

September 2003

Country report of Japan

Delegate of Japan for IEA-Annex 28
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1. Market of domestic water heating and space heating heat pumps in Japan

Market of air-source HP for DHW with CO₂ or R410A as a refrigerant

- 3,000 units from Oct. 2001 to Mar. 2002
- 11,000 units from Apr. 2002 to Sep. 2002
- 26,000 units from Oct. 2002 to Mar. 2003
- 33,000 units from Apr. 2003 to Sep. 2003 (estimated)
- 37,000 units from Oct. 2003 to Mar. 2004 (estimated)

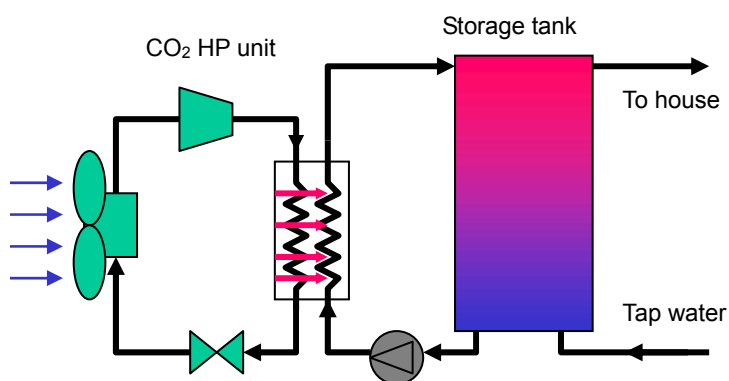
Heat pumps of combined DHW and floor heating

The new heat pumps of combined DHW and floor heating of was put on the market this year.

2. Heat pump systems in the market

2.1 Heat pumps for domestic hot water heating

The research and development on the heat pump water heater operated with carbon dioxide progressed, and three manufacturers had put systems on the domestic market in 2001: DENSO Corp., SANYO Electric Air Conditioning Co. and DAIKIN Industries. The heat pump water heater consists of a heat pump unit and a hot water storage unit. The heat pump makes hot water using cheap midnight electric power and stores it in a reservoir tank, and hot water is used in the daytime. In order to proliferate and to promote high-efficiency hot water systems, the Japanese government financially assists a part of installation expense of this system, and therefore it is very economical. Average COP of the heat pump unit is higher than 3.5.



Basic diagram of HPWH

In order to proliferate and to promote high-efficiency hot water systems, the Japanese government financially assists a part of installation expense of this system, and therefore it is very economical. Average COP of the heat pump unit is higher than 3.5.

In 2003 a new type of heat pump water heater was put in a domestic market from Hitachi Home & Life Solutions. Two refrigerant cycles and a small supplementary storage tank are equipped, and the compressors operate in response to hot water demand.

(1) DENSO Corporation

Working fluid		Carbon dioxide
Type of compressor		Hermetic scroll compressor with inverter operating DC motor
Applicable electricity rate system		Time-of-day lighting service
Rating	Power supply voltage	Single-phase 200 V
	Heat pump capacity	4.5 kW

	Power consumption	1.14 kW ^{*1}
	COP of heat pump unit	3.95 ^{*1}
	Hot water temperature at heat pump unit exit	Automatically controlled in response to hot water consumption: 65 to 90°C
	Hot water temperature at point of use	Approximately from 35 to 50°C in 1°C intervals, and 60°C
	Bath warming function	Full-automatic heating function
	Maximum hot water pressure	170 kPa
	Noise in operation	39 dB
	Heat pump unit	820mm(W)/300mm(D)/640mm(H)
Dimensions	Hot water storage unit	690mm(W)/740mm(D)/1890mm(H) for 370litters 600mm(W)/610mm(D)/1900mm(H) for 300litters
	Hot water storage capacity	370 litters/300 litters

Test condition	Outside air temperature	Tap water temperature	Hot water temperature
*1 Standard condition	16°C(DB)/12°C(WB)	17°C	65°C

(2) SANYO Electric Air Conditioning Co.

Working fluid		Carbon dioxide
Type of compressor		Hermetic two-stage rolling piston compressor with inverter operating DC motor
Applicable electricity rate system		Time-of-day lighting service
Rating	Power supply voltage	Single-phase 200 V
	Heat pump capacity	4.5 kW
	Power consumption	1.16 kW ^{*1} , 1.06 kW ^{*2} , 1.37 kW ^{*3}
	COP of heat pump unit	3.88 ^{*1} , 4.25 ^{*2} , 3.28 ^{*3}
	Hot water temperature at heat pump unit exit	Automatically controlled in response to hot water consumption: below 90°C
	Hot water temperature at point of use	Approximately from 36 to 48°C in 1°C intervals, and 60°C
	Bath warming function	Full-automatic heating function
	Maximum hot water pressure	170 kPa
Dimensions	Noise in operation	45 dB or 40 dB in calm mode
	Heat pump unit	930mm(W)/290mm(D)/620mm(H)
	Hot water storage unit	700mm(W)/840mm(D)/1800mm(H) for 370litters 540mm(W)/600mm(D)/1900mm(H) for 240litters
	Hot water storage capacity	370 litters/240 litters

Test condition	Outside air temperature	Tap water temperature	Hot water temperature
*1 Standard condition	16°C(DB)/12°C(WB)	17°C	65°C
*2 Summer condition	25°C(DB)/21°C(WB)	24°C	65°C
*3 Winter condition	7°C(DB)/4°C(WB)	9°C	65°C

(3) DAIKIN Industries

Working fluid	Carbon dioxide
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Type of compressor		Hermetic swing type compressor with inverter operating DC motor
Applicable electricity rate system		Time-of-day lighting service
Rating	Power supply voltage	Single-phase 200 V
	Heat pump capacity	4.5 kW
	Power consumption	1.21 kW ^{*1}
	COP of heat pump unit	3.72 ^{*1}
	Hot water temperature at heat pump unit exit	Automatically controlled in response to hot water consumption: from 65 to 90°C
	Hot water temperature at point of use	Approximately from 38 to 48°C, and 60°C
	Bath warming function	Full-automatic heating function
	Maximum hot water pressure	170 kPa
	Noise in operation	39 dB
Dimensions	Heat pump unit	825mm(W)/300mm(D)/735mm(H)
	Hot water storage unit	667mm(W)/700mm(D)/1788mm(H)
	Hot water storage capacity	370 liters

Test condition	Outside air temperature	Tap water temperature	Hot water temperature
*1 Standard condition	16°C(DB)/12°C(WB)	17°C	65°C

(4) Hitachi Home & Life Solutions

Working fluid		R410A (1.4kg x 2)
Type of compressor		Two hermetic scroll compressors with inverter operating DC motors
Applicable electricity rate system		Meter-rate lighting service
Rating	Power supply voltage	Single-phase 200 V
	Heat pump capacity	23.0 kW ^{*4} , 17.0 kW ^{*5} , 21.0 kW ^{*6}
	Power consumption	5.0 kW ^{*4} , 3.0 kW ^{*5} , 5.4 kW ^{*6}
	COP of heat pump unit	4.6 ^{*4} , 5.67 ^{*5} , 3.89 ^{*6} ,
	Hot water temperature in storage	60°C
	Bath warming function	Full-automatic heating function
	Maximum hot water pressure	170 kPa
	Noise in operation	48 dB
Dimensions	Heat pump & storage unit	850mm(W)/450mm(D)/1900mm(H)
	Hot water storage capacity	90 liters

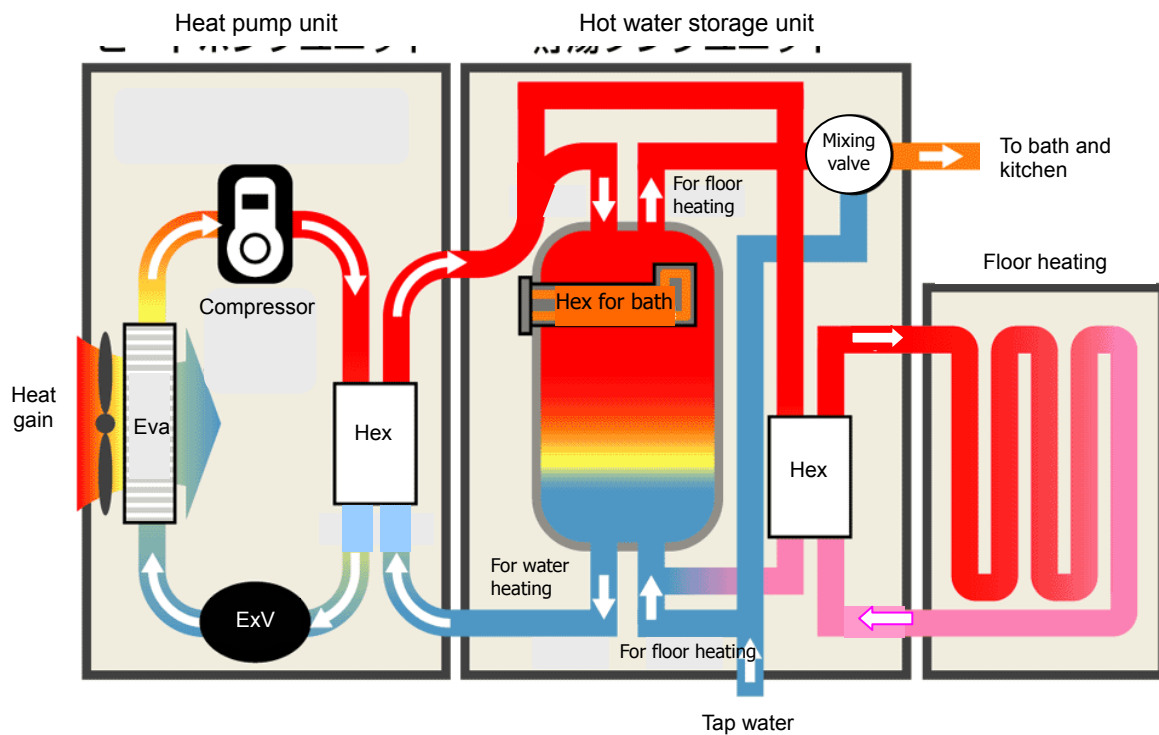
Test condition	Outside air temperature	Tap water temperature	Hot water temperature
*4 Standard condition	16°C(DB)/12°C(WB)	17°C	42°C
*5 Summer condition	25°C(DB)/21°C(WB)	24°C	42°C
*6 Winter condition	7°C(DB)/6°C(WB)	9°C	42°C

2.2 Heat pumps for combined domestic hot water heating and floor heating

(1) TOSHIBA Electric Appliances Co.

Working fluid		R410A (900g)
Type of compressor		Hermetic twin rotary compressor with inverter operating DC motor
Applicable electricity rate system		Time-of-day lighting service
Rating	Power supply voltage	Single-phase 200 V
	Heat pump capacity	4.5 kW ^{*1} , 4.5 kW ^{*2} , 7.0 kW ^{*7}
	Power consumption	1.1 kW ^{*1} , 1.04 kW ^{*2} , 2.25 kW ^{*7}
	COP of heat pump unit	4.1 ^{*1} , 4.3 ^{*2} , 2.5 for floor heating in winter
	Floor heating capacity	4.5 kW RO
	Area of floor for heating	26m ²
	Hot water temperature in storage	Automatically controlled from 65 to 75°C
	Bath warming function	Full-automatic heating function
	Maximum hot water pressure	150 kPa
	Noise in operation	48 dB
Dimensions	Heat pump unit	780mm(W)/270mm(D)/720mm(H)
	Hot water storage unit	700mm(W)/800mm(D)/1800mm(H)
	Hot water storage capacity	460 liters

Test condition	Outside air temperature	Tap water temperature	Hot water temperature
*1 Standard condition	16°C(DB)/12°C(WB)	17°C	65°C
*2 Summer condition	25°C(DB)/21°C(WB)	24°C	65°C
*7 Winter condition	7°C(DB)/6°C(WB)	9°C	80°C
	Combined water heating and floor heating operation		

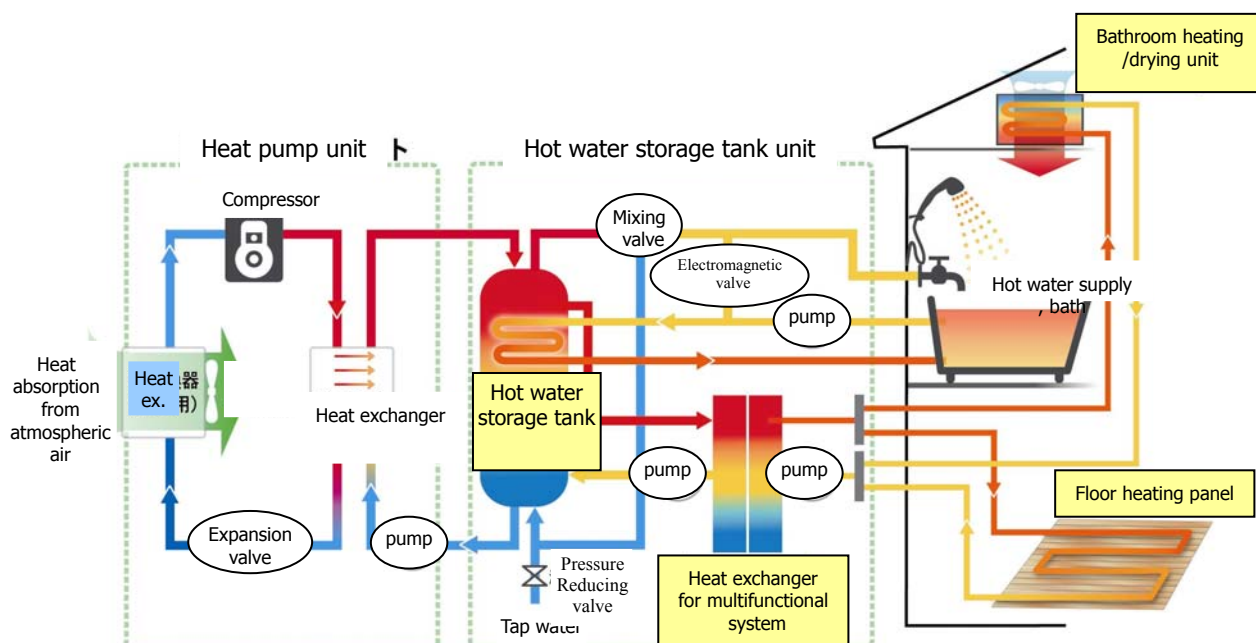


(2) DENSO Corporation

Working fluid	Carbon dioxide
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Type of compressor		Hermetic scroll compressor with inverter operating DC motor
Applicable electricity rate system		Time-of-day lighting service
Rating	Power supply voltage	Single-phase 200 V
	Heat pump capacity	6.0 kW
	Power consumption	1.44 kW*1
	COP of heat pump unit	4.17*1
	Hot water temperature at heat pump unit exit	Automatically controlled in response to hot water consumption: 65 to 90°C
	Hot water temperature at point of use	Approximately from 35 to 50°C in 1°C intervals, and 60°C
	Bath warming function	Full-automatic heating function
	Maximum hot water pressure	170 kPa
	Noise in operation	42 dB
	Heat pump unit	820mm(W)/300mm(D)/640mm(H)
Dimensions	Hot water storage unit	720mm(W)/800mm(D)/1890mm(H) for 460litters 690mm(W)/740mm(D)/1890mm(H) for 370litters
	Hot water storage capacity	460 litters/370 litters

Test condition	Outside air temperature	Tap water temperature	Hot water temperature
*1 Standard condition	16°C(DB)/12°C(WB)	17°C	65°C



3. Tariff of electricity rates

3.1 Meter-rate lighting service

Tokyo Electric Power Company is the biggest utility company in Japan. Its service area is Tokyo and its neighboring area. Meter-rate lighting service is the contract of electricity for residential customers in Tokyo Electric Power Company. Meter-rate lighting service B is the typical contract. Meter-rate lighting service C is prepared for customers who consume electricity more than 6 kVA.

Meter-rate lighting service B

Contract category		Unit	Rate in JPY
Demand charge	10A	Per contract	260.00
	15A	Per contract	390.00
	20A	Per contract	520.00
	30A	Per contract	780.00
	40A	Per contract	1040.00
	50A	Per contract	1300.00
	60A	Per contract	1560.00
Energy charge	Up to 1 st 120 kWh	1 kWh	15.58
	Over 120 kWh to 300 kWh	1 kWh	20.67
	Over 300 kWh	1 kWh	22.43

Meter-rate lighting service C

Contract category		Unit	Rate in JPY
Demand charge		1 kVA	260.00
Energy charge	Up to 1 st 120 kWh	1 kWh	15.58
	Over 120 kWh to 300 kWh	1 kWh	20.67
	Over 300 kWh	1 kWh	22.43

3.2 Optional rules for supply of electricity

This contract falls within the scope of the meter-rate lighting service and is aimed at customers who can shift their load from daytime hours to nighttime hours. Energy charge levels are set for two time periods. Two types of economical nighttime charges have been set so customers can select menu type suitable their lifestyle.

(1) Time-of-day lighting service: nighttime 8-hour type

In this contract, “day hours” means a time period from 7:00 a.m. to 11:00 p.m. every day and “night hours” means a time period other than the day hours.

Time-of-day lighting service, nighttime 8-hour type

Contract category		Unit	Rate in JPY
Demand charge	For 6 kVA or less	Per contract	1200.00
	For 7 kVA to 10 kVA	Per contract	2000.00
	For 11 kVA and over	Per contract	¥2000+¥260 x (contract capacity – 10 kVA)
Energy charge	Day hours	Up to 1 st 90 kWh	1 kWh 19.95
		Over 90 kWh to 230 kWh	1 kWh 26.45
		Over 230 kWh	1 kWh 28.70
	Night hours	1 kWh 5.95	
A discount of ¥230/kVA for five-hour-energized appliances is available.			
A discount of ¥130/kVA is available if energization-controlled nighttime thermal storage type appliances are used.			

(2) Time-of-day lighting service: nighttime 10-hour type

In this contract, “day hours” means a time period from 8:00 a.m. to 10:00 p.m. every day and “night hours” means a time period other than the day hours.

Time-of-day lighting service, nighttime 10-hour type			
Contract category		Unit	Rate in JPY
Demand charge	For 6 kVA or less		Per contract 1200.00
	For 7 kVA to 10 kVA		Per contract 2000.00
	For 11 kVA and over		Per contract ¥2000+¥260 x (contract capacity – 10 kVA)
Energy charge	Day hours	Up to 1 st 80 kWh	1 kWh 22.20
		Over 80 kWh to 200 kWh	1 kWh 29.45
		Over 200 kWh	1 kWh 31.95
	Night hours		1 kWh 6.25
A discount of ¥40/kVA for eight-hour-energized appliances is available.			
A discount of ¥270/kVA for five-hour-energized appliances is available.			
A discount of ¥170/kVA is available if energization-controlled nighttime thermal storage type appliances are used.			

4. Industrial standard of heat pumps for domestic water heating in Japan

No national standard of heat pumps for combined or alternative domestic water heating and floor heating is issued in Japan. The Japan Refrigeration and Air Conditioning Industry Association have issued a standard of heat pump water heater using carbon oxide as a working fluid, JRA 4050, in 2001. JRA4050 requires the performance test of the heat pump unit at steady state condition. Because most of the heat pump water heaters will be operated in nighttime in Japan, transient behavior of the heat pump system including hot water storage unit does not have a large importance.

(1) JRAIA’s activities related to the heat pump water heater

- 1) Heat Pump Water Heater Preparatory Committee was set up in November 2000.
- 2) Founding members of the Committee were DAIKIN Industries, DENSO Corp. and SANYO Electric Air Conditioning that had put forward the joint development with the electric power companies, and several other manufacturers joined the Committee later.
- 3) Committee activities were started with the aim of unifying test conditions so as to provide users with the information on products performance obtained under the common conditions to all the manufacturers.
- 4) In 2001, the testing and performance requirements for heat pump water heaters were established and then published as JRA standard 4050.

(2) Outline of JRA 4050:2001

JRA means a standard established by the JRAIA.

1) Scope

- Domestic hot water supply system;
- Air-source heat pump of which refrigerant is carbon dioxide; and
- Comprised of a heat pump unit and a hermetic hot water storage unit.

- 2) Performance of the heat pump unit
 - Test conditions of heating performance for the heat pump unit are unified.
 - Representative temperatures throughout a year are set as follows as the rated condition.

Temperature of outdoor air	16°C (DB) / 12°C (WB)
Temperature of incoming cold water	17°C
 - Temperature of outgoing hot water is set at 65°C (to prevent legionnaires' disease).
 - In order to ensure the hot water supply during the winter season, the heating condition during winter is established as shown below.

Temperature of outdoor air	7°C (DB) / 6°C (WB)
Temperature of incoming cold water	9°C

(The outdoor air temperature is identical with that of the heating condition for air conditioners.)
- 3) Performance of the hot water storage unit
 - Performance of standby heating

The provision is given which limits the minimum temperature of the hot water left as it is for 13 hours.
 - Performance of usable hot water

The provision is given which limits the minimum temperature of the hot water tapped for the twelfth time when hot water corresponding to one-thirteenth of the tank capacity is drawn off at an interval of one hour.
- 4) The provision is established to ensure the quality of water.

(3) Revision of JRA 4050:2001

- 1) Revision is now under way with its completion scheduled for 2004.
- 2) Performance of the heat pump unit
 - to provide basic data of the calculated values of annual power consumption under the summer condition as shown below.

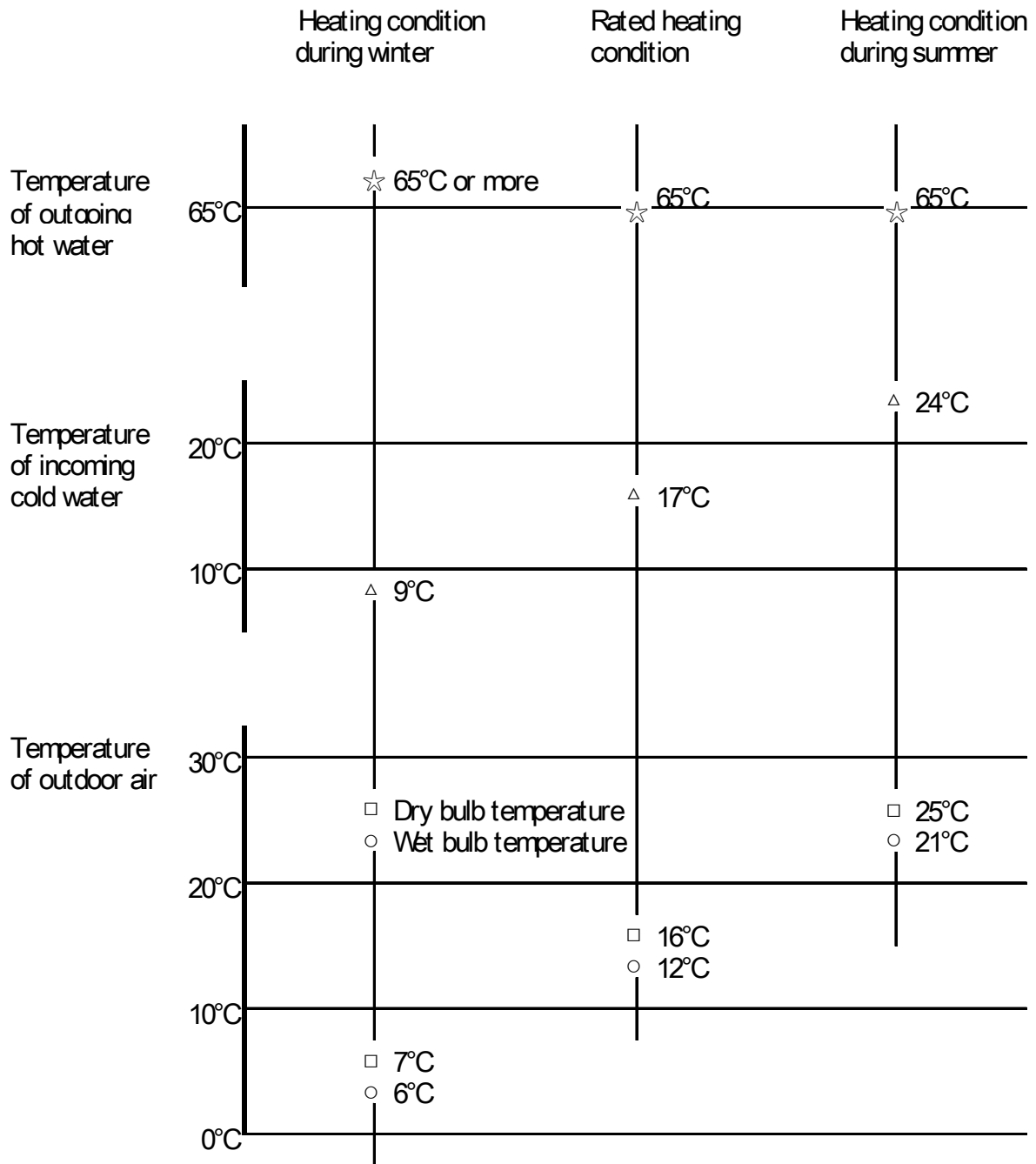
Temperature of outdoor air	25°C (DB)/21°C (WB)
Temperature of incoming cold water	24°C
 - to indicate performance in each of the following three periods; summer, winter, and mild climate of spring and fall.
- 3) Will add a provision which ensures the safety of the refrigerant circuit using CO₂.
- 4) Will add a provision which ensures the electrical safety.
- 5) Will review the provision for the water quality.

(4) Future tasks for the standards

- 1) To study a test method, which is similar to the condition encountered in an actual application.
- 2) To consider a calculation method for annual energy efficiency.
 - Research by related organizations and their opinions should be reflected.
 - Good results of Annex 28 are expected.

Temperature conditions in JRA4050: 2001

Item	Unit	Rated condition	Heating condition during winter
Outdoor temperature (DB/WB)	°C	16/12	7/6
Temperature of cold water supply	°C	17	9
Temperature of outgoing hot water	°C	65	High heating temperature during winter



5. Demand

5.1 Tapping profile for Tokyo area

Institute for Building Environment and Energy Conservation (IBEC) proposed several types of tapping profiles. The following L-mode is commonly used as a tapping profile for Tokyo area.

Tapping profile of IBEC-L mode

Time	Litter	Temperature	Litter/min
6:00	15.9	42°C	6

6:30	15.9	42°C	6
7:00	15.9	42°C	6
7:30	15.9	42°C	6
8:00	15.9	42°C	6
12:00	15.9	42°C	6
18:00	15.9	42°C	6
18:30	15.9	42°C	6
19:00	15.9	42°C	6
19:30	15.9	42°C	6
21:00	180.0	45°C	--
21:30	40.0	42°C	6
22:00	22.0	60°C	--

Hot water temperature must be over 60°C, which prevent legionella, to be added to bath tub.

5.2 Demand for floor heating

Usually the heating system in the Japanese dwelling is neither central system nor 24-hour system. To calculate the demand for floor heating, following values are sometimes used.

Floor heating area: 13.2m²

Heating period: 7-11, 19-23 (load at 7a.m. is doubled for pre-heating)

Room temperature: 18°C

Outdoor temperature: 7°C (Dec. to Feb.), 16°C (Sep. and Mar.)

Q-value: 3.4 W/m²K

A case study shows annual loads of floor heating is 4.2GJ(1.0Gcal).

6. Conformity to standards in Japan

Item	Outline	Hot water supply			Air conditioner, Heater		
		Gas, Kerosene hot water supply	Electric water heater	Heat pump Hot water supply/ Heater	Air conditioner	Gas, Kerosene hot water heater	Electric heater (Including regenerative heater)
1) JIS	<p>JIS (Japanese Industrial Standards) regulates various articles, parts and materials so that they can secure specified quality corresponded to the use object. When the products, parts, etc. are recognized to be agree with each item regulated in the corresponding JIS, JIS mark can be attached to the products or packages as a certified mark. JIS mark demonstrates that the product conforms to JIS, at the same time guarantees the quality.</p> <p>JIS is provided to almost all the products related to the hot water supply and heaters.</p>	<p>○</p> <p>Gas:S-2109 Petroleum:S-3024</p>	<p>○</p> <p>C-9219</p>	<p>×</p> <p>No standard at present</p>	<p>○</p> <p>C-9612</p>	<p>○</p> <p>Petroleum boiler: S-3021</p>	<p>○</p> <p>A-4003</p>
2) Electric Appliance Safety Law	<p>This is a law to secure safety of electric products, which are used in Japan.</p> <p>A manufacturer or importer can verify conformity to the technical standard of the corresponding product by selecting one of the following two methods.</p> <ul style="list-style-type: none"> • Certification by the third party • Self-confirmation <p>For the safety, the manufacturer or importer bears the responsibility</p>	<p>○</p>	<p>○</p>	<p>×</p> <p>No standard at present</p>	<p>○</p>	<p>○</p>	<p>○</p>

<p>3 Waterworks Law</p>	<p>Concerned with hot water supplier, hot water heater, and others, the handling standard is set for the water circuit and water-service installation directly connected to the waterworks.</p> <ul style="list-style-type: none"> • A measure that hot water discharged from a hot water supplier do not counter-flow to waterworks is required. • Materials of the water-service installation and type of feed water pipe are also set. 	○	○	○	×	(○) With possibility	×
<p>4) Heat pump hot water supply JRA Standard</p>	<p>JIS is not yet set. “Heat pump hot water supplier (JAR4050) using CO2 refrigerant” is provided as the standard of the Japan Refrigeration and Air Conditioning Industry Association. It regulates the following items.</p> <ul style="list-style-type: none"> • Performance of heat pump unit • Performance of hot water reserve unit • Each test condition • Marking to product <p>At present, performance only is regulated. The safety and others will be examined in the future.</p>	×	×	○	×	×	×
<p>5) Under-floor heating standard (Tendency to be regularized in the future)</p>	<p>An activity to target the regularization of under-floor heating performance of product using hot water made by utilizing function of the heat pump has started in the Japan Refrigeration and Air Conditioning Industry Association.</p> <p>Schedule of regularization is not determined.</p>	×	×	○	○	×	×

<p>6)Energy-saving Law</p>	<p>Energy consumption efficiency is regulated for 12 products that have been registered as specified equipment. Air conditioner, fluorescent light, TV, Refrigerator, Gas , Kerosene hot water supply are included as the domestic electrical appliances.</p> <p>The regulation value is set by top runner system, and the product value of the highest efficiency in set time becomes the regulation value after several years. The efficiency of the air conditioner is regulated by the average COP (*) in cooling and heating time, and this regulation will start at 2004.</p> <p>Rated cooling capacity:</p> <ul style="list-style-type: none"> • Below 2.5kW: Annual cooling/heating average COP 5.27 or more • Above 2.5 to 3.2kW: 4.90 or more • Above 3.2 to 4.0kW: 3.65 or more 	○	×	×	○	○	×
<p>7) Domestic Electrical Appliance Recycle Law</p>	<p>In order to dispose waste appropriately and utilize effectively and reuse resource, responsibility and obligation of the consumer, dealer, and manufacturer are clarified for 4 articles of the large-type domestic electrical appliances (air conditioner, TV, refrigerator, washing machine).</p> <p>(1) Obligation of taking-over used product; (2) Obligation of recycle; (3) Obligation of recovery and destruction of FREON GAS are charged in manufacturer.</p>	×	×	<p>Not object at present, but may become object in the future</p>	○	×	×

8) Electric Installation Technical Standard (Interior wiring regulation)	<p>The standard of design, work, and check for the electrical works at a place using electricity, the interior wiring regulation is set by Corporation Japan Electrical Association. (JEAC 8001-19)</p> <ul style="list-style-type: none"> • Restriction for ground voltage of interior distribution • Restriction for voltage drop • Design of interior wiring (Load calculation, cable thickness, earth, etc.) 	×	○	○	○	×	○
9) Fire Services Act (Tokyo Fire Defense Agency Installation Standard)	<p>This Act is set as a legal control for facilities, which use fire such as gas or Kerosene.</p> <p>The restricted items are also provided for the air conditioning equipment, which generates hot air by using electrical energy as heat source.</p> <p>Installation at a hidden place such as inside of the ceiling and under floor, heater safety regulation, etc.</p>	○	○	× Applied when heater is used	○	○	○
10) Safety Law of High-Pressure- Gas Engineering	<p>In order to prevent accident caused by high-pressure gas, production, sale, storage, transferring, other handling, consumption of high-pressure gas, and manufacturing and treatment of container are controlled.</p> <p>For the air conditioning equipment, equipment and pressure vessel of which inner diameter is over 160mm and refrigerating capacity is over 5 refrigeration ton per day are objects. The equipment and pressure vessel of which refrigerating capacity is below 5 refrigeration ton per day (Japan High-Pressure Gas Safety Law Standard) should be attached with mark after pressure test conforming to the safety standard (JIS B 8620) of the small-type refrigerating unit.</p>	×	×	(○) With possibility	(○) With possibility	×	×

11) FREON Gas Recovery Destruction Law	In order to suppress discharge of FREON Gas (CFC, HCFC, HFC) to the air, which affects destruction of ozone layer and global warming, as the special first-class products, air conditioner and refrigerating equipment for business use are placed under obligation of recovery and destruction of FREON Gas at manufacturing, repair, and disuse.	×	×	○ Hot water supplier for business use	○ Air conditioner for business use	×	×
12) Resource Effective Use Promotion Law	This law is set to execute recycle, reduction, reuse for establishment of circulating society free from society of mass consumption and mass disuse. The manufacturers of the products which are listed as the specified resource-saving products and specified reuse promotion products are required to challenge promotion of the use for long time and suppression of generation of used articles.	○	×	— Not object at present, but may become object in the future	○	×	×

○ : Applicable, × : Not applicable

7. Future plan

Japanese team is going to measure the performance of a commercial heat pump for combined water heating and floor heating from April 2004. The main purpose of this test is to investigate the method of estimating the annual energy consumption. The testing condition is not determined yet, but following items will be tested.

(1) Performance of hot water heater

- Standard test according to JRA4050: 2001.
- Test of transient behavior in accordance with tapping profile
- Test according to EN255-3

(2) Performance of floor heating

- Standard rating test
- Test of transient behavior in accordance with heat demand

(3) Performance of combined water heating and floor heating

- Not determined