Development of a packaged SOFC micro CHP system

Hydrogen & Fuel Cells Conference, NEC Birmingham

25th March 2009

Jeremy Harrison

The Energy Challenge facing the UK

UK Government Energy Policy Objectives:

Reduce CO2 emissions by 60% by 2050

Ensure security of energy supply

Eliminate Fuel Poverty*

....all within a competitive market

* Fuel Poverty is defined as a household spending more than 10% of disposable income on energy

The capacity gap

Coal & nuclear plant closures

26GW of plant closures by 2015

Demand may exceed supply in winter peaks ~ 2011

New capacity needed by 2020

~ 36 GW or 45% of UK capacity

Replacement with gas-fired CCGTs will:

not reduce overall CO2 emissions

lead to ~70% gas dependency – for power

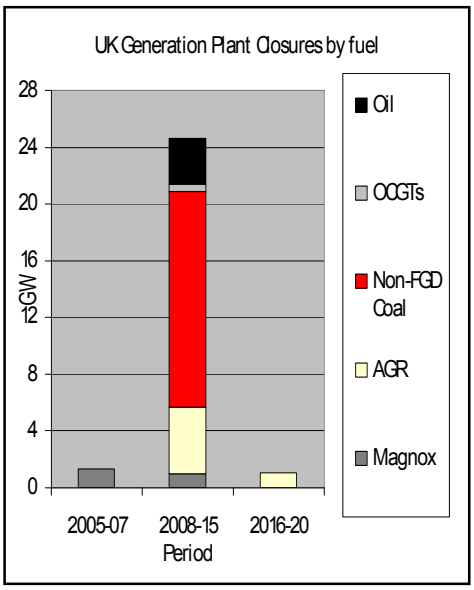
There are a number of uncertainties:

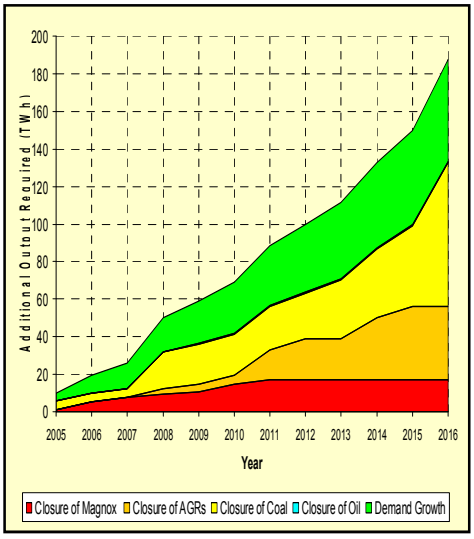
Environment – LCPD, Carbon

Growth of renewables, demand

Technology viability (type/fuel cost)

Government Policy





E.ON operates as an integrated player with strong positions across the traditional value chain in the UK

Generation

- Generating 10% of the UK's power requirements (incl. 13 industrial CHP sites)
- Consultancy providing specialist engineering and technical services
- Trading power, coal, gas, oil and carbon

Distribution (Central Networks)

- Central Networks brings power to 5 million customers
- Maintenance of 133,000 km of underground and overhead cables and almost 97,000 substations

Retail (E.ON Energy)

- Gas, electricity and Home Energy Services to over 6 million homes and small and medium businesses
- 13,000 industrial and commercial customers

Energy Services

- Metering Services, Home Installation and New Connections
- Our aim is to simplify business for major clients' power and gas needs through our one stop shop approach

E.ON employs more than 17 000 people in the UK

How will these challenges impact our low carbon future?

Change the way we think about and use energy

Think **beyond** our current paradigm

Recognise the need to **innovate** in meeting our energy needs

Acknowledge that consumers have a role to play in a **distributed energy economy** through microgeneration

How can Distributed Energy （DE） make a difference?

Distributed Energy can support a shift to low carbon future as it...

Produces energy at, or close to, the point of demand

Utilises locally available resources

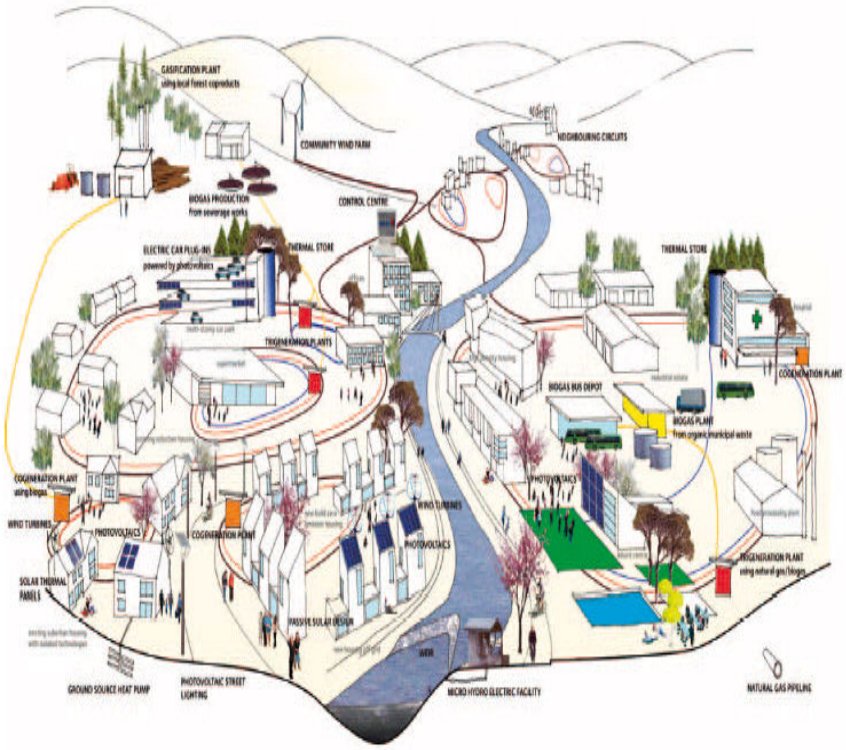
Allows incremental investment and risk

Avoids distribution losses

Avoids catastrophic failure

Includes all forms of energy

Empowers individuals



Source: Distributed Generation Coordinating Group （DGCG）

How micro CHP supports UK energy policy ?

Fuel Poverty

Micro CHP can do as much for fuel poverty by 2030 as all energy efficiency measures put together, including micro CHP

Policy Studies Institute, January 2005

Environmental

Micro CHP is one of the most cost-effective Carbon mitigation technologies

Energy White Paper

Security of supply

Reduces need for back-up capacity for intermittent (renewable) generation

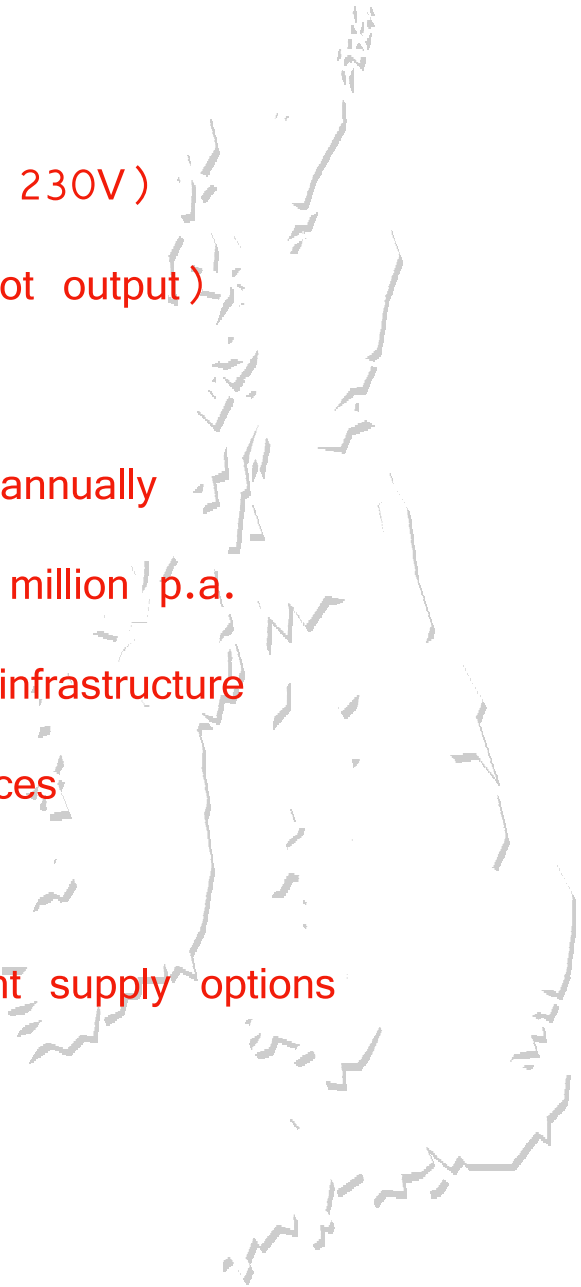
Environmental Change Institute, 2004

Competitive market

...savings in deferred network upgrades and improved operational efficiency estimated at up to £1.2 billion by 2020.

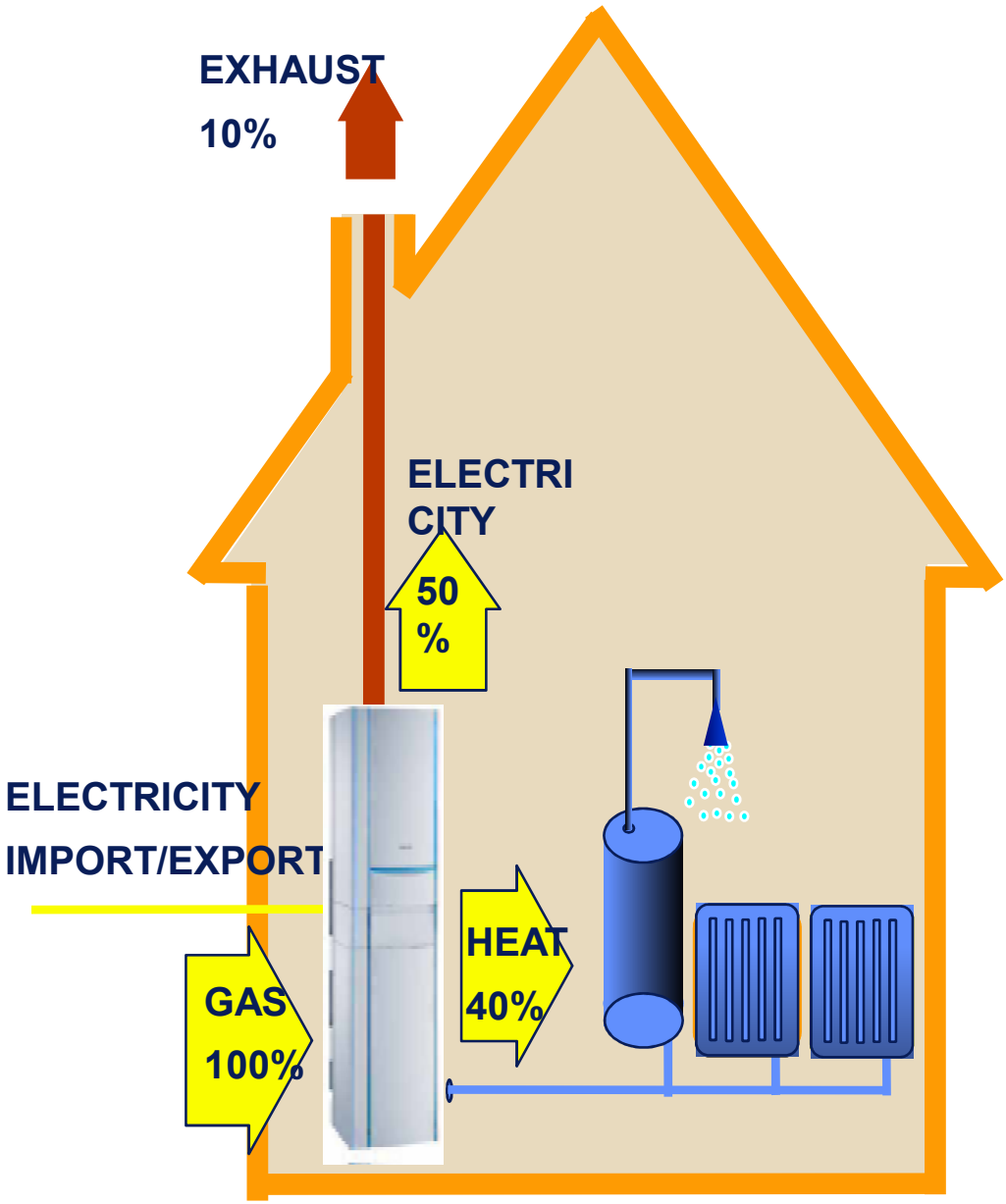
SIAM study, Mott McDonald 2004

Potential of micro CHP in UK



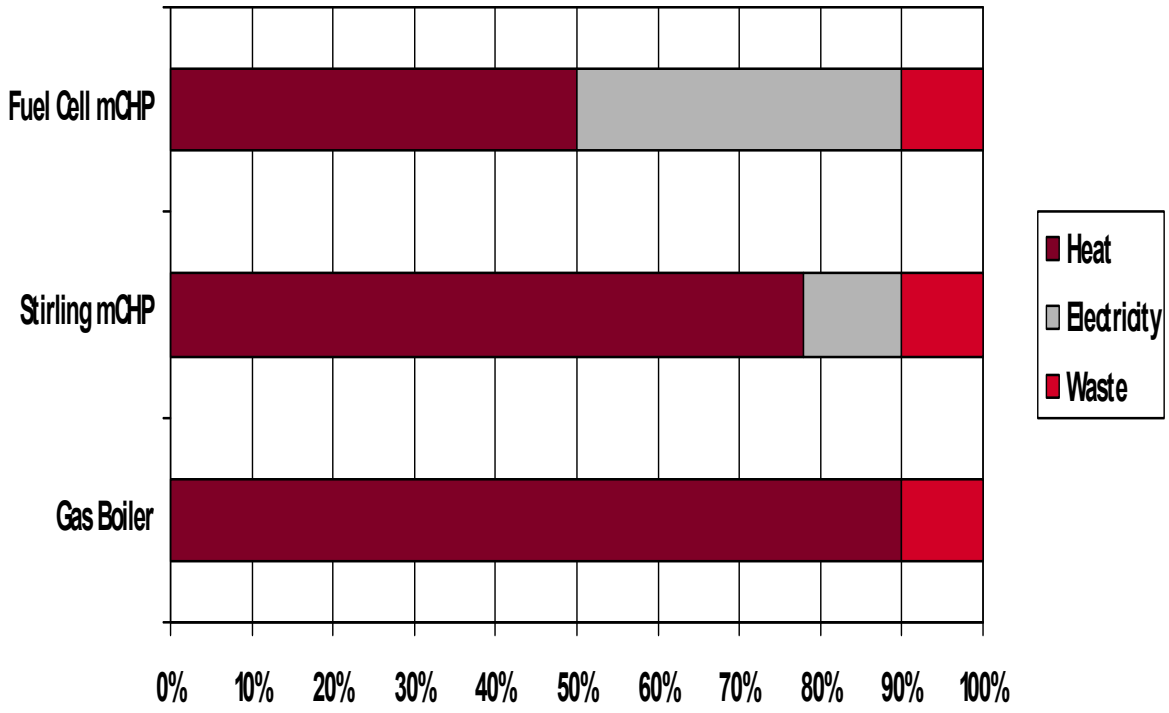
- 15-22GWe installed capacity (at 230V)
- Equivalent to nuclear capacity (not output)
- 12 million suitable homes in UK
- 33 million tonnes CO_2 reduction annually
- Boiler replacement market ~ 1.5 million p.a.
- Utilisation of existing fuel supply infrastructure
- Extends life of finite fossil resources
- Low risk, incremental solution
- Complements other energy efficient supply options

Micro CHP （Combined Heat & Power） concept



Micro CHP replaces boiler in conventional central heating system

Basic rationale for micro CHP

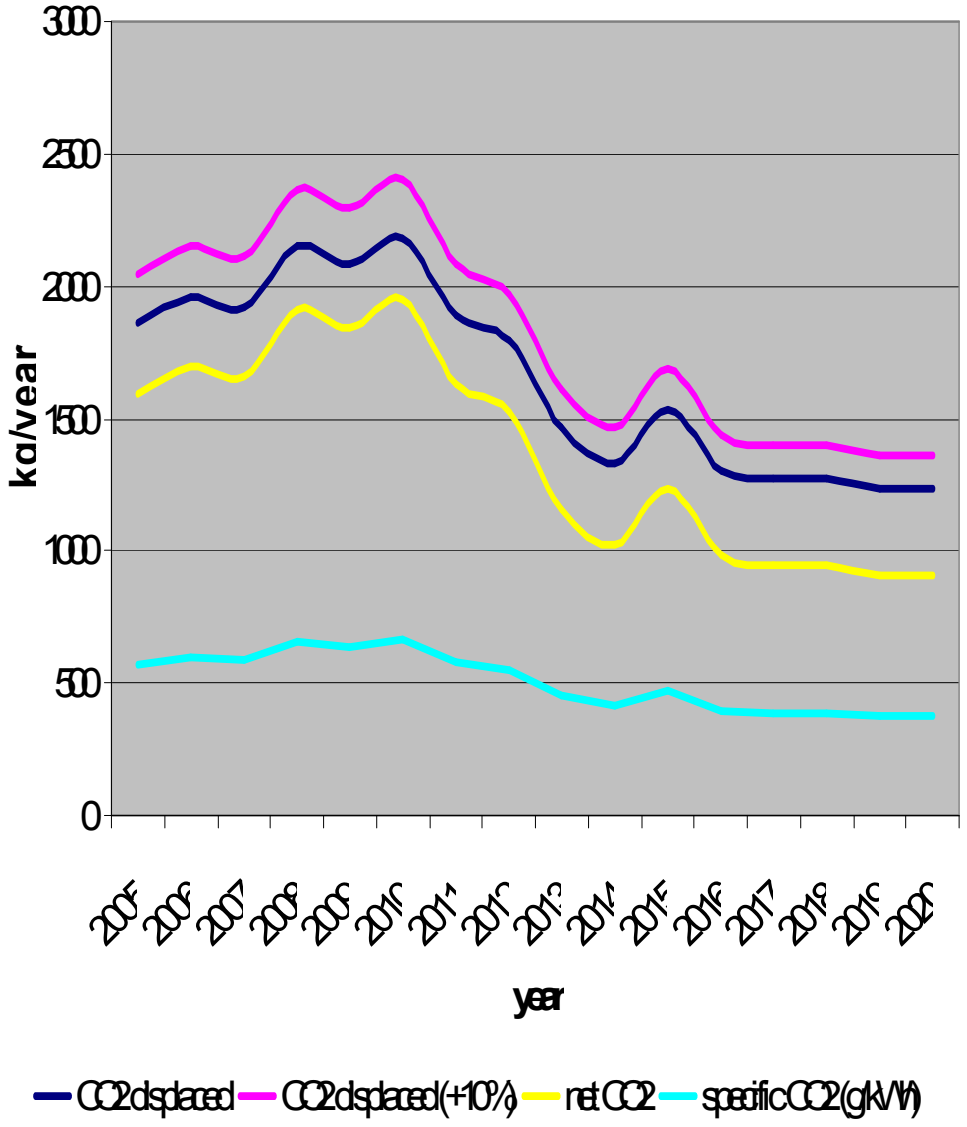


For same total system efficiency, each kWh of electricity produced ***costs*** value of 1kWh of heat, but is ***worth*** the avoided cost of 1kWh of electricity:

1kWh mCHP electricity costs 3.3p (€0.05) and is worth 10p (€0.15)

1kWh mCHP electricity costs 0.22kg CO_2 and is worth 0.568kg CO_2

CO_2 displaced by micro CHP generation*



* WG800 Mk2 micro CHP unit with 23,000kWh total annual thermal demand

Carbon mitigation from microgeneration

Technology	Total CO2 (kg/year)*	CO2 saving (kg/year)	Lifetime £/tonne	kg CO2/kWh generated
Condensing boiler	8596	-	-	-
Condensing boiler + PV	8088	509	786	0.25
Condensing boiler + wind	8342	254	591	0.06
Stirling micro CHP ($\acute{\eta}_{el}$ =10%; $\acute{\eta}_{tot}$ = 90%)	7515	1081	55	0.22
SOFC micro CHP ($\acute{\eta}_{el}$ = 40%; $\acute{\eta}_{tot}$ = 80%)	6075	2521	48	0.27

*family home, 23000kWh heat, 6000kWh electricity

Importance of capturing "waste" heat

CASE 1: WITH HEAT RECOVERY

Assume total efficiency, $\acute{\eta}_{tot}$ = 90% (50% electrical)

CO_2 emissions to generate electricity = 0.22 kg/kWh

CO_2 saving = 0.568 - 0.22 = 0.348 kg/kWh

Annual electricity production = 8760 kWh

Total saving= 3087 kg per year

CASE 2: NO HEAT RECOVERY, BUT HIGHER ELECTRICAL

Assume total efficiency, $\acute{\eta}_{tot}$ = 70% (all electrical)

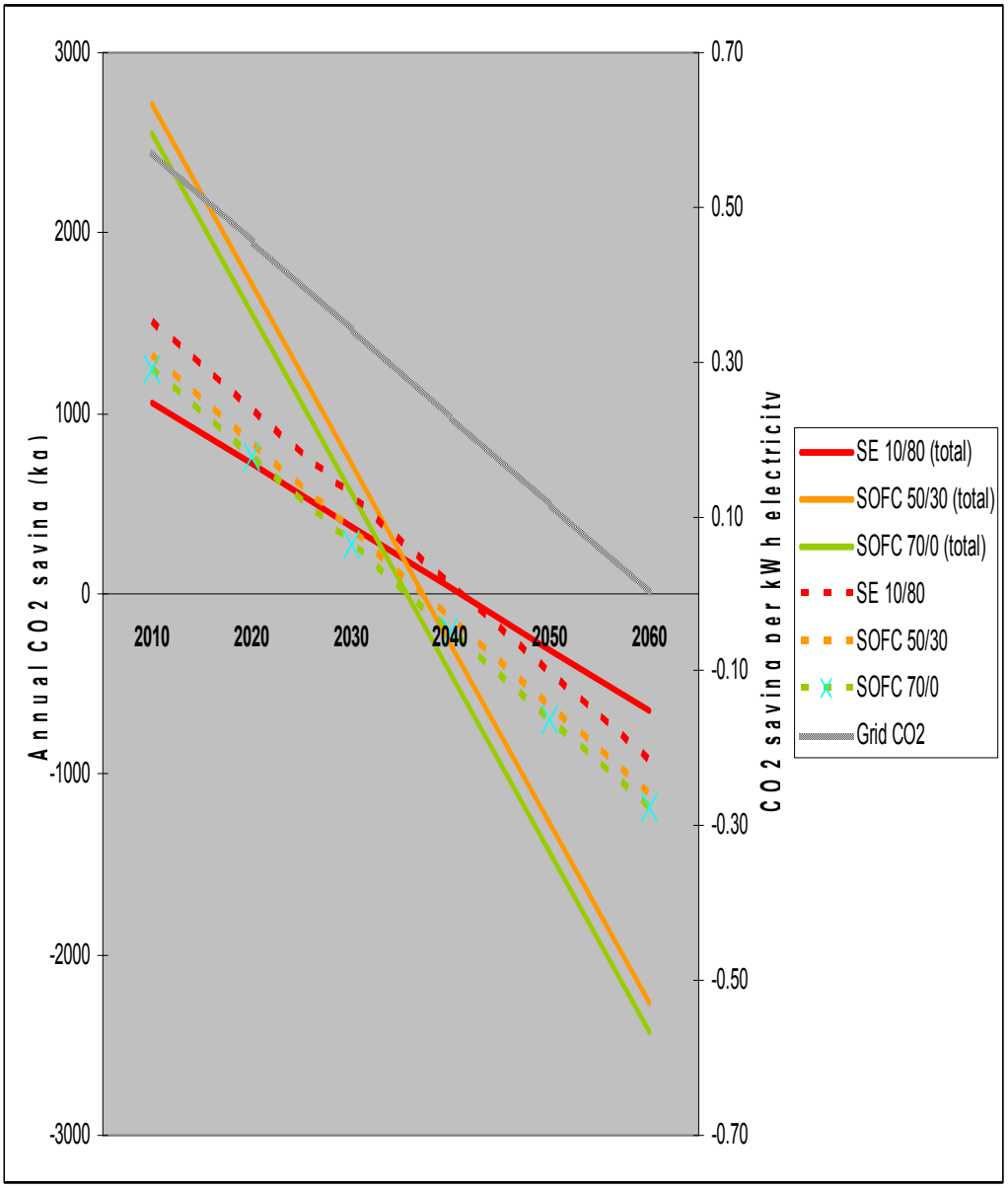
CO_2 emissions to generate electricity = 0.28 kg/kWh

CO_2 saving = 0.568 - 0.28 = 0.288 kg/kWh

Annual electricity production = 8760 kWh

Total saving= 2548 kg per year

CO_2 mitigation trend to 2060



Partnership approach to development

Ceramic Fuel Cells

- Focus on SOFC stack
- Electrical efficiency
- Degradation

Gledhill Thermal Storage

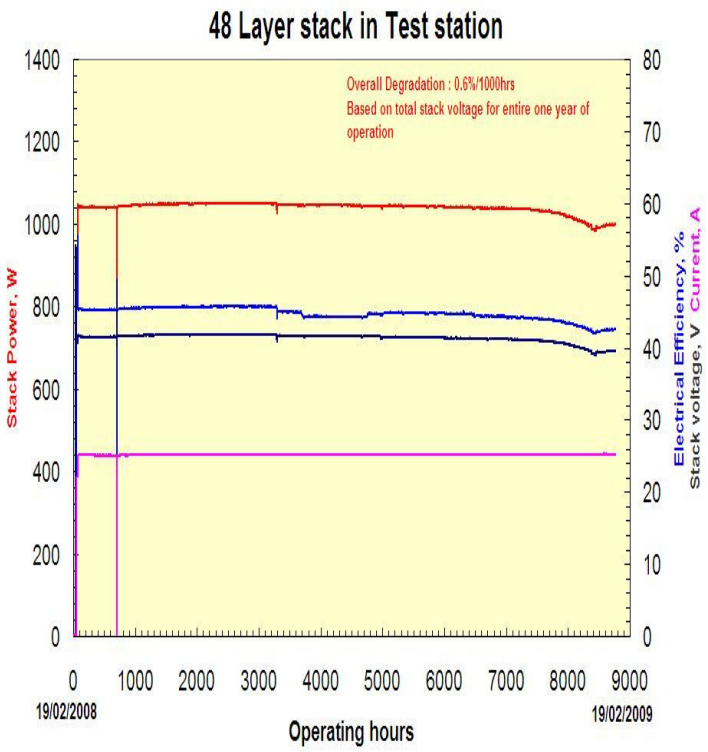
- Package integration
- Heat transfer
- Thermal storage
- Match to thermal demands of home

EON

- Market focussed development
- Modelling of electricity & heat production
- Evaluation of environmental and economic potential

Progress during 2008

- Stack efficiency >60%
- Package degradation < 2% per 1000 hours
- Matching of thermal output to domestic hot water baseload <400W_t
- Optimisation of package to avoid heat dumping & maximise electrical production
- Improved understanding of potential impact on energy system



Summary

SOFC micro CHP potential benefits & business opportunities

- Lower energy bills for customers
- Alternative revenue stream for supplier
- Societal and environmental benefits

...but significant challenges remain

- Need to demonstrate efficiency (electrical and total) & life
- Inability to recover full value (transaction costs destroy value)
- No long term mechanism to reflect environmental benefit
- Imbalanced tax regime

....and time is running out!