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ENERGY EFFICIENT REFURBISHMENT TOWARDS NEARLY ZERO ENERGY HOUSES FOR THE MEDITERRANEAN REGION

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A WORLDWIDE BUILDING SECTOR OVERVIEW

ENERGY CONSUMTION OF BUILDINGS

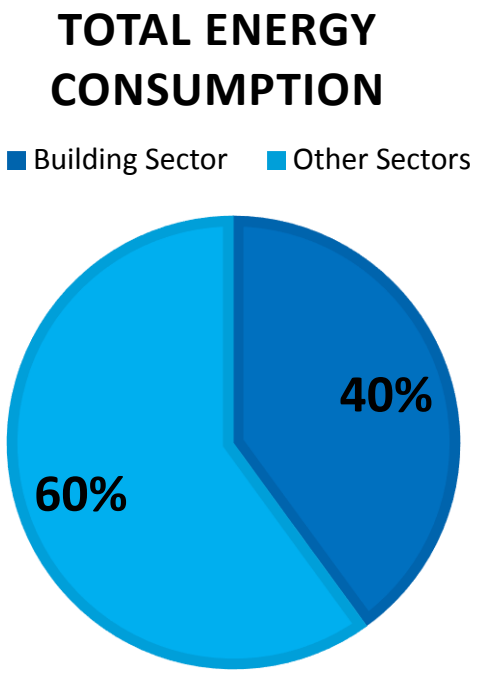
Buildings absorb about one-sixth of the world's resources.
Responsible for the consumption of:

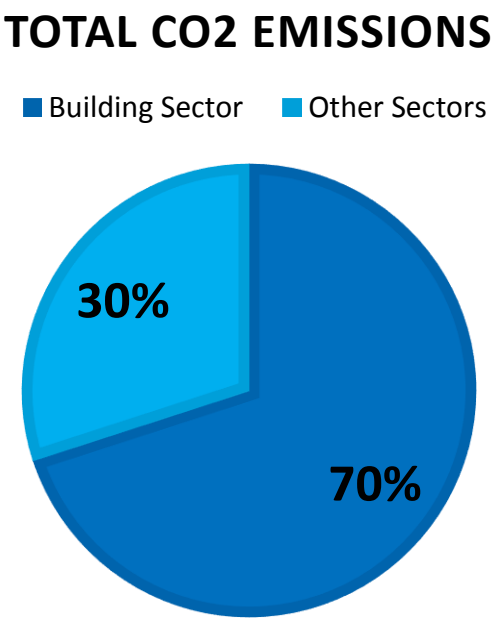
- **40% of the world energy**
- **16% of world** reserves of fresh water

Generating

- **70% of sulphur oxides and**
- **50% of carbon dioxide emissions.**

A WORLDWIDE BUILDING SECTOR OVERVIEW





Worldwide buildings are responsible for more than 40 percent of global energy use and one third of global greenhouse gas emissions, both in developed and developing countries.

These figures demand urgently the reduction of energy consumption in Buildings

EUROPE 2020 GOALS

The EU 2020 climate and energy package

Reduction in greenhouse gas emissions

CO_2

20%

Raise the share of the European energy consumption produced from renewable resources

20%

Improve energy efficiency towards nZEB

20%

By 2050 all existing buildings should be net zero energy buildings.

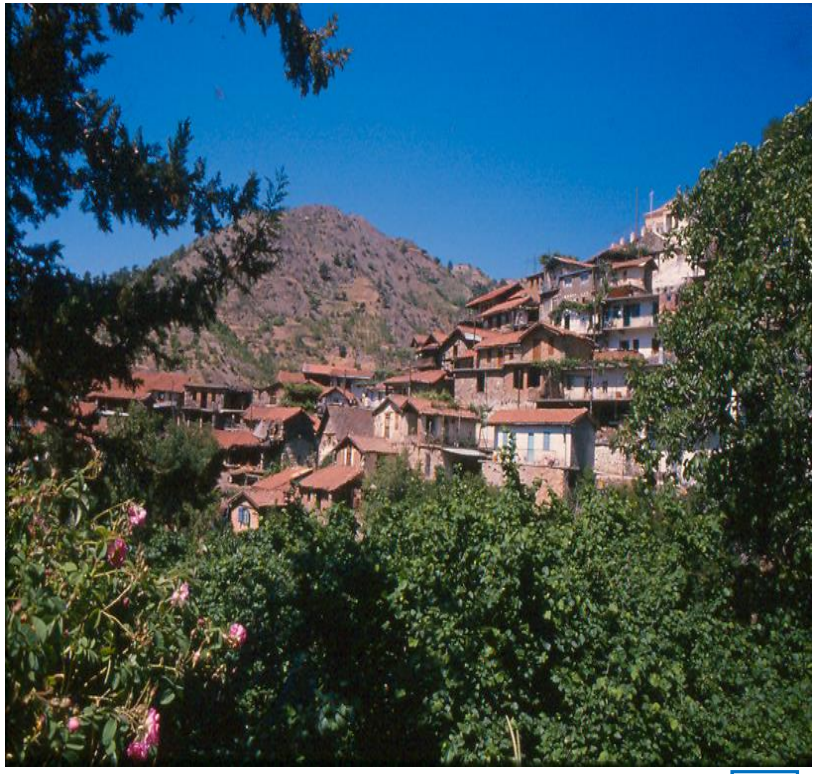
EUROPE'S BUILDING SECTOR

The average annual rate of new construction in Europe amounts to 1%.

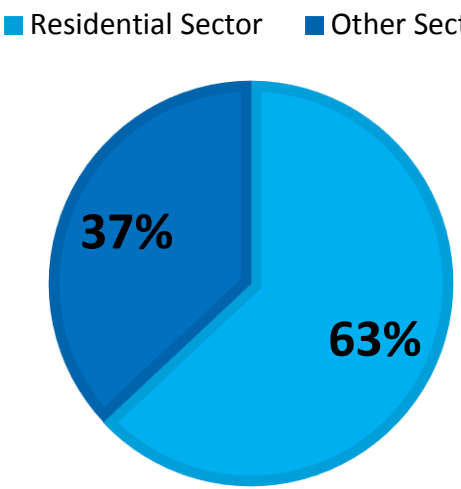
The improvement of the energy performance of the old building stock is a high priority in the research agenda of the European Union.

ENERGY REFURBISHMENT OF RESIDENTIAL BUILDINGS

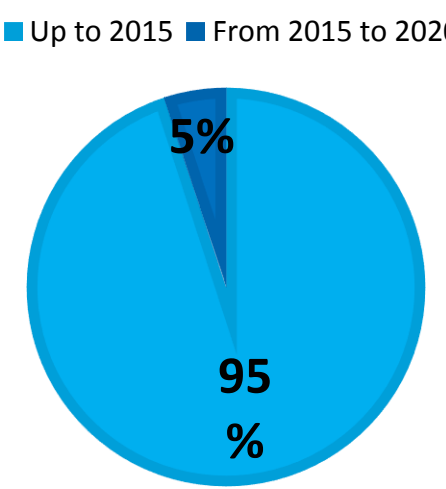
The household sector constitutes 75% of the existing building stock in Europe.



BUILDING SECTOR ENERGY CONSUMPTION



RESIDENTIAL STOCK



The retrofitting of residential buildings, provides significant potential for energy savings and for the sustainability of buildings in Europe

NEARLY ZERO ENERGY BUILDINGS

The radical upgrading of existing buildings in Europe, anticipating nearly zero-energy buildings, would save yearly, 32% of total primary energy use and savings is equivalent to 4 billion barrels of imported oil

A nZEB must have:

a. A high energy performance envelope

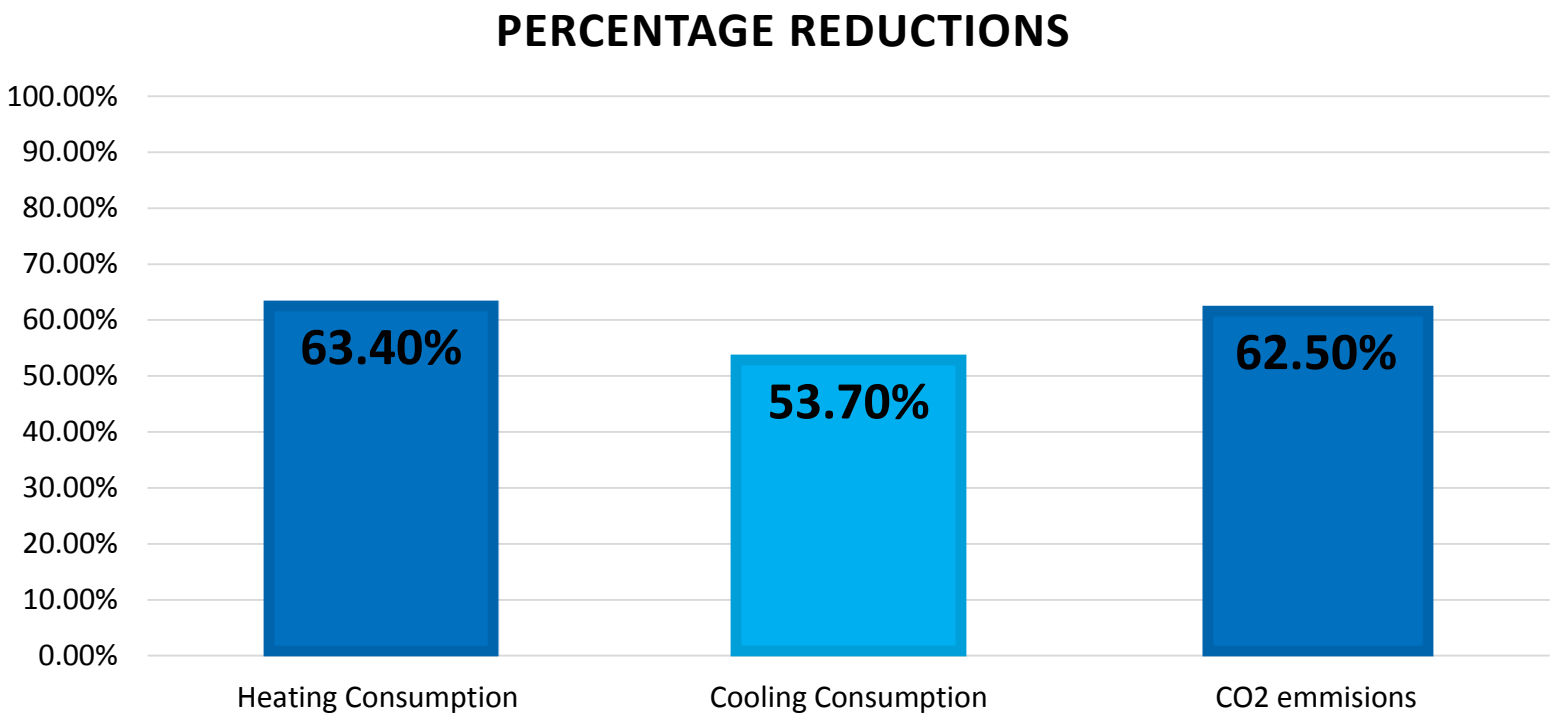
b. Energy efficient lighting, heating and cooling systems

c. Renewable energy sources

BRE zero carbon house UK includes photovoltaics, biomass boiler and ‘wind catcher’

A 'net zero carbon' development of 780 homes at Chichester, UK, with a centralized gas-fired combined heat and power (CHP) system

NEARLY ZERO ENERGY BUILDINGS
ESTIMATED SAVINGS



In Cyprus up to **3219363 GWh/year** can be saved if all the dwellings are converted into nZEB

THE CASE STUDY

The study focuses on **the conversion of an existing Single Family House**, representing one of the main residential typologies in Cyprus (50% of prevalence among the residential building stock), **into a cost effective nZEB house.**

Aims:

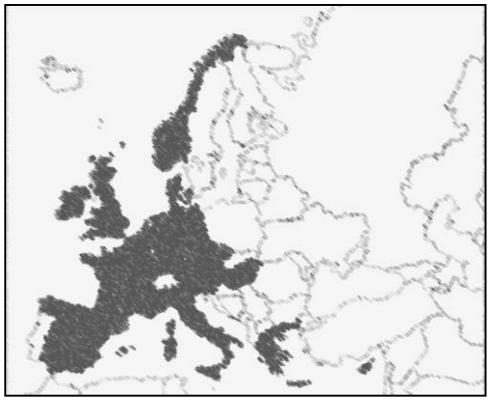
To fill in the current knowledge gap of nZEB in the Cyprus
To assess and upgrade the energy performance of the building stock
To highlight the potential of renewable energy use in family housing.

BACKGROUND

EPISCOPE – EU, IEE Project (http://episcope.eu)

Basic Idea

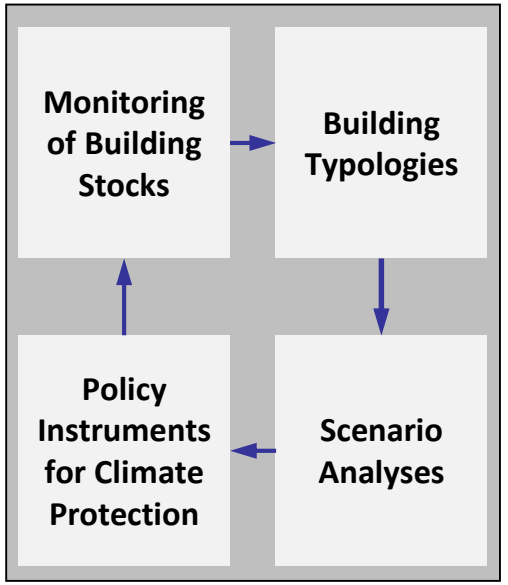
Improve the effectiveness of the energy saving refurbishment processes in the European housing sector.



17 Partners from 16 European countries Austria, Belgium, Cyprus, Czech Republic, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Slovenia, Spain, United Kingdom

Expected Outputs/Results

- Setup of national **building typologies**
- **Implementation of pilot actions**, identifying and qualifying typological criteria.
- **Application of scenario calculations** for the considered housing stock.
- Identification of a concerted set **of Energy Performance Indicators** reflecting the energy refurbishment state.
- **Recommendations** how regular monitoring can be achieved.



BACKGROUND

EPISCOPE – EU, IEE Project (http://episcope.eu)

NATIONAL BUILDING STOCK

Building Type Matrix

	Region	Construction Year Class	Additional Classification	Cyprus SFH Single-Family House	Cyprus TH Terraced House	Cyprus MFH Multi-Family House
1	national (Cyprus)	... 1980	generic	 CY.N.SFH.01.Gen	 CY.N.TH.01.Gen	 CY.N.MFH.01.Gen
2	national (Cyprus)	1981 ... 2006	generic	 CY.N.SFH.02.Gen	 CY.N.TH.02.Gen	 CY.N.MFH.02.Gen
3	national (Cyprus)	2007 ... 2013	generic	 CY.N.SFH.03.Gen	 CY.N.TH.03.Gen	 CY.N.MFH.03.Gen
4	national (Cyprus)	2014 ...	generic	 CY.N.SFH.04.Gen	 CY.N.TH.04.Gen	 CY.N.MFH.04.Gen

Older generation construction

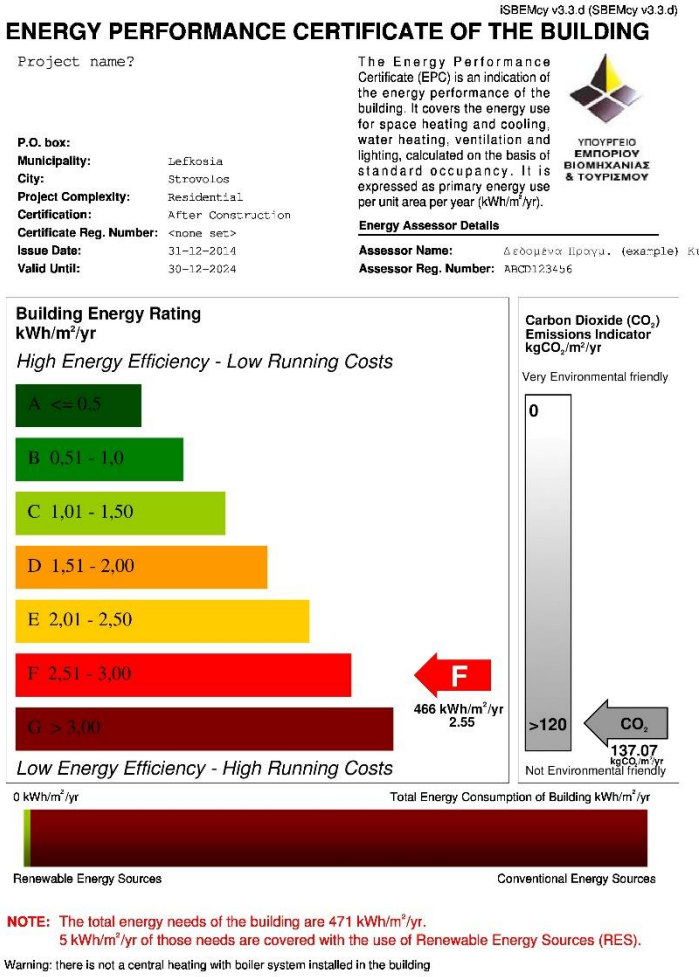
Construction Boom in Cyprus

First Minimum Energy requirements 2007

New minimum energy requirements 2014

METHODOLOGY

1. **Selection of the house**
2. The **energy performance** of the house was found **for its existing state**.
3. A **standard nZEB refurbishment scenario was applied**, based on the Directive 366/2014.
4. The **energy efficiency and the cost viability** for each **refurbishment measure** related to the **building envelope** elements thermal performance was **assessed**.
5. **An energy and cost optimized nZEB scenario was developed**
6. **Comparisons** between the **2 Scenarios** were performed.
7. **Conclusions** were reached.



iSBEMcy v3.3.d (SBEMcy v3.3.d)

ENERGY PERFORMANCE CERTIFICATE OF THE BUILDING

Project name?

The Energy Performance Certificate (EPC) is an indication of the energy performance of the building. It covers the energy use for space heating and cooling, water heating, ventilation and lighting, calculated on the basis of standard occupancy. It is expressed as primary energy use per unit area per year (kWh/m²/yr).

ΥΠΟΥΡΓΕΙΟ ΕΜΠΟΡΙΟΥ ΒΙΟΜΗΧΑΝΙΑΣ & ΤΟΥΡΙΣΜΟΥ

P.O. box:	
Municipality:	Lefkosia
City:	Strovolos
Project Complexity:	Residential
Certification:	After Construction
Certificate Reg. Number:	<none set>
Issue Date:	31-12-2014
Valid Until:	30-12-2024

Energy Assessor Details

Assessor Name:	Δεδομένα Προγρ. (example) Κι
Assessor Reg. Number:	ABCD123456

Building Energy Rating kWh/m²/yr

High Energy Efficiency - Low Running Costs

A <= 0,5
B 0,51 - 1,0
C 1,01 - 1,50
D 1,51 - 2,00
E 2,01 - 2,50
F 2,51 - 3,00
G > 3,00

F
466 kWh/m²/yr
2.55

Low Energy Efficiency - High Running Costs

Carbon Dioxide (CO_2) Emissions Indicator kgCO_2/m²/yr

Very Environmental friendly

0
>120
CO_2
137.07 kgCO_2/m²/yr

Not Environmental friendly

0 kWh/m²/yr — Total Energy Consumption of Building kWh/m²/yr

Renewable Energy Sources — Conventional Energy Sources

NOTE: The total energy needs of the building are 471 kWh/m²/yr.
5 kWh/m²/yr of those needs are covered with the use of Renewable Energy Sources (RES).

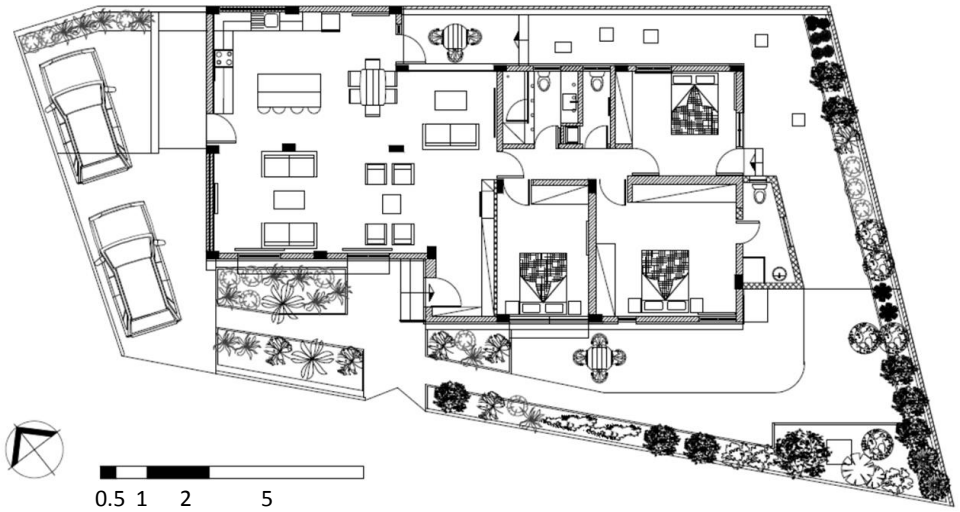
Warning: there is not a central heating with boiler system installed in the building

For the energy performance simulation iSBEM-Cy was used (the governmental software for the issuance of Energy Performance Certificates)

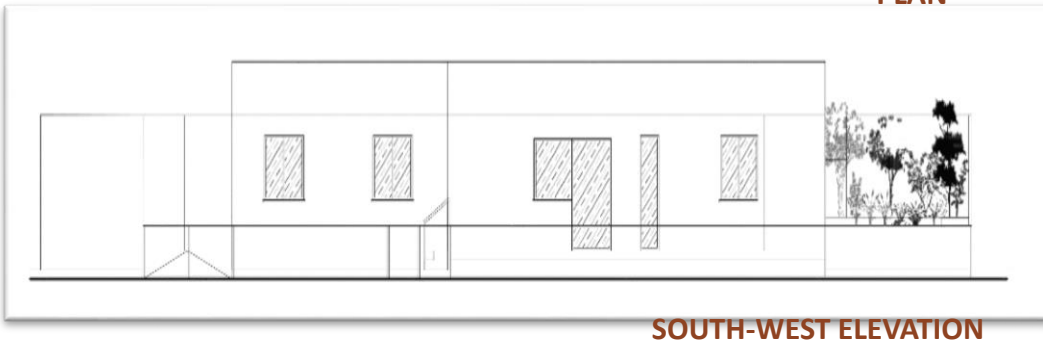
THE BUILDING

The **Single Family House** under study:

- Is **representative of its typology** for the period **prior to 1980.**
- **Is situated** in the Capital City of Nicosia, **inland area** of the island of Cyprus.
- Is a **single-storey dwelling** with a **usable heated living area of 134,5m2** and a **heated living volume of 396,9m3.**
- **It has a North-East to South-West orientation,** with **15%** of the total **wall surface corresponding to glazing,** of which 44% is North-East and 35% South- West oriented.
- **It has 3 bedrooms, 3 bathrooms and an open plan kitchen, dining and living room.**



PLAN



SOUTH-WEST ELEVATION

EXISTING STATE OF THE BUILDING

CONSTRUCTION CHARACTERISTICS

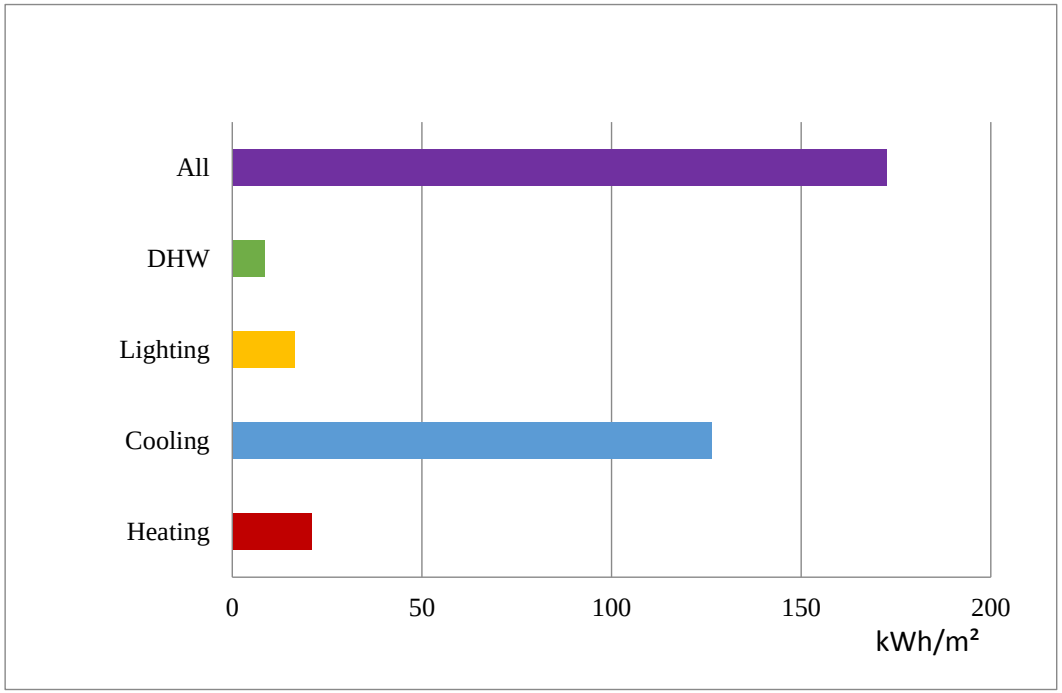
- Non-insulated flat concrete roof
- Rendered brick walls
- Floor concrete slab in contact with the ground
- Double glazed windows (recent refurbishment from single glazed ones)

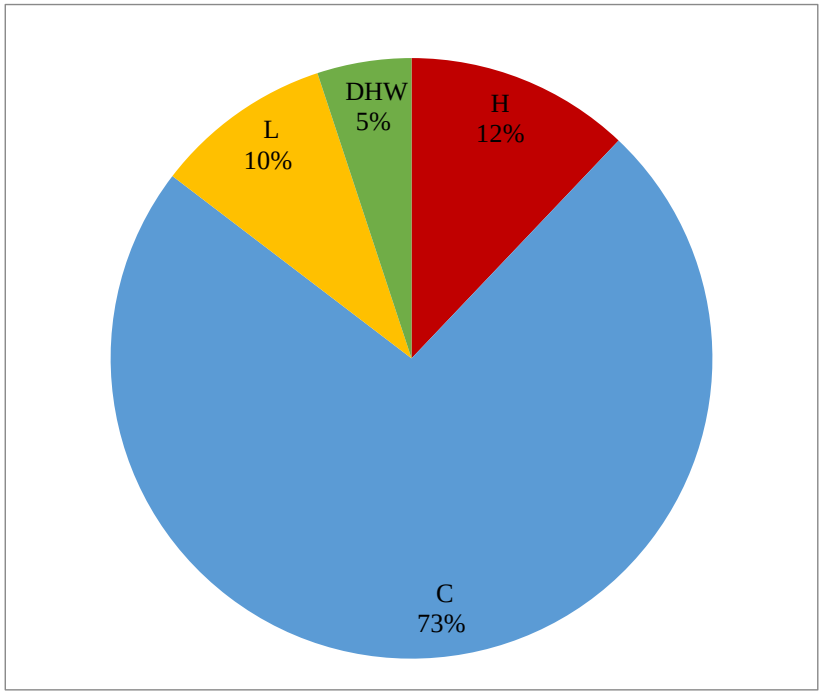
Construction Element	U-Value W/(m2k)
Flat roof	**3.08**
External walls	**1.39**
Floor in contact with the ground	**3.58**
Double glazed windows	**3.20**

ELECTROMECHANICAL EQUIPMENT

- For Heating and Cooling 5 standard air-conditioning split units.
- For Domestic Hot Water (DHW), solar thermal panels on the roof and a back-up electric element.

ENERGY CONSUMPTION
EXISTING STATE





- The Energy Performance Certificate (EPC) Categorization reaches the **class F.**
- **The total energy consumption** for the house reaches the **172.56 kWh/(m2a).**
- **The major energy consumption** is attributed to the high need for **cooling**.
- The energy consumption **for heating is 20.85 kWh/(m2a), for cooling is 126.48 kWh/(m2a), for DHW 8.74 kWh/(m2a) and for lighting is 16.49 kWh/(m2a).**

STANDARD nZEB REFURBISHMENT SCENARIO

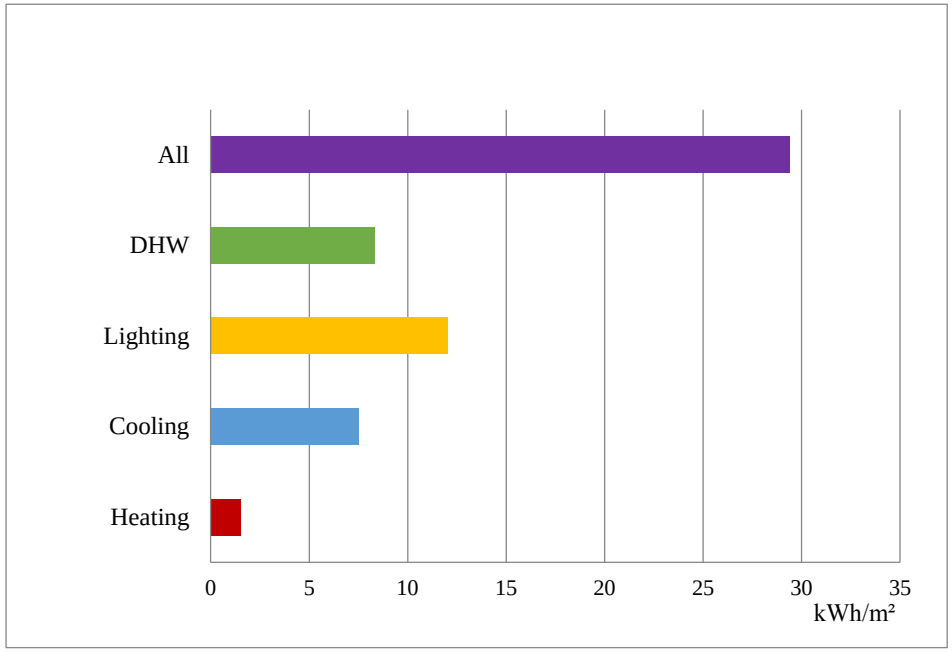
The Standard nZEB Scenario is based on the existing Directive 366/2014:

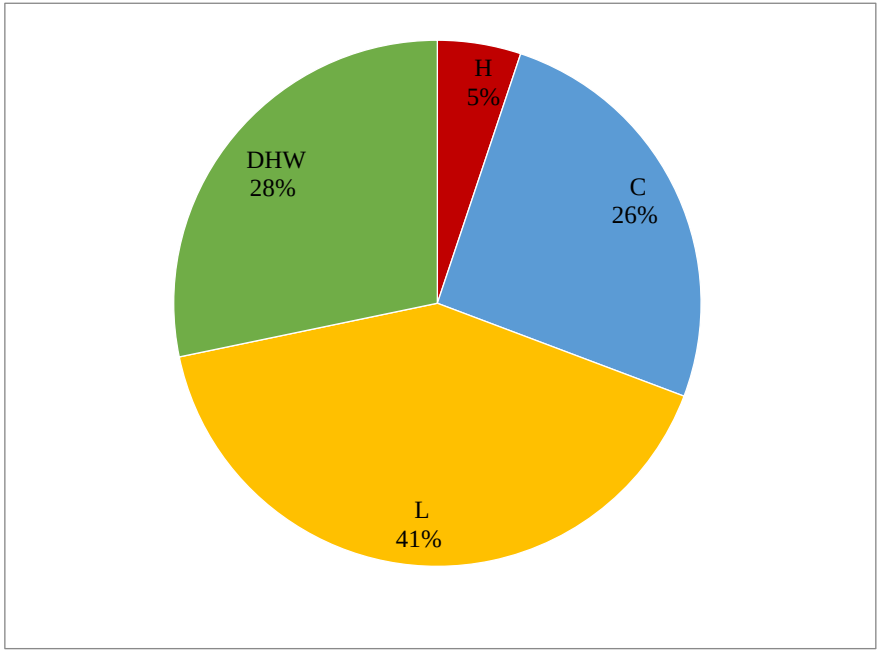
NZEB REQUIREMENTS FOR HOUSES	
Technical specifications - Construction Element	**U-Value W/(m²K)**
Flat roof	**0.40**
External walls	**0.40**
Double glazed windows	**2.25**
Energy Performance specifications	**Minimum requirements**
Energy Performance Certificate	**A**
Total Primary Energy consumption	**100 kWh/(m²a)**
Energy Demand for heating	**15 kWh/(m²a)**
Renewable energy percentage of the total primary energy consumption	**25%**

REFURBISHMENT MEASURES

- Addition of **90mm thermal insulation externally on the roof.**
- Addition of **80mm of thermal insulation** (expanded polystyrene) **externally on the wall**s
- Replacement of **the windows with new, thermally improved ones**
- Addition of **horizontal overhang shades** (aluminium frame and fabric) above the south-facing windows.
- Placement **of 3 photovoltaic panels** of total area of 4.8m2 on the roof with an inclination of 30°
- Substitution of the existing **AC units with ones of A+++ class**.

ENERGY CONSUMPTION
STANDARD nZEB SCENARIO

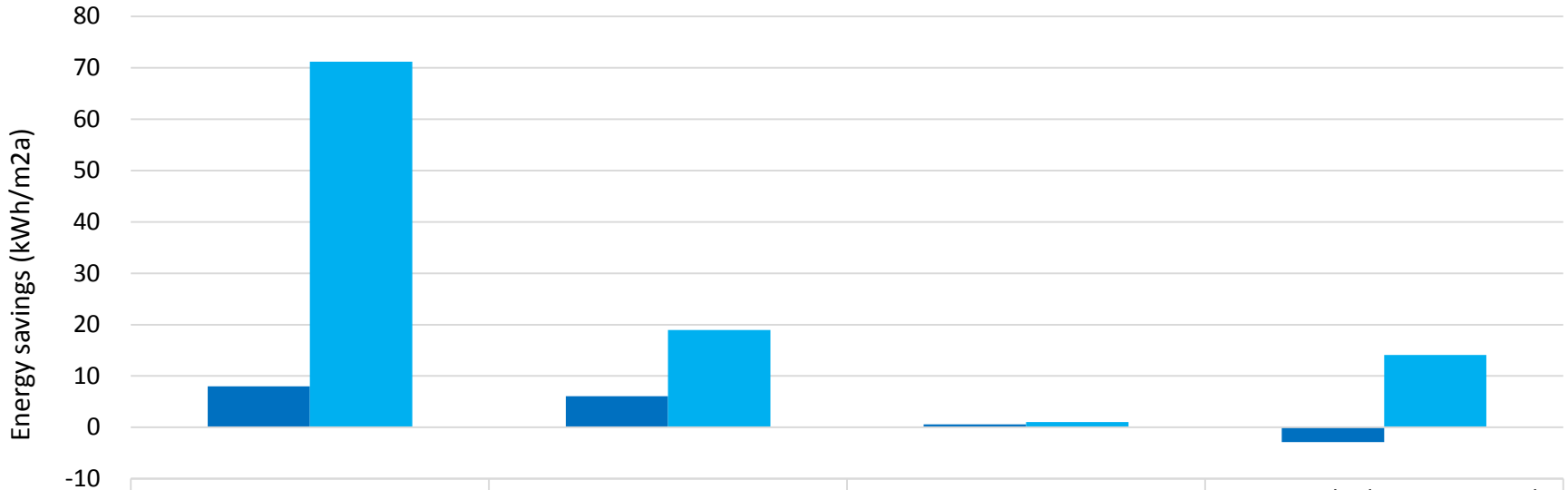




- The house was **raised by five EPC categories, from F to A**
- The **total final energy consumption is 29.41 kWh/(m2a)**
- The **energy consumption for heating is 1.51** kWh/(m2a) and for **cooling is 7.54** kWh/(m2a). The **lighting and DHW consumptions are 12.06kWh/(m2a) and 8.32kWh/(m2a).**

ENERGY CONSERVATION MEASURES

ENERGY IMPACT

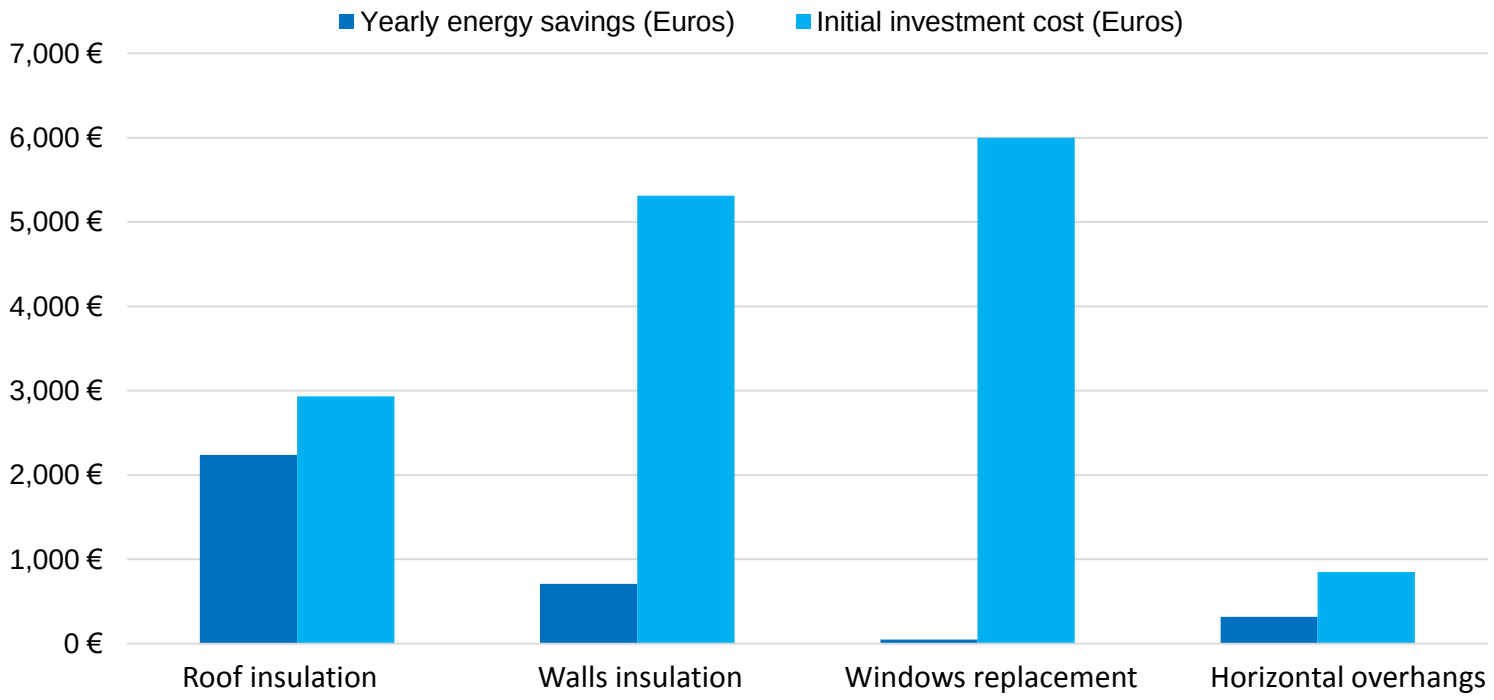


	Refurbishment - Roof	Refurbishment - Wall	Refurbishment - Windows	Exterior shading - Horizontal overhang
Heating	7.97	6.05	0.59	-2.87
Cooling	71.18	18.95	1.03	14.07

- The **placement of thermal insulation on the roof is the most effective measure.**
- The **cooling savings** after insulating the **roof are more than 3 times higher** than the ones incurring from the **placement of insulation on the walls**.
- The **replacement of the existing double glazed windows** with new ones, of lower U-value, results to **minimal energy savings**.
- **The placement** of the 1m length **overhangs** above the windows is **energy efficient only for Cooling**.

ENERGY CONSERVATION MEASURES

COST-EFFECTIVENESS

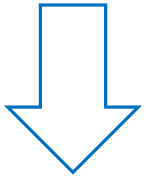


- **The most cost - effective measure is the addition of insulation on the roof**, with a **payback period of less than 2 years**.
- The horizontal overhangs have a 3 years payback time and the insulation of the walls 7 years.
- **The replacement of the double-glazed windows** with ones of better energy performance **is the least effective measure** with more than a century to amortize its initial investment cost.

OPTIMISED nZEB REFURBISHMENT SCENARIO

CHANGES FROM STANDARD nZEB SCENARIO

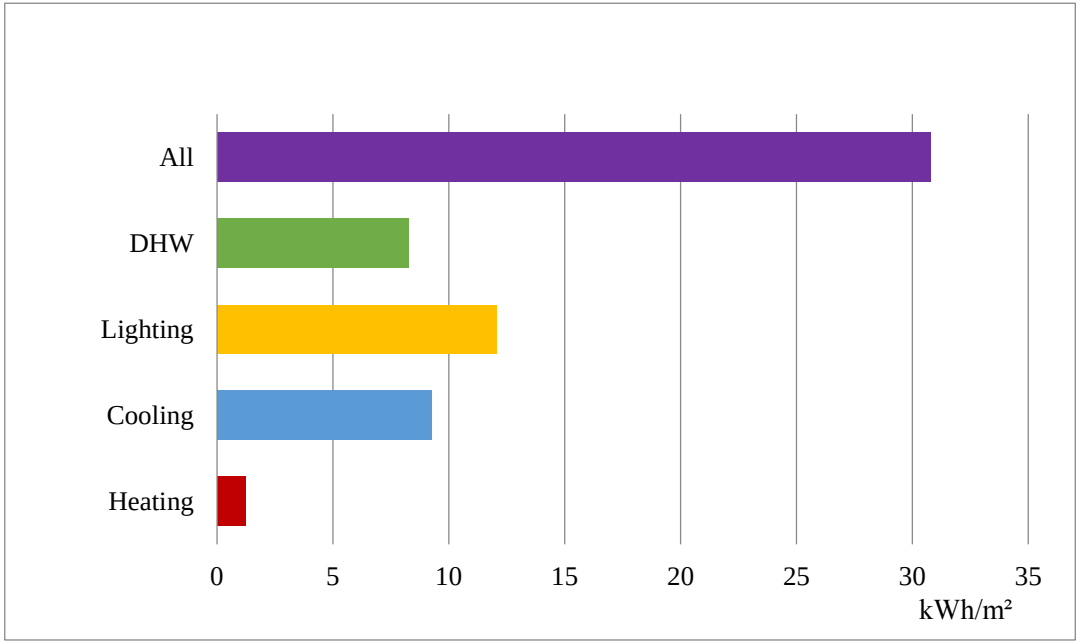
- **NO window replacement.**
- **Increase the number of PV panels from 3 to 12.**

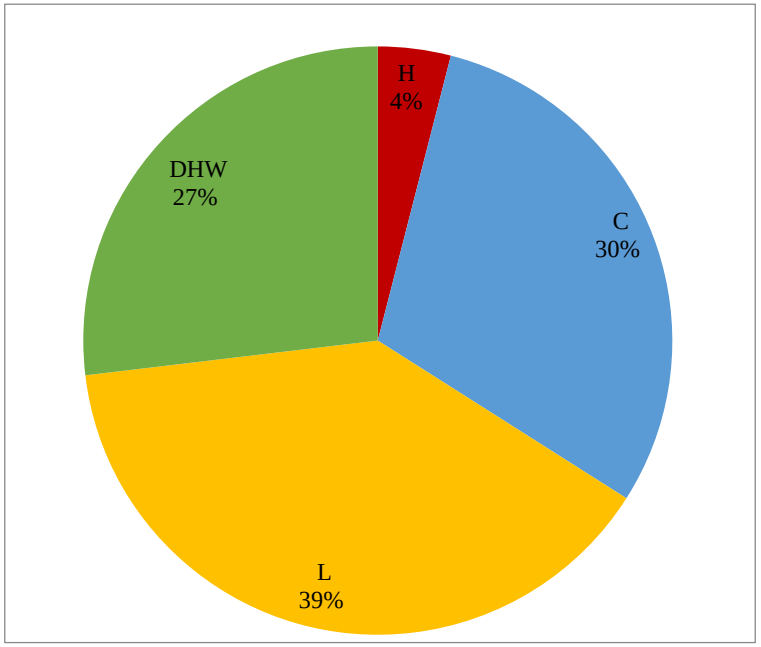


REFURBISHMENT MEASURES

- **Placement of insulation on the roof and the walls, achieving the same U-values as the standard nZEB Scenario.**
- **Installment of horizontal overhangs in the south facing windows.**
- **Substitution of the split units were with ones of higher energy efficiency (A+++)**
- **Placement of 12 PV panels amounting to 19,2 m2 on the roof.**

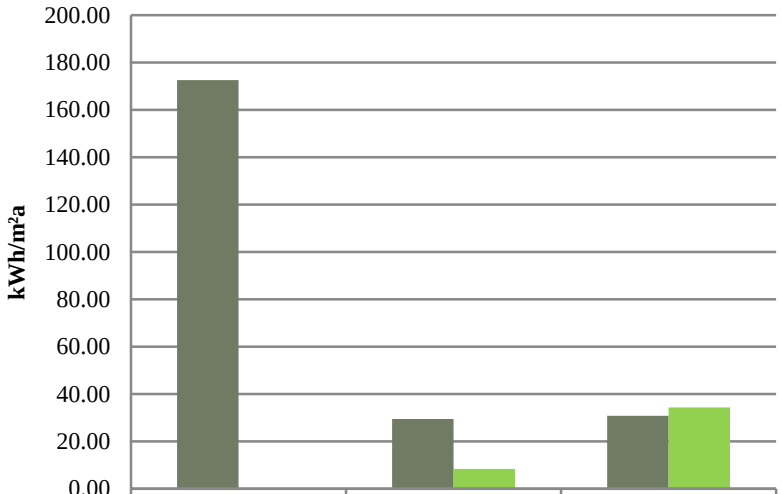
ENERGY CONSUMPTION
OPTIMISED nZEB SCENARIO



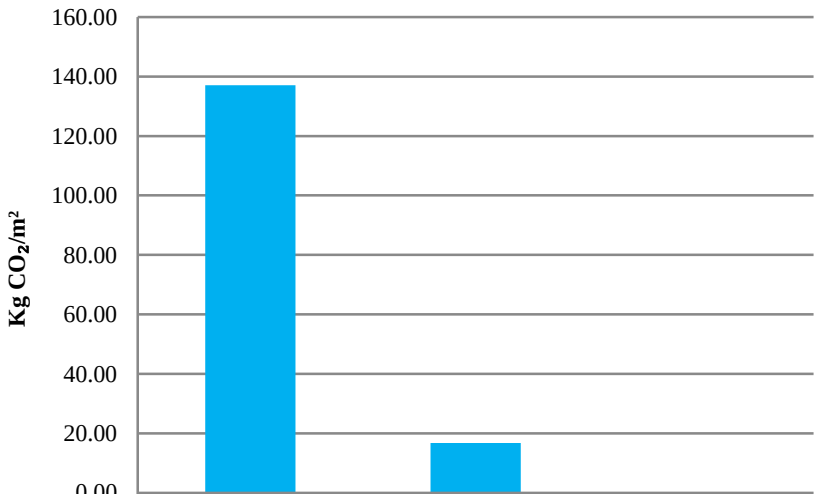


- The house was **raised by five EPC categories, from F to A.**
- The **total final energy consumption** is reduced to **30.79** kWh/(m2a)
- The **energy consumption for heating is 1.23** kWh/(m2a) and **for cooling is 9.24** kWh/(m2a)
- The **lighting and DHW consumptions are 12.04kWh**/(m2a) and **8.28** kWh/(m2a) respectively
- The Energy produced by the PV panels is **34.24** kWh/(m2a)

COMPARISON



	Existing	Standard nZEB	Optimised nZEB
Total Energy Consumption	172.56	29.42	30.79
Energy produced by the PV system	0.00	8.38	34.24



	Existing	Standard nZEB	Optimised nZEB
CO_2 Emissions	137.07	16.70	-2.74

- **Surplus energy production from the PV systems after the optimized nZEB refurbishment**

⇩

NO CO2 emissions

- **7 years payback period for the optimized nZEB scenario**

⇩

1 year less than the standard nZEB scenario

CONCLUSIONS

- The results indicate **the drawbacks of the minimum requirements towards nearly zero energy houses**, as drafted by the Cyprus government, **especially the replacement of the windows**, which is obligatory by the Directive.

- The **replacement of already double –glazed windows** has **a share of 24% of the total investment**, and incurs a **saving of only 2kWh/m2year** on the total energy consumption.

- **On the contrary, the placement of shading devices** presents both **an energy effective and economically viable choice**, although not included in the requirements according to the Directive 366/2014.

The cost effectiveness of the different refurbishment measures on the building envelope

The high amounts of energy produced from PV systems

redirect the definition of the nearly zero energy buildings in Cyprus

into a more flexible and cost effective choice, in order to constitute a feasible choice of refurbishment for old houses.

ULTIMATE AIM: SUSTAINABILITY

To live in harmony with nature

Defining new approach with the use of Bioclimatic, Energy Efficient Design and harnessing energy from the inexhaustible renewable energy resources on our own lands:

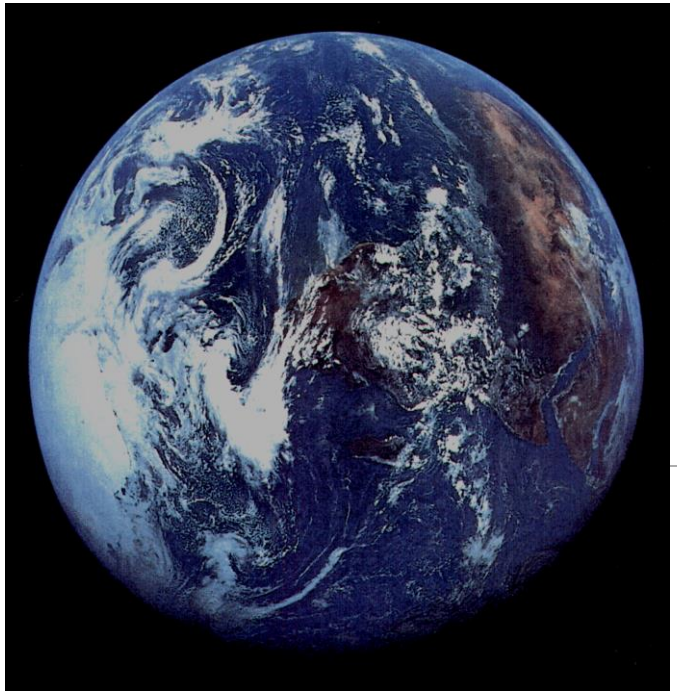
To Reduce

- The international tensions,
- Environmental pollution, and
- The dangers from global warming, energy production and use,

To provide

- New jobs,
- Energy resource security,
- Energy cost stability,
- Ecological sustainability, and
- A clean environment for our children and their children,

THANK YOU!



http://web.cut.ac.cy/episcope/