The Verification and Implementation of Practical Renovation for net-ZEB Office

June, 2017
WSBE17 Hong Kong

Hiroaki TAKAI
Principal Engineer (Environment), Design Department Head Office
TAKENAKA CORPORATION, Tokyo, Japan
Background

Promotion of “Energy saving Renovation of Existing middle and small stock buildings”
- Company’s branch offices or Local government offices in local cities
- Offices with 10,000 m² or less occupy 98% in Japan
- Urgent issues in Japan

Promotion of “Renovation of Façade and Interior while staying”
- There are few constructions to completely renovate energy saving exterior
- Minimization of perimeter thermal load is essential in small office
- Renovation while staying is important for tenants
Characteristics of this renovation project

- Net ZEB first renovation project in Japan
- Renovation while staying the office that is actually used
- ZEB office with thorough passive

Building Outline

Building type: office
Location: Chiba City, Japan
Site area: 1,432.02 ㎡
Structure·size: RC·S, 2 stories
Height: 8.1m
Building area: 679.52 ㎡
Gross floor area: 1,318.11 ㎡
Completion: 2003
Completion of Renovation: 2016
Design & Built: Takenaka Corporation
Interior of the building after renovation
The contents of planning and technologies

- Thorough reduction of Facade Thermal Load
- Maximization of utilize Natural Ventilation and Daylighting
- Improvement of Workplace Productivity and reduction of Energy Consumption by Changing Work Style
- Direct utilization of Geothermal and Solar Heat
- Increase of comfort by Radiating Air-Conditioning, Dessicant Air-Conditioning, Wellness Control etc.
- Improvement of BCP as a result

Integrating most advanced technologies for ZEB
Concepts of this office ZEB renovation

- Change the theory of comfort
- Create super energy-saving building
- Think smart work-style
- Become resistant to disaster
Change the theory of comfort

Daylighting from both sides

Daylighting from top-light

Natural ventilator (auto control)

Natural exhaust (auto control)

Outside blind (auto control)

CFD of Natural ventilation(Temp.)

Personal diffuser

Low humidity by Desiccant Air-Conditioning
Create super energy-saving building

Exterior

Replace to high insulated glass

Double skin

Radiation panel

Ambient LED lighting 300Lx & Thermal human sensor
Create super energy-saving building

**Geothermal pile**

**Geothermal utilization system**

- Geo-thermal heat-pump & Air-source heat-pump
- Parking well 67m

**Summer**
- Solar heat panel
- Photovoltaics
- Radiating panel Desiccant AHU (re-heat)
- Hot water tank
- Use for re-heat of desiccant AC in summer

**Winter**
- Solar heat panel
- Hot water tank
- Use for radiating heating in winter

**Solar heat utilization system**
Think smart work-style

Filing area
Inactive air-conditioning using ventilation
Work for short 30 minutes

Communication area
Change of view, angle, and interactive face each other in various areas.
Diversity of communication

Workplace
Concentrate on worker’s area.
Lighting and AC are controlled fitting to personal environment and request

Entrance area
Change to the office mode in this area coming back from outside.
Smooth mode change from public to private.

Reduction of power outlet consumption by sharing copy machines and others
Become resistant to disaster

Devices on the roof

Photovoltaics panel

Solar heat panel

Re-use lithium-ion battery
Integrated control

- Solar power generation
- Radiation air-conditioning
- Desiccant air-conditioning
- LED lighting control
- Geothermal heating
- Natural ventilation
- Solar heating
- Natural light

- Indoor sensors: Temperature sensors, Humidity sensors, Illuminometers, Beacons, Human detection sensors
- Outdoor sensors: Rain gauges, Vane anemometers, Actinometers, Temperature sensors, Humidity sensors

Wellness control

Cloud CPU
- Wellness personal system
- Real-time monitoring
- Zero energy control system

Router

Network

- Takenaka Corporation
  - Tokyo Main Office
- Asahi Facilities Inc.

Integrated control system
### Result before renovation

1,400 MJ/m²/year

### Result after renovation

MJ/m²/year

### ZEB ready

- over 50% reduction of consumption

### Nearly ZEB

- approximately 75% reduction of consumption and also has renewable energy

### Net ZEB

- approximately 75% reduction of consumption and remain are canceled by renewable energy

---

#### The prediction of energy consumption and energy generation

<table>
<thead>
<tr>
<th>Step</th>
<th>Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 0</td>
<td>Before renovation</td>
</tr>
<tr>
<td>Step 1</td>
<td>The value of comfort</td>
</tr>
<tr>
<td>Step 2</td>
<td>Super energy saving (Lighting)</td>
</tr>
<tr>
<td>Step 3</td>
<td>Super energy saving (Exterior)</td>
</tr>
<tr>
<td>Step 4</td>
<td>Super energy saving (Air-conditioning)</td>
</tr>
<tr>
<td>Step 5</td>
<td>Work Smart</td>
</tr>
<tr>
<td>Step 6</td>
<td>Solar power generation</td>
</tr>
</tbody>
</table>

- **Step 1**: Addition of natural ventilation openings, Maximum use of natural light, Desiccant air-conditioning for low humidity
- **Step 2**: LED lighting, Thermal human detection
- **Step 3**: Enhanced thermal insulation performance with high-insulation glass, Enhanced thermal insulation performance of roof and external wall, External window blinds built in double skin facade, Addition of natural ventilation openings
- **Step 4**: Geothermal and solar powered heat source, Ceiling radiation air-conditioning
- **Step 5**: Change in work styles, Sharing, Reduction of outlet consumption
- **Step 6**: Solar power generation

**Positive annual energy balance**

+1 %

**Reference Building**

1,400 MJ/m²/year
Result before renovation
1,400 MJ/m²/year

-9% -9%

Step 0 | Before renovation
Step 1 | The value of comfort
- Addition of natural ventilation openings
- Maximum use of natural light
- Desiccant air-conditioning for low humidity

Step 2 | Super energy saving (Lighting)
- LED lighting
- Thermal human detection

Step 3 | Super energy saving (Exterior)
- Enhanced thermal insulation performance with high-insulation glass
- Enhanced thermal insulation performance of roof and external wall
- External window blinds built in double skin facade
- Addition of natural ventilation openings

Step 4 | Super energy saving (Air-conditioning)
- Geothermal and solar powered heat source
- Ceiling radiation air-conditioning

Step 5 | Work Smart
- Change in work styles
- Sharing
- Reduction of outlet consumption

Step 6 | Solar power generation

Result after renovation
MJ/m²/year

-12% -14%

-8% -10%

-21% -18%

-20% -21%

Total -71%

Actual result after renovation
+3% +1%

ZEB ready: over 50% reduction of consumption
Nearly ZEB: approximately 75% reduction of consumption and also has renewable energy
Net ZEB: approximately 75% reduction of consumption and remain are canceled by renewable energy

The prediction of energy consumption and energy generation
Actual monthly & annual energy consumption and Photovoltaics
(May, 2016 – April, 2017)

Monthly energy consumption

Annual energy consumption

MJ/m²/month

MJ/m²/year

Photovoltaics

Month

Energy consumption

MJ/m²/month

MJ/m²/year

1月 2月 3月 4月 5月 6月 7月 8月 9月 10月 11月 12月

组织者:

International Co-owners:
Comparison before and after renovation

Actual primary energy consumption (MJ/m²・year)

Before Renovation

- Others
- Lighting
- Air Conditioning & ventilation
- Power Outlet

After Renovation (Including PV)

- Maximum Utilization & Control of Daylighting
- Task & ambient Lighting
- Several Lighting Control

71% Reduction

- Downsizing Building Services Capacity by Thermal Load Reduction
- Direct Utilization of Geo-thermal & Solar heat
- Maximum Utilization of Natural Ventilation and Control
- Environmental Setting for each areas and Control

32% Reduction

- Downsizing PC Devices
- Sharing of eco-saving copy machines and others

Reduction
Temperature difference between the ceiling, the floor, the furniture, the window, etc. is not so much. Radiation environment is nearly optimal for human body.
In Summary (ZEB renovation)

- We achieved net ZEB at this renovation office
- Improved comfort with radiation, low humidity, air flow feeling, bright light environment with daylight
- Downsizing of the facade thermal load is very important
- Big change of the office layout, change the environment setting point for each place, share copy machines, and we reduced power outlet consumption by 70%
- In addition to zero energy cost, overtime hours are greatly reduced by improving workplace productivity, and payback years is approximately under ten years.
- Effectively utilize geothermal and solar heat
In Summary (ZEB renovation)

- It is important to plan and execute comprehensively thinking about energy benefit, improvement of workplace productivity by improving work space recognition and comfort, improvement of BCP, increase of energy cost in the future, improvement of asset value of building.

- Our future task is further improvement of work style, compatibility between comfort improvement and energy consumption reduction.