2007年度版

ヒートポンプ給湯機 技術ロードマップ

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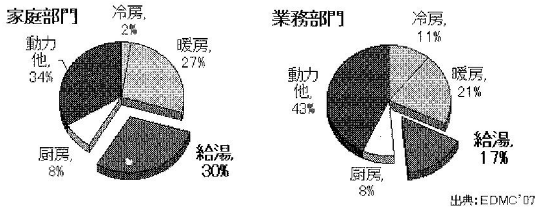
国内の給湯事情

○用途別エネルギー消費割合



○給湯分野のCO_2排出量

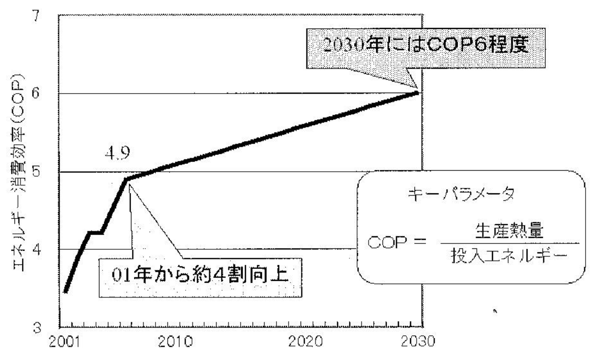
民生（家庭・業務）給湯需要　約7千万t-CO_2/年

参考：民生部門の排出量41千万t-CO_2

⇩

燃焼式給湯機をヒートポンプ給湯機にすれば CO_2 排出量を約 6 割削減できる

エネルギー消費効率の向上見通し



給湯分野の CO_2 排出構造と削減効果

エネルギー供給の脱炭素化（非化石発電、発電効率向上、CO_2回収貯留など） ← 電力会社の努力

×

ヒートポンプ技術の高度化（効率向上、適用分野拡大など） ← 機器メーカ 学会等の努力

×

現在の給湯需要の是正（高断熱化、自動水栓、過剰使用是正など） ← 消費者等の努力

↓

給湯分野のCO_2排出量の大幅削減

⇩

〈家庭用エコキュートの普及台数〉

- 2007年　100万台を突破（9月）
- 2030年　2,000万台の普及見通し

〈2030年のCO_2削減効果見通し〉

家庭用給湯	1,940万トン	合計 2,900万トン
業務用給湯	520万トン	
産業用（給湯・低温加熱・温水洗浄）	440万トン	

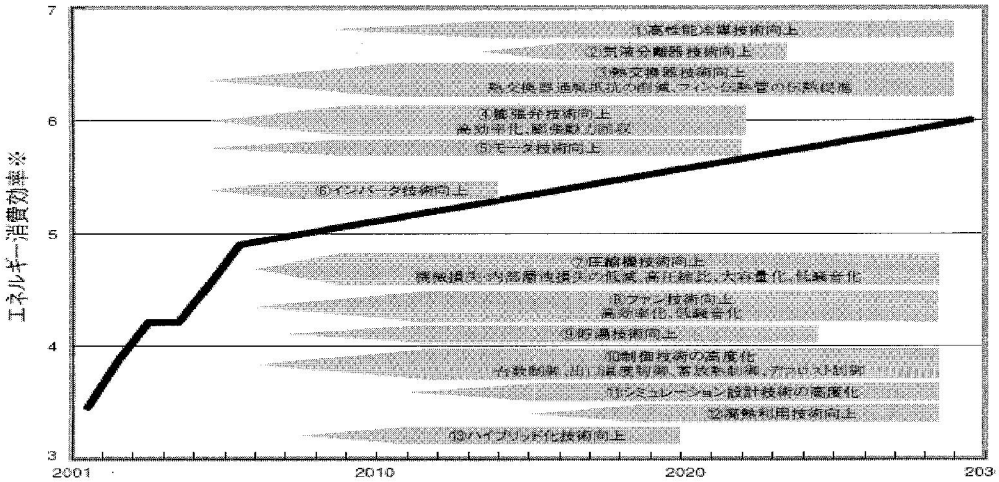
※国内の削減ポテンシャル合計は 5,880 万トン

⇩

効率向上だけでなく、製品種の多様化も期待　現在の参入企業は **約20社**

2001年〜	2010年〜		2020年〜		〜2030年
・給湯分野のCO_2削減 ・貯湯式高効率化 ・寒冷地対応 ・静音化	・直接給湯式 ・コンパクト化（貯湯槽一体型） ・暖房用給湯機 ・業務用貯湯式中型機 ・ハイブリッド式（ボイラ） ・ハイブリッド式（太陽・地中熱） ・大容量化 ・廃熱利用型給湯機 ・ダブルハンドル給湯機	・極寒冷地対応 ・給湯廃熱回収（銭湯・排水） ・排気熱回収式小型局所給湯機	・水熱源小型直接給湯式 ・産業用大型機 ・（ヘビーユース仕様）	・蒸気生成ヒートポンプ ・超小型・高効率化	

ヒートポンプ給湯機の技術ロードマップ



技術的ブレークスルー

・CO_2冷媒給湯機の開発	⑬地中熱利用 ⑨真空断熱材 ⑥SiCパワーデバイス ⑤高効率小型DCモータの最適設計 ④高効率エジェクタサイクル	⑬太陽熱パネル並列 ⑩負荷予測制御 ⑫排気熱回収 ⑥高効率マトリックスコンバータ ①高効率冷媒回路設計技術	⑬太陽熱減圧沸騰パネル蒸発器 ④膨張機一体型動力回収圧縮機 ③マイクロチャンネル型熱交換器 ②表面張力利用弁小型化 ①高度冷媒制御技術	⑨高密度蓄熱・潜熱蓄熱 ⑤センサレス次世代PMモータ ①新冷媒開発	⑫排水熱回収 ①水冷媒ダブルハンドル給湯機

Heat Pump Hot Water Supply Systems

(1) Aims

A great amount of energy is consumed for supplying hot water in the residential, commercial and industrial sectors. CO_2 emission from residential hot water supply systems only is estimated to be approximately 70 million tons-CO_2/year. Recently, heat pump hot water supply systems that may reduce CO_2 emissions significantly is in the process of propagation. Clarification of the roadmap of this technology will contribute to further progress of the heat pump technology, which is important to suppress global warming.

(2) Social and technical needs

Efficiency improvement and price reduction are common needs. In addition, size reduction, noise reduction, and improvement of performance in cold regions are also required. Multi-function products, including floor heating and central heating, snow melting products, direct hot water supply type products, small local hot water supply systems for lavatories, utilization of waste heat (such as remaining hot water after bathing), heat recovery systems (capable of simultaneous cooling and heating), hybrid products, commercial-use products, industrial-use products and other various products, are needed.

(3) Future directions for determining key mechanisms and parameters

There are many technical development elements, including refrigerant, compressors, heat exchangers, motor systems, recovery of coolant expansion energy, waste heat recovery technology, hybrid technology, and so forth. Parts of these technologies are described below.

(a) Refrigerant

Refrigerants currently in use are mainly classified as follows: Freon refrigerant and natural coolants. Various types of refrigerants were developed according to the uses and characteristics. The high temperature difference heating values at 65 ºC differ with the coolant types, while the theoretical COP is 12.9. That of CO_2 is 11.5, which is the highest, that of R410 is 9.1, and those of other Freon coolants and hydrocarbon coolants are about 8. It is expected that efficiency will be improved via circuit designs appropriate to the coolant characteristics and advanced coolant control.

(b) Hybrid technology

There are two types of main hybrid technologies: utilization of boilers for industrial use and large-scale users, and utilization of solar heat (solar panels) and ground heat. In terms of system configurations, the parallel systems mix heat produced by solar panels and heat pumps in storage tanks or at the outlets, while the integrated systems (installed on roofs, porches or walls) incorporate solar panel evaporators, or decompressed-boiling solar panel evaporators in heat pumps. Solar heat hybrid systems are expected to have remarkably improved efficiencies. If they are used decompressed-boiling solar panel evaporators, the efficiency of heat pumps using butane refrigerant may possibly be improved by about 80%.

(c) Noise reduction

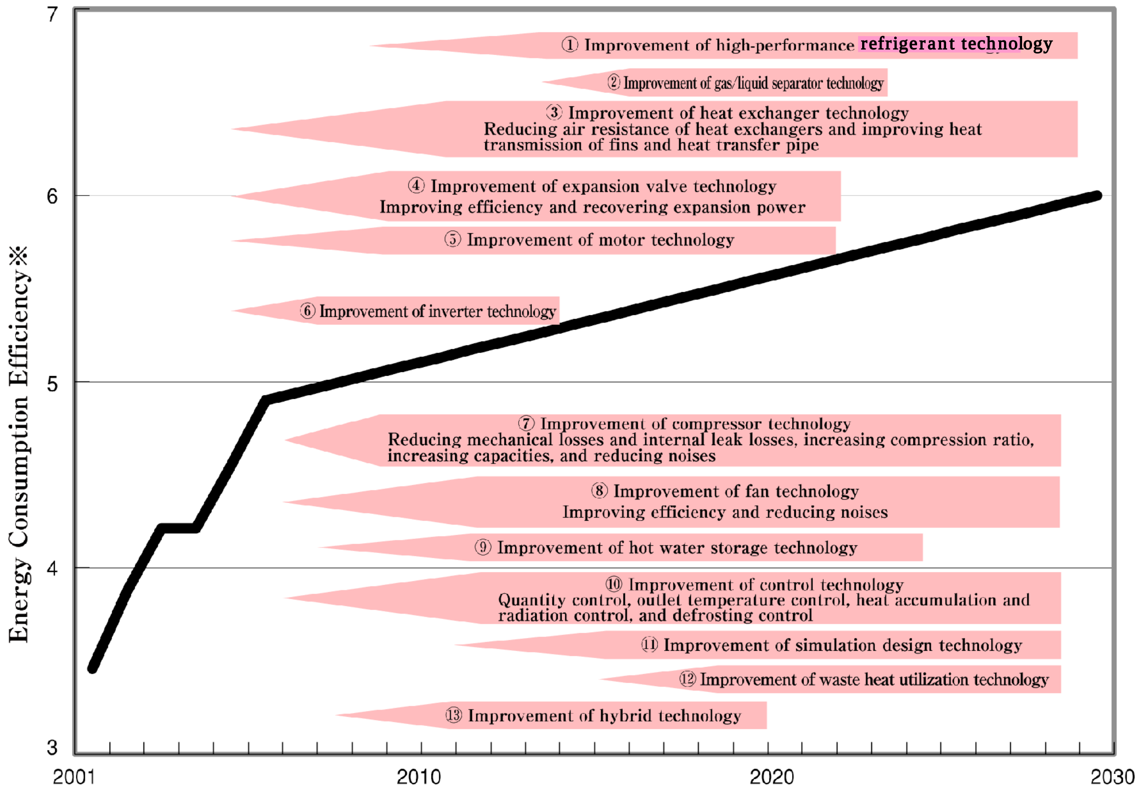
Noise reduction technology is important, since hot water storage type heat pump supply systems run at night. The noise level has reduced in the past five years from 45 dB to 38 dB owing to vibration reduction, suppression of noise transmission in solid matter, and noise quality improvement. Higher-speed rotation of compressors and fans is expected to further improve efficiency and reduce the size. Thus, noise reduction technology including noise quality improvement design and inverter technology should be improved.

(4) Contributions to society

Reduction of hot water needs by using high-performance insulating materials, improvements in efficiency of the heat pump hot water supply systems, and power de-carbonization by increasing the renewable energy power generation ratio and CCS (carbon dioxide capture and storage) are three major elements. In the long term, the synergy effect of these three elements will reduce CO_2 emissions in the hot water supply industry. The quantity of residential heat pump hot water supply systems will increase up to 20 million or so by 2030. The expected CO_2 reduction in 2030 including residential, commercial and industrial facilities, will be 29 million tons in Japan. Besides, export to overseas countries will increase, since Japanese manufacturers are good at these technologies.

Social & Technical Needs

2001～2010	・CO2 reduction in hot water supply industry ・Improvements in efficiency of hot water storage systems ・Noise reduction ・Performance improvement for cold regions
	・Direct hot water supply systems ・Size reduction (Storage tank integrated type) ・Water heaters for snow melting ・Middle-size hot water storage systems for commercial and industial use ・Hybrid systems (boilers)
2010～2020	・Hybrid systems (solar and ground heat) ・Larger-capacity hot water supply systems ・Double-bundle condenser hot water supply systems
	・Performance improvement for very cold regions ・Recovery of hot water supply waste heat (remaining hot water and waste hot water) ・Waste heat recovery type small-size local hot water supply systems
2020～2030	・Small-size direct hot water supply systems using water as heat sources ・Large-size systems for industrial use (heavy use)
	・Vapor generation heat pumps ・Very small-size and high-efficiency type products



Technical Breakthrough

2001～2010	・Development of hot water supply systems with CO2 coolant
	④ High-efficiency ejector cycles ⑤ Optimum design of high-efficiency, small-size DC motors ⑥ SiC power devices ⑨ Vacuum heat insulators ⑬ Utilization of underground heat
2010～2020	① High-efficiency coolant circuit design technology ⑥ High-efficiency matrix converter ⑫ Exhaust heat recovery ⑩ Load forecast control ⑬ Using solar heat panels together
	① Advanced coolant control technology ② Further size reduction using surface tension ③ Micro-channel type heat exchangers ④ Power recovery compressors with integrated expanders ⑬ Solar heat pressure reduction boiling panel evaporators
2020～2030	① Development of new coolant ⑤ Next-generation sensor-less PM motors ⑨ High-density heat accumulation and latent heat accumulation
	① Water coolant double-bundle hot water supply systems ⑫ Heat recovery from wastewater

Changes in Society and Markets

2001～2010	・Number of shipped heat pump hot water supply systems increased by 50% or more every year. ・Eco Cute subsidy system 50% or more increase
	・Approx. 20 companies entered heat pump hot water supply system market. ・Number of products reached 1 million (2006). ・First promise period in the Kyoto Protocol (2008) ・Number of products will reach 5.2 million (2010).
2010～2020	・Second promise period in the Kyoto Protocol (2013) ・Total number of homes will stop at 50 million. ・Consumption of electric power of new energy: 16 billion kW (2014)
	・Average people per family will lower below 2.5. ・Japanese influences upon the LNG market will lower (from about 50% down to 19%).
2020～2030	・Average people per family in Tokyo will be below two first in Japan.
	・Peak of traditional petroleum consumption ・Progress of de-carbonization of electric power ・Energy consumption in Asian countries will be doubled in comparison with that in 2004. ・Number of products reached about 20 million. (30 years)

※ Coefficient of Performance (COP)=Output of heat/Input energy

Heat Pump Hot Water Supply Systems

(1) Aims

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(2) Social and technical needs

Efficiency improvement and price reduction are common needs. In addition, size reduction, noise reduction, and improvement of performance in cold regions are also required. Multi-function products, including floor heating and central heating, snow melting products, direct hot water supply type products, small local hot water supply systems for lavatories, utilization of waste heat (such as remaining hot water after bathing), heat recovery systems (capable of simultaneous cooling and heating), hybrid products, commercial-use products, industrial-use products and other various products, are needed.

(3) Possibilities of mechanisms for advanced key parameters

There are many technical development elements, including refrigerant, compressors, heat exchangers, motor systems, recovery of refrigerant expansion energy, waste heat recovery technology, hybrid technology, and so forth. Parts of these technologies are described below.

(a) Refrigerant

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Noise reduction technology is important, since hot water storage type heat pump supply systems run at night. The noise level has reduced in the past five years from 45 dB to 38 dB owing to vibration reduction, suppression of noise transmission in solid matter, and noise quality improvement. Higher-speed rotation of compressors and fans is expected to further improve efficiency and reduce the size. Thus, noise reduction technology including noise quality improvement design and inverter technology should be improved.

(4) Prospects for the future

Reduction of hot water needs by using high-performance insulating materials, improvements in efficiency of the heat pump hot water supply systems, and power de-carbonization by increasing the renewable energy power generation ratio and CCS (carbon dioxide capture and storage) are three major elements. In the long term, the synergy effect of these three elements will reduce CO_2 emissions in the hot water supply industry. The quantity of residential heat pump hot water supply systems will increase up to 20 million or so by 2030. The expected CO_2 reduction in 2030 including residential, commercial and industrial facilities will be 29 million tons in Japan. Besides, export to overseas countries will increase, since Japanese manufacturers are good at these technologies.

A．Social and Technical Needs

2001-2005

・CO_2 reduction in hot water supply industry
・Improvements in efficiency of hot water storage systems
・Noise reduction
・Performance improvement for cold regions

2005-2010

・Direct hot water supply systems
・Size reduction (Storage tank integrated type)
・Water heaters for snow melting
・Middle-size hot water storage systems for commercial and industrial use
・Hybrid systems (boilers)

2010-2015

・Hybrid systems (solar and ground heat)
・Larger-capacity hot water supply systems
・Waste heat utilization hot water supply systems
・Double-bundle condenser hot water supply systems (heat recovery systems)

2015-2020

・Performance improvement for very cold regions
・Recovery of hot water supply waste heat (remaining hot water and waste hot water)
・Waste heat recovery type small-size local hot water supply systems

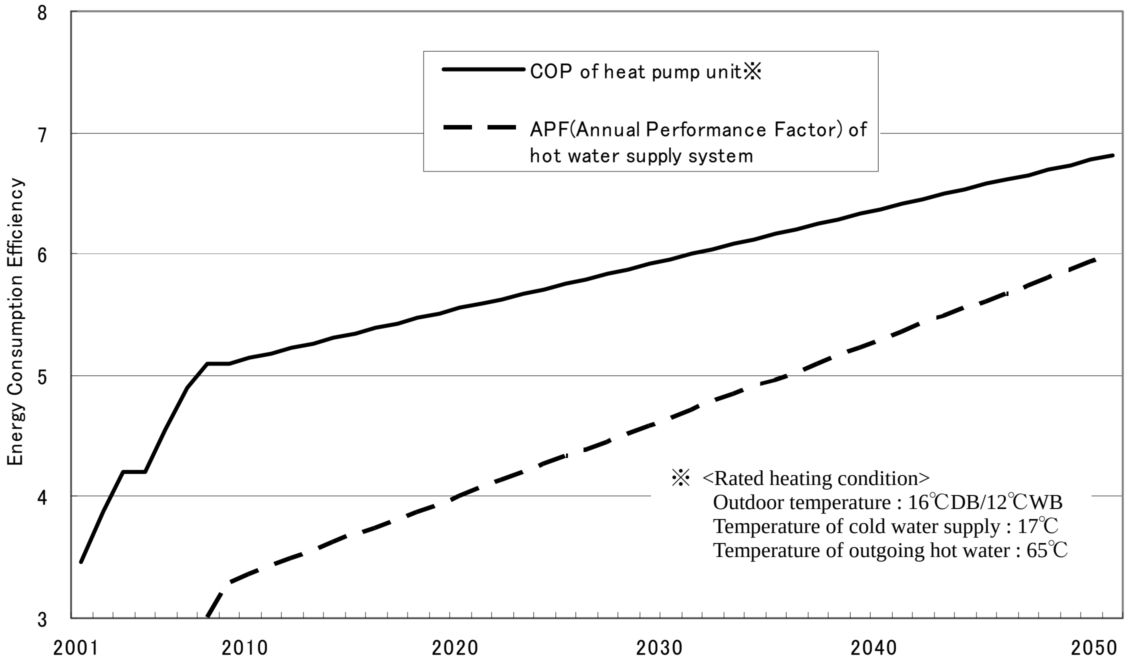
2020-2025

・Small-size direct hot water supply systems using water as heat sources
・Large-size systems for industrial use (heavy use)

2025-2030

・Vapor generation heat pumps
・Very small-size and high-efficiency type products

B． Energy Consumption Efficiency



C． Technical Breakthrough

Technical Breakthrough

2001～2010 ･Development of CO_2 refrigerant Heat Pump Water Heater
- ④ High-efficiency ejector cycles
- ⑤ Optimum design of high-efficiency. Small-size DC motors
- ⑥ SiC power devices
- ⑨ Vacum heat insulators
- ⑬ Utilization of underground heat

2010～2020
- ① High-efficiency refrigerant circuit design technology
- ⑥ High-efficiency matrix converter
- ⑫ Exhaust heat recovery
- ⑩ Load forecast control
- ⑬ Using solar heat panels together
- ① Advanced refrigerant control technology
- ② Further size reduction using surface tension
- ③ Micro-channel type heat exchangers
- ④ Power recovery compressors with integrated expanders
- ⑬ Decompressed-boiling solar panel evaporators

2020～2030
- ① Development of new refrigerant
- ⑤ Next-generation sensor-less PM motors
- ⑨ High-density thermal storage and latent thermal storage
- ① Water refrigerant double-bundle condenser hot water supply systems (heat recovery systems)
- ⑫ Heat recovery from wastewater

Reference ① ~ ⑬

① Improvement of high-performance refrigerant technology

② Improvement of gas/liquid separator technology

③ Improvement of heat exchanger technology

Reducing air resistance of heat exchangers and improving heat transmission of fins and heat transfer pipes

④ Improvement of expansion valve technology

Improving efficiency and recovering expansion power

⑤ Improvement of motor technology

⑥ Improvement of inverter technology

⑦ Improvement of compressor technology

Reducing mechanical losses and internal leak losses, increasing compression ratio, increasing capacities, and reducing noises

⑧ Improvement of fan technology

Improving efficiency and reducing noises

⑨ Improvement of hot water storage technology

⑩ Improvement of control technology

Quantity control, outlet temperature control, thermal storage and radiation control, and defrosting control

⑪ Improvement of simulation design technology

⑫ Improvement of waste heat utilization technology

⑬ Improvement of hybrid technology

D．Changes of Society and Markets

Changes in Society and Markets

2001～2010
- Number of shipped heat pump hot water supply systems increased by 50% or more every year.
- Subsidy system for CO_2 refrigerant Heat Pump Water Heater
- Approx. 20 companies entered heat pump hot water supply system market.
- Number of products reached 1 million (2007)
- Number of products reached 1.5 million (2008).
- First commitment period in the Kyoto Protocol (2008)
- Number of products will reach 5.2 million (2010).

2010～2020
- Second commitment period in the Kyoto Protocol (2013)
- Total number of homes will stop at 50 million.
- Consumption of electric power of new renewable energy: 16 billion kW (2014)
- Average people per family will lower below 2.5
- Japanese influences upon the LNG market will lower (from about 50% down to 19%).

2020～2030
- Average people per family in Tokyo will be below two first in Japan.
- Peak of traditional petroleum production
- Energy consumption in Asian countries will be doubuled in comparison with that in 2004.
- Number of products reached about 20 million. (2030)

			Baseline	Climate plan		
			2007	2015	2030	2050
[Name of the technology/solution] Heat Pump Hot Water Supply Systems	Savings	Consumption if old technologies are sustained (BAU)	100	100	100	100
		Consumption after implementing new technology and measures		(96)	(77)	(28)
		Net saving		(4)	(23)	(72)
	Cost (Investment, operation & maintenance, fuel)			–	–	–
	Cost Per PJ saved			–	–	–
	GHG reduction potential	Emission if old technologies are sustained and with current trends (BAU)	100 2,537Mt-CO_2	100 2,537Mt-CO_2	100 2,537Mt-CO_2	100 2,537Mt-CO_2
		Emission after implementing new technology and measures		96 2,443Mt-CO_2	77 1,956Mt-CO_2	28 719Mt-CO_2
		Total Reduction Potential		4 93Mt-CO_2	23 580Mt-CO_2	72 1,818Mt-CO_2
	Cost of GHG reduction			–	–	–