FUEL CELL POWER GENERATOR
PROJECT

Methane to Markets Expo
New Delhi, India
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Presentation overview

• Project background and motivation
• The PureCell 200 fuel cell power plant
• Site selection
• CBM gas qualification
• Supply of the power plant
• Site services
• Start up and operation
Project background

• Platinum catalyst market development

• Promote Fuel Cell implementation as gas energy converters

• Stationary fuel cell suppliers: UTC Power, etc.

• Motivation for a 200 kW fuel cell demonstration project
PureCell 200 Power Plant

- Fuel Gas
- Fuel Cell Stack
- Power Converter

Diagram showing the flow of natural gas through the fuel gas reformer, hydrogen-rich gas, steam, and air, leading to usable heat and clean exhaust.
Fuel Cell unit Chemistry

- **Gas Reformer**
  - Steam Reforming:
    - \( \text{CH}_4 + \text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{CO} \)
  - Water Gas Shift:
    - \( \text{CO} + \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{CO}_2 \)
  - Net Reaction:
    - \( \text{CH}_4 + 2\text{H}_2\text{O} \rightarrow 4\text{H}_2 + \text{CO}_2 \)

- **Fuel Cell Stack**
  - Anode:
    - \( 2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^- \)
  - Cathode:
    - \( \text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O} \)
  - Overall Reaction:
    - \( 2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{HEAT} \)
Inside the PureCell 200 Power Plant
Clean Energy Conversion

PURECELL™ EMISSIONS VS. US GRID AND NG ENGINE GENERATORS

Emissions Relative to PureCell™ 200 System

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>PureCell™ 200</th>
<th>Natural Gas Engines</th>
<th>US Grid</th>
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</thead>
<tbody>
<tr>
<td>Nitrogen Oxides</td>
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<tr>
<td>Sulfur Dioxide</td>
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<td>Carbon Monoxide</td>
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<td>Volatile Organic Compounds</td>
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<td>Particulate Matter</td>
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Project Site Selection

- Natural gas supply pipeline network
- Coal bed Methane gas (CBM) exploration site
- National power grid connection
- Make-up water availability

- Eventually selected Anglo Coal’s CBM site near Lephalele in Limpopo province of South Africa
CBM Gas Production Wells
CBM gas flare before project
CBM Gas Qualification

• Gas composition: 83% CH₄  14% CO₂  3% N₂

• Checked against Fuel Cell gas specification

• Nitrogen content sometimes above max specified

• Checked for gas impurities for PAFC

• Analytical Lab verified gas within specification
CBM Gas Treatment

• Gas reformer catalyst changed to Rhodium

• Water droplets in gas carry over some soda ash

• Gas scrubbing with clean water provided

• Final coalescent filtering to remove any droplets
Supply of PureCell 200 generator

• PureCell 200 end of series (next series 400 kW)
• Selected previously used 200 kW unit (3.6 years old)
• Modified gas reformer to handle up to 10% Nitrogen
• Converted for 50 Hz and upgraded controls
• Factory acceptance testing: Power output and 10%N₂
• Shipment to South Africa and site
• Total delivery period of 14 months
Fuel Cell Stack life output profile

VDCTOT vs. LoadTime on PP # 9262
From: 5/14/2002 To: 3/18/2007

- RATED POWER FIELD DATA
- Factory Test 8/11/08

DE-RATING REQUIRED WHEN VOLTAGE < 147 VOLTS
Site services provided

- Concrete plinth and roof for shade
- CBM gas scrubbing and filtering
- Make up water RO treatment and storage
- Nitrogen Purging gas bottles
- Electrical network connection
- Cell phone data communication link with control room at UTC Power in USA
Commissioning

- Check list on service connections completed
- UTC Power commissioning engineer dispatched
- Loaded water treatment resin and charcoal
- Filled cooling system with Glycol/water mix
- Data communication link working but unstable
- Problems with inverter and fuel cell resolved
- Plant commissioned and online
- Cell phone data link with central control in USA not reliable
PureCell 200 operation

- Operating modes: Grid connected and island mode with automatic change over
- 24/7 remote monitoring by UTCP in USA
- Telephone comms link replaced with wireless LAN
- Maintenance contract with UTCP
- UTC via KeyPlan provide local maintenance support
- Plant operating satisfactorily
Conceptual Capital Cost comparison

- Fuel cell power plant (400 kW) $3 000 / kW
- Biogas IC Engine generators $1 000 / kW
- New 4800MW coal power plant $2 700 / kW
- Nuclear power station - PWR $3 200 / kW
- Wind power generators > 1.5 MW $2 500 / kW

• NOTE: Factors not considered: plant life and scale, environment impact, carbon credits, etc.
Thank you for your attention