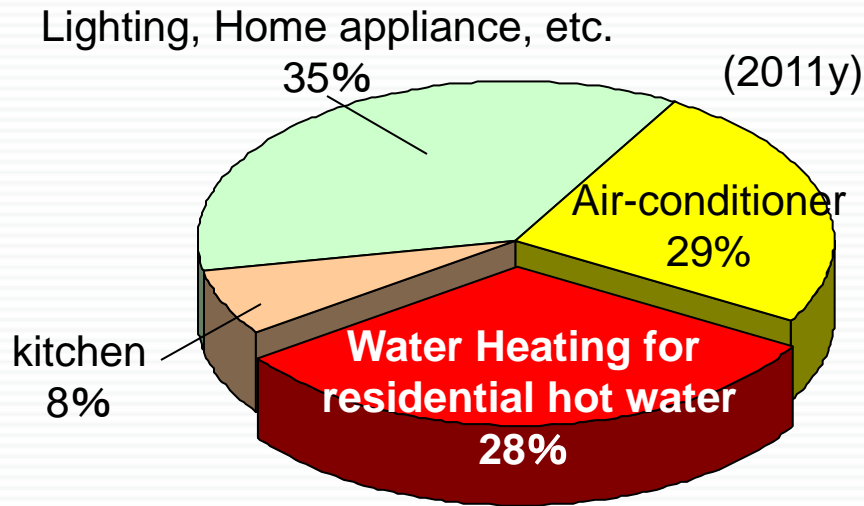


# High Efficiency Residential Air to Water Heat Pump with CO<sub>2</sub>

DENSO CORPORATION  
Naruhide Kimura

# 1. Outline of Air to Water CO<sub>2</sub> Heat Pump

## ➤ Home use energy consumption



Source : "Energy White Paper 2013" provided by Agency for Natural Resources and Energy (ANER)

Encouraging the spread of highly efficient Heat Pump is a key to protect the environment.

## ➤ 2001 Air to Water CO<sub>2</sub> Heat Pump

Joint Development { CRIEPI  
TEPCO  
DENSO

TEPCO: Tokyo Power Electric Company  
CRIEPI: Central Research Institute of Electric Power Industry

The first commercialized product in the world



By introducing CO<sub>2</sub> Heat Pump, promote energy saving and Fluorocarbon free technology at home

# Why CO<sub>2</sub> ?

		Applications	ODP	GWP	Flammability	Allowable limit (ppm)
Fluorocarbons	CFC12	Mobile air conditioning etc.	1	10,900	No	500
	HFC134a		0	1,430	No	1000
	HFO1234yf		0	4	Very mild	500
	HCFC22	Stationary air conditioning etc.	0.055	1,810	No	1000
	HFC410A		0	2,090	No	1000
	HFC32		0	675	Very mild	1000
Natural	HFC410A	Hot water supply	0	2,090	No	1000
	CO <sub>2</sub>		0	1	No	5000
	HFC134a	Domestic refrigerator	0	1,430	No	1000
	HC(R600a)		0	3	Yes	500
	NH <sub>3</sub>	Industrial Refrigerator	0	0	mild	25

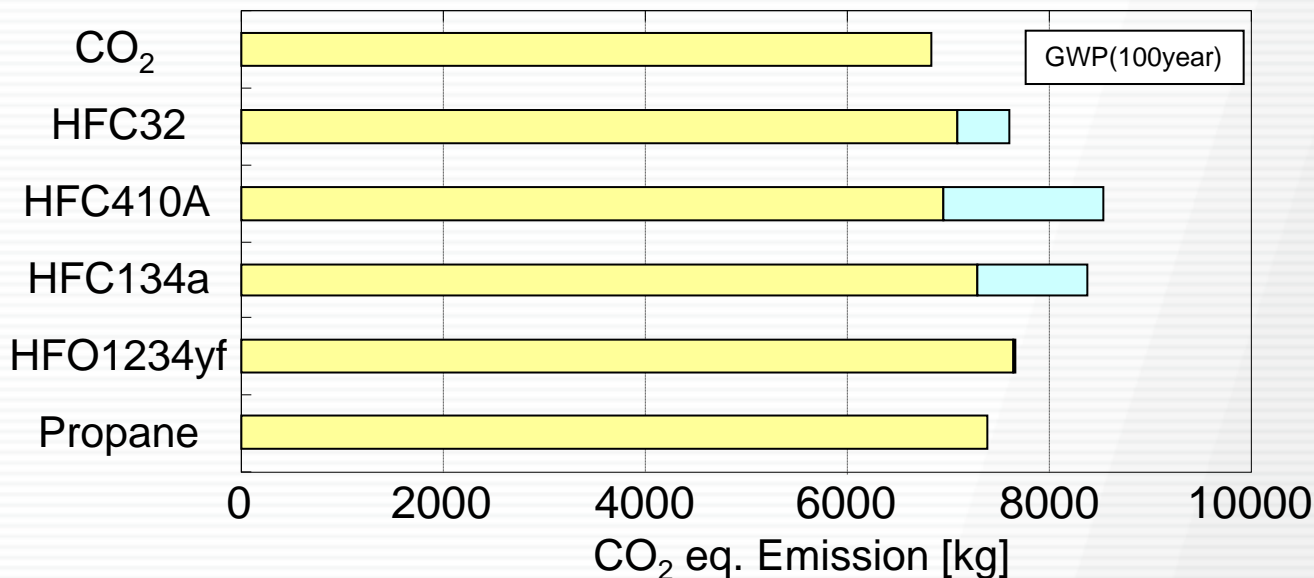
Source : Refrigerant Pocketbook by AGC

Promoting lower GWP refrigerant in each products

# Why CO<sub>2</sub> ?

## LCCP comparison (Life Cycle Climate Performance)

$$\text{CO}_2 \text{ eq. Emission} = \text{Indirect Emissions} + \text{Direct Emission}$$



### <Calculation condition>

- Indirect CO<sub>2</sub> emission: The amount of used heat is based on JIS C 9220.
- Direct CO<sub>2</sub> emission: The amount of charged refrigerant is assumed 1kg.
- CO<sub>2</sub> emission coefficient: 0.464[CO<sub>2</sub>-kg/kWh](1), Product cycle: 10years, operation time: 3.5h/day, Refrigerant leakage rate during operation 2%/year(2), Waste refrigerant recovery rate 31%(3)

Source: (1) "The emission factor list by Electric utilities" provided by MOE

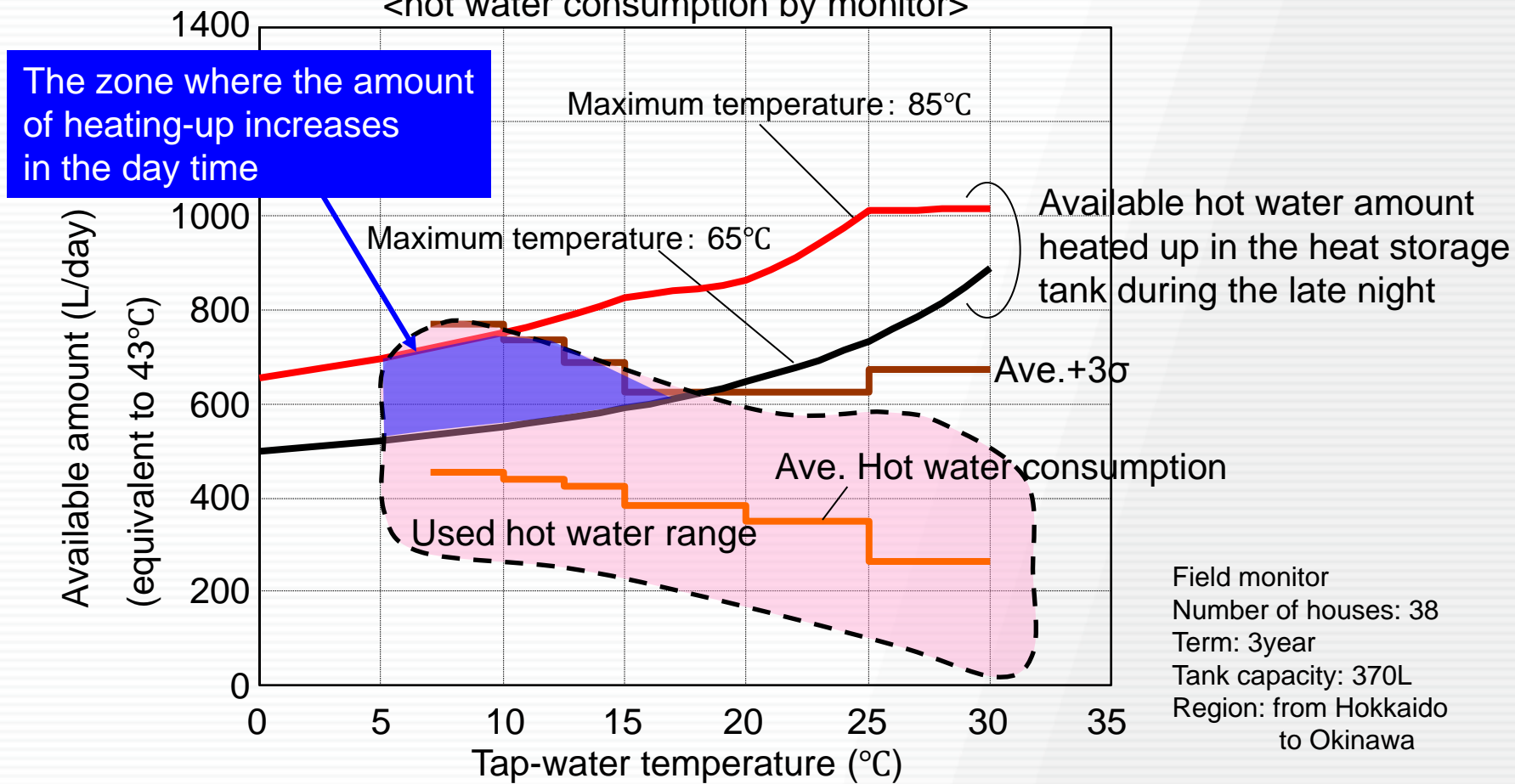
(2) "The issues and circumstances surrounding the refrigerant HFC in Japan" provided by METI

(3) "The total result of the recovery amount of the fluorocarbons from commercial refrigeration and air conditioning equipment based on the CFC Recovery and Destruction Law of fiscal year 2010" provided by METI

CO<sub>2</sub> is environment friendly refrigerant in hot water supply

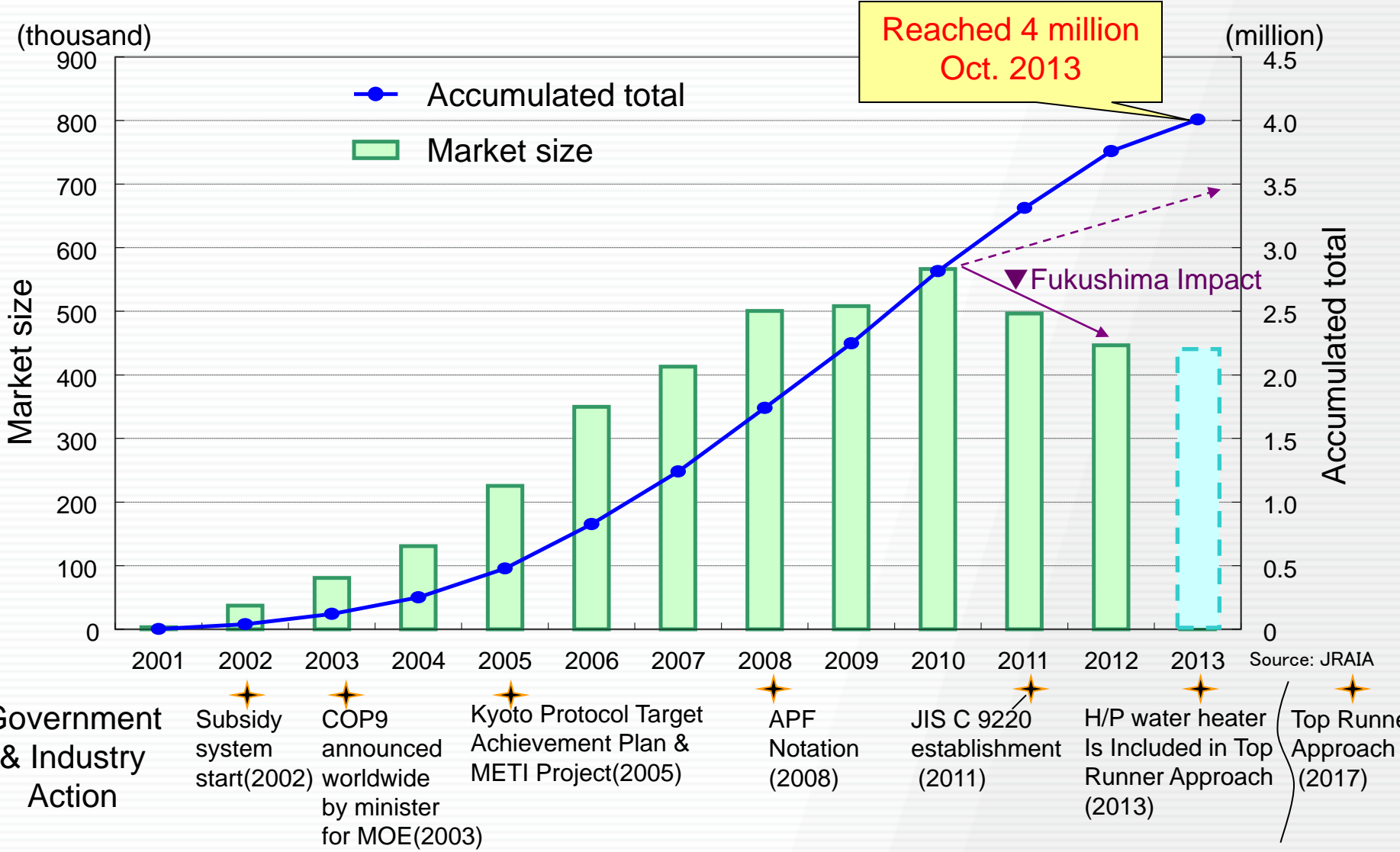
# Why CO<sub>2</sub> ?

The available hot water amount due to a difference of heating-up temperature  
 <hot water consumption by monitor>



CO<sub>2</sub> heat pump can contribute to energy consumption reduction during peak energy hours, even if its hot water consumption is high

# Accumulated total



Government & Industry Action

- ★ Subsidy system start(2002)
- ★ COP9 announced worldwide by minister for MOE(2003)
- ★ Kyoto Protocol Target Achievement Plan & METI Project(2005)
- ★ APF Notation (2008)
- ★ JIS C 9220 establishment (2011)
- ★ H/P water heater Is Included in Top Runner Approach (2013)
- ★ Top Runner Approach (2017)

Further spread and GWP reduction in the market of high-efficiency heat pump are required

**DENSO**

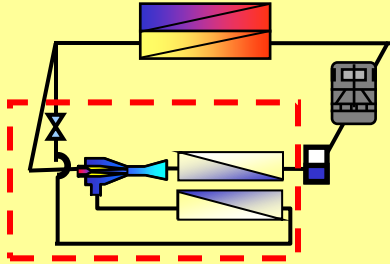
## 2. High efficiency technology



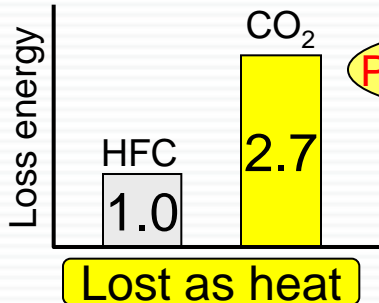
# Efficiency of the refrigeration cycle

## Ejector cycle (EJECS II)

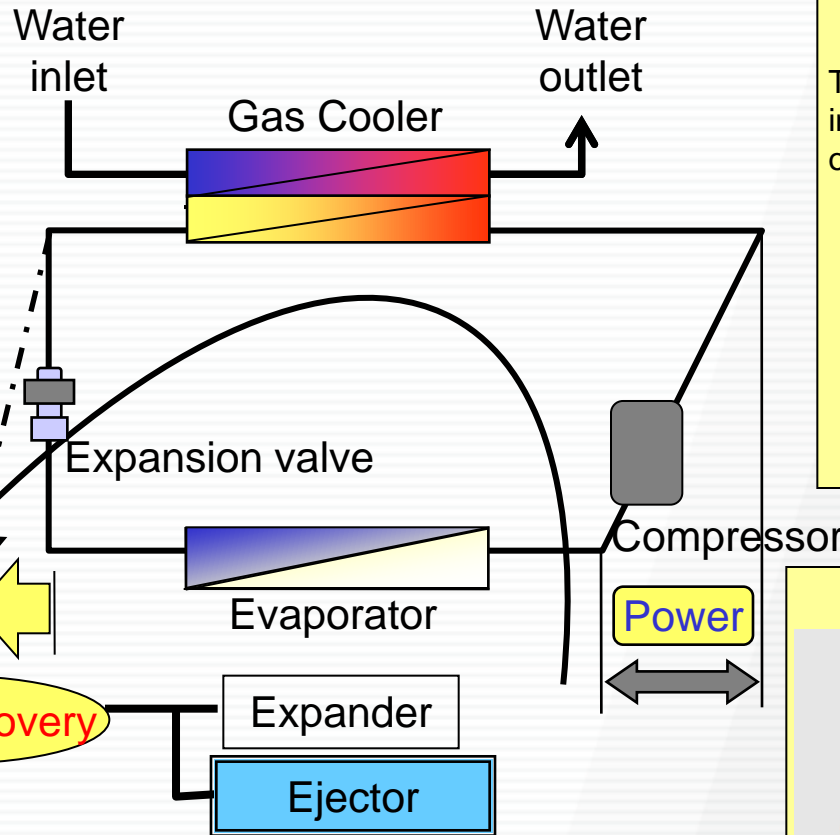
- Longer defrost interval
- Improved Evaporator performance



<Expansion loss>  
(JIS Rating conditions)



Power recovery

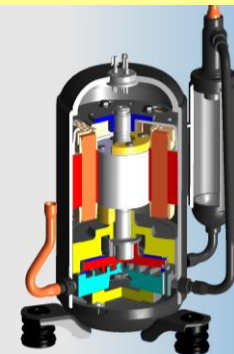


## High performance Gas Cooler

The heat transfer performance improvement by the miniaturization of the fin



## High efficiency Compressor



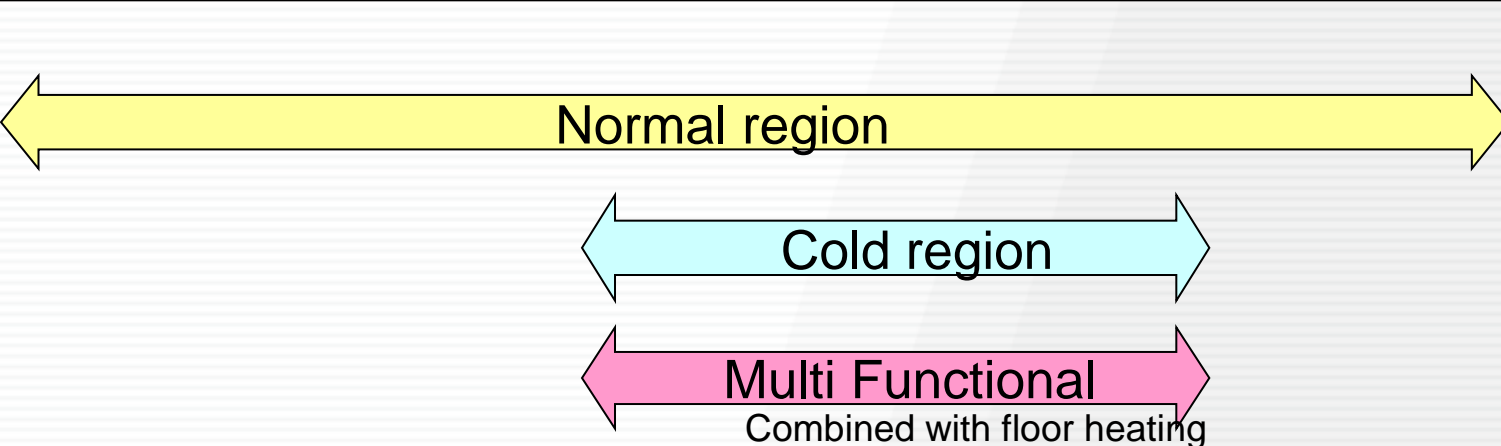
- Scroll
- Low pressure vessel
- Oil separation efficiency improvement
- Heating loss reduction
- Lower bearing loss

Improved the CO<sub>2</sub> heat pump performance by new developed technology, including NEDO support

# 3. Eco Cute Products

# Japanese Market Common Product Portfolio

(Typical product data)

Number of People	1~2	2~4	3~5	4~7	5~8
Storage Tank Volume	200L	300L	370L	460L	560L
Heating capability	4.5kW			6.0kW	7.0kW
Corresponding region (Include salt damage area)	 <p>Normal region</p> <p>Cold region</p> <p>Multi Functional Combined with floor heating</p>				

Product portfolio that covers a wide range of household size and region



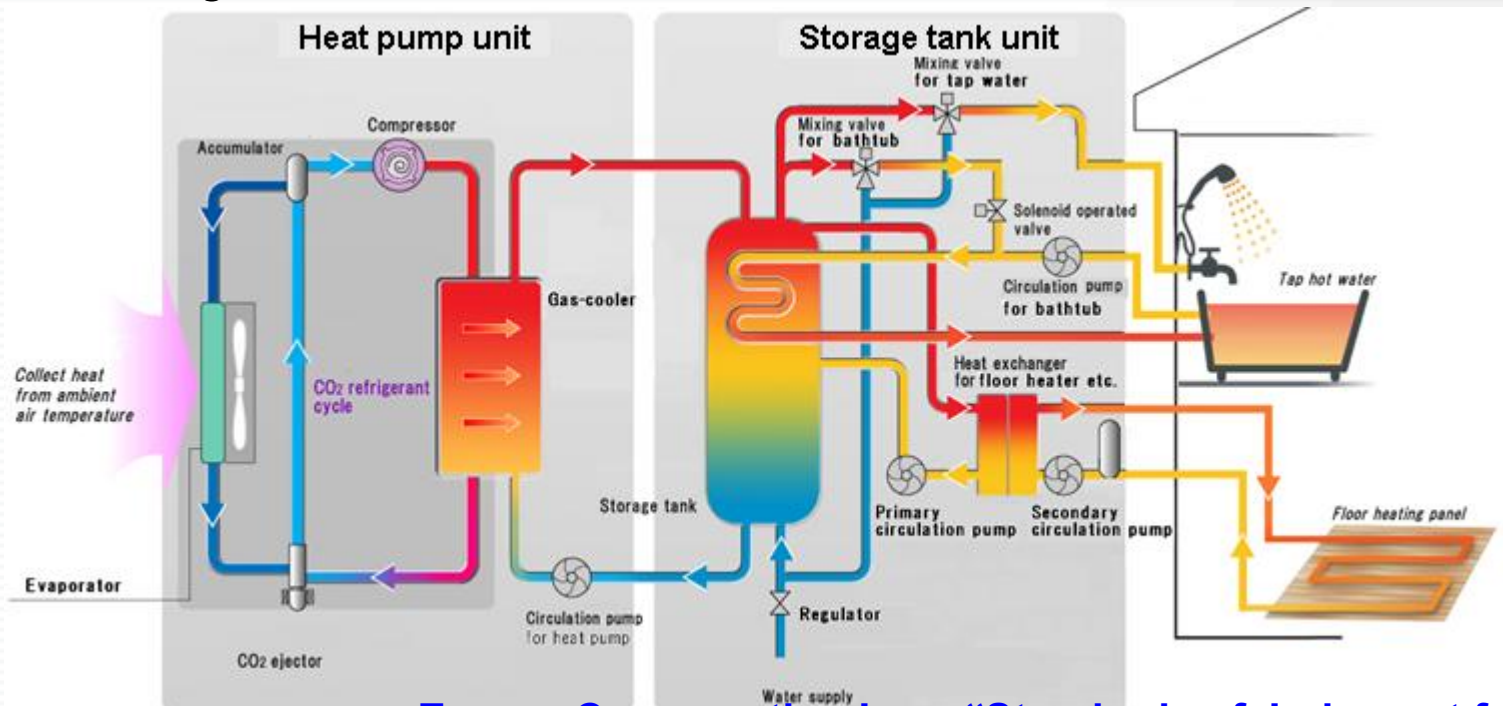
System diagram

## ■ Product feature

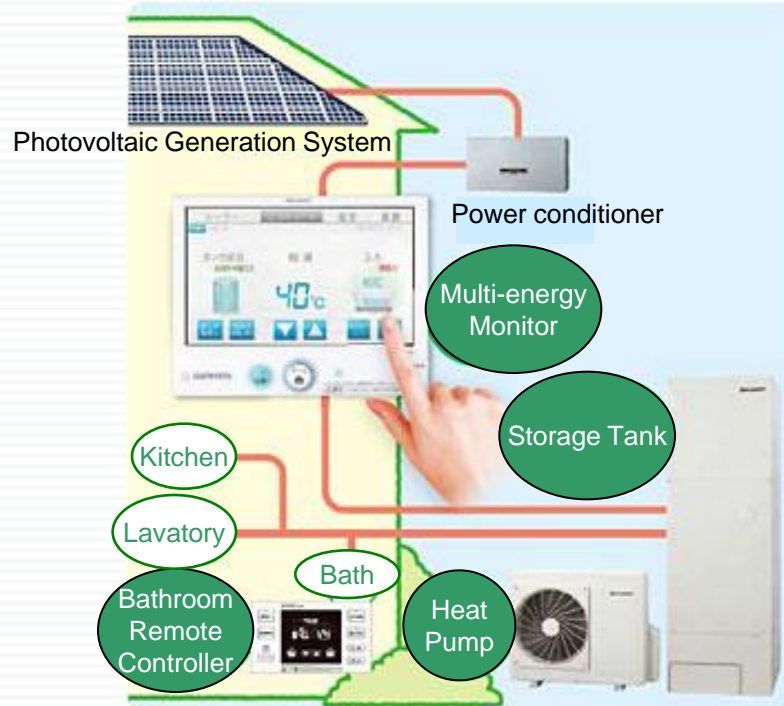
- Heating capacity 2.9kW for Living & Dining
- Heat pump heating capacity : 6kW

## ■ Technological Benefits

- Cascade heat process system
- Secondary heat exchanger for heating



Energy Conservation Law, “Standards of Judgment for Residential Construction Clients” certified (MLIT)

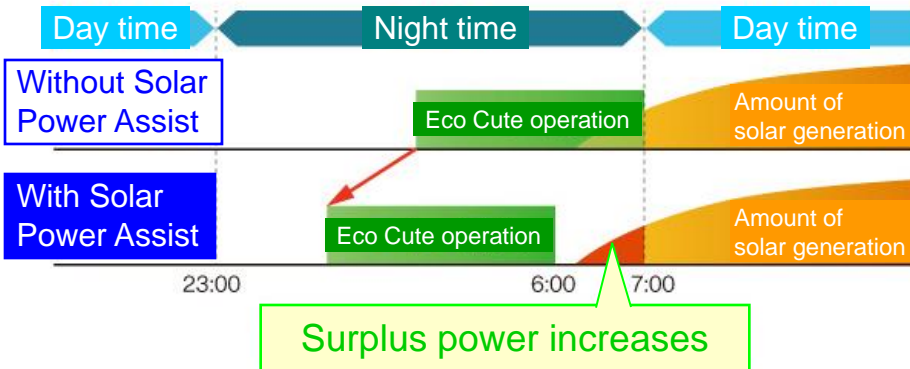


## Product Features

- **Integrated Controller** for PV system and Eco Cute
- **"Solar Power Assist"** Function:  
The Eco Cute system will operate with stored energy, prior to solar power generating operation in the morning
- **"Summer Mode"** Function:  
Day time saving function without any concern of running out of hot water

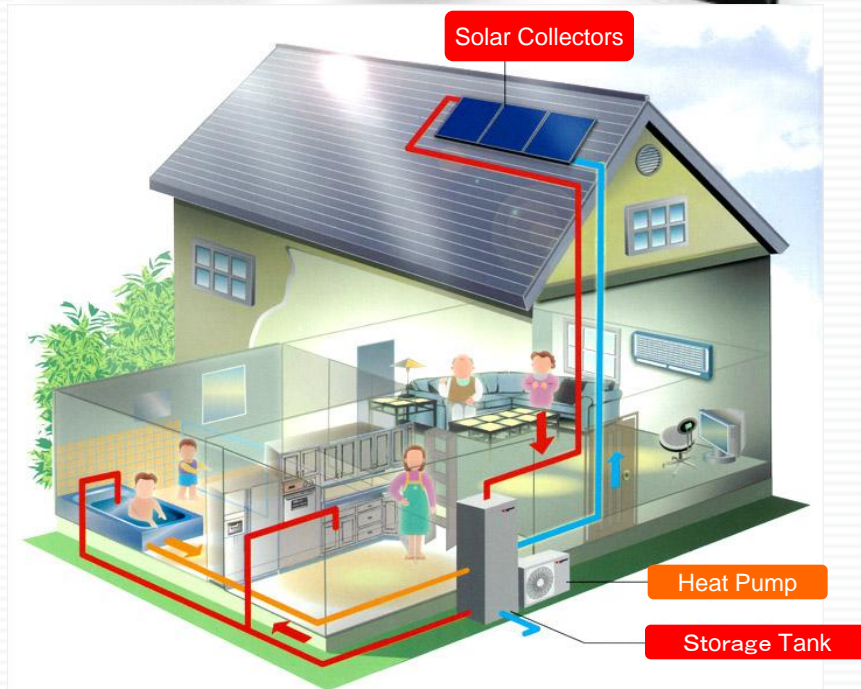
## Technological Benefits

- **Single management control** of PV system and Eco Cute
- **Optimum control** of Eco Cute by monitoring power generation condition and hot water usage



# Solar Heat Collector Hybrid Model

since 2010



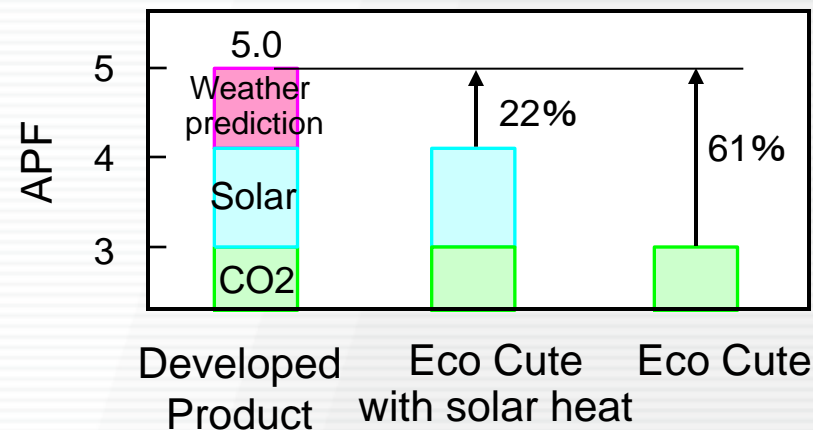
## ■ Product Features

- Best mix of **double renewable energy**
- Annual Performance Factor (APF): **5.0**
- **Smart design Solar Collector**

## ■ Technological Benefits

- Learning control system based on **weather prediction**
- **Heat Recovery** from bathwater

load of hot water supply : IBEC-L, Collector area : 4m<sup>2</sup>



- Air to water CO<sub>2</sub> heat pump (Eco Cute) is a world first good example that a new refrigerant product was expanded by government and industry together
- The appropriate refrigerant is different from each products section, CO<sub>2</sub> is the efficient refrigerant for heat pump water heater because of not only LCCP superiority but also wide range hot water temperature
- The support from parties involved is appreciated to grow Air to Water CO<sub>2</sub> Heat Pump market again

***DENSO***