ZEB Design Guidelines

"ZEB Design Guidelines" has been published online with the aim of providing explanations and technical guidance to operators, designers and builders etc. engaged in building construction as they aim to achieve ZEB Ready (50% energy saving from EE Standard).

- Introduction of technologies which contribute to the concepts, design approach and realization of ZEB Ready
- How to calculate energy consumption performance using the "web program"
- Approx. energy saving achieved by the employed technology
- Approx. cost estimates (CAPEX)

Labeling System (third-party verification)

"BELS (Building-Housing Energy-efficiency Labeling System)" can be used as a third-party verification indicator system which started from April 2016 based on the article of the "Building Energy Efficiency Act". BELS shows energy efficiency performance in 5 easy to understand levels, making it possible to promote buildings with higher energy efficient performance than the EE Standard.
Once ZEB Ready is achieved, a special indicator (ZEB mark) will be shown on the label.

Japanese Business Alliance for Smart Energy Worldwide

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Provisional translation

The Government of Japan is promoting the achievement and spread of ZEB, as part of its strategic Energy Plan and for the achievement of greenhouse gas reduction targets under the Paris Agreement.

Future of Green Building

Guide to ZEB

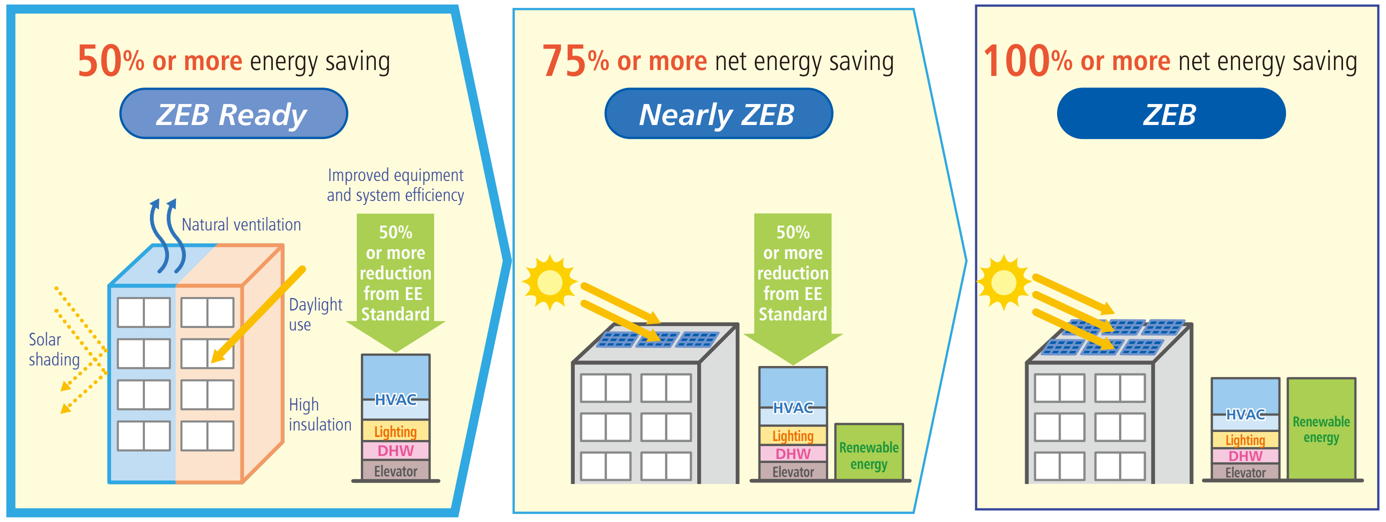
ZEB: Net Zero Energy Buildings

For Office Buildings

With the establishment of the Building Energy Efficiency Act in Japan, from April 2017 compliance with energy efficiency standards became compulsory for newly built non-residential buildings with a floor area of 2,000 m^2 or more. ZEB have also begun to draw attention as an option for environmentally friendly buildings, as an additional step for buildings beyond compliance with energy saving standards.

Definition of ZEB

The concept of ZEB has been expanded to the "ZEB Series" which can be aimed for according to actual for conditions.
The first step is to aim for super-low energy buildings which are defined as "ZEB Ready", and then aim for "Nearly ZEB" and above.



What are ZEB?

ZEB are buildings that maintain a comfortable indoor environment while realizing energy savings. This is done by reducing environmental load, using natural energy, and introducing high efficiency equipment and systems while aiming to introducing renewable energy.

Note: Energy consumption includes only HVAC, lighting, DHW and elevators, and does not include office equipment etc. used by tenants and operators. Therefore, some energy consumption will remain even when ZEB is achieved.

ZEB delivers 4 major benefits, while contributing to the prevention of global warming.

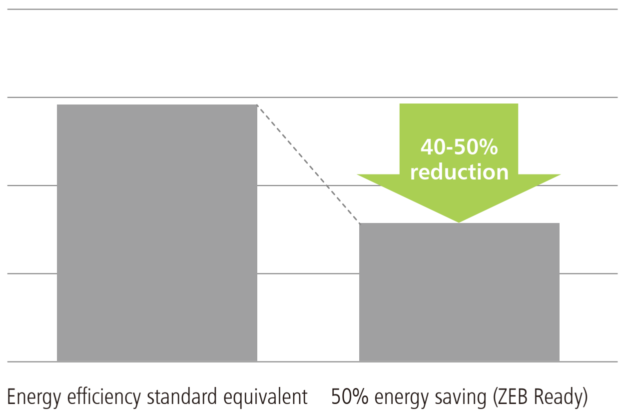
1 Reduction in Utility Costs

Able to reduce utility costs while maintaining and improving the quality of indoor environments

➡When an office building with a floor area of about 10,000 m² reduces energy by 50%, this makes it possible to reduce utility costs by 40-50% per year.

Note: Assuming office buildings with a floor area of about 10,000 m² for both EE Standard equivalent building and ZEB Ready, with utility costs converted from primary energy consumption. For electric power conversion, contracts for commercial power from Tokyo Electric Power Co. as of August 2016 (not including fuel cost adjustments or the allotted charges of the FIT scheme) were assumed, and for city gas conversion, general unit rates for standard Tokyo Gas contracts were assumed. Also note that this estimation includes only HVAC, lighting, DHW and elevators, and does not include energy consumption by office equipment etc., which makes up about 30% of total energy consumption. In addition, actual utility cost reductions may differ depending on workplace density and operating conditions.

Estimation of utility cost saving of “ZEB Ready”



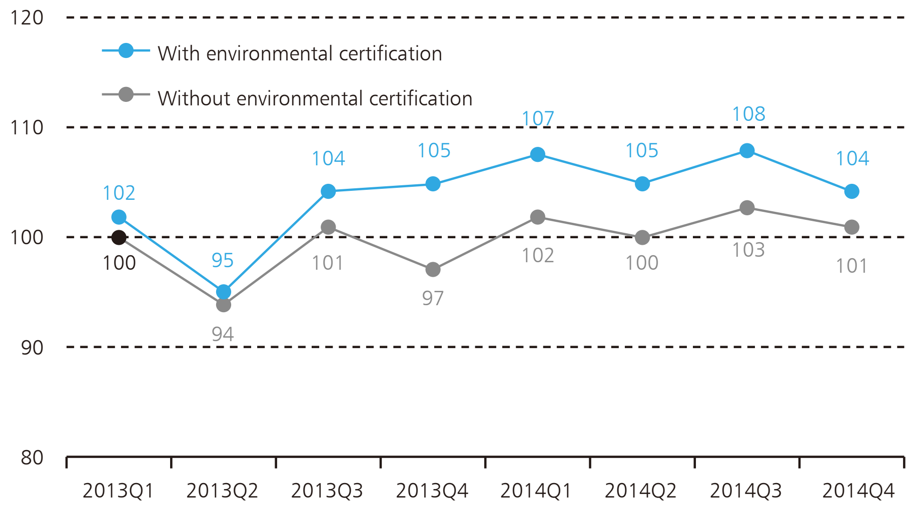
2 Improvement of Real Estate Value

Tenants and investors that are looking for environmentally friendly buildings are on the rise

➡A survey on office buildings located in the 23 wards of Tokyo shows “Buildings with environmental certificates (environmentally friendly buildings)” have a positive impact on “the rent in the new rental contracts”.

Note: Environmental certificates under this survey include certification based on an overall evaluation of the environment, including factors other than the energy saving performance of the building. It should therefore be noted that improvement of the real estate value may be affected by factors other than energy efficiency performance.

Differences in the rent fee in the new rental contracts due to the environmental certification



*A hedonic model was constructed to explain the rent with new rent contracts based on location, size, newness, specifications, closing time and environmental certification. By substituting the attributes of standard office buildings into this model the new rent contracts were estimated in terms of whether or not there was environmental certification.
Source: Xymax Real Estate Institute Corporation

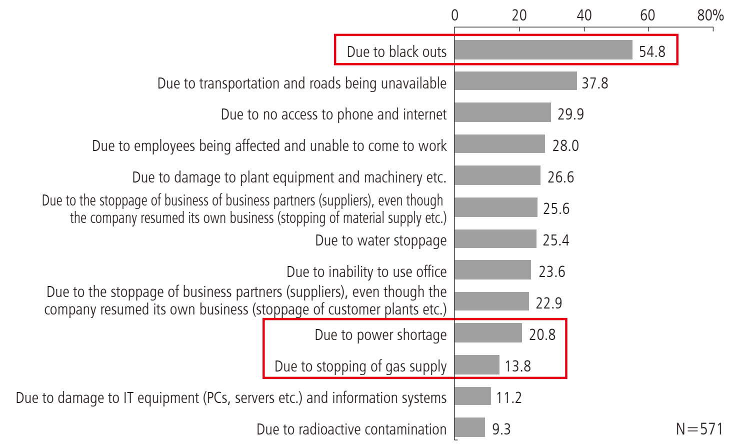
3 Business Continuity in case of Disaster

Business continuity in case of disaster is improved.

➡A survey shows, more than half of people responded that it was due to “black outs”, and many others noted energy infrastructure related issues.

When aiming for ZEB, operation becomes possible with low energy consumption, making it easier to maintain building functions.

Why did important work stop due to the Great East Japan Earthquake?



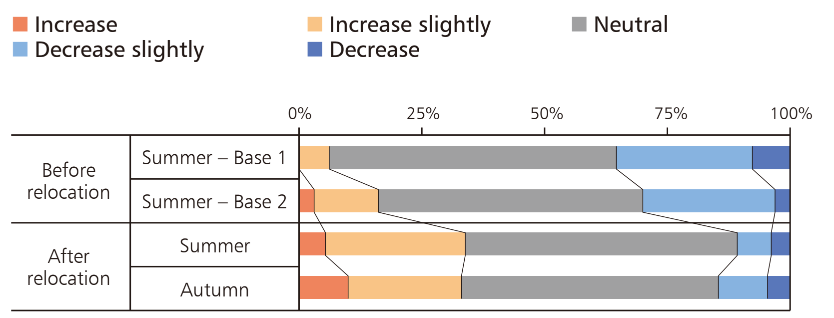
Source: Cabinet Office “Outline of the Survey of the Business Continuity Measures of Companies”

4 Improved Intellectual Productivity of Tenants and Operators

A comfortable indoor environment with improved intellectual productivity is expected

➡A survey on the workers shows that relocation to offices with natural energy utilization technologies makes an increasing number of operators feel that it is easier to work.

Evaluation of the effect on ease of work in offices using natural energy



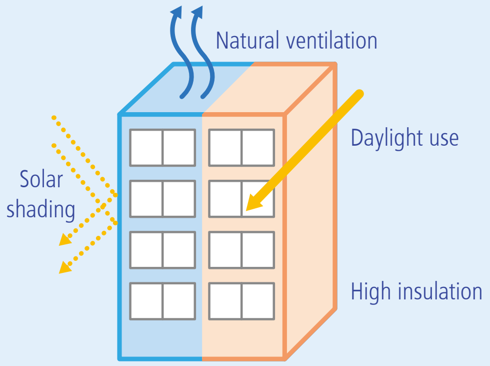
Source: Takenaka Corporation/University of Tokyo Institute of Industrial Science Survey of conditions on the effect of the introduction of external natural environments into office spaces with the aim of improved intellectual productivity

Need to consider the introduction of appropriate technologies from the early phase of construction planning

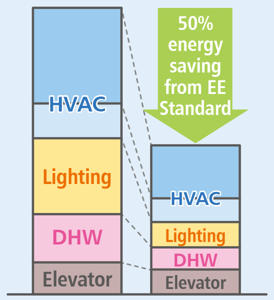
As a first step, aim for ZEB Ready

Achieving "ZEB Ready" using an architectural energy saving method (reduction in the environmental load and utilizing natural energy) and applying a high efficiency mechanical system is the first step to the ZEB Series. In addition to reducing the environmental load and utilizing natural energy, it is important to achieve "ZEB Ready" energy savings of 50% or more, through highly efficient equipment and systems. It is important to make effort towards "Nearly ZEB", with a net energy saving of 75% or more and "ZEB", with a net energy saving of 100% or more, considering actual conditions of the building, through additional energy savings and the use of renewable energy such as PV.

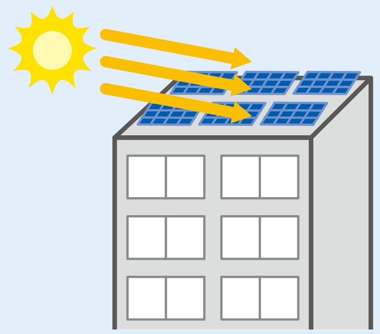
Control environmental load and utilize natural energy + **Apply high-efficiency mechanical system** + **Renewable energy**



Improved equipment and system efficiency

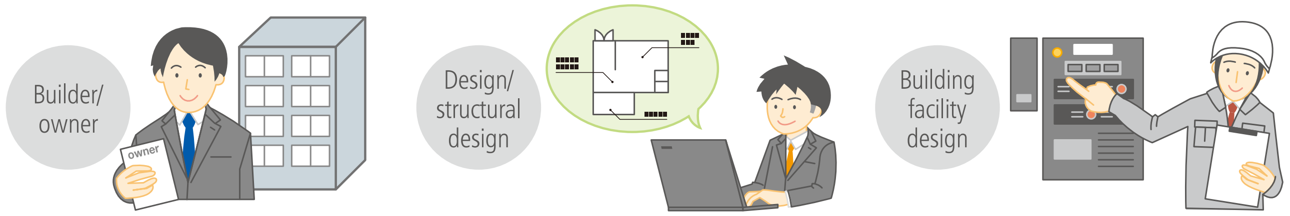


Note: Energy consumption in office equipment etc. used by tenants and operators is not included.

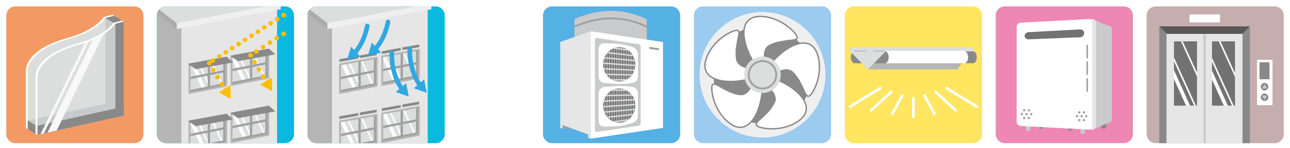


In order to achieve this, it is necessary to consult from the construction planning phase

To achieve "ZEB Ready", which is the first step towards ZEB, it is necessary to improve the efficiency of equipment and systems (active technology). And it is also necessary to make full use of architectural energy saving methods (passive technology), to enhance the envelope, which can be difficult to repair later. For this reason, consulting with experts from the early phase of construction planning is vital in order to materialize ZEB Ready buildings.



Control environmental load & utilize natural energy as much as possible + **High efficiency mechanical system**

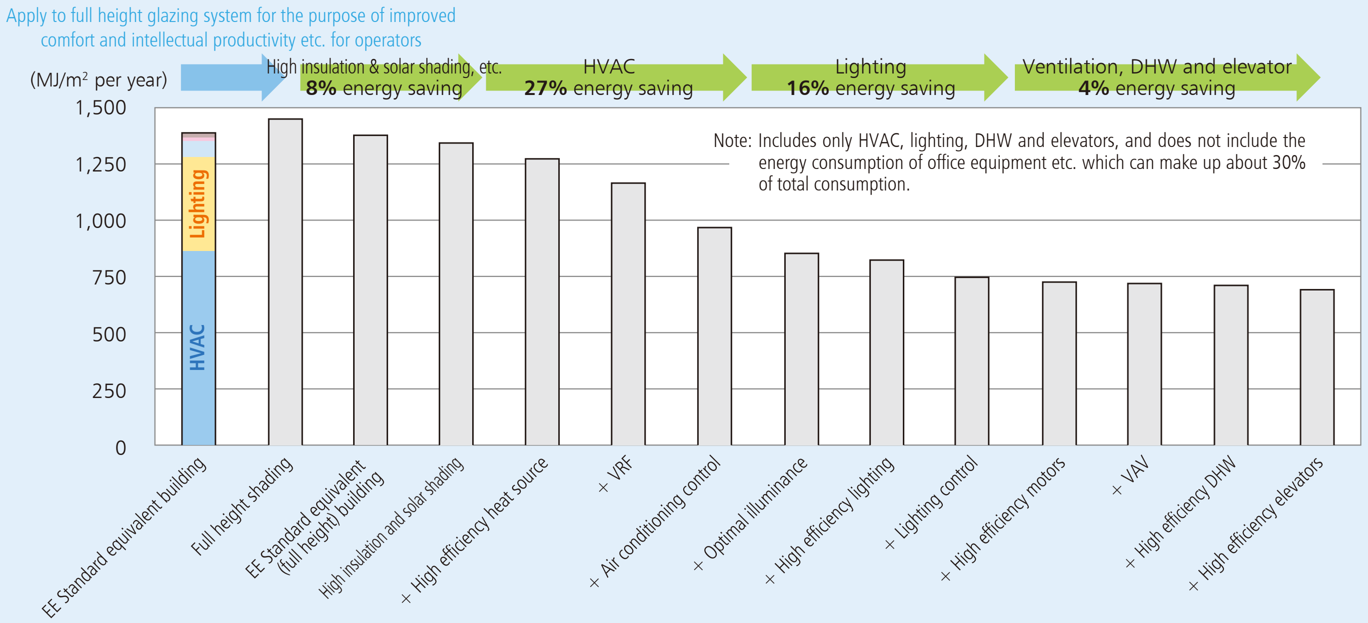


"ZEB Ready" can be achieved with about a 12%* increase in constructiosn costs

An estimation shows that "ZEB Ready" can be achieved by combining general high efficiency energy saving technologies and the introduction of the cutting-edge technology is not always necessary. Further, calculating the equipment and system costs and construction and management expenses etc. shows that the increase in construction costs is about 12%* in comparison with standard energy saving equivalent buildings. Also, in order to achieve both good architectural design and high energy performance (Nearly ZEB, "ZEB"), it is important to proactively implement passive technologies such as natural ventilation and daylight use etc.

◆Energy saving effect of measures (approx.)

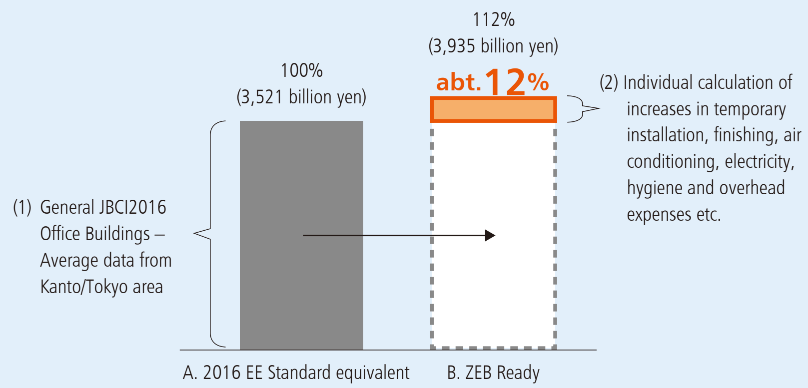
*Results of simulation based on Japanese construction costs



Source: Based on the estimates by the ZEB Roadmap Follow-up Committee

*Results of simulation based on Japanese construction costs

◆Rate of construction cost increase (approx.) *



- The approximate increase in cost for the overall building for "B. ZEB Ready" is 112%. In terms of individual technologies, the estimated increase in cost is 161% for HVAC equipment and 117% for electrical equipment (lighting).
- These construction costs are based on an estimation from model buildings as part of a case study, and approximate costs may fluctuate due to fluctuations in price caused by changing economic conditions or changes in the building specifications etc. Please note that when designing buildings at a level higher than ZEB Ready (50% energy saving), it is necessary to also consider the introduction of passive technologies (natural ventilation and daylight use with atriums or voids etc.) which are highly effective at conserving energy but also have a higher initial cost.

	Approx. ZEB Ready Cost (million yen)	Rate of increase
Construction work finishing (high insulation and solar shading)	1,106	102%
Air conditioning equipment (HVAC)	423	161%
Electrical equipment (lighting)	393	117%
Sanitation equipment (DHW)	191	100%
Elevator	69	100%
Temporary installation	246	111%
Earthwork	111	100%
Foundation work	144	100%
Frame	741	100%
Overhead expenses	457	113%
Total	**3,935**	**112%**
Tsubo unit price – 1,280,000 yen/tsubo		

(*Estimation for office buildings with floor area of about 10,000 m²)
Source: Based on the results of trials by the ZEB Roadmap Follow-up Committee with the cooperation of the Building Surveyor's Institute of Japan
Note: 1 tsubo ≈ 3.3 m²

ZEB cases are beginning to spread

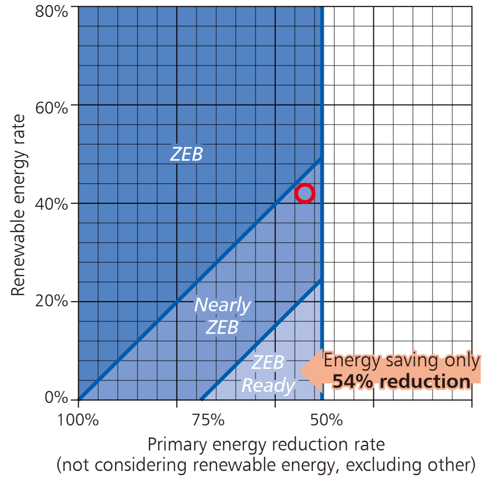
The number of new cases of ZEB are increasing year by year, from 5 in 2014 to 16 in 2015, 37 in 2016 and 45 in 2017. From April 2017 newly constructed non-residential buildings with a floor area of 2,000 m² or more have been required to comply with energy efficiency standards, so ZEB can be considered as one of the differentiations from energy efficiency standard equivalent buildings.

Case 1

[Concepts]

Create ZEB designs which maximize the use of the natural environment of the construction site and high efficiency facilities and equipment.

- Introduction of air conditioning systems using abundant well water
- Use of natural ventilation and daylight, and the introduction of PV and heat utilization systems
- Seek to convert to ZEB using high efficiency equipment and advanced BEMS



[Building Summary]

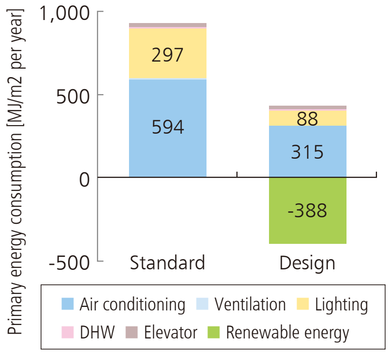
- Location: Ibaraki Prefecture
- Site area: 53,500 m²
- Building area: 728 m²
- Floor area: 2,235 m²
- Structure type: RC+S type
- No. of floors: 3 above ground
- Building use: Office space
- Annual working days: 240 days

[Price per Unit Floor Area]

- Aux. only/Equipment cost: 42,427 yen/m²
- Aux. only/Equipment cost + Construction cost: 72,862 yen/m²

[Energy Performance Evaluation]

- Design primary energy consumption of the building is 432MJ/m² per year (42MJ/m² per year including net renewable energy), achieving about a 54% energy saving compared with the standard.



	Standard [MJ/m² per year]	Design [MJ/m² per year]	BPI/BEI
Envelope	449	265	0.60
Air conditioning	594	315	0.53
Ventilation	5	1	0.18
Lighting	297	88	0.30
DHW	12	7	0.59
Elevator	24	19	0.80
Total	932	432	0.46
Renewable energy	0	-388	-
Total	932	42	0.05

[Summary of Implemented Equipment]

Envelope	Outer wall	Polyurethane foam 100 mm
	Roof	Extruded polystyrene foam 100 mm
	Window	Low-E double glazing + inner blind Low-E double glazing + inner blind + outer blind + eaves Low-E double glazing
Air conditioning	Heat source system	Combined central/individual
	Equipment	Water heat source "eco-cute" EHP
	System I	Utilization of unused energy★ High-efficiency integrated heat source system Fuel cell Unit quantity control system Well water air conditioning★ Solar heat use
	System II	Minimum outside air intake control Radiation air conditioning★ Temperature and humidity sensor control Human sensor control Task/ambient air conditioning★ CO_2 sensor control Night purge control Outside air cooling Optimal water temperature setting (VWT)
Machine ventilation	Equipment	Class 1 ventilation – Cascade ventilation
	System	CO_2 sensor Natural ventilation★ Temperature sensor
Lighting	Equipment	LED High-brightness induction lamp
	System	Brightness sensor control Time scheduled control Presence detection control Solar radiation blind control★ Task/ambient lighting
	Daylight use	Top light Light shelf
DHW	Heat source system	Central system
	System	Cogeneration system Solar heat use Well water heat use★
Renewable energy etc.		Solar power generation (PV) Wind use★ Geothermal use Storage battery★
System control etc.		Inter-facility integrated control system★ Equipment and user cooperative control system★ Load control★ Tuning etc.★

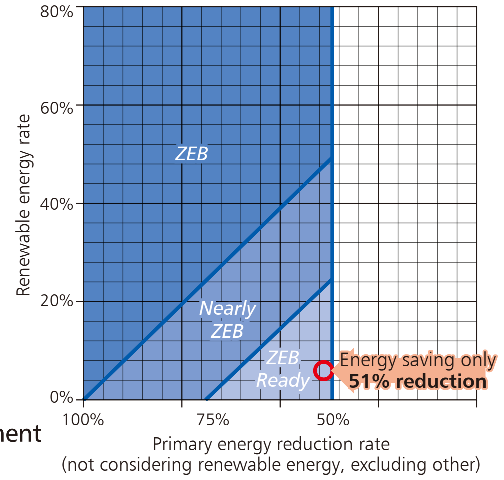
- BPI (Building PAL* Index): Standard and design building annual perimeter load ratio
- BEI (Building Energy Index): Standard and design building primary energy consumption ratio

Case 2

[Concepts]

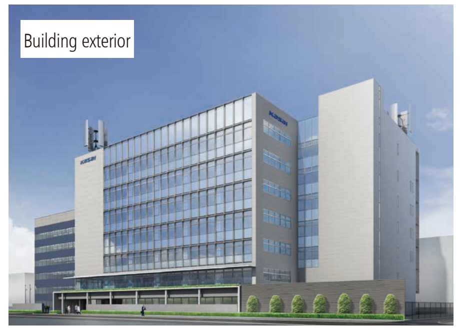
Actively introducing energy saving equipment and systems under the slogan of "Passing a beautiful earth down to the next generation. Striving to become a manufacturer that's friendly to people and the environment".

- Introduction of high-efficiency building multi-air conditioner, ice heat storage
- Introduction of fully LED lighting, brightness sensor dimming control and human sensors



[Building Summary]

- Location: Kanagawa Prefecture
- Site area: 38,841 m²
- Building area: 2,064 m²
- Floor area: 12,725 m²
- Structure type: S type
- No. of floors: 7 above ground, 1 basement
- Building use: Office space
- Annual working days: 244 days

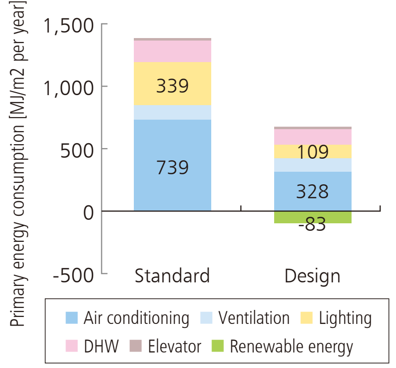


[Price per Unit Floor Area]

- Aux. only/Equipment cost: 26,329 yen/m²
- Aux. only/Equipment cost + Construction cost: 47,061 yen/m²

[Energy Performance Evaluation]

- Design primary energy consumption of the building is 677MJ/m² per year (594MJ/m² per year including net renewable energy), achieving about a 51% energy saving compared with the standard.



	Standard [MJ/m² per year]	Design [MJ/m² per year]	BPI/BEI
Envelope	450	345	0.77
Air conditioning	739	328	0.44
Ventilation	114	99	0.87
Lighting	339	109	0.32
DHW	172	122	0.71
Elevator	22	20	0.89
Total	1,386	677	0.49
Renewable energy	0	-83	-
Total	1,386	594	0.43

[Summary of Implemented Equipment]

Envelope	Outer wall	Glass wool (24K) 100 mm
	Roof	Extruded polystyrene foam 35 mm
	Window	Low-E double glazing (high solar shading type)
Air conditioning	Heat source system	Individual type
	Equipment	EHP
	System I	High efficiency building multi-air conditioner (ice heat storage) Heat pump type desiccant external controller★
	System II	Full heat exchanger Heat pump type desiccant external controller★ CO_2 sensor control Night purge control Temperature and humidity sensor control Replacement ventilation air conditioning
Machine ventilation	Equipment	Class 1 Ventilation – Local Ventilation
	System	CO_2 sensor Natural ventilation use★ Temperature sensor
Lighting	Equipment	LED
	System	Brightness sensing control Time scheduled control Presence detection control
DHW	Heat source system	Individual type
	System	Business use "eco-cute" EHP
Renewable energy etc.		Solar power generation (PV) Wind use★ Transformer achieving the Top-Runner Standard★ Wind power generation★
System control etc.		Load control★ Expansion to tuning operation etc.★

Note: Energy saving from equipment marked ★ has not been considered in the calculation above.