



Perfecting the Air

## **Carbon Neutrality Solution:**

**Healthy and Energy Efficient Air Conditioning(AC) system for ASEAN market**



July 23, 2024

## Daikin is Comprehensive Air Conditioning(AC) Manufacturer

Company name	Daikin Industries, Ltd.	Founded in <b>1924</b> 100 Years of History	<b>People-Centered Management</b>
Founded Established	October 25, 1924 (Founder : Akira Yamada) February 11, 1934		
Chairman President	Masanori Togawa (Chairman and CEO) Naofumi Takenaka (President and COO)	<b>100+</b> Production Bases In the World	<b>¥4.4 trillion</b> Overall Sales
Capital	85 billion Yen (FY2023)		
Employees	98,162	Business Development in <b>170+</b> Countries	<b>84%</b> of Daikin Sales are from outside Japan
Annual Sales	4.4 trillion Yen (FY2023)		
Group Companies	349 Consolidated Subsidiaries (31 in Japan, 318 overseas)	<b>Comprehensive AC Manufacturer</b> handling both AC and refrigerants	<b>98,000+</b> Employees
Head Office	Osaka, Japan		

PICHOONKUN





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## Agenda

- 1. Look back activity at CEFIA**
- 2. Update the verification result in Thailand**
- 3. Expand to Vietnam**
- 4. Summary**


# 1. Look back activity at CEFIA (1) Overview

1. 4<sup>th</sup>, CEFIA, Daikin(DK) proposed “AC-ECP (Air conditioning system with excessive cooling protect)”, as Carbon Neutral Solution and started verification in Thailand.
2. 5<sup>th</sup>, CEFIA, DK reported verification result.
3. AC Webinar in Feb 2024, DK reported “CO2 reduction impact” in ASEAN.
4. Today, in this 6<sup>th</sup> CEFIA, DK update verification result.

4<sup>th</sup> CEFIA  
Feb 16, 2023

**Introduced CN solution**

- ① **Market change after covid 19**  
-Energy consumption increased due to ventilation
- ② **Excessive cooling culture in ASEAN**  
-AC temp. setting is too low




ex:23 °C wearing jacket

**-Proposed “AC-ECP”.**  
**Started verification in Thai**

5<sup>th</sup> CEFIA  
Aug 25, 2023

**Reported result (1)**

- ① **Digest result**  
-Energy/CO2 reduction  
-Comfort by **ASHRAE std 55**



**CEFIA Webinar**  
Feb 15, 2024

**Reported result (2)**

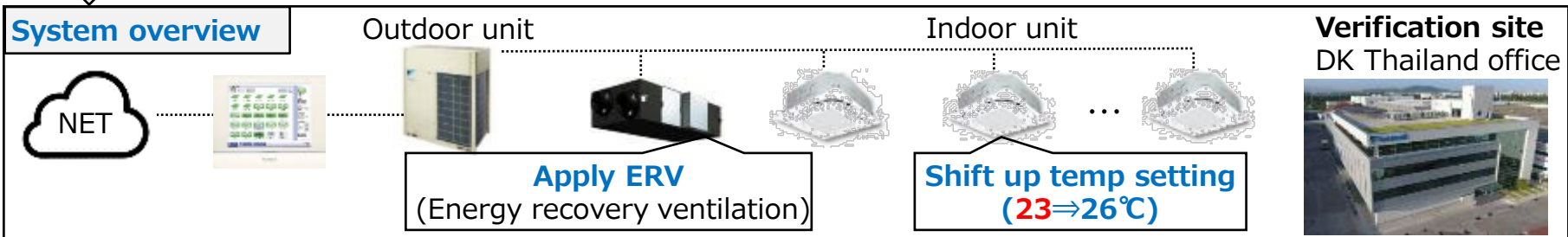
- ① Further energy reduction  
-CO2 demand control
- ② **CO2 reduction impact in ASEAN**

6<sup>th</sup> CEFIA  
Jul 23, 2024

**Report result (3)**

- ① **Importance of -Building air tightness**  
-Adjusting ERV to meet with target CO2 ppm (1000ppm)
- ② **Expand to Vietnam**

**UPDATE TODAY**

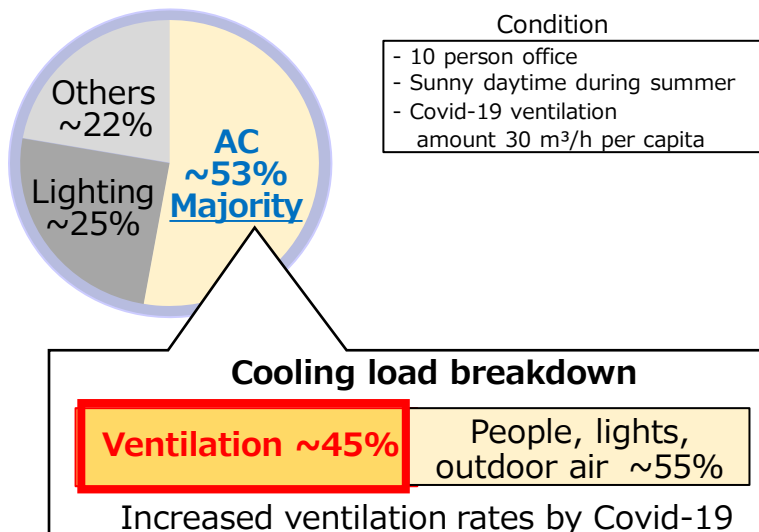


# 1. Look back activity at CEFIA

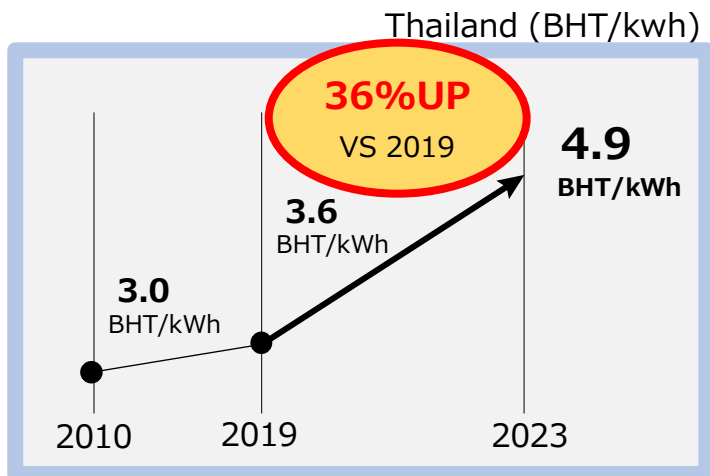
# (2) Market

## 1. Change after covid-19 pandemic

1) Energy consumption of AC is increasing due to the increased ventilation by covid-19

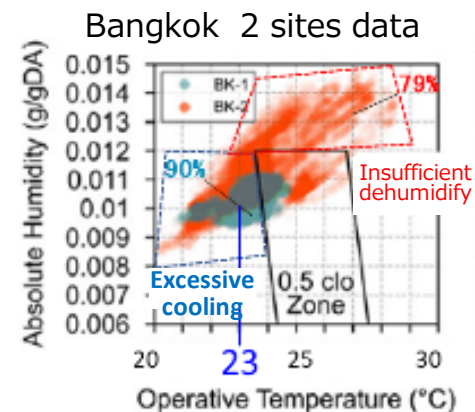
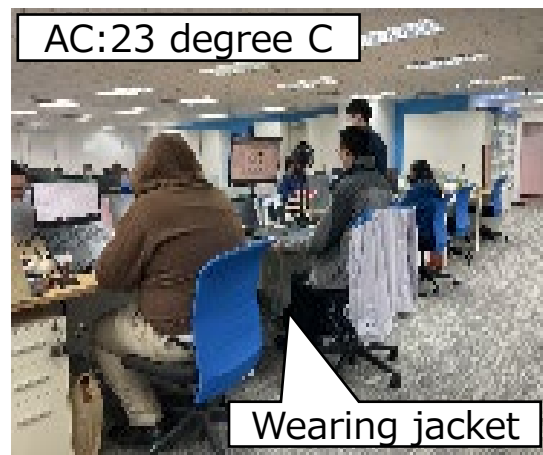


2) Energy bills are also rising due to unstable international situation.

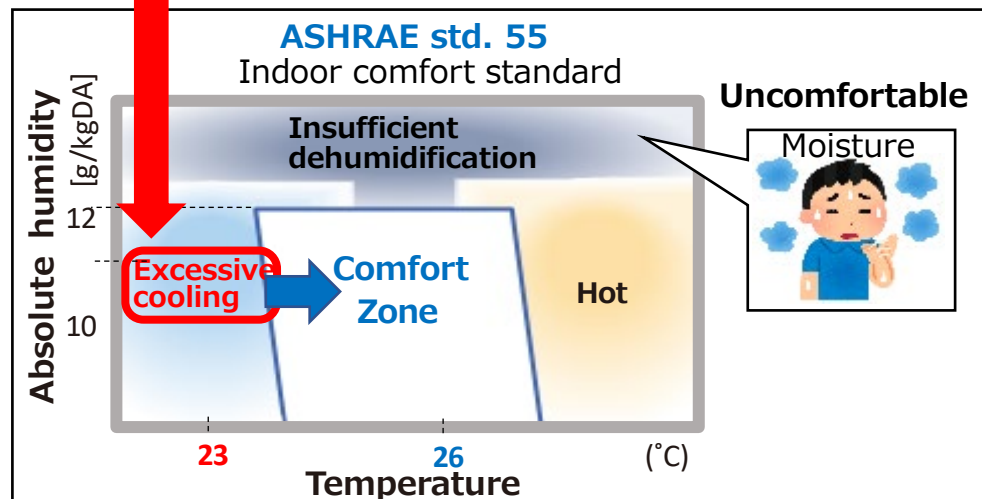


## 2. Excessive cooling culture in ASEAN

1) AC temp. setting is low at office. ex: 23 degree, wearing jacket.  
**If we can change this culture, big energy saving is achieved.**

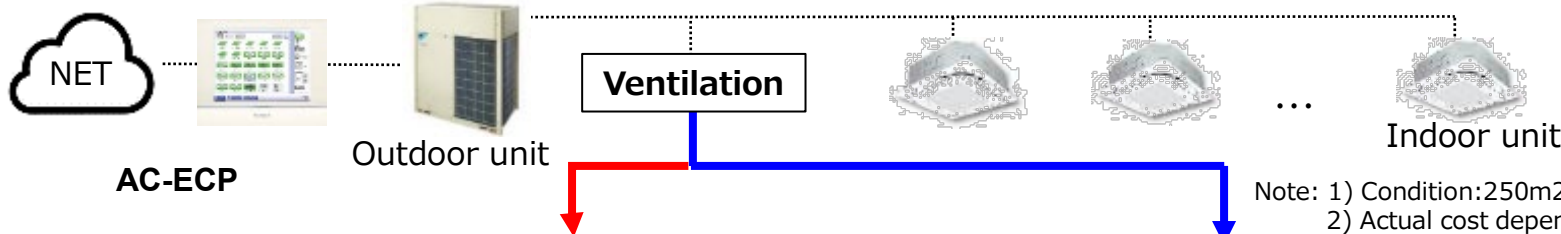


Source  
 Yuta Fukawa, Ryota Murakami, Masayuki Ichinose, Field study on occupants' subjective symptoms attributed to excessive cooling environments in air-conditioned offices in hot and humid climates of Asia, Build. and Environ. 195 (2021) 2,5.



# 1. Look back activity at CEFIA (3) "AC-ECP" as CN Solution

- Promote ventilation and AC that can simultaneously achieve energy saving and comfort.
- Replace normal ventilation with **energy recovery ventilation, ERV**, reducing the load of heat and moisture from the outside air, making it comfortable even at 26°C degree.



Note: 1) Condition: 250m<sup>2</sup> office area.  
2) Actual cost depends on project site.

	Normal ventilation	AC-ECP		
	No energy recovery	Energy Recovery Ventilation (ERV)		
Ventilation type	System A	System C	System D	System E
<p>Unprocessed outside air is supplied.</p>	<p>Heat exchanger</p>	<p>Heat exchanger Cooling coil</p>	<p>Optimized control AC</p>	<p>-CO<sub>2</sub> demand control -Positive pressure control</p>
AC set temperature	23 °C	26 °C		
Comfort	Excessive cooling	Within ASHRAE std55 comfort zone		
	No	Between NO & YES	Yes	
AC capacity	18 HP	12 HP		
Cost index			Down sizing of AC to almost offset ERV	
Energy	100%	66%	66%	53%
Equipment(AC, Venti)	100%	75%	99%	101%

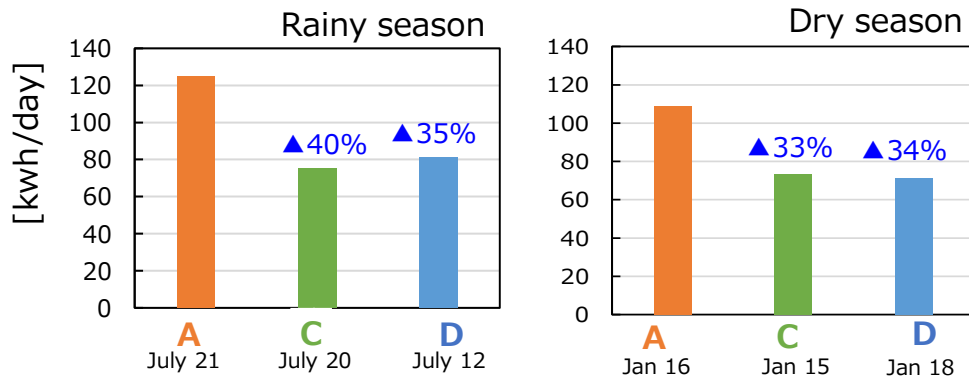


# 1. Look back activity at CEFIA (4) Digest of verification result

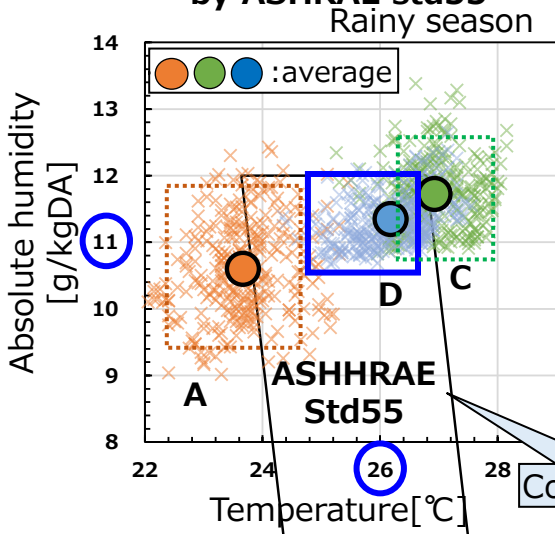
A: Conventional Natural ventilation, C: ERV only, D: ERV with cooling coil

1. Approx 40% of energy was saved in case of proposed "AC-ECP(C&D)" compared to normal ventilation(A).
2. AC-ECP (D) is the most comfortable because,
  - 2-1) No excessive cooling(26C), enough de-humidify(average 11g/kgDA) ⇒ Mostly in ASHRAE comfort zone.
  - 2-2) Questionnaire result is also matching with ASHRAE std55 evaluation.

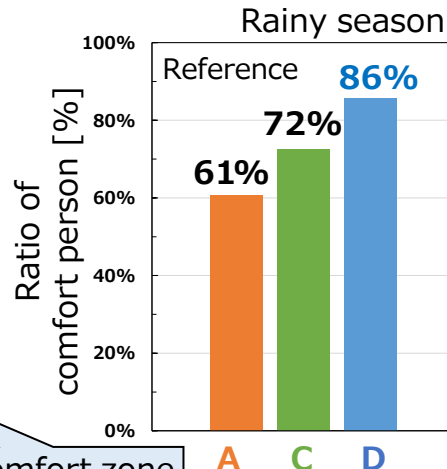
## 1. Energy consumption per day



## 2-1) Comfort zone by ASHRAE std55



## 2-2) Comfort by Questionnaire



## <Ref info>

-Verification site  
Daikin R&D building in Bangkok at 4<sup>th</sup> Floor

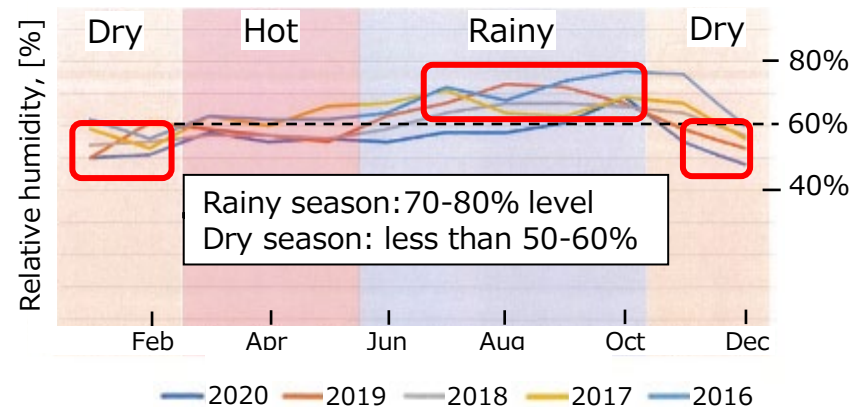
[Target office area]

- Office area: 250m<sup>2</sup>
- Ceiling height: 2.7m
- People: 50~20人

[Sensor location]

- 5 location
- temp, humid, CO<sub>2</sub>

## -Bangkok relative humidity by season



# 1. Look back activity at CEFIA (5) CO2 reduction impact in ASEAN 8

1. "AC-ECP" impact for VRF(※) type AC is estimated roughly,  
 -CO2 emission reduction: **2,700 kt-CO2/year**  
 -Thermal power generator reduction: **27 units**

※VRF: Variable refrigerant flow

Energy source: Natural gas case

	Total VRF stock (2008-2023)		Annual energy consumption
	K unit	K HP	G WH/year
Thailand	217	2,600	3,480
Vietnam	206	2,470	3,300
Indonesia	152	1,820	2,400
Singapore	137	1,640	2,200
Philippines	98	1,180	1,580
Malaysia	82	980	1,320
<b>ASEAN total</b>	<b>892</b>	<b>10,700</b>	<b>14,300</b>

Convert

Number of Thermal power generator		CO2 reduction
Without AC-ECP	With AC-ECP 40% reduction	kt-CO2 /year
unit	unit	
16.6	6.6	663
15.7	6.3	628
11.6	4.6	464
10.5	4.2	419
7.5	3.0	300
6.3	2.5	251
<b>68</b>	<b>27</b>	<b>2,700</b>

Condition

- 1) Total VRF stock: based on Daikin research.
- 2) Annual energy consumption = 16,031kwh/12HP/year.  
 approx. 10hr operation/day x 250day/year
- 2) Central type AC is excluded.

<Remark for impact>

- 1.Coal fuel source: approx. 1.8 times against natural gas case
- 2.Residence market: approx. 4 times bigger



	Thermal power generator
Rated power	50MW/unit
Operation rate	70%
Operated power	35MW/unit





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1. Look back activity at CEFIA

2. Update the verification result in Thailand

### Importance of

① Building air tightness(natural ventilation rate)

② Adjusting ERV to meet with Indoor air quality(IAQ) guideline

3. Expand to Vietnam

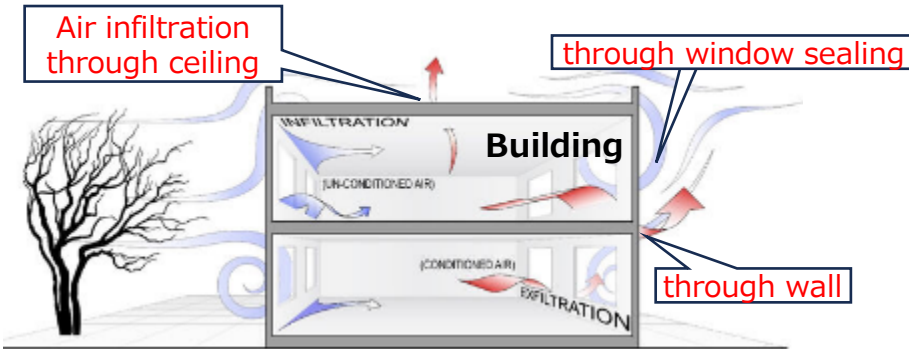
4. Summary

# ① Importance of building air tightness (natural ventilation rate)

## Market research result

- If air tightness on building is not good, **air infiltration occur** through wall, window sealing, etc, resulting in more energy consumption (energy loss).
- Daikin/KMUTT(Univ) made **market research on natural ventilation rate** in Thailand (N=5)  
Result: All the 5 offices are over our benchmark, meaning **air tightness is not enough**.

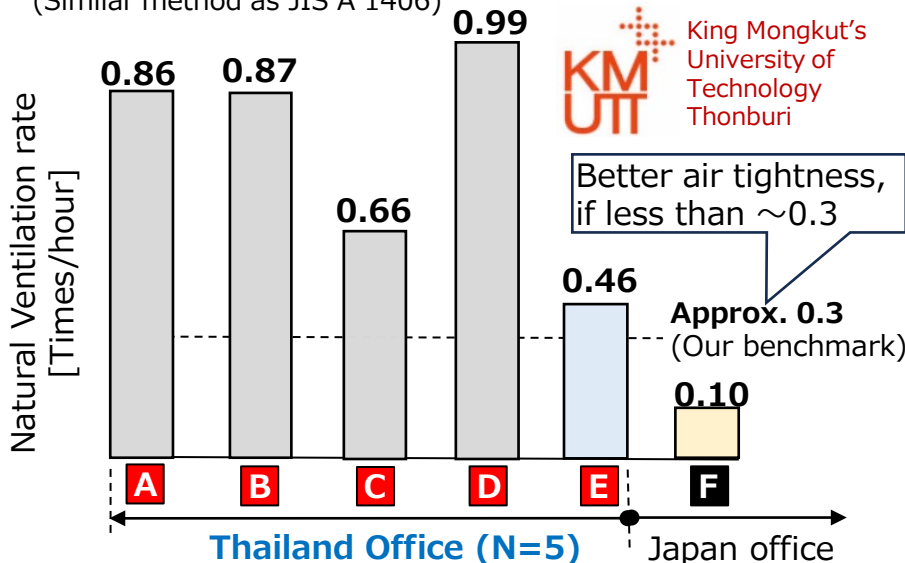
### 1. Air infiltration (Natural ventilation rate)



### 2. Result of market research

#### Natural ventilation rate in typical office building

(Similar method as JIS A 1406)



### <Ref info: Site description>

	Target build. (Office)	Area	Owner	Built year
<b>A</b>	Airport office	Chiang Rai	Gov. & private	1989
<b>B</b>	Bank office	Bangkok		1989
<b>C</b>	Airport office	Phuket	Gov.	1994
<b>D</b>	Kinder garden	Bangkok		1994 renovate 2007
<b>E</b>	R&D office	Bangkok	Daikin	2017
<b>F</b>	R&D office (ZEB)	Osaka, JP	Daikin	2015

### Site photo



# ① Importance of building air tightness (natural ventilation rate)

## Verification & result at Daikin verification Site

- 1. Impact of natural ventilation on energy consumption was verified.  
Method: Change natural ventilation rate by adjusting window opening.
- 2. Result: **As natural ventilation rate increases, energy consumption increases (loss).**  
In case of natural ventilation @0.71: **6% loss**  
@1.00: **13% loss**

### 1. Method

By using DK verification site, adjust window opening to **change/simulate** different natural ventilation rate

Verification site  
DK Thailand office



Test office area has 6 windows

Adjust window opening  
0cm, 0.6cm, 1.0cm



### Relations of window opening and natural ventilation rate

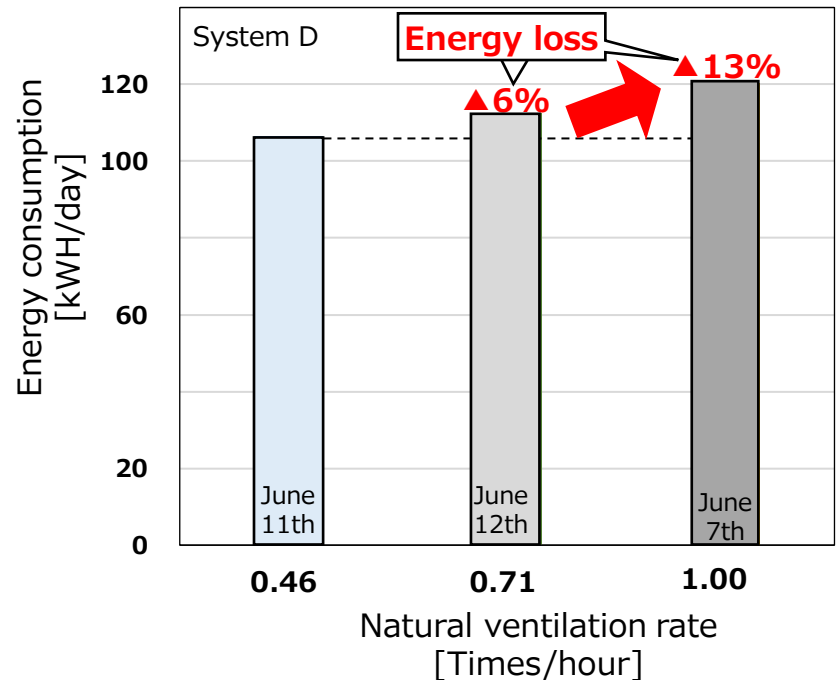
Window opening amount [cm]	Natural vent. rate [times/hour]
0.0 cm (close)	<b>0.46</b>
0.6 cm (open)	<b>0.71</b>
1.0 cm (open)	<b>1.00</b>

(Similar method as JIS A 1406)

### 2. Result

As natural ventilation rate increase, energy consumption increases as shown below.

### Impact of natural ventilation on energy



**Improving building structure to enhance air tightness important**

# ② Importance of adjusting ERV to meet with indoor air quality guideline

## Verification & result

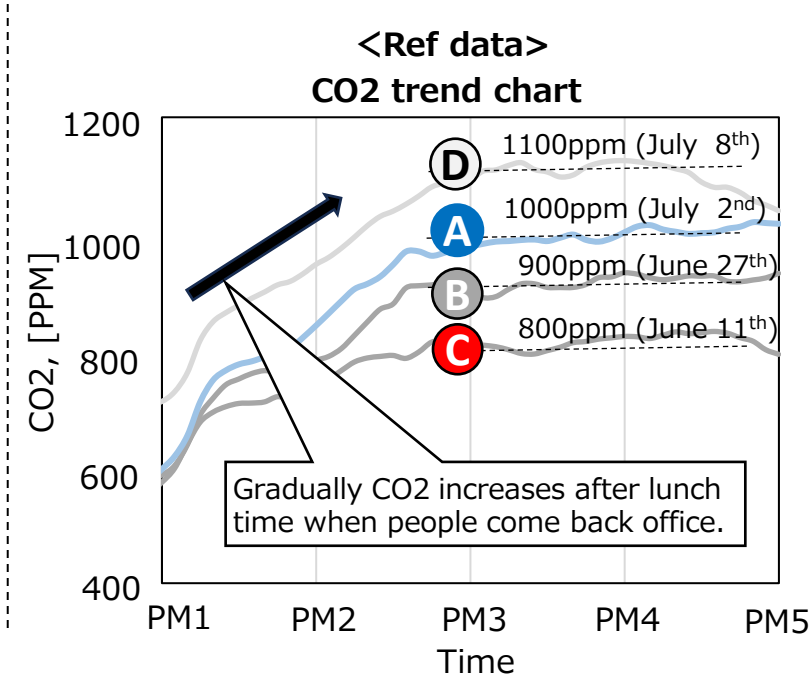
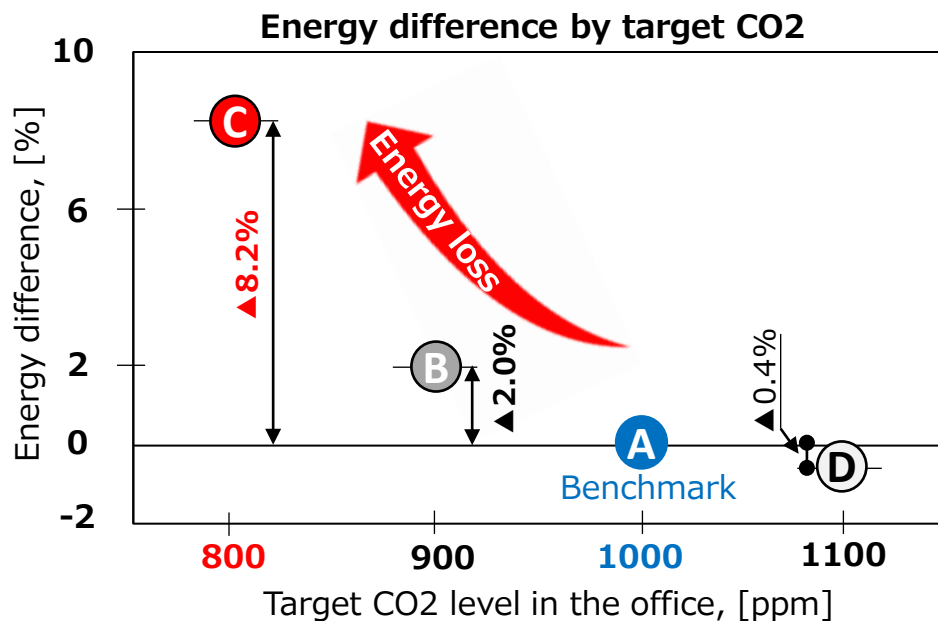
1. Impact of target CO2 concentration on energy consumption was verified.  
Method: Compare target CO2 in the office by changing ERV air volume (H, L, and mix)
2. Result  
In case of **800ppm CO2**, energy consumption **increase by 8.2%**, compared to 1000ppm

### 1. Method & condition

	IAQ guideline (Thailand case)	Verification			
		A (benchmark)	B	C	D
Target CO2 [PPM]	<b>Less than 1000</b>	<b>1000</b>	<b>900</b>	<b>800</b>	<b>1100</b>
ERV Air volume		High & low mix		High	Low



### 2. Result



Adjust ERV to meet CO2 level @ **near 1000ppm(IAQ guideline)** is important



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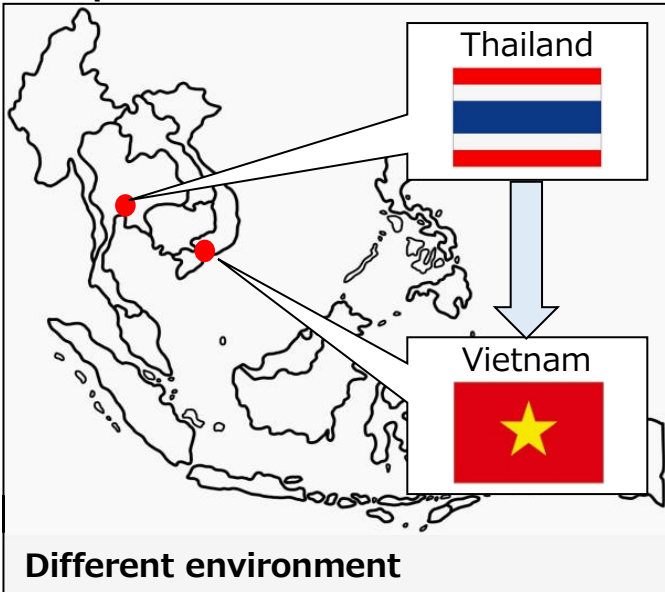
## Agenda

1. Look back activity at CEFIA
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# 3. Expand to Vietnam

- 1. Expand "AC-ECP" to Vietnam to verify under different environment.
- 2. Work with Ho Chi Minh City University of Technology in regard to academic aspect.
- 3. We have already finished installation of AC-ECP at Daikin service call center @38<sup>th</sup> floor

## 1. Expansion to Vietnam



## 2. Work with local university

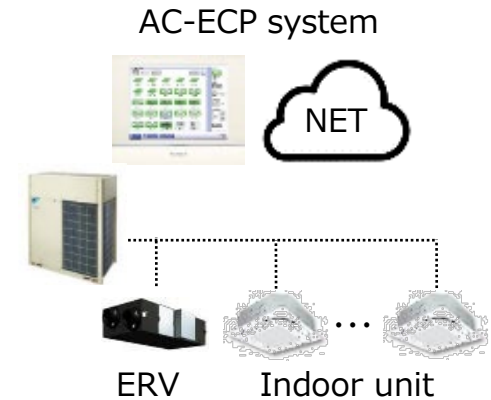
Ho Chi Minh City Univ of Technology

Department:  
Heat and Refrigeration Engineering



## 3. Verification site

Opal tower in Ho Chi Minh City



Daikin Service Call Center @38F



[Target office area]  
-Office area: 350m<sup>2</sup>  
-Ceiling height: 3.0m  
-50~85 staff

Application difference

Vietnam	Call center
Thai	General office



1. In addition to product evaluation, “operation & optimization”, “maintenance” is added.
2. These key points are verified by FY 25

FY24

FY25

## Product evaluation

## Operation and optimization

## Maintenance

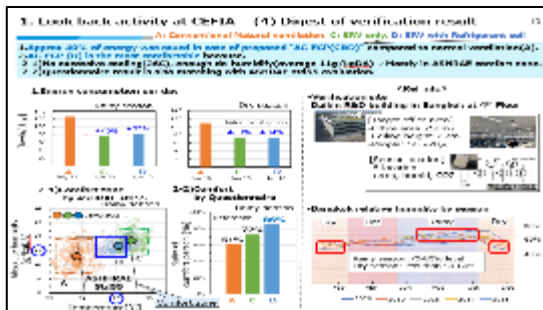
### Key point 1

### key point 2

### key point 3

#### 1. Product evaluation

- Energy/CO2 reduction
- Comfort by ASHRAE std 55



#### 2. Indoor air quality (IAQ) guideline

- CO2 target @1,000ppm

#### 3. Building air tightness

- Natural ventilation rate

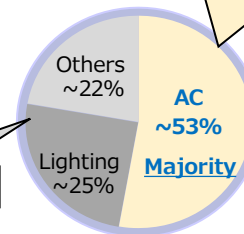
#### 1. Annual energy management

- AC energy is key for carbon neutral

EMS



Fluctuating power, so key for management



Constant power

#### 2. Optimization

- Seasonal
- IAQ & energy balance


#### 3. Others

#### 1. Proper maintain

- AC
- ERV
- EMS



Market recognition/government policy/Business model toward CN

- Daikin "AC-ECP", using ERV with cooling coil, contribute to Carbon Neutral(CN)
  - by reducing heat load and humidity from outdoor air, **comfort and big energy saving is achieved---approx. 40%.**
  - Roughly speaking, market impact is estimated **2,700 kt-CO2/year reduction for VRF market in ASEAN.** (Energy source: Natural gas)
  - Adjusting ERV to meet CO2 level @**near 1000ppm(IAQ guideline)** is important.  
**Ex. In case of 800ppm, approx. 8% of energy consumption is increased.**
- Building air tightness
  - Thailand N=5
  - Market research say that there are cases that natural ventilation rate is high.  
**Improving building structure to enhance air tightness is also key for CN.**  
**Ex. In case of 1.0(times/h) natural ventilation rate, 13% of energy loss.**
- Expand to Vietnam
  - Finish installation of AC-ECP and just **started verification** in July, 2024
  - Verification plan covers not only AC-ECP product, but also **operation, optimization & maintenance.** This will help to develop recognition, new policy, and new business model required for CN.

**To be continued  
at next CEFIA**