
Dr. Gloria Pignatta – g.pignatta@unsw.edu.au
Scientia Fellow and Lecturer
Faculty of Built Environment
UNSW Sydney, Australia

6th Jeffrey Cook Workshop on Zero Energy Settlements
Nov 24th, 2019
Traditional Building

- The annual energy balance of a typical building is negative
- > 40% of the world’s energy is consumed by buildings
- > 1/3 of the greenhouse gas emissions come from buildings

Nearly Zero Energy Building (nZEB)

- The annual energy balance of a nZEB is nearly zero
- Extremely energy efficient building connected with Renewable Energy Systems and the electrical grid
- More comfortable, reliable, affordable and sustainable
The European Union aims to have all buildings in the region under nZEB standards by 2020

LIMITATION:
high investment and maintenance cost for the extra performance required to achieve net Zero Energy Buildings.

ZERO-PLUS SOLUTION:
apply the zero-energy concept to groups of buildings so that benefits are shared and multiplied within the zero energy community as well as the investment and maintenance cost are reduced (Economies of scale).

- Total budget of ~ 4 M euros
- October 2015 – September 2019 (48 months) + 1 year of extension
- 16 international partners
OBJECTIVE

Development of a comprehensive and cost-effective modular system for Net Zero Energy residential neighborhoods, including the definition of guidelines for its design, construction, monitoring, and performance assessment.

Implementation of the system in 4 demonstration case study settlements across Europe, with varying climate boundary conditions and building typologies.

Sprawling the boundaries from NZE buildings to NZE settlements, i.e. from design at the single building level to the integrated settlement level.
Key Performance Indicators

I. Reduction of the **operational energy usage** in each residential unit
   
   0-20 kWh/m² per year

II. Generation of **renewable energy** on average in the NZE settlement

   50 kWh/m² per year

III. Reduction of **carbon footprint** towards resource-efficient, low-carbon, and climate-resilient buildings and districts

   total 408 tons CO₂ offset for all ZERO-PLUS case studies

IV. Reduction of the current **investment cost for a conventional NZE building** through a transition from single NZE buildings to NZE settlements

   16%
Additional ZERO-PLUS targets

• Ensure that:
  - building and microclimate design
  - systems implementation
  - construction
  - commissioning
  - actual operation
  - pre and post occupancy phases

are all part of the overall framework, protocols, and fine tuning.

• Ensure that the circle design-construction-occupancy has feedback mechanisms incorporated in it.

• allowing for a continuous learning and improvement process, so vital in the construction industry.
Case studies

4 demonstration case studies of residential NZE settlements across Europe under different climates, settlement scales, building typologies, construction technologies, regulations, common practices:

- **Derwenthorpe Community, York (UK)**
  *warm temperate climate*

- **Voreppe, Grenoble (FR)**
  *half-oceanic/half-continental climate*

- **Granarolo dell’Emilia, Bologna (IT)**
  *temperate and Mediterranean climate*

- **Peyia Village, Paphos (CY)**
  *mild Mediterranean climate*
Italian Case Study Settlement

Granarolo dell’Emilia, Bologna

TOPOGRAPHY: 28 m a.s.l., flat urban area

SETTLEMENT SIZE: ~9.600 m² (not including public spaces)

TYPE & NUMBER OF HOUSES: 8 single-family villas

DEMONSTRATION HOUSES: 2 single-family villas

CONCEPT: The entire neighbourhood has been thought to being built following the guidelines given within the framework of ZERO-PLUS project with the aim to improve the microclimatic conditions, the liveability, and the energy efficiency of the entire area.
Italian Case Study Buildings

V1

V2

TOT ZERO-PLUS LAND AREA per villa: ~2,750 m²

TOT GROSS FLOOR AREA per villa: ~250 m²

CONDITIONED NET FLOOR AREA per villa: 120 m²

NUMBER OF STORIES: 2 for V1 & 1 for V2
Implemented Technologies

BUILDING INTEGRATED ENERGY CONSERVATION SYSTEMS

• High performance envelope components by FIBRAN (XPS insulation panels of 220 mm for external walls and 75 + 70 mm for sloped roofs).

BUILDING INTEGRATED SMART ENERGY MANAGEMENT SYSTEM

• BEMS and Home Automation by ABB (1 Load controller & 1 REACT+ 4.6 kW module of integrated solar inverter and storage system per villa).

20-30 % of potential annual energy consumption reduction
Implemented Technologies

RENEWABLE ENERGY PRODUCTION SYSTEMS

- Photovoltaic panels
  (Installed 40 polycrystalline PV panels in total within the Italian settlement, where:
  - 14 PV panels were installed on the roof of each villa with 8 kWp of total power producing ~40 kWh/m² y, to cover single villa needs
  - 6 PV panels were mounted on the roof of each villa with 4 kWp of total power producing ~10 kWh/m² y, to cover community needs).
Implemented Technologies

SMART ENERGY MANAGEMENT SYSTEM AT SETTLEMENT LEVEL

- Integrated Energy Resources Management systems by ABB

Reduce operational costs through better management of the loads and resources on a district scale rather than on the scale of a single building.
Monitoring in the Italian NZE settlement

The **Pre-Occupancy monitoring** started in March 2019 with initial outdoor and indoor environmental measurements and targeted infrared thermography to verify the effective operation of the building envelope.

From left: microclimatic station (short-term outdoor monitoring); continuous spatial outdoor monitoring; microclimatic station (short-term indoor monitoring); Tinytag probe for IA Ta /RH (short-term indoor monitoring).

Dr. Gloria Pignatta
Monitoring in the Italian NZE settlement

Pre-Occupancy Building Diagnostics

From left above: Blower Door test for infiltration; U-value test for thermal transmittance and heat flow; Short-term monitoring of Ts in the external walls surface of both villas.

From left below: Tinytag Ta probe, Infrared identification of surface temperatures, thermal bridges, asymmetry.
## Simulated performances VS ZERO-PLUS KPIs

<table>
<thead>
<tr>
<th>Villa 1</th>
<th>Villa 2</th>
<th>PROJECT TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NET REGULATED ENERGY</strong>&lt;br&gt;= Regulated En.– En. Production</td>
<td>1.50 kWh/m² y</td>
<td>1.60 kWh/m² y</td>
</tr>
<tr>
<td><strong>ENERGY PRODUCTION</strong></td>
<td>50 kWh/m² y</td>
<td>50 kWh/m² y</td>
</tr>
<tr>
<td><strong>INITIAL COST REDUCTION</strong>&lt;br&gt;compared with the reference nZE building</td>
<td>24%</td>
<td>24%</td>
</tr>
</tbody>
</table>

Simulations calibrated with the pre-occupancy checks results and pre-occupancy monitoring data.
Monitoring in the Italian NZE settlement

The long-term monitoring started in June 2019.

- Intelligent models for evaluation of IEQ
- Intelligent models for analysis of energy demand, production and predictive maintenance
- Fault detection of sensors
- Generation of 15-day report for Problem Identification

All components are KNX bus system technology

Monitoring data accessible in real time!
Construction Completed

V1 – Nov’18

V2 – Feb’19
Informative Commissioning

Welcome

Package

Informed Consent Form

POE Questionnaire

Dr. Gloria Pignatta

UNSW Australia
Post Occupancy Evaluation (POE)

The **Occupancy** started in August 2018 in V1 & March 2019 in V2 when two families of 3 and 2 members relocated in the two villas, after the construction phase was completed. The **Post-Occupancy Monitoring and Evaluation** started in June 2019 and is currently on-going, in July 2019 the summer POE has been performed.

- **IAQ monitoring sensor** - Ta, RH, CO₂.
- **Room presence, luminance sensor** integrated in LR roof.
- **Weather station installed on the roof of V2**
Post Occupancy Evaluation (POE)

Case Study: Granarolo dell’Emilia, Bldgs: V4&V10, Rm: Living Room

Climatic Data
1. Winter
   1.1 Sunny winter day (morning AND noon AND evening)
   1.2 Cloudy winter day (morning AND noon AND evening)
2. Transition season – Spring
   2.1 Sunny spring day (morning AND noon AND evening)
   2.2 Cloudy spring day (morning AND noon AND evening)
3. Summer
   3.1 Sunny summer day (morning AND noon AND evening)
   3.2 Cloudy summer day (morning AND noon AND evening)

Questionnaires (Appendix C)

Semi-structured interviews (optional - to be conducted in case of ambiguity emerging from the questionnaires)

Data processing and analysis

Potential fine-tuning recommendations

- NO
- YES

Final report

Protocol for POE

Questionnaire translated in Italian
POE Preliminary Results

Ambient vs. Indoor Temperature (°C)
Daily Outdoor/Indoor & POE votes
19-25.07.19

~2.5°C
POE Preliminary Results

Survey data & some insights

Results from a very small sample:
- 1 day (sunny)
- 1 season (summer)
- 2 houses
- 6 tenants (1 minor)
- 5 respondents
- 12 questionnaires
  (Villa 4: morn-1, noon-2, eve-3; Villa 10: morn-2, noon-2, eve-2)
### POE Preliminary Results

#### Survey data & some insights

<table>
<thead>
<tr>
<th>Villa pseudonym</th>
<th>Gender</th>
<th>Age</th>
<th>Occupation</th>
<th>Education</th>
<th>Health</th>
<th>SBS symptoms experienced</th>
<th>Satisfaction with -</th>
<th>Overall satisfaction - perceived</th>
<th>Operation/m parking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V</td>
<td>T</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>female</td>
<td>45-64</td>
<td>housekeeping</td>
<td>n/a</td>
<td>us.healthy</td>
<td>none</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>male</td>
<td>45-64</td>
<td>retail</td>
<td>6-12</td>
<td>us.healthy</td>
<td>none</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>18-24</td>
<td>speech therapist</td>
<td>12-16</td>
<td>us.healthy</td>
<td>fatigue n. house related</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>female</td>
<td>&gt;65</td>
<td>technical</td>
<td>&gt;16</td>
<td>us.healthy</td>
<td>none</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>male</td>
<td>&gt;65</td>
<td>technical</td>
<td>12-16</td>
<td>us.healthy</td>
<td>none</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Men more critical per item BUT give higher **Forgiveness Factor (FF)**!

**FF**=Overall Satisfaction/Av. Individual Scores

Males = 1.219512 / Females = 0.967742
POE Preliminary Results
Survey data & some insights

![Bar chart showing survey results for ventilation, temperature, noise, light, and odours across different categories.](chart.png)
Take away messages

• **The transition to nZEBs** will reduce the energy consumption and the environmental impact associated to the building sector

• nZEBs can be designed for **different climates** and for **different building typologies**

• **New technologies** are constantly emerging to meet the zero-energy concept

• **Nearly Zero Energy Settlements** are more cost-effective, affordable, and reliable than single nZEBs

• By becoming more efficient and giving back as much as energy than they consume, **buildings and settlements can become Positive Energy** and play an important part in in creating a more competitive, secure, and sustainable future
Thank you for your kind attention!

Dr. Gloria Pignatta

g.pignatta@unsw.edu.au
Scientia Fellow and Lecturer
FBE, UNSW Sydney

Zero-Plus project

www.zeroplus.org
@zeroplusproject
@zeroplus_eu