BUILDING ENVELOPE A KEY ROLE PARAMETER FOR SUSTAINABLE BUILDINGS

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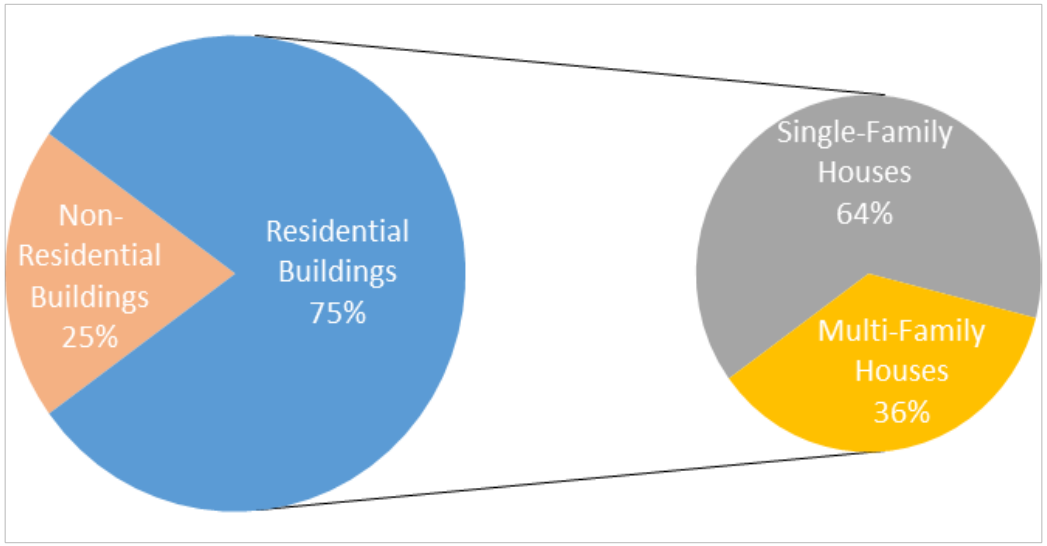
INTRODUCTION 1/2

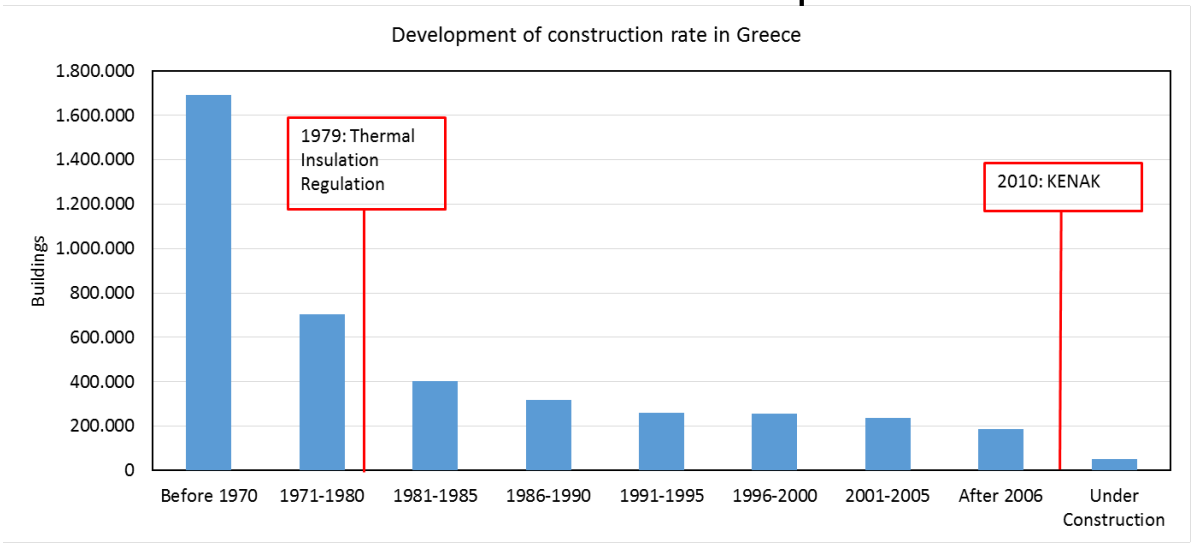
- Building sector: responsible for the 40% of the total final energy consumed in the EU
- Residential sector: responsible for the 27% of the total final energy consumption in 2010
- Tertiary sector: responsible for the 16%
- Energy Performance of Buildings Directive (EPBD) 2002/91/EC
- Recast Directive 2010/31/EC



INTRODUCTION 2/2

- Directive 2002/91/EC for the Energy Performance of Buildings (review (2010/31/EC))
- ***Greek legislation***
  - ✓ 1979-2009: Thermal Insulation Regulation of Greece
  - ✓ 2010-now: KENAK

  In accordance to the Greek regulation KENAK all buildings, newly constructed or deeply renovated, public or private, need to obtain an Energy Performance Certification (EPC). According to the Ministry of Reconstruction of Production, Environment & Energy over 590 thousand certifications have been issued in the period of 2011-2014.

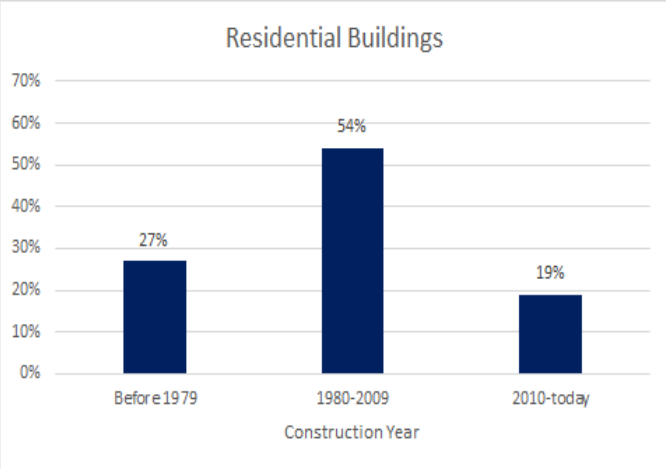


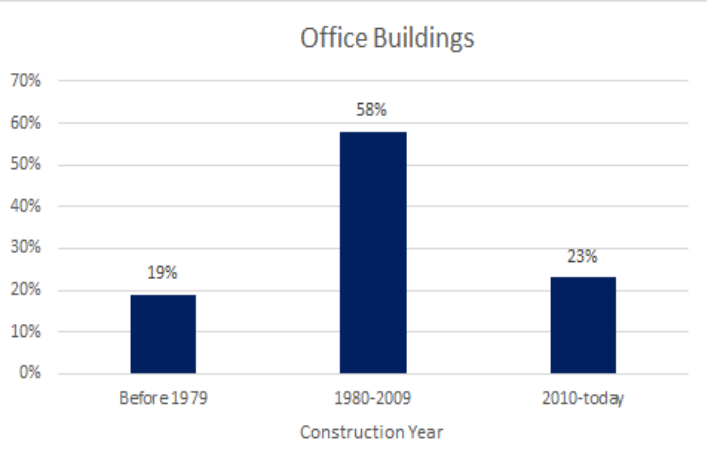
METHODOLOGY AND MEASUREMENTS 1/2

- Heat transfer coefficient (U-value):

$$U = \frac{1}{R} + \text{Convection and Radiation Heat Losses}$$

- Measurements of U-value for the two main vertical building elements, namely brick-walls and concrete elements.
- A sample of 52 Greek buildings: 26 residential and 26 office buildings





METHODOLOGY AND MEASUREMENTS 2/2

- Device TM 200 U

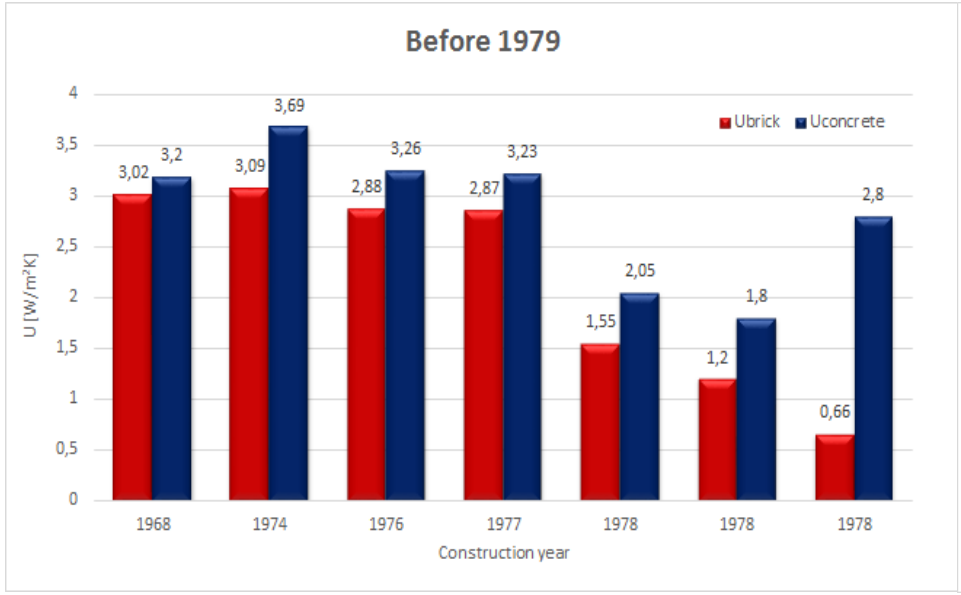
To calculate U-value, four conditions must be respected:

- The outside temperature should be low,
- The room should be heated
- The wall should not be exposed to wind and sun
- The temperature difference between outside and inside temperature should be more than 20°C

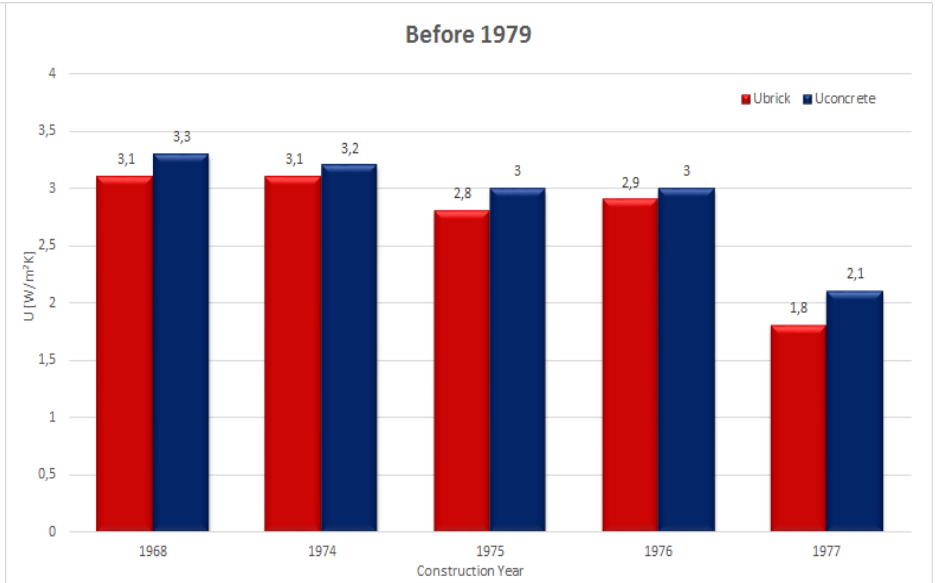
RESULTS 1/7

- The first statistical analysis depicts the relevance of U-values in different constructing time periods according to the insulation regulation that prevailed when the buildings, both residential and non-residential ones, were constructed.

Residential Buildings

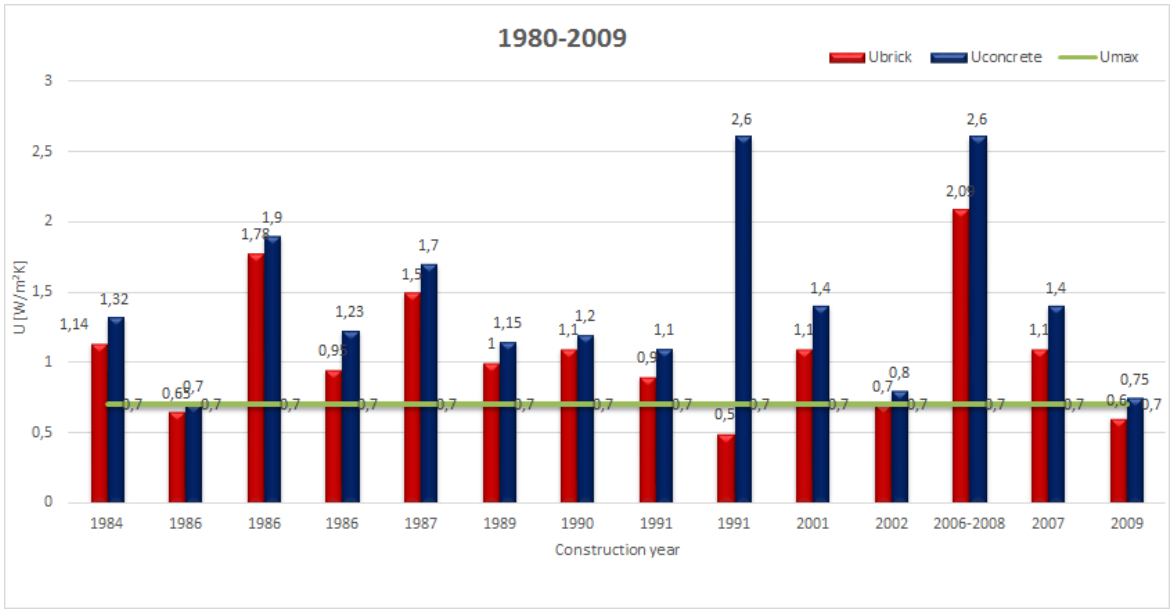


Office Buildings

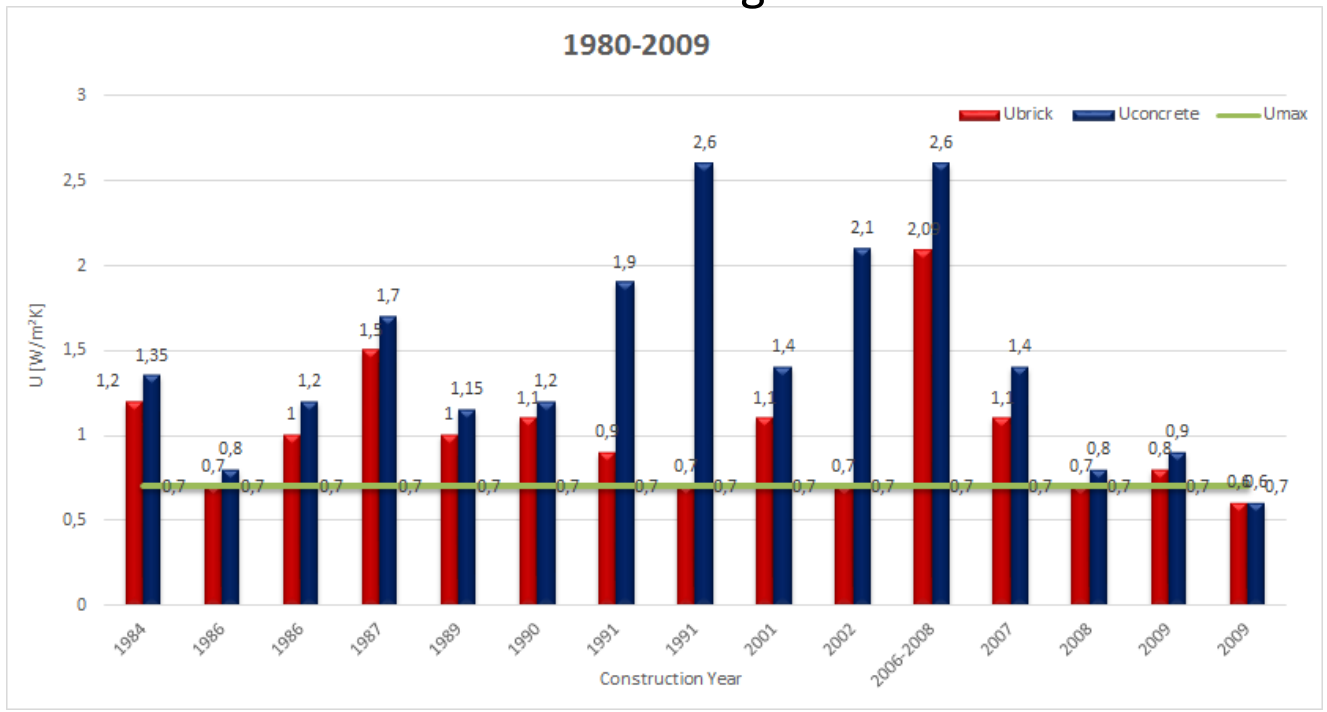


RESULTS 2/7

Residential Buildings

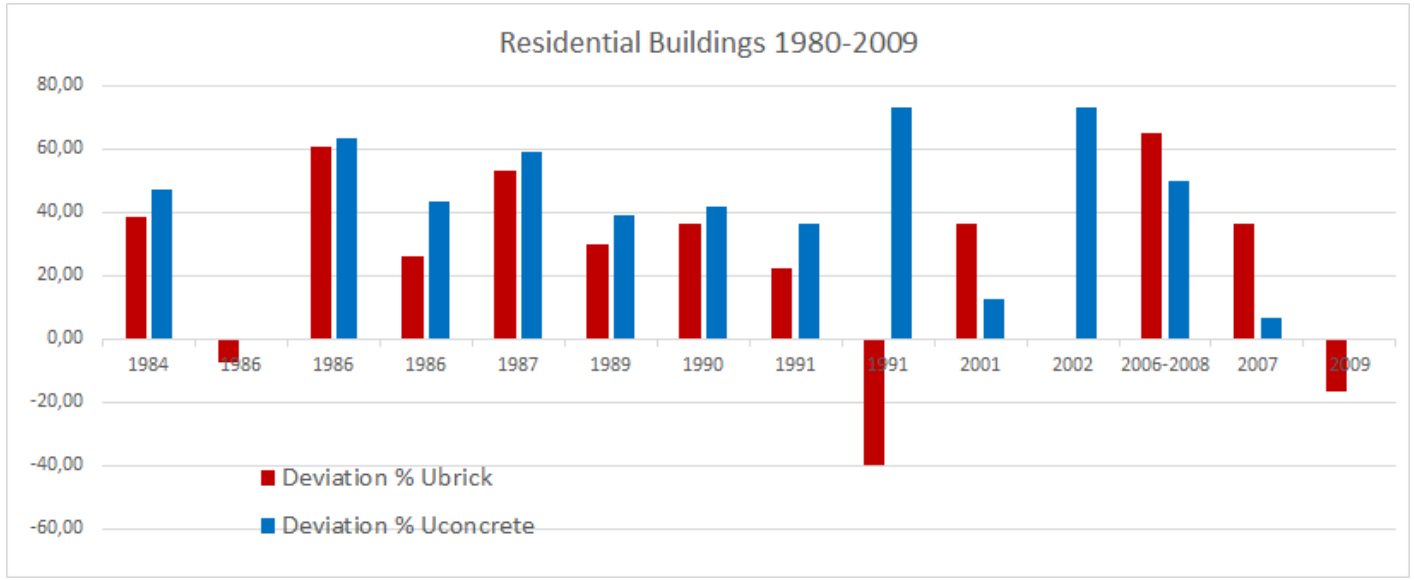


Office Buildings



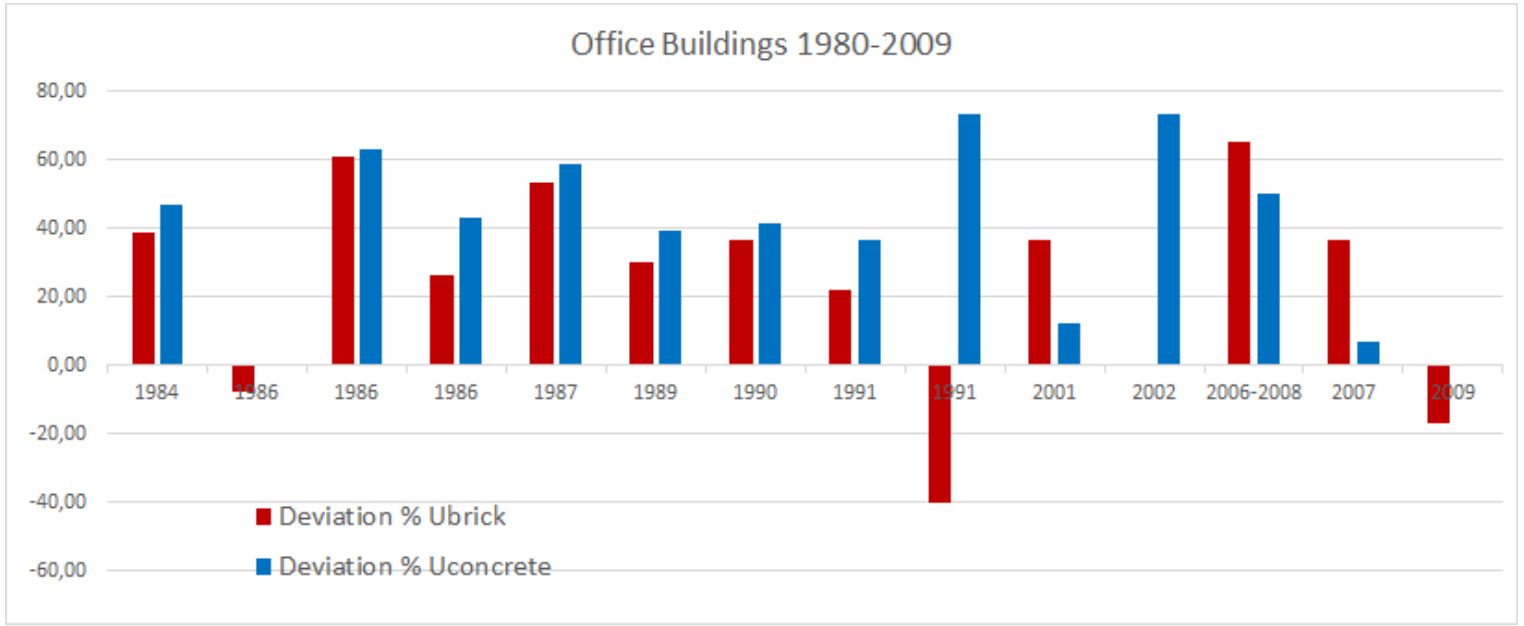
RESULTS 3/7

Residential	Buildings 1980-2009	
Umax	Deviation % Ubrick	Deviation % Uconcrete
0,7	38,60	46,97
0,7	-7,69	0,00
0,7	60,67	63,16
0,7	26,32	43,09
0,7	53,33	58,82
0,7	30,00	39,13
0,7	36,36	41,67
0,7	22,22	36,36
0,7	-40,00	73,08
0,7	36,36	12,50
0,7	0,00	73,08
0,7	65,00	50,00
0,7	36,36	6,67
0,7	-16,67	0,00
0,7	38,60	46,97



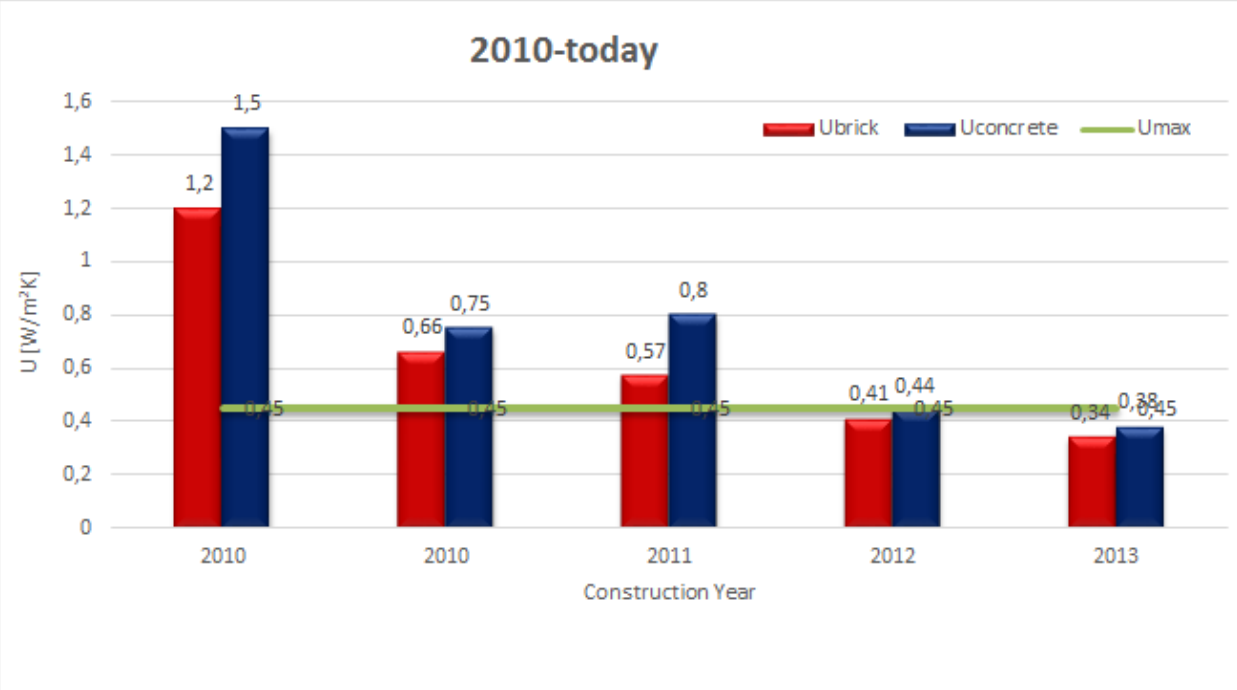
RESULTS 4/7

Office	Buildings 1980-2009	
Umax	Deviation % Ubrick	Deviation % Uconcrete
0,7	41,67	48,15
0,7	0,00	12,50
0,7	30,00	41,67
0,7	53,33	58,82
0,7	30,00	39,13
0,7	36,36	41,67
0,7	22,22	63,16
0,7	0,00	73,08
0,7	36,36	50,00
0,7	0,00	66,67
0,7	36,36	73,08
0,7	0,00	50,00
0,7	36,36	12,50
0,7	0,00	22,22
0,7	12,50	0,00

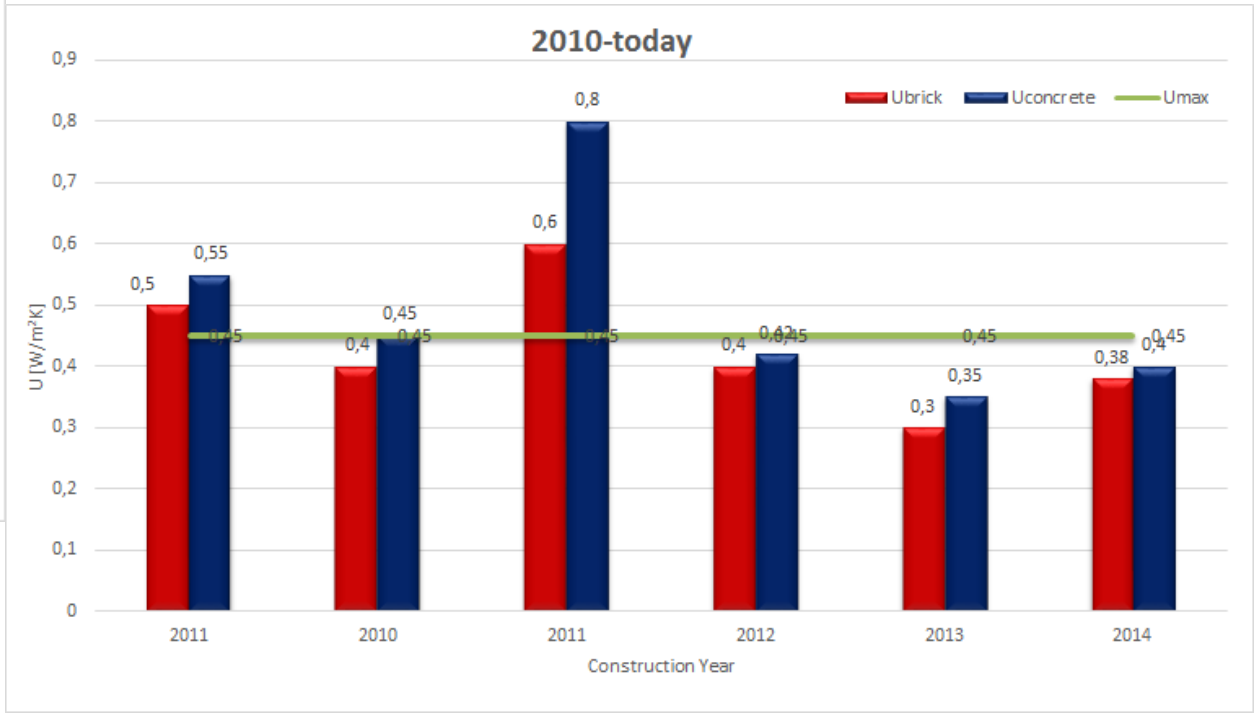


RESULTS 5/7

Residential Buildings

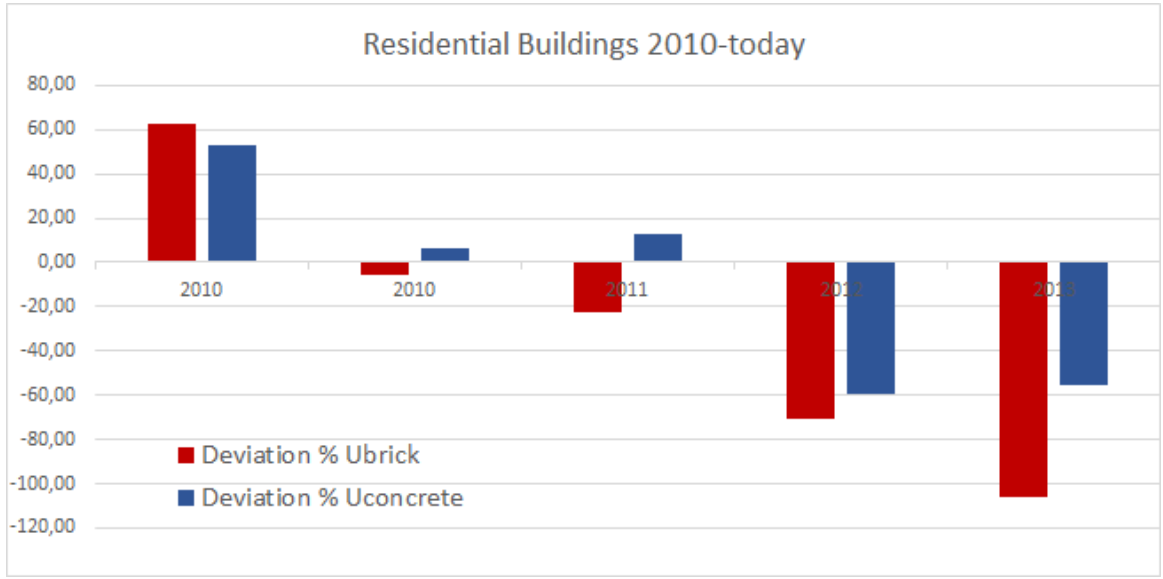


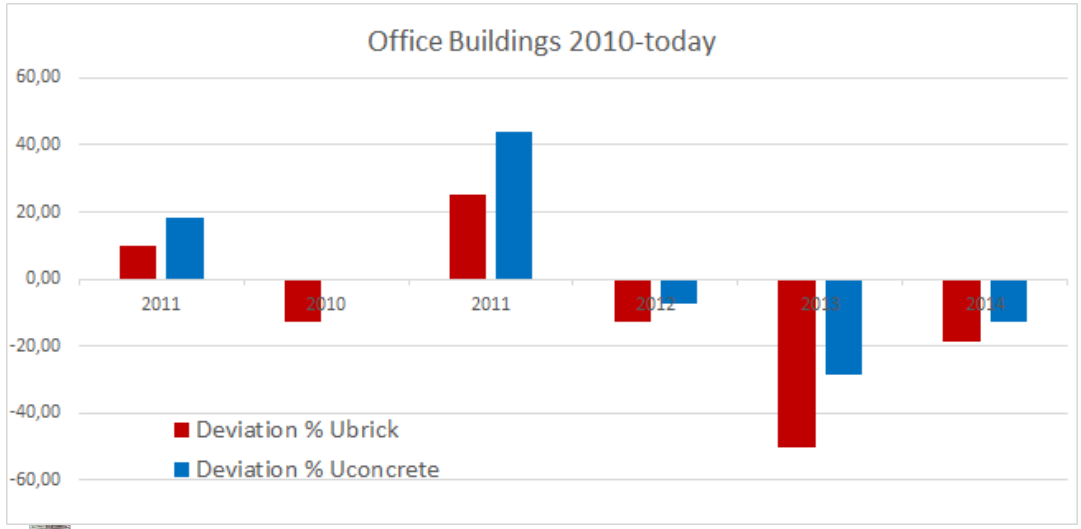
Office Buildings



RESULTS 6/7

Residential	Buildings 2010-today	
Umax	Deviation % Ubrick	Deviation % Uconcrete
0,45	62,50	53,33
0,45	-6,06	6,67
0,45	-22,81	12,50
0,45	-70,73	-59,09
0,45	-105,88	-55,56

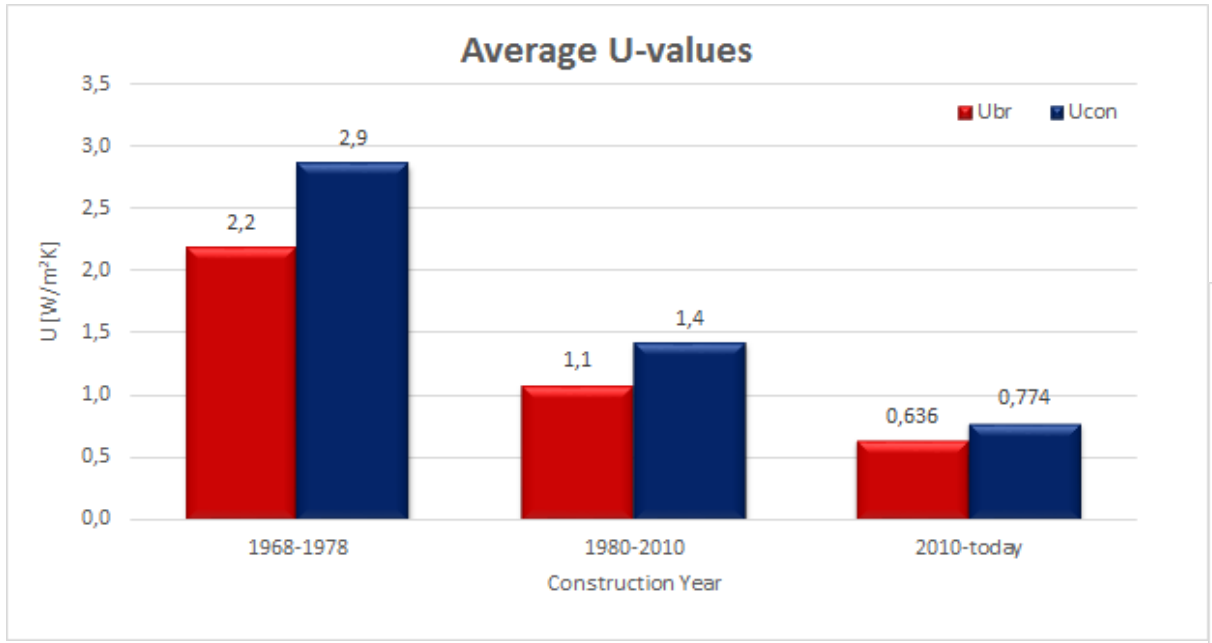




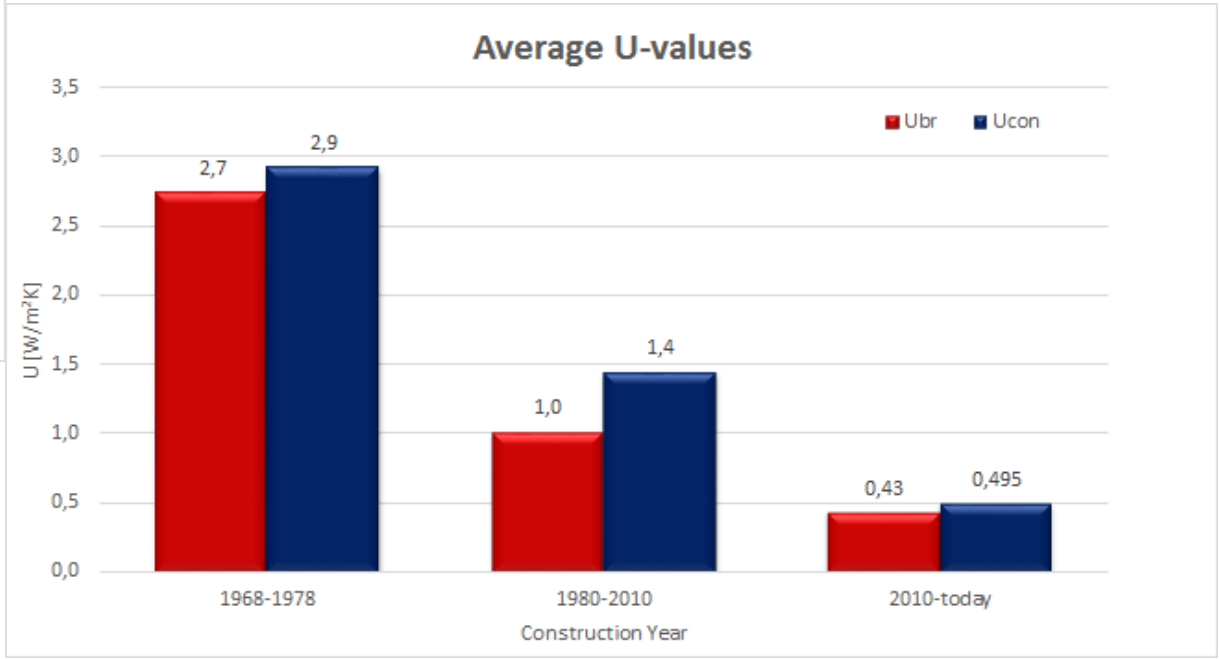
Office	Buildings 2010-today	
Umax	Deviation % Ubrick	Deviation % Uconcrete
0,45	10,00	18,18
0,45	-12,50	0,00
0,45	25,00	43,75
0,45	-12,50	-7,14
0,45	-50,00	-28,57
0,45	-18,42	-12,50

RESULTS 7/7

Residential Buildings



Office Buildings



ENVELOPE CONSTRUCTION MATERIALS ENVIRONMENTAL IMPACT 1/4

- LCA Analysis
  - ✓ Production processes of the materials
  - ✓ Auxiliary activities
  - ✓ Product's packaging
  - ✓ Storage
  - ✓ Transportation

- Output data namely emissions from mining, production, packaging, storage and transportation at the inventory phase:
  - ✓ SimaPro LCA software
  - ✓ Embodied EcoInvent LCA Database

ENVELOPE CONSTRUCTION MATERIALS ENVIRONMENTAL IMPACT 2/4

Material	kg CO_2eq	kg SO_2eq	kg PO_4eq	kg C_2H_4eq	EmbEn [MJ]
Steel	0.63761	0.00395	0.00018	0.00016	9.76
Reinforced concrete	0.34	0.90673	0.08972	0.03596	0.48
Cement Plaster	0.22134	0.00050	0.00005	0.00002	1.42
Cement portland	0.85807	0.00131	0.00018	0.00005	3.33
Brick	0.23595	0.00070	0.00007	0.00005	2.76
Stone	1.01494	0.00671	0.00057	0.00024	16.73
Plaster board	0.39033	0.00167	0.00019	0.00007	6.03
Common Plaster	0.26146	0.00036	0.00005	0.00003	1.45
Acrylic Plaster	0.20961	0.00087	0.00007	0.00009	4.96
Ceramic Tiles	0.95001	0.00418	0.00031	0.00021	15.72
Expanded Polystyrene (EPS)	3.24197	0.01268	0.00096	0.00054	76.16
Extuded polystyrene (XPS)	4.04462	0.01646	0.00125	0.00088	92.38
Glasswool (GW)	3.30205	0.01904	0.00158	0.00105	60.10
Polyurethane Foam (PUR)	4.42797	0.01934	0.00279	0.00212	92.30
Stonewool (SW)	2.17293	0.01303	0.00132	0.00059	24.90

ENVELOPE CONSTRUCTION MATERIALS ENVIRONMENTAL IMPACT 3/4

- Based on LCA results the production procedures as well as the transportation process contribute mainly to air emissions and more specific to CO_2 production.

- Focusing on insulation materials, the cradle-to-gate environmental evaluation results showed that expanded polystyrene and stonewool have lower contribution to environmental impact categories studied compared to extruded polystyrene and polyurethane foam. The functional unit used was for the 1kg of insulation material produced.

- In case the functional unit is changed to the mass of insulation material needed for insulating $1m^2$ of surface taking into consideration the thermal resistance R of the building element the results are slightly different. In that case expanded polystyrene, extruded polystyrene and stonewool have lower contribution to environmental impact categories studied compared to polyurethane foam.

ENVELOPE CONSTRUCTION MATERIALS ENVIRONMENTAL IMPACT 4/4

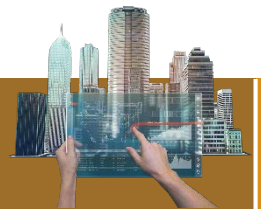
Potential measures for reducing the environmental impact of the basic building materials:

- the use of renewable energy sources for the energy needed at the production process, either on site, like for instance biomass, or off-site, like green electricity,
- the end-of-life management of building materials and the calculation of waste flows at the production processes, including the reuse, recovery and recycling potential,
- the upgrading of the industrial infrastructure (refurbishment, improved monitoring and control of energy consumption, implementation of Energy Management Systems such as ISO 50001),
- the reduce of transportation emissions by preferring locally extracted raw materials and also fostering the use of biofuels for the vehicles,
- the reuse and recycling of building materials.

CONCLUSIONS 1/2

- The necessity for improving the buildings' energy efficiency is expressed by a variety of legislations not only in Europe but worldwide.
- In Greece,
  - ✓ before 1979, when there was no thermal insulation regulation, the buildings envelopes were completely uninsulated and as a result buildings had significant heat losses.
  - ✓ Implementation of Greek Regulation of Thermal Insulation things began to evolve. At the beginning only applied at brick walls whereas armed concrete elements completely uninsulated.
  - ✓ The majority of buildings from this time period (especially 1979-2009), measured, failed to achieve the limits foreseen by the regulation.

However, it is encouraging to notice that, despite the depressing situation of the construction sector, the tight requirements of the new regulation, introduced in 2010, seem to be achieved in practice.



CONCLUSIONS 2/2

- Considering the building materials' environmental impact, it resulted that the use of resources lies in the heart of the materials' impact.
- It is therefore necessary to promote the use of best available techniques and to promote innovative solutions in the production processes, in order to reduce the depletion of the natural, finite resources.
- Another interesting point that emerged from the study is the need to minimize the transport of raw materials, which is responsible for significant environmental burden. In that sense promoting the use of resources locally available is one of the most important measures to reduce transport emissions and, of course, costs.

Thank you for your attention!!

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