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Qatar Fuel Additives Company Limited (QAFAC)
Renewable Energy Targets in the GCC

Deployment of new technologies will enable the region to meet ambitious goals.

Dubai: 0.13GW
AUH: 1.5 GW

Oman: 1.25 GW

Qatar: ~1 GW

KSA: 17 GW

Bahrain: 0.25 GW

Kuwait: 2.7 GW

GCC Renewable Energy Targets, 2020

UAE: 5%
Oman: 6%
Qatar: 10%
Kuwait: 5%
Bahrain: 1%

Source: Frost & Sullivan analysis of stated targets and plans by GCC countries
Fuel Cell Technologies

- Direct Methanol Fuel Cell (DMFC)
  - CH₃OH ➔ H₂O, CO₂ ➔ H₂O
  - H⁺ ➔ O₂, 50 – 120 °C

- Polymer Electrolyte Membrane FC (PEM)
  - H₂ ➔ H₂O
  - O₂ ➔ H₂O, 80 °C

- Alkaline Fuel Cell (AFC)
  - H₂ ➔ H₂O
  - O₂ ➔ H₂O, 90 – 100 °C

- Phosphoric Acid Fuel Cell (PAFC)
  - H₂ ➔ H₂O
  - O₂ ➔ H₂O, 100 – 250 °C

- Molten Carbonate Fuel Cell (MCFC)
  - H₂ ➔ H₂O
  - O₂ ➔ CO₂, 600 – 700 °C

- Solid Oxide Fuel Cell (SOFC)
  - H₂ ➔ H₂O
  - O₂ ➔ CO₂, 700 – 1000 °C

Diagram shows the flow of fuel and oxygen through the cell, with anode, electrolyte, and cathode as key components.
Advantages Methanol vs. Hydrogen

**Hydrogen Fuel Cells**

6 bottles of Hydrogen enables 33 hours of backup time at 1.5 kW

H₂ is volatile, requires high pressure or cryogenic storage in expensive and heavy to transport containers, and needs pressure reduced for fuel cell needs

**Direct Methanol Fuel Cells**

1 Drum of Methanol (200 liter) enables 200 hours of backup time at 1.5 kW

CH₃OH delivers efficient energy storage by volume, even compared with compressed H₂ at standard 150 bars

CH₃OH is a user friendly, easily transportable, non-explosive liquid and low cost for stationary or mobile storage
Methanol can be made sustainably from:

- Agricultural waste
- Animal waste; e.g. Smithfield Farms hog waste
- Construction waste – lumber, plywood
- Forestry and forestry products waste
- Municipal solid waste; e.g. Enerkem, Edmonton

40 million liters/year from urban garbage

Methanol is available globally used for cooking, heating, lighting, and transportation fuels

Oorja delivers methanol based electrical power for global health, education, economy

Provides enough power to supplement or supplant diesel gensets and batteries in target markets and applications
Methanol cooking and heating is especially important for replacement of inside burning of wood, charcoal, coal, etc. which cause serious health problems.

**DMFC: Key Enabler of Methanol Economy**

**Methanol Supply/Value Chain**

- **CO₂:** industrial exhaust & atmospheric
- **CH₂O + HCO₂H**
- **CH₄ Natural Sources**

**Chemical Transformations:**
- Hydrogenation or Reduction in H₂O
- Oxidation
- Selective Oxidation

**Applications:**
- Energy Storage & Fuels
- Cooking & Heating
- Lighting
- Transportation
- Electrical Power – UPS, Backup, and Main
- Direct Methanol Fuel Cell with H₂O by-product
- Synthetic Hydrocarbons & Products
About Oorja

Scalable Direct Methanol Fuel Cells

- 2014 1.5 kW to 5 kW – highest performance DMFC today
- 2015 7.5 kW to 30 kW clusters for backup and remote power
- 2016 100 kW hybrid micro grid systems to MW grid scale systems

Markets 2014 – 2017

- Logistics, extending battery life in e-forklifts, pallet loaders, etc.
- Telecom base stations backup and remote power needs
- Refrigerated Trucks, back up power for other applications
- Nanogrids, Microgrids and Distributed Generation

Drivers 2014 – 2017

- 1 year ROI in 24/7/365 logistics applications versus extra batteries, charging stations, and need for battery replacement
- Methanol fuel cells deliver lower TCO/LCOE than diesel gensets or H2 Fuel Cells in off grid locations, e.g. Telecom base stations
- Growing methanol production from sustainable waste and CO2
## Oorja Products Address Large Global Markets

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>• Materials Handling Equipment (MHE) – Logistics</td>
<td>• Refrigeration Trucks</td>
</tr>
<tr>
<td>• Cell Tower Base Station Back Up Power</td>
<td>• Remote Terminal Units (RTUs)</td>
</tr>
<tr>
<td>• Micro Grids and Distributed Energy Generation</td>
<td>• High Power Distributed Energy Generation</td>
</tr>
<tr>
<td>• Emergency Power – Lights, Buildings, Shelter</td>
<td>• High Power Micro Grids</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Product</th>
<th>Watts Power</th>
<th>Markets</th>
<th>Typical Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model S</td>
<td>500</td>
<td>Rural Power</td>
<td>LED, Phone, Laptop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mobile Power</td>
<td>Camper, Car, Boat</td>
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<tr>
<td></td>
<td></td>
<td>Mobile Power</td>
<td>RTU, Pipeline &amp; Ag Pumping</td>
</tr>
<tr>
<td>Model III</td>
<td>1,500</td>
<td>Battery Backup Power</td>
<td>Class III Forklifts, Pallet Loaders</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>UPS, Emergencies, Traffic Lights</td>
</tr>
<tr>
<td>Model IV</td>
<td>5,000–10,000</td>
<td>Battery Backup Power</td>
<td>Class I, Class II Forklifts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transport Power</td>
<td>Refrigeration Trucks</td>
</tr>
<tr>
<td>Model T</td>
<td>1,500-9,000</td>
<td>Backup Power</td>
<td>Telecom Base Stations</td>
</tr>
<tr>
<td>Model M</td>
<td>100,000</td>
<td>Micro-Grid</td>
<td>Remote, Local Power</td>
</tr>
</tbody>
</table>

*2015 products in green, others in design*
Model III on-board battery charger works with most Class III materials handling equipment. Other applications include power for refrigeration while trucks are loading and unloading to reduce noise and pollution.

- Battery Range Extension
- Improved productivity
- Reduced operating costs
- Increased Battery Life
- Increased performance
- No SOx and NOx pollution

**Key Features:**

- Only commercial direct methanol fuel cell (DMFC) for materials handling and refrigeration truck applications.
- Designed to fit on existing fork lifts and pallet loader vehicles
- Reduces TCO and LCOE for electrical vehicles
- Provides clean, environmentally friendly, quiet operation
- Operates in both indoors and outdoors
- Tolerates deep freezer, dust, rain and airborne particulates operating environments

**Technical Highlights**

<table>
<thead>
<tr>
<th>Power</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Maximum Electrical Power</td>
<td>1.5 kW</td>
</tr>
<tr>
<td>Voltage Options</td>
<td>24V; 36V; 48V</td>
</tr>
<tr>
<td>Idle to Peak Power</td>
<td>10 minutes maximum</td>
</tr>
<tr>
<td>Refueling Time</td>
<td>Less than 1 minute</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Dimensions</th>
<th></th>
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<tbody>
<tr>
<td>Weight</td>
<td>170 Lbs (79 Kg)</td>
</tr>
<tr>
<td>Operating Temp</td>
<td>-20º C to 45º C</td>
</tr>
<tr>
<td>Internal Pressure</td>
<td>Less than 2 psi</td>
</tr>
<tr>
<td>Fuel Tank Capacity</td>
<td>12 Liters (run time 12-16 hours)</td>
</tr>
</tbody>
</table>

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<tr>
<th>Ergonomics</th>
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<tbody>
<tr>
<td>Ease-of-use</td>
<td>Push button operation</td>
</tr>
<tr>
<td>Internal Pressure</td>
<td>Less than 2 psi</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Fuel</th>
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<tbody>
<tr>
<td>Fuel Cell Design</td>
<td>DMFC (Direct Methanol Fuel Cell)</td>
</tr>
<tr>
<td>Cooling Method</td>
<td>Air Cooled</td>
</tr>
<tr>
<td>Form Factor</td>
<td>Mountable with mounting bracket</td>
</tr>
<tr>
<td>Interfaces</td>
<td>Dry contacts, LCD, SIM card, USB, Wireless</td>
</tr>
</tbody>
</table>
DMFCs Reduce High Infrastructure Costs for Powering Materials Handling Forklifts, Pallet Loaders, etc.
Replacing APU’s with Clean Quiet Power

Before

After
Backup Power for Telecom Base Station Sites

Replacing Diesel Generators with Direct Methanol Fuel Cells

Diesel Generators

- Maintenance intensive
- Fuel or device theft common
- Inefficient at low/intermittent power
- Noisy and noxious emissions
- High LCOE especially remote and rural sites

Oorja

Direct Methanol Fuel Cells

- Low maintenance
- No theft threat to fuel or device
- High efficiency keeping batteries at desired state of charge (SOC)
- Quiet with no noxious emissions
- Low LCOE with 1 year payback
Reliable Operation for Remote Applications

- Methanol
- Oil and Gas Pipelines
- Telecom Tower

AC Power

48V DC
DMFC Micro Grids and Distributed Generation (DG)

- Microgrids are a large and rapidly growing global opportunity
- Power routers can deliver the least expensive green power as available, wind, solar, DMFC
- DMFC enhances energy security, reliability, and avoids transmission CAPEX and electricity line losses
- Market include rural and remote locations, campuses, military bases, science parks, new urban sustainable/green cities and more
85% of Rural Africa Has No Electricity
Oorja Nano Grid Provides Clean, Reliable, & Renewable Power for Rural & Remote Communities

Nanogrid

- Methanol Cookstove
- Direct Methanol Fuel Cells (0.5-1.5 KW)
- Control System
- Solar and Storage Solution
- Electricity for homes, small businesses

Sustainable Methanol

Renewable Methanol

Water as Output

Market Examples:
- Rural villages
- Mining communities
- Remote monitoring stations (RTUs)

Waste

Energy

Water

Waste

Sustainable Livelihoods
Model M: 100 kW – 1 MW (2016 Engineering Release)

• Model M delivers 100 kW power with run time based on fuel supply

• Fuel consumption maximum 100 Liter/Hour in normal operation

• A typical 400 gallon/1,500 liter “Tote” fuel tank enables 15 hours run time

• A typical 100,000 gallon/375,000 liter rail tanker car enables 3,750 hours run time

• Power output of 480 Volts @ 60 Hz, 3 phase, either 3 or 4 wire

• Real time monitoring via wireless interface provided by Oorja and/or micro grid service operator

• Up to 10 units may be connected to deliver 1 MW
100 kW to Multiple MW Micro Grid Power

- DC/AC Power
- Solar Farm
- Remote Communities
- Heat & Hot Water
- Desalination Plants
- Off-Grid Oil, Gas, Mining Sites

Oorja
Fuel is initially sourced from traditional feedstock such as natural gas, and transition over time to renewable production.

15% less carbon emissions than natural gas with no NOx or SOx.

**Story of a 1 MW Methanol Power Plant in GCC**

- 7,300 MT Annual Methanol Used
- 8,200 MT Annual water production

Methanol fuel cells provide a clean, 24/7 distributed power source to meet growing GCC electricity needs.

Water output can be repurposed for use in the region.
## Customers 2015

<table>
<thead>
<tr>
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<th>Microgrids and Telecom Base Station Power</th>
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<tbody>
<tr>
<td><strong>China</strong></td>
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<td><strong>Philippines</strong></td>
<td>Telecom Base Station Power</td>
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<td>Back Up Power</td>
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<td>• Emergency Shelters</td>
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<td></td>
<td>• Traffic Lights</td>
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<tr>
<td><strong>Japan</strong></td>
<td>Materials Handling Equipment</td>
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<td></td>
<td>Refrigeration Trucks</td>
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<tr>
<td><strong>U.S.</strong></td>
<td>Materials Handling Equipment Power</td>
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<td><strong>Middle East</strong></td>
<td>Hybrid Micro grid 18 kW Power Systems</td>
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<tr>
<td><strong>South Africa</strong></td>
<td>Telecom Base Station Power</td>
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<tr>
<td><strong>Mexico</strong></td>
<td>Telecom Base Station Power</td>
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Thank You

James H. Boettcher--Chairman of the Board

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