Latest Trends and Technologies of Energy Recovery Ventilators in Japan

Mitsubishi Electric Corporation

Nakatsugawa Works

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1. Ventilation and Air Conditioning Situation in Japan

- Overview of Ventilation and Air Conditioning in Japan
- Ventilation and Air Conditioning Regulations in Japan
- The building design and construction situation

2. Technological Trends of ERVs (Static Type) in Japan

- Product type
- Air volume control
- Multiple unit control/network
- Interlock control with air conditioners
- Installation/Maintenance

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1-1 Ventilation and Air Conditioning Situation in Japan

Overview of Ventilation and Air Conditioning in Japan

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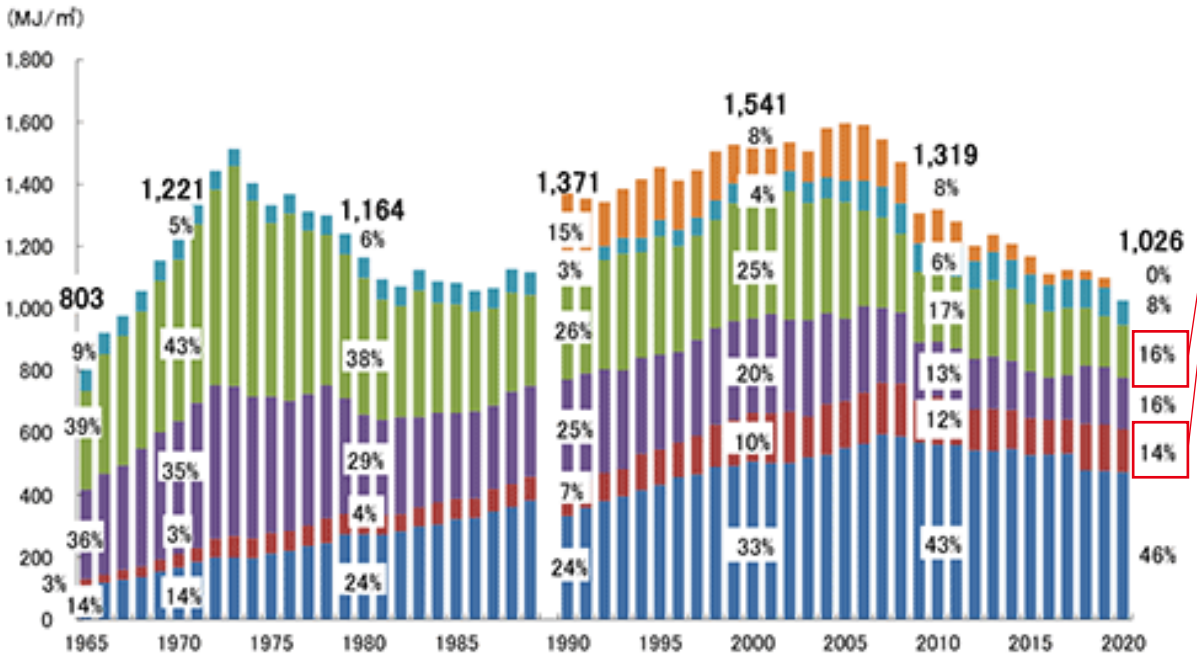
Energy Use in Building by Applications

Below is the bar chart showing energy Consumption ratio through year in business dept. in Japan.

Air Conditioner takes up high ratio.



Total load of Air Conditioning
(Heating and Cooling) : **30%**
*non-residential sector

- **Others/statistical error**
- **Kitchen**
- **Heating**
- **Hot water supply**
- **Cooling**
- **Power and Lighting**

Source: Agency for Natural Resources and Energy White Paper on Energy 2022 [No. 212-1-9] Changes in unit energy consumption by business and other sectors https://www.enecho.meti.go.jp/about/whitepaper/2022/html/2-1-2.html

Energy Saving of Air Conditioning System is
High Priority in Japan same as other countries.

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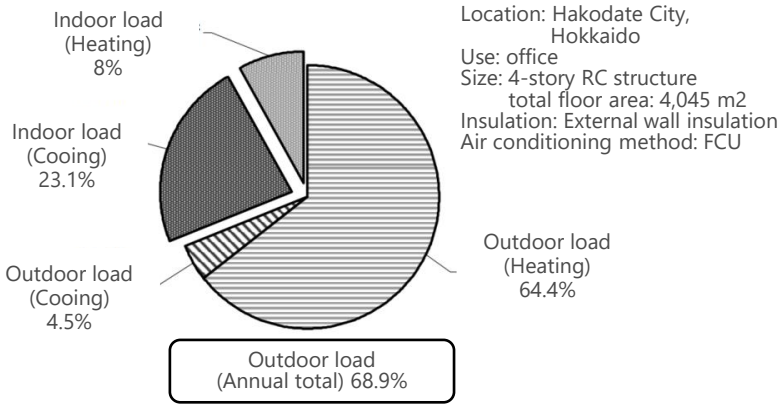
Three Types of Air Conditioning Load

We cannot live without air conditioning system. Therefore, in order to save energy, we must think about reducing power consumption by reconsidering the load on air conditioning system.

Total Air Conditioning Load



Location: Hakodate City, Hokkaido
Use: office
Size: 4-story RC structure
total floor area: 4,045 m2
Insulation: External wall insulation
Air conditioning method: FCU

Graph
Annual air conditioning load ratio
(Non-use of outside air load reduction technology)

Source: Research on the effectiveness of environmental load reduction technology in cold regions -Effects of ERVs and outside air intake control in highly insulated buildings-Hokkaido Development Technology Research Conference (2004)
<https://thesis.ceri.go.jp/db/documents/public_detail/24379/>

01 **Indoor Generated Heat**
Energy loss from heat generated by lightning, human, electronics, bath, kitchen, etc.

02 **Indoor Penetration Heat**
Energy loss from heat coming from walls or drafts of buildings with poor airtightness and insulation.

03 **Ventilation Outdoor Air Load**
Energy loss occurring when outside air enters when ventilating.

Ventilation outdoor air load takes a big part of energy loss in air conditioning system.

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1-2 Ventilation and Air Conditioning Situation in Japan

Ventilation and Air Conditioning Regulations in Japan

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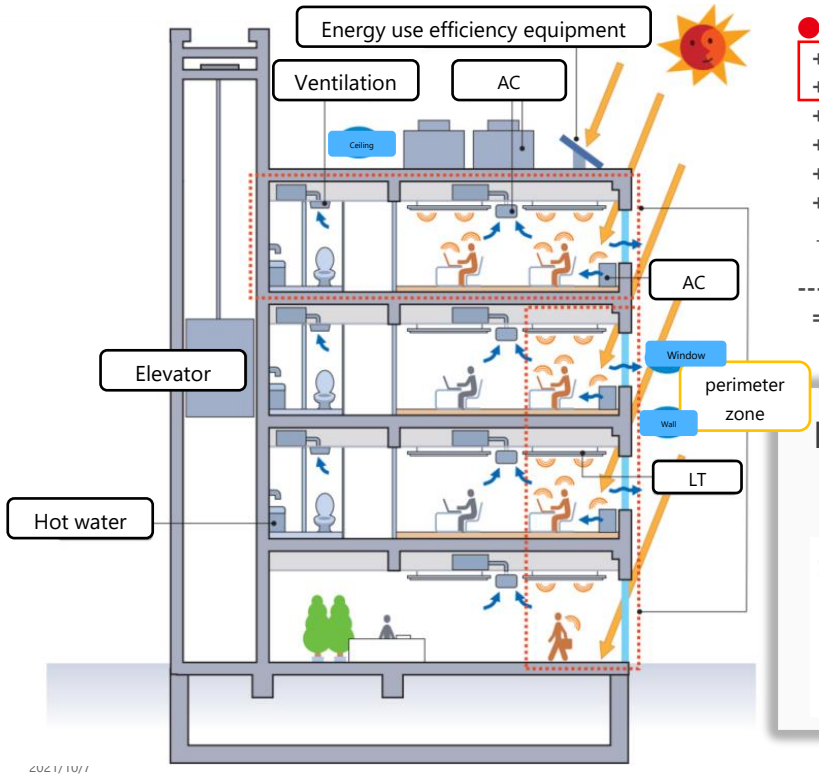
Regulations related to ventilation and air conditioning (laws, guidelines, etc.)

Laws and regulations related to energy conservation

Law/Regulation	Overview
Act on Rationalizing Energy Use	Laws related to energy-saving performance of equipment Example) Top-runner standards; stipulating performance and power
Building Energy Efficiency Act	Law on energy efficiency performance of all buildings. Buildings cannot be built unless the total energy consumption of insulation performance and equipment (air conditioning, ventilation, lighting, hot water supply, elevators, etc.) is below the specified value.



●Primary energy consumption
+ Primary energy consumption of air conditioning equipment(AC)
+ Primary energy consumption of ventilation equipment
+ Primary energy consumption of lighting equipment(LT)
+ Primary energy consumption of hot water supply equipment
+ Elevator primary energy consumption
+ Other (OA equipment, etc.) primary energy consumption
− Amount of reduction in primary energy consumption by energy use efficiency equipment

= Primary energy consumption

Ventilation fans and ERVs must also be taken into account

In order to achieve **ZEB/ZEH**, it is necessary to further **reduce energy consumption in the field of air conditioning and ventilation**.

<Efforts toward carbon neutrality in 2050>

Strengthening drastic efforts is essential

Aiming to secure ZEH/ZEB-level energy-saving performance for new construction

Aiming to secure ZEH/ZEB-level energy-saving performance on average for stock

2030年 2050年

ZEH/ZEB: Net zero energy house/building

2021/10/7
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Regulations related to ventilation and air conditioning (laws, guidelines, etc.)

Health and air quality laws and regulations

Law/Regulation	Building type	Required ventilation	Ventilation considerations
Building Standards Act * Minimum requirement	All Buildings	(1) 20 m^3/h/person or more, (2) (Non-residential) 0.3 to (residential) 0.5 times/h or more, whichever is greater	
Act on Maintenance of Sanitation in Buildings * Obligation to make efforts	Specific (large) buildings (*1)	30 m^3/h/person	• Mandatory maintenance of ventilation equipment (proper cleaning, inspection, etc.)
	Facilities that do not correspond to specific buildings	30㎥/h/person Required ventilation (assuming 350 ppm outside air)	• Require maintenance of ventilation equipment (proper cleaning, inspection, etc.) • If the required ventilation volume is insufficient, reduce the number of people in the room.
Guidelines for Improving "Closed Spaces with Poor Ventilation"	All Buildings	30 m^3/h/person, or CO_2 conc. of 1000 ppm or less (*2)	

After COVID-19, there is a **movement to increase the ventilation volume to 30m^3/h/person** as a countermeasure against infectious diseases.

(*1) Specific buildings under the Building Standards Act are buildings with a total floor area of 3,000㎡ or more that are used by a large number of people and are used for purposes such as entertainment venues, department stores, assembly halls, amusement centers, and shops. refers to (excluding school)
(*2) When using mechanical ventilation. CO_2 concentration is used as an indicator of air pollution and ventilation volume.

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1-3 Ventilation and Air Conditioning Situation in Japan

The design of the building and construction situation

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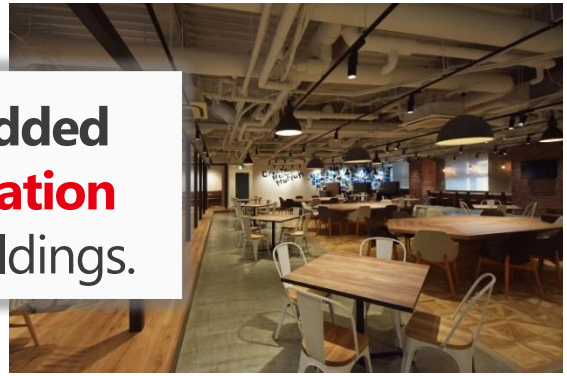
Trend of the design of building

Increase in intelligent buildings and smaller office compartments due to the impact of COVID-19

Environmental change	Changes of environment and needs
Intelligentization of small and medium-sized buildings	Changes in working styles (spread of remote work) have led to diversification of offices (satellite offices, etc.). → Japanese office building developers have announced the "intelligentization of small and medium-sized buildings".
Increasing the rate of adopting smaller office rental units and the individual decentralization method	Due to the spread of telecommuting and remote work due to the impact of Covid19, office rental units are becoming smaller. → Increased willingness to adopt separate decentralized ventilation and air conditioning systems.

There is a **growing need for high value-added decentralized air conditioning and ventilation equipment** for small and medium-sized buildings.



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Ventilation and Air Conditioning Situation in Japan

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Ventilation equipment is also evolving in product types and functions suitable for

" decentralized " (small size, multiple unit installation)

Product type	• Static type ERVs which is suitable for small product sizes are the mainstream, and there are a variety of product types (according to various buildings, securing installation locations)
Air volume control	• Realizes energy saving by air volume adjustment and sensor control
Group control of multiple units	• Improved controllability by operating multiple units
Interlocking with air conditioner	• Detailed zone control unique to decentralized ventilation and air conditioning
Improved installation workability	• Easy installation workability is important for multiple installations

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2-1 Technological Trends of ERVs (Static Type) in Japan

Product Type

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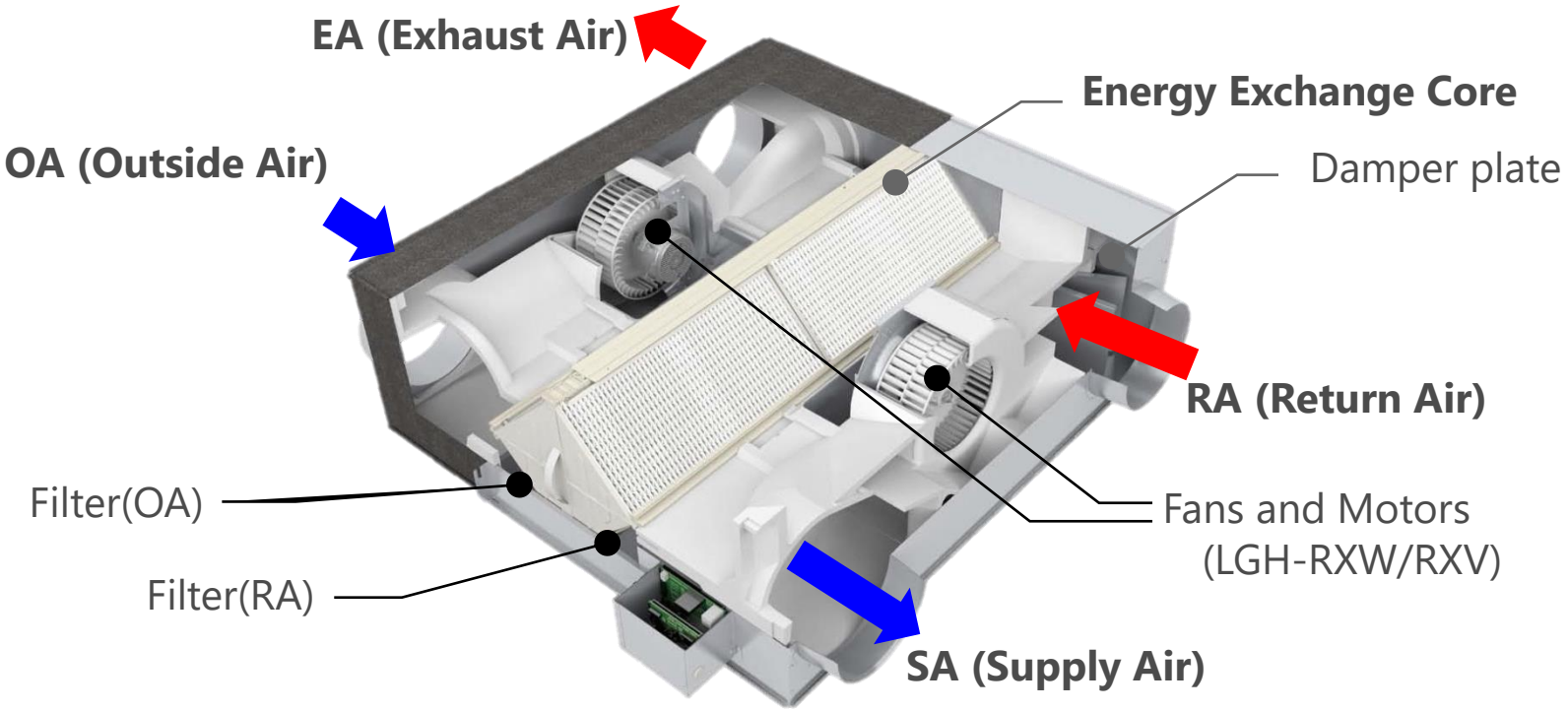
Energy Recovery Ventilator (ERV) : ventilator with a heat exchange unit

Registered product name " **LOSSNAY** " is an ERV which was developed by **Mitsubishi Electric**.



3 Major Components **Supply Fan, Exhaust Fan , and Energy Exchange Core**

- ERV simultaneously intakes fresh air and exhausts dirty air
- Energy Exchange Core returns both sensible heat and latent heat.

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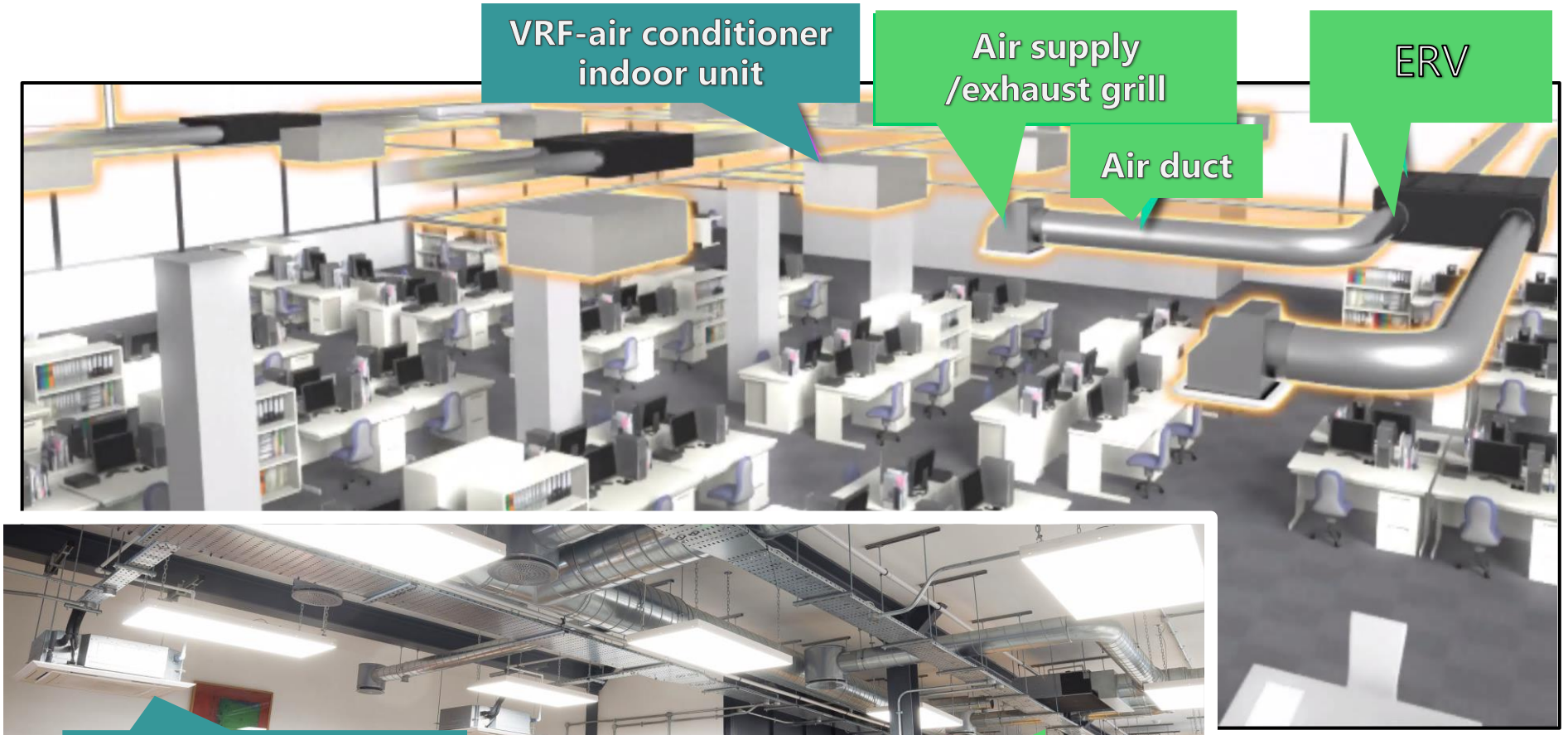
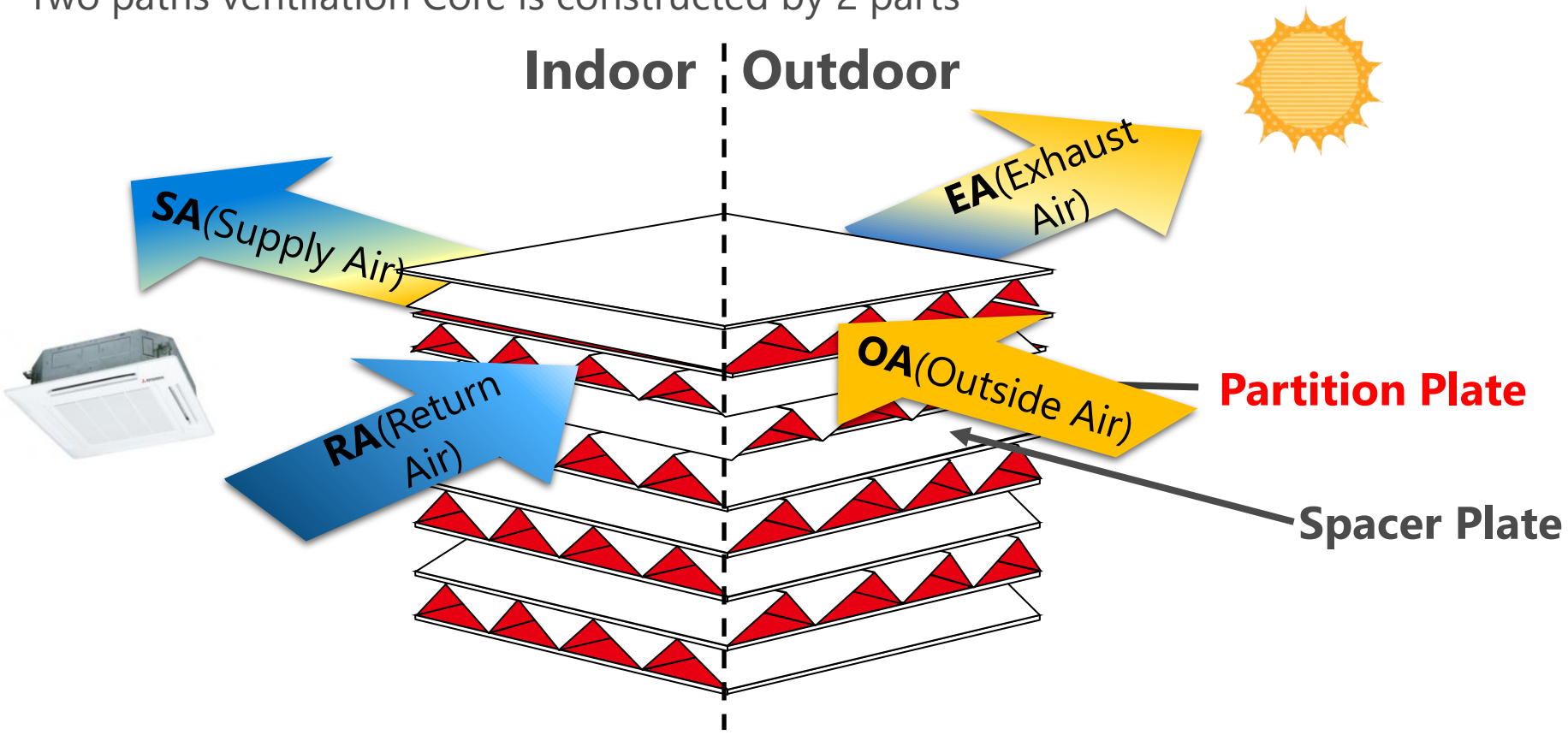
Typical product installation example (Ceiling concealed type)



VRF:
Variable Refrigerant Flow

Structure of Energy Exchange Core

Two paths ventilation Core is constructed by 2 parts



Spacer Plate	: Make supply air and exhaust air
Partition Plate	: Separated SA and EA, heat exchange

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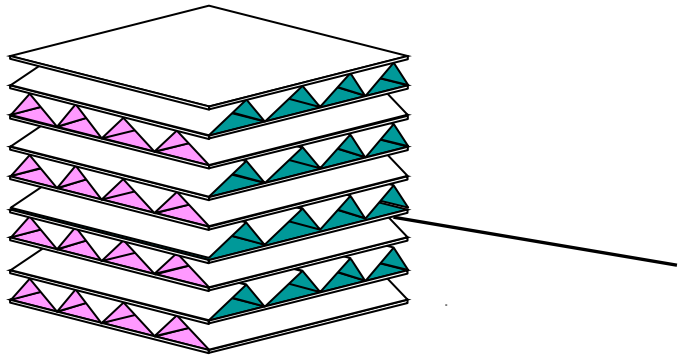
Heat exchange technology of Energy Exchange Core

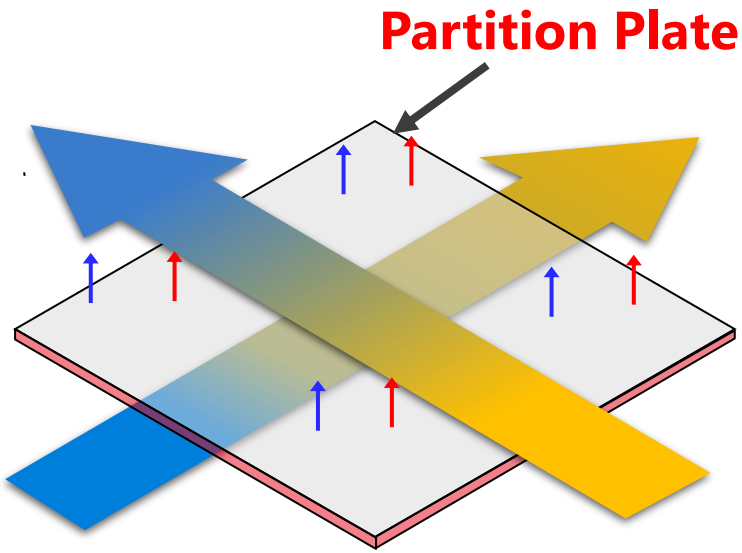
Total Enthalpy = Sensible Heat (Temp.) + Latent Heat (Humidity)

<The Baisic Principle of Physics>

- **Sensible Heat** tends to transfer from higher to lower temp.
- **Latent Heat** tends to transfer from higher to lower absolute humidity.



Energy Exchange Core



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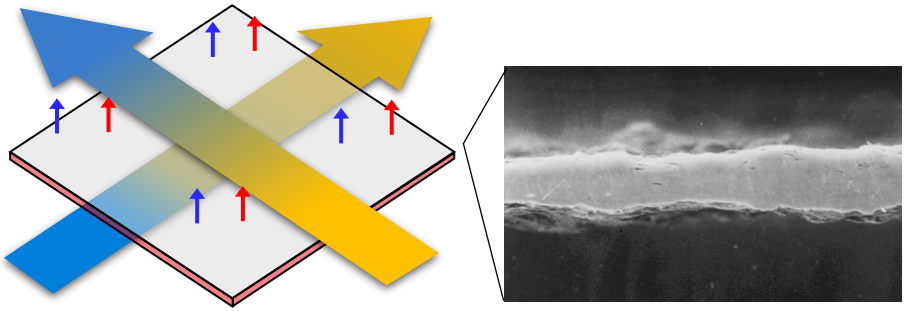
Technologies for static type ERV core materials

Species of Partition plate

Materials	Heat transfer rate [1)]	Moisture Transfer Rate [2)]	Air permeability [3)]	Benefits
Paper based	0.06 W/mK	12kg/m^2/day	>10,000 sec	Cost saving
Plastics	0.15～0.3 W/mK	9-10kg/m^2/day	>10,000 sec	Washable Suitable for wet condition



Partition Plate

1) JSME Data Book：Heat Transfer (Fourth Edition) P321-322
2) Measured by ISO 15106-2 (Mocon Method)
3) Measured by JIS P8117 (Oken Method)

In Japan, **paper is the main material for partition plate**.
…Because it has good moisture permeability and is relatively inexpensive.
Resin partition are limited to applications under high humidity

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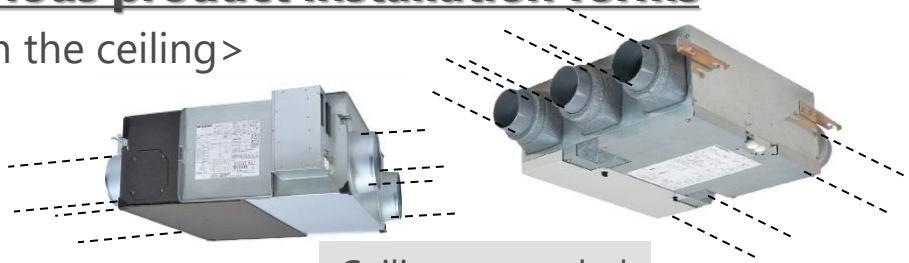
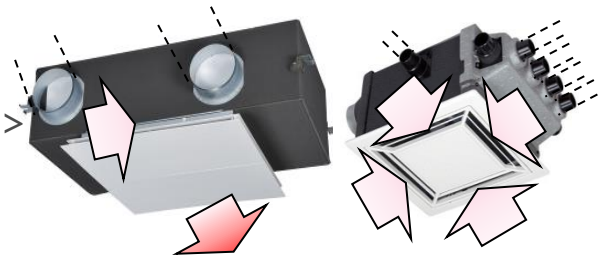
Various product installation forms

<In the ceiling>

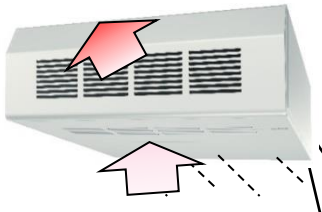


Ceiling concealed

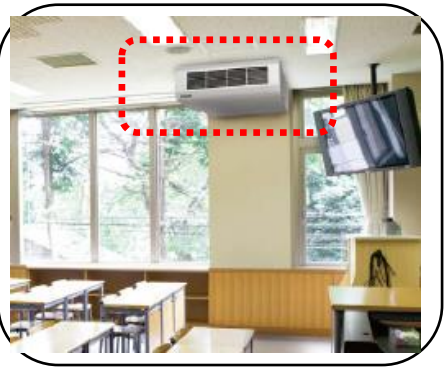
<On the ceiling>



Ceiling Cassette



Ceiling suspended



<On the wall>

Wall mount

<In the machine room>

Floor standing
In the wall

(Japanese model information)

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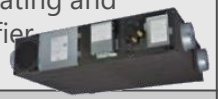
ERV product lineup (by Mitsubishi Electric Corp)

Product Type	Air volume [m³/h] (200 / 400 / 600 / 800 / 1000 / 2000 / ... / 10000)	Energy Recovery	Constant air volume	CO_2 sensor control	Bypass ventilation	Humidification
Wall mount		○				
Ceiling Cassette		○	○	○	○	
Ceiling Concealed — Standard		○	○	○	○	
With Humidifier		○		○	○	○
With heating and Humidifier 		○	○	○	○	○
Ceiling suspended		○		○		
Floor Standing		○			○	○

1,000 m³/h or less in any product type

Some models in this table do not have the function

(Japanese model information)

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2-2 Technological Trends of ERVs (Static Type) in Japan

Air Volume Control

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Method of air volume control

1) Control of individual products :

- **Constant air volume control** by adjusting motor output (see p. 22)
- **Multi-stage air volume control** (see p. 23)

Easy to adjust the air volume after unit installation. Positive pressure and negative pressure management, etc. Both low power consumption and high static pressure adjustment can be achieved even if the duct is long.

- **Air volume control for energy-saving by connecting CO_2 sensor** (see p. 24-29)

Air volume control by CO_2 concentration level. Because it is a decentralized system, each unit can be operated according to detected CO_2 concentration of each location individually. By using a smart switch and extra sensor, it is possible to control airflow rate by the CO_2 concentration at any position.

2) Control of multiple products :

- **System controller** makes the airflow rate change, turn on/off, in each multiple unit.

Several hundreds of AC units and ERV can be controlled.

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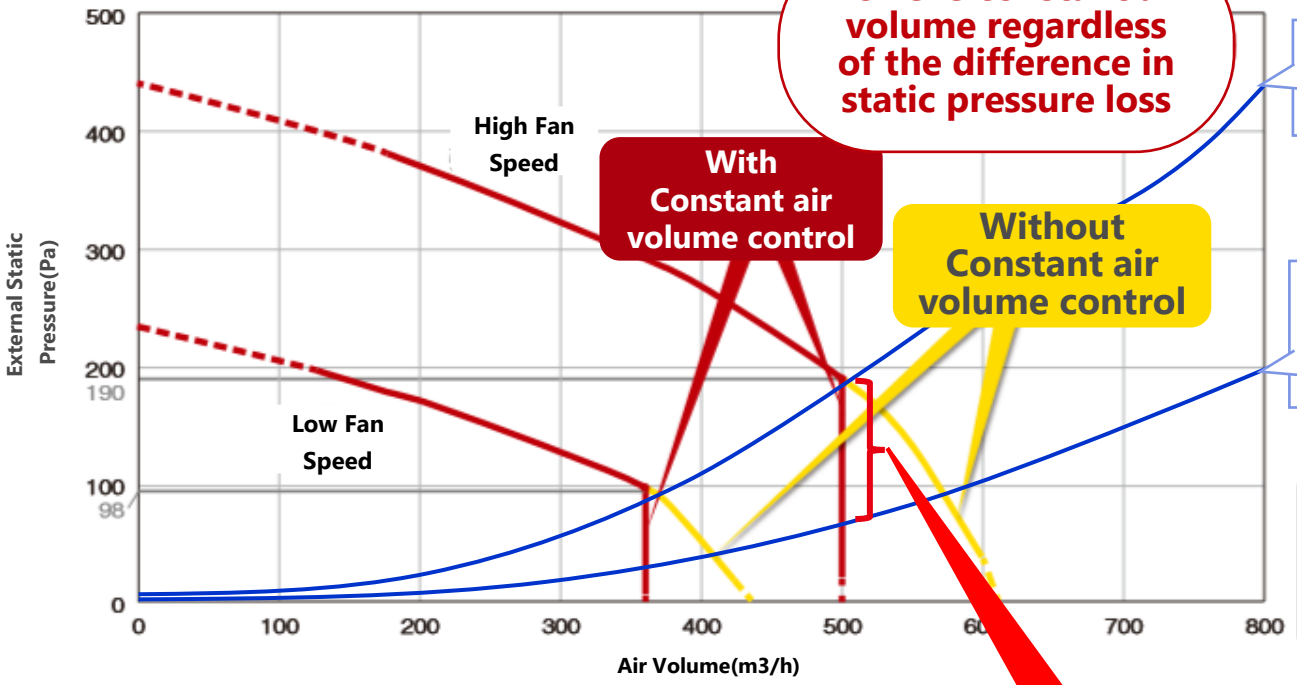
Constant air volume control

Automatically adjusts the ventilation air volume against static pressure loss **to ensure the air volume required by the design.**

By reducing the time and effort of adjusting the air volume at the site during installation, ERV contributes to the installer's upper limit on working hours starting in April 2024.

Example: Model LGH-N50RXW



*The dashed line is a reference value.
(JIS B 8628: 2017 Test method outside the stipulations)

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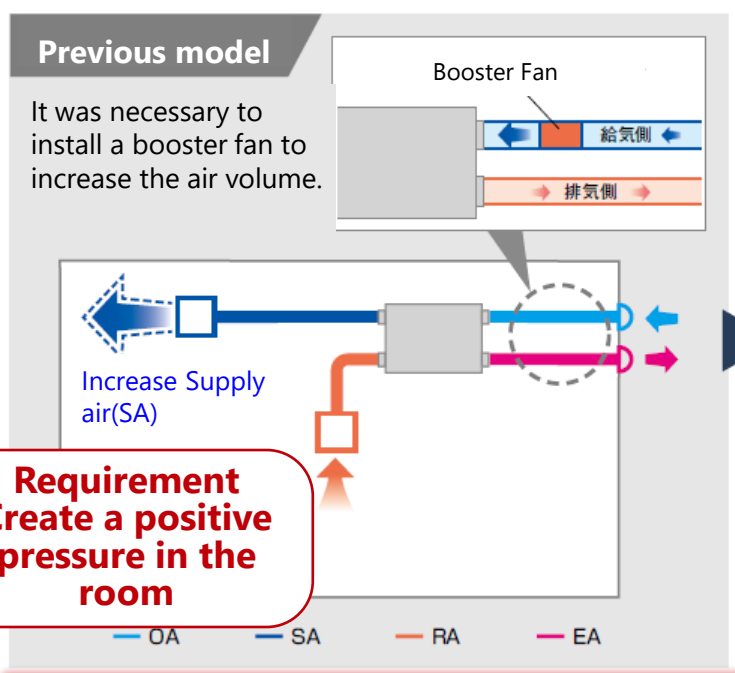
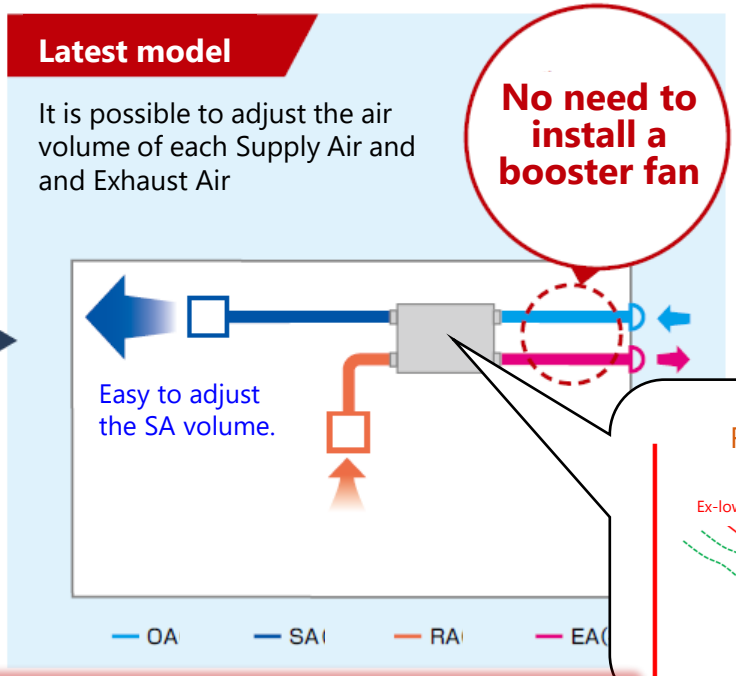
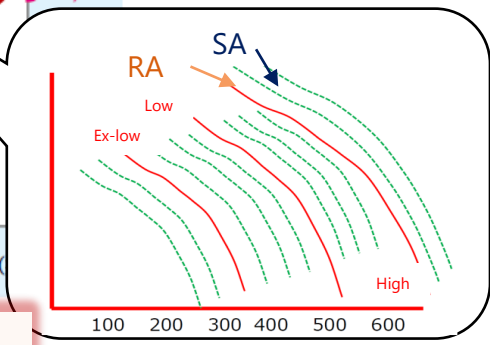
Multi-stage air volume control

Detailed settings such as adjustment of the air pressure balance in the room space are possible.

1) It is possible to select from eleven levels of ventilation air volume and set to 3 fan speeds (High, Low, Extra-Low).
2) It is possible to adjust the ventilation air volume of each supply air and exhaust air and tune the air pressure balance.







Ex. Requirement
Create a positive pressure in the room

Installation and adjustment of booster fans and dampers were required
⇒ **Easier to install and adjust as it is no longer needed**

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Example of high school in Hokkaido (Sapporo)

CO_2 concentration on ventilating by opening the door between classes

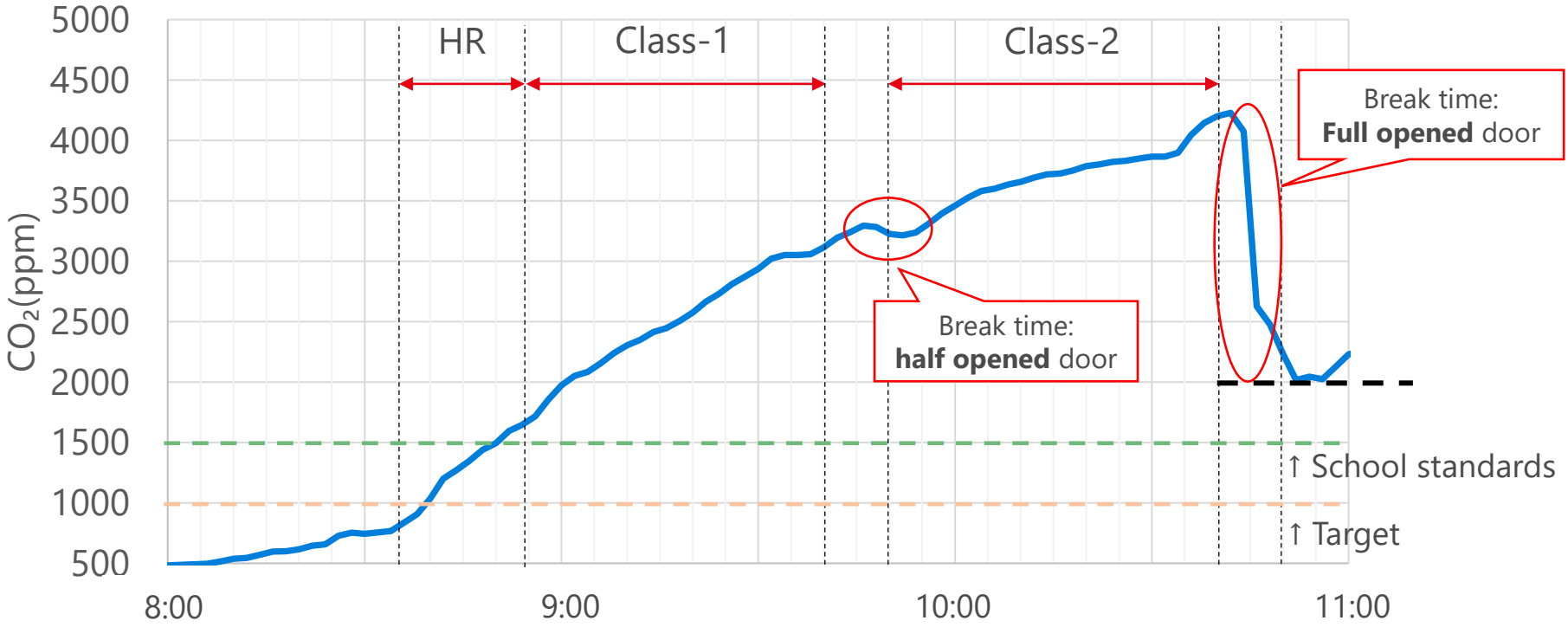

Fig. Change of CO_2 concentration in the classroom (28.January.2021. 33 students)

CO_2 concentration of **2,000 ppm** even when the door is opened.

⇒ **Clearly lack of ventilation**.

… because The door and windows are hard to open due to the **snow and cold climate**,
The number of **teachers and students cannot be reduced**. ⇒ **CO_2 concentration rises**

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Example of Nightclub in Tokyo (Ginza)

CO_2 concentration when the number of guests had been limited by reducing seats due to COVID-19

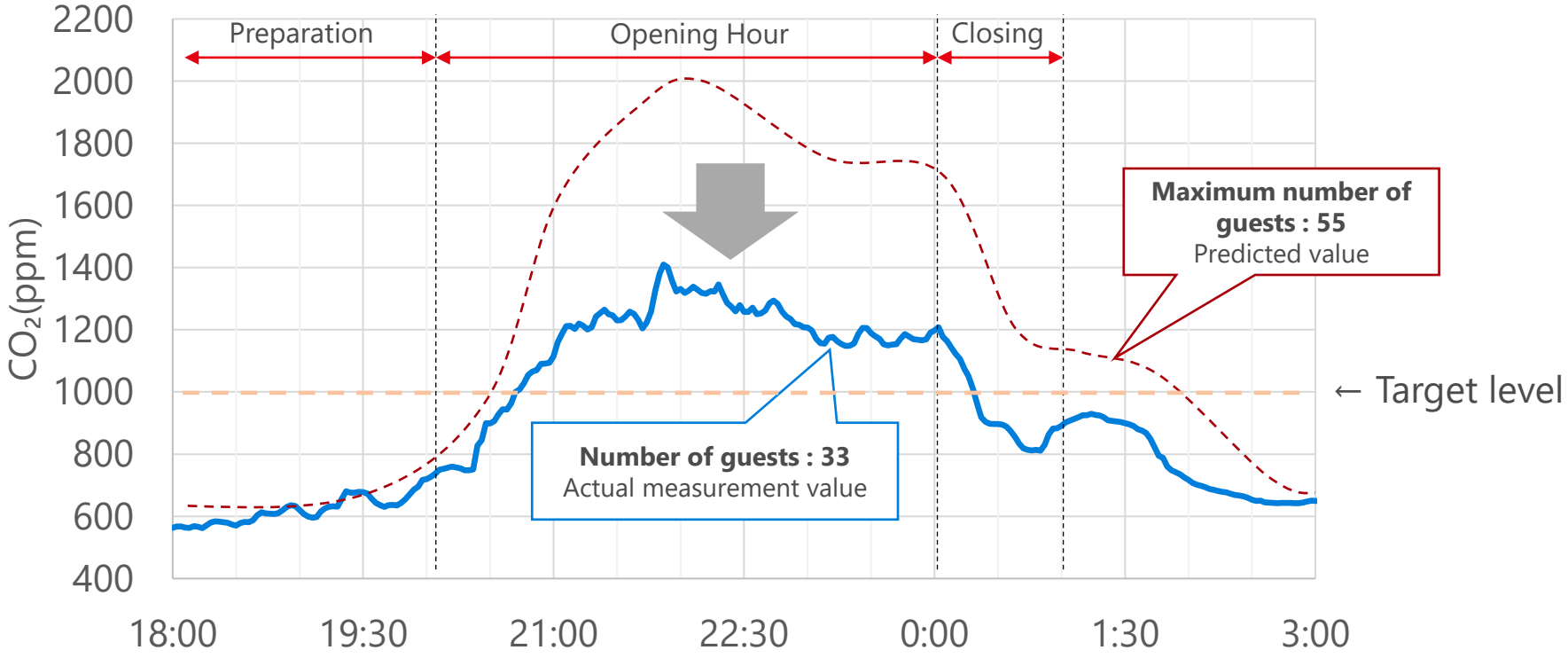

Fig. change of CO_2 concentration inside the shop (7. August. 2020)

CO_2 concentration of **1,400 ppm** even if the number of people is limited
⇒ It is necessary to **adjust the ventilation volume while monitoring the CO_2 concentration**

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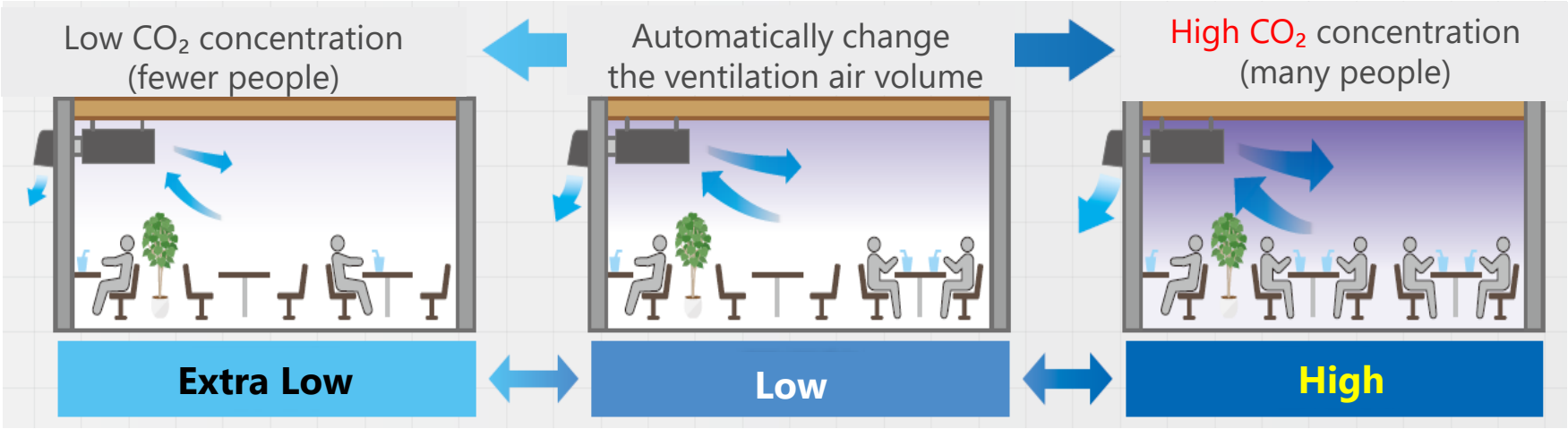
Air volume control for energy-saving by connecting CO_2 sensor

Realizes **energy-saving operation by adjusting the ventilation air volume in conjunction with the CO_2 sensor**

- It is assumed that **the number of workers in the office will decrease** as telework and satellite offices become common.
- By **minimizing the amount of outside air intake** according to the indoor CO_2 concentration, the **air conditioning load is reduced, and energy is saved**.



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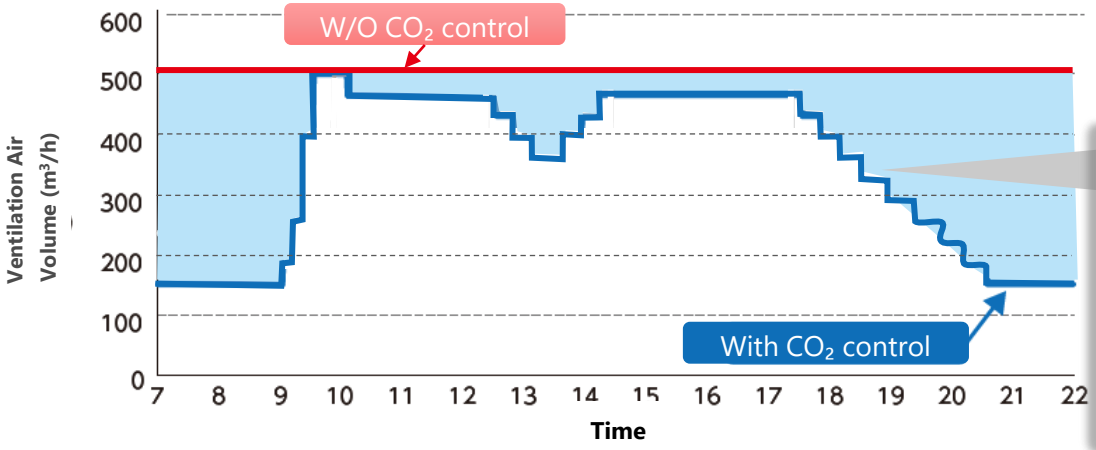
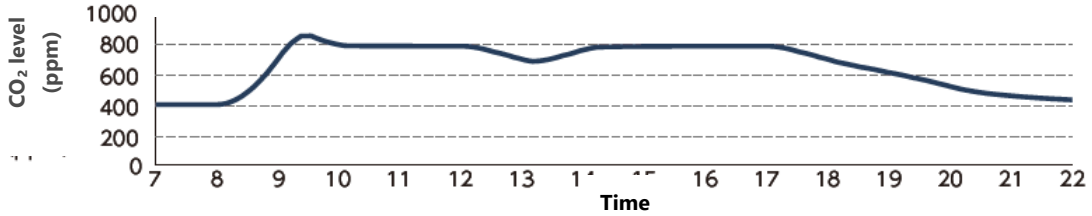
Air volume control for energy-saving by connecting CO_2 sensor

Result of ventilation air volume of ERV by changing indoor CO_2 concentration (Calculated)



Air volume can be adjusted in 11 steps automatically according to the indoor CO_2 concentration.

*** When the CO_2 sensor specified by Mitsubishi Electric is installed (target CO_2 concentration is set to 1000PPM)**



Calculation condition

Indoor and Outdoor Air Conditions

	Summer	Winter
OA	35℃ 75.3%	5℃ 71.9%
RA	27℃ 52.8%	20℃ 58.9%

Time and operating conditions for Air Conditioning and Ventilation(ERV)

Time	Air Conditioning	ERV(Previous model)	ERV(Latest model)
		CO_2-Sensor connected	
8:00-20:00	ON	Variable air volume by detected CO_2 level (Fan speed:3 steps, Automatic learning : OFF)	Variable air volume by detected CO_2 level (Fan speed:11 steps)
20:00-8:00	OFF		

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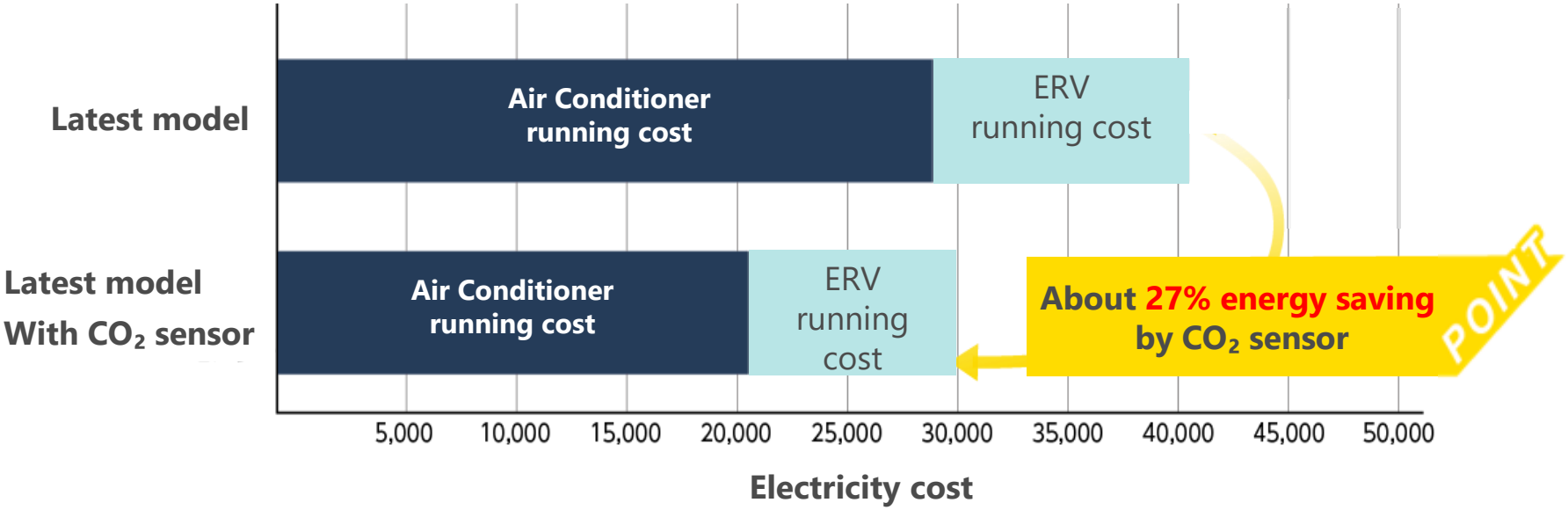
Air volume control for energy-saving by connecting CO_2 sensor

Calculation of Cost of electricity in AC and ERV <Ceiling concealed type>



Air volume control by using CO_2 sensor not only **saves the ERV operating power input,** but also **reduces the air conditioning load by improving energy exchange efficiency of ERV and minimizing the amount of outside air intake.**

Calculation condition
- Target room size 243㎥ (≒9.5x9.5x2.7m)
- Maximum number of people in the room: 12 (occupancy rate 67% for 18 people calculated based on the standard number of people of 5㎡/person)
- Seasonal days and temp and humid conditions: Summer: 3.5 months (75 weekdays, 32 holidays), Winter: 3 months (60 weekdays, 30 holidays)
- Equipment information: Air-Conditioner: Heating COP 3.6, Cooling COP 3.19, ERV LGH-N50RVX x 1 unit
- Ventilation frequency: 2.1 [times/h] (at maximum fan speed) ・Target CO_2 concentration setting: 1000ppm ・Electricity cost: 27 [¥/kWh]

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Visualization of the effect of air volume control

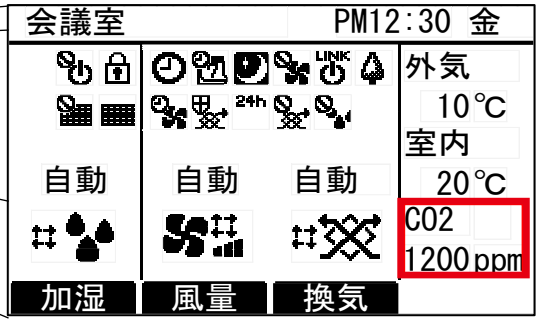
Display the indoor CO_2 concentration due to visualize the effect of air volume control

On the remote controller

<ERV remote controller>

(PGL-62DR2)

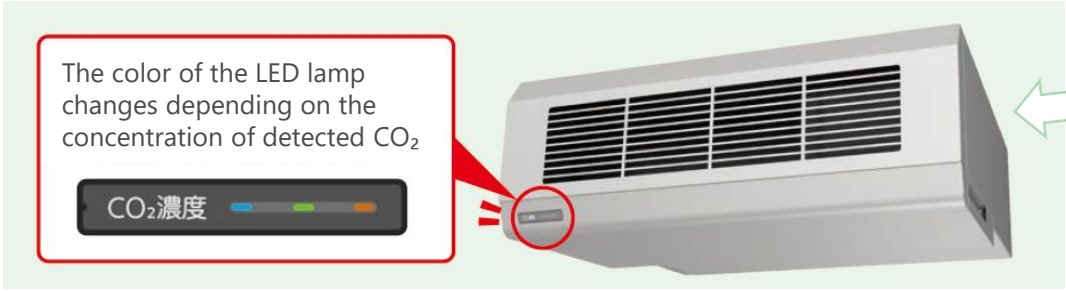
<CO_2 indication image>



On the smartphone or tablet*

*When using the "smart switch" and setting the IoT linkage function

On the product indicator



(SKU-40EXC)

(Japanese model information)

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2-3 Technological Trends of ERVs (Static Type) in Japan

Multiple unit control/network

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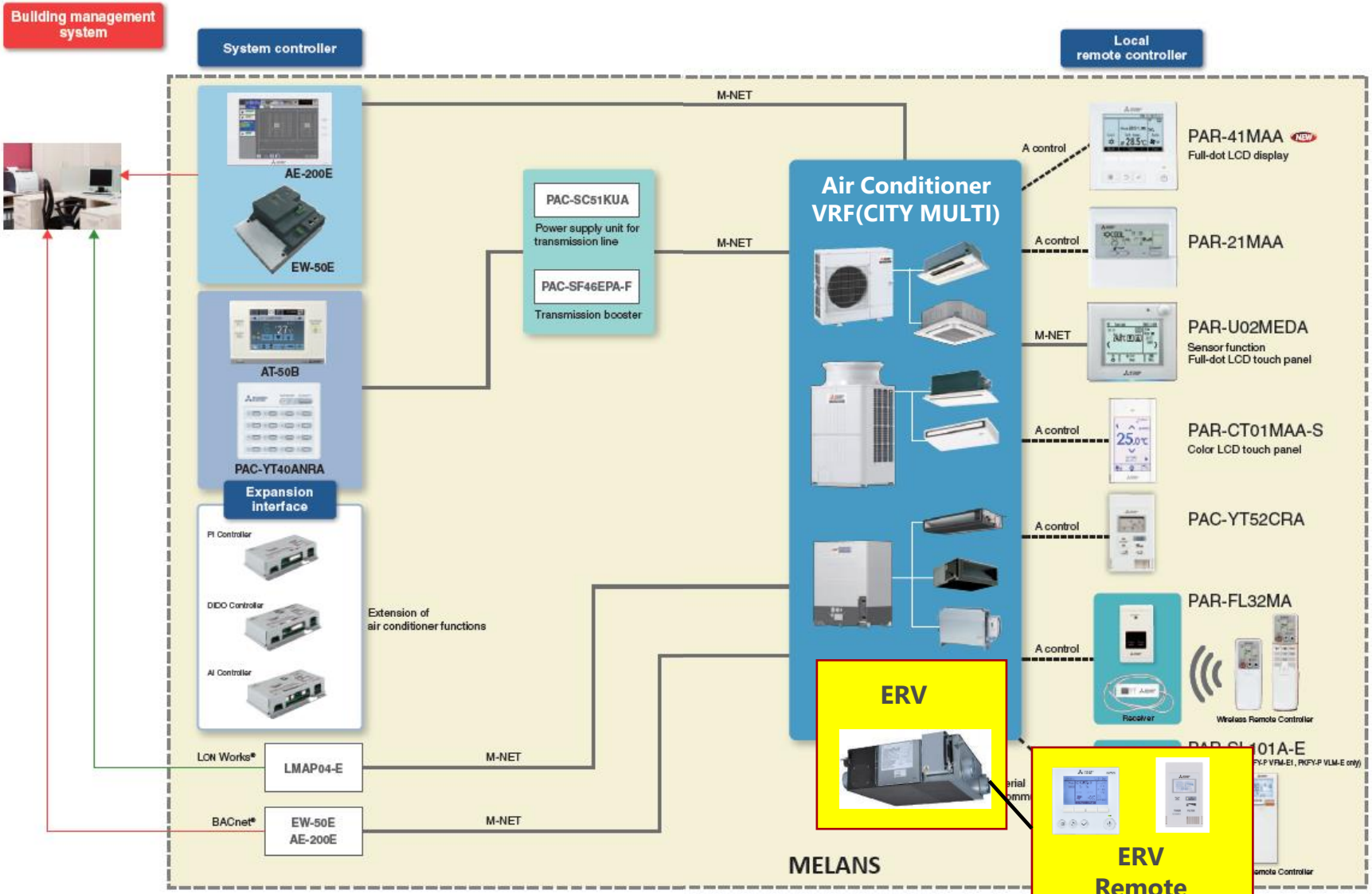
MITSUBISHI ELECTRIC
Changes for the Better

Mitsubishi Electric unique transmission network(M-NET)



(Export model information)

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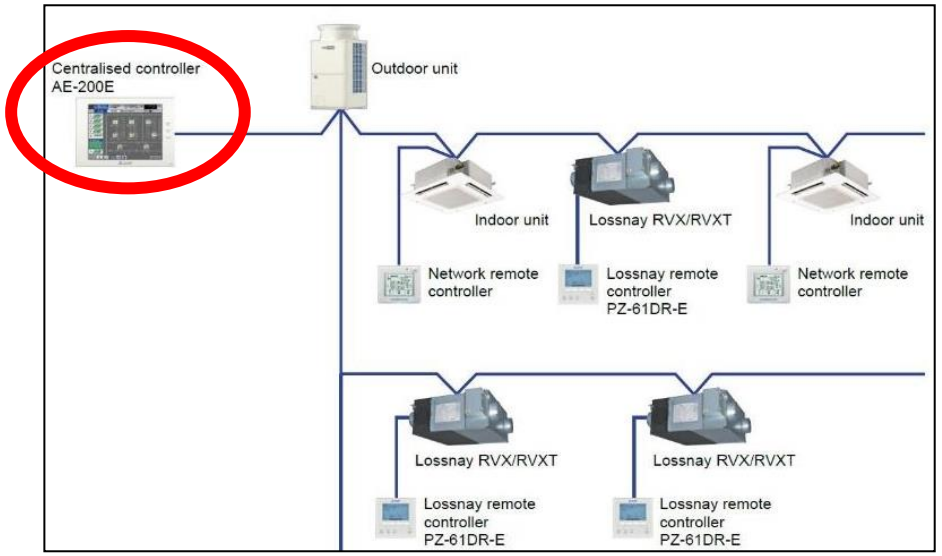
Using system controller to make the airflow rate change in multiple products

AE-200 (System controller)

- Up to 200 AC-indoor units and ERV can be managed (when using 3 units of EW-50J)
- With the built-in web server function, it is also possible to manage from a PC
- Functionality can be expanded with a license (option)
- E-mail notification is possible when an abnormality occurs
- Yearly/weekly schedules are provided as standard

< Points >

- Visualize the wasteful operation of air conditioners with the energy management function
- Using an extension controller, it is possible to manage air conditioning in a wide type of buildings.(from small to medium-sized buildings)



(Export model information)

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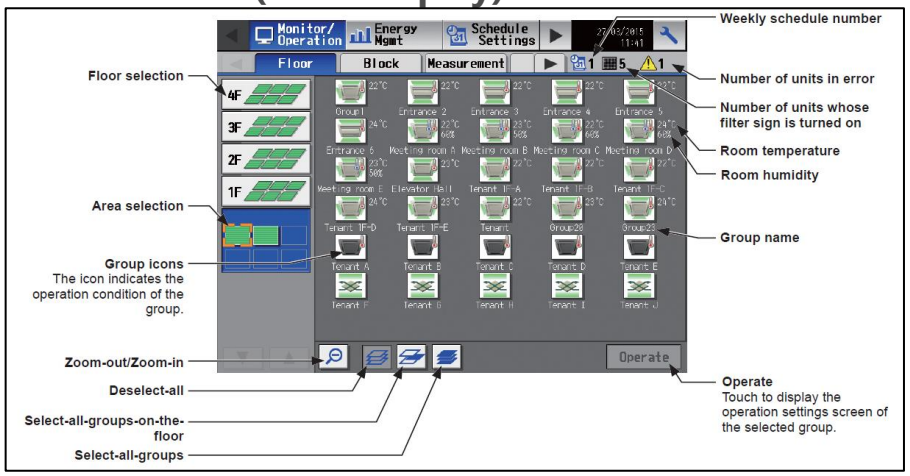
MITSUBISHI ELECTRIC
Changes for the Better

Using system controller to make the airflow rate change in multiple products

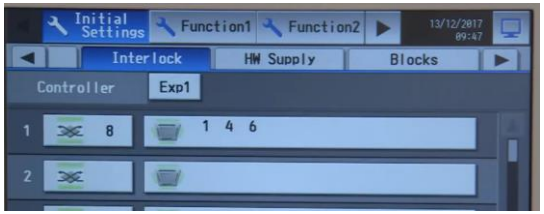
AE-200 (System controller)

Operation screen(Floor display)



Our air conditioners and ERV can be interlocked, so we can respond to details.

ERV interlock initial setting image



Operation setting screen (ERV Interlock)

(1) ERV Interlock

ON	OFF	Error	Interlocked LOSSNAY ON *1 *6	Interlocked LOSSNAY OFF *6

(2) ERV independent (non interlock)

ON	OFF	Error	Schedule set *2	Schedule disabled *2

Energy-saving ON *1	HOLD ON	Night purge ON/OFF *2	Operation suspended *4
		ON (Yellow) / OFF (Gray)*3	

(Export model information)

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2-4

Technological Trends of ERVs (Static Type) in Japan

Interlock control with air conditioners

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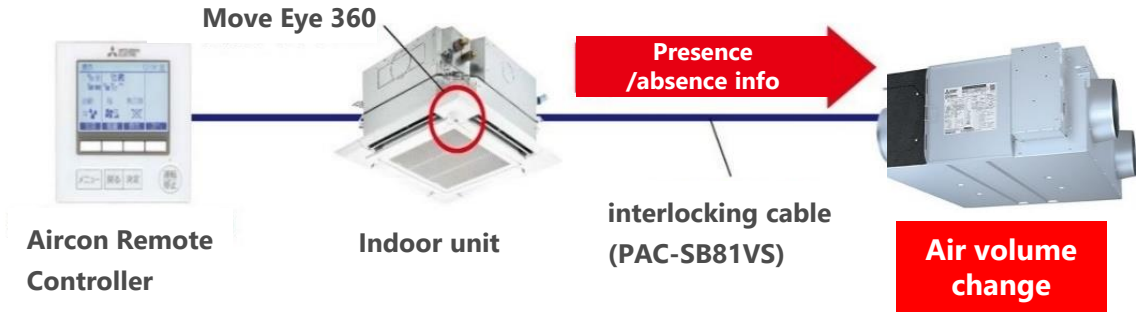
Interlock control with air conditioners

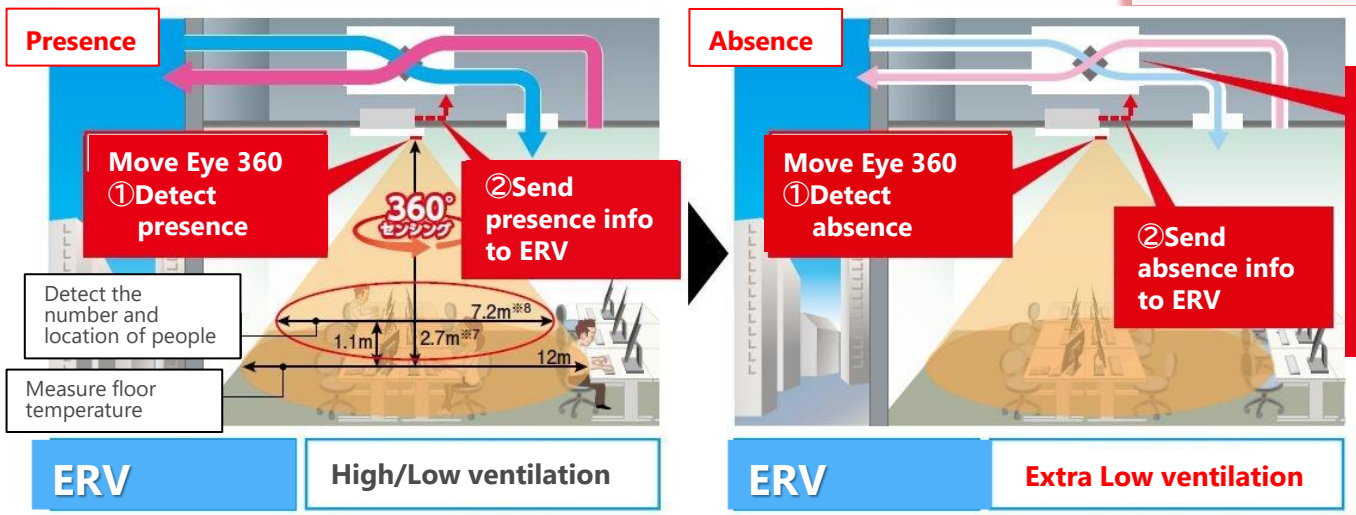
Realizes energy-saving operation by **adjusting the ventilation air volume** in "not crowded" cases by interlocking with the human motion sensor of the air conditioner

In the case of interlocking with Package Air Conditioner



- The motion sensor **"Move Eye 360"** is equipped in our air conditioning indoor unit
- ERV are linked to AC and **automatically Control the ventilation air volume based on the presence /absence of people** in the room

➡ **When no one is present, ERV changes automatically to the minimum ventilation volume (*does not stop)**



③ Extra Low fan speed control by continuously receiving ERV absence signals for a set time or longer
***Settings can be changed in units of 10 minutes from 10 minutes to 60 minutes.**

*Move Eye: A sensor that determines the presence of people in a room by detecting their position and movement.
Registered trademark of Mitsubishi Electric <Export model: i-see sensor>

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2-5 Technological Trends of ERVs (Static Type) in Japan

Installation/Maintenance

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Facilitate adjustments and setting changes after unit installation

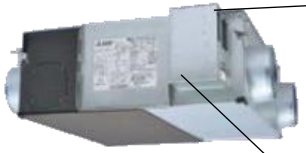
Even **after the ERV is installed, you can select and operate the air supply and exhaust air volume** from a maximum of eleven levels by using the ERV Remote Controller (PGL-62DR).

⇒ **No need to access the ERV unit**

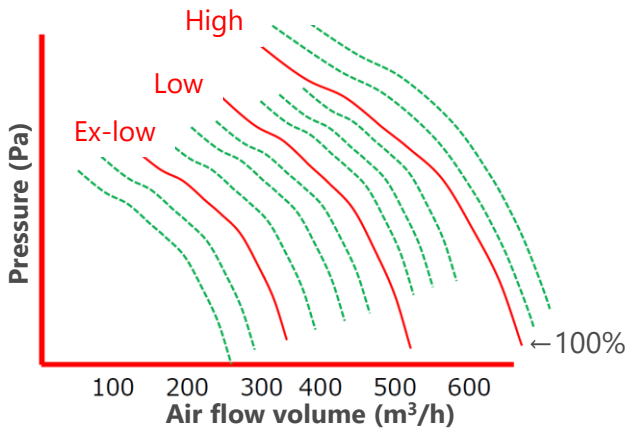
Detailed fan speed adjustment

It is possible to change 3 air volume (High Low Extra-Low) from the main operation screen.

The air volume of each of the 3 speed can be adjusted in 7% increments on the dedicated air volume setting screen.



Conventional ERV was set by the DIP switch on the circuit board in the product.



(Japanese model information)

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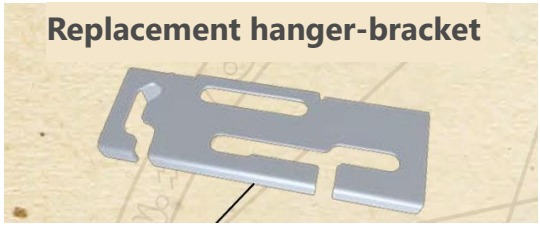
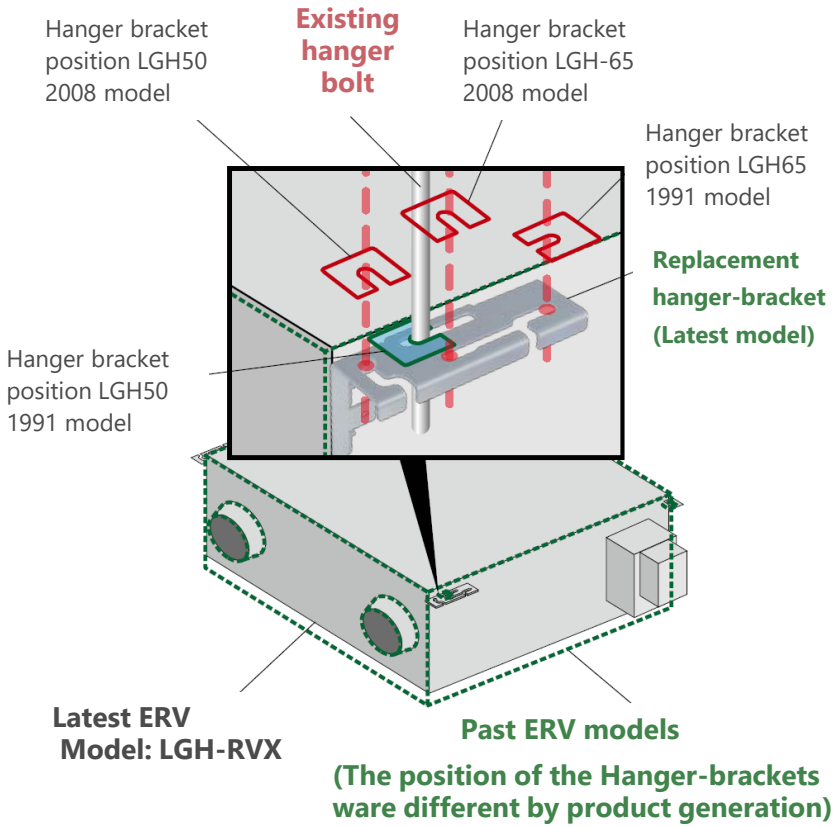
Hanger bracket for replacement

It has been 50 years since we launched our ERV, and it has been adopted in many buildings.

Equipped as standard with replacement hanger-brackets that can be connected to existing hanger bolts (right figure).
It reduces the on-site installation work such as anchor re-drilling, enabling cost reduction and shortening of the installation period.





General life of building : **50 to 100 years**
Expected life of ERV : **13 years** (depreciation years)
⇒ **ERV maybe replace at least once or twice during the life of the building**

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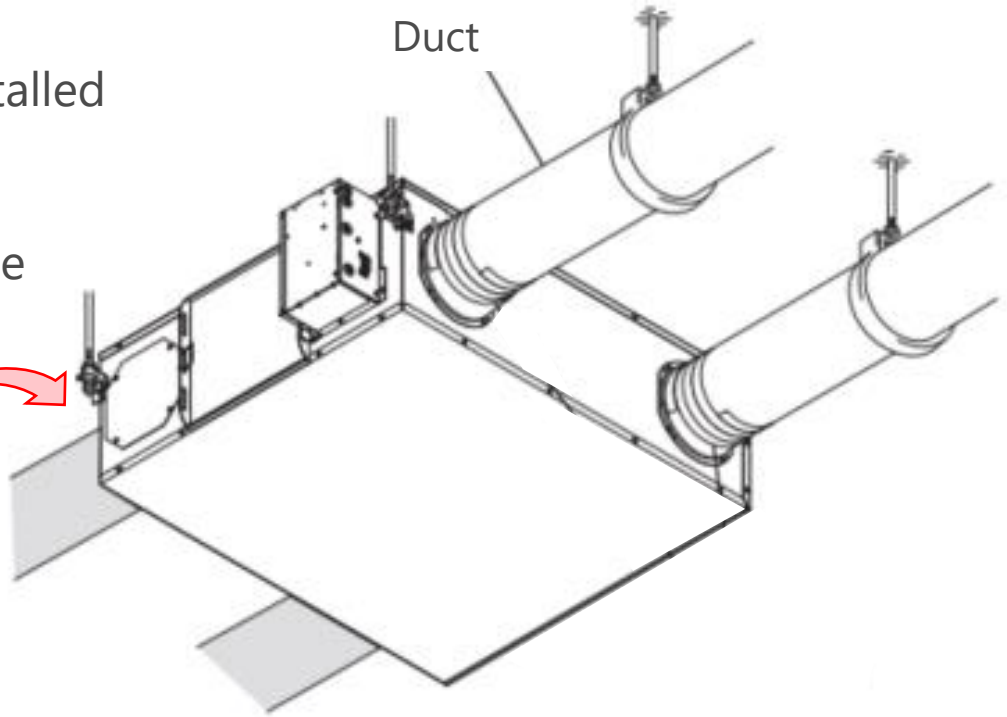
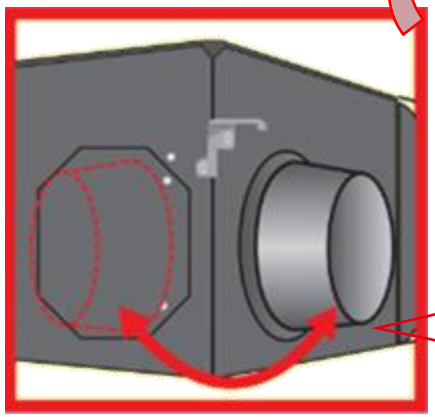
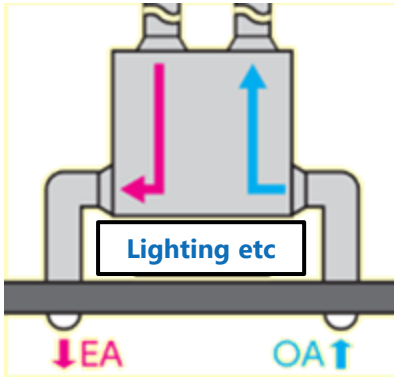
Duct direction change

When ventilation equipment is installed in the ceiling, other products (lighting, air conditioner) may be installed on the route of the ventilation duct.





The **duct direction of OA and EA can be changed** from the product



Avoid installations where the ducts would be blocked by lighting or air conditioning units.

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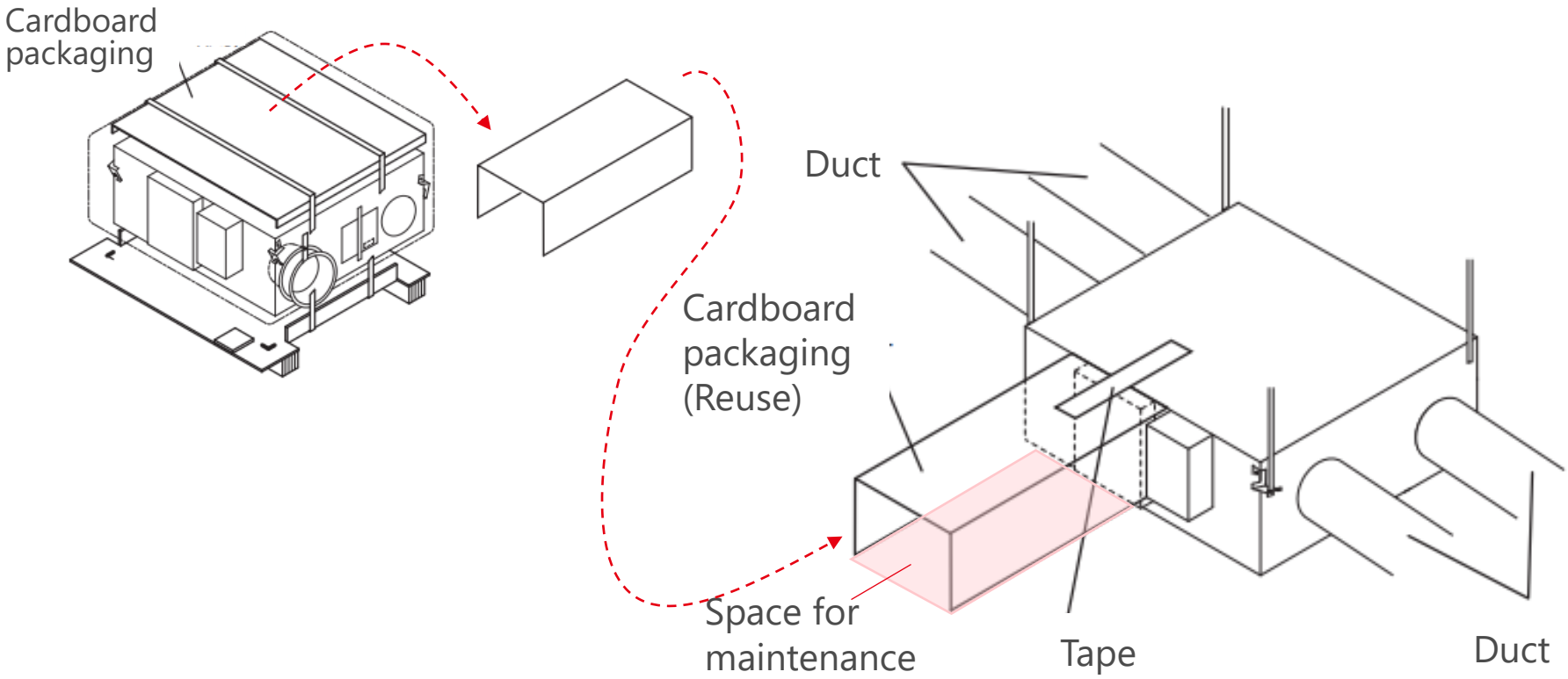
Keep the maintenance space using cardboard (Reuse)

When ventilation equipment is installed in the ceiling, **the space for maintenance may be unintentionally blocked by installation of ducts or other equipment.**



The cardboard packaging of the product can be used as a jig for securing maintenance space during construction (Reuse)

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Gas Transfer

7. Transmission Rate of Various Gases and Maximum Workplace Concentration Levels

Measurement Conditions	Gas	Air Volume Ratio Q_{SA}/Q_{RA}	Exhaust Air Concentration C_{RA} (ppm)	Supply Air Concentration C_{SA} (ppm)	Transmission Rate (%)	Max. Workplace Concentrations* (ppm)
Measurement method • Chemical analysis with colorimetric method for H_2SO_4 • Ultrasonic method with gas concentration device for CO, SF_6 • Infrared method with gas concentration device for CO_2 • Gas chromatography for others The fans are positioned at the air supply/exhaust suction positions of the element Measurement conditions: 24°C, 85% RH * OA density for CO_2 is 500 ppm.	Hydrogen fluoride	1.0	36	<0.5	~ 0	2
	Hydrogen chloride	1.0	42	<0.5	~ 0	
	Nitric acid	1.0	20	<0.5	~ 0	
	Sulfuric acid (H_2SO_4)	1.0	2.6 mg/m³	~ 0 mg/m³	~ 0	5
	Trichlene	1.0	85	1.36	1.6	25
	Acetone	1.0	5	0.04	0.8	500
	Xylene	1.0	313	<5.0	<1.6	50
	Isopropyl alcohol	1.0	3,000	<25	<0.8	200
	Methanol	1.0	41	0.49	1.2	200
	Ethanol	1.0	35	0.49	1.4	
	Ethyl acetate alcohol	1.0	25	0.28	1.1	200
	Ammonia	1.0	290	7.25	2.5	
	Hydrogen sulfide	1.0	15	0.24	1.6	5
	Carbon monoxide (CO)	1.0	71.2	0.43	0.6	
	Carbon dioxide (CO_2)	1.0	37,800	600	0.3	
	Formaldehyde	1.0	32	0.3	0.9	
	Sulfur nexafluoride	1.0	116	0.8	0.7	
	Toluene	1.0	6.1	0.1	1.7	50

*Refered from the announcement No.369 of Ministry of Health, Labour and Welfare on 1st October 2004.

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Humid recover etc

(2).Energy Recovery Calculation (Winter Example); LGH-100RVX-E

Supply Air	Lossnay ERV	Sensible HRV	General Fan
D.B. (°C)	16	16	0
A.H. (g/kg)	5.2	1.9	1.9
R.H. (%)	46	17	50
Enthalpy (kJ/kg)	29.2	21	4.7
Recovered heat (kW)	8.2	5.5	0
OA load (kW)	3.1	5.8	11.3
OA load ratio (%)	27	51	100

Indoor Unit of Air-Conditioner

Indoor Air

D.B.	**20°C**
A.H.	7.3(g/kg)DA
R.H.	50%
Enthalpy	38.5(kJ/kg)DA

Exhaust Air

Temp. efficiency: 80%
Enthalpy eff. (Heating): 72.5%
Ventilation rate : 1,000m3/h

Outdoor Air

D.B.	**0°C**
A.H.	1.9(g/kg)DA
R.H.	50%
Enthalpy	4.7(kJ/kg)DA

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Humid recover etc

(1).Energy Recovery Calculation (Summer Example); LGH-100RVX-E

Supply Air	Lossnay ERV	General Fan
D.B. (°C)	27.4	33.4
A.H. (g/kg)	13.5	22.2
R.H. (%)	59	68
Enthalpy (kJ/kg)	61.9	90.5
Recovered heat (kW)	9.5	0
OA load (kW)	3.9	13.4
OA load ratio (%)	29	100

Air-Conditioner

Indoor Air

D.B.	**25°C**
A.H.	9.9(g/kg)DA
R.H.	**50%**
Enthalpy	50.2(kJ/kg)DA

Exhaust Air

Temp. efficiency: 71.5%
Enthalpy eff. (cooling): 71.0%
Ventilation rate : 1,000m3/h

Calculation example
27.4℃
=33.4℃- (33.4℃-25℃) × 71.5%

Outdoor Air

D.B.	**33.4°C**
A.H.	**22.2(g/kg)DA**
R.H.	**68%**
Enthalpy	90.5(kJ/kg)DA

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Optional Filter lineup

Standard filter
PZ- RF8-E

(This filter is originally equipped in the Lossnay)
- Optional parts as replacement
- Washable & cleanable
- Clean once a year or every 3,000 hrs

- Filtration specifications
  EN779(2012): G3
  ISO 16890: Coarse 35%

High efficiency filter
PZ- RFM-E

- Optional parts
- Disposable
- Replace once a year or every 3,000 hrs

- Filtration specifications
  EN779(2012): M6
  ISO 16890: ePM10 75%

Advanced High efficiency filter
PZ- RFP2-E(New)

- Optional parts
- Disposable
- Replace when clogging.
  *For detail refer to next page.

- Filtration specifications
  ASHRAE 52.2-2017: MERV16
  ISO 16890: ePM1 75%,
  ePM2.5 80%,
  ePM10 95%
  GB/T14295-2008: YG class, 99.7%
  (Collecting efficiency for particles that are 0.5μm or larger at rated airflow)

*Filtration specifications are results of tests conducted by third-party and are not guaranteed values.

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Maintenance

Standard-Filter and Core Maintenance

STEP 1. Freq. Once a year/ Every 3,000 hr

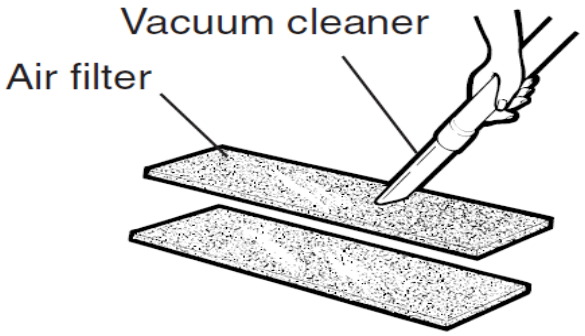
-Use a vacuum cleaner to remove dusts on the surface.

-To remove persistent dirt, wash with mild solution of detergent and warm water (Under 40 °C).

CAUTION

-Refrain from washing the filters with water over 40 °C and scrubbing them.

-Do not expose them to flame when drying.



STEP 2. Freq. Once every 2 yrs/ Every 6,000 hr

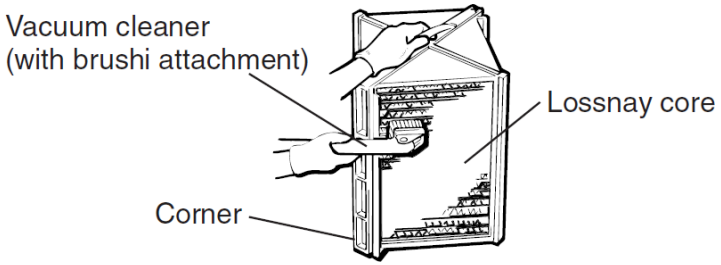
-Use a vacuum cleaner and a soft brush to remove dusts and dirt on the surface of the Lossnay cores.

CAUTION

-Refrain from using a hard nozzle of the vacuum cleaner. It may damage the surfaces of the Lossnay cores.

-Lossnay cores should not be washed in water.

Do NOT wash in water.



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