2014 Korea Update

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Hydrogen and Fuel Cells in Korea

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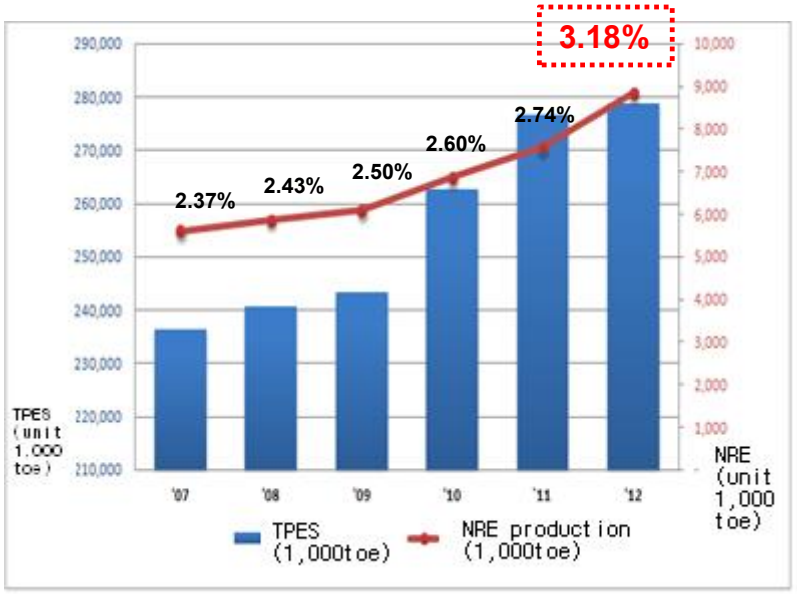
The Status of New and Renewable Energy(NRE)

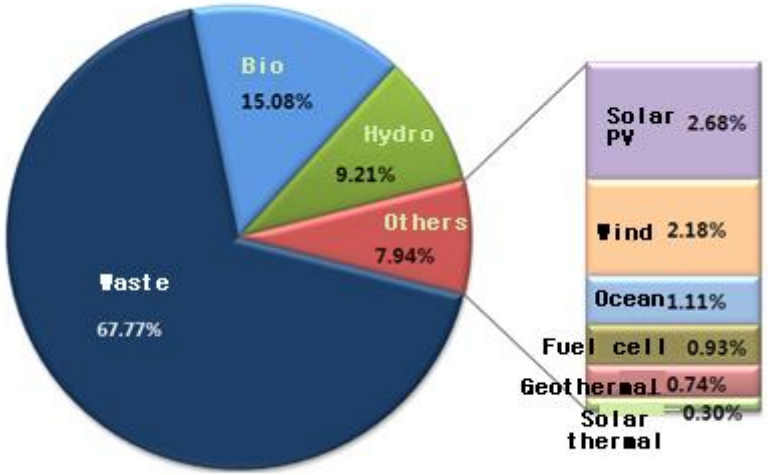
▶ NRE (New and Renewable Energy) Share in TPES (Total Primary Energy Supply): 3.18% (2012)
- TPES(278,698,000TOE) vs. NRE Supply(8,851,000 TOE)

▶ **NRE** supply has been increased by annual average of 9.6% (2007-2012)
(while annual average of TPES growth is 3.3%)

NRE Share in TPES



NRE Supply by Sources



- **RE : 8 Sources**

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

- **New Energy : 3 Sources**

Fuel-cell, Hydrogen, Coal Liquefaction or Gasification

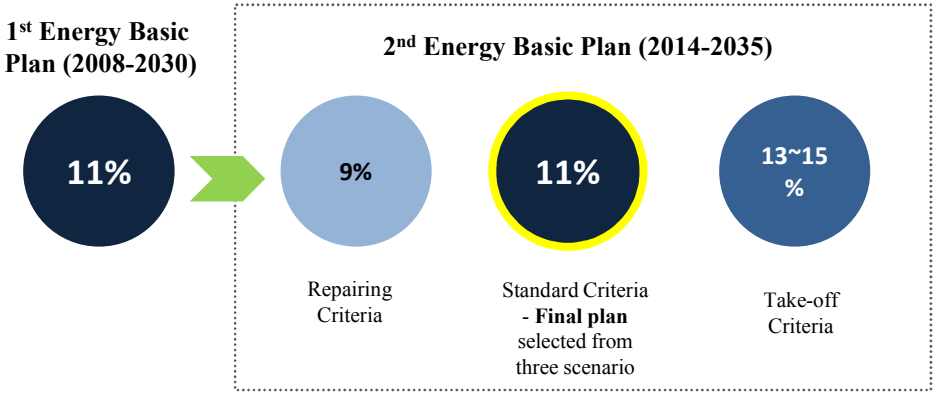
The Status of New and Renewable Energy : Policy

Policy Goal

Goal of supply 11% from New & Renewable Energy by 2035

* *4th New & Renewable Energy Basic Plan will be announced in 2014*

Compare share of renewable energy in the primary and secondary energy master plan



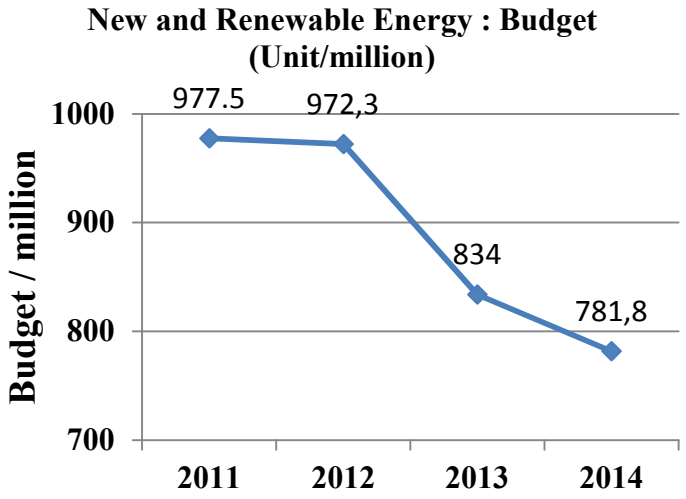
[Supply Status]

By 2012, the distribution share based on primary energy is 3.18%, while waste, bio and water power accounted for 92% of the total production of the renewable energy.

* Average Annual Increasing Rate (‘08-’12,%) : Solar (41), Wind (20), Fuel cell (109), Geothermal(43), Bio (33)

2014 New and Renewable Energy R&D : Budget

	2013 Budget	2014 Budget
New and Renewable Energy : Budget	834.02 (million dollar)	781.80 (million dollar)



2013 R&D Budget
264.85 million dollar

7.9%

2013 Hydrogen & Fuel-cell Budget
33.4 million dollar

2014 R&D Budget
242.84 million dollar

7.8%

2014 Hydrogen & Fuel-cell Budget
30.9 million dollar

-10.8%

[Technology Development]

- In the last five years (‘08 - '12), more than 70% of the total R & D budget have been supported by the selection and concentration strategy to the three main energy sources of photovoltaic (32.2%), fuel cells (21.9%) and wind (16.4%).

30MW fuel cell power plant at the Seo-nam Water Recycling Center

Expected Effect

- When the facility is completed, Seoul will hold an overall 75MW dispersed fuel cell power plant that increases electrical independency by fuel cell production approximately twice its original amount from **0.7% to 1.2%**
- By such measures, it is possible to yearly produce 590GWh electrical energy which is enough for 16,000 households and 300000Gcal of heat energy for 30,000 households.
- 2013 Seoul's electricity self-sufficient rate 4.2% (on the basis of 2013 consume quantity of 46,555GWh)
- On the basis of each household consumes 3600kWh of electricity and 10Gcal of heat each year.
- Seoul anticipates to increase its electrical independency from **2013's 4.2% to 2020's 20%** by continuing its dispersive renewable energy enterprise, such as installing fuel cell in public facilities.

▲ fuel cell power plants and green energy business overview

◈ **Construction area : 4,133㎡**

◈ **capacity of generating plant : 30MW**

서울특별시

Seoul City Plan for ‘Fuel Cell’ for eco-friendly power supply

Seoul, Management state of Fuel-Cell Facilities (The end of 2014)

Total	Power Plant (Attract private capital)	For home use (Green-Home Supply Business)	Seoul Project	Notes
290 Places, Capacity 6,085kW	2 Places Capacity 4,800kW	285 Places Capacity 285kW	3 Places Capacity 220kW	LOTTE SUPER TOWER 800kW *(400kW*2, Installation of Fuel-Cells is Complete.)

Case of Installation : Fuel-Cell Power Plant (Seoul)

고덕그린에너지(강동구 고덕차량기지 19.6MW)
(시험운전중, ´14.10월말 준공예정)

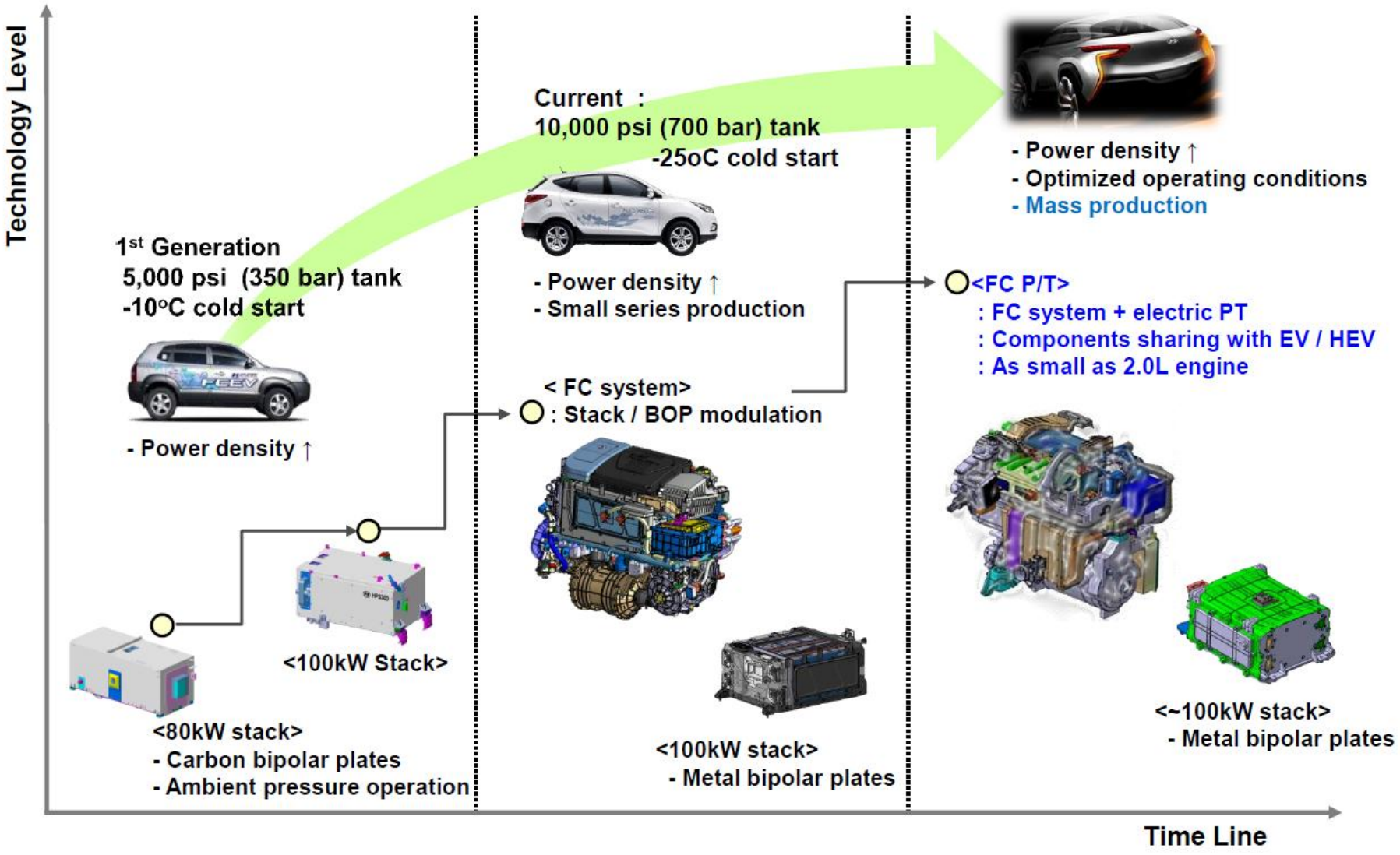
Place	Capacity	Date of Operation
Go-deok Green Energy	19.6 MW	2014.10
Seo-nam Water Recycling Center	30 MW	Plan

Seoul begins to develop ‘Fuel Cell’ for eco-friendly power supply

Fuel-Cells supply status :A total of 22 places, capacity 123.8MW

No.	Date of Operation (yy.mm)	Installed Place	Capacity
1	'06.11, '13.04	KOSEP(Korea South East Power CO.) / Gyeonggi	3.38MW
2	'08.03	POSCO ICT /Pohang	300KW
3	'08.09	HS ENP / Jeonju	2.4MW
4	'08.09	Natura Power / Gunsan	2.4MW
5	'08.09	KOMIPO(Korea Midland Power CO.) / Boryeong	300KW
6	'08.10	POSCO ENERGY /Pohang	2.4MW
7	'09.05	SH Corporation / Seoul	2.4MW
8	'09.10	MPC Youl Chon Power / Yeosu	4.8MW
9	'09.10	GS EPS / Dangjin	2.4MW
10	'09.10, ‘13.02	KOSEP(Korea South East Power CO.) / Il-san	5.2MW(2.4MW+2.8MW)
11	‘10.01	POSCO POWER / Inchoen	2.4MW
12	'10.05	Byuck San Engineering & Construction / Pusan	1.2MW
13	'10.08	GS Power /An-yang	4.8MW
14	'10.09, '11.06	TCS1 / Deagu	11.2MW(5.6MW*2)
15	'10.10	POSCO ENERGY / Sangam	2.4MW
16	'11.04	KOSEP(Korea South East Power CO.) / Il-san	2.8MW
17	'11.10	The Cobalt sky / Pusan	5.6MW
18	'12.01	MPC Youl Chon Power /Yeosu	5.6MW
19	'12.02	Seoul (For building, Hospital)	100kW
20	'12.02	Seoul (For building, Seoul Children’s Grand Park)	100kW
21	'13.08	KOSEP(Korea South East Power CO.) / Ulsan	2.8MW
22	'13.12	Gyeonggi Green Energy / Gyeonggi	58.8MW

FCEV Technology Roadmap



Establishment of KHIA (Korea Hydrogen Industry Association)

Role of Association

•Domestic hydrogen supply and demand Survey to make long-term counter plan

•Support research, development and government policies : Support logic development for government, Consulting for government and municipals, Revision and promotion of hydrogen proposed law, Suggestion of technology development and policy.

•Planning to build hydrogen supply infrastructure : Development of management plan for hydrogen supply pipeline in domestic, Efficiency improvement of hydrogen supply facilities, Demonstration project planning for hydrogen town and fuel cell vehicles

Participation :

Ulsan City / Oil Company / Gas Company / Fuel Cell Company

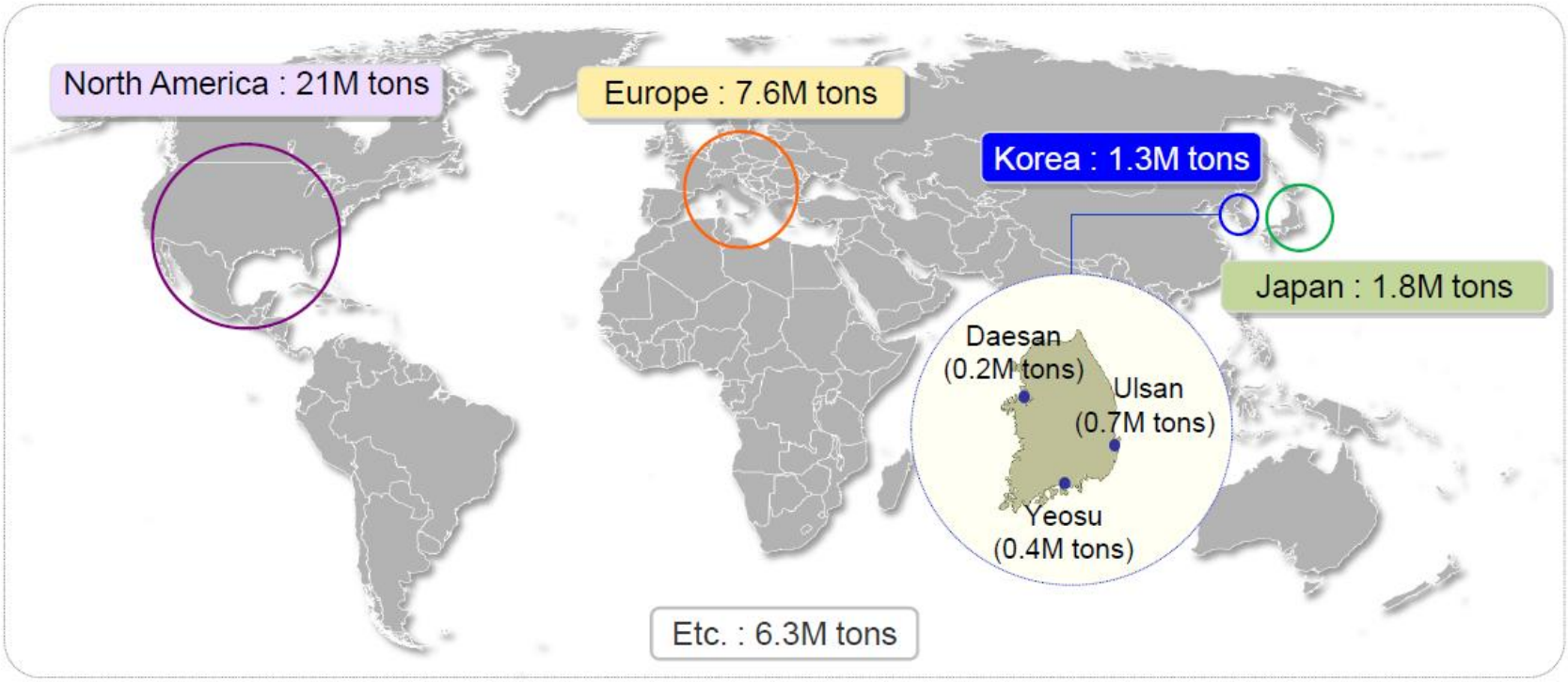
National Lab. / HMC

Hydrogen Production status

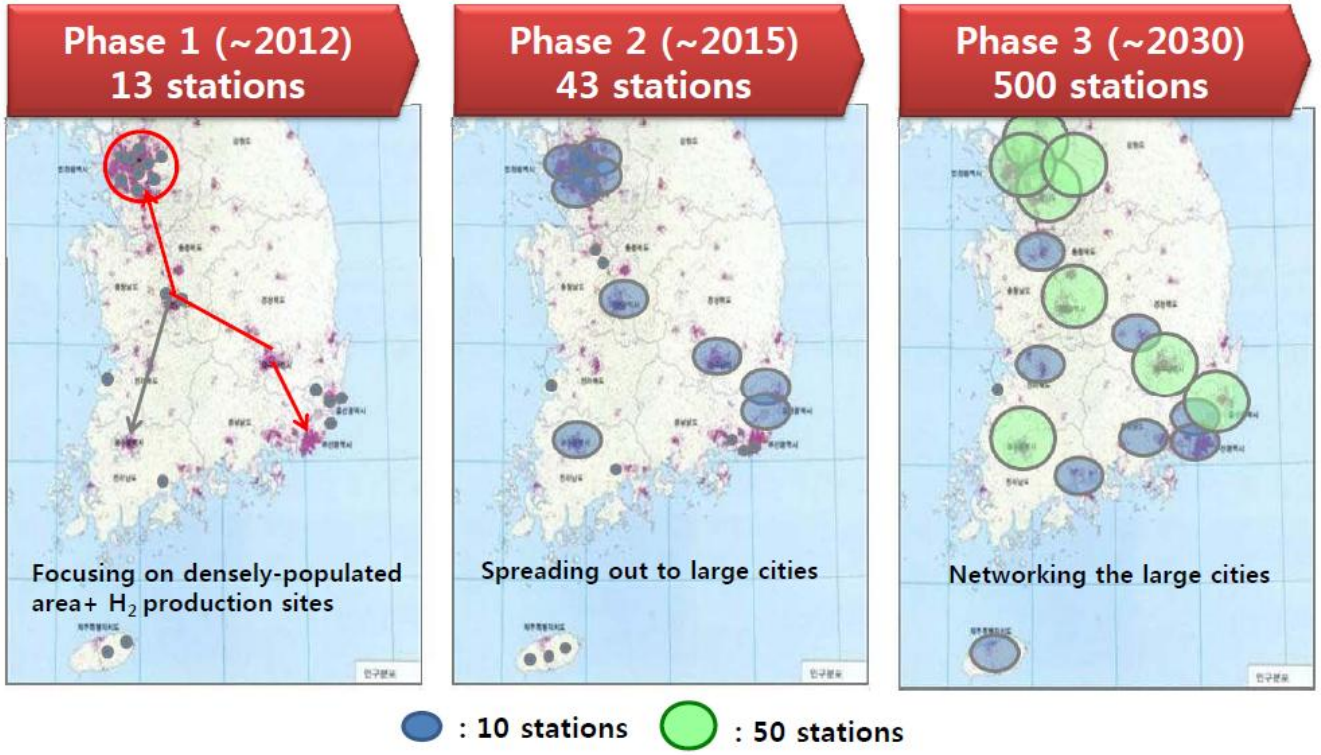
38 Million tons of Hydrogen are produced in the World

- Main methodology is a NG reforming
- In Korea, 1.3 Million tons (3.4% of world H_2 production) are produced. (By-product method is main)

● Annual Hydrogen production capacity in the World



Hydrogen Fueling Station Roadmap in Korea (Ministry of Environment)



Timeframe	~2012	~2013	~2015	~2020
Number of hydrogen fueling Stations	13	18	43	168

[FCEV Deployment]

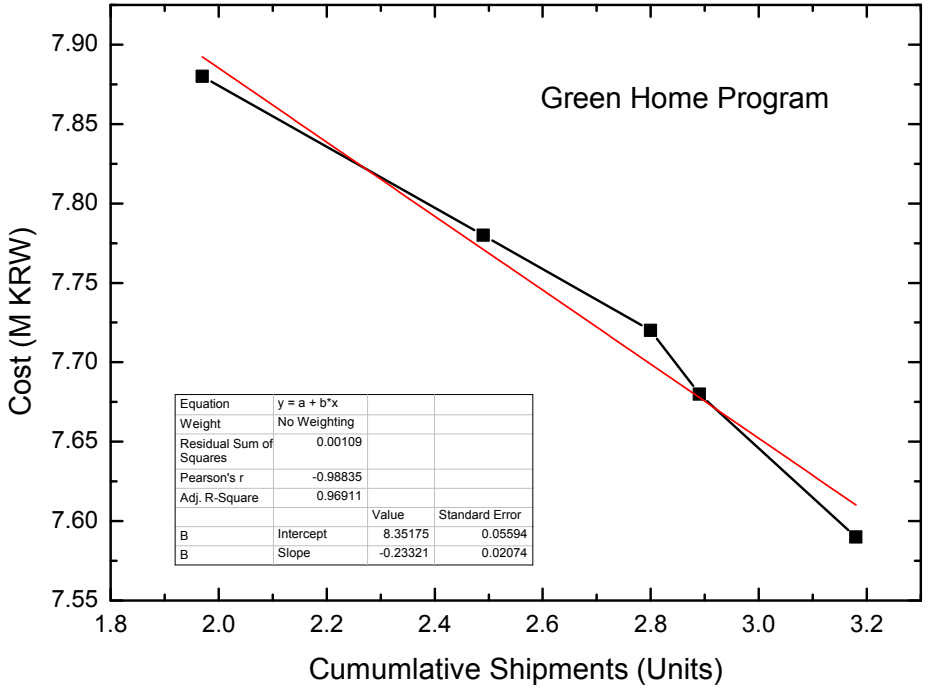
- 'Legislation of eco-friendly vehicle development and deployment'

: '13.5 FCEVs & 1 Hydrogen station (Gwangju) / '14.5 FCEVs & 1 Hydrogen station (Seoul, Ulsan, etc.)

- 2nd Plan for Air-Environment Management in Metropolitan area (2015 ~ 2024) → FCEV plan (10,000FCEVs, ~2024)

Learning Curves (Cost): 1,500 vs. 70,000(PEMFCs)

- Despite small scale of deployment, Green Home Project plays a critical role in developing healthy supply chain for stationary PEMFCs, being attributed to effectively developing core BOP components under the support of KETEP
- Cost reduction target: KRW 5,000,000 by 2020



C: cost at reference and given time
P: cumulated production at reference and given time
***lr*: learning rate**
a: learning index

$$C_t = C_o \left(\frac{P_t}{P_o} \right)^{-\alpha}$$

$$lr = 1 - 2^{-\alpha}$$

Thank you for your attention.

Selected Target Area: Ulsan

•Uljugun Onsanmyun districts

• Uljugun Cheongryangmyeon Sangnam districts

•Ulsan Seonamdong

Target area	Uljugun Onsanmyun Deoksinri	▪ Moorim P&P company housing : 34 households ▪ LS company housing : 16 buildings 298 households, Two-story building ▪ Korean Paper company housing : 200 households ▪ A lot of shopping center and within 2 km of Onsan national industrial Complexes
	Uljugun Cheongryangmyeon Sangnamri	▪ Many schools and Single-family Housing in this area ▪ Petrochemical complex within 2 km
	Namgu Seonamdong	▪ Large city within 1 km of Taekwang industry

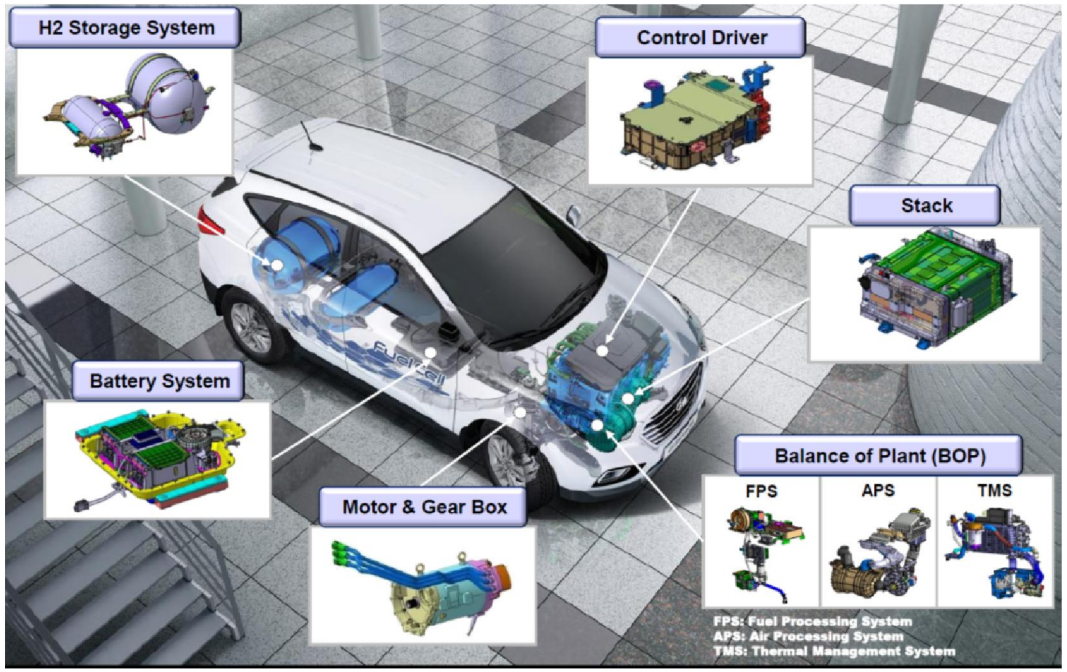
FCEV Development – Tucson ix

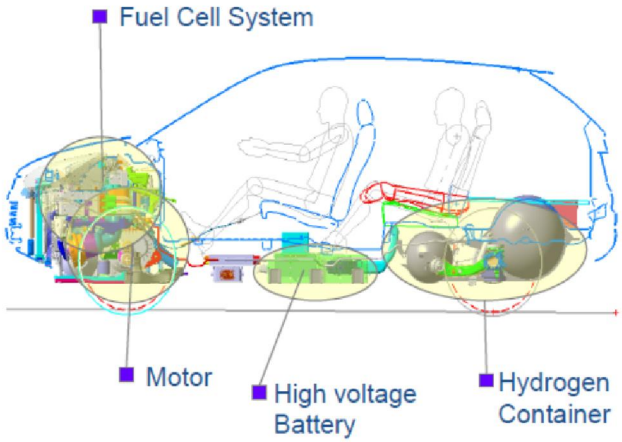
FCEV – Tucson ix

- Simple modular design of fuel cell system for volume production
- Significant cost reduction by metallic bipolar plate, AC induction motor, and Li-ion battery
- Improved vehicle performance for fleet & public customers
- Verification of cold starting and safety at -25°C

Fuel Cell Power	100 kW
Battery	24 kW
Motor System	Ac Induction/100 kW
H_2 Container	5.64kg (700 bar)
Fuel Economy	27.8 km/L (NEDC*)
Driving Range	594 km (NEDC*)
Acceleration (0 → 100kph)	12.5 s
Max. Speed	160 km/h

*NEDC : New European Driving Cycle





The Status of New and Renewable Energy : Policy

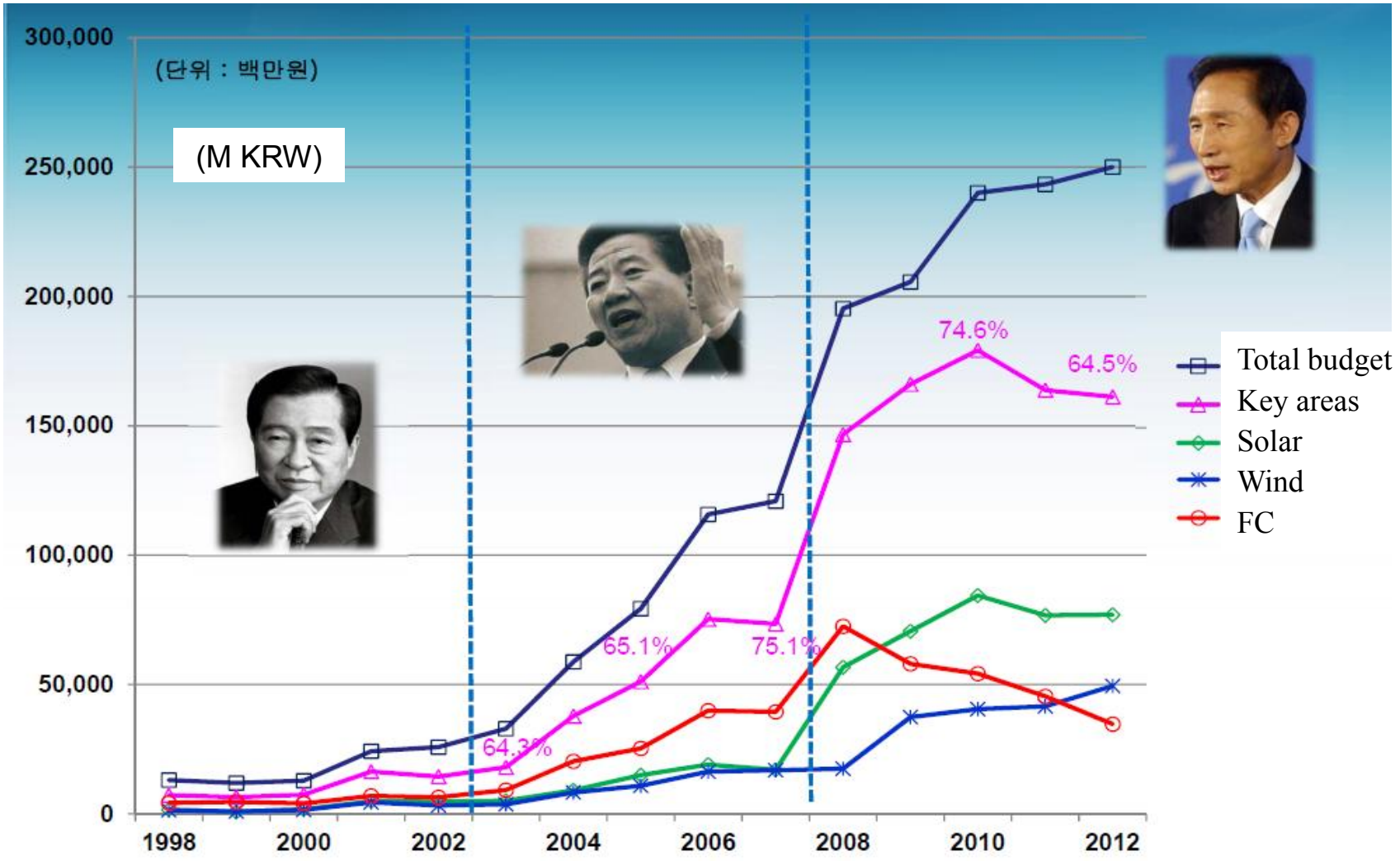
Policy Goal

Goal of supply 11% from NRE by 2035

* 4th New & Renewable Energy Basic Plan will be announced in 2014

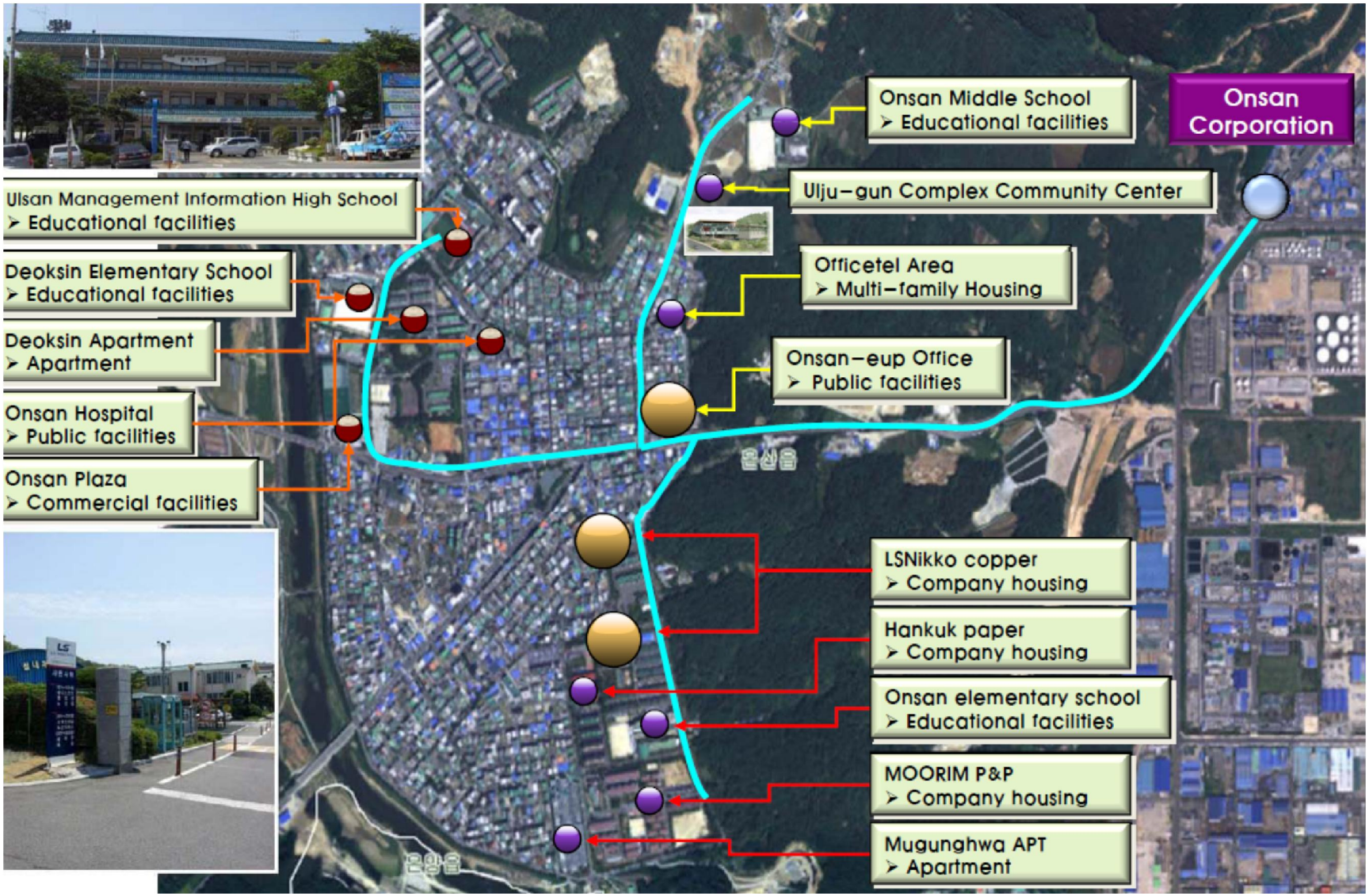
5 Promote Strategy	Detail Enterprise
Create new market including New NRE	◈ excavate new energy source ◈ expand or integrate heat and transportation ◈ expand public corporation market ◈ reform the government distribution market ◈ supports overseas expansion
Improve the System or Revitalize investment	◈ expand participation of resident ◈ expand investment of finance ◈ establishing environment-friendly energy town ◈ revitalizing rental business ◈ support strategic region
Reinforce the effectiveness of existing policy	◈ adjust RPS ◈ lift from delay burden ◈ rationalize weighted value ◈ reinforce small scale support ◈ improve the regulation
NRE R&D empowerment	◈ low cost R&D ◈ expand support for technical commercialization ◈ expand hybrid R&D ◈ reinforce positive R&D support ◈ cultivate human resource
Expand institutional Support basis	◈ improve using statics ◈ privately led A/S system ◈ rationalize the certification and standard ◈ build Test-bed ◈ reinforce the marketing

R&D Budget in FC & Three Key Areas



- **Increased emphasis on R&D in solar and wind powers for promoting fast commercialization since 2009.**

The location of the Hydrogen-Town Project :Ulsan



Fuel cell System

- 4 Companies of PEMFC Manufacturers in KOREA participated this project.
- 195 kW PEM Fuel Cell is installed in Hydrogen Town.

1kW

Fuel Cell Power

1kW

Hyundai Hysco

1kW

Hyosung

5kW

GS Caltex

10kW

Collaborative System Establishment

Cooperation with Local Government and Energy Related Government Institution

Classification	Total	Urban planning	Urban construction	Building	Energy	Traffic	Forest
Standards Emissions in 1990	3,430,000	0	640,900	1,960,400	565,500	603.200	-340,000
Target emissions n 2030	950,000	-55,932	174,955	514,175	214,231	180,920	-78,349
Reduction	2,480,000	55,932	465,945	1,446,225	351,269	422,280	-261,651
Ratio	72.3	1.6	13.6	42.2	10.2	12.3	-7.6

Renewable energy ratio	
Solar power	72,691 toe(5.4 %)
Geothermal heat	41,621 toe(3.1 %)
Waste	40,032 toe(3.0 %)
Bio	13,461 toe(1.0 %)
Fuel cell	36,545 toe(2.7 %)
Total	204,350 toe(15.2 %)

- ✓ Establishment of fuel cell model complex
- ✓ Installation promotion of fuel cell power plant

Construction of Buan Hydrogen Fuel Cell Collaborative Research Center

- ✓ World Class the Demonstration Facility and System Development

Ulsan regional Cooperation Research System Proposal

- ✓ Enhanced cooperation with Korea Institute of Energy Research (KIER) and Korea Energy Economics Institute(KEEI)
- ✓ Expand the research and development of fuel cell area with the energy related government institutions
- ✓ Promotion of research and development of hydrogen between the Institute and University in Ulsan
- ✓ Construction of integrated energy system renewable energy source

Hydrogen Strategy in Korea: KHIA

1. Background

- Lack of research and development support specialized agencies and hydrogen related policies
- The use of hydrogen in various fields (hydrogen fuel cell vehicles, fuel cell power generation etc.)
- Request of specialized agencies for price and supply/demand control participated with Industry, Academia, Government, Local governments

2. Association establishment

- Industry(for Supply/Demand), University and Research center(for Research and Development), Local governments (for Development of related regulations and Corporate participation)
- The Research Association of Hydrogen Supply Utilization Technology (HySUT), Fukuoka Strategy Conference for Hydrogen Energy Benchmark
- Organize association in hydrogen abundant area → expand to other regions

3. Role of Association

- Domestic hydrogen supply and demand Survey to make long-term counter plan
- Support research and development and government policies : Support logic development for government, Consulting for government and municipals, Revision and promotion of hydrogen proposed law, Suggestion of technology development and policy.
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4. Expected Effects

- Stable of hydrogen price due to balancing supply and demand
- Development hydrogen policy and R&BD plan
- Build up Hydrogen supply infrastructure for fuel cell electric vehicle
- Improvement of investment efficiency by hydrogen pipeline managem

[KHIA (Korea Hydrogen Industry Association)]