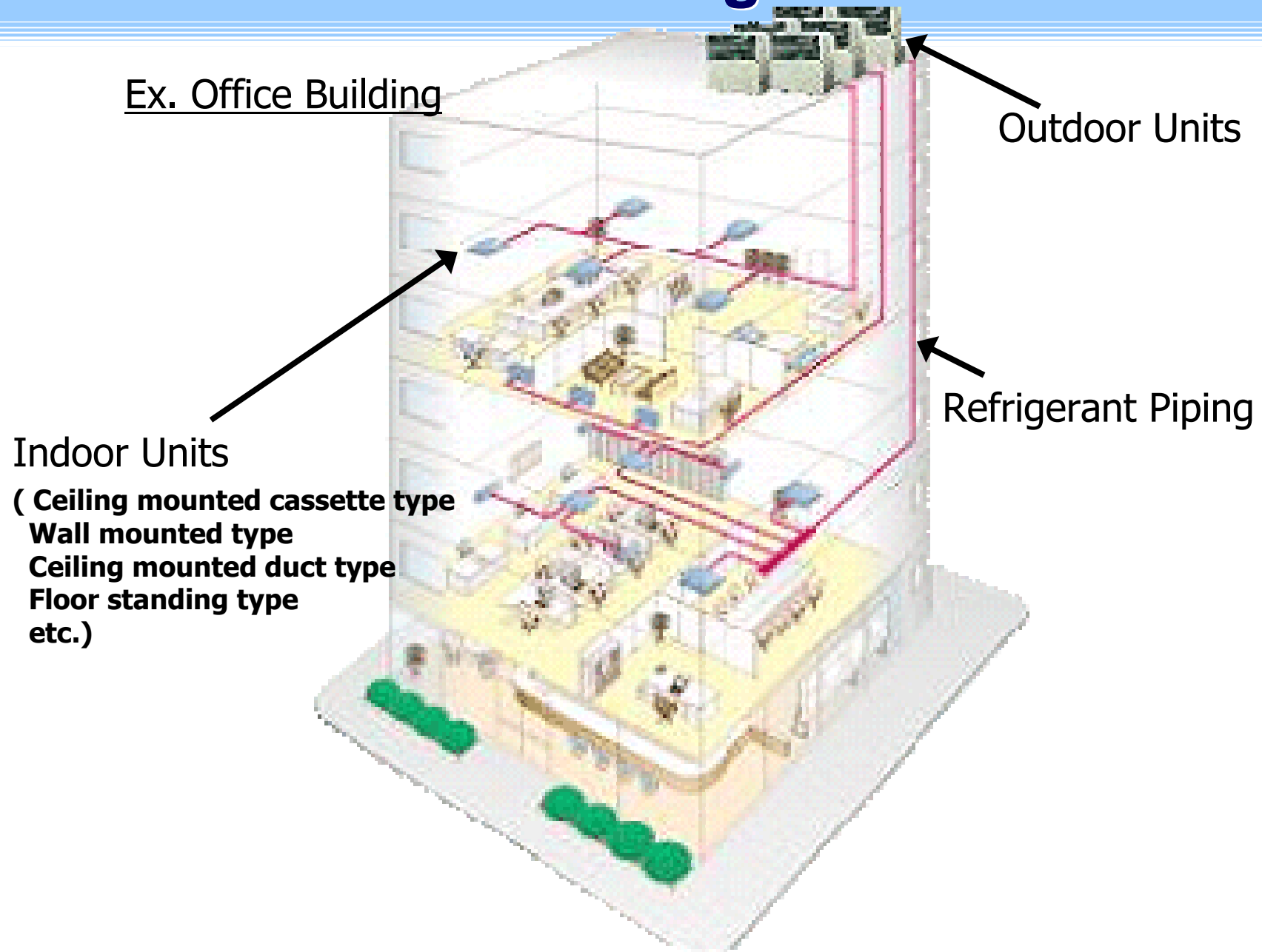


Development and Spread of GHP with a Power-generating Function (Fusion of air-conditioning and power generation)



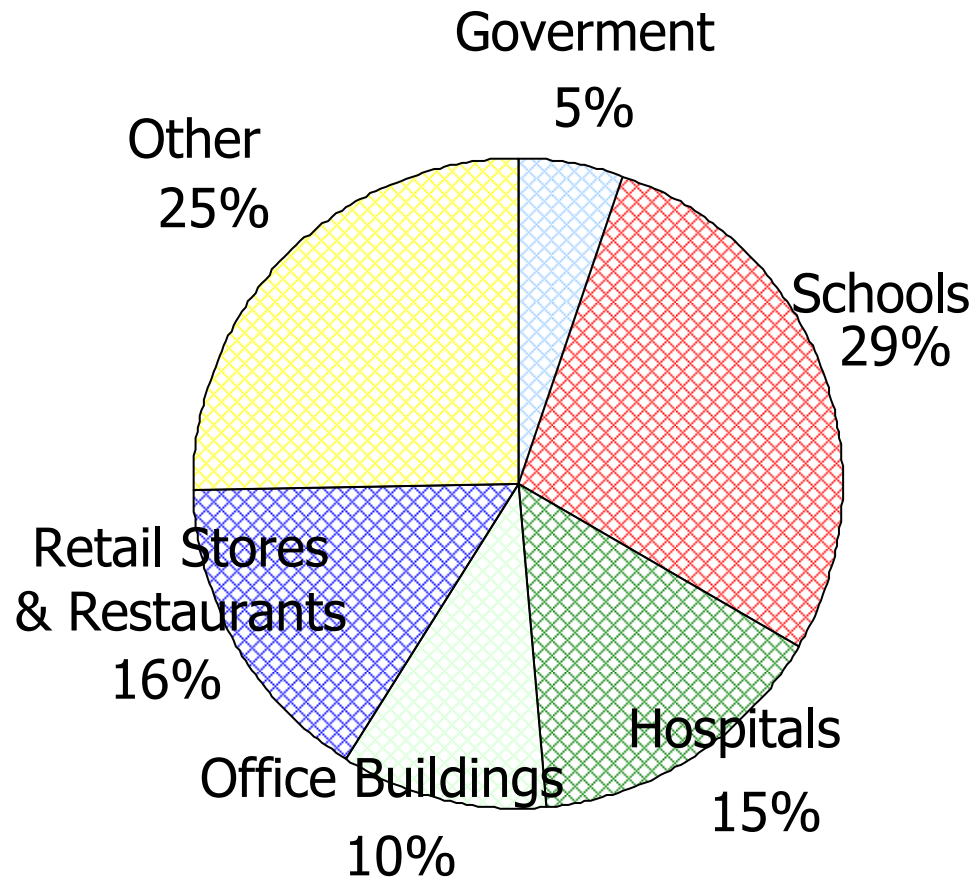
**Osaka Gas Co., Ltd.
Commercial & Industrial Market Development Dept.**

Installation Image of GHPs



Example of Installations

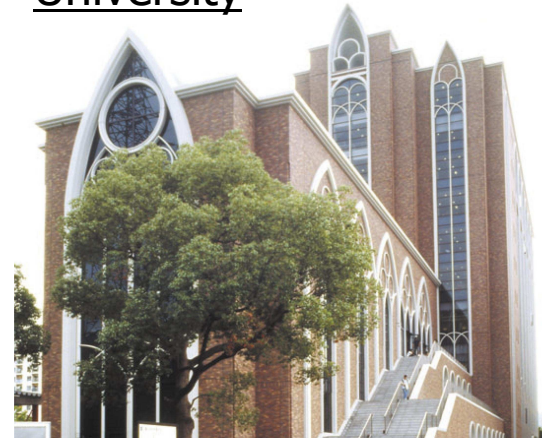
◆ Capacity basis of air-conditioning



Office Building

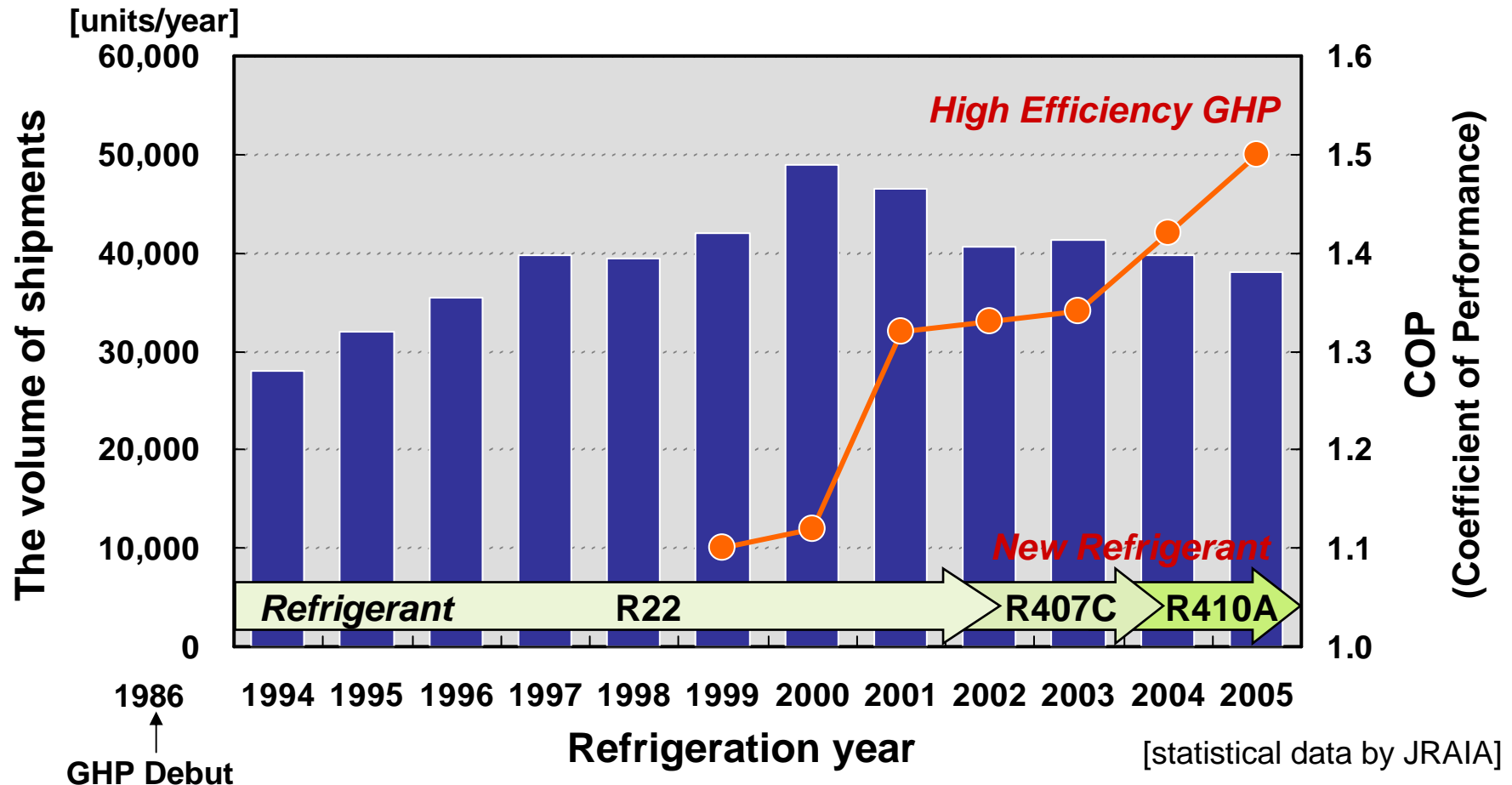


University



Spread of GHPs in Japan

Approximately, 40,000 units per year has been sold in Japan.



GHP : Gas Engine Driven Heat Pump
(Energy Saving, Low Electric Power, Low Running Cost)

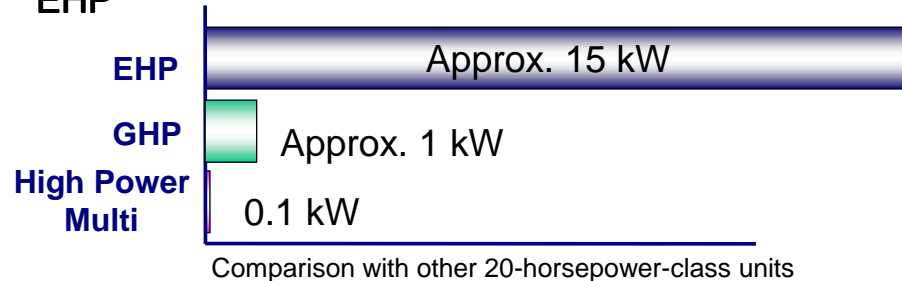
Putting the “High Power Multi” onto the Market

April 2003

Features of the High Power Multi air conditioner

- The comparison of power consumption with other 56kW class air-conditioner

* Approx. **1/150** of the power consumed by an EHP



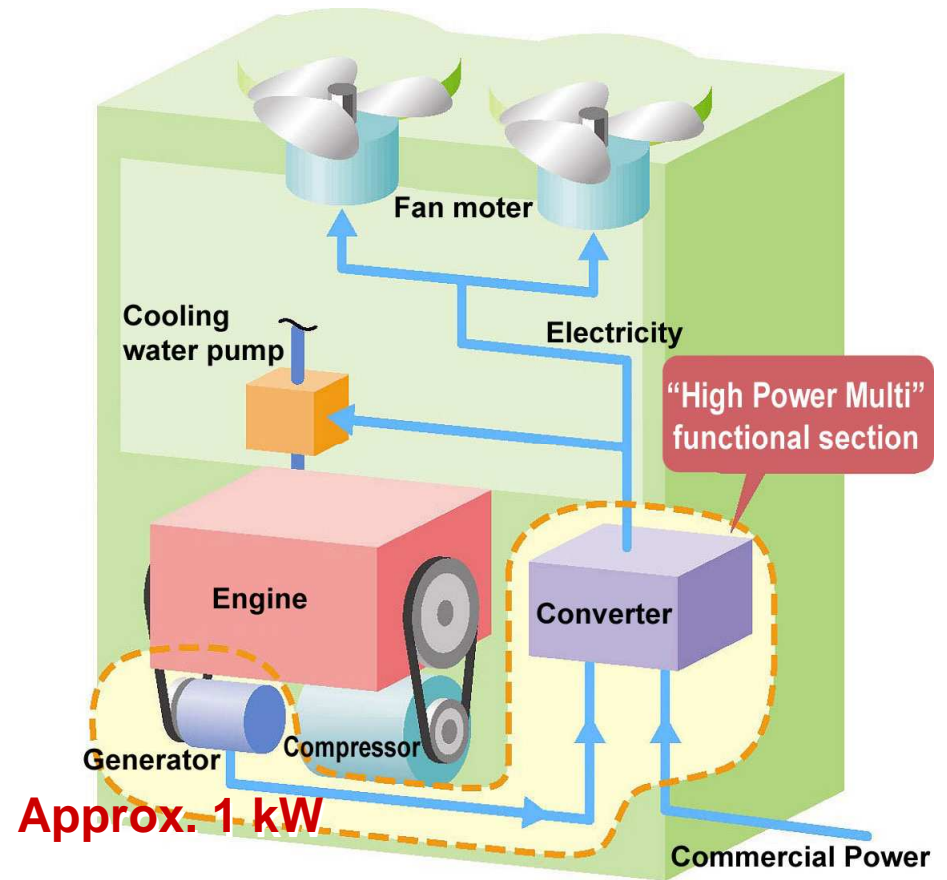
High Power Multi consumes the lowest power in the air-conditioning industry.

- High-efficiency power generation using engine surplus power during air-conditioning operation

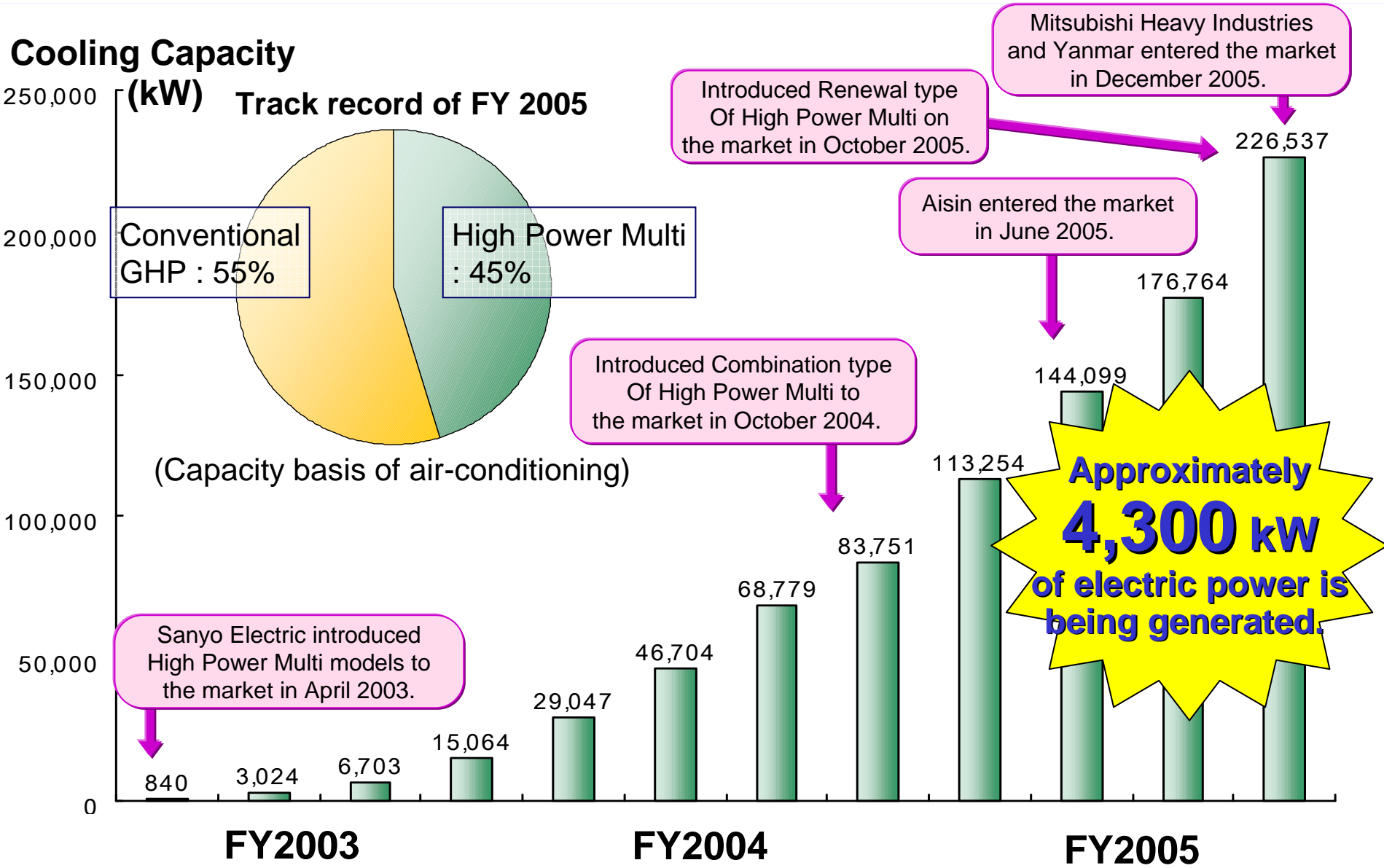
* Generating efficiency: Approx. over **40%** (HHV) (Surpassing large generators)

$$\text{Generating efficiency} = \frac{\text{Generated power (kW)}}{\text{Gas consumption increment resulting from power generation}}$$

Structure of the High Power Multi air conditioner



Cumulative Total of High Power Multi in Osakagas



Product Variety of High Power Multi (33 models offered by four manufacturers)

All GHP manufacturers have started to commercialize High Power Multi. The product variety has been expanded from 35.5kW to 84kW type.

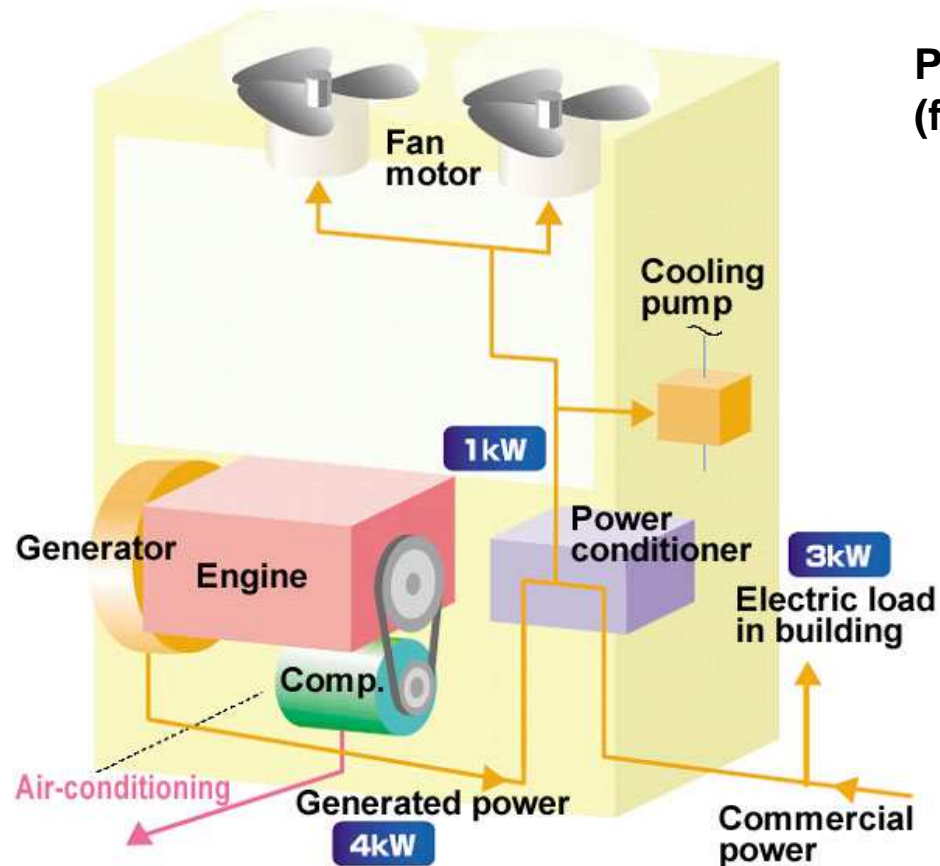
Manufacturer	Building Multi type				
	35.5kW	45kW	56kW	71kW	84kW
Sanyo	●	●	●		
	● ◆	● ◆	● ◆	●	
Aisin		● ◆	● ◆	● ◆	
Mitsubishi Heavy Industries		●	●		
Yanmar		● (◆)	● (◆)		● (◆)

● : High Power Multi ◆ : Renewal type of High Power Multi () : To be introduced in future

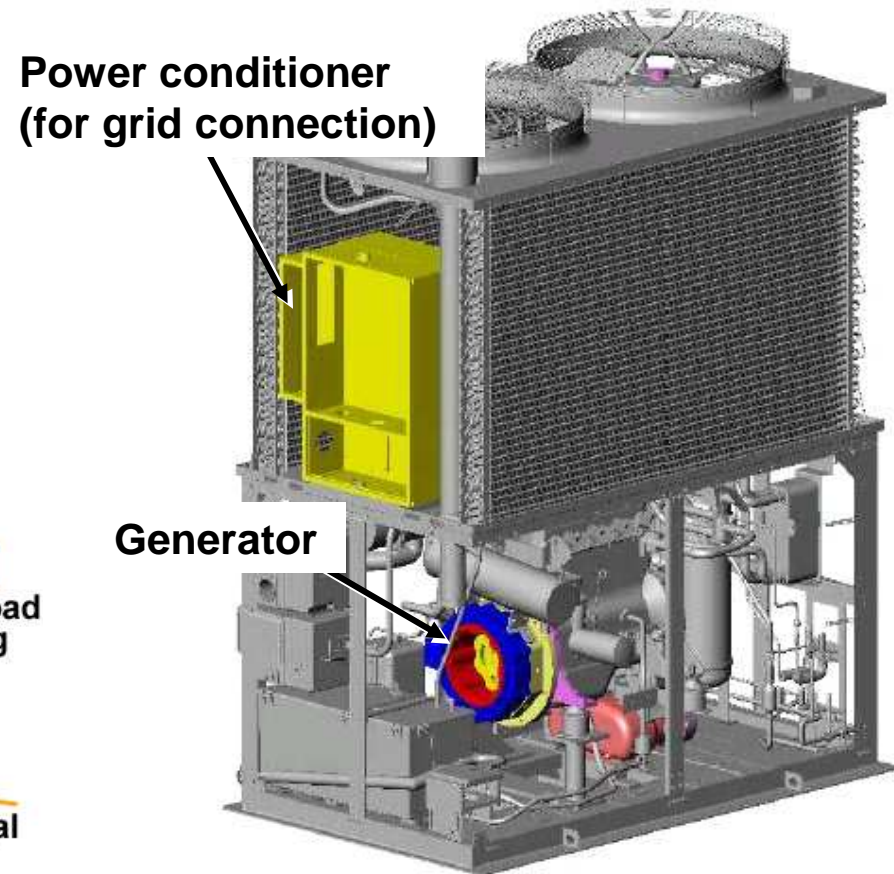
System outline and Internal view of Highpower EXCEL

April 2006

System outline



Internal view



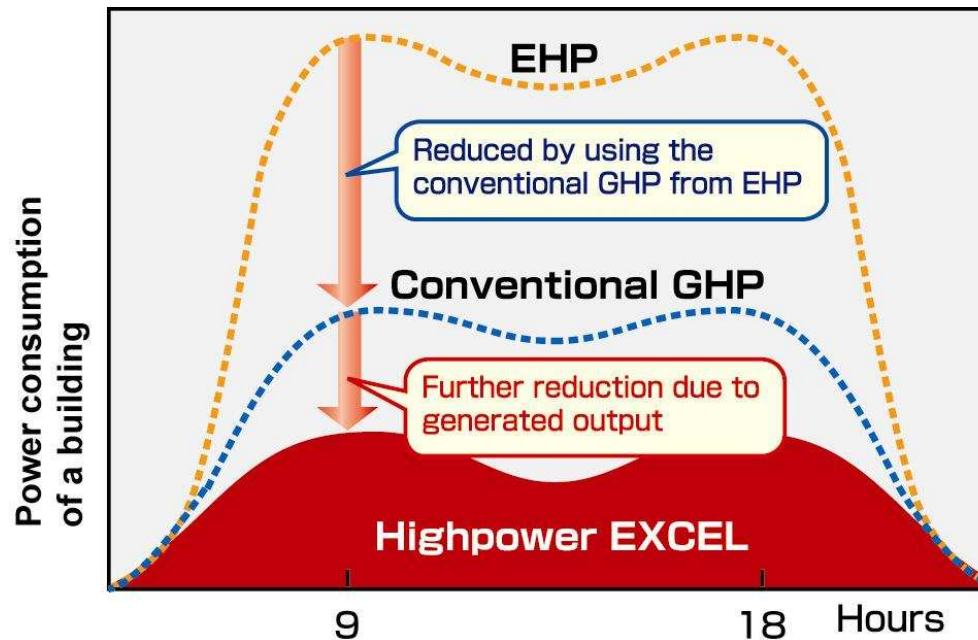
When electricity is generated by 4kW, 1kW is consumed in the outdoor unit, and the rest 3kW is supplied to the lighting and the wall outlet in the building by the Grid Connection.

Features of the Highpower EXCEL

“Power Peak Cut”

When in cooling or heating operation, the unit supplies a generated output to the building; the more air conditioning is installed, the more electricity is saved.

Comparison of the peak power of each system



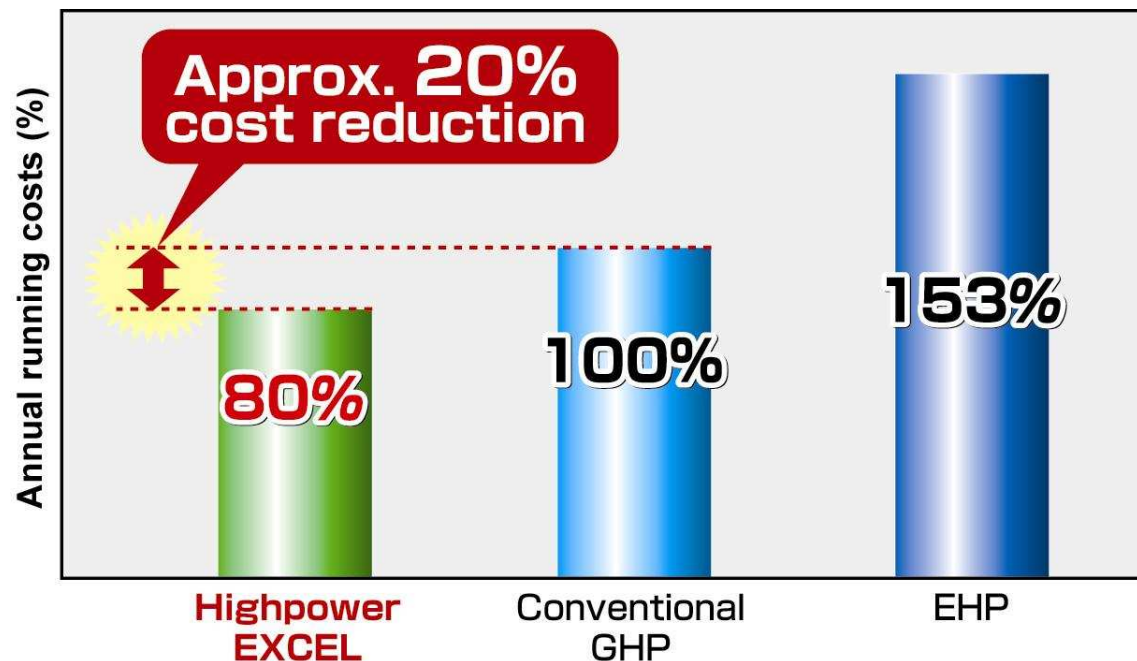
It is useful for the electric power load leveling by reducing the peak power.

Features of the Highpower EXCEL

“Increase in customer advantages”

Lower running costs

Approximately **20% cost reduction** achieved, thanks to high-efficiency power generation and peak cut



<Conditions for trial calculation>

Total floor area: 5,000 m²

Air conditioning capacity: 200 HP

Building purpose: Offices

Gas charge: First kind of Air Conditioning Contract A

Electric charge: High-voltage power

The length of operating time is as specified by our conditions for trial calculation.

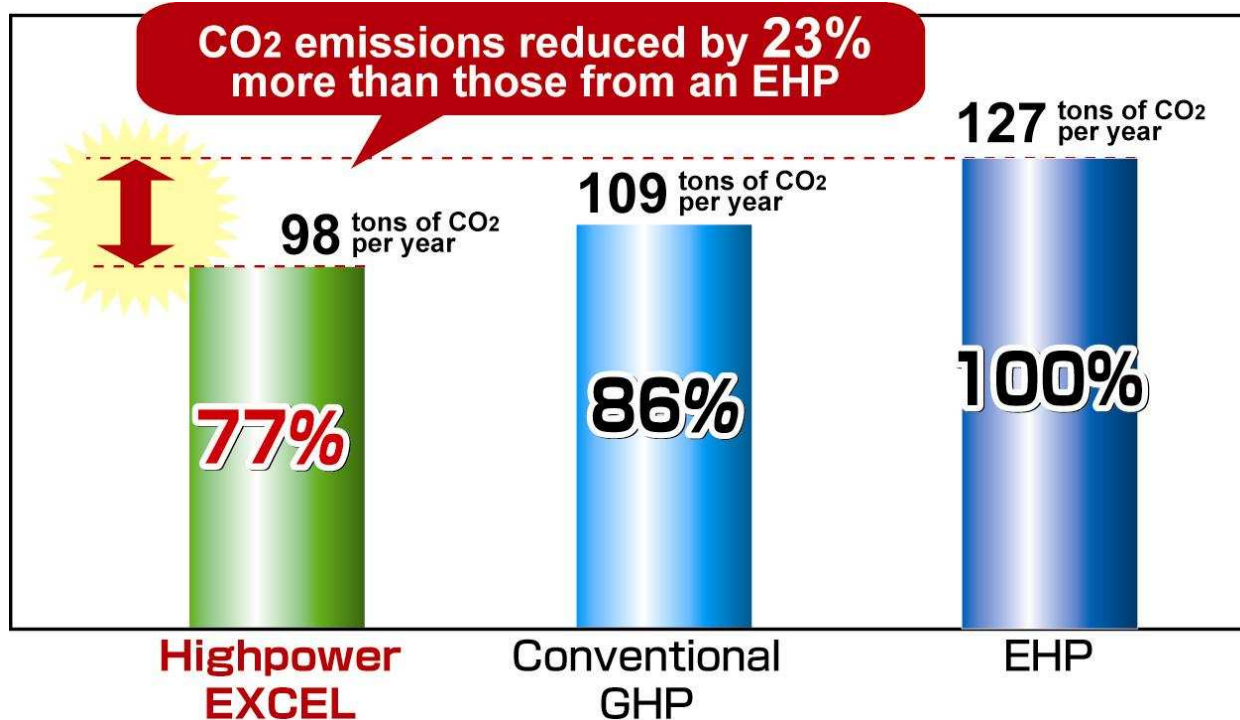
*Annual running costs for the gas heat pump taken as 100%

Features of the Highpower EXCEL

“Environment-friendliness” (Reduced CO₂ emissions)

Power generation with an efficiency exceeding that of conventional utility power generation can further reduce CO₂ emissions on top of the CO₂ reduction realized by the conventional gas heat pump.

CO₂ emissions reduction effect



<Conditions for trial calculation>

Total floor area: 5,000 m²

Air conditioning capacity: 200 HP

Building purpose: Offices

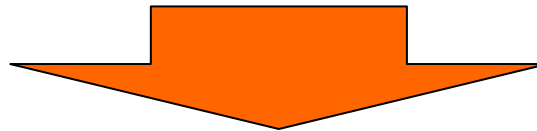
CO₂ emissions per unit of production

Electricity: 0.69 kg-CO₂/kW (Average for thermal power generation)

Gas: 2,288 kg-CO₂/m³ (on the basis of the 13A gas composition)

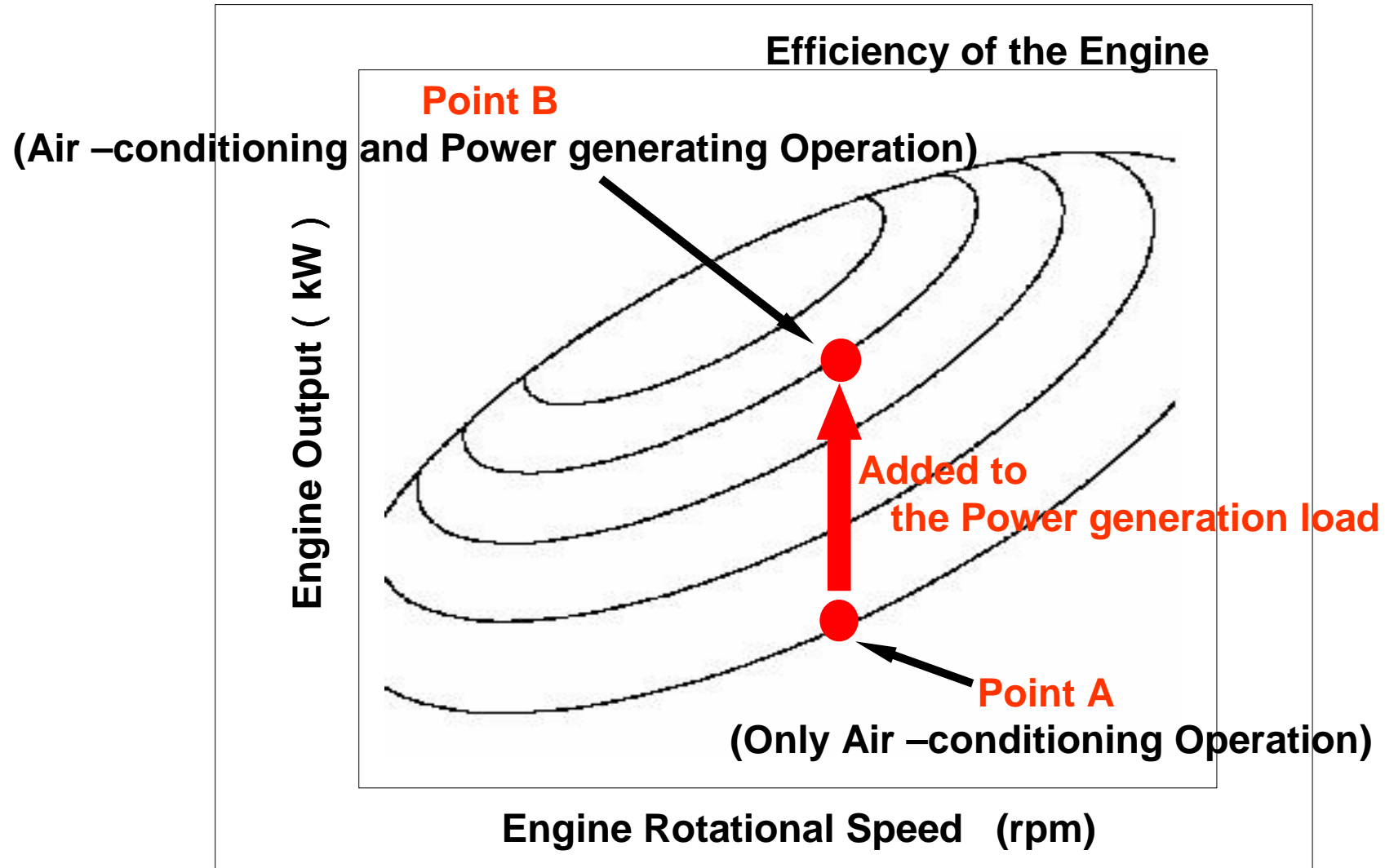
Future Challenges

Development of a system allowing us to move toward further energy conservation and CO₂ reduction

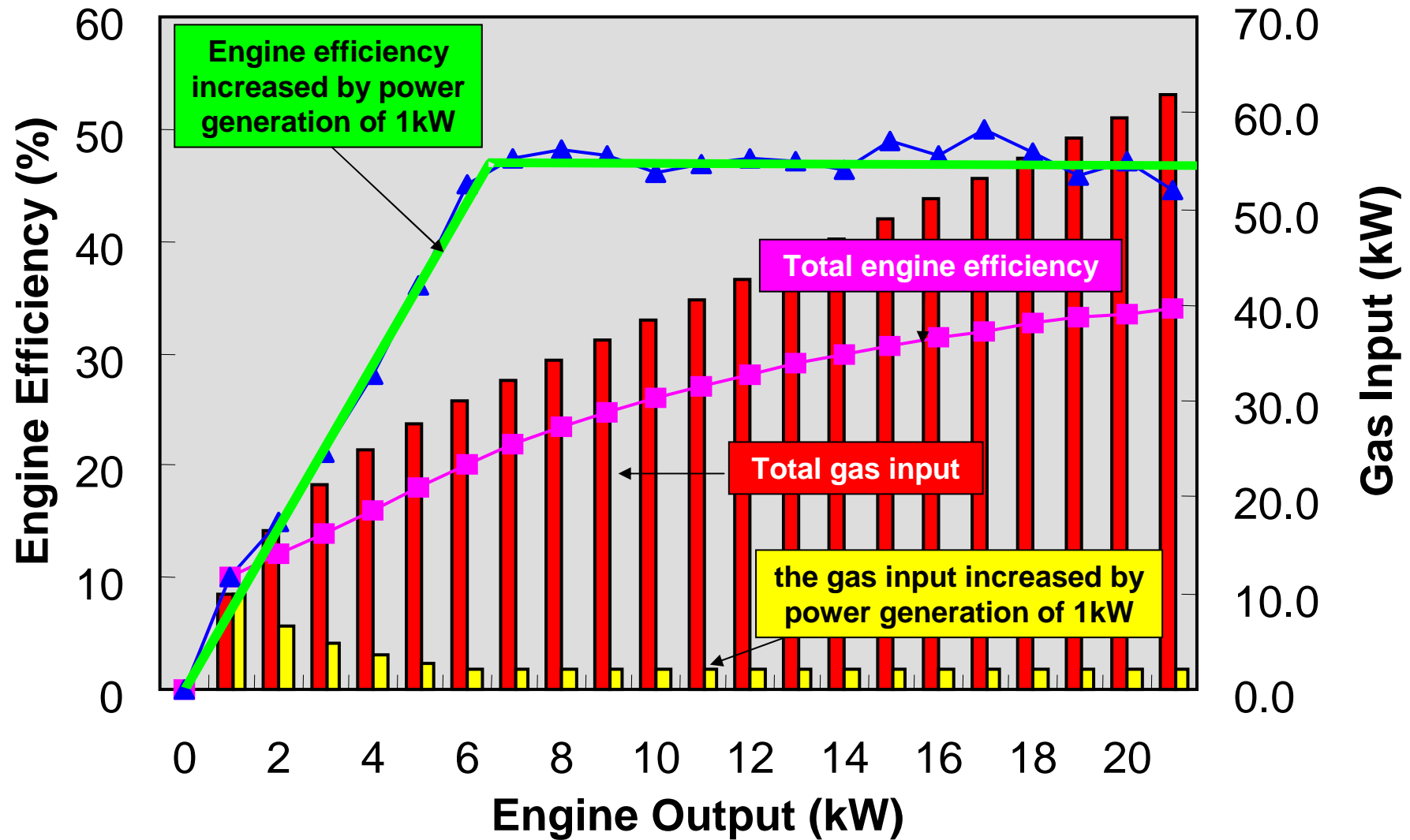


- * Development of technologies to efficiently maximize use of the engine surplus power**
- * Development of GHPs to efficiently use waste heat from engines**

Characteristics of the Engine



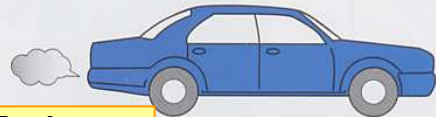
The reason of high-efficiency power generation



The Reason of the High Efficiency

Example) When it runs through 100km by car

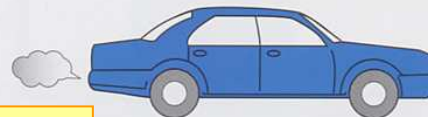
Drive with 2 people



Fuel
Consumption

5 ℓ

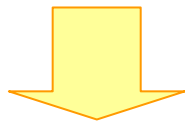
Drive with 3 people



Fuel
Consumption

6 ℓ

Even if the taking number is 1.5 times,
the amounts of fuel consumption increase only in 1.2 times.




That is to say . . .

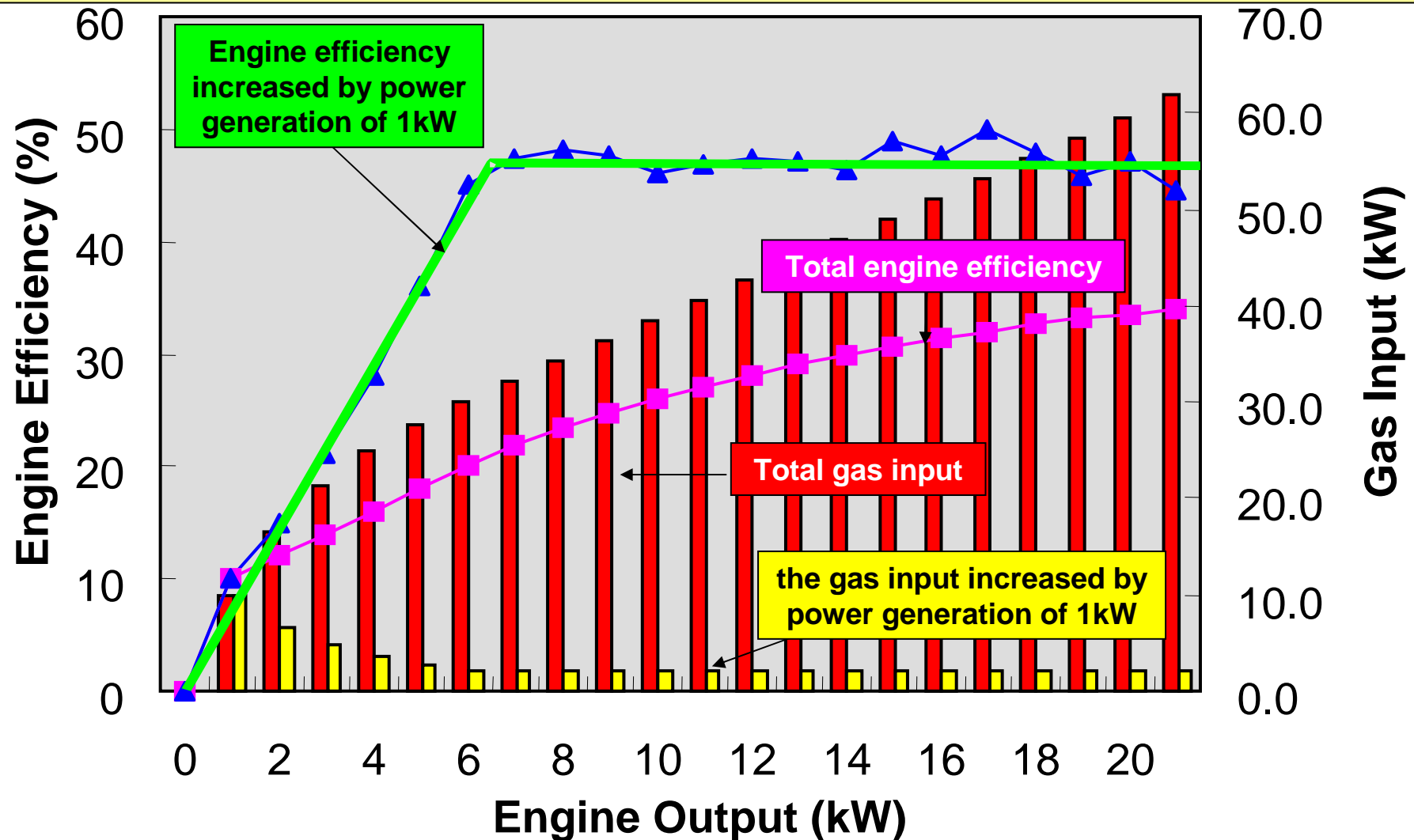
Power is generated at the same time with the GHP operating
for air conditioning.

There is a little gas input which is added for power generation.

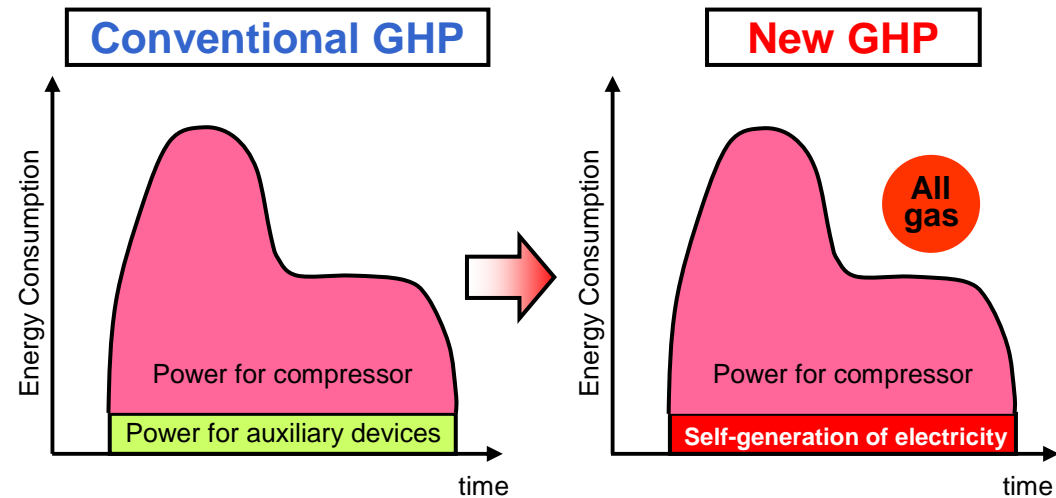
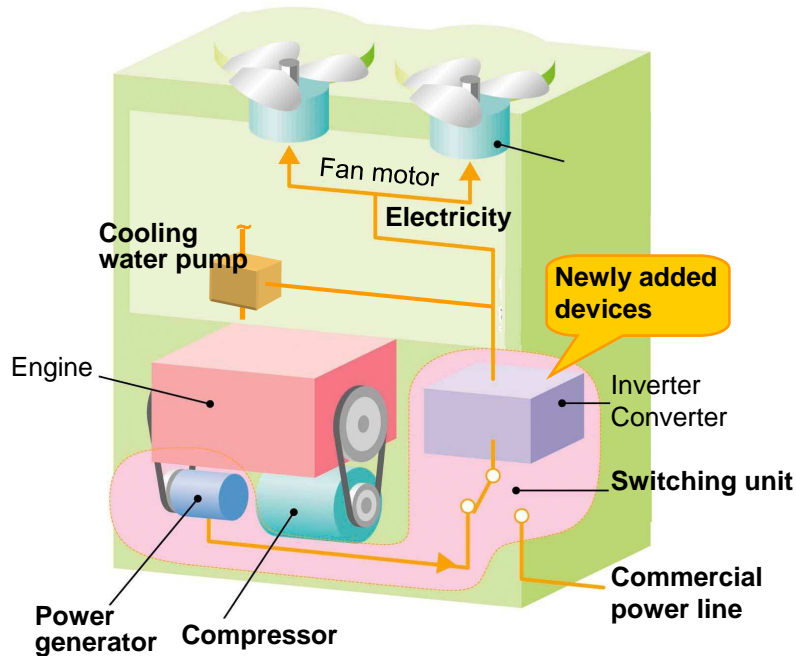
The reason of high-efficiency power generation

Power generating efficiency


 engine efficiency (Approx. 45 to 50%) × generator efficiency (Approx. 90 to 95 %) × converter/inverter efficiency (Approx. 95 to 97 %)



Development of GHP with a Power Generating Function

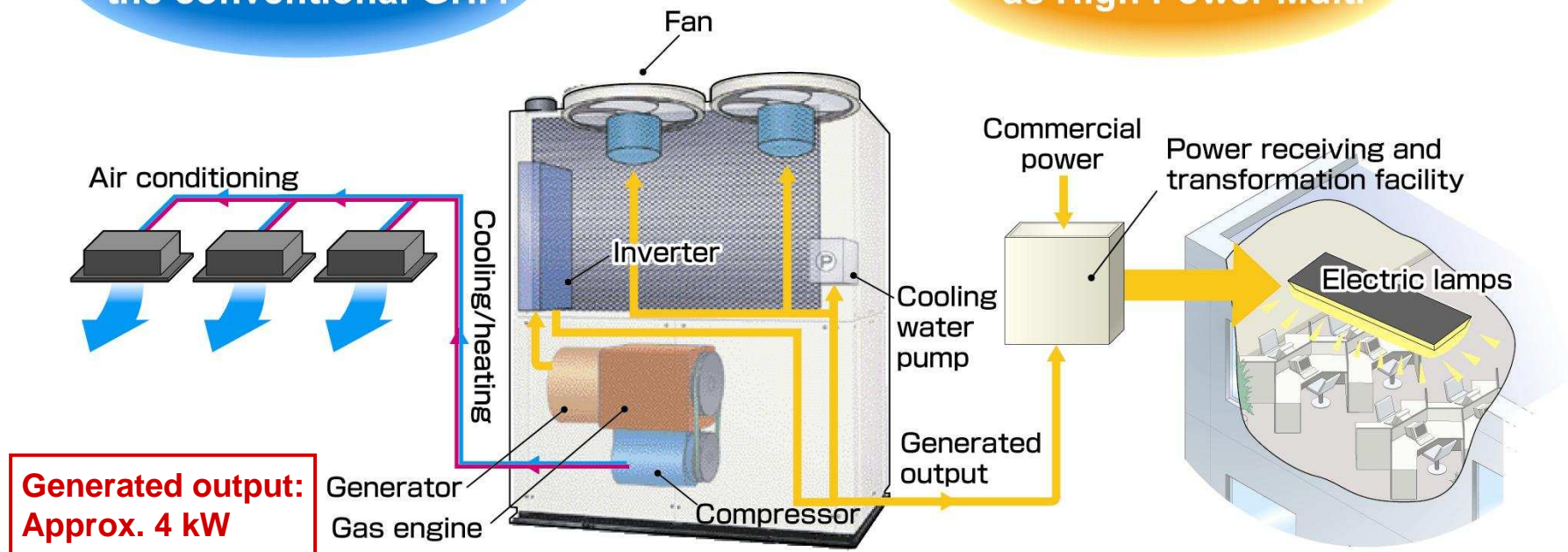


- Surplus power from the gas engine is used for power generation
→ the thermal efficiency of the engine increases
- Trouble or Power shortage
→ supply from commercial power lines

Installation Image of Highpower EXCEL

Air-conditioning is same as the conventional GHP.

High efficiency power generation is same as High Power Multi



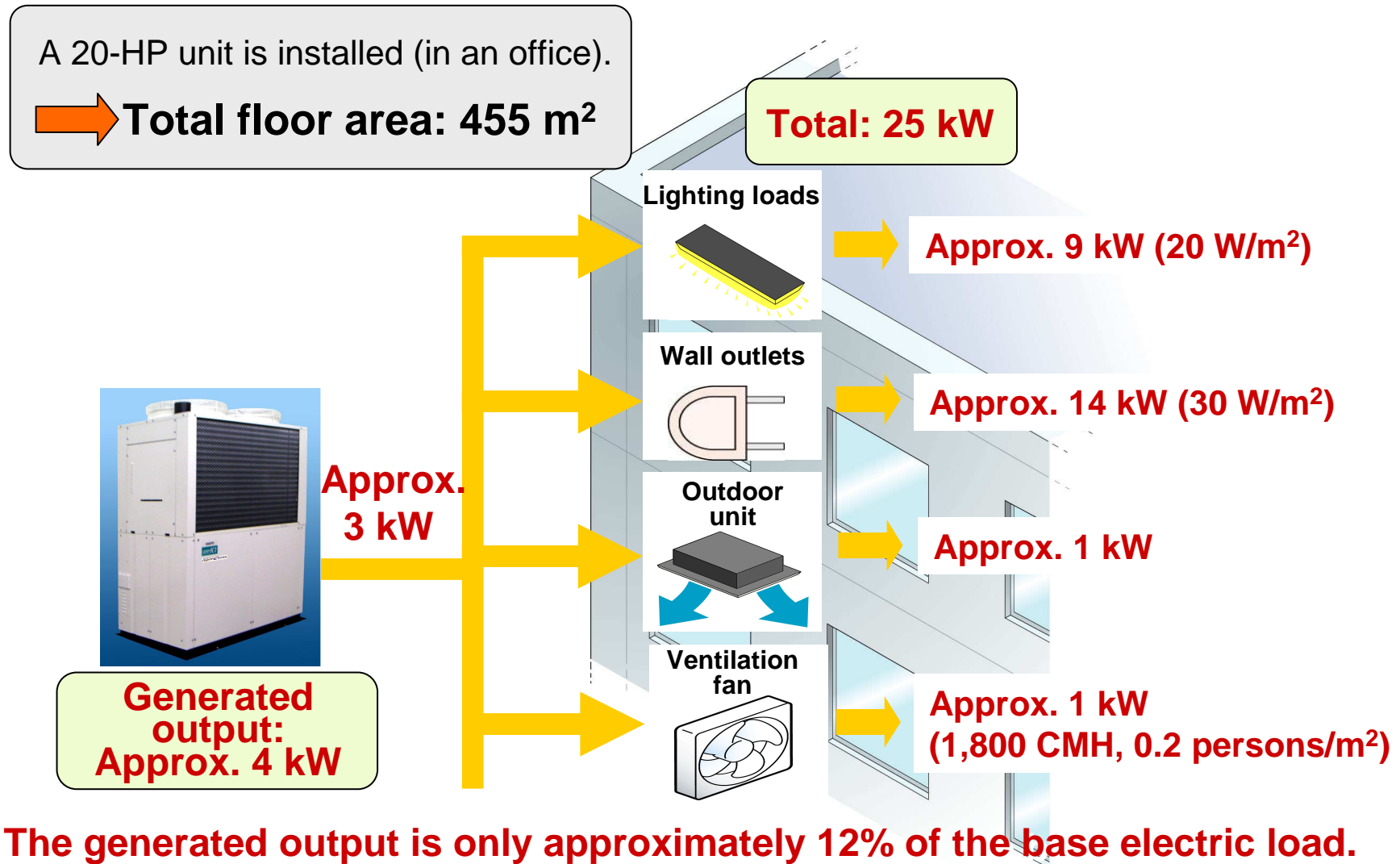
Gas-powered cooling and heating as before
Small-capacity power generation, low costs, and comfort

Power generation using engine surplus power assures **high-efficiency power generation: 40% or more**
(with reference to the HHV basis)

Generated Output of the “Highpower EXCEL” Unit and Electric Loads



The presence of an electric load is a must for running air conditioning (plus power generation).



Major Specifications of Highpower EXCEL

Outside dimensions	Height	mm	2,208
	Width	mm	1,735
	Depth	mm	1,000(+106)
Mass		kg	970
Capacity	Cooling	kW	56
	Heating	kW	63
Gas consumption	Cooling	kW	44(39)
	Heating	kW	48(43)
Power consumption	Cooling	kW	0(1.07)
	Heating	kW	0(1.07)
Generating capacity (*Power conditioner output)		kW	3.95 (2 kW at the rated operation)
Generating efficiency (with reference to the HHV basis)		%	40 or more
Power source		V	200, single phase
Operating noise		dB(A)	58
Maintenance interval		H	10,000

*The figures inside the parentheses are those under the condition in which power is not being generated.

*The generating capacity refers to the power conditioner output, which is outputted from the unit with the power that the outdoor unit consumes deducted.

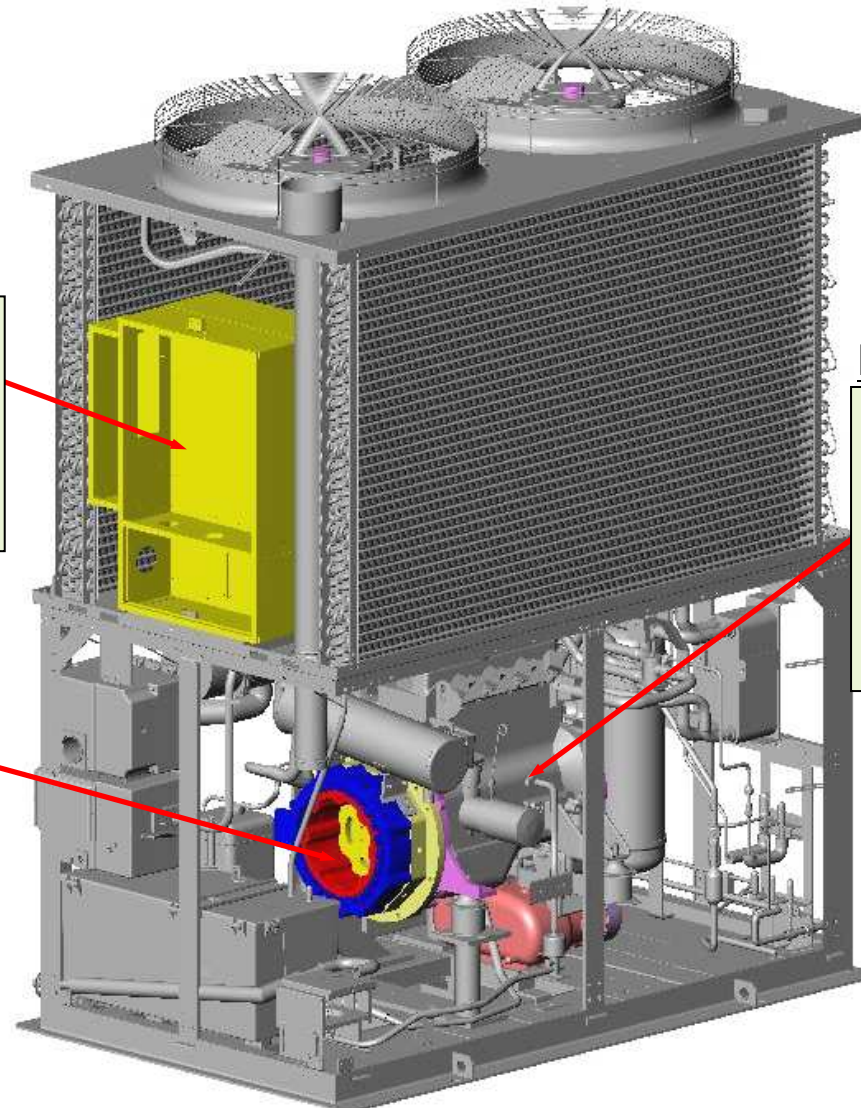
Newly Developed Elements Used in Highpower EXCEL

Power conditioner (for grid connection)

- * Maximum generated output: 3.95 kW
- * Built-in grid connection protecting device
- * Based on it for photo-voltaic generation

Generator

- * Permanent magnet type
- * Bearing-free type
- * Directly-coupled shaft



Engine

**Increased output
and reduced Nox**

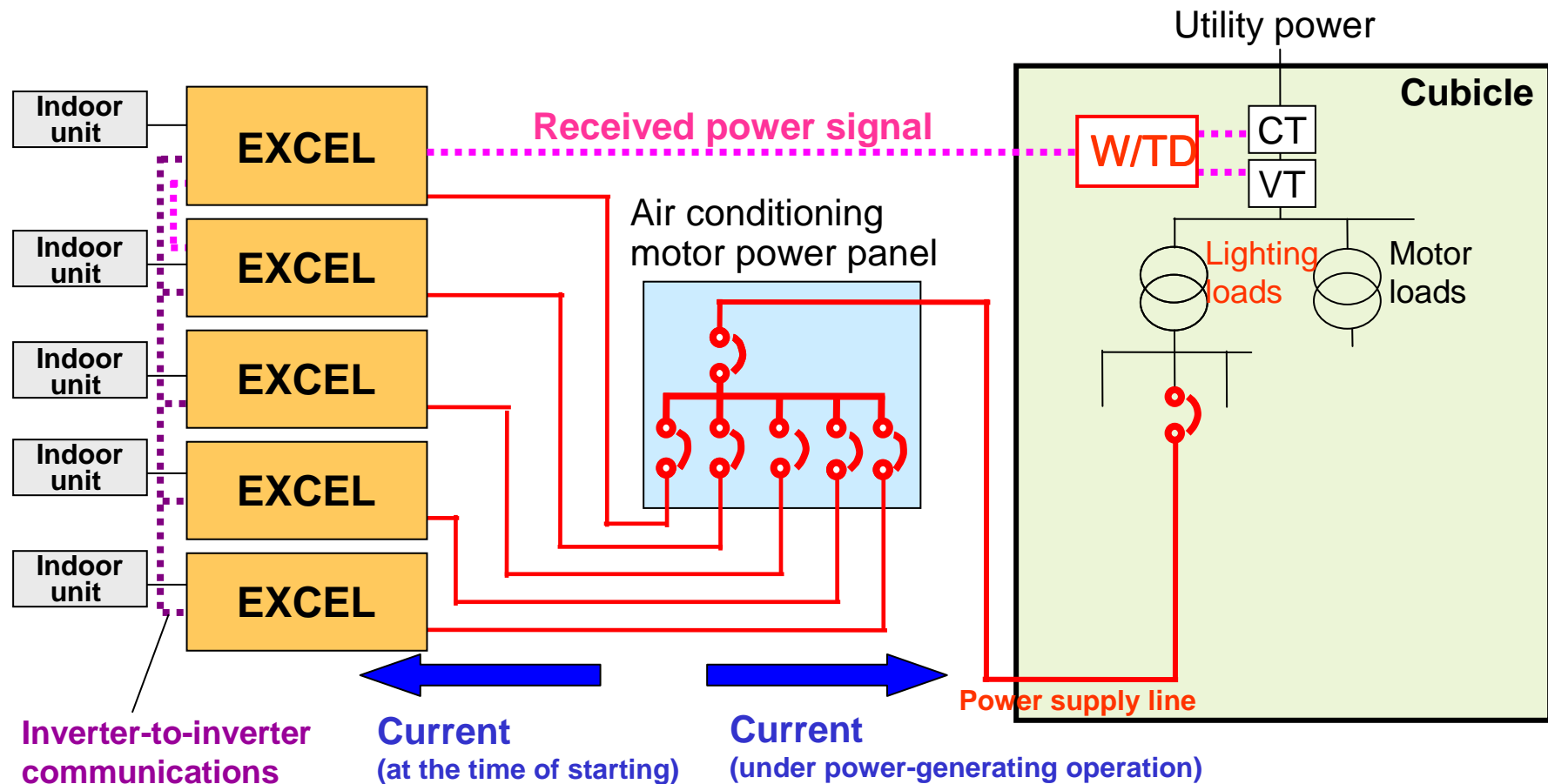


Engine tuning

- * Change the compression ratio
- * Improve the cam timing

Overview of the Power Generation Control Development and Wiring System

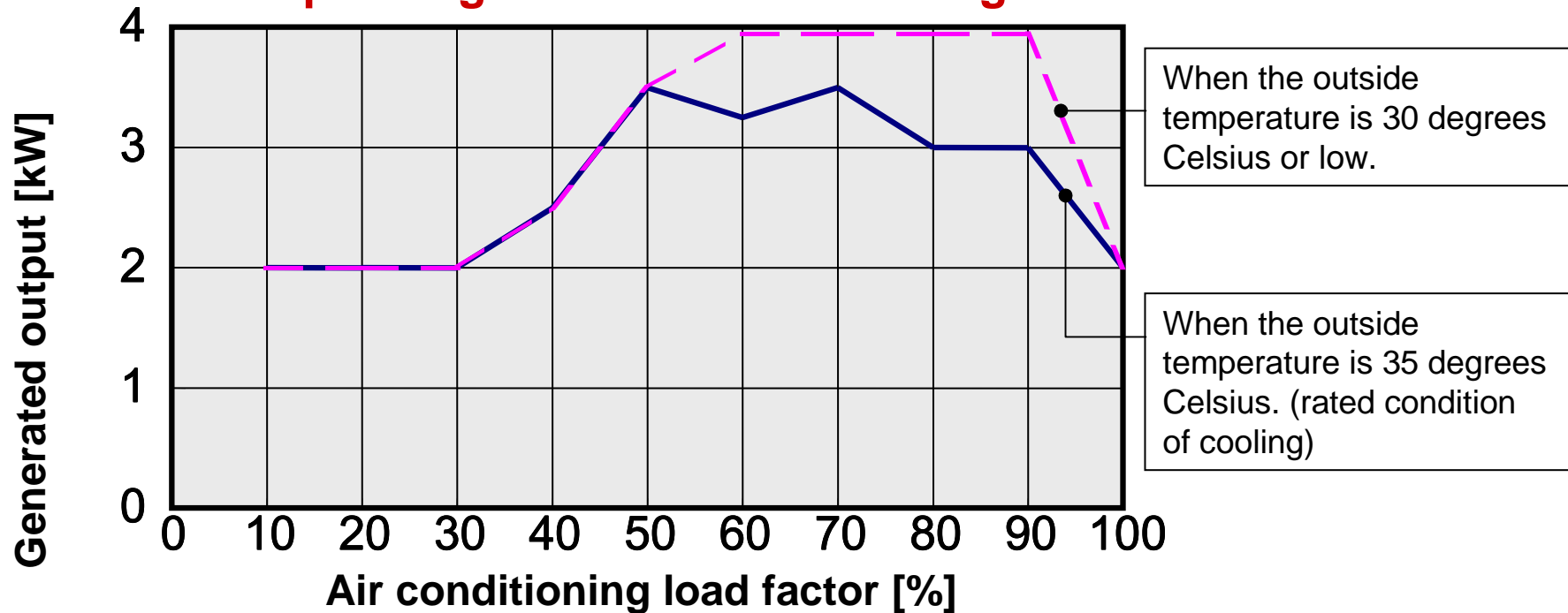
Structuring of a power generation control development and wiring system with multiple-unit operation in view



*Refrigerant piping and outdoor and indoor communications lines as before

Overview of Power Generation Control

The generated output varies between 2 and 3.95 kW depending on the air conditioning load factor.



*The generated output refers to the power conditioner output, which is outputted from the unit with the power that the outdoor unit consumes deducted.

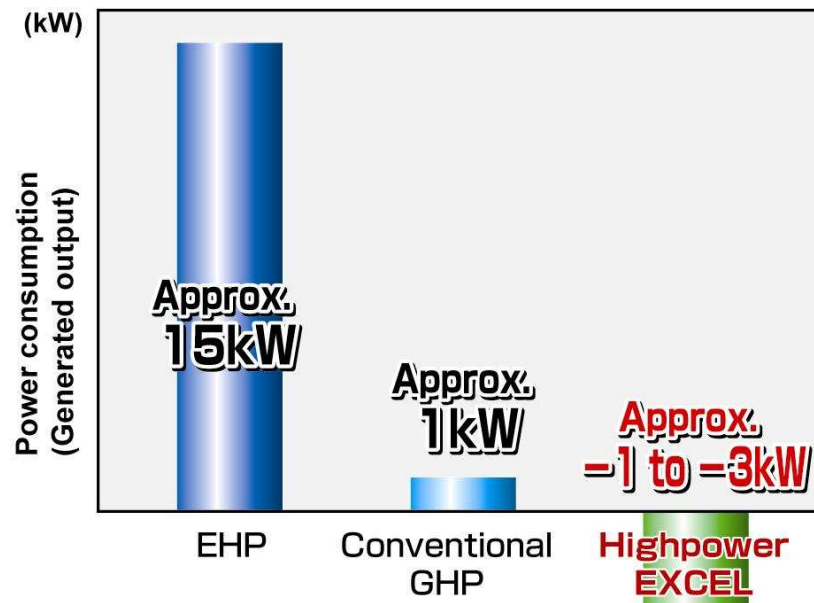
When air conditioning load factor is 100%, that is to say Engine load is high, generated output is 2kW. As engine surplus power increases, this system generates maximum about 4kW.

Features of the Highpower EXCEL

“Power Peak Cut”

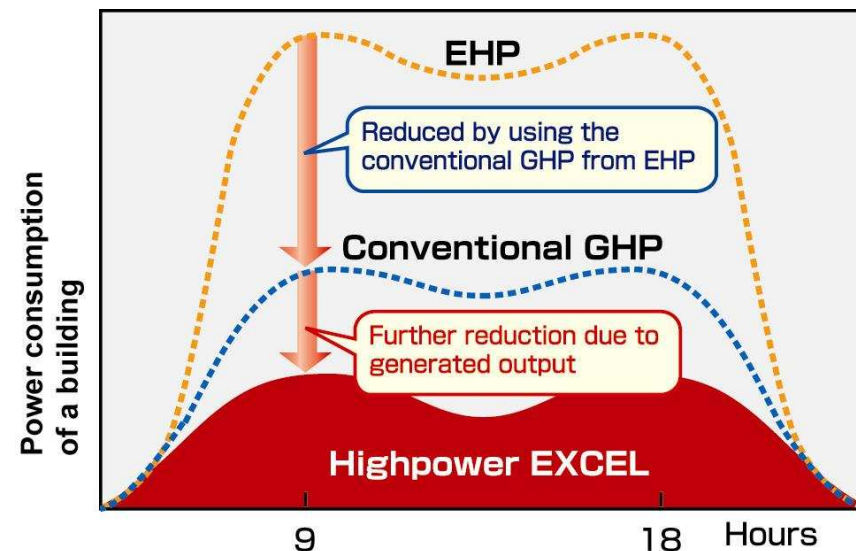
When in cooling or heating operation, the unit supplies a generated output of between 1 and 3 kW to the building; the more air conditioning is installed, the more electricity is saved.

Comparison of power consumptions



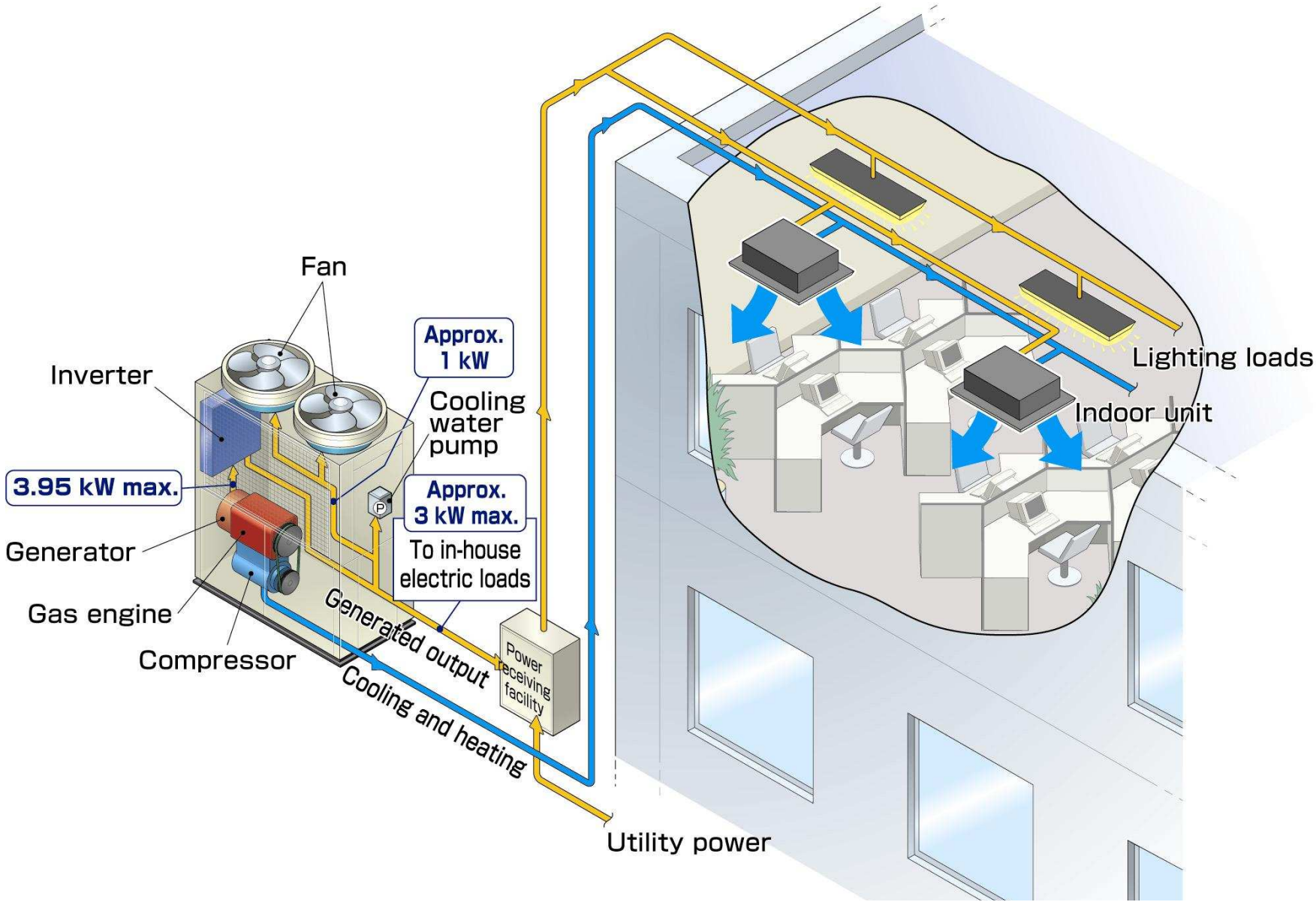
Supplied to the indoor unit, lighting loads, etc.

Comparison of the peak power of each system



It is useful for the electric power load leveling by reducing the peak power.

Visual presentation of an installed Highpower EXCEL



Scale of Power Generation of the “Highpower EXCEL” Unit



Power demand and air conditioning capacity by building purpose (for a building with a floor area of 10,000 m²)

		Office (OA type)	Hospital	Hotel	Store
Demand	W/m ²	71	50	50	70
Cooling load	W/m ²	123.3	104.7	87.2	139.5

For a building with a floor area of 10,000 m²



		Office (OA type)	Hospital	Hotel	Store
Demand	kW	710	500	500	700
Cooling load	kW	1233	1047	872	1395

Source: Planning and Design Manual for Natural-gas-powered Cogeneration 2002

The Highpower EXCEL unit secures a power generation capacity of 80 to 90% of common introductory cogeneration capacity.

		Office (OA type)	Hospital	Hotel	Store
Introductory cogeneration capacity (0.2 times the demand)	kW	<u>142</u>	<u>100</u>	<u>100</u>	<u>140</u>
Number of 20-HP units installed (To be selected on the basis of 1.2 times the cooling load)	Number of units	27	23	19	30
Generated output of the Highpower EXCEL units (4 kW times the number of units installed)	kW	108	92	76	120

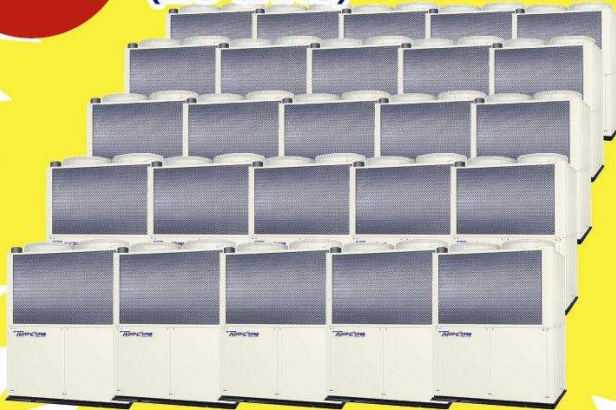
Toward the Achievement of Generating Output Comparable to That of Cogeneration through the Installation of Multiple Units



When you determine the number of units to be installed on the basis of the air conditioning capacity, the generated output will be between 10 and 20% of the total received power of the building in question.

Example

500 HP developed by Highpower EXCEL units (25 units)



Output: 100kW MAX

Equals

Gas cogeneration



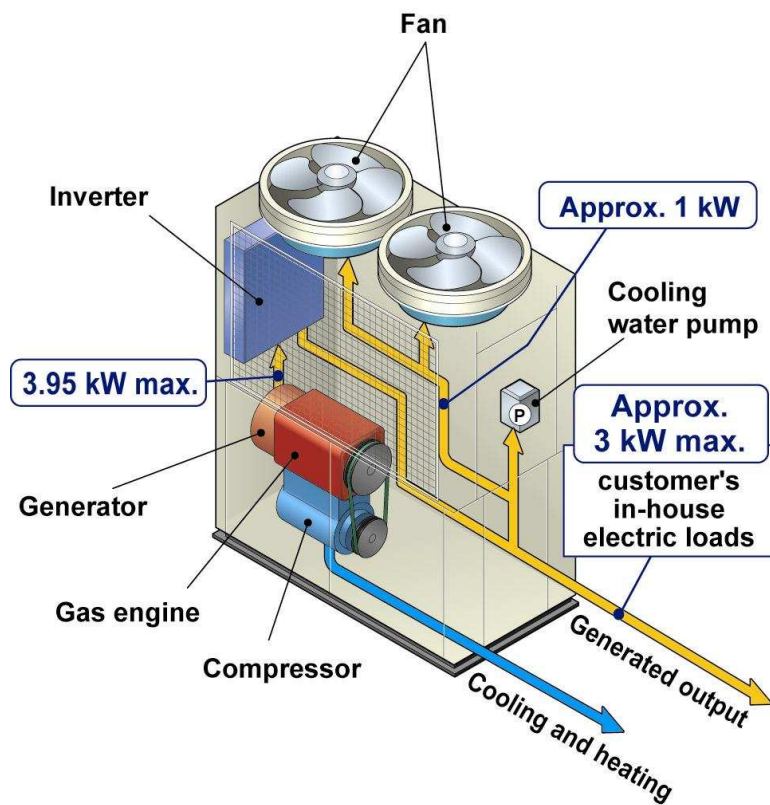
Output: 100kW

Features of the “Highpower EXCEL” Unit ②



“High-efficiency Power Generation”

Power generation using gas-engine reserve capacity assures a phenomenally high generating efficiency of **40% or more** (*as referred to the HHV basis).



Why high-efficiency power generation?

Example: Driving

A 1.5 times increase in the number of passengers results in only slightly higher fuel consumption. The same situation applies to the Highpower Excel. Even if the engine load running the generator is increased, gas consumption rises by only 5 to 10%.

① Driving with **two passengers** on board



Fuel consumption



② Driving with **three passengers** on board

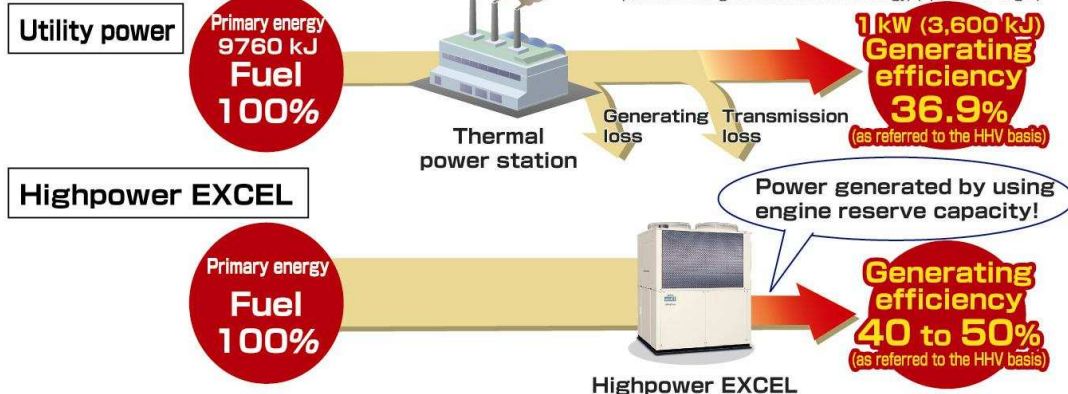


Fuel consumption



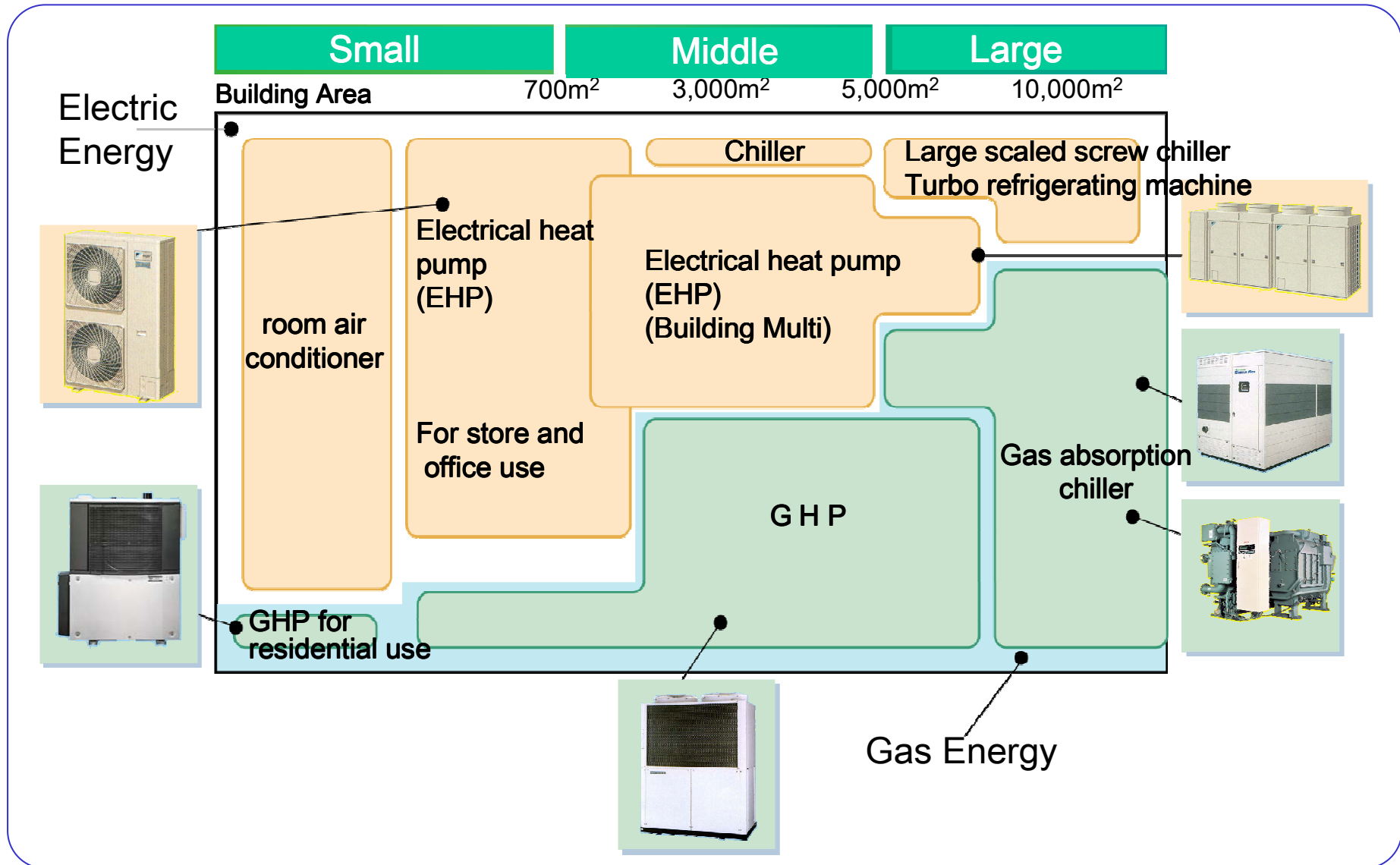
Comparison of generating efficiencies between the case of using utility power and that of using the Highpower EXCEL unit

Source: Enforcement regulations from the Energy Conservation Law (Law concerning the Rational Use of Energy) (April 2006 target)

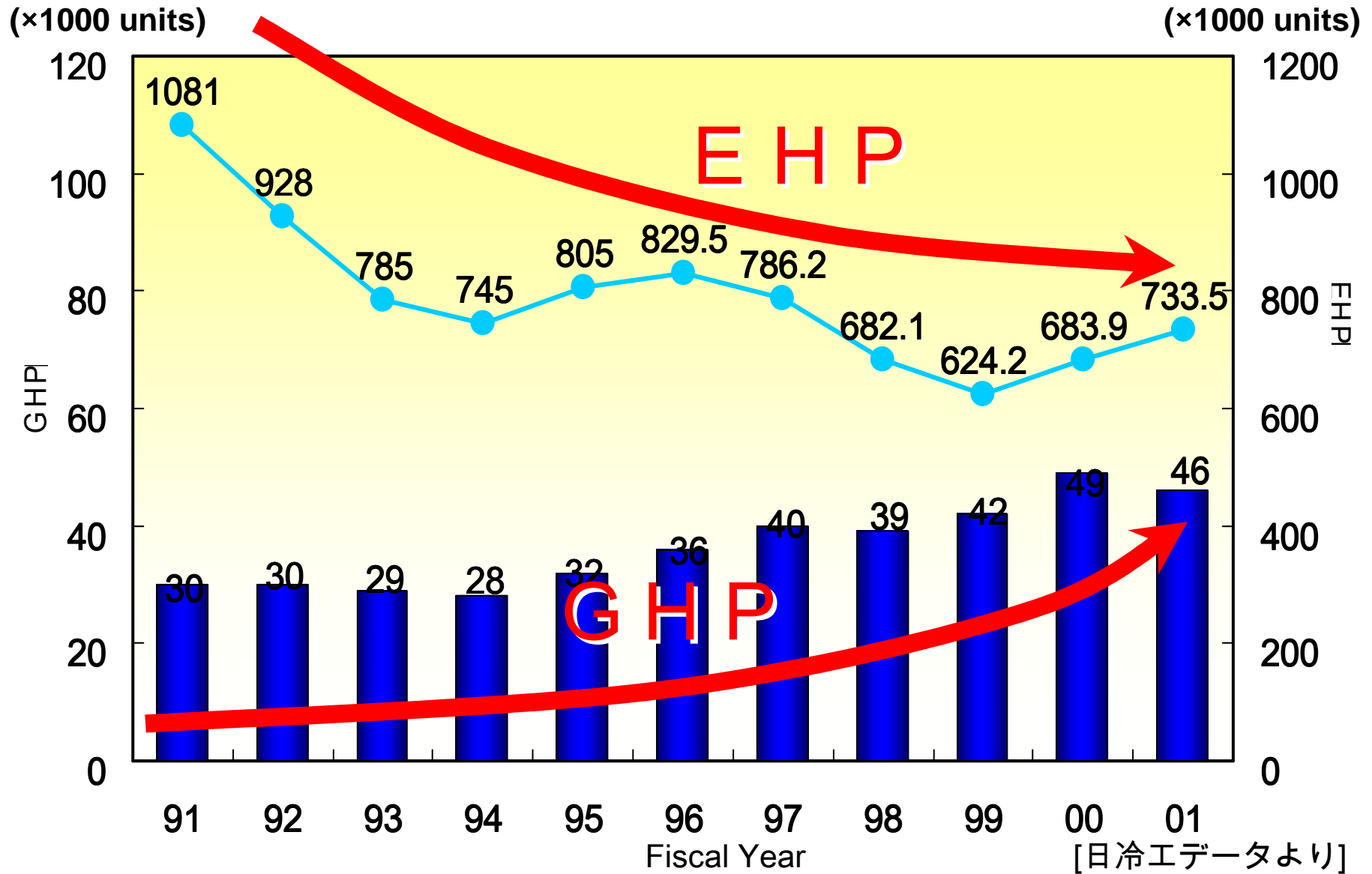


Source: Highpower EXCEL Data Sheet

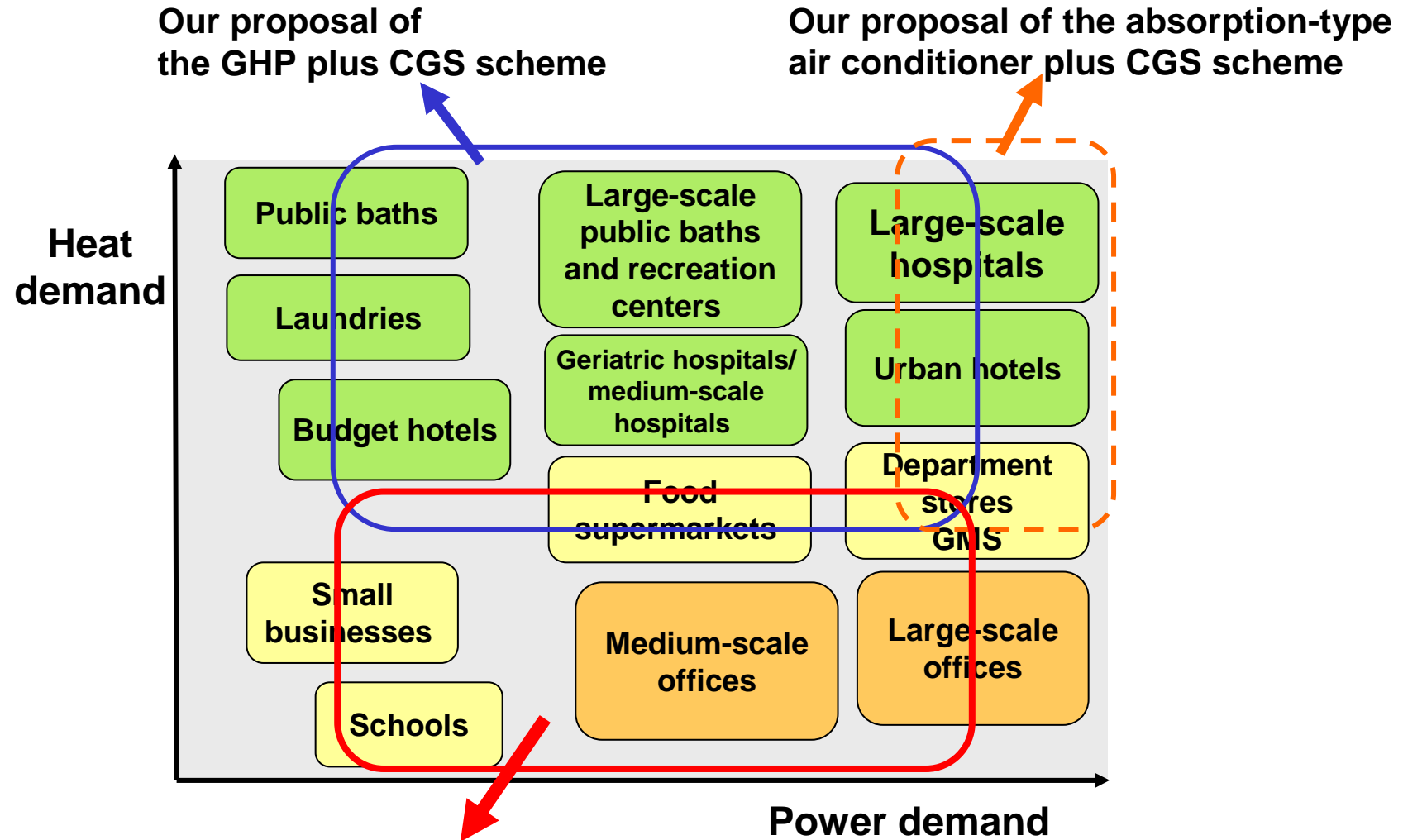
Overview of the Airconditioning Market (Osaka Gas)



Japanese Airconditioning Market



Sales Target for “Highpower EXCEL” Units



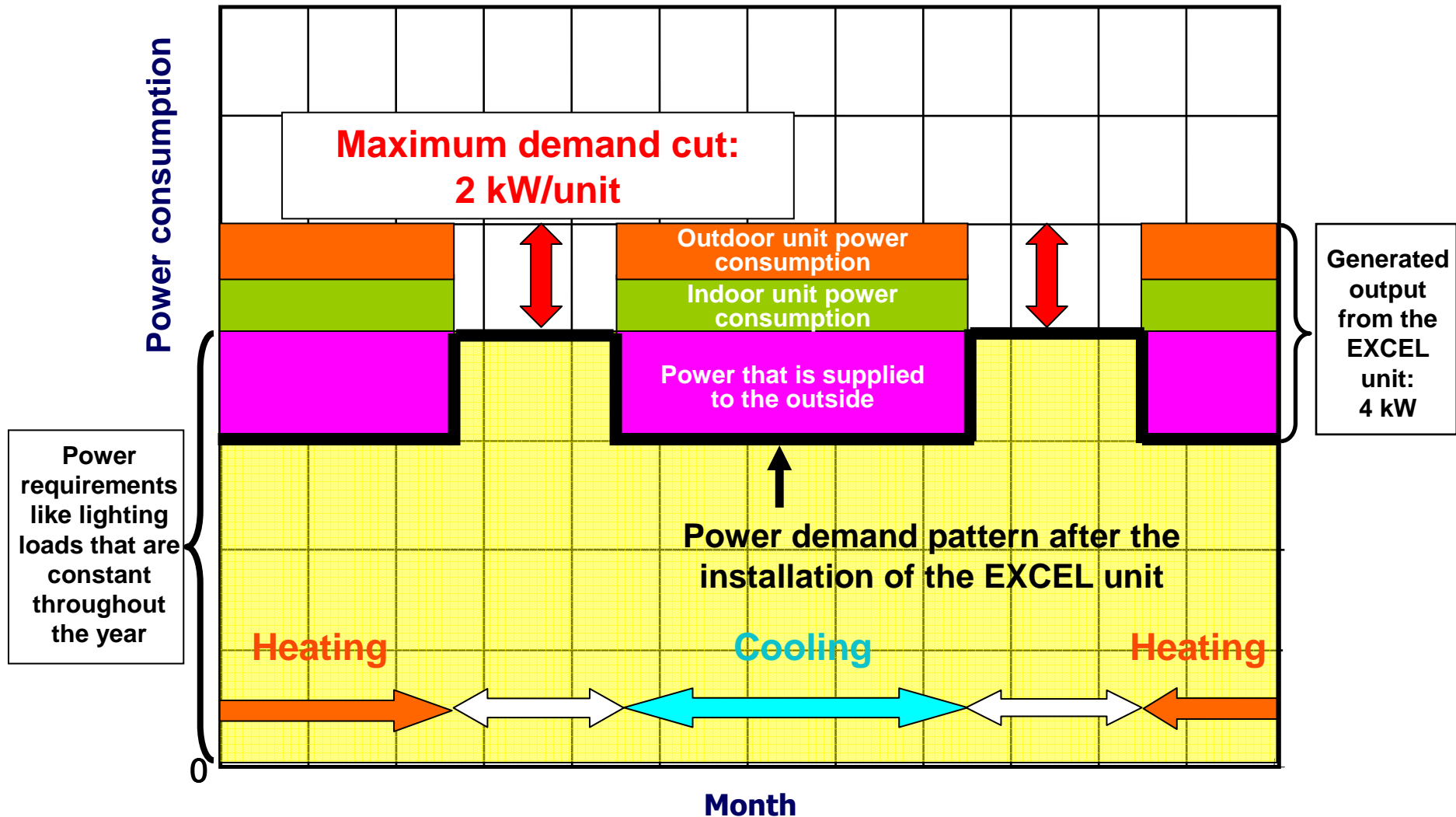
Energy proposal for business-use buildings with small heat demand

→ The main targets for “Highpower EXCEL” units are
“buildings for sales activities and business operations.”

Demand Cut Effect of the "Highpower EXCEL" Unit



Case where the EXCEL unit is installed in a building for which the power demand other than air conditioning is constant throughout the year

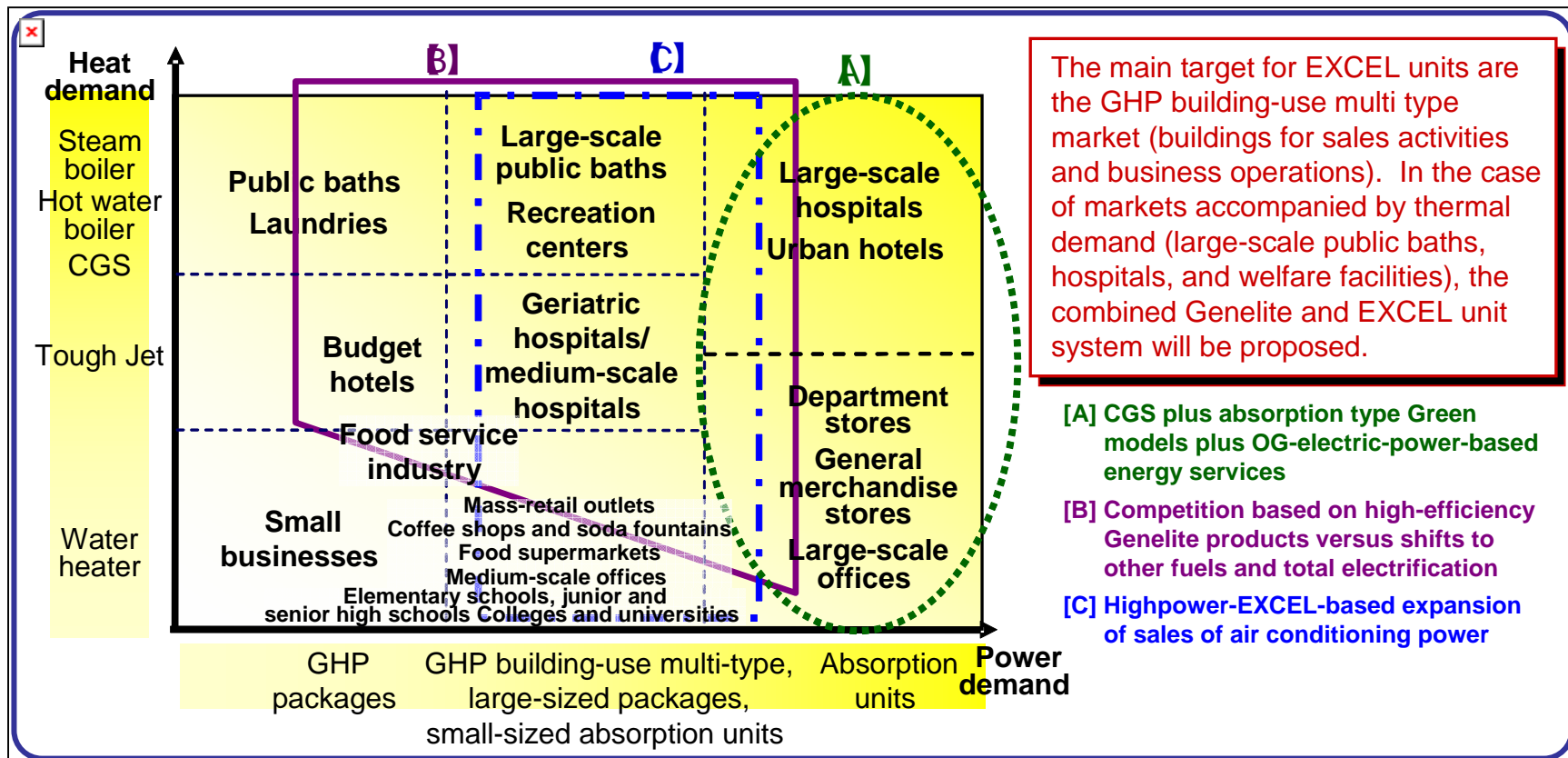


Positioning and Target of the Highpower EXCEL Unit

Strategic positioning

- * New and old housing markets: Replacements of CGSs in business-purpose buildings with lower thermal loads
- * Repeater market: Strategic products that will make up for the decrease in the gas quantity sold resulting from the purchase of more energy-efficient replacements

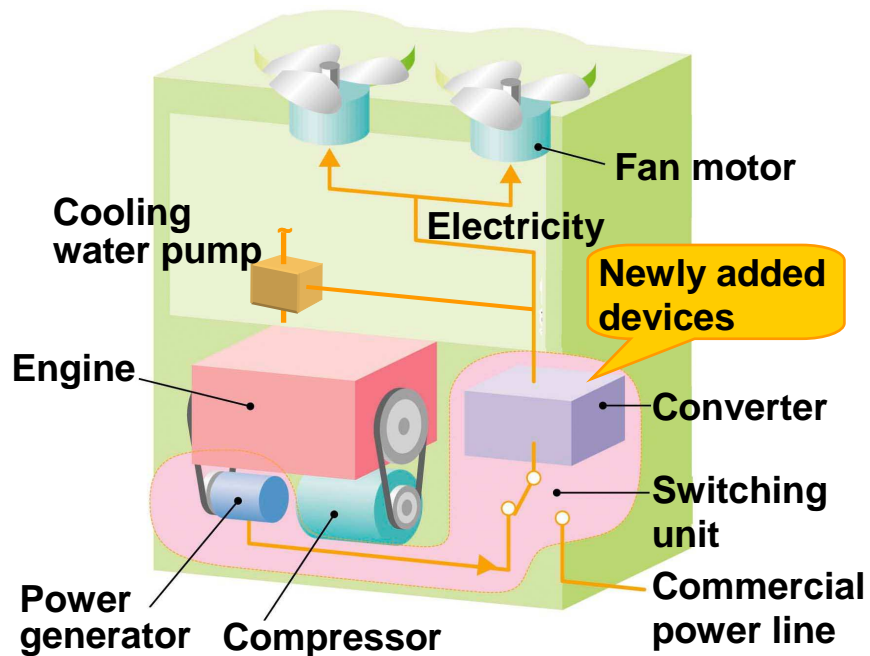
Sales target



Commercialization of High Power Multi

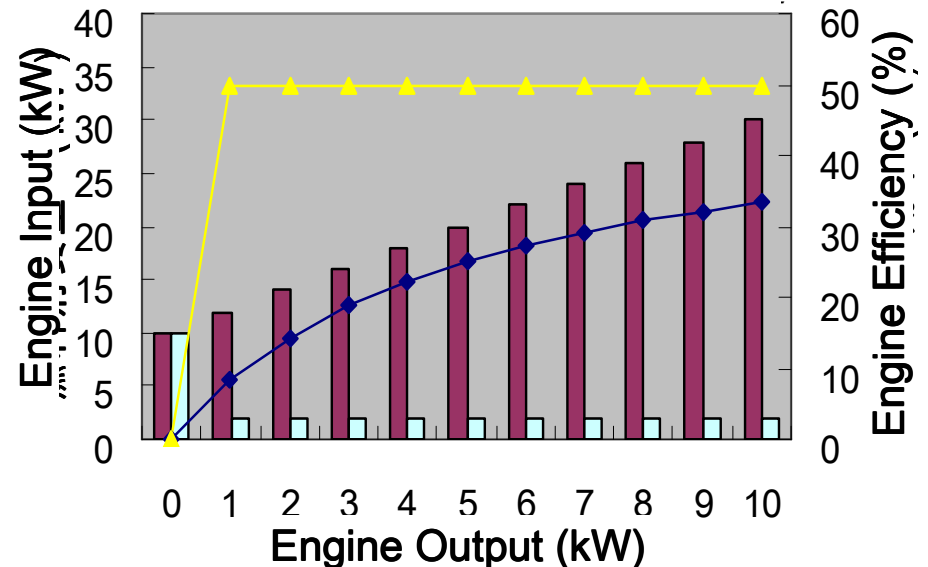
realizes higher power-generating efficiency than thermal power plant
(the generator and the converter are additionally installed in the conventional GHP)

Structure of this system

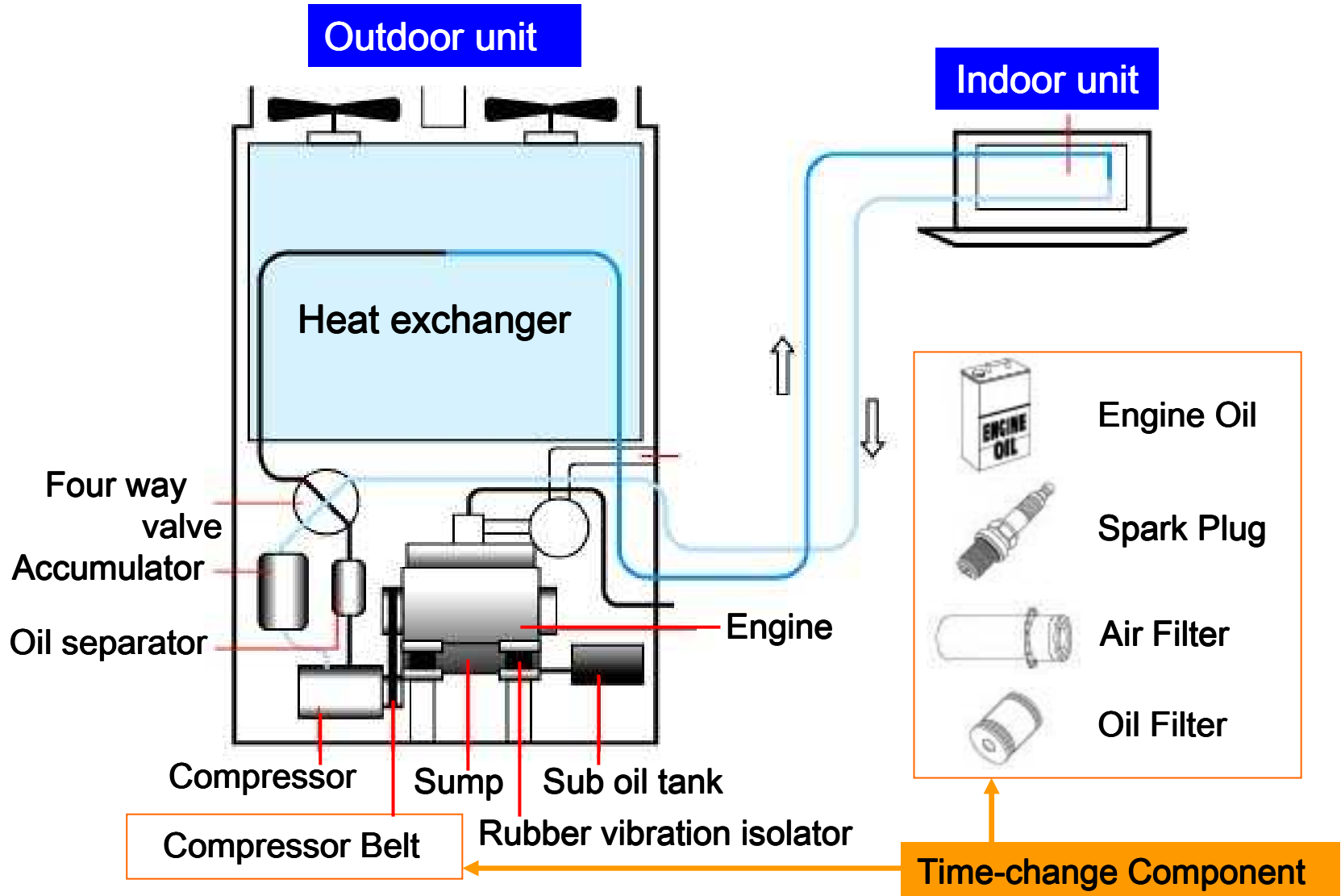


Feature of this system

- Lowest power consumption
in the air-conditioning industry
1/100 (100W)
- Higher efficiency power generation by using
the surplus engine power
Generating efficiency : 46% (LHV)

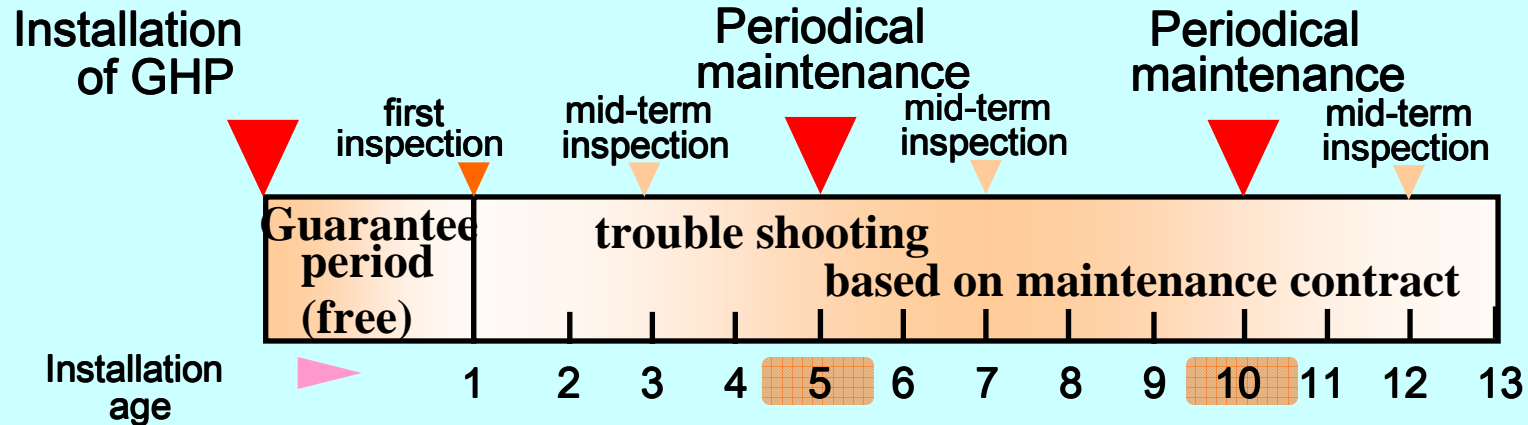


Time-change Component



Osaka Gas Maintenance Menu

Maintenance cycle



The three mid-term inspections are eliminated by using sky remote system.

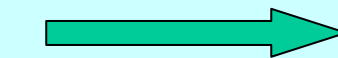
Principal maintenance contents

- exchange of the engine oil, spark plug, air filter etc
- adjustment of the valve clearance
- confirmation of the engine coolant level

Cost

(ex) 20HP type

¥35,000/unit



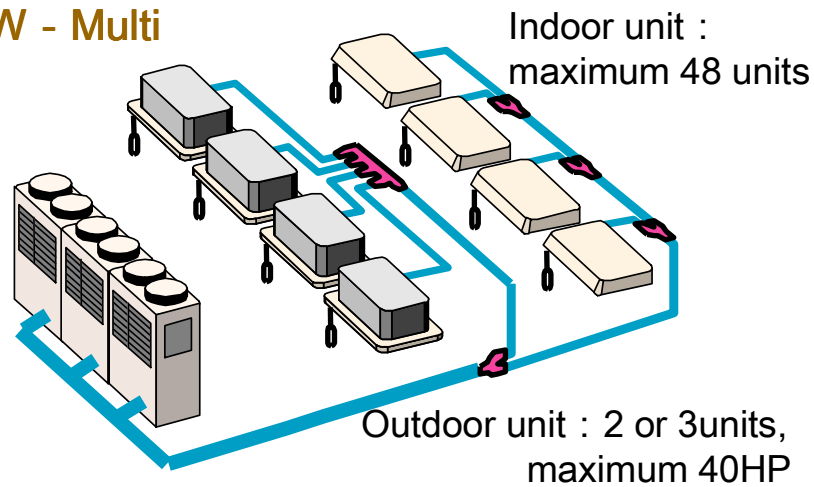
¥31,500/unit

sky remote system

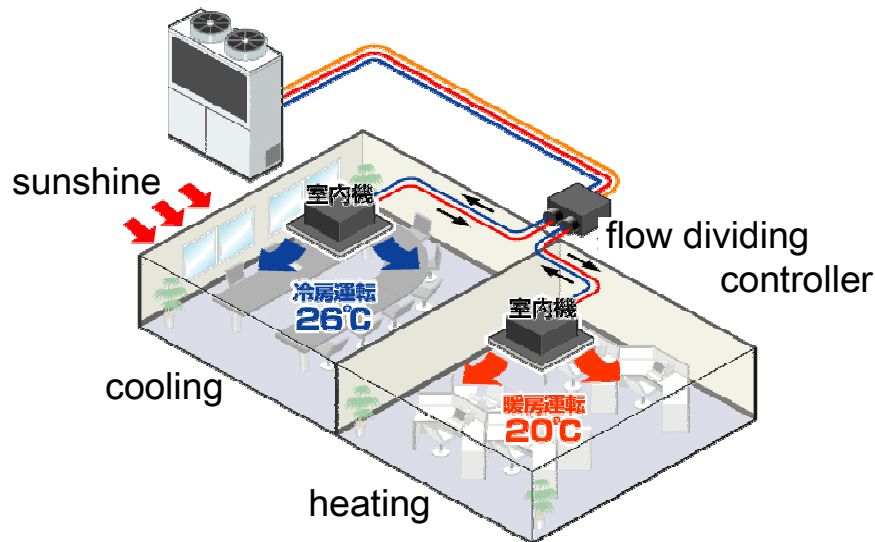
Lineup of GHP's ~ meet the various customer needs ~

High efficiency & Superb functionality

•W - Multi



•Simultaneously cooling & heating - Multi

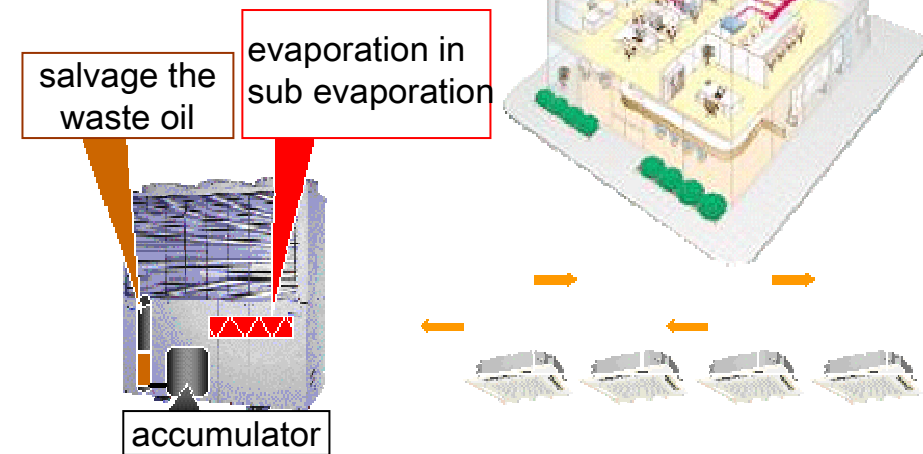


High efficiency & Renewal

•Quick Multi (cleaning less type)

•Quick Multi (self cleaning type)

- controlled by using microcomputer
- circulation of the liquid refrigerant and cleaning the remaining oil
- refrigerating cycle by using exhaust gas (characteristic of GHP) salvage the waste oil in its outdoor unit



Micro Cogeneration System (MCGS)

- Use of high reliability GHP parts (engine, silencer, radiator fins, cooling water pump, ventilation fan etc.)
- Use of mass production GHP parts

