Concept and Modeling of Net Zero Energy Buildings

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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 favor 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 CO2e Emissions
- Population Increase

No Pollution

Available for All
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.
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

Results are sets of non-dominated solutions represented as a Pareto Front. Each point of the Pareto Front is a possible best solution.

Black: design Variable Space, Dominated Variants
Red: Possible Solutions, Non-Dominated Variants
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, $\eta=98.3\%$.
- 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?