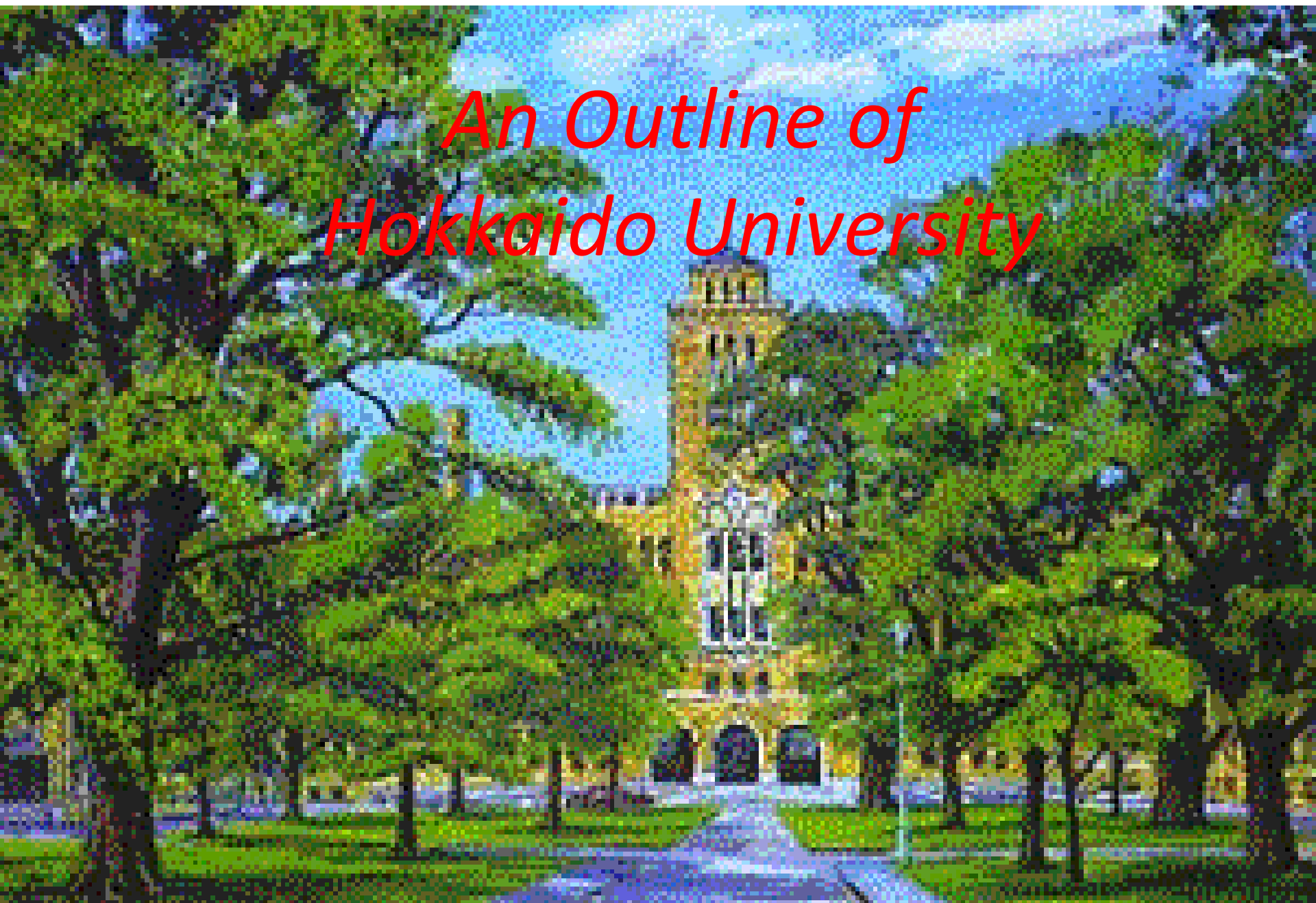


# *An Outline of Hokkaido University*



# The Top-Global Universities in Japan (2014.10)

## ➤ 7 Central National Universities and 1 Technical University

- Hokkaido University
- Tohoku University
- University of Tokyo
- Nagoya University
- Kyoto University
- Osaka University
- Kyushu University
- Tokyo Institute of Technology



## • 2 Major private Universities

- Waseda University
- Keio University

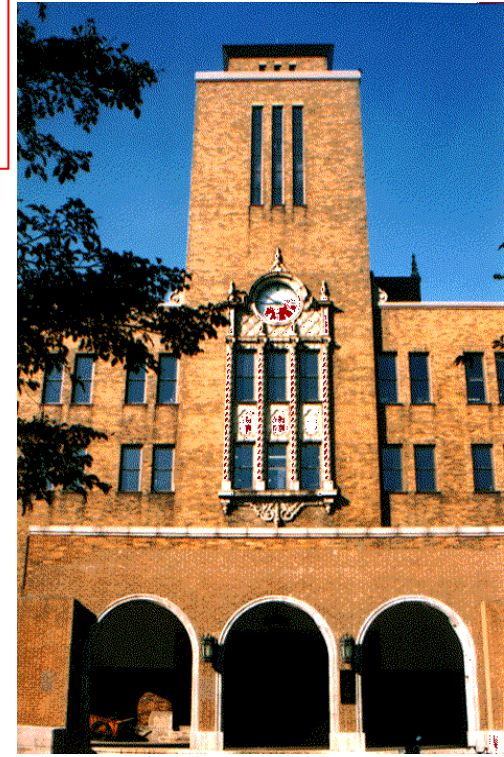
## • 3 Emerging Universities

- Tsukuba University
- Tokyo medical and dental Universities
- Hiroshima University



# Hokkaido University: 138 years history

- **1876 Sapporo Agricultural College was established.**
  - 1997 The faculty of engineering have shifted its emphasis from the undergraduate program toward the graduate one.
- 12 faculties and schools for under graduate
  - 19 post graduate schools
  - 28 Research Institutes and Centers
- 5,000 for the total staff
    - 2,500 for the academic staff
    - 2,500 for the clinical/ technical staff
- **Total amount of students : 20,000 students**
  - Graduate students: 7,000 students
    - 3,000 doctoral course students
    - 4,000 master course students
  - Undergraduate students: **13,000 students**
  - Foreign students: 1600 (80 from Europe, but nobody from Ireland)
- Graduate School of Engineering  
Staffs : total 620  
440 for teaching staffs and 180 for non teaching staffs
    - 140 full professors, 140 associate professors, 160 instructors
  - Students: total 5,000
    - 1,800 graduate students (600 PhD students)
    - 3,200 undergraduate students







# TOPUNIVERSITIES

Worldwide university rankings, guides & events

Undergraduate Studies

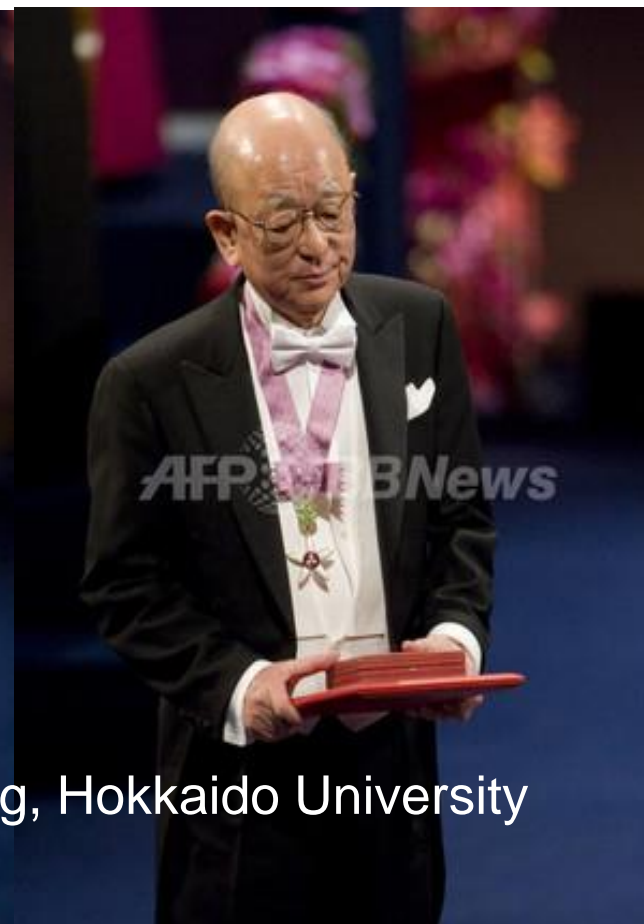
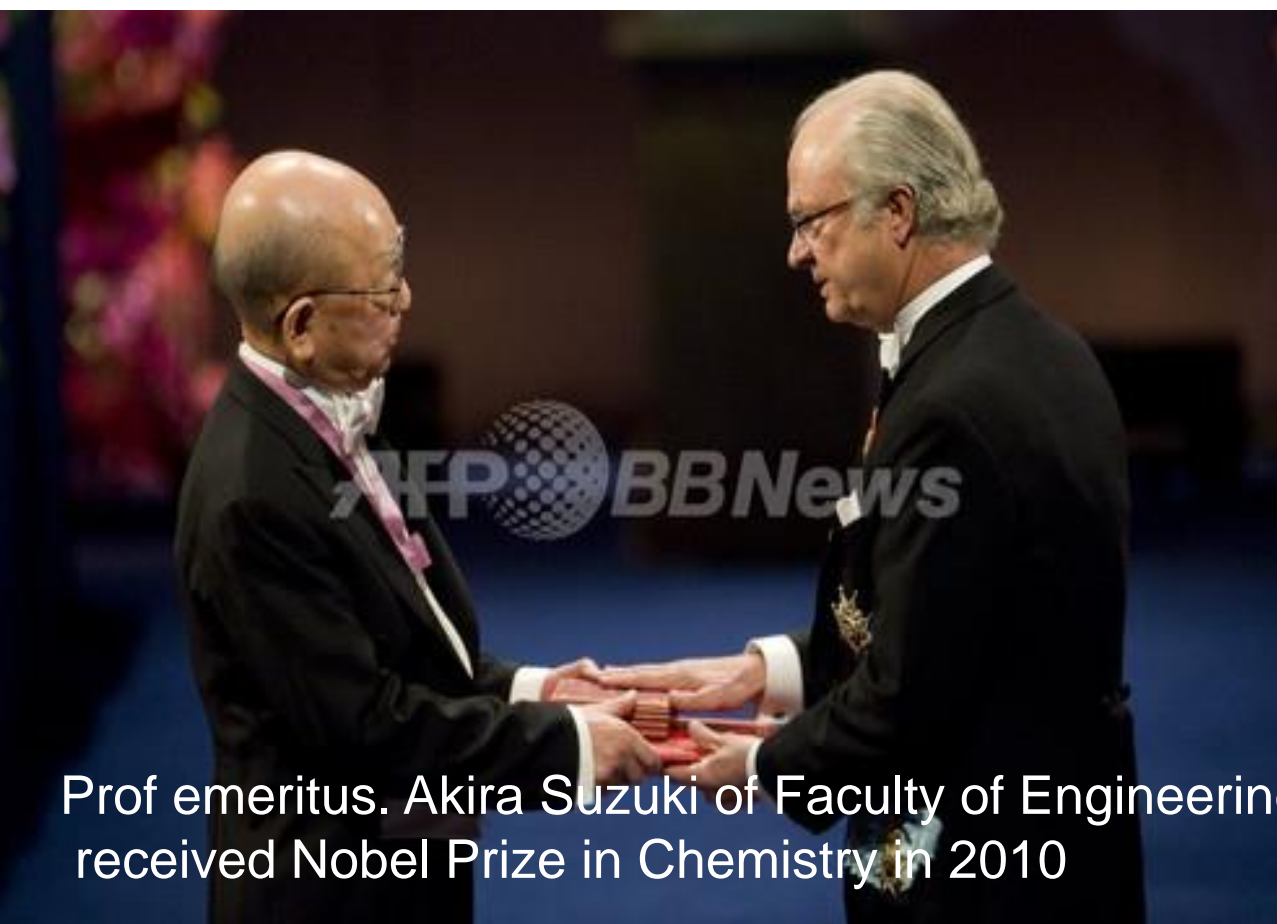
Where to Study Courses University Rankings Events QS Stars Student In



## QS World University Rankings® 2014/15

Welcome to the QS World University Rankings® 2014/15. Use the interactive ranking table below to explore the world's top universities, with options to sort the results by country, region and subject. You can also sort the ranking results based on the six individual indicators used (see the full methodology [here](#)). To compare two or more universities, log in or [register](#) as a site member.

Download the official QS World University Rankings App



Prof emeritus. Akira Suzuki of Faculty of Engineering, Hokkaido University received Nobel Prize in Chemistry in 2010



# TOP UNIVERSITIES

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Undergraduate Studies

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## QS World University Rankings® 2014/15

QS World University Rankings®  and QS Stars

Filter by region





Filter by location

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Note: Filtering by subject area will also resort the list by subject-area scores.

reset

RANK	UNIVERSITY	LOCATION	COMPARE & MEET	QS STARS
Overall Score	dublin			Show only
71 75.3	Trinity College Dublin		<input type="checkbox"/>	
139 62.6	University College Dublin		<input type="checkbox"/>	
366 37.0	Dublin City University		<input type="checkbox"/>	
551-600	Dublin Institute of Technology		<input type="checkbox"/>	

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# Environmental System Research Labo (Nagano Laboratory)

Education and Research for the Healthy and Sustainable environment

Create Only-One Technologies  
in the field of facility engineering and urban environment

## 1. Effective use of Renewable Energy Recourses→Passive and Active techniques

- Solar energy
- Ground thermal energy
- Heat pump application
- Energy storage
- Heat pump application
- Thermal insulation and windows

**Achieve  
both sustainable  
and comfort  
living space**

## 2. Sustainable Buildings and Environment

- ZEB(Net Zero Energy Building)
- ZEH(Net Zero Energy House)
- Smart Community

## 3. Healthy living space

- Higher Indoor Quality control
- Passive and active humidity control

## Policy; Challenging Spirits

- 1. Hop:** Basic material and device R&D for “Only-One” technologies
- 2. Step:** R&D for machines and Systems, and System Simulation Techniques
- 3. Jump:** Installation of developed devices and systems into actual buildings, then its evaluation and LAC

# Staffs and Students in Nagano's laboratry

## Staffs; 12

**Prof. Dr. Katsunori Nagano**  
**Assoc. Prof. Dr. Takao Katsura**  
**Assoc. Prof. Dr. Junya Togawa \***  
**Assist. Prof. Dr. Kang Yung-kyon**  
**Assist. Prof. Dr. Yoshiharu Sakata**  
**PhD researchers**

**Dr. Yuuki Nabeshima**

**Dr. Liu Hongzi**

**Tech. Officer Makoto Nakamura**

**Secretary Ms. Erika Mori.**

**Technical staff. Chiemi Aoki**  
**Stephen Conway**  
**+ 1 more**

**Guest Prof. Shigeaki Narita**

## Students; D4, M10, B5

<b>Mr. Fujii</b>	<b>D3 (Business)</b>
<b>Mr. Nakamura</b>	<b>D3 ( Business )</b>
<b>Ms. Wang</b>	<b>D1 (Chinese)</b>
<b>Mr. Yoshida</b>	<b>D1 ( Business )</b>
<b>Mr. Mori</b>	<b>M2</b>
<b>Mr. Jin</b>	<b>M2 ( Chinese )</b>
<b>Mr. Zhai</b>	<b>M2 ( Chinese )</b>
<b>Mr. Ogura</b>	<b>M1</b>
<b>Mr. Suzuki</b>	<b>M1</b>
<b>Ms. Takigami</b>	<b>M1</b>
<b>Mr. Morita</b>	<b>M1</b>
<b>Ms. Yagi</b>	<b>M1</b>
<b>Mr. Tei</b>	<b>M1 (Chinese)</b>
<b>Ms. Tasia Rahman</b>	<b>M1 (Bangladesh)</b>
<b>Mr. Ishima</b>	<b>B4 (→M1)</b>
<b>Mr. Kubo</b>	<b>B4 (→M1)</b>
<b>Ms. Saito</b>	<b>B4</b>
<b>Ms. Sugino</b>	<b>B4 (→M1)</b>
<b>Ms. Komaki</b>	<b>B4 (→M1)</b>



# Staffs and Students in Nagano's laboratry





# Development of desiccant ventilation system using natural meso-porous material produced in Hokkaido

Success story of our National project  
on developing a desiccant ventilation using Wakkanai siliceous shale  
which is natural meso-porous material produced in Hokkaido

Prof. Katsunori Nagano

Graduate School of Engineering  
Hokkaido University



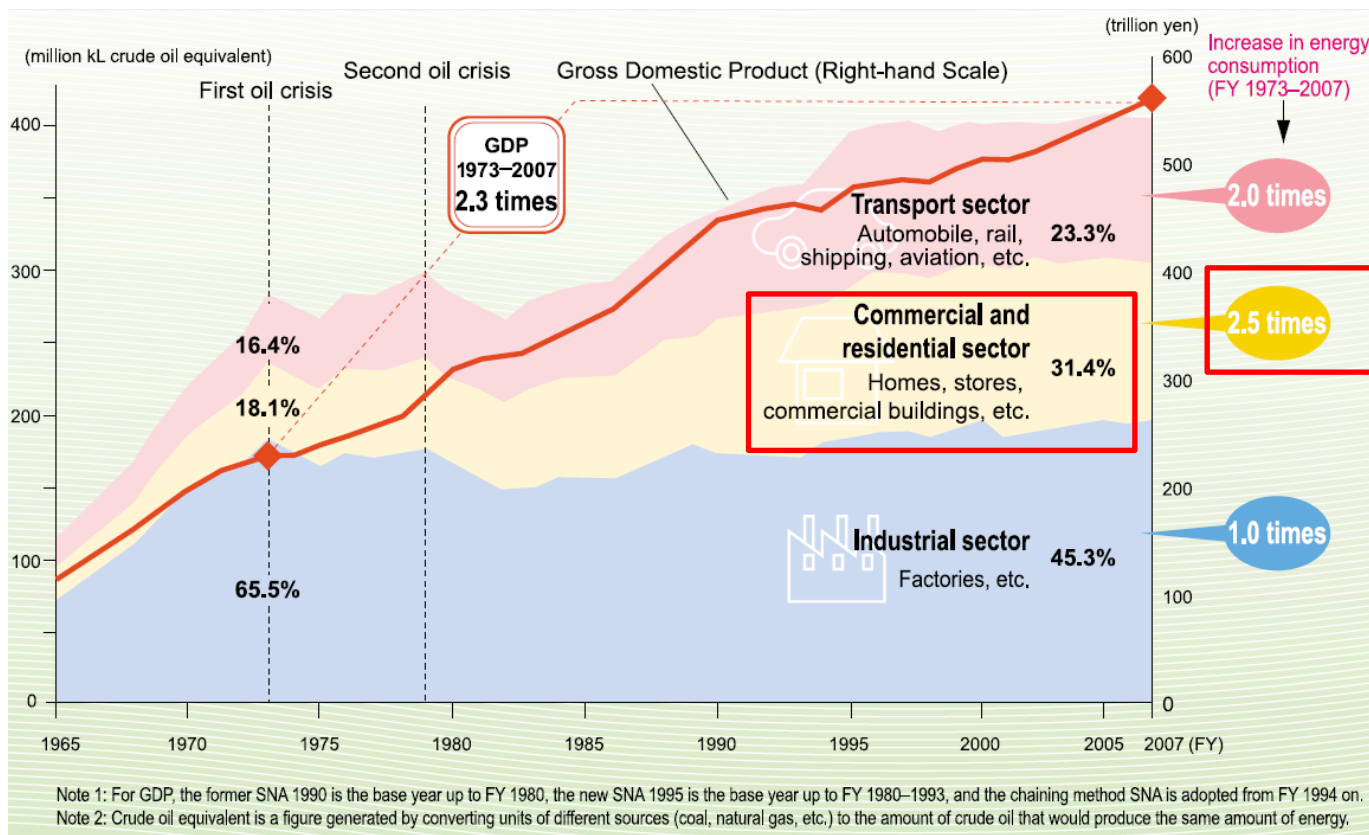


1. Background, new concept and objectives
2. Dehumidification process and advantage of separation of sensible and latent cooling demand
3. Wakkanai Siliceous Shale (WSS) as an adsorbent
4. Development of a WSS desiccant rotor
5. Development of a desiccant ventilation unit using a WSS rotor and its adsorption performance test
6. Conclusions



# 1. Background: Energy use of commercial and residential sector

- 1) The annual energy consumption of Japan in 2007 is 400 million *kL* crude oil equivalent
- 2) The energy use of commercial and residential sector is increasing and it in 2007 has been 2.5 times compared to that in 1973.  
Its fraction has become 31.4 % of the total energy consumption.

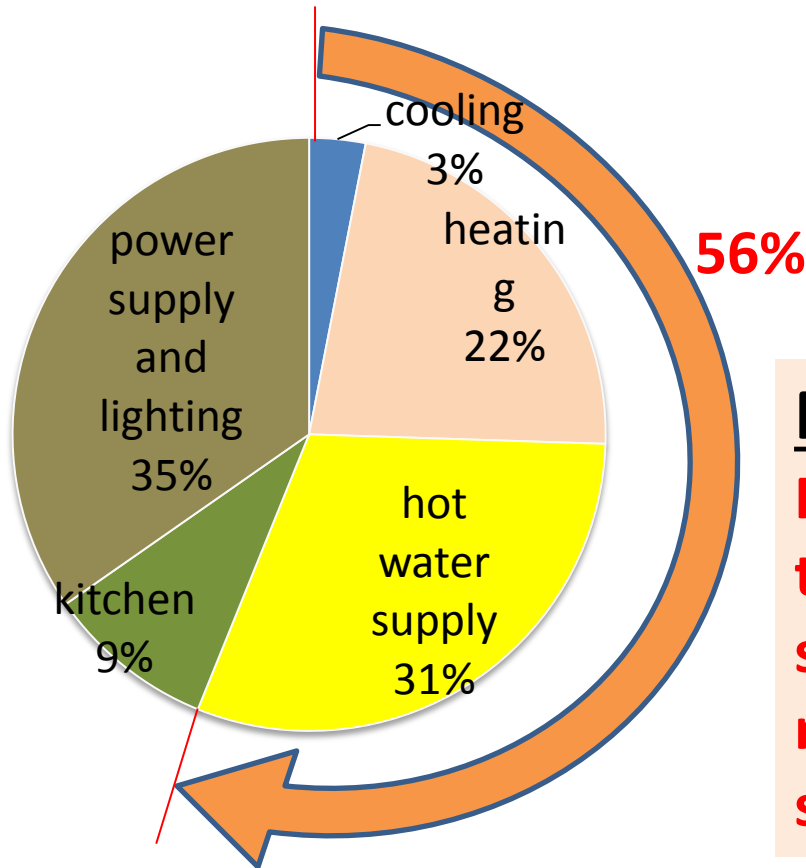






# 1. Background:

Energy consumption for heating, cooling and hot water supply has occupied 56% in the total energy in household.



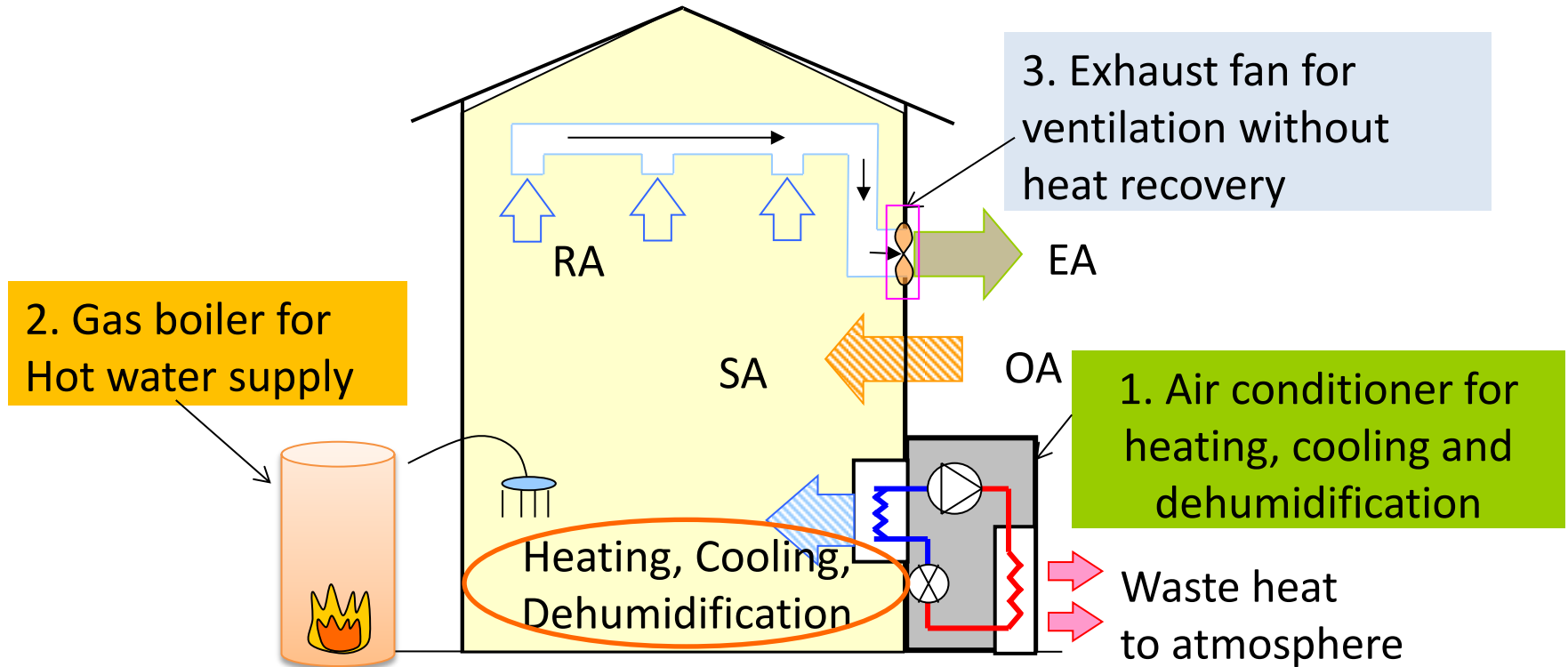
## Major issue:

**Reducing energy consumption for the air-conditioning, the hot water supply and the ventilation in the residential and the commercial sector is very important.**

Energy consumption in the household in Japan



# 1. Limitation of efficiency; Conventional energy supply system for houses



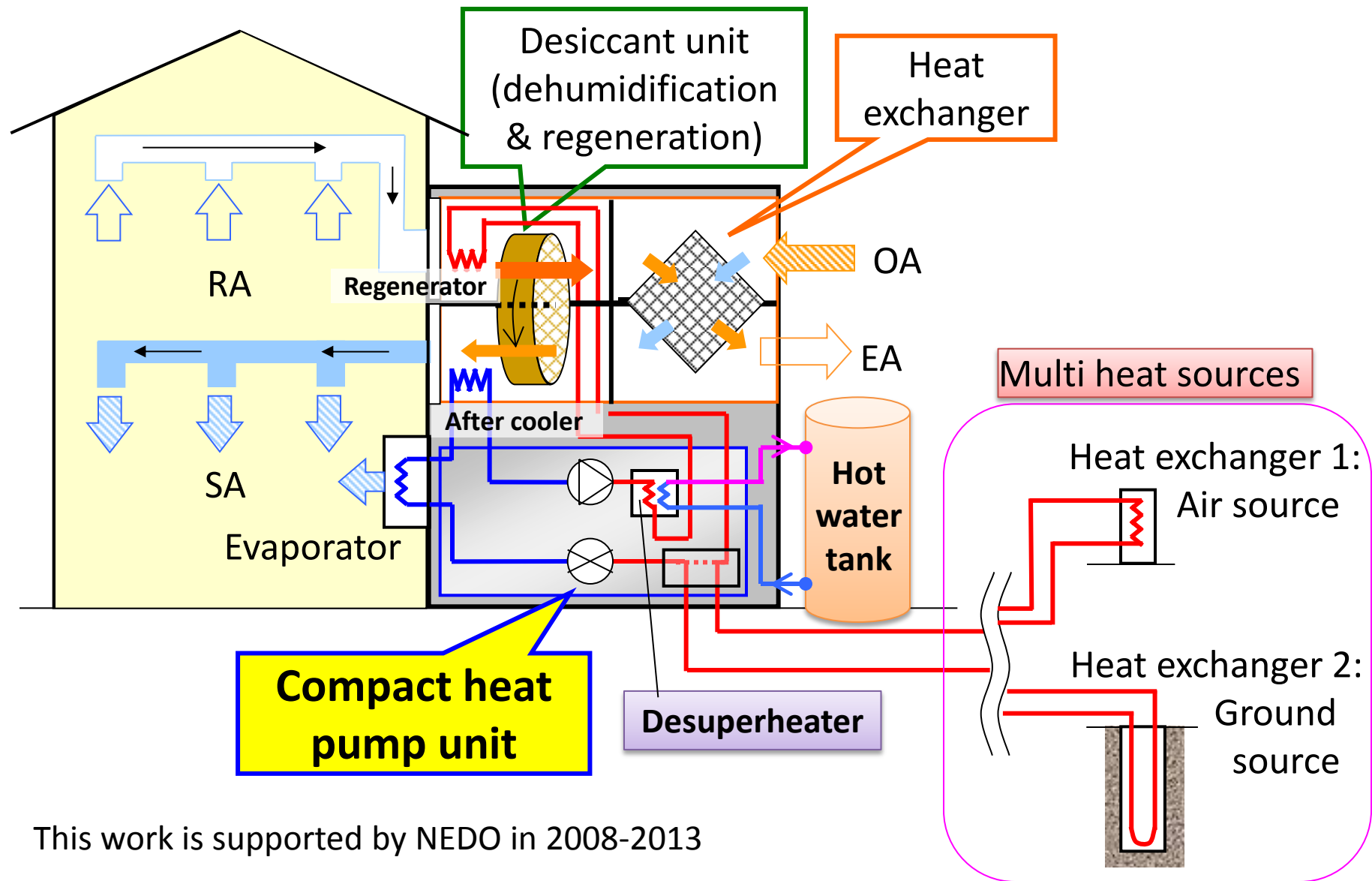
**Problem;**  
**These Work separately!**  
→ **Limit of modifying the efficiency of each unit**

## Solutions;

- 1) Concept of compact heat pump unit; Integrated system by using exhaust heat effectively
- 2) Introduction Desiccant process to remove latent cooling load; Separation Process of Latent and Sensible Heat



# 1. New concept; Compact heat pump unit integrated with desiccant AC



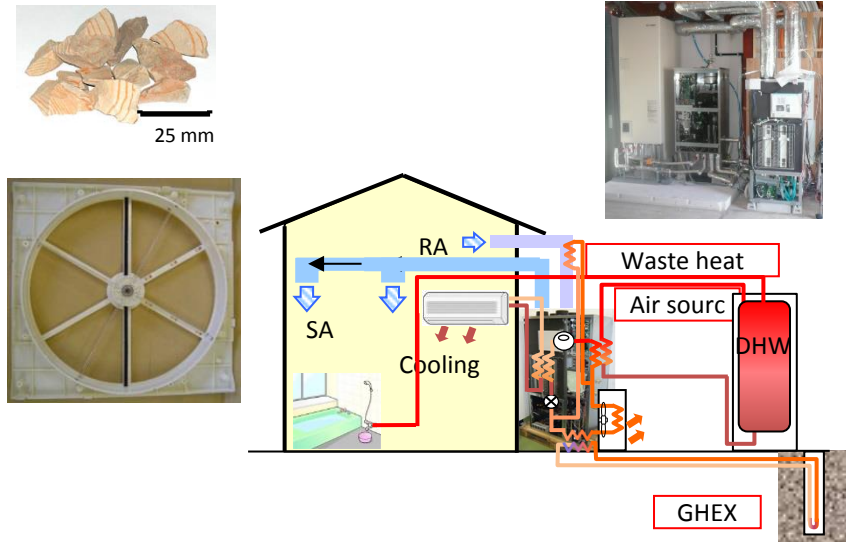
This work is supported by NEDO in 2008-2013



### 3. R&D of the Desiccant ventilation heat pump unit; NEDO project

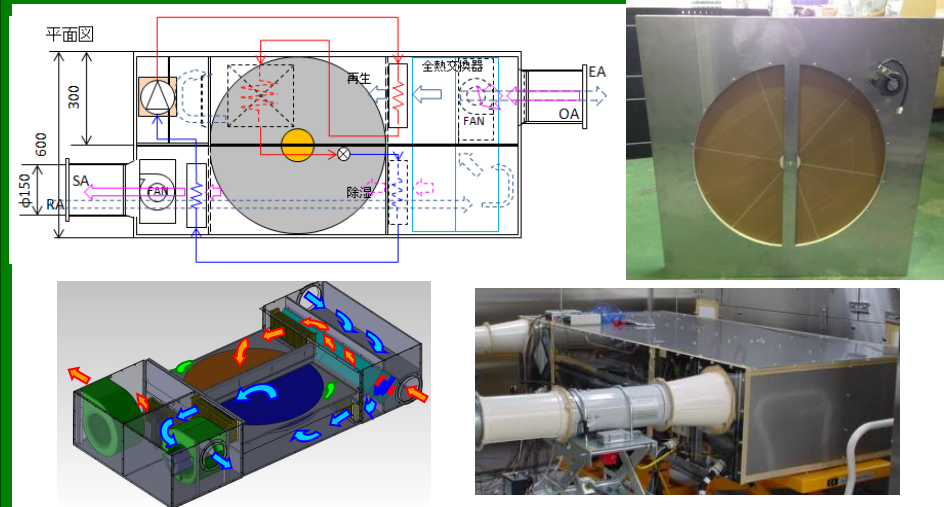


#### For housing purpose



**Goal; 35% reduction of primary energy consumption of the heating and the air conditioning and hot water supply of the house**

#### For building purpose



**Goal: 15% reduction of primary energy consumption of the air conditioning of the building**

**2007-2010: NEDO Innovating phase (Leader; Prof. Nagano+ 6 companies, 2million US\$)**  
**2011-2014: NEDO Developing phase (Leader; Prof. Nagano + 7 companies, 7 million US\$))**  
**2014-2016: NEDO Installation phase (Leader; Sunpot corp., Prof. Nagano assists, 2 million US\$)**



# 1. Objectives: Developments

## ● Compact heat pump unit integrated with desiccant ventilation using

### 1) Development of an original desiccant rotor;

- Base material; Natural meso porous material;

➡ Wakkanai Siliceous Shale (WSS)

- Target regeneration temperature at 40°C;

➡ for the effective use of waste heat of air conditioner

### 2) Development of the desiccant ventilation unit

- Combination of high performance enthalpy air heat exchanger and a desiccant rotor

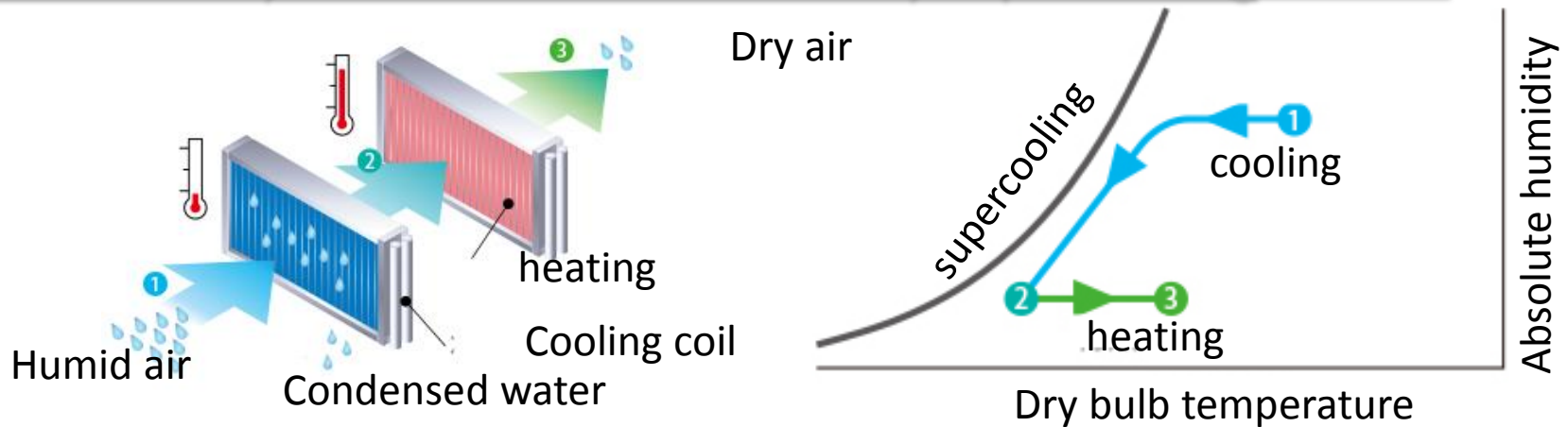
### 3) Compact heat pump unit integrated with desiccant ventilation

➡ for heating, cooling, ventilation with dehumidification and hot water supply

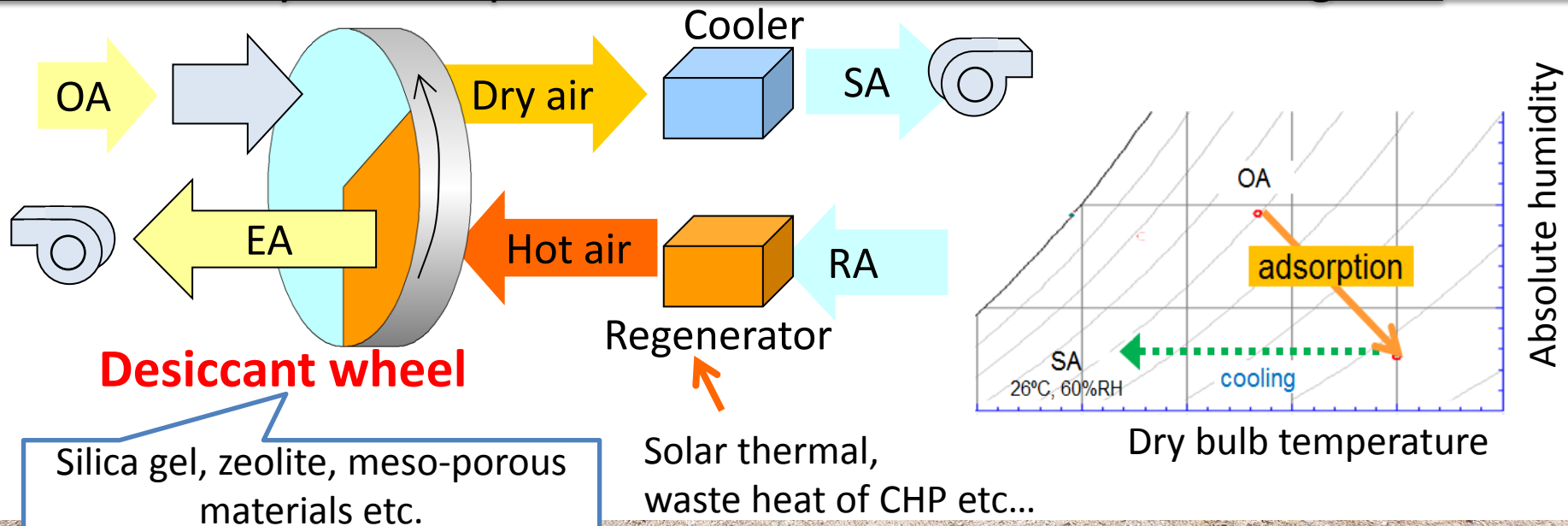


## 2. Dehumidification processes: Supercooling and Desiccant

### 1. Conventional system: Dehumidification by supercooling



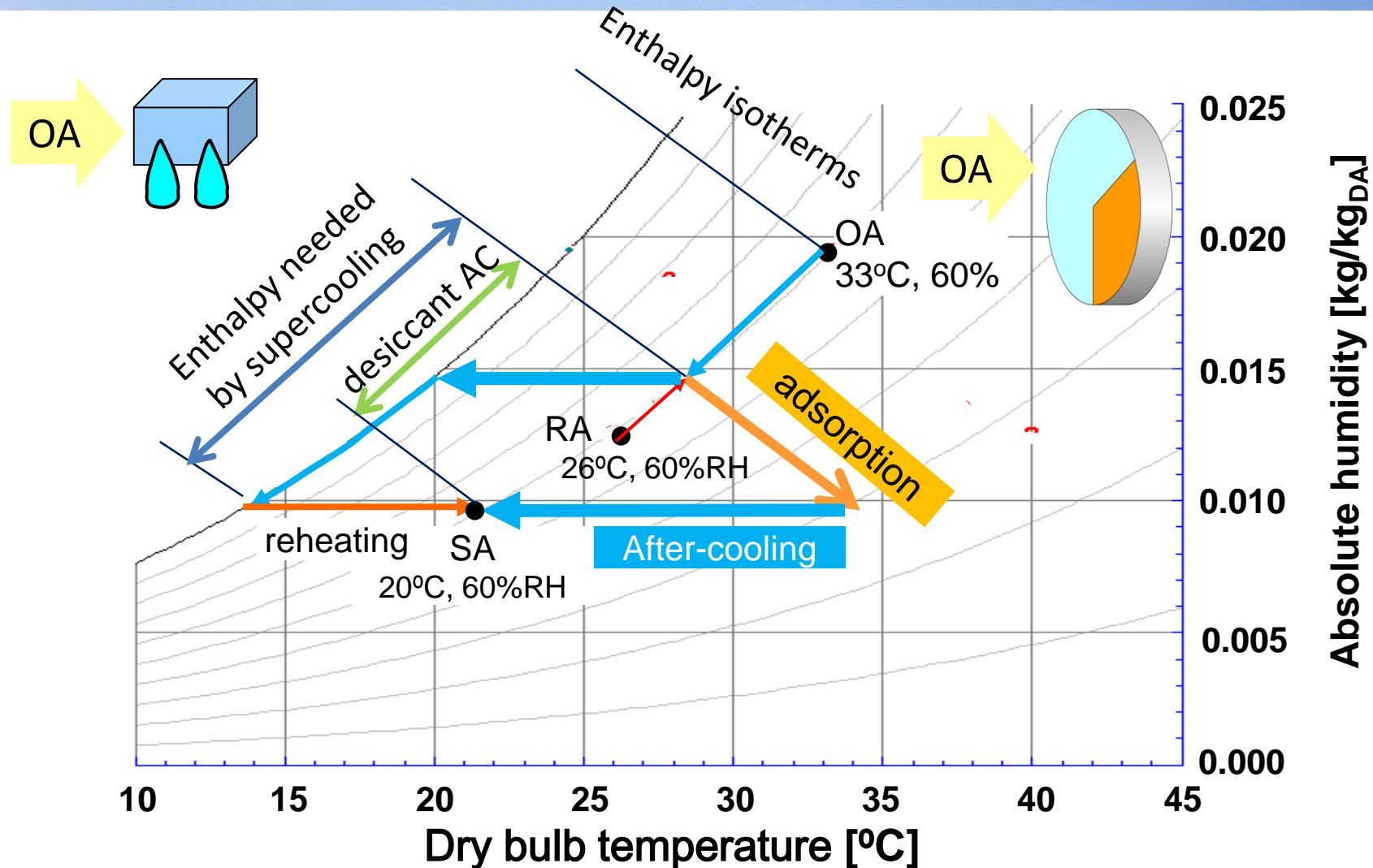
### 2. Desiccant system: Separation of latent and sensible cooling load







## 2. Energy conservation of desiccant air conditioning



Comparison of needed enthalpy for dehumidification on the wet air chart



### 3. Candidate of adsorbents for desiccant system

	Solid type				
	Silica gel group			Zeolite group	Polymer type
Adsorbent	Silica gel A type	Silica gel B type	MCM41 meso-porous silica	AQSOA(FAM) aluminophosphate zeolite (Mitsubishi Chemical)	Sodium polyacrylate
Adsorption mechanism	Chemical adsorption	Physical adsorption		Chemical and physical adsorption	Sorption (Swelling)
Regeneration temperature	Over 80 °C	50 – 80 °C	Over 80 °C	60 – 140 °C	50 – 70 °C
Advantage	Low humid adsorption	High humid adsorption	Pore distribution control	Low humid adsorption	High water Sorption
Disadvantage	Life time and odor	Life time and odor	Very expensive	Very expensive	volume expanding

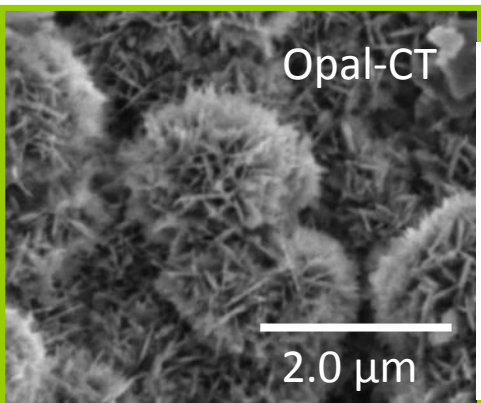
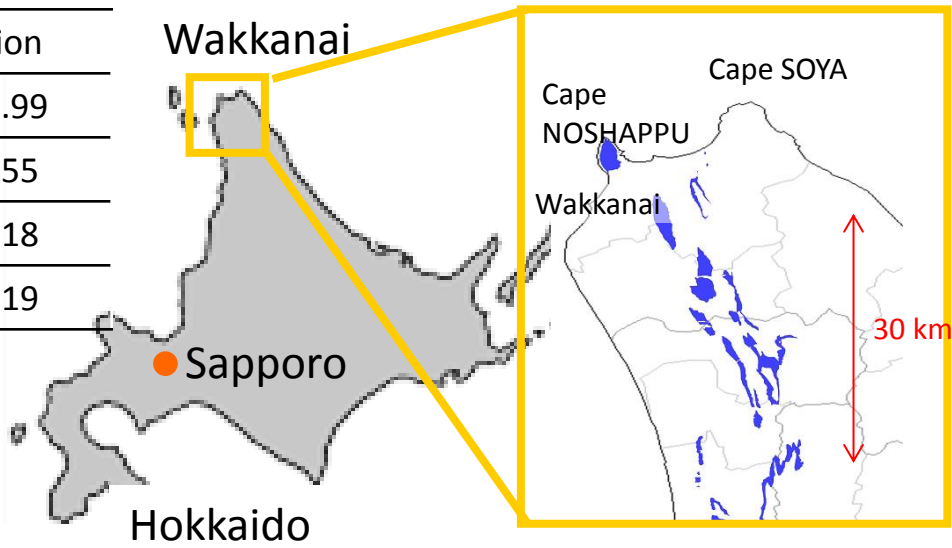
Characteristics of low price, low regeneration temperature and quick response of water adsorption/desorption are required in order to apply into an actual desiccant system



# 3. Wakkanai Siliceous Shale (WSS):*Natural meso porous material*

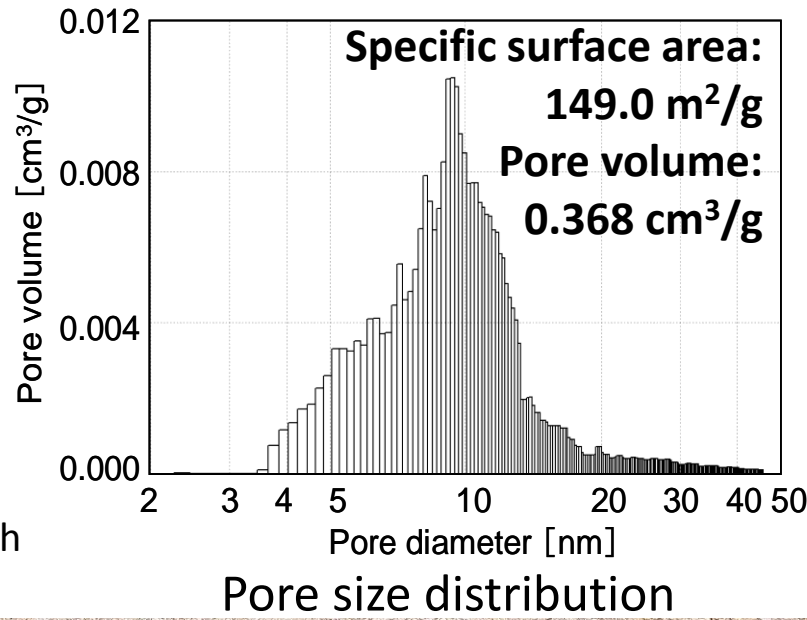


Chemical composition	
SiO <sub>2</sub>	85.99
Al <sub>2</sub> O <sub>3</sub>	6.55
Fe <sub>2</sub> O <sub>3</sub>	5.18
K <sub>2</sub> O	1.19



Non-deposition  
SEM photograph  
( × 30,000)

SEM SU1500,  
HITACHI HighTech  
(Nagano's Lab)



BET surface area  
analyzer; **NOVA e**,  
QUANTACHROME  
(Nagano's Lab)

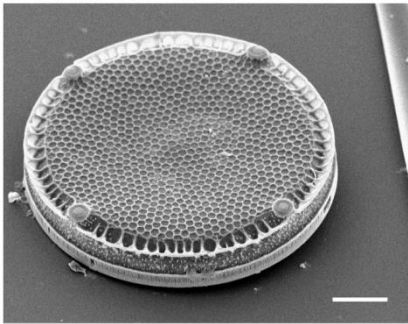




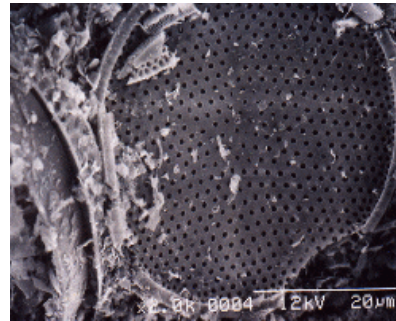




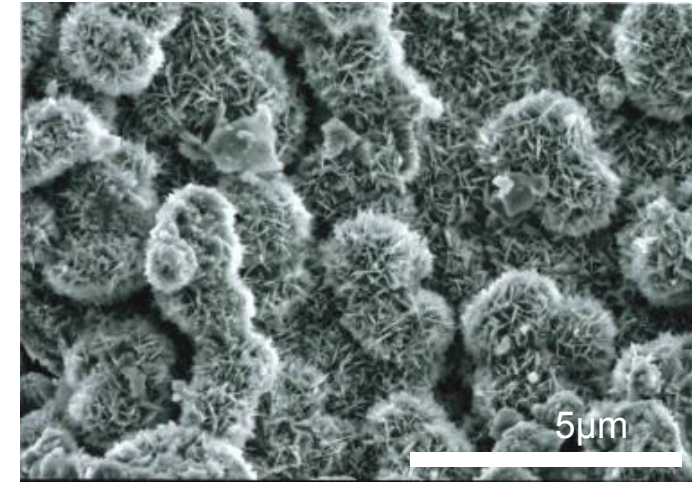
### 3. Difference between WSS and Normal diatomaceous soil



SEM of typical diatom



Normal diatomaceous soil  
Of sedimentary rock

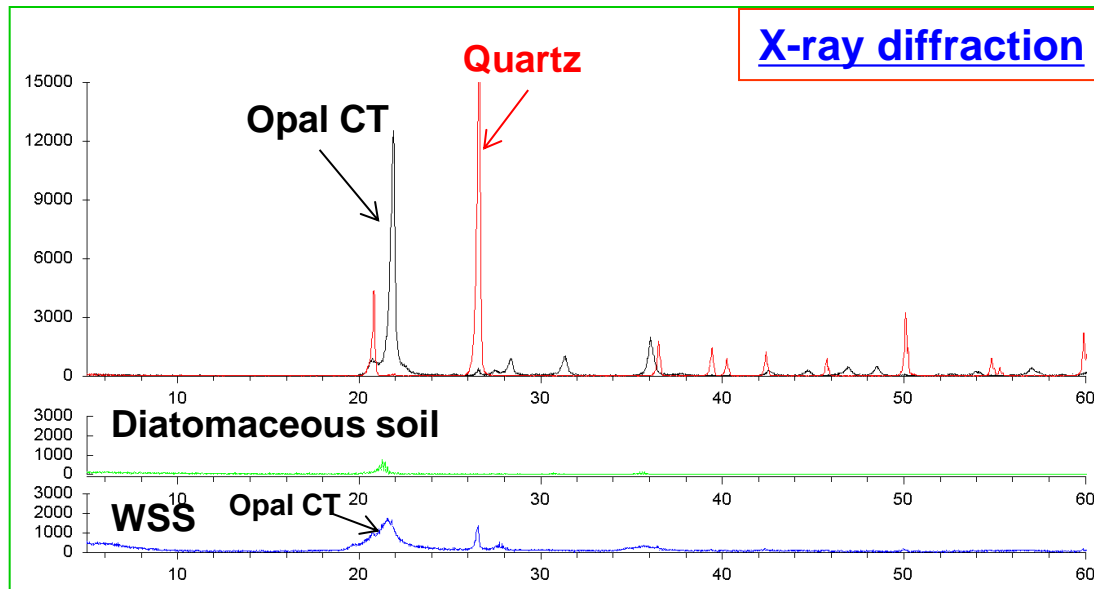


SEM of WSS

Spherical lepisphere fine particle which consists from nano scale flakes made from opal CT (Cristobalite-Tridymite) appears. It is understood that diatomaceous soil changed to metamorphic rock.



\*Meso pores (2nm - 50nm)  
are formulated between fine lepisphere

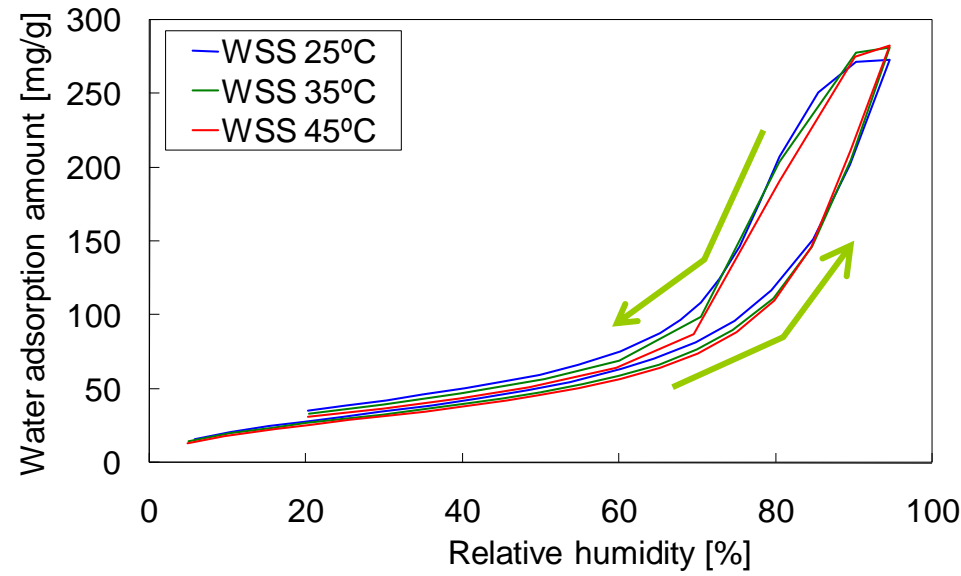


**XRD chart of WSS**  
(X-Ray: CuK $\alpha$  Power: 40kV, 30mA)

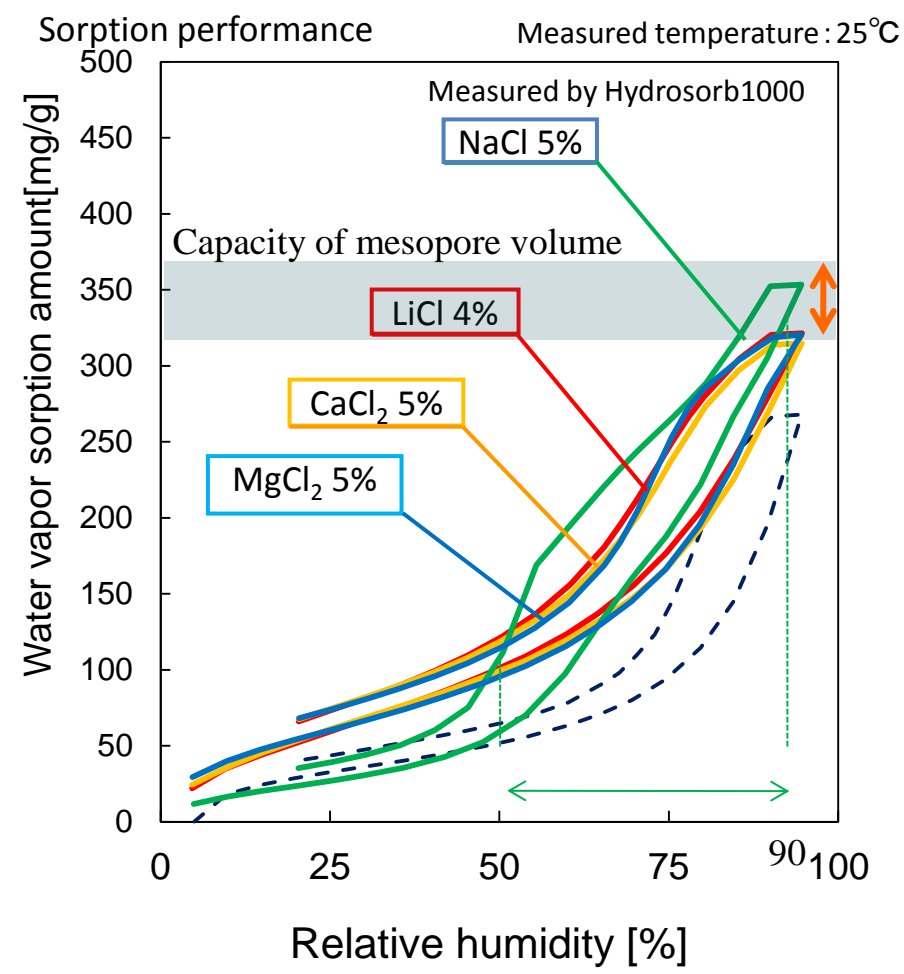


# 3. Adsorption isotherms of WSS

Dynamic water vapor adsorption analyzer;  
**HYDROSORB 1000**,  
QUANTACHROME Corp.  
(Nagano's Lab)



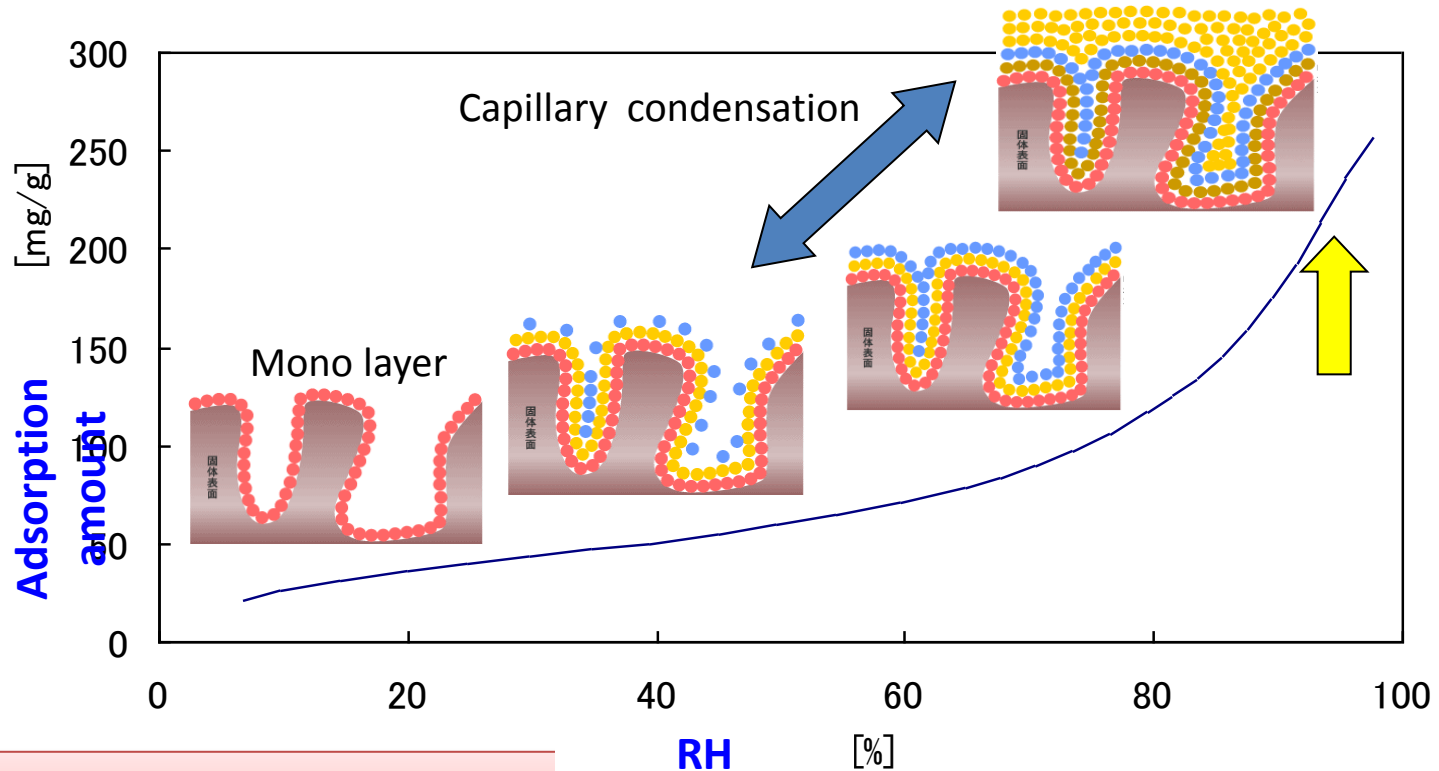
● Autonomous humidity control





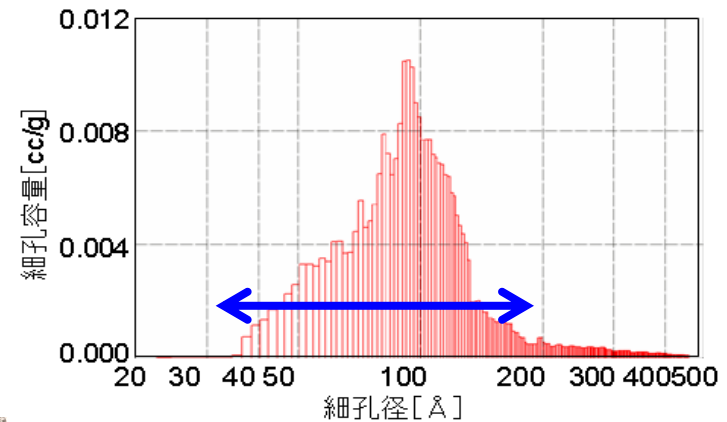


### 3. Maximum amount of vapor adsorption amount reaches at 270 mg/g



Breathing water vapor autonomously  
RH vs capillary condensation


RH40% → 32Å  
RH70% → 74Å  
RH90% → 210Å



### 3. Commercially available WSS building materials for passive humidity control

### さわやか せつこうボード

設置簡単




クローゼットや押入は、湿気がこもりがちです。このような収納スペースには、さわやか押入れボードをお使い下さい。ボードに含まれた特殊珪藻土が収納スペースの湿度を調節し、カビやダニの繁殖を抑えます。また、居室の調湿にはさわやかせつこうボードが適しています。

設計番号：第20525003号


### さわやか 押入れボード

設置簡単


● 表面仕上げバリエーション



S-8 [桐]




S-2 [ロザフロ]



S-3 [アンダラ]

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タイル	543
木材	163



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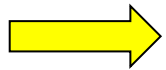


# 4. Development of Desiccant Rotor

## 4.1 WSS powdery process; Submicrometer diameter



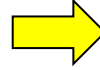
WSS rock



Hammer  
crusher



Particles  
2.5mm – 100 $\mu$ m



High speed blade grinder



Micro powder  
collector

0.5 $\mu$ m – 20 $\mu$ m



Evaluation of the Particle size distribution  
SLD-2300, SHIMAZU (Nagano's Lab)

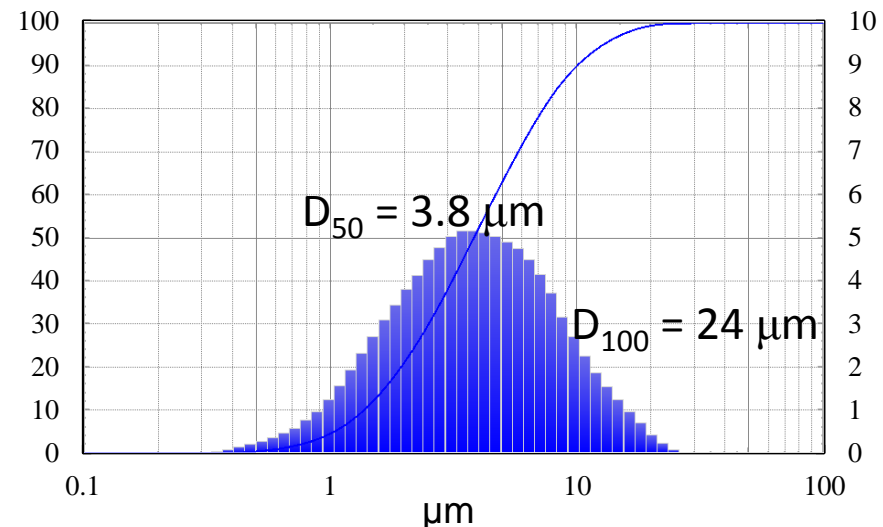


Fig. particle size distribution





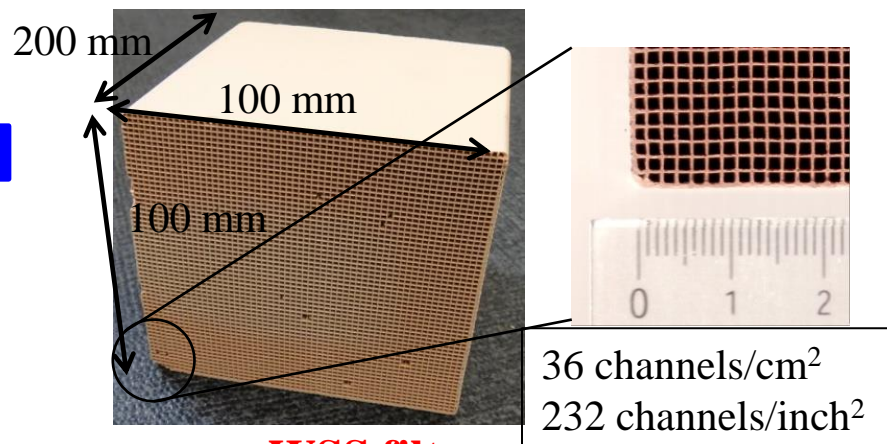
# Honeycomb structure for open chemical TES system using air

## Honeycomb structure;

1. Large contact area

2. Low pressure drop

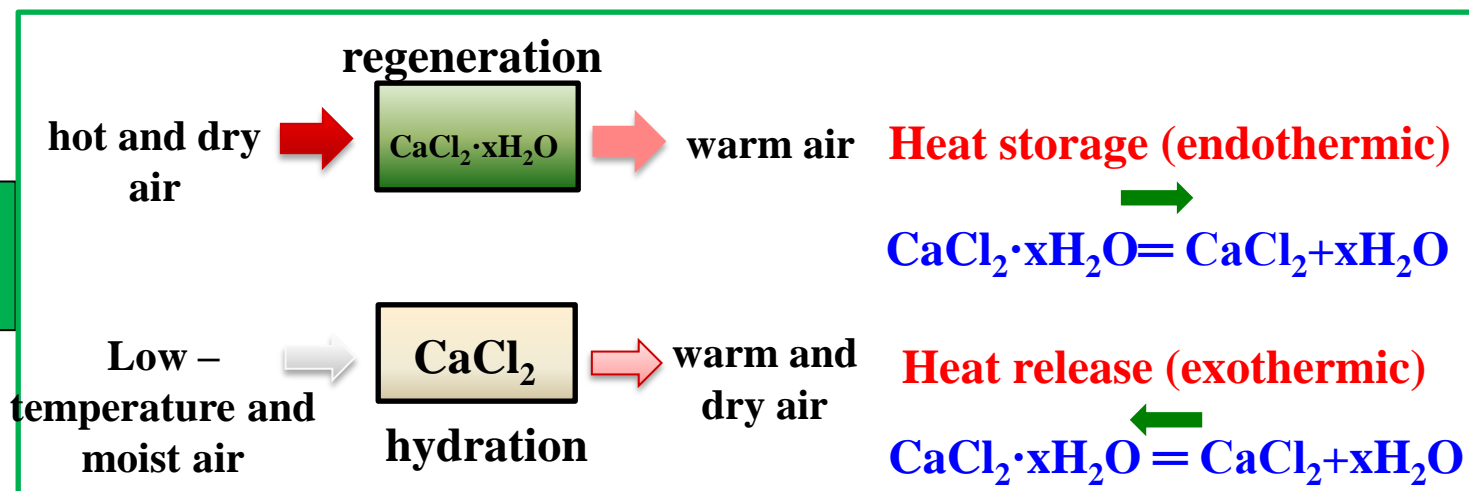
Open chemical TES system using air.



**WSS filter**

(Wakkanai siliceous shale (WSS) 80%, binder 20%)

Open system





# 4. Development of Desiccant Rotor

## 4.2 WSS contained pulp paper process



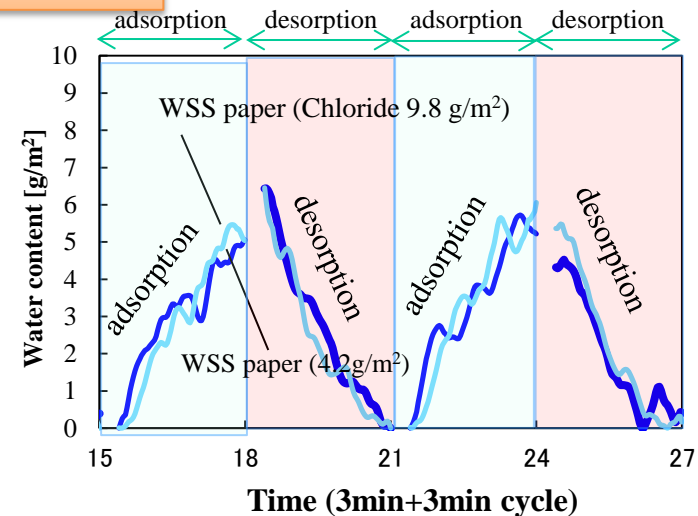
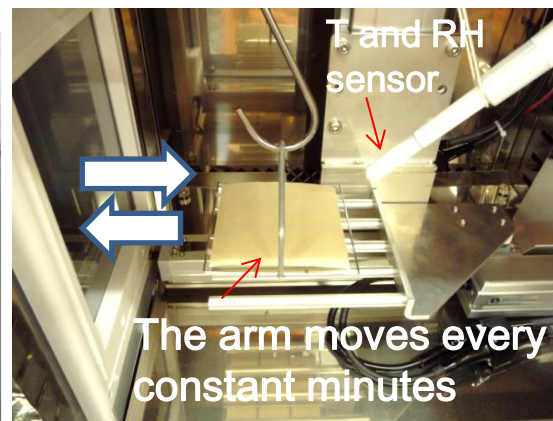
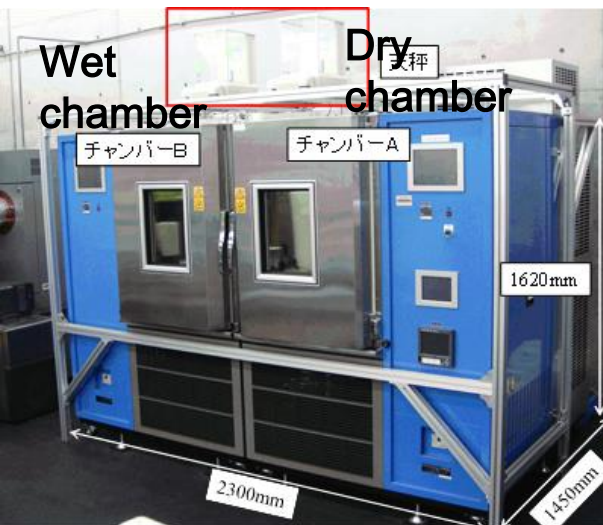
WSS-contained paper

original paper

Paper weight 100 g/m<sup>2</sup>  
Thickness 0.2mm  
WSS content :50 wt%

W 1.0m×L 1000 m

## Paper sample adsorption performance test dual-chamber



Evaluation of water vapor adsorption/desorption speed





# 4. Development of Desiccant Rotor

## 4.3 Desiccant Rotor producing process



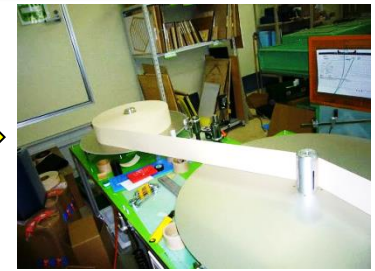
WSS-contained paper



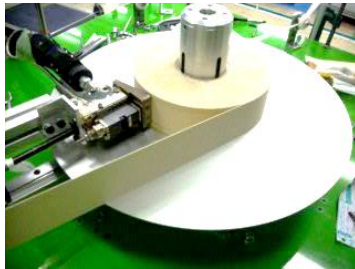
Paper corrugated



Slit process



Rewinding paper



Cross section glueing

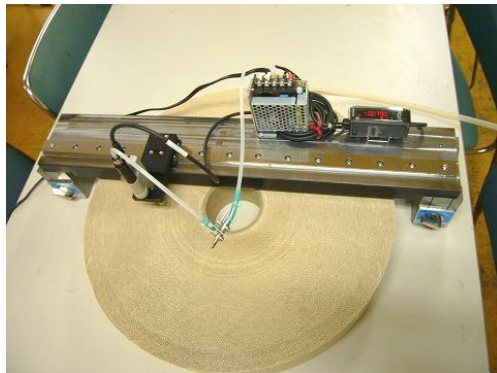


Resin coating process



**Desiccant rotor**

Quality  
control



surface soothing check



Rotation and dehumidification test







## 4. Produced WSS desiccant rotor

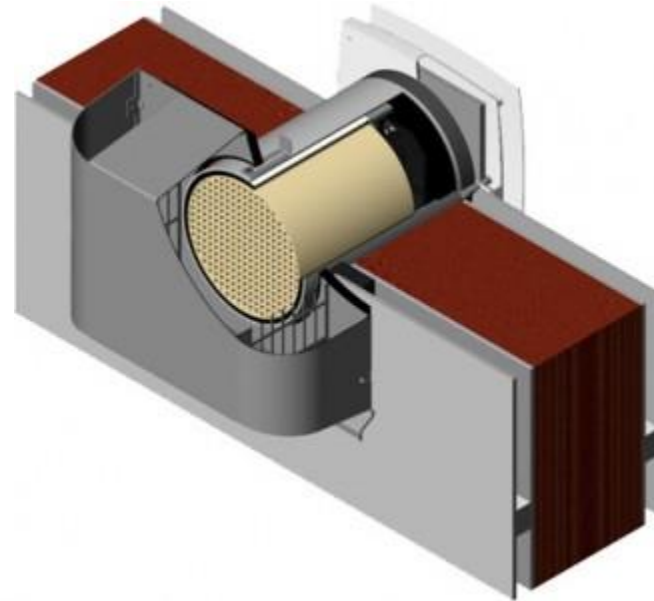


### Details of developed desiccant rotor

- Diameter 500mm  
Thickness 60mm  
Corrugate cell number  
300 cells per square inch

1 cell    height 1.2mm  
            width 3.4mm

Chloride salt impregnated for the enhancement of the water adsorption  
; 3.8 g (NaCl + MgCl<sub>2</sub>)/m<sup>2</sup>



  
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in  
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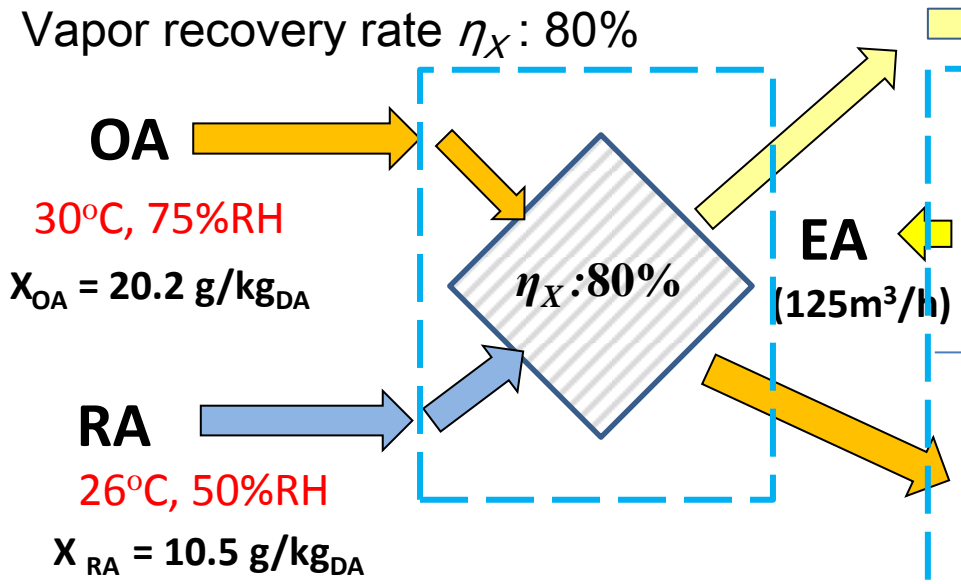
**VENTOsan®**  
ヴェントサン



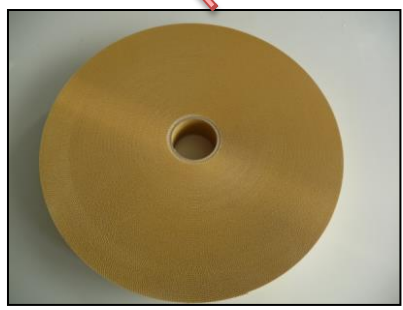
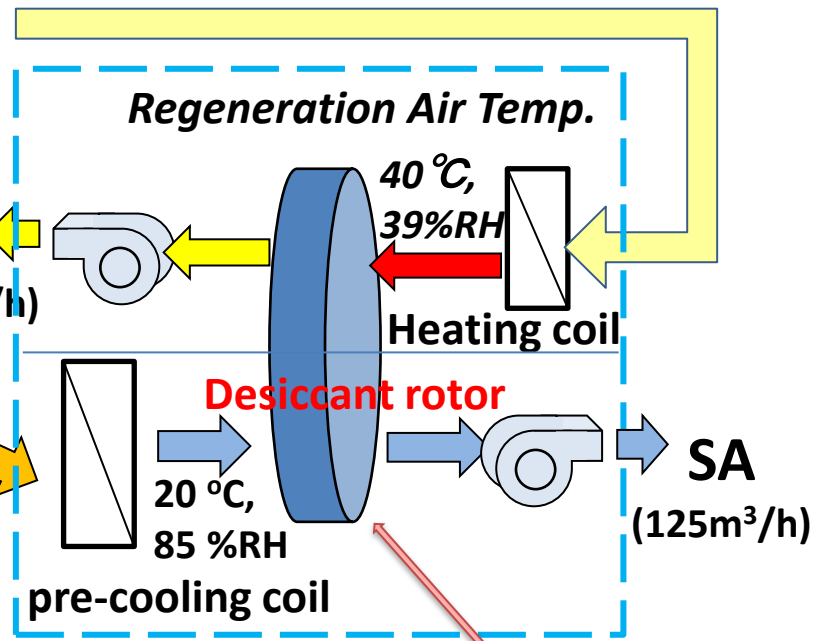


# 5. Desiccant ventilation unit with heat recovery element

(1) High efficiency enthalpy recovery element;  
Vapor recovery rate  $\eta_X$ : 80%



(2) Desiccant unit

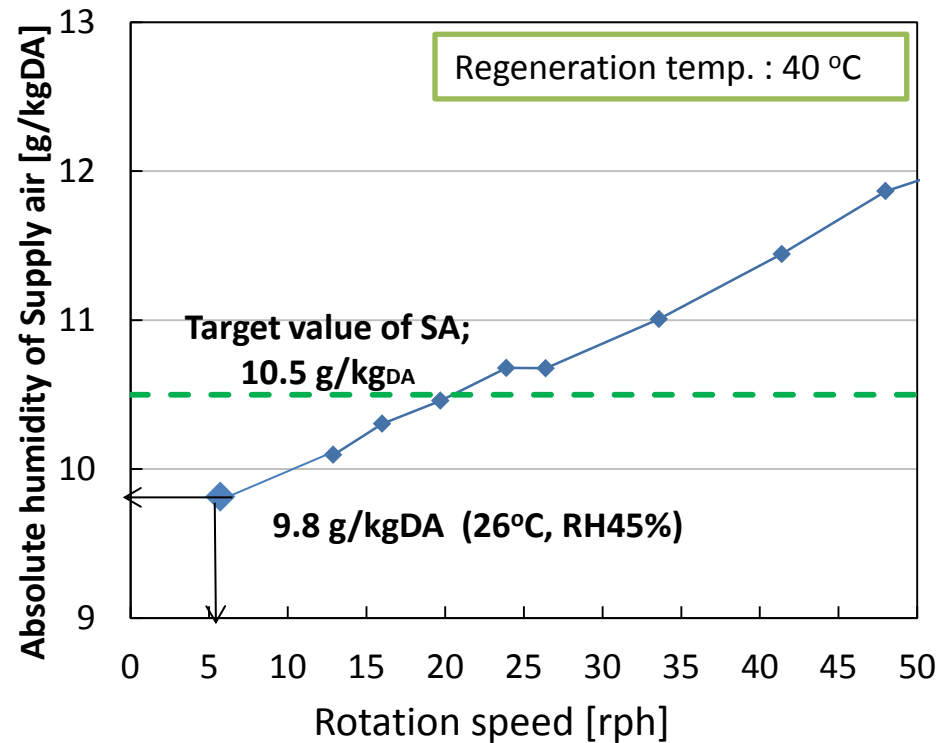


OA-SA side	Temperature	20 <sup>o</sup> C
	Relative humidity	85%
	Absolute humidity	12.5g/kg <sup>DA</sup>
RA-EA side	Temperature	40 <sup>o</sup> C
	Relative humidity	39%
	Absolute humidity	18.2g/kg <sup>DA</sup>
HEX	Vapor recovery rate	80%

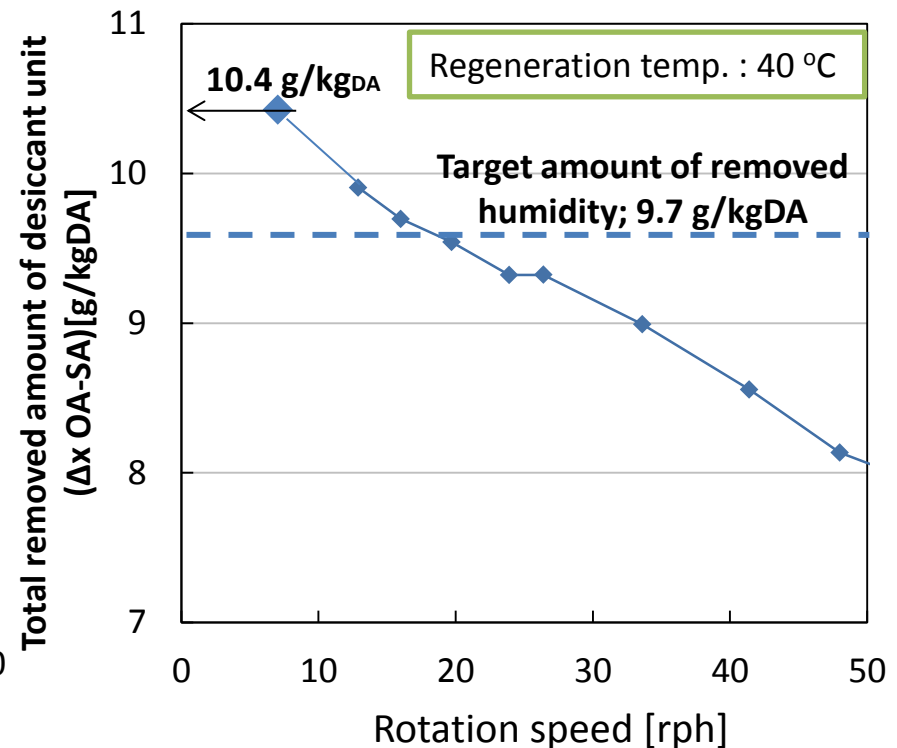




# 5. Dehumidification amount and SA absolute humidity



**Absolute humidity of SA ( $X_{SA}$ )**



**Dehumidification amount**

By using a high efficiency air enthalpy recovery element,  
dehumidification amount increases at lower rotation speed.

$$X_{OA} \gg X_{RA}$$

Dehumidification increased with increasing Rotation speed

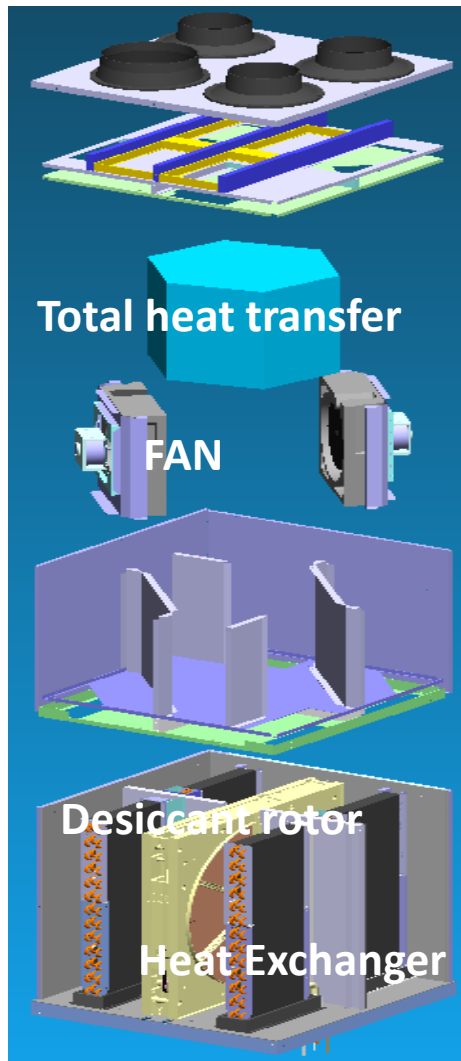
$$X_{OA} < X_{RA}$$

Dehumidification decreased with increasing Rotation speed



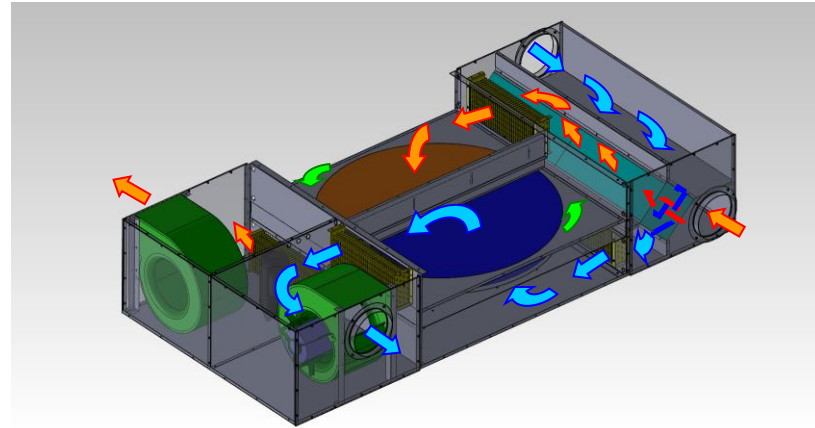
# 5. Design a prototype of a desiccant ventilation system

## Desiccant system for house use



Size  $640 \times 525 \times 1040$   
 Flow rate  $100\text{--}230 \text{ m}^3/\text{hr}$   
 Supply air  $26.3, 46\%RH$   
 $X_{SA} = 9.9 \text{ g/kg}_{DA}$   
 OA:  $30^\circ\text{C}, 75\%RH$   
 RA:  $27^\circ\text{C}, 50\%RH$   
 Flow rate  $180 \text{ m}^3/\text{h}$   
 Eclectic power  $0.46 \text{ kW}$

## Desiccant system for office building



Size  $1080 \times 2300 \times 450$  Flow rate  $300\text{--}900 \text{ m}^3/\text{hr}$   
 Supply air  $29^\circ\text{C}, 47\%RH$  ( $X_{SA} = 12.4 \text{ g/kg}_{DA}$ )  
 (OA:  $30^\circ\text{C}, 75\%RH$ , RA:  $26^\circ\text{C}, 60\%RH$ ,  $\text{m}^3/\text{h}$ )  
 Eclectic power  $0.7 \text{ kW}$



## 5. A developed multifunctional compact heat pump unit for houses



### Separation of sensible heat and latent heat by desiccant system

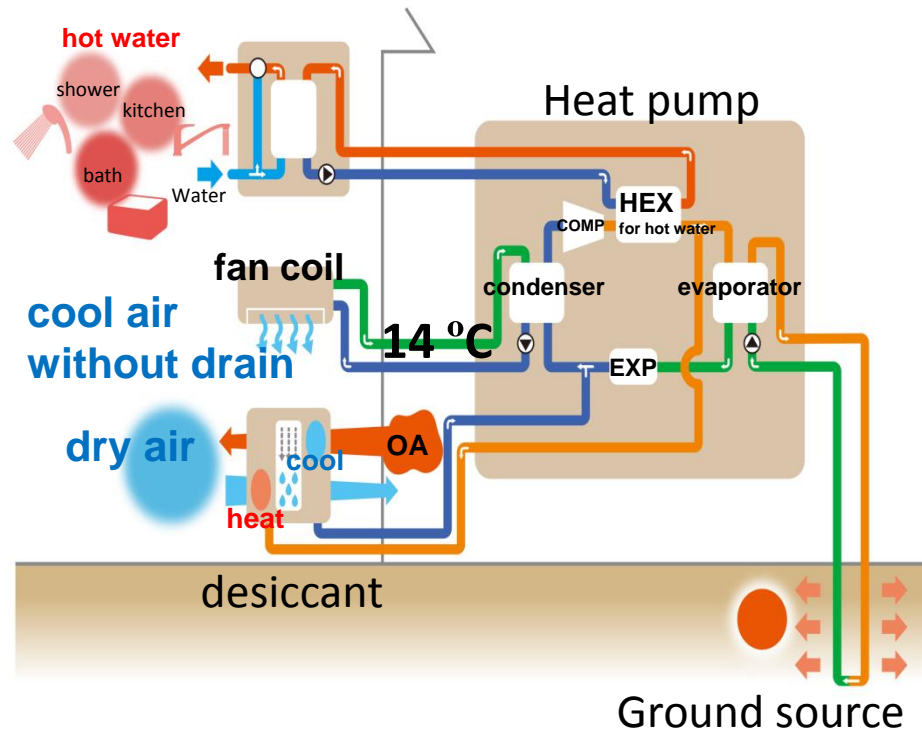
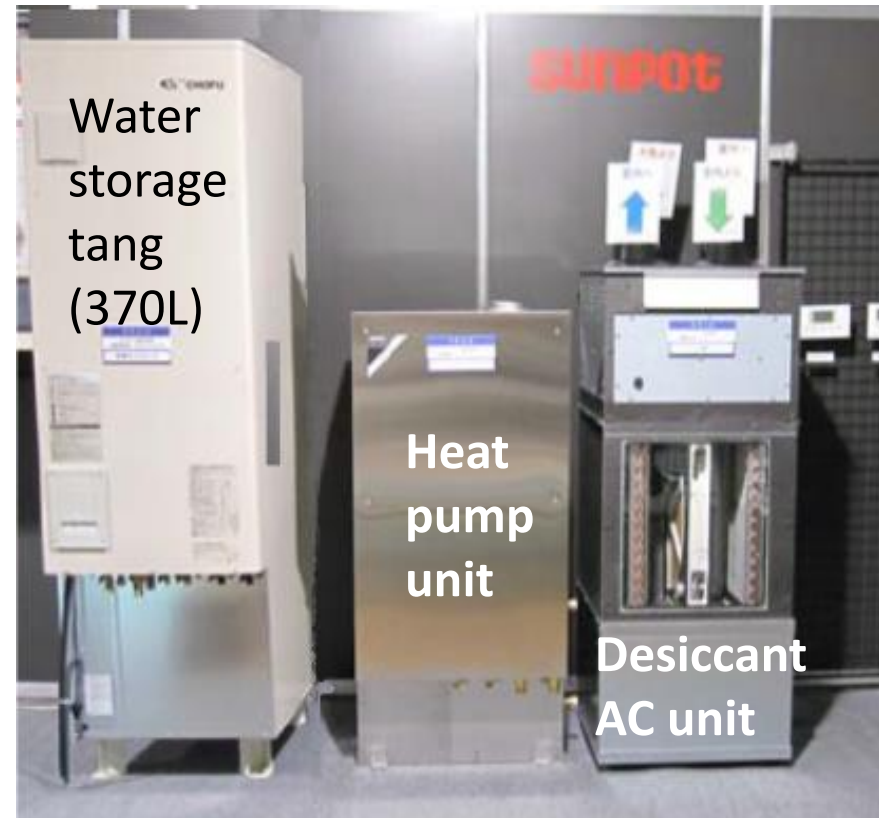
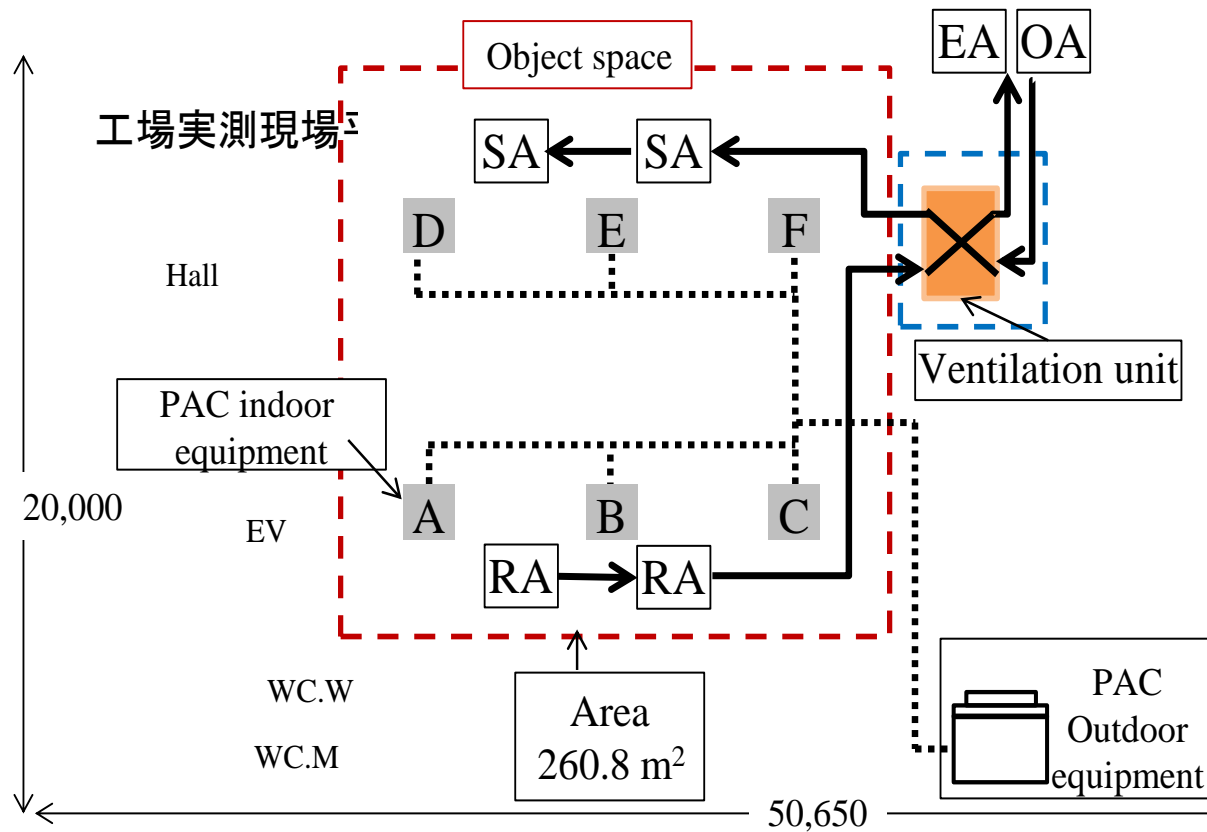


Fig. schematic drawing of compact Heat pump unit for heating, cooling and hot water supply with desiccant ventilation.



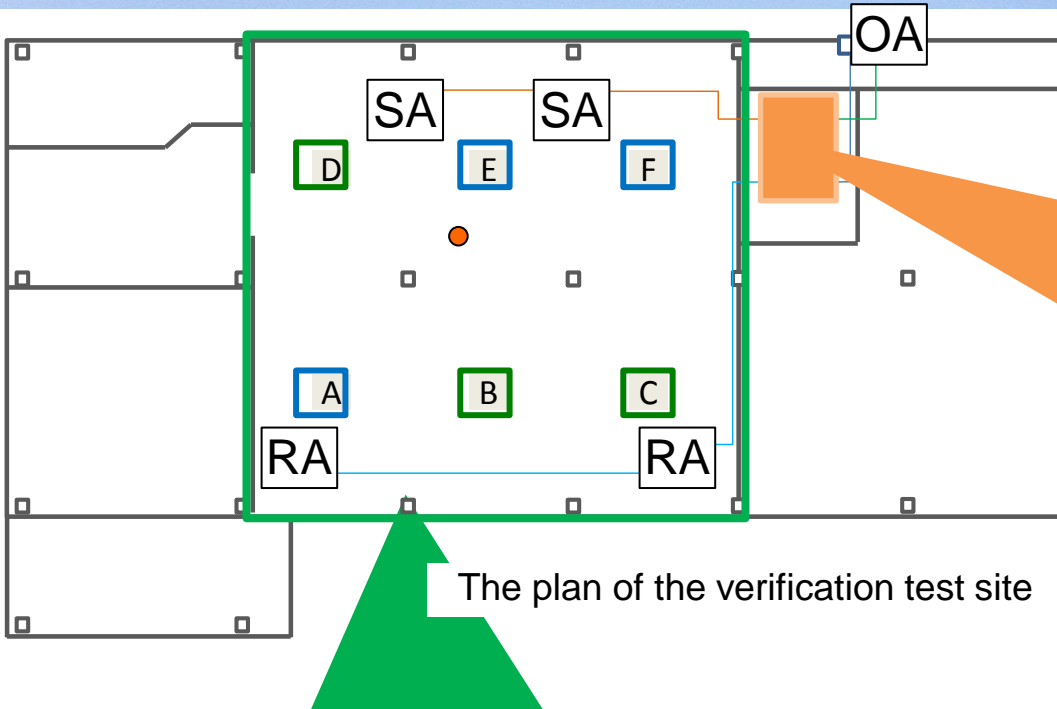
Newly developed compact heat pump unit with desiccant ventilation unit.



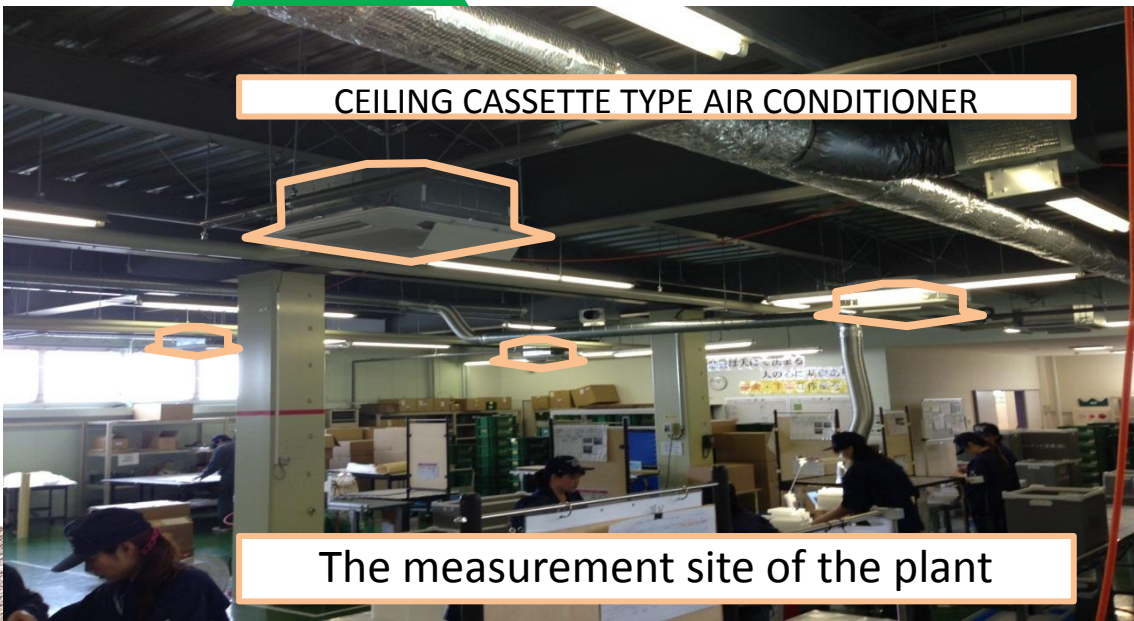




# 6. On site test of a developed desiccant AC unit for office building

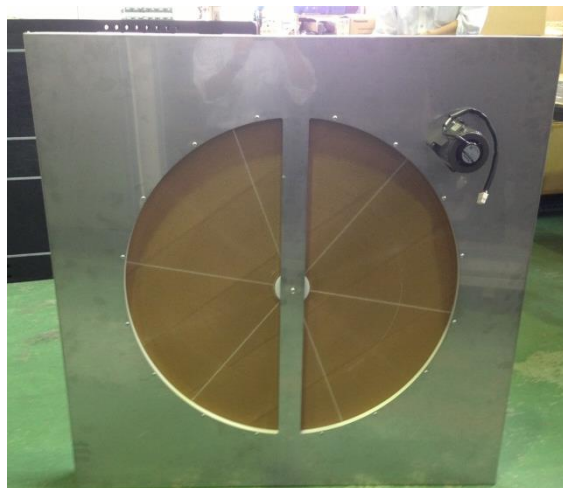


Outdoor arrangement(desiccant unit)



CEILING CASSETTE TYPE AIR CONDITIONER

The measurement site of the plant



Desiccant rotor



# Specification of the applied system

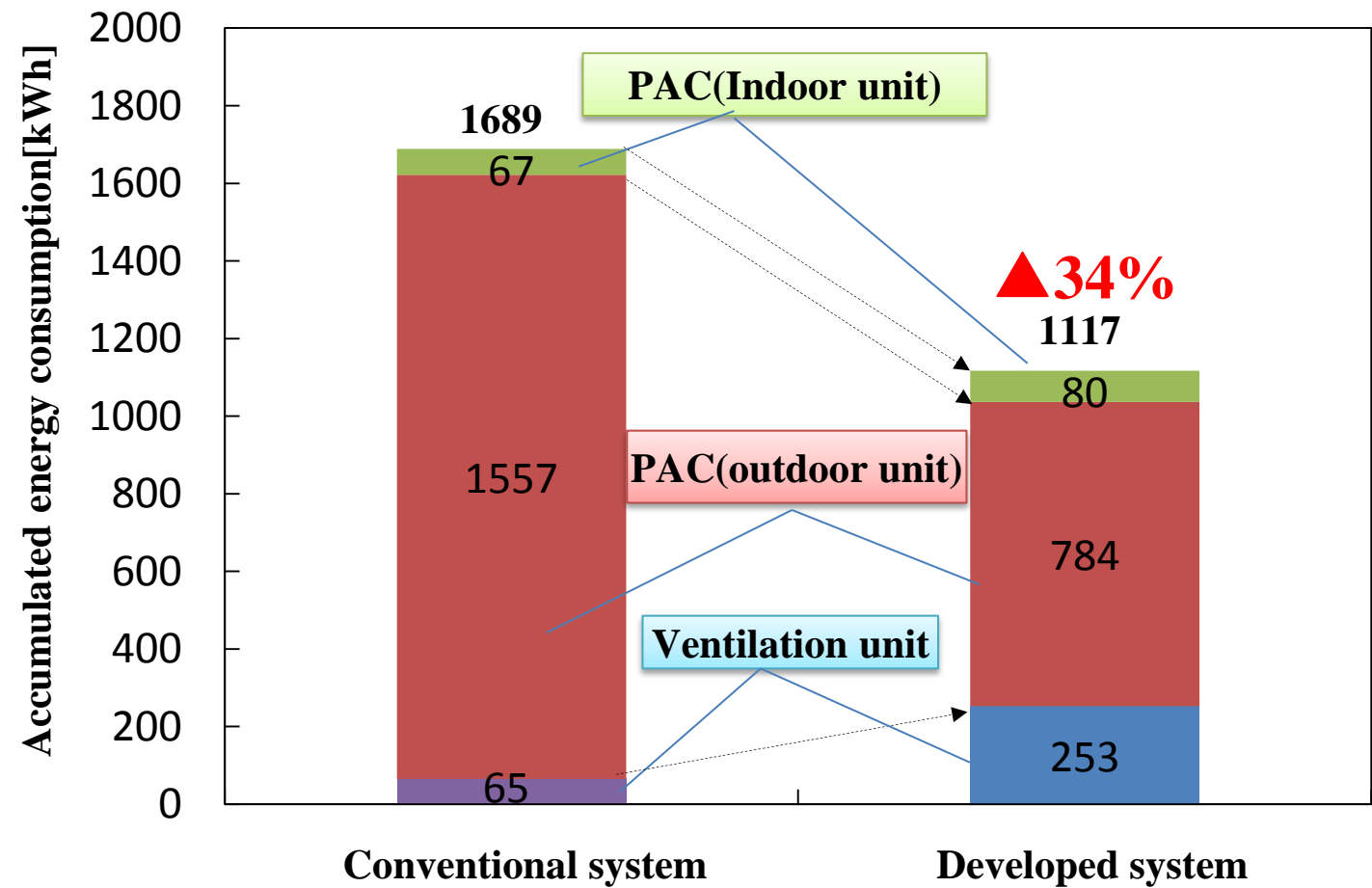
Building Air conditioner			
Air-conditioner	Air volume [m <sup>3</sup> /h]	Capacity [kW]	Energy consumption[kW]
Outdoor unit	-	56	13.47
Indoor units	1440	11.2	0.15
Ventilation Unit			
Ventilation unit	Flow rate [m <sup>3</sup> /h]	Heat recovery efficiency Latent /Sensible[%]	Energy consumption[kW]
Commercial products	500	66 / 68	0.22
Desiccant	500	72 / 81	1.5

Operation mode	Developed	Conventional
Ventilation unit	Desiccant	Commercial products
Evaporation Temp.	dew point (Sensible heat)	Approx.7 °C (Condensation)
Measuring period	July – September,2013 (80 days)	
Operating time	7:00 ~ 17:00	
Setting (Room)	26°C, 60 %, 12.6 g/kg <sub>DA</sub>	





# Comparison of accumulated energy consumption in summer season





1. Developed a new desiccant rotor using WSS as an absorbent.
2. Developed a desiccant ventilation unit in the combination with a high performance air- air enthalpy recovery element.
3. Prototype units for the office building and for the residential house were successfully developed. They have been installed in an actual building and a house. We proved that their performances achieved the target value.