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And Expert Group Meeting

# Energy Saving Technology Development for Agricultural Machinery and the Greenhouse in Korea

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Kyu Hong CHOI

Director/Senior Researcher  
National Academy of Agricultural Science  
Rural Development Administration

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# I . Energy Situation

## Energy Crisis in Korea

❖ Korea is highly dependent upon external sources

The world's 10th largest energy consumer

Dependency on overseas energy sources of 97%

The world's 9th largest emitter of CO<sub>2</sub>

- Fuel consumption with 130 million metric tons of carbon emission

Fossil fuels account for 83% of total energy supply

Energy consumption increases 1.1% per year

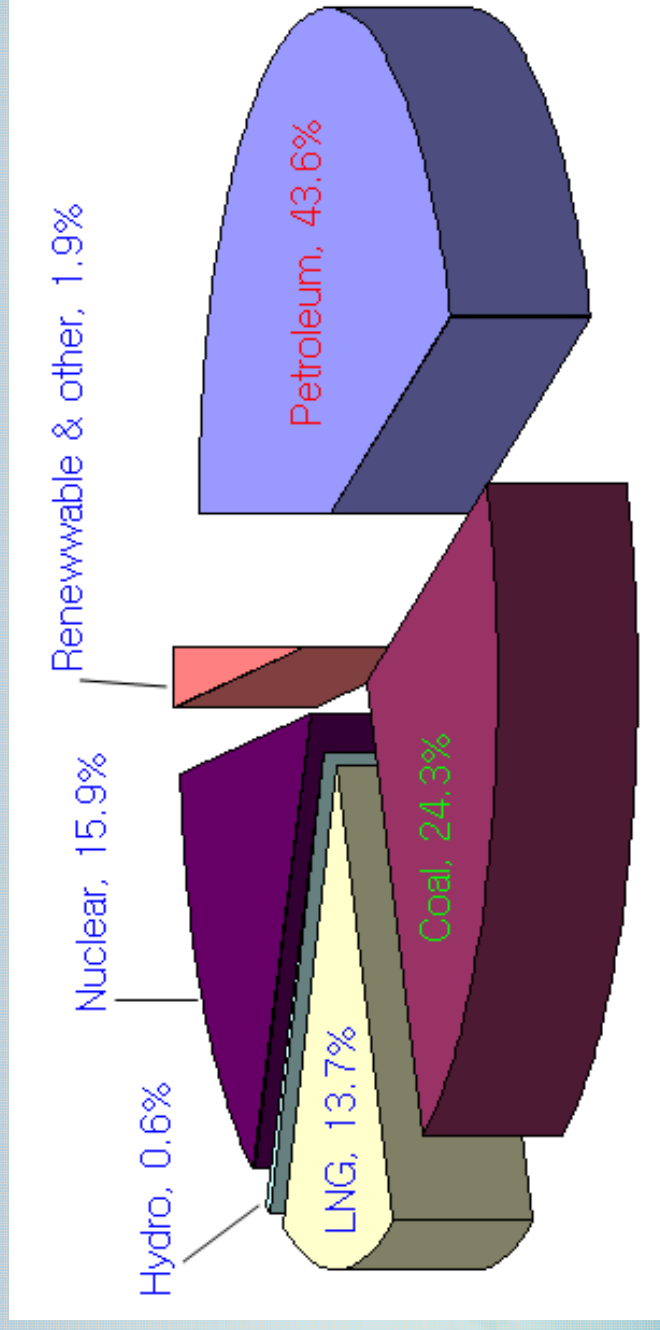
Current situation

\* If this pattern of energy consumption structure continues, economic loss will increase. **“Low Carbon, Green Growth”**



## Energy Status of Korea

- ❖ Total primary energy consumption : 242.9 million TOE(2007)
  - Nearly all fossil fuel in the transportation sector is from petroleum.
  - 5 Million vehicles are equipped with diesel engine in Korea.
  - Around 2 million tons of diesel fuel is consumed per year.

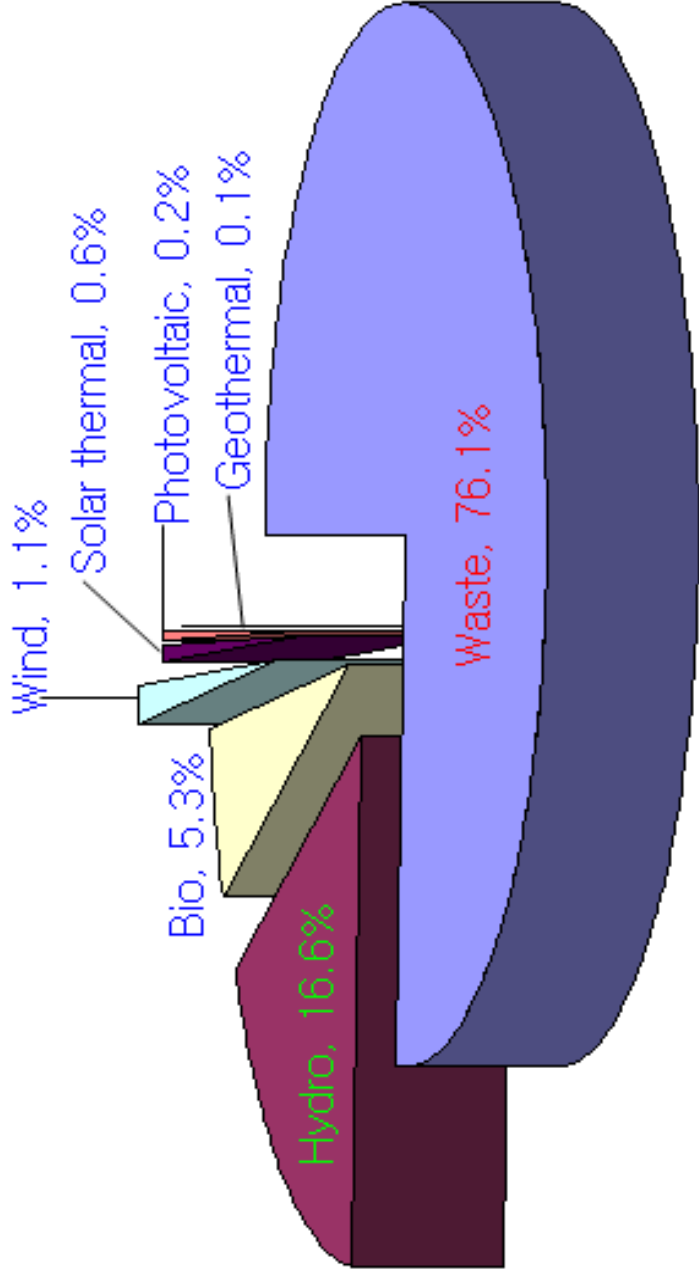




# New & Renewable Energy in Korea

❖ New & Renewable Energy fields are divided into 13 subcategories.

Around 2.4% of total consumed energy in Korea is produced from new & renewable energy (2007)



Waste

Hydro

**Bio**

Photovoltaic

Geothermal

Solar Thermal

Marine energy

Synthetic fuel from coal

Hydrogen

Fuel cell

Liquefaction

Gasification

❖ New & Renewable energy support up to 3.8% (~2013)

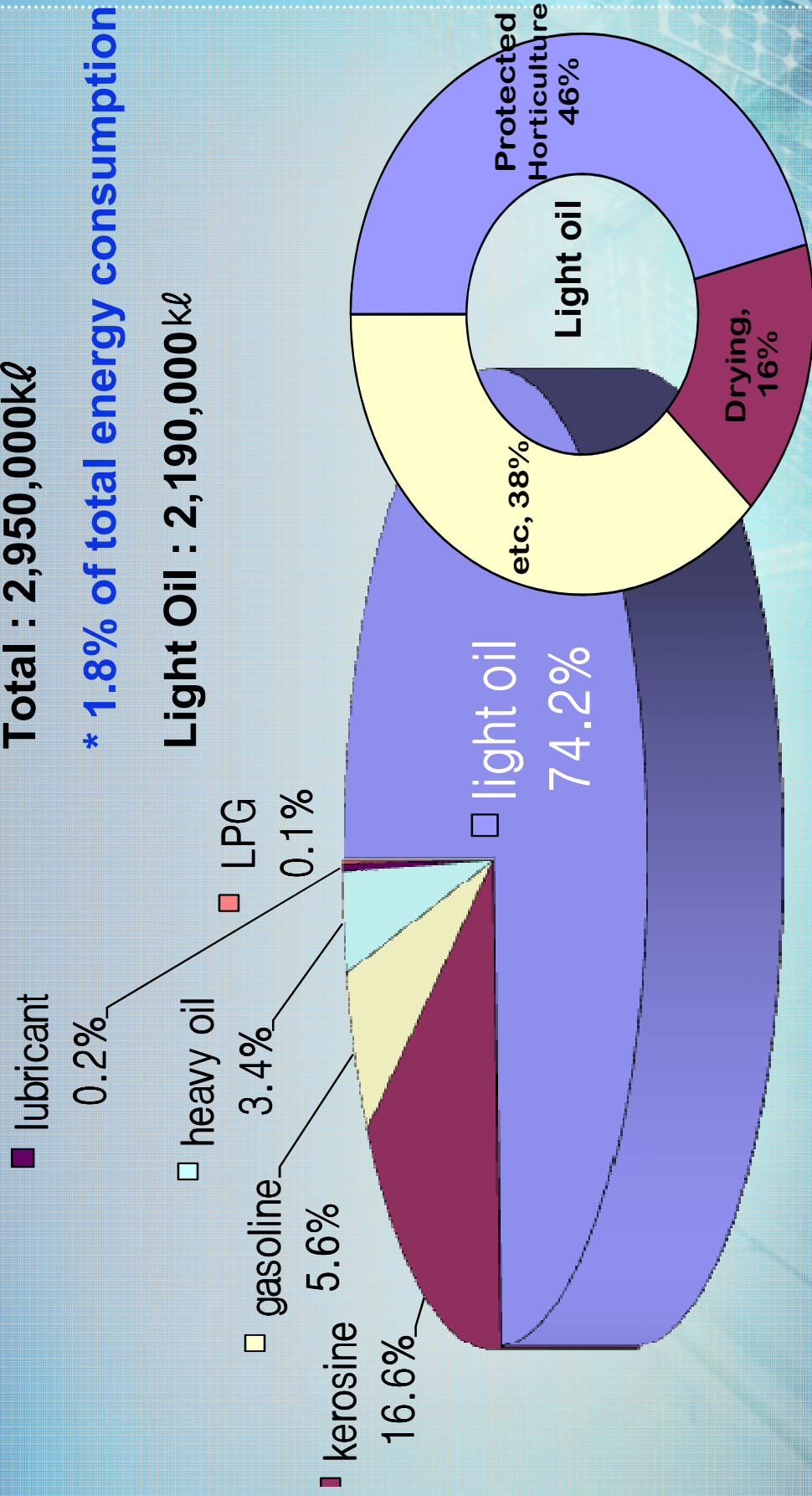
# II. Agricultural Energy

## Agricultural Tax Free Oil : 74%(light oil)

Total : 2,950,000kℓ

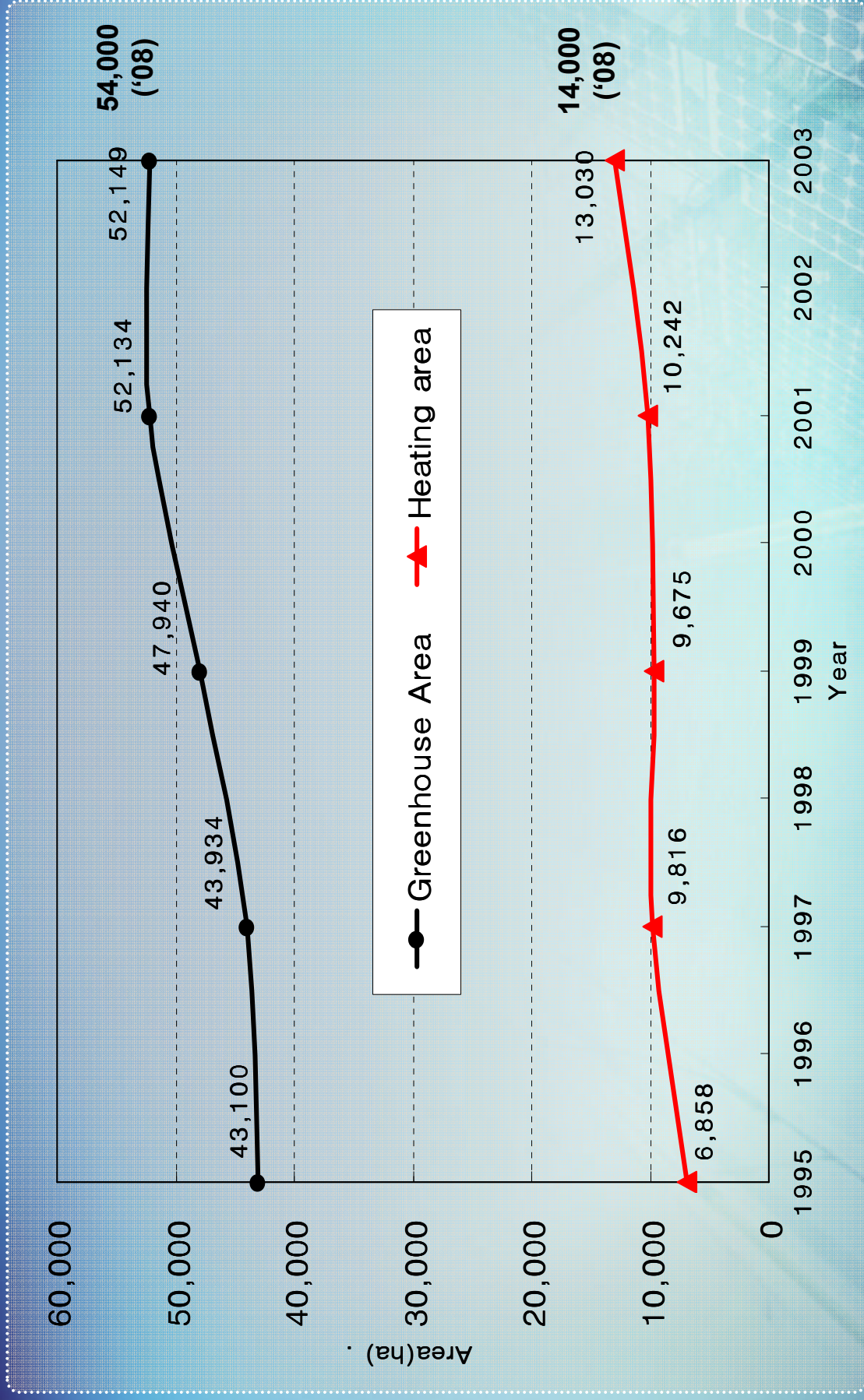
\* 1.8% of total energy consumption

Light Oil : 2,190,000kℓ





# Greenhouse Area (Installation and Heating)





## Petroleum (Dubai) and Tax Free Light Oil

Year	Dubai Price(\$/bbl)	Agricultural Light Oil Price(won/ℓ)
2002	24	365
2003	27	420
2004	34	475
2005	45	576
2006	57	610
2007	68	661
2008	110	1166



## Greenhouse Heating Cost

Year	Heating Cost Rate(%)
1980's	10~20
1990's	20~30
<b>2000's</b>	<b>30~40</b>

\* Heating Cost Rate = Heating Cost / Total Production Cost

**Goal of Heating Cost Rate : 10~20%**



# III. Energy Saving Technology

## Exhaust Heat Recovery System for Hot Air Heater

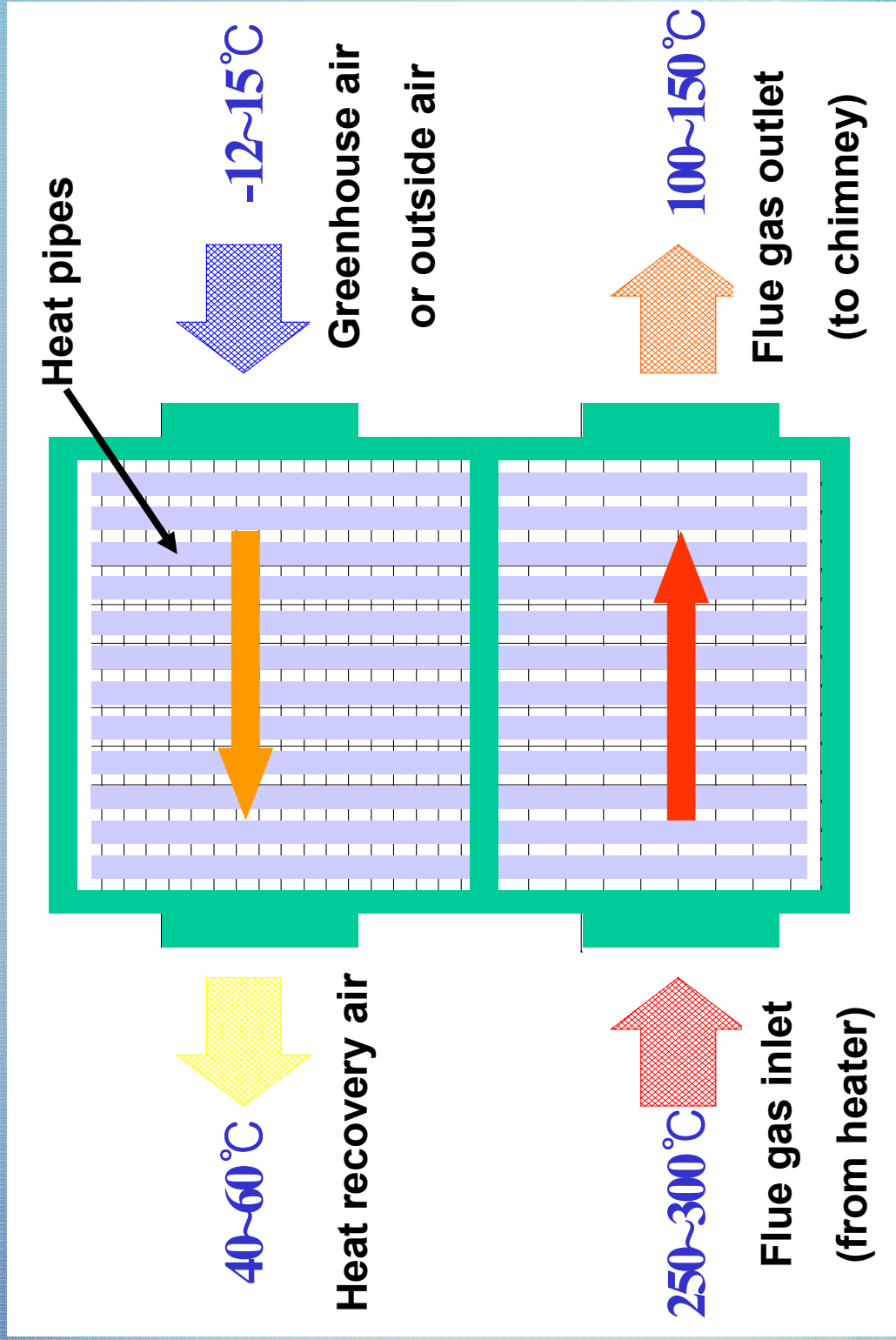
### Background

- ❖ Used as a heating device of greenhouse over 90%
- ❖ Heat loss of 10-20% from exhausting gas



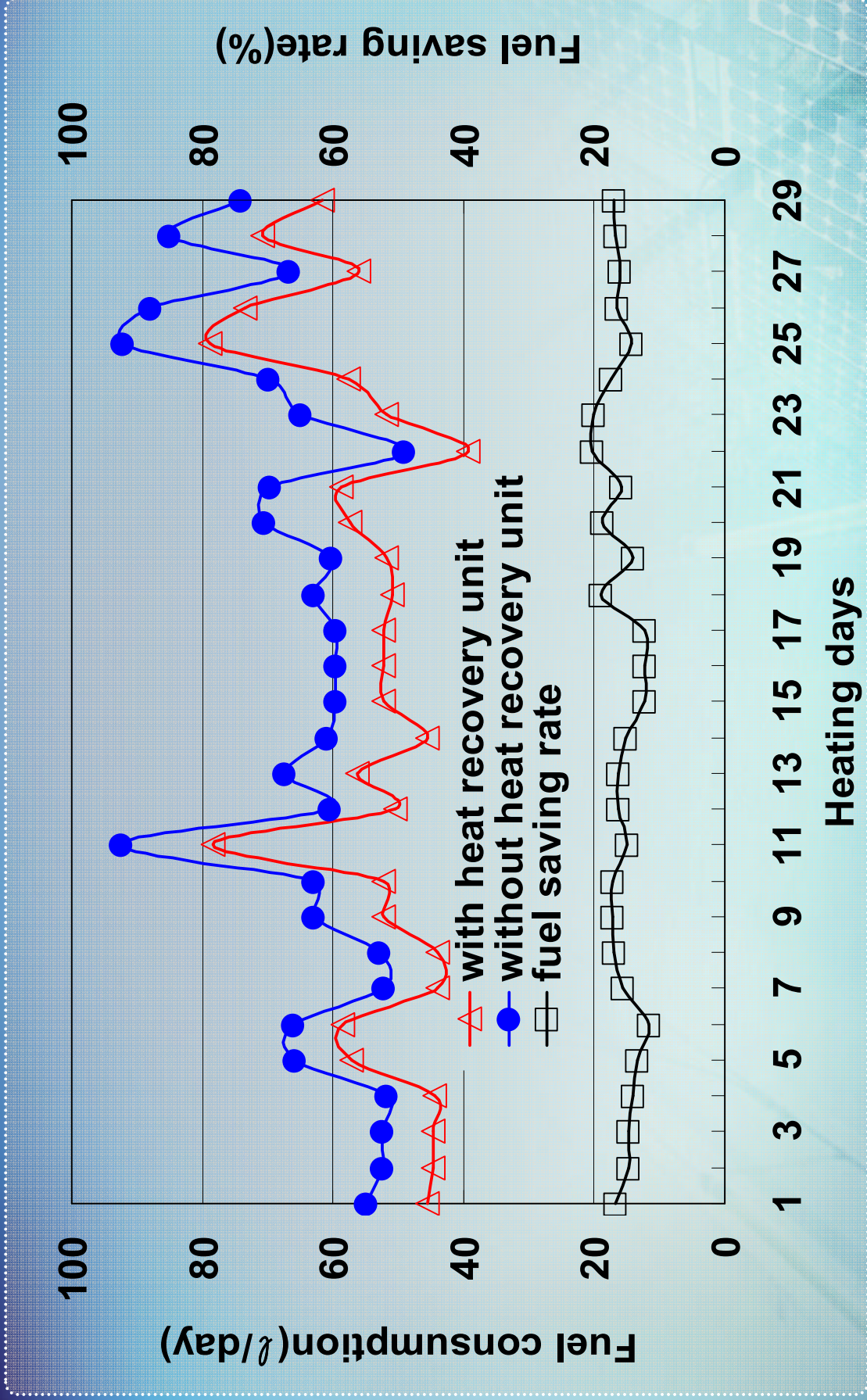


# Principle of Heat Recovery from Flue Gas



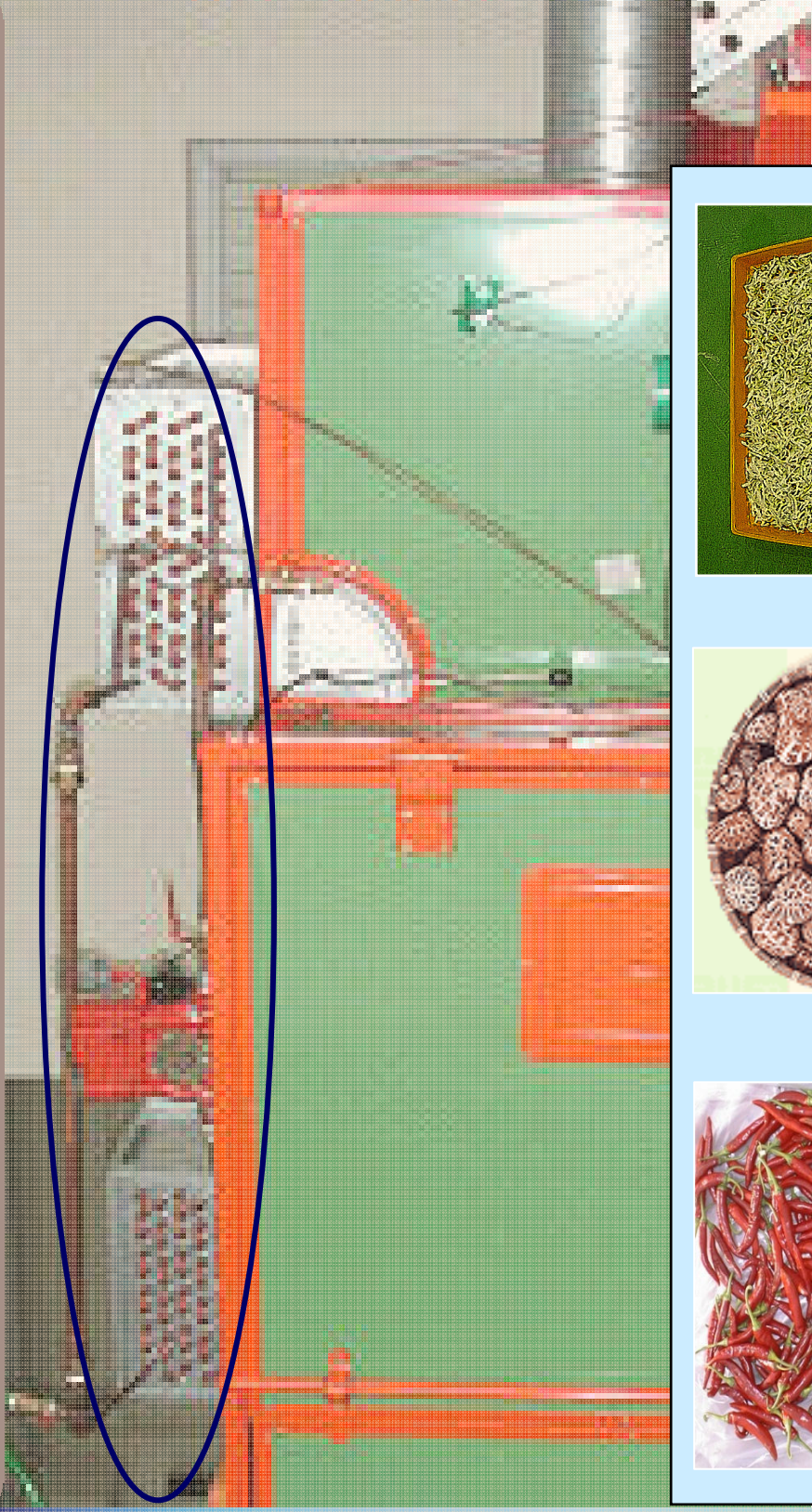


# Comparison between With and Without HRU

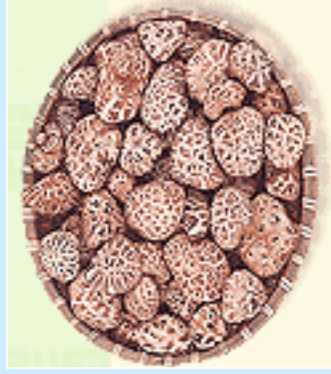




# Waste Heat Recovery System for Agricultural Dryer



**Radish**



**Mushroom**



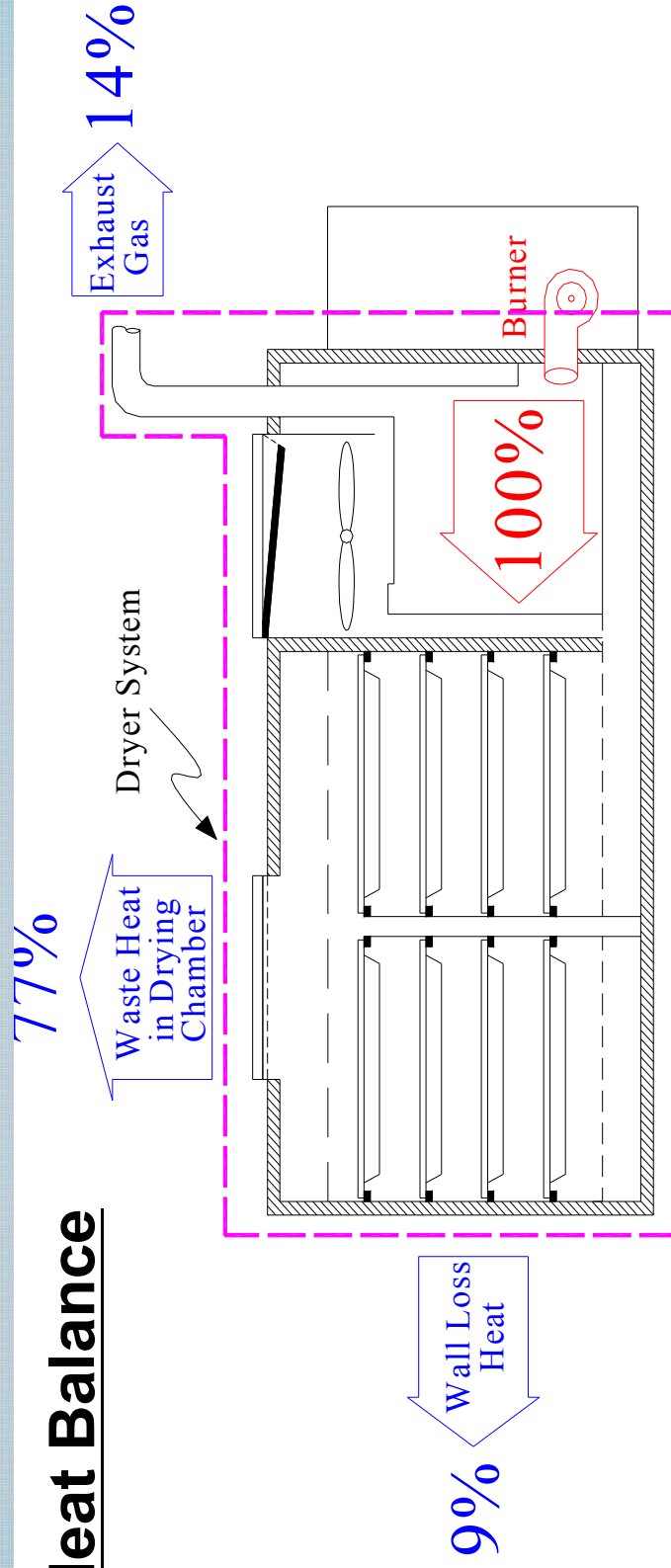
**Red pepper**



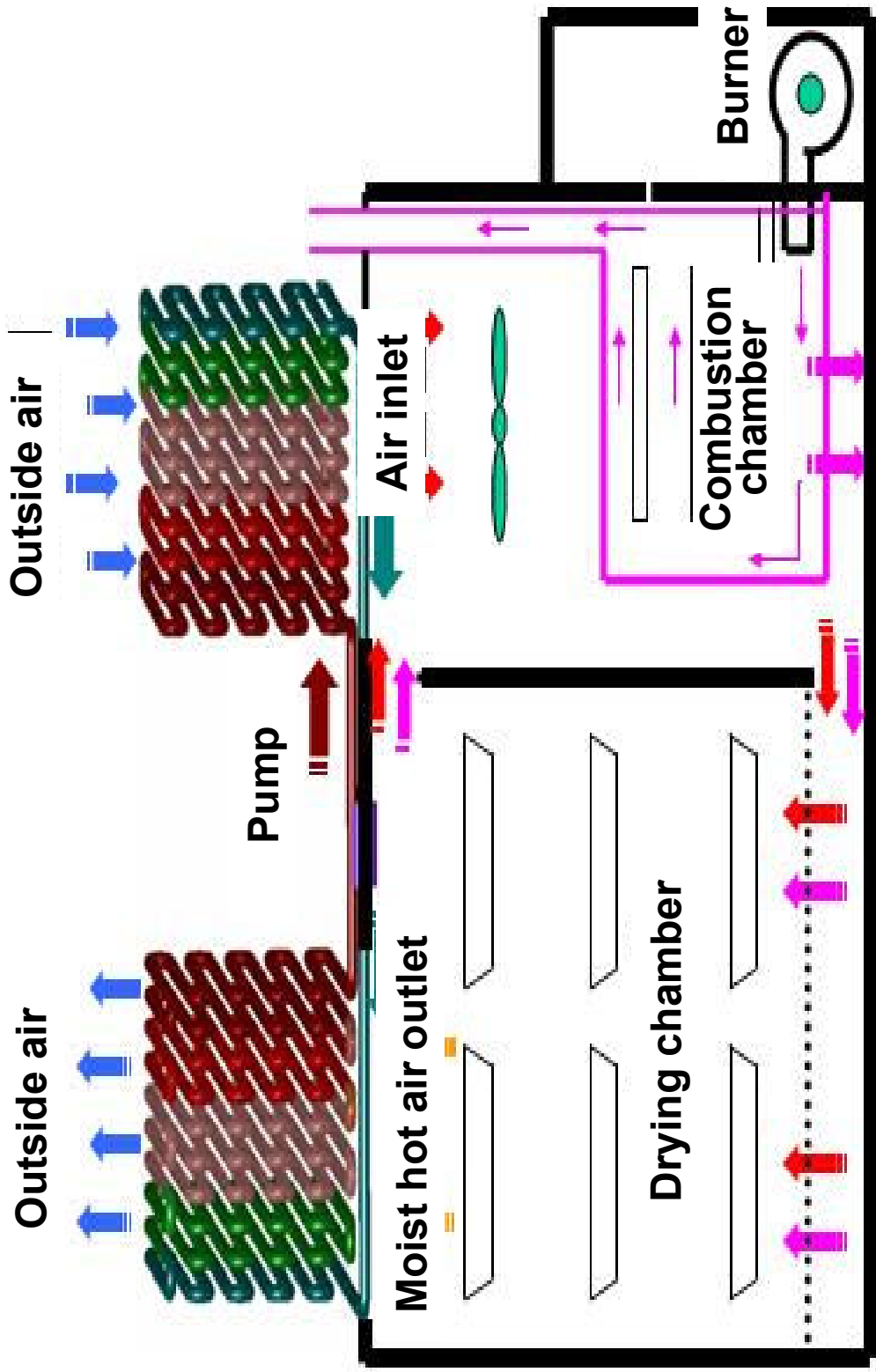
## Background

- ❖ No. of agricultural products dryer : 145,650('98) ⇒ 198,240('08)
- ❖ Waste heat of the air discharged from drying chamber reached 77% of the total combustion heat

## Heat Balance

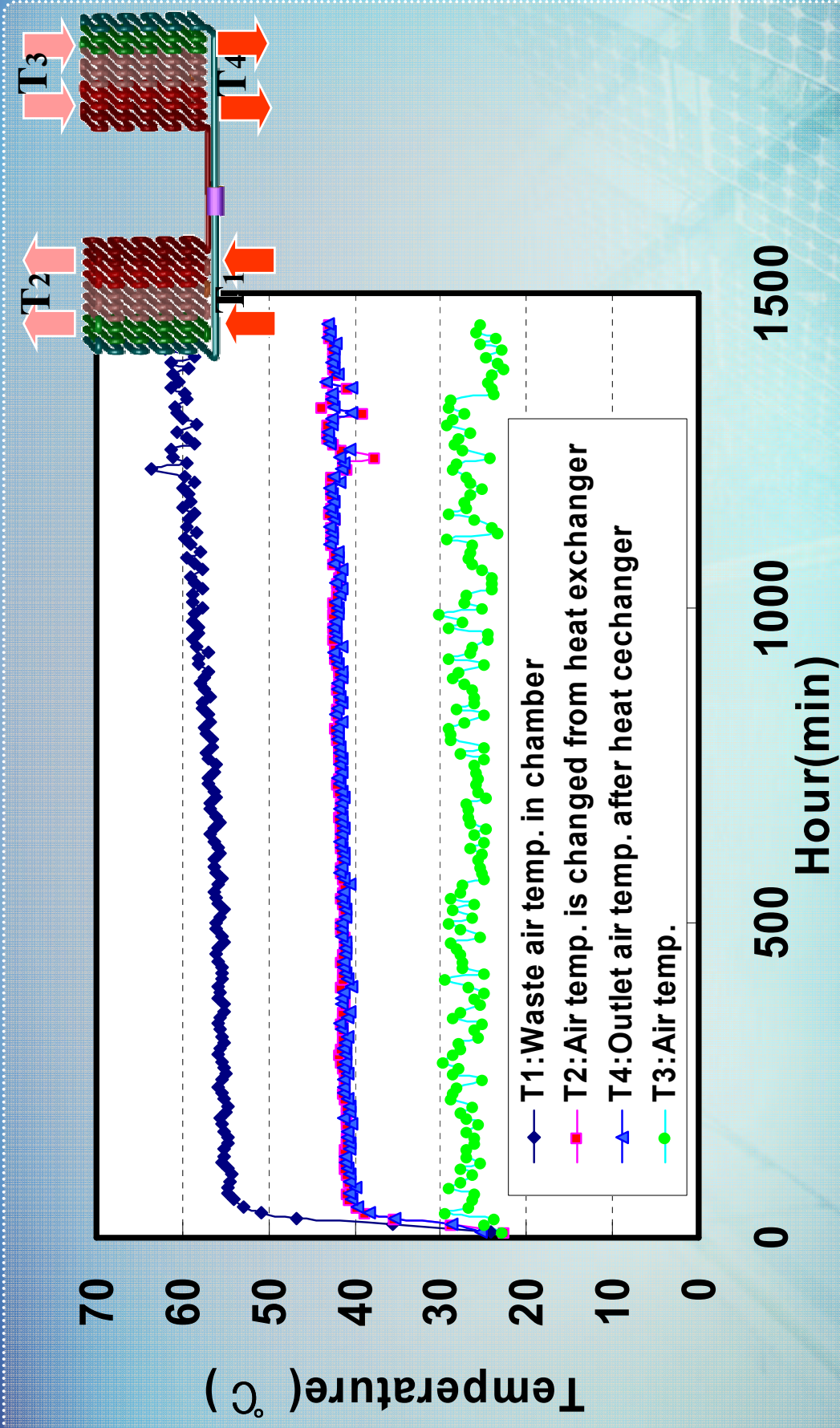


# Principle of the Waste Heat Recovery System



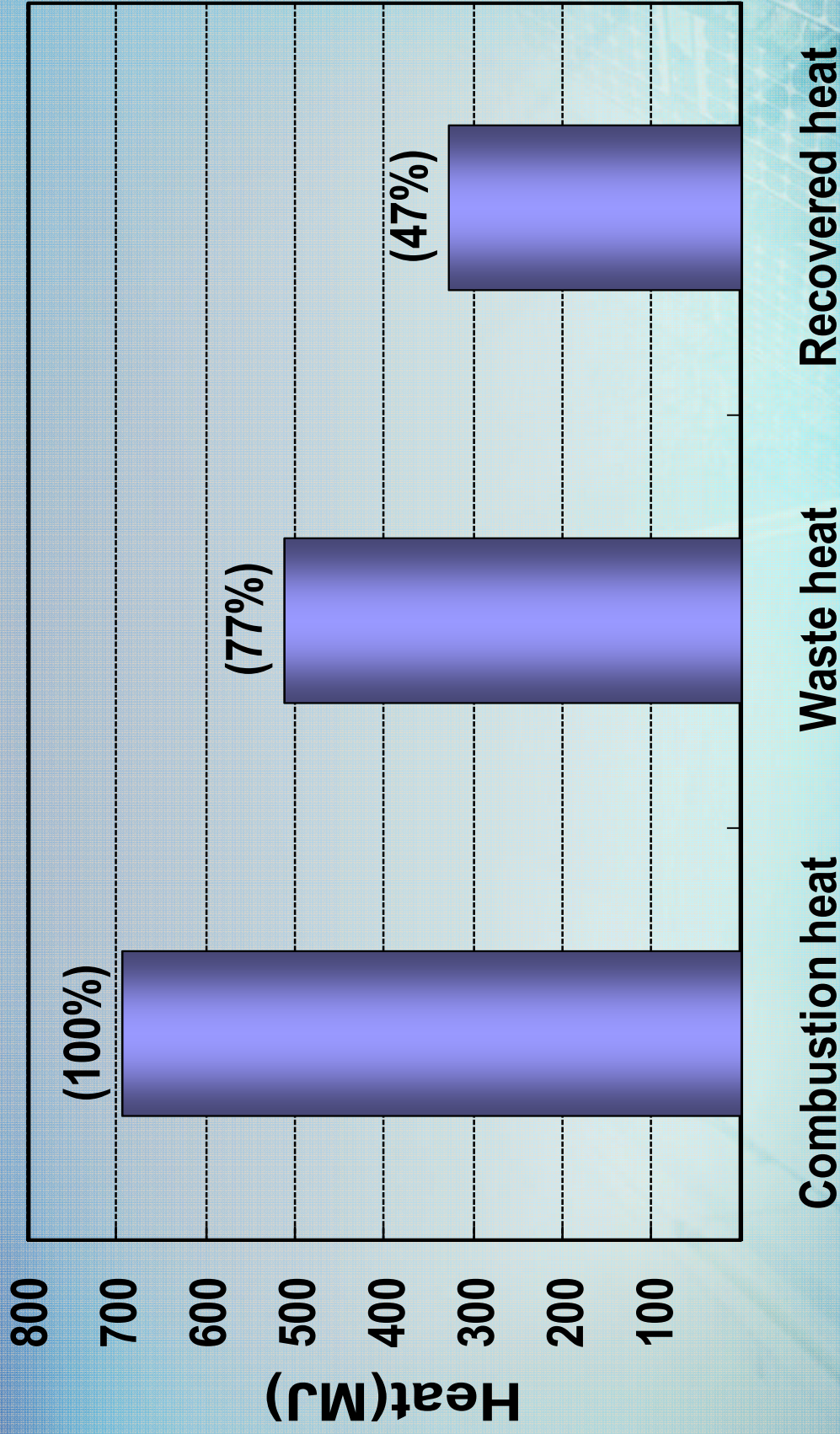


# Air Temperature Before and After Heat Exchanger



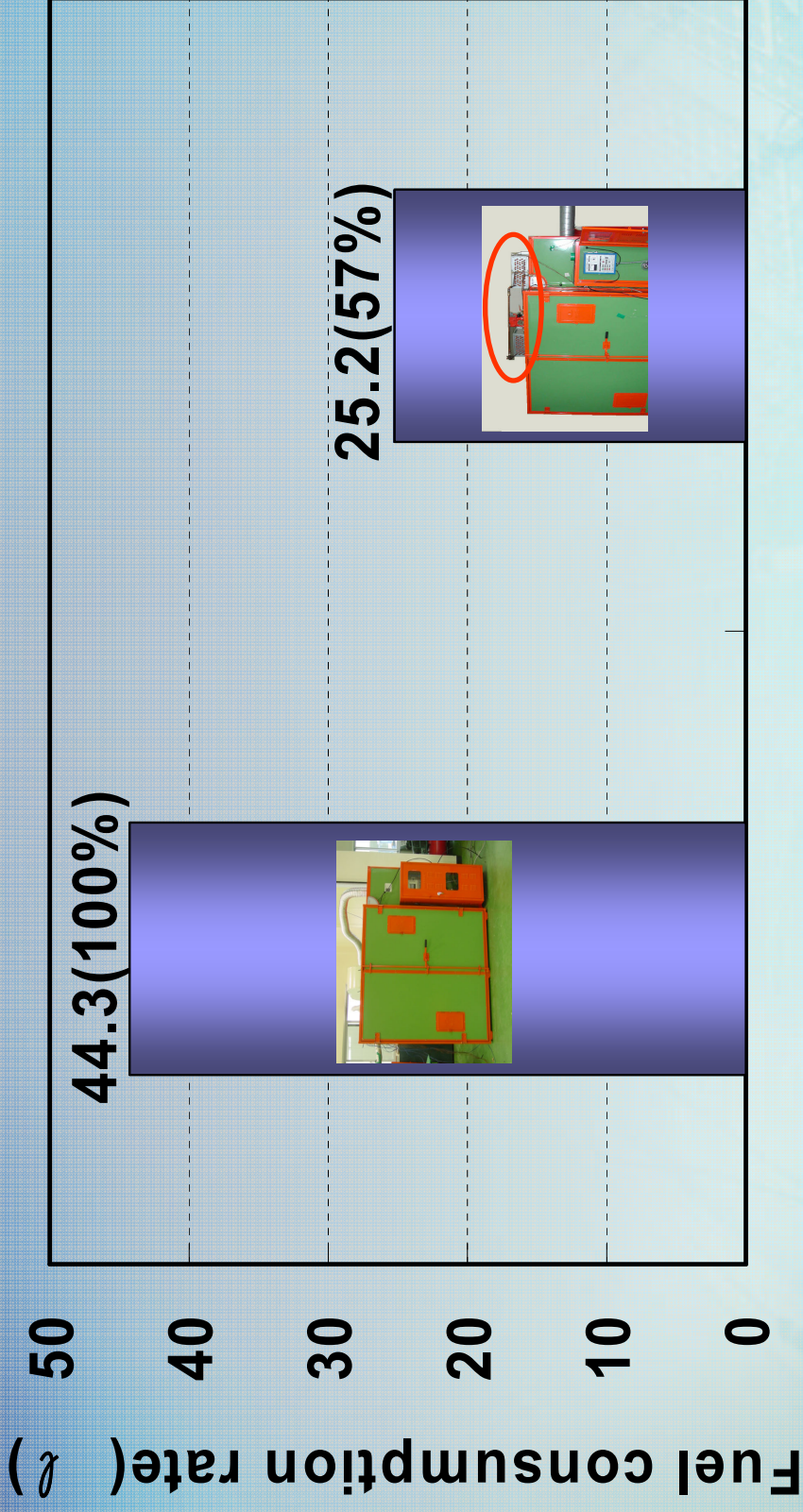


# Heat Balance of Waste Heat Recovery System





# Comparison between Conventional and WHR Dryer



**Conventional dryer**      **Waste heat recovery dryer**



## Automatic Rolling Shutter for Greenhouse Tunnel

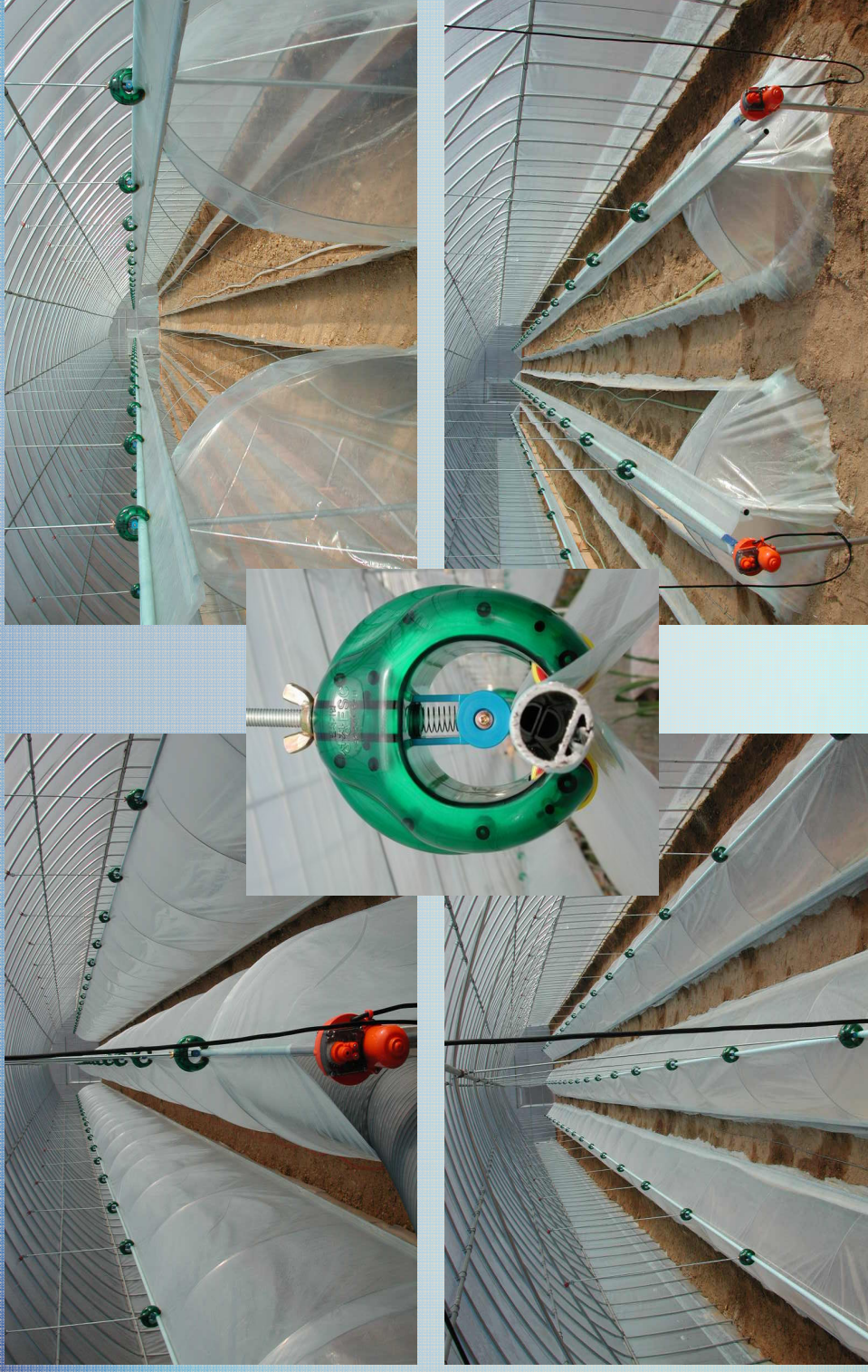
### Background

- ❖ The heating cost of winter season for protected horticulture is about 30~40% of total production cost.
- ❖ A horizontal thermal curtain made of a vinyl sheet or a thermal insulation sheet(non-woven fabric) is installed.
  - high cost, large heating volume, complex structure, cumbersome operation
- ❖ A thermal tunnel is formed only at an area where crops are grown, in order to warm only the crop growing area.





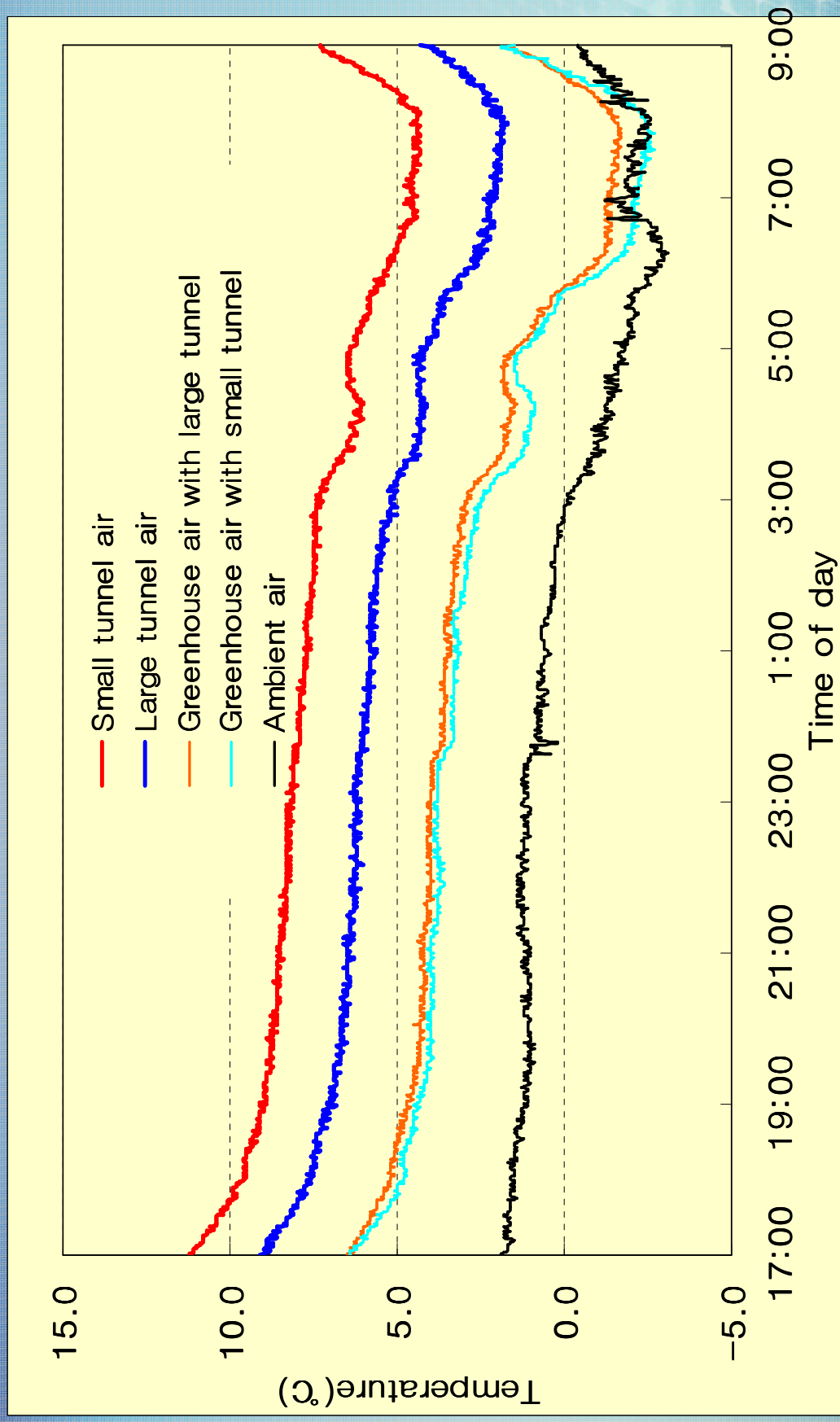
# Automatic Rolling Shutter for Greenhouse Tunnel



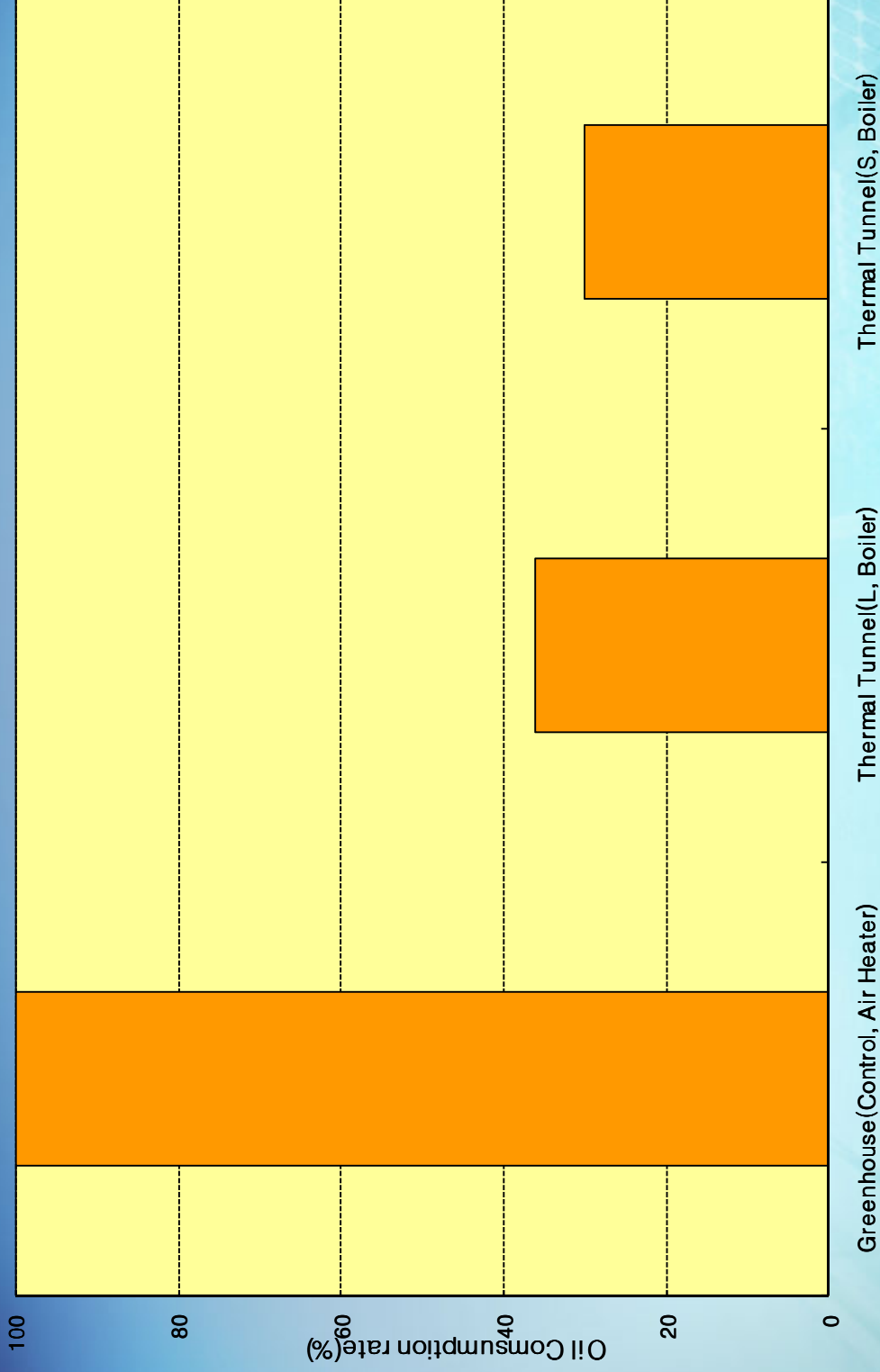
- ❖ Pipe holders are installed at intervals of 2 meters
- ❖ Opening and closing by human power  
→ Automatic opening and closing (Labor saving rate 90%)



# Thermal insulation effects of thermal tunnel



# Energy Saving Effect of Thermal Tunnel



- ❖ **The energy costs of large and small tunnels were 64%, 70% less than the controlled greenhouse respectively.**



# Application of Automatic Rolling Shutter



**Seedling Culture in Korea**



**Seedling Culture in Canada**

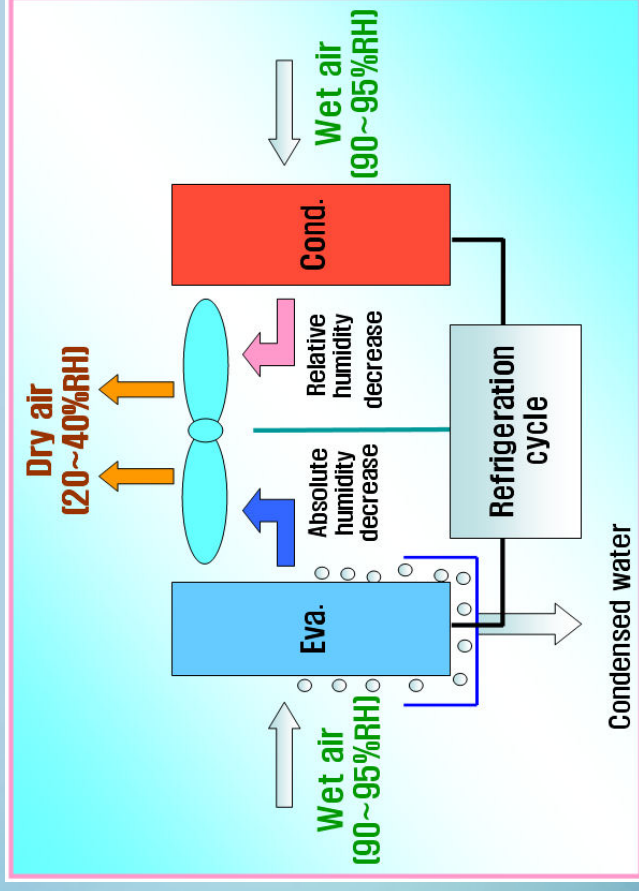
**Paprika Culture**



# Energy Saving Dehumidifier for Greenhouse

## Background

- ❖ **Relative Humidity in greenhouse during night time : over 90%**
  - Induction of diseases such as gray mold, anthracnose, etc.
- ❖ **Ventilation in winter season is not possible**
  - Energy loss, Chilling injury





## Comparison between Conventional and Dehumidifier



[Conventional]



[Dehumidified]



### Performance

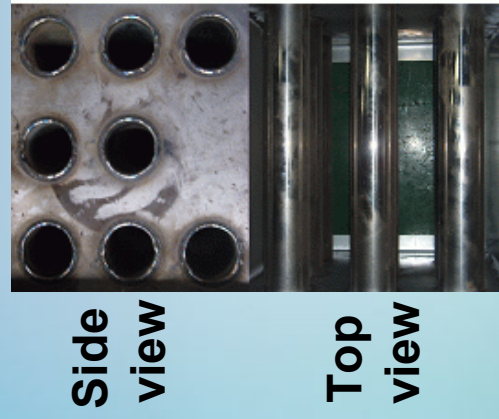
- ❖ Heating energy saving rate : 10%
- ❖ Dehumidification performance : 5-7 kg/h  
\* 15-25 deg, RH 70-90%
- ❖ Gray mold disease decreasing rate : 30%



## Heat Exchanger Improvement of Hot Air Heater

### Background

- ❖ No. of hot air heater : 127,557('00) → 178,430('06)
- ❖ Fuel consumption for greenhouse heating : 1.586 million kL('06)



- Reduce resistance of air flow
- Increase efficiency of heat exchange
- Increase heat utilization efficiency



# Heat Exchanger Improvement of Hot Air Heater

**Performance**

76.8  
%

11% increasing

87.8%

**Before**

**After**



**Measuring heat utilization  
efficiency**



# IV. Renewable Energy Research

## Biogas, Wind, Solar & Geothermal

- 20kW biogas engine
- Hot water heater with wind turbine
- Greenhouse window opening device with solar cell
- Geothermal heat pump for greenhouse heating





# Greenhouse Window Opening with Solar Cell





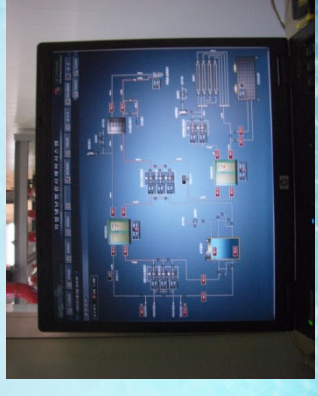
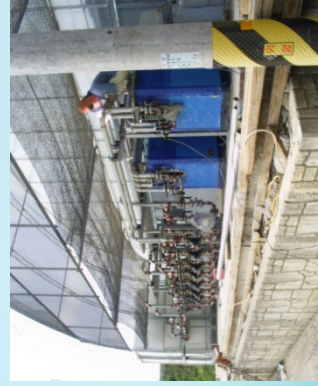
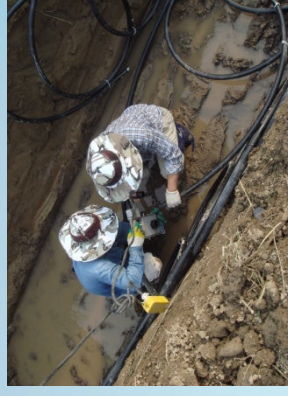
# Geothermal Heat Pump for Greenhouse Heating

## Background

❖ Increase of heating cost by high fuel price,  
decrease of farmhouse income

- Petroleum (Dubai) : ('07.8) 68\$/bl → ('08.7) 142 → ('08.8) 110

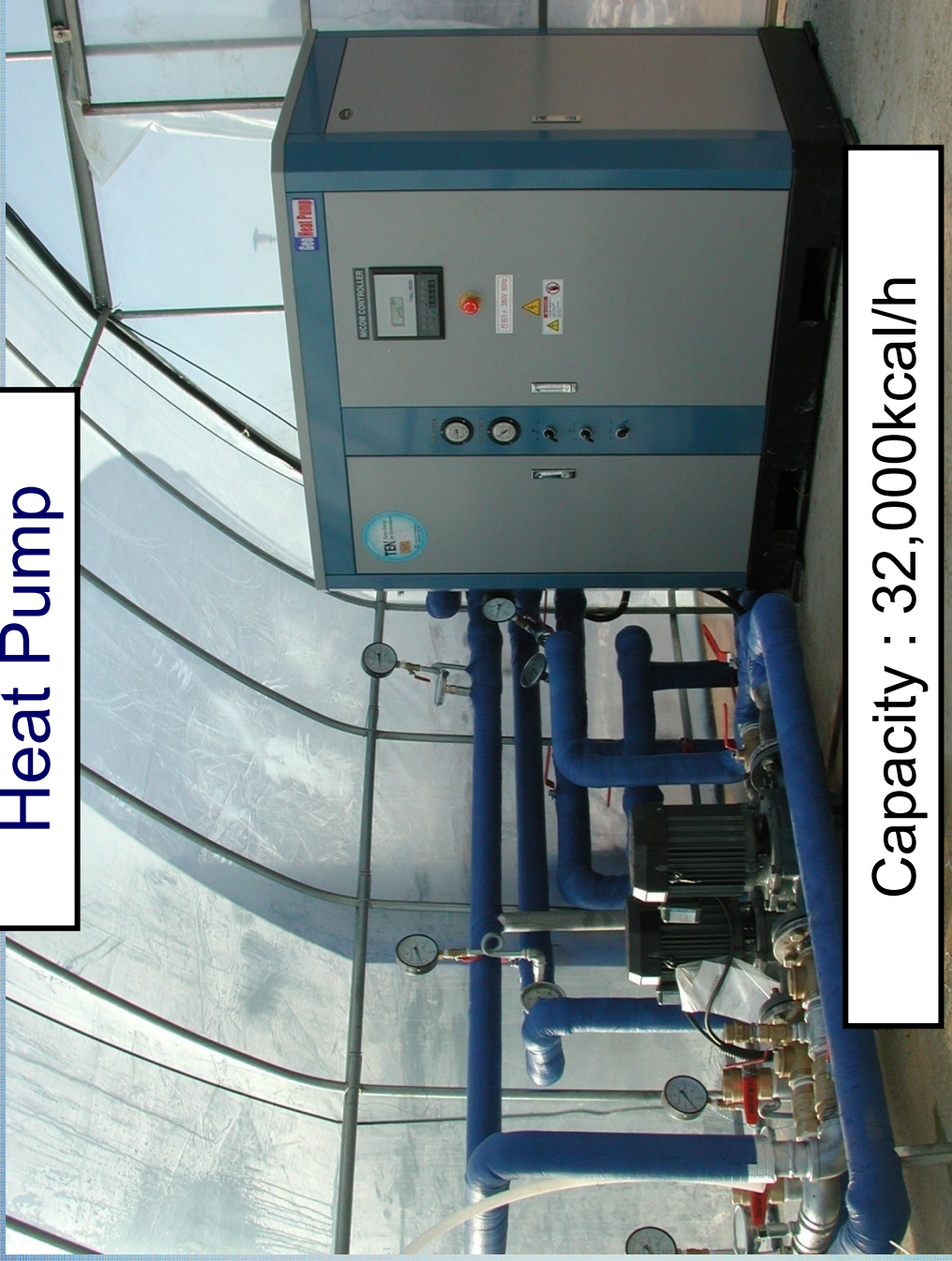
- Tax free light oil : ('07.8) 661 won/L → ('08.7) 1,328 → ('08.8) 1,166





# Geothermal Heat Pump for Greenhouse Heating

Heat Pump

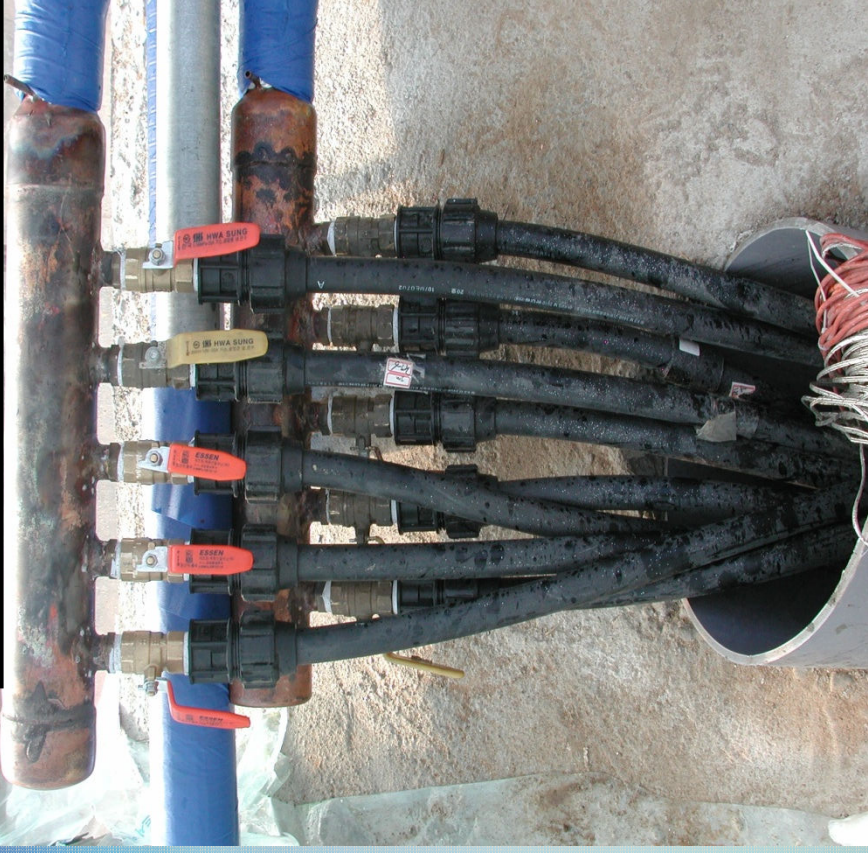


Capacity : 32,000kcal/h



# Geothermal Heat Pump for Greenhouse Heating

## Geothermal Heat Exchanger



Length : 1,860m[32,000<sub>kcal/h</sub> / (0.02kW\*860<sub>kcal/h</sub>)]



# Geothermal Heat Pump for Greenhouse Heating

## Heat Storage Tank

- Capacity : 64,000kcal(max.)
- Temperature : 30~50 °C
- Volume : 3,200ℓ





# Geothermal Heat Pump for Greenhouse Heating

## Greenhouse Heat Exchanger

32,000kcal/h(8,000X4)



### Performance

- ❖ Heating COP : 3-4
- ❖ Heating cost saving rate : 78%
- ❖ Installation cost : 550 million won/ha



# Brassica Breeding to Produce Bio-Diesel Oil



**Mokpo-CGMS**

**Production : 4,480kg/ha**



**Temperature Stability of Male  
Sterility**



## **Korea's Green Growth Strategy**

- ❖ **“Low Carbon, Green Growth”** is a key catchphrase in Korea.
- ❖ **Comprehensive Plan on Combating Climate Change**
  - Set the goal of the share of renewable energy to 11% by 2030
- ❖ **‘Green New Deal’ Stimulus Package**
  - Investment plan of 385 billion USD for the next 4 years on 9 projects
- ❖ **9 Key Green Projects :**
  - 1) Revitalization of 4 major river, 2) building green transportation
  - 3) building DB on national territory and resource, 4) water source management, 5) green car and cleaner energy program, 6) resource recycling program, 7) forest management & biomass program,
  - 8) green home, office and school,
  - 9) greener landscape and infrastructure





**Thank You!**