

# 착탈식 경장비용 연료전지 개발 현황 및 사업화 계획

2015.09.24.

황상문

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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



0.1-1 W

### Mobile Phone



2-5 W

### Computer



15-30 W

### Military, APU



25-200 W

### Materials Handling



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



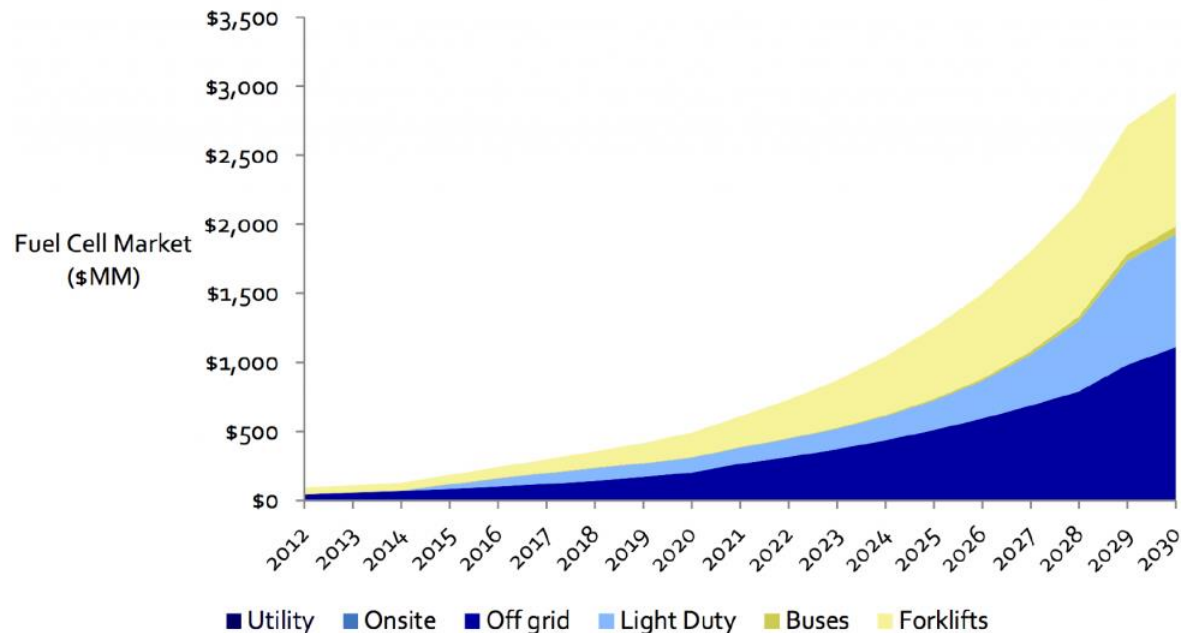
Source : Yamaha



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





## 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	12V /	12A /	12V /
Charge Current	3.3A	6.0A	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

## 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

## 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)

## 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.





## MHV

### Development trends of Fuel cell for material handling vehicles

2004  
-  
2005



#### Suggested the applicability of FC for MHV

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

2007  
-  
2009



#### 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

2010  
-  
2015



#### Dissemination of MHV with a FC power pack

Various types MHV appearance and commercialization

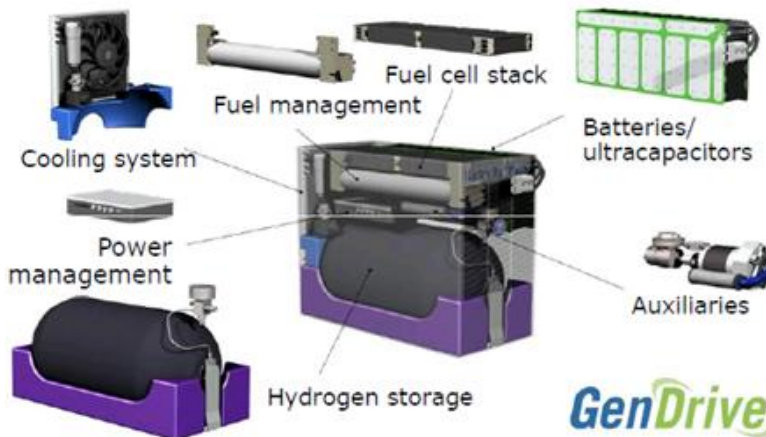
Feb. 27. 2014, total 78 sites and 6227 units in North America

## MHV [Plug-Power, USA]

**BALLARD**



FCvelocity - 9SSL



**plug power**  
FUEL CELL SYSTEMS



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



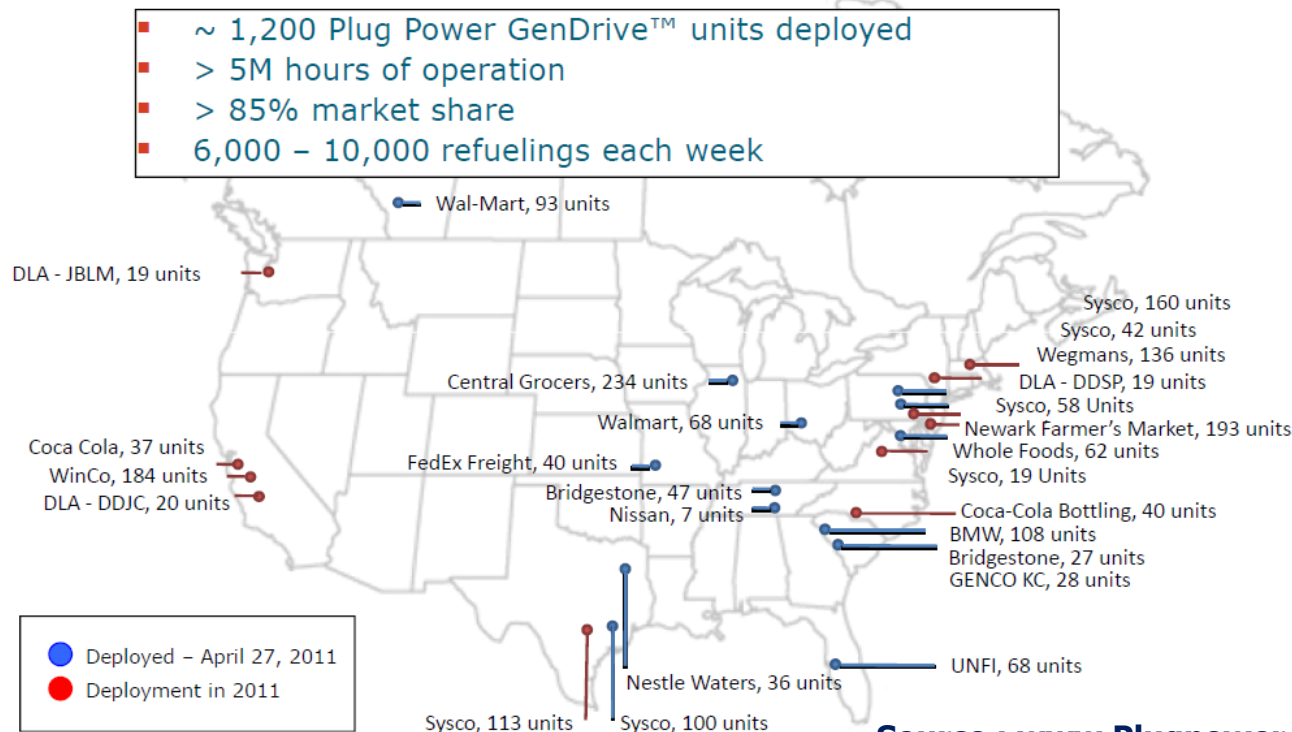
### GenDrive 3200,3330

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

## 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.



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

## 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	



## 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



## 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 ℃			
Environment	Indoor Use Only			
Emissions	Water Vapor			

## 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: SAE J2600-H35 Type A Compliant
Environment	Generation, Compression & Storage: Outdoor Dispenser: Indoor or Outdoor

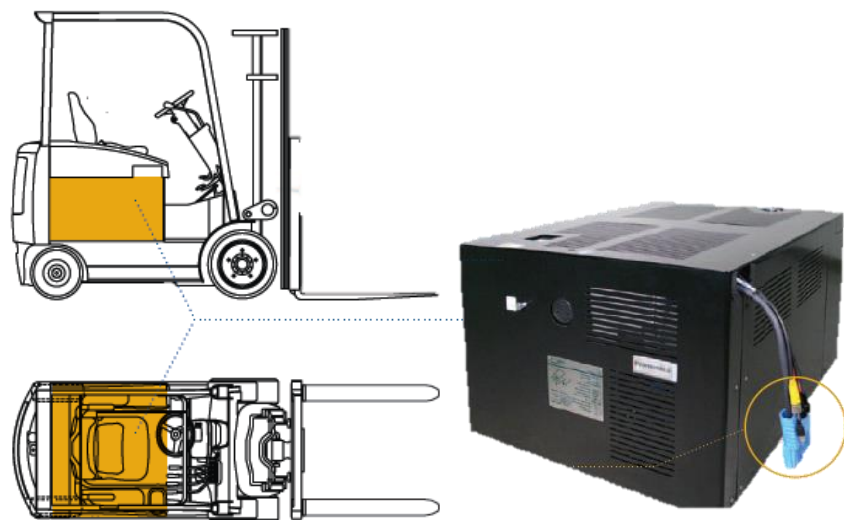
## Savings in annual ownership costs

- 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)	\$17,800	\$19,700	\$11,700	\$12,400
Fuel Cell / Battery System Maintenance	\$2,200	\$3,600	\$500	\$400
Facilities Space for Refueling / Recharging Infrastructure	\$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]

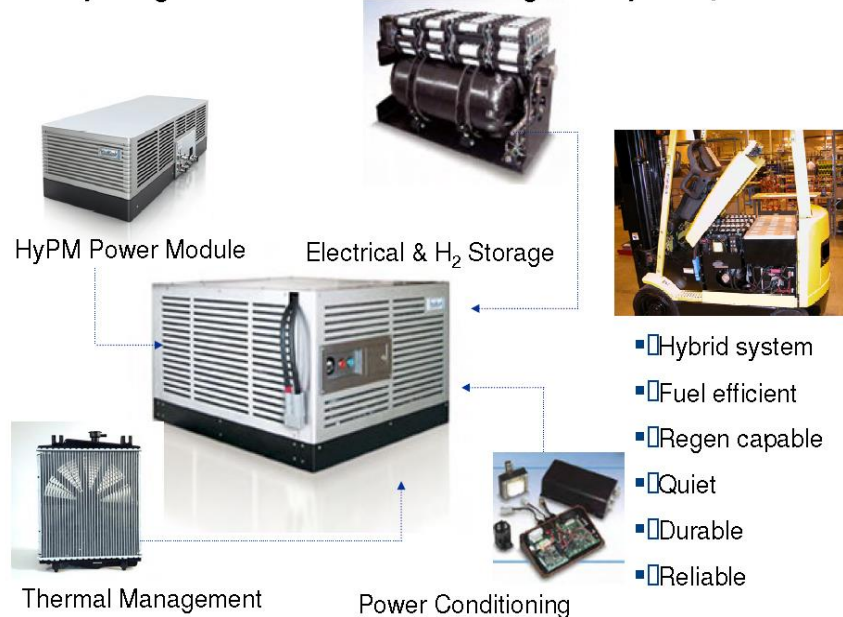


Undergoing field trials at General Motor's Ontario automotive assembly plant and FedEx logistics hub (the Toronto Pearson Airport)

Hydrogenics currently is focusing on Stationary.

**HYDROGENICS**  
Advanced Hydrogen Solutions

### Fully Integrated Solutions Fits Existing Battery Compartment



### HyPX Power Pack

Fuel Cell Type	PEMFC
Power	22-30kW

## MHV [Hydrogenics, Canada]

**HYDROGENICS**  
Advanced Hydrogen Solutions

### HyPX™ FUEL CELL POWER PACKS

Pure. Power. Performance.



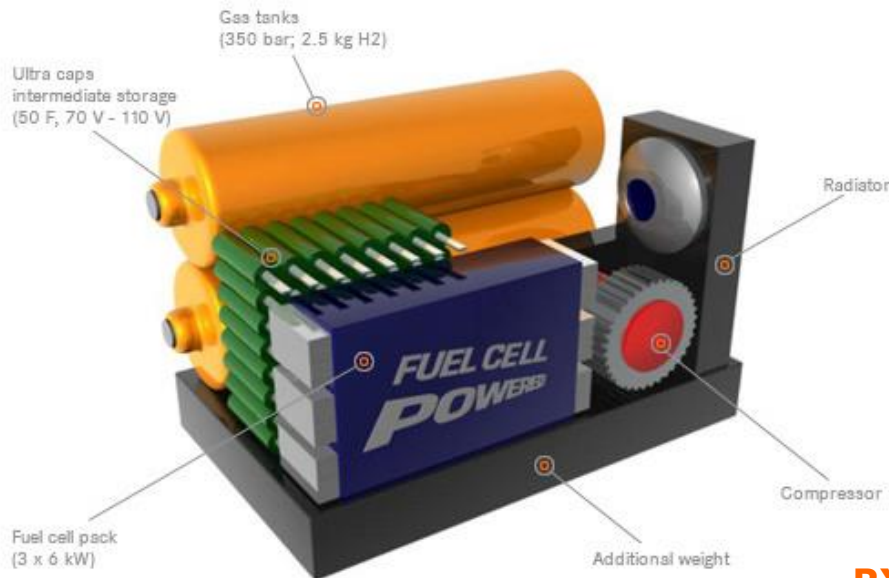
### HyPX™ 1-855

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)



## MHV [STILL, UK]



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

### RX 60-45

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

## 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>

## MHV [Jülich, 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)

## 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).

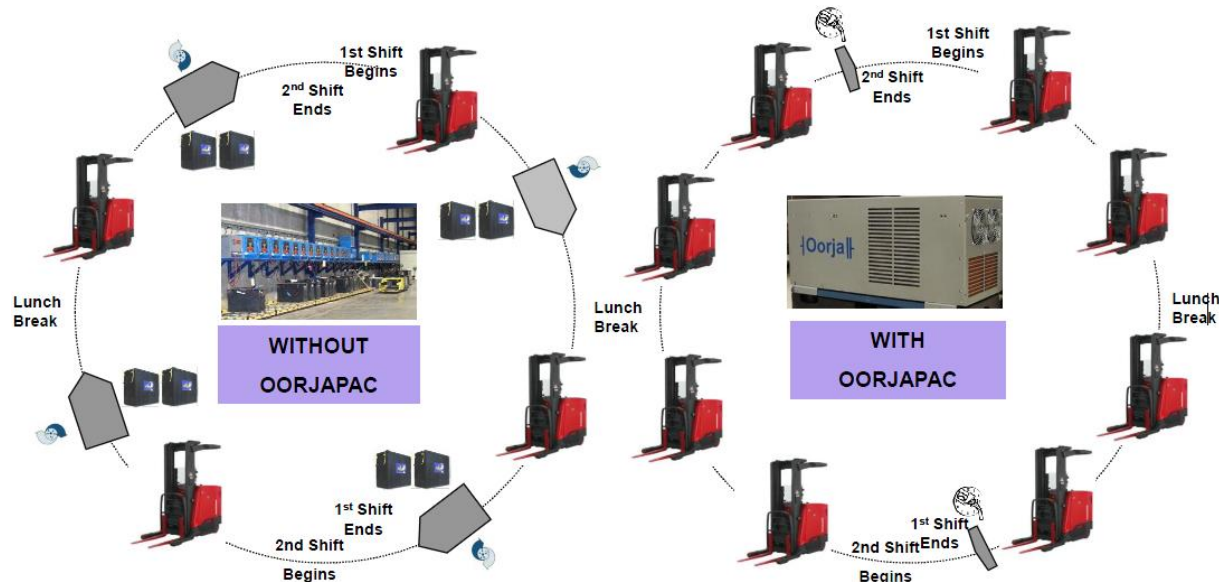


### OorjaPac Model 3

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



## MHV [Oorja, USA]



### 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



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## 국내 개발 동향



## UAV [LIG 넥스원]



500W  
DMFC pack



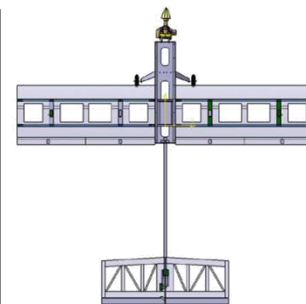
Aircraft Parts



Battery



## 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)

## 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> )

## 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]

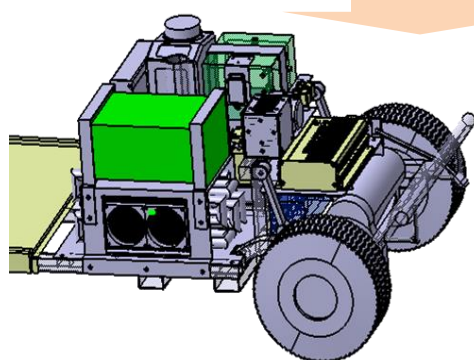


with 수성

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



## 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> )



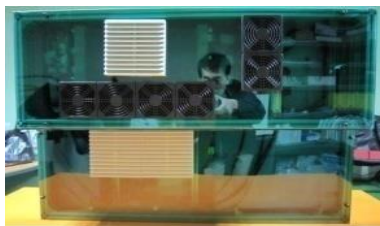
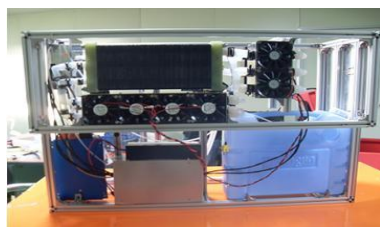
## MHV [PRO-POWER]

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

## MHV [PRO-POWER]

2011



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

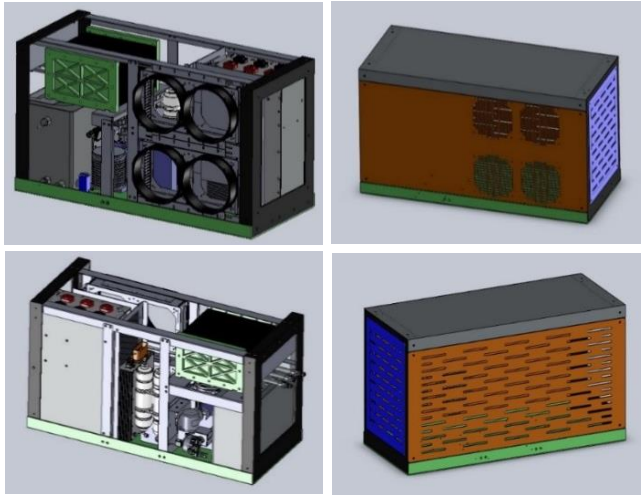


Fuel Cell –Battery Hybrid Forklift	
Fuel Cell Type	DMFC (1 kW Class)
Fuel Storage	14 L (100 % Methanol)
Fuel Type	Methanol Solution
Battery Type	Lithium Polymer
Battery Capacity	5.2 kWh (25.9V, 200Ah)
Maximum Load Capacity	1,300 kg
Driving Time	6 hrs



## MHV [PRO-POWER]

2014



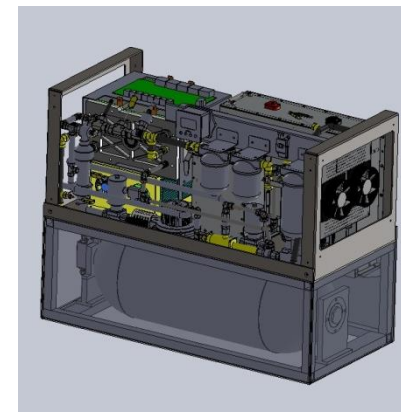
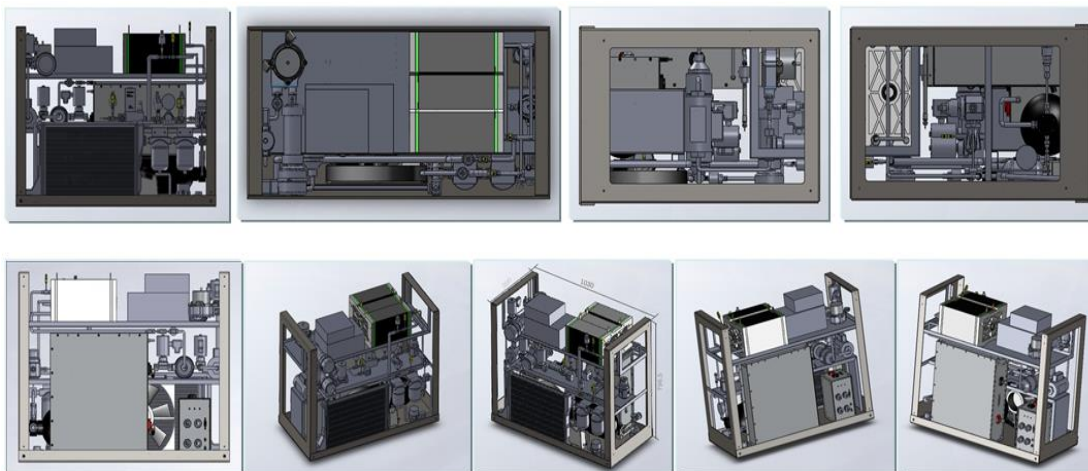
### SBR-15A FC\_ Class II

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

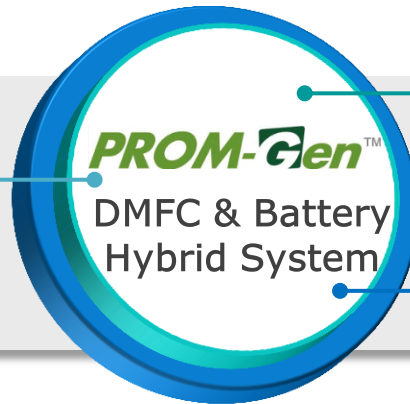
Fuel Cell Type	PEMFC (5 kW Class)
Fuel Storage	1.2 kg (700 bar)
Fuel Type	Hydrogen
Battery Type	Lithium Polymer
Battery Capacity	7.2 kWh ( 48 V, 150 Ah)
Driving Time	8 hrs

④

## 사업화 계획







## 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

**Extremely Low Operation Cost**

**No Need Charging Time**

**Lower Maintenance**

**Quiet Operation**

**Easy Fuel Supply**

**Solution to  
Energy Storage Capacity**

**Environment Friendly**



*PROM-Gen*

## 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



## PROM-Gen\_MHV





## Problems Encountered



## Current Solution

**UNSATISFACTORY** with

Diesel Generator



Noise

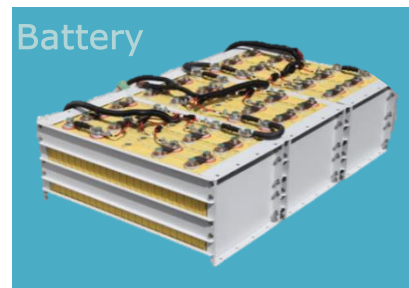
Higher Maintenance

PV



Installation Restriction  
Environment Problem

Battery



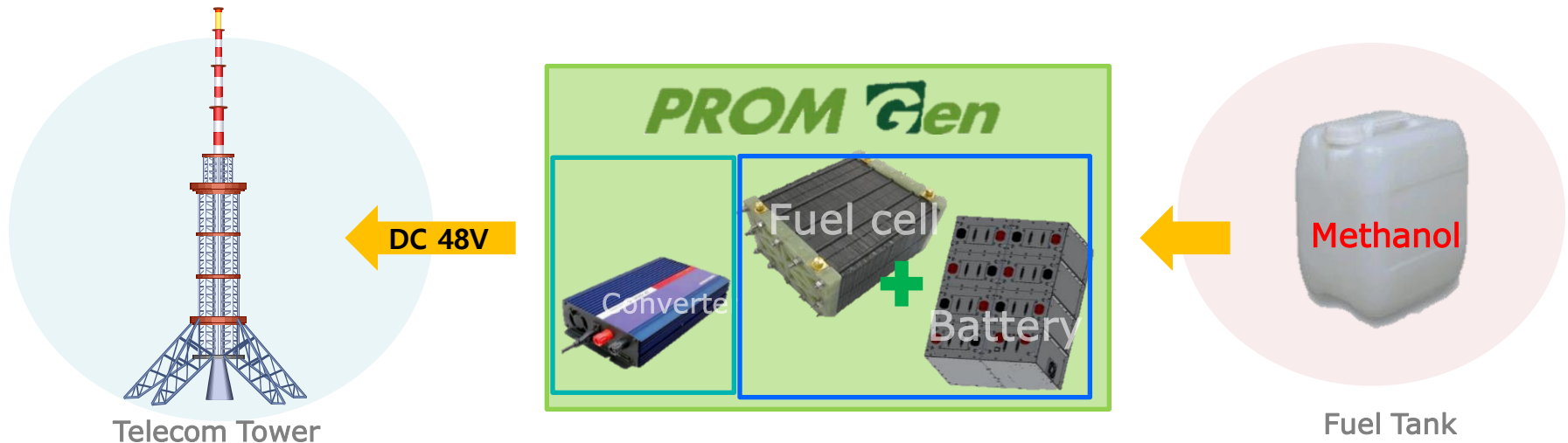
Long Charging Time  
Disposal Expense  
Storage Capacity

Wind



Low Electricity Quality  
Installation Restriction

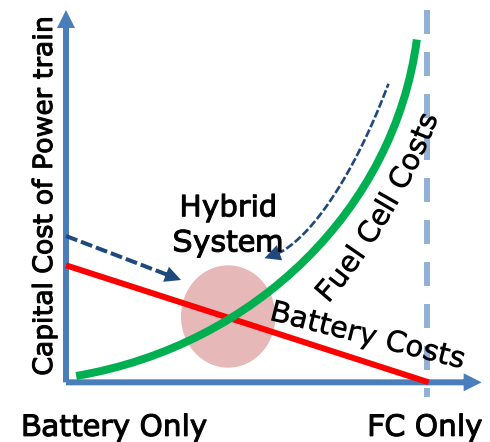
## Hybrid System is solution!



## 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)

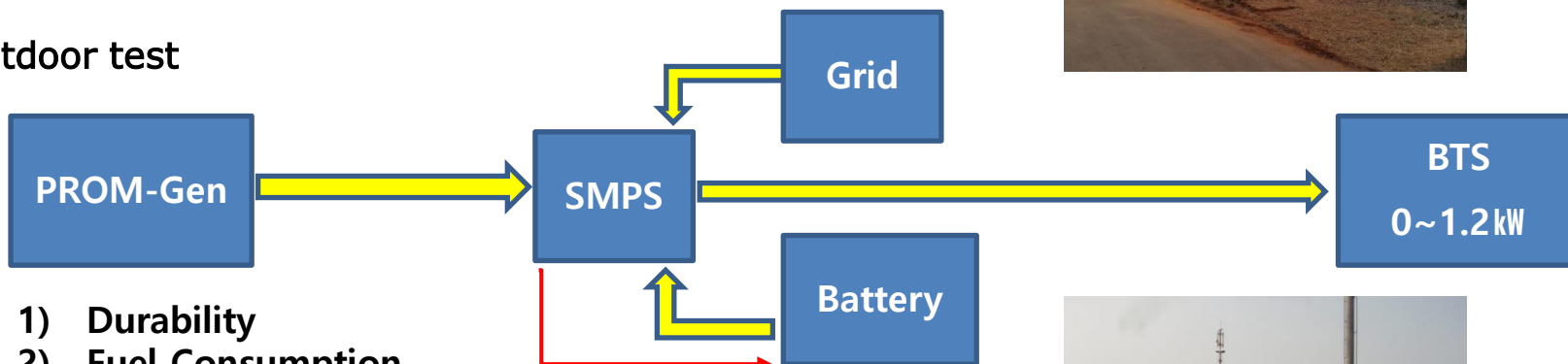
### 1<sup>st</sup> Indoor test



- 1) Durability
- 2) Fuel Consumption
- 3) System Efficiency
- 4) Load Change Following(0~1.25 kW)
- 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



## 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

