Cost-effectiveness of retrofits in Italy to the EnerPHit standard

2017 South Pacific Passive House Conference, Christchurch, New Zealand
Emu – from architects to systems
Summary

• Context: what are the Italians up to today
• Case study: retrofit of single-family house to EnerPHit standard
• The way forward: bringing Passive House to mainstream market
Context: Italy
Construction market

- Since 2008, investments in new construction have dropped by 62.7%.
- Investments in retrofits have increased by 23.6%.

...population growth in Italy has been near zero for over 30 years.
Culture vs climate

• Italian climate is warm
• Reality: 65% of population lives in heating-dominated climate
• National average: 2/3 of residential use of energy is heating
Environment

- Northern Italy: one of the most polluted areas in the world
Economy

• Cost of electricity per kWh:
  Italy: 0.18 €
  Germany: 0.25 €
  US: 0.10 € (0.11 $)

• Cost of natural gas per kWh:
  Italy: 0.08 €
  Germany: 0.07 €
  US: 0.03 € (0.03 $)

• Cost of energy: constant over time (for ROI analyses here)

• Interest rate: 2.5%    Inflation rate: 0.5%
Tax breaks for energy retrofit in Italy

- **Retrofits** of existing residential buildings, where heating is installed include thermal insulation, replacement of windows, shading, changes to heating/cooling system, etc.
- does not cover mechanical ventilation
- Up to **100,000 €** deductible per unit, in over **10 years**
- Apply to personal income tax
  - **pay out of pocket**
  - **deduct 65%** of expenses from taxes later (over 10 years)
Cost-effectiveness of insulation

• What can I buy for the same amount of money? (*)

(*) 70.00 €/m², includes EIFS components, labor, scaffolding, pre-tax, no tax breaks
Cost-effectiveness of insulation

• How good is the insulation I buy?

61 kWh/a heating, via air-to-water HP (COP 2.8)
**Cost-effectiveness of insulation**

- **What performance am I buying?**

<table>
<thead>
<tr>
<th>EIFS insulation used</th>
<th>insulation thickness on same budget [cm]</th>
<th>U value [W/m2K]</th>
<th>EnerPHit suitable?</th>
<th>Yie value [W/m2K]</th>
<th>thermal lag [h]</th>
<th>thermal attenuation [-]</th>
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<tbody>
<tr>
<td>EPS</td>
<td>21</td>
<td>0.15</td>
<td>Y</td>
<td>0.016</td>
<td>12h 25'</td>
<td>0.100</td>
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<tr>
<td>EPS + graphite</td>
<td>20</td>
<td>0.14</td>
<td>Y</td>
<td>0.019</td>
<td>12h 13'</td>
<td>0.126</td>
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<tr>
<td>Mineral wool</td>
<td>15</td>
<td>0.19</td>
<td>Y</td>
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<td>13h 50'</td>
<td>0.112</td>
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<td>Wood fiber</td>
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<td>0.29</td>
<td>N</td>
<td>0.036</td>
<td>14h 17'</td>
<td>0.109</td>
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<tr>
<td>Cork</td>
<td>9</td>
<td>0.34</td>
<td>N</td>
<td>0.051</td>
<td>12h 32'</td>
<td>0.130</td>
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</tbody>
</table>

Static transmittance according to ISO6946, dynamic transmittance to ISO13786
Building stock

• Substantial part built between 60s and 90s
• Most common technique: masonry, often with concrete frame
• Hardly any insulation
• No mechanical ventilation (only 1% of buildings has it)
Case study: single-family house
Existing conditions

• Built in 1962 as house of a marble dealer
• Brick masonry with some concrete element
• Mixed use:
  ground fl.: workshop and deposit
  2nd: one residential unit
  attic: unheated storage for house
• Good orientation, poor form factor of heated part
Existing conditions

view from north-east

view from south-west

detail of masonry
Surroundings – site climate data

- Satellite
- Site horizon survey
- Project horizon
- Project climate data

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Retrofit project

cross section

2nd storey floorplan (heated)
Baseline works + budget

- Seismic improvements to the building structure
- Major redistribution of internal spaces (2\textsuperscript{nd} storey)
- Design for future separation into two apartments
- Insulate envelope, replace windows
- Re-do all services, add mechanical ventilation

Baseline budget: \textbf{255.000 € + tax}
Assemblies: physics

- Assembly analysis

cross section
Assemblies: physics + budget

<table>
<thead>
<tr>
<th>thickness [cm]</th>
<th>00</th>
<th>02</th>
<th>04</th>
<th>06</th>
<th>08</th>
<th>10</th>
<th>12</th>
<th>14</th>
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<th>24</th>
<th>26</th>
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<tbody>
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<td>0.4590</td>
<td>0.3591</td>
<td>0.2949</td>
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<td>0.2173</td>
<td>0.1920</td>
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<td>0.1557</td>
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<td>€ 56.15</td>
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<td>constr. + heat 20y</td>
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<td>€ 81.16</td>
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Wall retrofit + heating: 0 / 10 / 20 / 30 years

61.32 kKh/a, EPS with graphite, 0.18 €/kWh, air-water heat pump (SCOP 2.8), interest 2.5%, inflation 0.5%

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Assemblies: physics + budget + tax breaks

tax breaks: deduct 65% of energy retrofit expenses from personal income tax, up to 100,000 € over 10 years

Wall retrofit + heating: 0 / 10 / 20 / 30 years + tax breaks

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Envelope: Junctions

- Perimeter solid brick walls: structural, so please don't cut them
- Internal brick masonry walls (also structural)
- Balcony: concrete slab wrapping around corner (bonus: concrete column)
Junctions: physics + budget

• Example: concrete balcony

![Image 1](PSI = 0.662 W/mK  
fRsi = 0.648  
Te = 1.0 °C  
Ti_min = 13.01 °C  
mold: yes)

![Image 2](PSI = 0.368 W/mK  
fRsi = 0.841  
Te = 1.0 °C  
Ti_min = 16.98 °C  
mold: no)

cost: 105.00 €/m
ROI: 10 years
(not including tax breaks)
Junctions: 3D is the magic number

- Example: concrete balcony

As is:
- CHI = 0.119 W/K
- fRsi = 0.273
- Te = 1.0°C
- Ti_min = 6.19 °C
- mold: yes! yes! yes!

Retrofit:
- CHI = -0.012 W/K
- fRsi = 0.735
- Te = 14.96 °C
- mold: with mechanical ventilation, no
Whole building analysis – PHPP 9

- Building 'as is'
  - av. U value: 1.44 W/m²K
  - 46mm timber frame windows, single pane
  - high temperature radiators
  - no mechanical ventilation

- Baseline: minimum for tax breaks (*)
  - av. U value: 0.18 W/m²K
  - 92mm timber frame windows, triple pane
  - areas with in-slab heating
  - mechanical ventilation

- EnerPHit
  - av. U value: 0.35 W/m²K
  - 68mm timber frame windows, double pane
  - in-slab heating
  - mechanical ventilation

(*)Mechanical ventilation is not mandatory in Italy.

However, typical results of energy retrofits without mechanical ventilation is: mold and condensation. We don’t do that.
Whole building analysis – PHPP 9

• Building 'as is'
  HD: 280.5 kWh/m2a
  HL: 116.1 W/m2
  high temp. radiators
  methane burner (old)
  heating bill: 4,500 €/a

• Baseline: minimum for tax breaks (*)
  HD: 51.2 kWh/m2a
  HL: 31.1 W/m2
  in-slab heating
  air-to-water heat pump
  heating bill: 610 €/a

• EnerPHit
  HD: 17.7 kWh/m2a
  HL: 13.1 W/m2
  areas with in-slab heating
  air-to-water heat pump
  heating bill: 210 €/a

what is 'good enough'?
Whole building analysis – PHPP 9

• Building 'as is'
  
  No tax breaks here
  Total cost is very similar (EnerPHit slightly more convenient)
  Poor form factor (you work with what you have)
  Some components still very expensive (triple pane glass)

• Baseline: minimum for tax breaks (*)
  
• EnerPHit
  
  +14 cm EIFS insulation
  +14 cm floor insulation
  +16 cm ceiling insulation
  upgrade to 92 mm, triple pane windows
  same insulation of thermal bridges
  same mechanical ventilation units
  less in-slab heating

upfront extra cost for EnerPHit: +22,000 € + 10% VAT (Jan 2016)
Whole building analysis – PHPP 9

• Building 'as is'
• Baseline: minimum for tax breaks (*)
• EnerPHit

Extra cost: 22,000 €
Pot. extra tax break: 14,300 €
Present value: 12,800 €

Can you pay out of pocket upfront?
Is your personal income tax high enough to deduct from?
Did you reach the 100k € deduction cap with other expenses?
Do you believe me?
Ok, let's do it!

...but not too fast
The way forward
Passive House consulting – a critique

• 25 years after, PH is still a niche

• The taylor-made approach is often a failure

• By winning beautiful battles, we risk to lose the war

• The battlefield that matters the most is mainstream market
Passive House 2.0

• Available at mainstream market price
• Adapt to local culture and climate
• Available to architects with basic training
• Available to trained tradespeople
• Integrate local products
• Becomes the baseline for comfort and efficiency
Simplify

- Learning from Lego
Simplify, standardize

• Learning from Lego

Sizes of assemblies and junctions for architectural design

Construction documentation

Insulation, air tightness, wind tightness

PSI value, fRsi value

goal: simplify design and calculation of PH

reality: may be perceived as rigid and unadaptable
Simplify, standardize, integrate

• Learning from Lego
Simplify, standardize, integrate

• Learning from Lego
Simplify, train

• Learning from Lego
Standardized PH construction systems

• 2016 - 1st system: Italian new construction (masonry)
• 2017 – 2nd system: North America new construction (timber frame)
• 2017 – 3rd system: Italian retrofit (masonry)
• …?
Emu Systems

thank you