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

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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**

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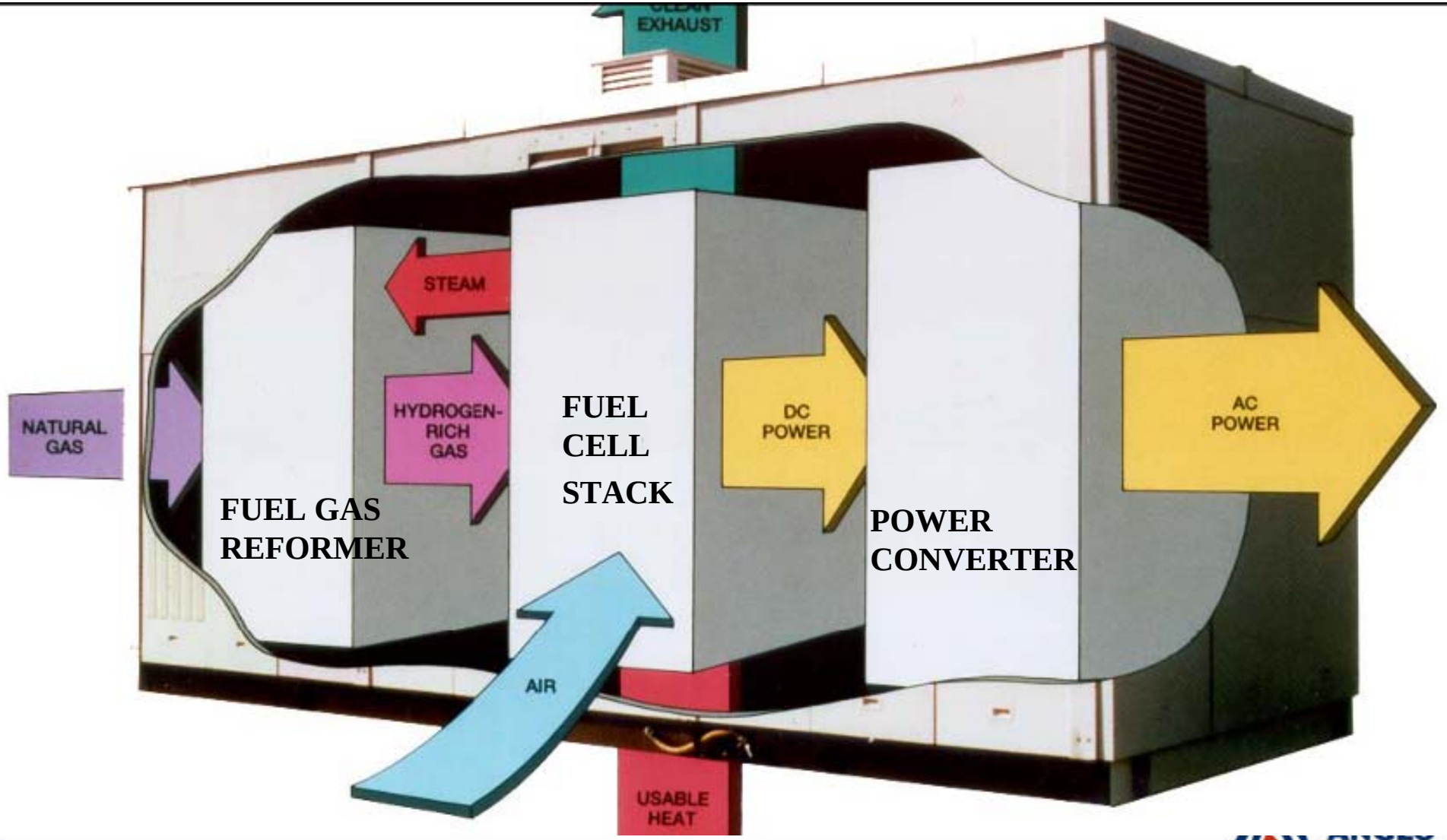
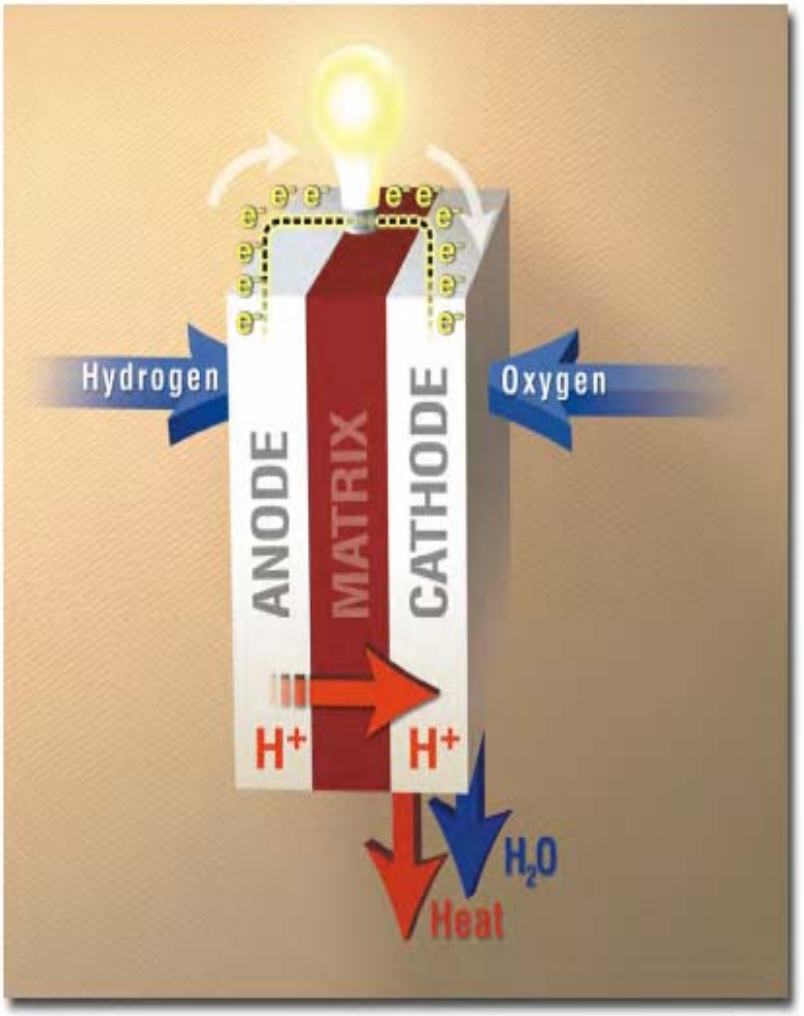
PureCell 200 Power Plant



Fuel Cell unit Chemistry

- **Gas Reformer**
  - **Steam Reforming:**
    - $CH_4 + H_2O\ (g) \rightarrow 3H_2 + CO$
  - **Water Gas Shift:**
    - $CO + H_2O \rightarrow H_2 + CO_2$
  - **Net Reaction:**
    - $CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$

- **Fuel Cell Stack**
  - **Anode:**
    - $2H_2 \rightarrow 4H^+ + 4e$
  - **Cathode:**
    - $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
  - **Overall Reaction:**
    - $2H_2 + O_2 \rightarrow 2H_2O + HEAT$



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Inside the PureCell 200 Power Plant

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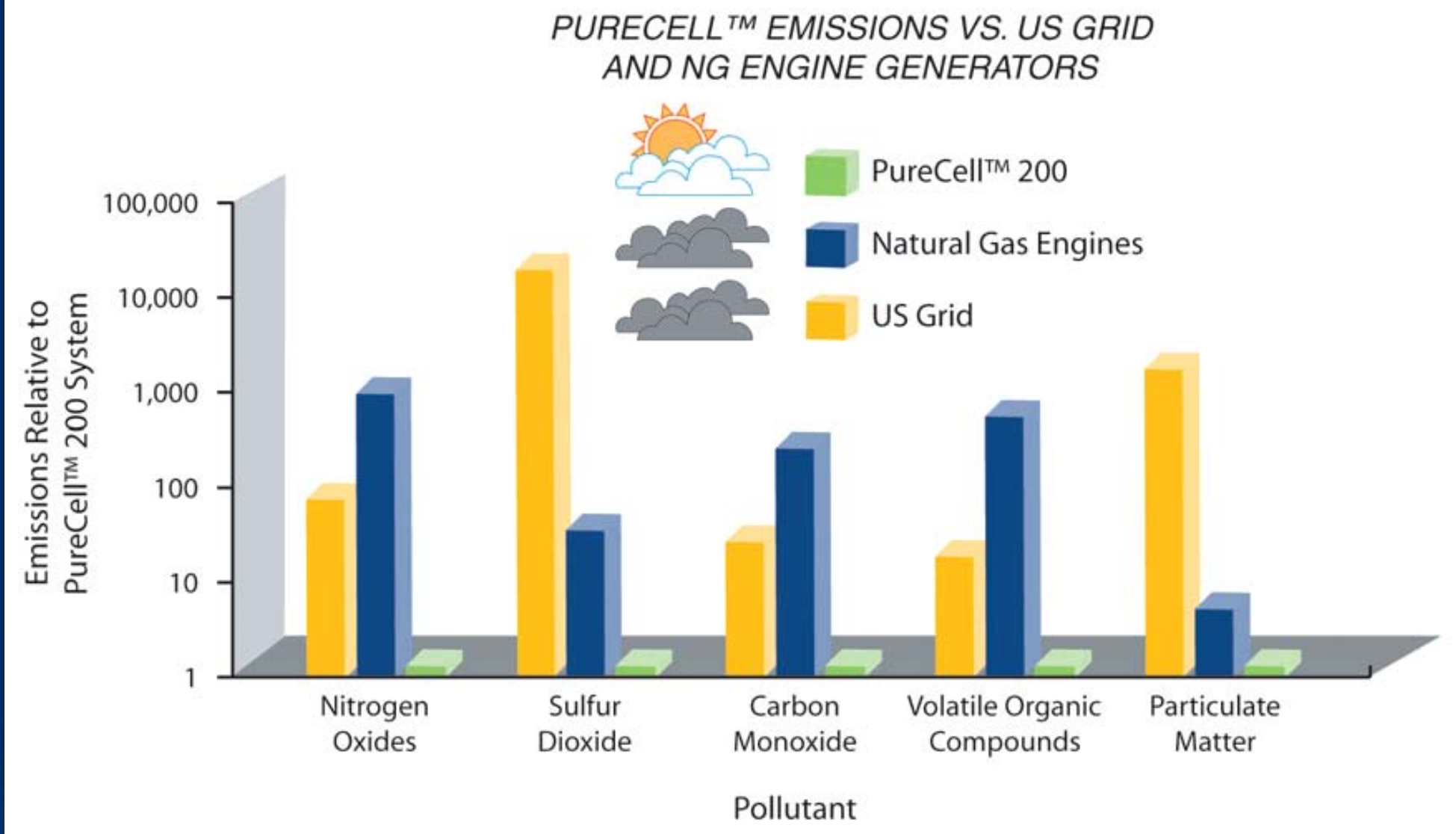
Clean Energy Conversion



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**

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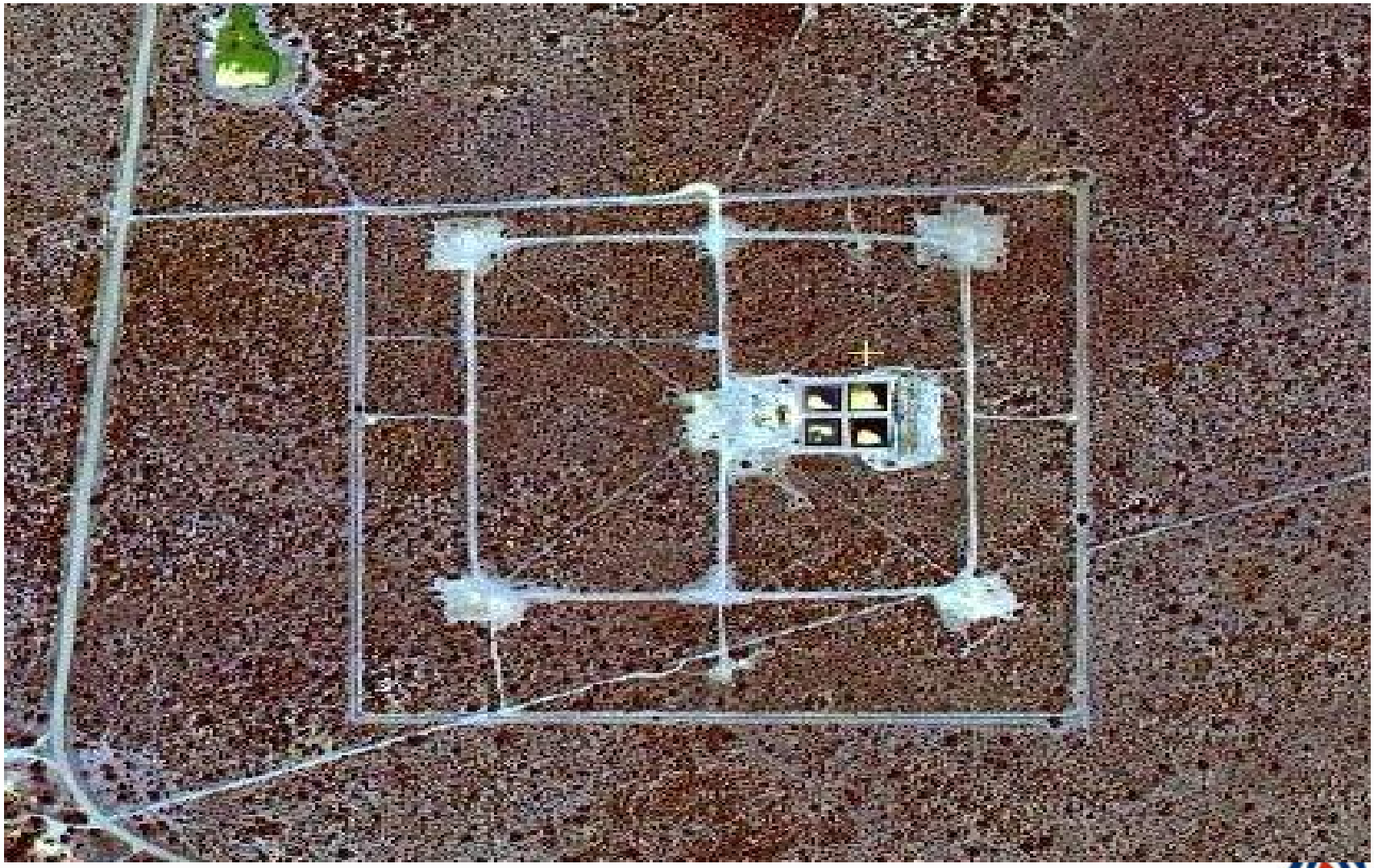
CBM Gas Production Wells



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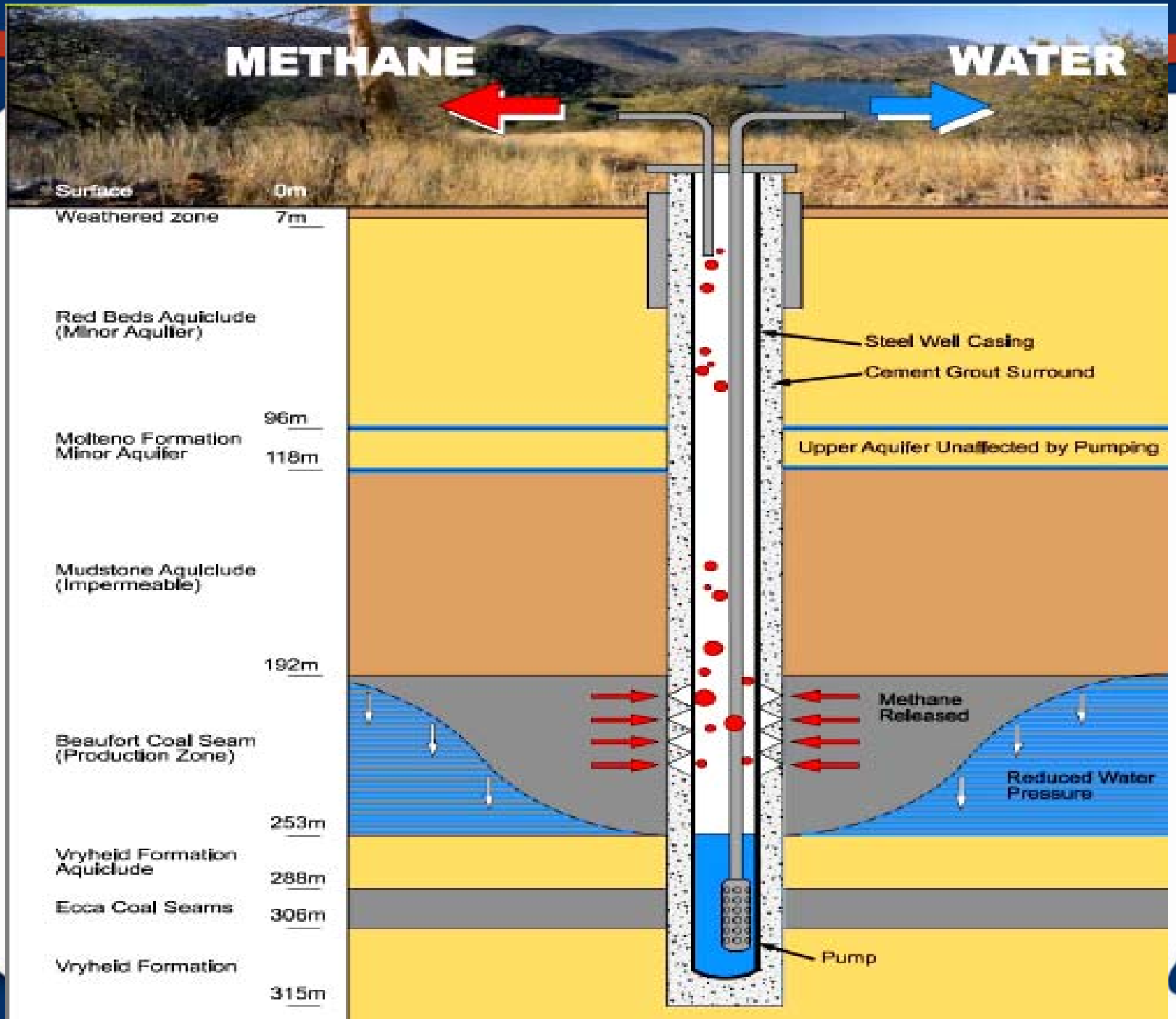

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CBM gas flare before project

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CBM Gas Qualification

- **Gas composition: 83% CH_4 14% CO_2 3% N_2**
- **Checked against Fuel Cell gas specification**
- **Nitrogen content sometimes above max specified**
- **Checked for gas impurities for PAFC**
- **Analytical Lab verified gas within specification**

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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

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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%N_2
- Shipment to South Africa and site
- Total delivery period of 14 months

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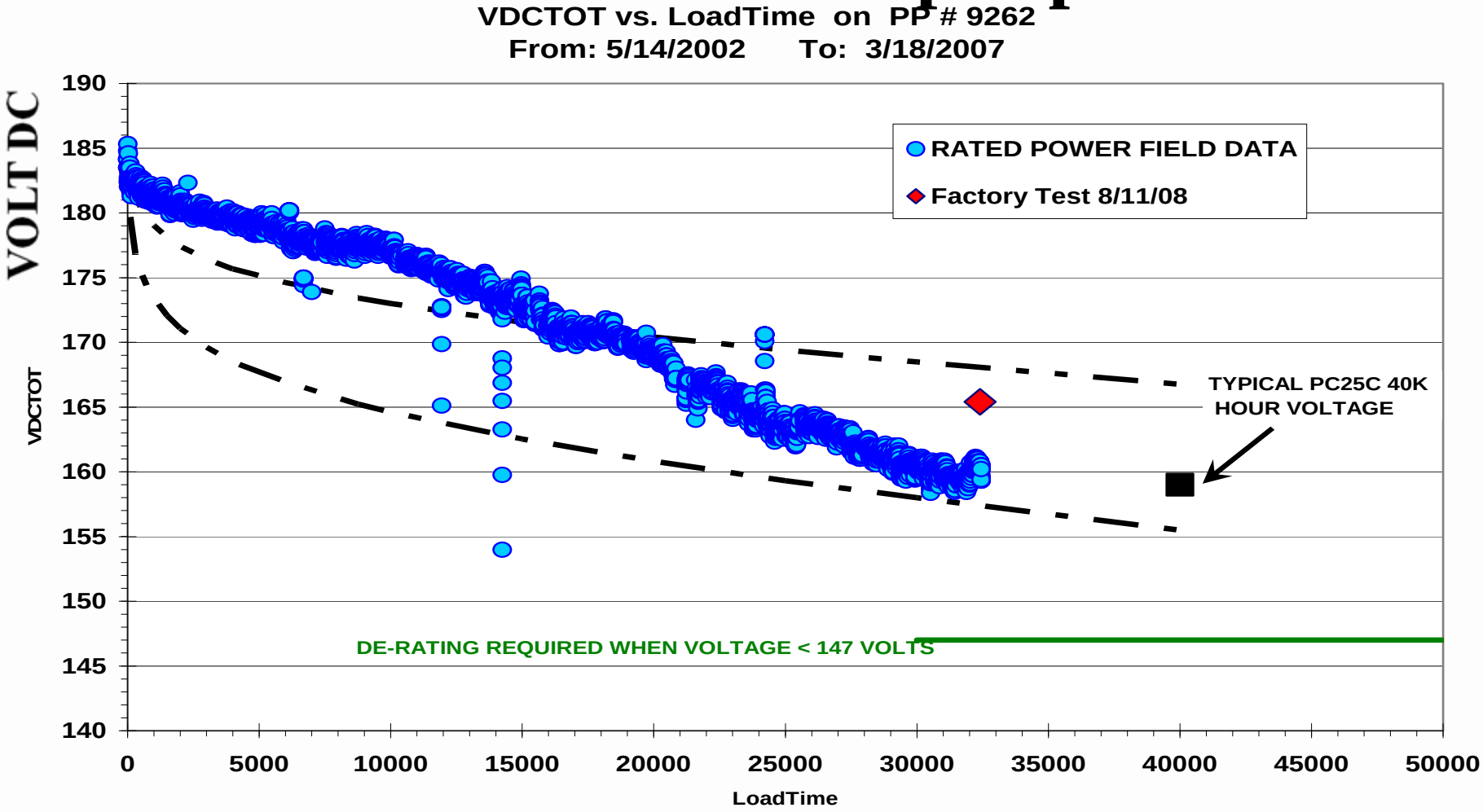
Fuel Cell Stack life output profile



LOAD TIME IN HOURS

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ARRIVAL ON SITE

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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

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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

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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**

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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 <u>not</u> considered: plant life and scale, environment impact, carbon credits, etc.**

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Thank you for your attention

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