



(주)두산

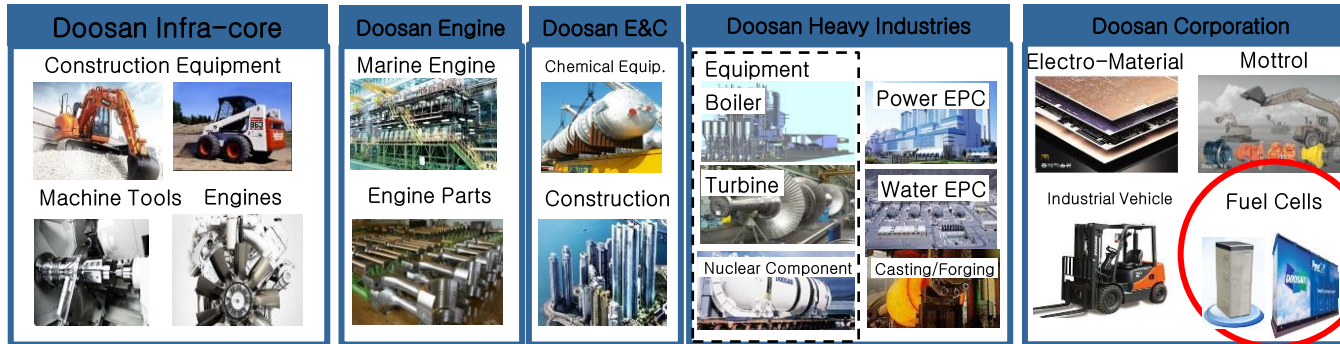
Large Scale Fuel Cell Power Generation Using By-product Hydrogen for Commercial Purpose

Nov. 2, 2016

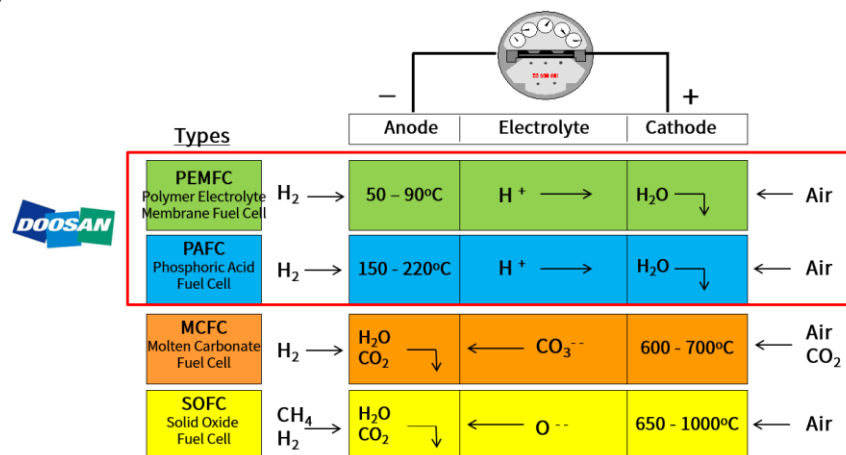
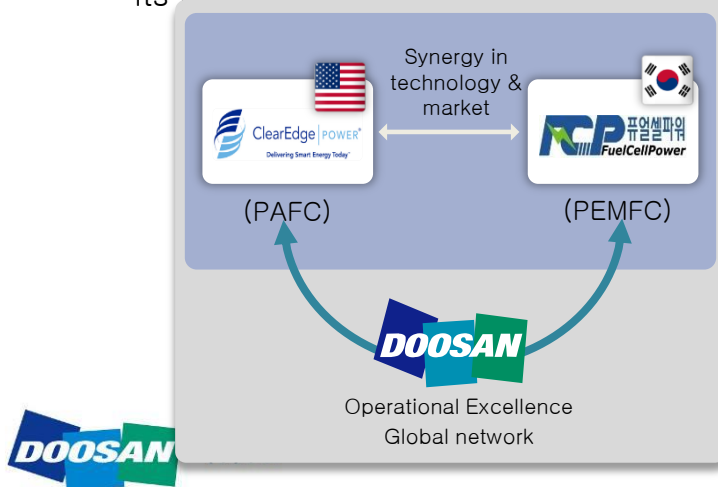
Doosan Fuel Cell BG

Doosan Group

- Global
 - 10th largest Conglomerate in Korea (119 years old)
 - : \$22 billion revenue (60% from global market), 42,000 employees



- Fuel Cell Business Group
 - By acquiring CEP and merged FCP in 2014, Doosan has become one of the major player in FC industry
 - Its major products cover PEMEC and PAFC



Hydrogen System(#1/2)

- **Advantage**

- clean energy : no environmental contaminant except the minimum NOx
- easily used as fuel for direct burning or fuel-cell system
- simple transport in a liquid/gas form
- easy storage such as high-pressure gas, liquid hydrogen, and metal hydride
- made it from water and, after use, recirculated back to water
- versatile usage from industry base material to almost every field including fuel, a car, and fuel-cell system

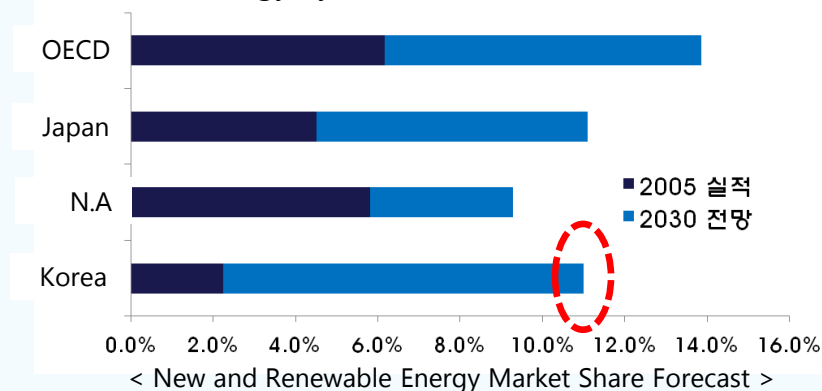
- **Power Generation in Domestic Market(Korea)**

- Large scale MCFC system at 20 sites by POSCO Energy
- PEMFC system is max. 10kW class by Doosan and other companies : increases the need of a larger scale PEMFC

CHP	2015yr	2020yr	2030yr
Market cap.(mil. \$)	241	332	2,091
Share(%)	0.8%	2.9%	76.3%

< Mid-/Large scale fuel-cell market size forecast >

- 11% market share of new and renewable energy by 2030 in Korea due to RPS(Renewable energy Portfolio Standards)



Hydrogen System(#2/2)

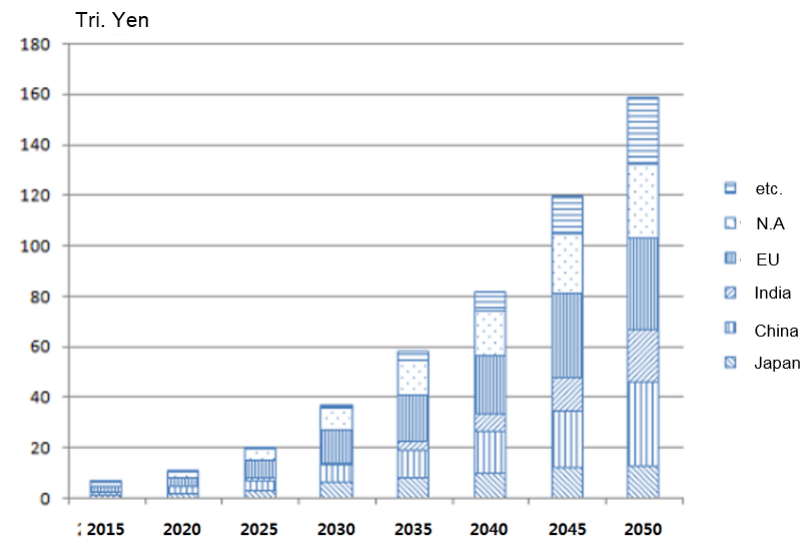
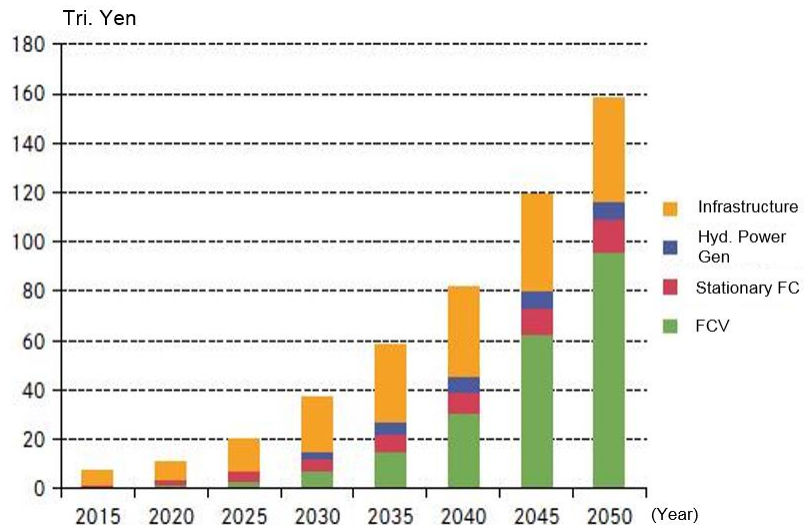
- Global market

- 0.5~10kW class for household/commercial use(90% is PEMFC)
- distributed power generation market might be 54GW/yr by 2020
- 110 FCVs / 1,000 household fuel-cell system in German, set up 100 hydrogen stations in Japan, 300 FCVs run in France, Tax free policy with New-Energy Vehicle in China(IPHE, 2015)

(unit : places)

Target of Hydrogen Facilities		2015 yr	2018 yr	2020 yr
	German	50	100	400
	France	~5	~5	40
	Netherlands	2~4	10	20
	the UK	9	30	70
	Norway, Denmark, Sweden, Finland	10	30	40

- Market forecast : '15(20 trillion yen) → '50(160 tri. Yen) by Nikkei BP Clean Tech. (Japan)



By-product Hydrogen(#1/3)

Domestic status(Korea)

- the output of by-product hydrogen 3,891,100 Nm³/h → used amount 296,400 Nm³/h
- a lot of potential markets
- Ulsan by-product hydrogen project in 2012



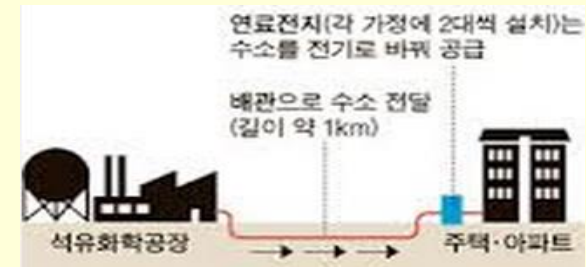
Product specifications

- Generating efficiency : 50%(LHV)
- Thermal efficiency : 30%(LHV)
- Gross efficiency : 80%(LHV)
- Size : W410 X D640 X H1,100
- Start-up time: <10m



Hydrogen Town at Ulsan*

- Installation year: 2012
- Installation capacity :
195kW (1kW-140units, 5kW-9units, 10kW-1unit)
- Fuel supply:
Chemical Factory : by-product hydrogen



- Fuel cell yearly operation rate: > 95%
- Heat production coefficient(/kW): 0.625

Electricity	Heat generation	Total energy
1,622,790kWh/yr	1,014,243kWh/yr	2,637,033kWh/yr

Replacement of fossil fuels**

331.4 TOE/yr

* Southern city in Korea

** Fuel cell new renewable energy Toe conversion factor: 1.789toe

By-product Hydrogen(#2/3)

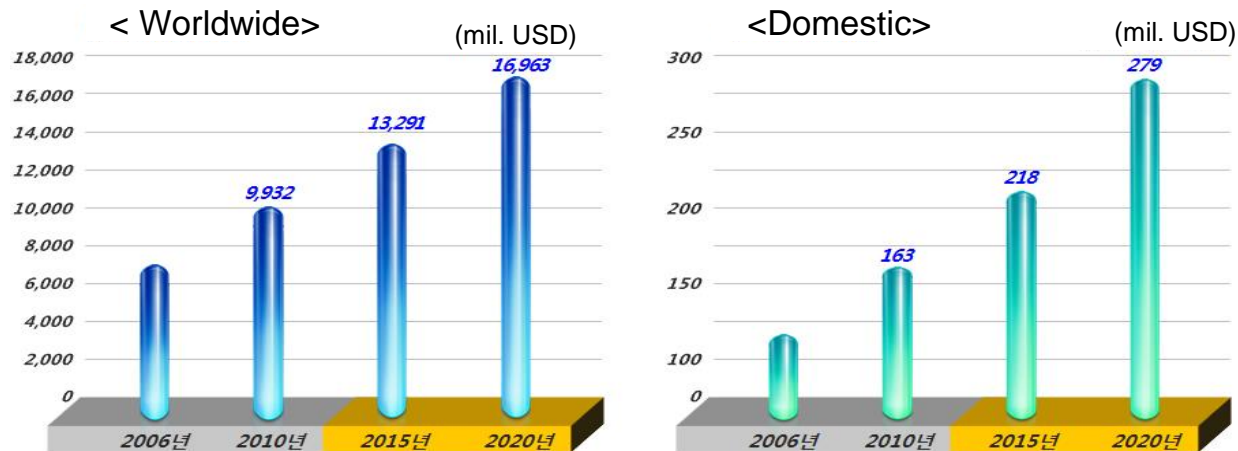
- FC system Biz. Model using by-product Hydrogen(Korea)

- system price \$10,480 /1kW, hydrogen \$0.13 / Nm³ (cost down by using by-product hydrogen)
→ A 100kW class PEMFC is a profit low limit

- Activation Plan of By-product Hydrogen FC system

- 1) Back-up power supply market

- : inevitable accident such as typhoon, thunder-storm disaster, and earthquake
- : temporary voltage drop in a sensitive factory line or a special office
- : overcome the weakness of battery ex) short life time and maintenance fee



< New and Renewable Energy Market , Frost & Sullivan >

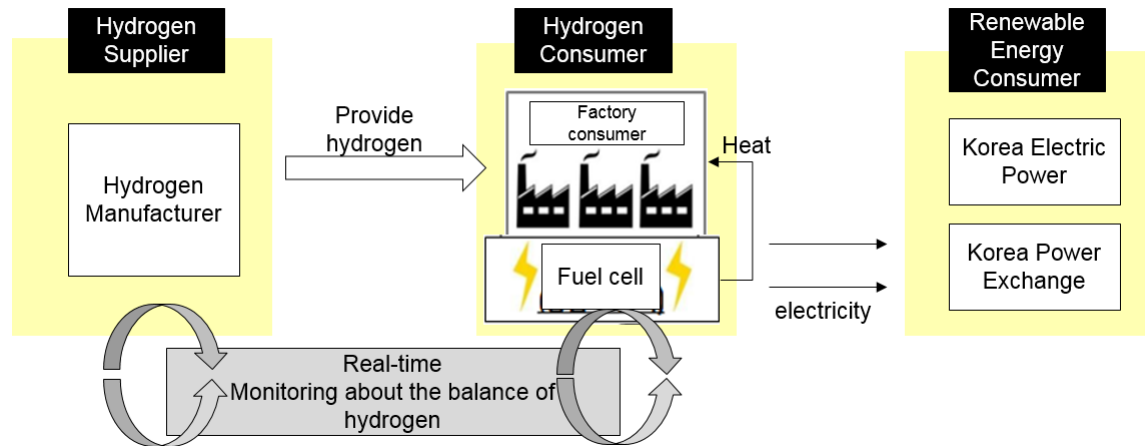
By-product Hydrogen(#3/3)

- Activation Plan of By-product Hydrogen FC system(conti.)

2) Smart Factory based on by-product hydrogen manufacturer

: provided by supplier through pipe line, but it would be discarded when supplying is over the upper limit

: by monitoring the amount of supplying and consuming , if it reaches the upper limit, operate the fuel-cell system. The generated power could be use → Maximize the energy efficiency and create profit



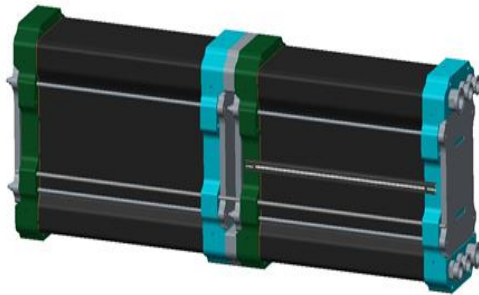
: Economic analysis

- reduce purchasing cost using by-product hydrogen
- reach the BEP(Break-Even point) in 7~8 years with 25~100kW fuel-cell system

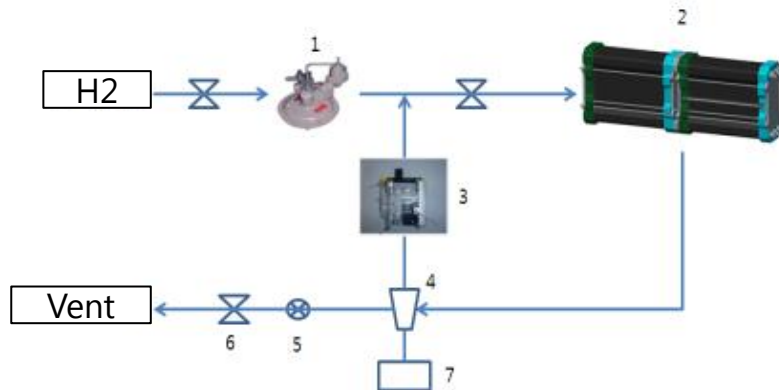
Discarded by-product	Fuel-cell capacity(kW)
137,970	25
275,940	50
551,880	100

Doosan Hydrogen FC-system

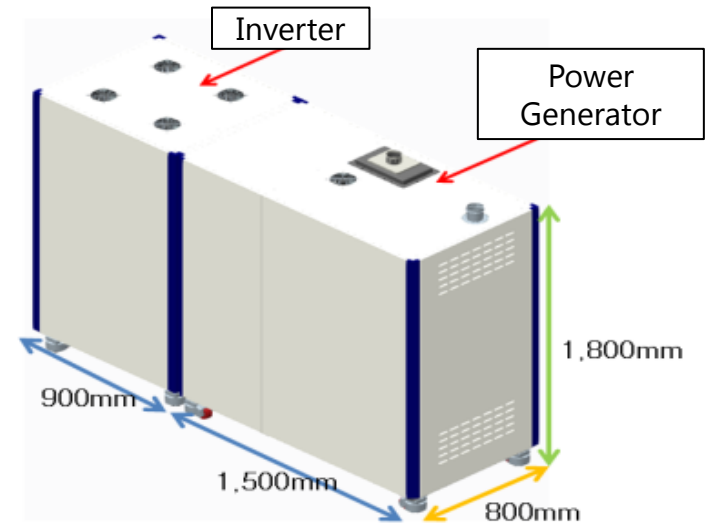
- developed 25kW class stack and system(Mar.,2016)
- will develop 100kW class stack and system(End of 2016)
- set up the control algorithm of hydrogen recirculation and purging technique
: recirculation path set-up
: purging time set-up
- chose proper BOPs such as air pump, gas regulator, and valves
- design system layout and PNID
- test operation and data acquisition



<25kW PEMFC Stack>



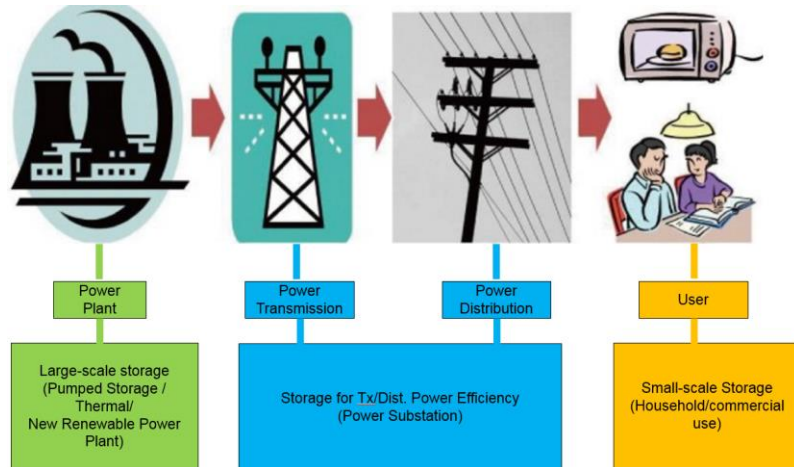
<Recirculation path>



< 25kW PEMFC system >

Other industry and Doosan Fuel Cell vision

- ESS(Energy Storage System) industry with the smart grid expands as new renewable power source increases
 - Smart Grid : real time monitoring and controlling the balance of power supply and consumption



< Energy Storage System
(Ministry of Trade, Industry and Energy in Korea. 2012)>

