Targeting Net-Zero Energy Settlements: the Italian journey in the Zero-Plus framework

Never Stand Still | Built Environment | High Performance Architecture

Dr. Gloria Pignatta – g.pignatta@unsw.edu.au

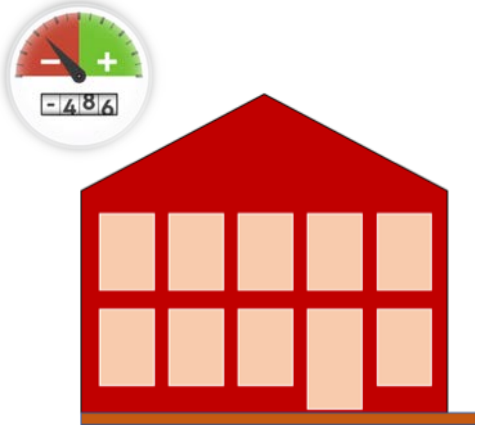
Scientia Fellow and Lecturer

Faculty of Built Environment

UNSW Sydney, Australia

6th Jeffrey Cook Workshop on Zero Energy Settlements

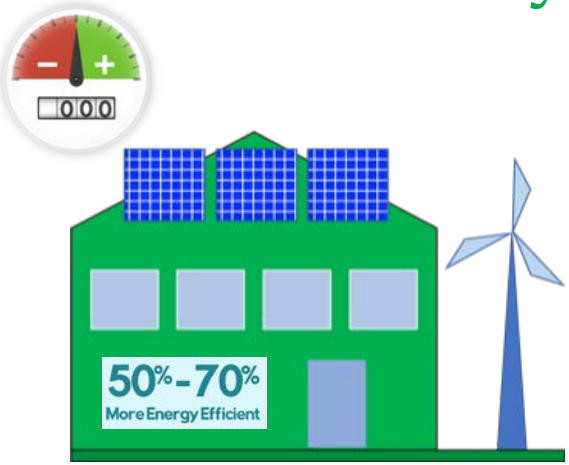
Nov 24th, 2019



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

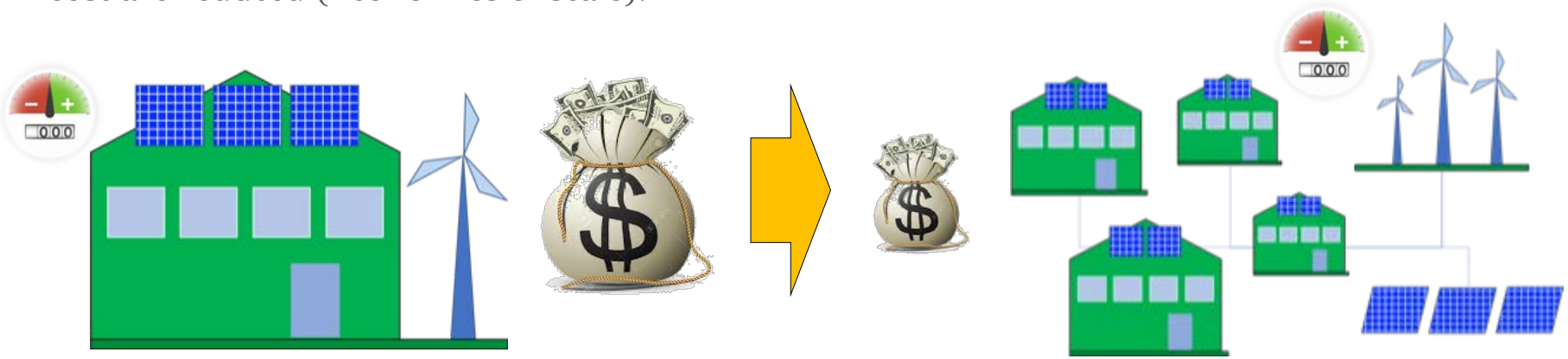
The European Union aims to have all buildings in the region under nZEB standards by 2020

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).



ZERO-PLUS: “Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology”

- EU H2020 – EE – 2014-2015
- 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 CO_2 offset for all ZERO-PLUS case studies*

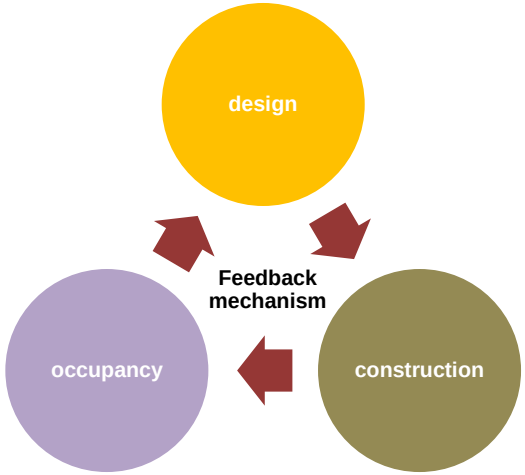
IV. Reduction of the current **investment cost for a conventional NZE building** through a transition from single NZE buildings to NZE settlements

→ *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.



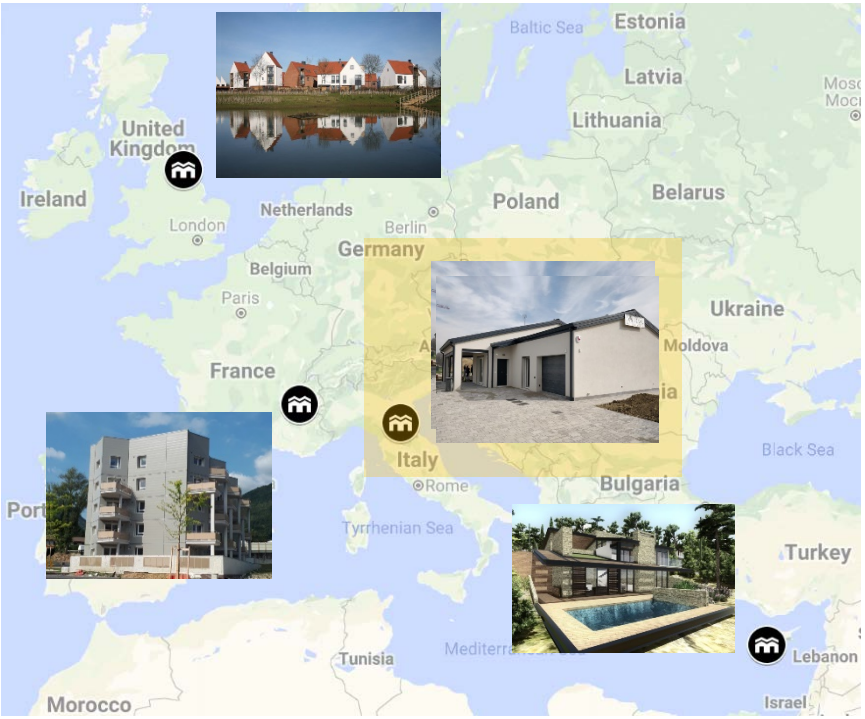
- Ensure that the circle design-construction-occupancy has feedback mechanisms incorporated in it.

- 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

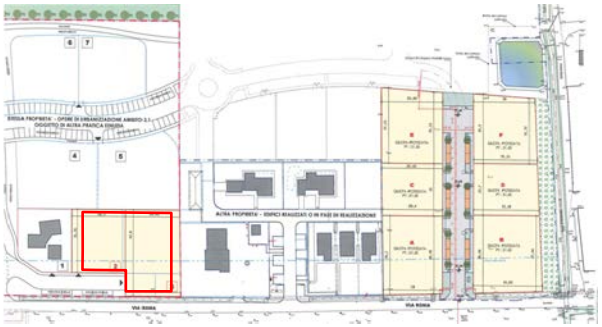
SETTLEMENT SIZE: ~9.600 m² (not including public spaces)

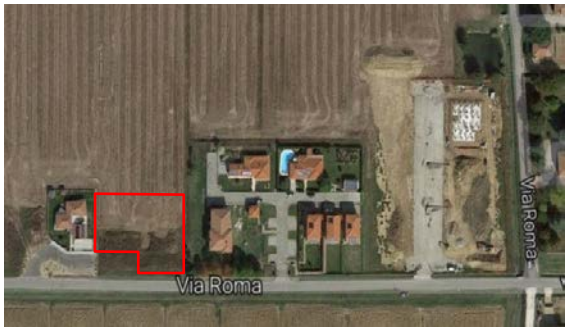
TYPE & NUMBER OF HOUSES: 8 single-family villas

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.

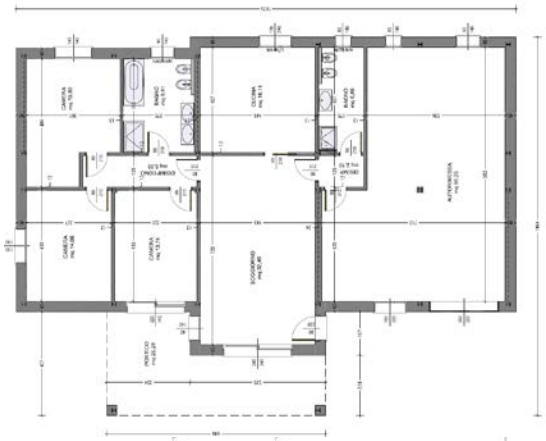
SETTLEMENT MASTERPLAN



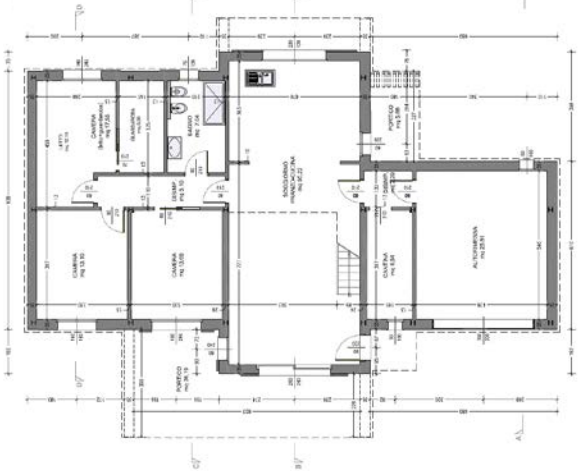


Italian Case Study Buildings

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

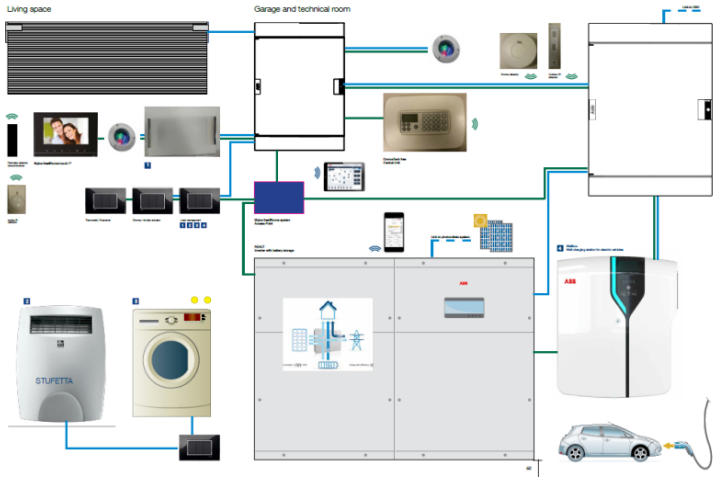
NUMBER OF STORIES: 2 for V1 & 1 for V2

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

PV panels in Villa 1

PV panels in Villa 2

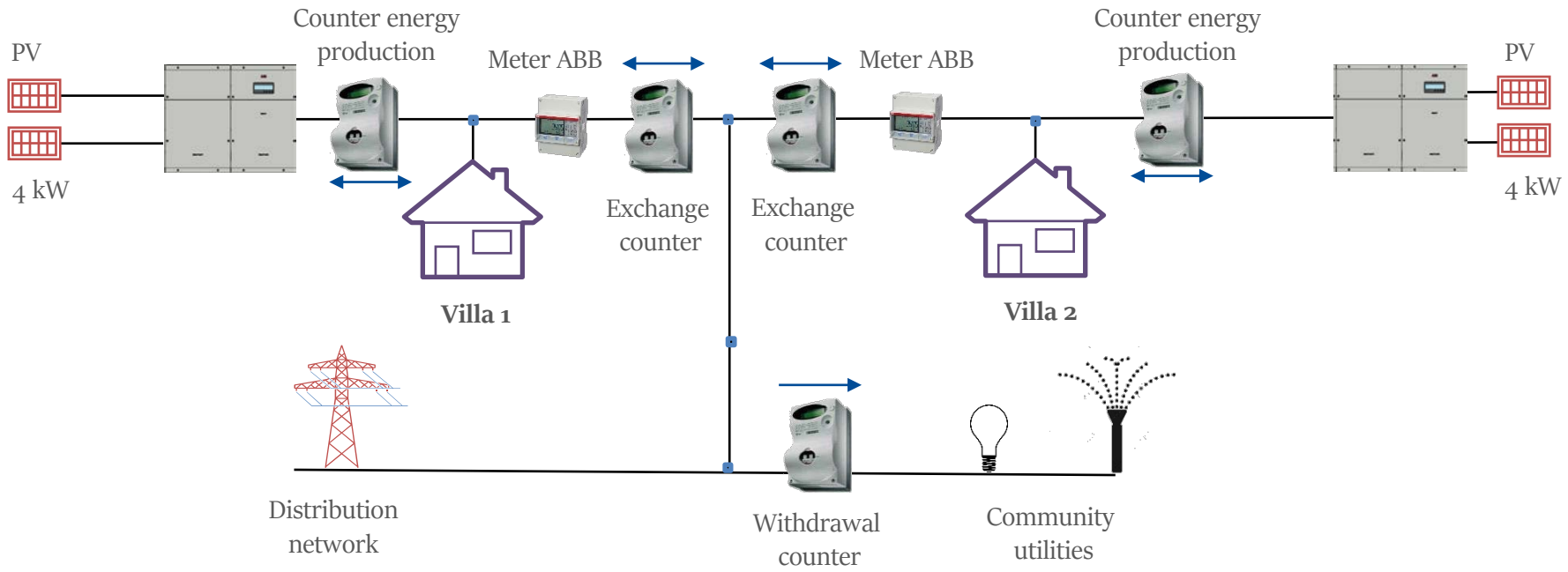
- Photovoltaic panels
  (Installed 40 polycrystalline PV panels in total within the Italian settlement, where:

  - 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 SETTLEMEMNT 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

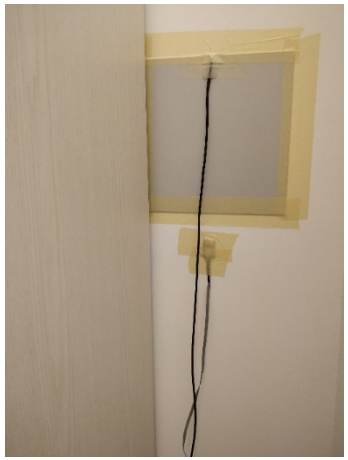
The **Pre-Occupancy monitoring** started in March 2019 with initial outdoor and indoor environmental measurements and targeted infrared thermography to verify the effective operation of the building envelope.




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).

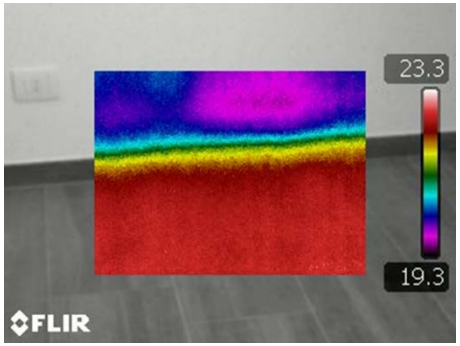
Monitoring in the Italian NZE settlement

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.



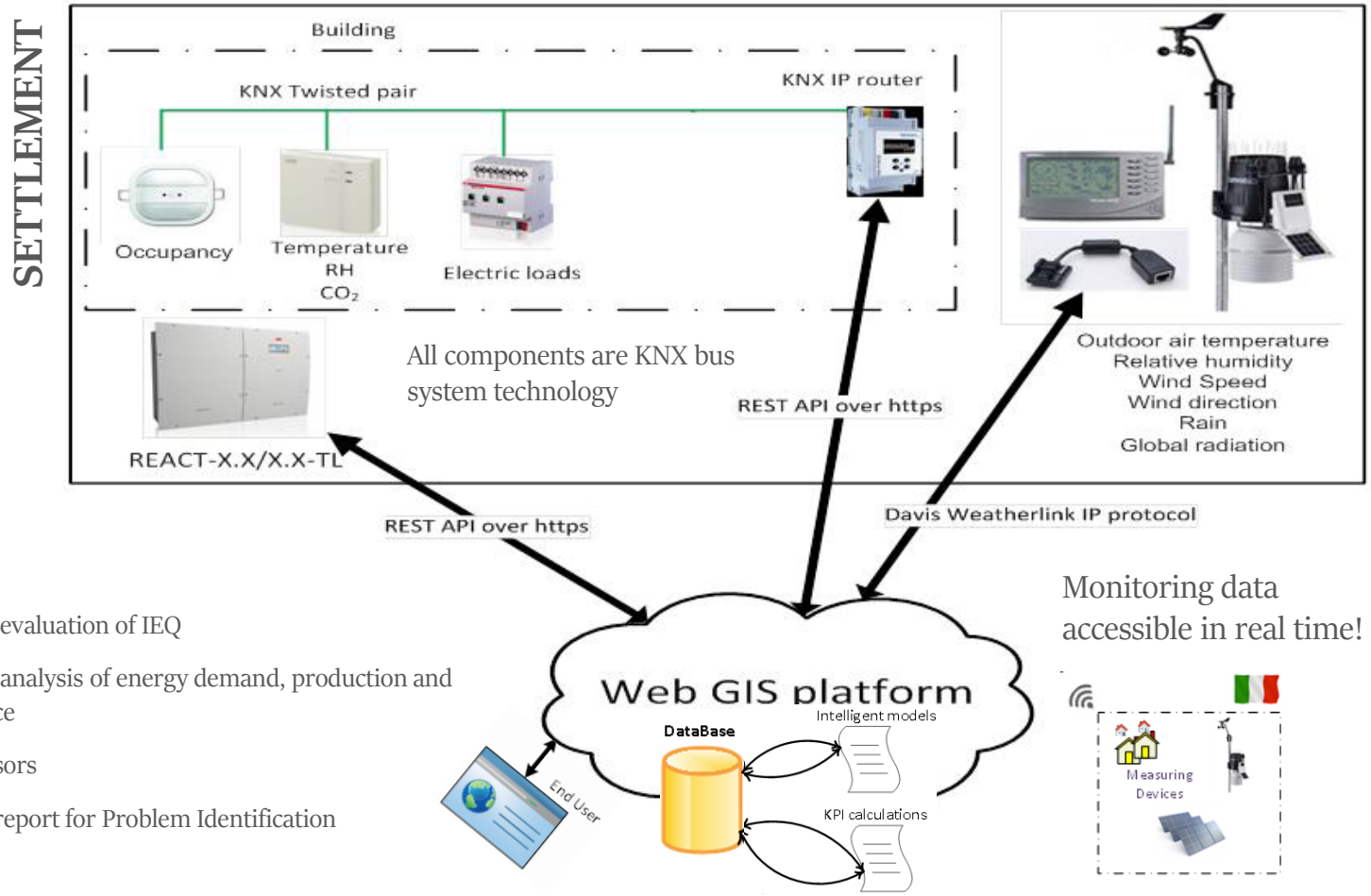
Simulated performances VS ZERO-PLUS KPIs

	Villa 1 	Villa 2 	PROJECT TARGETS
NET REGULATED ENERGY = Regulated En.– En. Production	1.50 kWh/m² y	1.60 kWh/m² y	**≤ 20 kWh/m² y**
ENERGY PRODUCTION	50 kWh/m² y	50 kWh/m² y	**≥ 50 kWh/m² y**
INITIAL COST REDUCTION compared with the reference nZE building	24%	24%	**≥ 16%**

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.



Monitoring data accessible in real time!

- 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

Construction Completed

V1 – Nov'18

V2 – Feb'19

Informative Commissioning

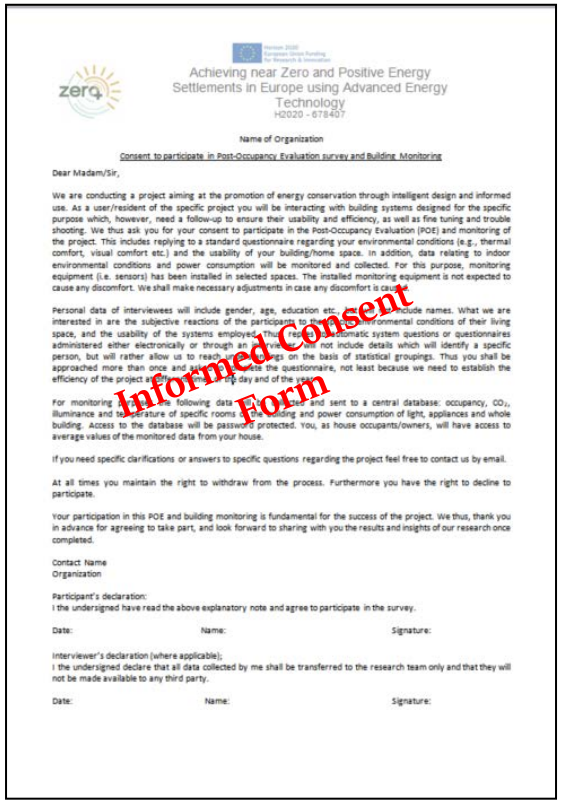
Horizon 2020
European Union Funding
for Research & Innovation

Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology
H2020 - 678407

Welcome Package

PACCHETTO DI BENVENUTO
GRANAROLO DELL'EMILIA
ABITAZIONE TIPOLOGIA A

CONTEDIL



Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology
H2020 - 678407

Informed Consent Form

Name of Organization

Consent to participate in Post-Occupancy Evaluation survey and Building Monitoring

Dear Madam/Sir,

We are conducting a project aiming at the promotion of energy conservation through intelligent design and informed use. As a user/resident of the specific project you will be interacting with building systems designed for the specific purpose which, however, need a follow-up to ensure their usability and efficiency, as well as fine tuning and trouble shooting. We thus ask you for your consent to participate in the Post-Occupancy Evaluation (POE) and monitoring of the project. This includes replying to a standard questionnaire regarding your environmental conditions (e.g., thermal comfort, visual comfort etc.) and the usability of your building/home space. In addition, data relating to indoor environmental conditions and power consumption will be monitored and collected. For this purpose, monitoring equipment (i.e. sensors) has been installed in selected spaces. The installed monitoring equipment is not expected to cause any discomfort. We shall make necessary adjustments in case any discomfort is caused.

Personal data of interviewees will include gender, age, education etc. [illegible] include names. What we are interested in are the subjective reactions of the participants to the [illegible] environmental conditions of their living space, and the usability of the systems employed. Thus [illegible] automatic system questions or questionnaires administered either electronically or through an [illegible] will not include details which will identify a specific person, but will rather allow us to reach [illegible] on the basis of statistical groupings. Thus you shall be approached more than once and [illegible] complete the questionnaire, not least because we need to establish the efficiency of the project at [illegible] the day and of the year.

For monitoring [illegible] following data [illegible] and sent to a central database: occupancy, CO_2, illuminance and temperature of specific rooms [illegible] building and power consumption of light, appliances and whole building. Access to the database will be password protected. You, as house occupants/owners, will have access to average values of the monitored data from your house.

If you need specific clarifications or answers to specific questions regarding the project feel free to contact us by email.

At all times you maintain the right to withdraw from the process. Furthermore you have the right to decline to participate.

Your participation in this POE and building monitoring is fundamental for the success of the project. We thus, thank you in advance for agreeing to take part, and look forward to sharing with you the results and insights of our research once completed.

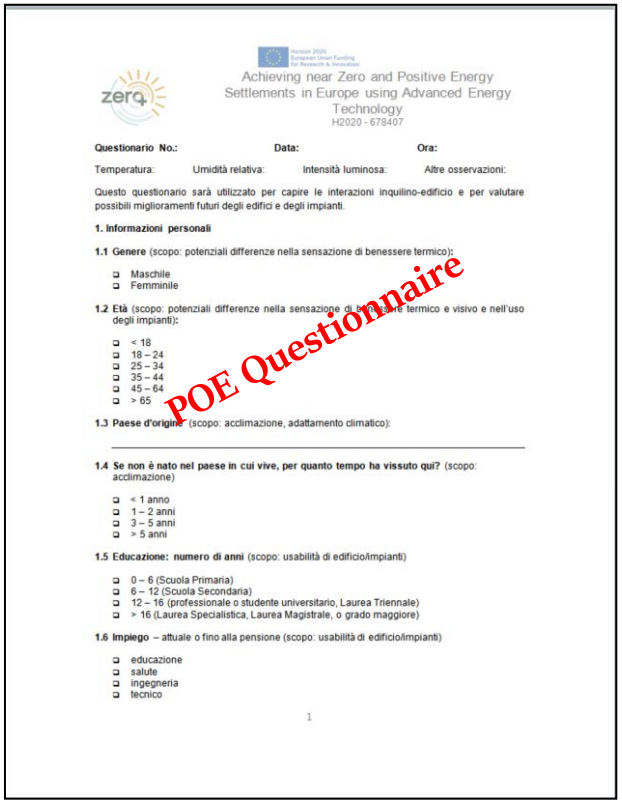
Contact Name
Organization

Participant's declaration:
I the undersigned have read the above explanatory note and agree to participate in the survey.

Date: Name: Signature:

Interviewer's declaration (where applicable);
I the undersigned declare that all data collected by me shall be transferred to the research team only and that they will not be made available to any third party.

Date: Name: Signature:



Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology
H2020 - 678407

POE Questionnaire

Questionario No.: **Data:** **Ora:**

Temperatura: Umidità relativa: Intensità luminosa: Altre osservazioni:

Questo questionario sarà utilizzato per capire le interazioni inquilino-edificio e per valutare possibili miglioramenti futuri degli edifici e degli impianti.

1. Informazioni personali

1.1 Genere (scopo: potenziali differenze nella sensazione di benessere termico):

- ❑ Maschile
- ❑ Femminile

1.2 Età (scopo: potenziali differenze nella sensazione di [illegible] termico e visivo e nell'uso degli impianti):

- ❑ < 18
- ❑ 18 – 24
- ❑ 25 – 34
- ❑ 35 – 44
- ❑ 45 – 64
- ❑ > 65

1.3 Paese d'origine (scopo: acclimazione, adattamento climatico):

1.4 Se non è nato nel paese in cui vive, per quanto tempo ha vissuto qui? (scopo: acclimazione)

- ❑ < 1 anno
- ❑ 1 – 2 anni
- ❑ 3 – 5 anni
- ❑ > 5 anni

1.5 Educazione: numero di anni (scopo: usabilità di edificio/impianti)

- ❑ 0 – 6 (Scuola Primaria)
- ❑ 6 – 12 (Scuola Secondaria)
- ❑ 12 – 16 (professionale o studente universitario, Laurea Triennale)
- ❑ > 16 (Laurea Specialistica, Laurea Magistrale, o grado maggiore)

1.6 Impiego – attuale o fino alla pensione (scopo: usabilità di edificio/impianti)

- ❑ educazione
- ❑ salute
- ❑ ingegneria
- ❑ tecnico

1

Post Occupancy Evaluation (POE)

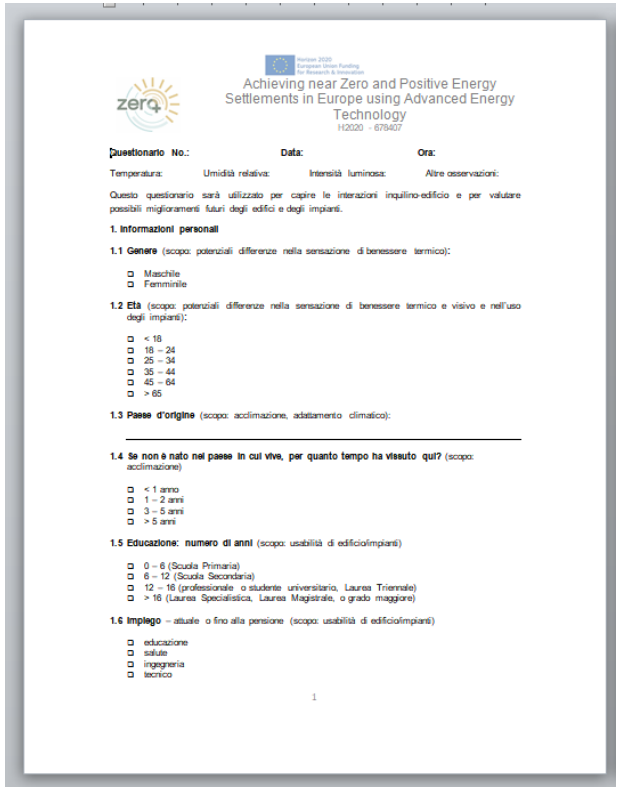
The **Occupancy** started in August 2018 in V1 & March 2019 in V2 when two families of 3 and 2 members relocated in the two villas, after the construction phase was completed.
The **Post-Occupancy Monitoring and Evaluation** started in June 2019 and is currently on-going, in July 2019 the summer POE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

IAQ monitoring sensor - Ta, RH, CO_2.

Room presence, luminance sensor integrated in LR roof.

Weather station installed on the roof of V2

Post Occupancy Evaluation (POE)



Achieving near Zero and Positive Energy Settlements in Europe using Advanced Energy Technology

H2020 - 678407

Questionario No.: **Data:** **Ora:**

Temperatura: Umidità relativa: Intensità luminosa: Altre osservazioni:

Questo questionario sarà utilizzato per capire le interazioni inquilino-edificio e per valutare possibili miglioramenti futuri degli edifici e degli impianti.

1. Informazioni personali

1.1 Genere (scopo: potenziali differenze nella sensazione di benessere termico):

- ☐ Maschile
- ☐ Femminile

1.2 Età (scopo: potenziali differenze nella sensazione di benessere termico e visivo e nell'uso degli impianti):

- ☐ < 18
- ☐ 18 – 24
- ☐ 25 – 34
- ☐ 35 – 44
- ☐ 45 – 64
- ☐ > 65

1.3 Paese d'origine (scopo: acclimazione, adattamento climatico):

1.4 Se non è nato nel paese in cui vive, per quanto tempo ha vissuto qui? (scopo: acclimazione)

- ☐ < 1 anno
- ☐ 1 – 2 anni
- ☐ 3 – 5 anni
- ☐ > 5 anni

1.5 Educazione: numero di anni (scopo: usabilità di edificio/impianti)

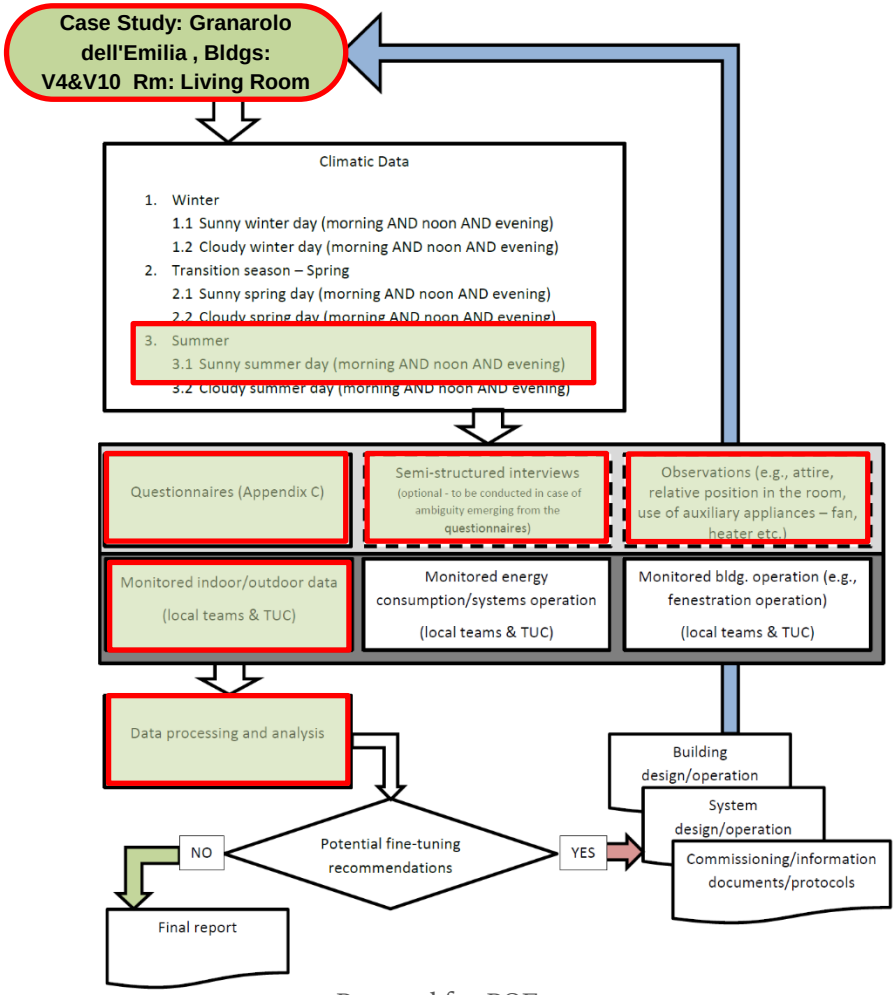
- ☐ 0 – 6 (Scuola Primaria)
- ☐ 6 – 12 (Scuola Secondaria)
- ☐ 12 – 16 (professionale o studente universitario, Laurea Triennale)
- ☐ > 16 (Laurea Specialistica, Laurea Magistrale, o grado maggiore)

1.6 Impiego – attuale o fino alla pensione (scopo: usabilità di edificio/impianti)

- ☐ educazione
- ☐ salute
- ☐ ingegneria
- ☐ tecnico

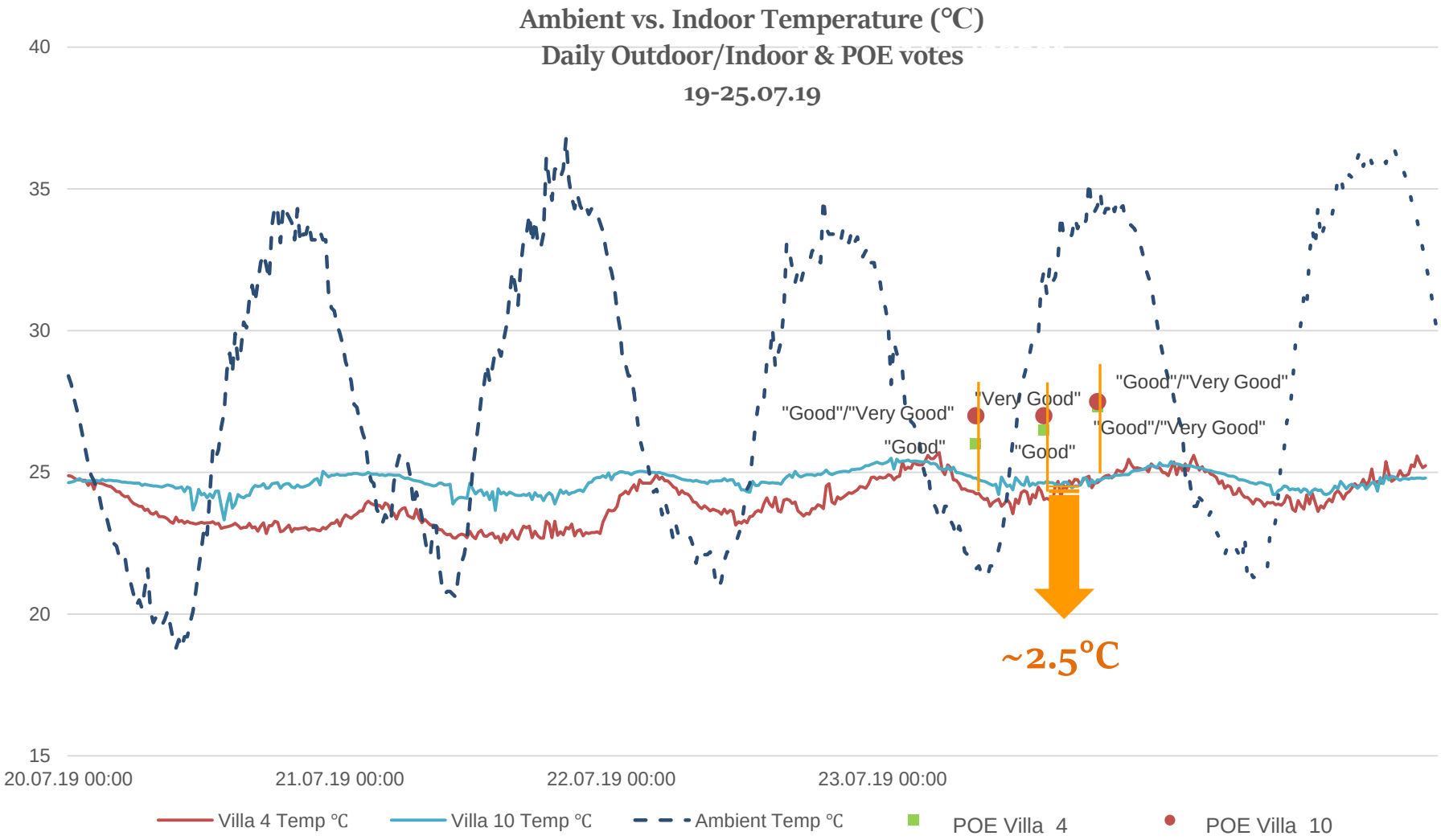
1

Questionnaire translated in Italian



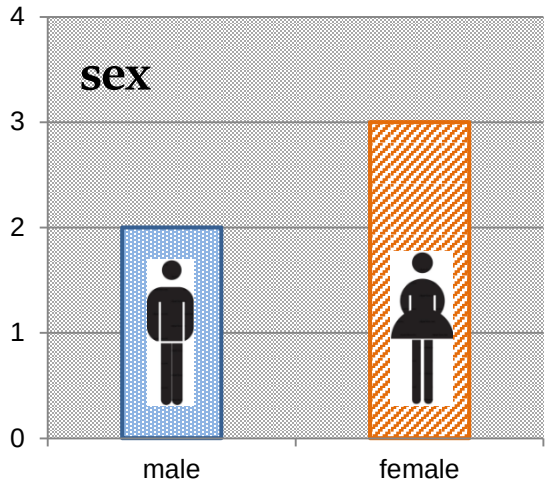
Protocol for POE

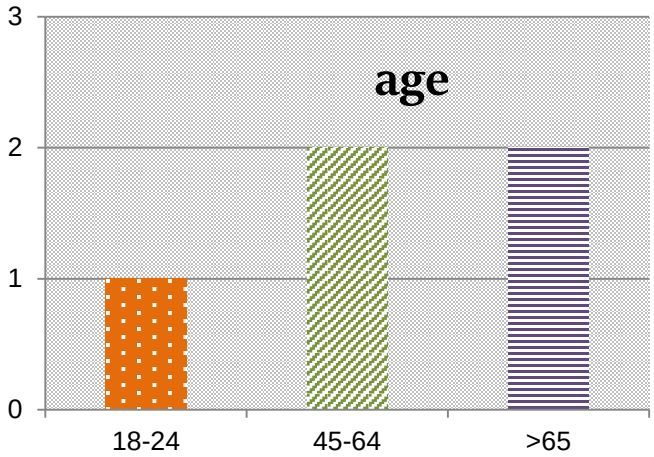
POE Preliminary Results



POE Preliminary Results

Survey data & some insights

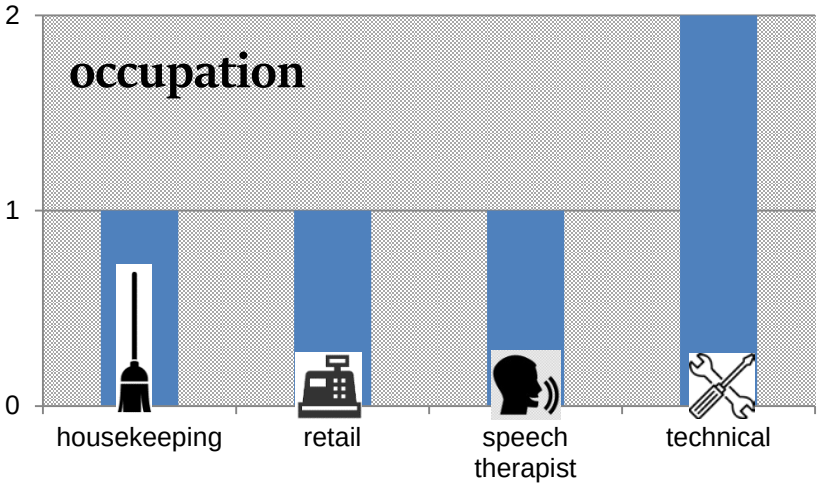


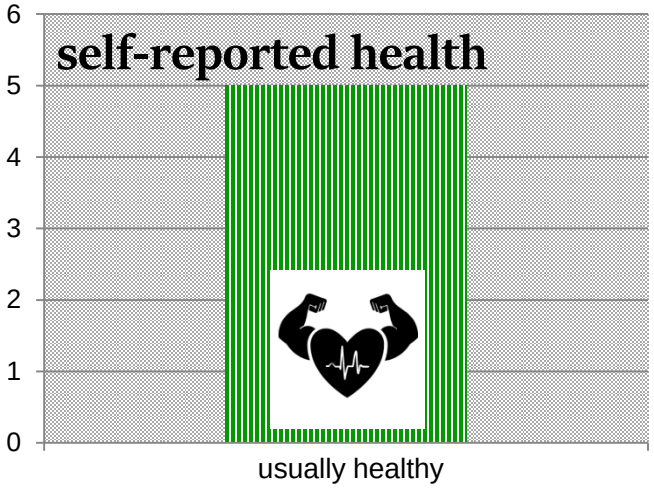


Results from a very small sample:

- 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

Villa pseudonym	Gender	Age	Occupation	Education	Health	SBS symptoms experienced	Satisfaction with -					Overall satisfaction - perceived	Operation/manipulations
							V	T	N	L	O		
4	female	45-64	housekeeping	n/a	us.healthy	none	4	4	4	4	4	4	widows/ doors
	male	45-64	retail	6-12	us.healthy	none	3	3	5	5	5	5	doors
	female	18-24	speech therapist	12-16	us.healthy	fatigue n. house related	4	4	5	4	4	4	widows
10	female	>65	technical	>16	us.healthy	none	5	5	5	5	5	4	HVAC
	male	>65	technical	12-16	us.healthy	none	4	4	4	4	4	5	HVAC

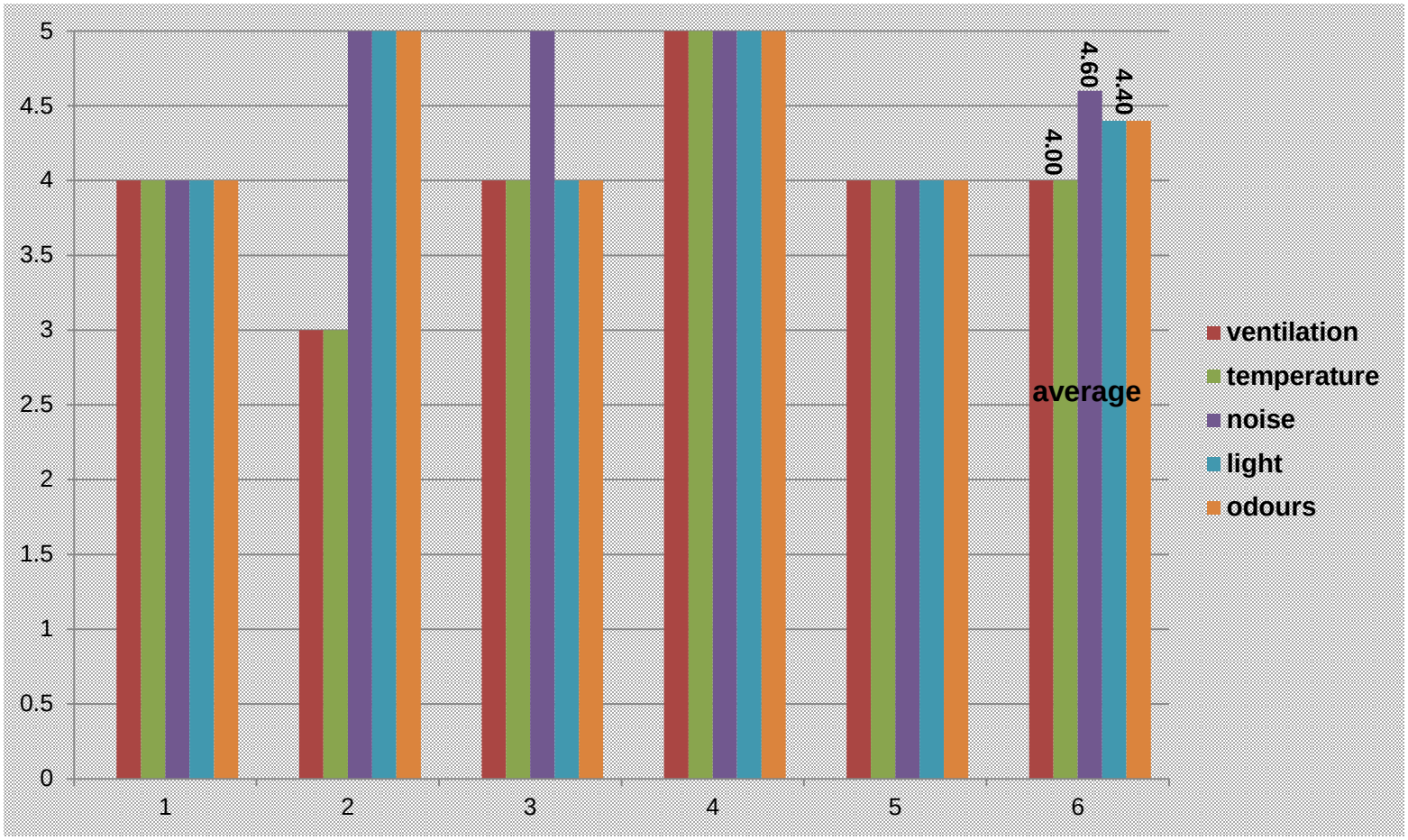
Men more critical per item BUT give higher **Forgiveness Factor (FF)!**

FF=Overall Satisfaction/Av. Individual Scores

Males = 1.219512 / Females = 0.967742

POE Preliminary Results

Survey data & some insights



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