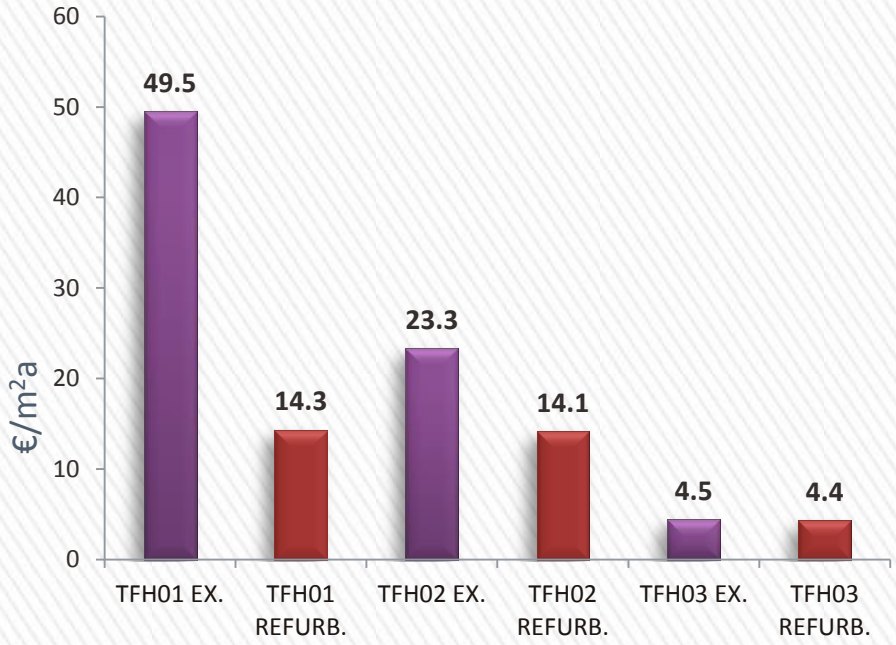
- Adding 20mm (Total 50mm) thermal insulation (expanded polystyrene) on roof slab.
- Adding 20 (Total 40mm) thermal insulation (expanded polystyrene) on external walls.
- Replacing double glazed aluminium frame windows with double glazed low-e windows.
- Retaining the existing heating and hot water system



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

Operational Cost €/m2 & Payback Period

Existing Condition Vs. Refurbishment scenario



Cost & Payback Period/years

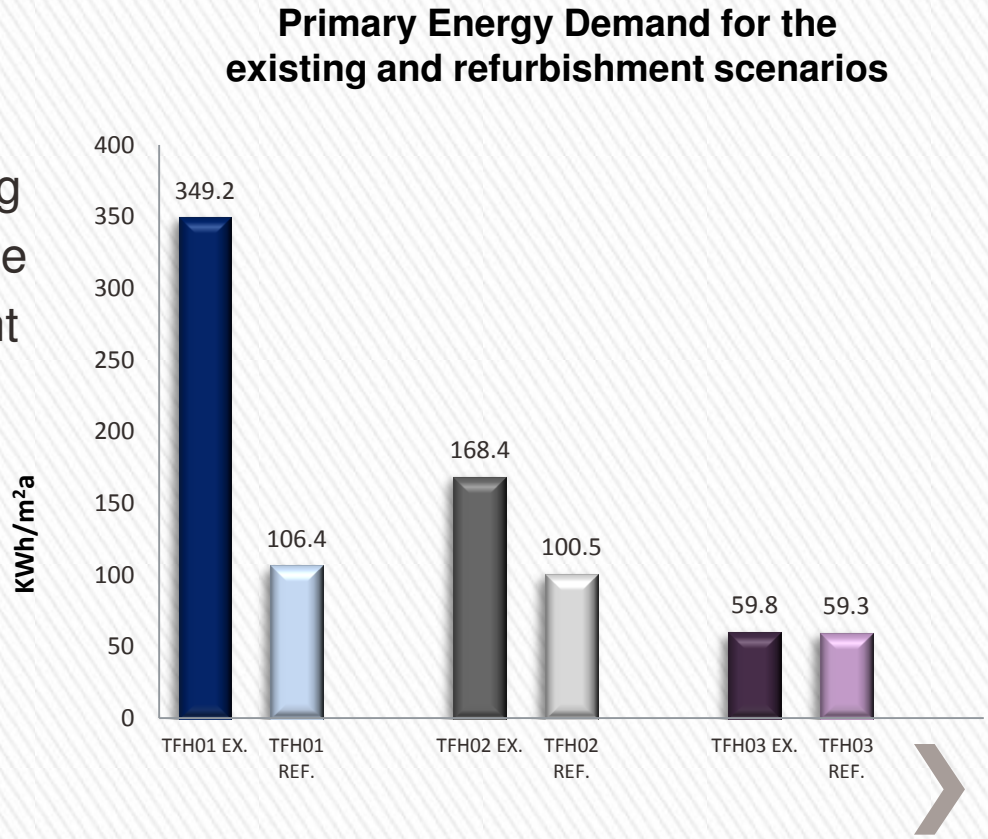
	TFH01	TFH02	TFH03
Installation & construction cost	€6380	€7790	€10355,75
Payback Period/ years	1.5	7	n/a

- THF01, highest savings, mountainous location, less surface area(compact), thermal insulation more effective.
- TFH02, dense urban inland area, solar collectors and a back up electric element for domestic hot water
- TFH03, lowest savings, large surface area, efficient well maintained heating and domestic hot water system, EPDB standards, the added thermal insulation cost does not balance out the resulting savings, very high pay-back period

Primary Energy Demand

Existing Condition Vs. Standard Refurbishment

- Comparing Primary Energy Demand saving for the existing Terrace Family Houses and the energy targeted refurbishment scenarios.



CONCLUSIONS

- Dwellings constructed before 2006 may benefit the most with targeted energy retrofitting scenarios on the building envelope and the existing heating supply system.
- With only introducing insulation and upgrading the heating systems they have average savings of 65% in Primary Energy Demand, 55% reduction in CO_2 emissions, 60% saving in operational cost.
- The payback period for using energy saving retrofitting measures is between 1.5-7 years.
- Residential building typologies can be an excellent tool to perform scenario analysis for energy conservation measures.
- Increasing insulation thickness of the thermally insulated houses is not cost-effective.
- In depth, comparative techno-economic (calculated and actual energy consumption).

Thank you for the attention.