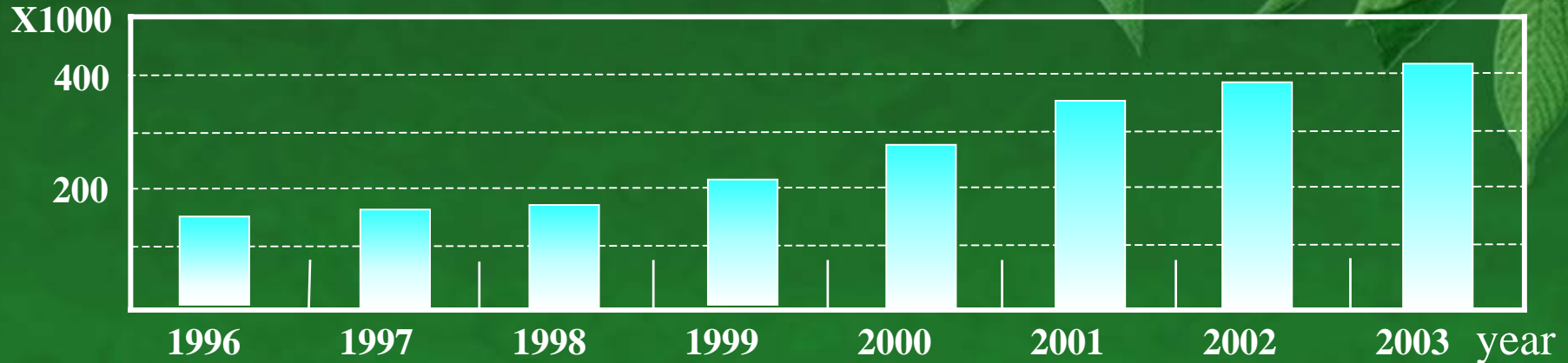




Development of multi-function CO2 Heat Pump Water Heater

Background of multi-function water heater

Market trend of gas combustion multi-function water heater

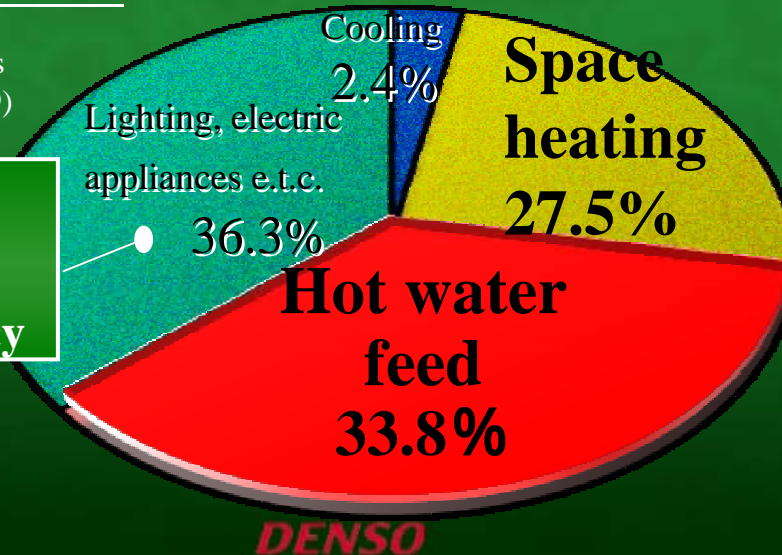


Market of multi-function hot water heater is glowing

Energy consumption at residence

• Annual report of residential energy statistics (1999)

• Proceed energy saving based on “Top Runner Approach” standards of energy efficiency



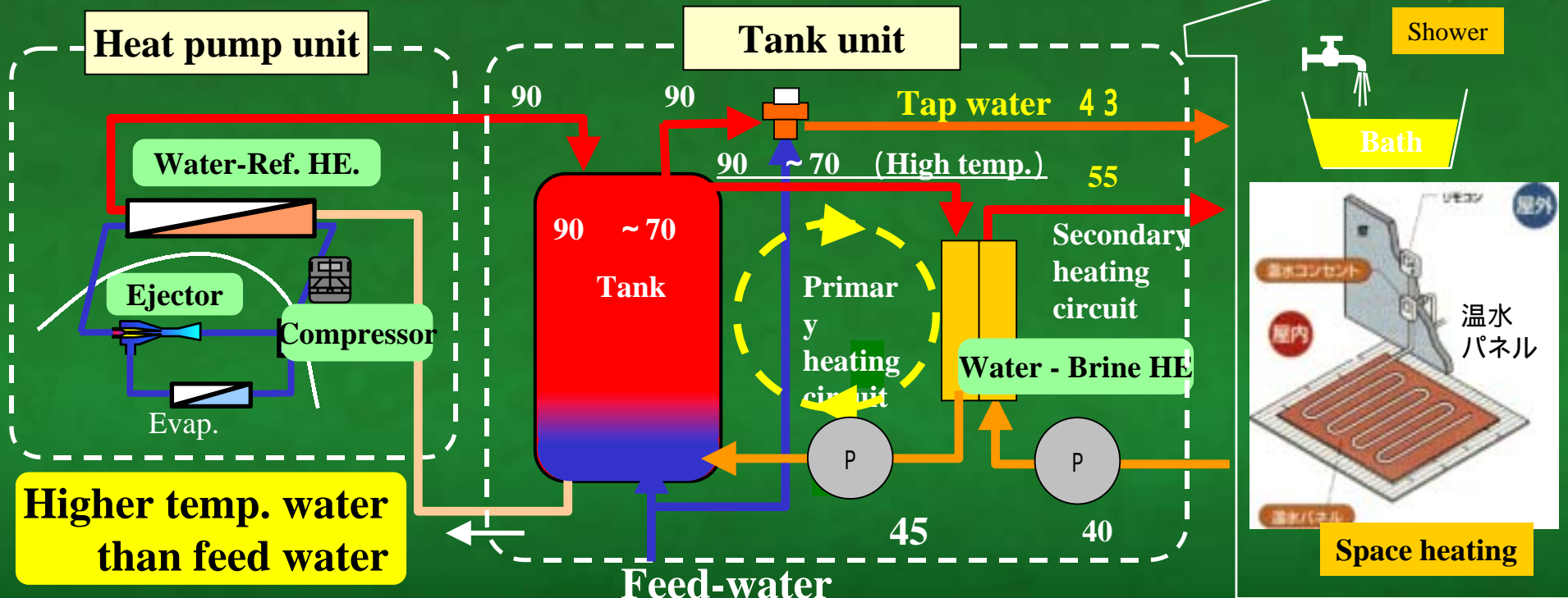
Need to develop high efficiency system

Main task of multi-function heat pump water heater

Characteristics of multi-function system

Use hot water in the storage tank directly for hot tap water

Use hot water in the storage tank indirectly for heat source of space heating



Main problem

Return water from primary heating circuit is mixed into cold feed-water

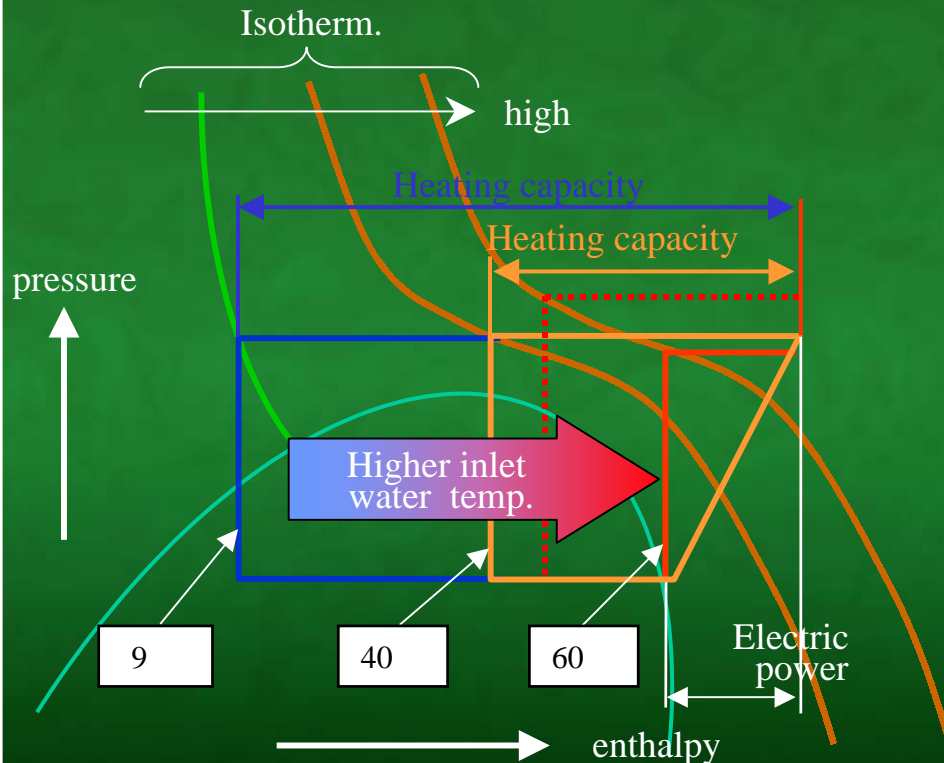
Heat pump COP becomes down with higher inlet water temp.

DENSO

Countermeasures of task

Characteristics of CO₂ heat pump

Decline of heating capacity and cop under high inlet water temp. cond.



Countermeasures for decline of COP

To use return water for tap water (medium temp. water)

Development of Cascade heat process system

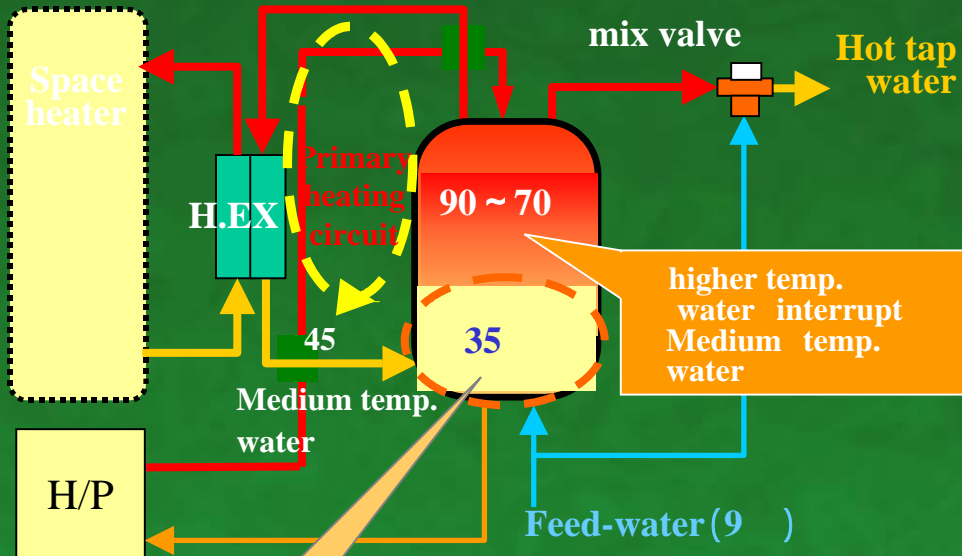
To improve heat pump cop at higher inlet water temp. condition

Development of ejector cycle for heat pump water heater

Outline of cascade heat process system

Conventional storage tank

Medium temp. water can not use
Heat pump COP becomes down



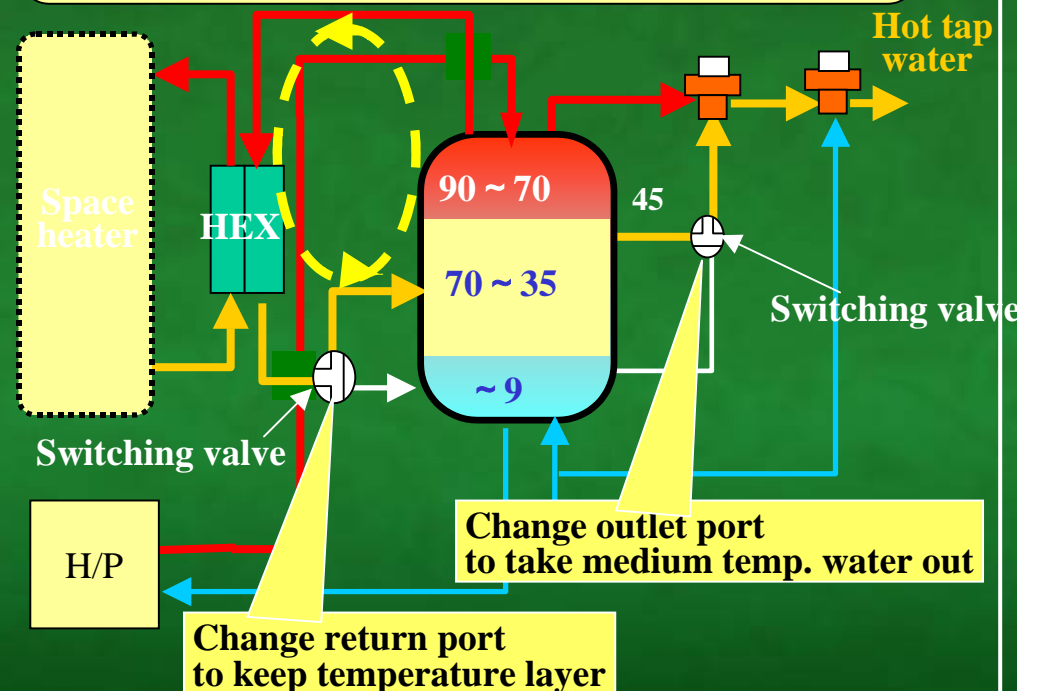
Medium temp. water and cold feed-water
flow into tank by turns.

Too low temp. for hot tap water
Cause inlet water temp. for heat pump rising
and COP becomes down

Cascade heat process system

Characteristics

2 additional water return ports for primary
heating circuit to prevent to mix water
2 additional outlet ports
to use medium temp. water for hot tap water

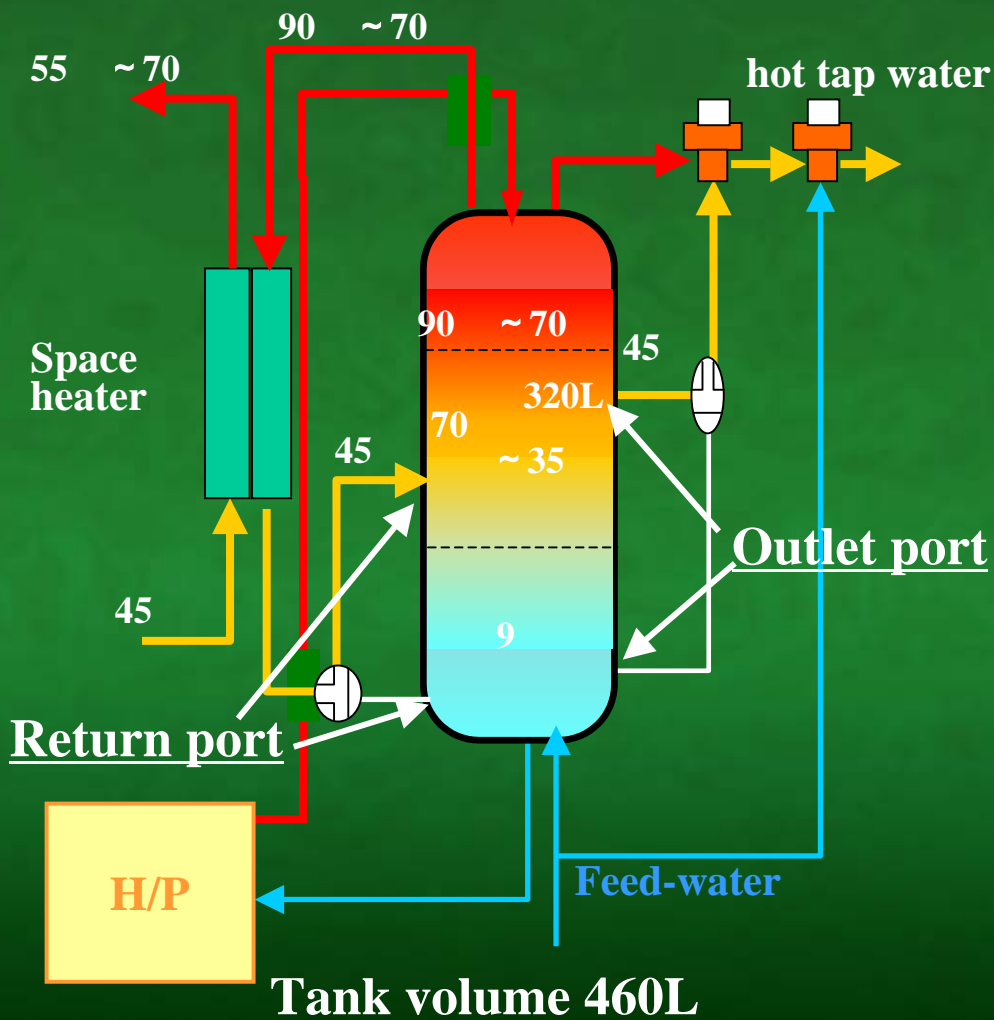


3 different temp. water in the 3 portions of the storage tank

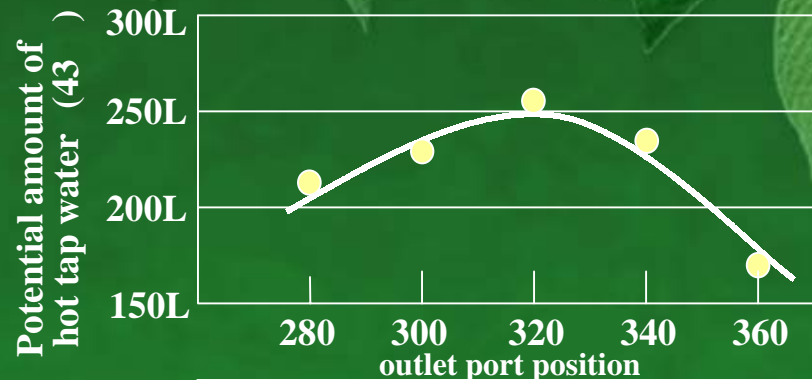
Optimization of port position for cascade heat process system

Basic idea:

Fit for general working pattern

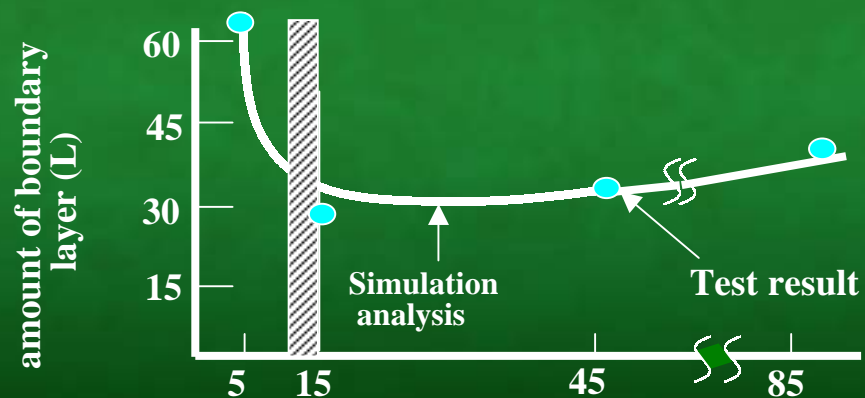


<Optimization of upper additional outlet port>



amount of hot tap water :IBEC L mode,
 floor heating area 13.2m²
 operation time 8hr, ambient temp. 7 ,
 feed-water temp.9

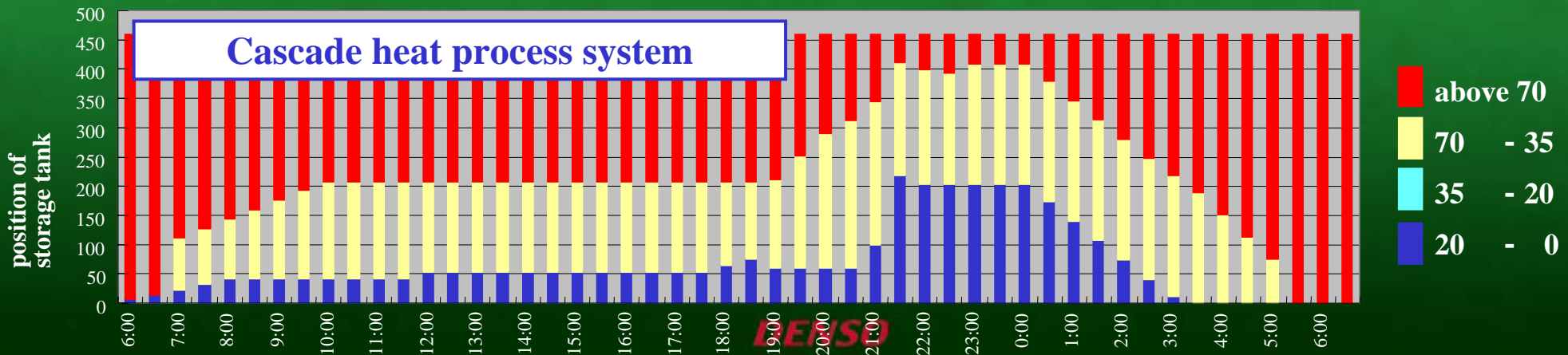
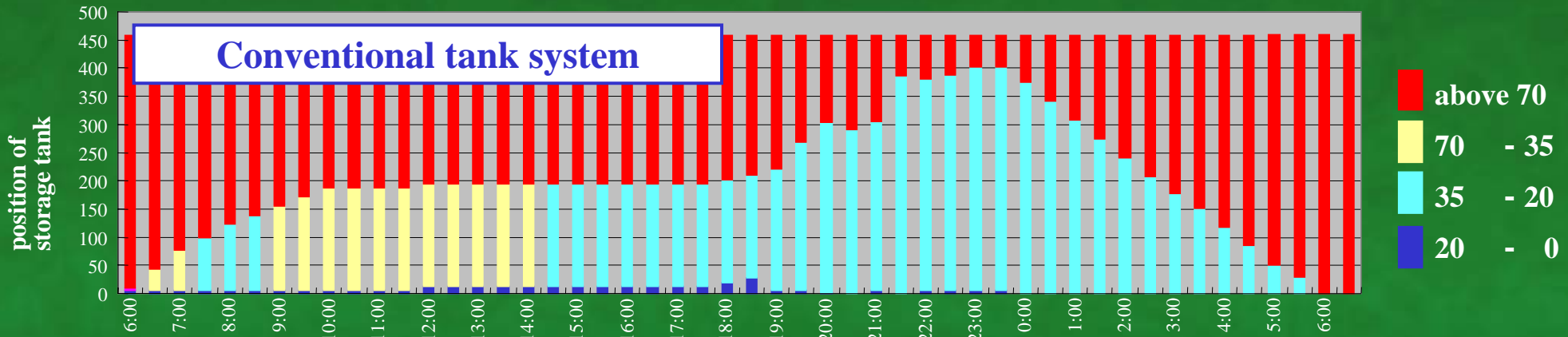
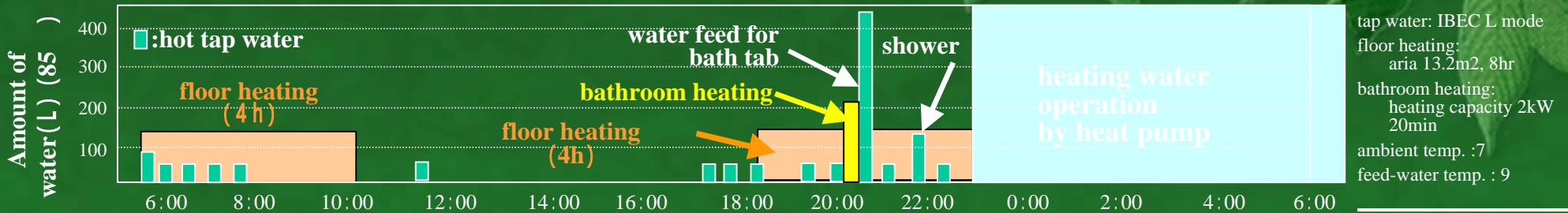
<Characteristic of boundary layer between hot and cold water>



above 15 , boundary layer can form

Evaluation result of cascade heat process system -simulation analysis-

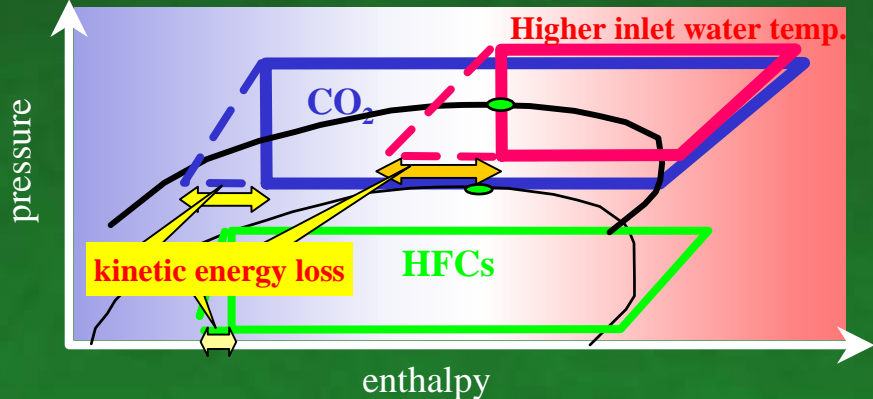
◇ operation pattern of tap water, floor heating, bathroom heating



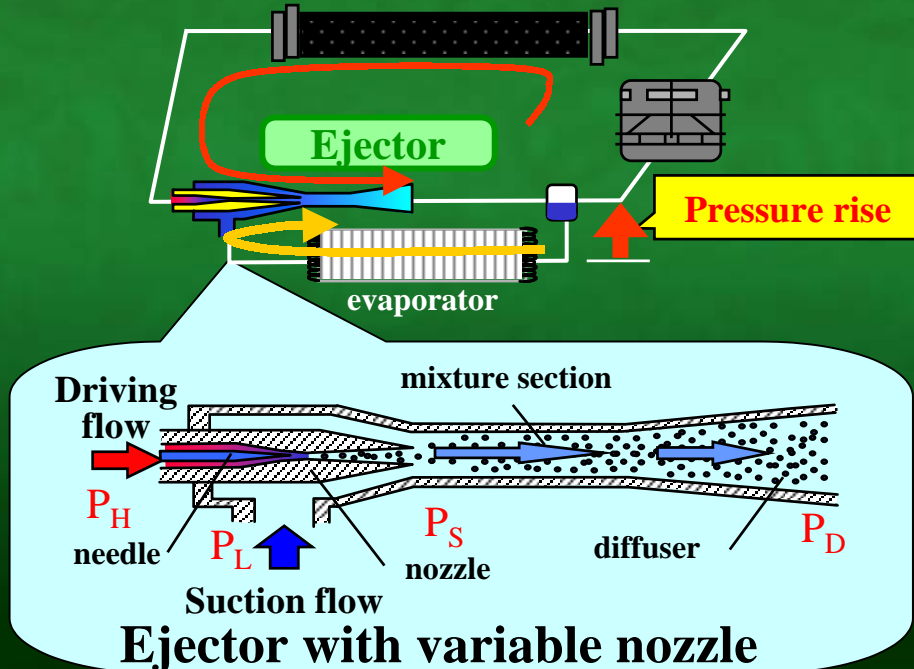
Outline of ejector cycle

Ejector cycle for CO₂ heat pump

Kinetic energy loss of CO₂ is 3 times higher than HFCs



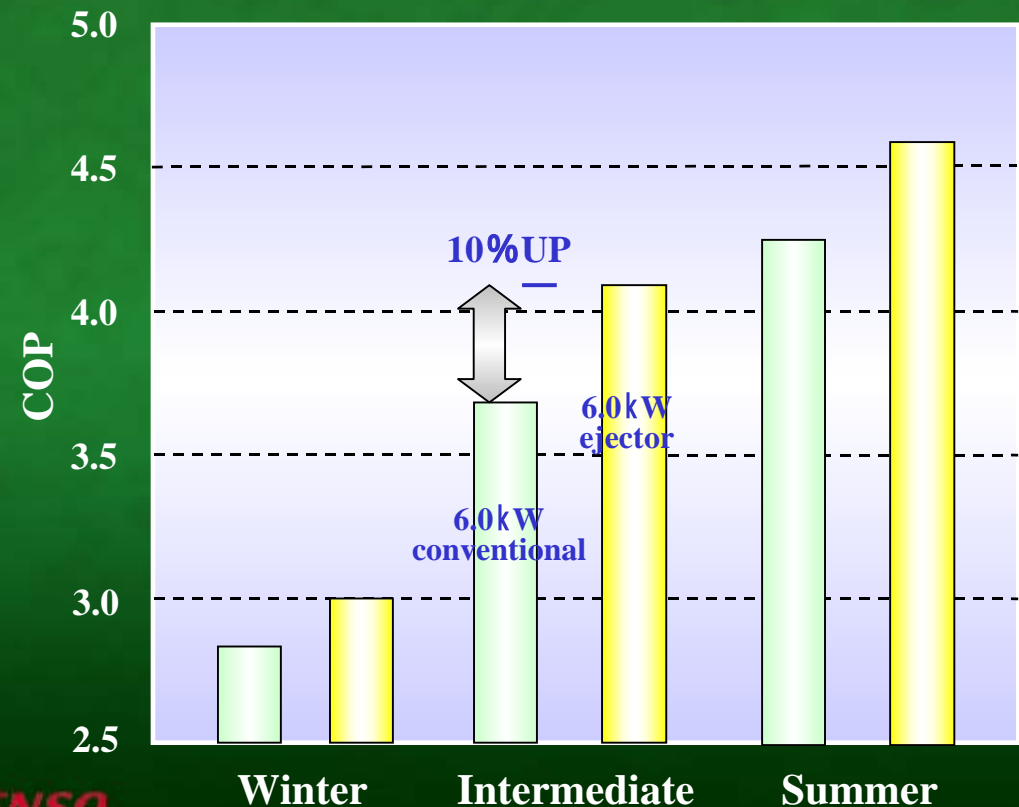
(Ejector cycle)



Benefit of ejector cycle

Condition	Ambient temp.(°C)	feed-water temp.(°C)
Winter	7	9
Intermediate	16	17
Summer	25	24

JRA4050 standard



Summary

1. We have developed cascade heat process system, and have evaluated this performance at field test.
2. We have started to product multi-function CO2 heat pump water heater using variable nozzle ejector cycle at July 2003.

