

# Introducing EcoEnergy Research Institute

2016. 3. 30

Jaekeun Lee

President/Ph.D.

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[www.ecoenergy.re.kr](http://www.ecoenergy.re.kr)



**EcoEnergy Research Institute Co., Ltd. (EcoEnergy)**  
**World Best EcoEnergy Solution Provider !!!**

# Contents

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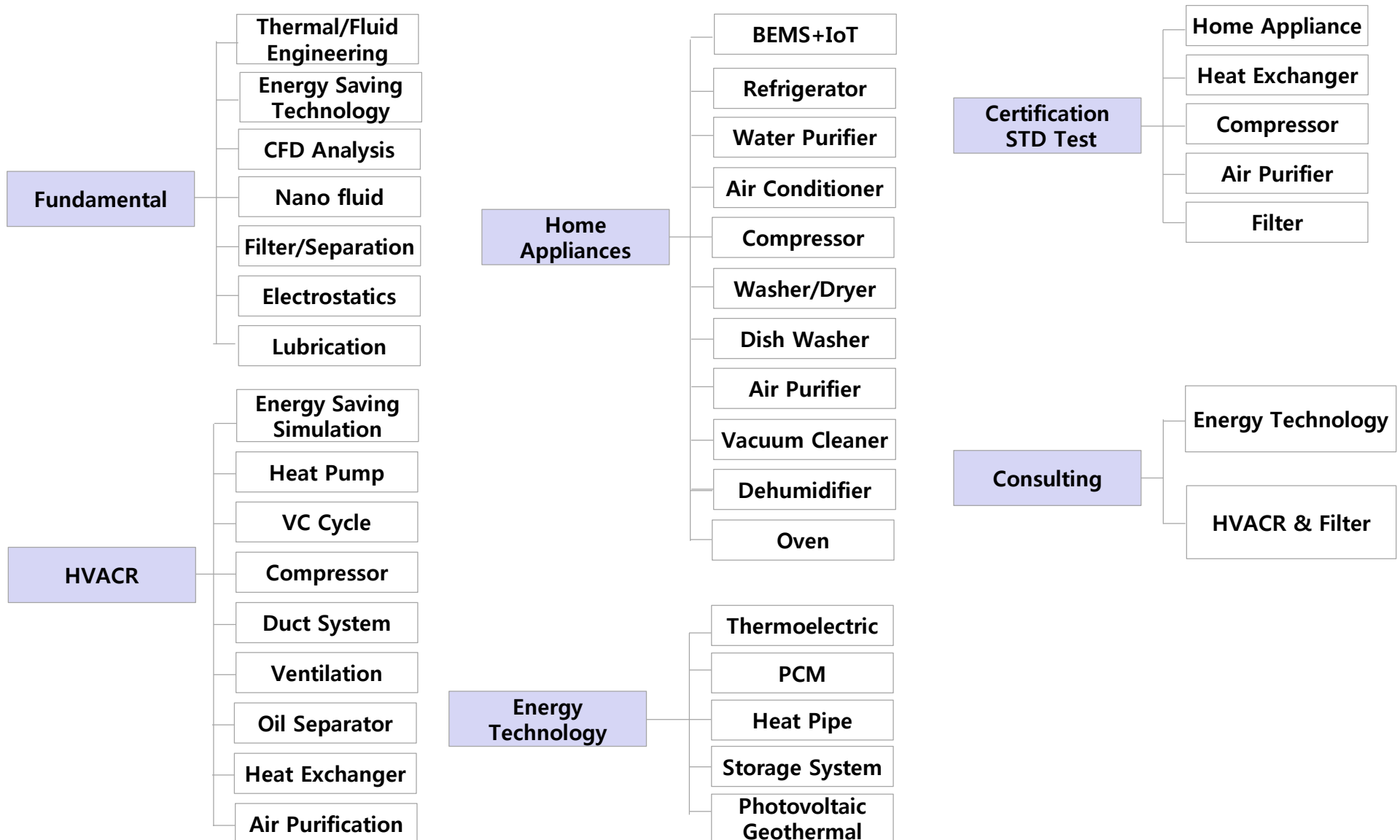


- **Introduction**
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# Introducing EcoEnergy Research Institute

<b>Company Name</b>	<b>EcoEnergy Research Institute Co., Ltd (EcoEnergy)</b>
<b>President</b>	<b>Jaekeun Lee (010-2127-7886, jklee@pnu.edu)</b>
<b>Established</b>	<b>in 2011</b>
<b>Location</b>	<b>Busan, Korea</b>
<b>Business Line</b>	<ul style="list-style-type: none"> <li>• R&amp;D &amp; Manufacturing of Home Appliances: Refrigerators Washing Machines, Air-Conditioners, Oven Ranges</li> <li>• Refrigeration Cycle, HVAC, Heat Pump Technology</li> <li>• Compressor &amp; Heat Exchanger Technology</li> <li>• BEMS/IoT: Building Energy Management System</li> <li>• Building Energy Simulation: Modeling &amp; Optimization</li> <li>• Environmental Energy Technology</li> <li>• Renewable Energy, Solar Cooling/Heating</li> <li>• Nanofluid &amp; Surface Coating Technology</li> <li>• Air Cleaning &amp; Vacuum Cleaner, Filtration, Electrostatics</li> </ul>
<b>Numbers of Employee</b>	<b>27 (7 Ph.D, 15 Master Degree)</b>
<b>Facilities</b>	<b>Psychrometric Calorimeter, Compressor Tester Air Cleaner Tester, Drier Tester, Vacuum Cleaner Tester. etc</b>
<b>President Work Experience</b>	<ul style="list-style-type: none"> <li>- Commercialized Products: 35 Models</li> <li>- Geothermal Heat Pump, Vacuum Cleaner, Membrane Filter</li> <li>- Patents No.: 75, Research Projects No.: 200</li> <li>- Journal Papers No.: 453</li> <li>- Books published: 10</li> </ul>

# Research/Business Area



# Strong Points of EcoEnergy Res. Ins.

## ● Excellent Faculties in Environmental Energy Technology

- R&D experts in Environmental Engineering, HVACR, Home Appliances
- Having experience with 200 research projects related to energy saving & home appliances

## ● Key Technology of Energy Issues

- Current key technology such as refrigeration cycle, heat pump, heat exchangers, compressors, BEMS/IoT, energy saving technology, air/liquid cleaning, surface coating, nanofluids/nanobubble technology
- Applied to home appliances such as air conditioners, refrigerators, cooking ovens, washing machines, driers, compressors, air cleaners, and vacuum cleaners.

## ● Global Top Research Facilities in Environmental Energy Engineering

- Psychrometric Calorimeter, Compressor Testers, Friction/Lubrication Testers
- Performance Testers of Air-conditioners, Refrigerators, Air Cleaners, Vacuum Cleaners

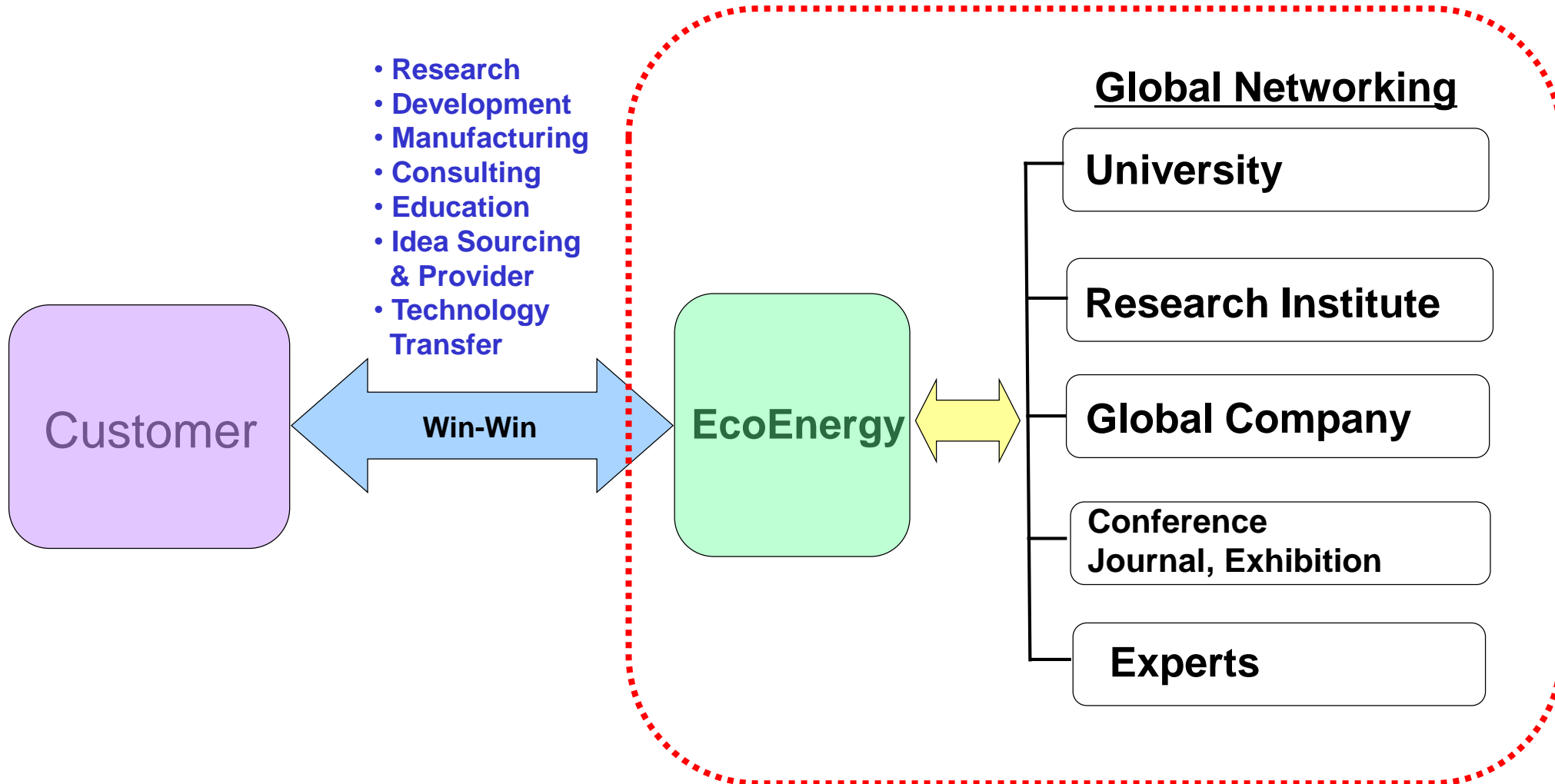
## ● Global Networking

- Making agreement with excellent universities and research institutes
- Acquainted with 120 researchers in environmental energy technology

## ● CEO's Excellent Work Experience

- Having job experience of home appliances & HVACR for 30 years
- 35 commercialized products such as Vacuum Cleaner, Geothermal Heat Pump and Membrane Filter

# Collaboration between EcoEnergy and Customer



# Introducing President



- **Name:** Jaekeun Lee
- **Contact:** (Tel) 010-2127-7886, (e-mail) jaekeun.lee@ecoe.kr, www.ecoenergy.re.kr
- **Educational:**
  - June 1992: University of Minnesota (USA), Ph.D. in Mechanical Engineering
  - May 1990: University of Minnesota (USA), M.S. in Mechanical Engineering
  - Feb. 1983: KAIST (Korea), M.S. in Mechanical Engineering
  - Feb. 1981: Pusan National University (Korea), BA in Mechanical Engineering
- **Work Experience:**
  - 2011.1- present : President, EcoEnergy Research Institute (EcoEnergy)
  - 2009.5- 2010.5 : Department Head of Mechanical Engineering, Pusan National University
  - 2008.8- 2010.6 : Director of Energy Technology Center
  - 2006.8- 2010.5 : Director of HVAC&R Technology Center
  - 2005.1- 2010.5 : Director, LG CARE(Center of Air-Conditioning Refrigeration and Energy)
  - 1993.3- 2010.10 : Professor, Mechanical Engineering Dept., Pusan National University
  - 1992.7- 1993.2: University of Minnesota, Post Doctoral Position
  - 1991.6- 1993.2: MSP Company (USA), Design of Environmental Protection Device
  - 1983.2- 1988.6: LG Electronics
- **Specialty:** HVAC&R (Heating, Ventilation, Air-conditioning, Refrigeration)
  - Heat Exchanger, Compressor, Heat Pump, Nanofluids, Filtration, Electrostatics
  - Environmental Energy Technology, Renewable Energy, Thermal-Fluid Technology
- **Commercialized/Technical Transfer Products**
  - 35 Models(Vacuum Cleaner, Geothermal Heat Pump, Air Cleaner..)
  - Vacuum Cleaner: 14 Models, \$2,000M Sales
- **Patents No.:** 55, Books published: 6
- **Research Projects No.:** 200, **Journal Publication No.:** 453 papers

# Global Networking

- Making agreement with excellent universities and research institutes
- Acquainted with 120 researchers in environmental energy technology

Nation	Institute	Specialty & Researcher
U.S.A	University of Maryland, CEEE	Environmental Energy, HVACR, MEMS (Prof. Radermacher...)
	University of Illinois, ACRC	HVACR, Heat Exchanger (Prof. Jacobi ...)
	Purdue University, CTRC	HVACR, Compressor, Heat Exchanger (Prof. Groll...)
	NIST	Standard of HVACR, Thermal Fluid (Dr. Domanski...)
China	Tianjin University	Refrigeration Cycle, geothermal Heat Pump (Prof. Ma Yitai )
	Shanghai Jiao Tong University	Green Building, HVACR (Prof. Zhang...)
	Xian Transport Tech.	Compressor, HVACR
Japan	Kyushu University	Environmental Energy Technology
	Shizuoka University	Compressors (Prof. Yanagizawa ..)
India	IIT	Environmental Energy Technology, HVACR (Prof. Das)
Korea	Seoul National University	Prof. M.S. Kim (Refrigeration), Prof. M.S. Choi (Nano Particles)
	Yonsei University	Prof. Y.H. Cho (Heat Transfer)
	Hanyang University	Prof. K.S. Lee (Heat Pump), Prof. K.H. Ahn (Particle Technology)
	KAIST	Prof. S.Y. Lee (Two Phase Flow), Prof. D.G. Lee (Materials)
	Pusan National University	Prof. M.Y. Ha (Heat Transfer), Prof. E.B. Jung (Noise/Vibration)
	POSTECH	Prof. S.J Lee (Heat Transfer, Fluid Flow)
	KIMM	Dr. Y.J. Kim, Dr. E.S. Yoon (Environmental Energy, Turbomachinery)
	KIER	Dr. Y.H. Kang, Dr. N.C. Baik (Zero Energy House, Renewable Energy)



# Research Facilities (1/2)

## • Established Global Top Research Facilities in Environmental Energy Engineering

Facilities	Specification
Psychrometric Calorimeter	5RT
Plate Heat Exchanger Tester (Shell-Tube Heat Exchanger)	5RT (19 kW, 25 Hp)
Compressor Simulator I	100-500W
Compressor Simulator II	1,744 ~10,465W
Compressor Simulator III	8,790 ~ 35,163W
Compressor Reliability Tester I	50 ~ 300W
Compressor Reliability Tester II	3 RT
Chiller Simulator	5RT
Environmental Chamber	3x4x4m, -40C°
Compressor Lubrication Tester	-180 Hz Thrust/Journal Bearing
Friction/Erosion Tester	6,000 N, Disc on Disc
Multi Air-Conditioner Tester	15 HP, KSC9306 ANSI/ASHRAE 16-1983
Safety Tester of Electrical App.	IEC60335, UL412/484 UL474/1995 Tester
Heat Recovery Ventilator Tester	100~3,000CMH ARI1060
Air Cleaner Tester	KSC9314, ACA,AHAM
Vacuum Cleaner Tester	ASTM, IEC60312

Facilities	Specification
Refrigerator Certification Tester	-50C°, AHAM HRF-1 ANSI/ASHRAE 72-1995
Reverberant Chamber Anechoic Chamber	4.8x4.8x4 m, 18 dB ISO 3741, 25 dB
Refrigerator Simulator	-40C°
Indoor Air Quality Tester	Dust, CO, CO2, O3
Pressure, Flow, Noise Tester	0.5~10 m/s
Dust Monitor	0.1~10 um
Hydrosol Counter	0.1~10 um
Climate Environmental Chamber	10-90%, -40C° ~ 60C°
Digital Microscope	X3,000
High Speed Camera	2,000 f/s
Micro Weight Balance	Accuracy 10 ug
Thermal Image Camera	Fluke
Thermal Fluid Analysis program	Fluent
TRNSYS/Coil Designer	Software
Vacuum/Compressed Air Line	10 torr

# Research Facilities(2/2)

## Psychrometric Calorimeter



성능 : 3RT급  
시험장치 : 공기 - 물 실험  
공기 - 냉매 실험(증발, 응축)  
공기 유량 : 4~50CMM  
냉매 유량 : 50~250kg/h  
물 유량 : 20~2,000kg/h

## Plate HEX Tester



성능 : 5RT급  
시험장치 : 냉매 펌프  
(90~500kg/h), Pre-heater(20kW), 응축기, 환온  
수조, 질량유량계, 온도센서,  
차압계, Receiver, Data  
acquisition system 등

## Fuel Cell Test Station



주요 사양  
- 연료전지 Stack  
셀 면적 200cm<sup>2</sup>, 셀 수 12셀,  
단위면적당 전류량 180 A/cm<sup>2</sup>  
Stack 용량 1.2 kW,  
운전 온도 80 °C 이하

## Compressor Simulator



성능 : 9RT급  
시험장치 1 : 냉동능력 100~500W  
(R-600a, R-134a용)  
시험장치 2 : 냉동능력 1,744~10,465W  
(R-22, R-410a용)  
시험장치 3 : 냉동능력 8,790~35,163W  
(R-410a용)

## Refrigerator Chamber



규격  
3,000Wx4,150Dx2,950H  
시험장치  
온도 -10°C~60°C±0.2°C 이내  
습도 20~95%RH±2% 이내,  
풍속 0.25m/s 이내

## Comp. Reliability Tester



시험장치 1 : 냉방능력 50~300 W (R134a,  
R600a용), 2대 동시 시험 가능  
시험장치 2 : 냉방능력 28,000~40,000  
Btu/h  
(a) 압축기 신뢰성 평가장치 1  
(b) 압축기 신뢰성 평가장치 2

## Multi Heat Pump Tester



시험장치  
실내 2실, 실외 2실구성  
시료시방능력 30hp, 7.5hp,  
15hp냉방능력,  
소비효율 측정가능

\*부산 테크노파크 보유

## Heat Exchanger Tester



성능측정범위  
냉방능력측정 1,500~15,360kcal/h  
난방능력측정  
1,500~15,360kcal/h  
시료 풍량  
250~2,000CFM

\*부산 테크노파크 보유

## Air-Cleaner Tester



규격  
KSC9314, KACA(공기청정  
협회규격), AHAM  
시험장치  
풍동, 청정류, 무향실, 탈취챔버

\*부산 테크노파크 보유

## Vacuum Cleaner Tester



규격  
ASTM, IEC 60312, KS  
시험장치  
미세먼지측정설비, 공기정화측정  
장치, ASTM 풍동

\*부산 테크노파크 보유

## Heat Pump Simulator



- 작동 범위 : 압축기 0~120 Hz, 실외기 팬  
0~1800 rpm, 팽창 밸브 가변 가능  
- 주요 지점압축기 압출구, 팽창밸브 압출구 등)  
온도, 압력 측정 및 Sight Glass를 통한 내부  
유동 관찰 가능  
- 압축기 : Hermetic Compressor 9~12 kBTU  
R-410A 사용

## Refrigerator Simulator



압축기  
1/2HP, 중온용, 단상220V, Control Box 포함  
응축기 및 Fan motor  
공랭식, 단상200V, 60Hz, 9W  
증발기 및 Fan motor  
공랭식, 단상220V, 60Hz, 6W

## Geothermal Heat Pump



부산대학교 제1교수연구동(108RT)

부산대학교 제1교수연구동 준공

지열(地熱) 이용한 에너지 절약형 시스템 도입

제1교수연구동은 기존 학교시설의 건축스타일과 달리 현대적 감각의 창의성 있는 건축미를 자랑하며, 건축가 김중업 선생이 설계한 인문관의 모습을 현대적으로 재해석하여 기능적, 형태적으로 연결하고 있다. 특히 신·재생에너지 중 지열(地熱)을 이용한 에너지 절약형 냉·난방시스템을 개발, 도입하여 향후 교육시설에 가장 적합한 신·재생에너지 모델을 제시할 것으로 기대를 모으고 있다. (2007.03.23)



## Cogeneration Heat Pump



부산대학교 제10공학관(특성화공학관)



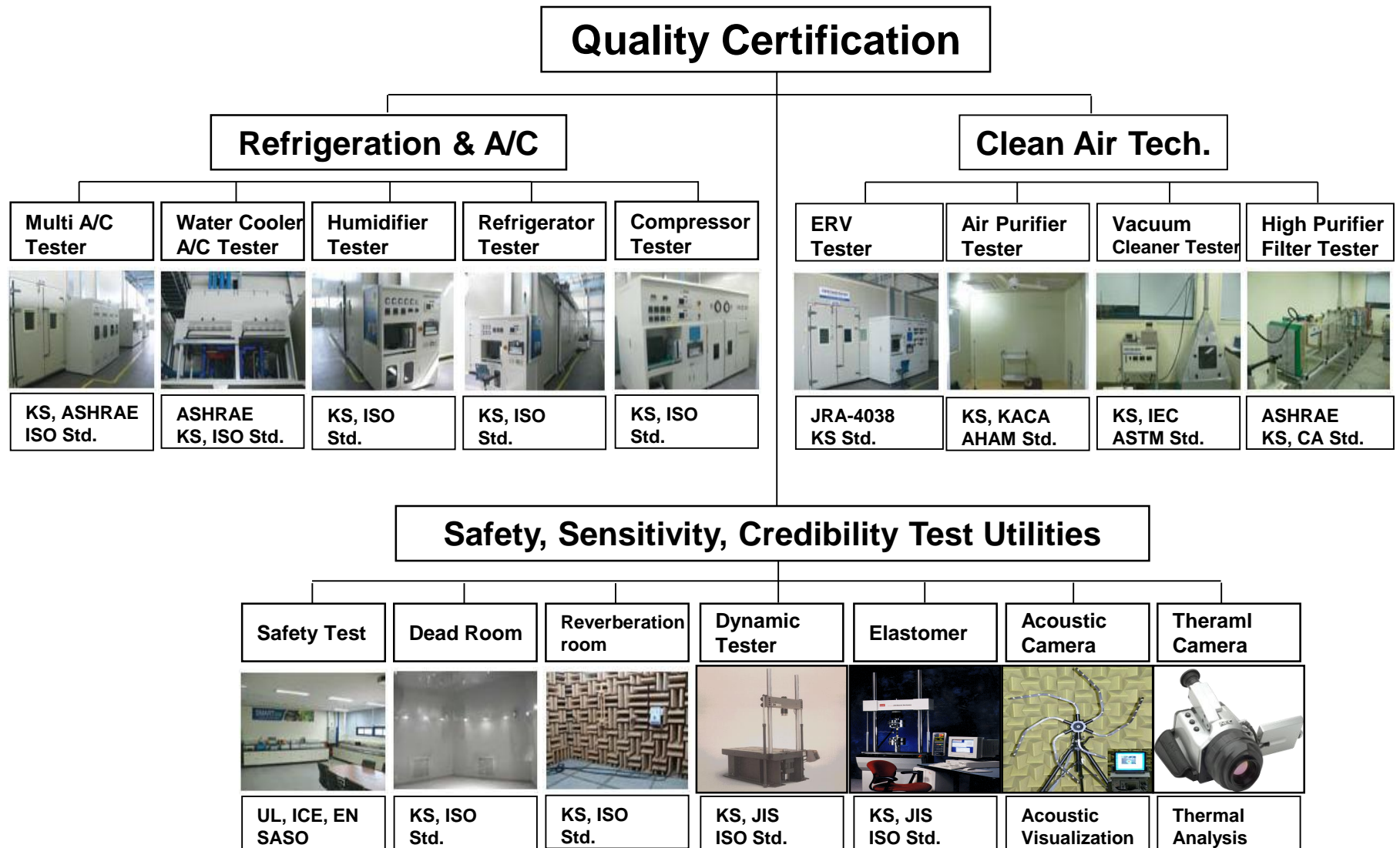
부산대 기숙사 (진리관)

-출력 : 30kW X 2 60kW -발전효율 : 50kW X 2 100kW -총합효율 : 85%

## Other Equipments

- 태양광발전 성능평가장치
- DOE(Green Building) S/W
- Heat Pipe성능평가장치
- 마이크로 열교환기 평가장치
- 압축기(리니어, 로타리, 왕복동식) 신뢰성 평가장치
- 풍력 발전 성능평가장치
- 열교환시스템 설계 S/W
- 열전도도 측정장치
- 나노입자 카운터
- 태양열 발전 성능평가장치
- 지열에너지 설계 S/W
- 비동열전달 측정설비
- 항온항습 Chamber
- Compressor Simulator
- 자기에너지 평가장치
- 에너지공정 설계 S/W
- 열전발전 / 냉동 성능평가장치
- 이마찰계수 측정장치

# Certification Testers (1/2)



\*Testers located in Busan TechnoPark, contracted with EcoEnergy



# Certification Testers (2/2)

## KOLAS Certification

Recovery Ventilator Equipment Test Lab

Air-conditioner Test Lab

Air-Cleaner Test Lab

Vacuum-Cleaner Test Lab

Refrigerator Test Lab



JRA-4038  
KS

KS, ISO  
ASHRAE

KS, KACA  
AHAM

KS, IEC  
ASTM

KS, ISO

-15 ~ 40 °C  
30 ~ 80 %  
1,500 ~  
15,360 kcal/h  
7 ~ 57 CMM

-20 ~ 60 °C  
20 ~ 90 %  
15,000 ~  
75,000 kcal/h  
18 ~ 100 CMM

Clean room :  
class 10000  
Particle counter  
: 0.1 ~ 20 µm  
Wind tunnel &  
Deodorization

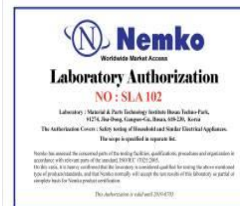
Dust  
emissions test  
Particle supply  
Particle  
instruments  
ASTM wind  
tunnel

Storage  
Temperature test  
Water Vapour  
condensation test  
Energy  
consumption  
Temperature rise  
time,  
Freezing test,  
Ice-making test



## Abroad Authority for Safety Test laboratory

### Electrical Safety Test of Refrigeration equipment



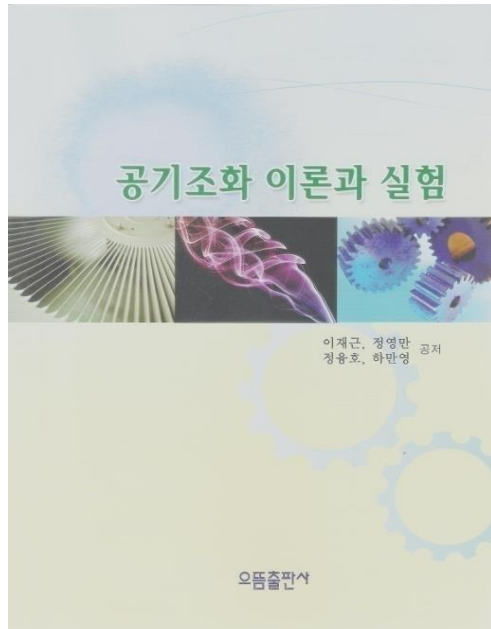
ISO 9001 : 2000, ISO 14001 : 2004



\*Testers located in Busan TechnoPark, contracted with EcoEnergy

# 6 Books published

**HVAC:Theory/Experiment**  
by Jaekeun Lee  
(p515, 2010)



**Refrigeration:  
Theory/Experiment**  
by Jaekeun Lee  
(p623, 2010)



**Compressor Technology:  
Theory/Experiment**  
by Jaekeun Lee  
(p639, 2011)



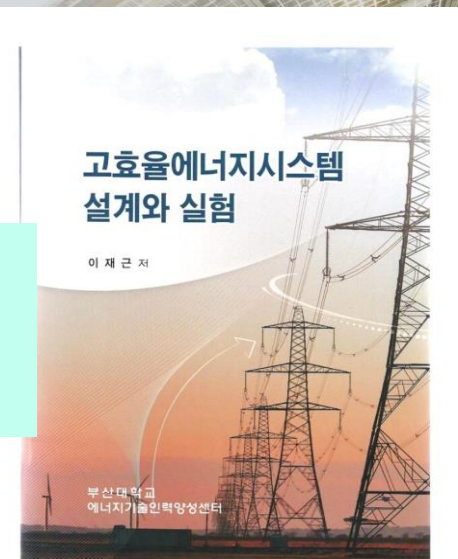
**Design of Renewable  
Energy System**  
by Jaekeun Lee  
(p656, 2010)



**Heat Exchanger:  
Theory/Experiment**  
by Jaekeun Lee  
(p582, 2011)



**High Efficient Energy  
System:  
Theory/Experiment**  
by Jaekeun Lee  
(p733, 2011)



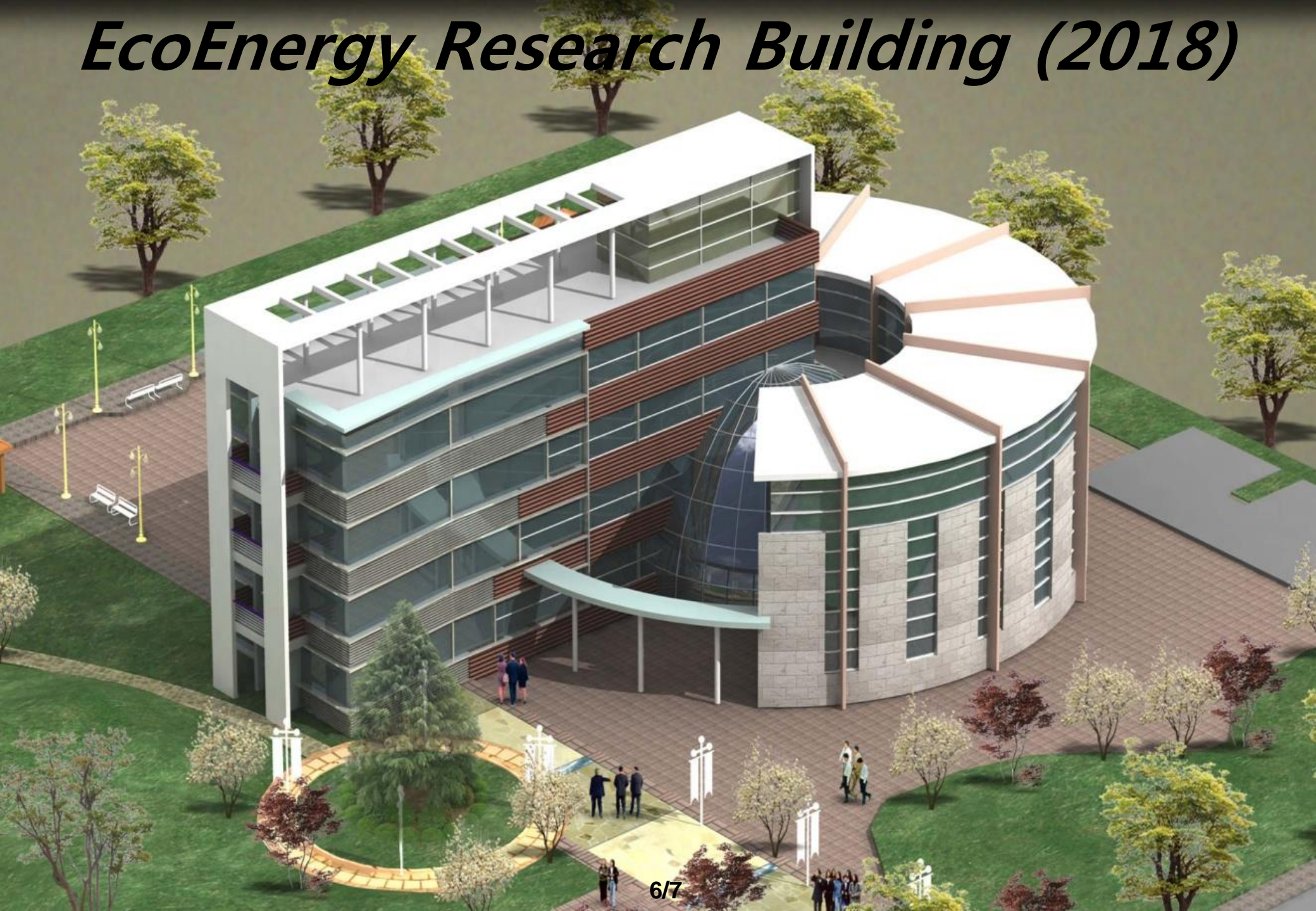
# ***VISION***



**EcoEnergy Research Institute Co., Ltd.**  
**World Best EcoEnergy Solution Provider !!!**



# *EcoEnergy Research Building (2018)*



# Introducing Research Experience of EcoEnergy

2016. 3. 30



**EcoEnergy Research Institute Co., Ltd. (EcoEnergy)**  
**World Best EcoEnergy Solution Provider !!!**



# Contents

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- **Air Conditioner & BEMS**
- **Compressor, Heat Exchanger**
- **Refrigerator, Washing Machine, Dryer**
- **Renewable Energy**
- **Oven, Dishwasher, Air Cleaner, Vacuum Cleaner**
- **MEMS/Nano Technology**

# Heat Exchanger, Compressor, Air Cleaner



## Heat Exchanger (2002~present)

- MF HEX, Fin-tube HEX
- Plate HEX, Shell-Coil HEX
- Plasma HEX, Total HEX
- Optimal & Compact Design
- HEX Fouling

## Compressor (2004~present)

- Scroll/Rotary Comp.
- Linear/Recipro. Comp.
- Thermal Analysis
- Lubrication & Reliability
- High Speed/High Pressure

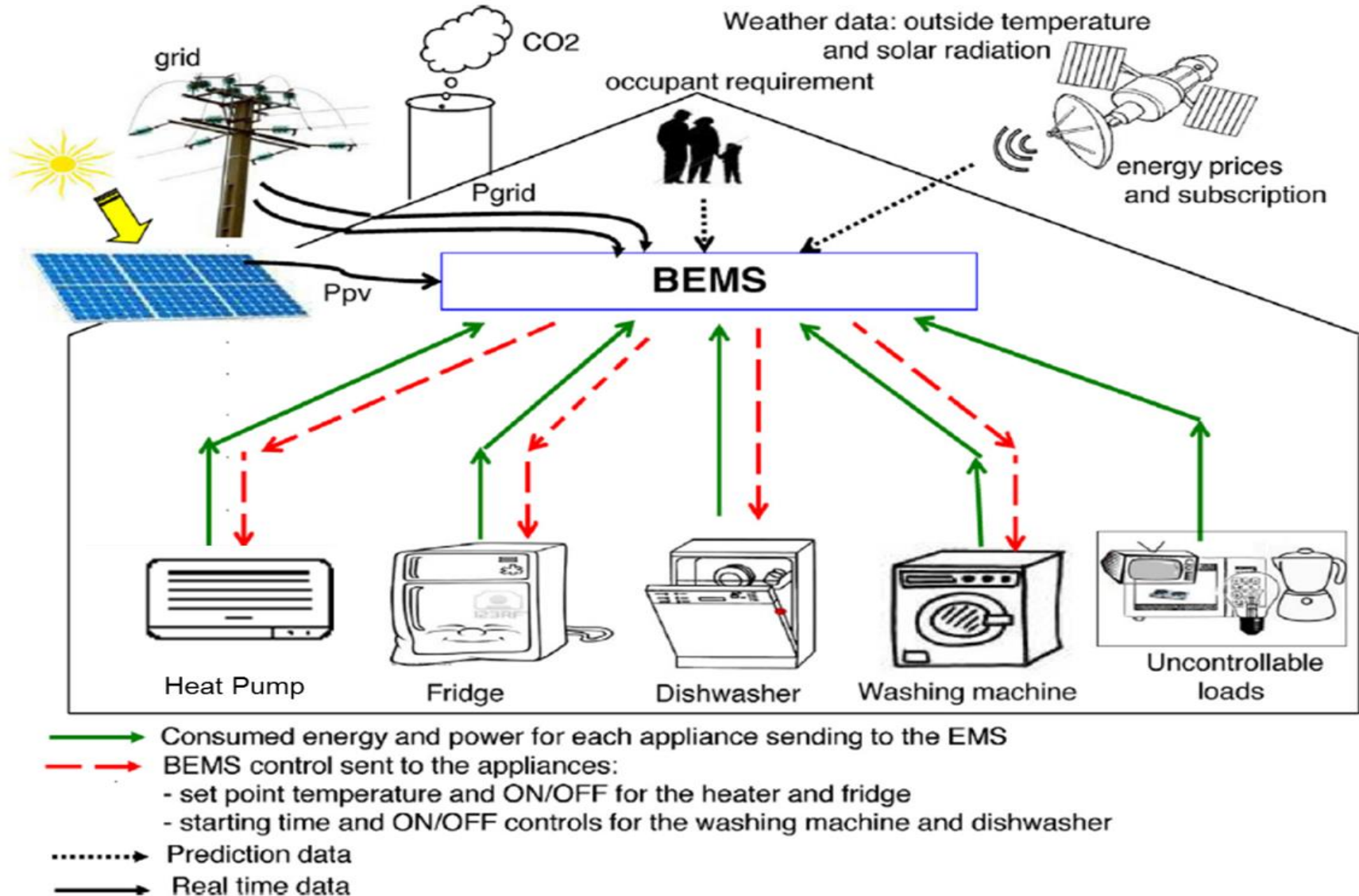
## Air Cleaner (2000~present)

- Design & Certification CADR
- Yellow Sands Removal
- PM2.5 Filter Module
- Electrostatic Precipitation
- Filter Design



# BEMS(Building Energy Management System)

## ▪ BEMS+IoT+Smart Appliances



# Research of Building HVAC & R

**BEMS/IoT (2008~present)**

- Building Energy Management System
- Building Energy Simulation
- Modeling& Optimization, LCC Analysis

**VRF Heat Pump (20HP) (2008~present)**

- High Speed Scroll Comp.
- New Heat Exchanger

**Chiller (2008~present)**

- Shell-Tube HEX
- Oil Return

**Geothermal Heat Pump (2006~2013)**

**Fuel Cell (2005~2008)**

**Heating/Cooling Load Program(2002)**

**Ventilation System(2000~2004)**

- School Ventilation & IAQ
- Comfortable Design

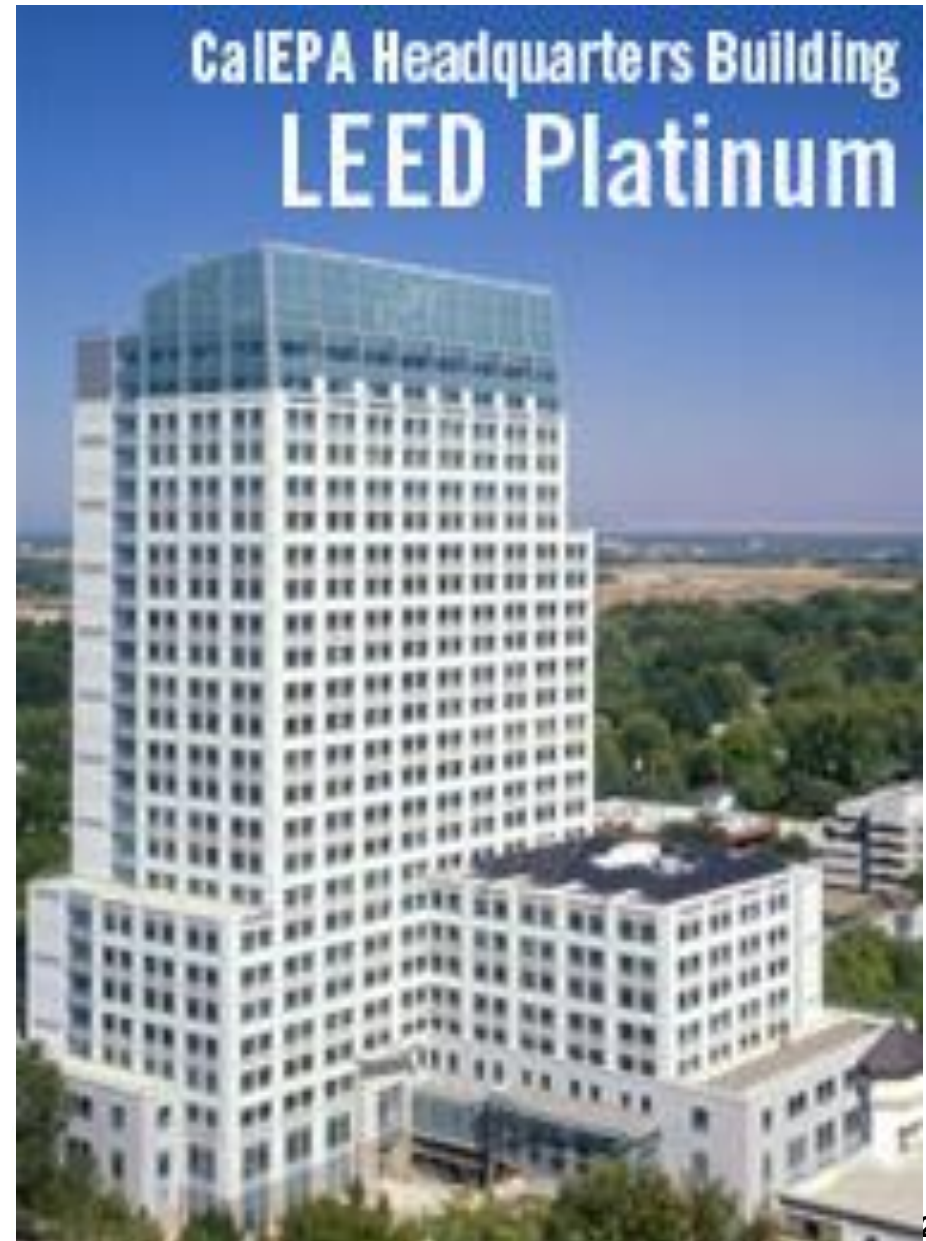
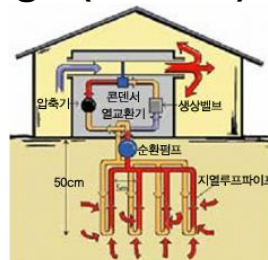
**Duct & Pipe Design (2001~2003)**

**Co-generation (2005~2010)**

**School Building Ventilation Design ('06~'10)**

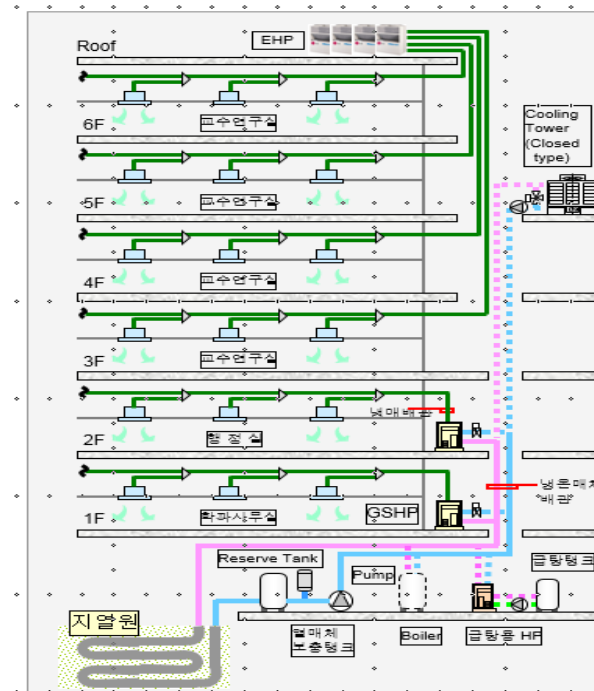
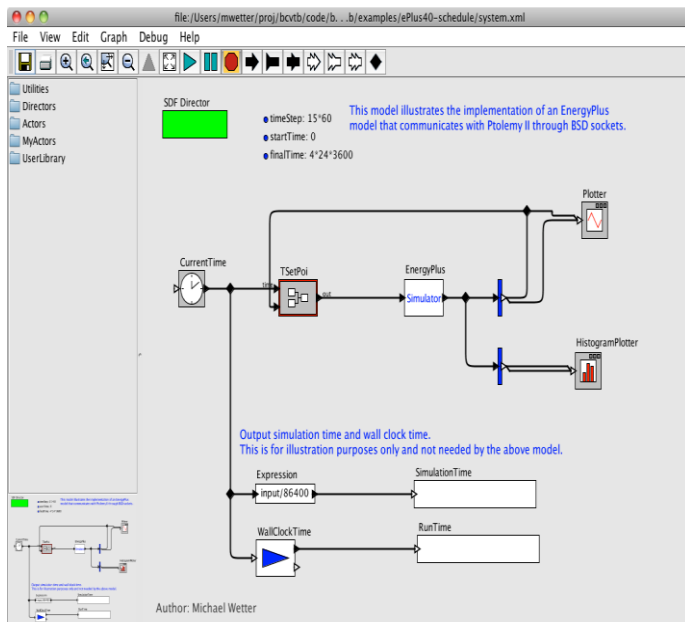
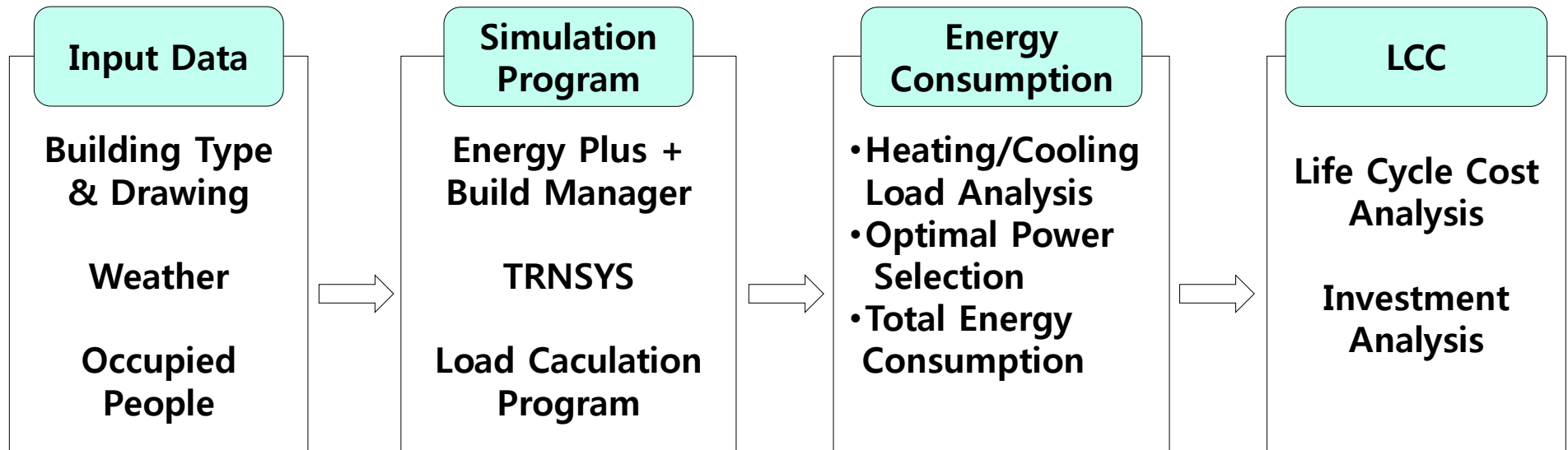
**Solar Cooling System (2010)**

- Adsorption Refrigeration
- PVT Module for Cooling

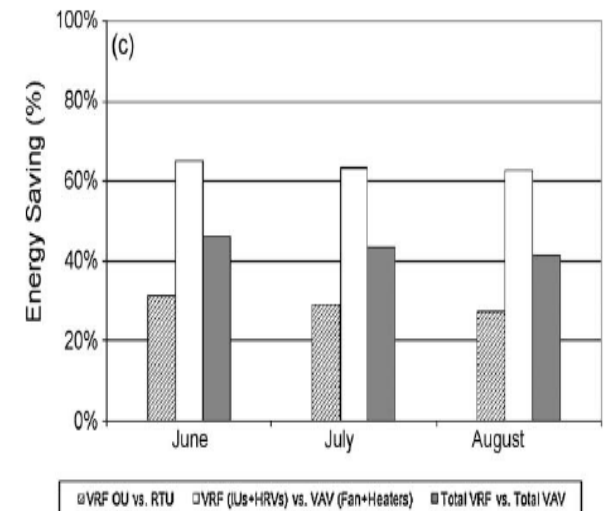




# Building Energy Simulation



**Example: Energy Saving Comparison Of VAV vs VRF System**



# Technology of Building Energy Saving

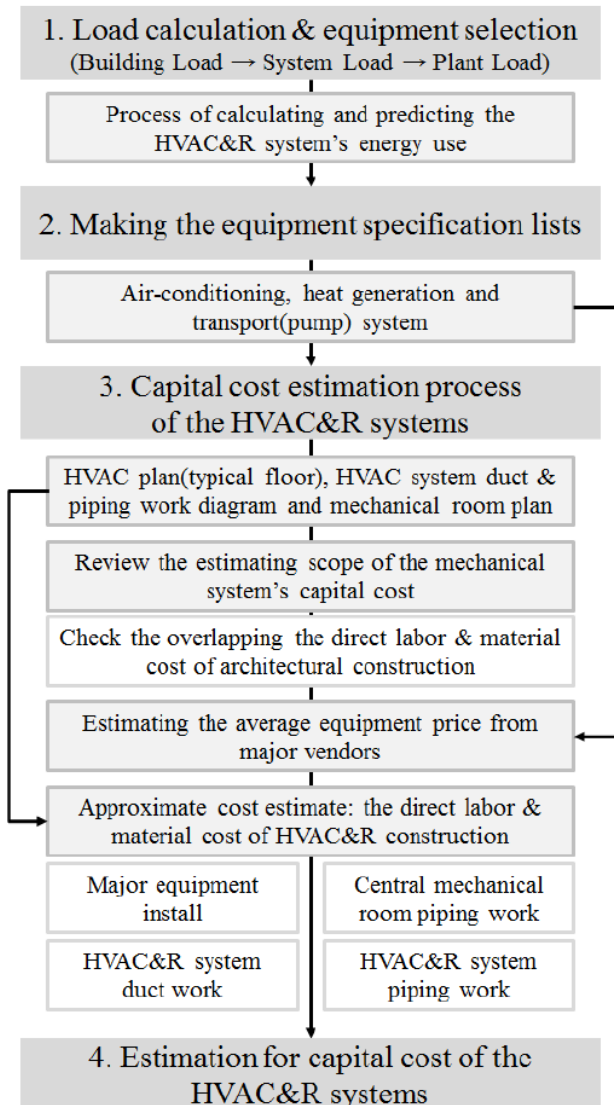
	Relevant Technologies		
<b>Component(24)</b>	Advanced Compressors	Advanced Desiccant Material	Backward-Curved/Airfoil Blower
	Copper Rotor Motor	Direct-Contact Heat Exchanger	Electrodynamic Heat Transfer
	Electronically Commutated Permanent Magnet Motor (ECPM)	Zeotropic Refrigerant	Electrostatic Filter
	Heat Pipe	High-Efficiency (Custom) Fan Blades	High-Temperature Superconducting Motor
	Hydrocarbon Refrigerant	Improved Duct Sealing	Larger Fan Blade
	Low-Pressure Refrigerant	Microchannel Heat Exchanger	Refrigerant Additive (Enhance Heat Transfer)
	Smaller Centrifugal Compressors	Twin-Single Compressor	Two-Speed Motor
	Unconventional (Microscale) Heat Pipe	Variable-Pitch Fans	Variable-Speed Drive
<b>System(14)</b>	<b>Dedicated Outdoor Air Systems (DOAS)</b>	<b>Demand-Control Ventilation (DCV)</b>	Chemical Heat/Cooling Generation
	<b>Apply Energy Model to Properly Size HVAC equipment</b>	<b>Alternative Air Treatment (to reduce OA)</b>	All-Water (versus All-Air) Systems
	<b>Displacement Ventilation</b>	<b>Ductless Split System</b>	Mass Customization of HVAC Equipment
	<b>Microenvironment (Task-ambient Conditioning)</b>	Novel Cool Storage	Natural Refrigerants
	Radiant Ceiling Cooling/Chilled Beam	Variable Refrigerant Volume/Flow	
<b>Equipment(10)</b>	Dual-Compressor Chiller	Dual-Source Heat Pump	Economizer
	Enthalpy/Energy Recovery Heat Exchangers for Ventilation	Engine-Driven Heat Pump	Ground-Source Heat Pump
	Heat Pump for Cold Climates	Liquid Desiccant Air Conditioner	Modulating Boiler/Furnace
	Phase Change Insulation		
<b>Controls/Operation(7)</b>	Adaptive/Fuzzy Logic HVAC Control	Building Automation System	Complete/Retro Commissioning
	Finite State Machine Control	Personal Thermostat (e.g. Ring Thermostat)	Regular Maintenance
	System/Component Performance Diagnostics		

# Energy Savings Potential for Building

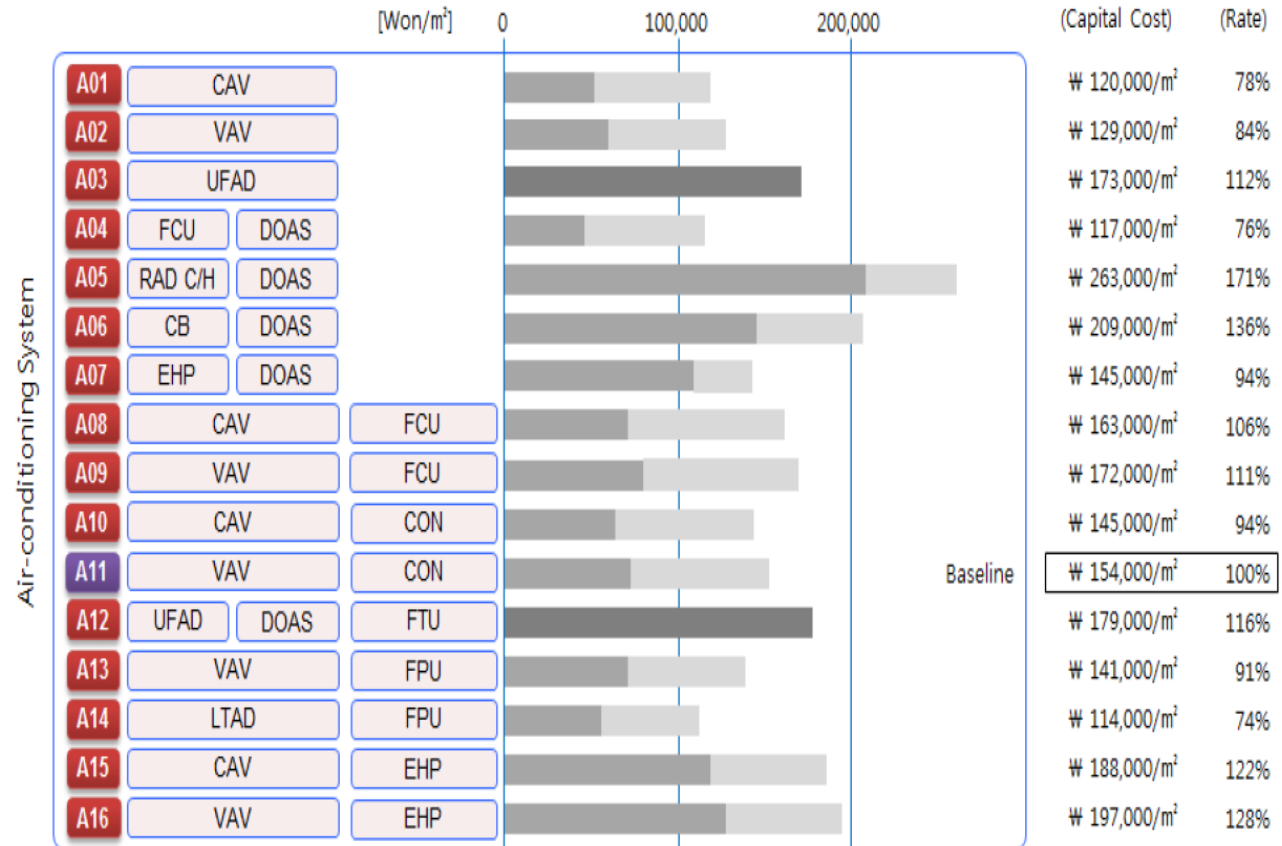
Technology Option	Technology Status	Technical Energy Savings Potential (quads)
Adaptive/Fuzzy Logic Controls	New	0.23
Dedicated Outdoor Air Systems	Current	0.45
Displacement Ventilation	Current	0.20
Electronically Commutated Permanent Magnet Motors	Current	0.15
Enthalpy/Energy Recovery Heat Exchangers for Ventilation	Current	0.55
Heat Pumps for Cold Climates (Zero-Degree Heat Pump)	Advanced	0.1
Improved Duct Sealing	Current/New	0.23
Liquid Desiccant Air Conditioners	Advanced	0.2 / 0.06 <sup>12</sup>
Microenvironments / Occupancy-Based Control	Current	0.07
Microchannel Heat Exchanger	New	0.11
Novel Cool Storage	Current	0.2 / 0.03 <sup>13</sup>
Radiant Ceiling Cooling / Chilled Beam	Current	0.6
Smaller Centrifugal Compressors	Advanced	0.15
System/Component Diagnostics	New	0.45
Variable Refrigerant Volume/Flow	Current	0.3

# HVACR Building Energy: Investment Design

## Initial Investment Estimation

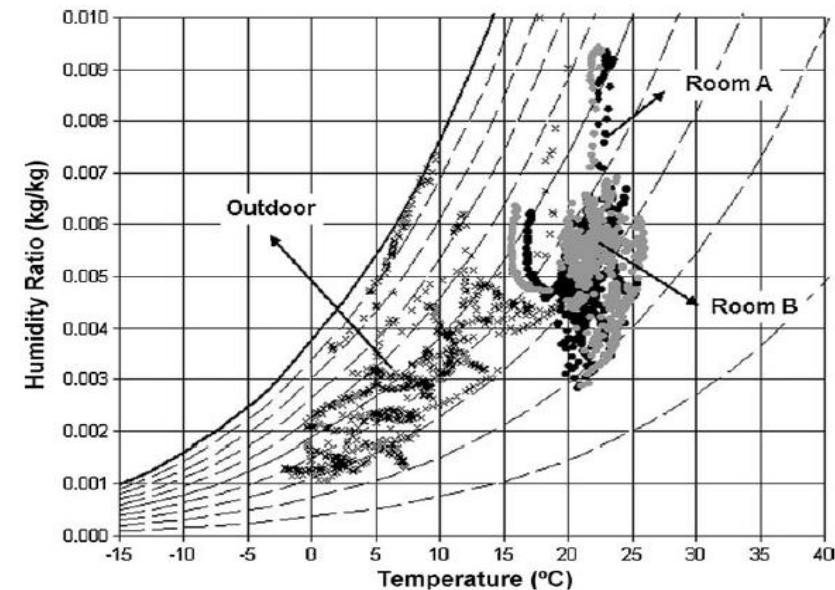
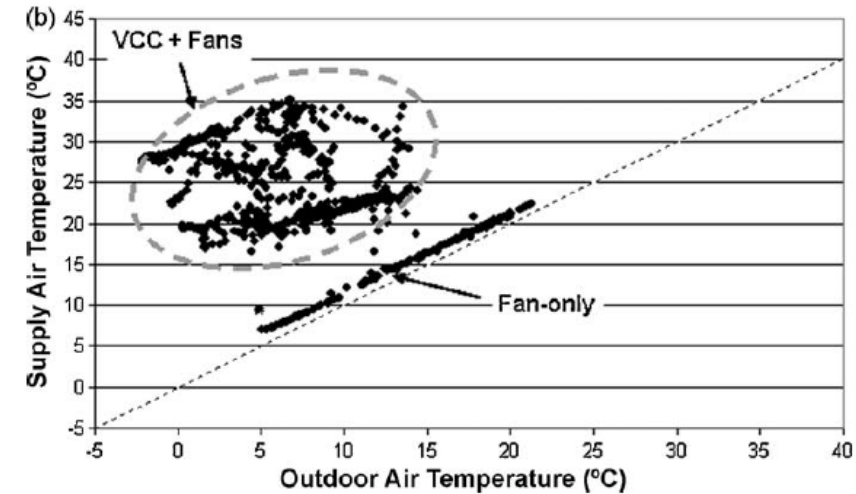
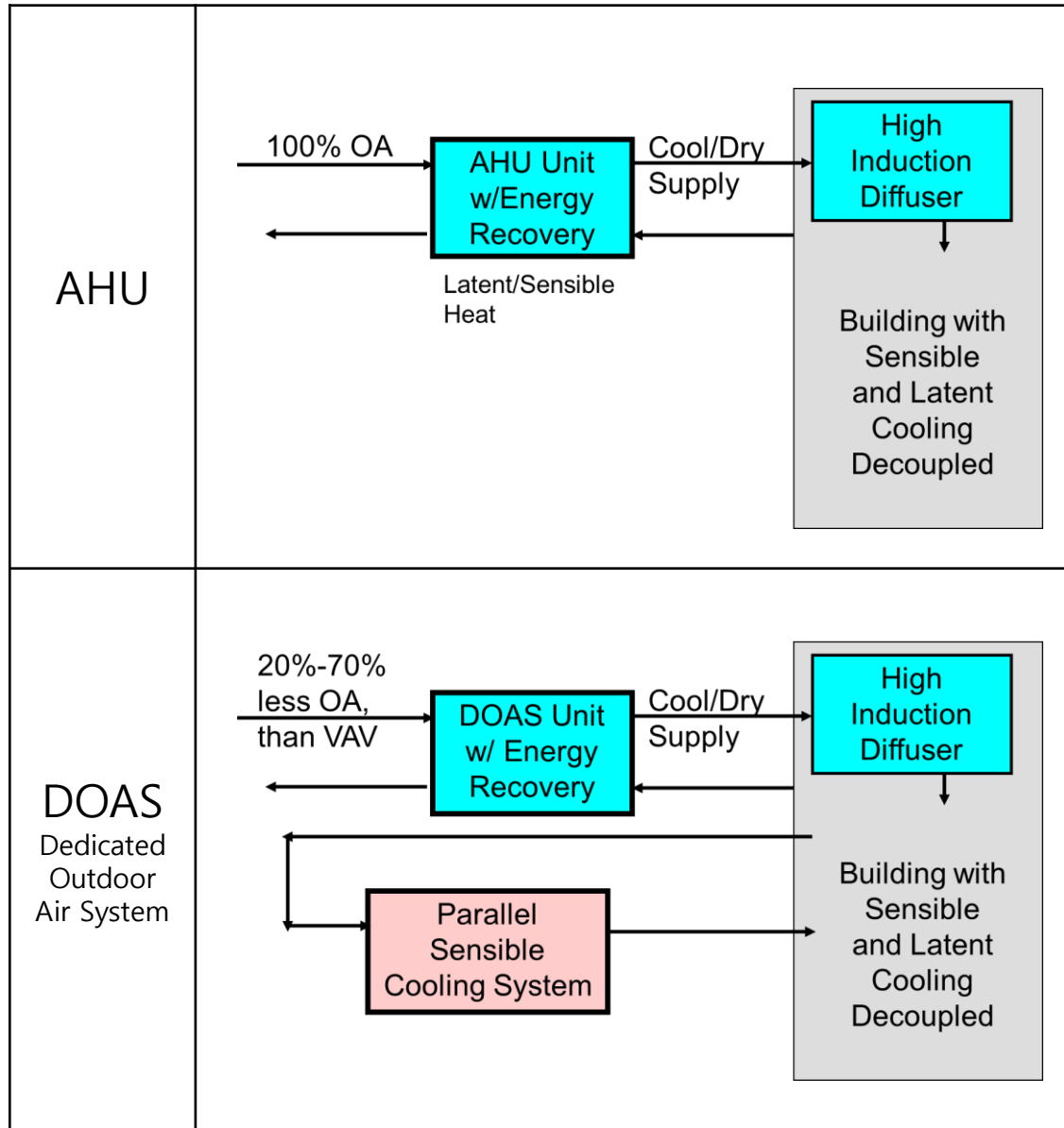


## Comparison of Initial Investment Estimation



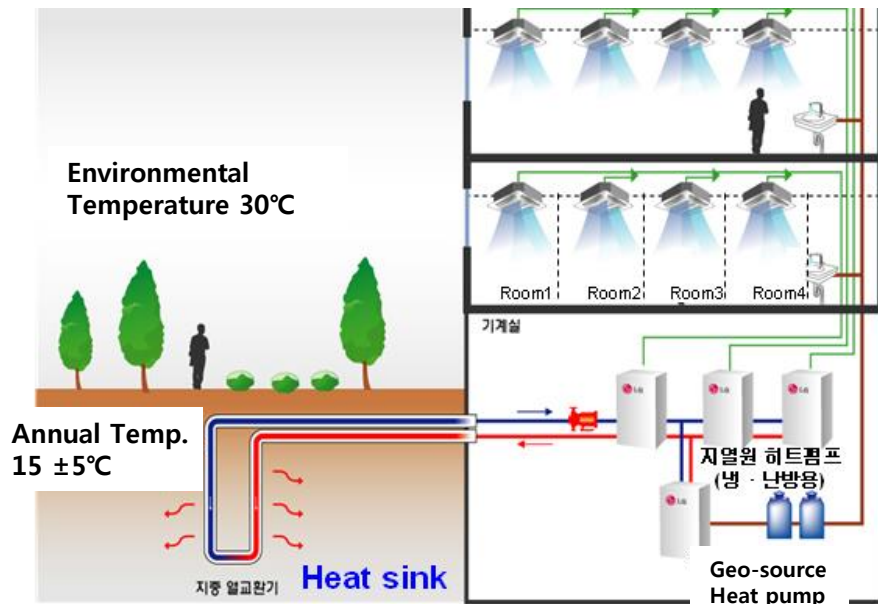


# Ventilation System Design

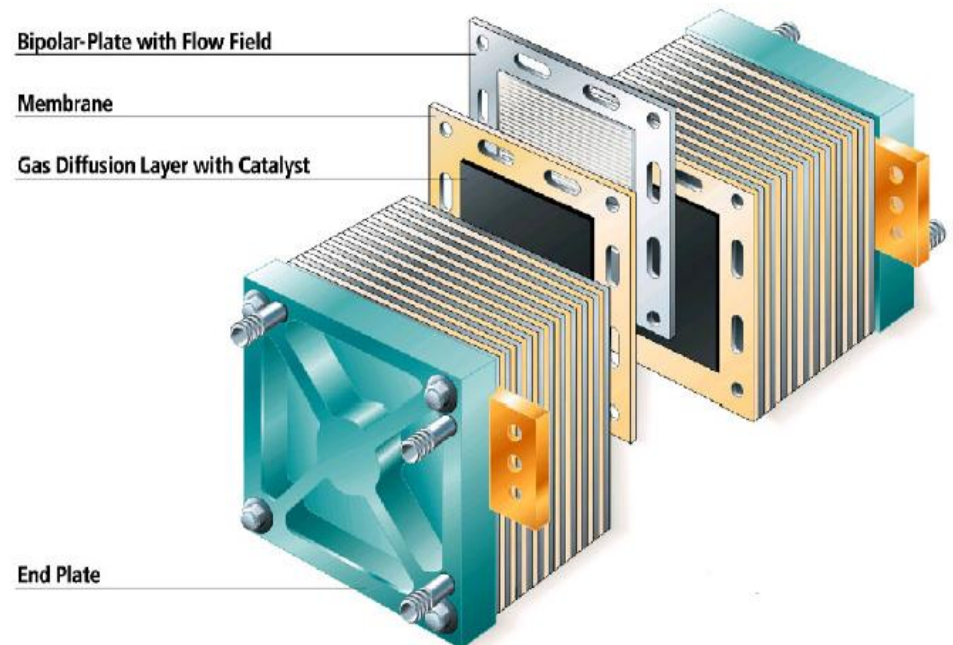


# Renewable Energy Research

1. Geothermal Heat Pump : Design of Ground Heat Exchanger and Monitoring Ground Temperature, Korean-typed Geothermal Heat Pump
2. Fuel Cell: Heat Balance/Water Management, Cooling Technology, Waste Heat Utilization
3. Solar Heating & Cooling, Application Technology of absorption chiller
4. Photovoltaic System : PVT Module for Cooling & Waste Heat Utilization
5. Nano-lubrication to Wind Power
6. Combined Heating Power Integration for Building
7. Green Campus, Green Building, and Zero Energy House



[Ground Source Heat Pump (Cooling) : 108 RT at PNU]



[Cooling System in Fuel Cell, 2006]

# Design & Evaluation of PNU Green Campus

Ground Source Heat Pump (GSHP), photovoltaic and solar heat systems have been installed in Pusan National University (PNU) campus and hospital buildings (2005-2010).

Green campus view of PNU (Yangsan campus)



Situation of Green Campus

		GSHP	Solar power	Solar heat	
Hospital	Oriental medicine	450 RT			Yangsan Campus
	Dental	405 RT			"
	Children	75 RT			"
School building	Medical C.	285 RT	50 kW		"
	Dental C.		50 kW		“(Cool tube)”
	Nursing C.	240 RT		400 m <sup>2</sup>	"
	Administration	120 RT			"
	Humanity C.	90 RT			Pusan Campus
	Power plant			400 m <sup>2</sup>	Yangsan Campus
Total		1,665 RT	100 kW	800 m <sup>2</sup>	



# PNU Geothermal Heat Pump System

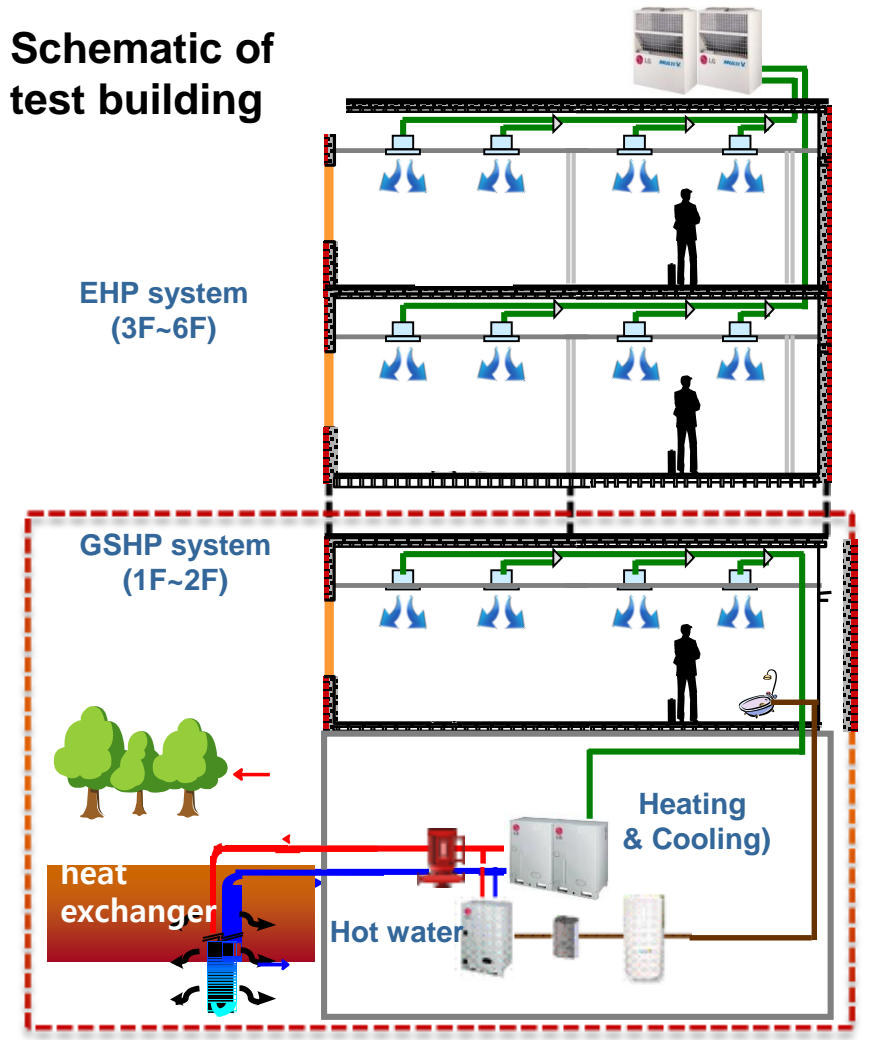
## System outline

- GSHP system and EHP (hybrid system) installed
- Total area of building : 7,070m<sup>2</sup> (B2~6F)
- GSHP system : 1F~2F(1,192m<sup>2</sup>)
  - Heat pump: 10HP x 10ea(heating and cooling) (90RT)  
10HP x 2ea(hot water) (18RT)
  - Ground heat exchanger : Closed vertical type  
(24borehole x 175m)
- Construction period : 2006. 4 ~ 2007. 2
- 10% Ethanol, Bentonite & Silica Sand for grouting

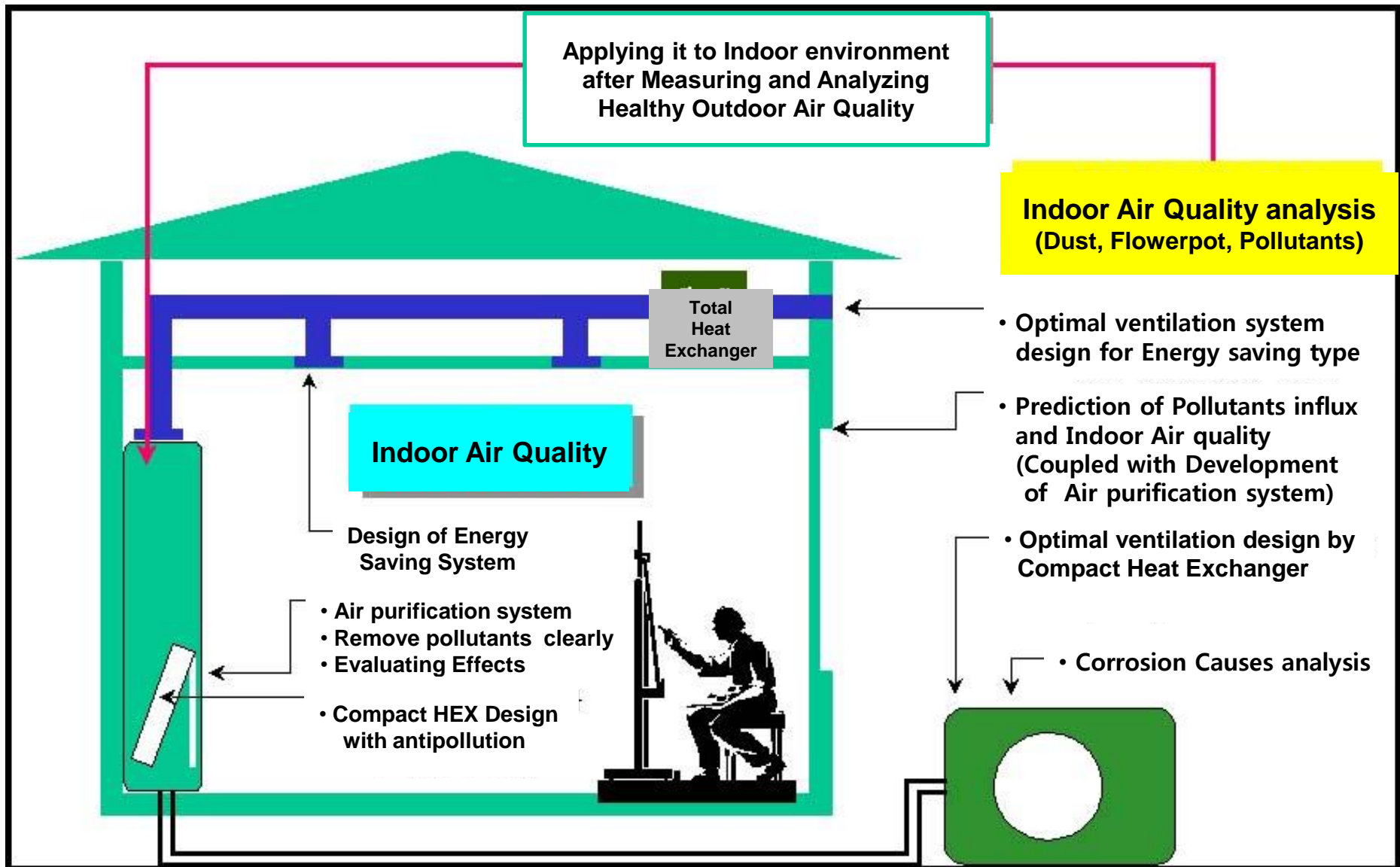


Pusan National University (PNU)

## Schematic of test building



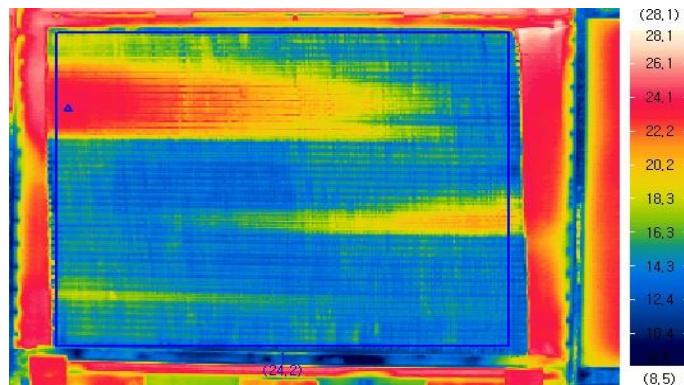
# IAQ & Ventilation



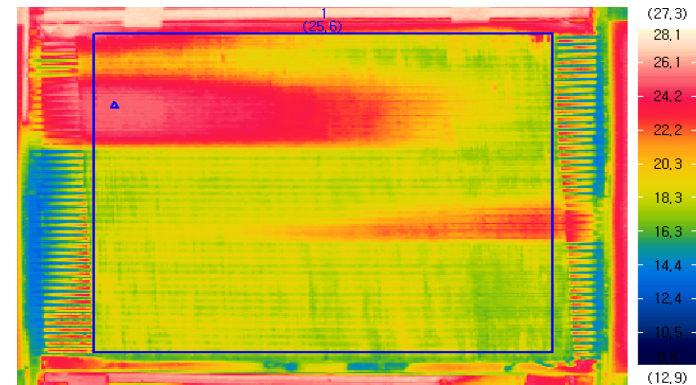
# Refrigerant Distribution of MF Heat Exchangers

Experiment results for refrigerant distribution analysis using a thermal camera (2010)

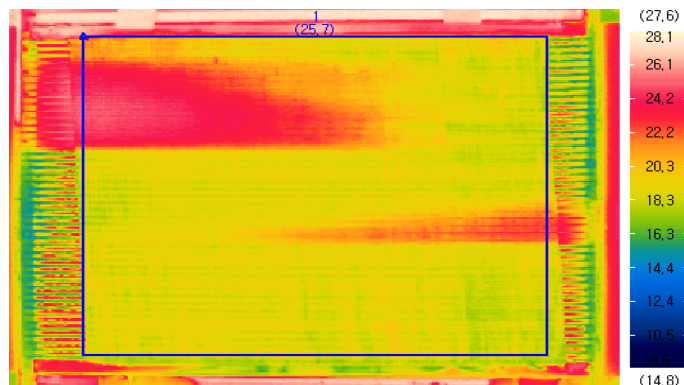
No distributor insertion  
(superheated area:2.3%)



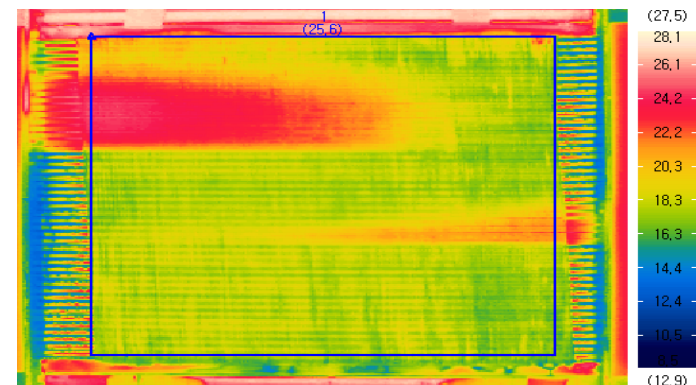
Distributor insert at position1  
(superheated area:10.1%)



Distributor insert at position2  
(superheated area:8.5%)

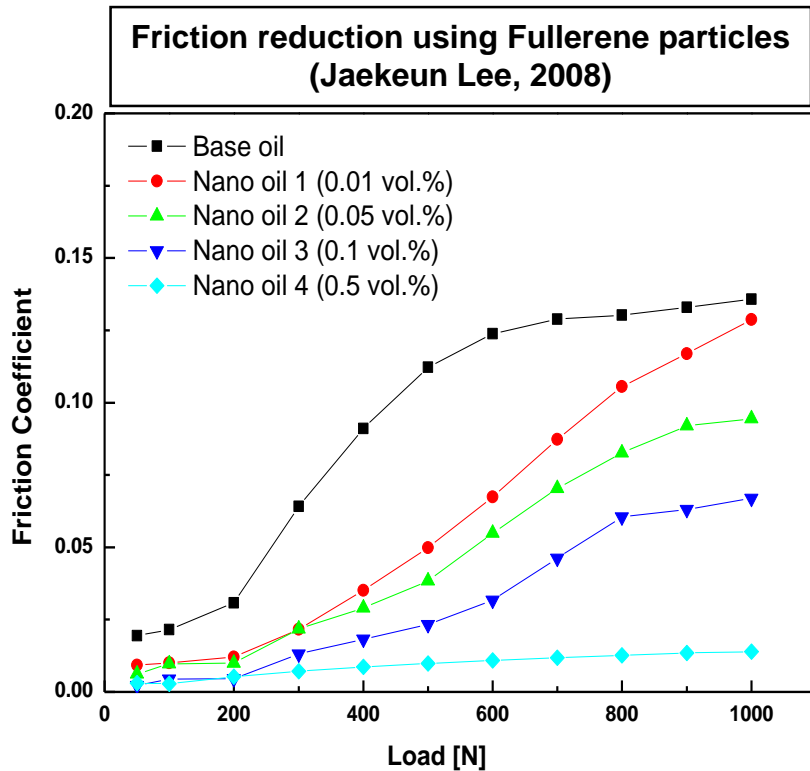
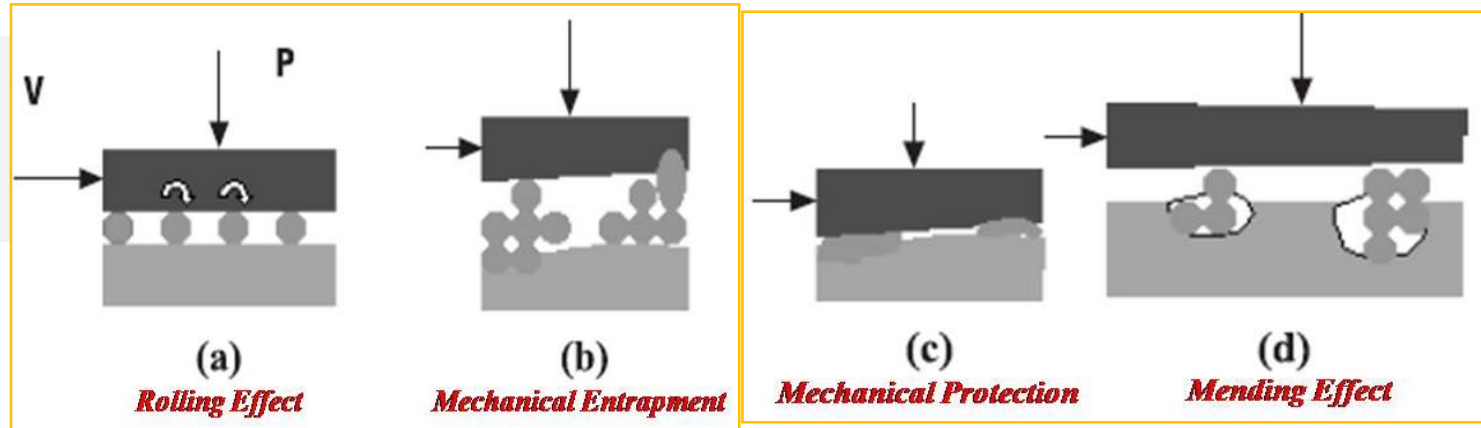


Distributor insert at position3  
(superheated area:6.1%)



# Nano Lubricants in Compressors (2005-2011)

- Low Friction
- Anti-wear
- High Extreme Pressure



Anti wear characteristics, Jaekeun Lee, 2008

(a) Abrasion with Raw Oil



(b) Abrasion with Nano Oil





# Refrigerator Research

## Energy Saving/Cycle

- High Efficient Cycle Design
- Low Power Consumption
- New Refrigerant
- New Concepts Cycles
- Global Regulation
- Gasket Simulator

## Fluid Flow/Heat Transfer

- Cold Air Distribution
- Ice/Water Technology
- Fan/Duct Design

## Evaporator/Condenser

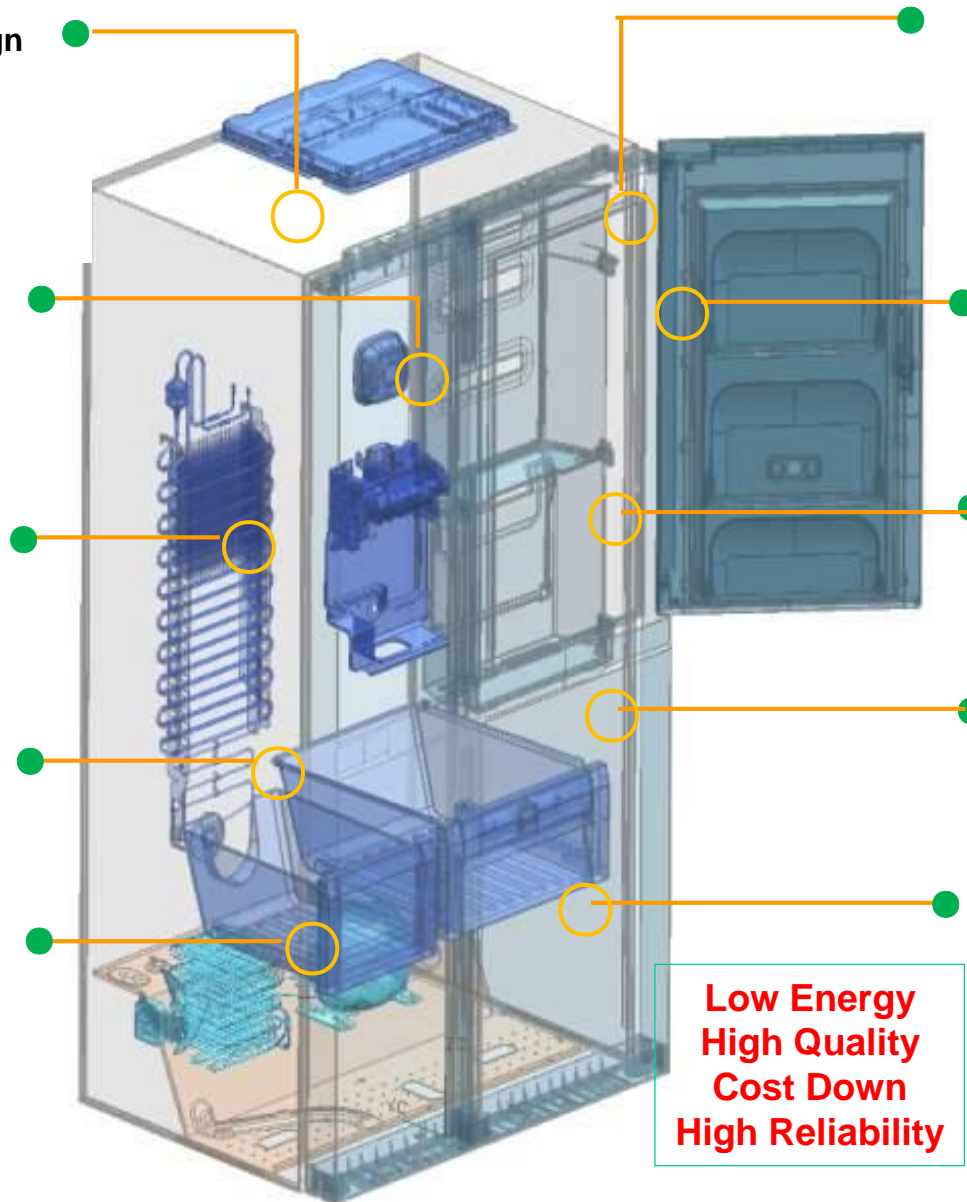
- Compact Design
- Defrosting Control
- MF HEXs/New Materials

## Sensor Application

- Temperature, Pressure
- Vibration, Flowrate

## Compressor Technology

- Inverter Control
- Low Noise, High Reliability
- Oilless Linear Compressor
- Reliability Test Period ↓



## Structural Design

- 3F(Fit,Finish,Feel) Design
- Cabinet/Door Design (DID: Door-in Door)
- Stiffness Analysis
- Deformation Analysis
- Packaging Drop Test

## Material/Processing

- Foaming, Gasket
- Insulation Material
- De-odor

## Freshness/ New Features 3S(Std, Simple, Share)

## Vibration/Noise Analysis

- Flow Induced Noise Tech.
- Low Noise/Vibration

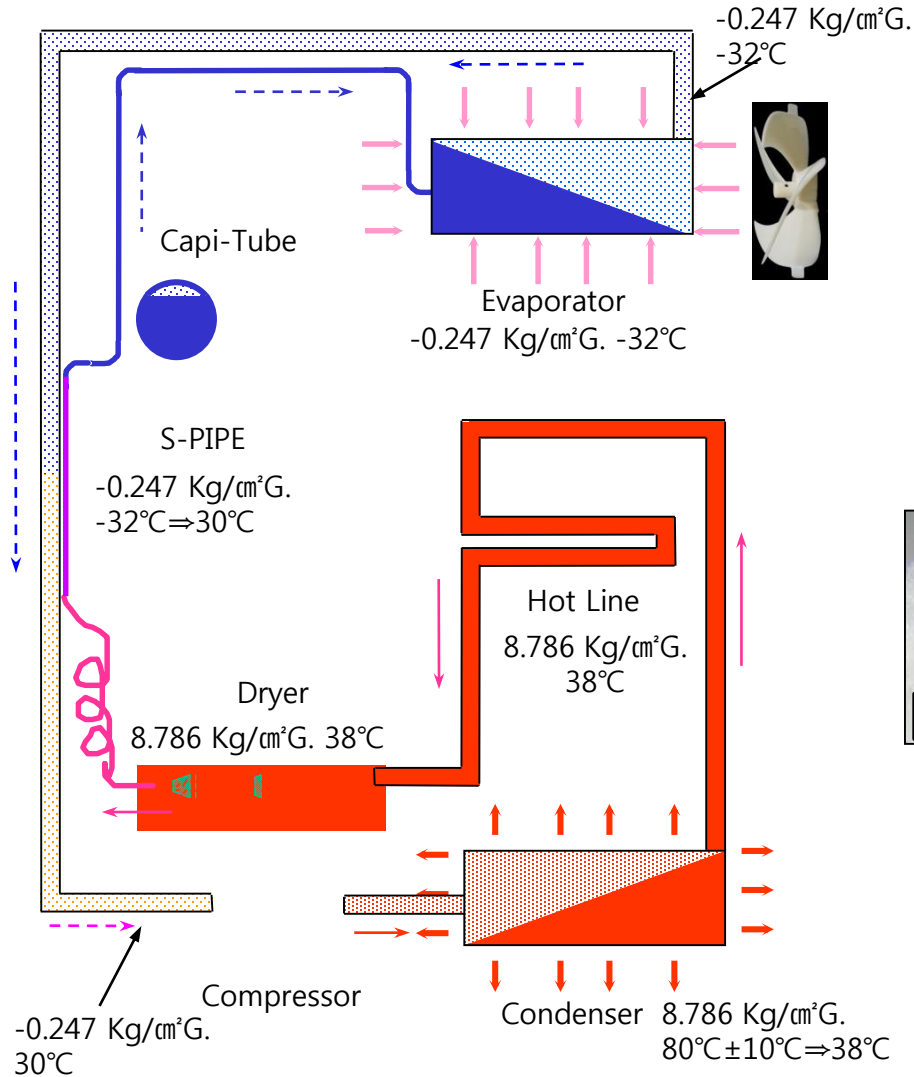
## System Algorithm Electronics

- Intelligent Control
- Signal Processing
- Failure Diagnosis
- Display



# Refrigeration Cycle Design

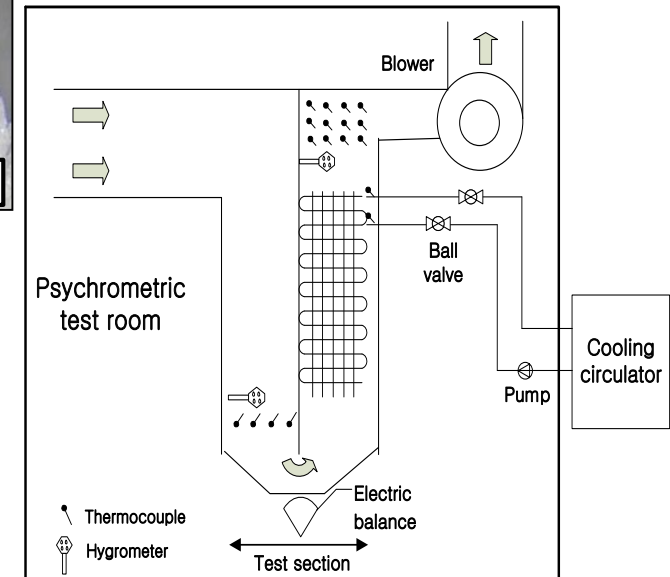
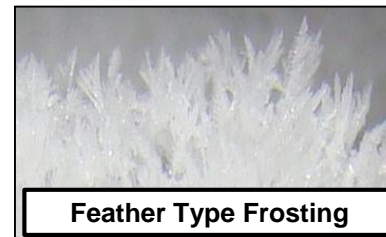
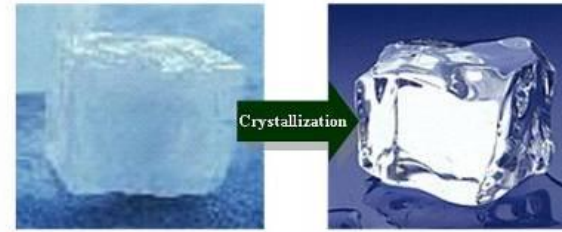
## Refrigerator Cycle Design (2005-present)



## Evaporator Design ('06-present)

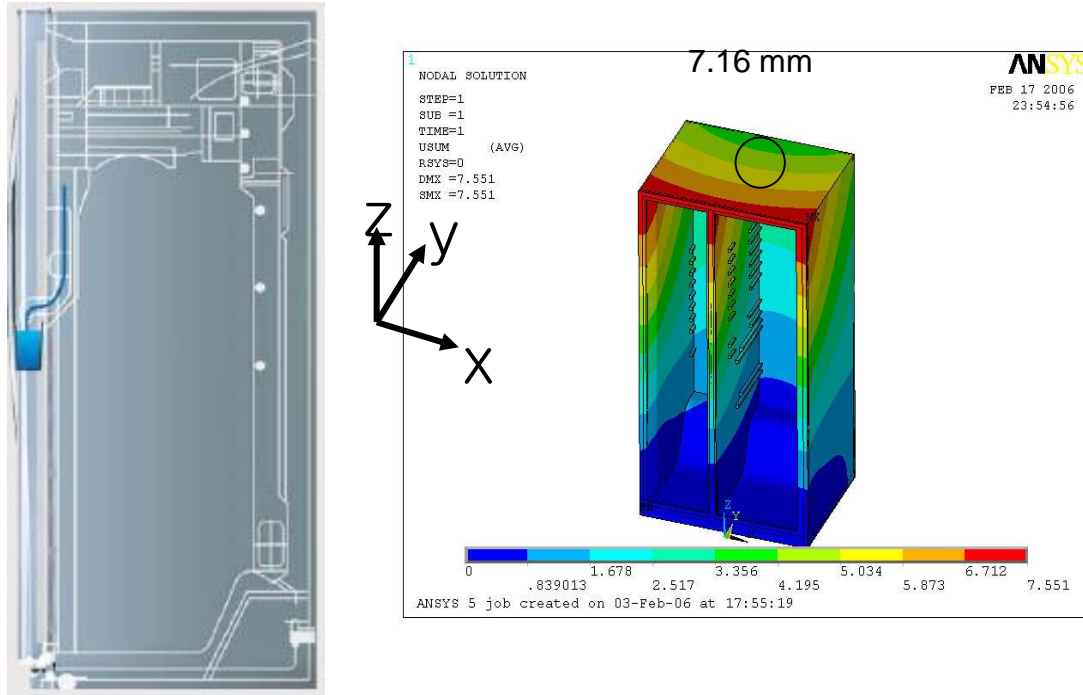
- Frost/Defrosting Test
- Heat Exchanger Test
- Flow/Pressure Measurement

## Crystal Ice Manufacturing ('11-'13)

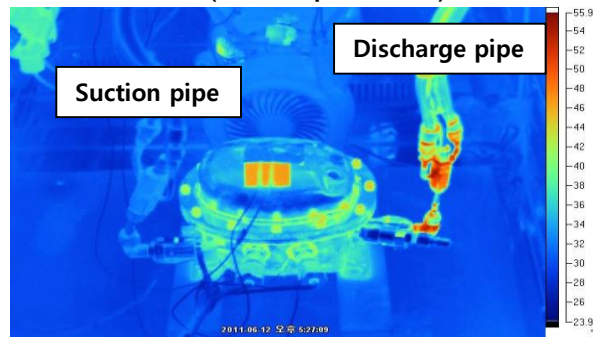


# Structural & Thermal Design of Refrigerators

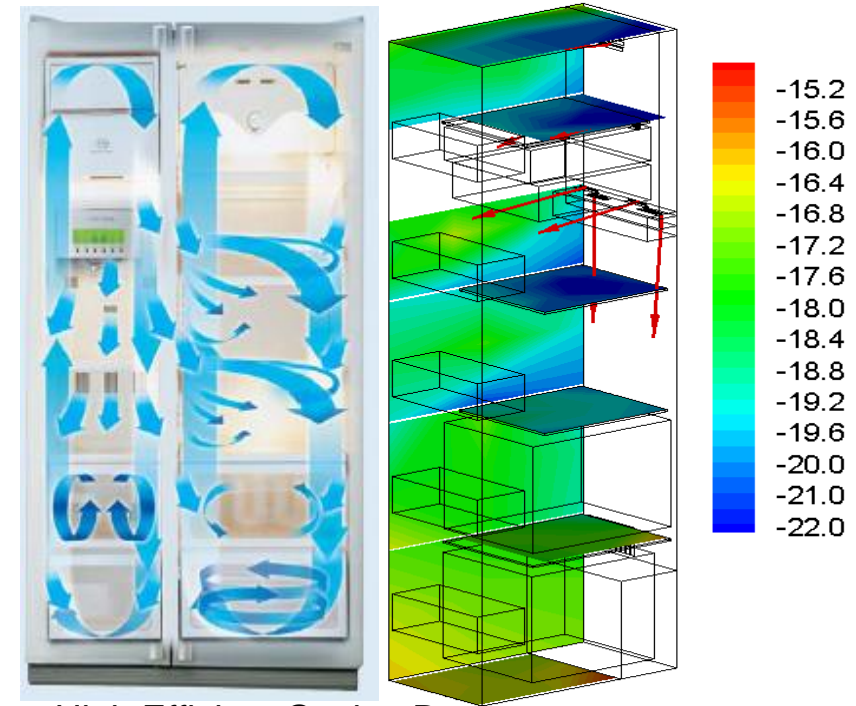
Structural Design/Stress Analysis of Cabinet  
(2004-present)



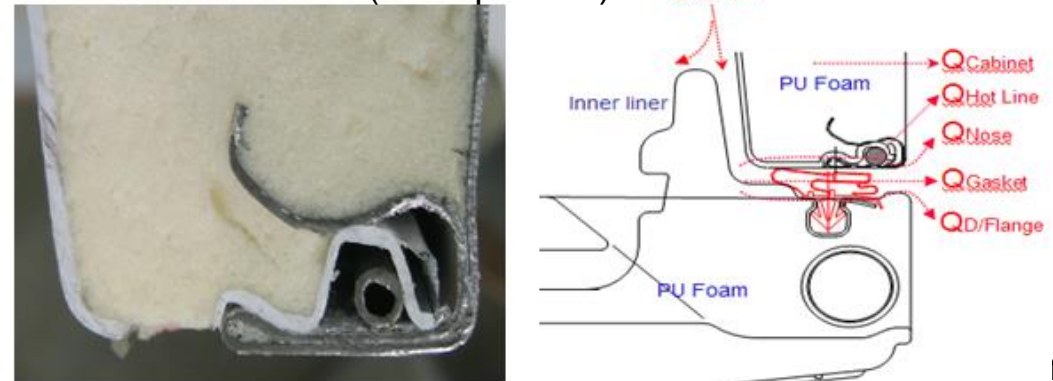
Thermal Analysis of Compressors  
(2008-present)



Cold Air Distribution: Visualization ('06-'16)



High Efficient Gasket Design  
(2010-present)



# Washer/Dryer Technology

## Energy Saving Technology

- Low Energy Technology
- Heat Transfer/Fluid Flow
- Fan/Pump/Duct Design

## Drive Controller Design

- Inverter Control
- Motor Control

## System Algorithm

- Software/Hardware
- Mechatronics
- Signal Processing
- Display

## Sensor Application

- Temperature, Pressure
- Electrode Sensor
- Vibration, Flowrate
- Humidity, Water Quality

## Material/Processing

## Structural Design/Analysis

- CAD/CAE/CAM
- Stress/Deformation Analysis
- Packaging Drop Test

## Motor Application

- Energy Conversion System
- BLDC Motor Control
- Motor Magnet Design

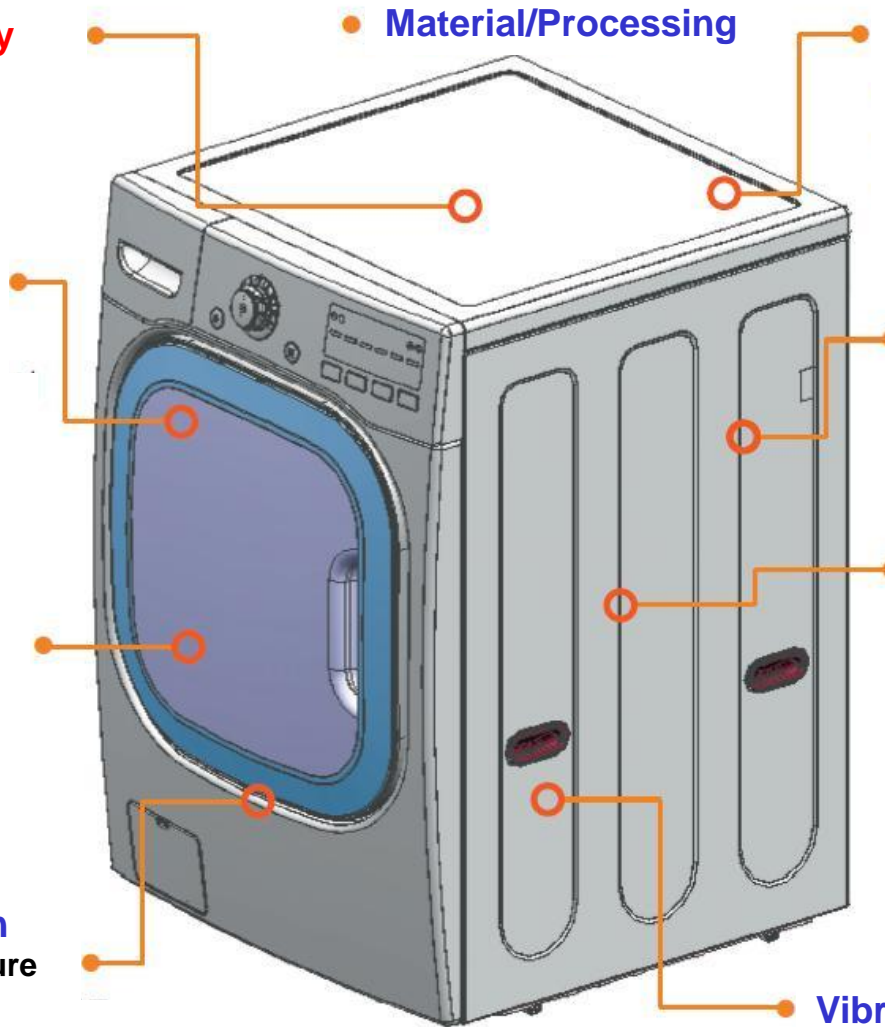
## Dynamics

- Spring/Damper Design
- Motion Analysis
- Stiffness/Fatigue
- Washing Mode
- Dewatering

## Vibration/Noise Analysis

- Unbalance Analysis
- Dynamic Simulation
- Low Noise/Vibration

## Clothes/Textile Tech. Detergent

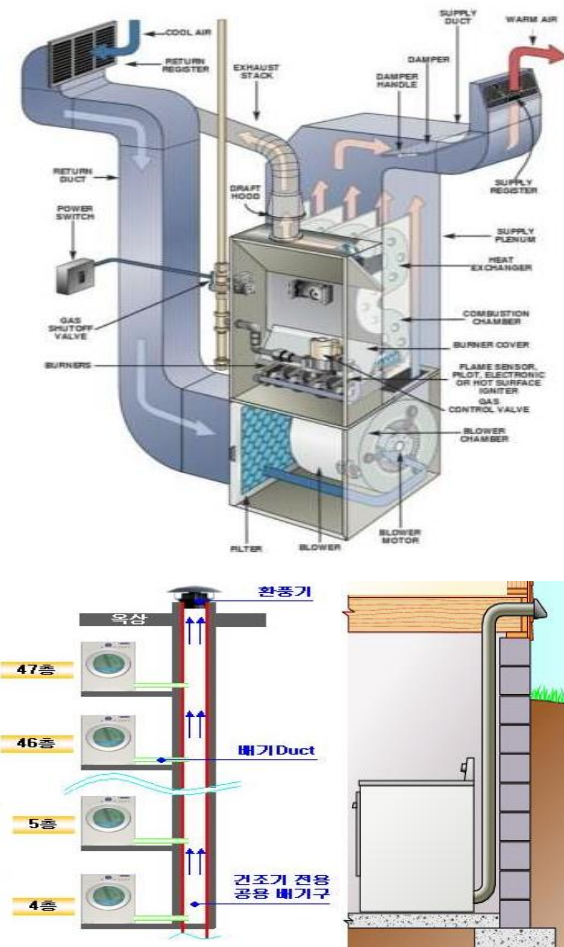




# Clothes Dryer Research

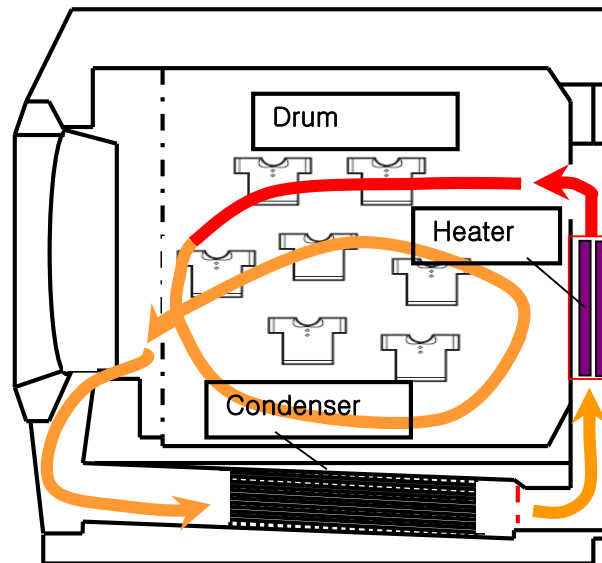
- Energy Saving Technology of Dryers (2008-present)
- Lint-free Module Design (2009)

< Vented Type >



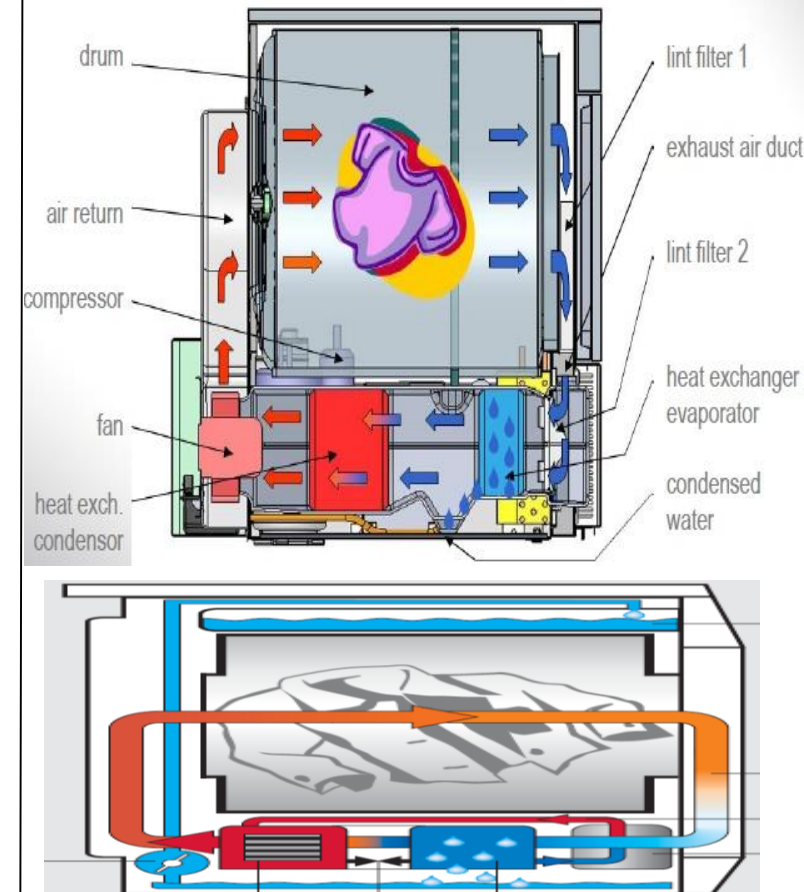
Energy Class D,C

< Condenser Type >



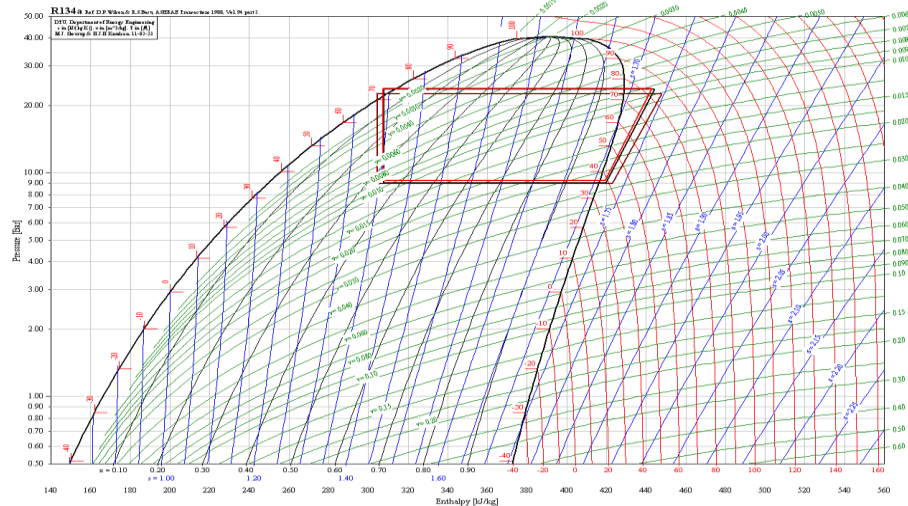
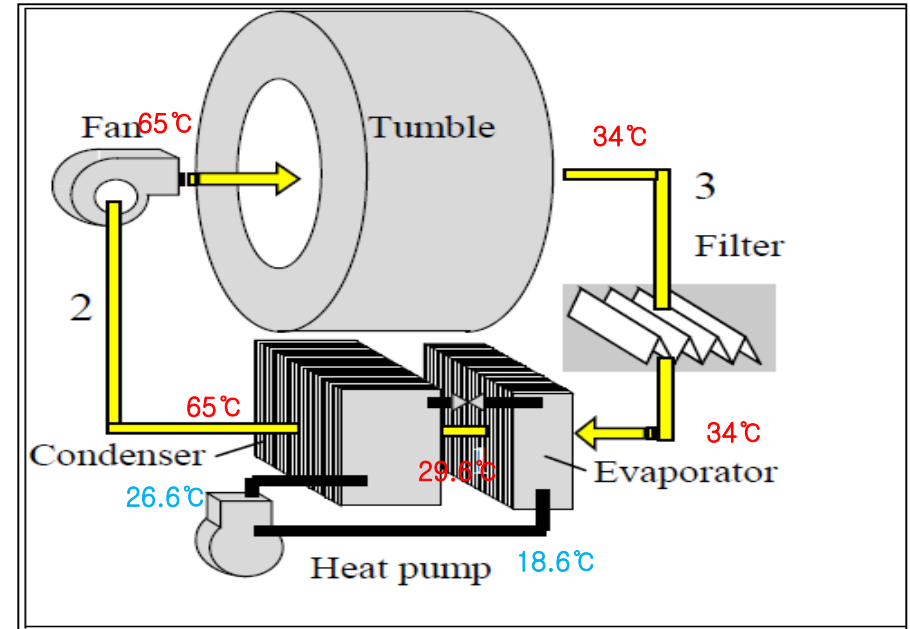
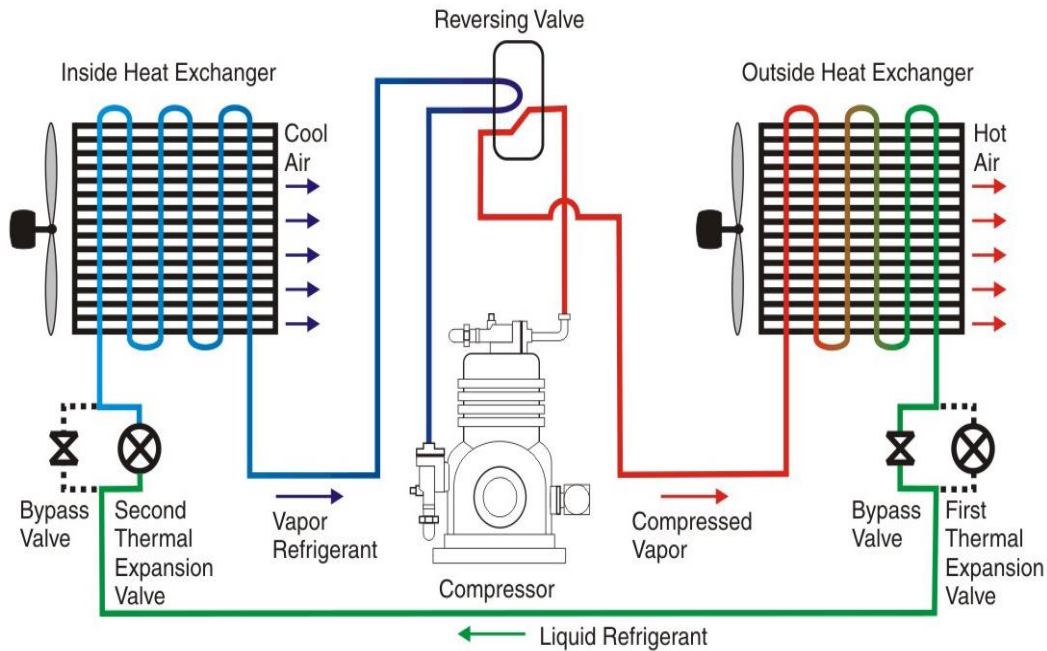
Energy Class B,C

< Heat Pump Type >

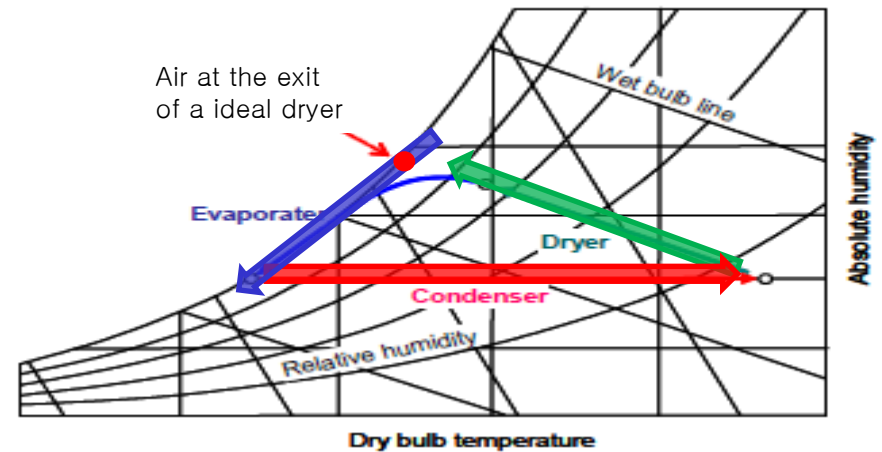


Energy Class A

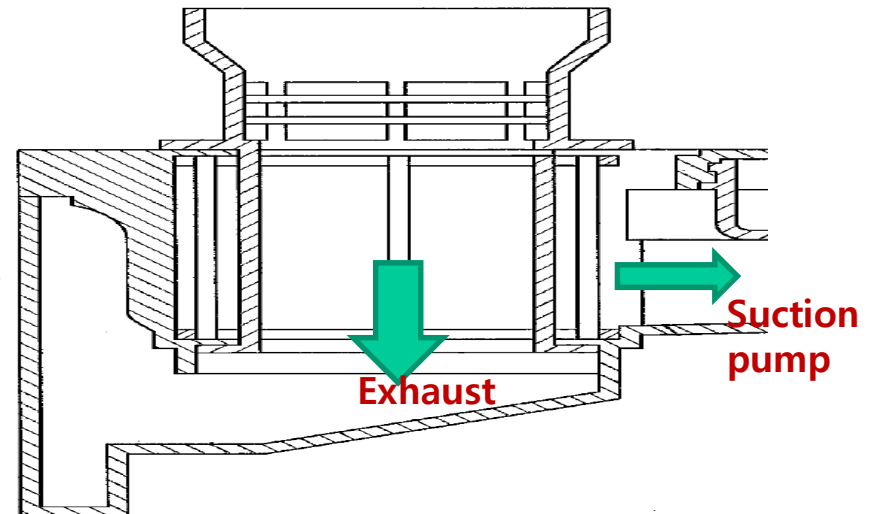
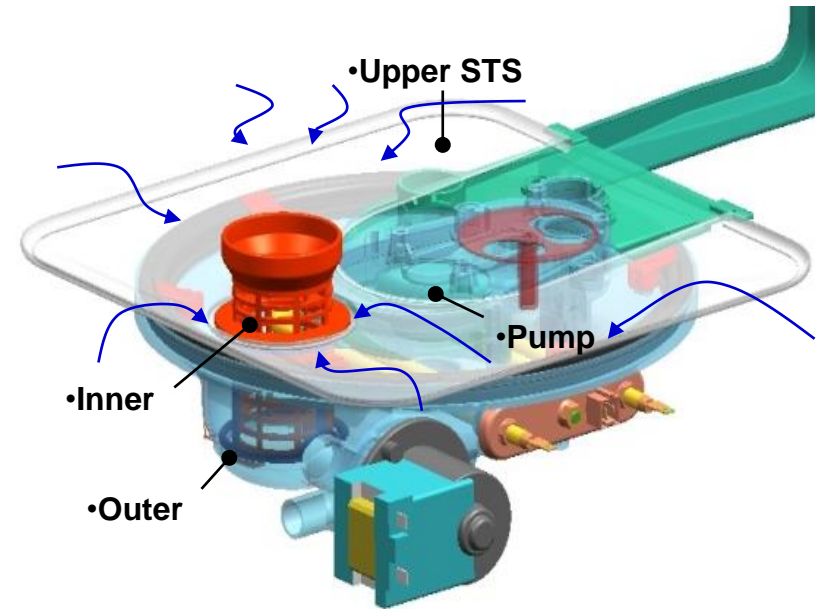
# Heat Pump Dryer Research



Air at the exit  
of a ideal dryer



# Dishwasher Research



Filter Design



Filter, Inner



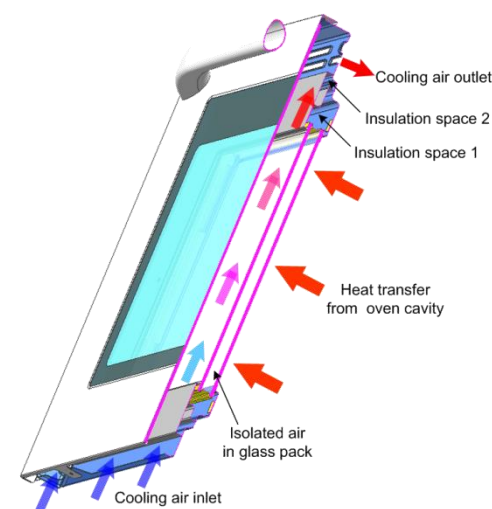
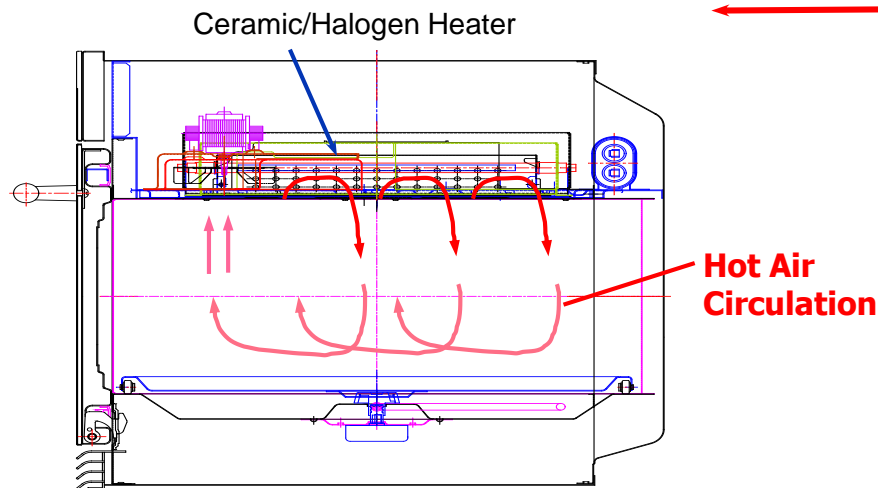
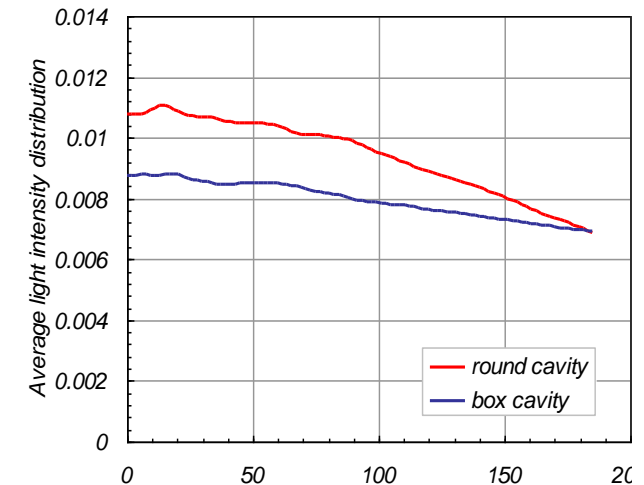
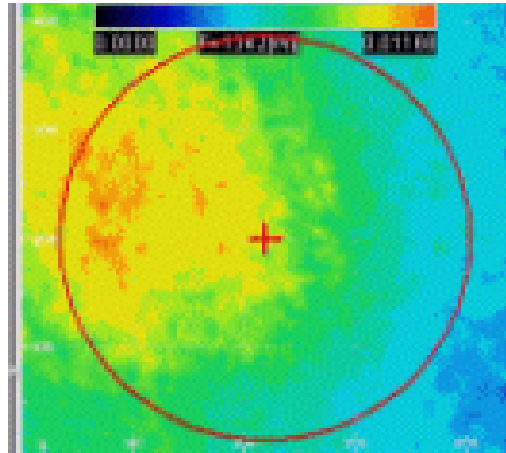
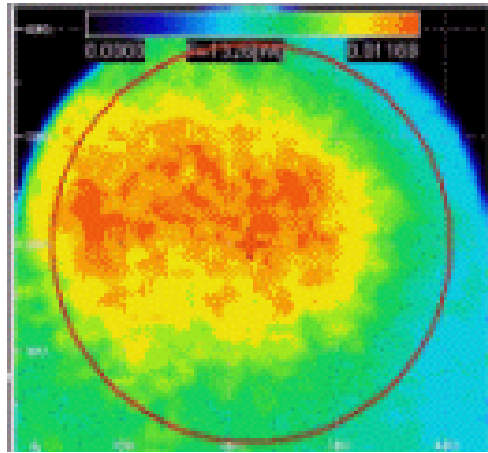
Filter, Middle



Filter, Micro

# Oven Research

- Oven Energy Simulator & Energy Saving Design
- Speedy Cooling/Fast Cooking in Cooktop
- Oven Easy Cleaning, Image Sensor Cooling
- Design of Smoke/Odor Collector (2010)





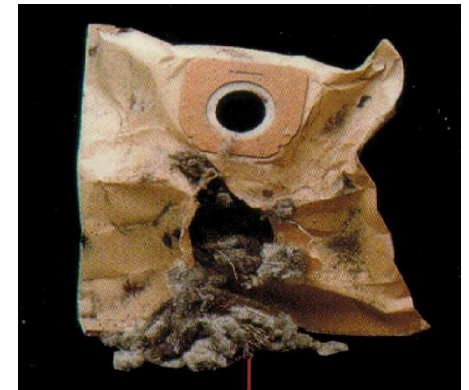
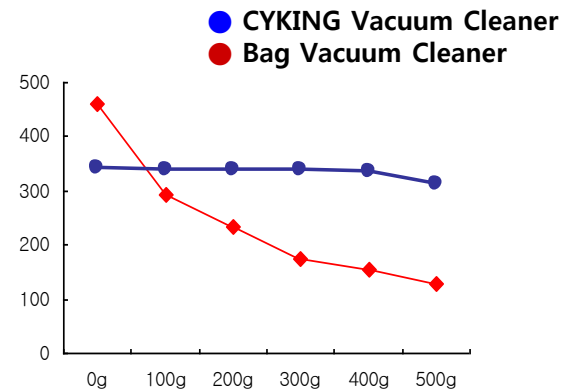
# Cyking Vacuum Cleaner (1999-present)

**CYKING**

V-C700AJ



Separation of Air and Dust  
Without Bag



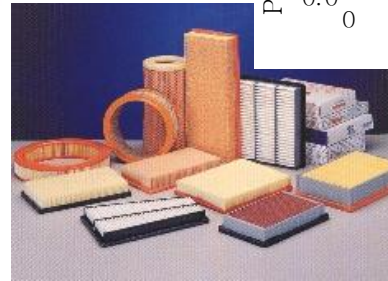
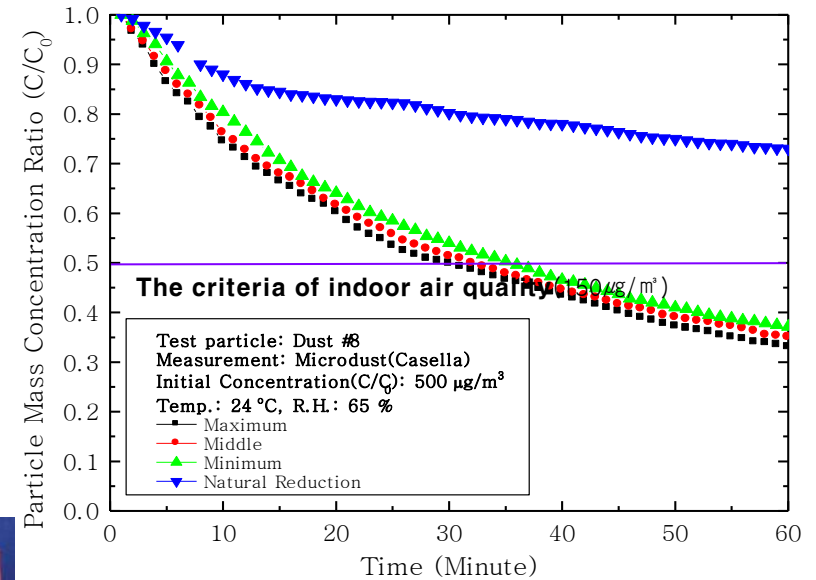
Sales since 2001: \$2B, 15B RMB, 2.3조원



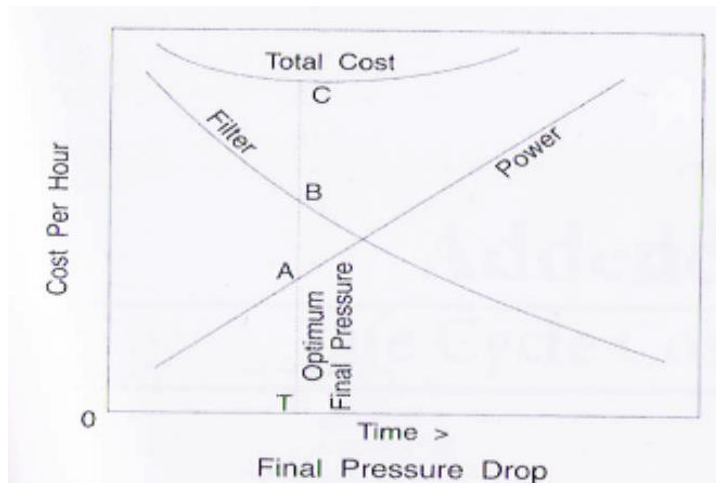
# Air Cleaner Research

High Efficient Air Cleaner Design (1998-present)  
 CADR Air Cleaner Evaluation  
 ASHRAE Air Filter Testing

Schematics of Air Cleaner



AHAM AC STD Tester: Dust, Odor



# NanoMEMS Technology

## 1. Nanofluids (2001-2014)

- Nanofluid for Heat Exchangers: Conduction & Convection
- Nano-Lubricants: Friction coefficient, Wear characteristic, Application methods

## 2. Nano/micro Particle Dynamics, Production (2003 – present)

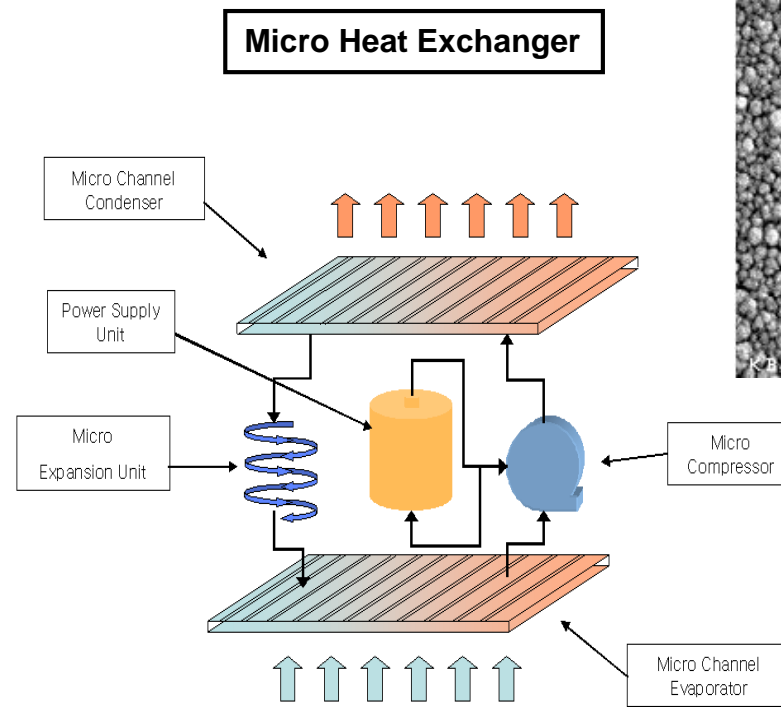
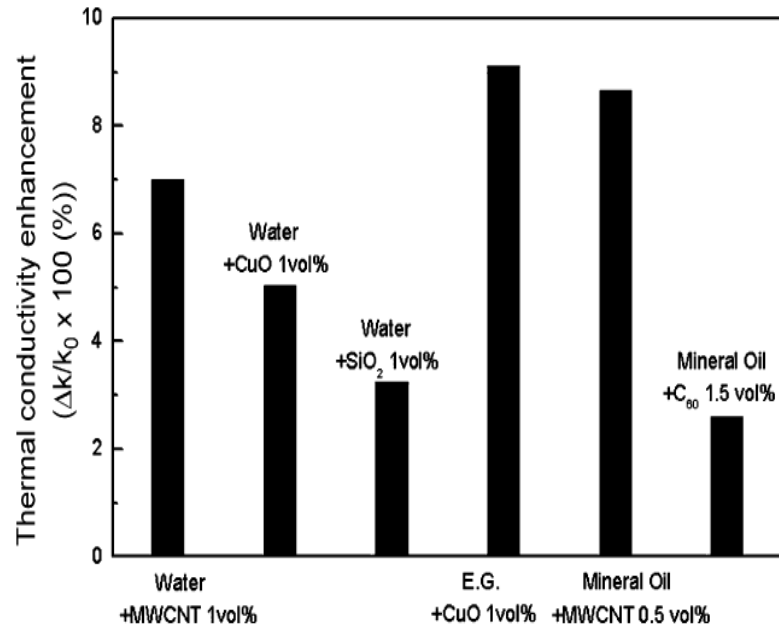
## 3. Nano Fiber: Air cleaning, Photo-catalyst (1998 – 2009)

## 4. Micro Compressors, Micro HEX, Micro EP/Air Cleaner, Hard Disk Drive, Micro Pumps

## 5. Nano Coating for Surface Treatment (2001-2006)

## 6. Nano/Microbubble Generation & Dynamics (2008-2010)

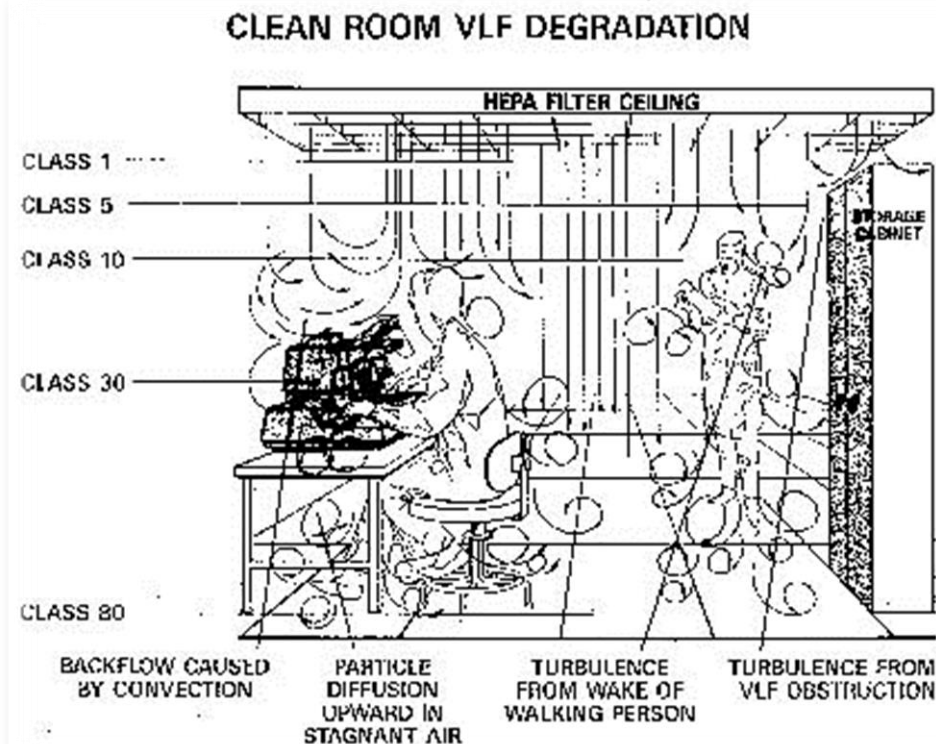
Thermal conductivity enhancement of Nanofluids  
: Jaekeun Lee, 2006



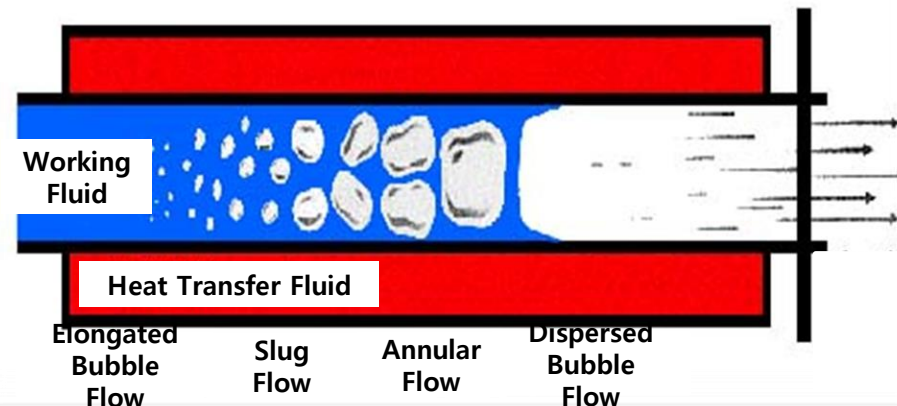
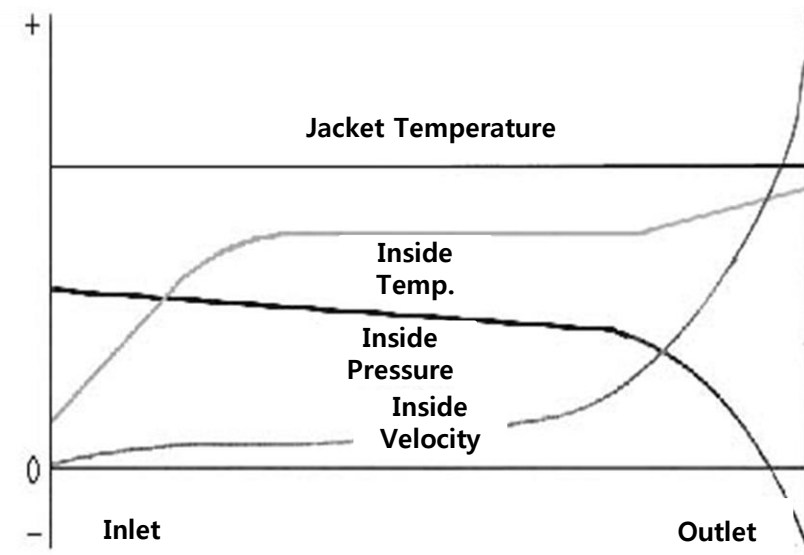
# Environmental Thermal Flow Analysis

1. Thermal Flow and Particle behavior Analysis on Environment energy (Particle Size: 1nm~500 $\mu$ m)
2. Flow Analysis of Heat Exchanger/Dryer/Boiler/
3. Fouling and Erosion Phenomenon
4. Powder/Particle Measurement, Separation and Collection

Clean Room Air current / Particle behavior analysis



Double pipe HEX (3 phase Thermal Flow analysis)  
Commercialization of Vacuum Dryer Device (Jangwo Co.)

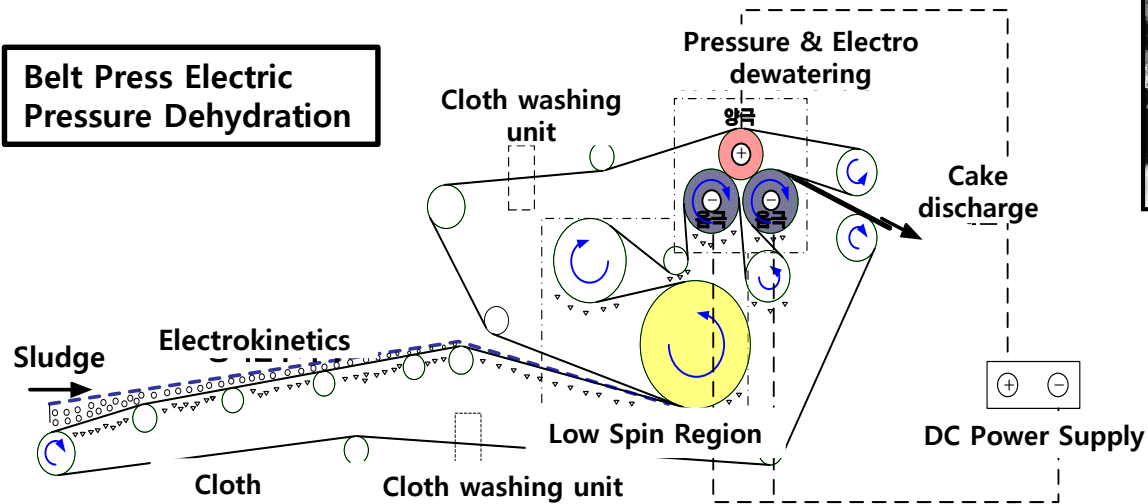




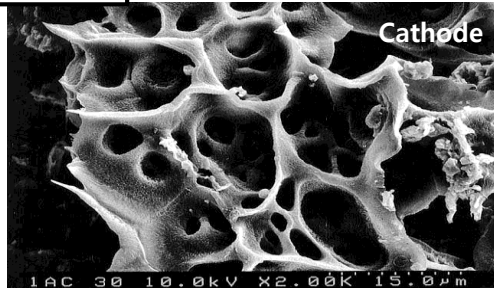
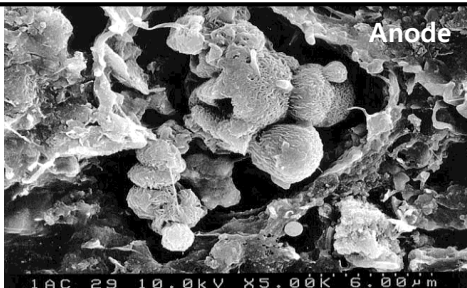
# Particle Separation

1. Filter/Electrostatic Precipitator
2. Separation Particle-Liquid using Osmotic Pressure / Electrocoagulation / Electrophoresis
3. Dehydration utilizing Pressure Filtration and Electrophoresis
4. Particle Separation using Triboelectrostatic
5. Separation Particle-liquid
6. Cyclone Design

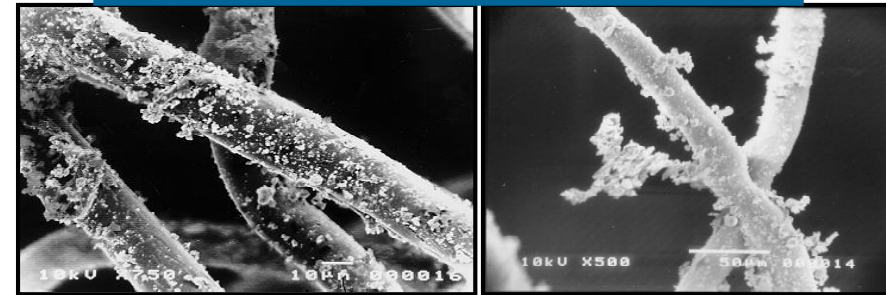
**Belt Press Electric Pressure Dehydration**



**Particle shape after Electro-dewatering**



**Particle shape piled up Filter (Left: conventional, Right: EAA Filter)**



**Triboelectrostatic**

