In-Field Fuel Consumption Reduction: Solar, Battery, Fuel Cell Hybrid Power System

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Contents

• **P200i – Current commercial SOFC product**
  o Overview
  o Core Technology
  o Specifications
  o Component Diagram
  o Durability
  o Capabilities
  o Beta Trials
  o Case Study
  o Typical Operation

• **Defense Product Development Path**
  o Defense Comparison
  o JP-8 Conversion
  o Solution
  o Applications

• **Summary**
The P200i is a small, lightweight fuel cell system that utilizes commercially available LPG (Propane) to monitor and tend an external battery bank to power remote electrical equipment.
Core Technology: Solid Oxide Fuel Cells (SOFCs)

- Robust ceramic electrolyte
- Very high operating temperatures (~700°C)
- High temperatures allow for onboard reforming of hydrocarbon fuels.
Core Technology: Fuel Processing

CPOX Reaction

\[ \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{H}_2 + \text{CO} \]

(Propane) (Air)

CPOX Reformer

SOFC Reaction

\[ \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{CO} \]

Anode

\[ \text{O}^-_2 \rightarrow \text{O}^-_2 \rightarrow \text{O}^-_2 \]

Cathode

\[ \text{O}_2 \] (Air)
P200i Operation

- Preset “turn on voltage” and “turn off voltage”
- Powers on at “turn on voltage”
- 15 minute heat up
- Charges battery until “turn off voltage” reached
- 20 minute cool down
P200i Specifications

- **FUEL:** Liquefied Petroleum Gas (LPG per GPA Standard 2140-97)
- **Efficiency:** 17% (4-5hrs run time per lb. of propane)
- **Power (net):** Initial 200W with turndown capability to 50W.
- **Power Type:** Designed to work with 12 - 48 VDC systems.
- **Maintenance Free:** No seasonal maintenance required
- **Size / Weight:** 60cm x 40cm x 20cm / 20kg
- **Operational Environment:** -30°C to +55°C, 4000m altitude, IP54
- **Remote Communication:** TCP/IP interface
- **Safety:** Onboard CO and Propane leak detection
P200i Durability

- Ruggedized design for extreme environments
- Survived vibration and 4ft drop tests
- Can operate at -30°C

Alaska Cell Repeater – Summer and Winter Pictures
P200i Capabilities

- Unlike other SOFC products – the P200i can turn on and off easily.
- Allows for less fuel consumption and ultimately higher lifetime efficiencies
- Lab testing has shown P200i hot zone life times can be in excess 6000 hours

Cycle test showing 250+ cycles
Beta Trials

• Currently in Closed Beta Trials with Multiple Customers/ Markets
  o Remote Sensor – Wind
  o Remote Sensor – Natural Gas Well
  o Telecom/ Cell Repeater Stations
  o Traffic Cameras
  o Railroad Signal and Sensors

Unrestricted Availability in Late 2017
Case Study: Rocky Mountain Location

• Weather station with road condition monitoring
  
  o No need for an additional power source during the spring, summer, and fall
  
  o Winter of 2016 – prior to P200i installation had an uptime of only 35%
  
  o Winter of 2017 – over 90% uptime after the P200i installation

P200i hybridized installation
Remote Rocky Mountain weather station

Battery Voltage Monitor

Oct 4-5 Snowstorm: P200i first automatic start since installation

Turn on voltage

Doppler Oct 5, 2016
Typical Operation

Battery Voltage Monitor
Oct 4-5th Zoom

Turn on voltage
Turn off voltage
Remote DoD Power Comparison

- Excessively noisy
- Difficult to hybridized with batteries or solar (AC based)
- Inefficient at low power
- Fuel: JP-8 – readily available

JP-8 Military Generator

- Quiet operation
- Easily coupled with solar for reduced fuel consumption
- High Efficiency – Good turndown capabilities
- Fuel: Methanol – not a common DoD fuel

Protonex M300 Methanol Fuel Cell System
Military/Defense Solution

- Solar/Battery/Fuel Cell hybrid to replace traditional 24/7 low power generators at FOBs or remote DoD sites
- Maintenance free – 100% uptime solution
- Dramatically reduce JP-8 consumption
JP-8 Fuel Processing

- Possible to modify the P200i to use JP-8 instead of propane
- Successful TRL-5 demonstration with desulfurized JP-8 has been performed by Protonex
- Several vendors have mature JP-8/desulfurization technologies tested at to higher TRLs
Military/Defense Applications

- Security Cameras
- Remote Sensors/Communication Relays
- UAV/Drone Recharging Stations
- Weather Stations

Hybridized JP-8 SOFC/Solar Package
Summary

• SOFCs have matured in recent years
• Triple hybrid systems (P200i/solar/battery) are gaining traction in the commercial remote power sector
• Opens up possibilities in military applications with similar remote power needs
• The technology to process JP-8 to be used in SOFC exists but has not been implemented yet

Thank You.
Questions?