The commercial application of stationary fuel cells in the built environment

15th September 2009
Bill Ireland – Director of Operations
Objectives

- Reduce greenhouse gases – CO$_2$, NO$_x$, SO$_x$
- 42% carbon reduction in Scotland by 2020
- 80% by 2050
- Waste reduction
- Increase distributed generation
- Reduce particulate pollution
- Renewable/Sustainable strategy
- Security of supply
Security of Supply

• UK - net importer of fuel
• By 2015 75-80% of EU gas and oil imported 80% traded oil and 50% traded gas
  Russia, Persian Gulf and West Africa
• Energy effects of Conflict
  Iraq
  Nigeria conflicts - production reduced
  USA / Iran “threat” on production
• Oil prices rising again
• Leverage/control ..... Russia/Ukraine – Dec 2005
  Russia/Georgia – Jan 2006
  Russia/Ukraine – Mar 2008

• UK infrastructure needs reviewing and upgrading
A Hydrogen Fixation?

- H₂ or not H₂
  that is the question!

\[
\begin{align*}
\text{CH}_4 & : \text{Bio-methane/NatGas} \\
\text{CH}_4 \text{O} & : \text{Methanol} \\
\text{C}_2\text{H}_6 & : \text{Ethane} \\
\text{C}_3\text{H}_8 & : \text{LPG} \\
\text{C}_2\text{H}_6 \text{O} & : \text{Alcohol} \\
\text{NH}_4 & : \text{Ammonia}
\end{align*}
\]
The versatility of hydrogen technologies
Fuel Cells – The Principles

• Multiple technologies
  – Proton Exchange Membrane
  – Phosphoric acid
  – Molten carbonate
  – Solid Oxide ....

• General principle
  \[ 4e^- \text{ & heat} \]
  \[ 2H_2 + O_2 \rightarrow 2H_2O \]

• **Chemical** reaction combining Hydrogen and Oxygen
Why Fuel Cells?

Conventional

Heat

COMBUSTION

Fuel = CH₄

CH₄ + O₂ + Heat → CO₂ + 2H₂O + Heat

Fuel Cells

Skip the Inefficiencies

Traditional Combustion Technology (Inefficient)

• Safe
• Clean
• Efficient (~ 50% e with CHP ~ 80%)
• Quiet
• Reliability
• Availability
• Cost competitive
Fuel Cells – The Myths

• NOT New
  Discovered in 1840 by William Grove
• NOT “future” technology
• H₂ generally not stored
• NOT extortionate prices
• NOT short stack life – 40,000+ hours warrantee
• NOT exceptionally dangerous
Applications

One Megawatt Fuel Cell System
King County Waste Water Treatment Plant, Seattle, Washington
DOD PAFC Experience 1996-2002

8th Air Force Hospital

NAS Jacksonville Hospital

Ft Huachuca Barracks

NAS Fallon Galley

Laughlin AFB Hospital
Deer Island, Massachusetts

New Haven, Connecticut

Columbia Blvd. – Portland, Oregon
Small Scale Fuel Cells - UPS

Robins AFB, GA Field Testing 5kW Residential Units

Keflavik Iceland Int. Airport

Ft Hood, TX Com Center

FAA Com Facility Sandersville, GA
Commercial Offices

600kWe and 350kW cooling or 750kW heating
Fresno, California
Fuel Cell Distribution

- Worldwide 60MWe at end of 2008
  Logan Energy >13MWe
- Europe less than 3MWe
- UK less than 0.5MWe
- Scotland – 0.0 MWe
Transport for London, Palestra

- 300,000ft$^2$
- Refurbished building
- BREEAM Excellent
- Energy efficiency and carbon reduction
- Reliable power
Transport for London, Palestra

- 200kWe fuel cell
- 700kWe ICE CHP
- Standby generator
- Absorption chiller
- 4+1 LV transformers
- 2 HV supplies
Transport for London, Palestra

- 200kWe
- 225kW heat
- High Grade generates 90kW cooling
- Low Grade 90kW heating for domestic water
Performance - Carbon reduction *

- 36% carbon reduction
  Combined Cooling Heat & Power

- 40% carbon reduction
  Combined Heat & Power

- Zero Carbon
  AD/Biogas

*All figures are approximate and specific to particular application and are based on grid supplied electricity and piped natural gas. These will vary from size and complexity of installation.

#Carbon reduction based on replacing grid electricity and grid gas fired boiler with grad gas fuelled fuel cell with absorption chiller.
Performance - Financial
Fuel Cell v ICE v Grid Comparison

- CCHP
- Extra Cost/saving per kWe
- 20 yr Life Cycle
- Assumed zero increase above inflation
- 25% more generation
Performance - Financial
Fuel Cell v ICE v Grid Comparison

• CCHP
• Extra Cost/saving per kWhe
• 20 yr Life Cycle
• Assumed zero increase above inflation
• 25% more generation
• 60% increase in primary energy cost?
Performance

- Low emissions
- Low noise – 65dbA
- Availability >95%
- Security of Supply

<table>
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<th>Emissions</th>
<th>lb/MWh</th>
<th>ppm dry</th>
<th>Tons/yr¹</th>
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<td>NOx</td>
<td>&lt; 0.01</td>
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<td>SOx</td>
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<td>CO</td>
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</table>
Available Capacities

- **PEM**
  - 1kWe to 50kWe

- **Phosphoric Acid**
  - 100kWe
  - 400kWe

- **Molten Carbonate**
  - 245kWe
  - 300kW
  - 346kWe
  - 1.4MWe
  - 2.8MWe
System Integration
Quad generation

Fuel Cell System & Power Module

Gas In
Gasification

Gas In
AD Gas

Gas In
Reformation

Export
Electrical distribution

By Product

Quad Generation

Cooling

DI water

Heating

Natural Gas
The Issues

• Lack of awareness
• Short term-ism
• Perception
• True life cycle costing
• Breaking the mould
• Cooperation
• Appropriate incentives
• Energy is cheap
• Heat in summer
• Early influence
Compliance

- Building Regulations – Technical standards
- Local Planning policy – 20% on site renewables
- Low noise
- Low emissions
Incentivisation

• Climate Reduction Commitment - £12/ton - £25 on a £3500 investment per kWe
• CHP QA discourages fuel cell installations
  – Enhanced Capital Allowance
    - 100% capital right off
  – Climate Change Levy
    - £1.59 for gas and £4.56 for electricity per MWh
• Energy from Waste – gate fees
• Renewable Obligations Certificates
• Feed in tariffs
• Level playing field
## Fuel Cell Applications

### Fuel Sources
- Natural gas
- CNG
- LPG
- Methanol
- AD gas
- H₂
- Syn Gas
- Other biofuels

### Applications
- Balanced demands
- Base load application
- Load following (elec)
- Reliable power
- Carbon reduction
Fuel Cell Applications

Sectors

- Hospitals
- University Campus
- Leisure facilities
- Data Centres
- Commercial developments
- Mixed use developments
- Industry
H₂ Generation
Reformation

Natural gas network

AD Gas

Reformer
200 – 250 kW

Compression &
storage 350 –
700 bar

Delivery system

Gasification

Gasification
H₂ Generation
Electrolysis

Electrical energy source

PV

Wind

Grid connected

Fuel Source

Purification

Compression & Storage

Electrolyser

Delivery system
In Summary

Fuel Cells:
- Efficient energy production
- Highest efficiency with balanced loads
- Clean – NO$_x$/SO$_x$
- Quiet
- Higher availability
- Reduce carbon
- Life cycle cost reduction
- Proven technology and improving
- “Transition fuel” technology