Best Practice Guide
for Steel Applications
in Zero Energy Building

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Part 1

Best Practice Guide for Steel Applications in Zero Energy Building
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Zero Energy Building

The total amount of energy used by the building on an annual basis is equal to the amount of renewable energy produced on the site.
**Definition of ZEB**

An energy-efficient **building** where, on a **source energy** basis, the actual **annual delivered energy** is less than or equal to the on-site renewable **exported energy**.


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**Nearly Zero Energy Building (nZEB)**

The nearly zero net energy required should be supplied from renewable energy sources, including those produced on-site or nearby.


*Source*: ZEMUSIC, Design Guide for steel intensive nearly-zero energy office buildings WP6.4

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**Net Zero Energy Building (NZEB)**

A building with greatly reduced energy needs from higher efficiency so that the energy required can be supplied with renewable technologies on site.

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**Net Plus Energy Building**

An incredibly efficient energy performing building, which generates more renewable energy than its annual needs.
Why we need ZEB?

The buildings and construction sector has a key role in the fight against climate change. According to a study by Grand View Research, the global ZEB market is expected to reach $78.8 billion by 2025.


Sources: Green Energy Technology Insight 2017 vol.8 no.5
What is the benefit of ZEB?

The buildings and construction sector consumes nearly 40% of total fossil fuel energy. ZEB can contribute to energy & cost savings and CO₂ reduction.

**Annual Energy saving**

60% - 90%

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**Cost saving**

- Community (337,000 ft²): $267,000
- Commercial (13,000–27,000 ft²): $8,000–21,000
- Residential (32,000–54,000 ft²): $1,500–23,000

**Return of investment**

ROI: 5 - 12 years

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*This calculation is based on the assumption of new buildings located in Vermont, USA. The financial factors such as SBA loan, local incentive and tax credit, have been considered in saving the cost of new buildings. See reference for details.

**Source**: Feasibility studies of energy retrofits – case studies of Nearly Zero-Energy Building renovation, Riikka Holopainen, 2016
How steel contributes to ZEB

The steel construction can reduce energy consumption and gas emissions.

01 **Thinner Walls**
Steel wall can be thinner than other walls to reach the same target value for insulation.

02 **Light weight**
Lightweight steel components enables ease of construction and diverse functionalities such as automatic ventilation systems.

03 **Off-site production**
Steel structures are built off-site under quality controlled, highly regulated and safe factory conditions.

04 **Various systems**
The radiant properties of steel make possible various types of heating systems for diverse building components.

05 **Non-organic**
Steel is a permanent material that can be infinitely recycled without loss of quality.
Steel application in ZEB

5 categories for the efficient steel application in ZEB

- **Solar Heat Collector**
  - Energy Efficiency

- **Steel Roof System**
  - Energy Efficiency

- **Double Skin**
  - Thermal Conductivity/Airtightness

- **Off-site Construction/Prefabrication**
  - Sustainability

- **Flexible Blind-Louver**
  - Thermal Conductivity

- **Flooring System with PCM**
  - Thermal Mass

- **Energy Pile System**
  - Energy Production

- **Building Integrated PV**
  - Energy Efficiency

- **Steel Window System**
  - Airtightness

- **High insulation Sandwich Panel**
  - Thermal Conductivity

- **Radiant Panel**
  - Energy Efficiency

- **Radiant Floor**
  - Energy Efficiency

- **High-efficient Heat pump**
  - Energy Efficiency
Energy efficiency simply means using less energy to perform the same work. Energy efficiency brings a variety of benefits: reduced greenhouse gas emissions, reduced demand for energy imports, and lower operational buildings costs.
Energy Efficiency

Steel is energy efficient. It is an excellent building material for transferring or collecting energy.

**Building Integrated PV Panel System**
Steel can make PV the best building exterior material with high performance.

**Light Shelf & Reflective Panel**
Steel ceiling panels can reduce lighting energy up to 12% with above 85% reflectance.

**Energy Pile System**
Steel is utilized as ground heat exchanger. It is used for both structural stability and energy production. Energy Production: Steel Energy Pile 80 W/m (Ordinary GHX 45W/m)

**Roof Integrated Solar Heat Collector**
Steel is an essential material in solar heat collectors. System Efficiency: Up to 80% (Average efficiency 40~50%)

**Radiant Panel System**
Steel radiant panel meets both thermal comfort and energy saving.

**Radiant Floor Heating System**
Radiant floor heating system made from steel can supply heat into a room efficiently by saving 15% of energy use.

Source: ArcelorMittal, POSCO, Tata Steel Europe, Ruukki Construction
Thermal Conductivity

**What is it?**

The thermal conductivity of a material is a measure of its ability to conduct heat.

**How does it contribute to ZEB?**

The material of low thermal conductivity could be good for insulation. That saves energy for heating and cooling.
Thermal Conductivity

Steel enhances thermal resistance in combination with other materials.

High-Insulated Steel Wall
Metal sandwich panel has higher insulation value (R) than conventional cavity wall under the same conditions for wall thickness.

Thinner Steel Wall
Metal sandwich panel can be thinner than conventional cavity wall under the same conditions of thermal resistance.

Steel with MW (Mineral Wool)
Steel with mineral wool facilitates lightweight, durable and fast construction.

Steel with PU (Polyurethane) / PIR (Polyisocyanurate)
Steel in combination with other special materials has great thermal and fire properties and it is visually appealing.

Thermally efficient steel-based design
A good steel-based design with effective external insulation drastically reduces building energy consumption.

Source: Sandwich Panels - ArcelorMittal, POSCO, Ruukki
Thermal Mass

What is it?

Thermal mass is the ability of a material to absorb and store heat energy.

How does it contribute to ZEB?

Thermal mass can play an important role in reducing energy use in heating and cooling systems.
Thermal Mass

Steel is used in energy storage systems. Steel can quickly store and release heat when needed.

**Merit of energy storage system**

Without Thermal Storage

With Thermal Storage (PCM Panel)

**Peak Shift**

**Peak Cut**

**Reduced Temperature Swing**

Thermal storage system can store heat at daytime and release it at nighttime.

**Radiant ceiling embedded in a PCM (Phase Change Material) layer**

Steel panel with PCM can efficiently maintain indoor temperature.

**Thermal Storage Tank**

Steel is the most useful material for thermal storage tanks.

Source: Ruukki, ZIMUSIC
Airtightness

**What is it?**

Airtightness is the fundamental building property of the resistance to air leakage.

**How does it contribute to ZEB?**

An airtight building has lower heating bills, better performing ventilation and increased thermal comfort.
Airtightness

Steel can be easily formed into various geometries to improve airtightness.

- **Highly Airtight Sealant**: Steel can reduce heating cost and improve thermal comfort by improving building airtightness.

- **Metal Window System**: Steel window can easily be formed into various geometries to improve airtightness.

- **Metal Sandwich Panel System**: Metal sandwich panels are some of the most airtight structures.

**Airtightness vs Heat Loss**

Airtight buildings can reduce energy for heating and cooling. Through envelopment techs with steel, building airtightness can be improved up to 70% compared to standard building.

**Metal Sandwich Panel System**

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Sustainability

What is it?

Sustainability means living within the resources of the planet without damaging the environment.

How does it contribute to ZEB?

Sustainable building increases construction productivity, conserves the natural environment and contributes to energy and resource savings.
Sustainability

Steel is the most eco-friendly and sustainable building material and makes ZEB possible.

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Prefabrication

Prefabrication guarantees construction speed and quality.

2 Dimension

3 Dimension

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Modular

Modular steel systems increase airtightness and minimize thermal bridge effect.

Modules Containers Cabins

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Reuse

Steel can be reused in the same or higher quality without reprocessing. This saves gas emissions.

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Flexibility

Steel makes flexible design possible for ZEB.

Movable System Funiture

Movable Steel Walls

Flexible Steel Louvre Window system

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Source: ArcelorMittal, POSCO, SCI, Fokker 7 Building; Schiphol Airport
Terminology

**Airtightness**: Resistance against air leakage through unintentional openings

**BEMS**: Building energy management system

**BIPV**: Building integrated photovoltaic system

**Energy Pile**: A pile used as ground heat exchanger in geothermal system

**HEMS**: Home energy management system

**HVAC**: Heating, ventilation and air-conditioning

**LCA**: Life cycle assessment

**LCC**: Life cycle cost

**nZEB**: Nearly zero energy building

**NZEB**: Net zero energy building

**PCM**: Phase change material

**PV**: Photovoltaic

**U-value**: Rate of transfer of heat through a structure [W/m²K]

**ZEB**: Zero energy building
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