





2015.09.24.

CNI세미나 2015-95

# 착탈식 경장비용 연료전지 기술개발 현황 및 시장전망



제7차 충남미래연구포럼



**충남연구원**  
ChungNam Institute





## 제7차 충남미래연구포럼



### 개 요

- 주 제 : 선박용 연료전지 기술개발 현황 및 시장 전망
- 일 시 : 2015. 9. 24.(목), 16:00~
- 장 소 : 충남연구원 2층 세미나실
- 발 제 자 : 황상문 상무(연구소장 겸임, (주)프로파워)
- 주요내용 : 착탈식 경장비용 연료전지 기술개발 현황  
세계시장 전망과 한국기업의 진로



### 진 행 순 서

시 간		소요 (분)	세부 행사내용	비 고
부터	까지			
16:00	16:10	10'	▶ 인 사 말 씀	· 미래전략연구단장
16:10	17:00	50'	▶ 주 제 발 표 “착탈식 경장비용 연료전지기술개발 현황”	· 황상문 소장 (주)프로파워
17:00	17:50	50'	▶ 질의응답 및 자유 토론	· 참 석 자 모 두
17:50	18:00	10'	▶ 정리 및 폐회 (석식)	· 미래전략연구단장



**발 제.**

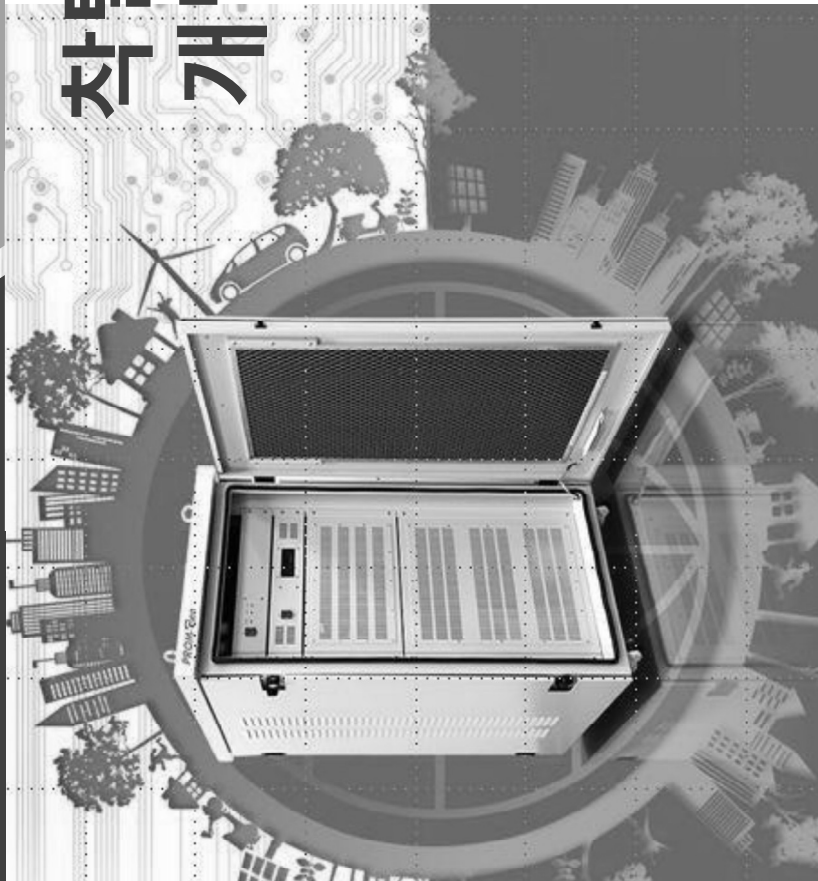
**착탈식 경장비용 연료전지  
개발현황 및 사업화 계획**

**황 상 문 상 무(연구소장)**

**(주)프로파워**



# 착탈식 경장비용 연료전지 개발 현황 및 사업화 계획



2015.09.24.

환상문

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## 03 국내 개발 동향

## 04 사업화 계획



①

## 경장비용 연료전지 개발 동향



## Trends on FC for Portable & Specific Purpose

- Micro Fuel Cells
  - Portable application & consumer electronics
- Light Traction
  - Electrical Scooters & Bikes, Wheelchairs
- Material Handling
  - Forklift, Airport Buggies
- Auxiliary Power Unit (APU)
  - Equal-zero-emission & Grid independent electric power supply
  - Boats, Motorhomes & Generator sets
- Emergency-power supply/  
Uninterruptible power supply
  - Telecommunication (Telecommunication base stations)
  - Computer centers, back-up power (border control, tunnel appl.)

MP3 Player	Mobile Phone	Computer	Military, APU	Materials Handling
				
0.1-1 W	2-5 W	15-30 W	25-200 W	1.5-10 kW

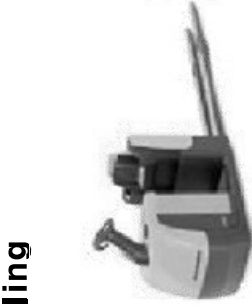


## ■ PEMFC & DMFC-Systems as range extender or battery replacement

### • Material Handling



Source : Oorja



Source :Julich



Source : Ballard



Source : PlugPower



Source : PROPOWER



Source : PROPOWER

### • Electro Mobile



Source : SFC



Source : KIER



Source : SOOSUNG



Source : SAMSUNG



Source : PROPOWER

### • Scooter



Source : SUZUKI



Source : SFC

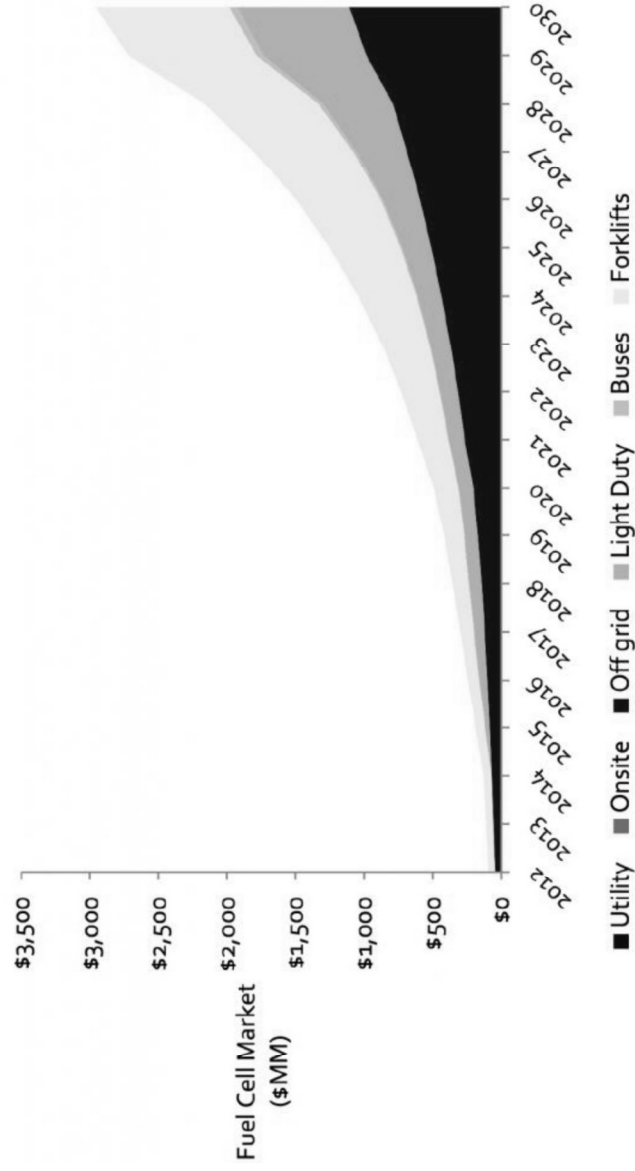


Source : Yamaha



Source : PROPOWER

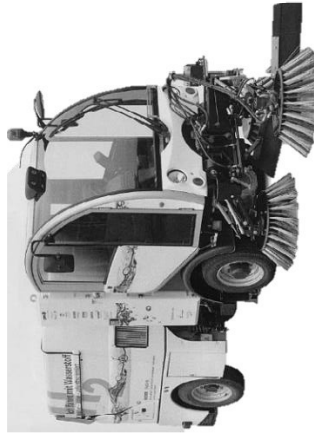
FC MHV (Material Handling Vehicles) does offer value to customers, according to Lux Research. FC MHV suffer less downtime compared to their electric counterparts, which take longer to charge. This will result in sales of 62,000 fc MHV (a CAGR of 21 percent from 2012), and revenues of \$973 million (a CAGR of 18 percent from 2012).



Source : Lux Research (2013)

## Reducing the environmental impact with the economical verification

- Electric Transportation equipment : Zero-emission, Low-noise, High-efficiency



## Comparing Fuel Cell with Battery – Lightweight, Continuous use

- Replacement of Lead-Acid Battery : Weight & Volume Reduction, Continuous use



## Comparison of Power source for Electric Forklift

### Battery Pack 3 set

1. Operation
2. Recharge
3. Cooling (After charging)



### FC System 1 set (Fuel Tank 1 set)



②

## 국외 개발 동향



# 국외 개발 동향\_Portable



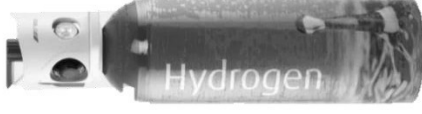
## APU [2012, SFC, Germany]



### EFOY COMFORT 80 / 140 / 210

Fuel Cell Type	DMFC	DMFC	DMFC
Max Power	40W	72W	105W
Charge capacity/day	80Ah	140Ah	210Ah
Nominal Voltage Charge Current	12V / 3.3A	12A / 6.0A	12V / 8.8A
Nominal Consumption/kWh	0.9L	0.9L	0.9L
Warranty	2years	2years	2years

## APU [2013, BOC, UK]



providing up to 24 hours of operation  
from a single 10 kg hydrogen cylinder

### BOC Hymera

Fuel Cell Type	PEMFC
Rated Output Power	150W
DC Output Voltage	13.3 ~ 14.2 V
Max. DC Output Current	12 A
Efficiency	~50% @ 100 W
Typical gas consumption rate @ 100W	1 L/min

# 국외 개발 동향\_Portable



APU [2013, NaBiCo, Japan]



PGMH-33

Fuel Cell Type	PEMFC(MgH <sub>2</sub> )
Rated Net Power	33 W
Output Voltage	AC 100V
Weight	7.5 kg
Fuel Cartridge	40 Wh (Supply 72minutes of power)
Warranty	3years

APU [2013, Horizon, Singapore]



MINIPACK Fuel Cell Charger

Fuel Cell Type	PEMFC
Rated Output Power	up to 2W
DC Output Voltage	3.8 ~ 5 V
Weight	210 g
Operating Environment	0~35 °C
Electrical Interface	USB 5V

# 국외 개발 동향\_Vehicle



## Scooter [YAMAHA, Japan]

2003



2007



### Yamaha FC-06

Fuel Cell Output	500W
Fuel	Methanol
Driving Range	200km
Max. Speed	40 km/h
배기량	50cc

### Yamaha FC-DII

Fuel Cell Output	1,000W
Fuel	Methanol 54%
Fuel Tank Capacity	3.6L
Battery	Lithium-ion
Max. Power	1.2kW
Range	125km (at 30km/h)

# 국외 개발 동향\_Vehicle



Scooter [2013, SUZUKI, Japan]



HyTec Fuel Cell Hybrid Scooter

Fuel Cell Type	PEMFC
Capacity	2.5 kW
Fuel	Hydrogen (350 bar)
Range	220 miles 350 km @ 30 mph
Project Member	Intelligent Energy

Scrubber [2013, Nilfisk, USA]



MINIPACK Fuel Cell Charger

Fuel Cell Type	PEMFC
Power	10 kW
Fuel	LPG
Project Member	Plug Power



## MHV

- Manufacturers of fuel cell stacks are involved in seeing how their fuel cell technology can be adapted and applied to this vehicle segment.
- System integrators are involved in building the fuel cell technology into hybrid power pack units that can be fitted to forklifts, pallet trucks and other similar vehicles.
- Material handling vehicle OEMs are involved, working along side the system integrators, in fitting of fuel cell systems to their forklift vehicles and promoting the technology.
- Users of material handling vehicles are involved in testing the fuel cell vehicles in the field.

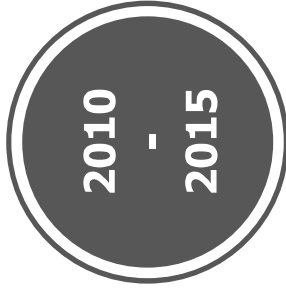
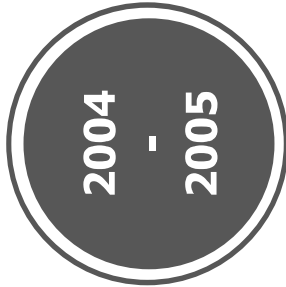


# 국외 개발 동향\_Vehicle



## MHV

- Development trends of Fuel cell for material handling vehicles



Suggested the applicability of FC for MHV

Logistics companies and fuel cell manufacturer developed FC MHV and succeeded in driving test



Developed the FC power pack for MHV

World fuel cell companies developed FC power pack for MHV and commercialization in earnest in the United States



Dissemination of MHV with a FC power pack

Various types MHV appearance and commercialization Feb. 27. 2014, total 78 sites and 6227 units in North America

# 국외 개발 동향\_Vehicle

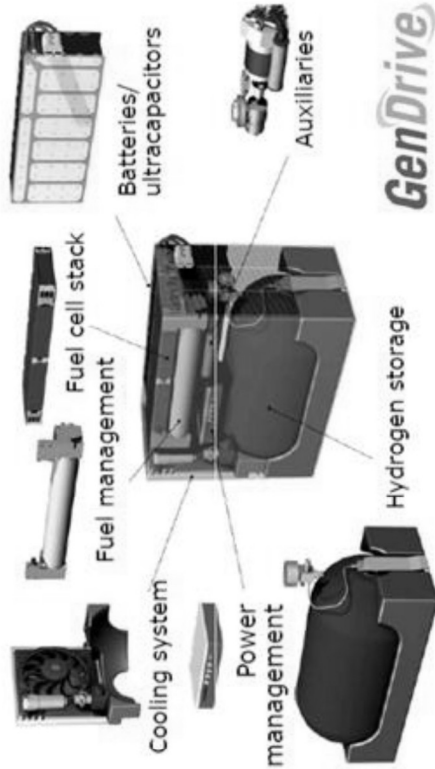


MHV [Plug-Power, USA]

**BALLARD®**



FCvelocity – 9SSL



**plugpower**  
FUEL CELL SYSTEMS



- ~1,200 GenDrive units deployed
- 5M hours of operation
- 85% market share
- 6,000-10,000 refueling each week

**GenDrive 3200,3330**

Fuel Cell Type	PEMFC
Power	1.5-3kW
Output Voltage	24V DC
FUELING SPEC	
Pressure	350bar
Fill Time	< 1.5min

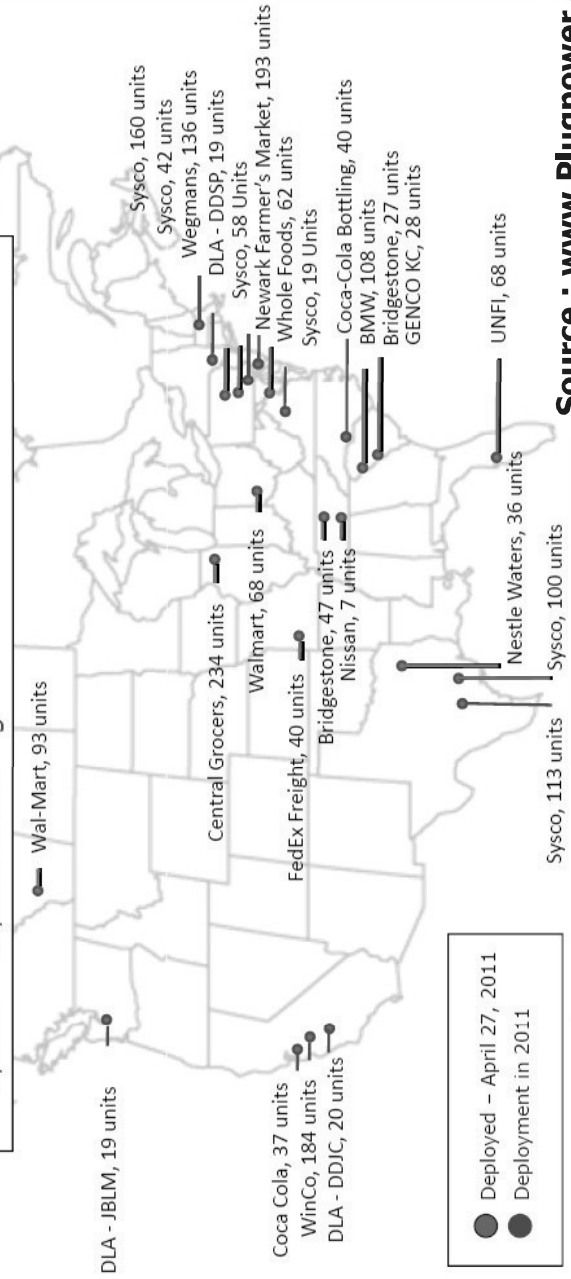
Source : [www.Plugpower.com](http://www.Plugpower.com) (2014)

## MHV [Plug-Power, USA]



- According to Fuel Cells 2000, Plug Power were over 4,000 fuel cell forklifts in use in the U.S. as of July 2013. While Latham, NY-based Plug Power currently has an 85 percent market share, other companies are getting in on the action as European logistics firms look to put fuel cell lift trucks in their warehouses. Plug Power is setting its sights high with a goal of shipping 3,000 units in 2014. The company currently has a sales backlog of 1,133 orders. Recent customers include BMW in Spartanburg, SC, Ace Hardware in Wilmer TX, Proctor & Gamble in Mehoopany, PA , Kimberly-Clark in Graniteville, SC.

■ ~ 1,200 Plug Power GenDrive™ units deployed  
 ■ > 5M hours of operation  
 ■ > 85% market share  
 ■ 6,000 – 10,000 refuelings each week



Source : [www.Plugpower.com](http://www.Plugpower.com) (2014)

# 국외 개발 동향\_Vehicle



## MHV [Plug-Power, USA]



PRODUCT SPECIFICATIONS	1500	1800	1700
Nominal Voltage	36 VDC	36 VDC 48 VDC	36 VDC 48 VDC
Maximum Continuous Power	8 kW	8 kW 10 kW	8 kW 10 kW
Dimensions	38.3" x 24.7" x 22.6"	38.5" x 27.2" x 22.75"	38.6" x 32.82" x 23.0"
Weight	2,150 lbs	2,250 lbs	3,000 lbs
Operating Temperature	-22°F ~ 104°F	-22°F ~ 104°F	-22°F ~ 104°F
Connector	SB 350	SB 350	SB 350
FUELING SPECIFICATIONS			
Hydrogen Storage	1.5 kg	1.6 kg	1.8 kg
Pressure	350 bar	350 bar	350 bar
Fill Time	< 3 min	< 3 min	< 3 min



Source : [www.Plugpower.com](http://www.Plugpower.com) (2014)

# 국외 개발 동향\_Vehicle



MHV [Plug-Power, USA]



PRODUCT SPECIFICATIONS	3300	3300-D
Nominal Voltage	24 VDC	24 VDC
Maximum Continuous Power	1.8 kW	3.2 kW
Dimensions	12.9" x 31.0" x 30.8"	12.9" x 31.0" x 30.8"
Weight	590 lbs	590 lbs
Operating Temperature	-22°F ~ 104°F	-22°F ~ 104°F
Connector	SB 175	SB 175
FUELING SPECIFICATIONS		
Hydrogen Storage	0.72 kg	0.72 kg
Pressure	350 bar	350 bar
Fill Time	< 1.5 min	< 1.5 min

Source : [www.Plugpower.com](http://www.Plugpower.com) (2014)

# 국외 개발 동향\_Vehicle



## MHV [NUVERA Fuel Cells, USA]



- Nuvera Fuel Cells has supplied high-performance motive fuel cells to major automakers and manufacturers of industrial vehicles for over 12 years.



Product	CS25	CM25	CM32	RL25
Rated Power (30sec)	25 kW		31 kW	25 kW
Voltage	36 VDC		48 VDC	36 VDC
Operating Current Range	-50~1,150 A	-400~1,150 A	-280~1,150 A	-400~1,150 A
Energy Storage Capacity	19.1 kWh	35.7 kWh	36.5 kWh	35.7 kWh
Size (mm)	889 x 667 x 602	970 x 798 x 602		970 x 510 x 781
Target Weight (kg)	839	1,406		1,155
Fuel Specifications				
Refueling Time	60 sec		120 sec	
Hydrogen Storage	0.5 kg		1.0 kg	
Hydrogen Pressure		350 bar		
Hydrogen Port		SAE J-2600 H35, CE 0036		
Ambient Operating Tem.		-4~35 °C		
Environment		Indoor Use Only		
Emissions		Water Vapor		

Source : [www.Nuvera.com](http://www.Nuvera.com) (2014)

## MHV [NUVERA Fuel Cells, USA]

- Forklifts using fuel cells from other manufacturers are using Nuvera's PowerTap on-site hydrogen generation and refueler, which can produce up to 50 kg of hydrogen per day.
- PowerTap is a steam methane reformer and Nuvera claims about 45% of the hydrogen will come from water, producing 70 tons less carbon dioxide and avoid 330,115 kWh of electrical consumption annually.



Production Rate (PTG-50)	50 kg/day (865 scfh)
Hydrogen Output Purity	99.995% or greater (meets SAE J2719)
Dispensing Pressure	5000 psig (350 bar), settled
Storage Capacity	Configurable modules from 12 ~ 128 kg
Compressor	Standalone, hydraulically driven intensifier
Electrical Requirements	480 VAC, 60 Hz, 3 Phase
Gas Requirements	Natural gas pipeline, 7 - 14" H <sub>2</sub> O
Operating Temperature	-4°F to 113°F (-20°C to 45°C)
Standards Compliance	System Designed to: CSA 5.99, HGV4 NFPA 2/70/52/55, IFC, ASMEB 31.3 Dispenser Nozzle: SAF J2600-H35 Type A Compliant
Environment	Generation, Compression & Storage: Outdoor Dispenser: Indoor or Outdoor

Source : [www.Nuvera.com](http://www.Nuvera.com) (2014)



## Savings in annual ownership costs

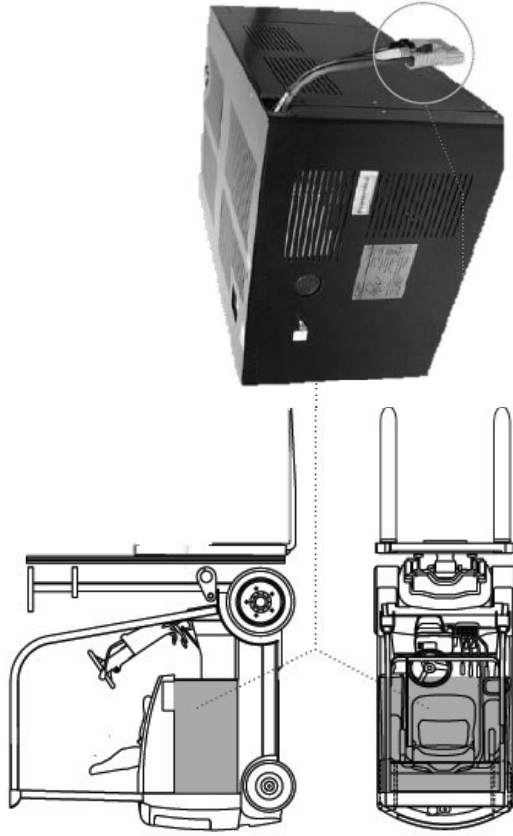
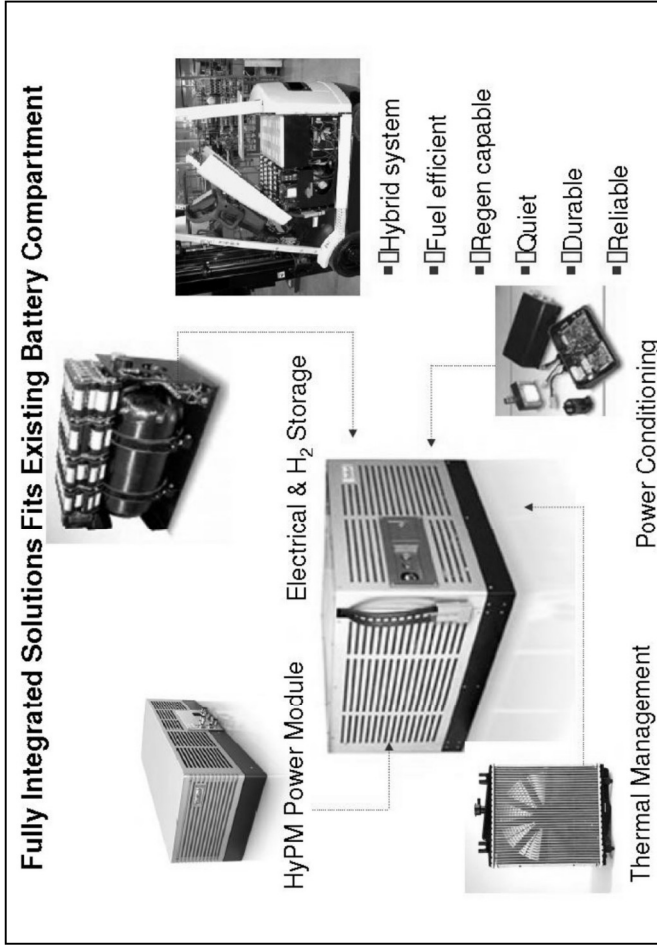
- According to NREL analysis, a typical high throughput warehouse can expect up to 10 percent savings in annual ownership costs, resulting in a payback of less than one year. (5.6 percent savings in 3kW Class III Pallet Jack)
- 80% lower refueling / recharging labor cost, 75% less space as compared with battery recharging infrastructure

Green Text = Advantage	10kW Class I Forklift		3kW Class III pallet Jack	
	Fuel-Cell Powered	Battery-Powered	Fuel-Cell Powered	Battery-Powered
Annual Cost of Ownership Per Lift (Total)				
Fuel Cell / Battery System Maintenance	\$17,800	\$19,700	\$11,700	\$12,400
Facilities Space for Refueling / Recharging Infrastructure	\$2,200	\$3,600	\$500	\$400
	\$500	\$1,900	\$500	\$1,900
Cost of Fuel / Electricity	\$2,400	\$500	\$1,400	\$400
Labor Cost of Refueling / Recharging	\$800	\$4,400	\$500	\$3,200
Annual Cost of Infrastructure Capital & Maintenance	\$3,700	\$1,400	\$3,700	\$1,300
Annual Cost of Fuel Cell / Battery Systems	\$2,600 (\$3,700 w/o tax credit)	\$2,300	\$1,300 (\$1,800 w/o tax credit)	\$1,300
Annual Cost of Lift Truck Capital & Maintenance	\$5,600	\$5,600	\$3,900	\$3,900
<b>Operational Characteristics</b>				
Time for Refueling / Changing Batteries	6-8 min/day	30-45 min/day	3-5 min/day	25-35 min/day
Number of Fuel Cell / Battery Systems for Multiple Shift Operations	1	2-3	1	2-3
Total Fuel Cycle Energy Use (total energy consumed/kWh delivered to the wheels)	~12,000 Btu/kWh	>14,000 Btu/kWh	~12,000 Btu/kWh	>14,000 Btu/kWh
Fuel Cycle Greenhouse Gas Emissions (g CO <sub>2</sub> equivalent)	800 g/kWh	1,200 g/kWh	800 g/kWh	1,200 g/kWh
Estimated Product Life	8-10 years	4-5 years	8-10 years	4-5 years
No Harmful Air Emissions at Point of Use	✓	✓	✓	✓
Quiet Operation	✓	✓	✓	✓
Wide Ambient Operating Temperature Range	✓	✓	✓	✓
Constant Power Available Over Shift	✓	✓	✓	✓

Source : DOE Energy Efficiency & Renewable Energy (2014)

## MHV [Hydrogenics, Canada]

**HYDROGENICS**  
Advanced Hydrogen Solutions



Undergoing field trials at General Motor's Ontario automotive assembly plant and FedEx logistics hub (the Toronto Pearson Airport)

Hydrogenics currently is focusing on Stationary.

### HyPX Power Pack

Fuel Cell Type	PEMFC
Power	22-30kW

Source : [www.Hydrogenics.com](http://www.Hydrogenics.com) (2012)

# 국외 개발 동향\_Vehicle



MHV [Hydrogenics, Canada]

**HYDROGENICS**  
Advanced Hydrogen Solutions

**HyPX™ FUEL CELL  
POWER PACKS**

Pure. Power. Performance.



HyPX™ 1-855			
Nominal Voltage	80V		
Size (LxWxH)	855 x 1028 x 784 mm	33.7 x 40.5 x 31 in	
Net Power Output (Continuous)	10 kW		
Max. Power Output – Peak for 15 sec.	30 kW		
Available Electrical Energy	25 kW		
Weight	1150 kg	2535 lbs	
H <sub>2</sub> Fuel Storage Capacity	1.6 kg	3.5 lb	
H <sub>2</sub> Fuel Storage Pressure @ 15°C	350 bar	5000 psi	
H <sub>2</sub> Fuel Fill Port	TN1 350 bar H <sub>2</sub>		
Safety / Certifications / Standards	CE		

Source : [www.Hydrogenics.com](http://www.Hydrogenics.com) (2012)

# 국외 개발 동향\_Vehicle



MHV [STILL, UK]



**STILL**



**RX 60-45**

The vehicles were used, for example, at Munich and at Hamburg airport, at German logistics and transportation company HHLA and at chemical company BASF.

Fuel Cell Type	PEMFC
Power	10kW (endurance)
Power	Max. 30kW (15 sec)
Size (mm)	855 x 1,028 x 1,150
Nominal Voltage	80V
Fuel	Hydrogen (350bar) - 25kW

Source : [www.still.co.uk](http://www.still.co.uk) (2013)

# 국외 개발 동향\_Vehicle



— MHV [Toyota, Japan]

**-Demonstration 2 units;  
will be commercially available by 2015**

**- experiment**

- **Period** December 2012- March 2014
- **Location** Toyoda Gosei Co., Ltd. Kitakyushu (Kitakyushu, Fukuoka Prefecture)
- **Contents** Two product fuel cell forklift 2.5t, 1 group hydrogen station
- **Fuel** Use of hydrogen generated secondarily from Sumitomo Metals Co., Ltd. Nippon Steel Yahataseitetsusho



**FCHV-F prototype**

<b>Fuel Cell Type</b>	<b>PEMFC</b>
<b>Power</b>	<b>8-10kW</b>
<b>Fuel</b>	<b>Hydrogen</b>
<b>Project member</b>	<b>Toyoda Gosei Co., Ltd., Toyota Motor Co.</b>

**Source : Toyota Industries (2013)**

# 국외 개발 동향\_Vehicle



— MHV [Julich, Germany]

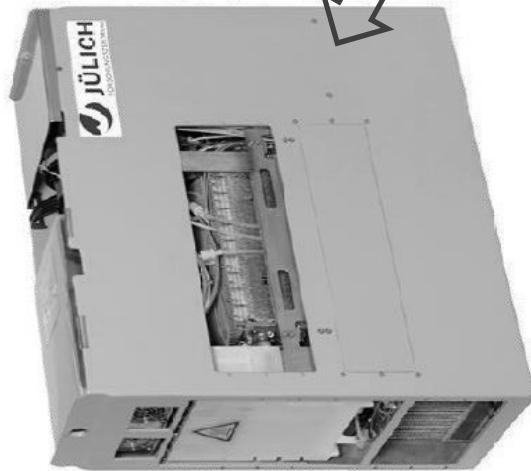
2007 DMFC V3.1



2009 - 2012 DMFC V4



DMFC V3.3 Hybrid System



Peak Power	7kW
MeOH Cartridge	20L (Approx. 20hrs)
Battery	Lithium-ion 45Ah
Stack Nominal Power	1,300W
Number of Cells	90ea
Lifetime	3,000 hrs
Power Density	75mW/cm <sup>2</sup> @450mV
Weight	44
Dimensions	600x381x482mm

Source : FZJ-Research Centre Juelich (2012)

# 국외 개발 동향\_Vehicle



— MHV [Oorja, USA]

Oorja Fuel Cells (Oorja Protonics Inc) has also been busy, signing up UniPro Foodservice Inc. as a potential customer for Oorja's DMFC range-extender technology for materials handling vehicles (MHV).



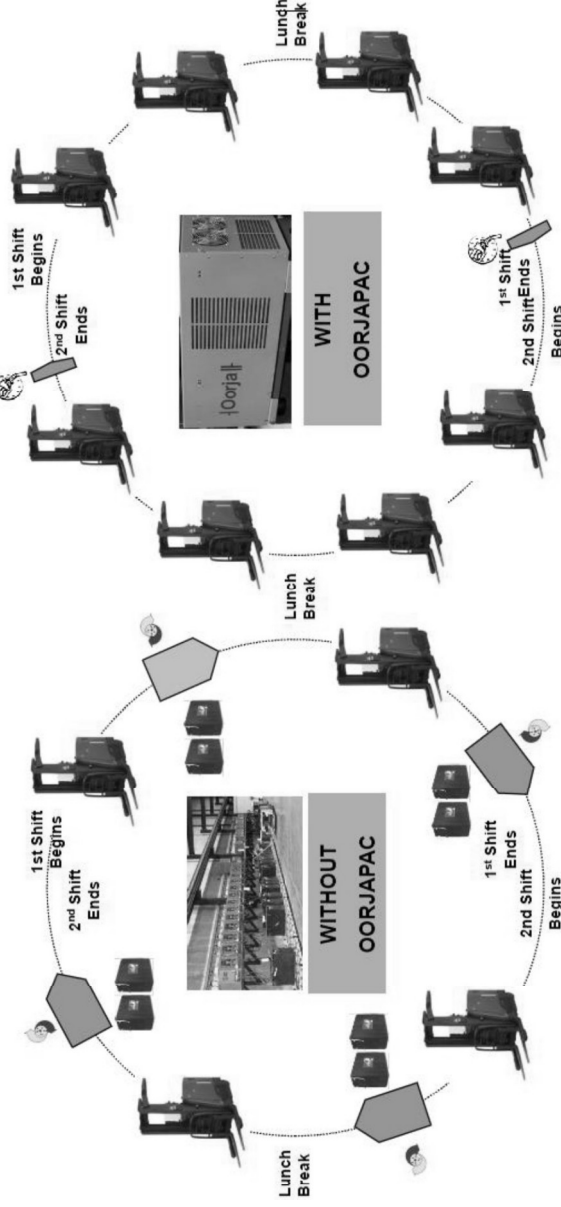
## OorjaPac Model 3

Fuel Cell Type	DMFC
Power	20kWh/day
Output Voltage	24/36/48V DC
FUELING SPEC	
Fuel Tank Capacity	12 L (Approx.12-16Hours)
Fill Time	< 1.5min

Source : Oorjafuelcells.com (2013)

MHV [Oorja, USA]

**Oorja**  
Enabling Power



## OorjaPac Model 1

Nominal Power (W)	4.5kW
Output Current (A)	62.5A
System Power Density(W-Hr/liter)	268
Stack Life (Hrs)	8,000

Operating Costs : \$0.18/kW

Assumptions : 8 hours, 2 shifts

Payback : Full payback in 12~15 months  
6 months is a little payback

## OorjaPac Model 3

Nominal Power (W)	1.5kW
Output Current (A)	62.5A
System Power Density(W-Hr/liter)	231
Stack Life (Hrs)	8,000

Assumptions : 75 units, 2 shifts, age 7 years

The total operating cost of \$ 3.2M savings

Payback : Full payback in 19 months

5 months is a little payback

Source : Fuel Cell Today, Fuel cell industry review 2012 (2012)



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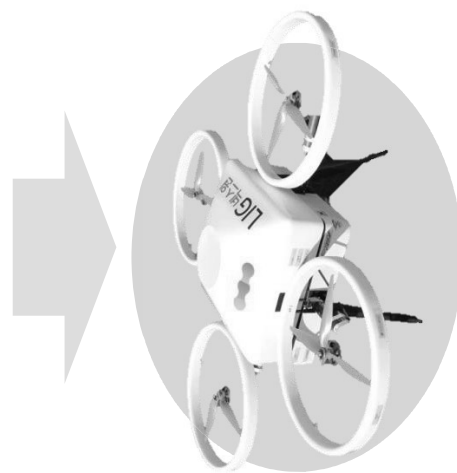
## 국내 개발 동향



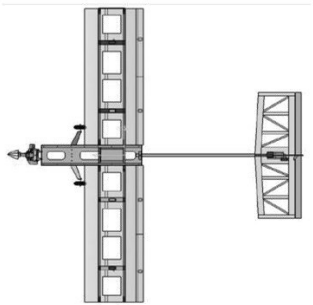
# 국내 개발 동향\_Vehicle



## UAV [LIG 넥스원]



## UAV [인하대학교]



Motor	400 W
Fuel Cell	200 W DMFC
Fuel Storage	1.7L
Fuel Type	Methanol
Battery Type	Lithium Polymer
Battery Capacity	96 Wh (18.5V, 5.2Ah)

# 국내 개발 동향\_Vehicle



## Camping Trailer [LIG 넥스원]

2012



(42V or 220VAC)

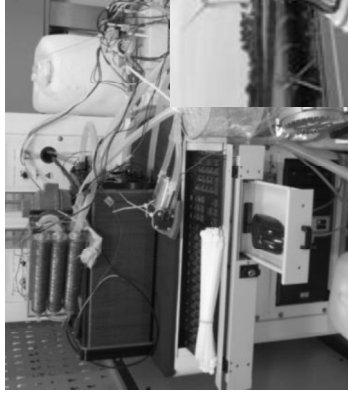
2014



(42V or 220VAC)



## Light Duty Vehicle [KIER]



### DMFC-EV

Fuel Cell Power

2,000W

Battery Power

76.7V/ 120Ah (9.2kWh)

Bipolar plate

266X155

System Weight

63kg (연료탱크포함)

MEA

110 Cells (301cm<sup>2</sup>)

# 국내 개발 동향\_Vehicle



## Scooter [PRO-POWER]



with S&T모터스

Fuel Cell	1 kW DMFC
Fuel Storage	3.5 L (100 % Methanol)
Fuel Type	Methanol
Battery Type	Lithium Polymer
Battery Capacity	1.37 kWh (25.9V, 53Ah)
Speed	30km/h Max. 48km/h
Driving Range	210km

## Scrubber [PRO-POWER]



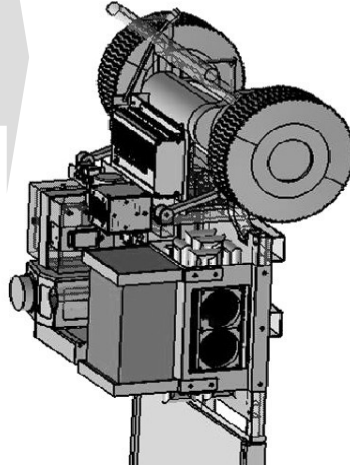
with 수성

Fuel Cell	1kW DMFC
Fuel Storage	14 L (100 % MeOH)
Fuel Type	Methanol
Battery Type	Lithium Polymer
Battery Capacity	7.4 kWh (37V, 200Ah)
Productivity rate 1 side broom theoretical/ actual	8,160 m <sup>2</sup> /hr

# 국내 개발 동향\_Vehicle



## Electric Cart [PRO-POWER]



Motor	400 W
Fuel Cell	500 W DMFC
Fuel Storage	2.0 L
Fuel Type	Methanol
Battery Type	Lithium Polymer
Battery Capacity	500 Wh(25.9V, 22Ah)

## Electric Cart [KIER]



### DM-Mini V501

Fuel Cell Power	500 W
Battery Power	12V/ 18Ah *2ea (432Wh)
Fuel Tank Capacity	2.5 L (약 10 Hours)
System Weight	23kg (연료탱크포함)
MEA	70 Cells (100cm <sup>2</sup> )

# 국내 개발 동향\_Vehicle



## MHV [PRO-POWER ]



2010

SWR1300L\_1<sup>st</sup>



SSR14\_1<sup>st</sup>



SSR14\_1<sup>st</sup>

Fuel Cell –Battery Hybrid Forklift	
Fuel Cell Type	DMFC (1 kW Class)
Fuel Storage	12 L (100 % Methanol)
Fuel Type	Methanol Solution
Battery Type	Lithium Polymer
Battery Capacity	3.9 kWh (25.9V, 150Ah)
Maximum Load Capacity	1,300 kg
Driving Time	5 hrs

2011

MHV [PRO-POWER]



## SSR14\_2<sup>nd</sup>

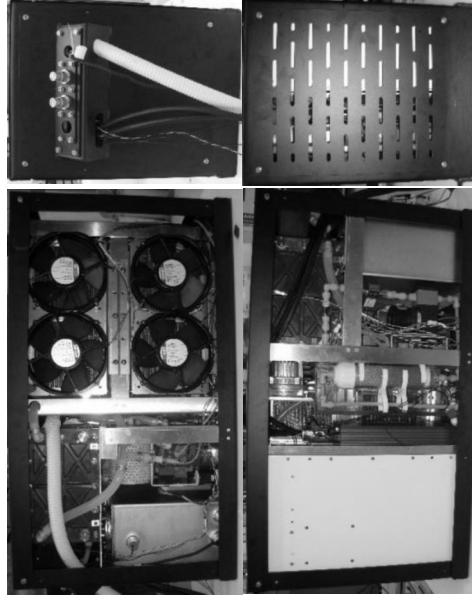


Fuel Cell –Battery Hybrid Forklift	
Fuel Cell Type	DMFC (1 kW Class)
Fuel Storage	14 L (100 % Methanol)
Fuel Type	Methanol Solution
Battery Type	Lithium Polymer
Battery Capacity	5.2 kWh (25.9V, 200Ah)
Maximum Load Capacity	1,300 kg
Driving Time	6 hrs



## MHV [PRO-POWER]

2014



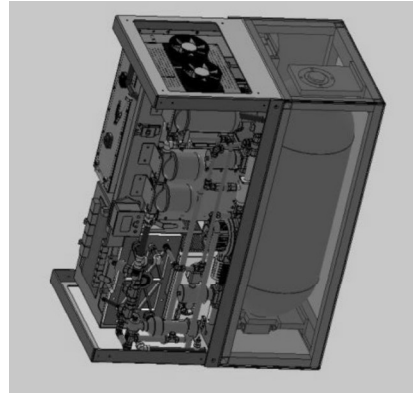
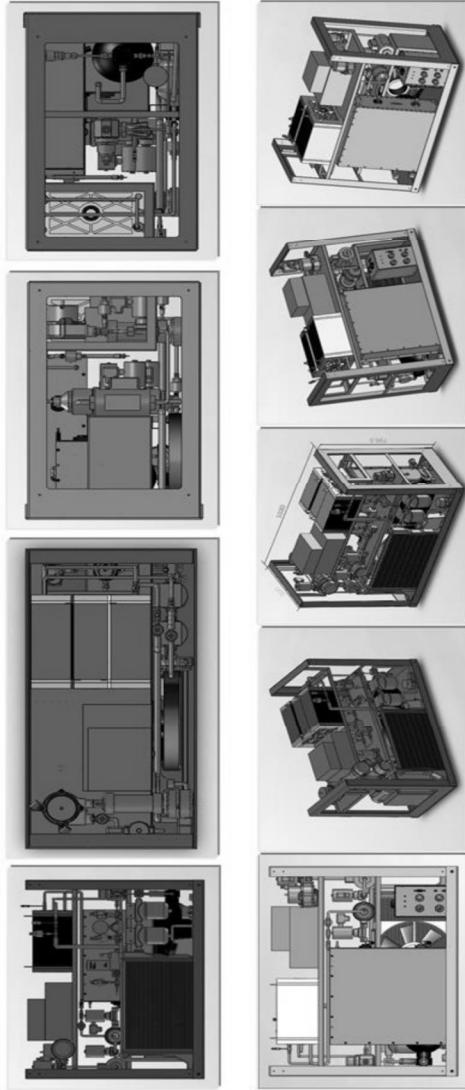
### SBR-15A FC\_ Class II

Fuel Cell Type	DMFC (1.5 kW Class)
Fuel Storage	12 L (100 % Methanol)
Fuel Type	Methanol Solution
Battery Type	Lithium Polymer
Battery Capacity	3.6 kWh ( 48 V, 75 Ah)
Driving Time	8 hrs



## MHV [PRO-POWER ]

2014



### SBF-25A FC\_ Class I

Fuel Cell Type	PEMFC (5 kW Class)
Fuel Storage	1.2 kg (700 bar)
Fuel Type	Hydrogen
Battery Type	Lithium Polymer
Battery Capacity	7.2 kWh ( 48 V, 150 Ah)
Driving Time	8 hrs

4

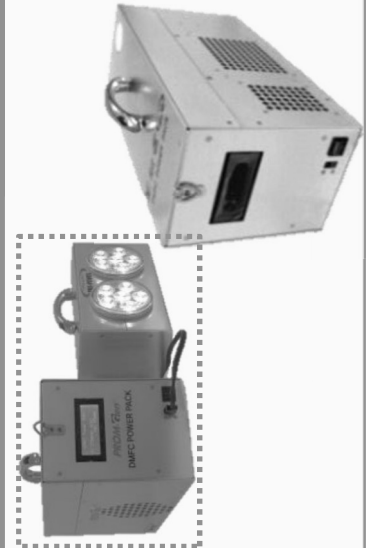
## 사업화 계획



## PROM-Gen™ DMFC & Battery Hybrid System

### Portable

- DMFC 50 ~ 250 W
- 개인용 제품 충전용
- 휴대용 분야 응용
- 국방용



### APU & Emergency

- DMFC 0.5 ~ 3 kW
- 캠핑용
- 통신타워



### Light Traction/ Material Handling

- DMFC 1 ~ 3 kW
- 지게차
- 청소차



## PROM-Gen\_DM

**No Need Charging Time**

**Lower Maintenance**

**Quiet Operation**

**Easy Fuel Supply**

**Extremely Low Operation Cost**

**Solution to  
Energy Storage Capacity**

**Environment Friendly**



PROM-Gen

# 사업화 계획 Telecom-tower [BTS]



PROM-Gen\_DM



Working Hours : 9hrs/day during 6 months

## PROM-Gen\_TBP

< 1 kW Class PROM-Gen™ >



# PROM-Gen™

Back-up Fuel Cell Hybrid System

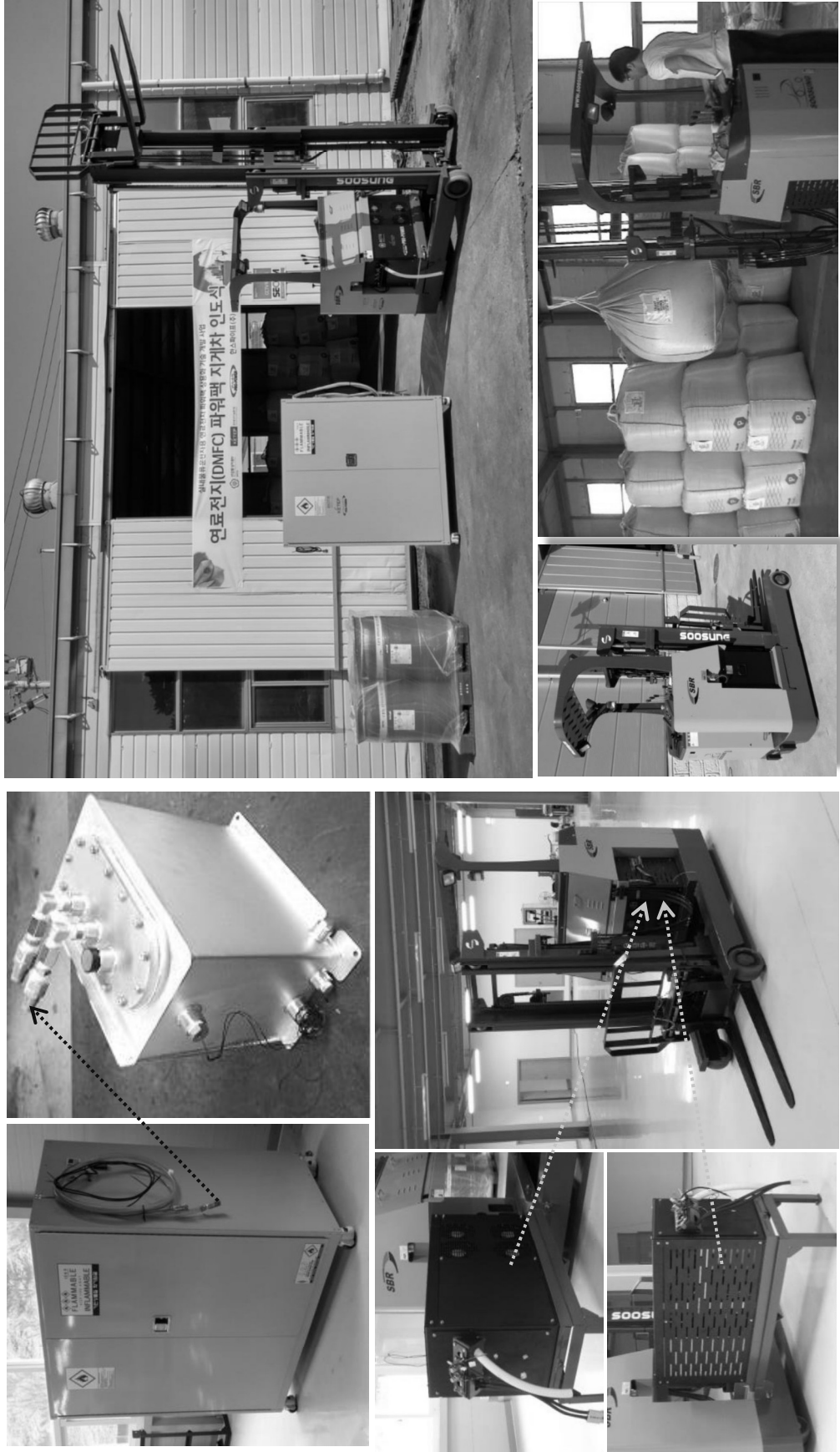
## Specifications

Model	PROM-Gen™ DM1000
Rated Power	1,000W - 1,000W DMFC System - 1.92kWh Lithium Battery
Out put Power	DC 48VDC
Generating Capacity	Max. 2.9kWh (1hr) 25.9kWh/day (24hrs)
Dimension	1,260mm*600mm*800mm (H x W x D)
Weight	150KG

# 사업화 계획 Forklift [MHV]



## PROM-Gen\_MHV



## Problems Encountered



Power Outage  
(Unstable Power Region)



Off-Grid Power Supply  
(Remote Area)

## Current Solution

## UNSATISFACTORY with



Diesel Generator

Noise

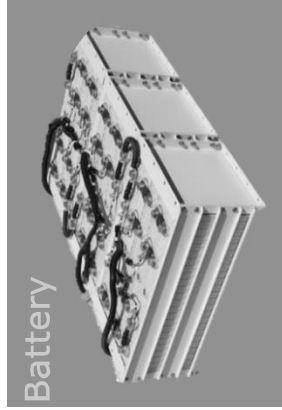
Higher Maintenance



PV

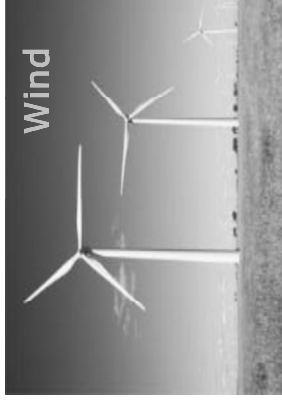
Installation Restriction

Environment Problem



Battery

Long Charging Time  
Disposal Expense  
Storage Capacity

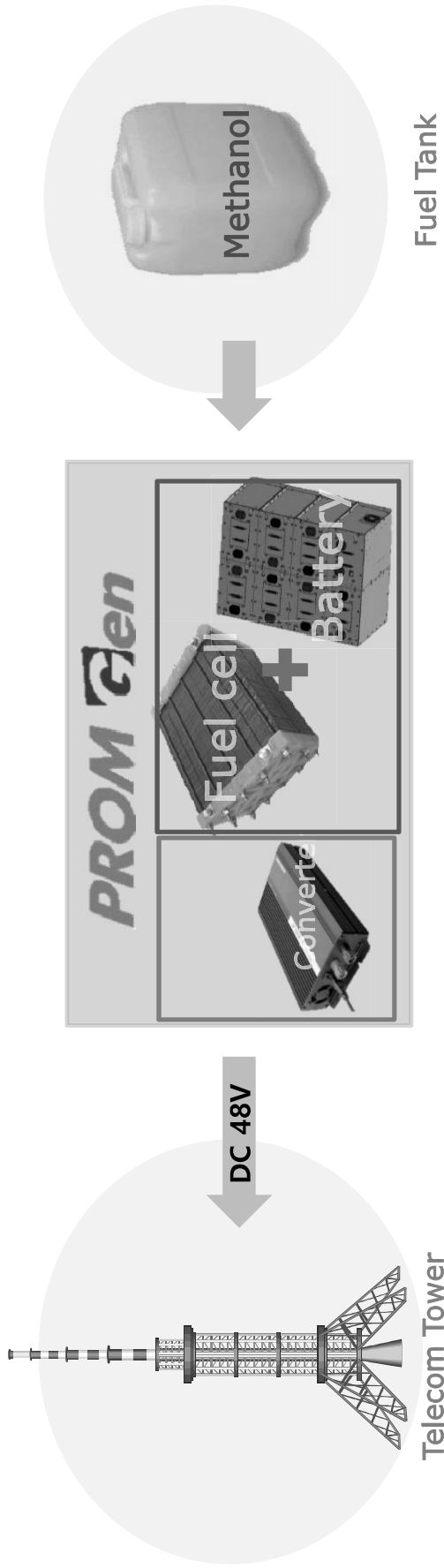


Wind

Low Electricity Quality  
Installation Restriction



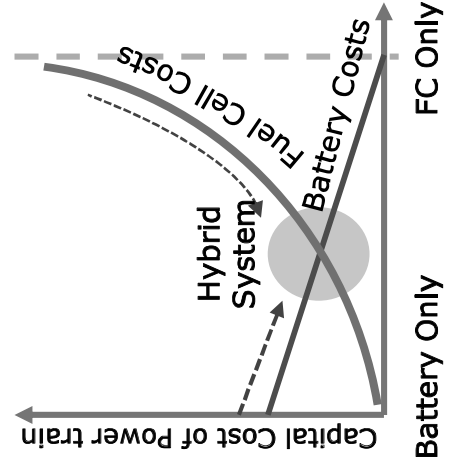
Hybrid System is solution!



## Hybrid

Maximization of respective advantages

- Relatively high efficiency
- Fast load response
- Directly continuous power generation
- Reasonable cost



## Trial Test of PROM-Gen in India (2015)

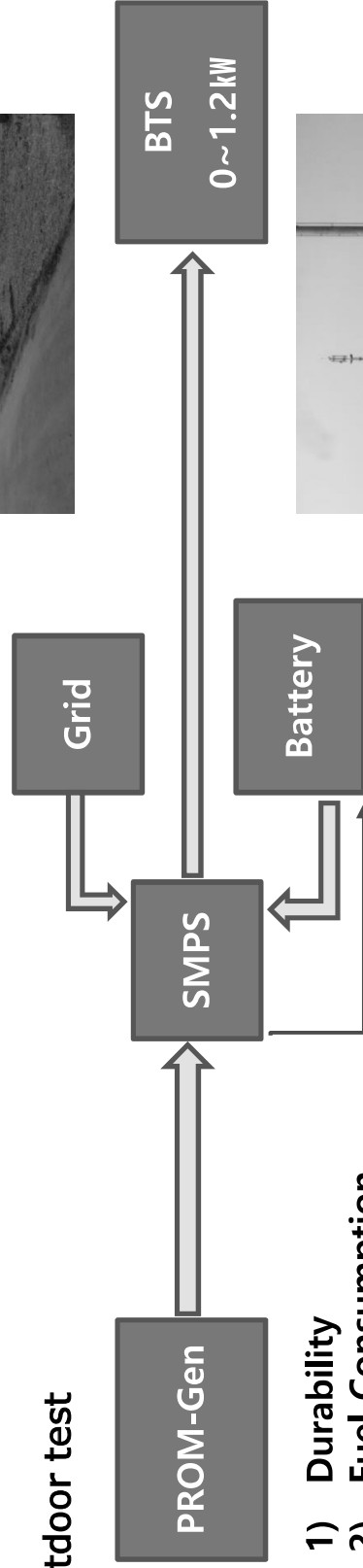
### 1<sup>st</sup> Indoor test



- 1) Durability
- 2) Fuel Consumption
- 3) System Efficiency
- 4) Load Change Following(0~1.25kW)
- 5) Start-Stop(2~3 times or All day continuous)



### 2<sup>nd</sup> Outdoor test



- 1) Durability
- 2) Fuel Consumption
- 3) System Efficiency
- 4) Load Change Following(0~1.2kW)
- 5) Start-Stop(2~3 times or All day continuous)
- 6) Battery Charging



BTS  
0~1.2kW

## Selection of strategic markets

1<sup>st</sup> market entry → India, Bangladesh, Myanmar

2<sup>nd</sup> market expansion → Countries in Africa, Japan, Indonesia, The Philippines

### India

#### Enter the Telecom Tower market (Reliance, Indus Tower, ATC)

- 530,000 telecom towers installed.
- Due to sudden increase in the diesel fuel costs, there is higher demand for substitute energy.
- In India, there are eight hours of blackout on average.

### Japan

#### Telecom Tower and independent power supply market

- Higher demand for emergency due to high frequency earthquakes and Tsunami.

### Africa

#### Small sized power plant market (household & miner lodging)

- First enter the Republic of South Africa, Mali and Senegal and expand into neighboring countries.

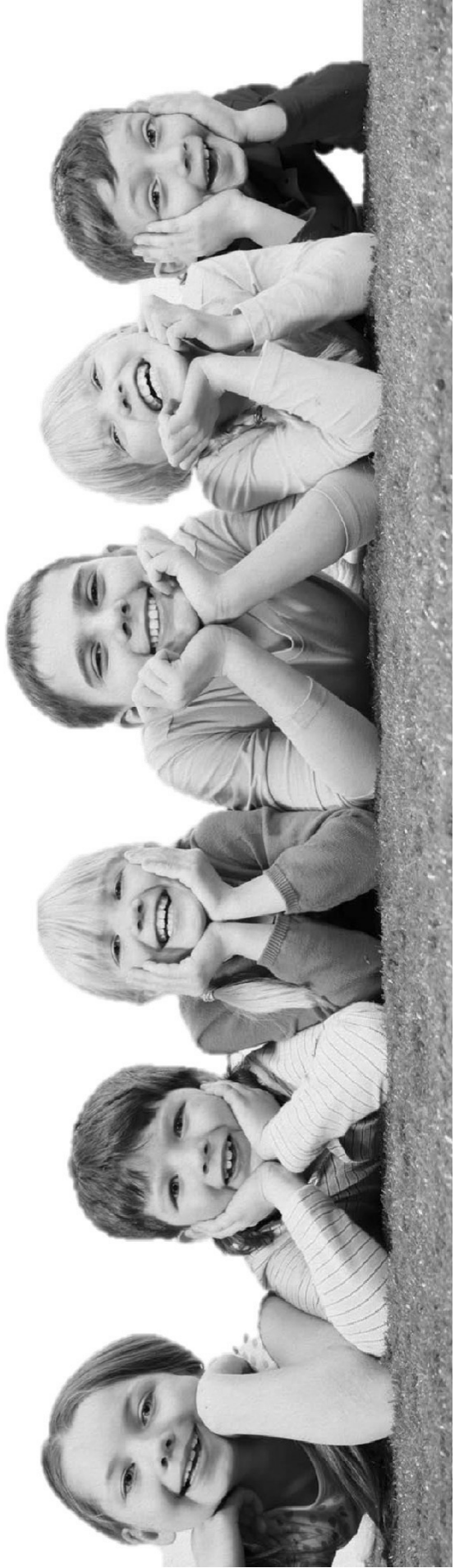
### Southeast Asia

#### Telecom Tower and independent power supply market

- Due to economic growth, there is a severe shortage of power supplies.
- Higher demand in countries with numerous islands.(Philippine, Indonesia)



# THANK YOU



# MEMO

# MEMO

# MEMO

# MEMO



# MEMO



