

IGRC2014 Plenary F

“What could be the important technology game changers?”

Fuel Cell: Game Changer Technology

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1. Osaka Gas: a profile

2. Fuel cell technology as game changer

3. Conclusion

1. Osaka Gas: a profile

Key Facts

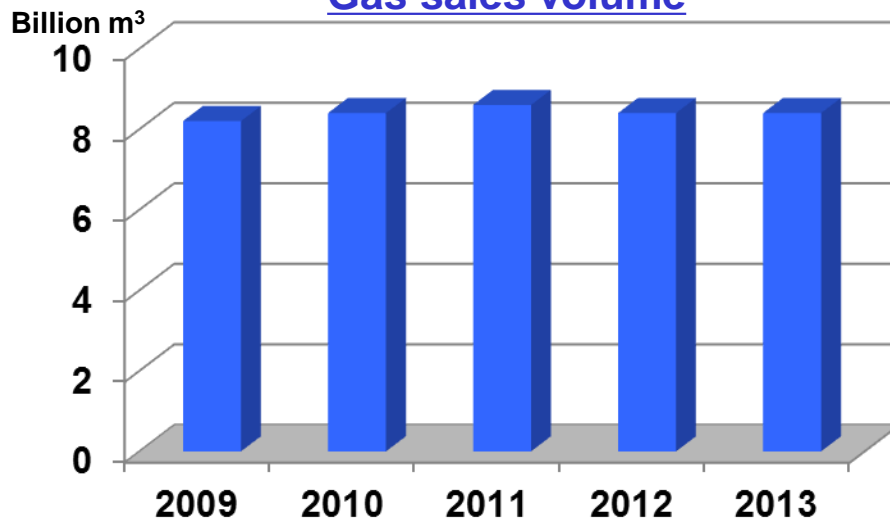
(Consolidated, March 2014)

- Gas business started in **1905**
- **7 million** natural gas customers in Kansai Region
- **61,300km** pipeline network
- **150** affiliated companies
- **21,250** employees

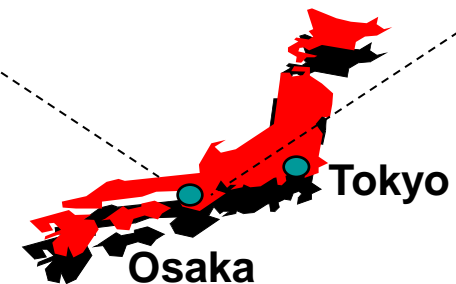
Financial/Operational Highlights

- Revenues: **¥1,513 billion** (US\$14.8 billion)
- Net Income: **¥41.7 billion** (US\$405 million)

Gas sales volume



Natural gas service area

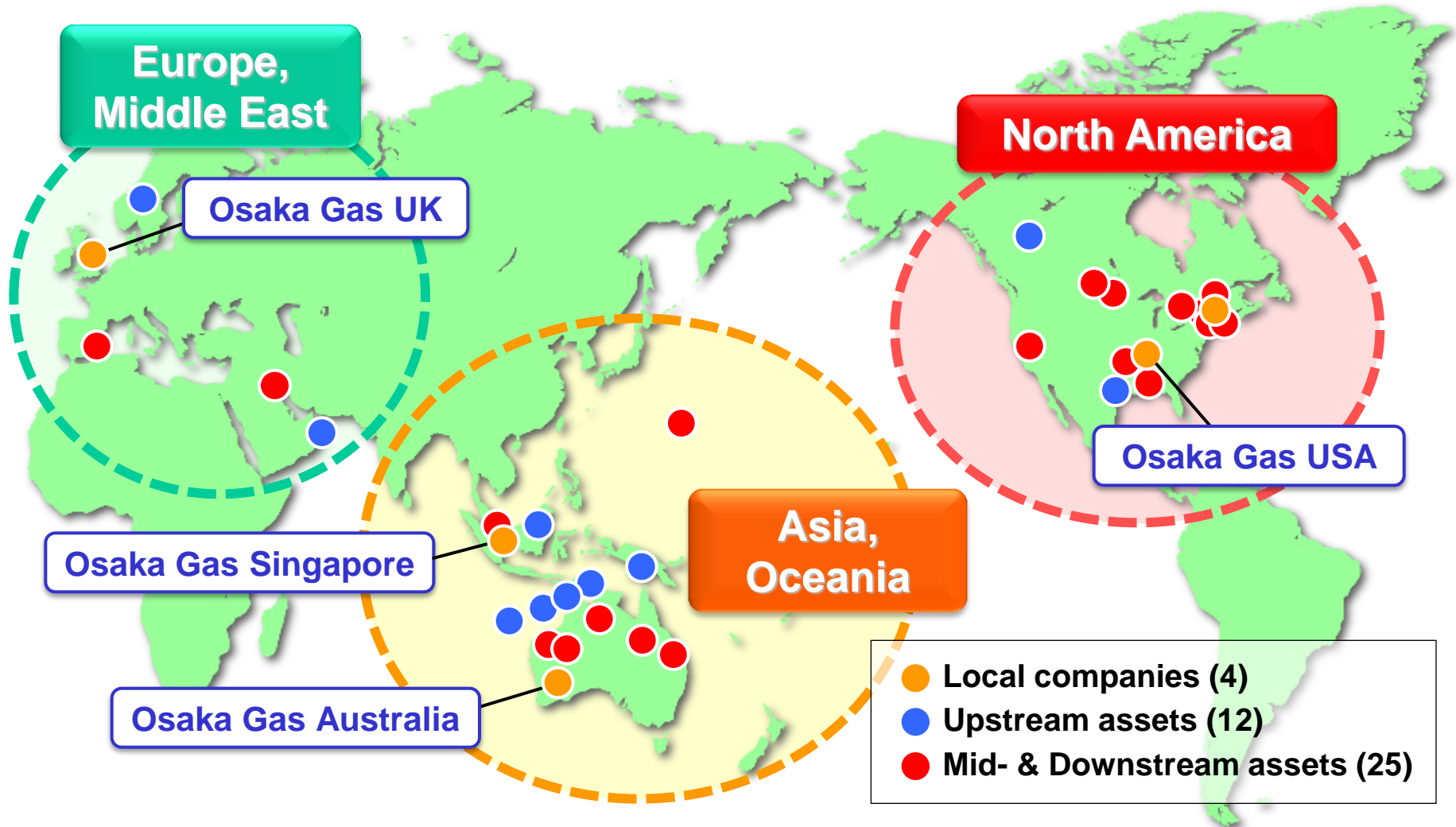


Power Generation Capacity

Approx. **3.0 GW** (2014/5) → **6GW** (Est. 2020s)

International Energy Businesses along Energy Value Chain

Broad business activities: upstream to mid- and downstream



1. Osaka Gas: a profile

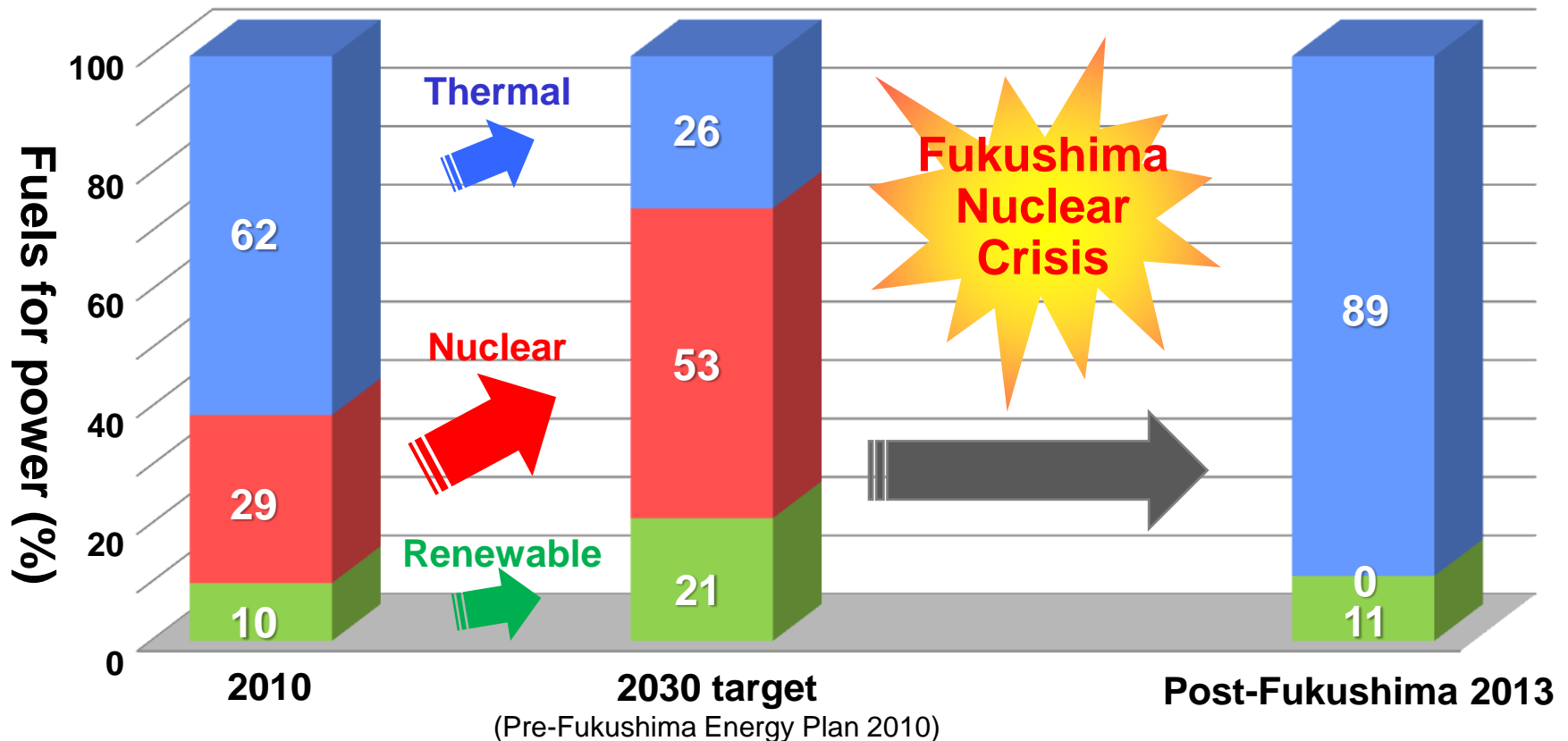
2. Fuel cell technology as game changer

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Impacts of 2011 Earthquake and Nuclear Crisis

Pre-Fukushima: focus on 3Es - Energy security / Environment / Economic efficiency - by nuclear expansion

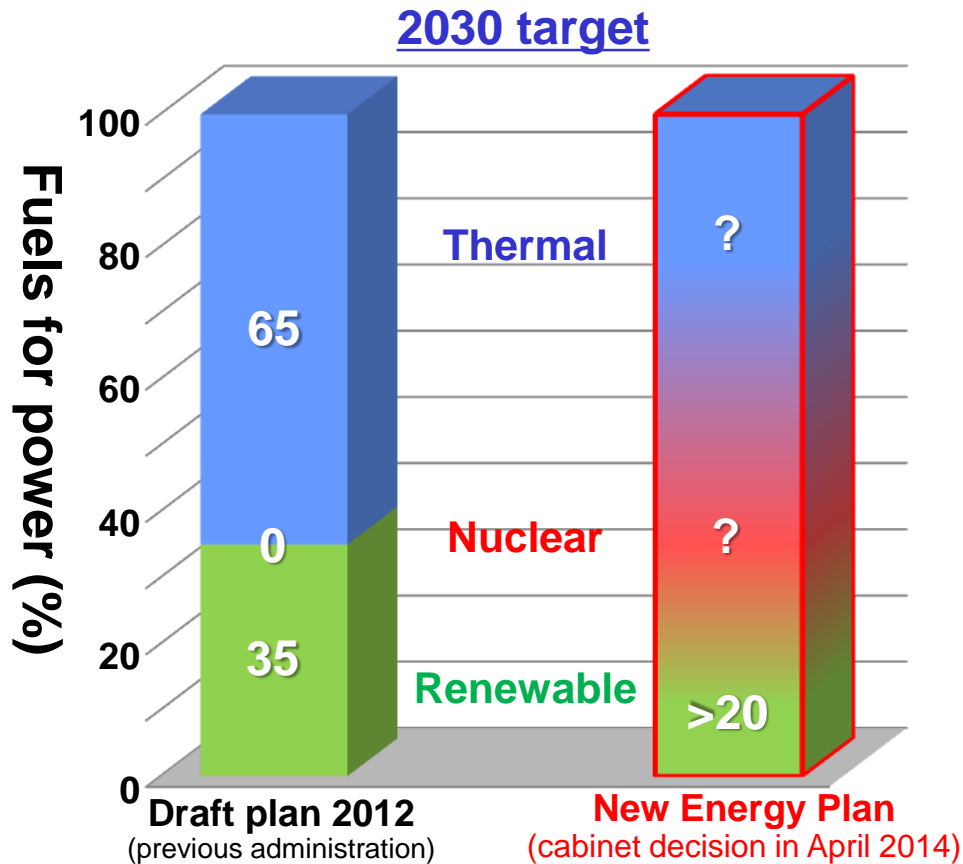
Post-Fukushima: changed landscape due to suspension of all nuclear plants



Previous game plan has to be changed.

Uncertainty over Japan's Energy Future

Uncertain future fuel composition: game changer technologies needed



New Energy Plan

(cabinet decision Apr. 2014)

Policy orientations

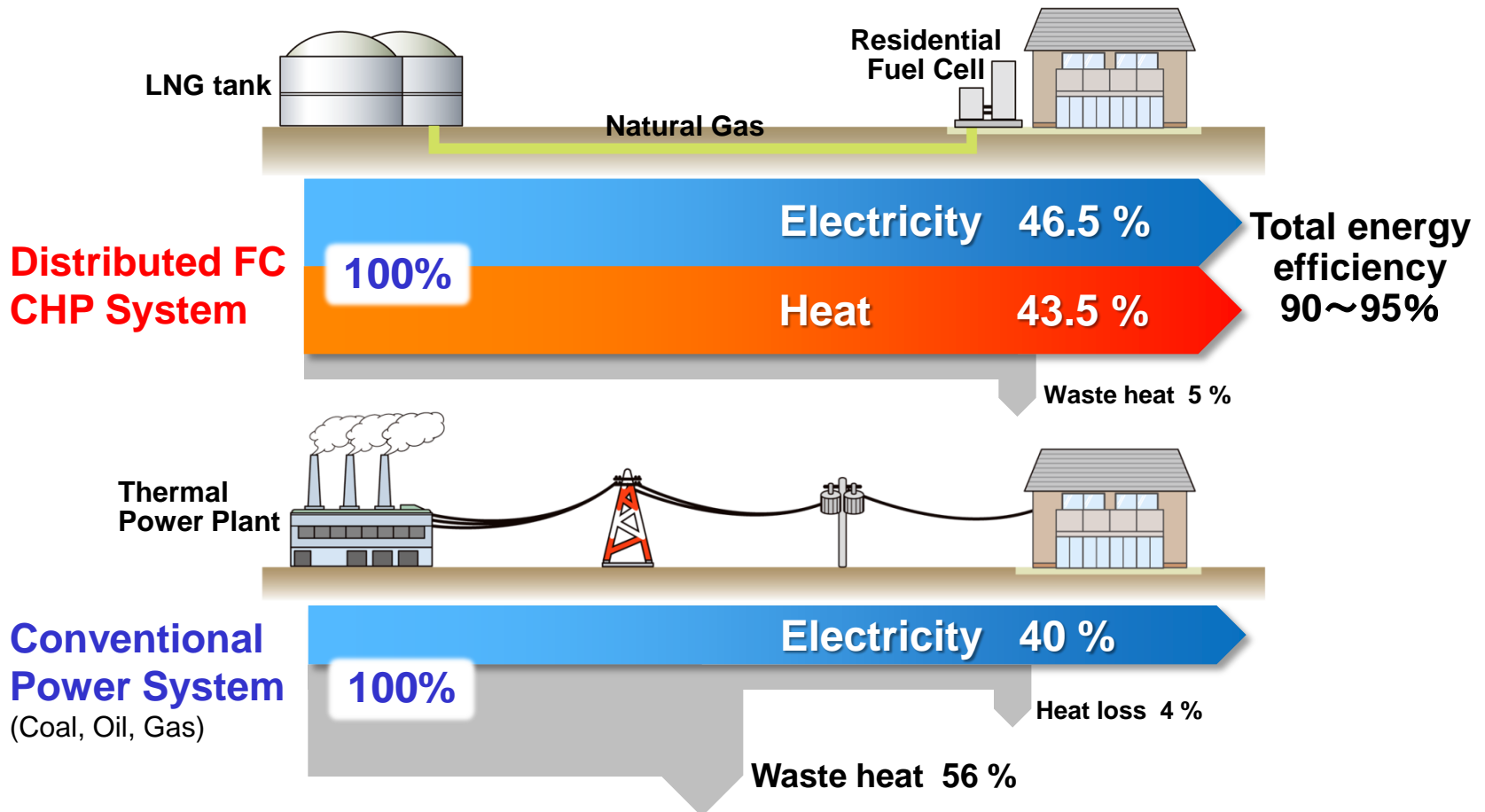
- **3Es+S: Safety**
- **Advanced energy-saving society**
- **Renewable energy**
- **Promotion of cogeneration**
- **Realization of a hydrogen society**
 - ✓ **Stationary Fuel Cells**
 - ✓ **Fuel-Cell Vehicles**

Policy requirements

- ✓ **Resilient energy supply:** dependency on large centralized power plants not preferable
- ✓ **Alternative for nuclear:** need for reducing CO₂ emissions

CHP by Fuel Cell: a Game Changer

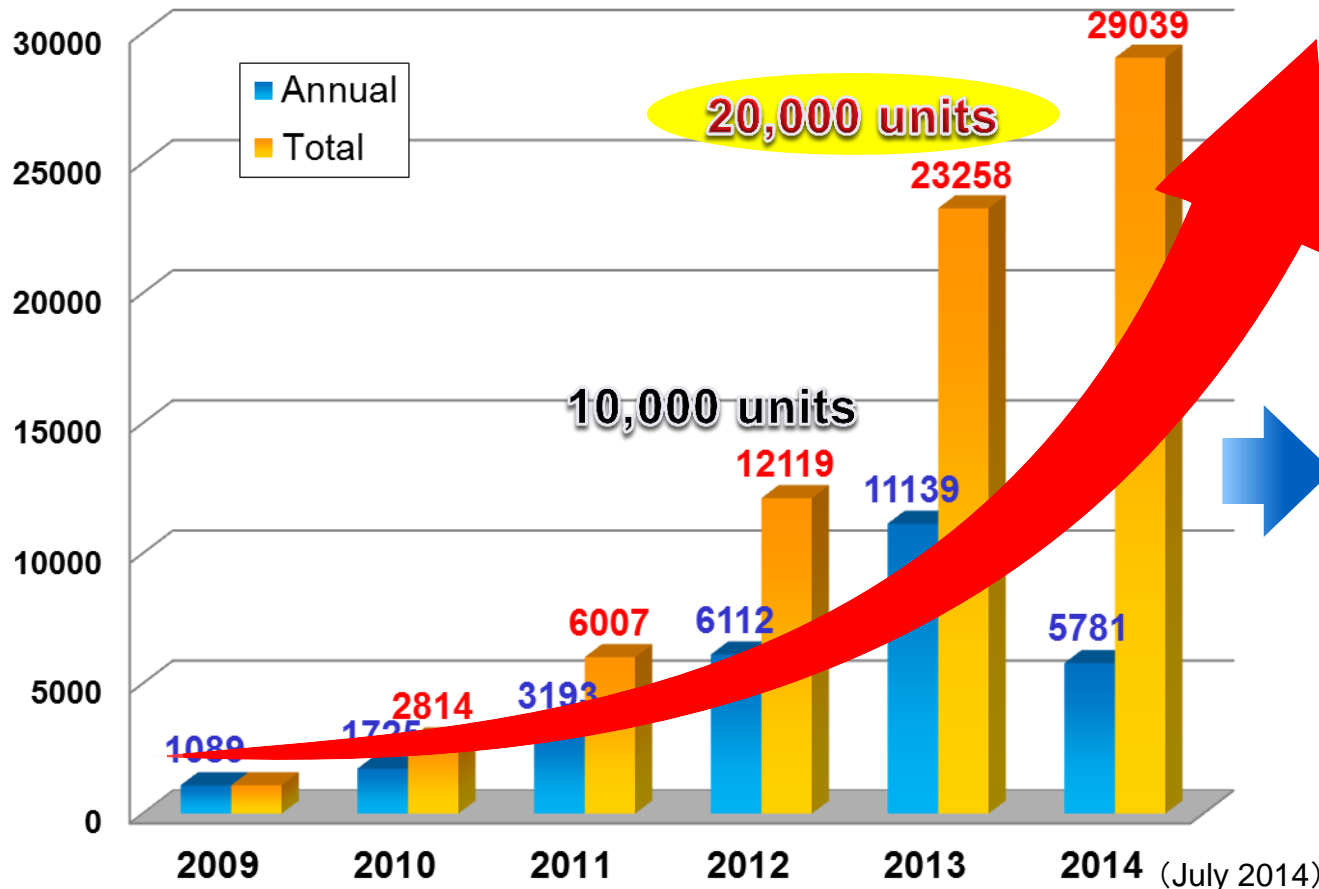
- Distributed power sources: fuel cell CHP has higher efficiency than conventional power plants
- Economic/environmental advantages to be further enhanced through improvement in electrical efficiency and heat utilization



Target for Market Expansion of Residential Fuel Cell

- Government Plan: 5.3 million units by FY 2030
- Osaka Gas to remain industry leader of residential fuel cells

Sales Results and Target 30,000 units

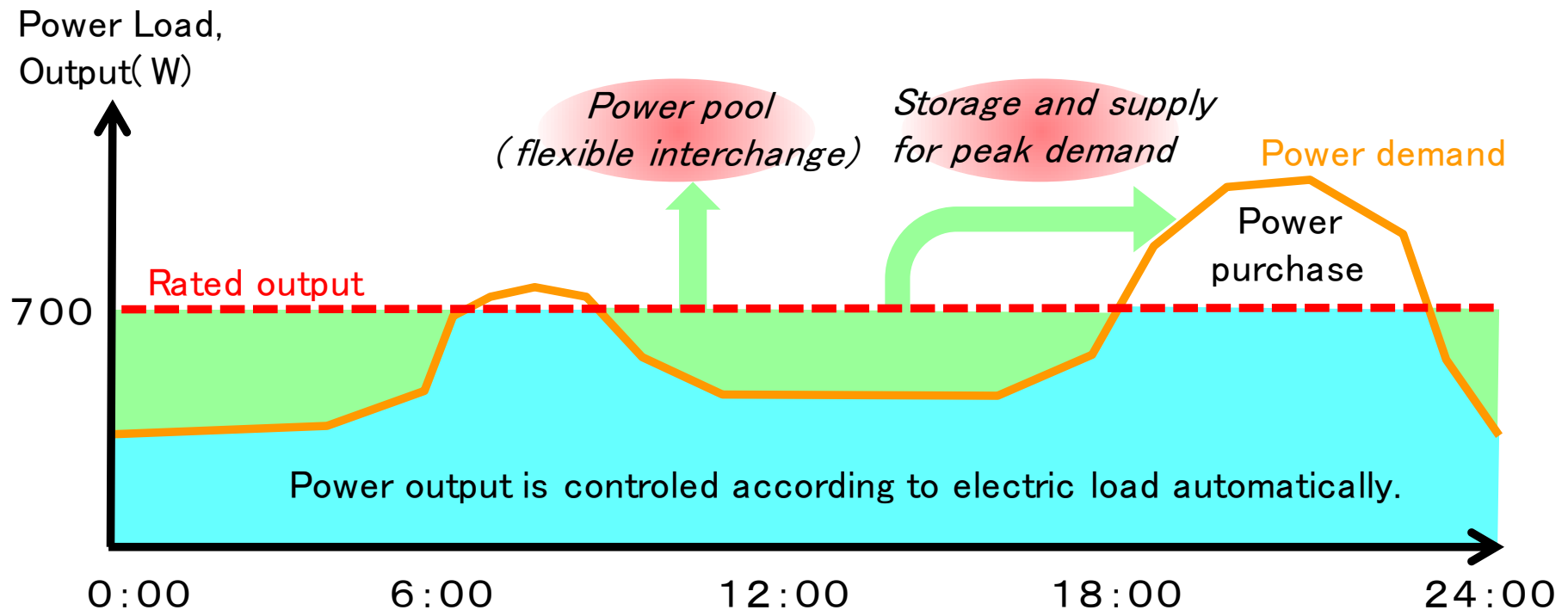


Osaka Gas' Target
200,000 units
by 2020

New Energy Plan
5.3 million units
by FY 2030

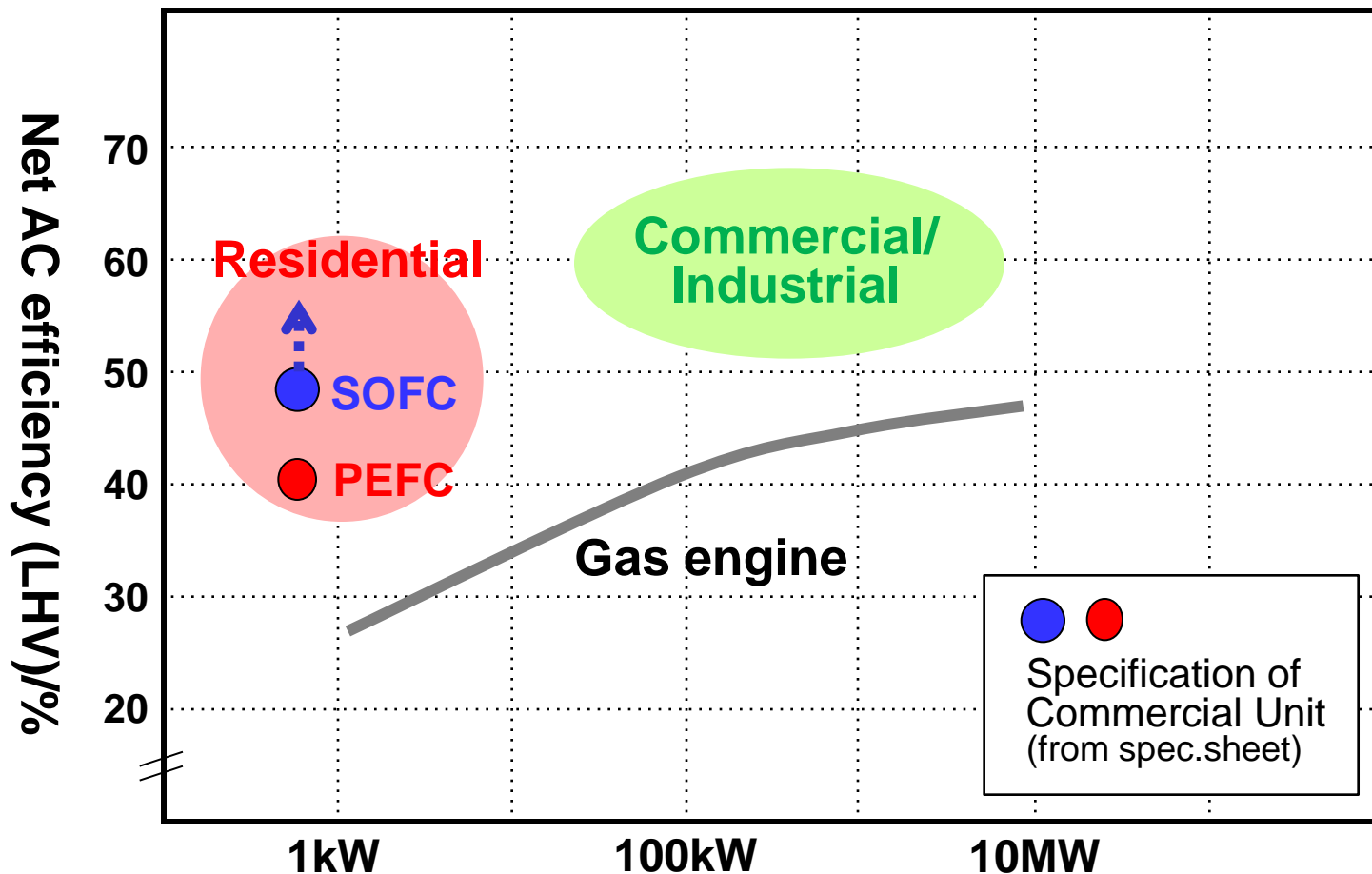
Rated Operation of Fuel Cell

- ENE-FARM operates at automatic load-following mode
- Rated operation will enhance its durability and maximize its power-shaving effects in future



Commercial and Industrial Applications Fuel Cell

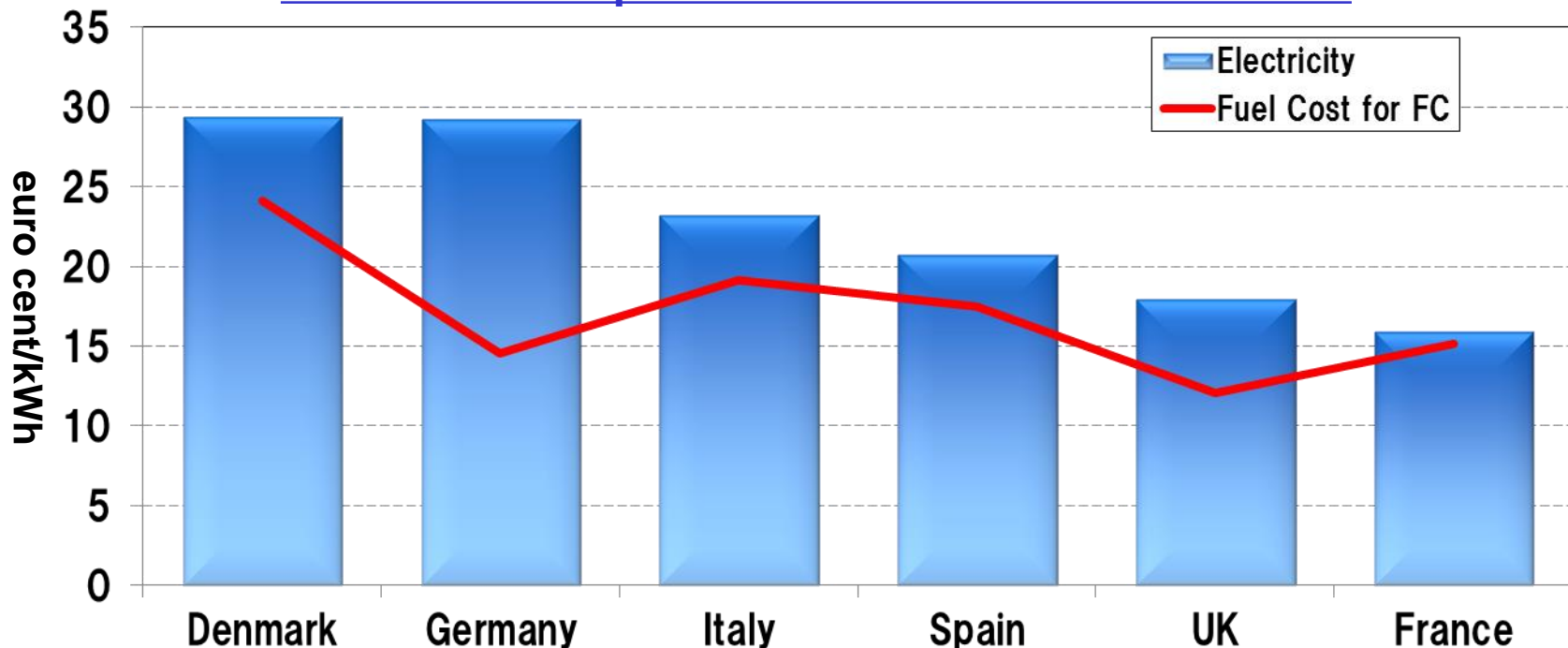
- Commercial and industrial fuel cells also under development.
- Commercial / industrial FCs expected to spread over medium- to long-term: small units advantageous in early market introduction phase



Economics of Residential Fuel Cell in EU countries

- In major EU countries, fuel cost for ENE-FARM is lower than electricity price. (NB. FC at rated operation, running cost only)
- Operation value of FC to be enhanced when electrical efficiency is improved.

Estimation of Operational value for Residential FC



*electrical efficiency: 46.5% (LHV)

Source: Eurostat , 2013

3. Conclusion

- Fuel cell: a game changer technology for realizing sustainable energy systems for the future.
- Osaka Gas is committed to develop fuel cell technologies and to lead fuel cell industries.

Future Challenges

- **Cost reduction**
- **Improving efficiency**
- **Down-sizing**
(necessary for market expansion in Japan)

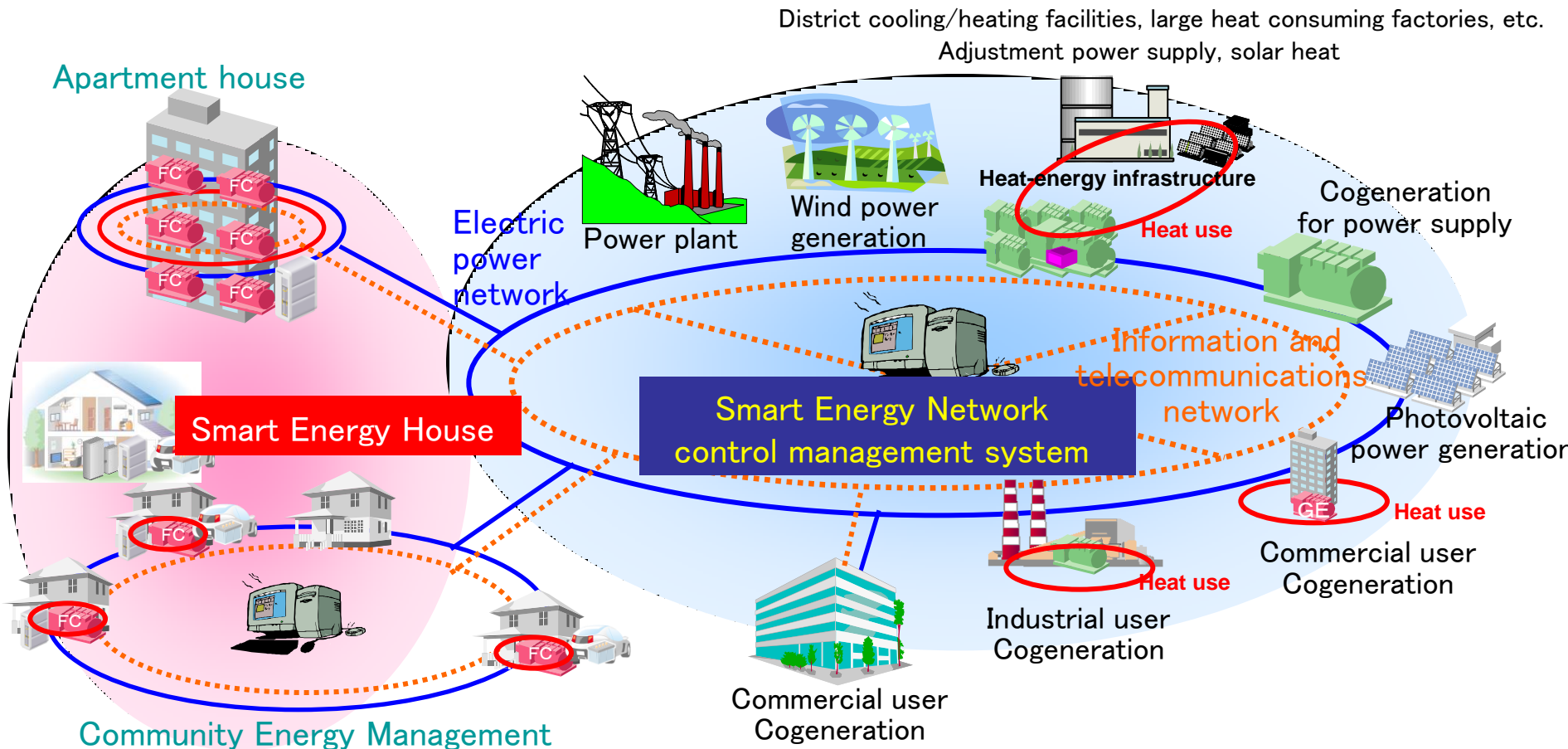
Technology Innovation

Game Changer for Sustainable Future

Thank You

Smart Energy Network System Concept

- Cooperation with the distributed power supply and power system by using Cogeneration systems.
- Pursuit of further reductions in energy consumption and CO₂ emissions by connecting between Smart Energy Network and House



Residential CHP Lineup of Osaka Gas

Osaka Gas has sold 100,000 residential CHP units by August 2013.

Specification of residential CHP system

Efficiency: at rated power, LHV basis

	Gas engine	PEFC	SOFC
Electrical efficiency	26.3%	39.0%	46.5%
Heat recovery efficiency	65.7%	56.0%	43.5%
Rated Power Output	1.0 kW	700 W	700 W
Operating mode	SS (Start and Stop)	Continuous, DSS	Continuous

Gas engine "ECOWILL"



Osaka Gas has sold 80,000 units.
(launched in 2003)

PEFC "ENE-FARM"



Osaka Gas has sold 20,000 units.
(launched in 2009)

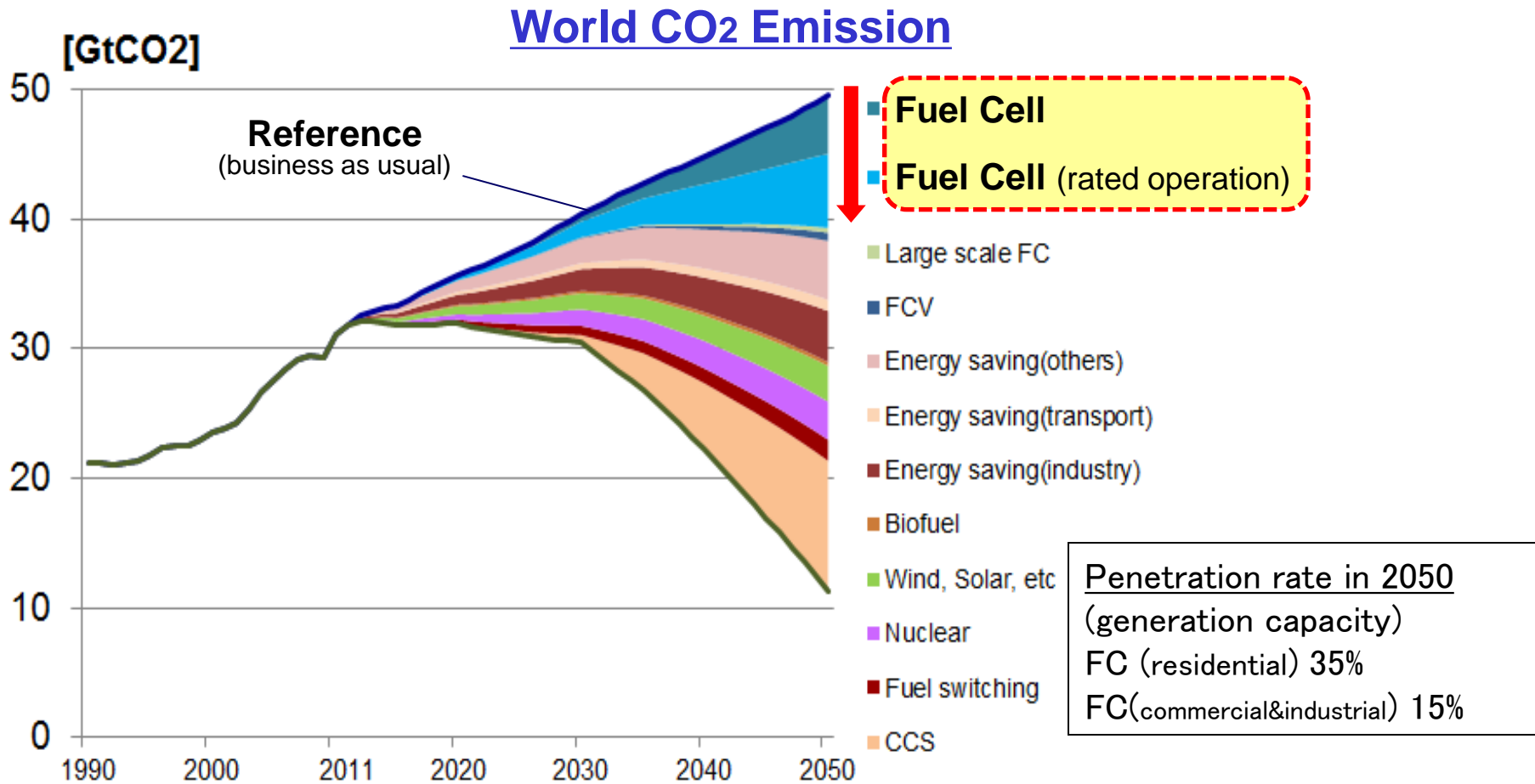
SOFC "ENE-FARM type S"



Launch in April 2012

Potential of Fuel Cell in Reducing CO2 Emissions

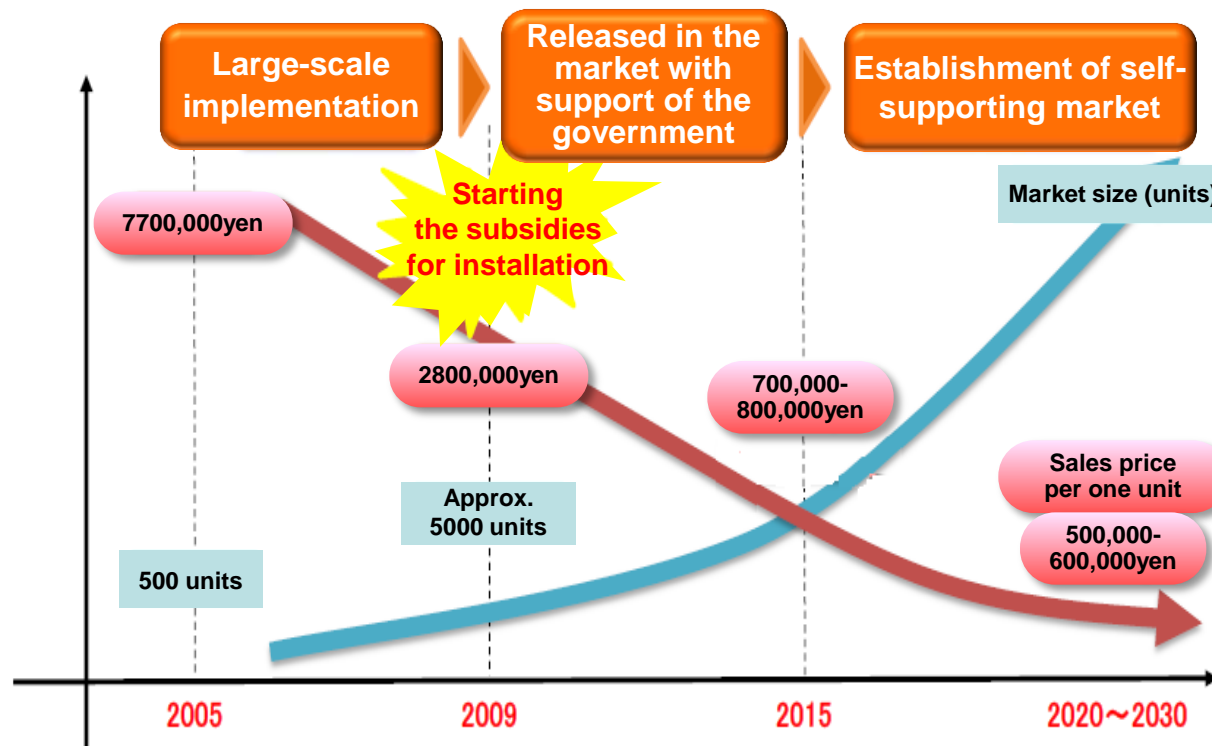
If the fuel cell technology is widely adopted, it has a potential to reduce 22% of CO2 emission from BAU case.



Cost Reduction Target for Market Expansion

- Ministry of Economy, Trade and Industry targets cost reduction for the market expansion of residential fuel cells.
- When reverse power flow becomes possible, its effectiveness to be improved

Dissemination scenario of residential fuel cells



* The prices including installation costs are incurred by end-users.

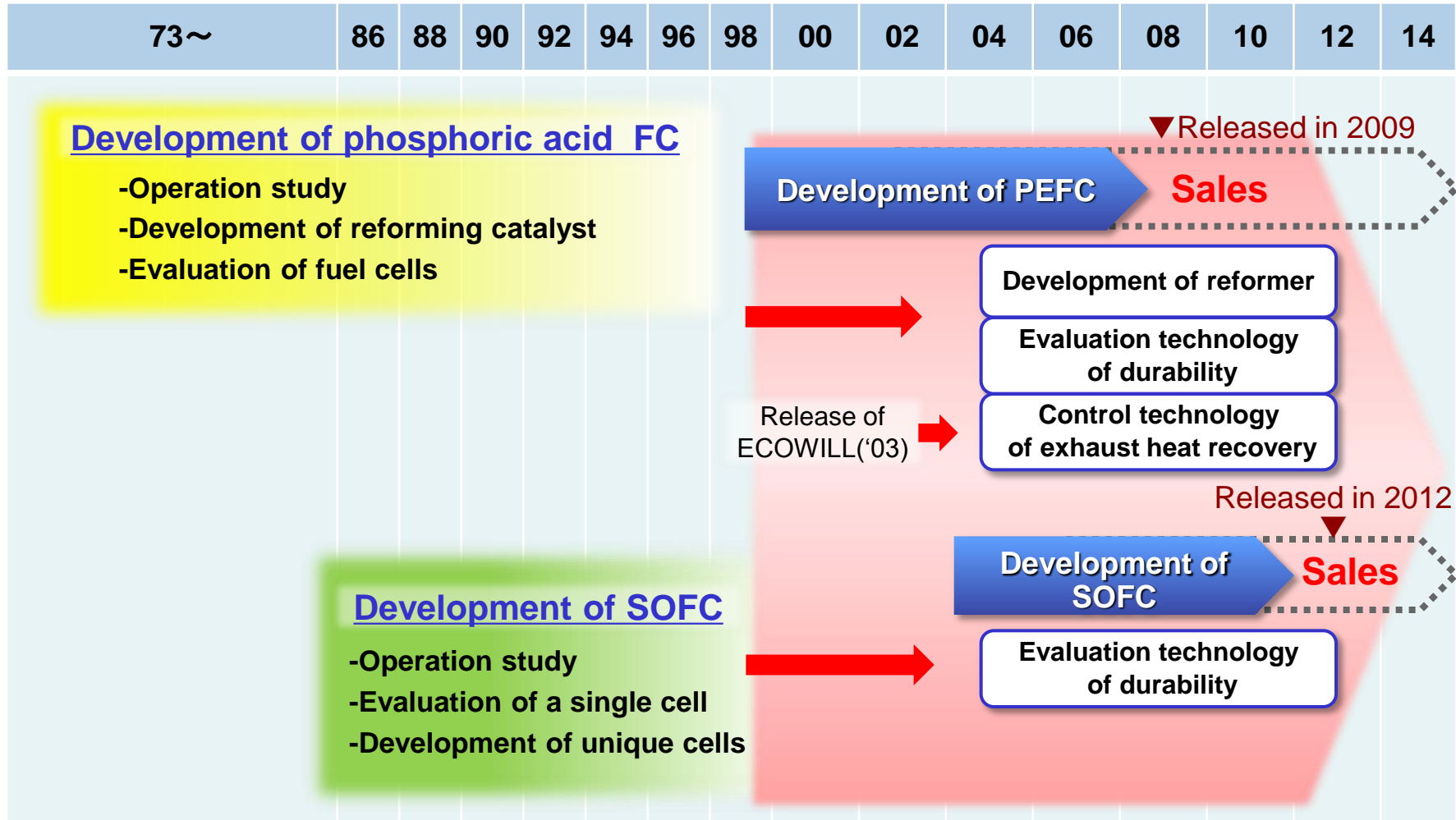
* 1: In case of a family of four, the utility cost is reduced for 50,000 – 60,000yen per a year by installing ENE FARM (estimated by Tokyo Gas). Therefore, the self-supporting market can be realized when the price of fuel cells is reduced to 700,000 – 800,000yen, while a conventional water heater costs about 200,000yen.

* 2: In case of a family of three, the utility cost is reduced for 30,000 – 40,000yen per a year by installing ENE FARM (estimated by Tokyo Gas). Therefore, the self-supporting market can be realized when the price of fuel cells is reduced to 500,000 – 600,000yen, while a conventional water heater costs about 200,000yen.

[Reference] Estimation report by METI

Osaka Gas' R&D on Fuel Cell

Accumulated fuel cell technologies since PAFC development in 1980's



Residential Fuel Cells —Technology of Osaka Gas—

- Osaka Gas takes advantage of the catalyst technology for gas production and the technologies accumulated in 1970s – 80s.
- Osaka Gas provides early resolution of problems in cooperation with the government and other interested companies.

Spirit of OG

Addressing any challenge
Progressive approach



Acquiring the key technologies
of fuel cell

Fuel reforming technology

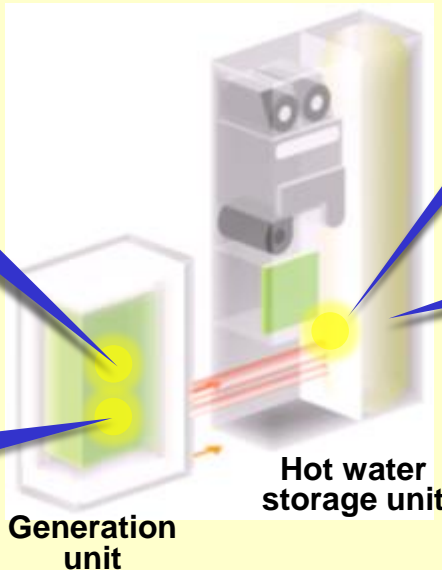
Utilization of catalyst technology

- Gas production from coal and petroleum
- Reformation of phosphate FC

Evaluation technology of cell durability

Advantage of know-how accumulated by development efforts of FC in the past

- Evaluation of phosphate FC
- Evaluation of SOFC for commercial use



Control technology of exhaust heat recovery

Packaging technology

Utilization of the technology accumulated by development of ECOWILL

- Cost reduction effort
- Improvement of workability of maintenance and installation

**We holds 33 patents
related to fuel cells**

Osaka Gas's Evaluation Technology of Durability

- Accelerated aging test is adopted for long-term durability evaluation instead of actual 10-year operation which would be difficult to conduct.
- We are leading commercialization of fuel cells based on the know-how of acceleration **aging test acquired through development of catalyst and by using the world-class level of test facilities.**

Evaluation test of main parts

The data of estimated service life was acquired from the long-term durability test in a simulated operation condition (high temperature / humidity / power current, etc.).

- Evaluation systems for PEFC's parts: approx. 60 units
- Evaluation systems for SOFC's parts: approx. 30 units



Evaluation systems for PEFC's parts



Evaluation systems for SOFC's parts

Evaluation test of stack cells

The durability of stack cells was evaluated by measuring the output fluctuation under the various operation conditions.

- Evaluation systems for PEFC's stacks: approx. 10 units
- Evaluation systems for SOFC's stacks: approx. 30 units



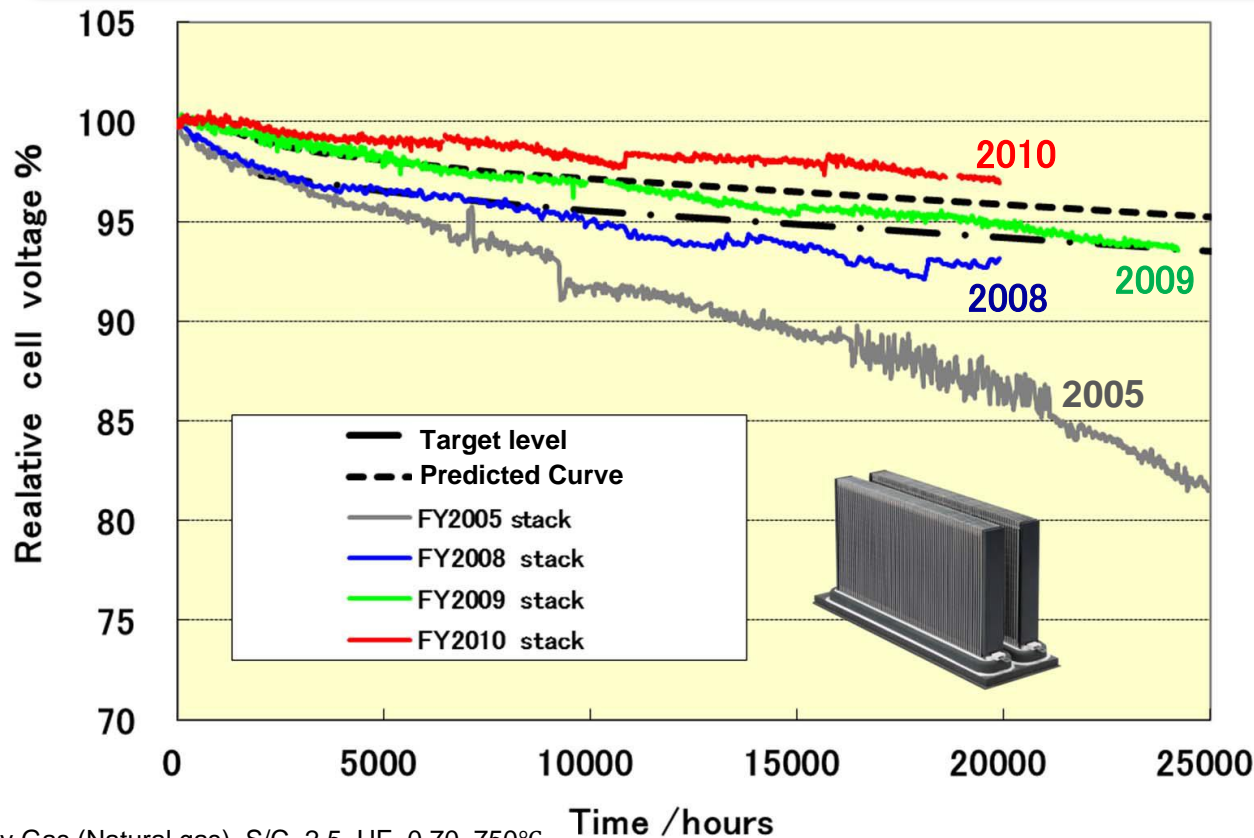
Evaluation systems for PEFC's stacks



Evaluation systems for SOFC's stacks

Durability test of SOFC stacks

- Improving durability year by year, the stack cells of 2010 year system achieved preventing efficiency degradation twice as much as that of 2008 year system.
- The current commercial products provide high durability for 10 years.
- Osaka Gas have established a method of lifetime estimation by evaluation test and simulation.



Osaka Gas's evaluation test systems