Renovation Technology That Optimizes Renewable Energy;
Targeting a Zero-Energy Building (ZEB)

SANKEN SETSUBI KOGYO CO., LTD. JAPAN
# Company Profile

**Company Name**
SANKEN SETSUBI KOGYO CO., LTD.
Established in 1946.

**Head Office**
Kayabacho First Building, 17-21 Shinkawa 1-Chome, Chuo-ku, Tokyo 104-0033

**Paid-in Capital**
¥739,954 thousand

**Number of Employees**
Technical Staff 832
Clerical Staff 328
Total 1,160 (As of April 1, 2019)

**Net Sales**
¥79,127 million (FY 2019) \(\approx\) $750 million

**Construction Business License**
(Toku-24) No.1879 by Minister of Land, Infrastructure, Transport and Tourism

**Business Lines**
Plumbing Business, Architectural and Construction Business, Electrical Contracting Business, etc.

**First-Class Architect Office Registration**
No. 16996 by Governor of Kanagawa Prefecture

[https://skk.jp/en](https://skk.jp/en)
Representative projects

New Olympic Stadium for Tokyo 2020
Total area 194,000m²  B2F-5F 68,000 seats by 11/2019

Toranomon I, 2-chome redevelopment project in Tokyo
A-1  Tower 237,000 m²  B4F-49F  265 m
Medium, high-rise office, Low rise hotel, commercial facility
By 2023
What is a ZEB (Zero Energy Building)?

- **ZEB** is a building that utilizes high-efficiency air-conditioning systems, natural daylight and enhances the heat-insulation to save energy usage as much as possible while maintaining comfortable indoor environment and generating electricity by photovoltaic and wind power generation on the site.

- **ZEB** minimizes the supply of electricity from power plant that uses fossil fuels.

**ZEB** is necessary to reduce climate change and to realize a Low-Carbon Society.
1. **Minimize the load**
   Enhancing the heat-insulation
   Control of internal heat generation

2. **Introducing high-efficiency systems**
   Sensible heat and Latent heat decoupled
   air-conditioning system

3. **Utilizing renewable energy**
   PV, Geo-heat, Solar thermal, Natural ventilation

**Achieve ZEB**
A prerequisite for ZEB is to reduce energy consumption by 50% or more.
Outline of Innovated Technology for ZEB of SANKEN
Location: Tsukubamirai-city, Ibaraki-pref.
40km (25mils) northeast from Tokyo
Site Area: 4,123m² (44,380ft²)
Floor Area: 2,258m² (24,305ft²)
Reinforced-Concrete structure
Floor Number: Three stories
Completion date: Oct, 1992
TSUKUBA TECHNICAL CENTER IN JAPAN
Title: Renewal of TTC towards Zero Energy Building

A prize of Renewal Award from SHASE in 2014

SHASE: Society of Heating, Air-Conditioning and Sanitary Engineers of Japan
Minister of the Environment Award at the countermeasure technology advanced introduction department of global warming prevention activities in 2014.

Title: The ZEB is interwoven with Wind, Sun and Geothermal heat.
Carbon Neutral Award from JABMEE in 2014.

: Japanese Association of Building Mechanical and Electrical Engineers
Title: The 6th Sustainable Architecture Award

Sustainable Architecture Award from IBEC in 2016.

:Institute for Building environment and energy conservation.
Innovated Technologies
Elemental Technologies

1. Architectural
   ① Exterior thermal insulation
   ② Low-e pair glass

2. Air-conditioning system
   ① Decoupling Latent heat and Sensible heat
      Ceiling radiant panel, Latent heat treating system
   ② Direct use of renewable energies
      Geo-heat, Solar thermal, Natural ventilation

3. Electric equipment and lighting system
   ① High efficiency lighting (LED)
   ② Daylight control and zone control of lighting
   ③ High efficiency transformer
Main heat source for the air-conditioning system

**Cooling:** Direct utilization of geo-thermal energy and solar thermal energy

(Solar thermal energy for regeneration process of desiccant coil unit)

**Heating:** Direct utilization of solar thermal energy
Air-conditioning systems that decouple and treat sensible heat load and latent heat load

Concept of Energy-Saving Effect
Decoupled Sensible and Latent Air-conditioning System

**General Method**
Both are treated simultaneously by one air-conditioning system

**Decoupling Method**
- Independent Sensible Heat Treating System: *Ceiling radiant panel*
- Independent Latent Heat Treating System: *Dehumidifying unit* and *Desiccant coil unit for Outdoor air system*

**SANKEN’s decoupled Sensible and Latent Air-conditioning System**
Energy-Saving Effect Concept of Decoupled Sensible and Latent Heat Air Conditioning System

### General Method
- **Total heat load**: 100
- **Sensible Load**: 70
- **Latent Load**: 30
- **Heat Source Equipment**: Chilled Water at 7°C
- **COP**: 3.0
- **Total Energy Consumption**: 33.3 kW

### Decoupling Method
- **Total heat load**: 100
- **Sensible Load**: 70
- **Latent Load**: 30
- **Heat Source Equipment**: Chilled Water at 7°C
- **Cold Water at 7°C**: COP=3.0
- **COP**: 6.5
- **Total Energy Consumption**: 10.8 kW
- **Total Energy Consumption**: 10.0 kW

**38% Reduction**
Energy Saving Effects (Renewable Energy)
of an air-conditioning system separating latent and sensible heat

Utilization of groundwater and solar thermal to Desiccant System

**General Method**
- Total heat load: 100
- Sensible Load: 70
- Latent Load: 30
- Heat pump chiller
  - Chilled Water at 7°C
- COP: 3.0
- Total Energy Consumption: 33.3 kW

**Decoupling Method**
- Total heat load: 100
- Sensible Load: 70
- Latent Load: 30
  - 12
  - 18
- Heat Source Equipment
  - Solar thermal at 55°C
  - Chilled Water at 16°C
- COP: 6.5
- Total Energy Consumption: 12.6 kW + 4.3 kW = 16.9 kW

50% Reduction
Energy Saving Effects (Renewable Energy)

of an air-conditioning system separating latent and sensible heat

Utilization of groundwater and solar thermal to Desiccant System

<table>
<thead>
<tr>
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<tbody>
<tr>
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<tr>
<td>+ <strong>Groundwater at 16°C</strong></td>
<td></td>
</tr>
<tr>
<td>+ <strong>Solar thermal at 55°C</strong></td>
<td></td>
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<tr>
<td><strong>Renewable energy</strong></td>
<td></td>
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<td><strong>33.3 kW</strong></td>
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<td><strong>80% Reduction</strong></td>
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Decoupled Sensible Heat and Latent Heat Air-conditioning System

Sensible Heat Load Treating System
(Radiant Ceiling Panel)
Appearance of Radiant Ceiling Panel

A panel made of aluminum → Good heat conductance, Lightweight
Slit between the panel → Natural convection effect
Comfort of Radiant Air-Conditioning

- Heat radiation is the biggest heat quantity of the heat released by a human body.

- The temperature distribution of the room is even because there are only a few drafts.
Energy Saving of Radiant Air-Conditioning

- The Cooling is possible by sending cold water to the ceiling metal panel at 18°C, and the efficiency of the heat source COP is improved by a factor of 1.5 or more.

- Further, since water having a specific heat of 1 Cal/g·K and it is used as the cooling refrigerant, the conveying electrical power is about 30% of that of air.
SANKEN developed a PMV controller for the Radiant A/C system. It controls the PMV, which is the theoretical comfort index in the room.

PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied) ISO7730 (1994)

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<th>Scope of application of PMV</th>
<th>7 stage evaluation of PMV</th>
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<tbody>
<tr>
<td>PMV</td>
<td>-2 &lt; PMV &lt; +2</td>
</tr>
<tr>
<td>Metabolic equivalent</td>
<td>+3 Hot</td>
</tr>
<tr>
<td>Amount of clothing</td>
<td>+2 Warm</td>
</tr>
<tr>
<td>Air temperature</td>
<td>+1 Slightly warm</td>
</tr>
<tr>
<td>Mean Radiant Temp</td>
<td>0 Neutral</td>
</tr>
<tr>
<td>Mean air velocity</td>
<td>-1 Slightly cool</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>-2 Cool</td>
</tr>
<tr>
<td></td>
<td>-3 Cold</td>
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</table>
Thermal Image of the Ceiling Panel

During Cooling

※Blue (Low temperature) ⇔ Red (High temperature)
Decoupled Sensible Heat and Latent Heat
Air-conditioning System

Latent Heat Treating System
(Desiccant Coil Unit and Dehumidifying unit)
Desiccant Coil Unit

Batch Process System composed by two desiccant coils

- Indoor Exhaust
- Pre-Cooling Outdoor Air
- Chilled Water 18°C (Directly utilizing groundwater)
- Hot Water 55°C (Directly utilizing solar thermal energy)
- 3-Way Valves × 4
- 4-Way Dampers × 2
- Regeneration Exhaust
- Dehumidified air
- Chilled Water
**Operation data on 29/08/2013**

- Batch Interval: 5min
- Chilled Water Temperature: 17.9°C (Groundwater)
  
  Flow rate: 22.6L/min.
- Hot Water Temperature: 55.2°C (Solar thermal)
  
  Flow rate: 21.2L/min.

  **Average Temperature:** 24.8°C
  **Average Absolute Humidity:** 7.7g/kg'

- Chilled water temperature of pre-cool coil: 17.9°C(Groundwater)
Outdoor Air Dehumidifying Unit

1. Outdoor Air
2. Heat Exchanger
3. Air-conditioner
4. FAN

Dehumidified Outdoor Air

Diagram showing the flow of air through the system, with labels for each component.
Operating Condition by PMV control

- Temperature [℃]
- Relative humidity [%]
- PMV [-]
- Time [h]

※0.45clo, 1.1met

- Outside humidity
- Indoor humidity
- Indoor Temperature
- Outside Temperature
- Panel surface temperature
- Groundwater temperature
- Supply water temperature

Comfortable range
Energy Consumption and Energy Balance

https://skk.jp/en/zeb/
Primary Energy Consumption in the Office Area

- We have been operating the renovated system since 2010.
- We have continued in introducing new technologies and improving energy conservation.
- We have achieved the ZEB since 2013.

- Primary energy consumption of the office area in 2014 was 313 MJ/m²/year.
- Primary energy consumption of the reference office building is approximately 1600 MJ/m²/year.
Electric Energy Balance

The Photovoltaic Power Generation and the Electric Power Consumption of the Whole Building in 2014

Annual electric power consumption was less than annual photovoltaic power generation. We achieved net ZEB.
Rating of TTC in ZEB Evaluation Chart

TTC is rated on ZEB as net Zero Energy Building

Volume of Energy Consumption [MJ/m²/year]

Volume of Energy Supply [MJ/m²/year]

ZEB

Nearly ZEB

ZEB Ready

TTC

Energy Savings

Reduction of 100% or more (Net Zero)

Reduction of 75% or more

Reduction of 50% or more

Reference Building

Benchmark Primary Energy Consumption

400 (25%)

800 (50%)

1200 (75%)

1600 (100%)

400

800

1200

1600

Reduction of 25% or more

1600

1200

800

400

400

Volume of Energy Consumption [MJ/m²/year]
Conclusions

- We have achieved a **ZEB** of the *existing building by the renovation work*.
- The ZEB has been accomplished mainly by **high-efficiency system** and *load minimization*, and it does not rely on a large amount of photovoltaic generation.
- **Sensible heat and latent heat decoupled air-conditioning system** is the most important element of the ZEB technology in ASEAN.
- Utilizing renewable energy directly is also an important element of the technology in ZEB, and it is able to operate without heat source machine.
SANKEN’s Actions in ASEAN

*SANKEN* would like to emphasize that **ZEB** is necessary to stop the climate change and to realize a Low-Carbon Society for our children and their future.

*SANKEN* will continue to cooperate in the dissemination of **ZEB**, which will improve **health** and **productivity** of the people in ASEAN with **minimized energy consumption**.
Thank you all for your attention !!

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