Concept and Modeling of Net Zero Energy Buildings

Fatima Harkouss [a, b], Pascal Henry Biwole [b, c] , Farouk Fardoun [a]

[(a)] University Institute of Technology, Department GIM, Lebanese University, Saida, Lebanon

[(b)] Université Cote d'Azur, J.A. Dieudonné Laboratory, UMR CNRS 7351, Parc Valrose 06108 Nice, France

[(c)] Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont–Ferrand, France

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What is Net Zero Energy Building (NZEB)

NET

Building may use energy from utility grid during some times of the day.

But it returns RE back to the grid during other times.

Balance that equals out over the course of a year.

ZERO ENERGY

Annual balance between both energy sources is at least zero or in favorite of the RE.

BUILDING

Building with low energy demands.

Demands assured by both sources: Grid and RE systems.

Why NZEB

Why Renewable Energy (RE)

Sustainable

Economy

No Pollution

Available for All

Why Buildings

49% Worlds Electricity Consumption

21% Worlds CO_2e Emissions

Population Increase

Steps to NZEB

Passive Strategy

- Envelop Insulation
- Orientation
- Shading devices
- Natural ventilation
- Daylighting

Energy Efficient Technology

- Lighting
- Appliances
- HVAC

RE Systems

- Photovoltaic (PV)
- Wind turbine
- Solar collector (SC)

Challenge in NZEB design

Find the best combination of design strategies that will face buildings' energy performance problems.

Insulation Thickness

1 cm

7 cm

5 cm

3 cm

10 cm

Glazing Type

Single Glazing

Double Glazing Argon

Double Glazing Krypton

Shading Device

Internal Blinds

External Blinds

No Blinds

Window to Wall ratio

10 %

20 %

15 %

5 %

Natural Ventilation

Forced Ventilation

Ventilation Rate

Orientation

N

E

W

S

PV system area

Slope

Wind Turbines

Geothermal Energy

Solar Domestic Hot water system

Collectors Area

Pump flow rate

Our Objectives

- Inspect Passive Design, Energy Efficient and Renewable Energy options for a case study NZEB.
- Investigate the best combination in different climatic zones in Lebanon (Beirut, Cedars, Qartaba, Zahle) and France (Nice, Nancy, Limoges, Embrun, La Rochelle).
- Final goal is an attempt to define certain weighting

factors for the key parameters to attain NZEB.

Multi-Objective Optimization (MOO)

MOO an effective technique to get the perfect design solution for a specific intention.

To start MOO, define the following:

1-Objective functions to Minimize/ Maximize

2- Decision variables

3-Constraints

4-Algorithm

Multi-Objective Optimization

Objective functions:

Minimize cooling Load, Minimize heating Load, Minimize Electric consumption, Minimize Life Cycle Cost.

Decision Variables:

External walls U-value, Roof U-value, Window to Wall ratio at each façade, Glazing type, Natural ventilation control, Overhangs size, Photovoltaic array area, Solar Collectors area.

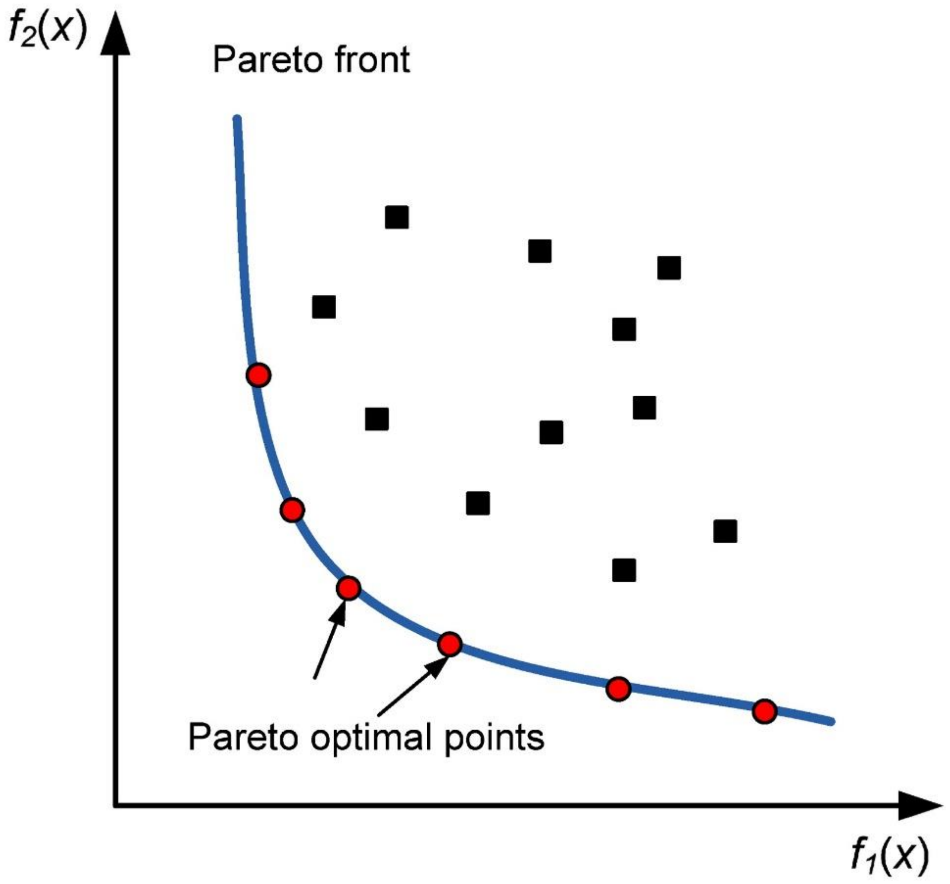
Constraints:

Comfort, Zero Energy Balance.

Algorithm:

Non-Dominating Sorting Genetic Algorithm (NSGA-II).

MOO Results



Black: design Variable Space, Dominated Variants

Red: Possible Solutions, Non-Dominated Variants

Results are sets of non-dominated solutions represented as a Pareto Front.

Each point of the Pareto Front is a possible best solution.

Multi-Criteria Decision making (MCDM)

MCDM process to select the final optimal solution among all available possibilities.

Elimination and Choice Expressing the Reality (ELECTRE III) method classifies Pareto front points, to choose the most adequate solution.

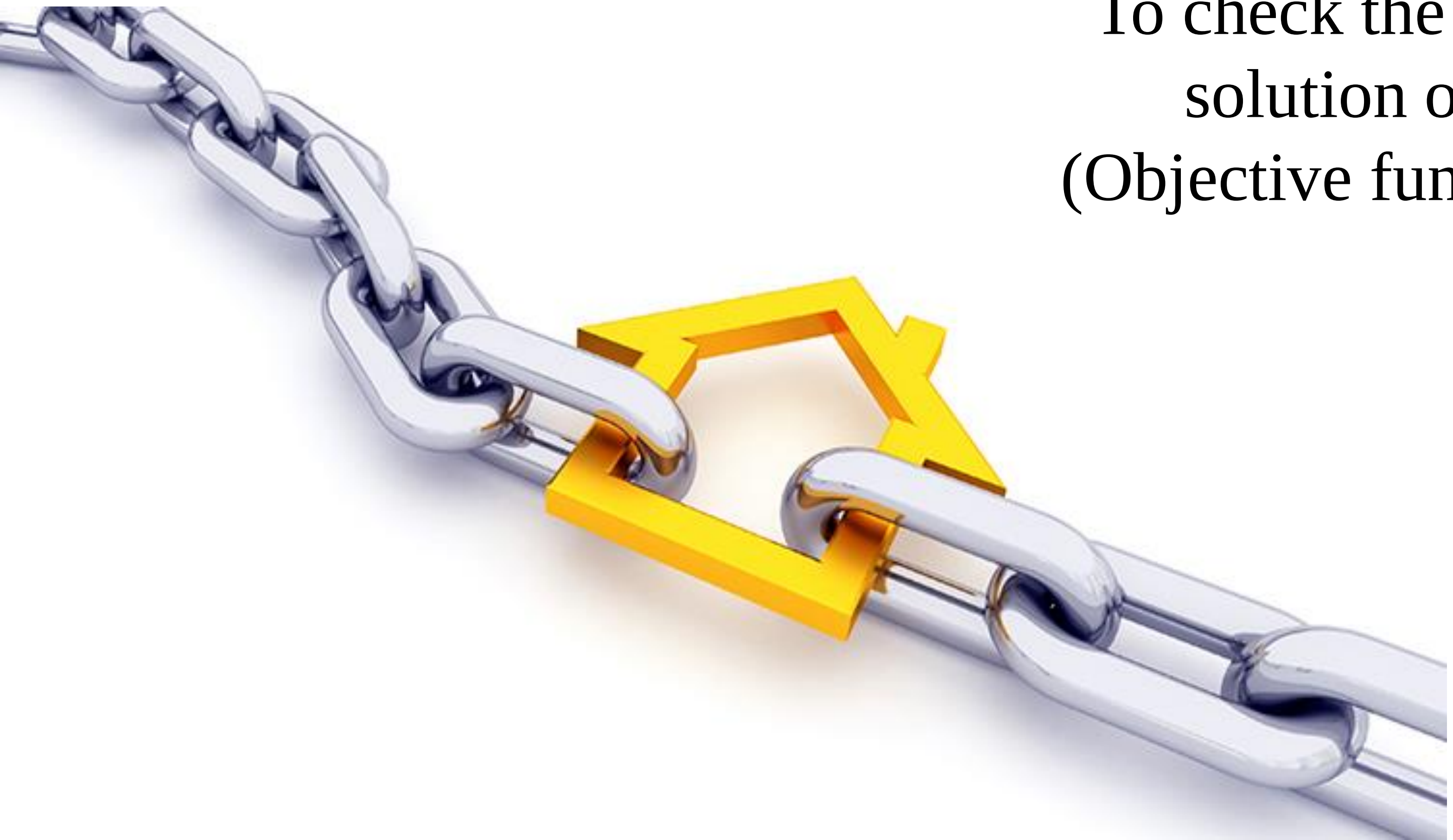
To start ELECTRE III, the decision maker (DM) must assign the following:

1-Indifference (5%), Preference (10%) and Veto Thresholds (30%).

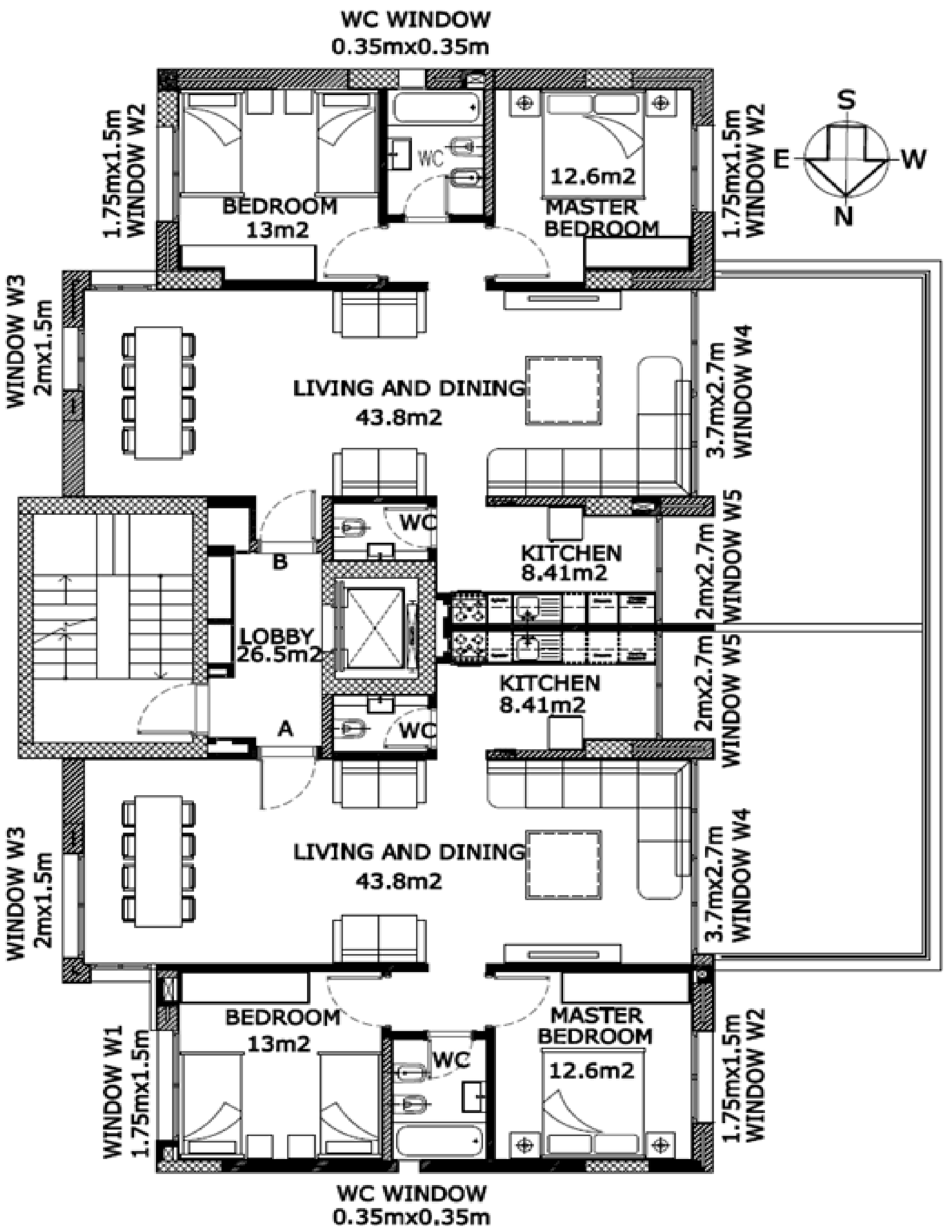
2-Weights for each objective function using

Analytical Hierarchy Process (AHP).

Sensitivity Analysis



To check the robustness of the final optimal solution on different DM preferences (Objective functions weights, and thresholds).



Application

- 3 stories NZEB in Cedars/Lebanon (Cold Climate).
- Two apartments, each apartment is 102 m2.
- Heating loads covered by natural gas condensing boiler, η=98.3%.
- Solar Collectors to cover hot water demands.
- PV system to generate electricity.
- Optimum design parameters decrease annual Thermal Load and LCC by 33% and 31% respectively, compared to the baseline model.

ANY QUESTIONS?