

Korea Activities within Hydrogen and Fuel Cell

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- Energy Situations in Korea

Population: ~50 million

Energy Import (97%)

5th Largest Oil importer

2nd Largest LNG importer

10th Energy consumption

- Hydrogen and Fuel Cell Program since 1988

Background: Urgent Energy and Environmental Challenges

Programs: Research,

Development,

Validation,

Demonstration,

Commercialization

Defined NRE Resources

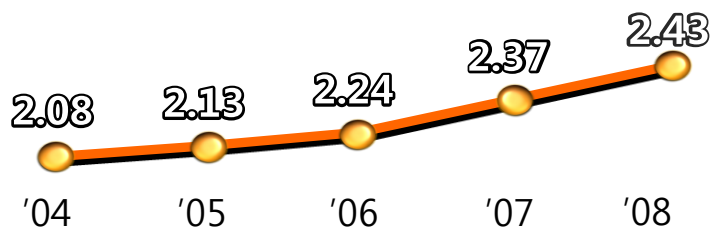
Renewable Energy : Transform natural resources such as sunlight, water and biomass into usable energy sources

8 sources : PV, Solar Thermal, Wind, Waste, Bio(LFG, Bio-Fuels), Hydro, Geothermal, Marine

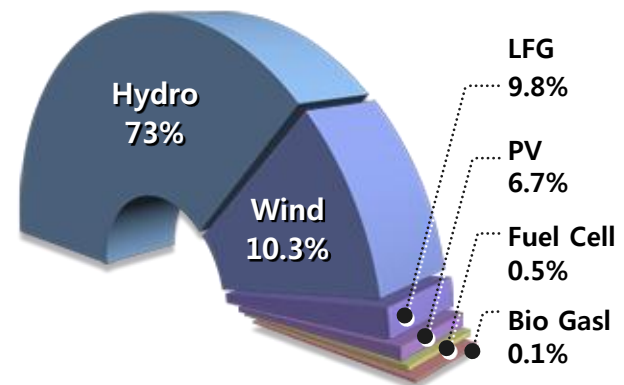
New Energy : conventional fossil fuels processed and used as cleaner energy sources

3 sources : **Fuel cell, Hydrogen**, Coal Liquefaction or Gasification

NRE Share (%)



Power Generation from NRE (2008)



Policy Schemes for NRE

Deployment Program

General Subsidy

(1994~), Factories, Individual Buildings, Schools, etc
Government 50%+Individuals 50%
Budget : 14 bil won(11.6mil USD), 2010

Local deployment

(1996~), Public buildings, Social welfare facilities, etc
Government 50%+Local 50%
Budget : 70 bil won(58.3mil USD), 2010

1 Million Green Homes

(2009~), Residential house, Apartment house, etc
Government 50%+Individuals 50%
Budget : 96.2 bil won(80mil USD), 2010

International Cooperation



- Intergovernmental Meetings, Initiatives, Partnerships,
- Bilateral Cooperative Activities (Spain, Germany etc)
- IPHE (International Partnership for Hydrogen and Fuel cells in the Economy)
- IEA/REWP (Renewable Energy Working Group)
- APEC/EGNRET (Expert Group on NRE technology)
- IRENA (International Renewable Energy Agency)
- APP/REDGTF (Renewable Energy & Distributed Generation Task Force)

Certificates System

- Renewable Energy Certificate Scheme
 - 546 models in 25 items

Strategic Choice of 9 Potential Sectors

based on **Marketability, Technical Ability, Urgency**

	9 Sectors	World Market Size	Domestic Production	Technology Level (Advanced Stations=100)
<p>Rapid Development of World Market Development of related Domestic Industries</p> <p> Early Growth Engine</p>	Photovoltaic	20.0 bil. \$	140 mil. \$	83%
	Wind	37.5 bil. \$	400 mil. \$	79%
	LED	14.0 bil. \$	1,160 mil \$	65%
	Electrical IT	13.0 bil. \$	70 mil. \$	85%
<p>Huge Potential World Market Urgent Need for Technological Advance</p> <p> Next-Generation Growth Engine</p>	Hydrogen Fuel Cell	3.2 bil. \$	–	66%
	IGCC (Integrated Gasification Combined Cycle)	8.6 bil. \$	–	56%
	CTL / GTL (Coal-to-Liquids/Gas-to-Liquids)	28.5 bil. \$	–	50%
	Energy Storage	0.5 bil. \$	–	60%
	CCS (CO2 Capture & Storage)	–	–	65%

Vision of Hydrogen Economy (MKE, 2003, revised 2008)

2003 ~ 2012
R&D and Demonstration
<ul style="list-style-type: none"> Demonstration and Supply under Government Support Hydrogen Energy Market Share <ul style="list-style-type: none"> ▶ 0.03%

2013 ~ 2020	2021 ~ 2030	2031 ~ 2040
Market Formation	Market Expansion	Initial Phase of Hydrogen Economy
<ul style="list-style-type: none"> Accomplishment of Technical Development Expansion of Hydrogen Infra. Self-Growing Market 		

'03-'05	'06-'08	'09-'12
R&D	Demo	Market Intrusion
<ul style="list-style-type: none"> Decentralized (250-1000kW) Industrial (10-50kW) Residential (under 3kW) 		<ul style="list-style-type: none"> 400 MW 80 units 10,000 units
<ul style="list-style-type: none"> Hydrogen Station Fuel Cell Vehicle Fuel Cell Bus 		<ul style="list-style-type: none"> 10 units 500 units 20 units



Fuel Cell System Market Share		
<ul style="list-style-type: none"> Decentralized 1,000 MW Industrial 2,000 units Residential 100,000 units 	10%	15%
Fuel Cell Vehicle Market Share		
<ul style="list-style-type: none"> Hydrogen Station 500 units Fuel Cell Vehicle 50,000 units 	15%	50%

Roles and Activities of Ministries

- Ministry of Knowledge Economy (MKE)

KETEP (Korea Institute of Energy Technology and Evaluation), established in 2009

- Planning, Evaluation, and Management of **all the energy R&D programs**

- R&D Programs for Renewable Energy (11 types)

Hydrogen, Fuel cell, Photovoltaic, Solar thermal, Wind, Bio, Waste, Geothermal, Marine energy, Synthetic fuel

- **Hydrogen Fuel Cells**

Establishing infrastructure for hydrogen production, storage, conveyance and supply as well as ensuring safety measures

Elucidating basic mechanism for commercial adoption of fuel cell as a strategic technology for future hydrogen infrastructure

Promoting innovative technology for reducing price and enhancing performance and durability

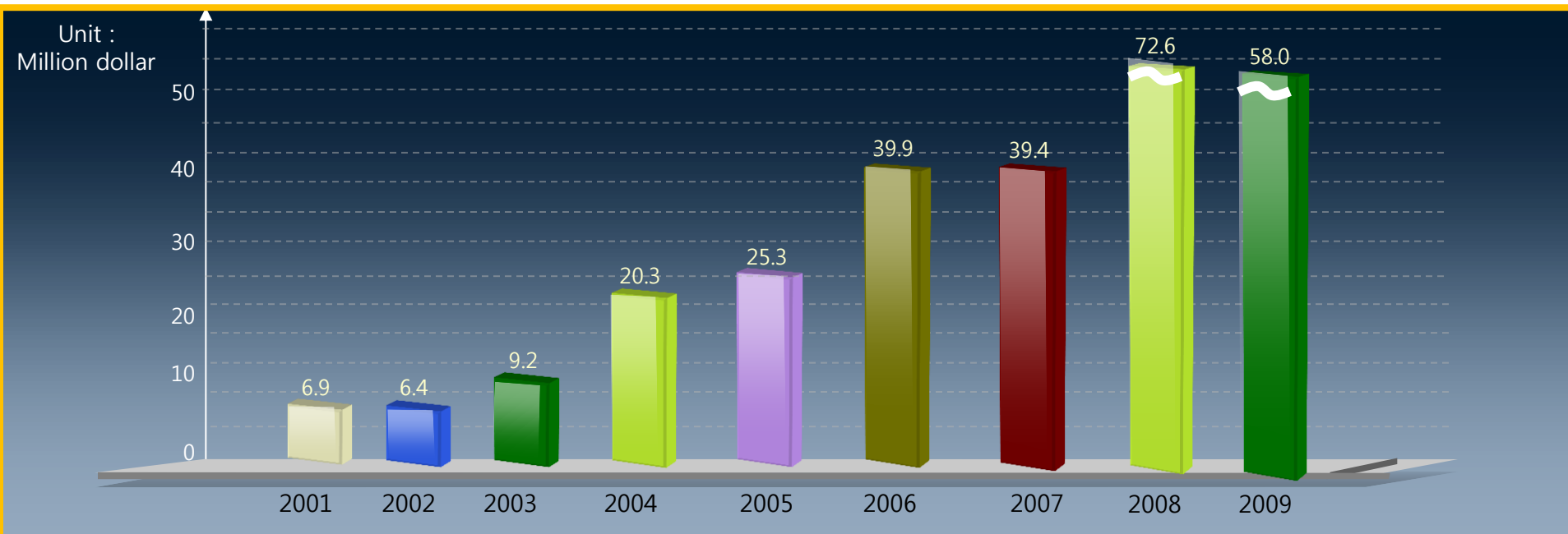
Roles and Activities of Ministries

Changes in public R&D investment (unit: Million USD)

R&D area	2006	2007	2008	2009
Energy Efficiency	69.2	79.0	103.5	143.0
CCS	10.2	15.2	19.5	20.0
Resources Technology	13.1	13.7	16.4	16.6
New and Renewable Energy	115.8	120.9	195.3	205.6
Power Generation and Electricity Delivery	144.6	163.3	123.4	114.5
Nuclear Power	-	-	50.8	61.0
Radioactive Waste Management	-	-	-	4.4
Energy & Resources Recycling	-	4.5	7.2	11.5
Sum	352.9	396.6	516.1	576.6

Roles and Activities of Ministries

Development of Hydrogen and Fuel cell



Ministry of Education, Science & Technology (MEST)

21st Century Frontier R&D Programs: '03-'12

Hydrogen production	Biological, Photocatalytic, and Photochemical Production, Water Electrolysis
Hydrogen storage	Metal Hydrides, Chemical, Hydrides, nano-Structured materials, and etc.
Hydrogen Utilization and Policies	
Budget	\$ 100M (Government:\$86M, Industry:\$14M)

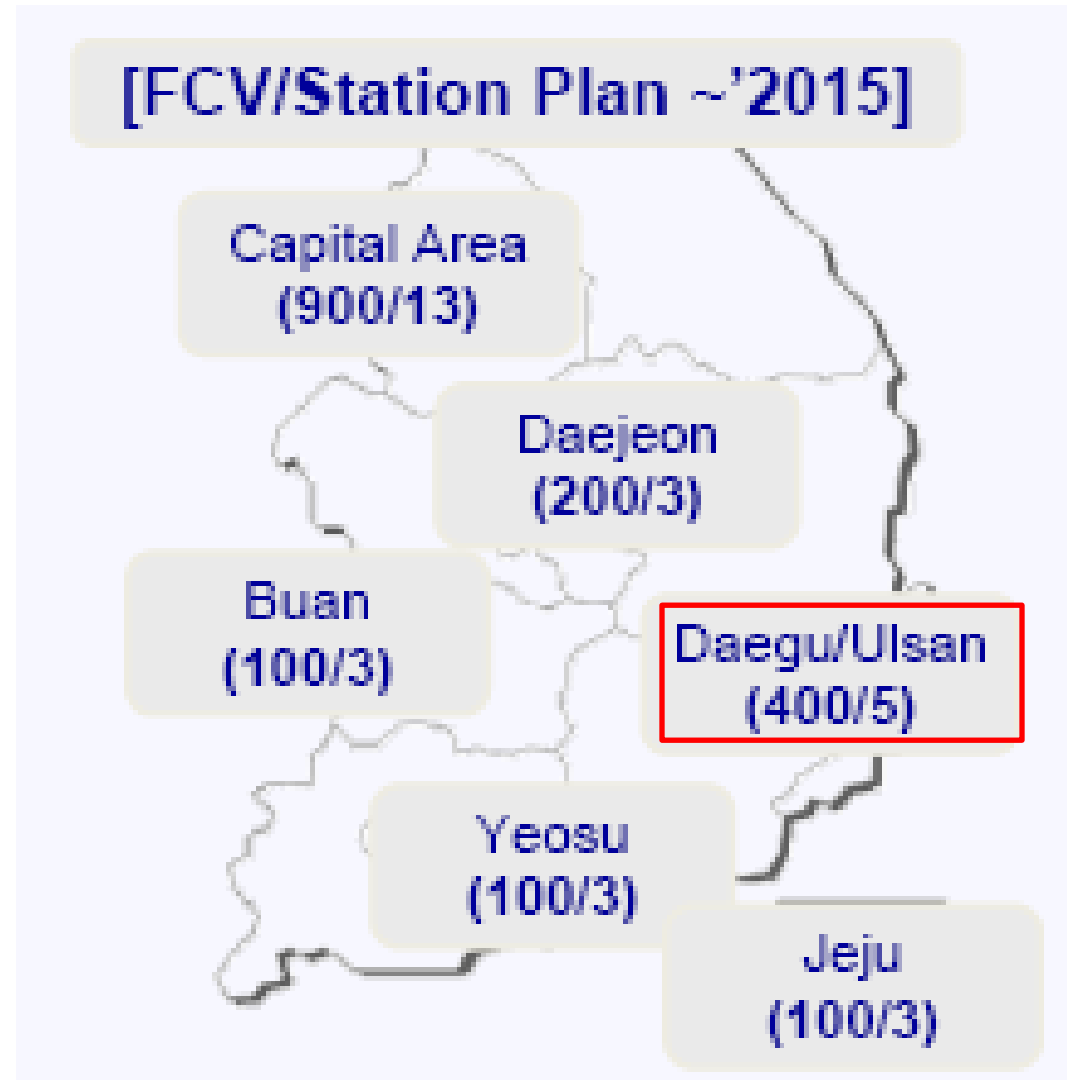
Domestic FCV Fleet Program

	Domestic Fleet program (Phase I)	Domestic Fleet program (Phase II)
Period	Aug. 2006-July 2009	Dec. 2009-Nov. 2011
Vehicles	30 passenger cars 4 buses	80 passenger cars
Hydrogen fueling station	5 new stations (total: 10 stations)	Validate 700 bar H ₂ stations (2) Upgrade 350 bar H ₂ station
Operation	743,500 km (including Bus) Avg. fueling economy: 19.2 km/l	Resolve technical issues before starting small scale mass production
participation	Private companies	3 private companies, 1 province
Budget	\$ 46.6 M (Government \$23.3 M)	\$17.6 M (Government \$5.3 M)

FCV Status & Near-Term Plans

Eco-friendly vehicle town:

Hyundai-Kia Motor Co.:
MOU with Ulsan local government



FCEV Commercialization

1st Gen.
['00 ~ '04]

STEP 1

- Core Technology Development
- Outsourced Stack
- 1st FCV
- Several FCVs/year

2nd Gen.
['05 ~ '08]

STEP 2

- System Technology Development & Fleet Operation
- Hyundai's Stack
- Graphite BP
- Tens of FCVs/year

3rd Gen.
['09 ~ '11]

STEP 3

- Semi-Automatic Production
- Hyundai's Stack
- Metallic BP
- Hundreds of FCVs/year

4th Gen.
['12 ~ '14]

STEP 4

- Pre-commercial Production (Pilot-scale)
- 1,000 FCVs/year

5th Gen.
['15 ~]

STEP 5

- Commercial Production
- Initial Market
- 10,000 FCVs/year



Domestic Monitoring Program
(2006.08 ~ 2010.07)



Validation Program
(2009.12 ~ 2011.11)

Small Scale Production

• 2012 ~

- Tucson iX FCV (100kW)

• 2008 ~ 2009

- Borrego FCV (115 kW)
- FC-BUS Gen II (200kW)

• 2007

- Tucson, Sportage FCV-II (100 kW)
- FC-BUS II (200 kW)



i-Blue Concept car
• 2006

- Tucson, Sportage FCV (80 kW In House Stack)
- FC-BUS (160 kW In House Stack)

• 2004 ~ 2005

- Tucson FCV (80 kW)
- Sportage FCV (80 kW)



• 2000 ~ 2002

- Santa Fe FCV (75 kW)
- Sportage (10kW)



US DOE Fleet Program
(2004.09 ~ 2009.12)

Member of CaFCP
(2000.11 ~ Present)

Recent accomplishments

Hyundai-Kia Motor Co. - Seoul Metropolitan City (April 2011)

33 Fuel cell vehicles: 115kW (19 vehicles) + 100kW (14 vehicles)

Mileage: 23 km per 1ℓ of hydrogen

Max. speed: 160 km

Driving distance: 650 km

Hydrogen station in Seoul: 3 (completed) + 1 (being built)



Production of the **Hyundai ix35 Fuel Cell** began in Jan. 2013, making Hyundai the **first automaker** to begin commercial production of a hydrogen-powered vehicle.



Hyundai plans to manufacture **1,000 units** of the hydrogen-powered ix35 Fuel Cell vehicles **by 2015**

Hyundai ix35 Fuel Cell

Hydrogen consumption:

0.95 kgH₂/100km – equivalent to 27.8km/L (3.6L/100km)

Hydrogen tank capacity: 5.6kg at 700 bar pressure.

Driving distance: 594km

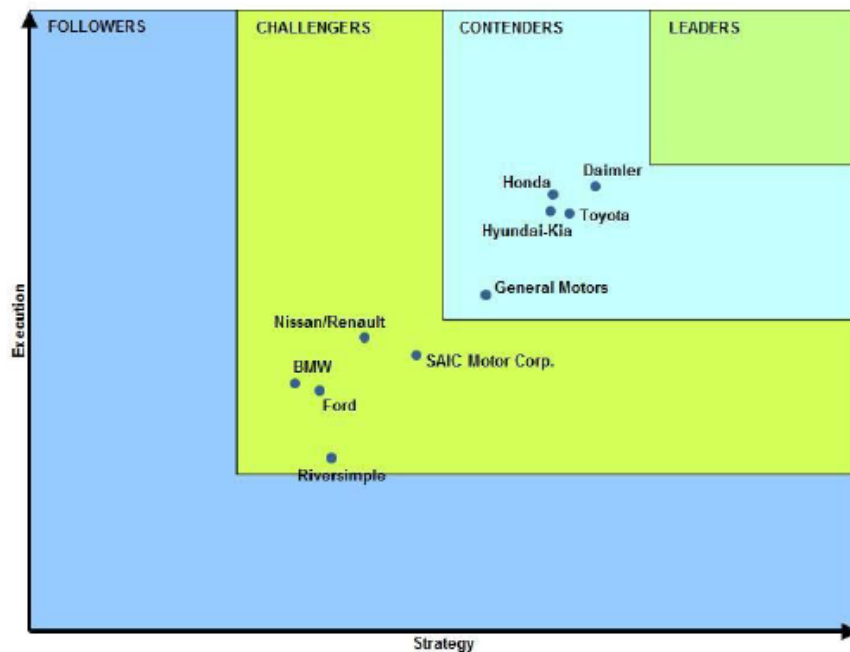
Maximum speed: 160km/h

from 0-100km/h: in 12.5 seconds.



CEV Specific Capability Ranking

- Daimler (69.9) > Honda (66.7) > Toyota (66.1) > HYUNDAI-KIA (65.1)
- Hyundai-KIA's fuel cell electric vehicle technology, Top ClassV



Daimler

- Ballard's factories (Vancouver) 38% lease
- Early '12year, FC Stack manufacturing facility will be completed

Hyundai-Kia

- '11 EU FCEV was selected as demonstration business
- '12~'14year, 1000 demonstration cars (Nordic target) will be produced

GM

- 500 people committed to design and process development
- 150 people supported basic research (R & D Center)
- SAIC and the co-development, sharing of development platform

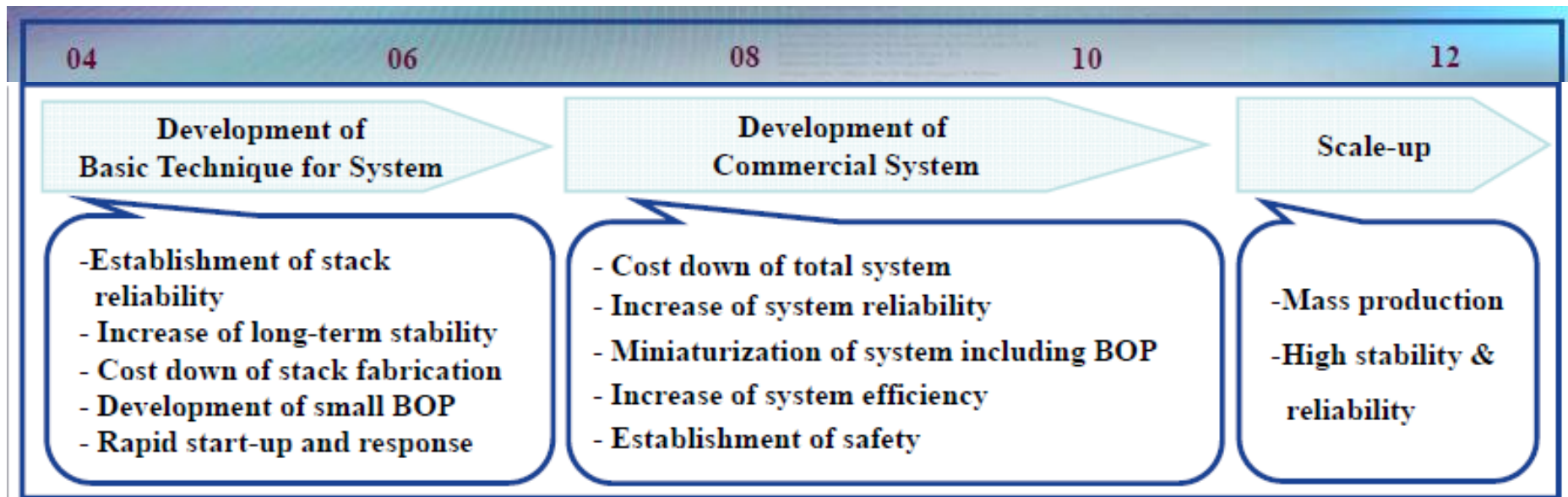
Nissan

- Development of commercial-level performance FC ('11)
- 1.6 times price reduction compared to '05year

PEMFC/SOFC for Residential Power Generation

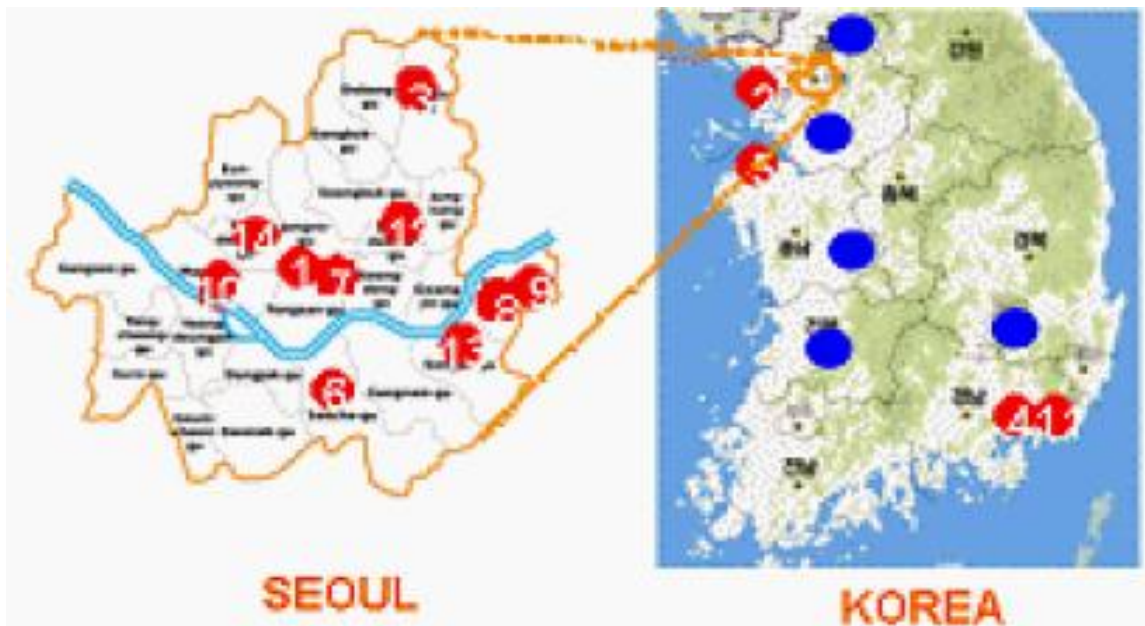
Target

Efficiency > 40%, \$15,000/kW

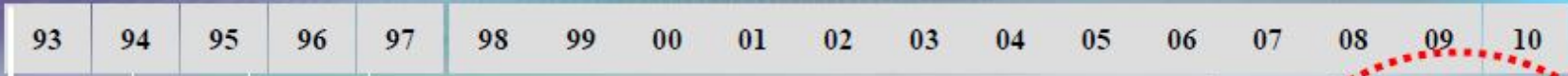


40 units ('07) → 70 units ('08) → 100 units ('09)

- Development of PEMFC (GS) as well as SOFC (KEPCO) leading by companies
- Benchmarking of advanced techniques for enhancement of system efficiency and reliability
- Share of common technologies of stack, reformer, and BOP with PEMFC for vehicle
- Feasibility study of SOFC for auxiliary power unit (APU)



MCFC Development for Power Generation Application



2 kW Plant

Basic Research
Fabrication Processing
Small Stack operation

Established the Basic Technology

25 kW Plant

Enlargement
Increase cell No.
Internal manifolds
25 kW class stack

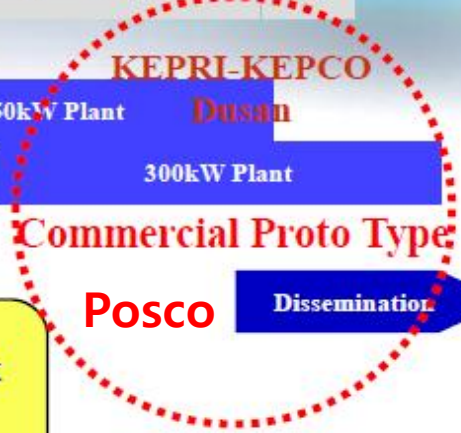
Components Enlargement
25 kW stack test

100 kW Plant

- Enhancement cell and stack
- System Integration (BOP)
- Operation mode

Pilot Plant Test , Boreyong TP

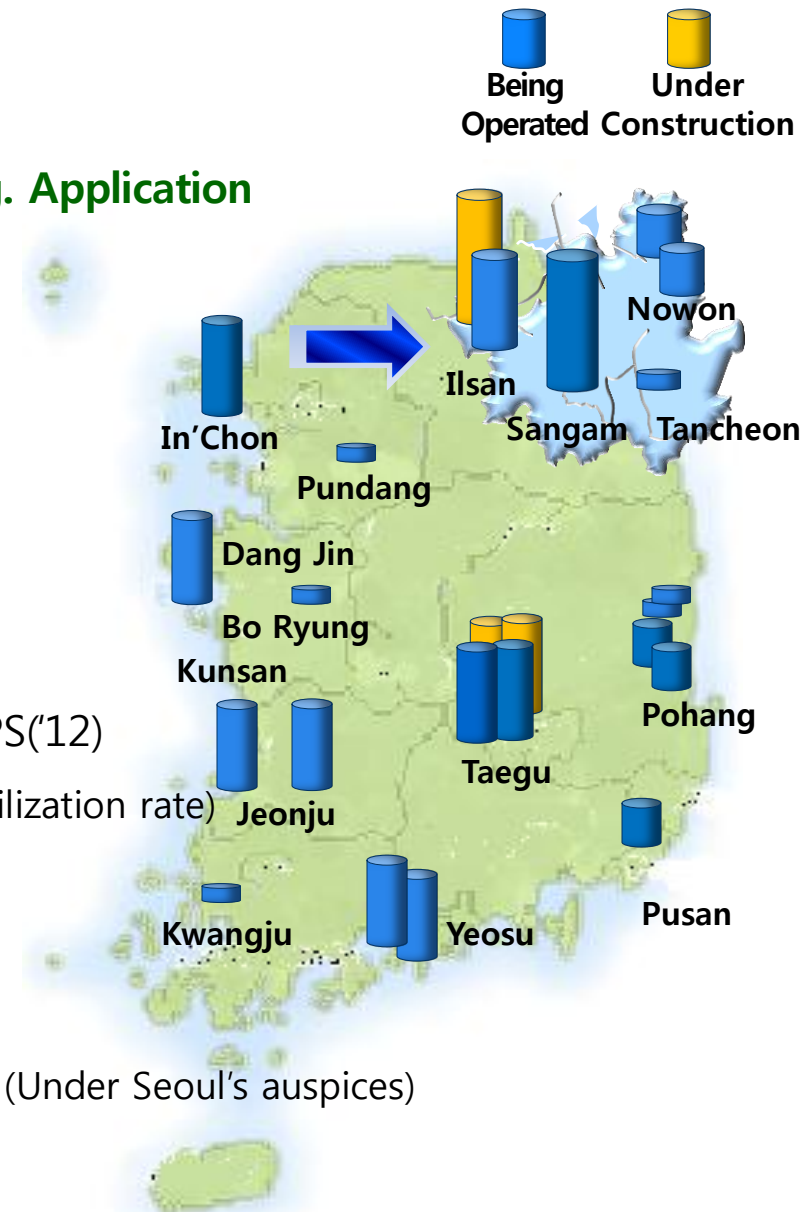
250kW Plant



Domestic Installation Status

Under the Support Policies, Settled Domestic demand-shaping & First-Hit for Bldg. Application

- **Under Feed-In-Tariff: Domestic Sales (40MW)**
 - Installed Seoul, Pusan, and Taegu (Big-City Centered)
 - Switching to Big Scale Centered (From small scale)
 - Namdong Power Plant : 250kW('06) → 2.4MW('08)
→ 2.8MW('09) → Multi-MW
 - Parallel-ADG (In case of Pusan Sewage disposal plant)
 - Supply heating together with electric power (Nowon district)
- **On negotiation with targeted companies against RPS('12)**
 - Grand Scale of demand (Owing to High-efficiency, High utilization rate)
 - **Expected install. of 80MW scale for power plants**
(Appx. 30% RPS market)
- **Expected gradual expansion (for Bldg. Application)**
 - In operation of the Seoul Pilot Project of fuel cell for Bldg. (Under Seoul's auspices)
 - Expected expansion to private bldg owners
(due to Revision of RPS, and Accredited scheme for eco-friendly bldg)



Recent accomplishments

Korea Electric Power Co. + Posco Power + Samchully Gas Co.
(\$300 M dollars for 60MW power plant) in Kyunggi Province)

2012. 06 15MW Fuel cell power plant

2013. 06 45MW Fuel cell power plant

Posco Power – built Fuel cell power plants (**40MW** in operation)

2.4MW Power plant in Seoul



Domestic fuel cell market forecast

section	2010			2012			2015			Note
	Sales	Employment (person)	The ratio of sales compared to government subsidy(%)	Sales	Employment (person)	The ratio of sales compared to government subsidy (%)	Sales	Employment (person)	The ratio of sales compared to government subsidy (%)	
Residential ¹ PEFC	310	120	53	350	150	49	1000	500	113	2012, 2015 including exports
Vehicle PEFC	380	530	38	800	750	64	6000	5771	374	Forming 120 parts of 2010's Related parts suppliers
S.P.G MCFC	1,215	200	192	1,900	360	258	8000	800	901	2015 including exports
Niche market DMFC	25	15	12	70	40	28	1700	300	567	Including exports
Total	1,930	865	79	3,120	1,300	106	16,700	7,371	454	

1) Cumulative sales and employment until 2010

2) Sales of 2012, 2015 : The year estimate (including export), Employment person is cumulative vehicle sale performance

Sales unit : hundred million won
1 hundred million won = 87,000 dollars

- Writing about the number of vehicle produced by based on production costs to sales of parts suppliers for vehicle production until 2010
- Prediction sales account pursuant to FCV mass-produce in 2012. 2015

Fuel cell business and Market

Type	Field	Korean companies
PEFC	<p>Consumer and Commercial (1kW~ 50kW)</p> <p>vehicle car/bus/truck (50kW~250kW)</p> <p>etc (military, submarine, airship, transportation, exclusive power supply...)</p>	<p>FUELCELLPOWER, GS FUELCELL, HYOSUNG, LG CHEM, SK, SAMSUNG ELECTRONICS, LG ELECTRONICS, LS cable & system, LSIS, KYUNG DONG NAVIEN, SAMCHULLY, HANWHA chemical corporation, DONGJIN SEMICEM, HANKOOK TIRE, HUYNDAI MOTOR COMPANY etc..</p>
SOFC	Distributed power generation (250kW~several MW)	<p>KEPCO POSCO SAMSUNG SDI</p>
MCFC	Distributed power generation (250kW~several MW)	<p>KEPCO POSCO POWER DOOSAN HEAVY INDUSTRIES & CONSTRUCTION</p>

1 hundred million won = 87,000 dollars