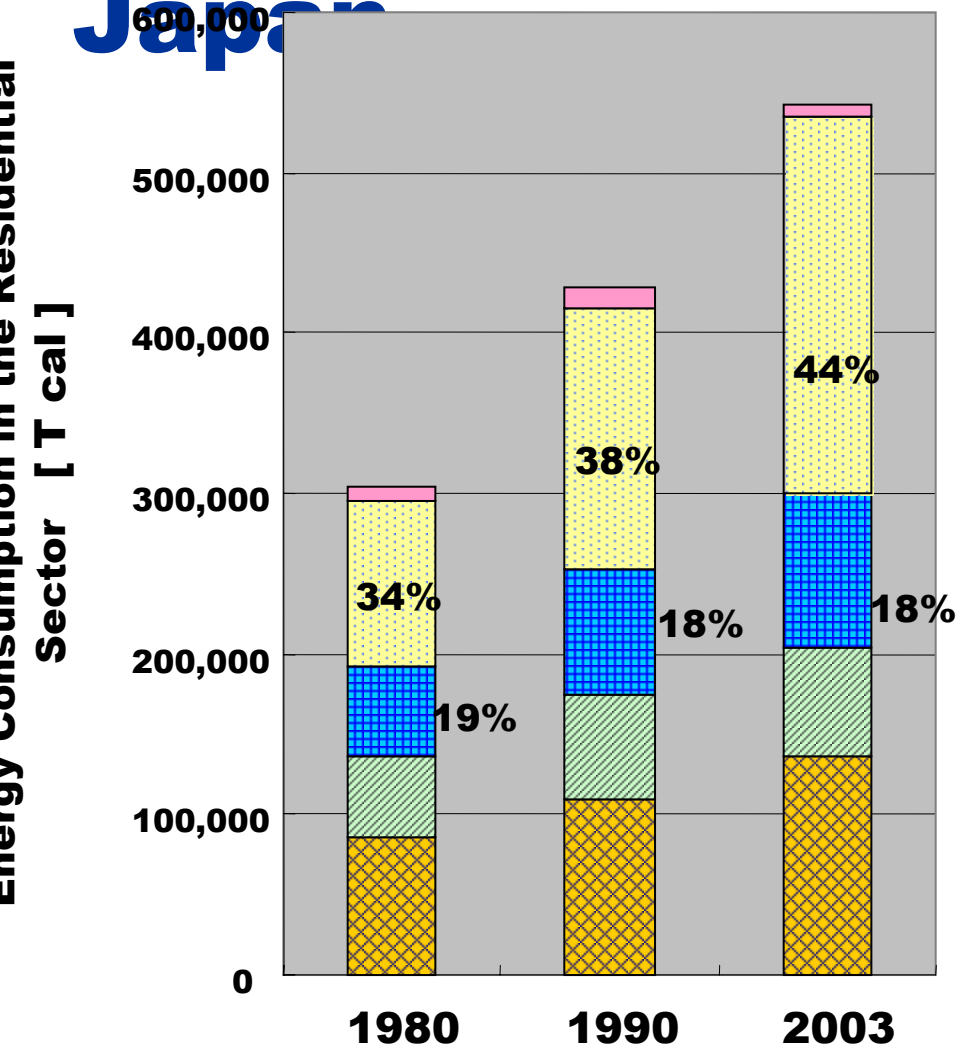
Development of Residential PEFC at Osaka Gas

Residential Cogeneration Development Department

Osaka Gas Co., Ltd.

Hiroshi NAKAJIMA

End-Use Residential Energy Consumption in Japan



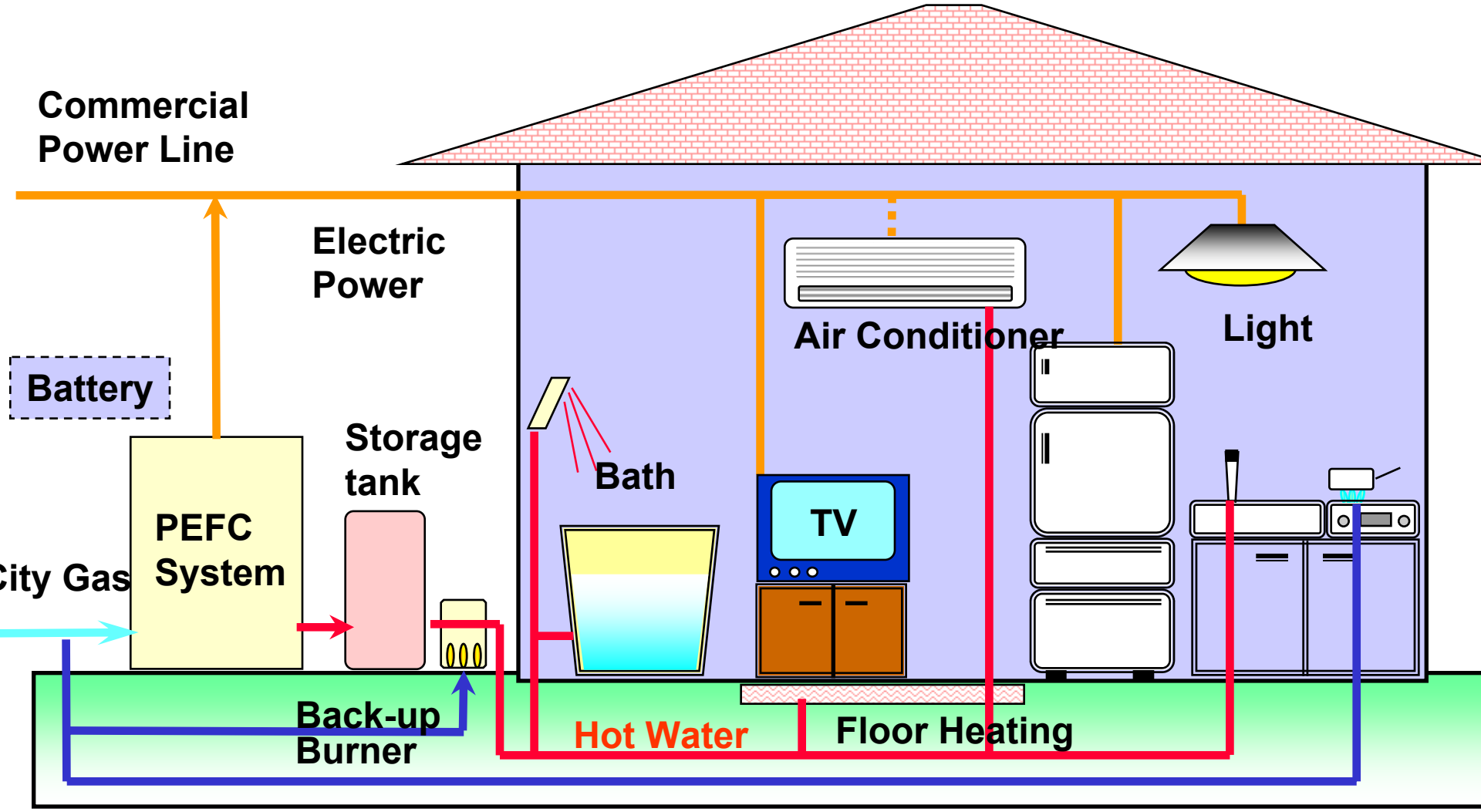
Consistent Increase in demand in the Residential Sector

Promotion of Energy conservati and New energy implementatio

Implementation target of FC 2.1 million kW in FY 2010

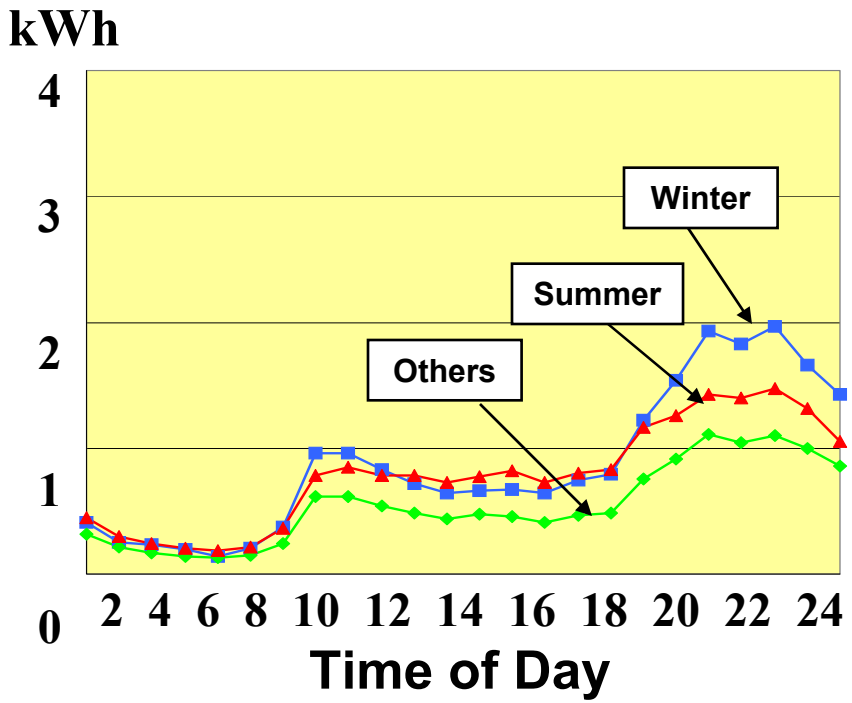
The Source : 2005 EDMC Handbook of Energy & Economic Statistics in

PEFC Cogeneration System for Residential Application



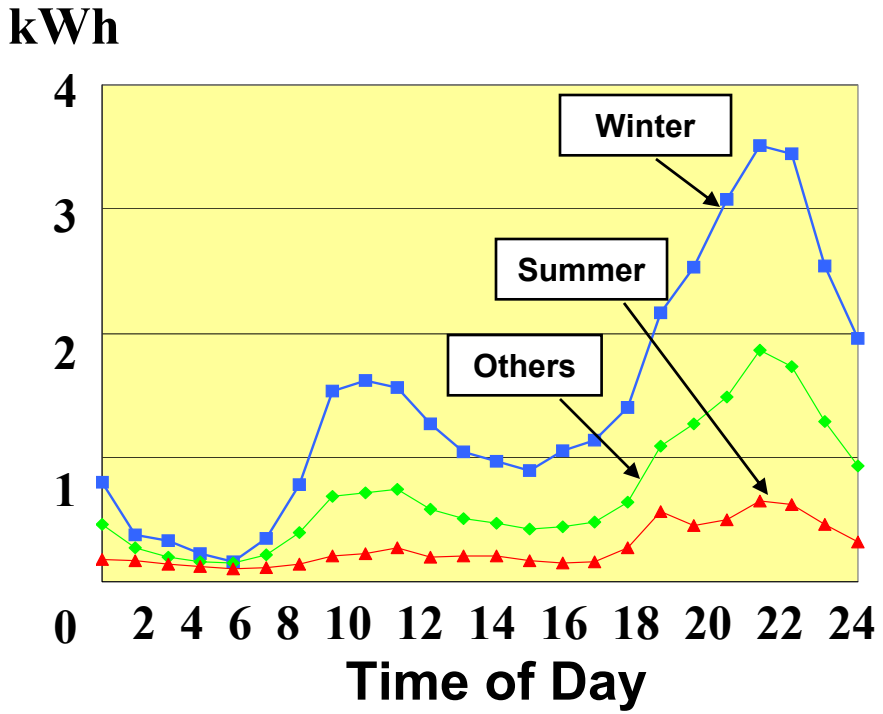
Demand of a Standard Japanese Household

Electric Power Demand



Annual Demand : 5,576kWh

Hot Water Demand



Annual Demand : 6,060kWh

Surveyed by Institute of Research & Innovation in 1998

Target Specification of PEFC Unit in FY 2005

Nominal Power	700 W	1 kW
T/D (W)	250 / 500 / 700	300 / 500 / 750 / 1000
Net AC Eff.	>27.0%>30.5%>31.5%	>27.0%>30.0%>31.0%>31.5%
Heat Recov. Eff.	>23.0% >34.0%>39.0%	>24.0% >33.0%>38.0%>41.0%
Hot water Temp.	> 60 °C (only for hot water supply)	
Grid Connection	Interconnected without reverse sending	
Operation	Continuous, Start & Stop	
Life	10 years	

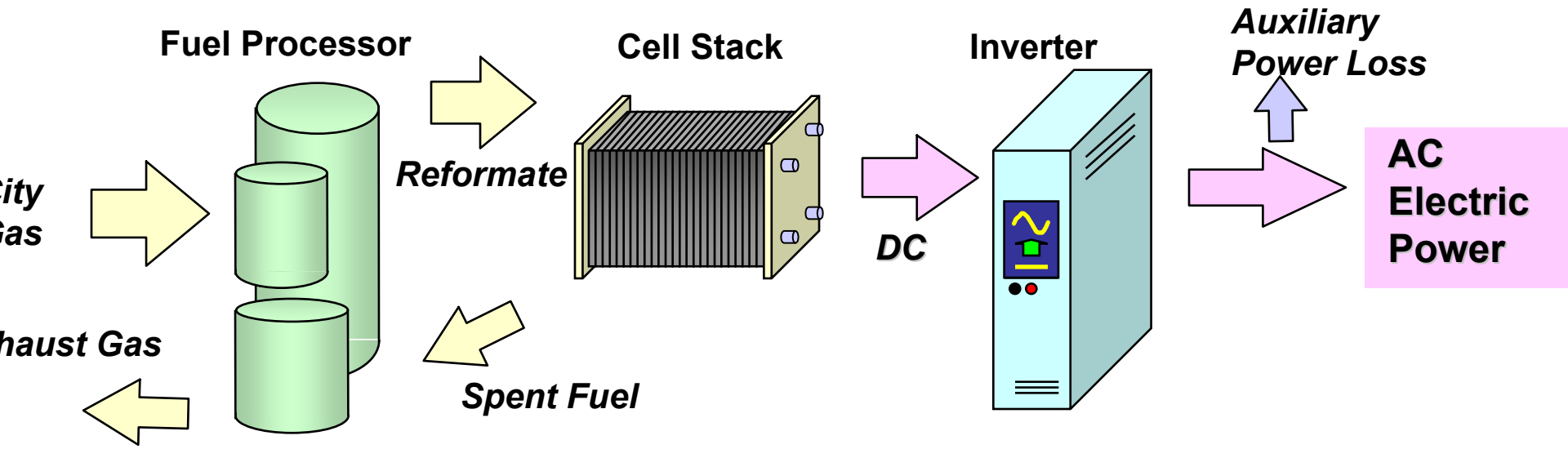
Efficiencies in HHV, Heat Recovery Efficiency at the outlet of main body, Hot Water Temperature at storage tank.

Targeting System Efficiency (1kW)

Electric Efficiency (HHV)

Target@ 1kW 81% x 48.5% x 90% x 89% = 31.5%

(@ 300W 72% x 53% x 88.5% x 81% = 27%)



Heat Recovery

10% (10%)

31% (14%)

Hot Water

Heat Recovery Efficiency (HHV)

Target@1kW 41%

(`@300W 24%)

※ Efficiencies in HHV

( ) 300W Generating

Osaka Gas R&D Activities for PEFC

Fuel Processor

Catalyst Development

(Desulfurizer, Reformer,
Shift Converter, CO Removal)

Fuel Processor Development

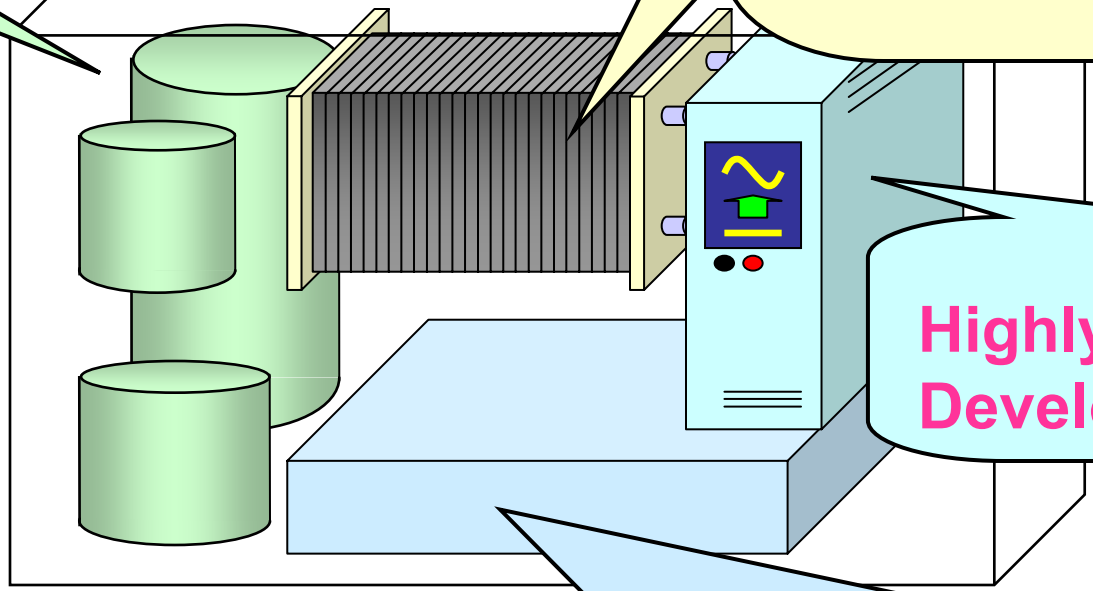
Cell Stack

Evaluation of Cell Reliability from User's Point of View

(Influence of Operating Conditions & Impurities)

Bipolar-Plate Development

(Carbon Compound for Bipolar-plate)



Inverter

Highly Efficient Inverter Development

uxiliary System

Heat Recovery System Development

(Heat Exchanger, Hot Water Management System)

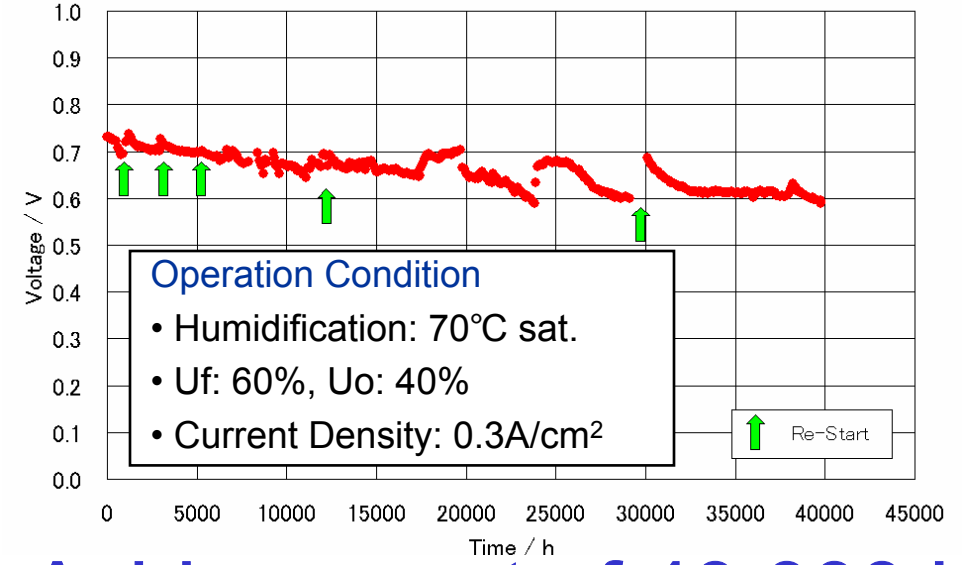
Evaluation Study of PEFC Single Cell at Osaka Ga

Investigation of the durability of cell for 90,000 hrs under the actual condition

- ◇ Durability test under the standard Condition
- ◇ Investigation of the Effects of Impurities
- ◇ Elucidation of Degradation Mechanism

↓

- ◇ Development of Accelerated Evaluation Method



- ✓ Using 37 Apparatuses
- ✓ MEAs: 8 manufactures, 22 types, 220 cells
- ✓ Cumulative operation time: 1.5 million hrs

Achievement of 40,000 hrs operation of single

NEDO's Project (Degradation Factor Analysis of Cell Stack

Exchange of the top-runner's knowledge concerning the cell degradation

{ Shorten the collecting period of Long-term durability test data

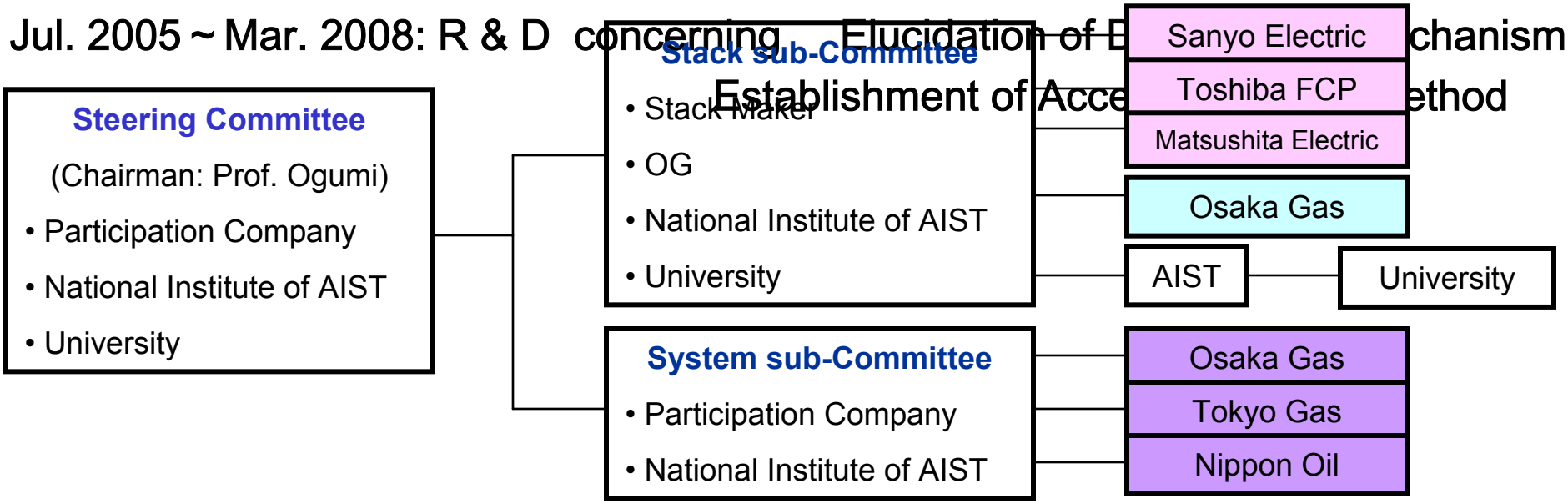
{ Degradation Factor Analysis of Cell Stack and Development of Accelerated Test ethod

Objective: Confirmation of >40,000 hrs Durability of Cell Stack by developed celerated

Test Method (~ the end of 2007 fiscal year)

Oct. 2004 ~ Jun. 2005: Formulation of Research Guide toward Establishment of Accelerated Test Method

Jul. 2005 ~ Mar. 2008: R & D concerning Elucidation of D chanism Establishment of Acce ethod



Osaka Gas's Fuel Processor

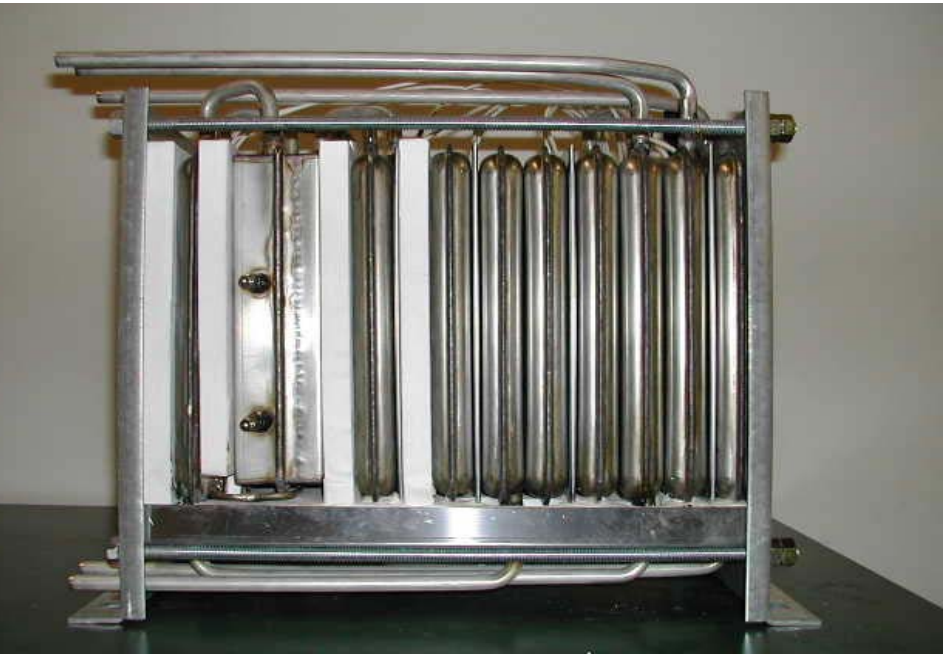
ligh Thermal Efficiency
(Low Heat Radiation Loss)

ong Durability

ost Reduction Capability
at mass production stages

Integration of Components

Simple Structure with Stamped Material



1kW class Fuel Processor

1kW FPS Dimensions

W 280mm ×D 440mm ×H 395mm

Composition of Reformed Gas

H2	75.5 %
CO2	20.1 %
CH4	1.5 %
CO	**0.8 ppm**
N2	2.9 %

Fuel Processing Reactions

Steam Reforming Process

City Gas

⇩

Desulfurizer

Steam →

⇩

Reformer

$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

($CH_4 + H_2O \rightarrow CO +$

⇩

Shift Converter

$CO + H_2O \rightarrow CO_2 + H_2$

Air →

⇩

CO Remover

$CO + 1/2\ O_2 \rightarrow CO_2$

⇩

Reformed Gas

H_2 75.5%, CO_2 20%, CH_4 1.5%, N_2 3%, CO<1ppm

Remaining CO

1 0 %

1 %

< 1 ppm

Characteristics of Fuel Processor

Characteristics of FPS

All in one package : type 500W,750W,1kW,2kW

High thermal efficiency : > 82% (HHV)

Extremely low outlet CO concentration

: < 1 ppm (initial) < 10 ppm (after 90,000 hours)

No catalyst exchange including desulfurizer

Long durability : > 90,000 hours

Low cost (in mass production) : < US $500

Total accumulated operating hours

Exceed 400,000 hours (40 sets)

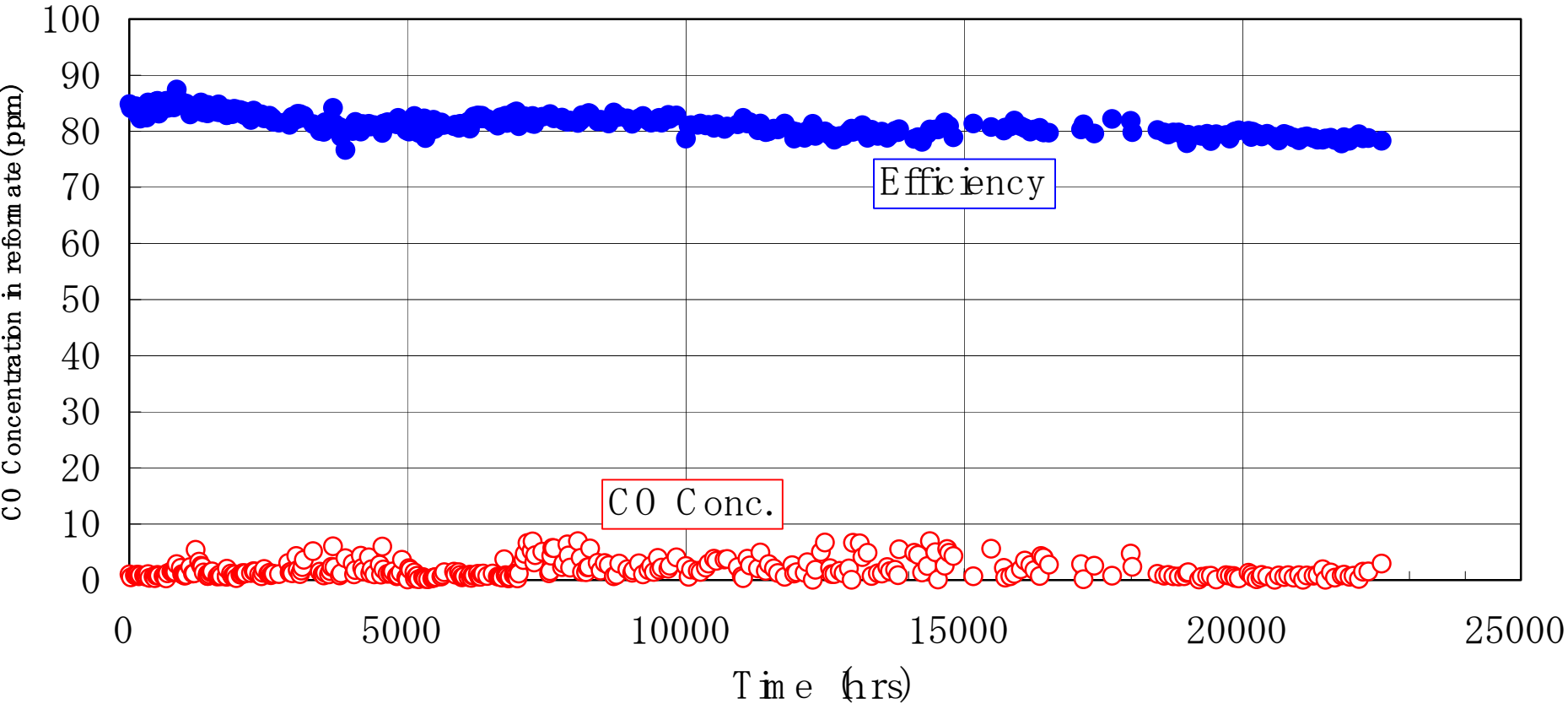
Sales of FPS Total 280 se

For domestic : 7 companies

For overseas : 8 companies

Long-term Durability of the Fuel Processo

(Continuous Operation at Rated Load)

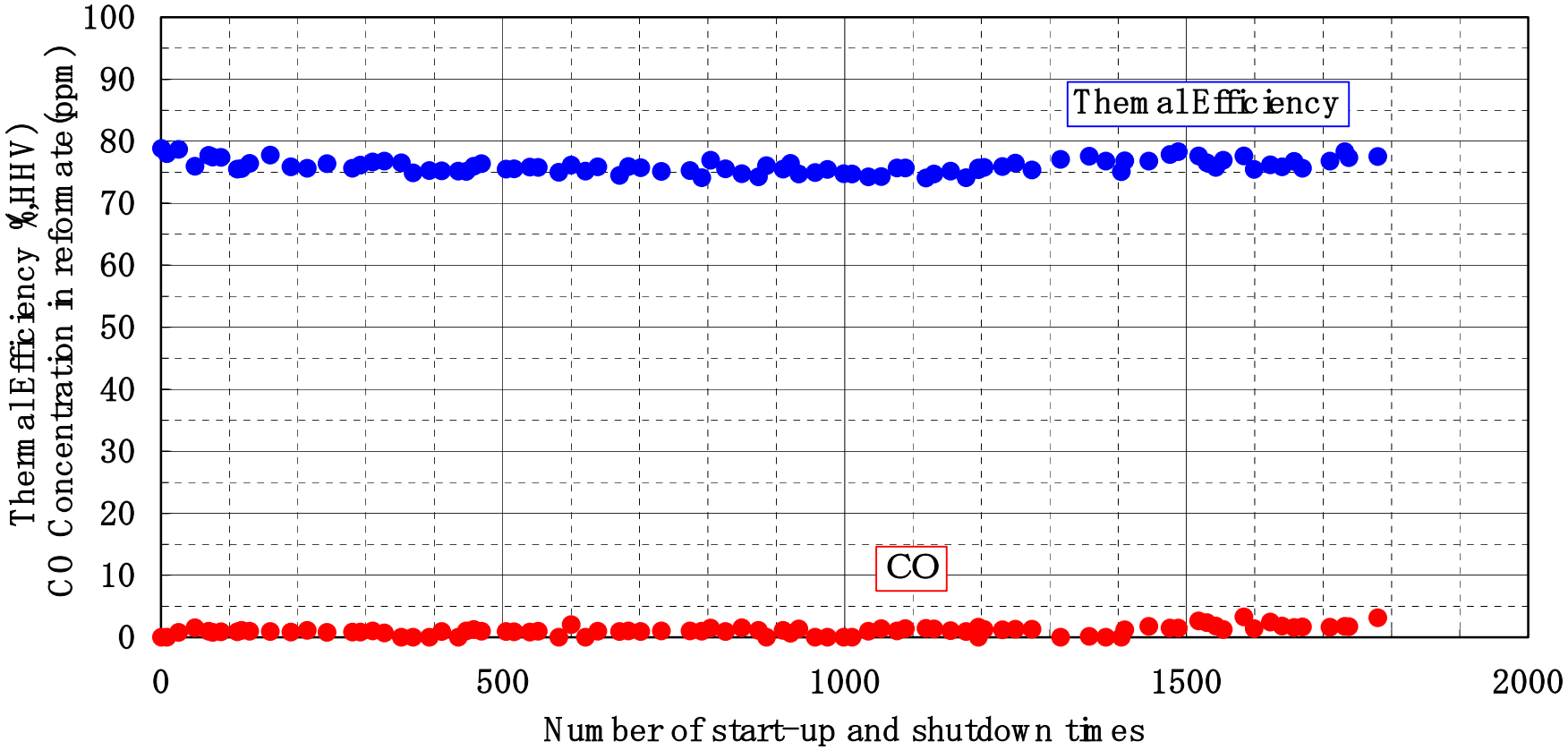


Fuel Processor: FPS-1000, Condition: S/C = 2.5 ~ 2.7, O_2/CO = 1.5.

Stable performance of the fuel processor has been demonstrated for more than 22,000 hours.

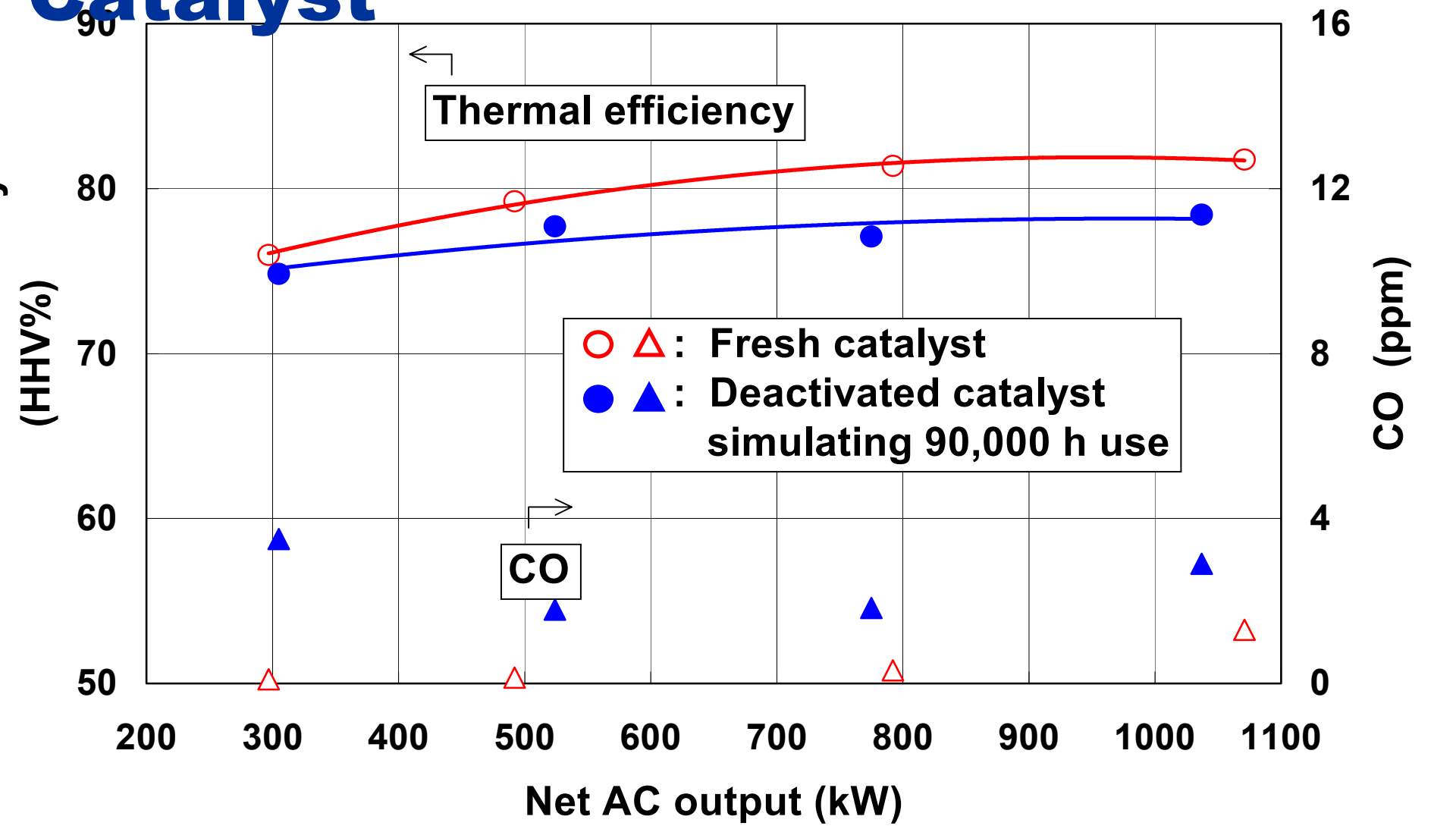
$$\text{Thermal efficiency} = \frac{\text{H2 energy consumed at cell stack}}{\text{Input fuel gas energy}}$$

Durability under Start-up and Shutdown test

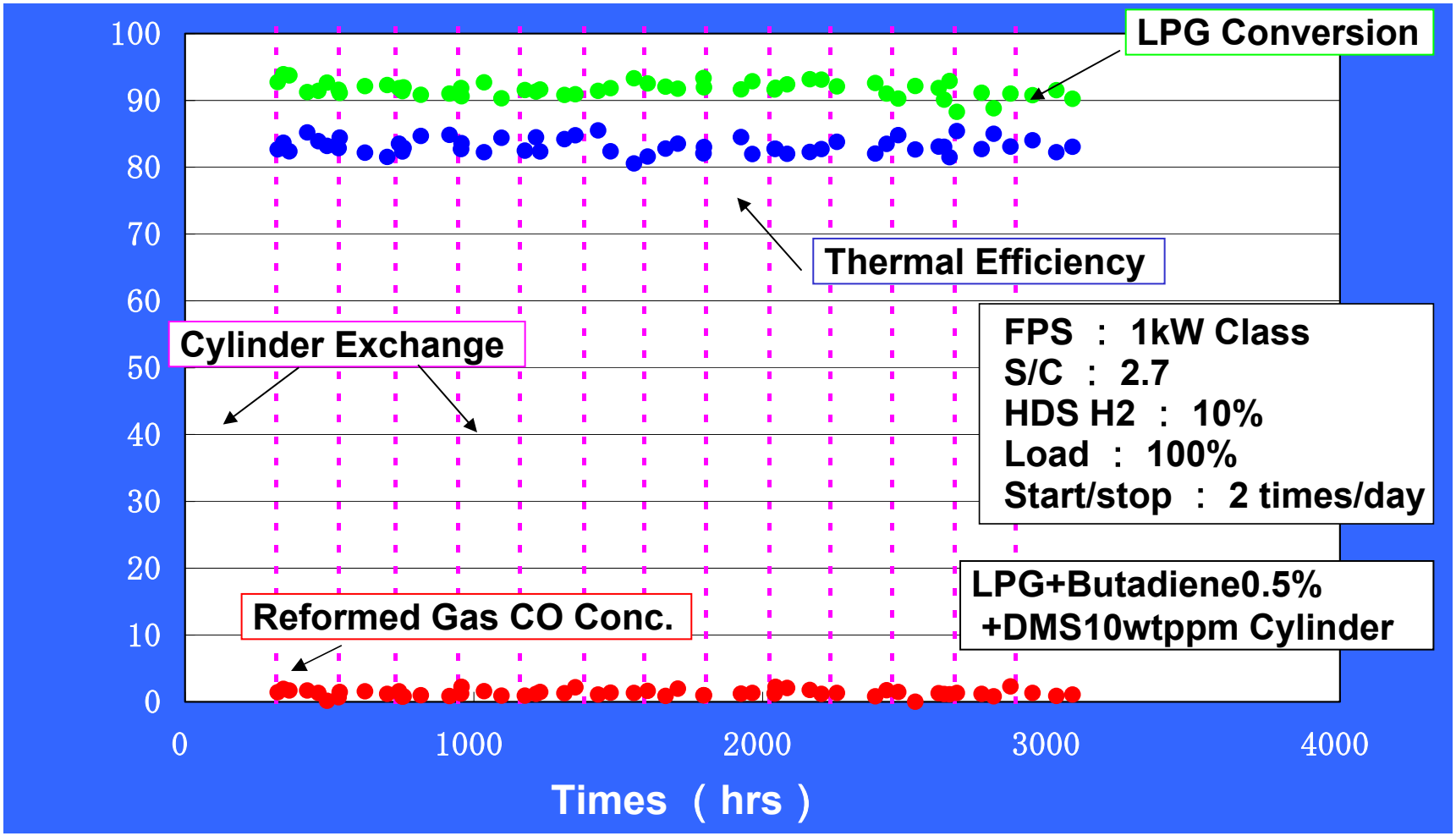


Without Nitrogen Purge FPS : 750W Class S/C : 2.7

Performance of Fuel Processor Using Deactivated Catalyst



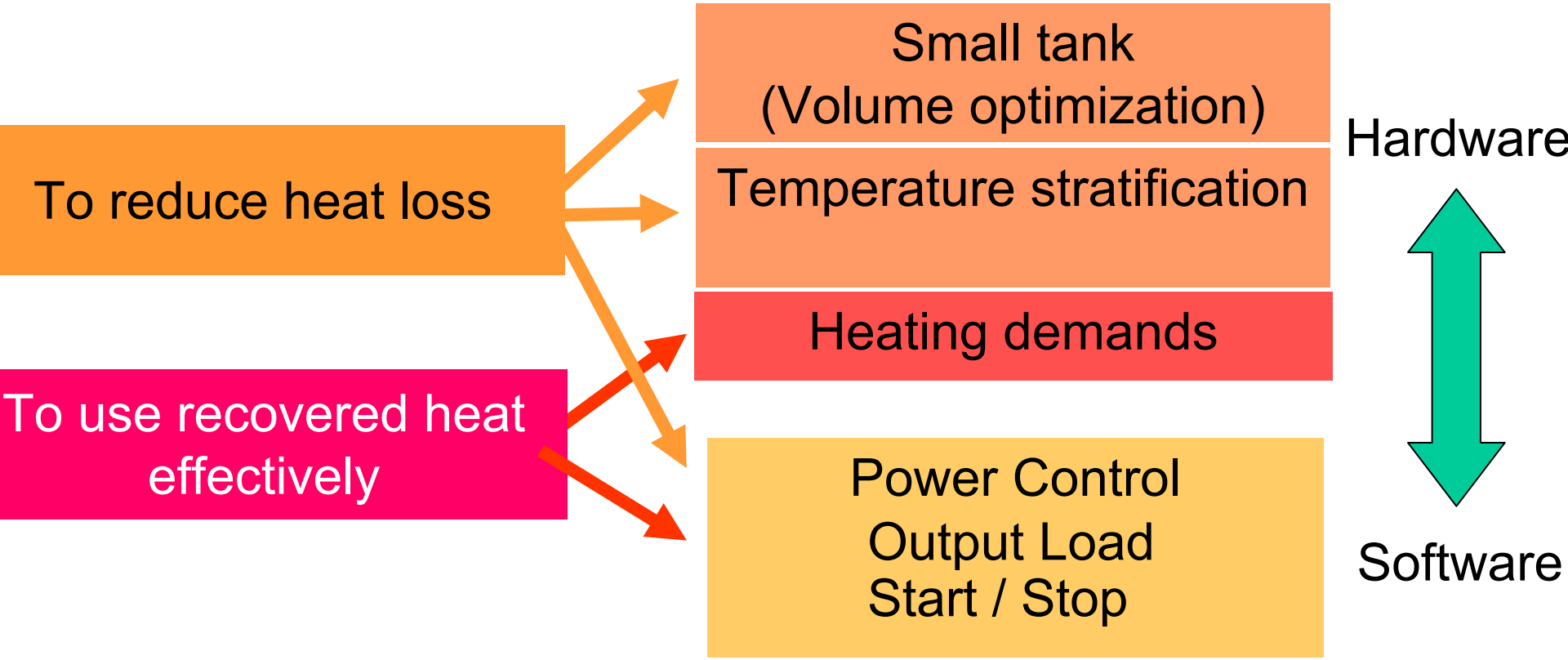
LPG FPS Durability under Continuous Operation Test



Start-up / Shut-down without N2

Heat Recovery System and Operation Software Development

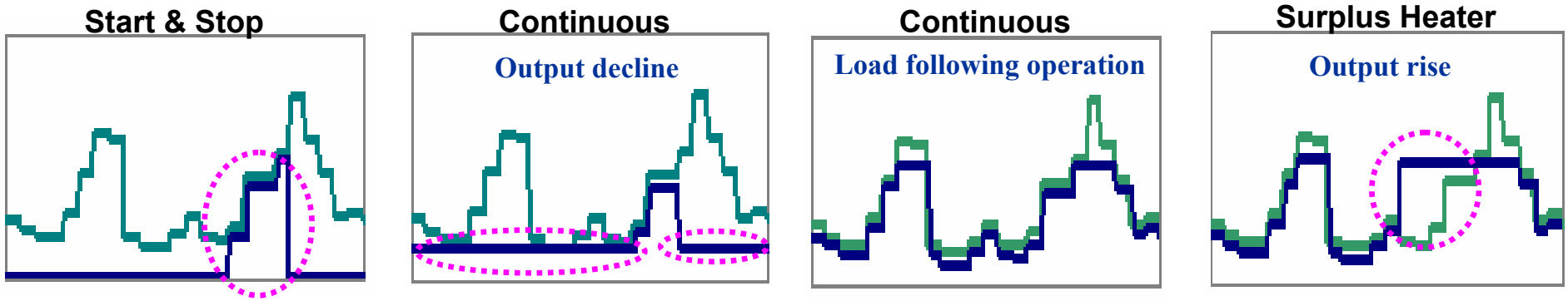
To reduce heat loss and use recovered heat effectively is required for energy saving



PEFC Optimized Operation

① For every PEFC
Only input FC Specifications
(Power & Heat Efficiency, Start and Stop energy loss, standby power
onsumption)
② For all and any Customer → Optimum Control
③ For all seasons
peration

tart & Stop ⇔ Daily S & S ⇔ Continuous ⇔ Surplus Heater Operatio



Summer (surplus heat) ⟷ Spring & Autumn ⟷ Winter (shortage heat)

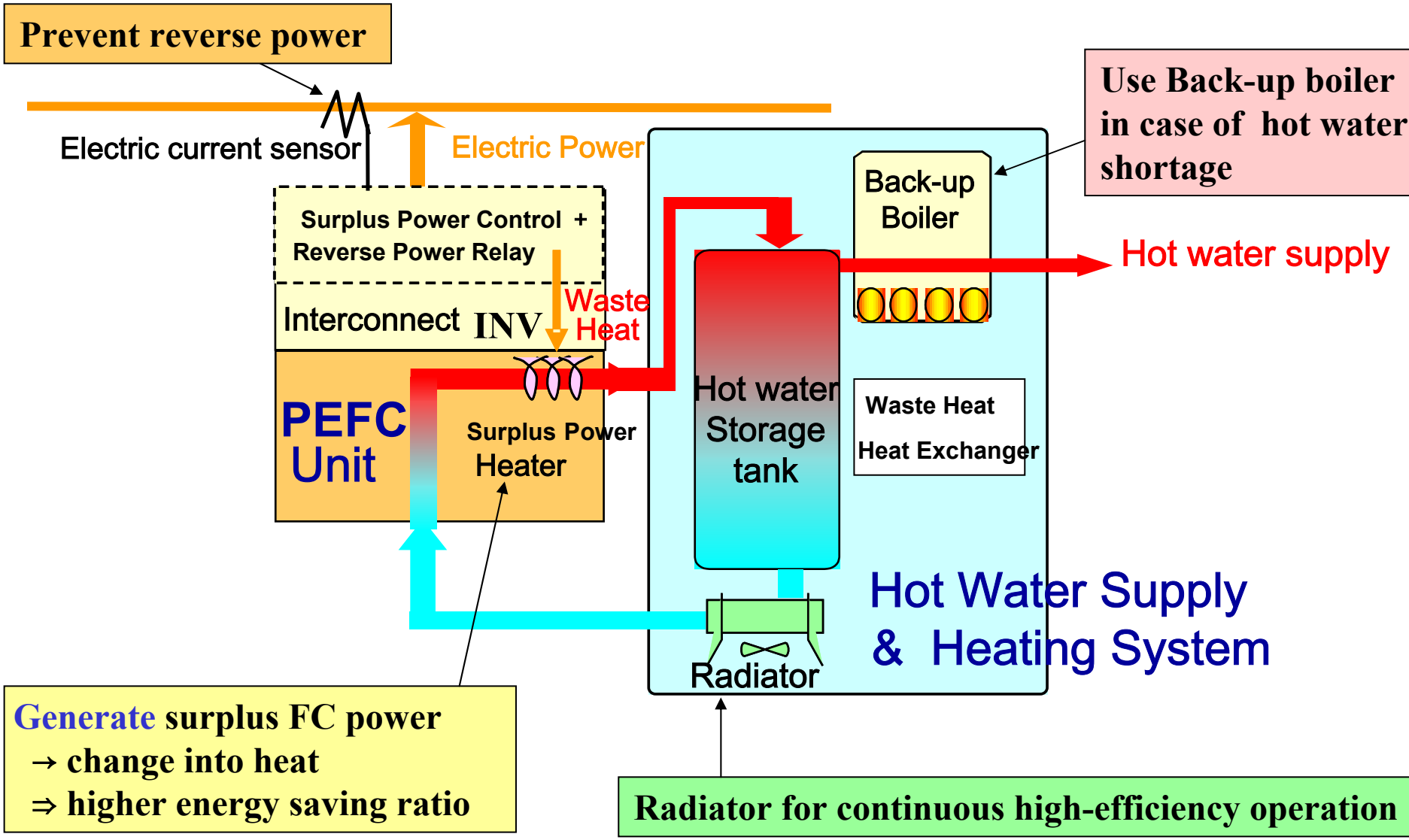
Evaluation of learning control
- Yearly Operation hours 5,500 ~ 8,500 hr
- Yearly Energy saving 4 ~ 22%

Heat recovery System

Specifications of Heat recovery Unit

		Specifications
Control		Optimum Control
BU Effic.	Hot water	Over ８３％
	Heating	Over ７５％
Heat recovery		Hot water Heating(partially)
Installation Space		４４０ｘ７５０mm
Weight		１２０ｋｇ
Communication		Two way
Remote Controller		Navigation System (Energy saving)
Standby power		5～10W

Heat recovery System



Field Test at Customers Houses

Purpose of Field Test

Evaluation of system reliability and durability

Acquisition of the data in actual installation environment

Evaluation of energy-saving

Examination of the optimal operation

Extensive field test with prototype units (2002.4 ~) and improved units (2005.2 ~) in 10 sites

Participation in Large-Scale Demonstration of Stationary PEFC (NEF)

(2005FY 1st term : 28 units)

SANYO Electric 750W

TOSHIBA FCP 700W

Matsushita Electric Industrial 1kW

PEFC System Development Schedule

Long term and extensive durability tests are required.
System operation software should be optimized for each system.
Basic system design has been able to be focused.

→ **Started joint development programs with promising manufacturers in July, 2003**