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Commercialization of Residential FC ENE-FARM
～ Current status and driving force for the success ～

Toshiba ENE-FARM

ENE-FARM is a common brand name of a residential fuel cell system in Japan.

26, June 2014

Toshiba Fuel Cell Power Systems Corporation

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Japanese Residential FC: ENE-FARM

Past:
Commercialization started in FY2009

Present:
Accumulated volume up to 80,000 units with 175% CAGR

Future:
Challenge to 1.4m units in FY2020
5.3m units in FY2030

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2. Commercialization Activities in Toshiba
3. Governmental and Industrial Activities as Driving Force for Successful Commercialization
4. Summary

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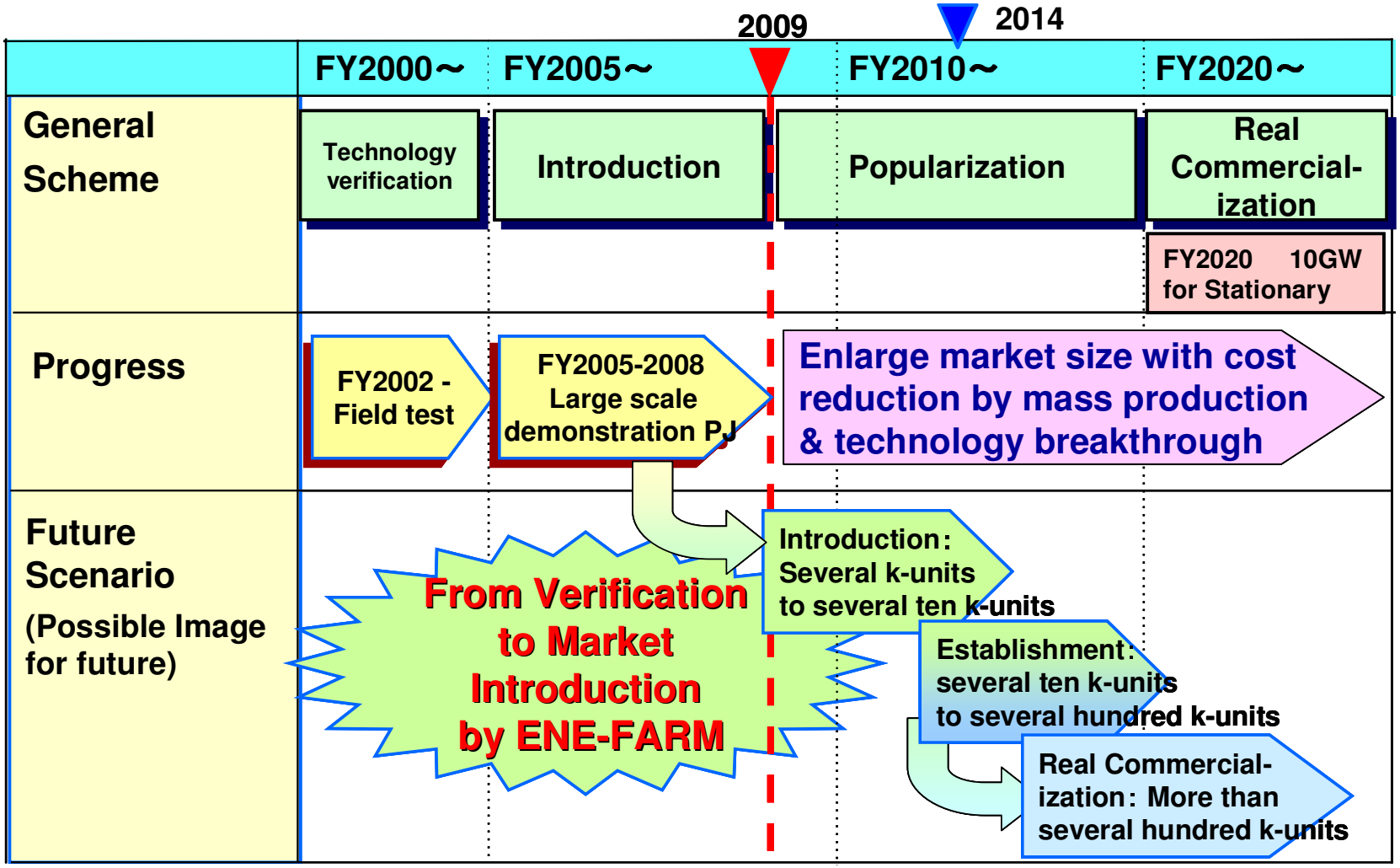
History and Plan of ENE-FARM Commercialization in Japan

- After technology verification and large scale monitoring program, Japan started initial commercialization of 1kW class residential PEMFC "ENE-FARM" in FY2009. Around 80,000units are now operated in Japanese household.



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Status of ENEFARM Dissemination: Total Trend

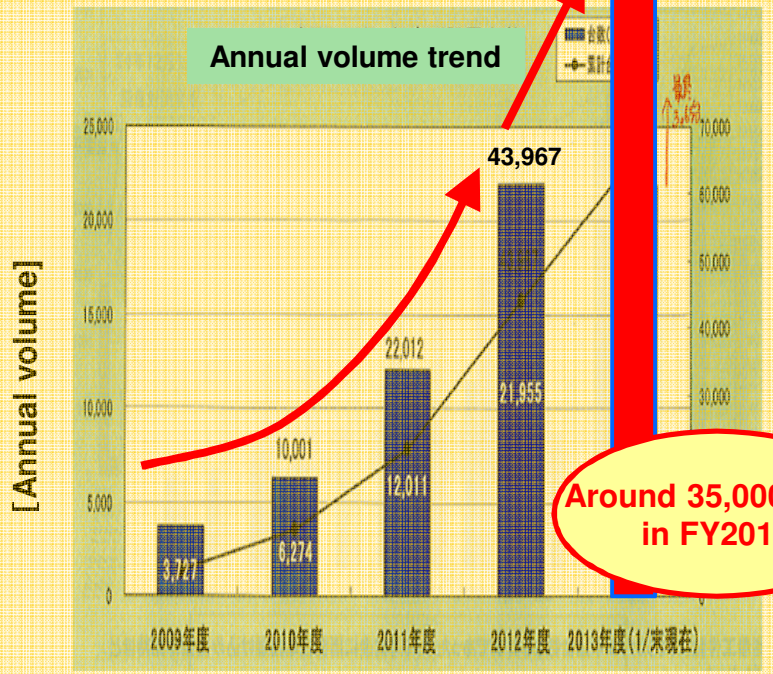
Start commercialization

Sales started in 2009 with the declaration by government and energy companies on January, 28, 2009.

Trend of sales volume

The sales volume has been increased year by year.

Accumulated volume is now around 80,000units in Japanese households.



* Data by FCA (Fuel Cell Association) as of January

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Key factors for the successful commercialization in Japan

(from IPHE Conference in 2011)

Residential PEM is on the commercialization phase since 2009 in Japan!

2. NEDO Field Program
3. NEDO BOP Project

4. FCCJ Activity

3 Aspects

5 Factors

1. Toshiba Activities

Governmental leadership

Collaborative development under NEDO Project

[Governmental efforts]

Technology potential of manufacturers w/ long history

[Core competence in technologies]

Collaboration among Japanese companies FCCJ

Partnership with Energy companies and manufacturers

[Company collaboration]

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History of Stationary Fuel Cell in Toshiba

After the long term experience by PAFC, Toshiba FCP started PEFC development in FY1999 and forward to commercialization in FY2009.

1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014

Millennium PJ | NEF・IBEC test | NEF Large Scale Demo Prg. | Commercialization

FC vending machine

700W Residential FY2000 Model

FY2002 model

NEF LSDP First model

FY2005

NEF LSDP Final model

FY2007

Initial Commercial model

FY2009

2nd Commercial model

FY2012

New Model in FY2014

FY2014

28 years experiments of PAFC development in Toshiba

1980 1990 2000

50kW Pilot plant

TEPCO 11MW Plant（23k hrs.）

NEDO 1 MW Plant

Onsite 1MW Plant(16khrs)

Onsite 200kW PC25C

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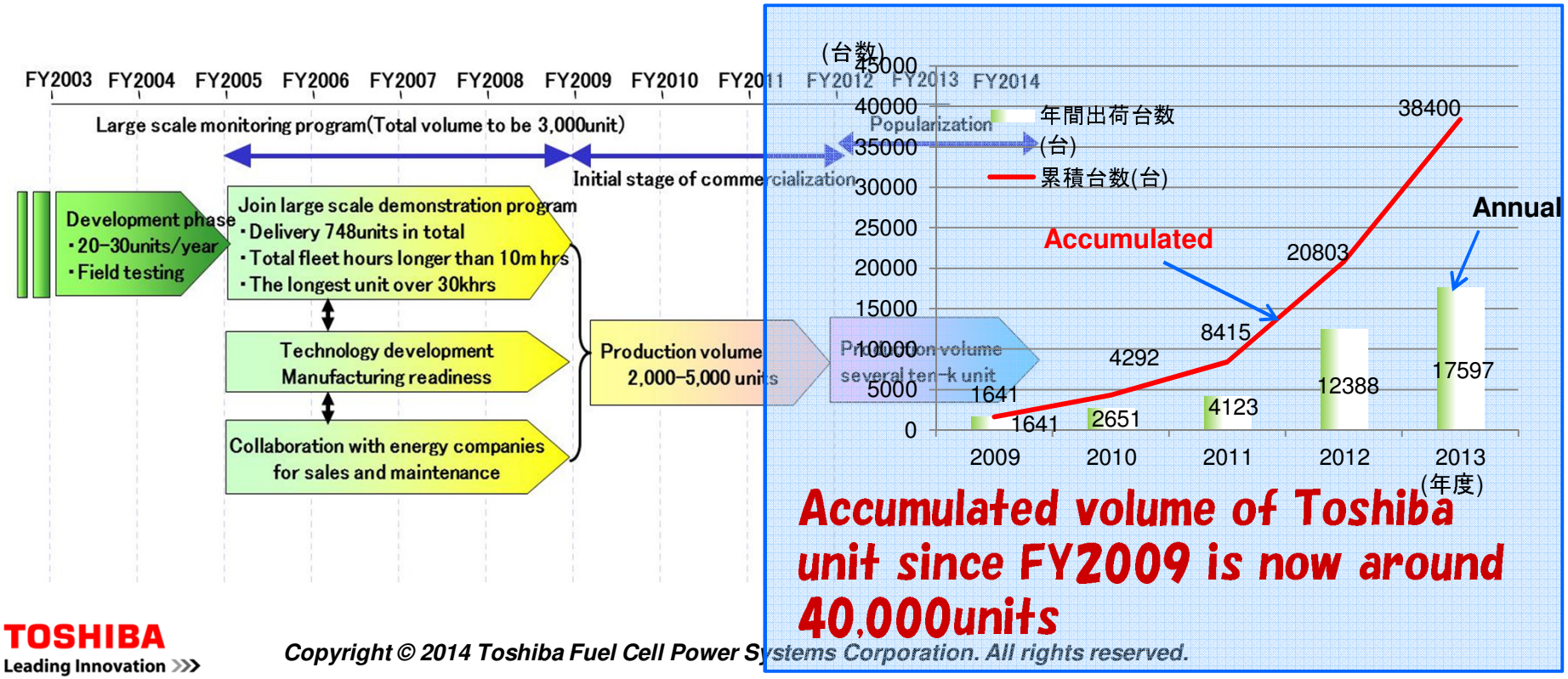
Overall Business Status in Toshiba FCP

- Joined to " Large scale demonstration program" since FY2005 throughFY2008.
- Initial commercialization of ENEFARM started in FY2009 with estimated several thousands of annual volume.
- Selling volume around 8,000 unit by 1st generation unit for three years, since 2009 through 2011.
- Expanding business by 2nd generation unit. 30,000 units to be estimated by two years, FY2012 and 2013.
- Expanding manufacturing capacity with new facility (25,000units/y in FY2014)
- New 3rd generation units was just delivered in April 2014.



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New Toshiba ENE-FARM Released in FY2014

–Lower price with higher performance(95%ttl)
–10 years durability
–Easier installation by less space requirement
–Wider applications
  Possible installation for condominium
  Higher GI capability w/ battery hybrid

Toshiba booth at FC EXPO 2014

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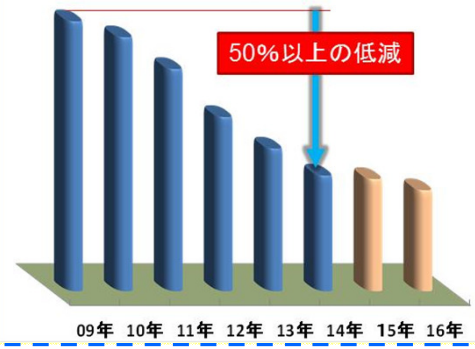
Main Efforts for New Toshiba ENE-FARM

Further cost reduction

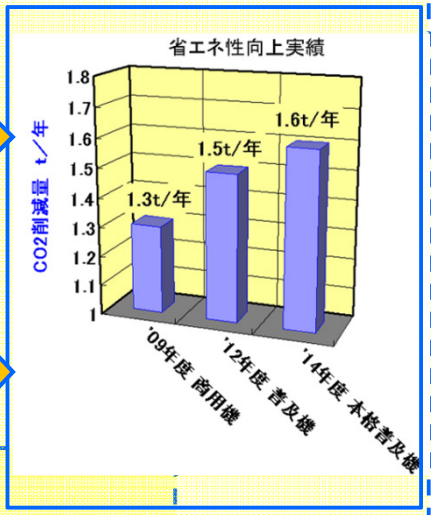
- Three core approaches by technology, manufacturing and purchasing
- CR approach with "Reduce Concept"
  ⇒More than 50% from FY2009



Module piping for significant component reduction

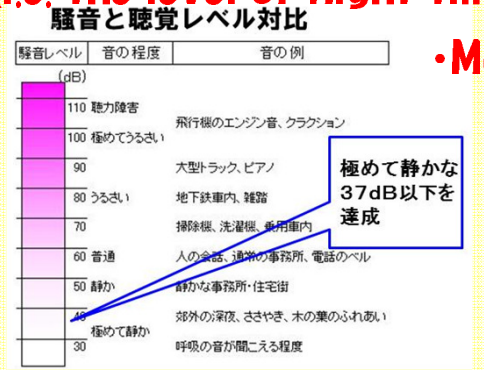
Higher performance

- Efficiency improvement w/ longer cell durability offers higher CO2 reduction. 1.6t/y is estimated by new ENE-FARM.

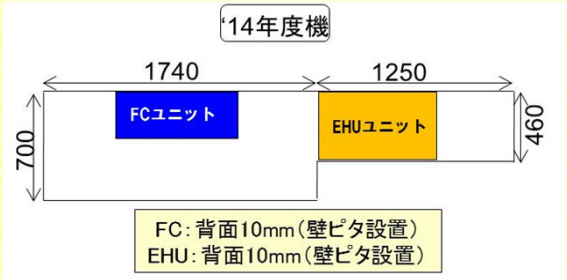


Other efforts

- Lower noise level: 37dB achieved (i.e. the level of night time in residential area)



- More compactness for installation(depth 79⇒70cm)



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New Applications for Market Expansion Exhibited in FC EXPO

System for Condominium

1.Installed in piping shaft space with 1.1㎡
2.FF ventilation for closed space
3.Higher tolerance for earthquake

Expanded GI Function System

1.Black out start capability
2.Possible power supply during start up
3.Transient capacity up to 1.7kW
4. Faster transient with battery

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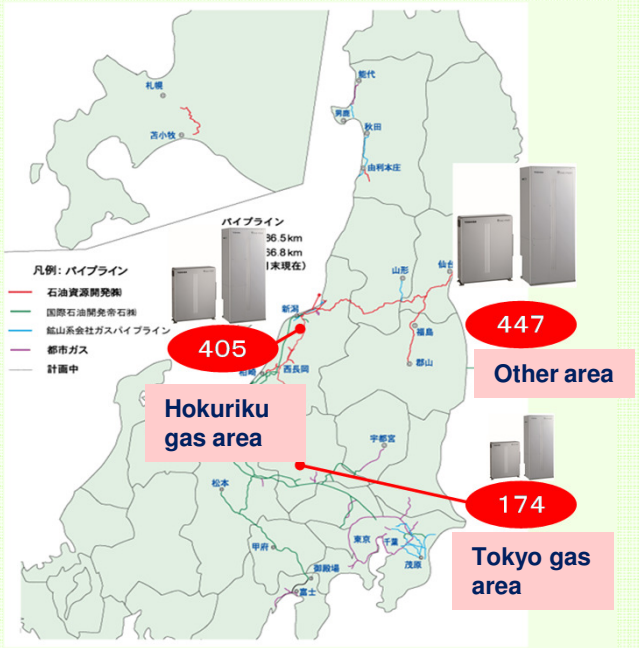
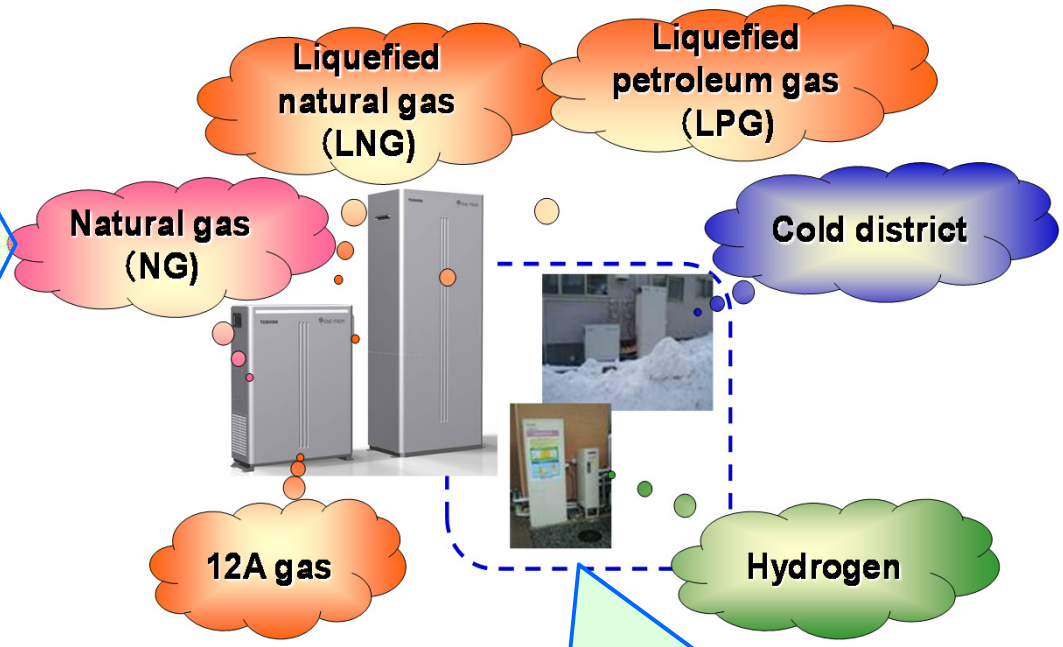
Diversity for various fuel and environment

Toshiba ENE-FARM preparing enough options for various fuels and environmental conditions since FY2009.



（国産天然ガスパイプライン）

A thousand units of Toshiba ENE-FARM is already operated with domestic natural gas, which is very similar to EU high calorie gas.



Cold district opt. 1658units
Pure H2 opt. 38units

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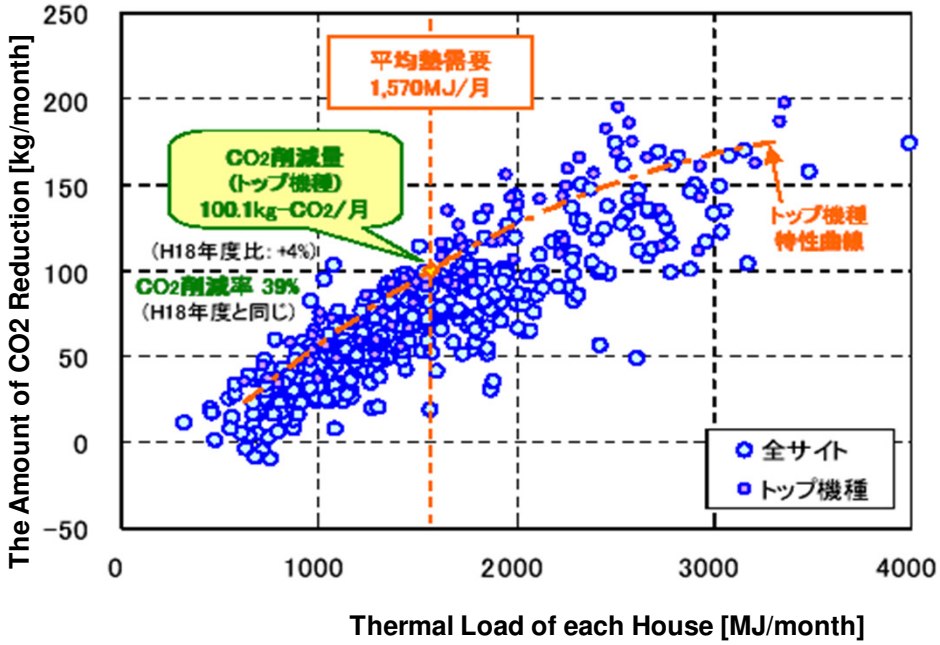
Large Scale Monitoring Program Leaded by METI/NEDO

In advance of commercialization, over 3,300unit of residential PEFC were installed and verified in FY2005 through 2008. In the program, system showed enough performance and reliability as future commercial product.



Five system manufacturers joined to the program, and delivered 3,307units.
Toshiba delivered 748 units among them.

Residential PEFC showed 100kg/month of CO2 reduction as the average.

But the program was not only for such technology and product verification!!

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Essential Purpose of the Strategic Program

Usual reaction to the program:
It's the crazy volume and a kind of surprise!.
Why do you need so many units for it?
⇒It is essential to establish sales and maintenance channel with energy companies and also prepare manufacturing facility.

The program was really the practice and absolute step for initial commercialization just after the death of valley.

Development
- >35% Electric / >85% Total Efficiency
- System durability longer than 70kh
- Reliability better than 5% annual failure rate
- Significant CR (to 1/8 level through 5years)
- Tolerant system for raw fuel (NG & LPG)
- Light weight for installation (104kg)
- Low noise design (<40dB)

Verification
- Delivered around 800units since 2005 until 08
- The longest units recorded 30kh in real field
- Total fleet operation time to be 10million hrs
- CO2 reduction to be 1.2-1.4t/year
- Reliability potential for commercialization

Commercialization readiness
- Preparing production process
- Maintenance and sales channel with energy companies
- Getting Japanese certification

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BOP Pj as NEDO Collaborative/Consortium Project

Competition

Close strategy

Differentiation

Collaboration

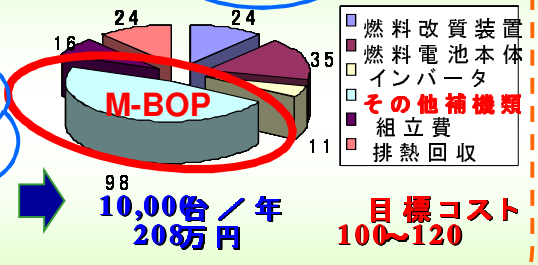
Open strategy

Standardization

Dilemma in High Technology Development

Can we achieve the cost reduction enough for commercialization?

BOP has the highest portion in cost allocation, which is collaborative area for joint development.



10,00台／年
208万円

目標コスト
100~120

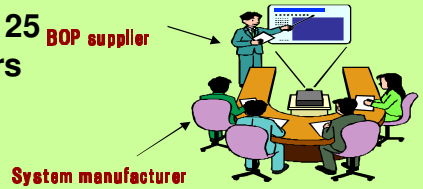
Strategic study by METI, energy companies and manufacturers in Autumn, 2004

Open Spec.

- Common spec. delivered by METI/NEDO

Open Discussion

- Discuss by 25 BOP makers and 5 sys makers



Regional symposium

- Discussion to start FC workshop by regions

NEDO project started in July, 2005 by systems and M-BOP companies

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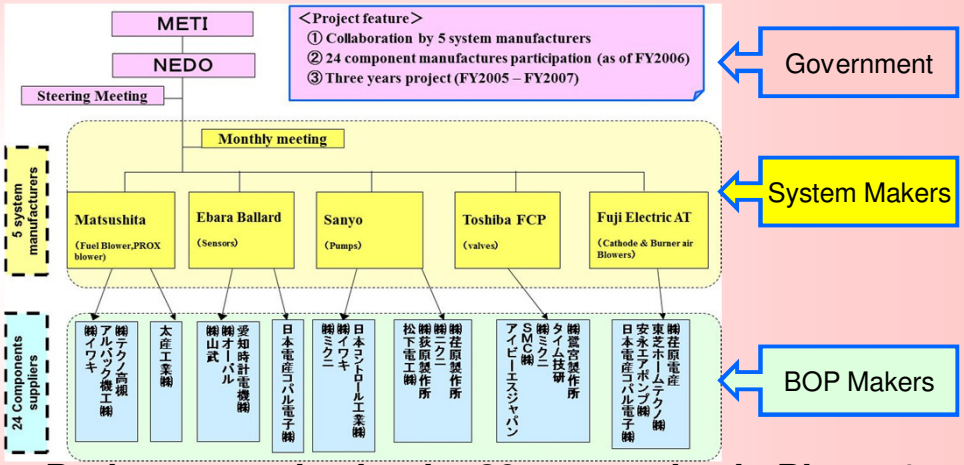
Summary of NEDO BOP Project

- Common specification and target were clearly defined to eight components.
- 40 companies joined to NEDO BOP project for 5 years activity

[Phase1]
Pumps
Blowers
Valves
Sensors

[Phase2]
PCS
HEX
Water Sys.

8 components selected in the Pj



Project organization by 29 companies in Phase 1

Outcome attained from the project

(a) Performance

Every component meets the target performance such as for efficiency and in/out conditions.

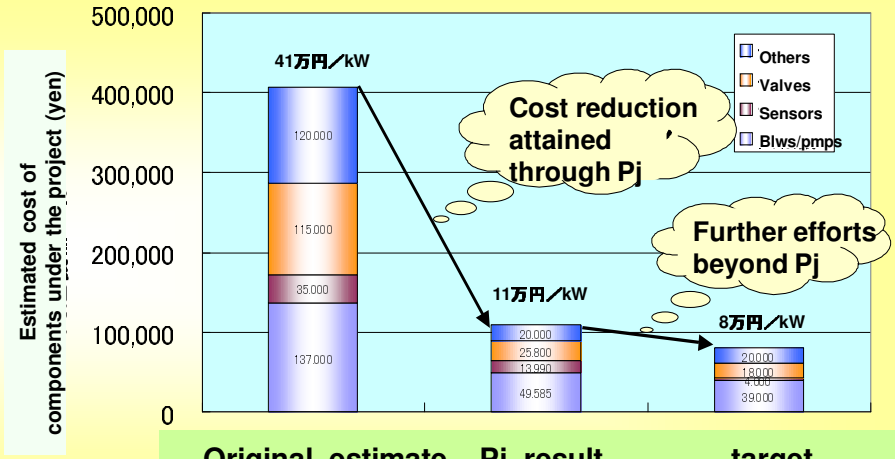
(b) Durability

Every component meets the life longer than 40k hrs, which was verified by acceleration test.

(c) Cost

Cost potential of 110k yen is expected with 10k units/year of production volume

Many developed components were directly applied to ENE-FARM



Original estimate Pj result target

Cost estimation estimated through the project

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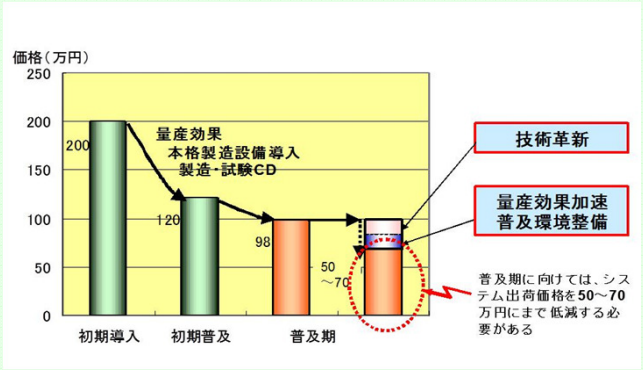
Cost Down Studies in FCCJ toward Real Commercialization

*FCCJ: Fuel Cell Commercialization Conference of Japan by around 100 companies

Discussion of technical approach for PEFC future business

Cost scope for full scale commercial phase

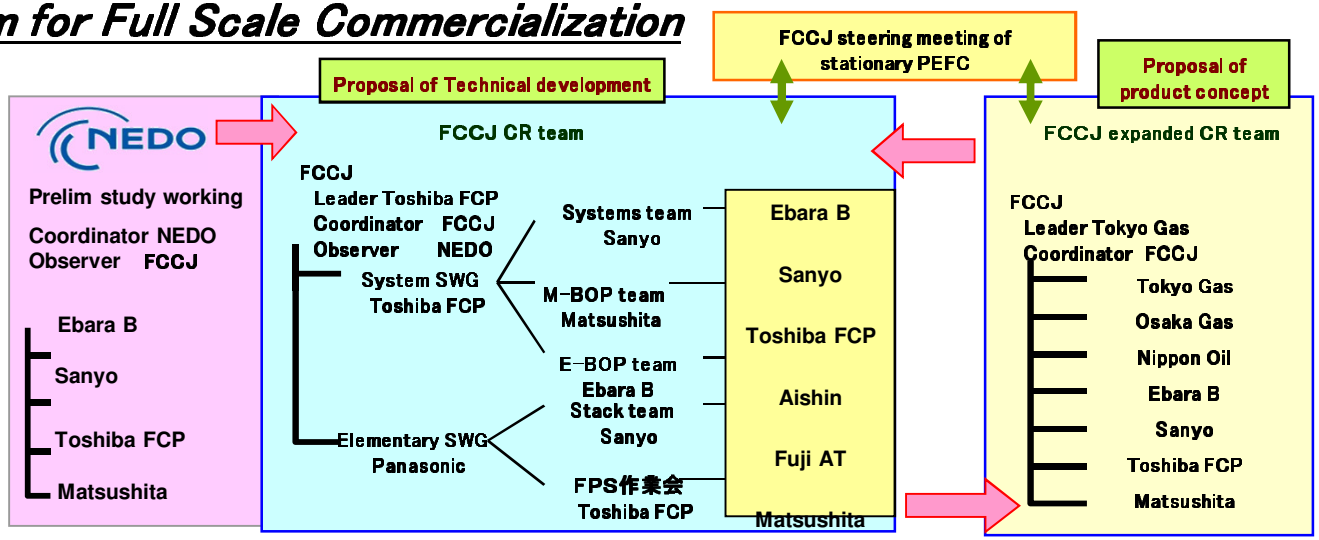
How can we promote our cost reduction toward full scale commercial phase of PEFC?



Cost estimation through the discussion

FCCJ Cost reduction Team for Full Scale Commercialization

- Preliminary discussion at NEDO (Aug. 2006)
- Detail and specific discussion by FCCJ team. Started activities by 5 working group (Nov. 2006)
- Discussion of system specification w/ energy companies (May, 2007)



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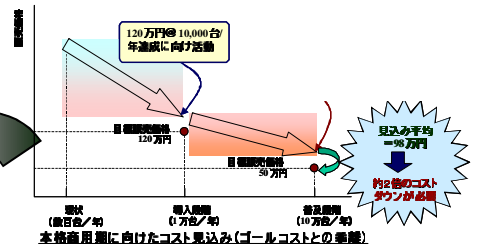
Process Flow of Team Activities

More than 30 engineers discussed future cost potential based on current technology, and made up the specific theme for further cost reduction.

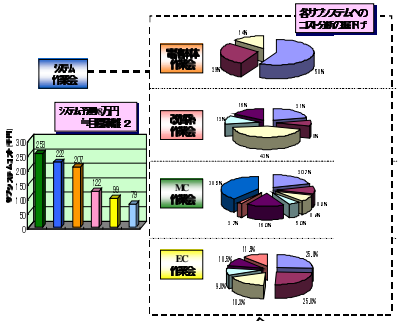
1. Recognition of cost gap

CR gap recognized; 500k-yen target vs. 900k-yen estimati



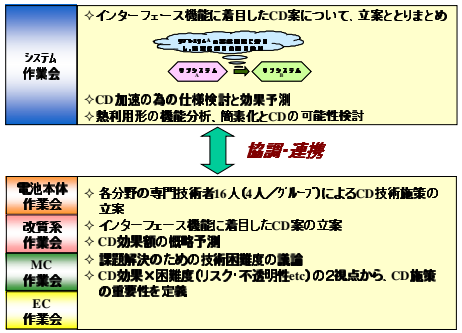
2. Cost analysis

Cost analysis of each category by team engineers



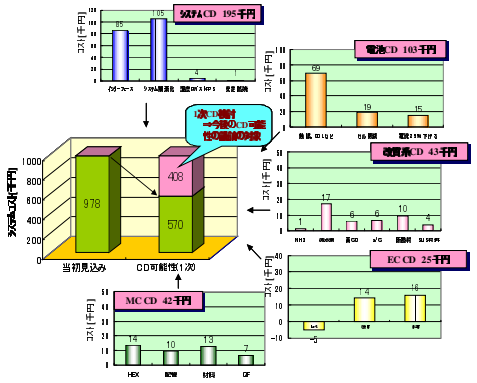
3. Theme brain storming

Possible theme from component and system



4. Rough estimation of CR effect

Rough estimation of CR effect by each theme



5. Theme selection

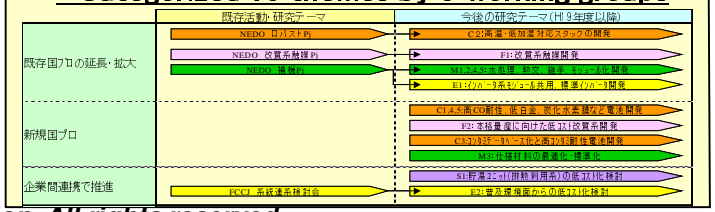
Possible theme selection

Specify each theme
- Purpose
- Content
- Necessity as NEDO Pj
- Pj organization
- Pj schedule
- Budget

Preliminary themes

分野	No.	開発テーマ案	目的・開発内容等	国プロ化の要望
電池本体	C1	高CO耐性PEFCの研究開発	CO=2000ppm耐性	新規PJ
	C2	高温・低加湿対応スタックの開発	温度80～90℃、無加湿～RH30%	現行ロバストPJのスコープ拡張
	C3	コンタミデータバイスと高コンタミ耐性電池研究開発	システム低コスト化	新規PJ
	C4	低白金MEAの高性能・高耐久性研究	例えばPt<1g/kW	(未定)
	C5	炭化水素系膜の劣化メカニズム解析	低コスト化・高温運転対応	(未定)
改質系	F1	改質系触媒開発	メンテナー脱硫剤、高活性シフト触媒、ATR改質触媒、耐酸化性向上、パーツ技術等	現行改質触媒開発PJのスコープ拡大
	F2	本格量産に向けた低コスト化改質系開発	ATR方式等の高効率改質系	新規PJあるいは補機PJの延長線上
電気系	E1a	インバータ系のモジュール・サブモジュールの共用化開発	低電圧ー大電流インバータ(効率維持)	現行補機PJの延長線上
	E1b	標準インバータ開発	低コスト化インバータ	(継続編集中)
	E2	普及環境面からの低コスト化検討	基準・規格化、認証試験、系統連系環境整備	FCCJ系統連系検討会で検討
機械系	M1	水処理装置開発	LCCを踏まえた低コスト水処理装置・機器	現行補機PJの延長線上
	M2	熱交換器共用化開発	ガス凝縮器、水ー水熱交器	現行補機PJの延長線上
	M3	使用材料の最適化・標準化	コンタミデータバイス化→低コスト化代替材料	新規PJ
	M4	本格量産における低コスト組手の開発	現状Qファスナーの更なる低コスト化	現行補機PJの延長線上
	M5	機械系機器・配管のモジュール化研究	MIPISに関したアルチ配管、それに応じた機器類	現行補機PJの延長線上
システム系	S1	貯滑エンドの低コスト化検討	仕様・構成の検討等	企業間連携での活動主体

Categorized 15 themes by 5 working groups



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Business and Market Expansion toward the Future

Develop ENE-FARM as Core Product
Release 2nd Gen system in FY2012!

Hydrogen Society

Performance improvement

Release 2nd Gen system in FY2012!

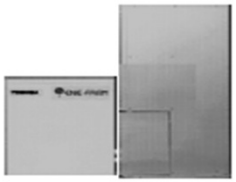
Fuel Diversification

- LNG, LPG
- Natural gas for overseas

HEMS

Various application

Condominium



Compact system

For Cold area

-20degC ambient

HEMS、Smart grid with PV and Battery

- ***Continuous improvement of ENE-FARM as core product (cost, performance, reliability and durability and maintainability)***
- ***Offering and preparing wider application to expand the market (HEMS, expanded GI option, fuel diversity, option for colder area)***

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～ Thank you ～

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