

# Hydrogen Industry and Association of KOREA

Korea Hydrogen Industry Association

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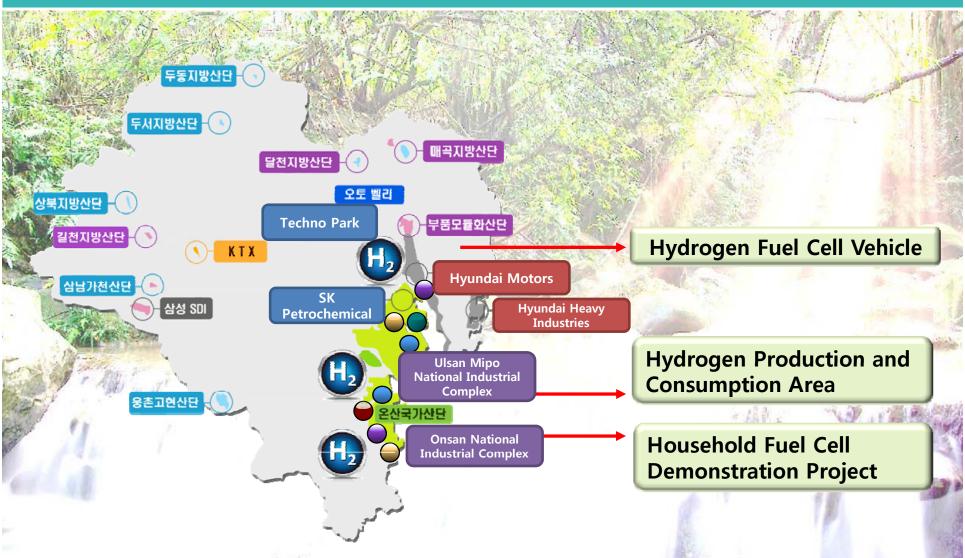








## **Ulsan: The Global City of Chemical and Automobile Industry**



Hydrogen Fuel Cell → New Growth Engines of Ulsan

# Optimization of Hydrogen Network in Ulsan Petrochemical Industrial Complex

#### **Data collection**

- 1. Visit/Consult companies
- 2. Collect Basic data
- 3. Integrate/ Present Advisory report
- 4. Plan/Consult for Commercialization

#### **Analysis and Inventories**

- 1. Analysis of the data collected
- 2. Establish Material Balance
- 3. Classify data and make database
- 1. Progress and Final Report

#### **Report writing**

- 1. Analysis of the data collected
- 2. Development study for fuel cells
- 3. Study on hydrogen-based town planning

#### **Expert Advisory Group**

Council of Ulsan Petrochemical Complex,
Council of Onsan National Industrial Complex Superintendent,
Council of Yongyeon Yongjam Superintendent,
Council of foreign-invested enterprises in Ulsan Plant Manager,
Roadmap for Ulsan Petrochemical Industry
NCN HR Professional Career,
Korea Gas Safety Corporation,
Ulsan Fine Chemical Center

### **Target for Hydrogen Network Optimization**

#### Hydrogen inventories in Ulsan industrial complex

- 1. Total Survey for company that has hydrogen production and discharge, consumption in industrial complex
- 2. Build inventory on the basis of survey

#### **Optimum network business plan in industrial complex**

- 1. Utilization of by-product hydrogen (PSA Tail-gas included)
- 2. Joint PSA use of low purity by-product hydrogen
- 3. Build optimum network and commercialization plan

### Hydrogen fuel cell power supply and residential area supply plan

- 1. Status analysis of the fuel cell power generation
- 2. Economic analysis for fuel cell power generation
- 3. Build residential area supply plan

### **Ulsan Petrochemical Complex**



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# Basic Data Survey of Hydrogen companies related



No	Company	H <sub>2</sub> produ ction	Bypro duct H <sub>2</sub>	Used in Proc ess	Used in fuel	Incin erati on	Sell	Purch ase
1	SK Energy	0	0	0	0		0	0
2	KPIC		0	0	0		0	0
3	Samsung BP Chem		0				0	
4	Samsung Fine Chem	0	0	0	0		0	
5	Solvay		0			0		
6	\$-Oil	0	0	0				
7	Isu Chemical	0	0	0			0	0
8	Capro	0	0	0	0			0
9	кос		0				0	
10	KP Chemical	0		0				0
11	Taekwang		0	0	0		0	0
12	Hanhwa Chem		0	0	0		0	
13	Hyosung		0	0	0		0	
14	Foosung		0			0		
15	Deokyang						0	0

	Company	H <sub>2</sub> produ ction	Bypro duct H <sub>2</sub>	Used in Proc ess	Used in fuel	Incin erati on	Sell	Purc hase
16	Dongdeok						0	0
17	SDG						0	0
18	SPG						0	0
19	LG Health Care			0				0
20	SKC			0				0
21	SKCEVONIK			0				0
22	SK Lubricants			0				0
23	SK NJC			0				0
24	Samsung Petrochemical			0				0
25	Samyang Genex			0				0
26	Korea PTG			0				0
27	Kolon Industry			0				0
28	BASF			0				0
29	Korea Alcohol			0				0
30	Hansol Chemical			0				0

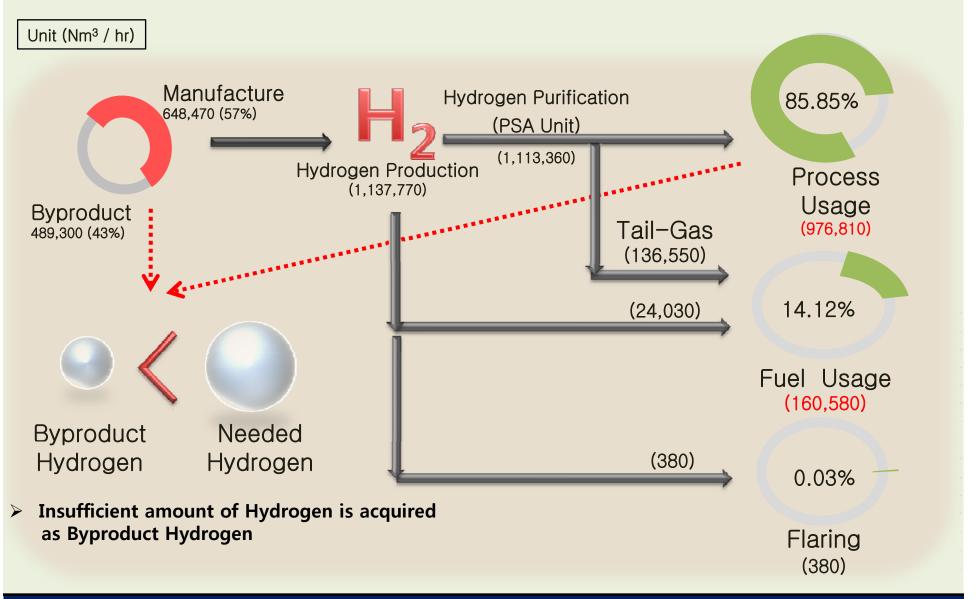
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### Main Usage of Hydrogen

- Hydrodesulfurization,
- Modification of the hydrocarbon, Cyclohexane manufacture
- Olefinic hydrocarbons → Saturated hydrocarbons
- Acetylenic hydrocarbons → Olefinic hydrocarbons
- Polymerization process-Adjusting the molecular weight of the polymer
- Removing sulfur in raw naphtha material
   Hydrodesulfurization, Dewaxing of base oil
- The addition of unsaturated hydrocarbons
   (Di-olefin → Mono-olefin)
- Caprolactam manufacture
- PX/MEX manufacture, PTA manufacture
- Adjusting the molecular weight of the polymer
- Sorbitol manufacture, Saturation of unsaturated fatty acids

- RED reproduction, Hydrotreating
- Production of Ethyl amine, Synthetic alcohol
- PX/MEX manufacture, PTA manufacture
- Remove acetophenone(ACP)
- · Removal of hydrogen peroxide products in PO
- Production of hydrogen peroxide
- CHDM (1,4-Cyclohexane Dimethanol)
  manufacture
- Production of Terephthalic acid (PTA)
- Production of Sorbitol, Martinique pool, poly glycidyltol
- Production of THF, BDO
- Acetylenic, saturated of olefinic hydrocarbon)
- Production of PTHF

## Overall Mass Balance of hydrogen (Ulsan)



# The amount of hydrogen for Hydrogen fuel cell vehicles

$$1 \text{ Nm}^3 = \frac{100^3 \text{ cm}^3}{22.414 \text{ l}} \frac{\text{mol}}{\text{mol}} \frac{2 \text{ g}}{10^3 \text{ cm}^3} \frac{\text{Kg}}{10^3 \text{ g}} \frac{273 \text{ K}}{288 \text{ K}} = 0.0846 \text{ Kg}$$

Produced Hydrogen by new process: 50,000 Nm<sup>3</sup> / h

### The number of operative FCEV

$$\frac{33,501,600 \text{ Kg}}{\text{yr}} = \frac{355 \text{ Km}}{3.6 \text{ Kg}} = \frac{0.9}{15,000 \text{ Km}} = \frac{198,218 \text{ vehicles/yr}}{(\approx 200,000 \text{ vehicles/yr})}$$

### Operating costs of Fuel cell vehicle (Tucson)

- ⇒ 3.6 Kg Hydrogen → 320 Km driving
- $\triangleright$  0.085 Kg/ Nm<sup>3</sup> : 3.6 Kg hydrogen = 42.55 Nm<sup>3</sup> hydrogen
- ► Cartridge hydrogen sales prices (Fuel cell vehicles)
  - \$ 0.7 / Nm<sup>3</sup> × 42.55 Nm<sup>3</sup> = \$ 29.8 : \$ 9.3 for 100 Km
  - \$ 0.8 / Nm<sup>3</sup> × 42.55 Nm<sup>3</sup> = \$ 34.0 : \$ 10.6 for 100 Km
- ► Pipeline hydrogen sales prices (Fuel cell vehicles)
  - \$ 0.4 / Nm<sup>3</sup> × 42.55 Nm<sup>3</sup> = \$ 17.0 : \$ 5.3 for 100 Km
  - The length of H<sub>2</sub> pipeline in Ulsan is about 100 Km
- ► Gasoline sales prices (IC engine vehicles)
  - $$ 1.9 / L \times 32.0 L = $ 60.8 : $ 19.0 for 100 Km$

# Production and supply of Deokyang Hydrogen

# **Hydrogen Source** each business site

	(LNG SMR)	40,000 Nm³/hr		
Ulsan	(Chloro-Alkali)	12,000 Nm³/hr		
	(PDH etc.)	12,000 Nm³/hr		

Yeosu	(Chloro-Alkali)	32,500 Nm <sup>3</sup> /hr		
10000	(Naphtha Cracking etc.)	6,500 Nm <sup>3</sup> /hr		

Gunsan (Chloro-Alkali) 2,500 Nm
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Seosan	(Naphtha Reforming etc.)	5,500 Nm³/hr
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#### **Distribution of Hydrogen purification**



111,000 Nm<sup>3</sup>/hr

Deokyang Ltd.



#### About 104,000 Nm<sup>3</sup>/hr

Refinery and Petrochemical Applications Pipe Line

- Ulsan: SKE, Lotte Chemical, SKC Evonic etc.
- Yeosu: GS Caltex, Kumho, LG etc.
- Gunsan: OCI

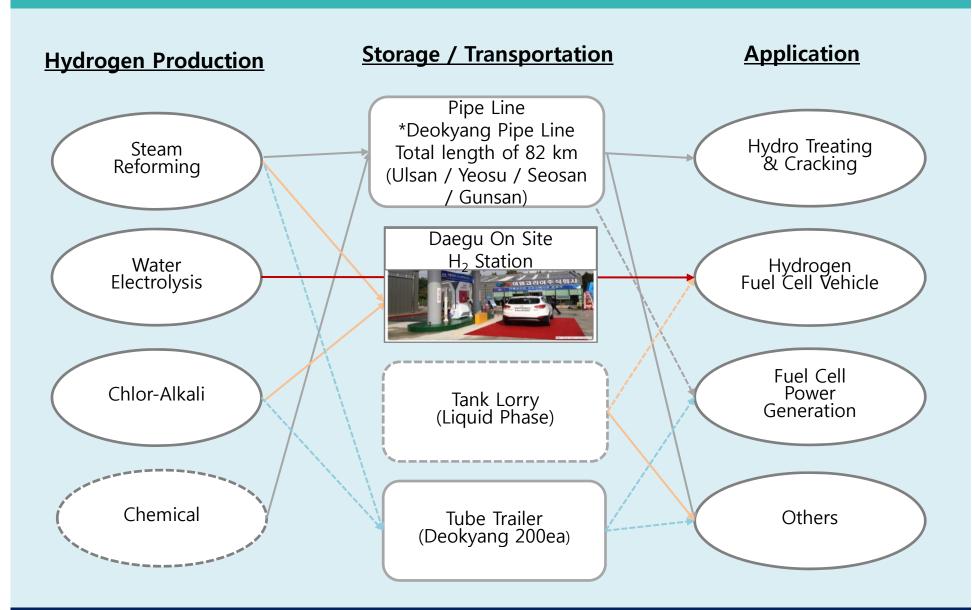
#### About 7,000 Nm<sup>3</sup>/hr

**Tube Trailer** 

Semiconductor, glass industry, metal heat treatment purposes

- Samsung electronic, Hynix, Hyundai hysco

## **Overall Scheme of Domestic Hydrogen industry**



# Hwaseong Fuel Cell PP 58.8MW MCFC

• Site : Hwaseong Balan Industrial Complex

• Capacity: 58.8MW

Annual Electricity Generation: 464 GWh (covers 70%)

Annual Heat Output: 195,000 Gcal (covers 20% of ho

• Installation Area: 20,000 m<sup>2</sup>

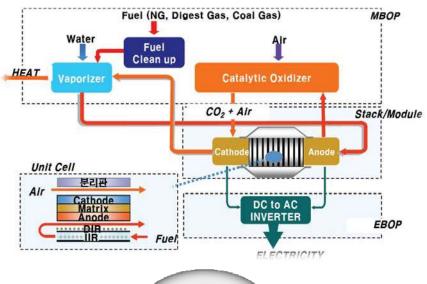
Consortium: Posco Energy, Samchully, Korea Hydro

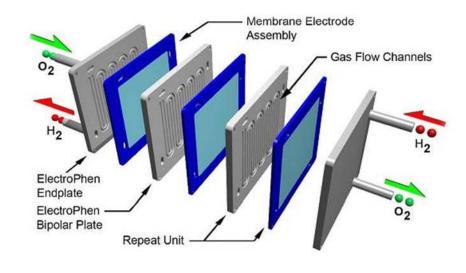


	Installation site	Company	Operation Date	Capacity (MW)
1	Bundang	KOSEP	'06.11	0.25
2	Pohang	POSCO	'08.03	0.3
3	Pohang	POSCO ENERGY	'08.08	2.4
4	Jeonju	HS holdings	'08.09	2.4
5	Gunsan	Natura Power	'08.09	2.4
6	Boryeong	KOMIPO	'08.09	0.3
7	Nowon	SH Public Company	'09.05	2.4
8	Yeosu	MPC Yulchon power	'09.10	4.8
9	Dangjin	GS EPS	'09.10	2.4
10	Ilsan	KEWP	'09.10	2.4
11	Incheon	POSCO ENERGY	'09.11	2.4
12	Busan	BYUCKSAN	'10.05	1.2
13	Sangam	SH Public Company	'10.09	2.4
14	Daegu	TCS1	'10.09	5.6
15	Ilsan	KEW	'11.04	2.8
16	Daegu	TCS1	'11.06	5.6
17	Saha	BFC	'11.10	5.6
18	Yeosu	MPC Yulchon power	'12.01	5.6
19	Eunpyeong	Seobuck Hospital	'12.02	0.1
20	Kwangjin	Children's Grand Park	'12.02	0.1
21	Ilsan	KEW	'13.03	2.8
22	Ulsan	KEW	'13.10	2.8
23	Hwasung	Gyeonggi Green Energy	'13.12	58.8
Total			115.85	

### **Hydrogen Fuel Cell Power Generation**

### ♦Technology Sector Review







- LNG is supplied to reform and supply hydrogen to MCFC
- Thermal balance and CO<sub>2</sub> supply are optimized in system
- Direct hydrogen MCFC is not developed yet



- There are few cases of large-scale power generation PEMFC
- Durability Problem of Platinum Poisoning by Low
   Temperature Operation (High Purity Hydrogen needed)



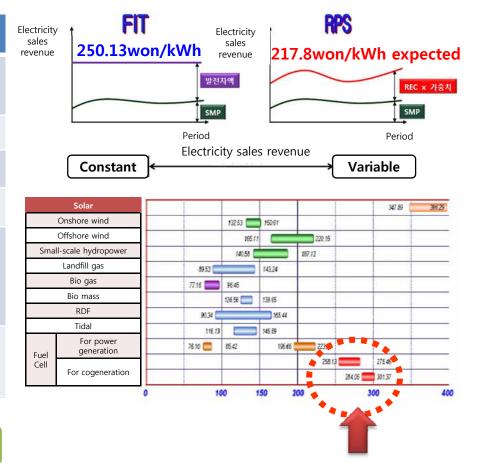
Direct Hydrogen PEMFC for large-scale Power Generation is expected to increase in near future, it is essential to develop catalyst and MEA Technology.

### **Policy of Power Generation**

### Policy Areas

**Feed in Tariff Renewable Energy** [FIT] Portfolio Standard [RPS] - Produced Electricity is purchased at - Pre-set of production amount. - Market determines the price, the price set by the government. Mechanism - The amount of electric power is due to the imposition of determined by the company. obligation amount. Easy to achieve policy target by **Supply Goals** Variable target amount. assigned amount. **Power** It is needed to purchase all of the Set target amount by electric Selection requested amount. United States, United Kingdom, Germany, Spain, France, Denmark, **Countries** Canada (16 countries) etc. (34 countries) Reducing production costs by The mid and long-term price promoting competition guarantees maintain certainty of among providers. investment. **Advantages** Financial burden of Technology development and government is reduced industrial growth due to stable because the price is attracting investment. determined by private sector. The government's huge financial Overemphasized in specific burden. energy source. Disadvantages Lack of incentives for lower The infrastructure should be production costs due to lack of essential for system introduction. competition between companies.

The fuel cell weight of 2.0, Assuming REC 50 won / kWh



Competition within the Renewable Energy



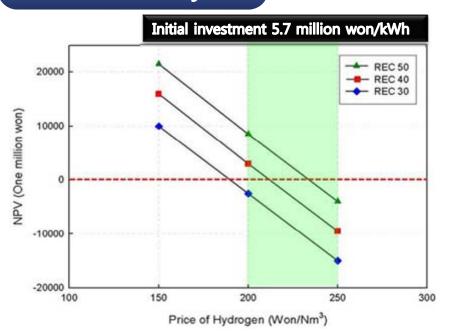
Competition among the Renewable Energies

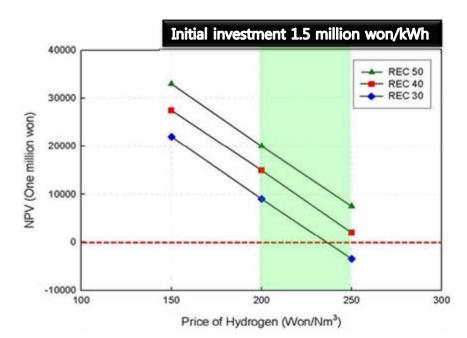


- Change from RPS to FIT to reduce Financial Burden of Government.
- Expected to intensify competition among Renewable Energies.
- RPS is adopted in 2012, and MW scale MCFC is installed by POSCO Energy.

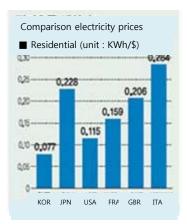
### **Economy of Large-scale Fuel Cell Power Generation**

#### **Economic Analysis**





- Expenses: Annual maintenance cost of 900 Mwon, Water costs 1.5 Mwon, Labor costs 40 Mwon. Net present value is calculated with REC price and variable hydrogen price.
  - Fuel cell power generation with current hydrogen price has low economic value in 30~50 won/kWh REC price
  - Good economic value with Future Technology
     Development and the REC price based on Hydrogen
     Production Cost from 200 to 250 won / NM³ (2012 REC 30~70 won / NM³)





## History for preparing Hydrogen Association



**Establishing Committee of Korea Hydrogen Industry Association** 





Operations Green hydrogen industry Research Group

Aug.

Compositing and operating of world's largest hydrogen town

Aug.

Nov.

2006

2009

2010

2011

2012

2013

2014

Feb.



Promoting fuel cell for transportation practical cluster

('10.6~'13.4)



Green technology commercialization project implementation using by-product gas

Feb.



Launching the world's first mass production line of hydrogen fuel cell vehicles

Dec.



Hydrogen industry development seminar for professionals

### Establishment of Hydrogen Association (Jan. 2014)

President: Lee Chi Yun (CEO of Deokyang. Ltd)

#### •Executive Director:

Pack, Jong Hoon (Chairman of Green Hydrogen Industry Study Group),

Kim, Jun Bom (Professor, University of Ulsan), Kim, Ki Cheol (Vice president of Deokyang. Ltd), Cha, Jun Gi (Managing director of SDG), Woo, Hang Soo (Director of Ulsan Tech. Material Center)

#### •Founding Members:

Ulsan council, Deokyang, SDG, Ulsan Technopark, University of Ulsan, Hyundai Motors, Korea Research Institute of Chemical Technology, Around 100 Hydrogen Business Related Companies, Research Centers and Universities

#### \* Role

Survey of domestic hydrogen supply Propose Government policy and R&D Plan Study for Safety and Environmental Issues Hydrogen Quality Standard and Specification Convergence of Hydrogen Related Industries Build Future Plan for Hydrogen Economy Society





## Hydrogen Fuel Cell Association Establishment



#### 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 plan

- Industry(for Supply and 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 areas → 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 related 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



### 4. Expected Effects

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

#### **Members**



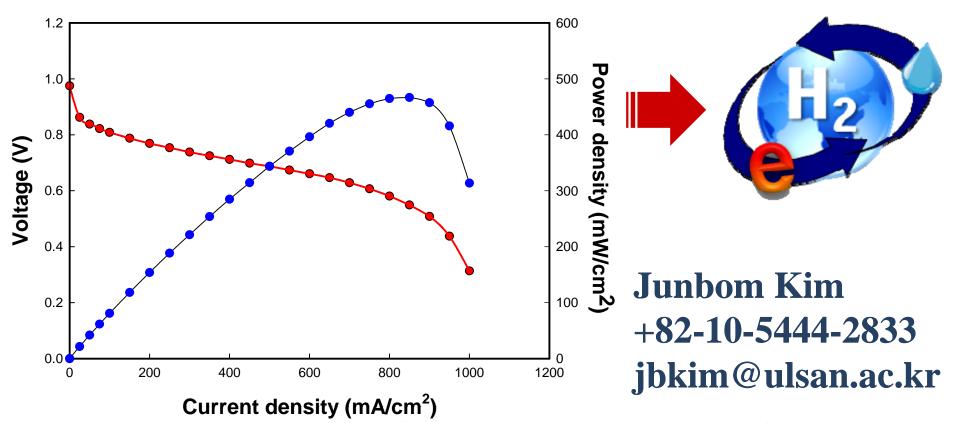
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# Thank you for your attention!

$$E = E_0 - blog(i) - Ri - mexp(ni)$$

#### Polarization curve



**J.B. Kim**, S.M. Lee, S. Srinivasan, *Modeling of Proton Exchange membrane Fuel Cell Performance with an Empirical Equation*, J. Electrochem. Soc, Vol. 142, No. 8, August 1995