



The Future of the European Gas Industry, Regulations & Emerging Technologies

ASGE Technical Conference
Las Vegas, 6 June 2017

Paul Needley
CEng FIMechE



Introduction

Paul Needley – Chartered Engineer
Managing Director – Enertek International Ltd

Industry Roles:

- Board member of HHIC
- Chair of the HHIC mCHP Steering Group
- Industry Member of the All Party Parliamentary Group for Energy Studies Executive Council



Contact details: paul.needley@enertek.co.uk



Enertek International Ltd

International Consultants in Gas, Oil and Electrical Appliance Design, Development and Certification.

- Independent Company. Est 1988
- Based in East Yorkshire, UK
- Operations worldwide
- 30 Staff including 20 Engineers
- Design, Development, Independent testing / product assessments
- UKAS (ILAC) Accredited Quality System (ISO 17025)
- Assistance with Acquiring Certification
- Market Specification and Advice
- Clients include major multinationals, small businesses and Government Departments
- Confidentiality Assured





UK and / or Europe?

- Brexit likely to have no effect on gas appliance design or safety
- The UK and European Gas Industry is very integrated
- ISO Standards are not dependent on the EU
- The UK government will not accept any lower Standards than mainland Europe





European Energy Policy Objectives

- 1) To reduce emissions – CO₂ and NO_x
- 2) To use energy more efficiently

These two objectives are connected - simply using less energy reduces emissions, but larger emission reductions are required to meet international agreements.





Challenges

- The laws of physics limit maximum efficiency
- Building energy consumption – Insulation helps but can be impractical and uneconomical

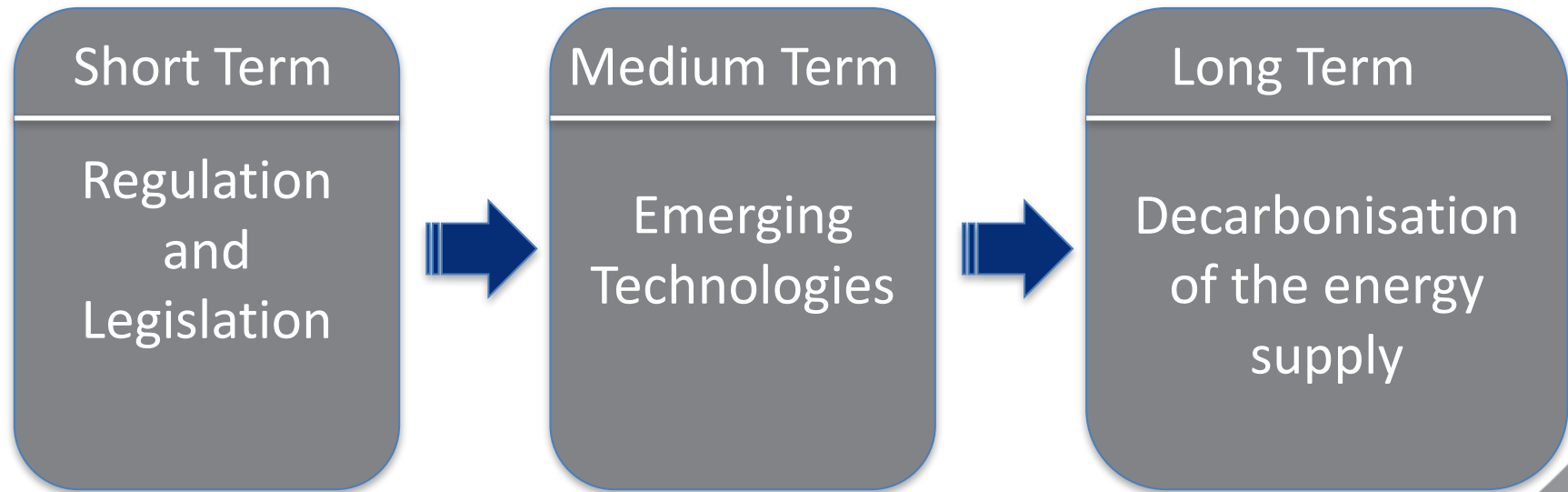


- New, innovative solutions are required



The Solution?

Today I will proposed three scenarios:





Regulation and Legislation

Government level

- Driven by International agreements
- Most recently the Paris Agreement
- UK Climate Change Act

Industry level:

- Product and installation standards
- Product certification requirements





International Agreements



The Paris Agreement


- No more discussion on that one here today

UK Climate Change Act

- A commitment to reduce UK CO₂ emissions to 80% of the 1990 level by 2050



Industry Level Legislation

- Driving change by forcing innovation.....
- Historical precedents exist
 - Pre 1995 – No national requirement for certification.
 - Voluntary schemes existed
 - ✓ UK – British Standards (BSI)
 - ✓ British Gas Approval
 - ✓ BSI Kitemark 





1993

Gas Appliance
Directive (GAD) was
published

Notified Bodies
were appointed to
facilitate
certification



1996

January 1st – GAD
was introduced

CE Marking of gas
equipment
became
mandatory

GAD required
third party
(Notified Body)
certification



CE Marking of Gas Equipment

- The product (appliance) has to meet:
 - All Necessary European Directives
 - And
 - Be manufactured under a certified quality system
- Only then can the manufacturer affix a CE Mark

CE



The Gas Appliance Directive (GAD)

To acquire Certification to the GAD:

- Agree a Technical Solution with a Notified Body to prove compliance with the **Essential Requirements** of the GAD

This is achieved by either:

- Compliance with a harmonised EN European Norm (Standard)
- Or
- A bespoke agreement (if no harmonised Standard exists)





What are 'all necessary Directives?'

Typically; depending on type of appliance:

- Gas Appliance Directive
- Low Voltage Directive
- EMC Directive
- Boiler Efficiency Directive
- Eco Design of Energy-related products Directive (2015) with additional requirements in 2017 and 2018)
- Energy Labelling Directive (2015)
- Construction Products Regulations
- Machinery Directive
- Pressure Equipment Directive
- And others will be in the future...

Other Relevant Legislation

Whilst CE Marking enables the product to be sold in Europe,
National rules sometimes limit installation

For example, in the UK

- Building Regulations Part L, Part G
- WRAS Scheme for water fittings

Other countries have similar legislation

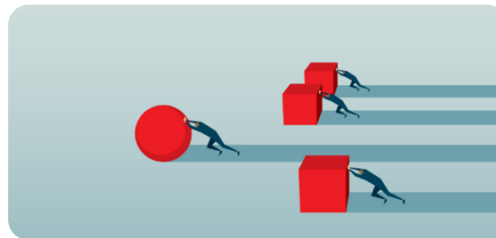




Does Legislation drive innovation?

Yes: Evidence exists for both safety and performance...

- GAD mandated spillage shut off devices (TTB's)
- GAD mandated overheat thermostats
- GAD mandated safety devices on gas fires (ODS)
- BED increased boiler efficiency levels
- Gas related deaths (UK) fell by over 50% between 1997 and 2007



The following survey information was kindly provided by BSI...

Survey Findings – Safety of gas appliances

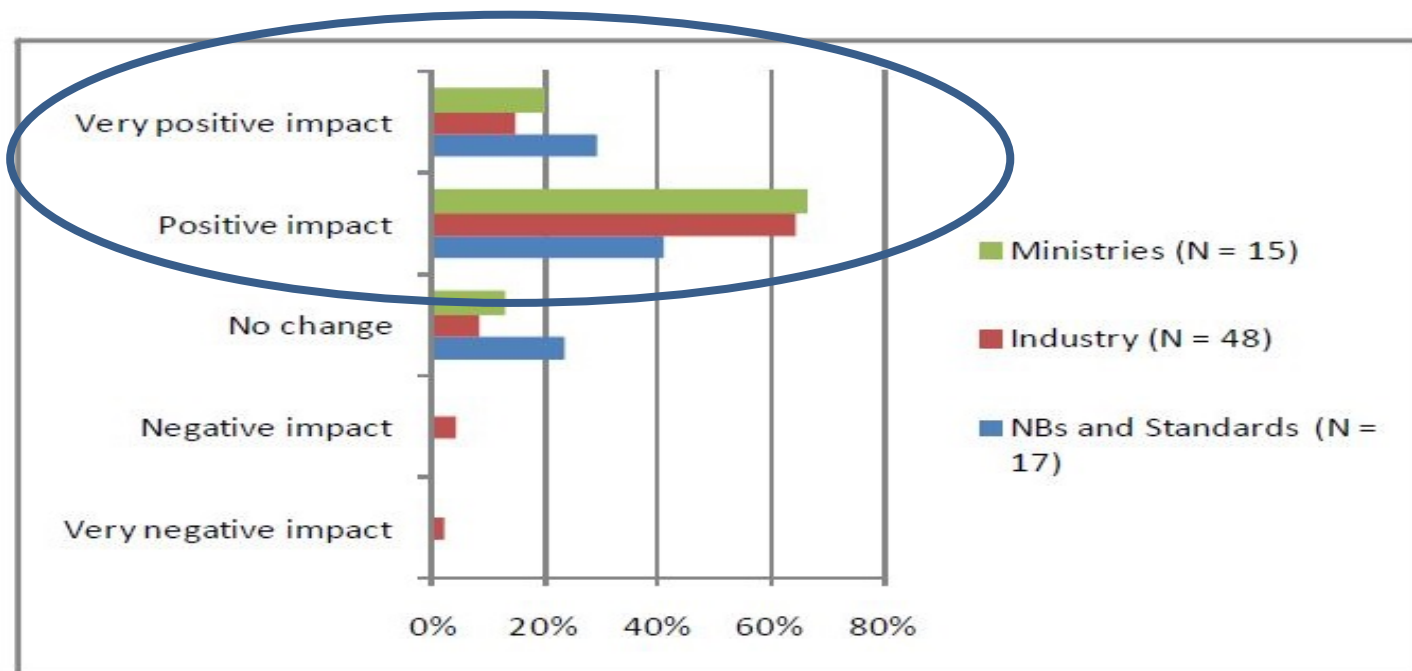


Figure A3.5: Responses to the question: *Has the GAD resulted in an improvement of the level of safety of gas appliances (including fittings) within its scope?*

Survey Findings – Trade in gas appliances

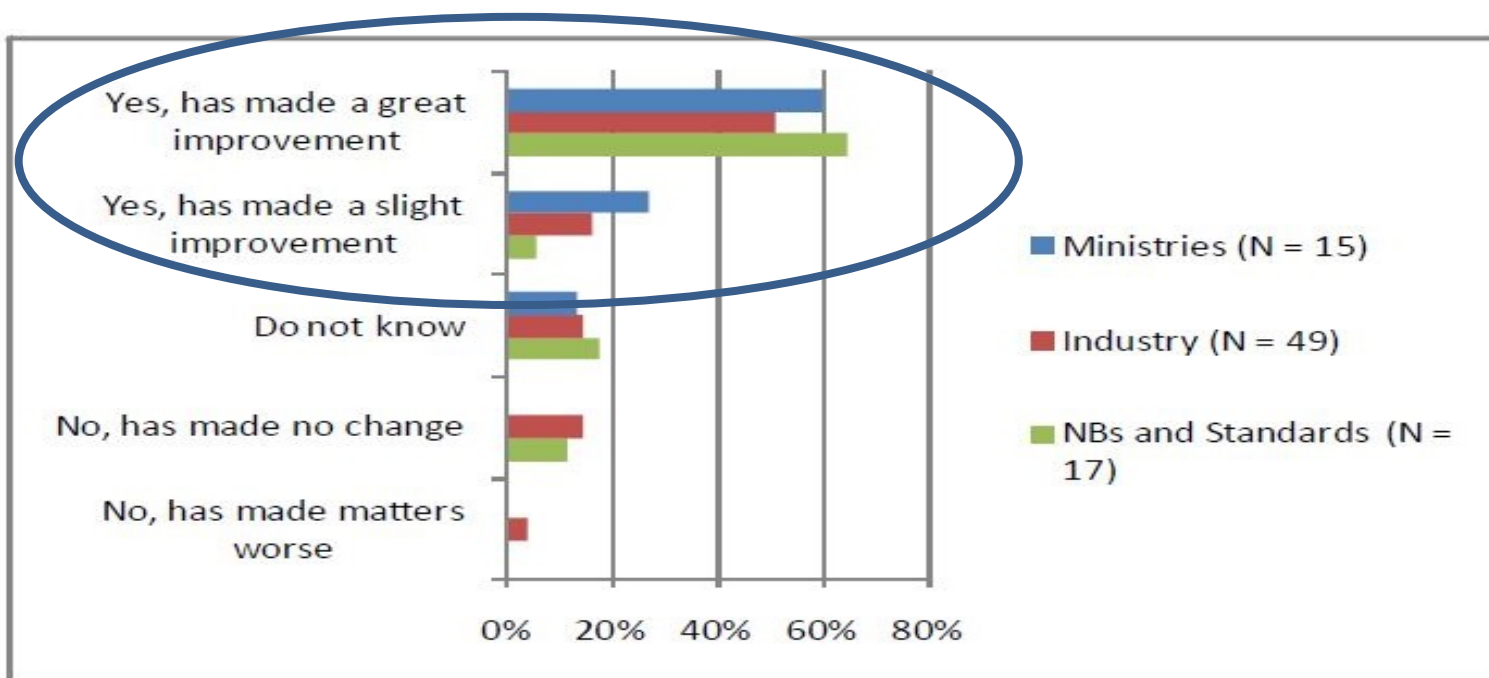


Figure A3.3: Responses to the question: *Do you think that the GAD has contributed to an effectively operating internal market?*



What Next?

The GAD has some weaknesses:

- There are now over 55 Notified Bodies with varying levels of expertise
- Standards do not always keep pace with innovation
- Products are certified for their intended use only
- A certified cooker caused at least 8 deaths
- National surveillance authorities do not have jurisdiction overseas





The Gas Appliance Regulation (GAR)

On 21 April 2018 the GAR will replace the GAD

Key changes include the requirement:

- to meet the 'state of the art'
- to perform a risk assessment
- to consider foreseeable misuse





The following slides are reproduced with kind permission from Graham McKay.

BSI is one of only 3 GAR Notified Bodies accredited to date)

Graham McKay

**Global Head of Gas & Electrical
Products**

BSI Group, Holywell Park, Ashby Road,
Loughborough, LE11 3AQ, United Kingdom

Contact: graham.mckay@bsigroup.com

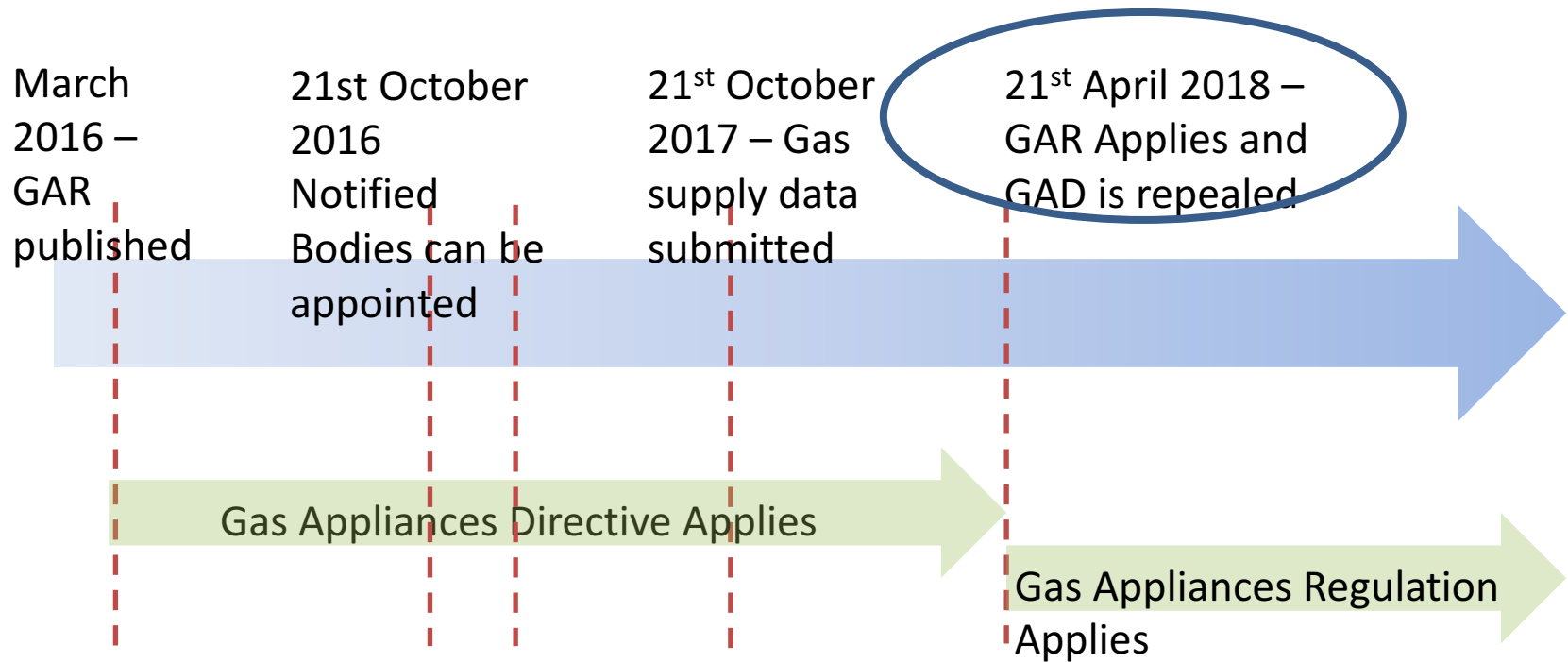


Outcome of Commission Review into GAD



- GAR Published March 2016
- Regulation not Directive so no new national laws needed
- Comes into force 21 April 2018 across all EU
 - Products comply with current legislation until 20 April 2018
 - Products comply with new Regulation from 21 April 2018
 - Products placed on market before 21 April not affected
- GAD will be repealed

Timeframes for Changes from the GAD to GAR



February 2017
– BSI
appointed as
GAR Notified
Body

Copyright © 2016 BSI. All rights reserved.



1) Scope Changes

- “Cooking” defined



- “Burning” defined



- “Washing” defined



1) Scope Changes

- “Air-Conditioning” now included
- Fittings no longer need to be “separately marketed”
- Removed exclusion for water temperature $>105^{\circ}\text{C}$
 - High-temp boilers are now within GAR scope

The great “water temperature” anomaly...



Gas Boiler

Thermostat set to 95°C

GAD applies... so requires

- NB Type Testing
- NB Factory Surveillance

LVD, EMC & PED may apply too (all self-declaration)

Copyright © 2016 BSI. All rights reserved.

The great “water temperature” anomaly...



Gas Boiler

Thermostat set to 110°C

GAD no longer applies...

LVD, EMC & PED may apply too (all self-declaration)

So the **higher-risk** product has a much reduced regime...?

Copyright © 2016 BSI. All rights reserved.

2) Economic Operator Duties

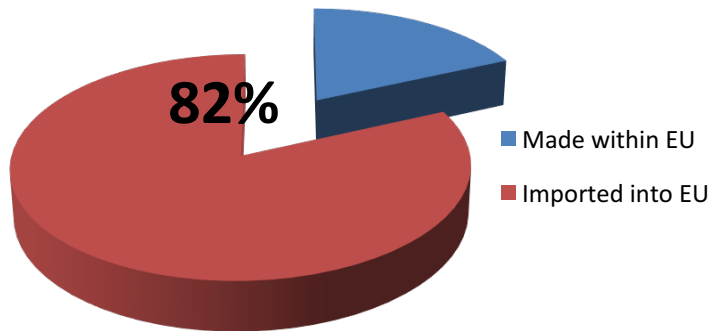
Duties for “Manufacturers” – now defined

- And “Importers”
- And “Distributors”...



New duties for importers

- **82%** of gas appliances found to be unsafe were made outside the EU
- Growing problem as shift in manufacturing to outside the EU
- Hard to take action against non-EU “manufacturer” under GAD...
- Importers have to cooperate with the authorities and take more responsibility to ensure that:

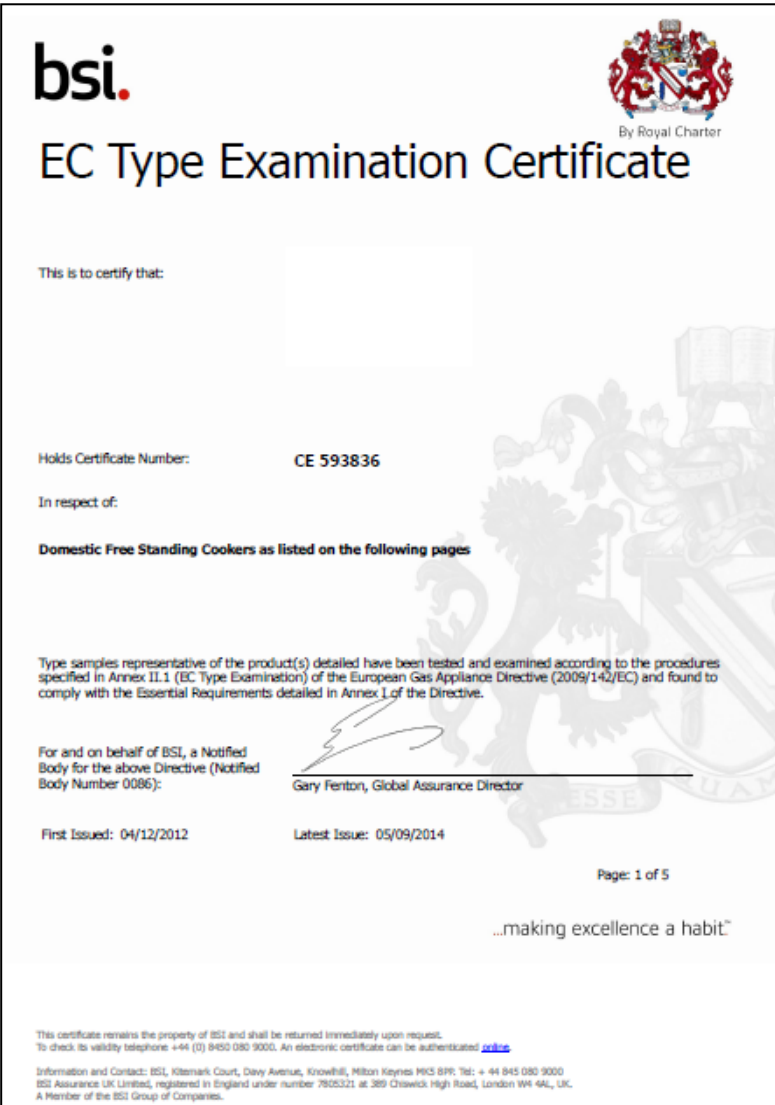


- GAR Process has been followed
- Appliances are compliant
- Instructions are adequate
- Complaints are investigated
- Action is taken to ensure safety

Conformity Assessment Procedures

Validity Periods

- New regulation introduces a **maximum** certificate validity period of 10 years.
- During this ten year period you can still make modifications to the product as you do currently.
- At the end of the validity period the manufacturer can apply for an extension and a new Type Examination Certificate may be issued with a new 10 year expiry.



The image shows a BSI EC Type Examination Certificate. At the top left is the BSI logo. At the top right is the Royal Coat of Arms with the text 'By Royal Charter'. The title 'EC Type Examination Certificate' is prominently displayed. Below this, it states 'This is to certify that:'. The certificate number 'CE 593836' is listed under 'Holds Certificate Number:'. The product description 'Domestic Free Standing Cookers as listed on the following pages' is under 'In respect of:'. A paragraph of text describes the testing process: 'Type samples representative of the product(s) detailed have been tested and examined according to the procedures specified in Annex II.1 (EC Type Examination) of the European Gas Appliance Directive (2009/142/EC) and found to comply with the Essential Requirements detailed in Annex 1 of the Directive.' The signature of Gary Fenton, Global Assurance Director, is present under 'For and on behalf of BSI, a Notified Body for the above Directive (Notified Body Number 0086):'. The issue dates 'First Issued: 04/12/2012' and 'Latest Issue: 05/09/2014' are at the bottom. The footer includes the BSI logo, copyright notice, and contact information.

bsi.

By Royal Charter

EC Type Examination Certificate

This is to certify that:

Holds Certificate Number: CE 593836

In respect of:

Domestic Free Standing Cookers as listed on the following pages

Type samples representative of the product(s) detailed have been tested and examined according to the procedures specified in Annex II.1 (EC Type Examination) of the European Gas Appliance Directive (2009/142/EC) and found to comply with the Essential Requirements detailed in Annex 1 of the Directive.

For and on behalf of BSI, a Notified Body for the above Directive (Notified Body Number 0086):

Gary Fenton, Global Assurance Director

First Issued: 04/12/2012 Latest Issue: 05/09/2014

Page: 1 of 5

...making excellence a habit™

This certificate remains the property of BSI and shall be returned immediately upon request. To check its validity telephone +44 (0) 8450 080 9000. An electronic certificate can be authenticated [online](#). Information and Contact: BSI, Kitemark Court, Davy Avenue, Knowlhill, Milton Keynes MK5 8PP. Tel: + 44 845 080 9000 BSI Assurance UK Limited, registered in England under number 7805323 at 389 Chiswick High Road, London W4 4AL, UK. A Member of the BSI Group of Companies.

5) Notified Body Impact

- Significant changes to Notified Body rules
 - The requirements for appointment of notified bodies has changed to ensure they are **competent** across the whole of the EU to carry out the work they are appointed for.
- Already seeing some of the 50+ Notified Bodies resign
- BSI has already been appointed under GAR

GAR Requirements for Notified Bodies – Key changes

- ...shall have the requisite technical competence in the specific field and must have sufficient and appropriate experience to perform the conformity assessment procedures
- ...shall have personnel responsible for conformity assessment procedures with sound technical and vocational training, appropriate knowledge and understanding of the essential requirements and applicable harmonised standards.
- ...shall participate in activities and groups to ensure proper cooperation and coordination.

6) GAR Essential Requirements

Generally only relatively minor changes... but a few new important requirements for manufacturers:

1. To take into account the “state of the art”
2. To perform a risk assessment for all products placed on the market – must consider foreseeable misuse
3. To implement hazard/risk reduction techniques
 - Remove / Guard / Warn – in that order

Intention is these will help deal with weak standards etc.



Summary - Legislation

- The new legislation is well intentioned
- As a Regulation, (not a Directive) it is implemented by EU law, not National legislation.

Finally regarding legislation:

- The key to successful high efficiency and low emission appliances depends on one key sector of the industry -
Gas Engineers working in product development



2) Emerging Technologies

- Heat Pumps – Electric
- Heat Pumps – Gas
- Hybrid Heat Pumps
- mCHP
- Heat Networks
- Solar PV
- Solar Thermal



Heat Pumps – Electric

- Ground Source or Air Source
- Coefficient of Performance typically up to 3 (300% efficiency)
- Relatively expensive
- Struggle with high temperature heating requirements.





Heat Pumps – Gas

Adsorption (e.g. Viessmann) or Absorption (eg Robur) technology

Intensive R&D taking place. Good potential

Robur K18

The world's first gas heat pump for domestic use





Hybrid Heat Pumps



- Suitable for retrofit – Add a heat pump to an existing boiler
- Integral products becoming available – e.g. Viessmann Vitosorp
- Overcomes low temperature issues



Micro Combined Heat & Power

Co-generation of heat & power in a domestic setting

Replaces or supplements a boiler

Technologies available include:

- Stirling engine
- Internal combustion engine (ICE)
- Organic Rankine Cycle
- Fuel Cells
- Thermo-acoustic Stirling Engine
- Microturbine



Overall Advantages of mCHP

- mCHP appliances are more efficient than power stations because the heat is used
- There are no transmission losses between generation and point of use
- Electricity is generated at times of peak demand
- Widescale adoption of mCHP reduces the need for new power stations
- The user saves money on energy costs proportional to the difference between the cost of gas and electricity
- Improved security of supply - the user is potentially grid independent



The Potential for mCHP

- Mass adoption would reduce the need for power stations
- mCHP operates at times of peak demand – Time of day tariffs?
- A virtual Power station or smart grid could be created by utilities controlling mCHP through the internet of things
- mCHP can run on a variety of fuel sources
- mCHP can be deployed much faster than new power stations can be built
- mCHP has the potential to revolutionise the energy market
- New business models may emerge – leasing, services etc.



Stirling Engine mCHP

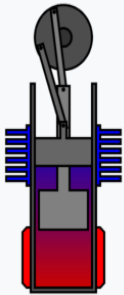
Invented by Robert Stirling in 1816

External combustion – Low maintenance

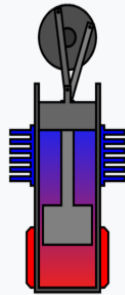
Electrical efficiency circa 15%

Power:Heat ratio approx. 1:8

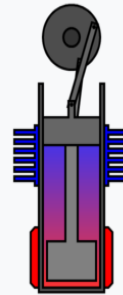
https://en.wikipedia.org/wiki/Stirling_engine#/media/File:Stirling_Animation.gif



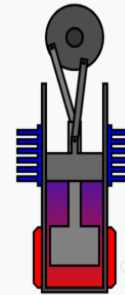
1. Power piston (dark grey) has compressed the gas, the displacer piston (light grey) has moved so that most of the gas is adjacent to the hot heat exchanger.



2. The heated gas increases in pressure and pushes the power piston to the farthest limit of the **power stroke**.



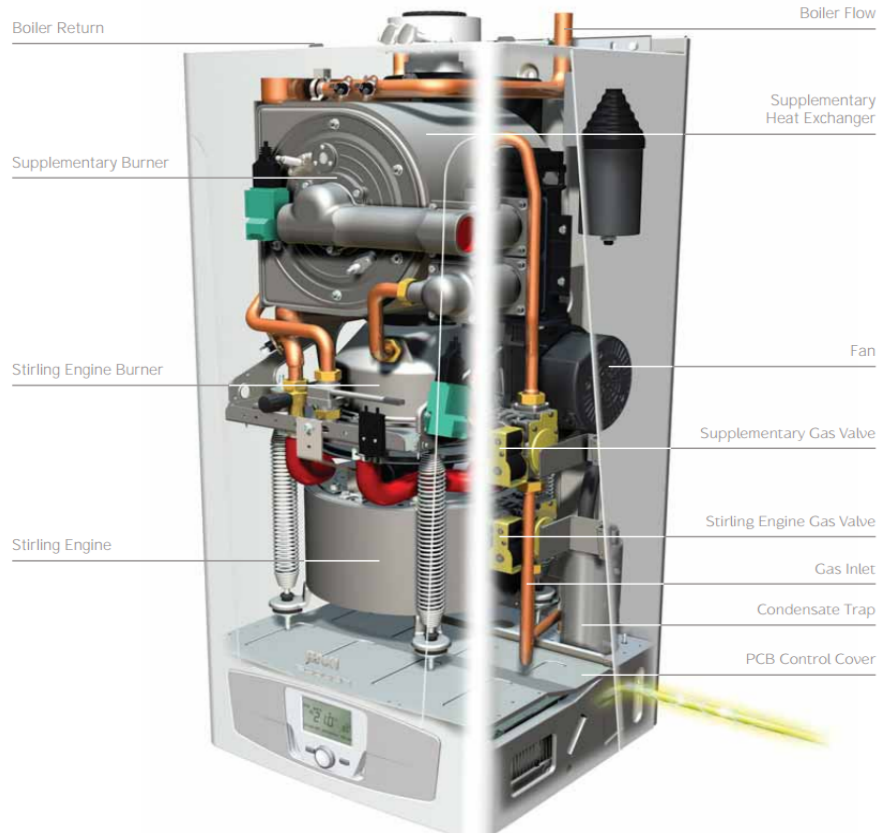
3. The displacer piston now moves, shunting the gas to the cold end of the cylinder.



4. The cooled gas is now compressed by the flywheel momentum. This takes less energy, since its pressure drops when it is cooled.



Commercialisation of Stirling Engines



Baxi offer a 1kW domestic wall hung product – Ecogen

A boiler replacement with a supplementary heat exchanger

Looks and behaves like a boiler



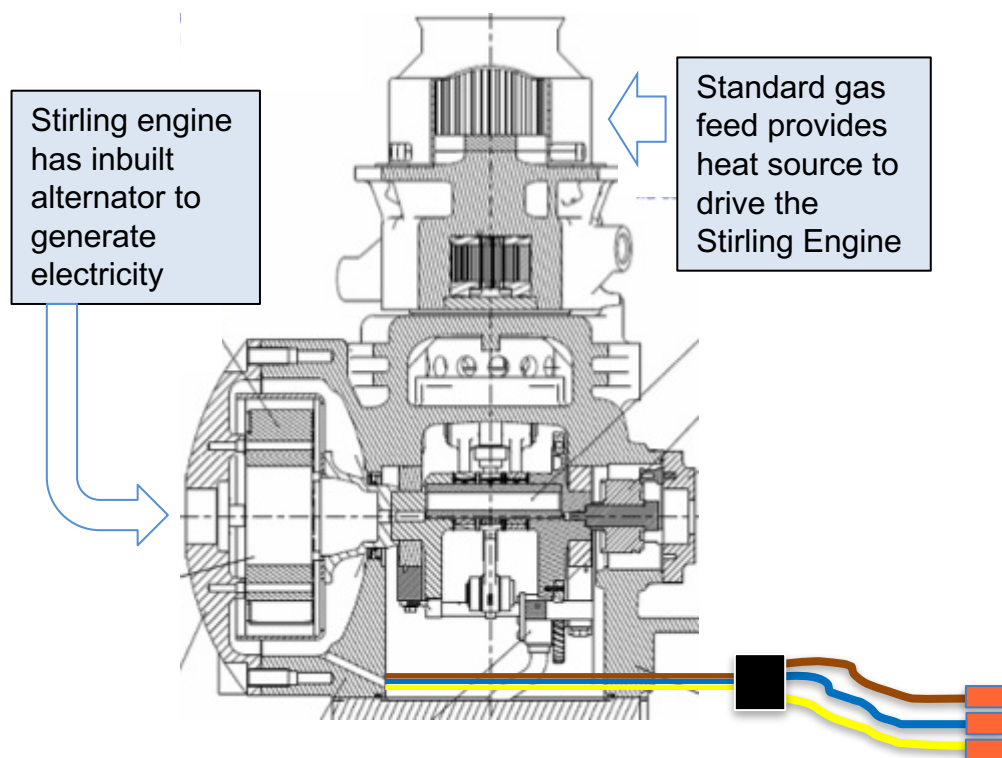
Inspirit Energy:
Based in Sheffield U.K.

Developing a 3 kW
Stirling Engine



Micro CHP: The Inspirit Stirling Engine

Inspirit has developed and is commercialising a mCHP Stirling engine



3kW of electricity
revenue worth up to £2,600 p.a depending on heat
demand & run hours

Advanced Technology

- ◆ Patented heater head thermal energy transfer.
- ◆ Kinematic Beta Stirling Engine with combined displacer and compressor piston.
- ◆ Rhombic drive assembly for low noise and vibration characteristics.
- ◆ Dry gearbox to eliminate oil penetration.
- ◆ Sealed for Life to minimise maintenance frequency and costs



Internal Combustion Engine mCHP

Internal combustion – familiar technology

Electrical efficiency circa 25%

Power:Heat ratio approx. 1:4

Several manufacturers –

- Baxi Dachs,
- Honda
- Sustainable Power



Sustainable Power (U.K.) – Spice 2E (2kW_e)





Honda 1kWe (Japan / Germany)



Organic Ranking Cycle



Flow Energy:

Flow offer a mCHP appliance based on the ORC as part of a 'home energy' package



Flow Group's Test facility



Flow mCHP Units
undergoing life tests





Fuel Cells

Various types of fuel cell are available or under development

Electrical efficiency circa 50%

Power:Heat ratio approx. 1:1

PEM (Proton Exchange Membrane) and SOFC (Solid Oxide Fuel Cell) are the most common

Several manufacturers including:
Viessmann & Ceres Power

Installations planned under ene.field



Introduction and welcome

Welcome to ene.field, Europe's largest ever demonstration and investigation project for fuel cell micro CHP technology.

Micro CHP stands for 'micro combined heat and power'. This technology generates heat and electricity simultaneously, using your gas supply as the energy source. In this instance it does so with a fuel cell, producing energy for you to use at home.

We thank you for your participation in this innovative project and we look forward to learning from your experiences of living with a micro CHP system.

In this document you'll find an introduction to the project and quick facts on fuel cell micro CHP. There are also some tips on how to use your system most effectively. The best thing to do is to understand what your system can produce and to keep an eye on the electricity and heat you use at home. Fuel cell micro CHP is a technology for everyone and fits well to a modern lifestyle.

If you want to learn more about the project or wish to get in touch with the ene.field team visit our website <http://enefield.eu>. Any technical related questions regarding your system should be directed to your installer or energy supplier.

Enefield project

<http://enefield.eu/>



Heat Networks

- Also known as District Heating
- Ideal for city centre apartments
- Enable economies of scale
- Facilitate efficient central boiler plant or CHP
- Substantial investment by EU Governments





Solar PV & Solar Thermal

- Advantages most prevalent in summer
- Not useful at times of peak demand
- Good as a supplementary source of heat /power
- Outside the scope of gas engineering





The Challenges for emerging technologies?

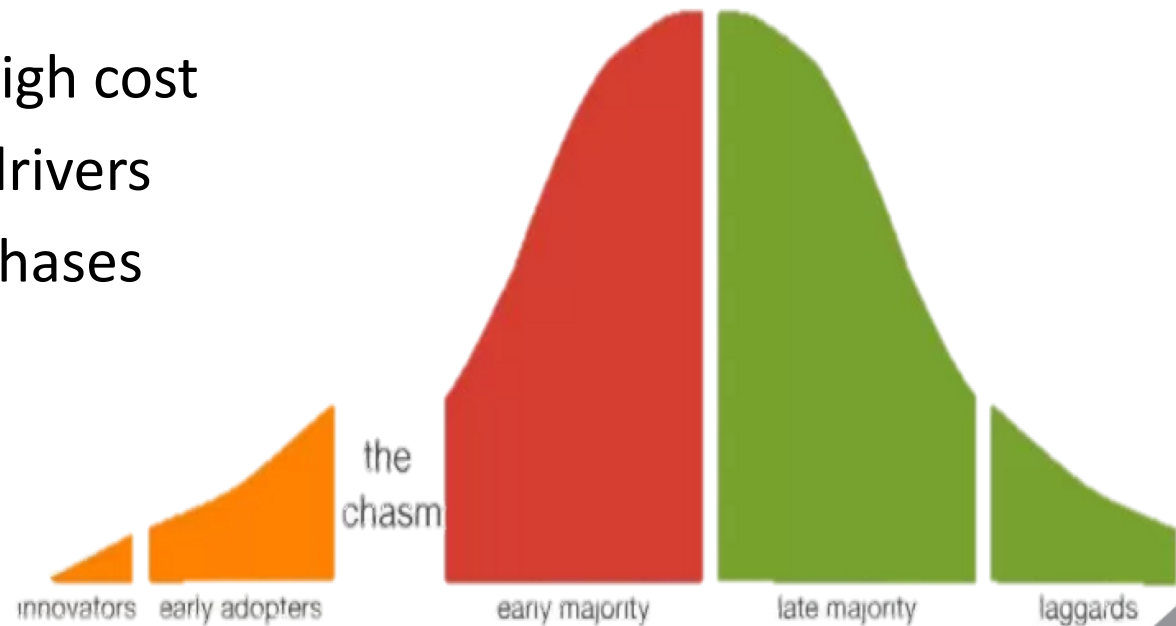
Cost v Payback

Low Volume = High cost

Lack of market drivers

Alternative Purchases

The Chasm





How to avoid the chasm

Government incentives

- Feed In Tariff
- Export tariff
- Installation subsidies?
- R&D / Tooling support?

Smart meters and time of day tariffs?



Requirements for Mass Market Success

Payback needs to be less than 5 years

Products need to be easy to install

Reliability needs to be ensured

Products need to be widely available

In summary, only engineers can make it happen!



3) Decarbonising the Energy Supply

Typical options for decarbonising the electricity supply:

- Wind
- Tidal / Wave / Hydro
- Biomass or biogas instead of coal or natural gas

Options for decarbonising the gas supply:

- Green gas – Inc. Anaerobic digestion
- Blending hydrogen into methane
- 100% hydrogen





Electricity generation companies are making good progress

Gas companies are aware of the 2050 CCA threat;

- Green gas is unlikely to offer much more than 5% of Europe's need
- Hydrogen blending is favoured in Europe
- 100% hydrogen is being evaluated for the UK

Without a solution, the gas industry could be redundant by 2050



NGN H21 Project



H₂1 Feasibility study in 2016 to convert Leeds, UK to Hydrogen around 2025

<http://www.northerngasnetworks.co.uk/archives/document/h21-leeds-city-gate>

UK Government has committed to £30M for next stage feasibility



Hydrogen production methods:

- Steam Methane Reformers with Carbon Capture and Storage under the North Sea
- Electrolysis from excess electricity production during windy periods





Hydrogen Conversion

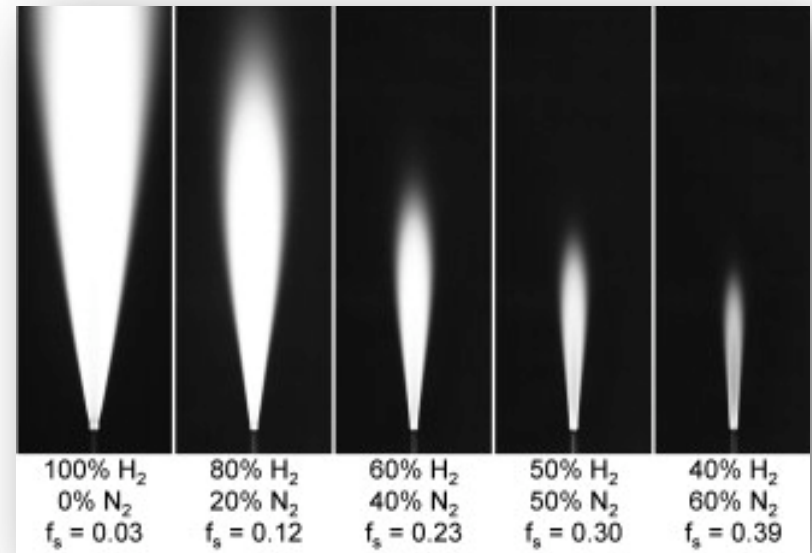
- Existing polypropylene gas pipes are deemed suitable
- Towns gas (pre North sea gas) was >50% H₂
- The grid was converted in the 1970's so it can be done again
- If Leeds is successful it would be done elsewhere sequentially
- Gas appliances would need to be converted or replaced



Hydrogen Appliances

Engineering challenges:

- Flame detection (no Carbon ions)
- Flame visibility
- Flame speed
- Cooking performance
- Volatility and potential for ignition



The UK Government is consulting on the technical feasibility of hydrogen appliances.

Engineering is the key!



Overall Summary

The future of the European Gas Industry depends upon:

- Engineers meeting the new legislation
- Engineers developing new technologies
- Engineers decarbonising the gas grid

Gas Engineering is set to become exciting in Europe.

Why should the USA be any different?



Finally:

Thank you for your kind invitation to speak at your 2017 conference and thank you for Listening

It has been a pleasure addressing an audience of engineers at a time when engineering has never been more important

Any Questions?

paul.needley@enertek.co.uk

www.enertekinternational.com