Data Book on Heat Pump & Thermal Storage System

2011–2012

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1. Statistics

1-1. Japan

1-1-1 Changes in domestic supply of primary energy

(10^15J[1PJ]) ※ 10^15J[1PJ])= 0.0258 million kl in crude oil equivalent

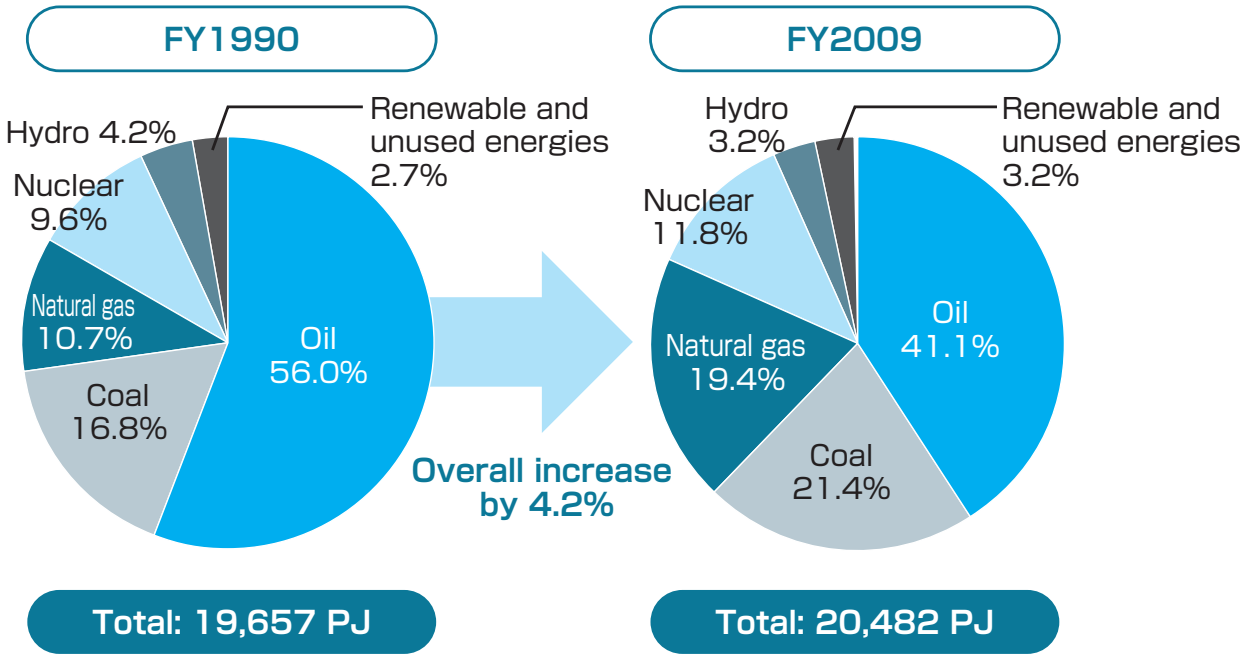
FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Oil	11,003	11,149	11,386	11,113	11,727	11,800	11,758	11,476	11,148	11,330
Change rate against FY1990	0.0	1.3	3.5	1.0	6.6	7.2	6.9	4.3	1.3	3.0
Coal	3,308	3,391	3,295	3,310	3,515	3,638	3,733	3,848	3,619	3,851
Change rate against FY1990	0.0	2.5	▲ 0.4	0.1	6.3	10.0	12.9	16.4	9.4	16.4
Natural gas	2,102	2,252	2,276	2,333	2,456	2,538	2,681	2,792	2,849	3,011
Change rate against FY1990	0.0	7.2	8.3	11.0	16.8	20.8	27.6	32.8	35.5	43.3
Nuclear	1,887	1,989	2,077	2,325	2,500	2,700	2,782	2,910	3,011	2,836
Change rate against FY1990	0.0	5.4	10.1	23.2	32.5	43.1	47.4	54.2	59.5	50.3
Hydro	833	908	768	892	625	761	741	819	838	774
Change rate against FY1990	0.0	9.0	▲ 7.8	7.0	▲ 25.0	▲ 8.6	▲ 11.0	▲ 1.8	0.6	▲ 7.1
Renewable and unused energies	524	532	527	521	534	564	579	603	590	607
Change rate against FY1990	0.0	1.4	0.5	▲ 0.6	1.8	7.7	10.6	15.0	12.5	15.8
Supply of primary energy (total)	19,657	20,221	20,330	20,494	21,357	22,001	22,275	22,447	22,054	22,410
Change rate against FY1990	0.0	2.9	3.4	4.3	8.6	11.9	13.3	14.2	12.2	14.0

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oil	11,157	10,820	10,891	10,844	10,595	10,575	10,007	10,001	9,041	8,408
Change rate against FY1990	1.4	▲ 1.7	▲ 1.0	▲ 1.4	▲ 3.7	▲ 3.9	▲ 9.1	▲ 9.1	▲ 17.8	▲ 23.6
Coal	4,203	4,294	4,437	4,567	4,997	4,756	4,818	5,031	4,918	4,391
Change rate against FY1990	27.1	29.8	34.1	38.1	51.1	43.8	45.7	52.1	48.7	32.8
Natural gas	3,133	3,129	3,219	3,370	3,359	3,394	3,751	4,088	4,019	3,975
Change rate against FY1990	49.1	48.9	53.1	60.3	59.8	61.5	78.5	94.5	91.2	89.1
Nuclear	2,873	2,838	2,593	2,108	2,486	2,677	2,661	2,317	2,248	2,411
Change rate against FY1990	52.2	50.4	37.4	11.7	31.7	41.8	41.0	22.8	19.1	27.8
Hydro	778	747	724	831	828	672	767	650	666	648
Change rate against FY1990	▲ 6.6	▲ 10.4	▲ 13.1	▲ 0.3	▲ 0.6	▲ 19.4	▲ 7.9	▲ 22.0	▲ 20.1	▲ 22.2
Renewable and unused energies	616	601	610	632	623	676	697	715	669	651
Change rate against FY1990	17.6	14.6	16.5	20.6	18.8	29.1	33.0	36.5	27.6	24.2
Supply of primary energy (total)	22,761	22,429	22,473	22,352	22,888	22,757	22,707	22,808	21,564	20,482
Change rate against FY1990	15.8	14.1	14.3	13.7	16.4	15.8	15.5	16.0	9.7	4.2

See endnotes 1 - 5.

■ Source: Energy Supply and Demand (preliminary data) in FY2009, Ministry of Economy, Trade and Industry website

1-1-2 Domestic primary energy supply



See endnotes 6 - 10.

■ Source: Energy Supply and Demand (preliminary data) in FY2009, Ministry of Economy, Trade and Industry website

1-1-3 Changes in final energy consumption by sector

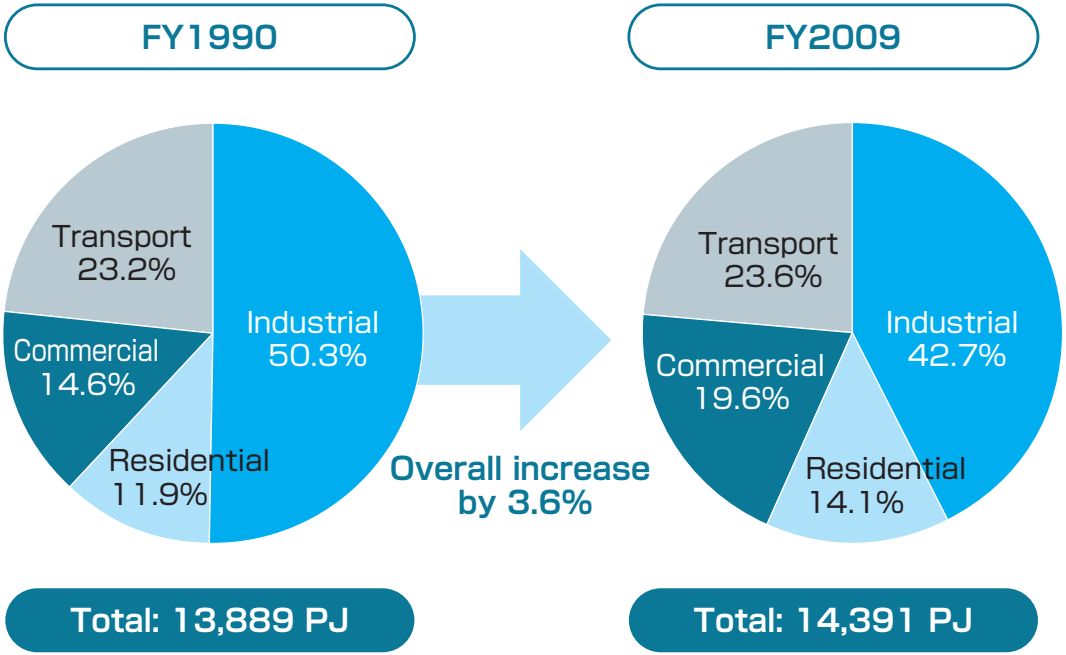
(10^15J[1PJ])

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Industrial	6,993	6,991	6,914	6,797	7,035	7,164	7,320	7,411	6,998	7,157
Change rate against FY1990	0.0	0.0	▲ 1.1	▲ 2.8	0.6	2.4	4.7	6.0	0.1	2.4
Residential	1,655	1,693	1,768	1,860	1,866	1,973	1,981	1,977	1,997	2,052
Change rate against FY1990	0.0	2.3	6.8	12.4	12.7	19.2	19.7	19.4	20.7	24.0
Commercial	2,024	2,021	2,069	2,162	2,226	2,375	2,376	2,391	2,523	2,664
Change rate against FY1990	0.0	▲ 0.1	2.2	6.9	10.0	17.4	17.4	18.2	24.7	31.6
Transport	3,217	3,387	3,449	3,518	3,697	3,806	3,891	3,923	3,910	3,941
Change rate against FY1990	0.0	5.3	7.2	9.4	14.9	18.3	20.9	21.9	21.5	22.5
Total	13,889	14,092	14,200	14,337	14,824	15,318	15,567	15,702	15,428	15,814
Change rate against FY1990	0.0	1.5	2.2	3.2	6.7	10.3	12.1	13.1	11.1	13.9

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Industrial	7,221	6,940	7,066	7,075	7,157	7,064	7,098	7,055	6,278	6,140
Change rate against FY1990	3.3	▲ 0.8	1.1	1.2	2.3	1.0	1.5	0.9	▲ 10.2	▲ 12.2
Residential	2,114	2,057	2,129	2,067	2,093	2,182	2,105	2,135	2,058	2,035
Change rate against FY1990	27.7	24.3	28.7	24.9	26.5	31.8	27.2	29.0	24.3	23.0
Commercial	2,712	2,829	2,934	2,891	2,960	2,995	3,061	2,981	2,921	2,823
Change rate against FY1990	34.0	39.8	45.0	42.8	46.2	48.0	51.3	47.3	44.3	39.5
Transport	3,928	3,958	3,876	3,840	3,833	3,756	3,705	3,619	3,471	3,392
Change rate against FY1990	22.1	23.0	20.5	19.3	19.1	16.7	15.2	12.5	7.9	5.4
Total	15,975	15,784	16,006	15,872	16,043	15,996	15,968	15,790	14,727	14,391
Change rate against FY1990	15.0	13.6	15.2	14.3	15.5	15.2	15.0	13.7	6.0	3.6

■ Source: Energy Supply and Demand (preliminary data) in FY2009, Ministry of Economy, Trade and Industry website

1-1-4 Final energy consumption by sector



■ Source: Energy Supply and Demand (preliminary data) in FY2009, Ministry of Economy, Trade and Industry website

1-1-5 Changes in CO_2 emissions by sector

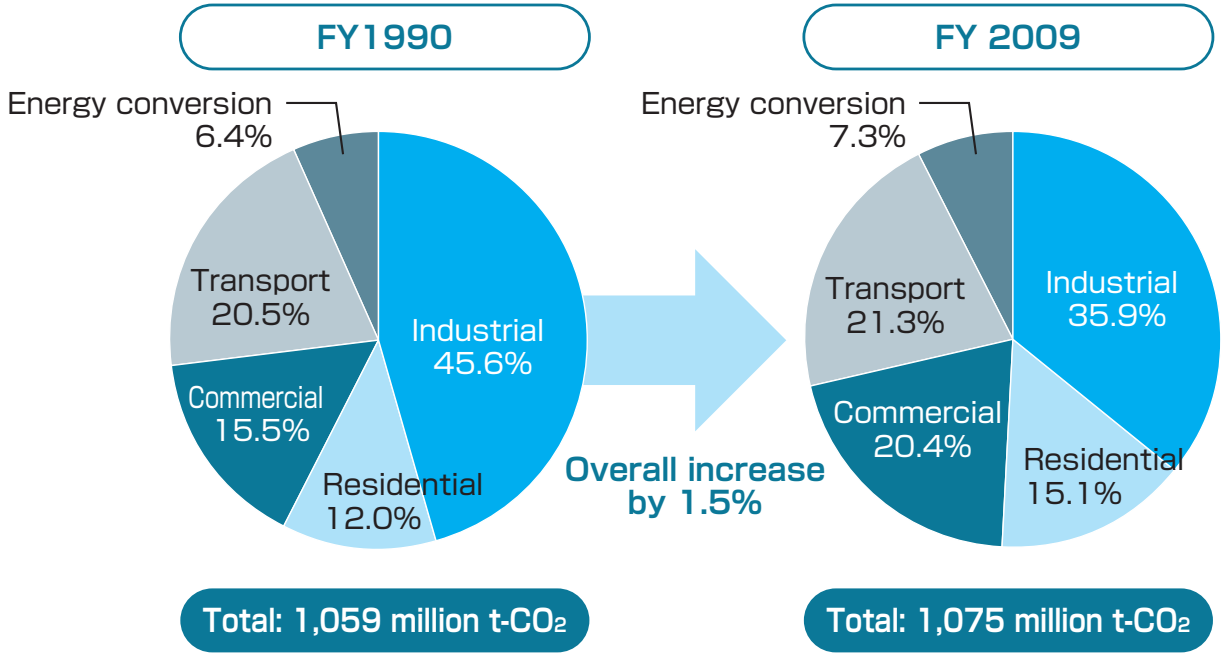
(million t-CO_2)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Industrial	482	476	466	455	473	471	480	480	445	456
Change rate against FY1990	0.0	▲ 1.3	▲ 3.3	▲ 5.6	▲ 2.0	▲ 2.3	▲ 0.4	▲ 0.3	▲ 7.7	▲ 5.3
Residential	127	129	136	138	145	148	148	144	144	152
Change rate against FY1990	0.0	1.5	7.0	8.2	13.8	16.2	16.0	13.2	12.9	19.2
Commercial	164	164	168	169	181	185	185	182	187	201
Change rate against FY1990	0.0	▲ 0.5	2.5	3.0	9.9	12.7	12.4	10.5	14.1	22.5
Transport	217	229	233	238	250	258	263	265	264	266
Change rate against FY1990	0.0	5.3	7.4	9.5	15.2	18.5	21.0	21.8	21.3	22.5
Energy conversion	67.9	68.8	69.0	67.3	74.3	73.3	71.7	72.3	73.1	72.1
Change rate against FY1990	0.0	1.4	1.7	▲ 0.9	9.4	8.0	5.6	6.5	7.8	6.2
Total energy-related CO_2 emissions	1,059	1,067	1,074	1,068	1,123	1,135	1,147	1,143	1,113	1,148
Change rate against FY1990	0.0	0.7	1.4	0.8	6.0	7.2	8.3	8.0	5.1	8.4

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Industrial	467	450	461	465	465	459	457	467	419	386
Change rate against FY1990	▲ 3.1	▲ 6.7	▲ 4.3	▲ 3.5	▲ 3.5	▲ 4.7	▲ 5.2	▲ 3.0	▲ 13.2	▲ 19.9
Residential	158	154	165	168	168	174	166	180	171	162
Change rate against FY1990	23.6	20.6	29.8	31.5	31.5	36.7	30.1	41.1	34.2	26.9
Commercial	206	214	227	232	232	236	235	243	235	220
Change rate against FY1990	25.4	30.0	38.4	41.0	41.3	43.4	43.0	47.9	43.0	33.6
Transport	265	267	262	260	259	254	251	245	235	229
Change rate against FY1990	22.1	23.0	20.7	19.7	19.4	16.9	15.3	12.9	8.1	5.4
Energy conversion	70.8	68.9	76.6	73.8	73.9	79.3	77.0	82.9	78.3	78.8
Change rate against FY1990	4.3	1.6	12.9	8.7	8.9	16.9	13.4	22.2	15.4	16.2
Total energy-related CO_2 emissions	1,167	1,153	1,193	1,198	1,198	1,203	1,185	1,218	1,138	1,075
Change rate against FY1990	10.2	8.9	12.6	13.1	13.2	13.5	11.9	15.1	7.5	1.5

■ Source: Energy Supply and Demand (preliminary data) in FY2009, Ministry of Economy, Trade and Industry website

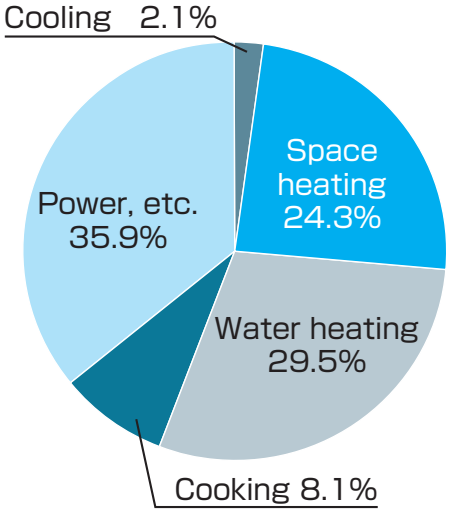
1-1-6 CO_2 emissions by sector



■ Source: Energy Supply and Demand (preliminary data) in FY2009, Ministry of Economy, Trade and Industry website

1-1-7 Residential sector Energy consumption by end-use

Energy consumption by end-use per household (FY2008)



Space heating	Electricity	Solar	Town gas	L P G	Kerosene
	13%	0%	17%	4%	65%

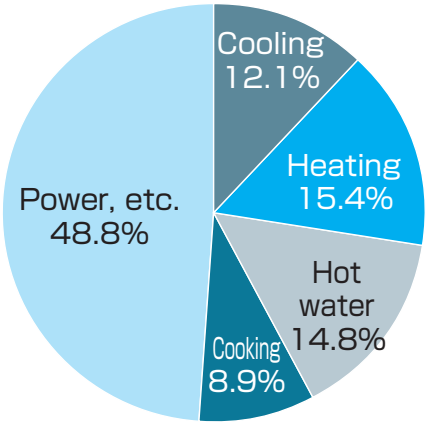
Water heating	Electricity	Solar	Town gas	L P G	Kerosene
	11%	3%	38%	30%	17%

*Coal, etc. 0.4%

Fossil fuels

■ Source: EDMC handbook of energy and economic statistics in Japan (FY2010 edition)

Energy consumption by end-use per floor area (FY2008)



	Electricity	Thermal	Gas	Oil	Coal
Cooling	42%	6%	48%	5%	0%
Heating	9%	2%	24%	63%	2%
Hot water	4%	4%	43%	43%	6%

*Thermal energy includes heat from district heat supplier, geothermal and solar energy, etc.

Fossil fuels

■ Source: EDMC handbook of energy and economic statistics in Japan (FY2010 edition)

1-1-9 Residential sector Domestic shipments of air conditioner

(Units)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Car air conditioner	6,316,518	5,912,096	5,628,798	5,453,268	5,645,095	5,672,385	5,991,461	5,298,904	4,811,213	4,805,119
Room air conditioner	6,590,422	7,364,120	5,680,544	5,081,736	7,316,391	7,988,333	8,248,031	6,272,249	6,724,606	6,437,707

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Car air conditioner	5,093,772	5,084,446	5,155,349	5,123,158	4,706,711	4,535,488	5,020,732	4,768,421	4,405,981	4,777,556
Room air conditioner	7,192,303	7,521,359	6,866,051	6,465,568	7,036,933	7,573,317	7,416,903	7,382,136	7,579,023	6,906,155

■ Source: Japan Refrigeration and Air Conditioning Industry Association

1-1-10 Residential sector Domestic shipments of heaters

(Units)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric heaters	2,546,962	2,199,649	1,879,674	1,950,083	2,246,366	2,419,688	2,026,783	1,999,904	1,771,817	1,801,855
Gas heaters	542,867	523,805	451,064	464,498	561,571	608,561	682,636	737,935	757,482	721,493
Gas-fired hot air heaters	155,746	135,464	135,536	126,854	128,678	114,566	122,517	140,867	146,730	168,395
Gas-fired water heaters and space heaters	52,280	49,346	46,869	53,310	78,695	89,099	97,191	104,267	103,605	118,979
Oil heaters	7,944,970	7,422,999	6,591,090	6,747,442	7,649,145	8,644,864	8,426,007	7,251,464	7,379,858	7,417,225
Oil-fired hot air heaters	426,879	431,664	388,716	392,766	414,050	420,770	410,728	356,373	325,918	311,501
Air conditioners (except cooling-only type)	4,893,911	5,595,754	4,428,074	4,277,592	6,240,919	7,050,854	7,543,394	5,898,190	6,383,868	6,167,726

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electric heaters	1,399,360	1,471,232	1,666,500	1,520,680	1,167,245	–	–	–	–	–
Gas heaters	768,695	752,878	687,927	663,015	694,451	763,493	799,737	723,589	391,738	335,715
Gas-fired hot air heaters	205,111	249,499	277,360	256,252	258,271	251,410	241,255	212,389	216,054	188,480
Gas-fired water heaters and space heaters	167,529	184,247	220,219	250,462	243,705	223,614	221,557	203,013	179,638	180,333
Oil heaters	7,464,594	7,062,435	6,124,268	6,055,144	6,279,910	6,377,348	5,625,126	4,277,490	3,885,810	4,179,225
Oil-fired hot air heaters	304,853	310,442	305,756	308,162	279,611	261,959	179,932	149,219	110,669	109,545
Air conditioners (except cooling-only type)	6,954,553	7,313,136	6,721,450	6,378,417	6,956,475	7,485,341	7,301,460	※7,382,136	※7,579,023	※6,906,155

*The figures in FY2007-2009 represent the number of units shipped of all room air conditioners.

■ Source: “Yearbook of Machinery Statistics” and “Yearbook of Statistics on Iron & Steel, Non-ferrous Metals and Metal Products,” the Ministry of Economy, Trade and Industry; Japan Refrigeration and Air Conditioning Industry Association

1-1-11 Residential sector Domestic shipments of water heaters

(Units)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric water heaters	256,892	250,828	220,017	217,102	214,615	205,103	257,211	228,085	204,221	192,826
Gas-fired water heaters	3,642,693	3,627,710	3,327,451	3,326,042	3,273,968	3,261,890	3,141,752	2,769,414	2,689,232	2,609,668
Bath tub gas-fired water heaters	1,611,753	1,545,188	1,481,222	1,580,189	1,727,708	1,824,840	1,835,621	1,677,067	1,581,652	1,719,991
Oil-fired water heaters	687,248	709,070	674,648	739,440	802,864	908,164	909,065	761,451	666,482	680,309
Solar water heaters	165,311	165,991	136,909	137,616	182,364	198,931	185,203	90,989	72,735	71,218
Heat pump water heaters for household use	–	–	–	–	–	–	–	–	–	–

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electric water heaters	223,616	231,896	236,574	238,910	247,532	245,792	236,752	229,711	198,976	142,677
Gas-fired water heaters	2,699,392	2,597,090	2,604,330	2,493,547	2,432,485	2,446,310	2,566,435	2,515,702	2,306,877	2,210,541
Bath tub gas-fired water heaters	1,694,429	1,601,805	1,535,289	1,549,697	1,462,530	1,353,347	1,332,676	1,204,222	1,194,470	1,198,246
Oil-fired water heaters	704,273	697,480	599,855	603,169	554,145	500,009	423,167	371,670	330,262	351,321
Solar water heaters	73,015	73,442	65,210	54,665	58,807	56,344	53,318	47,939	56,517	39,176
Heat pump water heaters for household use	–	3,399	37,230	80,775	130,813	225,628	349,822	413,132	500,222	508,141

■ Source: “Yearbook of Machinery Statistics” and “Yearbook of Statistics on Iron & Steel, Non-ferrous Metals and Metal Products,” the Ministry of Economy, Trade and Industry; Japan Refrigeration and Air Conditioning Industry Association

1-1-12 Commercial and industrial sectors Domestic shipments of refrigerators and air conditioners

(Units)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Packaged air conditioners	1,002,068	1,054,881	880,376	740,123	772,772	819,257	843,411	734,374	654,495	633,637
Ice storage packaged air conditioners	–	–	–	–	–	776	2,148	3,778	5,682	8,941
Chilling units	14,739	14,103	11,434	10,683	11,081	11,449	12,178	11,322	9,841	8,545
Gas engine heat pump air conditioners	–	–	–	–	–	33,974	39,142	39,833	40,180	45,850
Absorption chillers	–	–	–	–	4,653	4,807	4,505	4,286	3,922	3,492
(USRT)	–	–	–	–	705,861	749,384	681,162	774,198	707,432	589,362
Centrifugal chillers	–	–	–	–	238	395	363	340	251	284
(USRT)	–	–	–	–	102,011	141,735	151,693	143,580	121,290	128,809

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Packaged air conditioners	708,306	725,349	648,201	684,871	758,554	807,954	782,299	756,975	724,946	601,629
Ice storage packaged air conditioners	10,948	8,737	8,455	6,900	6,221	6,882	5,827	6,525	5,718	4,536
Chilling units	9,804	9,466	8,634	8,655	9,045	9,911	9,428	9,371	8,773	7,048
Gas engine heat pump air conditioners	49,636	42,821	40,843	40,446	38,170	35,868	30,690	26,149	22,163	17,623
Absorption chillers	3,405	3,076	2,879	2,878	2,639	2,396	2,204	1,949	1,662	1,411
(USRT)	666,005	549,799	480,879	550,094	513,420	467,600	449,552	347,627	287,056	248,355
Centrifugal chillers	410	319	260	349	431	453	536	588	606	403
(USRT)	179,137	169,572	137,744	196,655	270,696	299,205	409,837	440,736	437,994	212,796

■ Source: Japan Refrigeration and Air Conditioning Industry Association

1-1-13 Commercial and industrial sectors Domestic shipments of water heaters

(Units)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Oil-fired hot water boilers	38,997	39,057	35,175	31,714	31,583	34,133	34,430	33,444	26,589	25,604
Gas-fired hot water boilers	—	—	—	—	—	1,645	1,172	1,252	1,056	1,051
Vacuum or non-pressure type hot water boilers (oil-fired)	6,029	6,928	5,560	5,993	5,871	5,578	5,541	4,880	4,436	5,144
Vacuum or non-pressure type hot water boilers (gas-fired)	2,616	2,785	2,290	2,421	2,348	2,331	2,555	2,472	2,520	3,037
Once-through boilers	—	—	25,380	23,880	18,590	17,250	17,200	16,800	15,249	17,287
Heat pump water heaters	—	—	—	—	—	—	—	—	—	—

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Oil-fired hot water boilers	21,211	19,326	17,480	16,174	15,549	13,670	9,869	9,575	7,244	7,013
Gas-fired hot water boilers	957	890	462	790	659	576	612	543	572	400
Vacuum or non-pressure type hot water boilers (oil-fired)	4,365	4,449	3,468	4,370	4,070	3,284	2,751	2,463	2,156	2,177
Vacuum or non-pressure type hot water boilers (gas-fired)	2,677	2,319	2,481	2,856	2,144	2,507	2,435	2,274	2,157	1,700
Once-through boilers	16,892	15,839	15,772	15,502	15,041	15,271	14,517	13,539	13,219	11,893
Heat pump water heaters	249	161	340	300	490	806	1,559	2,206	3,343	3,065

*The capacity of oil-fired hot water boilers (for commercial use) is 30,001 kcal/h or larger (1989-1996), larger than 34.9 kW (1997 and beyond).
*The rated output of vacuum or non-pressure type hot water boilers (oil-fired) and that of vacuum or non-pressure type hot water boilers (gas-fired) are 46.5 kW or larger.
*Combustion type small water heaters for business use are not included here.

■ Source: Yearbook of Heating, Air Conditioning and Hot Water Equipment, Survey by Tokyo Electric Power Co.

1-1-14 Commercial and industrial sectors Number of buildings with thermal storage systems

(No. of buildings)

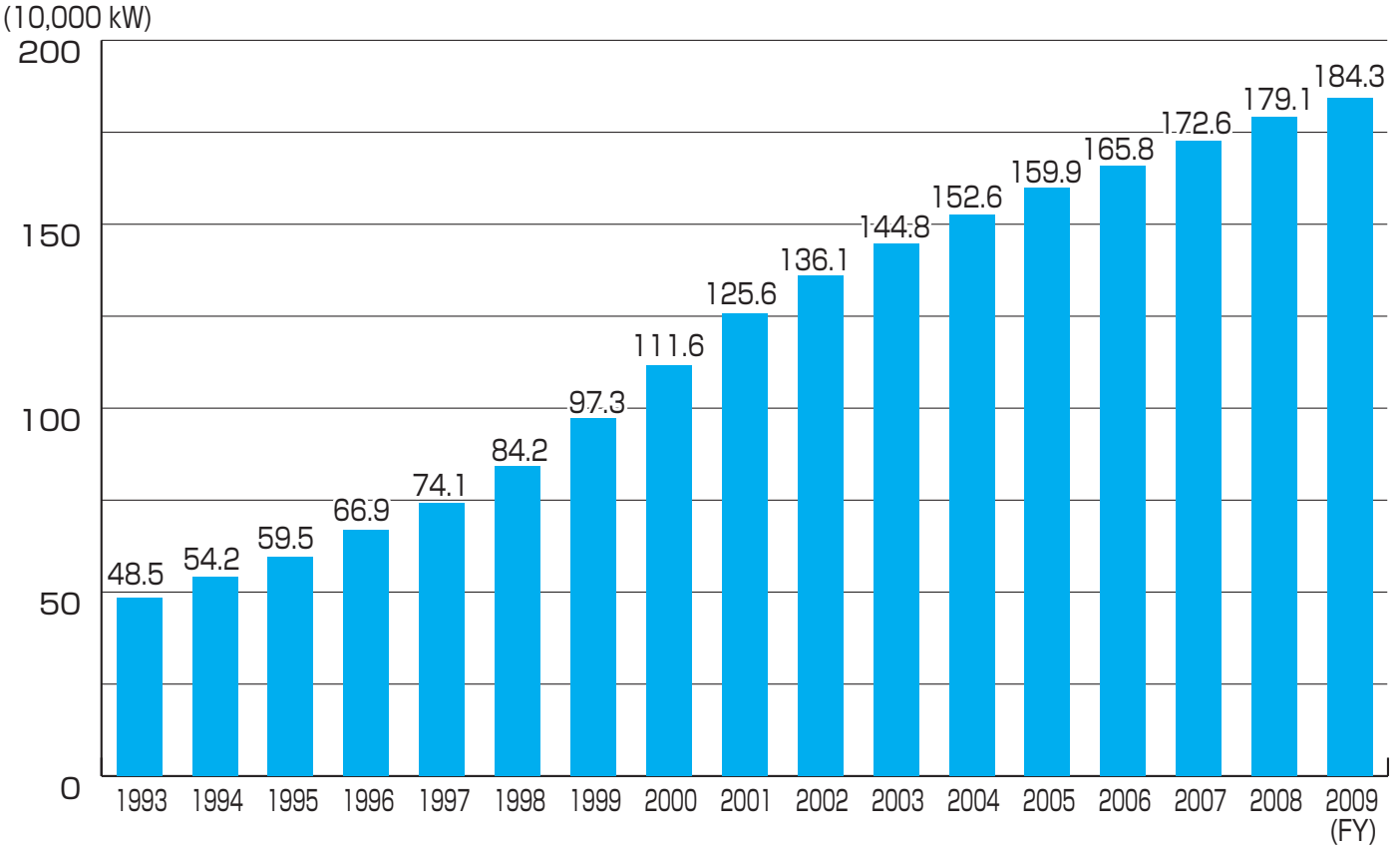
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Ice storage	Eco Ice mini	—	—	—	—	—	—	—	—	184	1,265
	Eco Ice (Packaged type: 10 horsepower or larger)	19	41	63	93	122	204	587	1,306	2,569	4,382
	Eco Ice (centralized type)	209	285	370	485	576	669	822	1,002	1,195	1,412
	Tank capacity (m³)	15,321	19,072	22,676	29,572	37,182	42,203	54,952	68,171	81,103	103,152
Water thermal storage		1,246	1,430	1,576	1,757	1,884	1,981	2,083	2,172	2,265	2,343
	Tank capacity (m³)	896,991	1,003,678	1,116,511	1,243,811	1,332,080	1,409,376	1,476,515	1,538,503	1,612,833	1,684,234
Total number of buildings		1,474	1,756	2,009	2,335	2,582	2,854	3,492	4,480	6,213	9,402

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ice storage	Eco Ice mini	2,561	3,701	4,714	5,382	5,940	6,636	7,296	8,228	8,869	9,513
	Eco Ice (Packaged type: 10 horsepower or larger)	6,528	8,430	10,099	11,199	12,213	13,125	13,762	14,322	14,808	15,296
	Eco Ice (centralized type)	1,641	1,849	2,039	2,155	2,281	2,375	2,460	2,546	2,611	2,662
	Tank capacity (m³)	122,358	141,419	166,996	179,957	197,523	210,934	221,332	235,395	245,764	256,321
Water thermal storage		2,412	2,474	2,548	2,596	2,625	2,656	2,673	2,711	2,729	2,753
	Tank capacity (m³)	1,737,126	1,782,575	1,845,560	1,887,307	1,909,126	1,949,859	1,989,259	2,028,491	2,070,373	2,113,033
Total number of buildings		13,142	16,454	19,400	21,332	23,059	24,792	26,191	27,807	29,017	30,224

*The data represent the stock at the end of each fiscal year.

■ Source: Survey by Heat Pump & Thermal Storage Technology Center of Japan

1-1-15 Commercial and industrial sectors Peak shift in kW by using thermal storage systems



■ Source: Survey by Heat Pump & Thermal Storage Technology Center of Japan

1-1-16 Commercial and industrial sectors Thermal energy sold in the heat service business

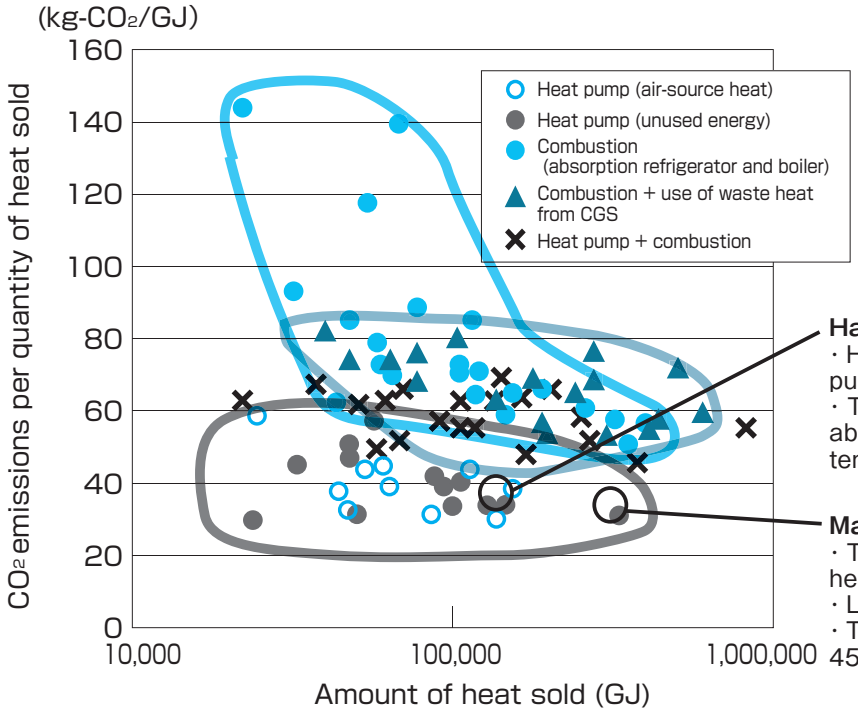
(GJ)

FY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Heating	4,368,114	4,983,421	5,396,723	6,137,528	6,578,314	7,308,391	7,598,513	7,747,602	7,916,584	8,370,507
Cooling	3,545,965	4,330,159	4,854,131	5,248,725	7,444,505	7,974,300	8,788,491	10,298,722	11,606,562	12,521,154
Hot water supply	447,125	488,148	529,749	504,938	507,826	540,134	474,426	441,851	448,152	442,162
Total	8,361,204	9,801,728	10,780,603	11,891,191	14,530,645	15,822,825	16,861,430	18,488,180	19,971,300	21,333,822

FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Heating	8,897,772	8,451,825	9,365,466	9,078,849	9,324,075	9,802,647	8,783,362	9,298,117	8,793,551	8,720,226
Cooling	13,310,747	13,717,669	13,372,557	13,459,762	15,180,402	14,869,052	14,993,405	15,388,798	14,864,890	13,910,767
Hot water supply	439,650	429,650	425,961	419,590	397,548	400,179	392,184	384,909	371,826	365,714
Total	22,648,175	22,599,144	23,163,975	22,958,190	24,902,019	25,071,870	24,168,946	25,071,818	24,030,265	22,996,714

■ Source: Heat Service Business Handbook (FY2009 edition)

1-1-17 Commercial and industrial sectors CO_2 emissions from district heating and cooling plants



CO_2 emissions of heat pump are less than those of combustion and others.

Harumi Island District
- Heat in the air is used as the heat source of heat pump.
- There are water thermal storage tanks with about 20,000 cubic-meter capacity (equivalent to ten 50-meter swimming pools).

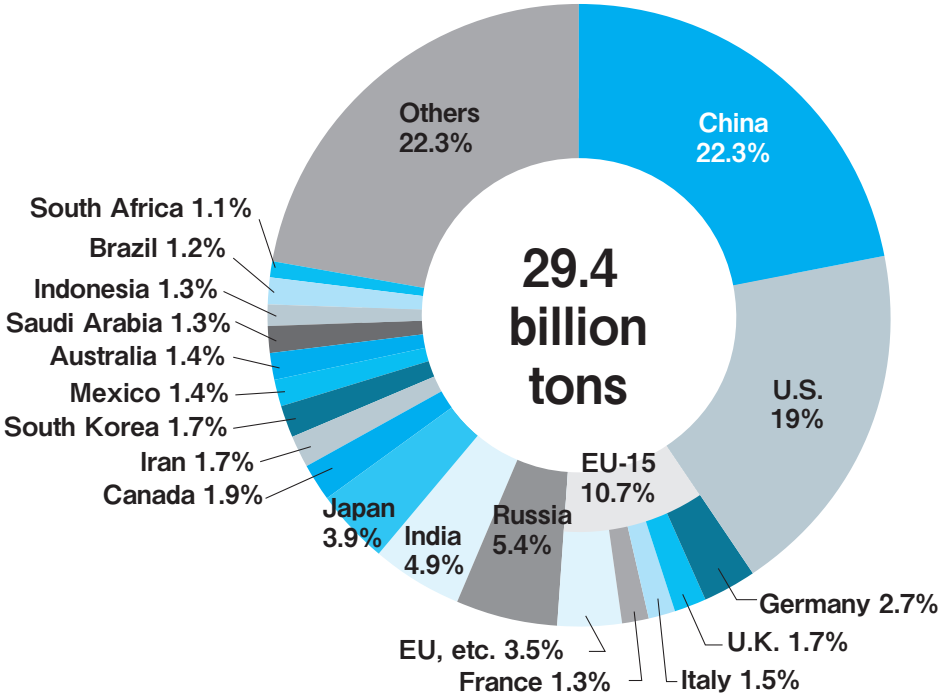
Makuhari New City Hi-tech Business District
- Treated sewage is used as the heat source of heat pump.
- Large heat recovery heat pumps are adopted.
- There are water thermal storage tanks with about 45,000 cubic-meter capacity.

*Conditions for trial calculations:
- The values are cited from "FY2009 edition of Heat Supply Business Handbook (actual values in FY2008)."
- CO_2 emission intensities and values prescribed by the Act on Promotion of Global Warming Countermeasures (the intensities of steam (except steam for industrial use), hot water and cold water supplied by others are applied to exhaust heat purchased), and electricity represents the actual FY2008 data from the Federation of Electric Power Companies of Japan [Environmental Action Plan for the Electricity Industry [0.373 kg- CO_2/kWh is used as the value that reflects the credits under the Kyoto Mechanism]

■ Source: Trial calculation by Heat Pump & Thermal Storage Technology Center of Japan

1-2. Overseas

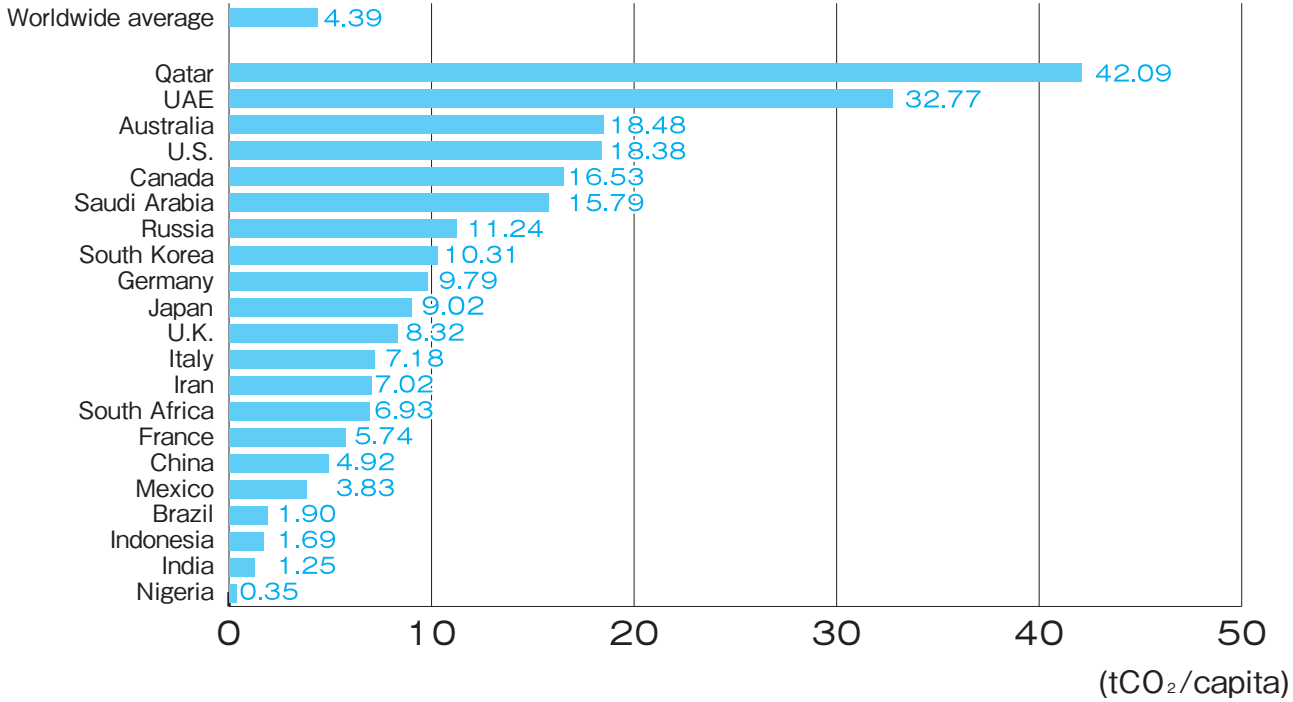
1-2-1 Global energy-related CO_2 emissions (2008)



*EU-15 are member countries at the time of COP3 meeting (in Kyoto).

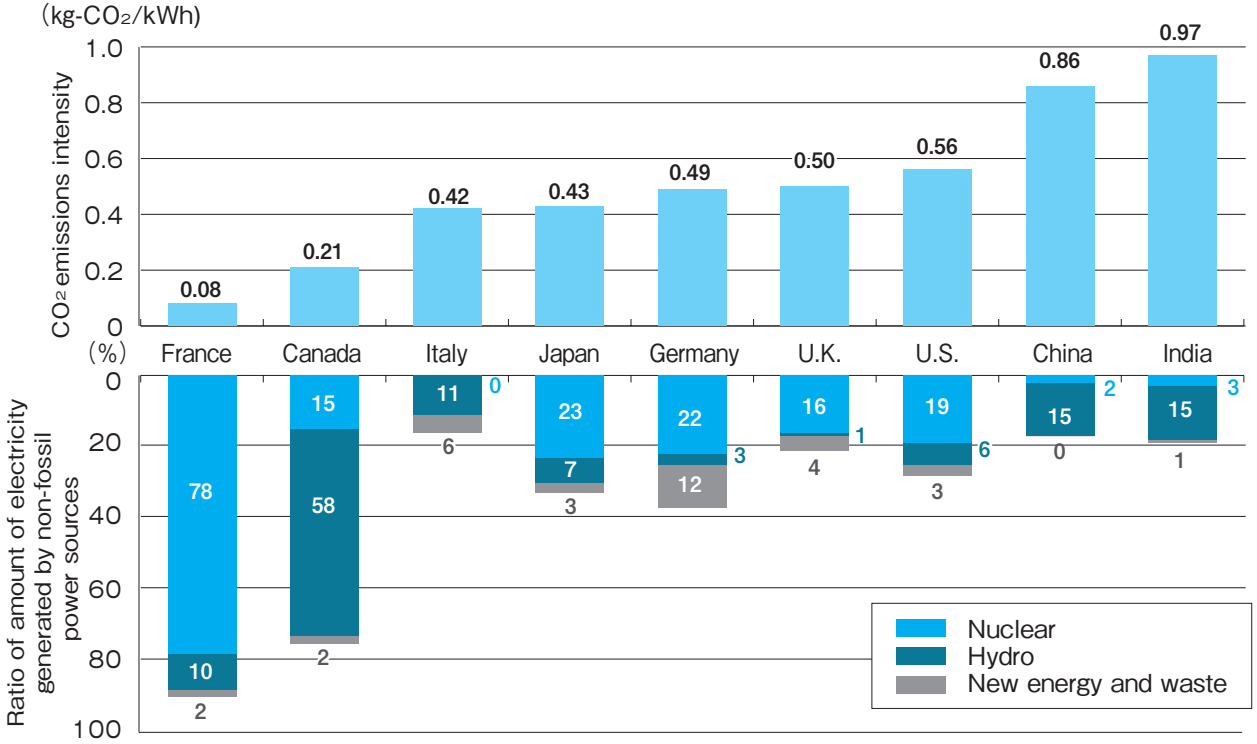
■ Source: Developed by the Ministry of the Environment based on IEA "CO_2 EMISSIONS FROM FUEL COMBUSTION 2010 EDITION"

1-2-2 Energy-related CO_2 emissions per capita by country (2008)



■ Source: Developed by the Ministry of the Environment based on IEA "CO_2 EMISSIONS FROM FUEL COMBUSTION 2010 EDITION"

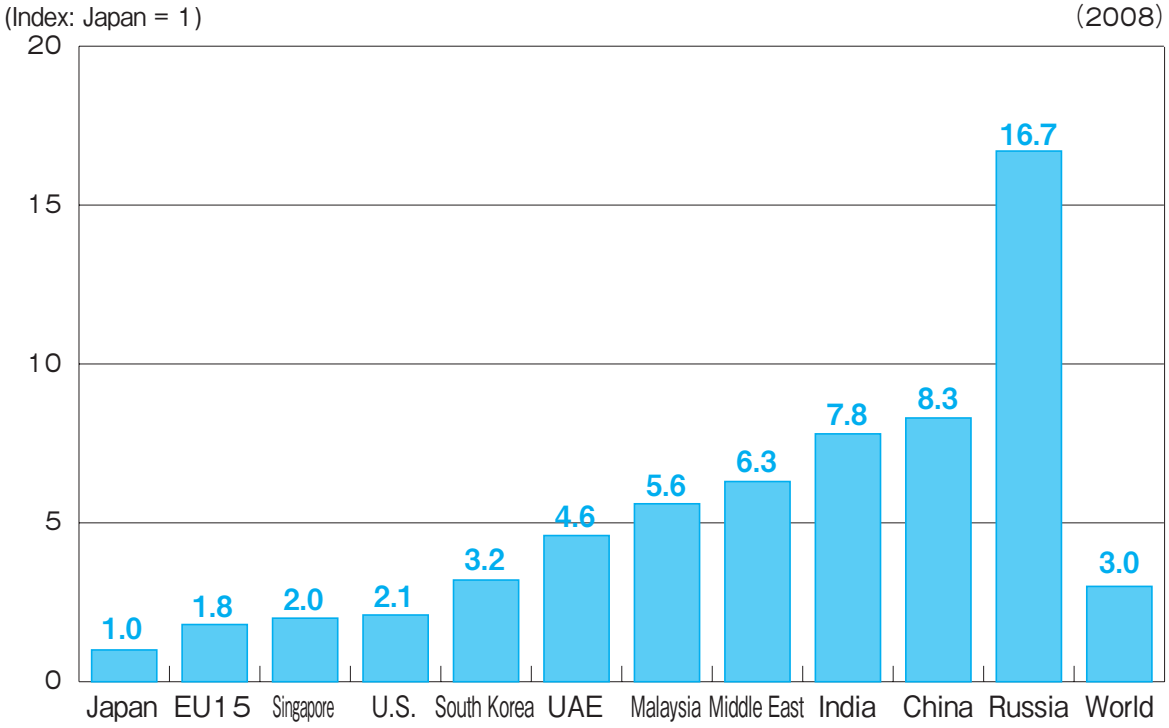
1-2-3 CO_2 emissions intensity in major countries



Note: Values for Japan include private power generation facilities. CHP plants (including cogeneration) are included (the values of FY2007, and China and India represent the values of FY2006).

■ Source: Those developed by the Federation of Electric Power Companies of Japan based on IEA "ENERGY BALANCES OF OECD COUNTRIES (2009 EDITION)" and "ENERGY BALANCES OF NON-OECD COUNTRIES (2008 EDITION)"

1-2-4 Primary energy consumption per GDP in major countries



Total consumption of primary energy (tons in crude oil equivalent) / real GDP (U.S. dollars) is calculated with Japan = 1.

■ Source: Developed by Energy Conservation Center, Japan based on IEA "ENERGY BALANCES OF OECD COUNTRIES (2008 EDITION)" and "ENERGY BALANCES OF NON-OECD COUNTRIES (2008 EDITION)"

1-2-5 Global demand for air conditioners

(1,000 units)

	2003	2004	2005	2006	2007	2008
Worldwide total	55,194	59,877	64,212	71,793	74,806	71,546
Japan	7,307	7,679	8,279	8,317	8,143	8,493
China	17,450	19,270	19,800	23,025	24,449	23,160
Asia (excluding Japan and China)	6,200	6,924	7,580	8,330	9,333	9,379
Middle East	2,195	2,355	2,929	3,640	3,974	4,197
Europe	5,064	6,326	6,158	6,651	8,137	6,144
North America	13,275	13,368	14,853	16,516	14,979	14,435
Latin America	2,158	2,225	2,753	3,166	3,496	3,436
Africa	815	839	1,015	1,248	1,401	1,412
Oceania	730	890	845	900	894	890

(Estimation)

■ Source: Japan Refrigeration and Air Conditioning Industry Association

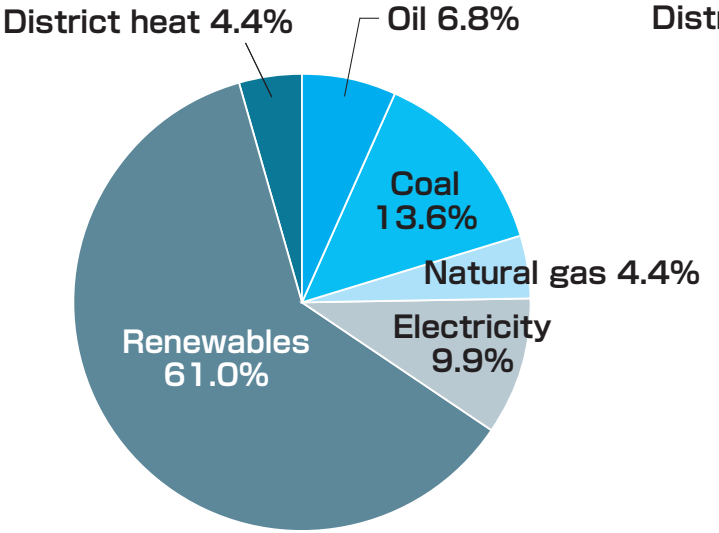
1-2. Overseas

Asia, Middle East and Oceania

1-2-6 Energy consumption by energy commodity in China

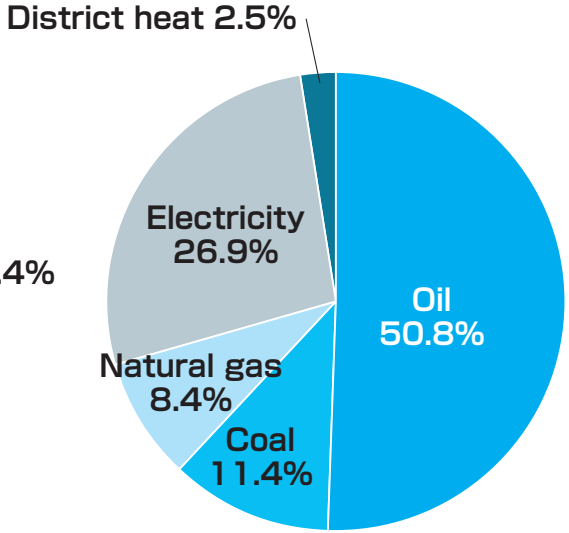
Energy consumption by energy commodity in China (2007)

Residential sector



Renewables are biomass and waste, etc.

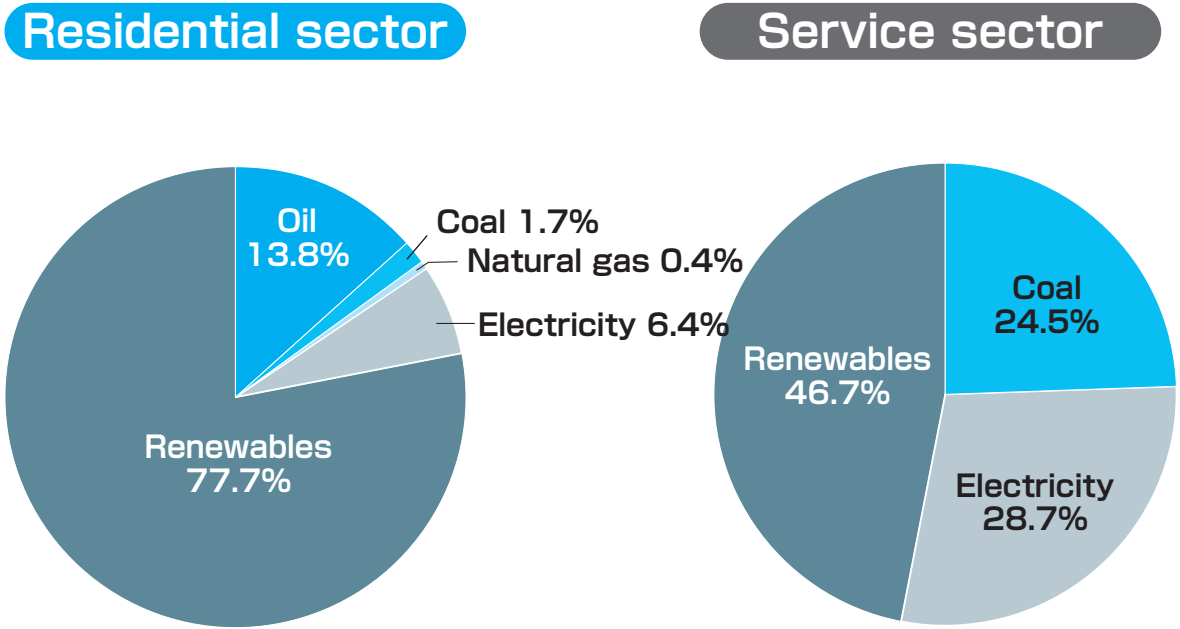
Service sector



■ Source: Developed by HPTCJ based on data from IEA

1-2-7 Energy consumption by energy commodity in India

Energy consumption by energy commodity in India (2007)



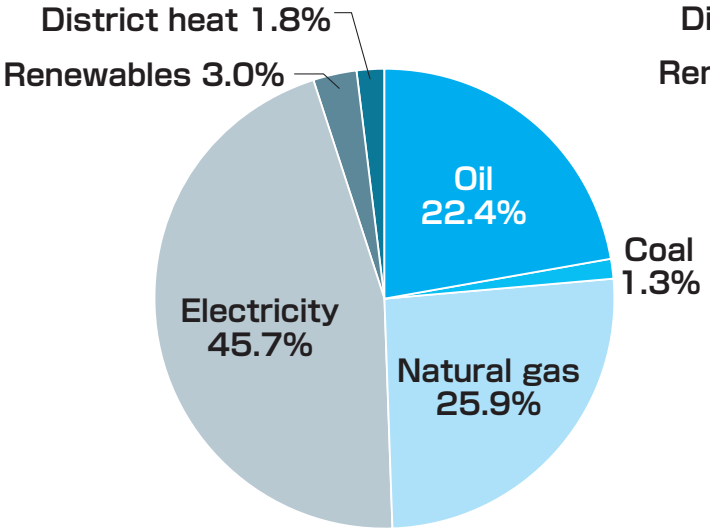
Renewables are biomass and waste, etc.

■ Source: Developed by HPTCJ based on data from IEA

1-2-8 Energy consumption by energy commodity in OECD Pacific

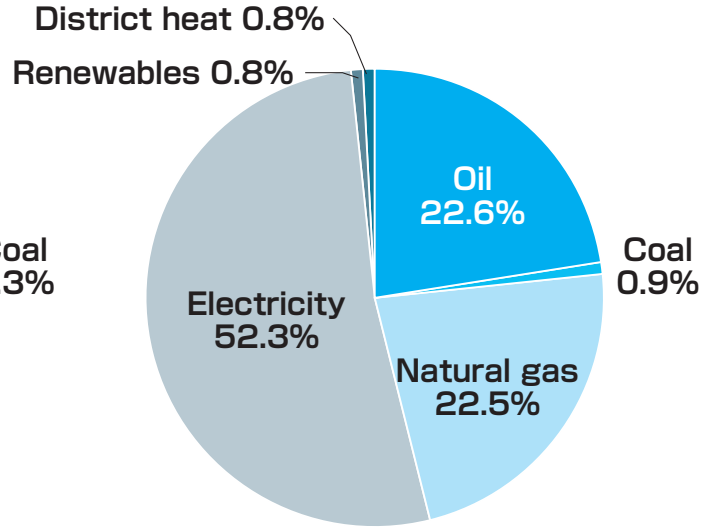
Energy consumption by energy commodity in OECD Pacific (2007) (Excluding U.S. and Canada)

Residential sector



Renewables are biomass and waste, etc.

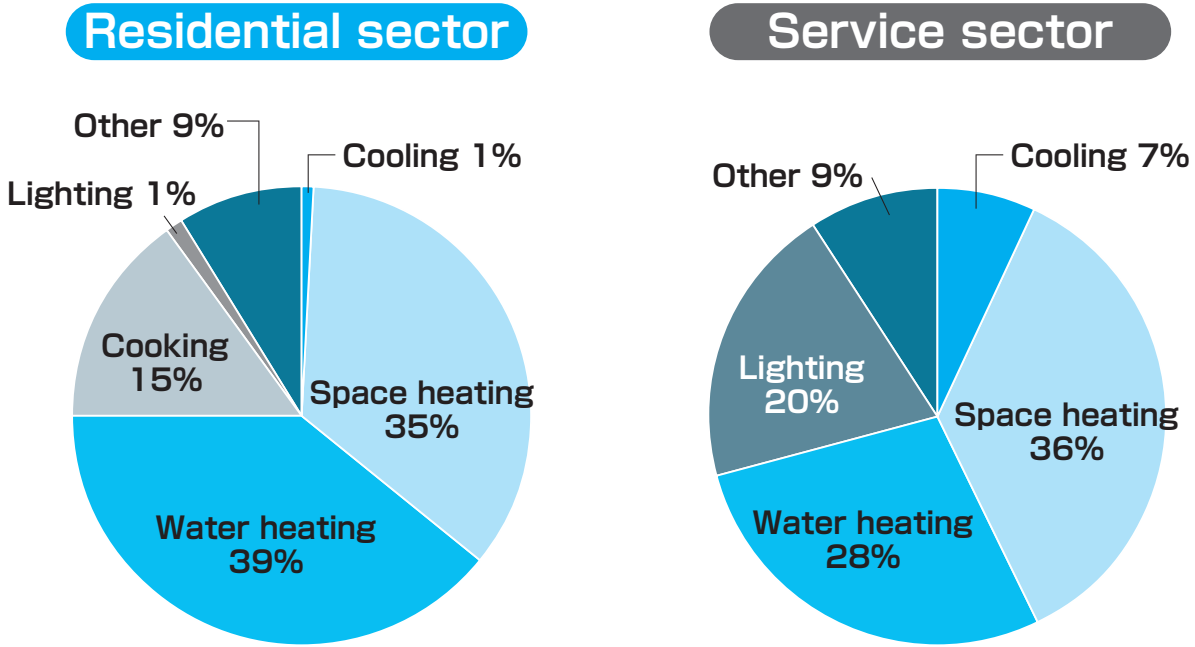
Service sector



■ Source: Developed by HPTCJ based on data from IEA

1-2-9 Energy consumption by end-use in China

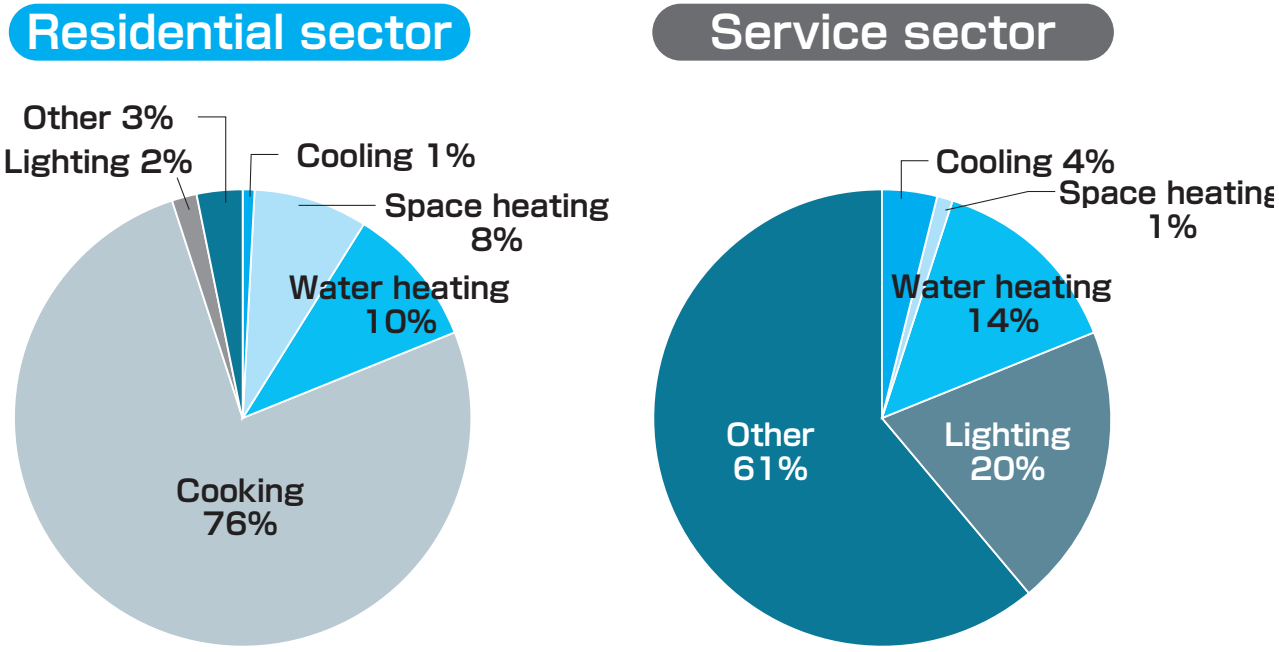
Energy consumption by end-use in China (2007)



■ Source: Developed by HPTCJ based on data from IEA

1-2-10 Energy consumption by end-use in India

Energy consumption by end-use in India (2007)



■ Source: Developed by HPTCJ based on data from IEA

1-2-11 Demand for air conditioners in Asia, Middle East and Oceania (excludes U.S. and Canada)

(1,000 units)

	2003	2004	2005	2006	2007	2008
Japan	7,307	7,679	8,279	8,317	8,143	8,493
China	17,450	19,270	19,800	23,025	24,449	23,160
India	940	1,064	1,249	1,401	1,852	1,982
South Korea	1,430	1,472	1,516	1,603	1,603	1,483
Indonesia	511	642	705	707	927	968
Taiwan	928	1,020	977	1,014	1,014	910
Malaysia	476	513	585	734	769	785
Thailand	497	535	659	692	723	700
Pakistan	149	279	403	509	615	620
Hong Kong	415	445	467	582	590	576
Philippines	433	507	503	505	505	504
Vietnam	116	133	161	209	312	419
Singapore	152	156	158	159	164	165
Bangladesh	27	27	41	43	74	83
Sri Lanka	21	22	43	49	52	52
Other countries in Asia	106	109	114	124	133	133
Total of Asia (excluding Japan and China)	6,200	6,924	7,580	8,330	9,333	9,379

(1,000 units)

	2003	2004	2005	2006	2007	2008
Saudi Arabia	885	972	1,176	1,324	1,418	1,504
UAE	234	269	465	770	828	880
Iran	354	360	374	480	533	546
Israel	200	206	250	250	258	262
Oman	81	84	95	150	191	228
Qatar	30	45	67	137	177	198
Kuwait	103	106	155	172	193	197
Iraq	159	159	159	159	164	164
Bahrain	33	37	53	60	65	66
Lebanon	42	43	49	48	53	58
Other countries in Middle East	74	75	85	90	94	94
Total of Middle East	2,195	2,355	2,929	3,640	3,974	4,197

Australia	676	834	776	808	799	795
New Zealand	48	50	63	86	89	89
Other countries in Oceania	6	6	6	6	6	6
Total of Oceania	730	890	845	900	894	890

(Estimation)

■ Source: Japan Refrigeration and Air Conditioning Industry Association

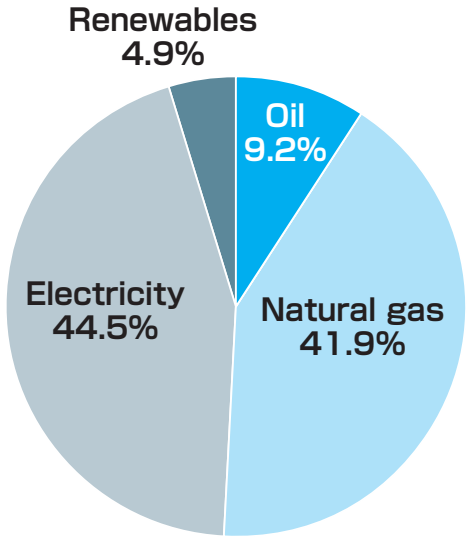
1-2. Overseas

North and Latin America

1-2-12 Energy consumption by energy commodity in U.S. and Canada

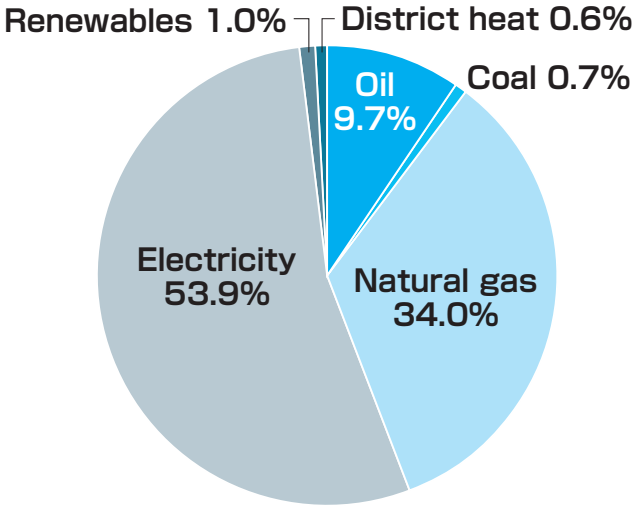
Energy consumption by energy commodity in U.S. and Canada (2007)

Residential sector



Renewables are biomass and waste, etc.

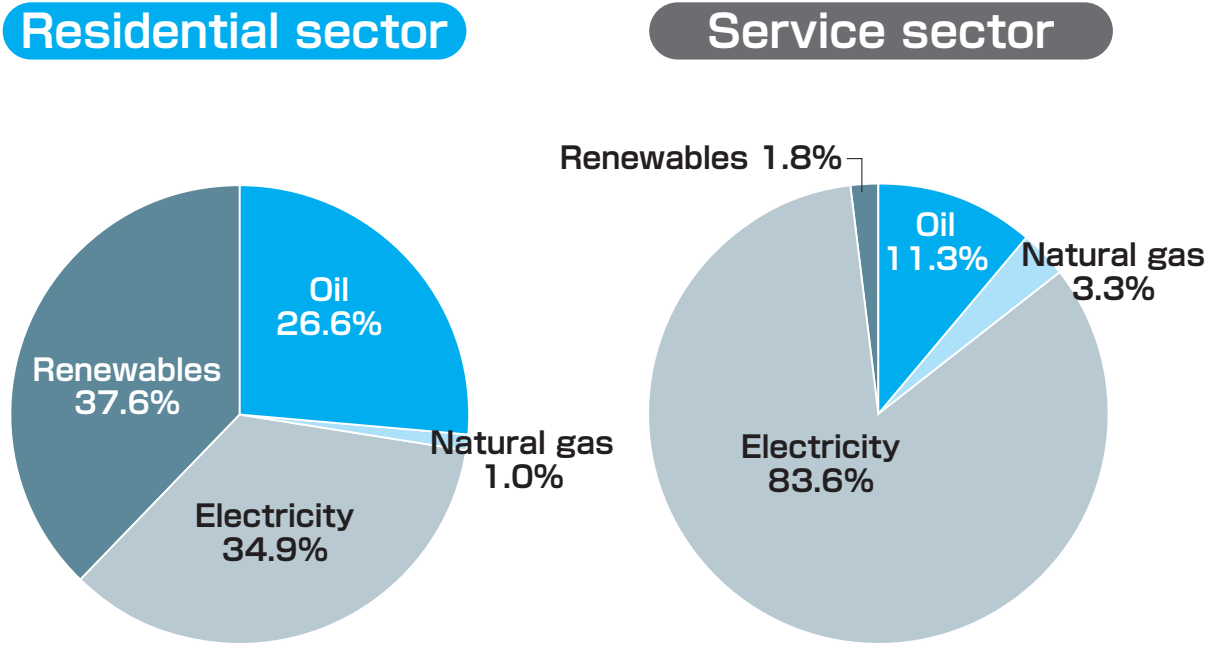
Service sector



■ Source: Developed by HPTCJ based on data from IEA

1-2-13 Energy consumption by energy commodity in Brazil

Energy consumption by energy commodity in Brazil (2007)

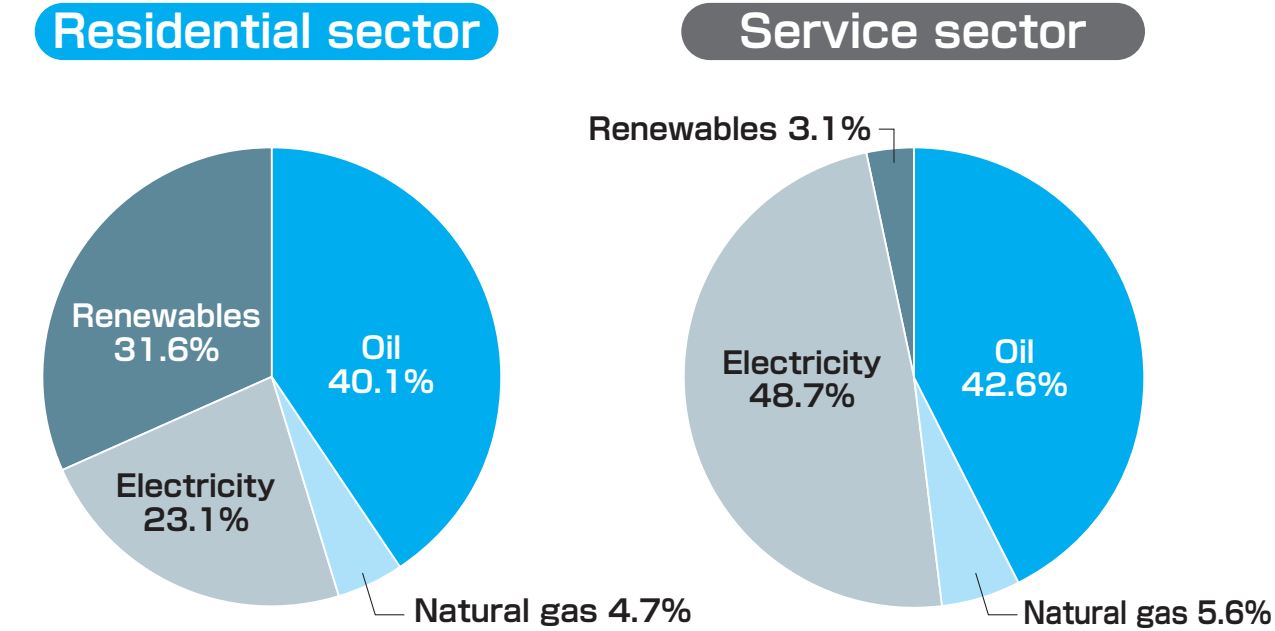


Renewables are biomass and waste, etc.

■ Source: Developed by HPTCJ based on data from IEA

1-2-14 Energy consumption by energy commodity in Mexico

Energy consumption by energy commodity in Mexico (2007)



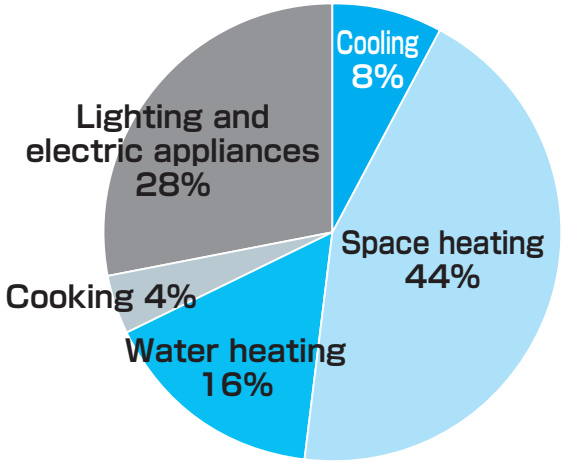
Renewables are biomass and waste, etc.

■ Source: Developed by HPTCJ based on data from IEA

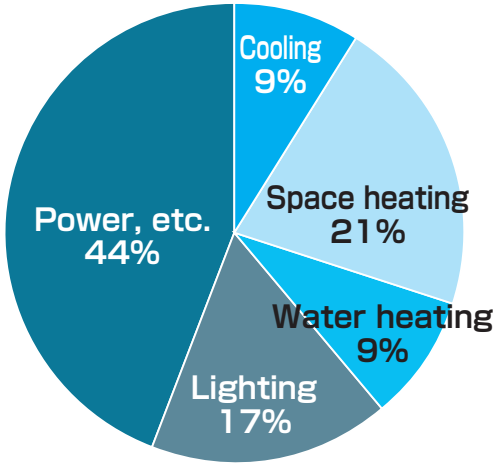
1-2-15 Energy consumption by end-use in U.S.

Energy consumption by end-use in U.S. (2007)

Residential sector



Service sector



■ Source: “ETP2010,” IEA

1-2-16 Demand for air conditioners in North America and Latin America

(1,000 units)

	2003	2004	2005	2006	2007	2008
U.S.	12,900	12,970	14,442	16,136	14,604	14,060
Canada	375	398	411	380	375	375
Total of North America	13,275	13,368	14,853	16,516	14,979	14,435
Brazil	1,103	1,112	1,168	1,210	1,265	1,242
Argentina	213	229	629	931	997	963
Mexico	363	381	407	443	635	639
Puerto Rico	106	113	138	143	148	141
Venezuela	87	97	112	132	136	136
Other countries in Latin America	286	293	299	307	315	315
Total of Latin America	2,158	2,225	2,753	3,166	3,496	3,436

(Estimation)

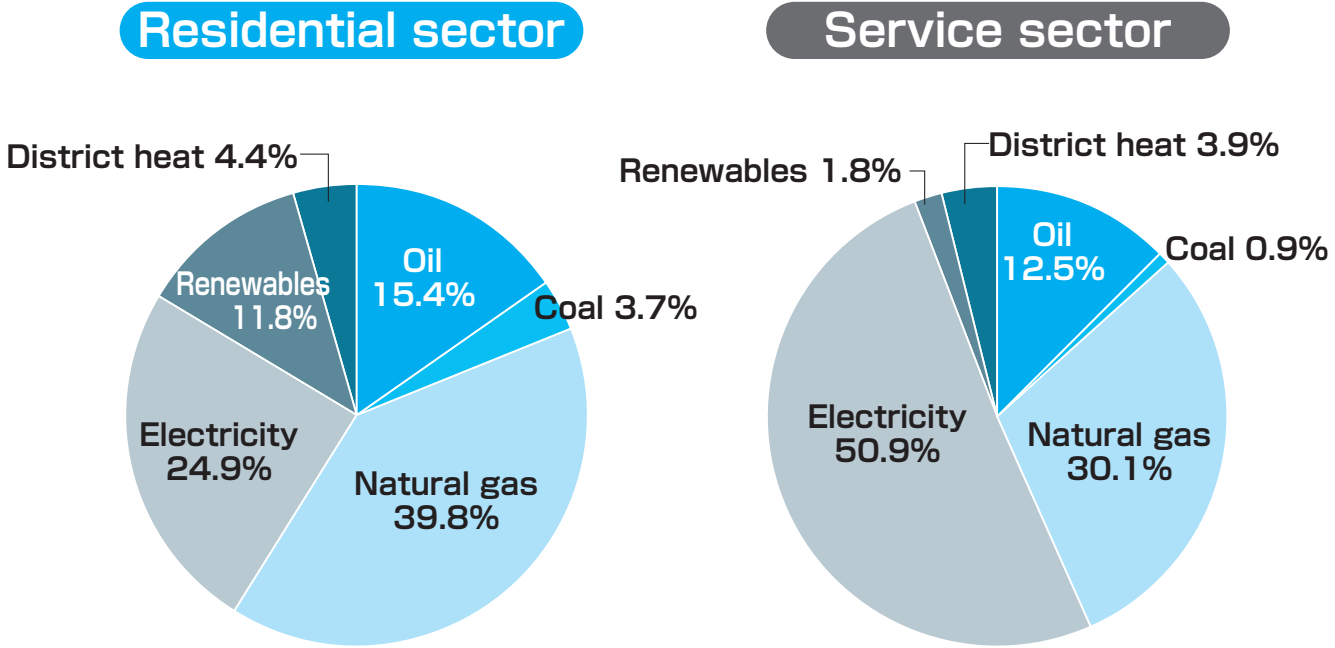
■ Source: Japan Refrigeration and Air Conditioning Industry Association

1-2. Overseas

Europe and Africa

1-2-17 Energy consumption by energy commodity in OECD Europe

Energy consumption by energy commodity in OECD Europe (2007)



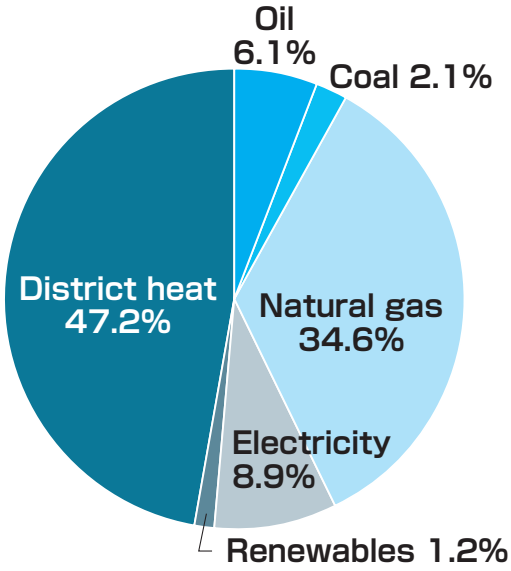
Renewables are biomass and waste, etc.

■ Source: Developed by HPTCJ based on data from IEA

1-2-18 Energy consumption by energy commodity in Russia

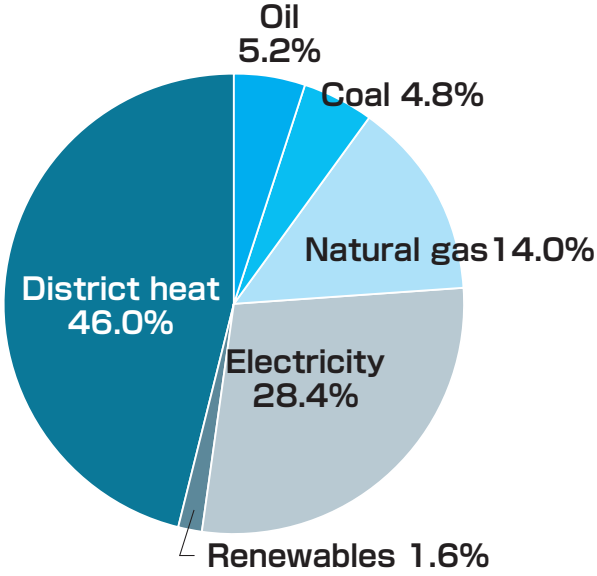
Energy consumption by energy commodity in Russia (2007)

Residential sector



Renewables are biomass and waste, etc.

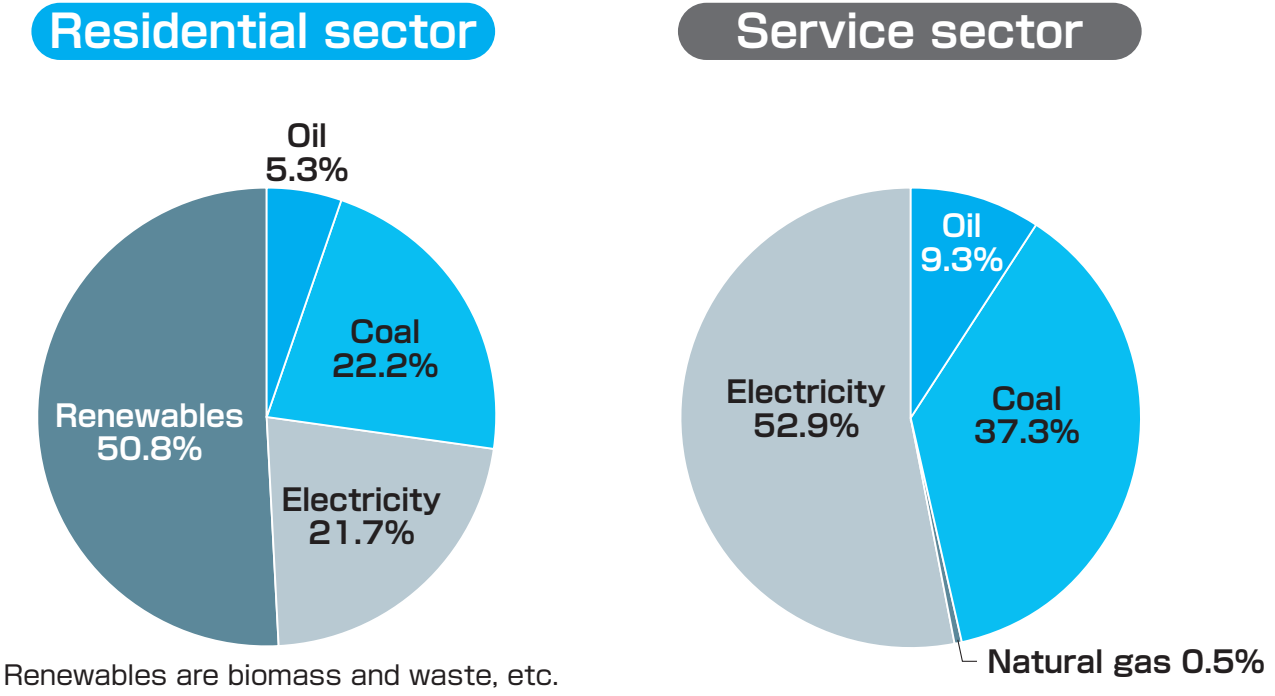
Service sector



■ Source: Developed by HPTCJ based on data from IEA

1-2-19 Energy consumption by energy commodity in South Africa

Energy consumption by energy commodity in South Africa (2007)



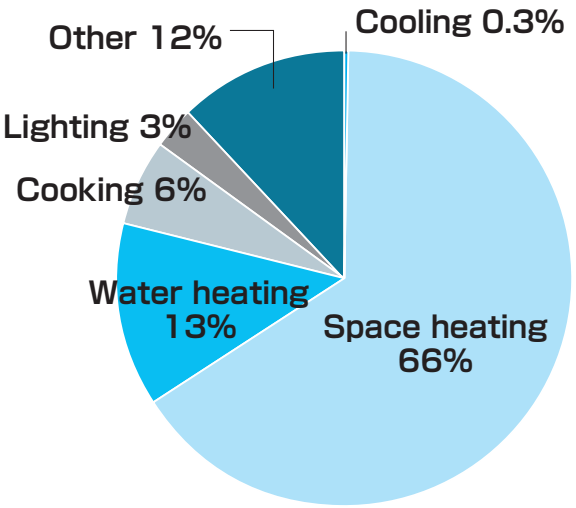
Renewables are biomass and waste, etc.

■ Source: Developed by HPTCJ based on data from IEA

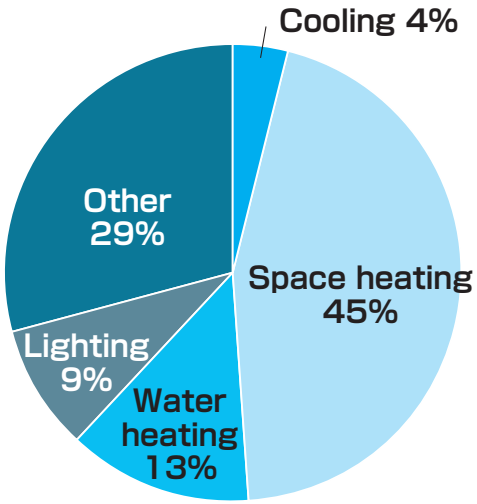
1-2-20 Energy consumption by end-use in OECD Europe

Energy consumption by end-use in OECD Europe (2007)

Residential sector



Service sector



■ Source: “ETP2010,” IEA

1-2-21 Demand for air conditioners in Europe and Africa

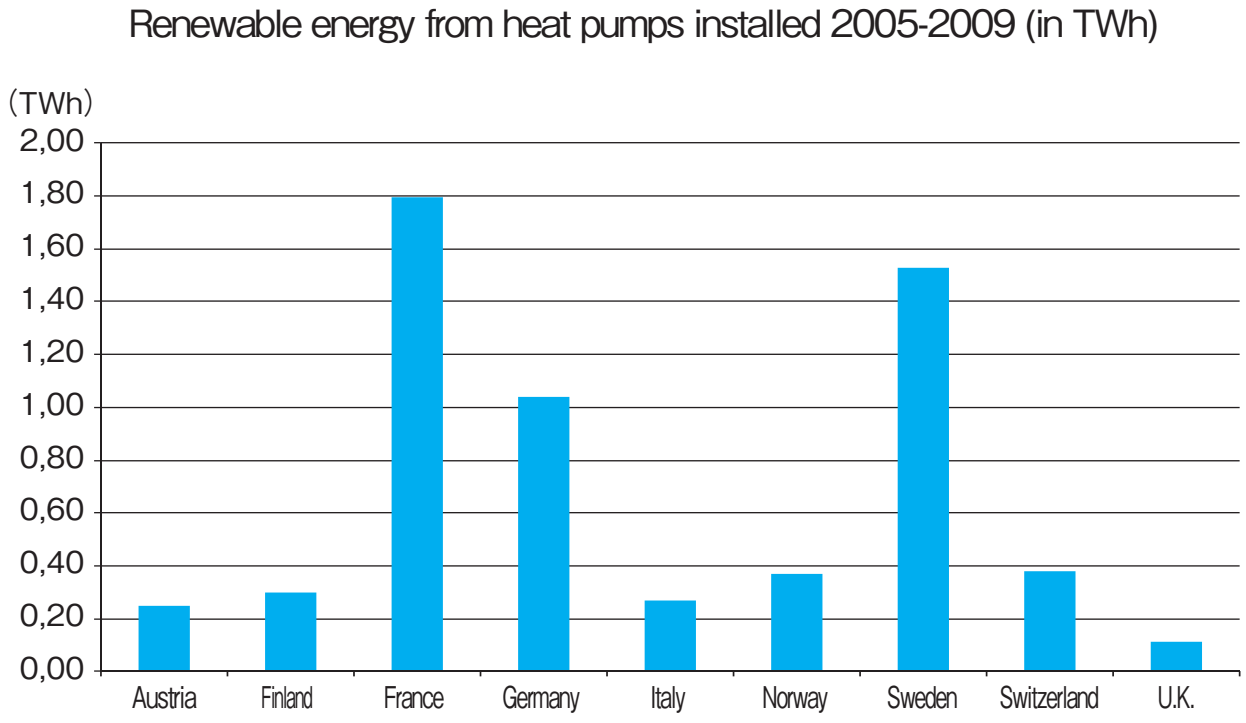
(1,000 units)

	2003	2004	2005	2006	2007	2008
Russia	423	449	594	759	1,221	1,159
Italy	1,460	1,739	1,118	1,163	1,583	1,101
Turkey	385	689	759	973	1,150	926
Spain	1,004	1,427	1,629	1,271	1,229	482
Greece	413	379	346	372	528	452
France	303	495	335	460	505	366
Ukraine	131	131	178	198	247	180
U.K.	155	184	193	213	222	157
Bulgaria	34	34	44	102	134	129
Portugal	75	83	109	149	166	125
Romania	63	63	90	103	128	115
Germany	75	83	103	116	136	114
Sweden	23	32	51	74	84	80
Croatia	27	27	52	63	74	74
Hungary	47	47	62	68	75	70
Poland	28	28	36	46	57	56
Other countries in Europe	418	436	459	521	598	558
Total of Europe	5,064	6,326	6,158	6,651	8,137	6,144
Egypt	235	244	278	334	367	384
Nigeria	144	147	151	221	270	276
South Africa	101	107	157	161	159	141
Algeria	18	18	31	112	125	128
Libya	41	42	61	75	102	105
Kenya	5	5	14	19	52	52
Other countries in Africa	272	277	323	326	326	326
Total of Africa	815	839	1,015	1,248	1,401	1,412

(Estimation)

■ Source: Japan Refrigeration and Air Conditioning Industry Association

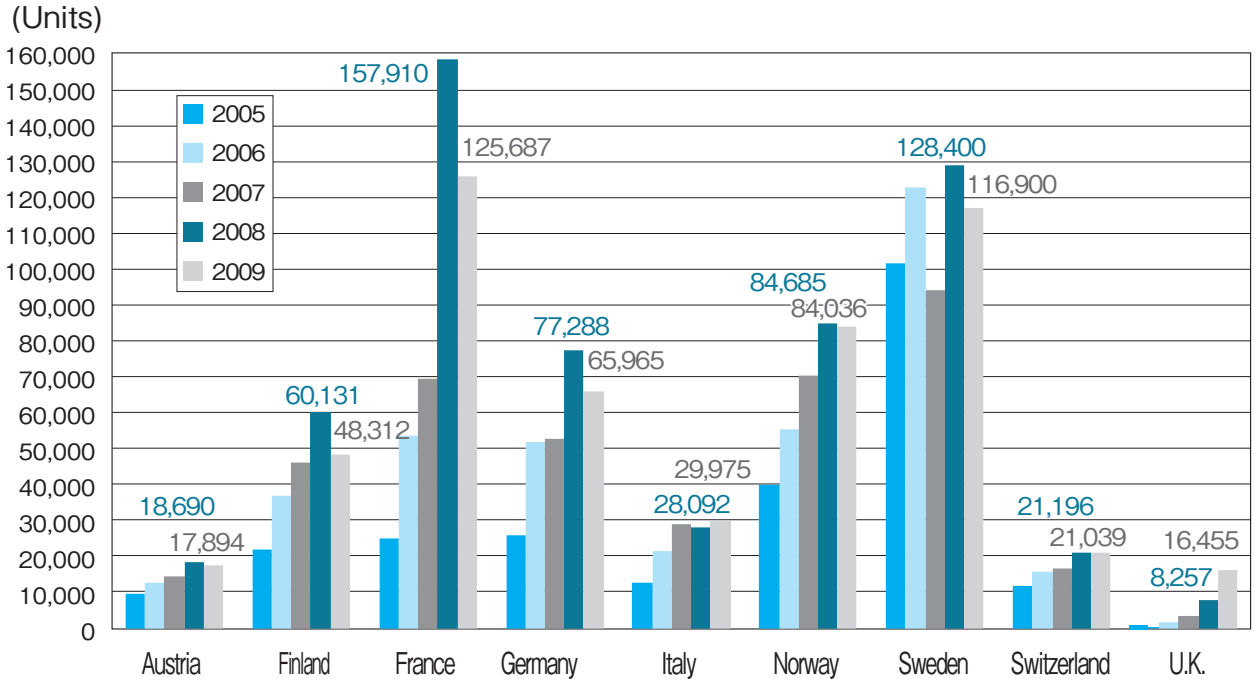
1-2-22 Amount of renewable energy used by heat pumps in Europe



■ Source: "Outlook 2010 European Heat Pump Statistics/Summary," EHPA

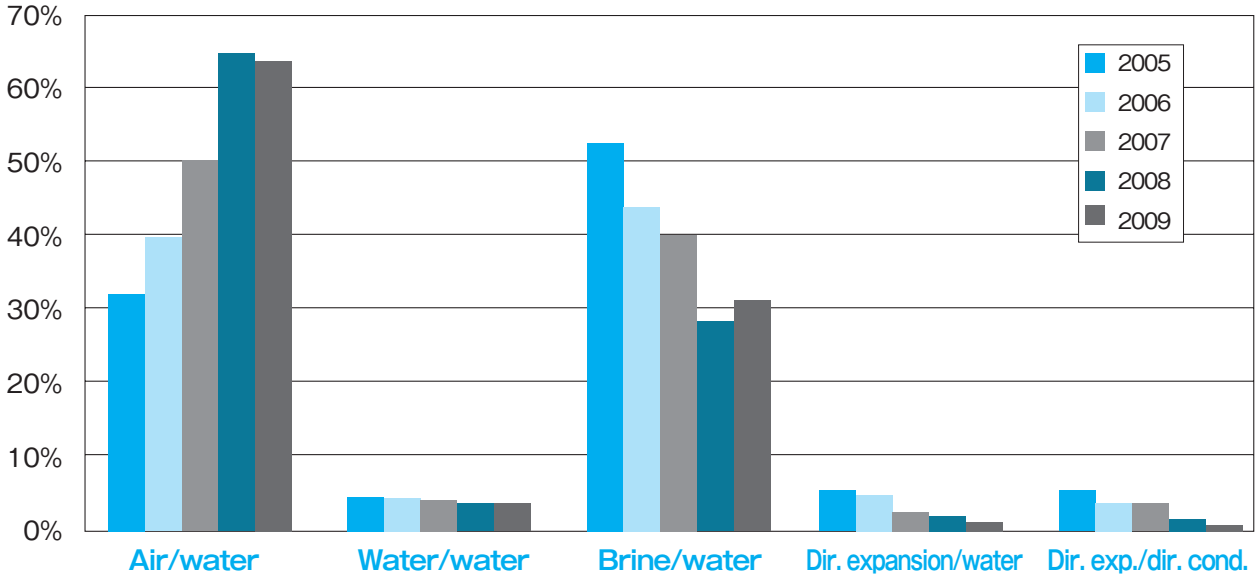
1-2-23 Number of heat pumps shipped per year in European countries

Heat pump units sold 2005-2009 per country (including air-air heat pumps)



■ Source: "Outlook 2010 European Heat Pump Statistics/Summary," EHPA

1-2-24 Market shares by energy source in EU 9



*The graph represents the total of nine European countries (Austria, Finland, France, Germany, Italy, Norway, Sweden, Switzerland and the U.K.).

■ Source: "Outlook 2010 European Heat Pump Statistics/Summary," EHPA

1-2-25 Ground-source heat pumps installed in Europe

Number and installed capacity of GSHP in the EU countries in 2008

	Number	Capacity (MWth)
Sweden	320,687	2,909.0
Germany	150,263	1,652.9
France	121,886	1,340.7
Finland	46,412	857.9
Austria	48,641	544.8
Netherlands	19,310	508.0
Poland	11,000	180.0
Ireland	9,673	157.0
Italy	7,500	150.0
Czech Republic	9,168	147.0
U.K.	10,350	134.6
Denmark	11,250	123.8
Belgium	9,500	114.0
Estonia	4,874	63.0
Hungary	350	15.0
Slovenia	1,125	12.2
Lithuania	200	4.3
Romania	40	2.0
Greece	194	1.9
Slovakia	8	1.4
Bulgaria	19	0.3
Latvia	10	0.2
Portugal	1	0.2
Total EU 27	782,461	8,920.2

The number of ground-source heat pumps installed in Japan is 474 (in 2009).

■ Source: “HEAT PUMPS BAROMETER,” EUROOBSERVER, Environmental Management Bureau of the Ministry of the Environment

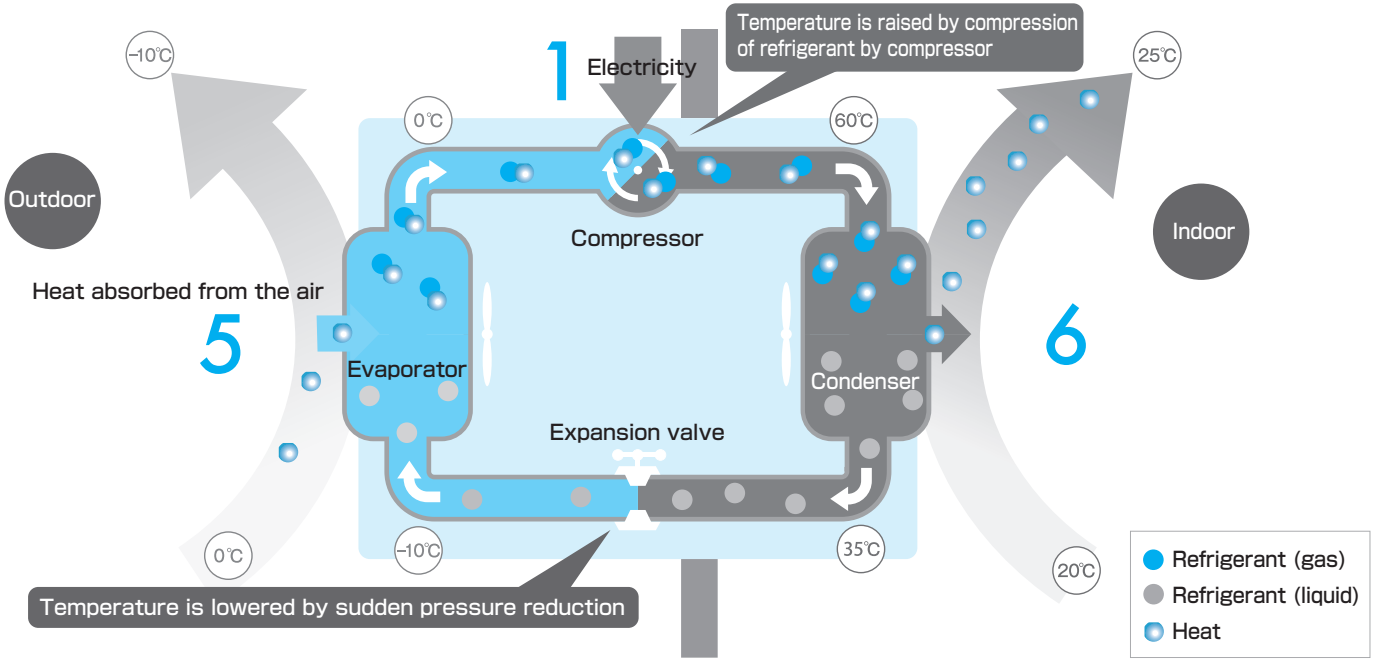
2. Commentary

2－1．Heat pump

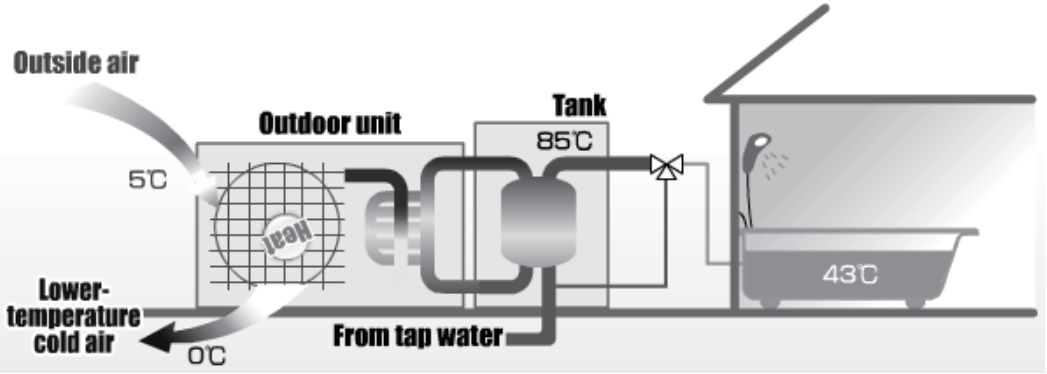
2-1-1 Mechanism of heat pump

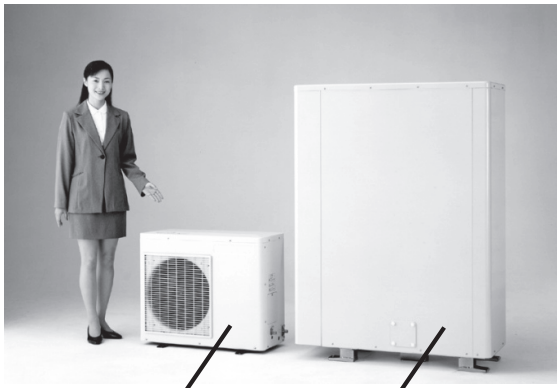
1 unit of electricity + 5 units of heat in the air → 6 units of thermal energy

(an example of air conditioner for household use)



2-1-2 Heat pump water heater (Eco cute)





Heat pump unit (Outdoor unit)

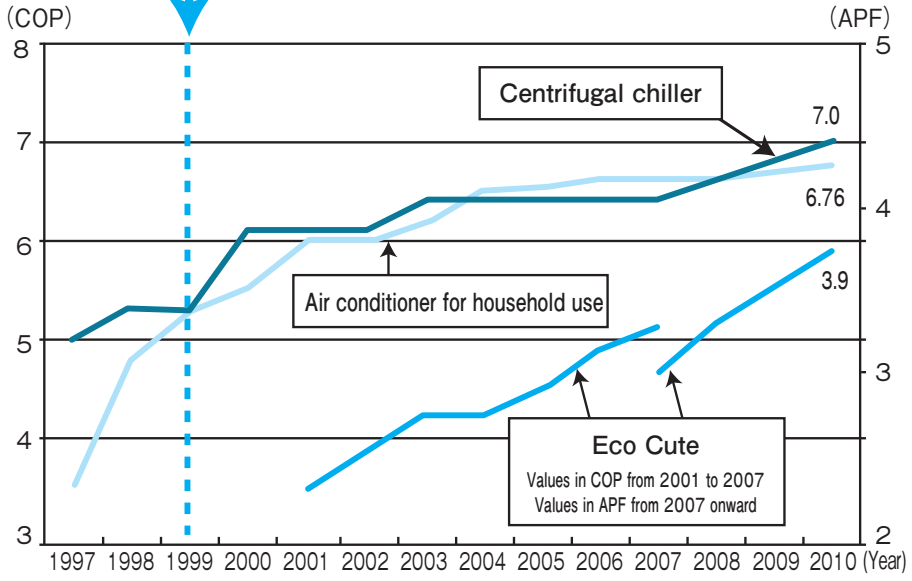
Hot water tank

- Air source heat pump
- CO_2 refrigerant
- Produce hot water up to 90℃
- Started sales in 2001

2-1-3 Changes in efficiency of heat pumps

Efficiency of heat pumps improves year by year.

Introduction of Top Runner Program* *Refer to P.93

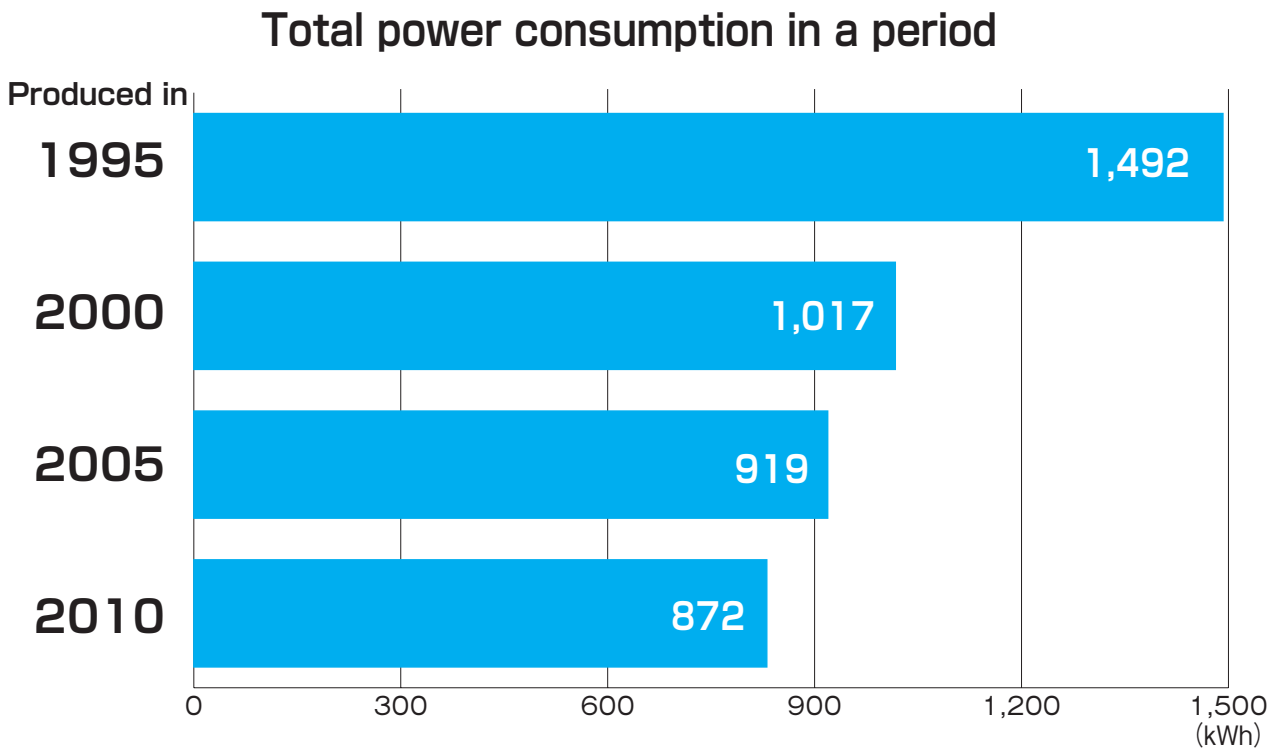


*The values represent high-quality products; air conditioners for household use are 2.2 kW – their size is not regulated.

- COP : cooling and heating capacity (kW) / power consumption (kW)
- Operation conditions for cooling : outside air temperature of 35℃ and room temperature of 27℃
  Operation conditions for heating : outside air temperature of 7℃ and room temperature of 20℃ (JIS C 9612 rated conditions)
- APF: annual performance factor. Quantity of heat of hot water supplied per unit power consumption when equipment is operated throughout a year

■ Source: Manufacturer brochures and the Energy Conservation Center, Japan website

2-1-4 Changes in power consumption by air conditioners for household

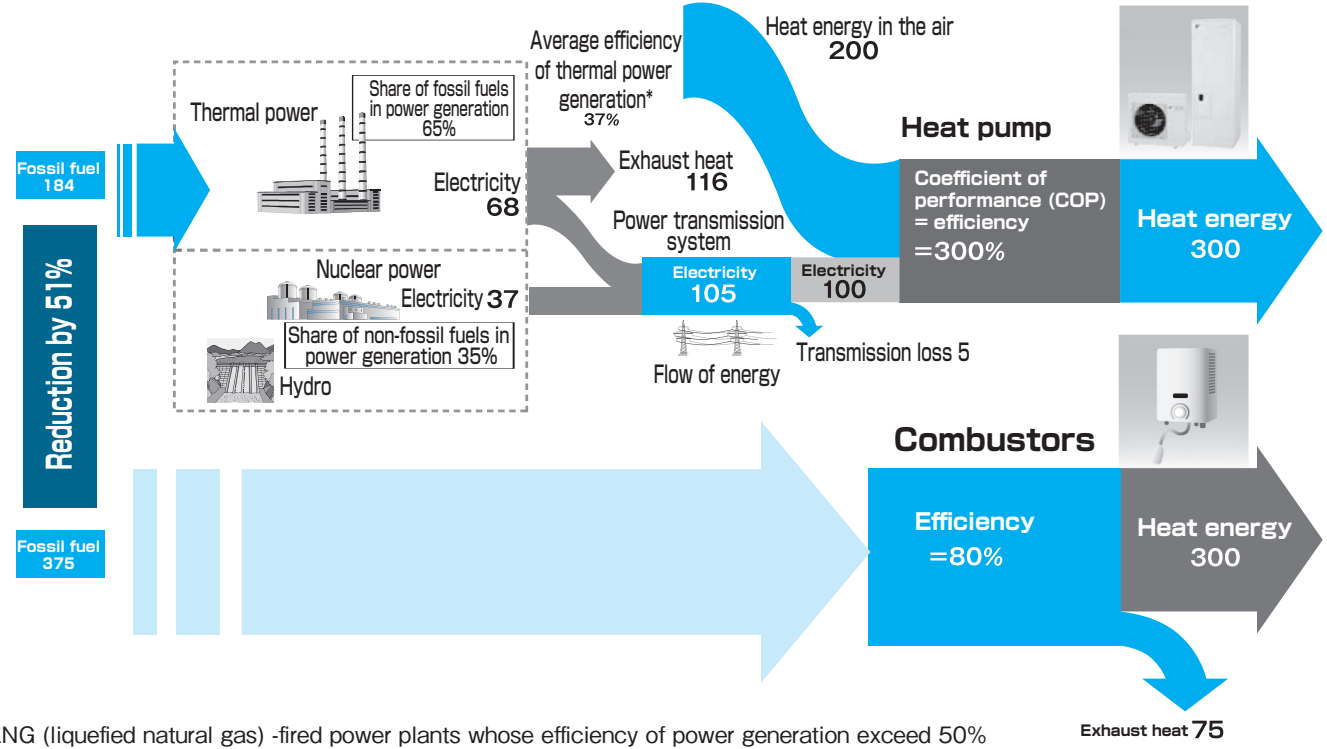


*Simple average value of cooling and heating wall-mounted air conditioners of 2.8 kW class energy-saving types
*The values change depending on the environment where air conditioners are installed and usage conditions.

■ Source: Japan Refrigeration and Air Conditioning Industry Association

2-1-5 Comparison of fossil fuels consumption by heat pumps and combustors

Heat pumps contribute significantlly to reduction of fossil fuel consumption

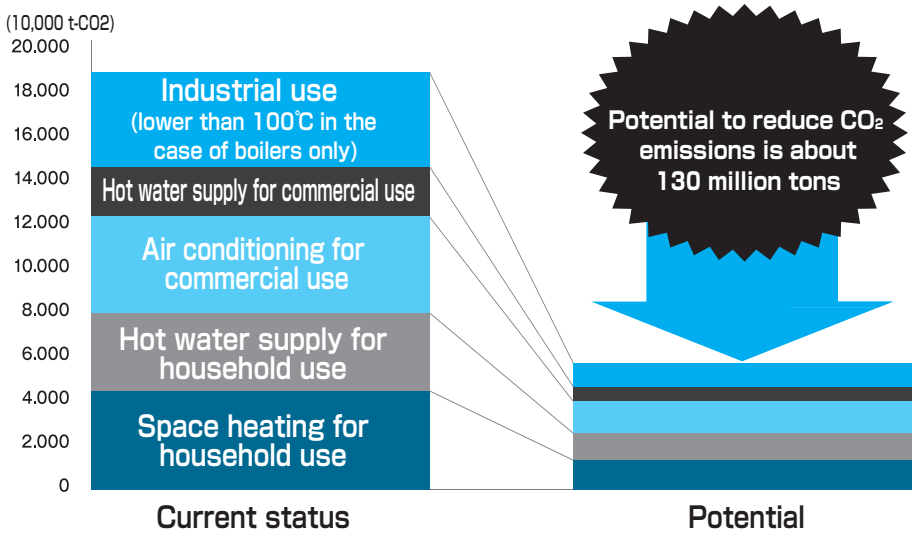


*LNG (liquefied natural gas) -fired power plants whose efficiency of power generation exceed 50% due to efficiency improvement have been constructed in recent years.

■ Source: Trial calculation by Heat Pump & Thermal Storage Technology Center of Japan

2-1-6 Potential of heat pumps to reduce CO_2 emissions

The potential of heat pumps to reduce CO_2 emissions is 130 million tons by adding 100 million tons in non-industrial sector and 30 million tons in industrial sector : Moreover, if the high-temperature range (100℃ or higher) in the industrial sector and the agricultural sector are added, the potential reaches about 140 million tons.



Sector-specific potential to reduce CO_2 emissions

(10,000 t-CO_2)

Space heating for household use	3,050
Hot water supply for household use	2,370
Air conditioning for business use	2,900
Hot water supply for business use	1,530
Industrial use (in the case of boilers only), lower than 100℃	3,290
Subtotal	13,140
Industrial use (in the case of boilers only), 100℃ or higher	876
Agricultural use	28
Total	14,044

*Conditions for trial calculations:

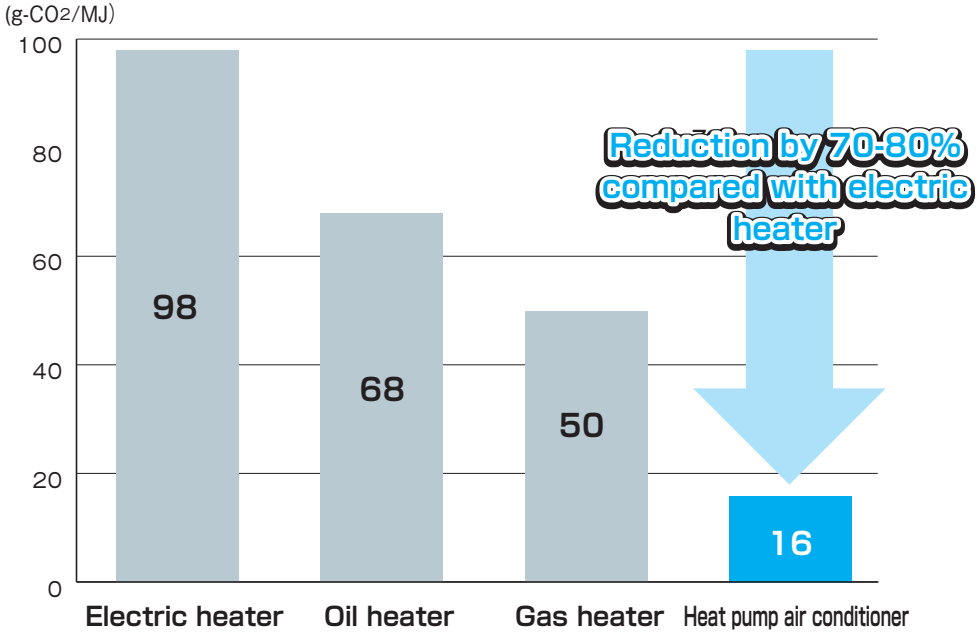
To calculate, based on the amount of energy used in Japan in breakdown by application, CO_2 emissions in the future when all combustors, etc. are replaced by high-efficiency heat pumps.

Assumed annual average efficiency: combustion-type space heater 0.75, electric space heater 1.0, high-efficiency heat pump air conditioner 6.0, high-efficiency heat pump air conditioner (for use in cold climate areas) 4.0, combustion-type water heater 0.78, electric water heater 0.9, and heat pump water heater for household use 4.0. As for equipment for commercial use and industrial use, see the “White Paper on Heat Pumps and Thermal Storage.”

■ Source: Trial calculation by Heat Pump & Thermal Storage Technology Center of Japan, Study Group on Economic Effect of Heat Pump (composed of Heat Pump & Thermal Storage Technology Center of Japan, Japan Electro-Heat Center and Mitsubishi Research Institute, Inc.)

2-1-7 Residential sector CO_2 emissions from heaters

Comparison of CO_2 emissions among space heaters for household use

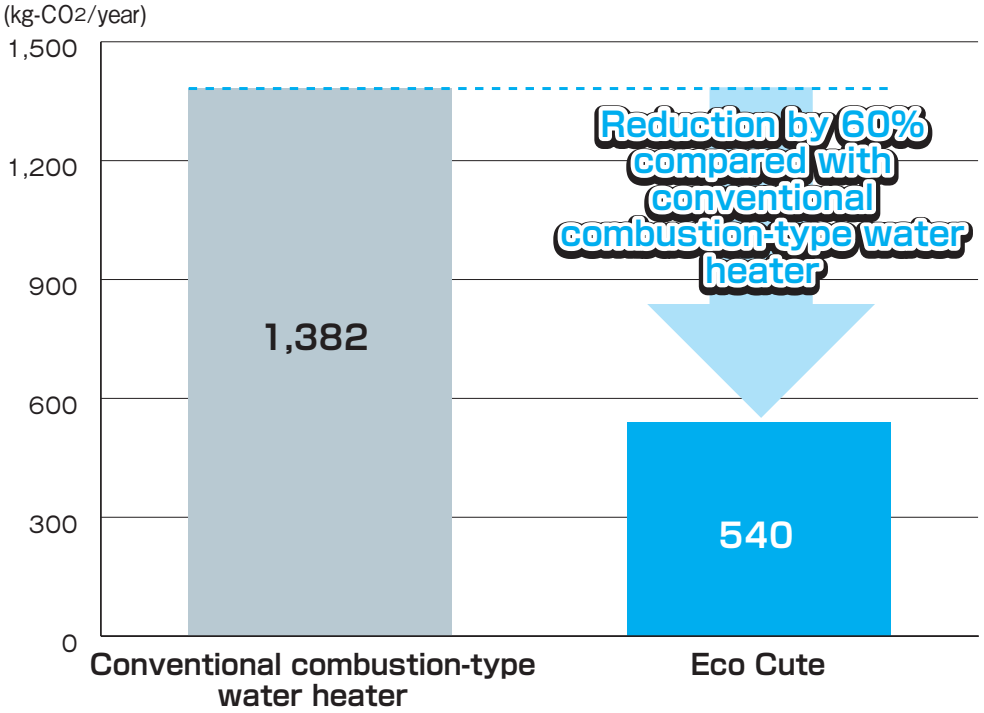


*Conditions for trial calculations:
・CO_2 emission factor: electricity 0.351 kg-CO_2 /kWh (actual value announced in 2009 by the Federation of Electric Power Companies of Japan [after reflection of the credits under the Kyoto Mechanism]), kerosene 0.0185 tC/GJ, city gas 0.0136 tC/GJ ("List of Calculation Methods and Emission Factors under Calculation, Report and Announcement Systems (after revision)," the website of the Ministry of the Environment)
・Equipment efficiency: heating by heat pump air conditioner COP (energy consumption efficiency) 6.0, and electric heater, oil-fired heater and gas-fired heater 1.0

■ Source: Trial calculation by Heat Pump & Thermal Storage Technology Center of Japan

2-1-8 Residential sector CO_2 emissions from water heaters

Comparison of CO_2 emissions between water heaters for household use



*Conditions for trial calculations:
・Assumed annual hot water supply load 19.4 GJ per year, annual efficiency of Eco Cute 3.5, and efficiency of conventional combustion-type water heater 0.8
・CO_2 emission factor of electricity 0.351 kg-CO2/kWh (actual value announced in 2009 by the Federation of Electric Power Companies of Japan)
・Calculated by CO_2 emission factor of fuels for conventional combustion-type water heaters 0.057 t-CO_2 /GJ (weighted average of CO_2 emission factor for city gas, LPG and kerosene)

■ Source: Trial calculation by Heat Pump & Thermal Storage Technology Center of Japan

2-1-9 Economic effect with dissemination of heat pumps

Outlook for economic effect (medium case*1) by "conversion from combustion-type heat source equipment, etc. to high-efficiency heat pump equipment"

*1: The ratio of introduction to the upper limit of the number of units to be introduced is 50%.

Number of units of heat pump equipment to be introduced (replacement of existing equipment)

(unit: 1,000)

Sector	Application	2020	2030
Residential	Hot water supply (Eco Cute)	1,952.0	1,997.0
Commercial	Local air conditioning (high-efficiency VRF for building)	40.5	51.2
	Central air conditioning (high-efficiency centrifugal chiller)	5,727.1	6,523.0
	Hot water supply (HP water heater for business use)	74.0	101.0
Industrial	Air conditioning in factories	4.5	7.3
	Heating (hot water supply)	40.2	65.3
	Drying at lower than 100℃	46.1	74.9
	High temperature (higher than 100℃)	1.2	3.4
Total		7,885.6	8,823.1

Amount of economic effect

(unit: trillion yen)

	2020	2030
Direct effect*2	1.8	2.2
Production inducement*3	4.6	5.6
Total	6.4	7.8

(unit:1,000 people)

	2020	2030
Employment creation	234	283

*2: Direct effect means an economic effect caused by the heat pumps sold and installed (the amount of ultimate demand).
*3: Production inducement means an amount of production caused to meet the intermediate demand for raw materials and fuels that are newly required to produce heat pumps.

Economic ripple effect of overall heat pumps in Japan (direct effect + production inducement effect) is estimated to total about 12 trillion yen in 2020 and about 13 trillion yen*4 in 2030.

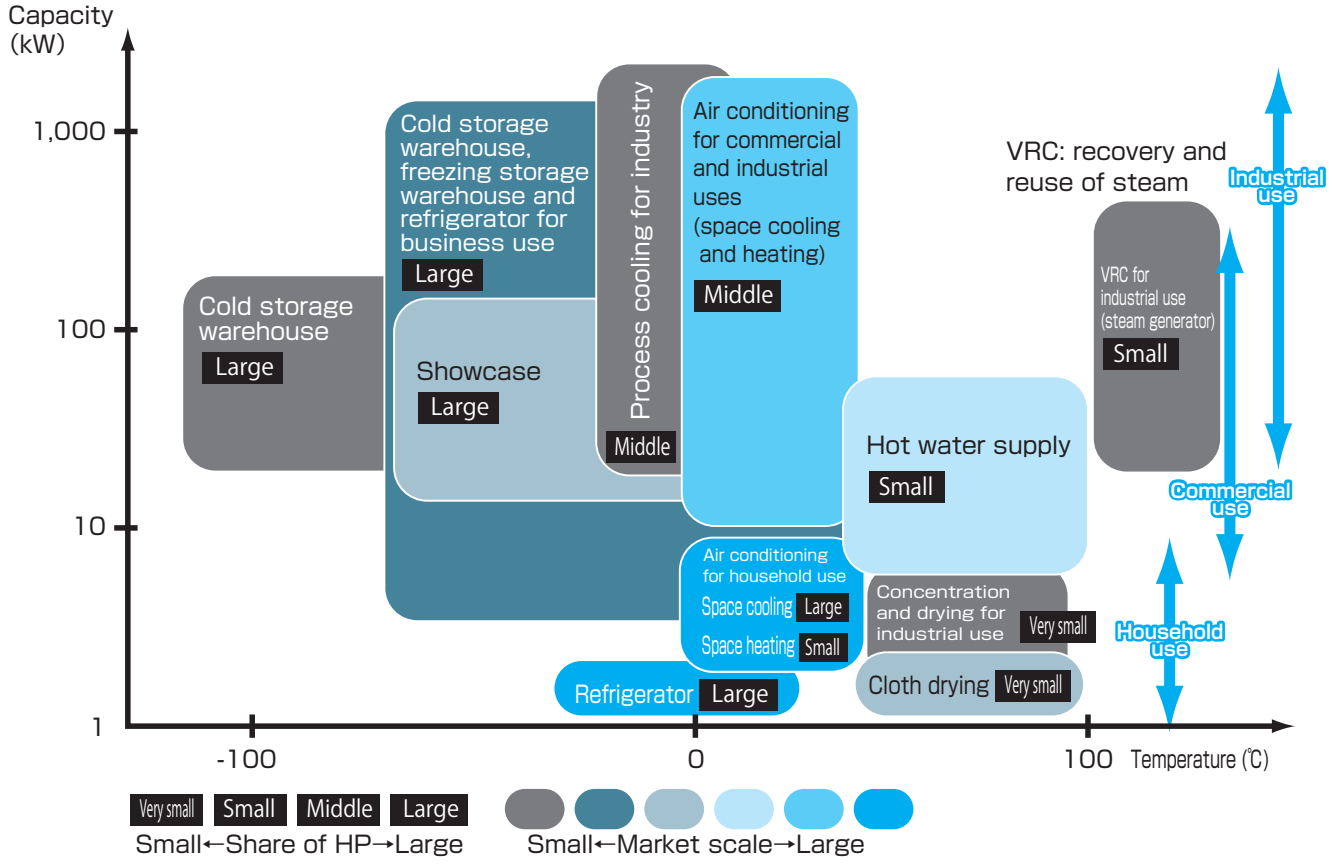
*4: The direct effect of heat pump equipment other than "conversion from combustion-type heat source equipment to high-efficiency heat pump equipment" is estimated to total about 1.5 trillion yen, and it is assumed that the production inducement factor is the same as that of respective scenarios.

■ Source: Trial calculation by Study Group on Economic Effect of Heat Pump (composed of Heat Pump & Thermal Storage Technology Center of Japan, Japan Electro-Heat Center and Mitsubishi Research Institute, Inc.)

2-1-10 Lineup of heat pumps

Application	Area of application	Applicable equipment
Air conditioning	Air conditioning for household use (space cooling and heating)	Room air conditioner
		Hot water floor heating
	Air conditioning for business and industrial uses (space cooling and heating)	Room air conditioner
		Packaged air conditioner
		VRF
		Chilling unit
		Centrifugal chiller
		Heat pump air conditioner for greenhouse cultivation
Cooling	Refrigerator	Refrigerator
	Cold storage warehouse, freezing storage warehouse and refrigerator for business use	Chilling unit
		Centrifugal chiller
	Showcase	Freezing and refrigerated display case
	Vending machine	Heat pump vending machine
	Process cooling for industry	Centrifugal chiller
Hot water supply	How water supply	Heat pump water heater (Eco Cute)
		Heat pump water heater for business use
Heating and drying	Cloth drying	Heat pump washing and drying machine
	Concentration and drying for industrial use	Heat pump steam and hot water generator
		Hot air heat pump
		Heat pump drying unit
	VRC for industrial use (recovery and reuse of steam)	Vapor recompression (VRC) heat pump
	Snow melting	Heat pump snow melting system

2-1-11 Heat pump technology application areas



2-1. Heat pump

Wider use of heat pump technologies

2-1-12 Air source heat pumps for use in cold climate area

Thanks to recent technical improvement, efficient heating is realized with heat pumps specified for use in cold climate areas.

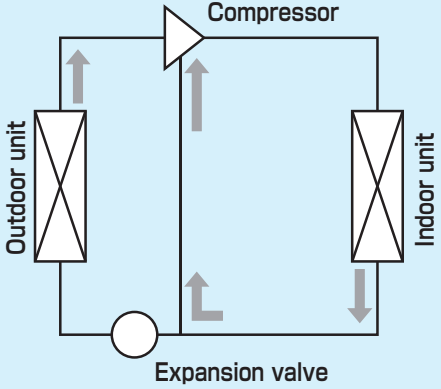
■ Example of heat pump specified for use in cold climate areas
(In the case where injection circuits are adopted)

*There is a two-stage compression system, etc. to improve quick heating and defrosting performance.

- Water repellent finishing of fins
- Shortening of defrosting time

↓

Reduction in interuption of operation
Reduction in wasted energy



Sophistication of inverters

↓

Optimum operation from low to high speeds

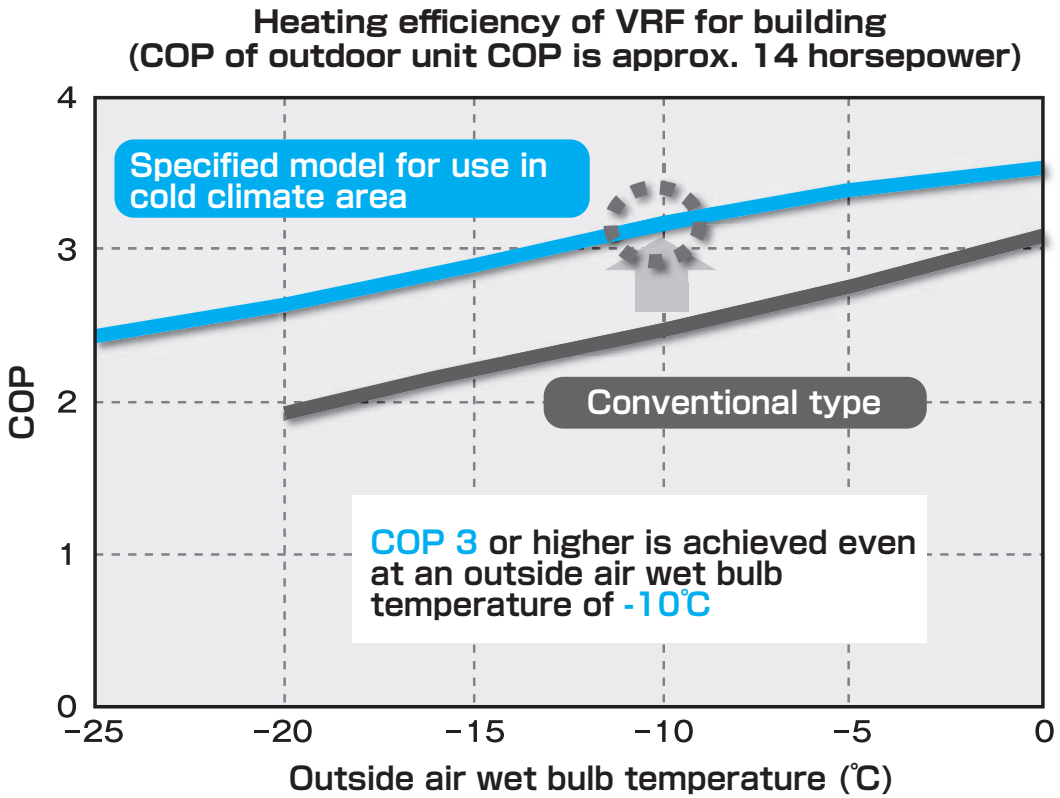
- Increase in rotation speed of compressors
- Adoption of injection circuits

↓

Ensuring of heating and hot water supply performance when outside air temperature is low

2-1-13 Efficiency of heat pumps for use in cold climate area

Air conditioners and Eco Cute can be operated even at outdoor temperature of -25℃

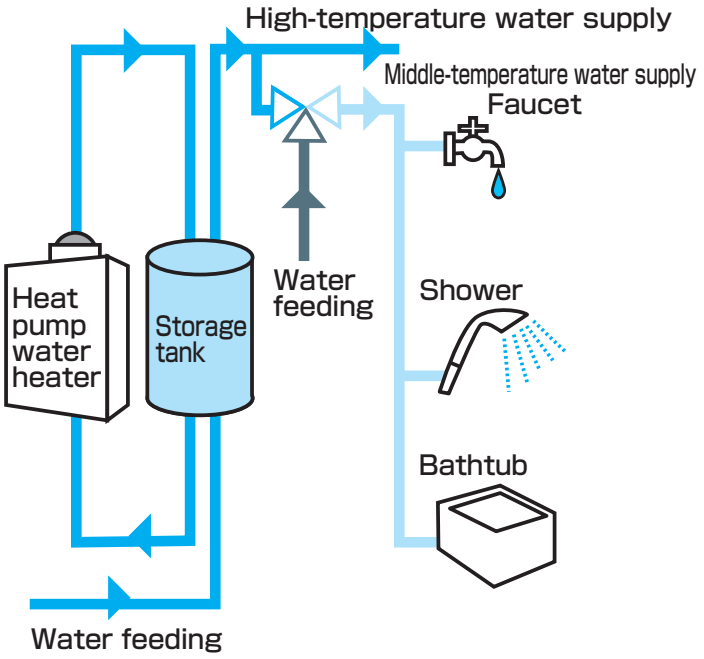


■ Source: Daikin Industries, Ltd.

2-1-14 Type of heat pump water heaters for commercial use

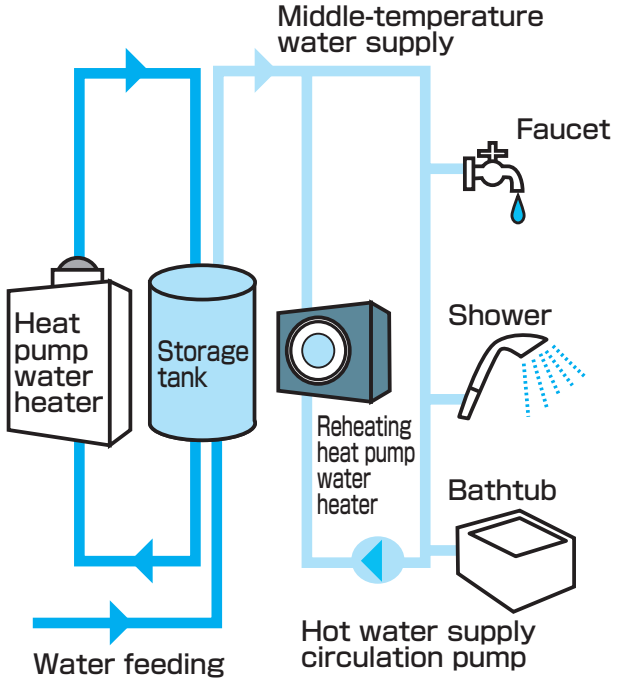
• Single pass type

For restaurants, shops and small-scale facilities



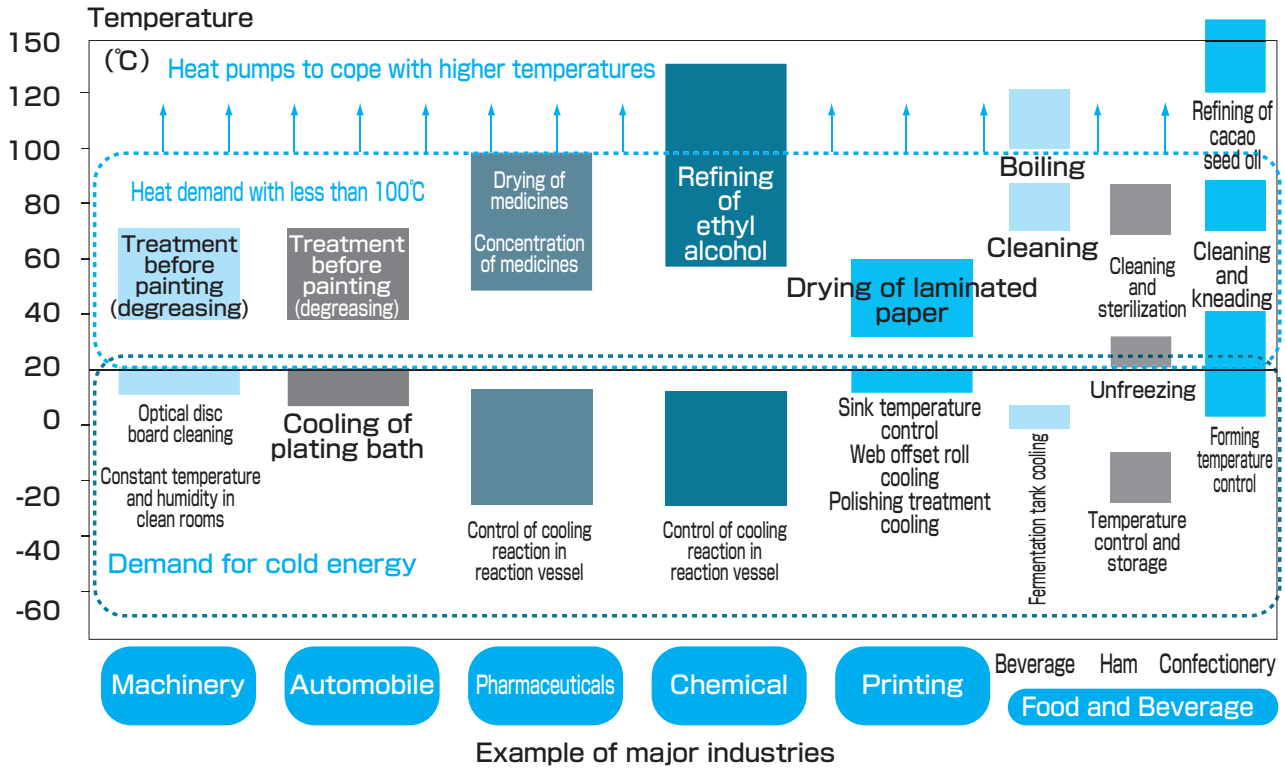
• Circulation type

This type is largely used in medium-to-large scale facilities where there are many points of hot water supply and the piping distance to faucets is long such as hospitals, hotels, etc.



2-1-15 Example of heat demand distribution in industrial sector

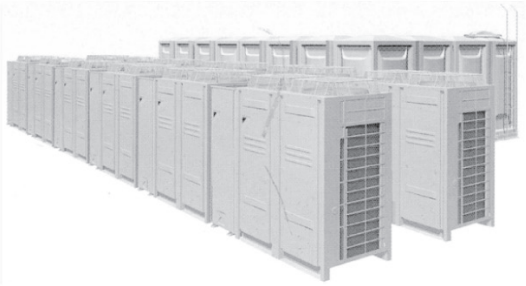
- Manufactuing processes in factories have a lot of heat demand with less than 100℃, which can be met by heat pumps.
- As each industry has demand for both heating and cooling, the use of heat recovery heat pumps is effective.



2-1-16 Increase in capacity and output at higher temperature of heat pump for industrial use

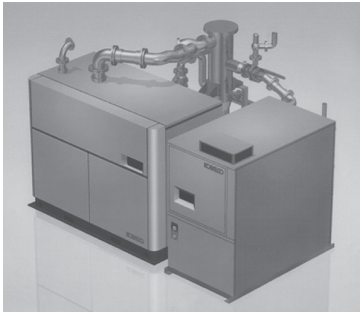
Increase in capacity

Increase in capacity of single unit



Increase in capacity by modules

Output at higher temperatures



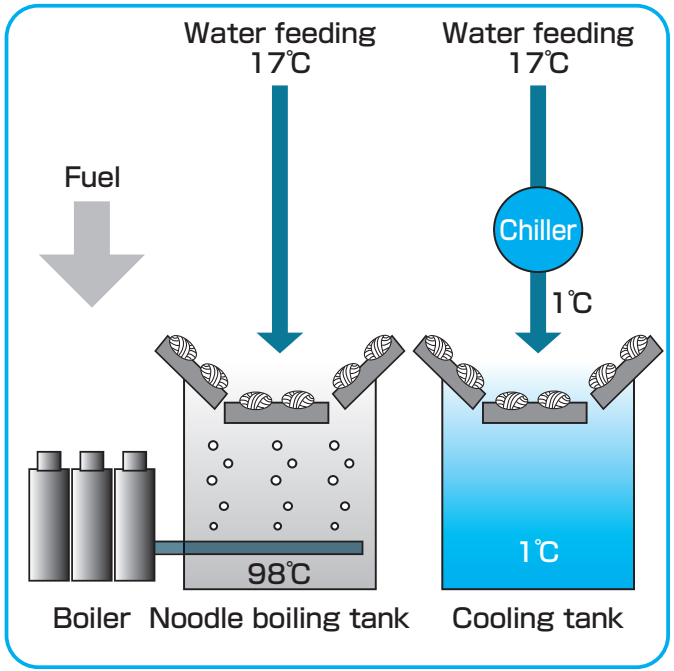
Steam generator at 165℃

Extended use in sterilization and cleansing applications and drying processes

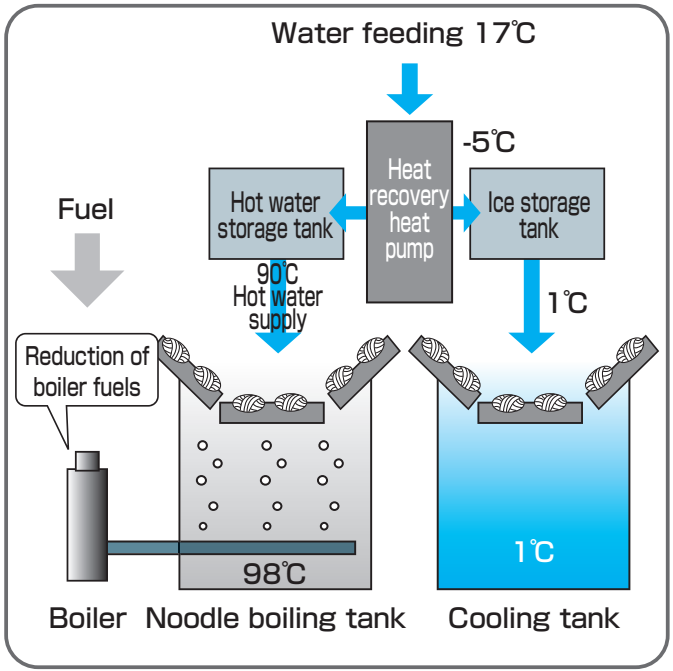
2-1-17 Heat pumps utilized in industrial sector (1) (noodle-making process)

Cold and hot energy can be supplied at the same time by using heat recovery heat pumps.

Conventional system



New system

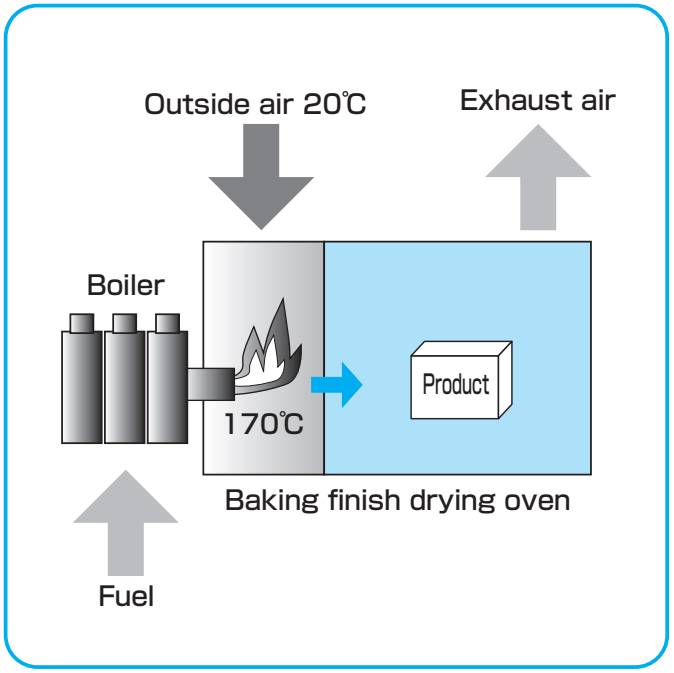


CO_2 emissions reduced by 31% and energy consumption reduced by 35% (at A noodle-making factory)

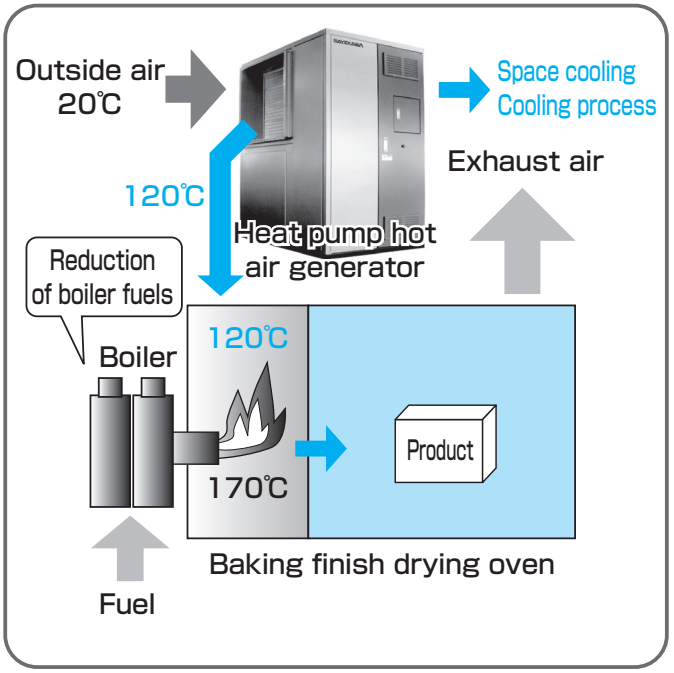
2-1-18 Heat pumps utilized in industrial sector (2) (paint drying process)

Combination of heat pump hot air generator and boiler is used for drying processes.

Conventional system



New system

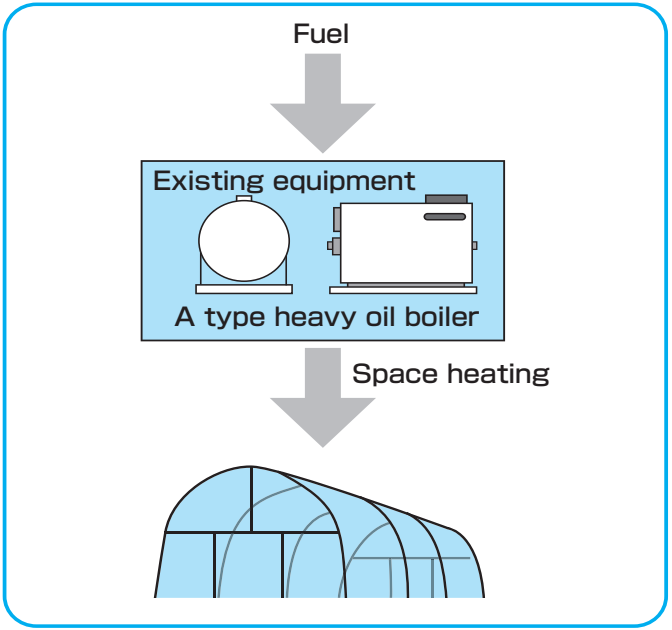


CO_2 emissions reduced by 13% and energy consumption reduced by 17% (at B factory)

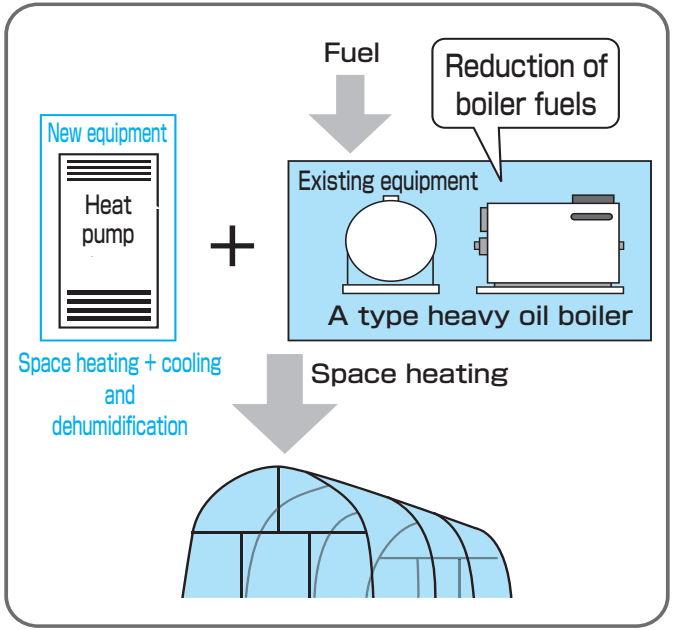
2-1-19 Heat pumps utilized in agricultural sector (protected horticulture)

The combined use of heat pumps and boilers for protected horticulture reduces the consumption of boiler fuels.
Heat pumps also contribute to stabilization of quality by making use of cooling and dehumidification functions.

Conventional system



New system



CO_2 emissions reduced by 9% and energy consumption reduced by 10% (at C rose garden)

2－2. Thermal storage system

2-2-1 What is thermal storage system?

Thermal storage system: a system to store thermal energy (chilled water, hot water, ice, etc.) that is produced during nighttime in thermal storage tanks and released during daytime

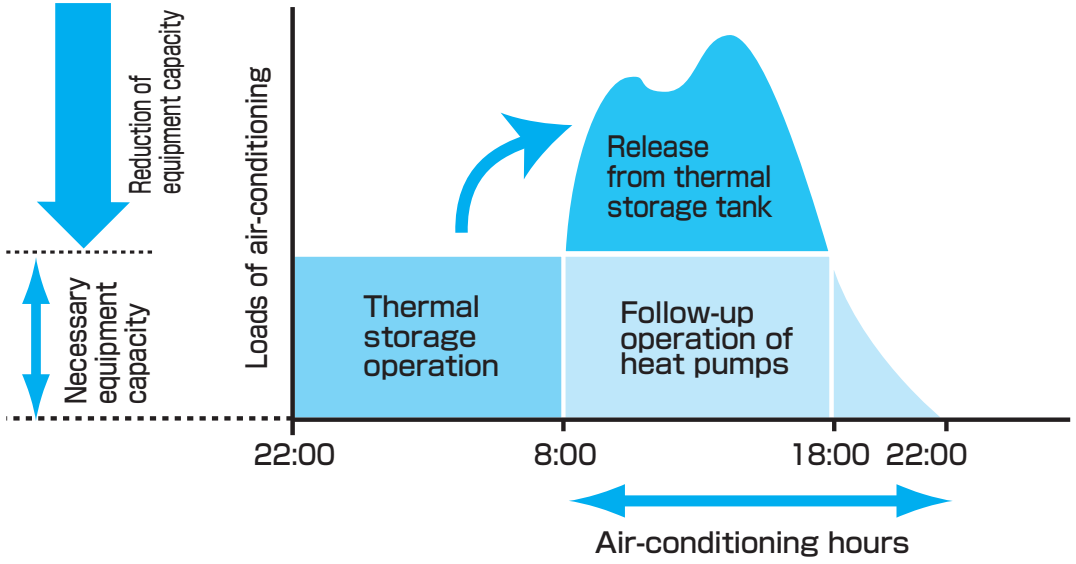
Thermal storage system

Air conditioning	・Thermal storage air-conditioning system
Hot water supply	・Heat pump water heater (Eco Cute, etc.) ・Electric water heater
Others	・Thermal storage showcase ・Process cooling for industry

2-2-2 Merits of thermal storage air-conditioning system

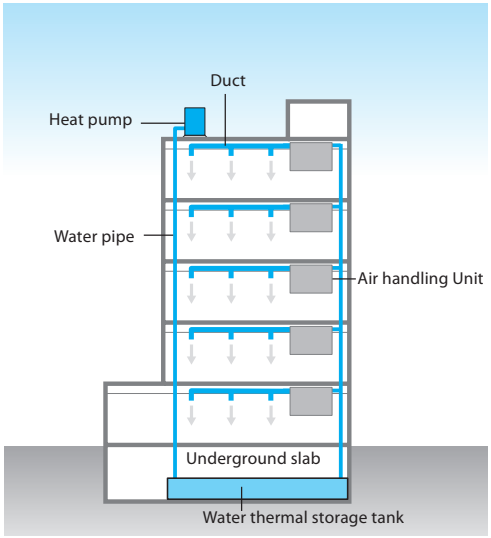
(1)Energy-saving performance: highly efficient rated operation regardless of air-conditioning loads
(2)Cost efficiency: low-cost nighttime power can be used.
(3)Electric power load leveling: as the loads in the peak hours during daytime can be shifted to nighttime, electric power demand can be leveled.

Thermal storage air-conditioning system



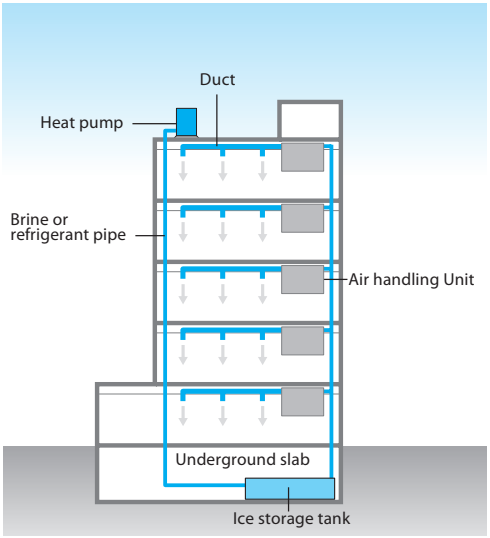
2-2-3 Types of thermal storage air-conditioning systems (1)

Water thermal storage air-conditioning system



○ Classification
Central air conditioning
○ Applicable building
Medium-to-large scale
○ Characteristics
Underground double slab space can be used as water thermal storage tank.
Water in the thermal storage tank can be used for firefighting in the event of a fire or as daily life water in the event of a disaster.

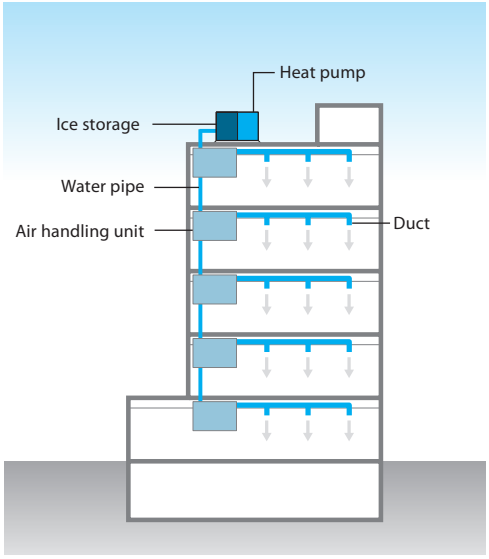
Ice storage air-conditioning system (on-site construction type)



○ Classification
Central air conditioning
○ Applicable building
Medium-to-large scale
○ Characteristics
Underground double slab space can be used as ice storage tank.
The capacity of a tank can be made smaller than that of water thermal storage.

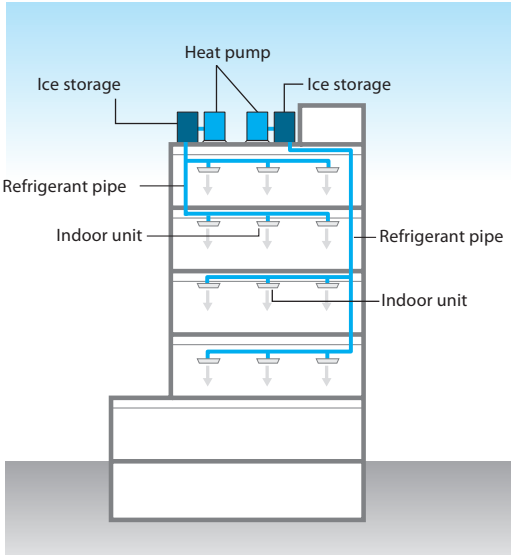
2-2-4 Types of thermal storage air-conditioning systems (2)

Ice storage air-conditioning system (unit type)



○ Classification
Central air conditioning
○ Applicable building
Medium-to-large scale
○ Characteristics
Heat pump and ice storage tank are integrated into a single unit. Installation is possible even in the case of no underground double slab space.

Ice storage air-conditioning system (VRF or packaged type)



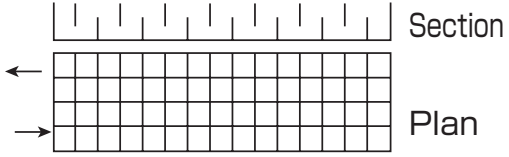
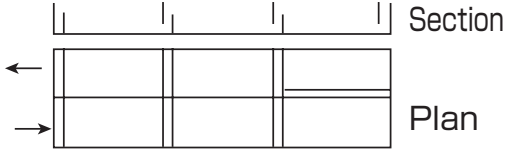
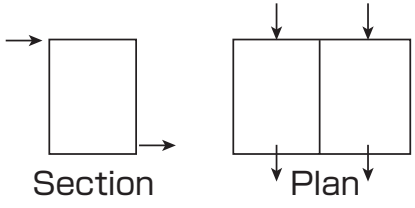
○ Classification
Decentralized air conditioning
○ Applicable building
Small-to-medium scale
○ Characteristics
VRF or packaged air conditioner is integrated with ice storage tank. They can be easily applied to renewal of air-conditioning system.

2-2-5 Comparison between water thermal storage system and ice storage system

	Water thermal storage	Ice storage
Capacity of thermal storage tank	· Volume is larger than ice storage. · Area of waterproof and thermal insulation increases when a building body is used.	· Volume can be made smaller than water thermal storage.
Heat loss	· Heat loss is larger than ice storage.	· Heat loss becomes smaller because of downsizing of volume.
Coefficient of performance (COP) of heat pump	· COP is high because of high evaporation temperature.	· COP decreases because of low evaporation temperature at the time of ice making.
Temperature of outlet chilled water	· Temperature is usually stable, but it slightly changes according to use condition.	· Temperature remains stable at 0 to 4℃ during ice melting operation regardless of the temperature of returned water. · The same characteristics as water thermal storage after completion of ice melting.
Distribution energy	· As a thermal storage tank is usually open type, pump head tends to be large. · If heat exchanger between primary and secondary equipment is installed, the actual head can be reduced.	· Large in the case of an open type ice storage tank installed underground. · Small in the case of installation on the roof or a sealed type of ice storage tank. · Distribution power can be drastically reduced by adoption of low-temperature cold wind and large temperature-difference of chilled water on the secondary system.
Cost efficiency	· Cost of heat pump equipment is low. · Cost of water proof and installation are very low.	· Cost of heat pump equipment is very high. · Cost of construction of a ice storage tank is relatively high.

2-2-6 Types of water thermal storage system

Types of representative water thermal storage tank

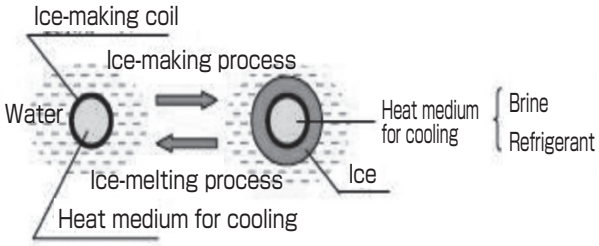
Type		Shape	Structure	Diagram (plane and elevation)
Combined fully-mixed tank		Combined tank type	・Use in double slab on the bottom	
Temperature stratification	Combined temperature stratification	Combined tank type	・Use in double slab on the bottom ・Use between floors in the machine room ・Independent structure	
Temperature stratification	Single/parallel temperature stratification	Independent type	・Use between floors in the machine room ・Independent structure	

2-2-7 Ice-making system of ice storage system

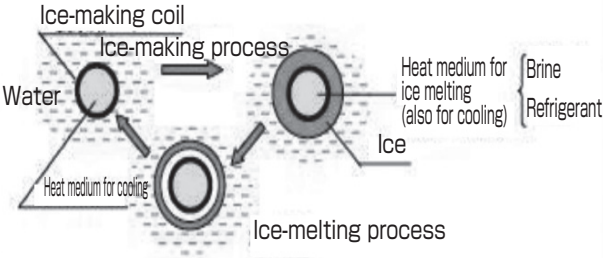
Static ice system

Ice is statically made and stored, and ice produced sticks to ice-making surface. Therefore, ice is limited to solid ice. Static ice.

Static type/external ice-melting system



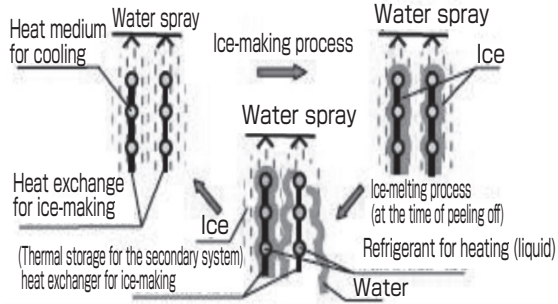
Static type/internal ice-melting system



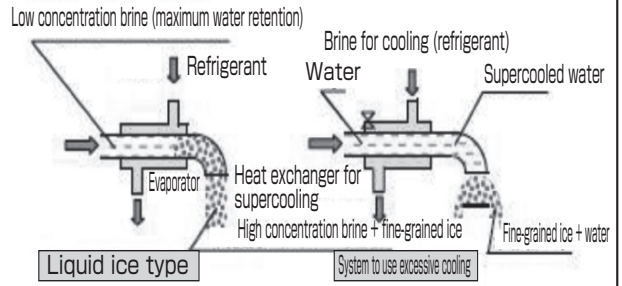
Dynamic ice system

Ice is dynamically made and stored, and ice produced is separated from ice-making surface and stored. Dynamic ice.

Dynamic type (ice release) /ice-harvesting type (ice shards)



Dynamic type (ice release)/liquid ice excessive cooling type



3. Policy and program

3－1．Japan

3-1-1 Long-term outlook for energy supply and demand

- Status quo case: Assumes that no new energy technology is introduced and equipment efficiency remains the same after 2005.
- Effort continued case: Assumes continuous efficiency improvements based on existing technology.
- Maximum introduction case: Assumes maximum dissemination of leading-edge technologies close to practical use.

(1)Final energy consumption

(Million kl in crude oil equivalent)

	FY2005		FY2020					
			Status quo case		Effort continued case		Maximum introduction case	
		Share		Share		Share		Share
Total of final consumption	413	100%	421	100%	401	100%	375	100%
Industrial	181	44%	180	43%	180	45%	177	47%
Commercial	134	32%	149	35%	134	34%	121	32%
Residential	56	14%	61	14%	56	14%	52	14%
Business, etc.	78	19%	88	21%	78	20%	68	18%
Transport	98	24%	92	22%	86	22%	78	21%

	FY2030					
	Status quo case		Effort continued case		Maximum introduction case	
		Share		Share		Share
Total of final consumption	424	100%	391	100%	346	100%
Industrial	179	42%	179	46%	174	50%
Commercial	154	36%	130	33%	103	30%
Residential	66	16%	56	14%	47	14%
Business, etc.	87	21%	74	19%	56	16%
Transport	91	22%	82	21%	69	20%

(2)Primary energy supply

(Million kl in crude oil equivalent)

	FY2005		FY2020					
			Status quo case		Effort continued case		Maximum introduction case	
Primary energy supply in Japan	588		627		596		553	
Classification by type of energy	Real value	Share	Real value	Share	Real value	Share	Real value	Share
Oil	255	43%	227	36%	215	36%	190	34%
LPG	18	3%	18	3%	18	3%	18	3%
Coal	123	21%	128	20%	120	20%	107	19%
Natural gas	88	15%	114	18%	103	17%	89	16%
Nuclear energy	69	12%	99	16%	99	17%	99	18%
Hydropower	17	3%	19	3%	19	3%	19	3%
Geothermal	1	0%	1	0%	1	0%	1	0%
New energy, etc.	16	3%	22	3%	22	4%	30	5%

	FY2030					
	Status quo case		Effort continued case		Maximum introduction case	
Primary energy supply in Japan	637		590		515	
Classification by type of energy	Real value	Share	Real value	Share	Real value	Share
Oil	220	35%	204	35%	168	33%
LPG	18	3%	18	3%	17	3%
Coal	131	21%	119	20%	92	18%
Natural gas	112	18%	94	16%	71	14%
Nuclear energy	107	17%	107	18%	107	21%
Hydropower	19	3%	19	3%	20	4%
Geothermal	1	0%	1	0%	2	0%
New energy, etc.	29	5%	29	5%	38	7%

(3)Energy related CO_2 emissions

(million t-CO_2)

	FY 1990	FY2005		FY2020					
				Status quo case		Effort continued case		Maximum introduction case	
			Growth rate from 1990		Growth rate from 1990		Growth rate from 1990		Growth rate from 1990
Total of CO_2 emissions	1,059	1,203	14%	1,199	13%	1,119	6%	981	▲ 7%
Industrial	482	455	▲ 6%	445	▲ 8%	441	▲ 9%	408	▲ 15%
Commercial	292	412	41%	426	46%	371	27%	306	5%
Residential	127	174	37%	173	36%	154	21%	132	4%
Business, etc.	164	238	45%	253	54%	218	33%	174	6%
Transport	217	257	18%	240	10%	224	3%	200	▲ 8%
Energy conversion	68	79	17%	89	31%	83	22%	66	▲ 3%
Ratio of total emissions to the 2005 level	-	-		0%		▲ 6%		▲ 16%	
Ratio of total emissions to the 1990 level	-	11%		11%		5%		▲ 6%	

	FY2030					
	Status quo case		Effort continued case		Maximum introduction case	
		Growth rate from 1990		Growth rate from 1990		Growth rate from 1990
Total of CO_2 emissions	1,193	13%	1,071	1%	836	▲ 21%
Industrial	442	▲ 8%	435	▲ 10%	382	▲ 21%
Commercial	442	51%	360	23%	235	▲ 19%
Residential	189	49%	154	22%	104	▲ 18%
Business, etc.	253	54%	206	25%	131	▲ 20%
Transport	235	8%	210	▲ 3%	173	▲ 20%
Energy conversion	75	10%	65	▲ 5%	46	▲ 33%
Ratio of total emissions to the 2005 level	▲ 1%		▲ 10%		▲ 27%	
Ratio of total emissions to the 1990 level	11%		1%		▲ 18%	

■ Source: Report of supply and demand subcommittee of Advisory Committee for Natural Resources and Energy (August 26, 2009), the website of the Ministry of Economy, Trade and Industry

3-1-2 New growth strategy

Expansion of green business by dissemination of heat pump technology highly effective in reducing CO_2 emissions was selected as a major policy [Cabinet decision, June 2010].

Strategy to become an environment and energy powerhouse through green innovation

[Targets for 2020]

"New environment-related market of more than 50 trillion yen"
"New employment of 1.4 million people in the environmental sector"
"Reduction of the world's greenhouse gas emissions by 1.3 billion tons or more by capitalizing on the technologies of Japan's private sector"

[Major policies]

- **Revolution of life styles through improvement of amenity and quality of life**
  ⇒ Zero emission from houses, offices, etc.
  Dissemination of eco-houses, expanded use of renewable energy, further dissemination of heat pumps, and 100% shift to next-generation lighting such as LED, organic EL, etc.

- **Project for rapid expansion of renewable energy use**
  ⇒ Creation of renewable energy related market of 10 trillion yen by 2020
  System to buy electricity generated by renewable energy at fixed prices, smart grid, wind power generation, utilization of heat from woody biomass, use of aerothermal (heat pump), and utilization of hot water produced from geothermal and solar heat

■ Source: Website of Prime Minister of Japan and His Cabinet

3-1-3 Energy Basic Plan (heat pumps and others)

● Expansion of renewable energy utilization (including aerothermal, geothermal, etc.)[Cabinet decision, June 2010]

- Promotion of heat pump utilization in hot water supply and air conditioning, etc. for industrial, commercial and household uses
- Promotion of research and development of next-generation heat pump systems (ultra-high efficiency heat pumps)

● ZEH (Zeronet Energy House)

ZEH is expected to become a standard for newly built houses by 2020.
The number of houses to be renovated for energy conservation is expected to double from present levels.
ZEH is expected to be realized in the average number of newly built houses by 2030.

● ZEB (Zeronet Energy Building)

ZEB is expected to be realized in newly built public buildings, etc. by 2020.
ZEB is expected to be realized in newly built public buildings as average by 2030.

● High-efficiency water heaters for household use to be introduced in almost all households except for single-person households by 2020

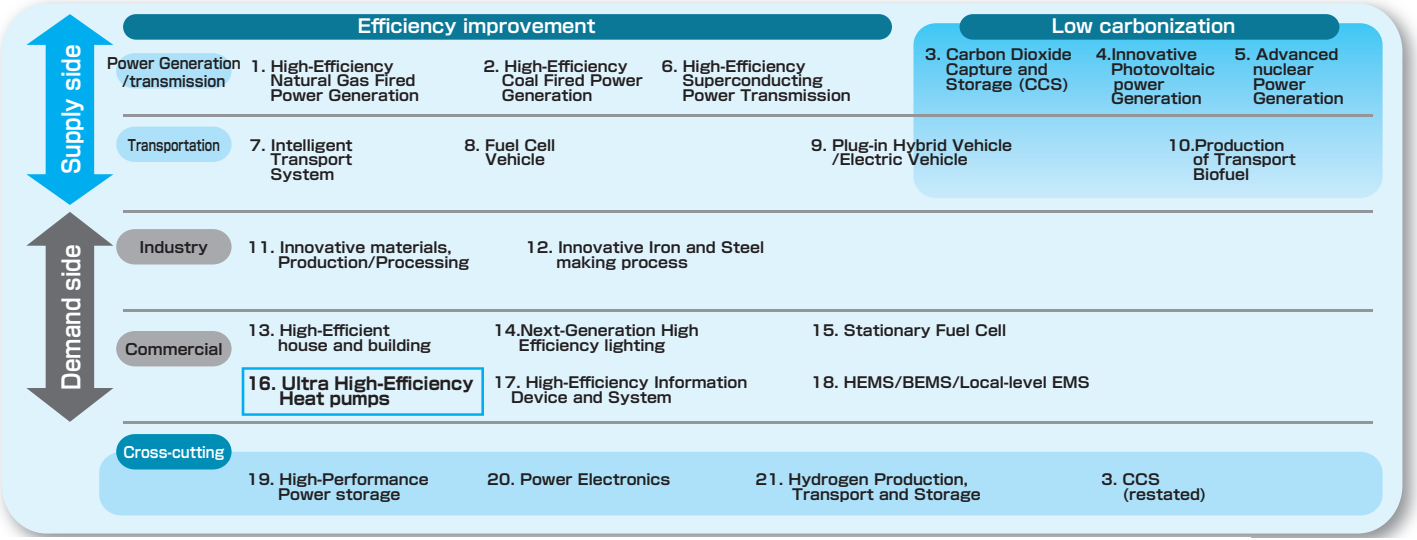
Such water heaters are expected to be introduced in 80 to 90% of all households by 2030.
The use of high-efficiency water heaters for business use will be expanded.

3-1-4 Cool Earth - Innovative Energy Technology Program

In 2007, Japanese Prime Minister announced a long-term target - "Cool Earth 50" - to halve the world's greenhouse gas emissions by 2050.
To achieve this target, "Cool Earth - Innovative Energy Technology Program" was developed (announced on March 5, 2008).
"Ultra-high efficiency heat pumps" were included in the "21" innovative technologies to be prioritized.

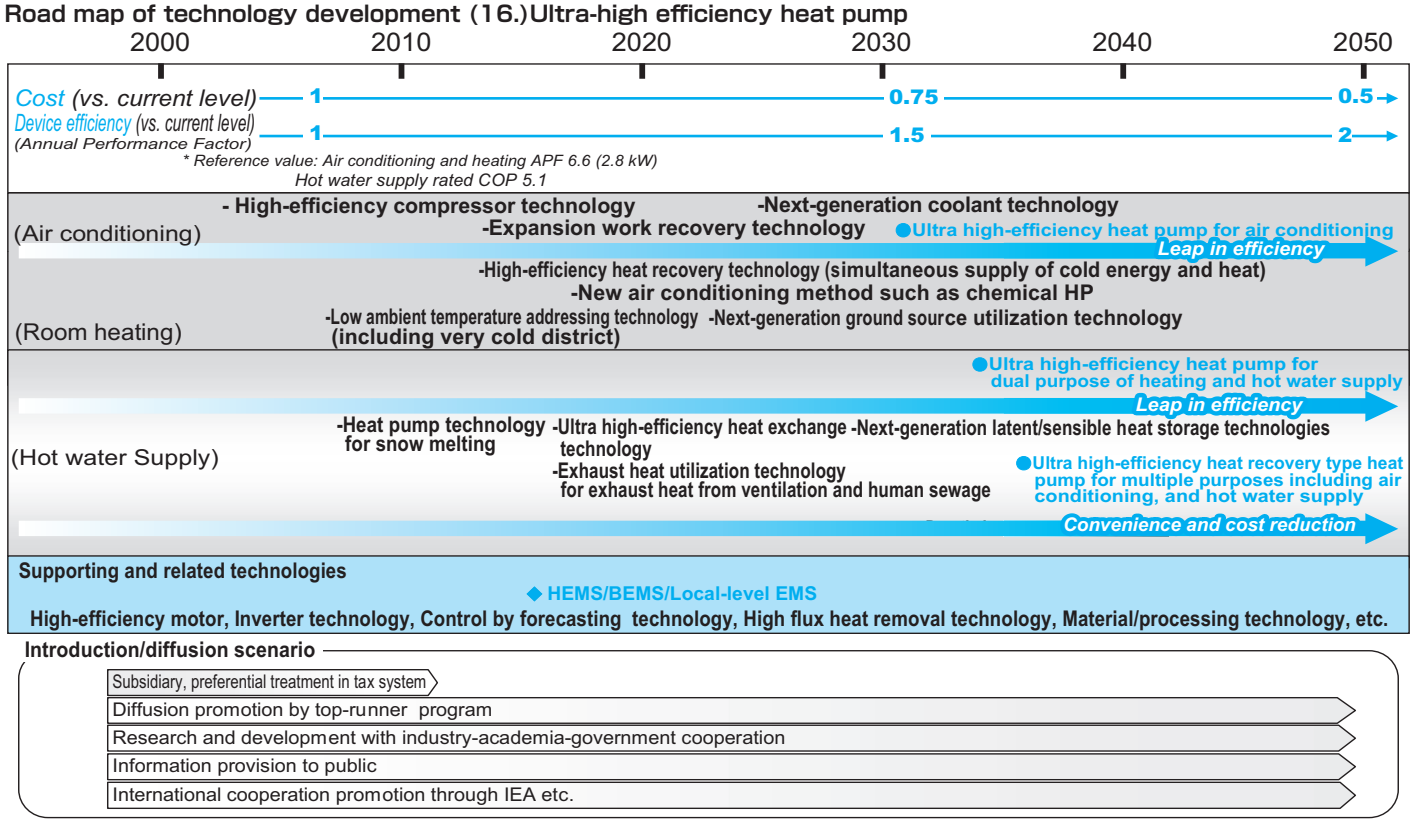
"21" Technologies to be Prioritized

"21" technologies that can drastically reduce CO_2 emissions were selected; these technologies enable both efficiency improvements and reduced carbon emissions for both the energy supply and demand streams.



■ Source: Development of "Cool Earth-Innovative Energy Technology Program," the website of the Ministry of Economy, Trade and Industry

3-1-5 Cool Earth - Innovative Energy Technology Program (ultra-high efficiency heat pump)



■ Source: Development of "Cool Earth-Innovative Energy Technology Program," the Website of the Ministry of Economy, Trade and Industry

3-1-6 Top Runner Program

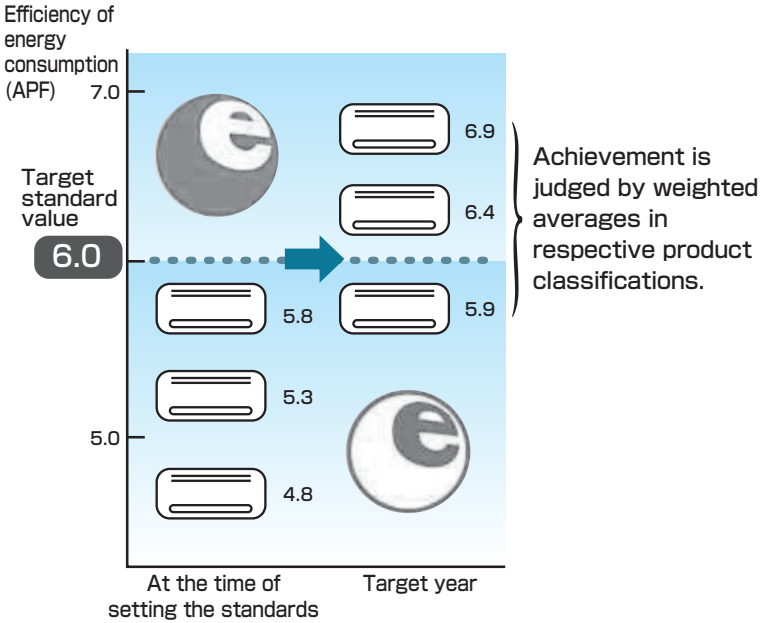
In response to the 3rd Conference of the Parties to United Nations Framework Convention on Climate Change (COP3) held in Kyoto in 1997, the law concerning the Rational Use of Energy was largely revised in 1998. The revised law was put in to effect in April 1999.
The “Top Runner Program” was adopted to increase energy efficiency in the production process of machinery and equipment to slow energy consumption increases, particularly in non-industrial and transportation sectors.

Top Runner Program:

To raise energy standards of applicable machinery and equipment to levels higher than the most efficient commercial machinery and equipment currently available.

Targeted machinery and equipment:

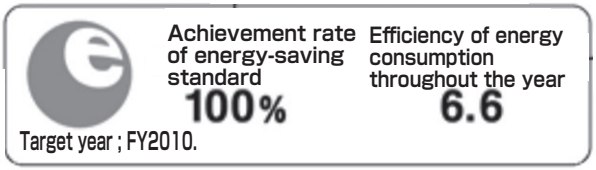
Passenger vehicles, freight vehicles, air conditioners, electric refrigerators, electric freezers, electric rice cookers, microwave ovens, lighting equipment, electric toilet seats, TV sets, video cassette recorders, DVD recorders, computers, magnetic disk units, copying machines, space heaters, gas cooking appliances, gas water heaters, oil water heaters, vending machines, transformers, routers, switching units (Total of 23 items as of March 2011)

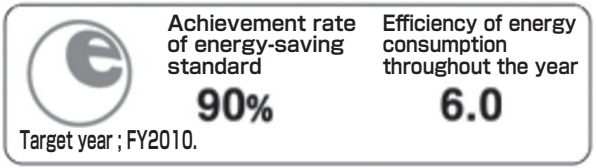


3-1-7 Energy-saving labeling program

This labeling program was introduced as JIS standard in August 2000. Labeling enables manufacturers to show the energy-saving performance of their equipment. The program covers 16 items including air conditioners, refrigerators, TV sets and fluorescent lights.

(1)Energy-saving performance mark	Products of high energy-saving performance (achievement rate of energy-saving standard is 100% or higher) are awarded green tags, and unachieved products (less than 100%) are awarded orange tags.
(2)Achievement rate of energy-saving standard	The level of achievement of target values specified for respective product classifications (Top Runner Standards = energy-saving standards) is shown by %.
(3)Efficiency of energy consumption	The amount of energy used by products - annual electricity consumption, for example - is based on the measuring methods specified for respective product classifications.
(4)Target year	Target years are the timing of achievement of energy-saving standards, and are set for respective products.





[New target year, target values and name of classification]

(Products in target year FY2010)

(The values in the table represent APF target standards revised in June 2009.)

Cooling capacity		~3.2kW	~4.0kW	~5.0kW	~6.3kW	~7.1kW	~28.0kW
Wall-mounted type	Regulated size	5.8(A)	4.9(C)	5.5(E)	5.0(F)	4.5(G)	
	Free size	6.6(B)	6.0(D)				

(Products in target year FY2010)

Cooling capacity	~3.2kW	~4.0kW	~5.0kW	~6.3kW	~7.1kW	~28.0kW
Those other than wall-mounted type	5.2(H)	4.8(I)	4.3(J)			
Multi-type	5.4(K)		5.4(L)			5.4(M)

■ Source: Website of Agency for Natural Resources and Energy

3-1-8 Label Display Program for Retailers Uniform (unified energy-saving label)

This program was enforced in October 2006 to allow retailers to show specific information about energy conservation of products. Labels are indicated on air conditioners, TV sets, electric refrigerators, electric toilet seats and fluorescent lights (for household use).

Check points of "uniform energy-saving label"

Multi-stage evaluation system

The standards for multi-stage evaluation are decided in accordance with the situation of achievement of energy-conservation standards for products now on the market, and it is the system to show energy-saving performance rated on a scale of one star to five stars. Those products of highest energy-saving performance are given five stars and that of least energy-saving performance are given one star.

Air conditioner	
Multistage rating system	Achievement rate of energy-saving standards
★★★★★	109% or higher
★★★★	100% or higher to less than 109%
★★★	90% or higher to less than 100%
★★	80% or higher to less than 90%
★	Less than 80%

The unified energy-saving label can be downloaded from the "website of information about energy-saving type products."
http://www.eccj.or.jp/cgi-bin/real-catalog/index.php

■ Source: Website of Agency for Natural Resources and Energy

3－2. Overseas

3-2-1 EU RES-Directive and Heat pumps

Heat Pumps As Renewable Energy Source

～ EU RES-Directive and Heat pumps ～

Heat pumps use renewable energy sources, namely energy found in the air (aerothermal), ground (geothermal), and water (hydrothermal). In the EU RES-Directive, the European Commission and Parliament documents measures for promoting the use of renewable energy resources (2009/28/EC) .

EU RES-Directive (approved in April 2009)

Renewable energy sources covered by Directive

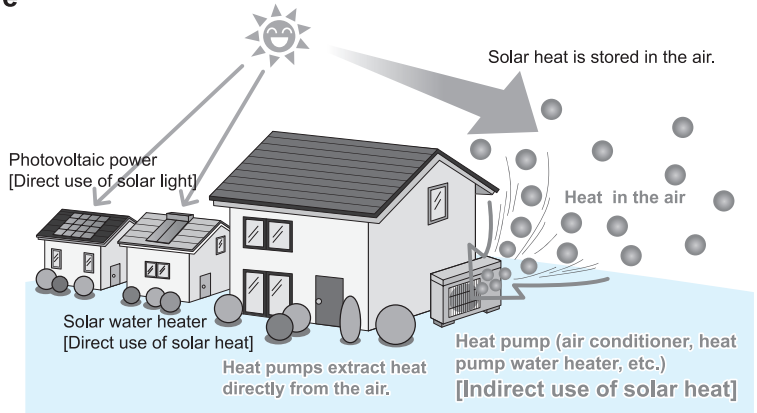
- **Wind**
- **Solar energy**
- **Geothermal energy**
- **Aerothermal energy**
- **Hydrothermal energy**
- **Ocean energy**
- **Hydropower**
- **Biomass**
- **Landfill & Sewage treatment plant gas**
- **Biogass**

"aerothermal energy" = heat in the ambient air

"geothermal energy" = heat beneath the surface of solid earth

"hydrothermal energy" = heat in surface water

Heat pumps, as well as PV or Solar water heater, utilize Solar energy.



$$ERES^{*1} = Qusable^{*2} \times (1 - 1/SPF^{*3})$$

*1 Amount of ambient energy captured by heat pumps to be considered renewable energy
*2 Estimated total usable heat delivered by heat pumps
*3 Estimated average seasonal performance factor for those heat pumps

3-2-2 Targets of introduction of renewable energy in Europe

Ratio of renewable energy to final energy consumption

	2006	2007	2008	Target in 2020
EU27	8.8%	9.7%	10.3%	20.0%
Sweden	42.7%	44.2%	44.4%	49.0%
Finland	29.2%	28.9%	30.5%	38.0%
Latvia	31.3%	29.7%	29.9%	40.0%
Austria	24.8%	26.6%	28.5%	34.0%
Portugal	20.5%	22.2%	23.2%	31.0%
Romania	17.5%	18.7%	20.4%	24.0%
Estonia	16.1%	17.1%	19.1%	25.0%
Denmark	16.8%	18.1%	18.8%	30.0%
Lithuania	14.7%	14.2%	15.3%	23.0%
Slovenia	15.5%	15.6%	15.1%	25.0%
France	9.6%	10.2%	11.0%	23.0%
Spain	9.1%	9.6%	10.7%	20.0%
Bulgaria	9.3%	9.1%	9.4%	16.0%
Germany	6.9%	9.0%	8.9%	18.0%
Slovakia	6.2%	7.4%	8.4%	14.0%
Greece	7.2%	8.1%	8.0%	18.0%
Poland	7.4%	7.4%	7.9%	15.0%
Czech Republic	6.4%	7.3%	7.2%	13.0%
Italy	5.3%	5.2%	6.8%	17.0%
Hungary	5.1%	6.0%	6.6%	13.0%
Cyprus	2.5%	3.1%	4.1%	13.0%
Ireland	3.0%	3.4%	3.8%	16.0%
Belgium	2.7%	3.0%	3.3%	13.0%
Netherlands	2.5%	3.0%	3.2%	14.0%
U.K.	1.5%	1.7%	2.2%	15.0%
Luxembourg	0.9%	2.0%	2.1%	11.0%
Malta	0.1%	0.2%	0.2%	10.0%

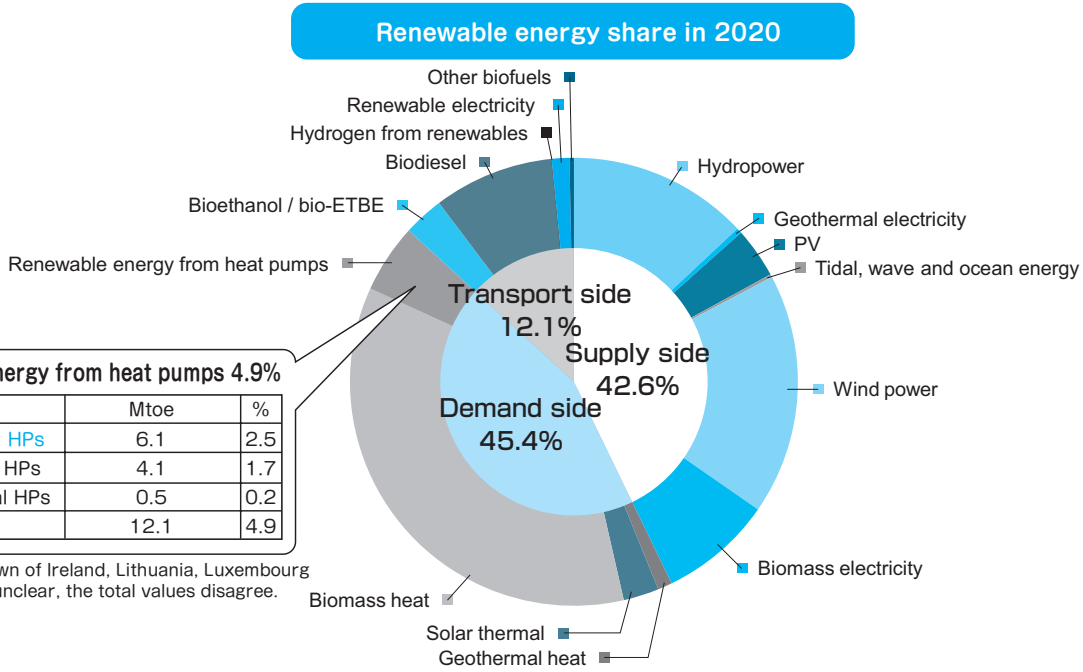
*French overseas provinces (French Guiana, Guadeloupe, Martinique and Reunion) are excluded.

■ Source: Eurostar newslerase 30/2010

3-2-3 Renewable energy introduction plan and heat pumps in EU

European Environment Agency (EEA) announced its renewable energy introduction action plan in February 2011.

EU has declared a target to increase the ratio of renewable energy to total energy consumption to 20% by 2020.
Renewable energy from heat pumps in 2020 will be 4.9% - much higher than 2.9% of PV.
The share of air-source heat pumps to be introduced will be high.



Renewable energy from heat pumps 4.9%

	Mtoe	%
Aerothermal HPs	6.1	2.5
Geothermal HPs	4.1	1.7
Hydrothermal HPs	0.5	0.2
Total	12.1	4.9

*As the breakdown of Ireland, Lithuania, Luxembourg and Finland is unclear, the total values disagree.

■ Source: “Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States,” EEA

3-2-4 Greenhouse gas emissions reduction targets of Copenhagen Agreement (COP15) (Annex I Parties)

Quantified economy-wide emissions targets for 2020

Annex I Parties	Quantified economy-wide emissions targets for 2020	
	Emissions reduction in 2020	Base year
Japan	25% reduction, which is premised on the establishment of a fair and effective international framework in which all major economies participate and on agreement by those economies on ambitious targets.	1990
United States of America	In the range of 17%, in conformity with anticipated U.S. energy and climate legislation, recognizing that the final target will be reported to the Secretariat in light of enacted legislation. The pathway set forth in pending legislation would entail a 30% reduction in 2025 and a 42% reduction in 2030, in line with the goal to reduce emissions 83% by 2050.	2005
Russian Federation	15-25 % The range of the GHG emission reductions will depend on the following conditions: - Appropriate accounting of the potential of Russia's forestry in meeting the obligations of the anthropogenic emissions reduction; - Undertaking by all major emitters the legally binding obligations to reduce anthropogenic GHG emissions.	1990
Australia	-5% up to -15% or -25% Australia will reduce its greenhouse gas emissions by 25% on 2000 levels by 2020 if the world agrees to an ambitious global deal capable of stabilising levels of greenhouse gases in the atmosphere at 450 ppm CO2-eq or lower. Australia will unconditionally reduce emissions by 5% below 2000 levels by 2020, and by up to 15% by 2020 if there is a global agreement which falls short of securing atmospheric stabilisation at 450 ppm CO2-eq and under which major developing economies commit to substantially restrain emissions and advanced economies take on commitments comparable to Australia's.	2000
EU*1 and its Member States (Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom) acting in common	20%/30% As part of a global and comprehensive agreement for the period beyond 2012, the EU reiterates its conditional offer to move to a 30% reduction by 2020 compared to 1990 levels, provided that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities.	1990

*1 Currently, not all EU Member States are Annex I Parties

3-2-5 Greenhouse gas emissions reduction targets of Copenhagen Agreement (COP15) (Non-Annex I Parties)

Nationally appropriate mitigation actions for Non-Annex I Parties.

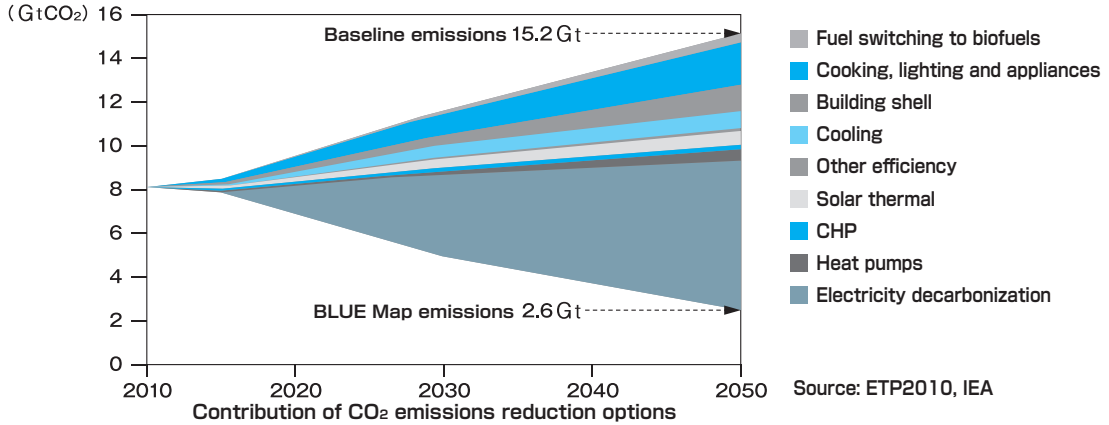
Non-Annex I Parties	Actions
China	China plans to reduce CO_2 emissions per GDP in 2020 by 40 to 45% from the 2005 level, increase the ratio of non-fossil energy by 5% by 2020, increase its forest area by 40 million hectares from the 2005 level by 2020, etc. These are voluntary actions.
India	India plans to reduce CO_2 emissions per GDP by 20 to 25% (excluding the agricultural sector) from the 2005 level by 2020. This plan is voluntary and is not legally binding.
Brazil	Brazil plans to reduce emissions by 36.1 to 38.9% from BAU. Specifically, Brazil plans to prevent deterioration of tropical rain forests and cerrado (a type of vegetation pattern in savannas), recover granaries, improve energy efficiency, increase biofuels and hydroelectric power generation, promote alternative energy and improve the steel industry and others.
South Africa	South Africa plans to reduce emissions by 34% from BAU by 2020 and 42% from BAU by 2025. As these actions need support of technology, funds and capacity building from advanced countries, it is necessary to reach an ambitious, fair, effective and binding agreement at the meeting in Mexico under a convention and a protocol. If such capacity building support is provided, emissions in Africa peak out in the period from 2020 to 2025, stabilize for about ten years and then start to decrease.
South Korea	South Korea plans to reduce emissions by 30% by 2020 on business as usual case.
Mexico	Mexico plans to reduce greenhouse gas emissions by 30% from BAU by 2020 on the assumption that sufficient funds and technical assistance are provided by advanced countries as part of a worldwide agreement. Mexico adopted a special climate change program in 2009, including appropriate actions for reduction and adaptation in all sectors. With safe implementation of this program, emissions can be reduced by 51 million tons (in CO_2 equivalent) from BAU by 2012.
Singapore	Singapore plans to reduce emissions by 16% from BAU by 2020, though it depends on a legally binding worldwide agreement as country-specific reduction actions. Singapore also implements its “Sustainable Singapore Plan” that was announced in April 2009.
Indonesia	Indonesia plans to reduce emissions by 26% from BAU by 2020. As specific actions, Indonesia plans to manage wetlands, decrease the pace of forest reduction, foster carbon capture by forests and agricultural land, improve energy efficiency, develop alternative energy, reduce solid and liquid waste generation, and shift to low-carbon-emission traffic.

Effect of CO_2 emissions reduction with heat pumps

ETP2010 (Energy Technology Perspectives 2010) states that the synergistic effect of decarbonization in the power generation sector and the efficiency improvement of energy consumption by using heat pump equipment and others on the demand side makes a significant contribution to CO_2 reduction.

[Building sector] Big reductions in CO_2 emissions are expected in space cooling, space heating and hot water supply.

· Heat pump is a low-cost energy-saving technology now available.



Source: ETP2010, IEA

Contribution of CO_2 emissions reduction options

[Industrial sector] Heat pumps are expected to be alternatives to boilers.

· Heat pumps with larger capacity and higher temperature will lead to replacement of boilers.

■ What is ETP2010 (Energy Technology Perspective 2010)?

· At the G8 Gleneagles Summit in 2005, the G8 leaders asked IEA (International Energy Agency) for advice about scenarios and strategies for the future of energy.
· "Energy Technology Perspectives" is a report to respond to the request of G8. Based on analyses of two or more scenarios (on measures, emissions reductions and costs), the report is followed by road maps for core technologies concerning the roles of necessary technologies to be developed.
· Following ETP2006 and ETP2008, this report (ETP2010) is the third edition.

3-2-7 Position of heat pump in renewable energy (Germany)

In Germany, the "Renewable Energies Heat Act" (enforced in January 2009) made it mandatory for new buildings to introduce heat (for heating, hot water supply, etc.) generated by renewable energy, including heat pump utilization.

■ Classification of renewable energy by the German Ministry of Environment

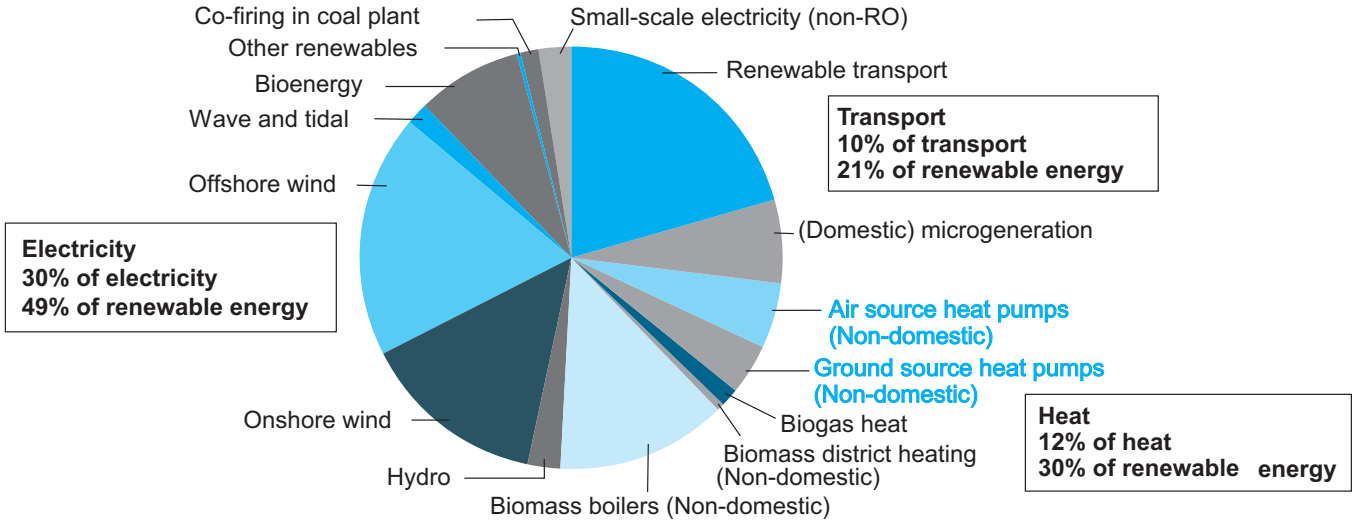
Primary energy source	Manifestation	Energy conversion		Secondary energy
		Natural	Technical	
SUN	Biomass	Biomass production	Cogeneration plant / Conversion plant	Heat, electricity, fuel
	Hydropower	Evaporation, precipitation, melting	Hydropower plant	Electricity
	Wind power	Atmospheric motion	Wind turbine	Electricity
		Wave motion	Wave power station	Electricity
	Solar radiation	Ocean currents	Ocean current power station	Electricity
		Heating of Earth's surface and atmosphere	Heat pumps	Heat
			Ocean thermal energy conversion	Electricity
		Solar radiation	Photolysis	Fuel
			Solar cell, Photovoltaic power station	Electricity
			Solar cell, Solar-thermal power station	Heat, electricity
MOON	Gravity	Tides	Tidal power station	Electricity
EARTH	Mainly Isotope decay	Geothermal	Geothermal cogeneration plant	Heat, electricity

■ Source: "Renewable Energies-Innovations for a Sustainable Energy Future (2009)," the German Ministry of Environment

3-2-8 Position of heat pump in renewable energy (U.K.)

The U.K. government has worked out an action plan for the power generation, heat and transportation sectors with the aim of increasing the ratio of renewable energy to be introduced to 15% by 2020 (The U.K. Renewable Energy Strategy (July 2009)).
The plan expects heat pumps to be introduced.

Illustrative mix of technologies in lead scenario to 2020



■ Source: The U.K. Renewable Energy Strategy

3-2-9 Federal Tax Credits for Consumer Energy Efficiency (U.S.)

Federal Tax Credits for Consumer Energy Efficiency

Purchasers of highly efficient space heating, cooling, and water heating equipment can receive tax credits, as detailed below.

Qualifying products	Air source heat pumps	Central air conditioning (CAC)	Electric heat pump water heater	Geothermal heat pumps
Tax Credit	$300			30% of cost with no upper limit
Expires	December 31, 2011			December 31, 2016
Requirements	Split Systems: HSPF ≥ 8.5 EER ≥ 12.5 SEER ≥ 15 Package systems: HSPF ≥ 8 EER ≥ 12 SEER ≥ 14	Split Systems: SEER ≥ 16 EER ≥ 13 Package systems: SEER ≥ 14 EER ≥ 12	Energy Factor* ≥ 2.0	Closed Loop: EER ≥ 14.1 COP ≥ 3.3 Open Loop: EER ≥ 16.2 COP ≥ 3.6 Direct Expansion: EER ≥ 15 COP ≥ 3.5
Details	Must be an existing home & your principal residence. New construction and rentals do not qualify.			Existing homes & new construction qualify. Both principal residences and second homes qualify. Rentals do not qualify. Tax Credit includes installation costs.

* Energy Factor is the measure of overall efficiency for a variety of appliances. For water heaters, there are three factors: 1) the recovery efficiency, or how efficiently the heat from the energy source is transferred to the water; 2) stand-by losses, or the percentage of heat lost per hour from the stored water compared to the content of the water: and 3) cycling losses.

3-2-10 Incentive program for renewable heat utilization (U.K. and Australia)

<U.K.>

Renewable Heat Incentive (RHI)

○An incentive program to refund money to owners of equipment that use renewable heat in proportion to the quantity of heat produced.

○This program is slated to start in July 2011.

Outline of this program

1. RHI tariffs from 2011 for the non-domestic sectors will be;
   - Ground and water source heat pumps
   - RHI payments to be claimed by, and paid to, the owner of the heat installation.
   - Eligible heat pumps will be required to have a COP of 2.9 or above.
2. Auxiliary equipment such as heat exchanger, radiator, etc. will be covered.
3. Levels of support
   - Ground-source HP, Water-source HP < 100kWth, 4.3 pence/kWh, 20yrs, Metering
   - Ground-source HP, Water-source HP ≥ 100kWth, 3 pence/kWh, 20yrs, Metering

■Source: Renewable Heat Incentive (Department of Energy and Climate Change)

<Australia>

Renewable Energy Certificates (REC)

Under the Australian Government's Renewable Energy Target, new heat pump water heaters may be eligible to create renewable energy certificates (REC). The REC's benefit for consumers is usually a point of sale discount.

Renewable Energy Bonus Scheme

-The rebate encourages households to reduce their emissions by installing a heat pump hot water system and is in addition to the Australian Government's other incentive of RECs.

-The Rebate provides eligible applicants with a rebate of $600 for installation of an eligible heat pump hot water system.

■Source: Renewable Energy Bonus Scheme – solar hot water rebate guidelines and application form (Department of Climate Change and Energy Efficiency)

3-2-11 ENERGYWISE™ funding (New Zealand)

<New Zealand>

Funding for clean efficient heating

Under the Warm Up New Zealand: Heat Smart programme, homeowners can get up to NZ$500(NZD) funding towards the cost of installing a clean efficient heater in their primary living area if there isn't one there already, their home is insulated and was built before 2000. The types of clean heating products covered are approved ENERGY STAR®* heat pumps, wood burners and pellet fires, etc.

* ENERGY STAR is the global mark of energy efficiency, typically awarded to the top 25% most energy efficient products by category. In the programme multi-split and ducted heat pump or gas systems are not eligible for funding.

Funding for solar and heat pump water heating

EECA is now offering a $575(NZD) grant towards installing a heat-pump water heater. To be eligible for ENERGYWISE™ funding for a heat pump water heater, the following criteria have to be met:

- You have to choose from a list of eligible systems.
- The system must be installed in the house you live in most of the time (not a business or holiday home).
- It must have a building consent if that's required in your area.
- A licensed plumber must install the system.
- The system must be installed before 30 June 2013.
- Cash-back grants can only be paid to homeowners – not landlords, builders, or developers.
- The installed system must be new and not second-hand or reconditioned.
- No other EECA grant can be paid for a water-heating system at the same property.

■ Source: ENERGYWISE™ funding (The Energy Efficiency and Conservation Authority)

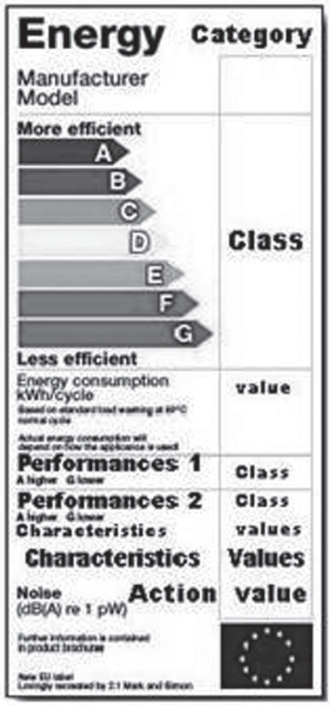
3-2-12 Assistance systems for heat pump introduction in Europe

Country	Contents
Belgium	Geothermal heat pumps are eligible for tax reduction (new buildings). Tax reduction on investments for boiler replacement also covers heat pumps (all types). In all cases, the tax reduction rate is 40% (maximum 2770 Euro); the seasonal performance factor must be minimum 3.
Finland	Heat pump installations qualify for the tax reduction scheme that applies to renovation and extension works in private households. Up to 60% of the labour costs related to renovation and extension may be deducted by each owner of a private property. The maximum amount for each owner is 3000 Euro.
France	The subsidy is offered by means of tax reduction that varies depending of the year of purchase and type of heat pump. In 2010, 25% of the ASHP costs are deductible, whereas 40% for GSHP not only for heat pump costs but also labour costs.
Germany	Market Incentive Program (MAP) introduced in 1999 which offered government grants for the commercialization and deployment of renewable energy systems incorporates heat pumps since 2008. To access the fund it is obligatory to verify a minimum SPF, depending on the type of heat pump. According to the new rules of July 2010 the SPF of air/water heat pumps has to reach at least 3,7 ; for ground-coupled a minimum of 4,3 is required.
Hungary	The heat pump installations qualify for a subsidy that applies to new constructions and renovations of private households. Up to 35% of the total investment related to new construction and renovation can be applied. The maximum amount of the subsidy for each owner has a ceiling of 5000 Euro. For commercial buildings the subsidy rate could be 30%. The new support plan for renewable energy ("Széchenyi Plan") starts in 2011.
Italy	Tax incentive is available. 55% of the total cost (equipment and installation) of heat pumps can be deducted from income revenue in similar installments over a 5 year period. Heat pumps must meet certain minimum of COP and EER. i.e. for air/air; COP of 3.9 and EER of 3.4, for brine/air; COP of 4.3 and EER of 4.4, for water/water COP of 5.1 and EER of 5.1
Norway	There is a public company to support renewable energy and energy efficiency established by Government and it gives a subsidy of 1100 Euro for private households who install a ground source or air-to-water heat pump system. There are no subsidies for air-to-air heat pumps. For commercial buildings and industrial heat pumps, financial support with a limitation on return on investment is available.
Sweden	Heat pump installations qualify for the tax reduction scheme that applies to renovation and extension works in private households. Up to 50% of the labour costs related to renovation and extension may be deducted by each owner of a private property.
U.K.	Renewable Heat Incentive (refer to 3.2.8)

■ Source: EHPA Outlook 2010

3-2-13 Labeling program (Europe)

The European Commission issued EU Directive (2002/31/EC) on energy labeling of household air conditioners in March 2002. EU member countries shall introduce the EU Directive in their domestic laws. The efficiency of energy consumption is classified into seven stages from A to G.



Classification of energy efficiency of household air conditioners (split type) (less than 12 kW)

	A	B	C	D	E	F	G
Heating (COP) (W/W)	＞3.6	3.4-3.6	3.2-3.4	2.8-3.2	2.6-2.8	2.4-2.6	＜2.4
Cooling (EER) (W/W)	＞3.2	3.0-3.2	2.8-3.0	2.6-2.8	2.4-2.6	2.2-2.4	＜2.2

* COP (coefficient of performance) = heating capacity (kW) / rated power consumption (kW)
COP and EER are synonyms (no unit of quantity required).

3-2-14 Labeling program (U.S.)

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. The program's initial target was the labeling of computers and monitors. At present, the program covers heating and cooling systems, appliances and industrial facilities, etc.

* Japan adopted the program for OA equipment in 1995.
The program is also adopted in Australia, Canada, New Zealand, Taiwan and EU.

Since January 1, 2009

Energy efficiency standards for air-source heat pumps and central air conditioners for household use			
	SEER	EER (Btu/kW)	HSPF (heat pump only)
Split type	≧14.5	≧12	≧8.2
Packaged type	≧14	≧11	≧8.0

* SEER (seasonal energy efficiency ratio) = the total amount of cooling (Btu) by air conditioners in a usage period in a typical year is divided by the amount of electricity (Wh) inputted during the period.
* EER (energy efficiency ratio) = cooling capacity (Btu) / rated power consumption (kW)
* HSPF (heating seasonal performance factor) = the total amount of heating (Btu) by heat pumps in a usage period in a typical year is divided by the amount of electricity (Wh) inputted during the period (* 1 Btu = 1,055.06 J).

3-2-15 Labeling program (China)

It became mandatory in 2005 for the products registered in the "list of products subject to energy efficiency labeling" to put the unified label at the designated places. Moreover, the efficiency of energy consumption is classified into Class 1 to Class 3 for household air conditioners. And products of lower than Class 3 are not allowed to be produced, sold or imported.

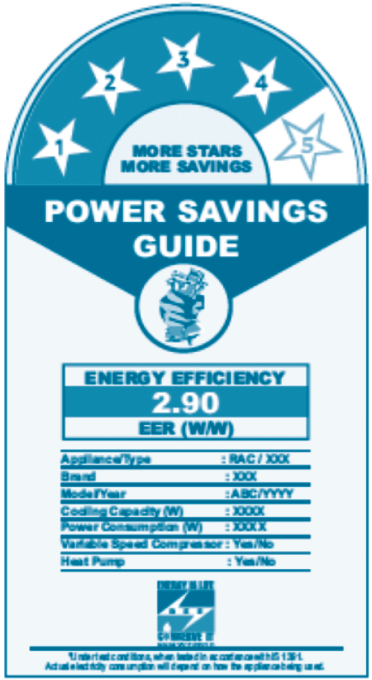
Boundary values of split-type air conditioners with a cooling capacity of 4.5 kW

Class	2004 standard (EER)	Class	2010 standard (EER)
		Class 1	3.6
Class 1	3.4	Class 2	3.4
Class 2	3.2	Class 3	3.2
Class 3	3.0		
Class 4	2.8		
Class 5	2.6		

*EER (energy efficiency ratio) = cooling capacity (Btu) / rated power consumption (kW)

3-2-16 Labeling program (India)

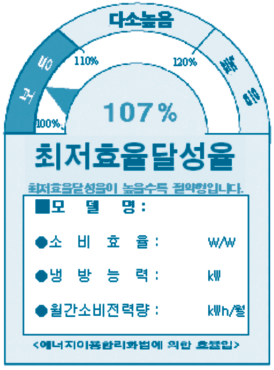
Efficiency evaluation of air conditioners by Bureau of Energy Efficiency



- The labeling program rates ACs from 1 to 5 stars based on efficiency.
- Air conditioners with a capacity of 3 TR or lower are applicable (1TR = 12,000 Btu).
- Window type and split type are applicable.
- Multi-type for building is not applicable.

3-2-17 Labeling program (South Korea)

New energy-saving labeling program started in 2008.



Level	"Non-ducted and ducted unitary (Including window type) "	Split type, RCC < 4kW
1	3.20 ≤ R	4.00 ≤ R
2	2.90 ≤ R < 3.20	3.60 ≤ R < 4.00
3	2.60 ≤ R < 2.90	3.20 ≤ R < 3.60
4	2.30 ≤ R < 2.60	2.80 ≤ R < 3.20
5	2.00 ≤ R < 2.30	2.40 ≤ R < 2.80

$$R = \frac{\text{Cooling EER(CEER)} + \text{Heating EER(HEER)}}{2}$$

Targeted products: refrigerators, freezers, Kimuchi refrigerators, air conditioners, washing machines, drum-type washing machines, dish washers, dish dryers, rice cookers, vacuum cleaners, electric fans, air cleaners, incandescent lamps, fluorescent lights, stabilizers, heat pumps, automobiles, etc.

- Program started in January 2009.
- Scope of application
  The rated cooling power consumption is 7,500 W or lower and the rated cooling capacity is 23,000 W or lower. Water-cooled type, duct type, mobile type and multi-type for buildings are not applicable. The average energy efficiency ratio (EER) is measured by KSC 9306 test.
  EER is calculated by using CSPF (cooling seasonal performance factor) and HSPF (heating seasonal performance factor).

Endnotes

1: Domestic supply represents the amount that is calculated by deducting exports and inventory adjustment from the total supply.
2: Renewable and unused energies represent the total amount of natural energy, geothermal energy and unused energy.
3: Natural energy includes photovoltaic power generation, solar heat utilization, biomass direct utilization and wind power generation, etc. (heat in the air is not included). As for photovoltaic power generation and wind power generation, those with installed capacity of less than 1,000 kW are not included (generators at households are not included as their installed capacity is less than 1,000 kW).
4: Unused energy includes “energy recovered from the waste” such as waste power generation, black liquor direct utilization, waste wood direct utilization and waste tire direct utilization; waste gasification, “waste fuel products” made from recovered oil, “direct utilization of waste energy” such as waste heat supply and utilization, recovery of industrial steam and recovery of industrial electricity.
5: Some figures in FY 2009 represent the previous fiscal year because the statistics have not been announced yet.
6: Domestic supply represents the amount that is calculated by deducting exports and inventory adjustment from the total supply.
7: Renewable and unused energies represent the total amount of natural energy, geothermal energy and unused energy.
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9: Unused energy includes “energy recovered from the waste” such as waste-to-energy power generation, black liquor direct utilization, waste wood direct utilization and waste tire direct utilization; waste gasification, “waste fuel products” made from recovered oil, “direct utilization of waste energy” such as waste heat supply and utilization, recovery of industrial steam and recovery of industrial electricity.
10: Some figures in FY 2009 represent the previous fiscal year because the statistics have not been announced yet.

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1: Domestic supply represents the amount that is calculated by deducting exports and inventory adjustment from the total supply.
2: Renewable and unused energies represent the total amount of natural energy, geothermal energy and unused energy.
3: Natural energy includes photovoltaic power generation, solar heat utilization, biomass direct utilization and wind power generation, etc. (heat in the air is not included). As for photovoltaic power generation and wind power generation, those with installed capacity of less than 1,000 kW are not included (generators at households are not included as their installed capacity is less than 1,000 kW).
4: Unused energy includes “energy recovered from the waste” such as waste power generation, black liquor direct utilization, waste wood direct utilization and waste tire direct utilization; waste gasification, “waste fuel products” made from recovered oil, “direct utilization of waste energy” such as waste heat supply and utilization, recovery of industrial steam and recovery of industrial electricity.
5: Some figures in FY 2009 represent the previous fiscal year because the statistics have not been announced yet.
6: Domestic supply represents the amount that is calculated by deducting exports and inventory adjustment from the total supply.
7: Renewable and unused energies represent the total amount of natural energy, geothermal energy and unused energy.
8: Natural energy includes photovoltaic power generation, solar heat utilization, biomass direct utilization and wind power generation, etc. (heat in the air is not included). As for photovoltaic power generation and wind power generation, those with installed capacity of less than 1,000 kW are not included (generators at households are not included as their installed capacity is less than 1,000 kW).
9: Unused energy includes “energy recovered from the waste” such as waste-to-energy power generation, black liquor direct utilization, waste wood direct utilization and waste tire direct utilization; waste gasification, “waste fuel products” made from recovered oil, “direct utilization of waste energy” such as waste heat supply and utilization, recovery of industrial steam and recovery of industrial electricity.
10: Some figures in FY 2009 represent the previous fiscal year because the statistics have not been announced yet.

Data Book on Heat Pump & Thermal Storage System 2011-2012

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