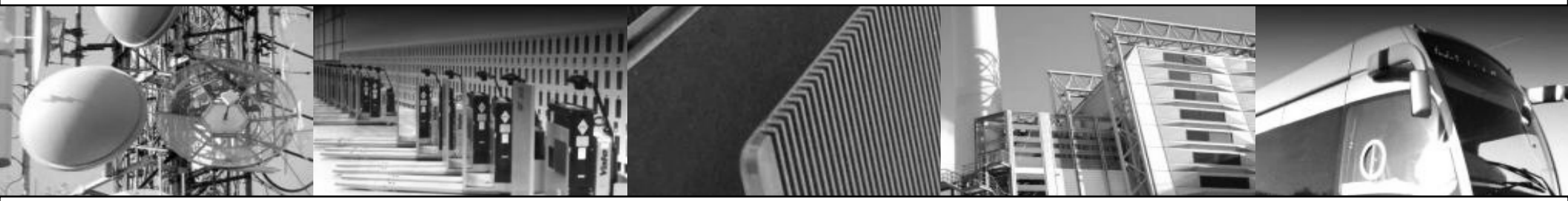

BALLARD®

The Energy Sustainability Conclave 2013

Techno Economic Feasibility of Fuel Cells

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How a Fuel Cell Works

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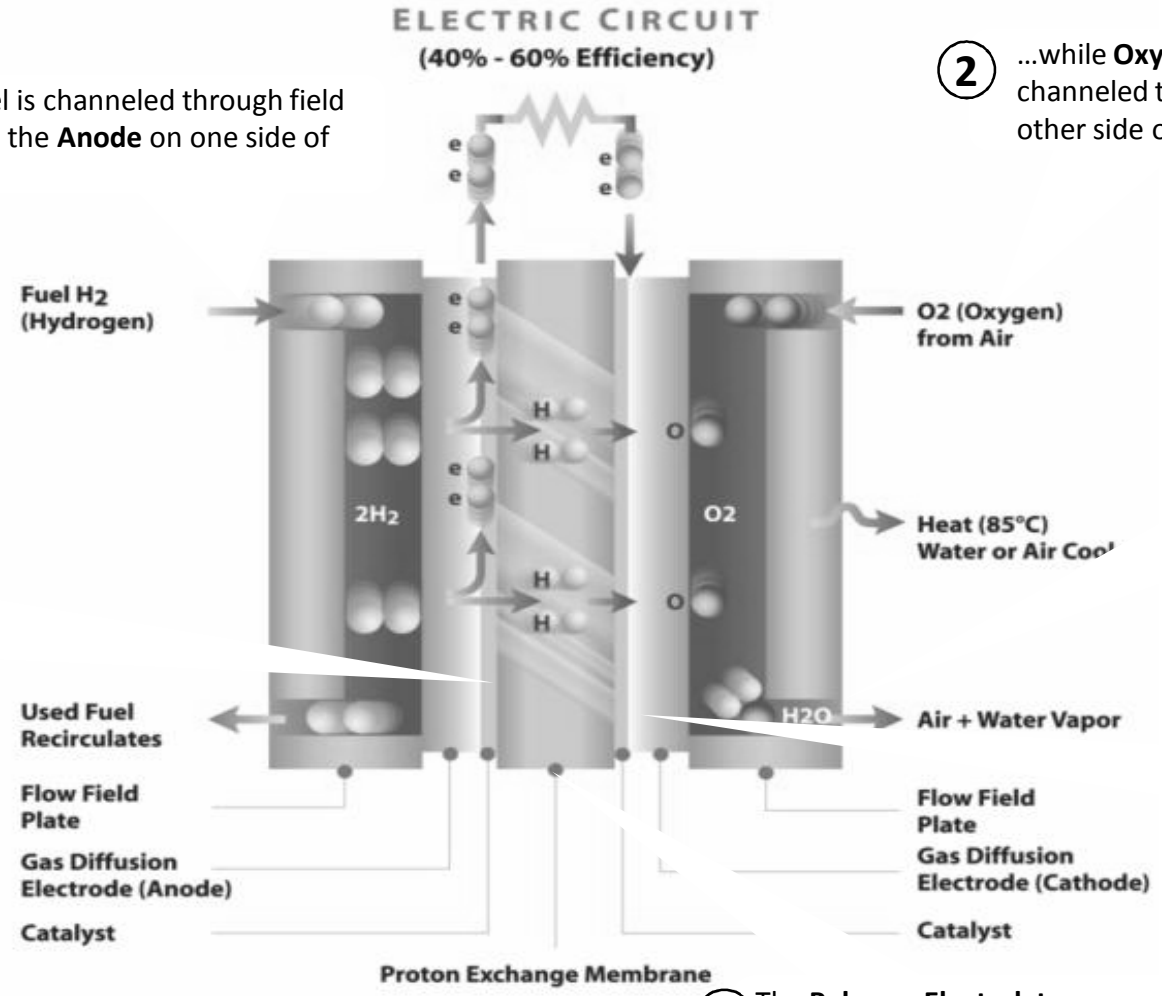
1 **Hydrogen** fuel is channeled through field flow plates to the **Anode** on one side of the fuel cell…

2 …while **Oxygen** from the air is channeled to the cathode on the other side of the cell



3 At the **Anode**, a **platinum** catalyst causes the **Hydrogen** to **split** into positive **Hydrogen ions** (protons) & negatively charged electrons

4 The **Polymer Electrolyte Membrane (PEM)** allows only the positively charged ions to pass through to the cathode…

5 …and the negatively charged electrons are forced to travel along an external circuit to the **Cathode**, creating an electrical current

6 At the **Cathode**, the electrons and positively charged hydrogen ions combine with **Oxygen** to form **Water**, which flows out of the cell

Smarter Solutions for a Clean Energy Future

Who We Are

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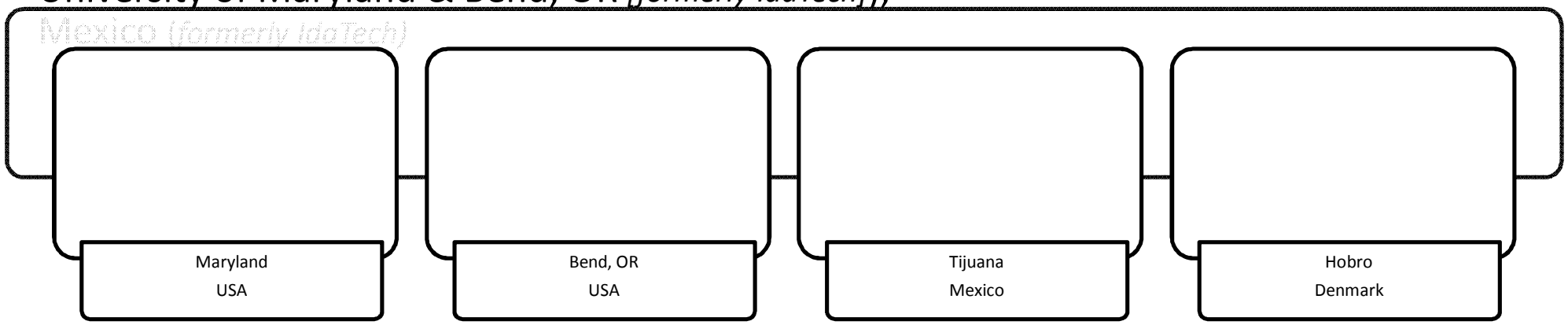
- **Ballard Power Systems, Inc. is a recognized global leader in clean energy PEM fuel cells**
  - Design, manufacturing, distribution, support
  - Multi-market focus
  - Capture 80% of PEM Fuel Cell Market Worldwide.
  - Our list of Indian Customers includes: Indian Defense, Tata Motors, Mahindra & Mahindra, Aditya Birla Group
- **Headquarters in Burnaby, BC, Canada**
- **Operations:** Canada, Denmark, U.S.A. (Lowell, MA, University of Maryland & Bend, OR *[formerly IdaTech]*), Mexico *(formerly IdaTech)*

Burnaby HQ facility



Ballard Fuel Cell Products

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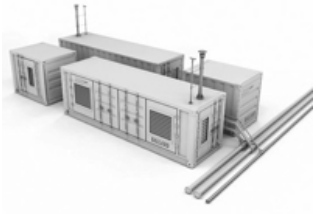
STATIONARY POWER

Backup Power

$1.0B

- Extended runtime versus batteries
- Reduced weight and size
- Competitive lifecycle cost

Distributed Generation



1 MW CLEARgen™ system

$3.0B

- Highly efficient
- Scalable
- Low lifecycle costs

MOTIVE POWER

Materials Handling

$0.8B

- High productivity
- Constant power availability
- Minimal hydrogen refueling time

Bus/Rail and Automotive

$2.0B

- Economic benefits for local partners
- Decreased GHG emissions
- Decreased fuel costs

Leveraging Common Fuel Cell Product Platforms

○ = Total Addressable Market (TAM)

ENGINEERING SERVICES

Availability of Hydrogen

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Sources of hydrogen for Fuel Cell systems

- **By-product hydrogen – Industrial Waste**

  : Hydrogen created as a by-product of chlor-alkali production, at carbon monoxide plants & other chemical production

- **Steam-reformation of Methanol**

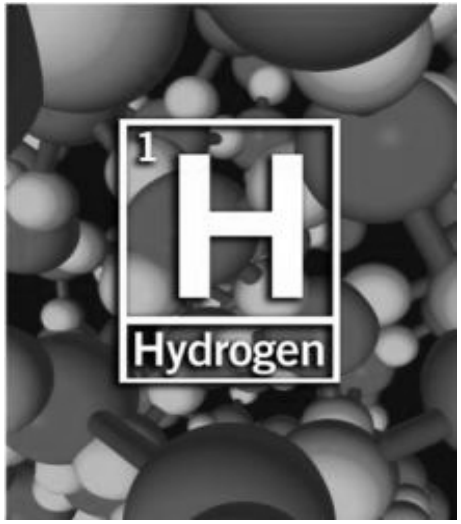
  : Methanol steam reforming is one of the most promising routes to produce high purity hydrogen for mobile fuel cell applications.

- **Gasification of biomass**

  : Converts organic waste to a hydrogen-rich gas stream

- **Electrolysis from "renewable" energy sources**

  : Large-scale energy storage using hydrogen produced during off-peak times



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Source of By-product Hydrogen

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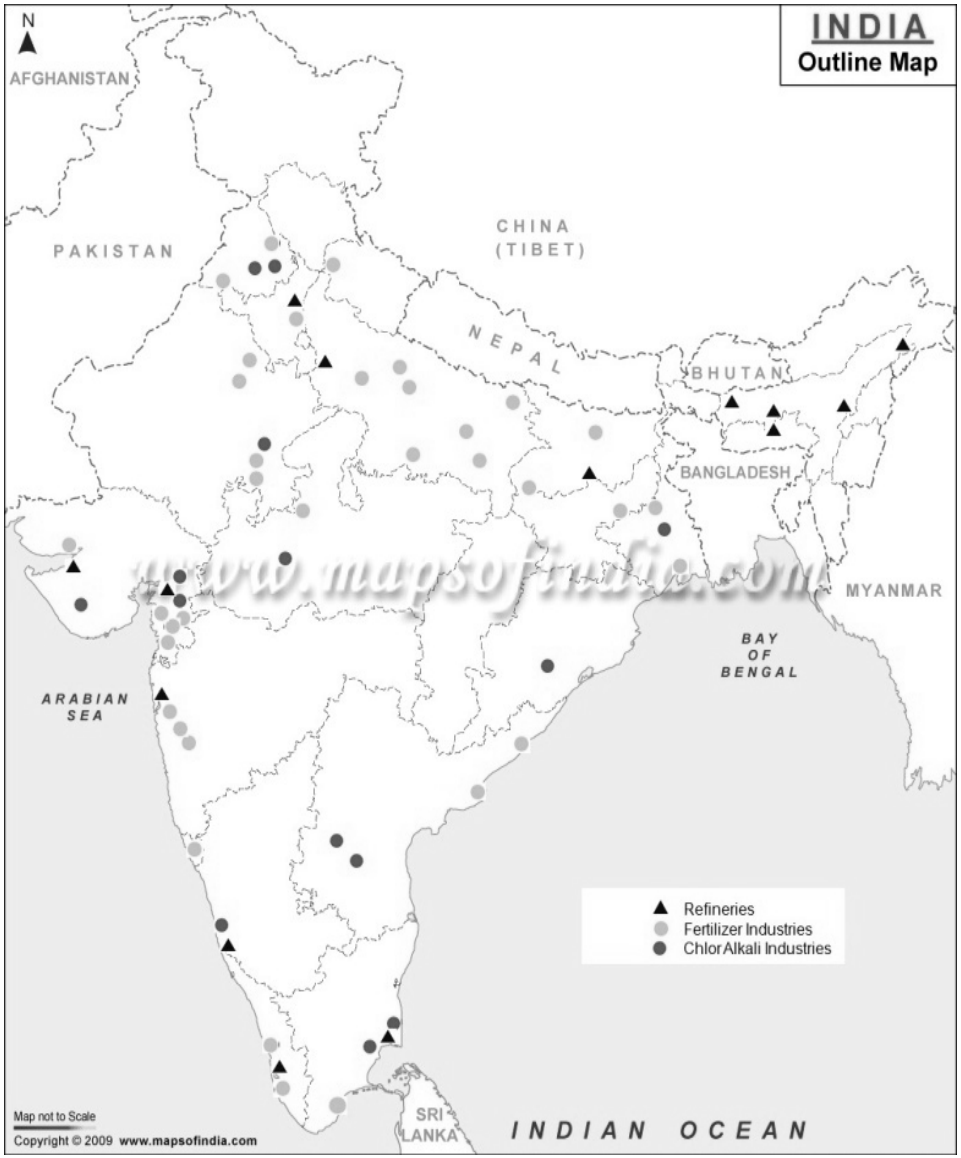

- Hydrogen infrastructure exists while not extensive
- Sources of By-product hydrogen
  - Chlor-alkali plants
  - Refineries
  - Captive plants for fertilizer, soap, glass plants, Sugar Industries
- Industrial waste Hydrogen available form these plants is sufficient to provide green power to more than 50,000 telecom towers in nearby vicinity.

Existing Site Configuration

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Hydrogen Cylinders

Site Monitoring & Control System

Fast Charge VRLA Batteries

Fuel Cell Stack

ElectraGen™-ME (Liquid-Methanol Fuel Cell)

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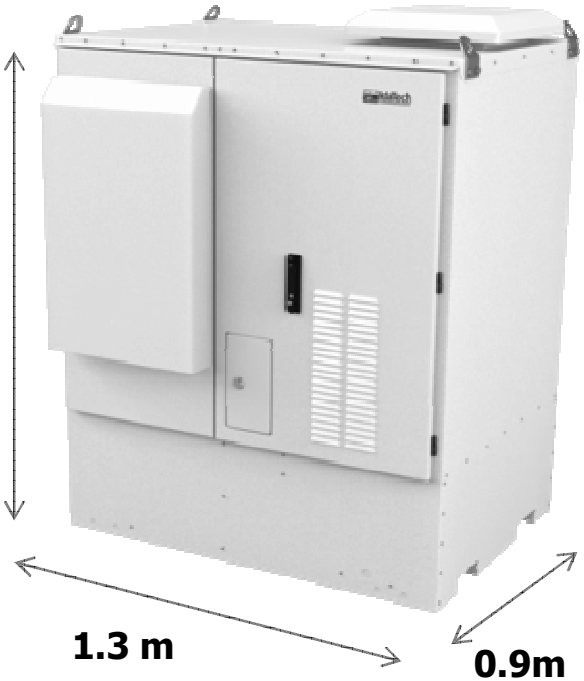
Next Generation Reformer-Based Backup Power Fuel Cell System



< 300 kg

Run Time	Load
40 hours	5 kW
100 hours	2 kW
140 hours	1 kW

Product Configurations

- **2.5 kW** or **5 kW**
- **24 Vdc** or - **48 Vdc**
- Standard (**-5C** to **46C**) or Cold (**-40C** to **46C**)
- Fuel: **HydroPlus** (Methanol-Water liquid fuel)
- **CE** and ANSI/CSA **FC-1** certified

Key Features

- Integrated fuel cell (PEM) + reformer system
- 225 liter tank (up to 40 hrs autonomy @ 5kW)
- Weight < 300 kg (dry)
- 2 x 2.5 kW stack design (alternate usage, redundancy)
- Customer user interface keypad with LCD display for set-up and diagnostics (no PC required)
- Dry contacts (8) + SNMP interface

Value Proposition

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High Reliability

- Commercially proven
- Industry leading technology

Autonomous Solution

- Extended duration runtime
- Remote monitoring
- Flexible fueling

Reduced Operating Costs

- Minimal maintenance
- Longer lifecycle – less frequent replacement
- Not subject to pilferage issues
- Up to 20% more efficient than alternatives

Environmentally Friendly

- > 95% reduction in CO, NOx and Sox
- > 50% reduction in CO_2
- Zero particulate matter

Flexible Siting

- Light weight, small footprint
- Quiet - no vibrations
- Low emissions

ElectraGen™-ME Functionality

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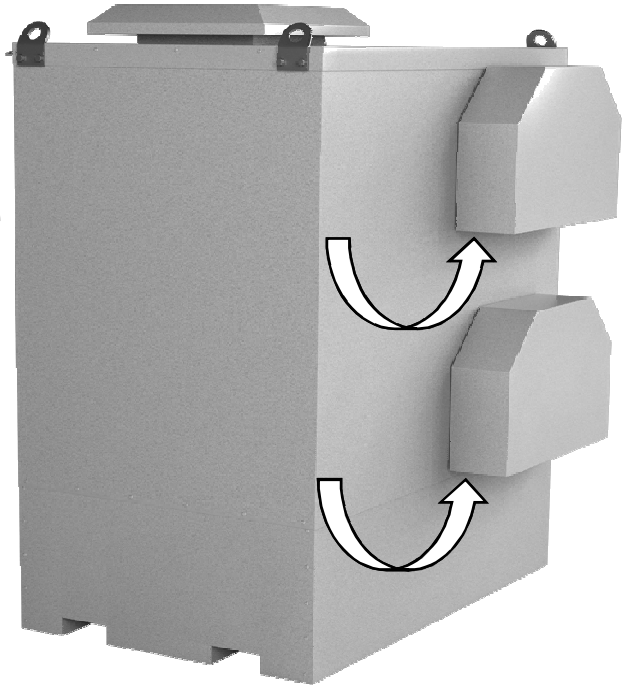
H_2O Vapor Formation

H_2O Dissipation Through Back Exhausts



Purification Stage

Reformation Stage

Vaporization Stage

Heating Stage

O_2 from Ambient Air

ElectraGen™ ME 2.5kW System

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Product No. 0017850 - ElectraGen™ ME 2.5kW -48VDC System

- The design life of the Fuel Cell System is 10 Years.
- The expected stack life is 8,000 running hrs and expected reformer life is 10,000 running hrs for Vodafone sites in Bihar/Assam circles (Average 2 start/stop cycles every day).

Liquid-Methanol Fuel Cell Vs. Solar

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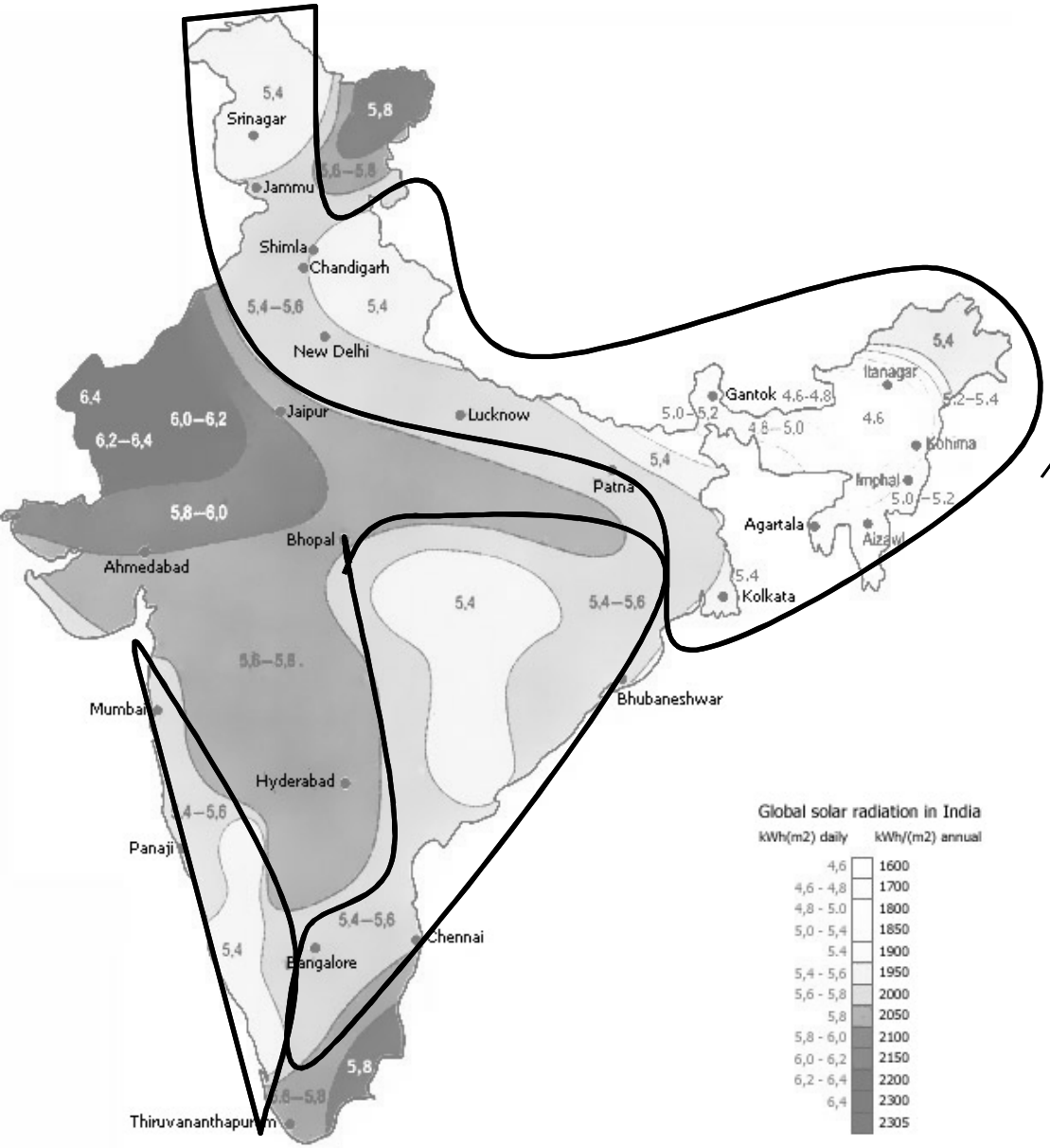

- Liquid-Methanol Fuel Cell is the only practical, scalable, reliable & efficient Green backup power Solution at low solar-radiation regions or any roof-top cell site.
- Liquid-Methanol fuel cell solution enables “diesel free” sites with 100% uptime.
- Footprint of liquid-methanol fuel cell solution is very small compared to other backup power solutions.

Fuel Cells are "Green"

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Telecom Backup Power Technology Comparison

Methanol Fuel Cell System Vs. Diesel Generator

	ElectraGen ME System Fuel Cell system with Methanol-Water Reformer	**Diesel Generator**	**Emissios Savings**
Exhaust Emissions			
Nitrogen Oxides (NOx)	0.007 g/kWh	7.5 g/kWh	**>95%**
Carbon Monoxide (CO)	0.17 g/kWh	8.0 g/kWh	**>95%**
Sulfer Oxides (SOx)	0 g/kWh	12 g/kWh	**100%**
Particulate Matter	0 g/kWh	0.8 g/kWh	**100%**
Carbon Dioxide (CO2)	683-783 g/litre	2,830 - 2,930 g/litre	**>75%**
Exhaust Emissions			
Decibel rating	**Quiet**: 52 dB at 1 m 47 dB at 7 m	**Loud**: 68 dB at 7 m	Very Low Noise & Vibrations
System Efficiency			
System Efficiency (%)	33-35%	10-20%	High Efficiency
Operational Costs			

Telecom Installations

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docomo (Japan)

(South Africa)

T · ·Mobile
(USA)

telcel (Mexico)

TSTT (Trinidad)

(Chile)

Telecom Installations

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Vietnamobile

5.0 kW ElectraGen™ME BTS (Vietnam)

Telin

2.5 kW ElectraGen™ME BTS (East Timor)

AXIS

2.5 kW ElectraGen™ME BTS (Indonesia)

About HydroPlus™ (62% Methanol & 38% DI Water)

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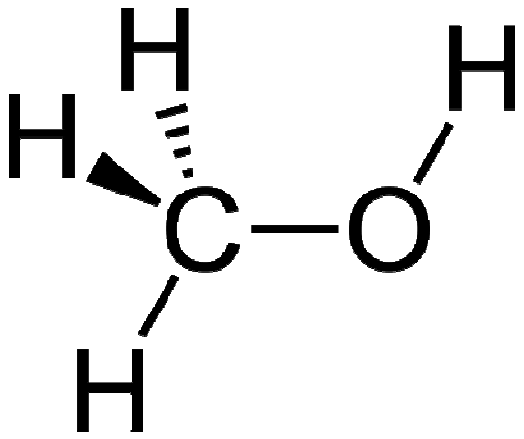
- **Methanol is a common liquid**
  - Global production in 2012 – 90 billion liters
  - Methanol, also known as methyl alcohol or wood alcohol, is an ideal hydrogen carrier. With a chemical formula of CH3OH, has more hydrogen atoms in each gallon than any other liquid that is stable in normal conditions.
- **Methanol applications**
  - Windshield washer fluid (up to 50% methanol)
  - Fuel additive – Over 3.5 billion liters in China 2007
  - Solvent
  - Manufacture of plastics and building products
- **Benefits of methanol based fuel**
  - Easily transported liquid fuel
  - Extremely low freezing point < -60° C
  - May be stored for years without degradation
- **Renewable sources of methanol**
  - Produced by crude glycerol in mass production
  - Waste CO_2, wood waste, and others are in development
  - Global production of bio-methanol now greater than 280 million liters annually



Other Methanol Applications

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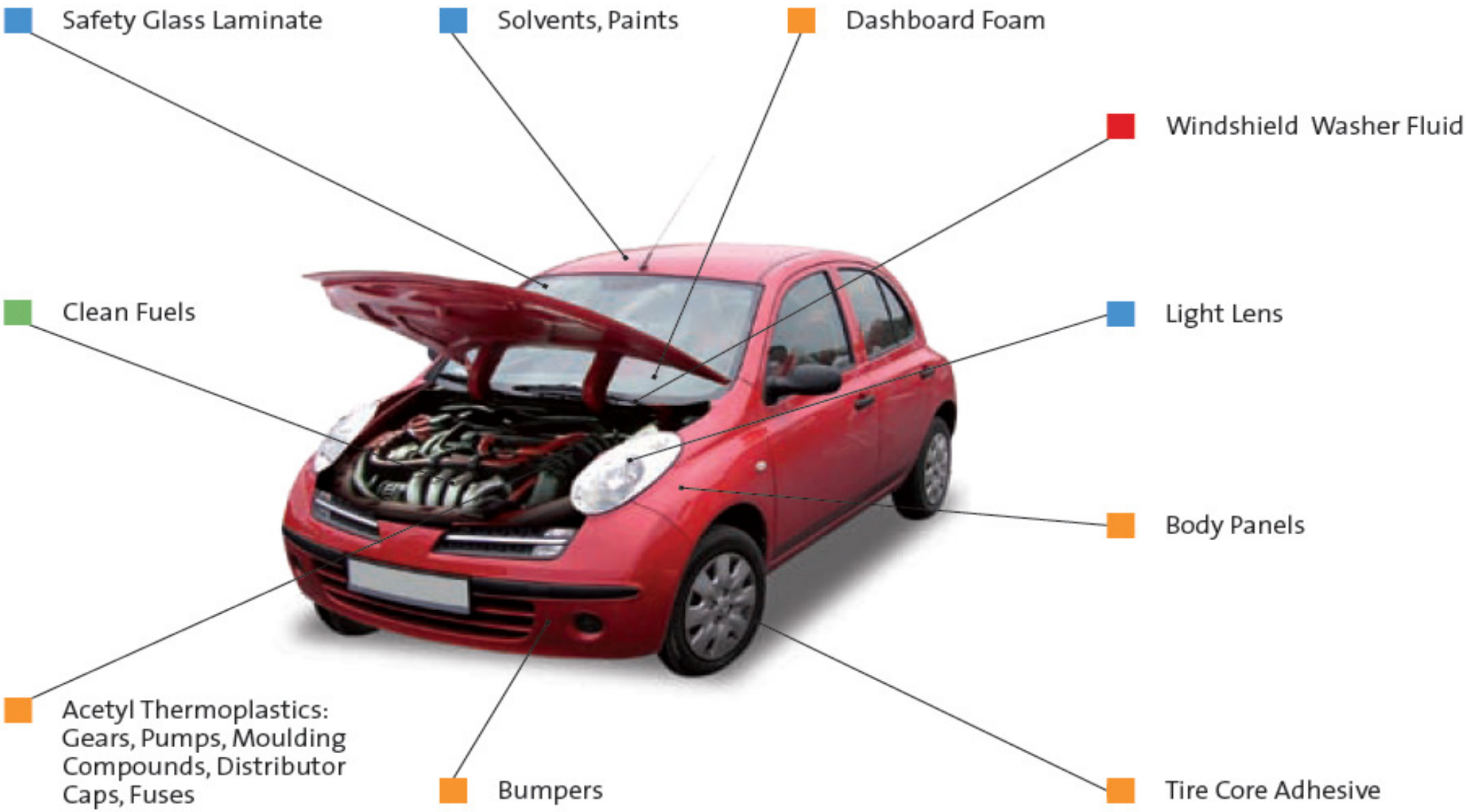

Methanol is everywhere

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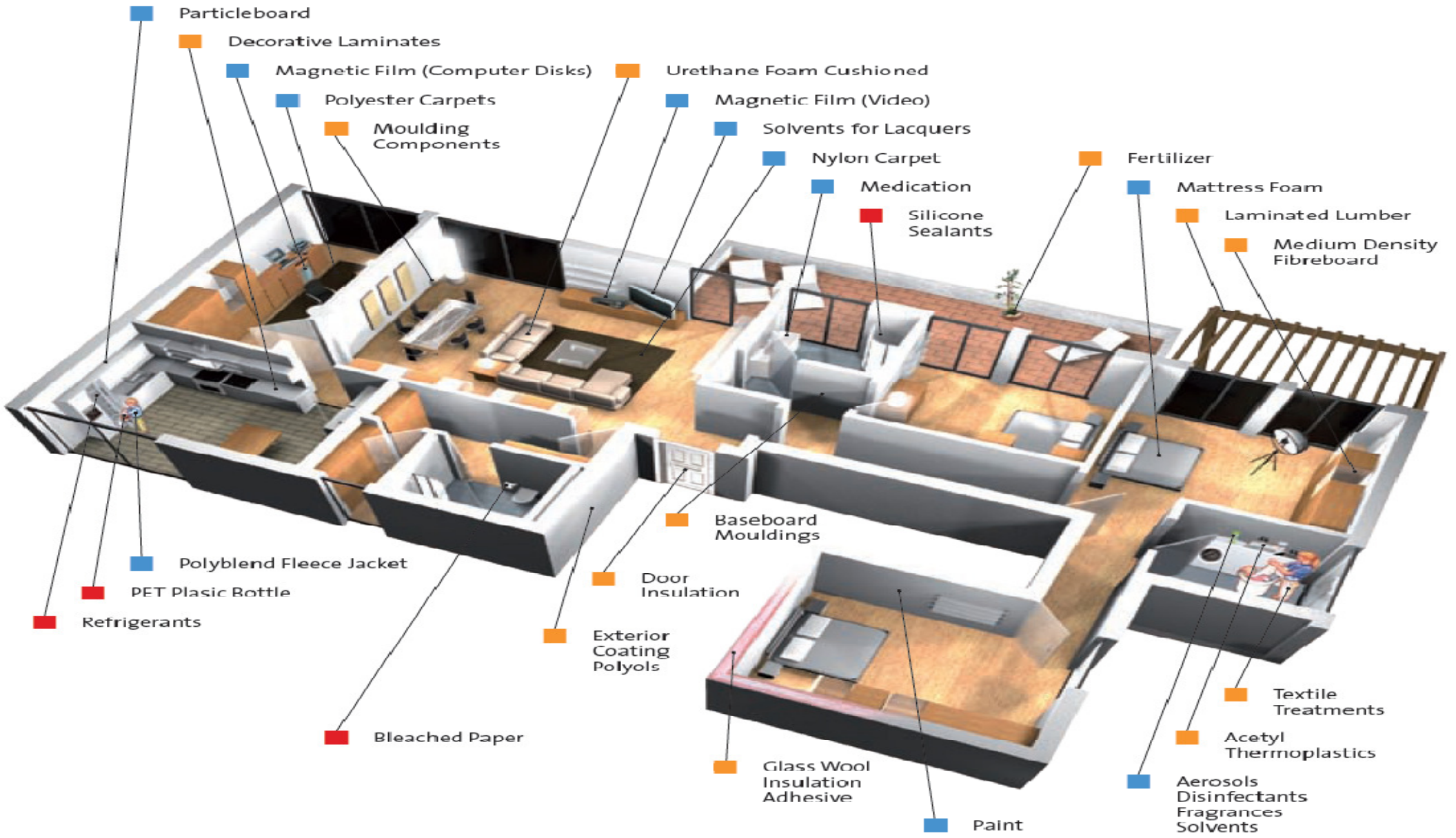

Current State of Methanol in India

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- India accounted for four percent of the overall Asia-Pacific methanol market demand share in the year 2011
- Methanol primarily produced in India from natural gas and naphtha.
- India is a large importer of Methanol. Current methanol consumption is 2.5 million tonnes and production capacity in the country is 0.585 million tonnes thereby creating gap of 1.915 million tonnes which would primarily met through imports from Middle East.
- The demand is growing at 10% and is expected to continue to be met through imports. The two major end-use segments for methanol are chemical and energy.
- In the chemical segment, methanol is used for production of formaldehyde, acetic acid, di-methyl terephthalate (DMT) and a range of solvents. The consumption of methanol in the energy segment is substantial as blending component for petrol and methyl tertiary butyl ether (MTBE), tertiary amyl methyl ether (TAME) and di-methyl ether (DME).

Methanol Domestic Price Trend

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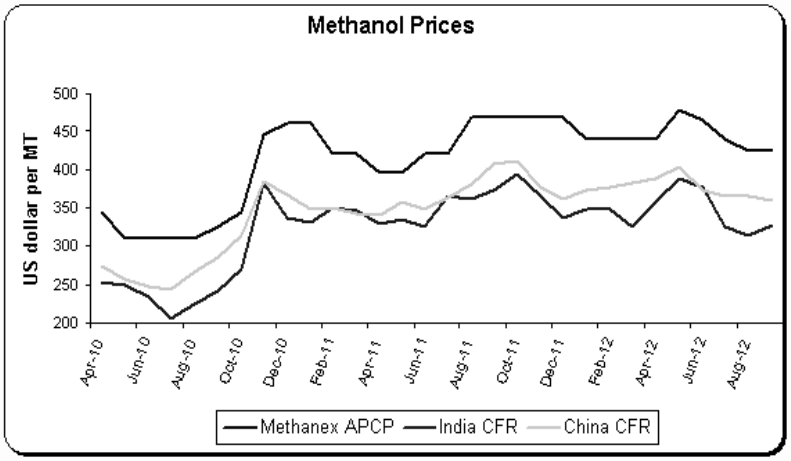

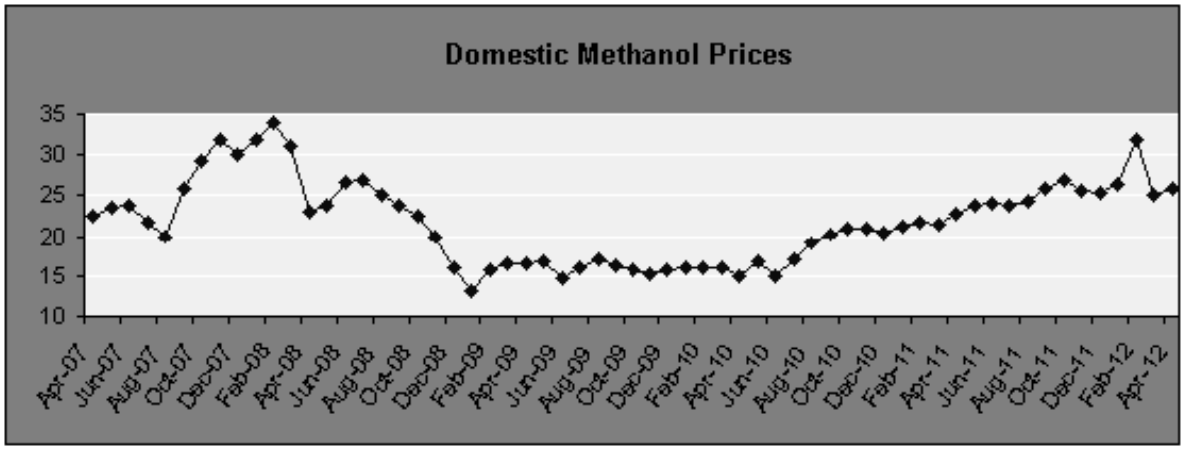

- Methanol- a bulk traded commodity and an Industrial chemical, is also known as synthesis gas and methyl alcohol or wood alcohol.
- More than 60% of Methanol domestic demand is being meeting by imports and the international market has a direct bearing on domestic prices.
- Methanol international prices (USD/MT) stays flat compared to diesel & petrol prices in last 3-5 Years.
- Latest methanol Price is 25 INR/kg.
- HydroPlus is a mixture of 62% Methanol & 38% DI Water.

Poor-Grid Sites with 1000L external tank

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- We propose to install 1000L external tank to increase the refueling time to 45-60 days instead of 10-15 days.
- 1000 Liters of HydroPlus is equivalent to ~900 kWh of available backup power without refueling.
- Upto 2500 Litres of HydroPlus can be stored at any telecom site.

HydroPlus Fuel Packaging at Warehouse in 200 Litres drums and 1000 litres tank

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HydroPlus

HydroPlus

Packaged HydroPlus Storage in 200 Litre Drums

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HydroPlus

HydroPlus Fuel Vendors established worldwide

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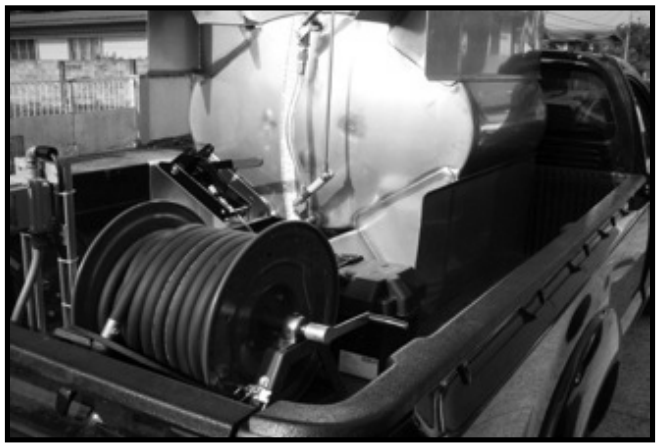
Easy Transportation – HydroPlus Liquid Fuel

55 Gallon/200 Liter Drum
Manual Pump



Refueling Truck – For Large Fleet
Automatic High Speed Pump

HydroPlus System Re-Fueling – Type I

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When re-fueling large deployments or sites that require extra efforts to re-fuel, Ballard's service partners offers an all-inclusive refueling solution to eliminate concerns with refueling. This re-fueling solution gives the technician the ability to safely and efficiently re-fuel system deployments with little effort at all possible locations.

System Specifications:

- 100 ft. Re-Fueling Hose
- Automatic Shut-off Nozzle
- Skid or Trailer Configurable
- 12 - 15 Minutes to Fill System
- Compact Design
- Fits Most Vehicles

HydroPlus System Re-Fueling – Type II

BALLARD
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When re-fueling large deployments (500+ sites) or sites that require extra efforts to re-fuel, Ballard's service partners offers an all-inclusive refueling solution to eliminate concerns, if any, with refueling. This re-fueling solution gives the technician the ability to safely and efficiently re-fuel system deployments with little effort at all possible locations.

System Specifications:

- 100 ft. Re-Fueling Hose
- Automatic Shut-off Nozzle
- Skid or Trailer Configurable
- 12 - 15 Minutes to Fill System
- Compact Design
- Fits Most Vehicles

Mobile Refueling Unit

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½ Ton Commercial Truck

HydroPlus fuel vendors established worldwide

Remote Communication

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Dry Contacts
Standard

SNMP v2c
Standard

Cellular Modem
SNMP Data
Optional, Data Plan Required

SMS Modem
Dry Contacts
Optional

150KW Fuel Cell Backup Power Systems inside Container

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Close container of 150KW Systems

Open container of 150KW Systems

150KW, zero-emission fuel cell of deployed at Anglo American to provide power at one of its mining operations plant in South Africa.

Case Study: Demonstration of MW Mobile Fuel Cell System

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- Megawatt-scale utility applications
- 5 year demonstration at large Ohio utility
- Provides generating capacity during peak usage periods in the months of May through September
- Zero GHG emissions
- Sufficient to power more than 600 homes
- Housed in a tractor-trailer for mobility

Tata Motors Bus built using Ballard Fuel Cell Technology

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Tata Motors displayed the first fuel cell bus built in India at Auto Expo 2012 in New Delhi. Tata Motors have plan to deploy 12 Hydrogen fuel cell buses in India this year.

Fuel Cell Integration into a Hybrid Drive System

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FCvelocity™-HD6

- 6th generation fuel cell technology
- Enhanced fuel cell durability
- Improved efficiency
- Reduced cost
- Industry leading 12,000 hr/5yr warranty

Case Study: Fuel Cell powered underground mining locomotive in South Africa, on 09 May 2012.

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