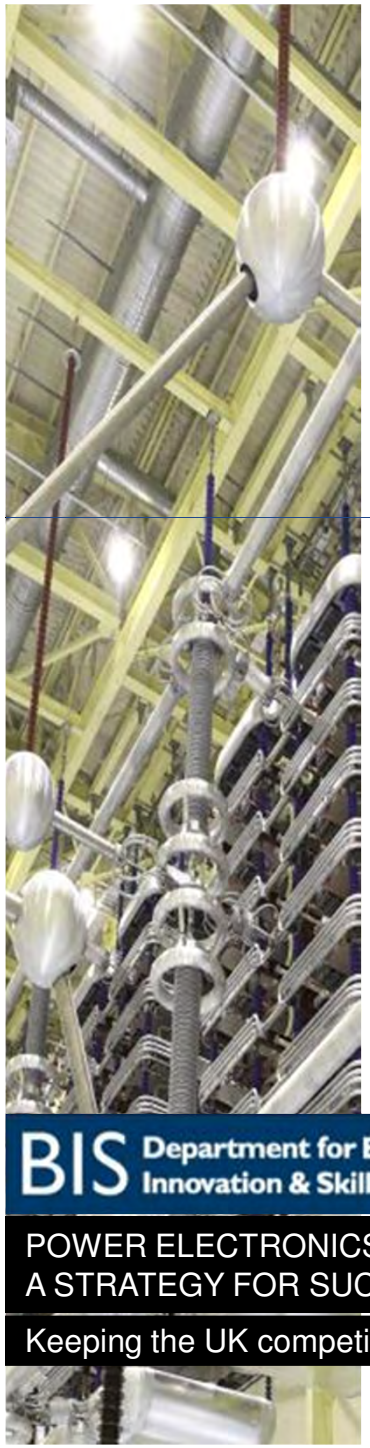

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POWER ELECTRONICS: A STRATEGY FOR SUCCESS

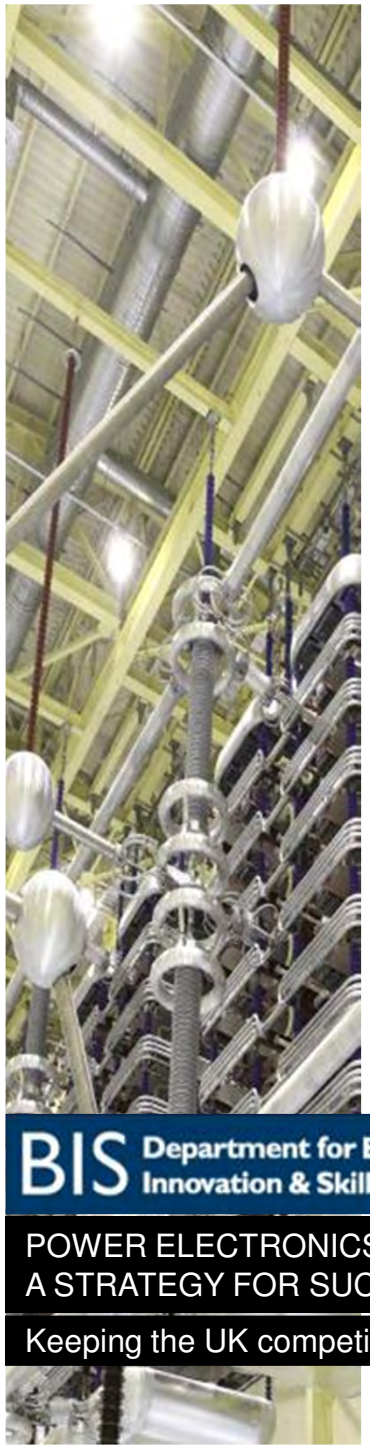
Keeping the UK competitive

OCTOBER 2011

Prof Bill Drury

Emerson – Control Techniques /

University of Bristol / Newcastle University



Power Electronics is a UK Success Story

World class companies across a number of market sectors

ALSTOM
DYNEX
International IOR Rectifier
eVince technology
GOODRICH
ROLLS ROYCE
DIODES
e2v
CONVERTEAM
THE POWER CONVERSION COMPANY
NXP
ABB
SIEMENS
IQE
EMERSON Industrial Automation
CONTROL TECHNIQUES
TRW
TEXAS INSTRUMENTS

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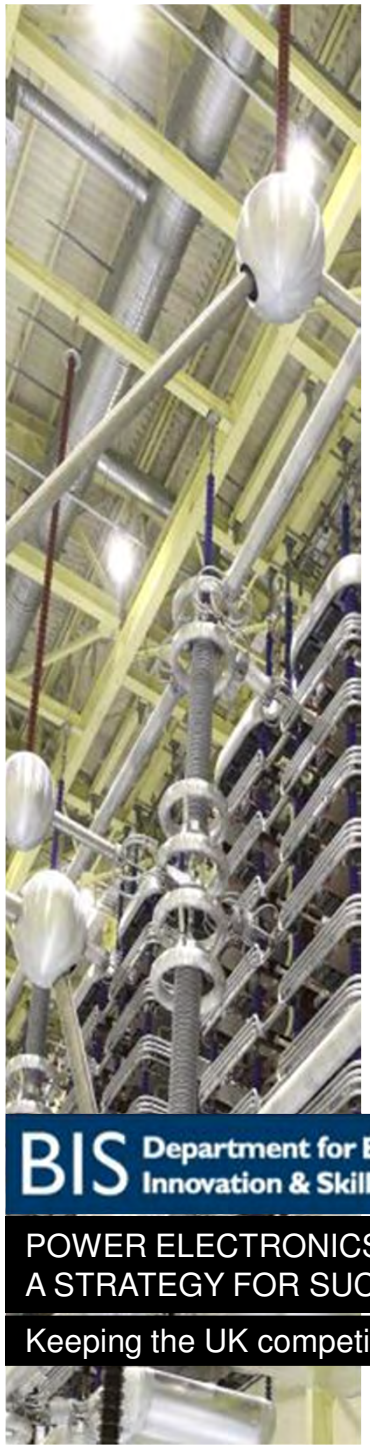
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Innovative SME's delivering new approaches and technologies to the market



Power Electronics is a UK Success Story

Internationally recognised universities educating the next generations of power electronic engineers and expanding the knowledge base through research

University of BRISTOL

The University of Nottingham

Newcastle University

UNIVERSITY OF CAMBRIDGE

MANCHESTER 1824

University of Strathclyde

The University Of Sheffield.

THE UNIVERSITY OF WARWICK

Imperial College London

Swansea University Prifysgol Abertawe

THE UNIVERSITY OF EDINBURGH

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POWER ELECTRONICS
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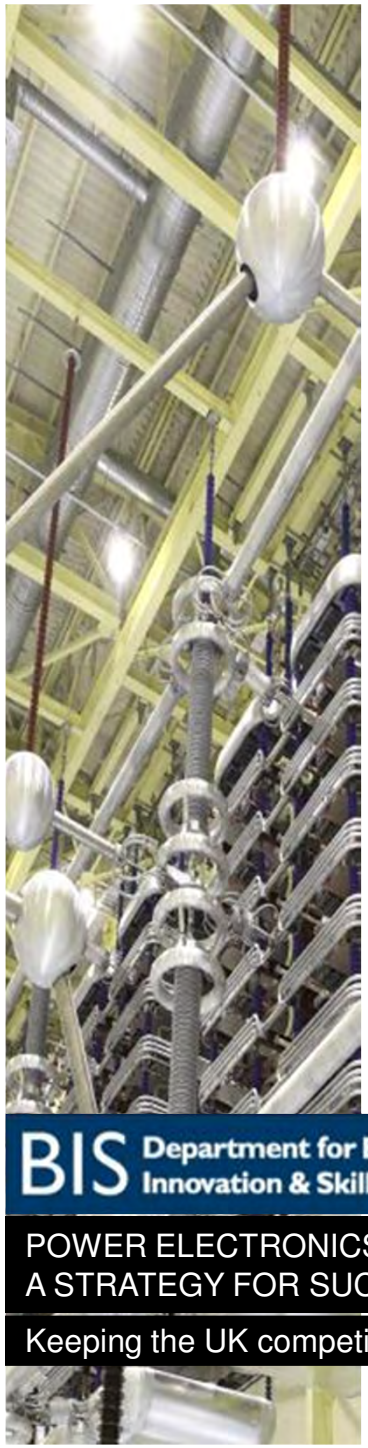
Keeping the UK competitive



What is Power Electronics?

- Power Electronics manages power not data
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- Wherever there is a need to modify a form of electrical energy – i.e. change its voltage, current or frequency – then Power Electronics comes into play

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A STRATEGY FOR SUCCESS

Keeping the UK competitive

Power Electronics - The Enabling Technology

Transport

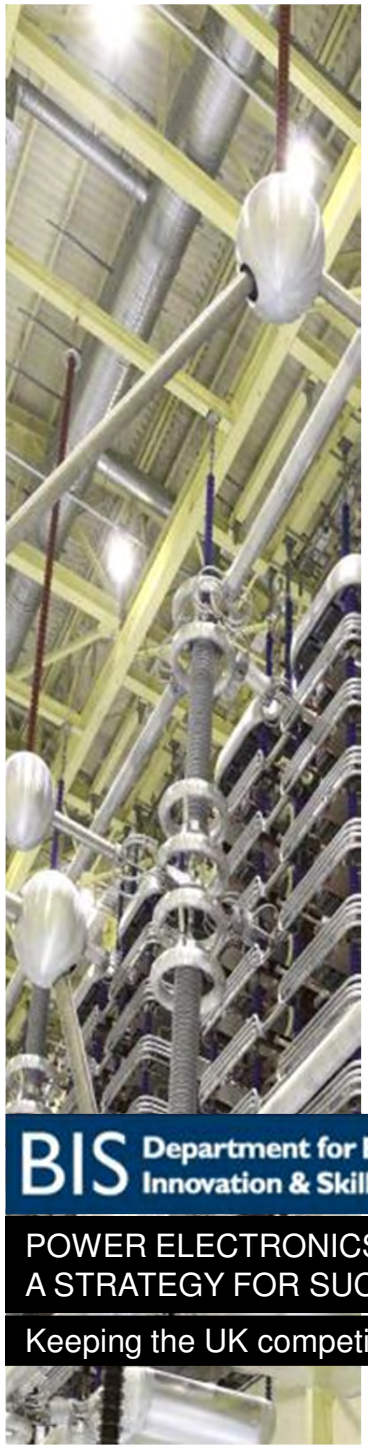
Domestic & Consumer

Industrial

Energy

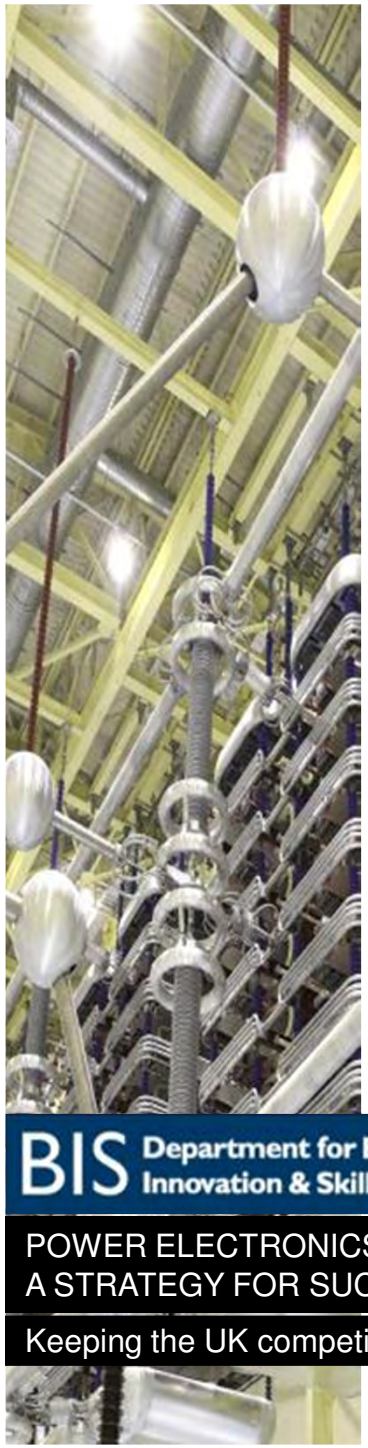
power electronics inside

Commercial



Power Electronics - A Global Market

- £135 billion direct market with 10% CAGR
- The market is Global and Competitive
- Multi-national companies with Global design and manufacturing locations
- The UK is competitive in key Global markets *including* in the "systems" area:
  - Aerospace
  - Industrial Drives / Marine Drives / Renewable Energy Converters
  - Automotive
  - HVDC



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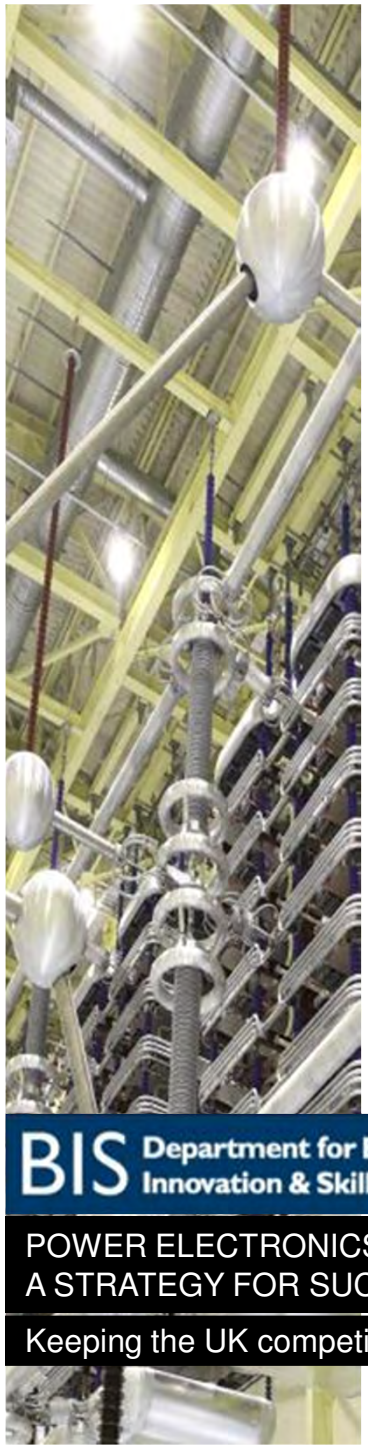
A STRATEGY FOR SUCCESS

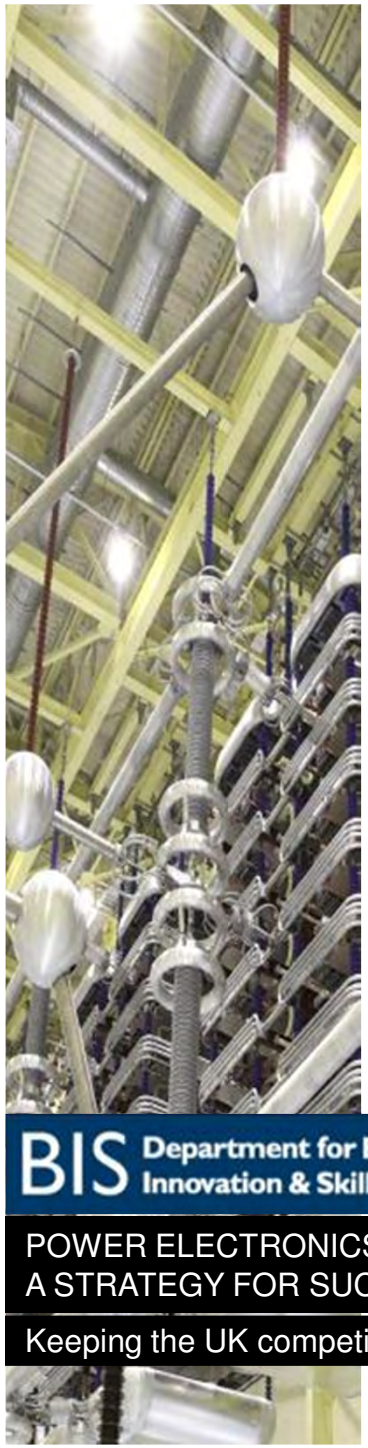
Keeping the UK competitive

Power Electronics – A UK Strength

- **UK Electronics Industry:**
  - **contributes > £50bn to UK GDP**
  - **500,000 jobs in 25,000 companies**
- **A key Power Electronics Manufacturer**
  - **>£4bn of Power Electronics product (most exported)**
  - **Order(s) of magnitude higher for the enabled systems**
- **An international reputation for Design**
  - **Design for Global manufacture**
- **A strong SME base**
  - **Driving Innovation & key component supply**
- **Established and good routes to market**



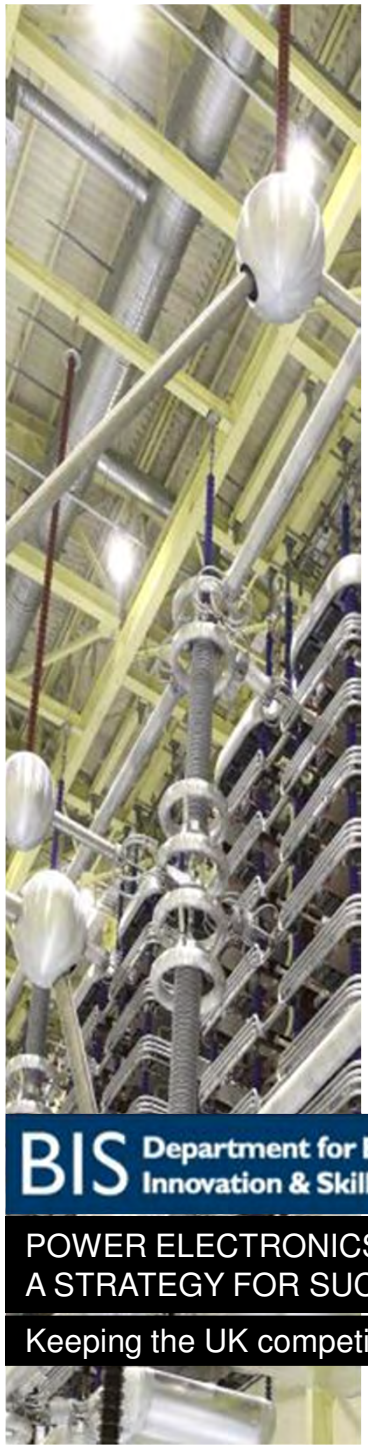
Challenges for Power Electronics (and the way forward)



Challenge 1: The Power Electronics Community lacks cohesion and representation

Approach:

The National Forum for Power Electronics will maintain and increase the momentum gained during the preparation of this report, driving through its recommendations and monitoring progress made.



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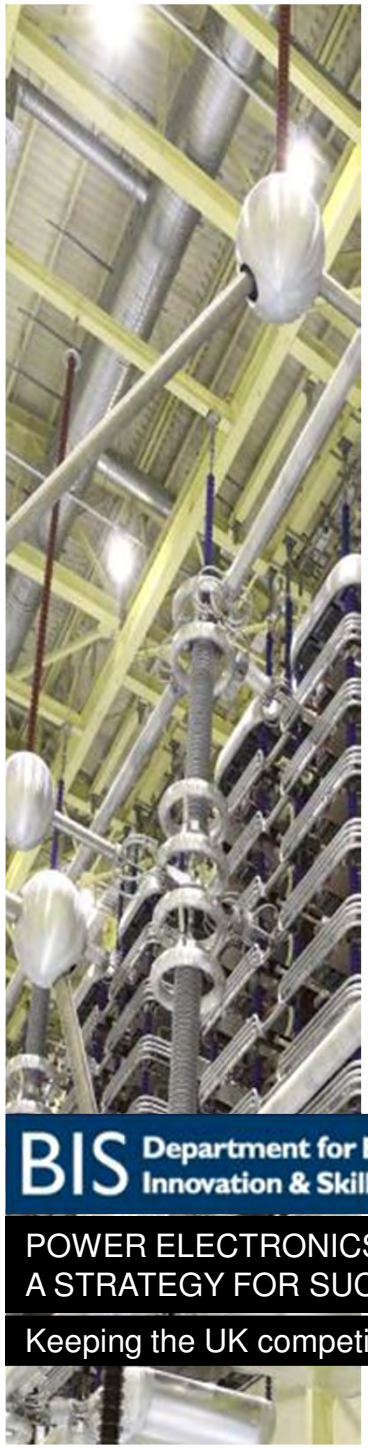
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Challenge 2: The UK needs to be an exemplar low-energy/low-carbon economy

Approach:

Foster the reputation of the UK as an exemplary producer and user of Power Electronics technologies – a world-leader in low carbon, renewables, manufacturing and sustainability. Critical to this is to develop a clear vision for our electricity infrastructure – to define the ‘Smart Grid’.



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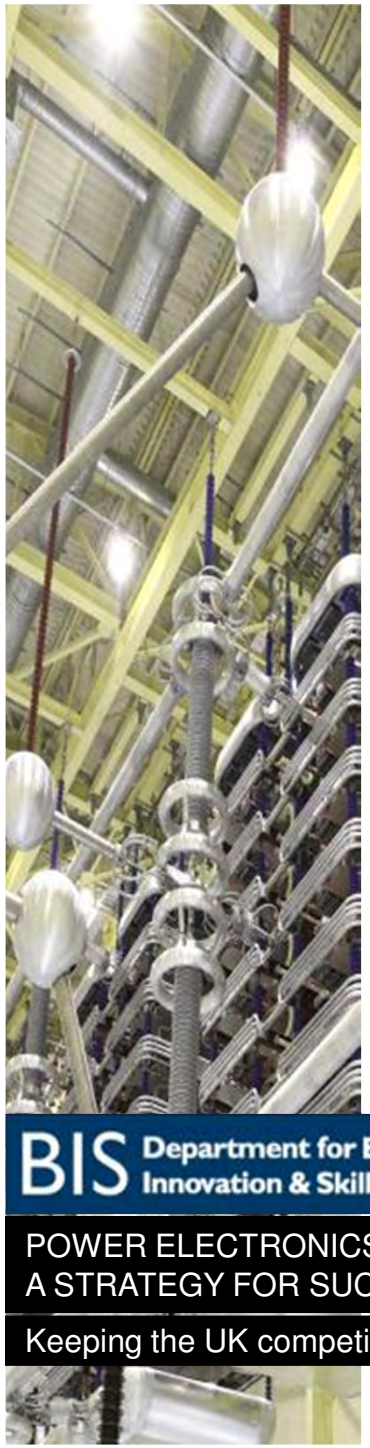
Challenge 3: To ensure the UK remains at the forefront of innovative Power Electronics design and manufacture

Approach:

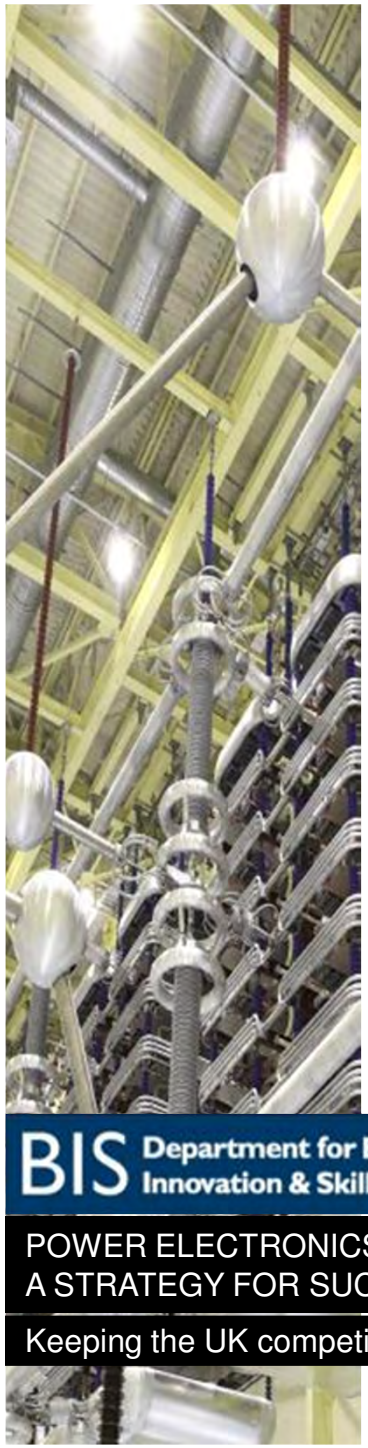
To drive innovation in both product design and manufacture. To foster collaboration across industry sectors and supply chain barriers, promoting best practice and access to international standards. Long-term disruptive technologies need focused support through to pre-production.



Challenge 4: To ensure a good supply of talented Power Electronics engineers

Approach:

The National Forum would promote Power Electronics in all areas of education, from primary schools onwards, to maintain a critical mass of competent talent on which the viability and vibrancy of the sector depends. Collaborative industrial involvement is needed. Government has also to play its part, and the strategy proposes a number of zero-cost actions to promote the value of STEM



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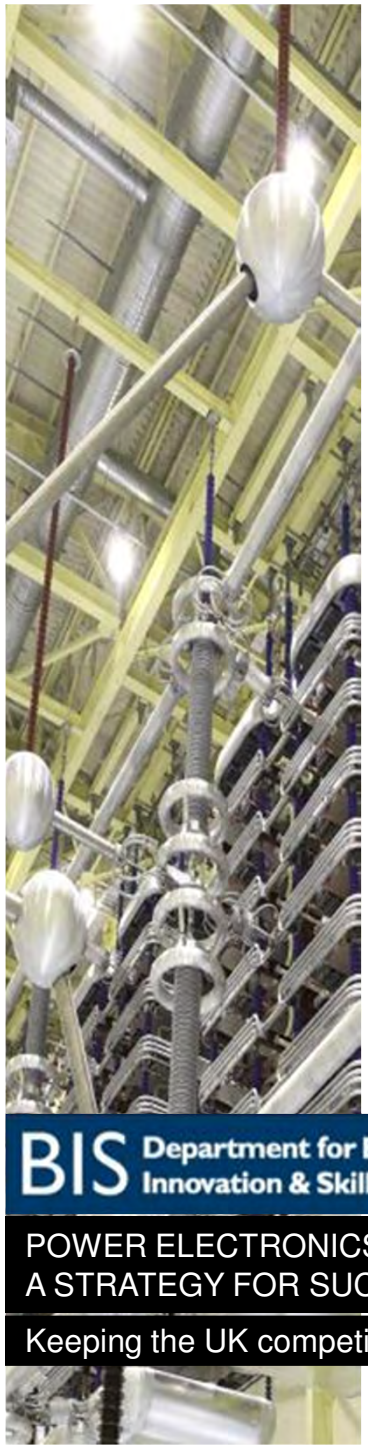
Challenge 5: To improve access and the exchange of leading technology

Approach:

It is necessary to bridge the gaps between universities, start-ups and industry, so that innovation is pulled through in a timely manner. The onus is on all parties to recognise the needs and the opportunities, to make the necessary investment and to create the mechanisms for vibrant relationships.



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Keeping the UK competitive

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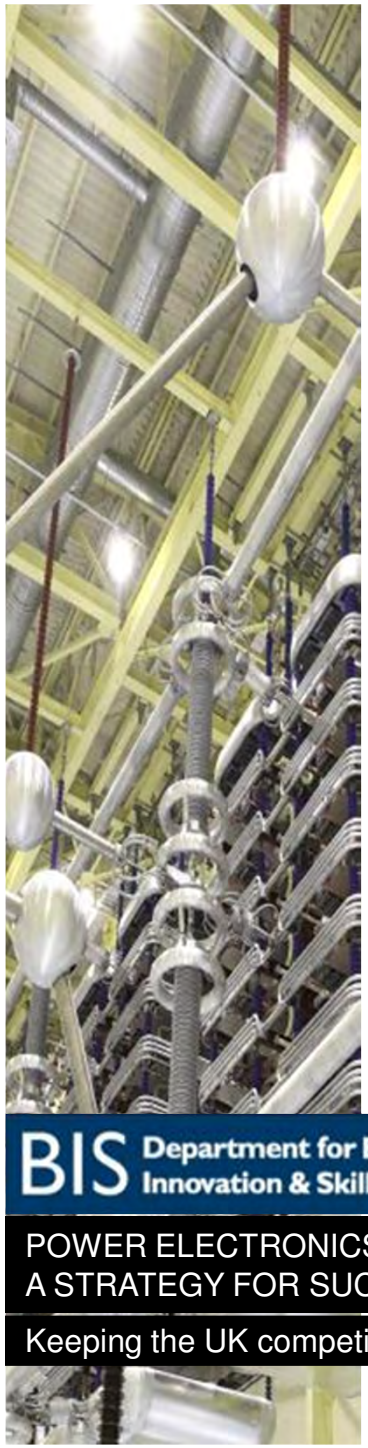
- The Report
  - celebrates success
  - projects a vision for even greater future success
  - identifies threats and opportunities
  - gives detailed direction to industry, academia and government to fulfil the UK's potential



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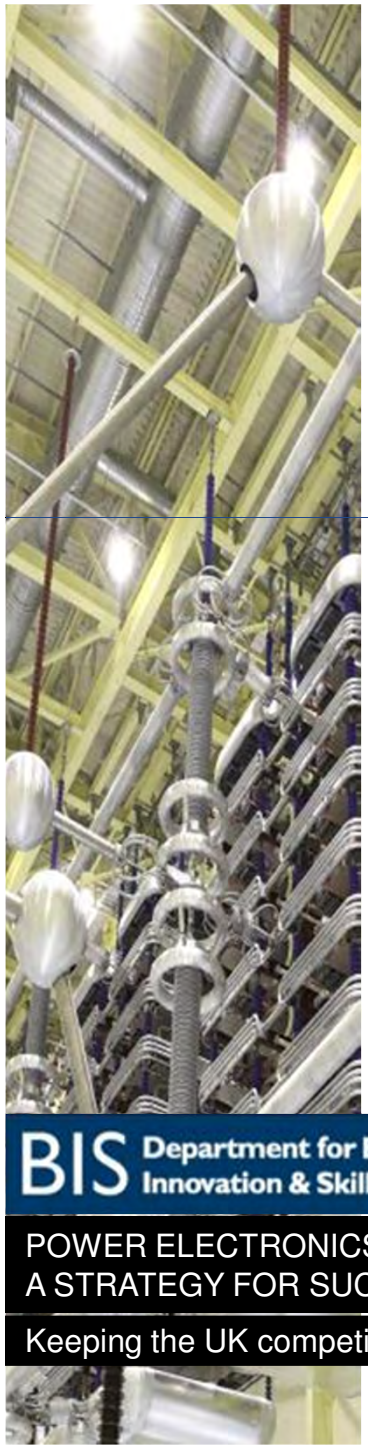
Mark Prisk MP

Minister of State for Business and Enterprise



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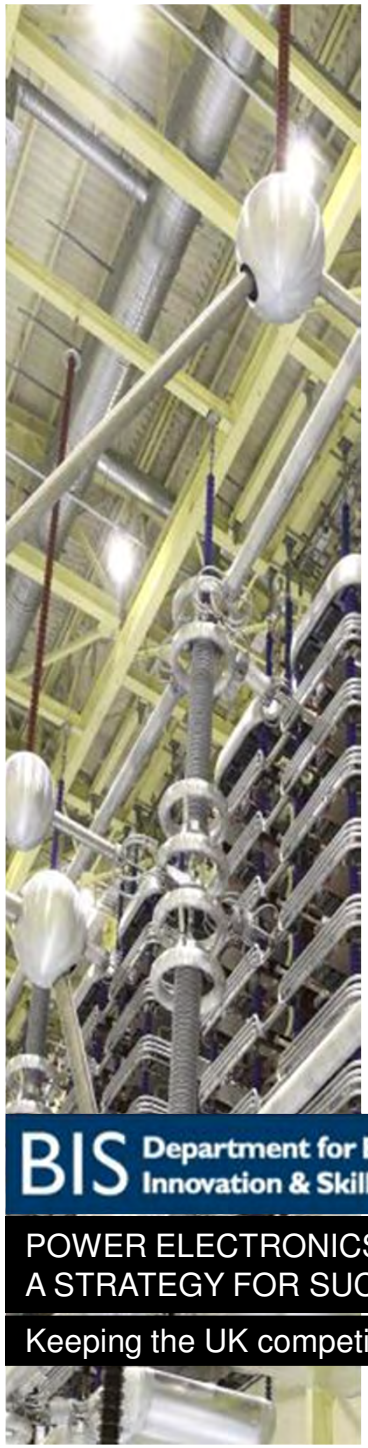
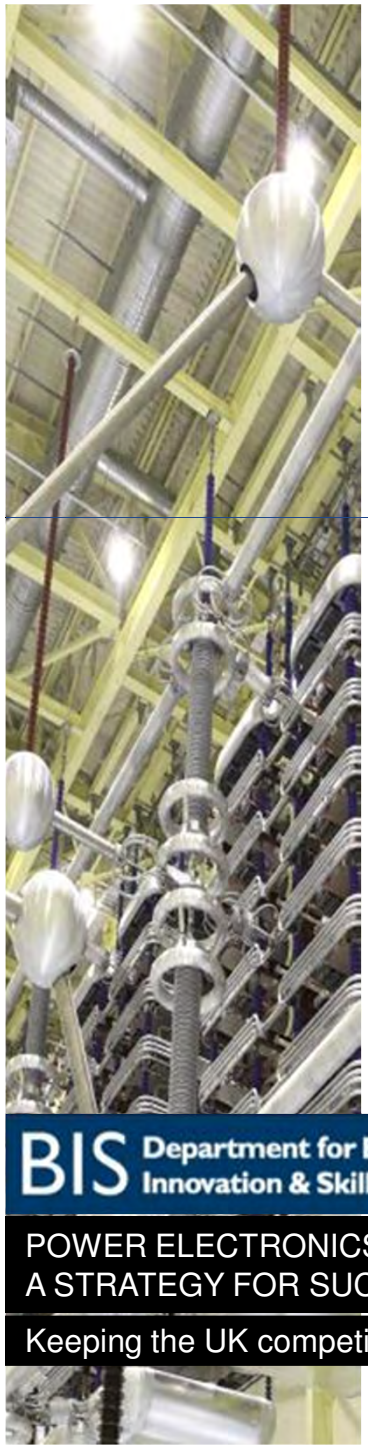
STRATEGY OVERVIEW



Strategy Overview

1. Introduction – Bill Drury
2. The UK Industrial & Academic Position – Derek Boyd
3. Challenges, Opportunities & Actions
   - National Forum for Power Electronics – Gareth Taylor
   - UK exemplar low energy/carb. economy – Graham Ferry
   - Support Design and Manufacture – Rob Haase
   - Supply of PE Engineers – Bill Drury
   - Improve Access to Technology – Phil McGoldrick



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INTRODUCTION

Prof Bill Drury
Emerson – Control Techniques /
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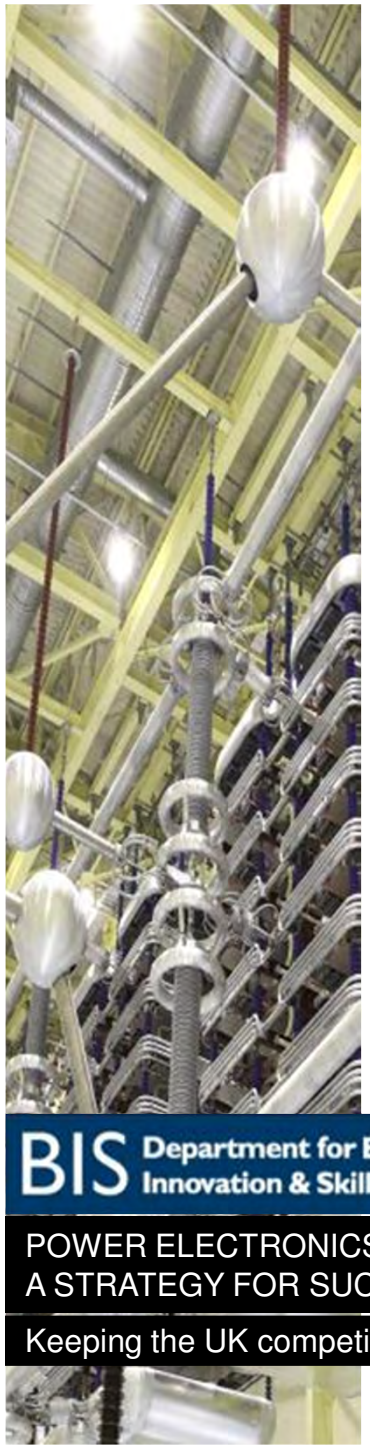
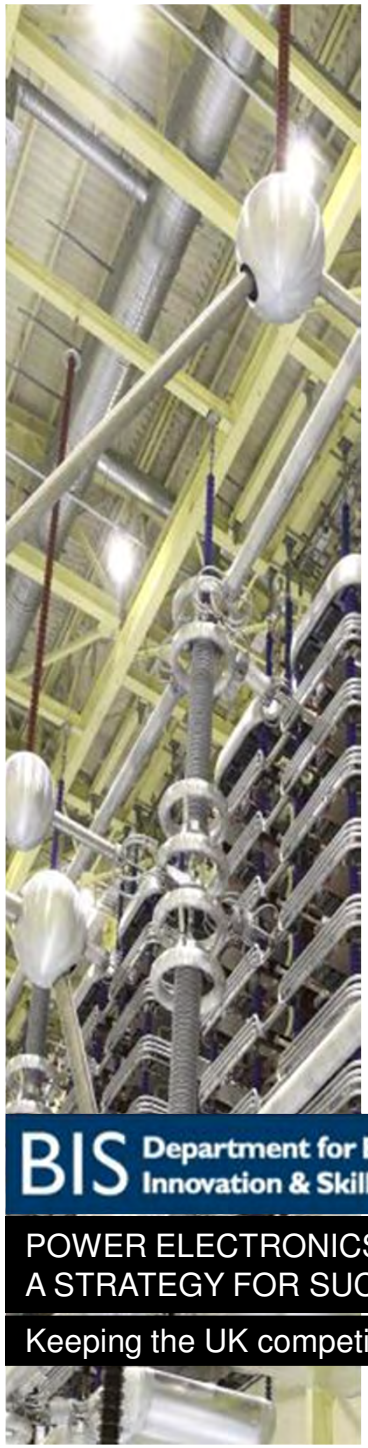


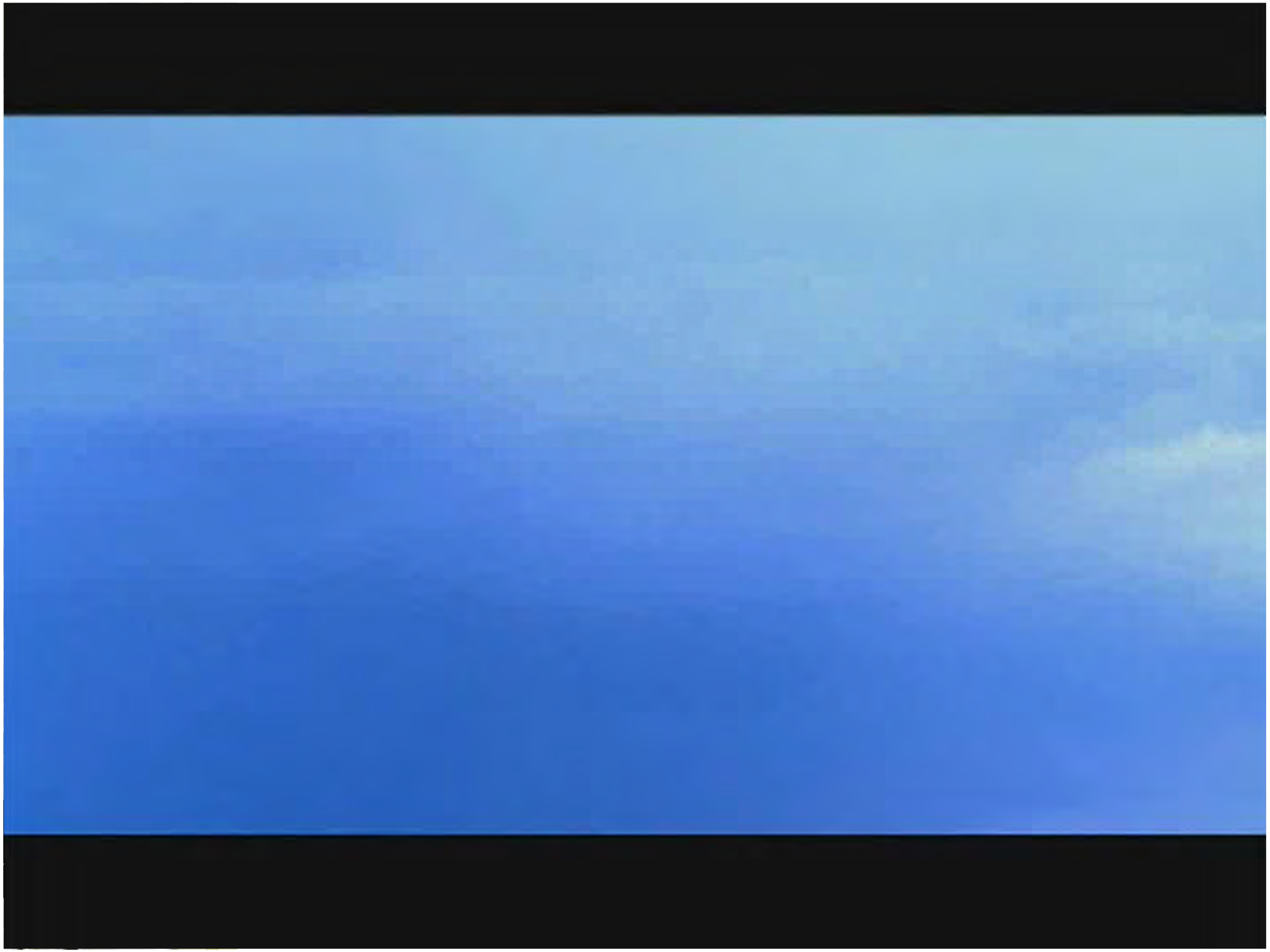
What is Power Electronics?

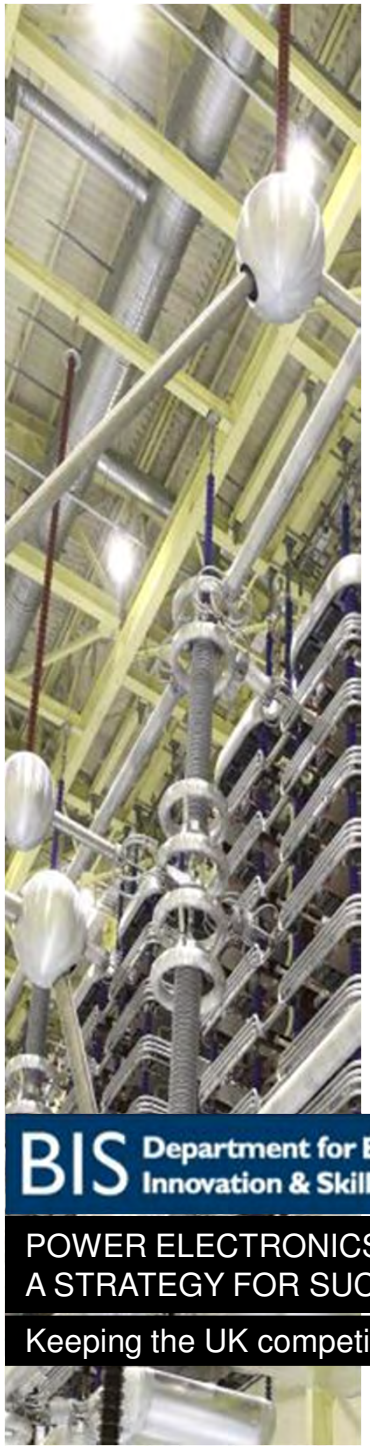
- "Electronics" / microelectronics is used to carry communications or data. Power Electronics manages power/energy
- It is used from the mW (eg mobile phone) through to multi-GW (eg HVDC energy transmission between countries
- Wherever there is a need to modify a form of electrical energy – i.e. change its voltage, current or frequency – then Power Electronics comes into play



What is Power Electronics?

- A picture is worth a thousand words…..





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Power Electronics -
The Enabling Technology (but rarely seen)

Transport

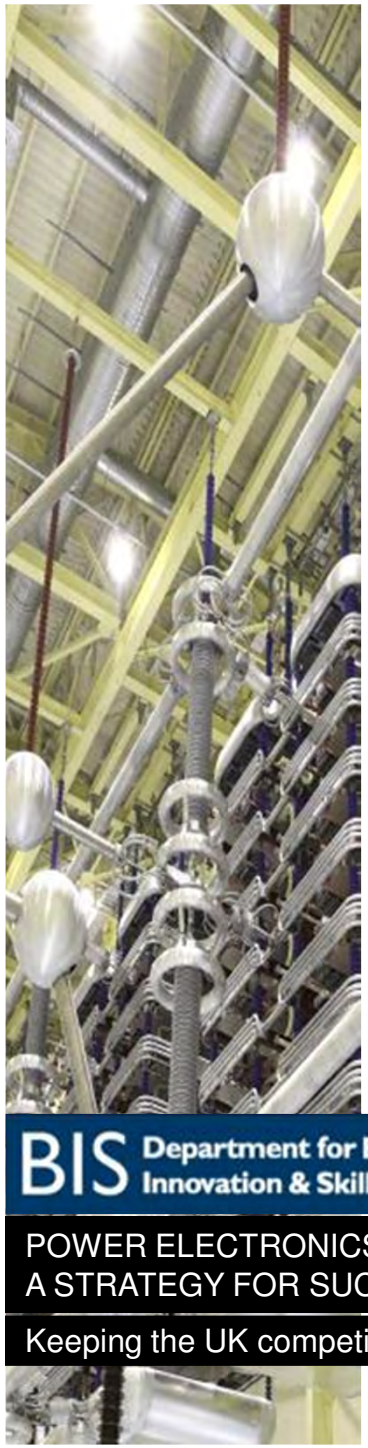
Domestic & Consumer

Industrial

Energy

power electronics inside

Commercial



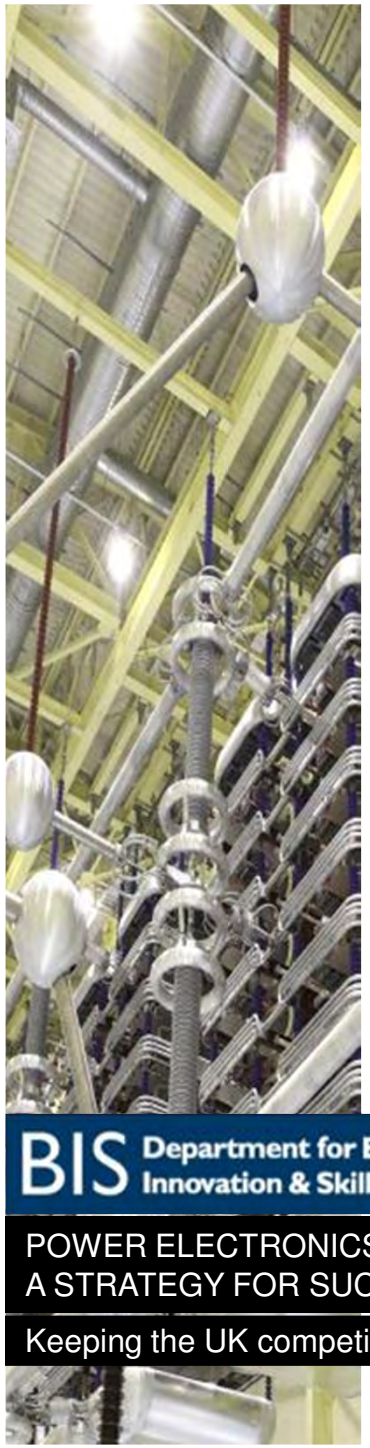
Is Power Electronics Important?

Power Electronics is critical to National Strategic objectives:

- Carbon Reduction / Energy Efficiency
  - UK Government targets a 34% cut in 1990 emission levels by 2020 & >80% cut by 2050
  - UK legislation mandates 15% of <u>all</u> energy will come from Renewable sources by 2020 (= >5-fold increase from 2009)
- Manufacturing

  .....
- Innovation

  .....



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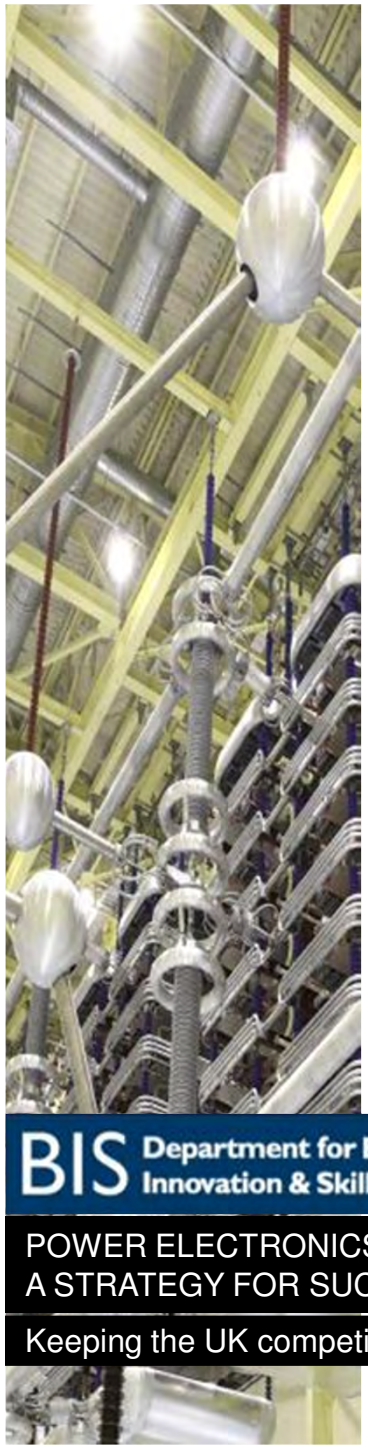
Power Electronics makes a difference

- 60% of all electrical energy is used in Industrial Electric motors
- Power Electronic control reduced energy consumption typically by 30-40%, and could be applied effectively in about 50% of applications*
- Power Electronic Motor Control has potential to **reduce total electrical energy consumption by 9%**

* Electronics enabling efficient energy use, e4u, 2009



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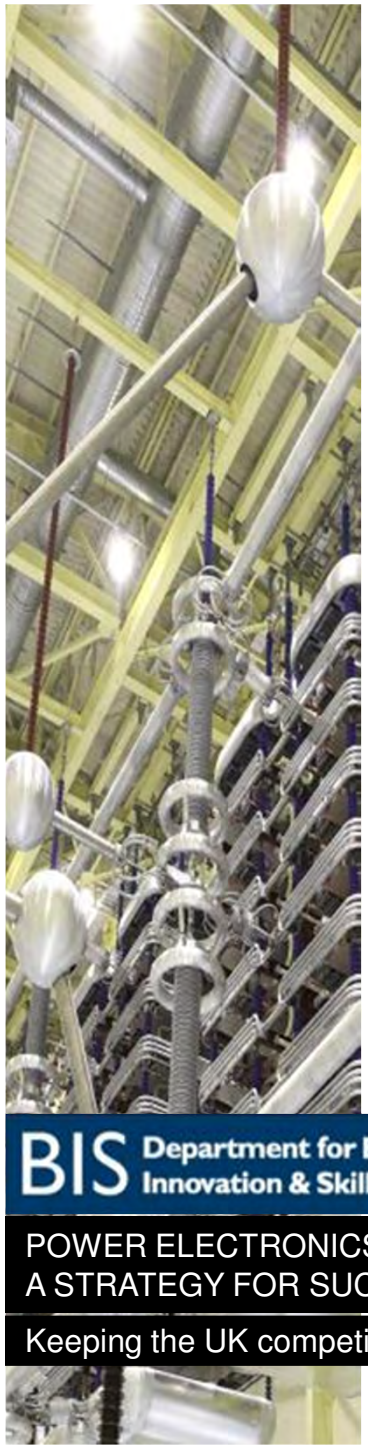
Power Electronics - A Global Market

- £135 billion direct market growing at 10% pa
- The market is Global and Competitive
- Global companies with Global design and manufacturing locations
- UK is good at Power Electronics!
- In the "systems" area alone, global strength in:
  - Aerospace
  - Industrial Drives / Marine Drives / Renewable Energy Converters
  - Automotive
  - HVDC



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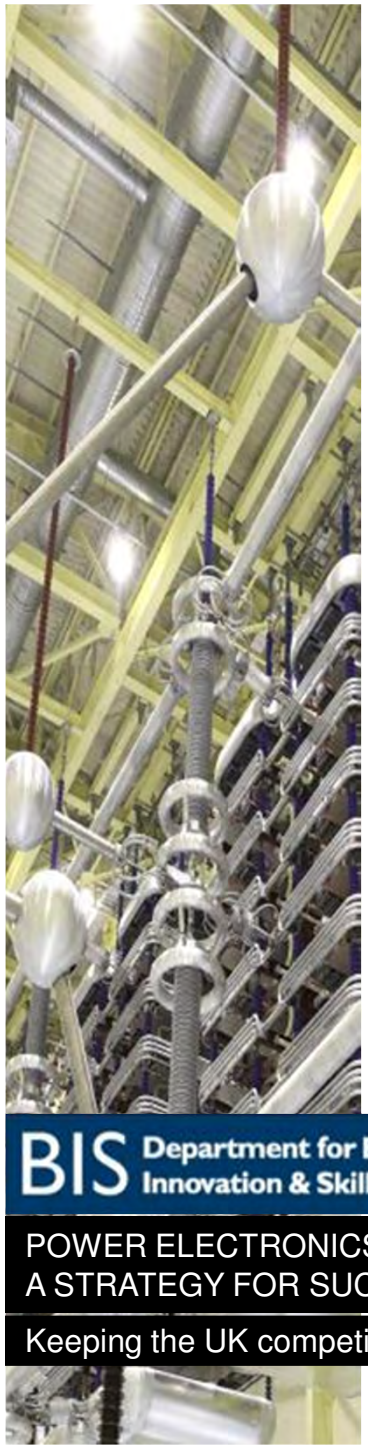
BUT

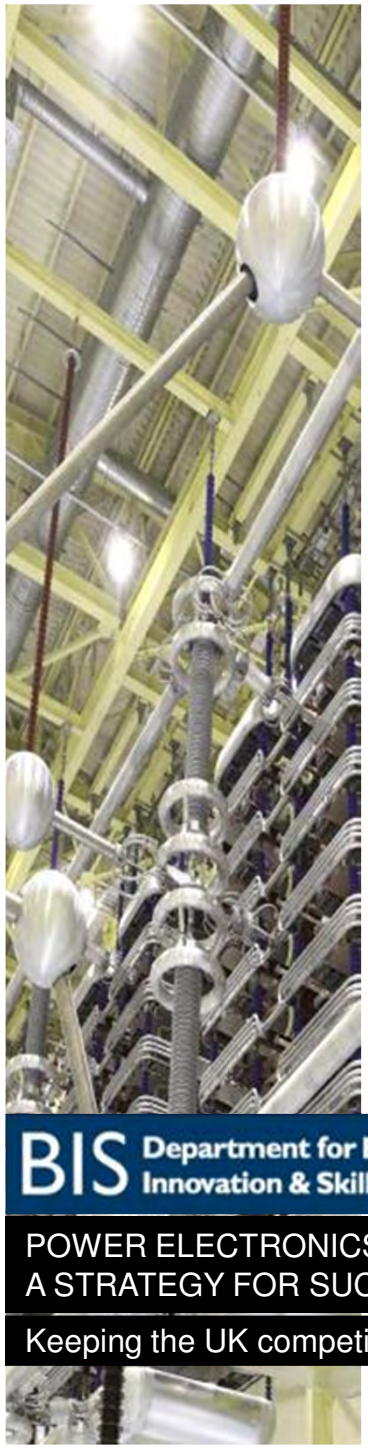
The community is fragmented and faces real challenges in the future

So we decided to do something about it!



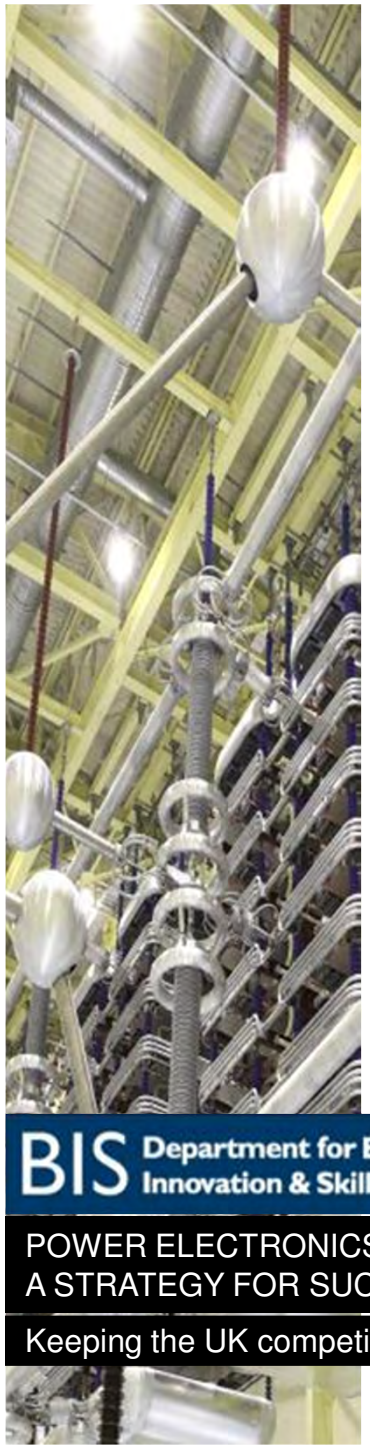
The Power Electronics Strategy Group

- Led by BIS and NMI
- Strategy Group – Industry, Academia, TSB, EPSRC, Carbon Trust, ETN, Trade Associations..
- Engaged with an ever growing Power Electronics community - 5 Regional Workshops
- Identified 4 exemplar industry sectors
  - Transport
  - Energy generation, transmission & distribution
  - Consumer electronics & lighting
  - Industrial drives



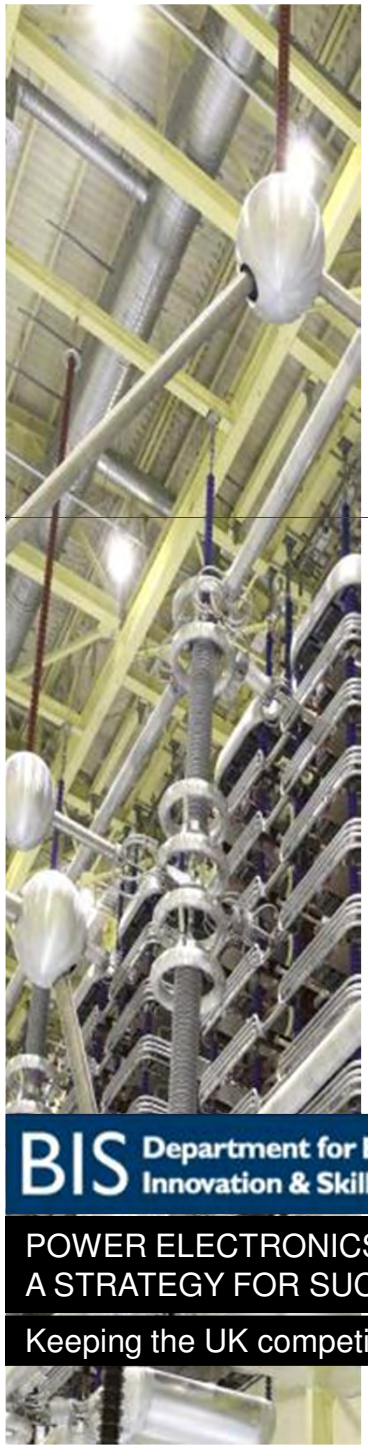
Regional Workshop - Common Issues

Strengths	Weaknesses
• International reputation for Design and Innovation • Good Supply Chain • World Class University Research and Undergraduate teaching • Good Market Access	• Fragmented Power Electronics Community • Availability of suitably skilled Engineers • Power Electronics not recognised • Industry, Universities and Government not co-ordinated
Opportunities	**Threats**
• Growing Student Power/Energy interest • Sponsoring Students key to recruitment	• Inability to recruit high quality Engineers • Tuition Fees



UK Strength and Opportunity

- For each exemplar market sector we reviewed
  - The market
  - The UK supply chain
  - The technology base
  - SWOT analysis
  - Illustrative case studies
- We also considered our university capability
- We concluded that ……..



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Keeping the UK competitive

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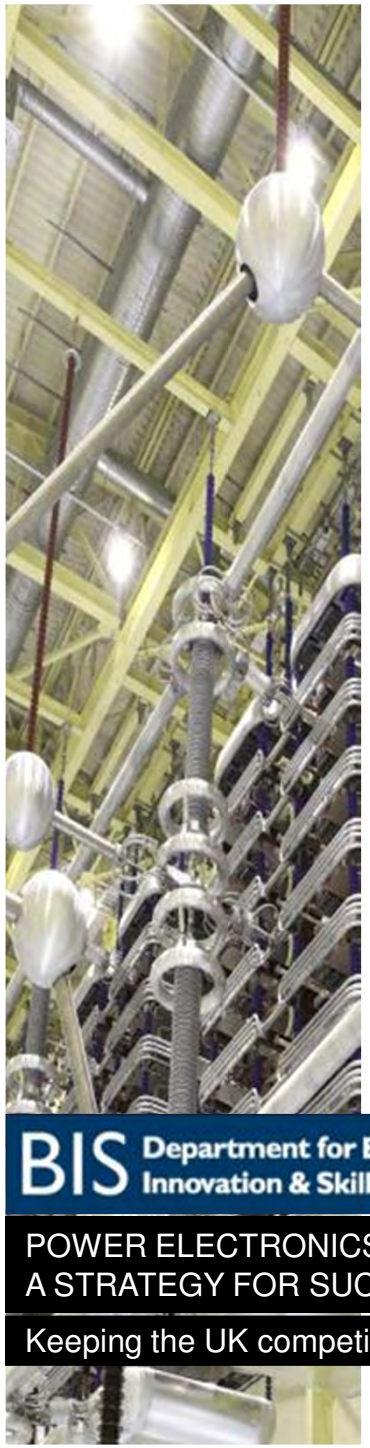
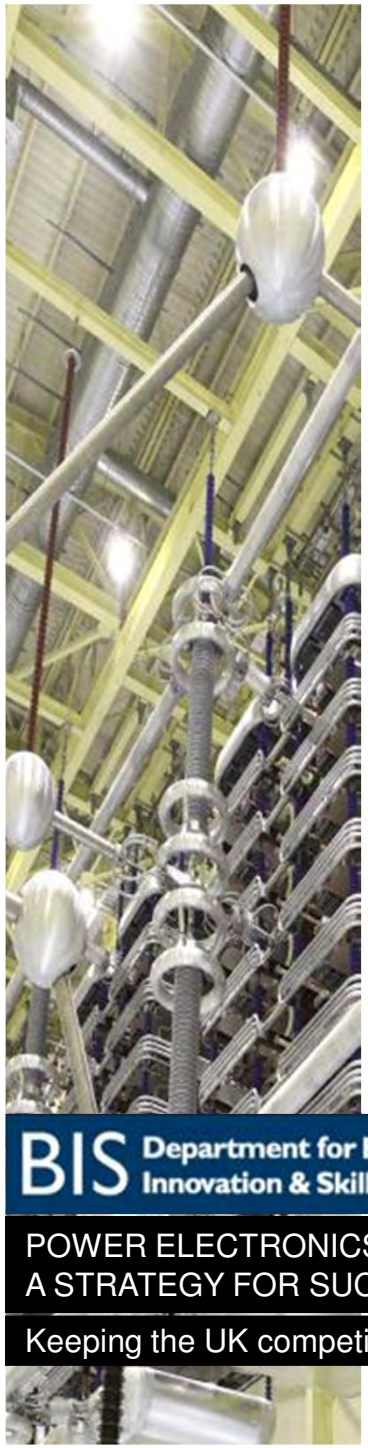
Dr Derek Boyd
Chief Executive, NMI
UK Capability



Sector mapping

- Academia >14
- Energy >14
- Transport >14
- Consumer & Lighting >7
- Industrial, Commercial & Military >11
- Semiconductors >17
- Equipment & Materials >8
- Supporting Organisations >18



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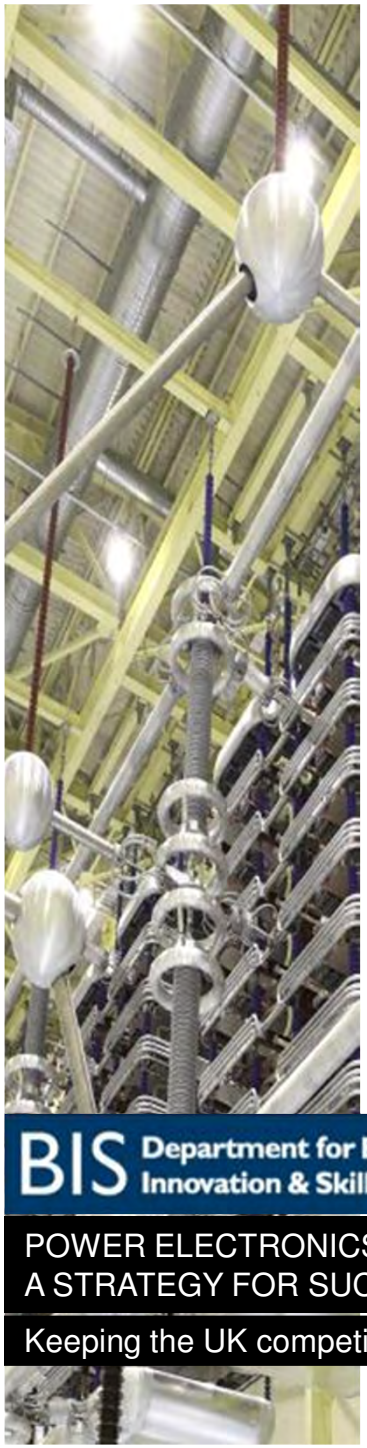
Academia



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University of Cambridge

Imperial College London

University of Leicester

University of Strathclyde Glasgow

Newcastle University

The University of Nottingham

Loughborough University

The University of Warwick

The University of Edinburgh

University of Bristol

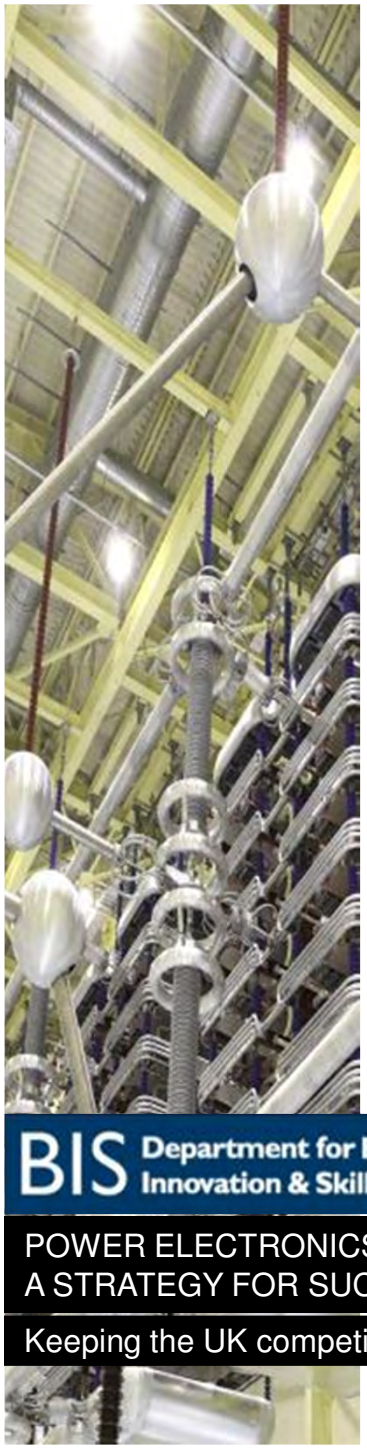
Swansea University Prifysgol Abertawe

The University Of Sheffield.

Manchester 1824 The University of Manchester

University of Greenwich

Cranfield University



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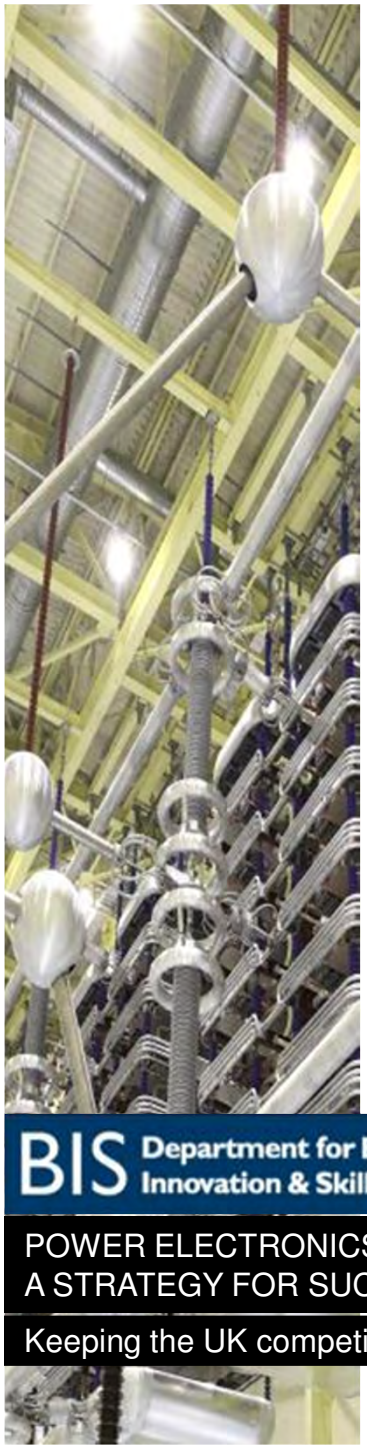
Energy



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SIEMENS

PPA energy

muRata Ps
Murata Power Solutions

ALSTOM

ABB

narec

CONVERTEAM
THE POWER CONVERSION COMPANY

Rolls-Royce

invro

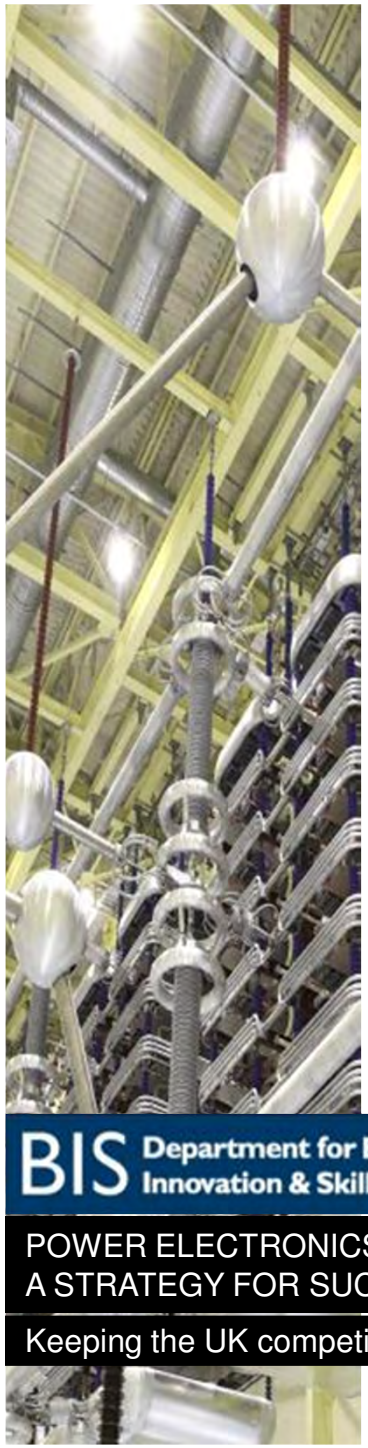
IST Power Products Ltd

nationalgrid

eVince technology

MITSUBISHI HEAVY INDUSTRIES, LTD.

GenDrive
POWERING CHANGE



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Transport

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SEVCON

conekt powered by TRW

MIRA

GOODRICH

EADS

RICARDO

AgustaWestland

Aero Engine Controls

NISSAN

LOTUS

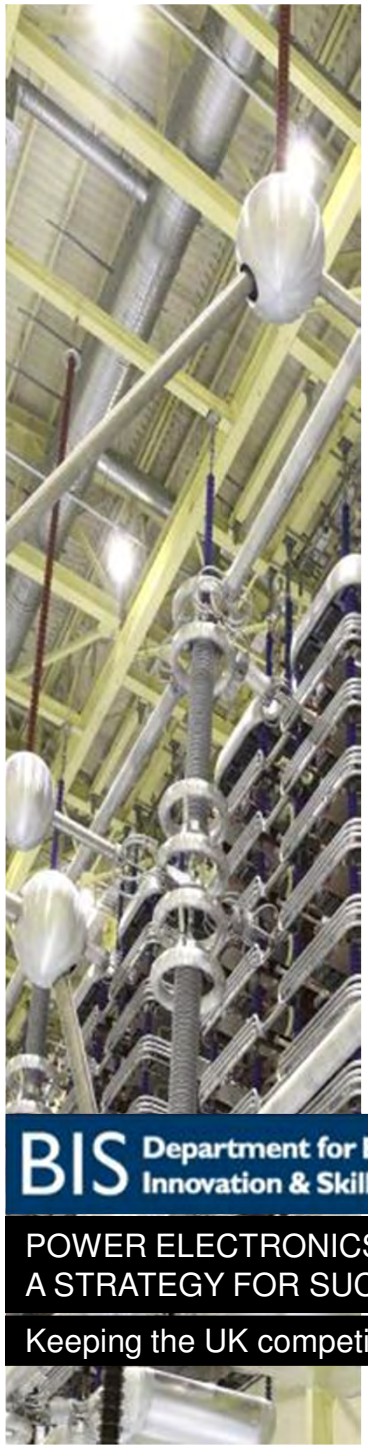
JAGUAR

LAND ROVER

Mercedes-Benz

McLaren

prodrive



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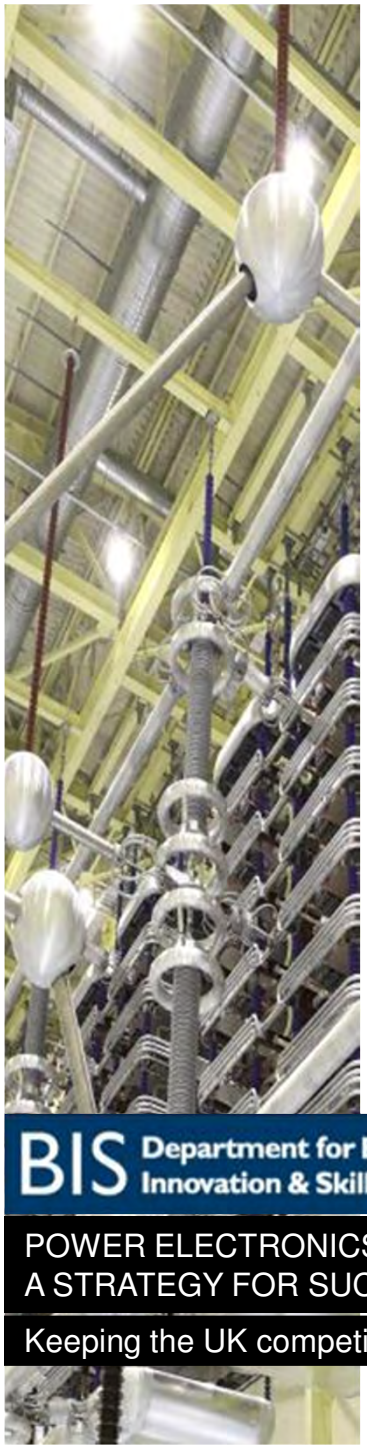
Consumer & Lighting



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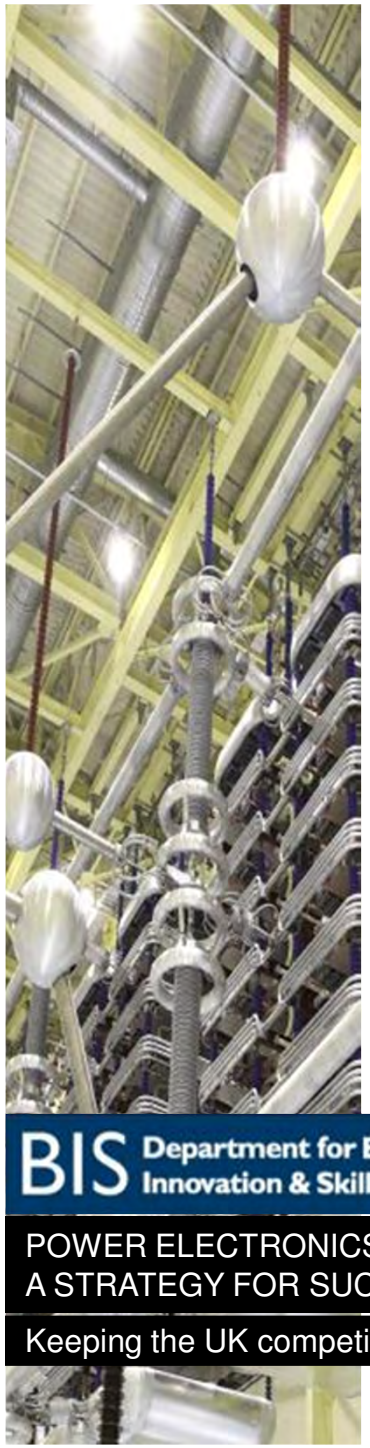

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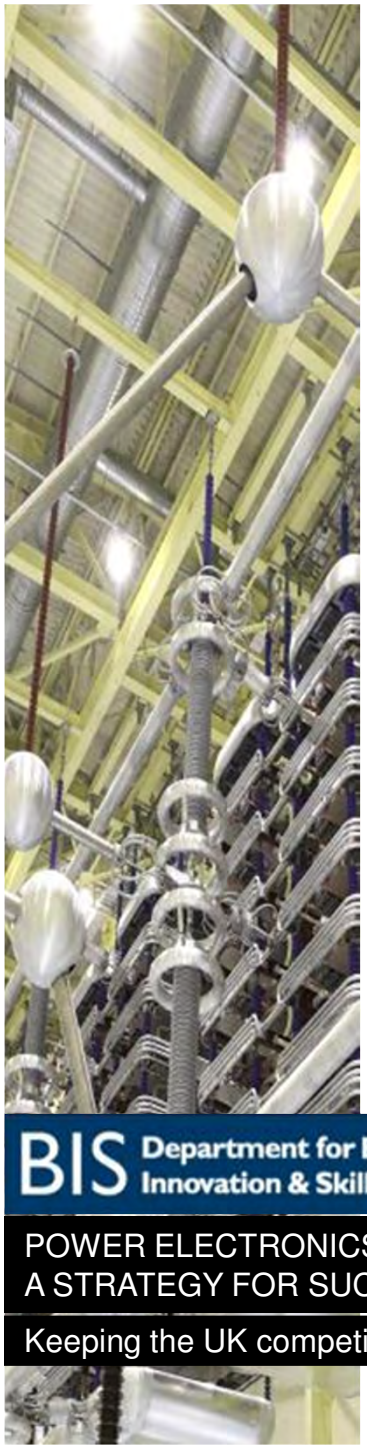
POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Industrial, Commercial & Military



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TT electronics SEMELAB

e2v technologies

stadium POWER

Raytheon Systems Limited

turbopowersystems
Electrical Machines & Power Electronics

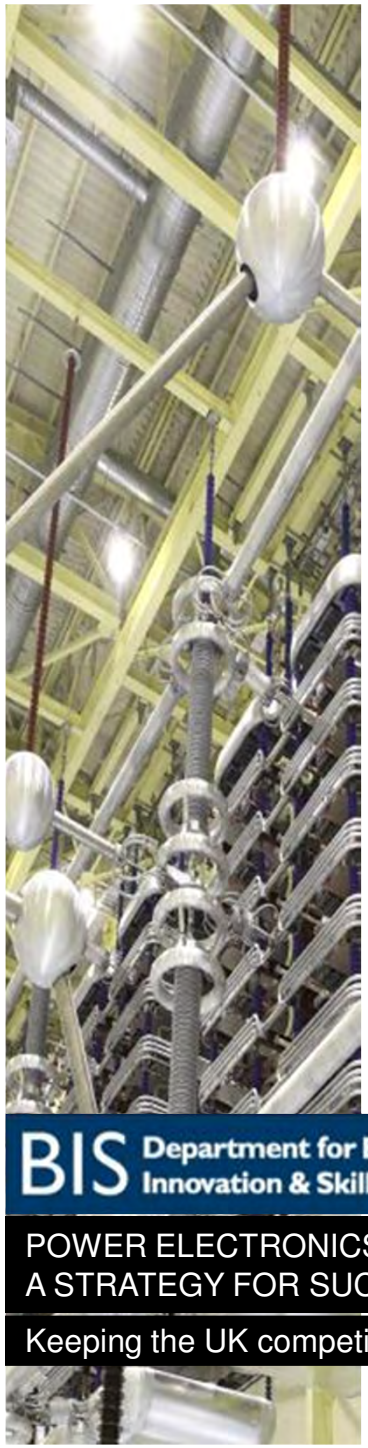
BAE SYSTEMS

EMERSON
Industrial Automation

CONTROL TECHNIQUES

TMD

DMS technologies
Engineering with Energy



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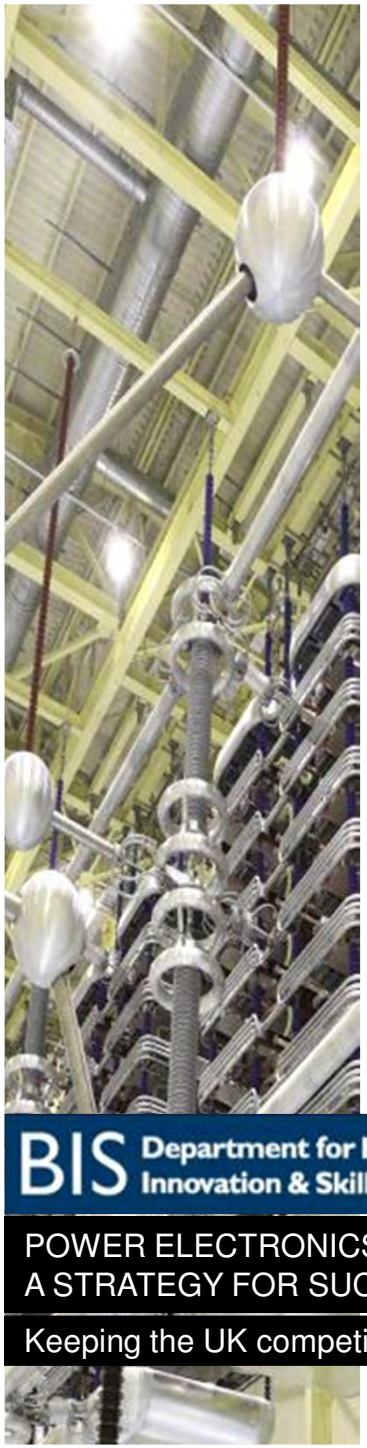
Semiconductors



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Infineon

DYNEX SEMICONDUCTOR

BOURNS® Reliable Electronic Solutions

Texas Instruments

GaNSystems Inc

freescale™ semiconductor

DIODES INCORPORATED ZETEX SEMICONDUCTORS

dialog SEMICONDUCTOR

International IOR Rectifier

Anvil Semiconductors

NXP founded by Philips

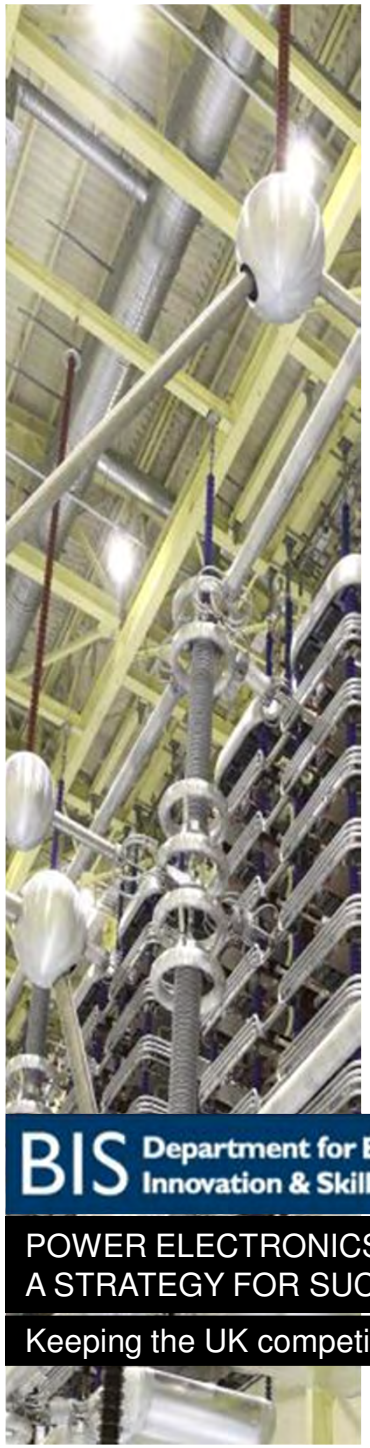
SEMEFAB Success on Silicon

pamantys

CamSemi

eltek semiconductors ltd

IXYS



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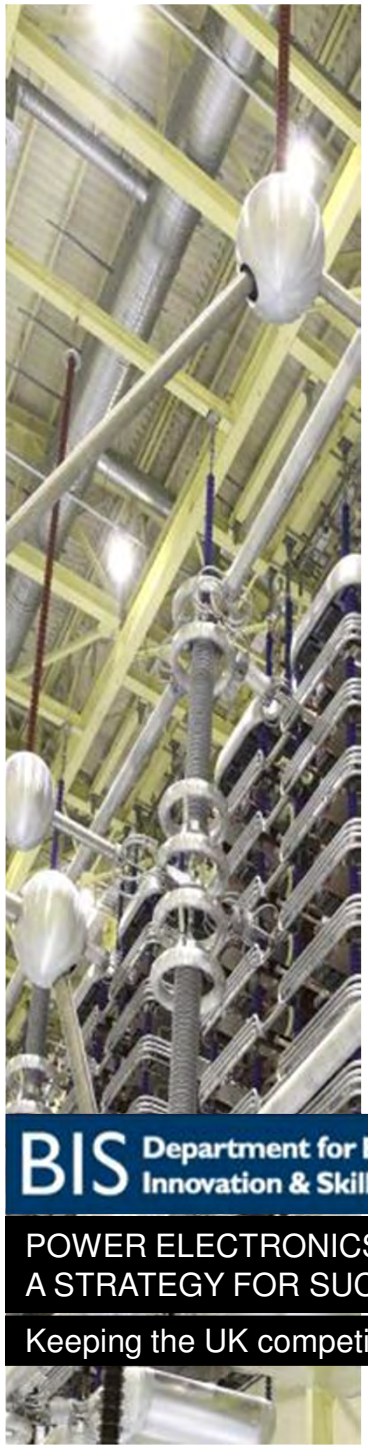
Equipment, Materials & Passives



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SPTS

NCL

OXFORD INSTRUMENTS

IQE SILICON

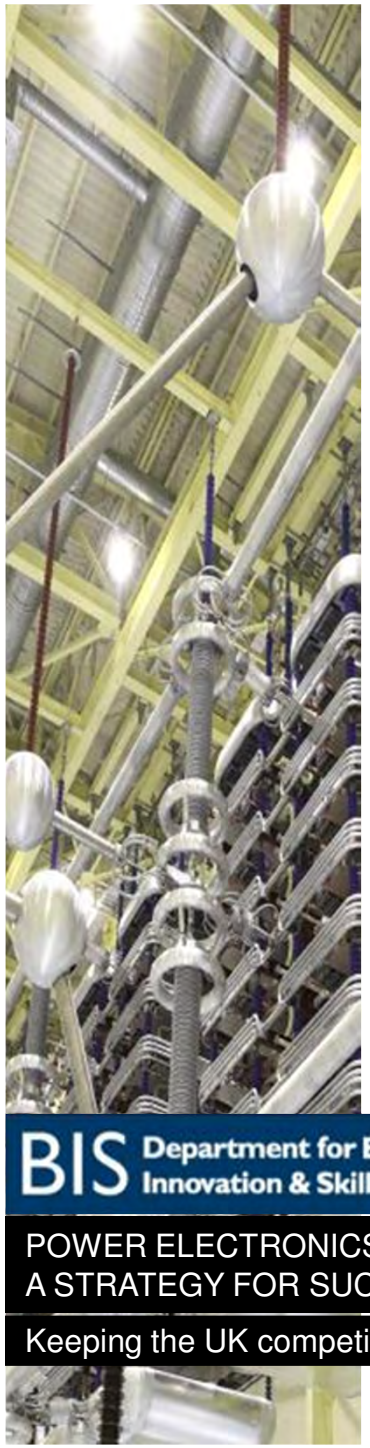
compugraphics
photomask solutions
shaping up to your needs

AIXTRON

KYOCERA

elementsix™

eXception



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Supporting Organisations

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semta

BIS
Department for Business Innovation & Skills

Knowledge Transfer Network
Electronics, Sensors Photonics

EPSRC
Engineering and Physical Sciences Research Council

nmi
Together We're Better

intellect
REPRESENTING THE UK TECHNOLOGY INDUSTRY

ETN

UK TRADE & INVESTMENT

estnet

CARBON TRUST

e3 academy

Technology Strategy Board
Driving Innovation

GAMBICA
AUTOMATION INSTRUMENTATION & CONTROL LABORATORY TECHNOLOGY

UK Electronics Skills Foundation

ieMRC
Innovative electronics Manufacturing Research Centre

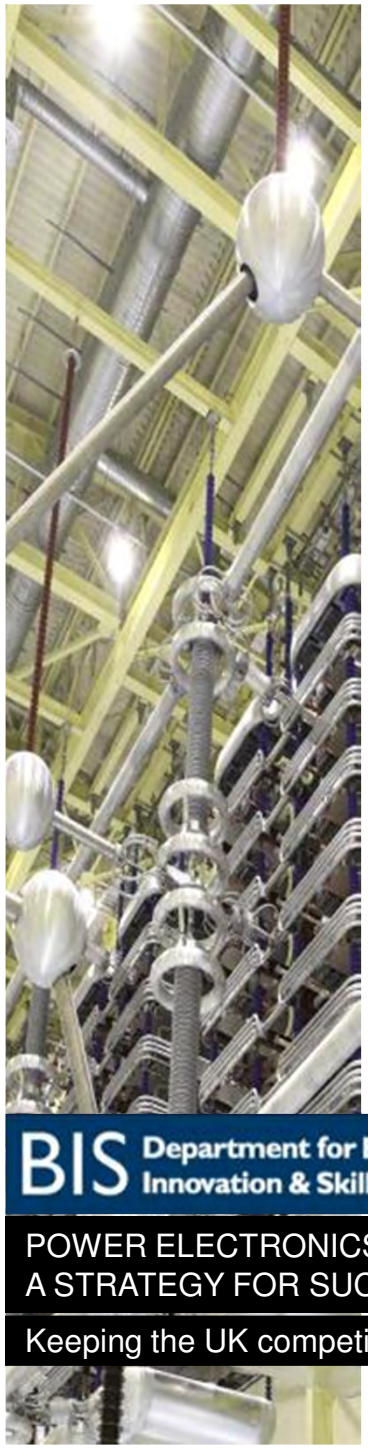
IET
CELEBRATING 140 YEARS
The Institution of Engineering and Technology

JEMI

ECPE

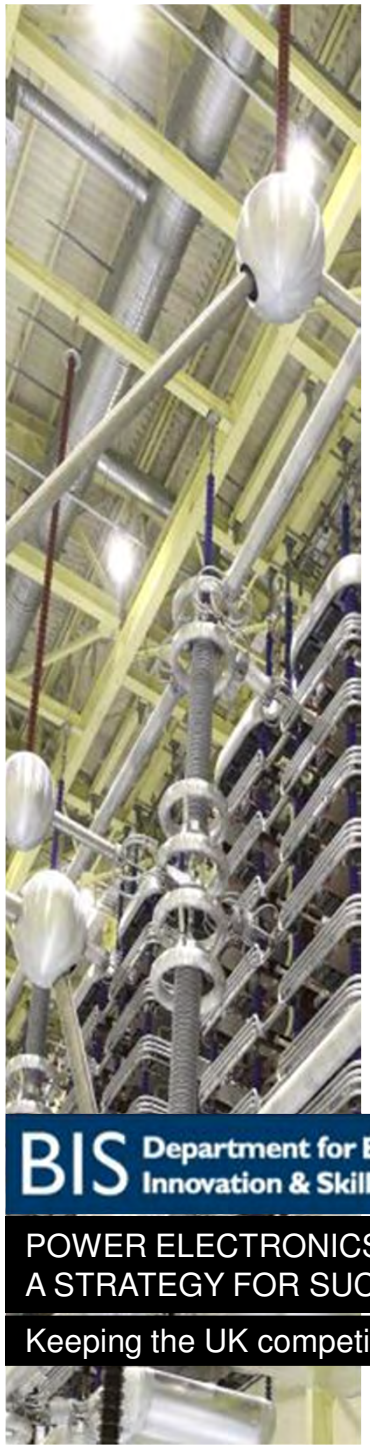
TWI

iMAPS
UNITED KINGDOM



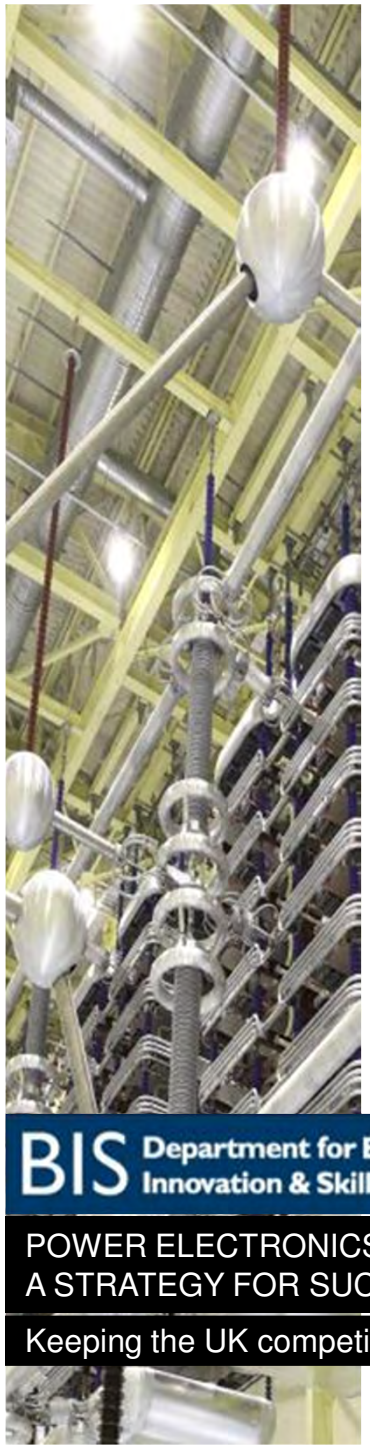
In Conclusion…

- Outstanding capability in the UK
- Faced with some key challenges…and we need to get our act together!
- The National Forum will provide a focal point, but we need
  - Industrial activism
  - Unity of purpose & cohesion
  - Resources
- It has commitment from the leading Trade Associations, BIS & the ESP KTN…
- Let's make it happen!



Challenges, Opportunities & Actions

1. A National Forum for Power Electronics
2. UK exemplar low-energy/ low-carbon economy
3. To ensure the UK remains at the forefront of innovative Power Electronics design and manufacture
4. To ensure a good supply of talented Power Electronics engineers for both industry and academia
5. To improve access to leading technology and engineers, bridging industry and universities



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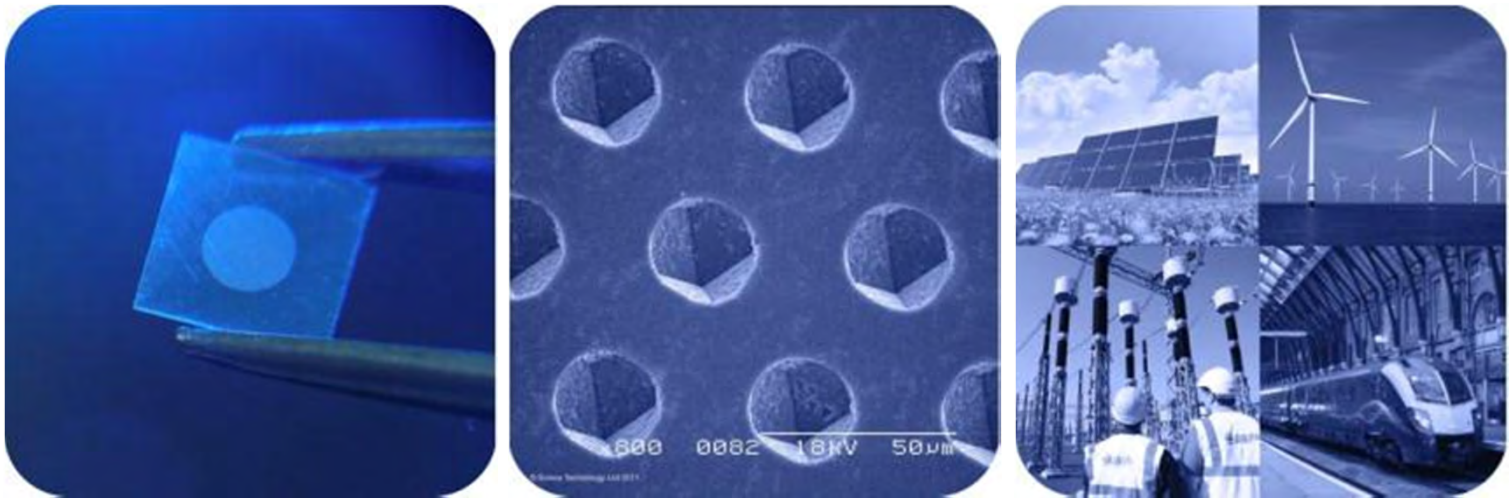
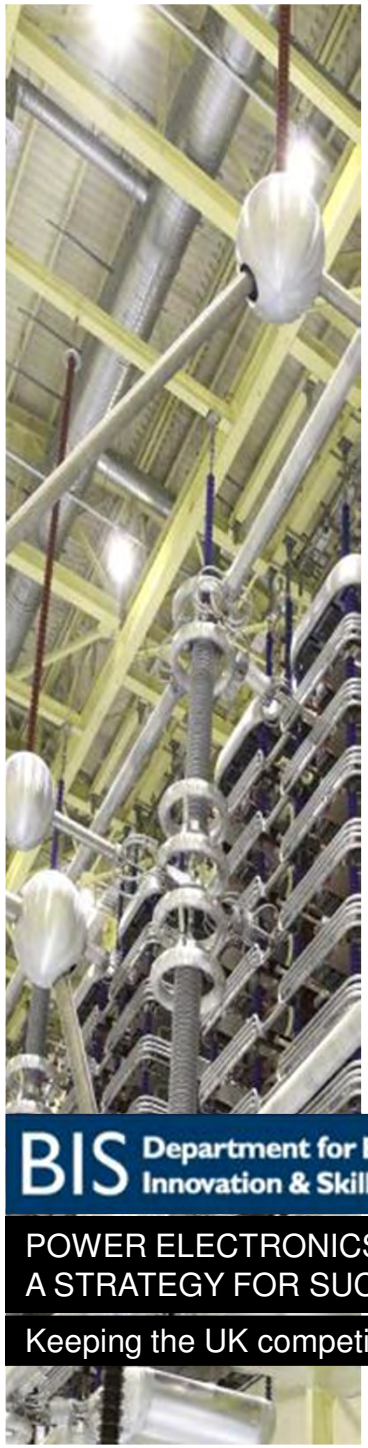
eVince technology



Dr Gareth Taylor

CEO



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Keeping the UK competitive

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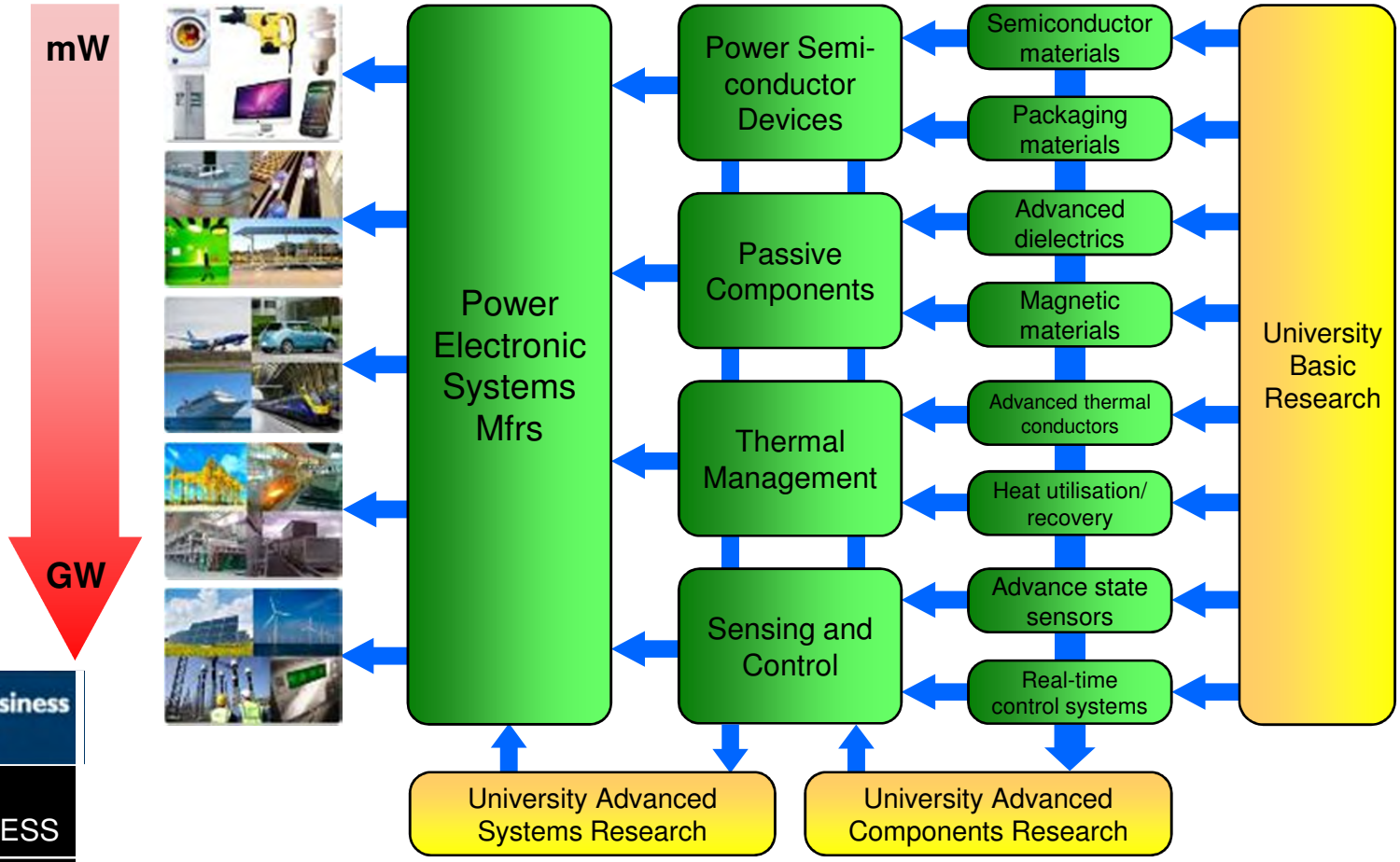

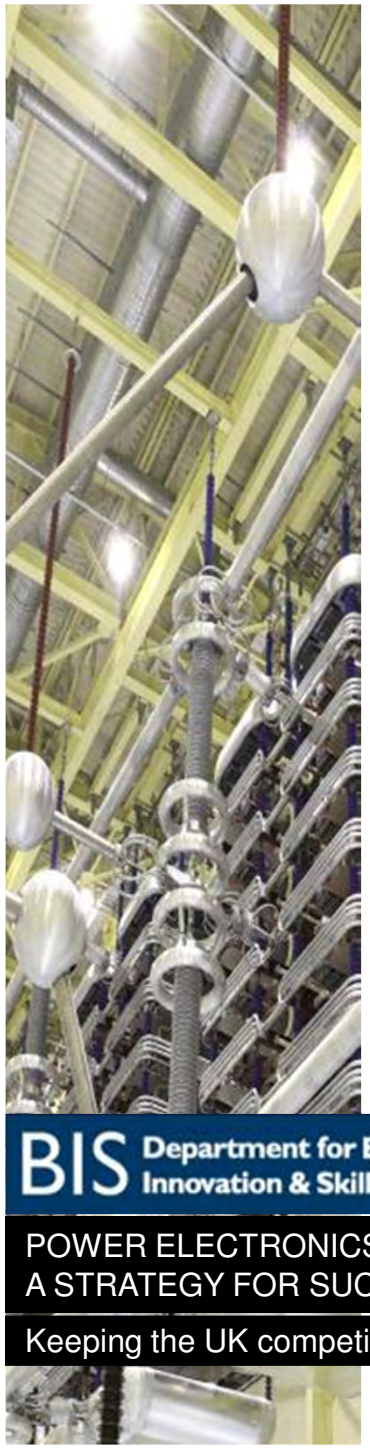

1 A National Forum for Power Electronics

- A focal point for UK power electronics
- Public awareness of PE as keystone to CO_2 reduction
- Cross fertilisation
- Innovation pull through
- Creating and building bridges for UK success

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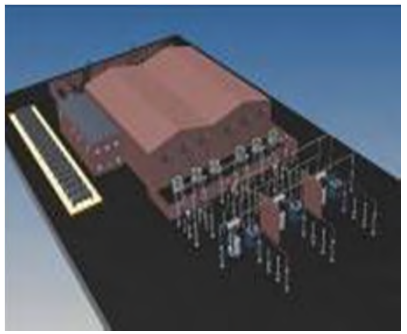
GRID | ALSTOM

Off-shore wind farm

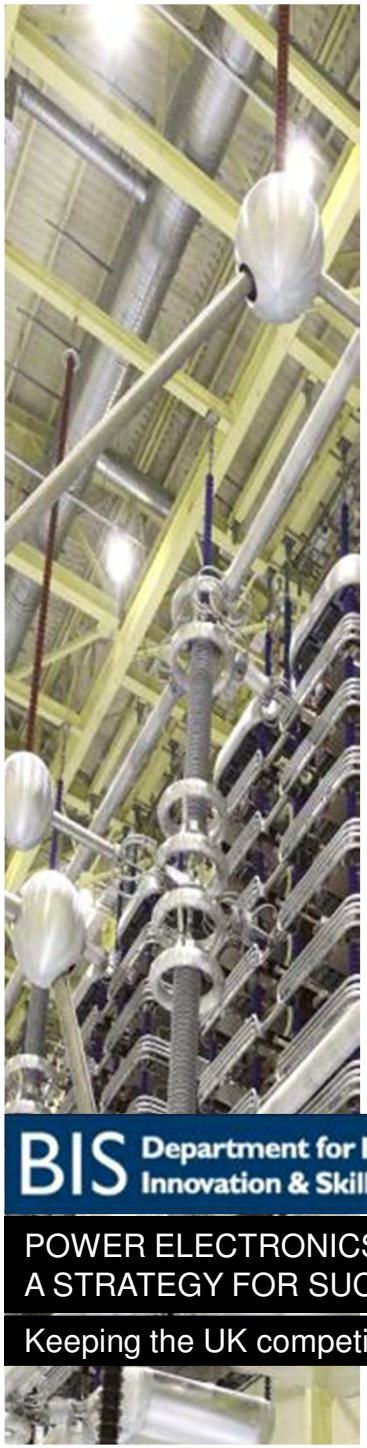
HVAC platform

HVDC platform



On-shore HVDC station

Graham Ferry
HVDC R&D



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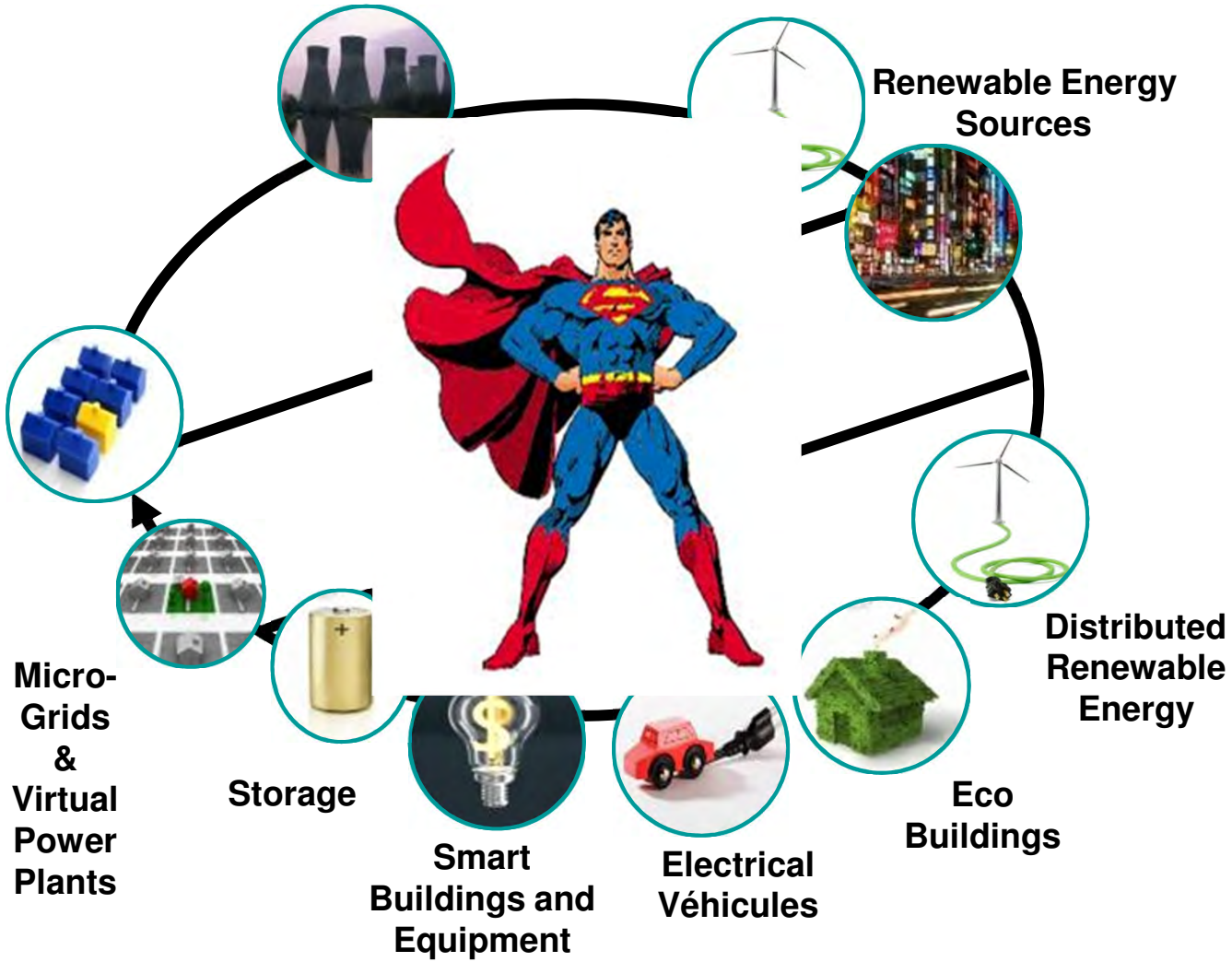
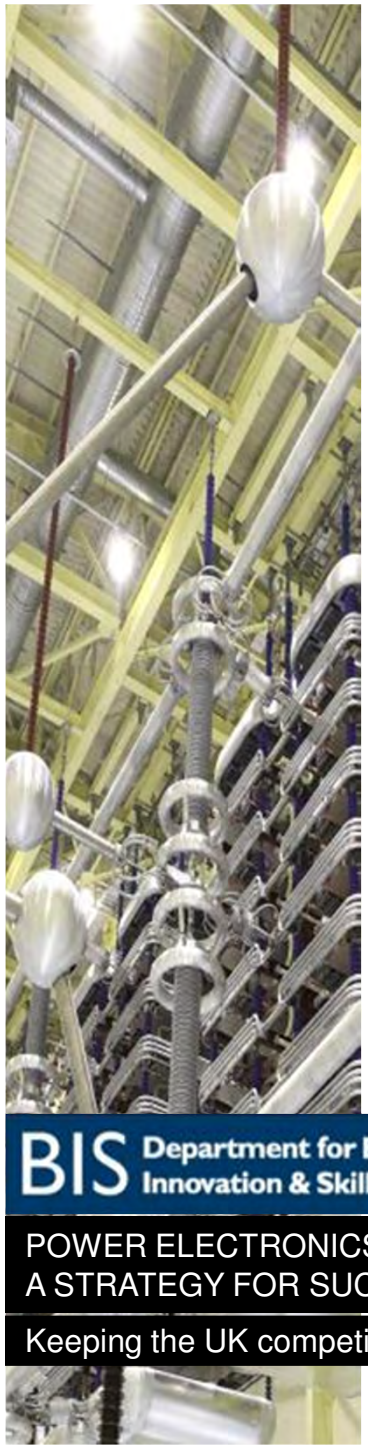
2 UK exemplar low-energy/ low-carbon economy





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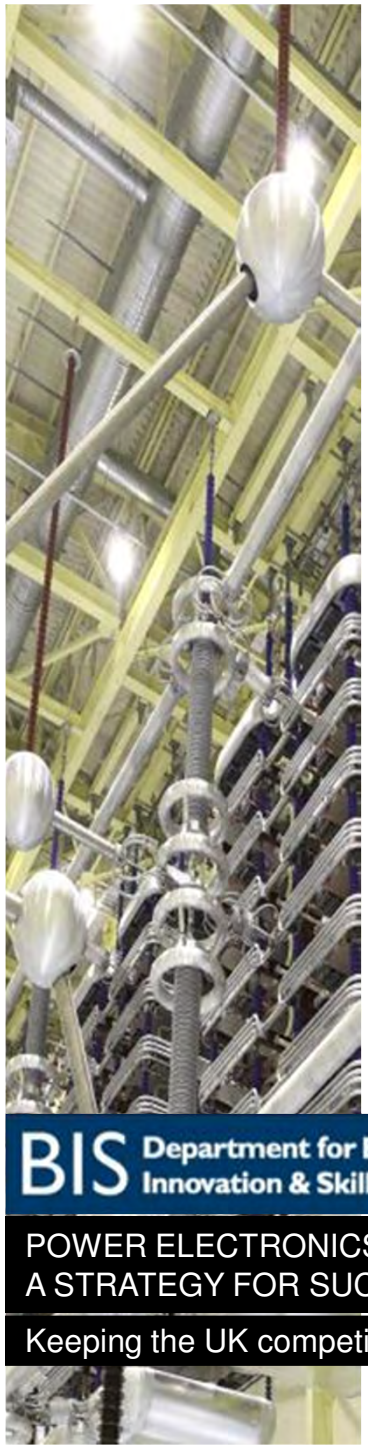
2 UK exemplar low-energy/ low-carbon economy

- Smart Grid Team work



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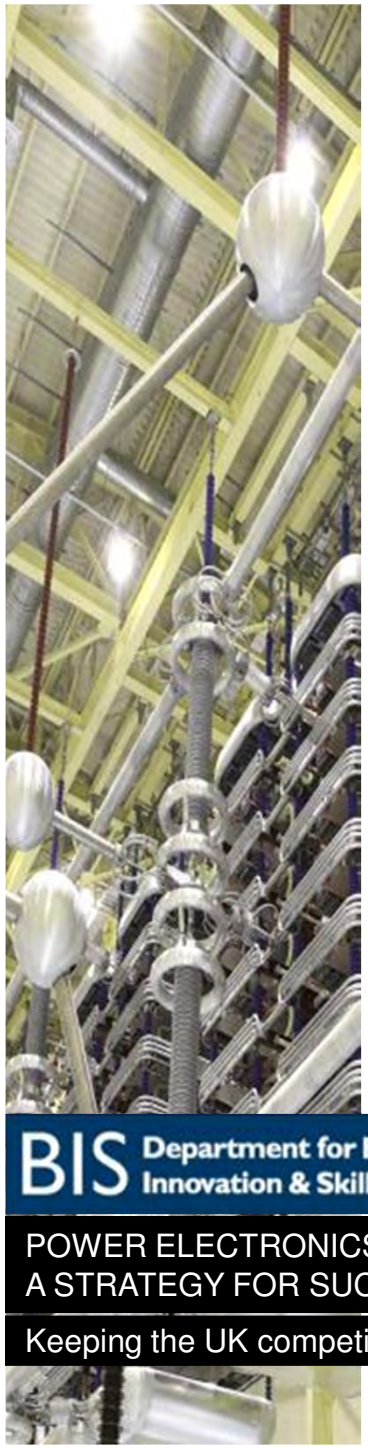
International IOR Rectifier

Robert Haase, Technology Director



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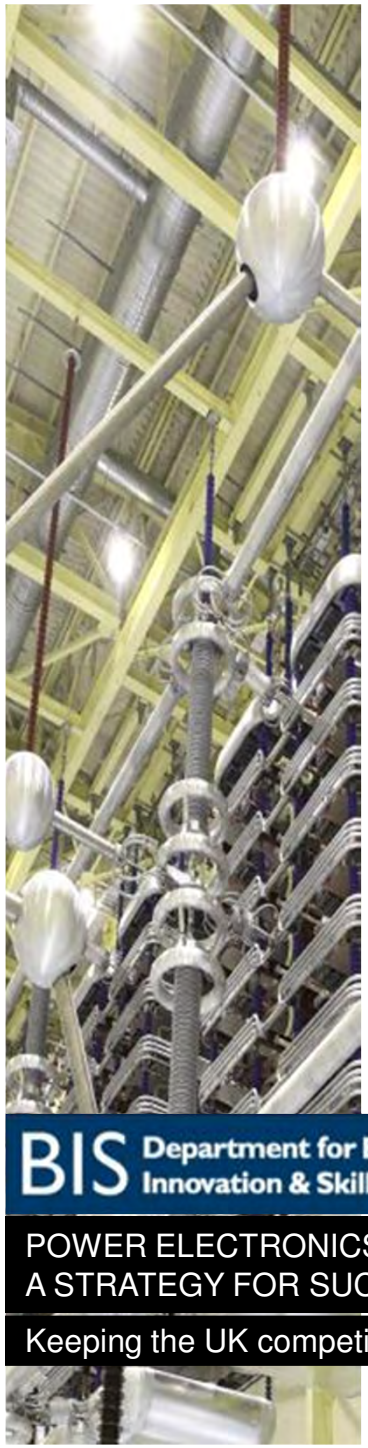
POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

3 To ensure the UK remains at the forefront of innovative Power Electronics design and manufacture

- UK needs to be recognised as a major exporter of essential components which are enabling low carbon economic growth of nations like China
- World class technology is being developed from the legacy of major semiconductor manufacturing facilities dating back to 80's. Investment is required to retain viability
- Advanced manufacturing and technology development projects are internationally mobile



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POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

3 To ensure the UK remains at the forefront of innovative Power Electronics design and manufacture

- Retain skills and develop new talent
- Embrace innovation at all levels
- Attract year on year investment to retain high margin advanced manufacturing
- Recognition of UK's contribution to global low carbon economic growth
- Export growth

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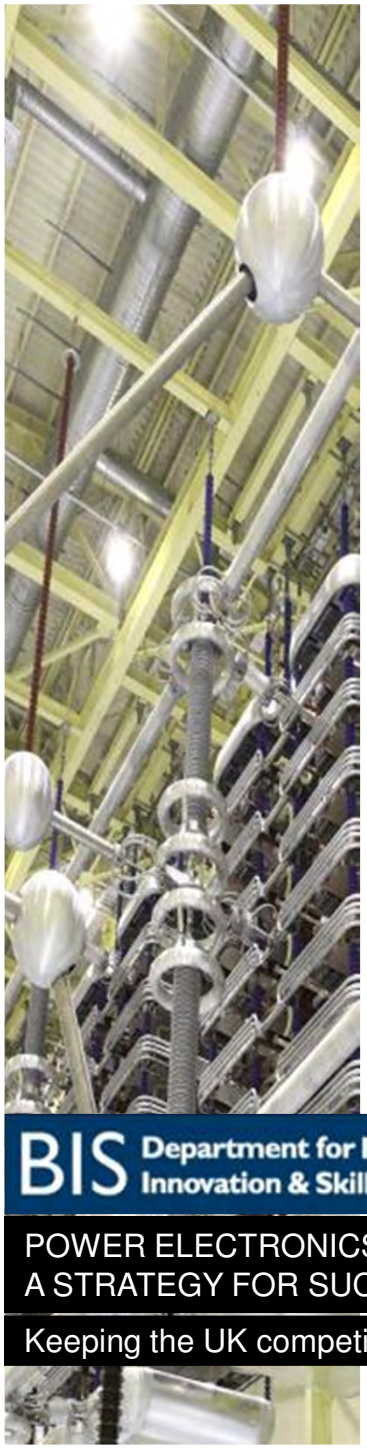
Bill Drury – Visiting Professor / Technical Advisor

University of BRISTOL

EMERSON Industrial Automation

CONTROL TECHNIQUES



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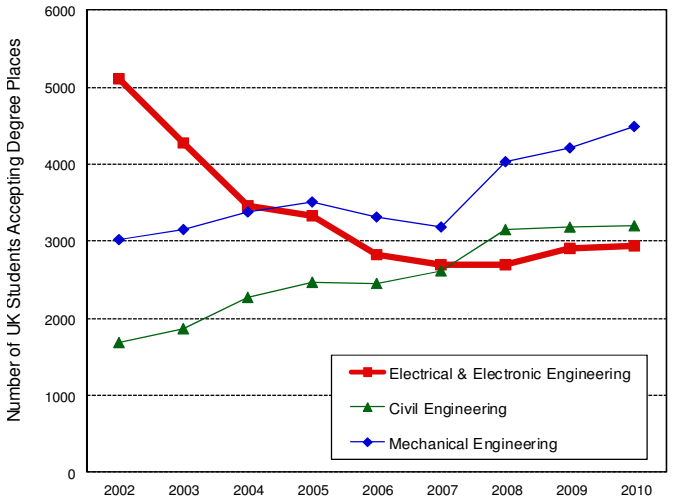
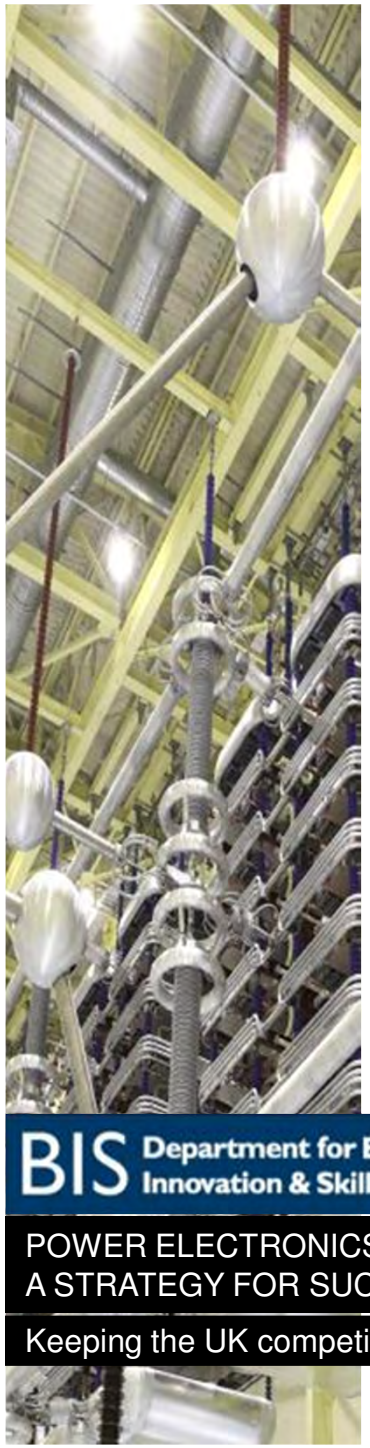
4

To ensure a good supply of talented Power Electronics engineers for both industry and academia

- 41% fewer UK students in 2010 (cf 2002) accepting a place to study EEE
- 33% of engineering graduates take non-engineering related jobs
- University fees rise to circa £9k in 2012
- 12.9% fewer 15-19 year olds in 2018 than there were in 2008





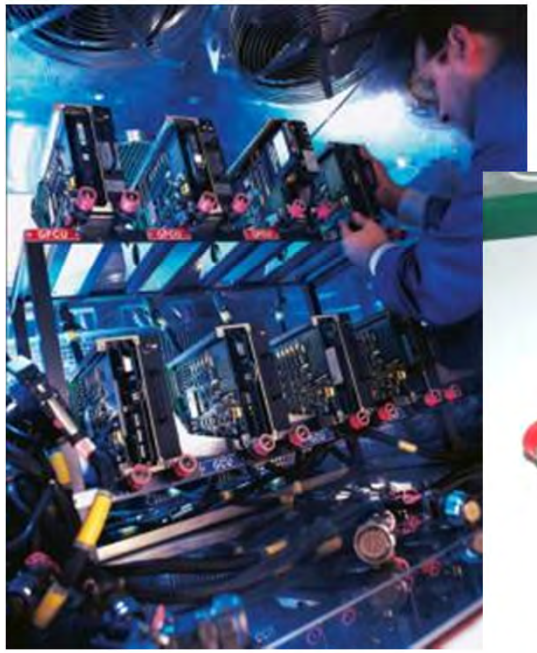
4

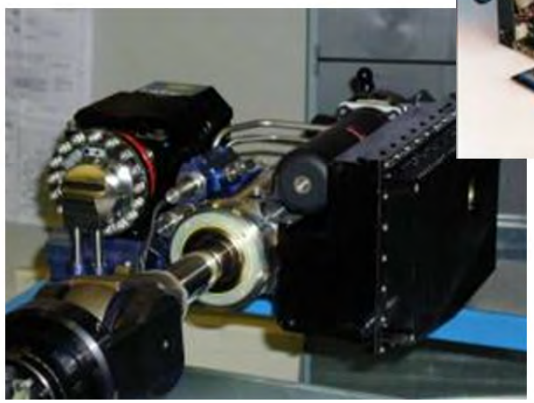
To ensure a good supply of talented Power Electronics engineers for both industry and academia

- Hearts and Minds action in primary & secondary Schools to promote/value engineering
- Vocational Routes to all levels of Engineering
- Tertiary education to recognise the National importance of Engineering & Power Electronics
- Postgraduate research and training funding to be directed to strategic objectives
- Recognise the global market for Power Electronics talent
- Maintain and improve standards of teaching
- Ensure critical mass of key academic teams without stifling innovation

GOODRICH

Philip McGoldrick
Technology Manager
Goodrich Power Systems





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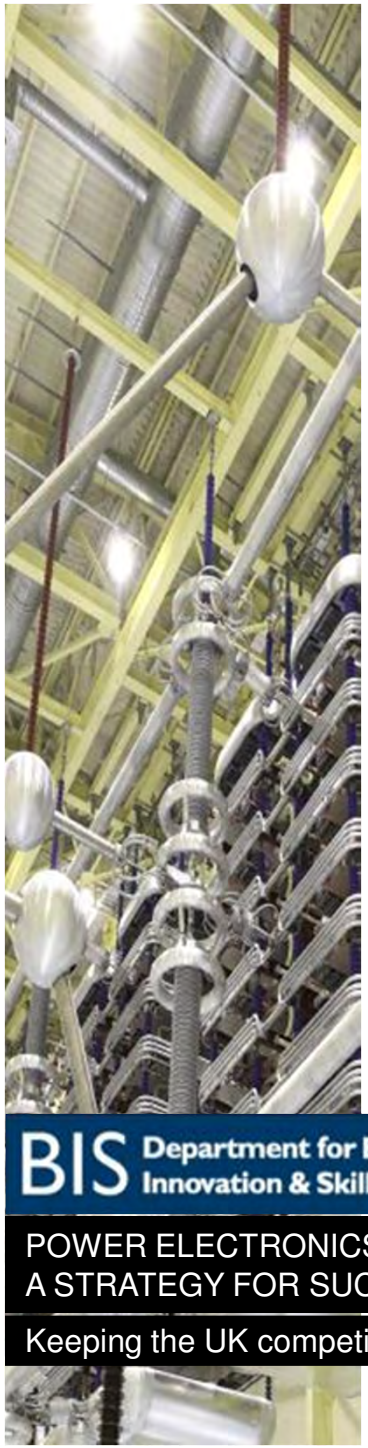

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A STRATEGY FOR SUCCESS

Keeping the UK competitive

5

To improve access to leading technology and engineers, bridging industry and universities

- Virtual power electronic research centre.
  Pull-through from industrial Tier 1's.
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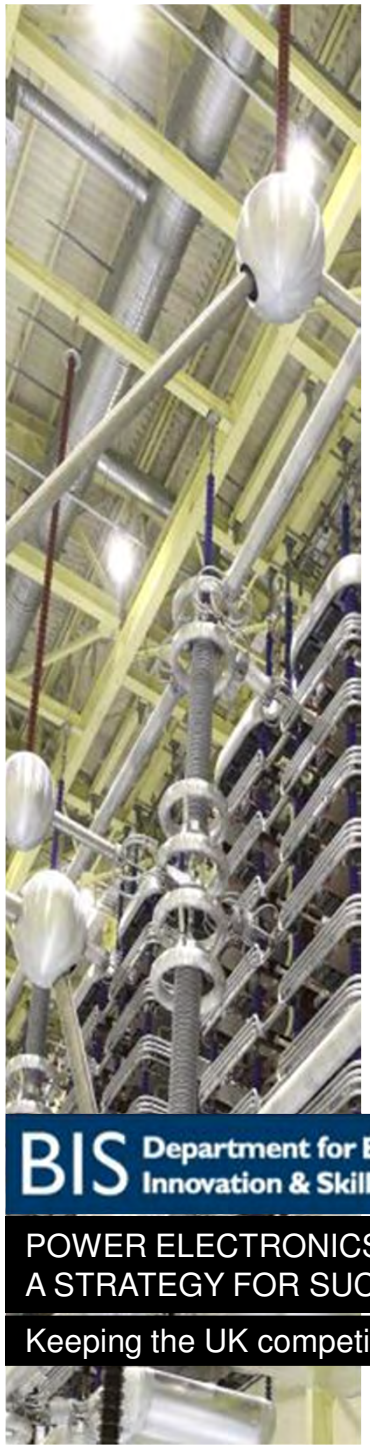

5

To improve access to leading technology and engineers, bridging industry and universities

What Aerospace Industry can do to improve access to technology . . . . .

Contribute to cross-sector technology roadmaps.

Cross-fertilisation.

UK aerospace industry is one of only two countries that can undertake complete new technology systems for future airliners.

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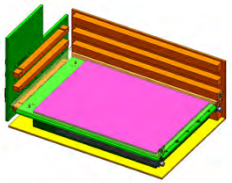
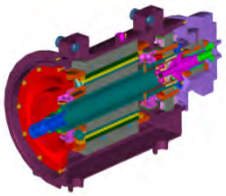
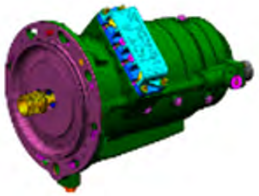
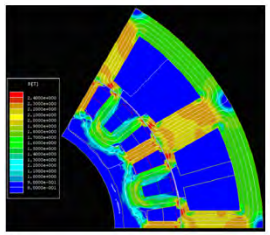
What Goodrich can do . . . . .

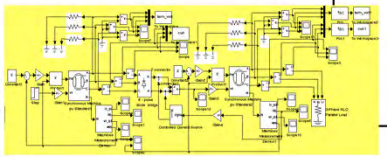
CAD, Simulation, Integration

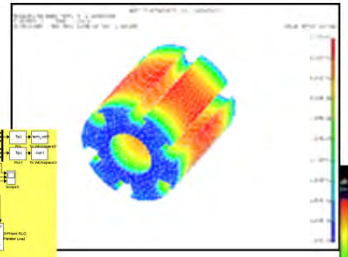


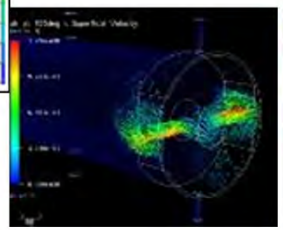


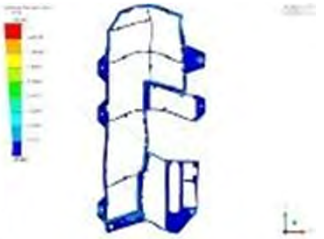


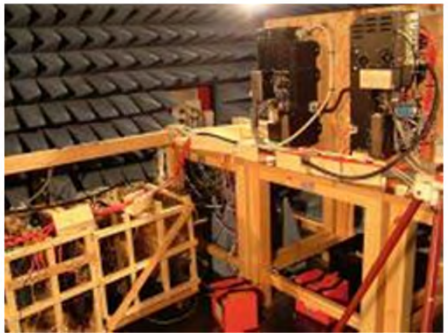












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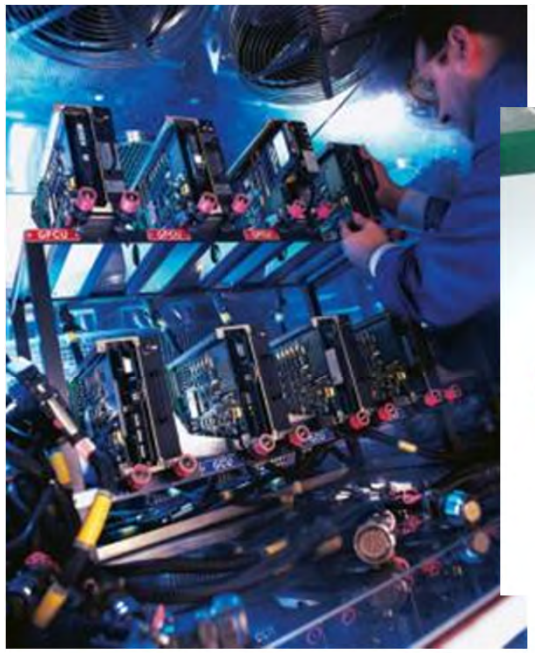

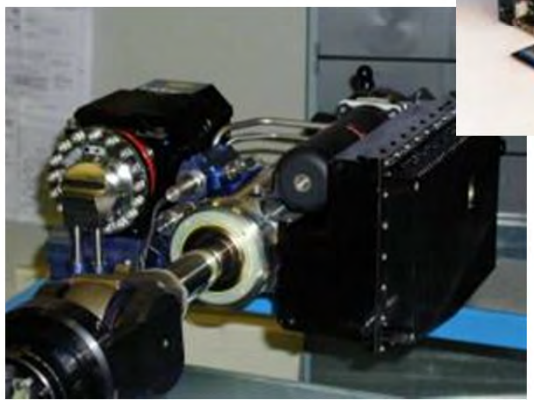

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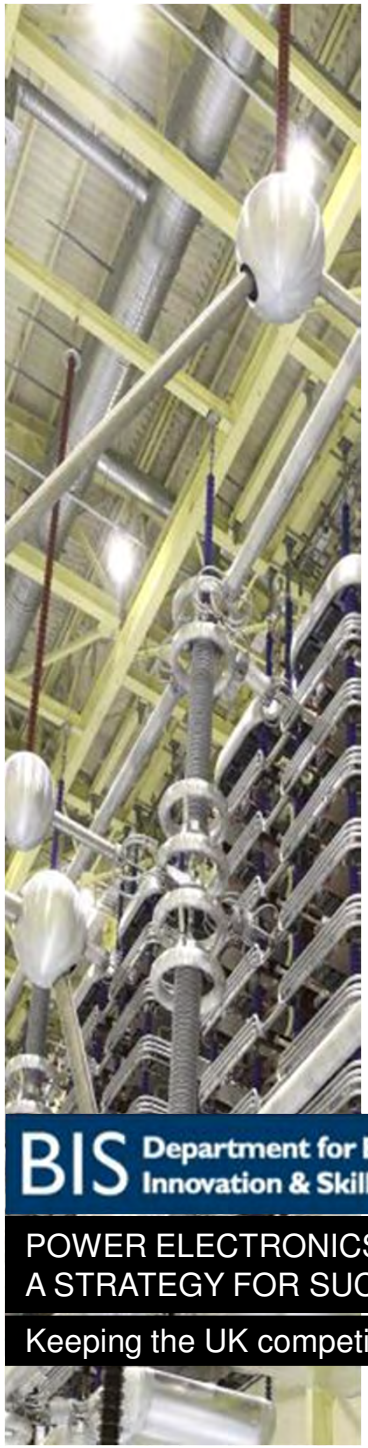

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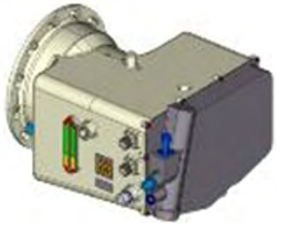

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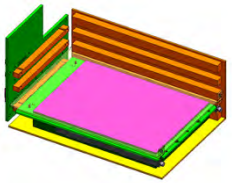

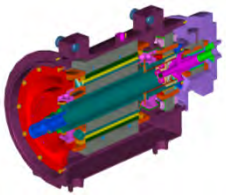

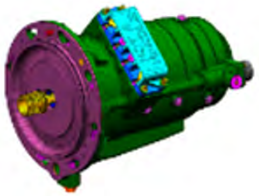

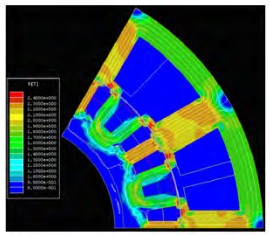

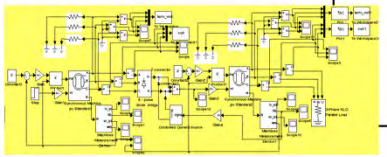

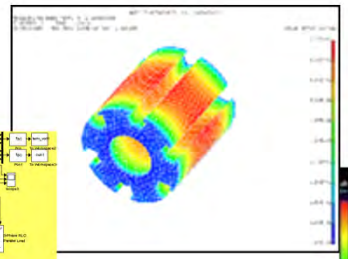

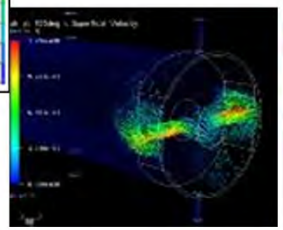

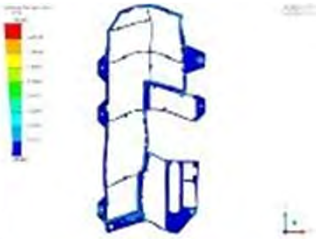

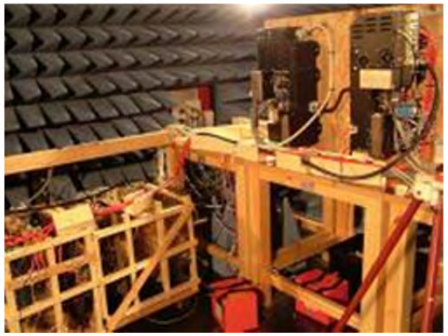

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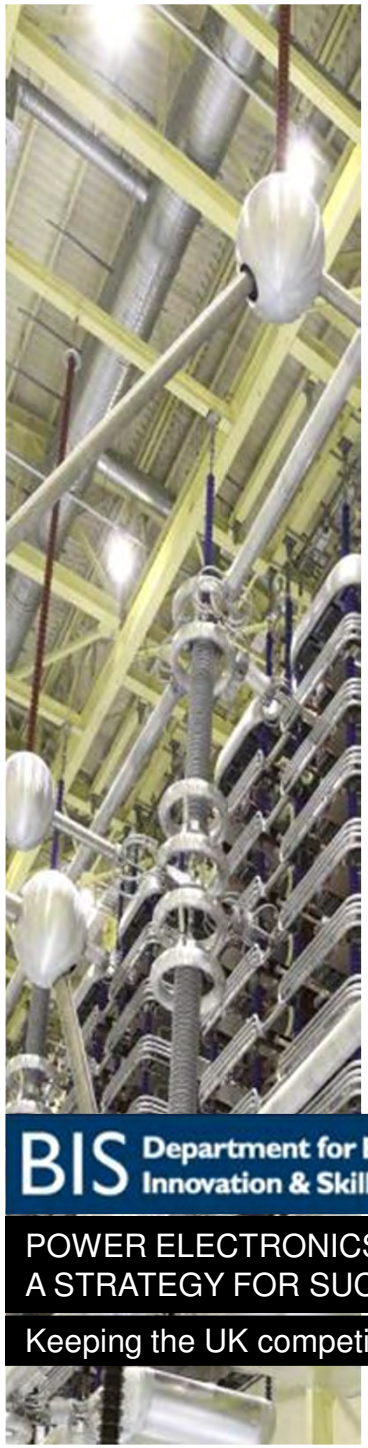
POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive



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POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Panel session

EMERSON
Industrial Automation
CONTROL TECHNIQUES

Industrial Drives

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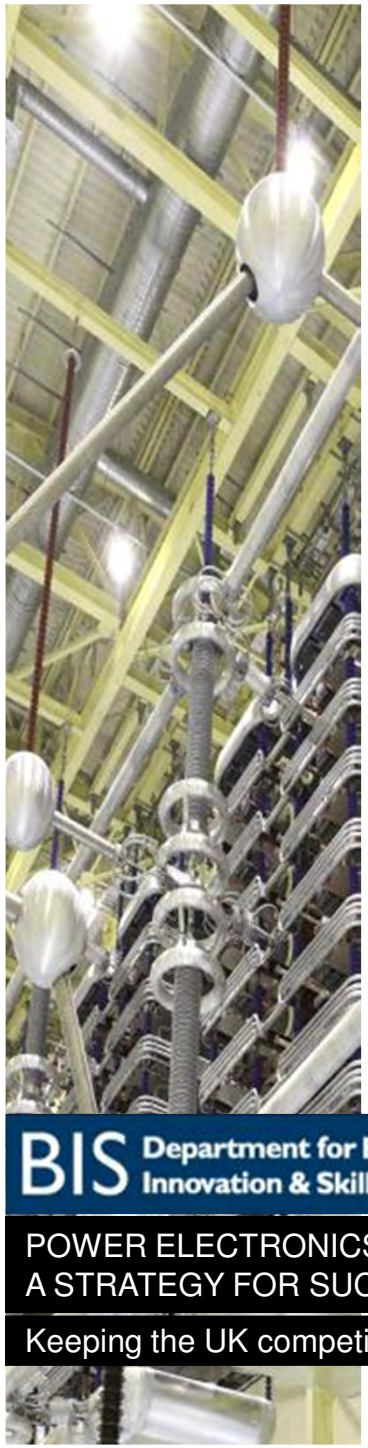
POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Bill Drury
Technical Advisor



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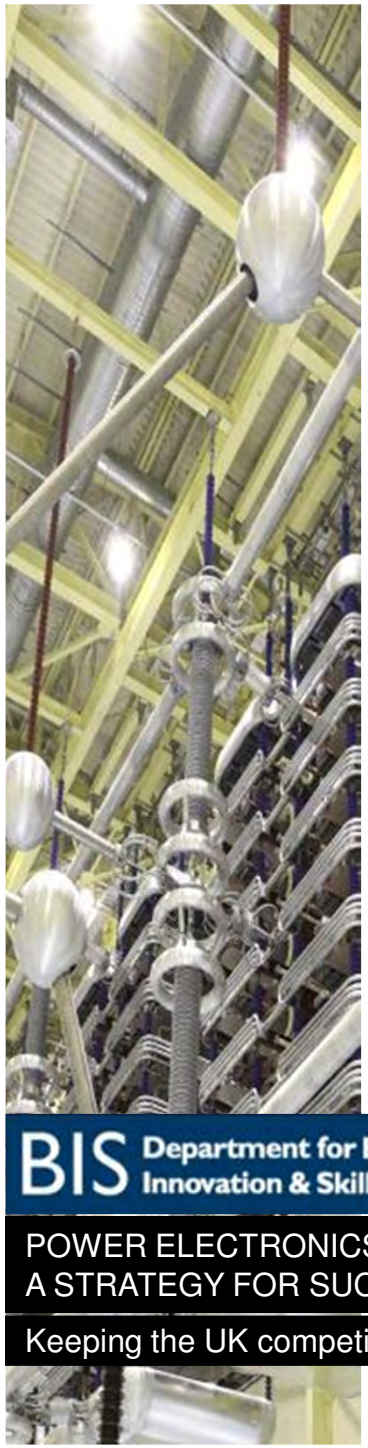
POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Industrial Drives
Market Size

- Global Market £8.5bn. 13% CAGR
- Fragmented market and supply - No one supplier has more than 25% of the world market



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POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Industrial Drives
UK Strengths & Capabilities

- 6 of the top 10 global market leaders have design and/or manufacturing facilities in the UK
- World Class Universities

EMERSON Industrial Automation

SIEMENS

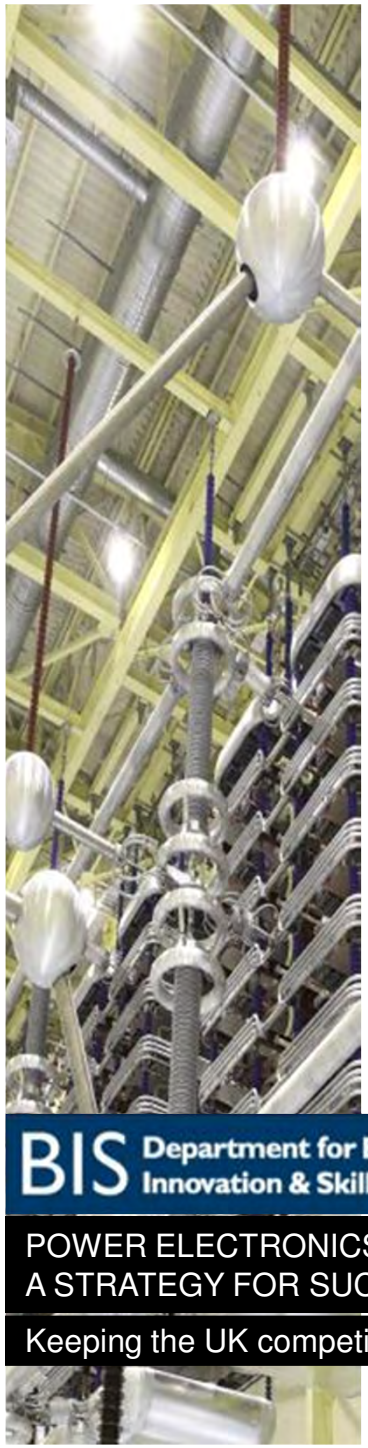
CONTROL TECHNIQUES

CONVERTEAM
THE POWER CONVERSION COMPANY

YASKAWA

ABB

Parker SSD DRIVES



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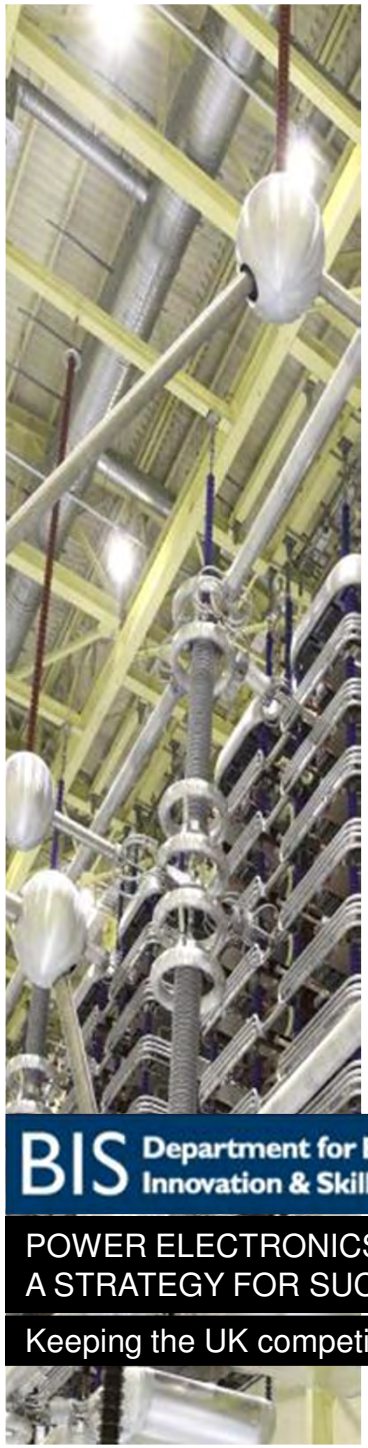
POWER ELECTRONICS
A STRATEGY FOR SUCCESS

Keeping the UK competitive

Regional Workshop – Industrial Drives Issues

Strengths	Weaknesses
• International reputation for Design / Innovation • Profitable can fund non disruptive innovation • 6 out of top 10 global suppliers have UK based design / manufacturing • Good Supply Chain • World Class University Research and teaching	• Drives not seen as "low carbon" enabler in legislation • Availability of skilled staff • Time to Market / Response time to market too slow • Industry, Universities and Government not coordinated
Opportunities	**Threats**
• High added value manufacture • Technology feed in to Renewables and the Smart Grid. • Sponsoring Students key to recruitment	• Inability to recruit high quality Engineers would make global companies move their design and manufacturing out of the UK.



Agenda

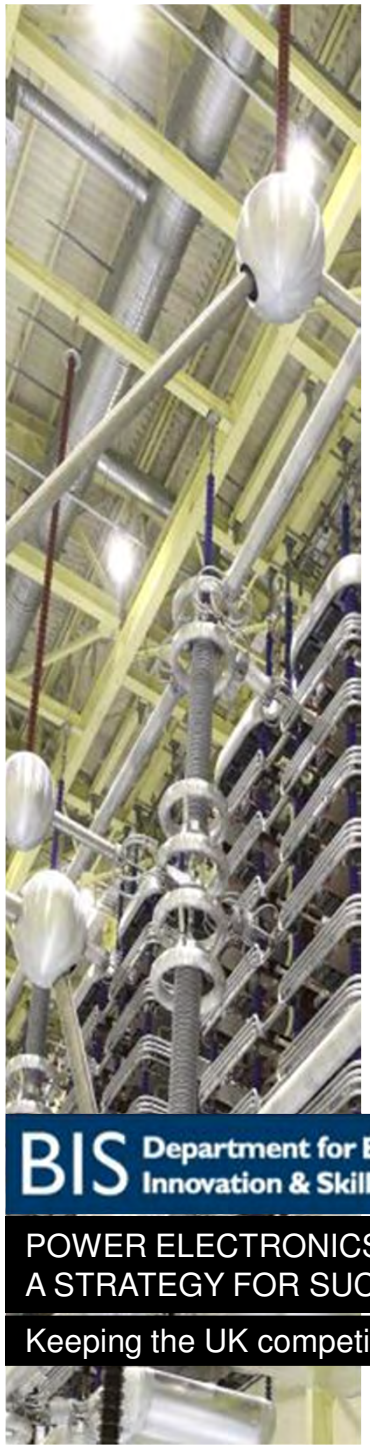
BIS Department for Business Innovation & Skills

Power Electronics: A Strategy for Success

Launch Event, **18 October 2011, 9:30 – 14:00**

BIS Conference Centre, 1 Victoria Street, London,

09:30	**Registration & Coffee** **Delegates are asked to be seated by 10:00am**	
10:10	Chairman's welcome and introduction to Power Electronics: A Strategy for Success	Bill Drury, Chairman, Power Electronics Strategy Working Group
10:20	Keynote Address	Mark Prisk MP, Minister of State for Business and Enterprise
10:30	Strategy Overview A series of short presentations from members of the Power Electronics Strategy Group looking in more detail at some of the key issues raised in the report.	Bill Drury supported by Working Group Subject leaders
11:30	Break and Coffee	
11:45	Panel Session Meeting the Challenges – Your views Your chance to put questions to the Power Electronics Working Group members.	Power Electronics Working Group
12:45	Networking Lunch and Exhibition A buffet lunch will be served and you have the opportunity meet some companies in the power electronics supply chain.	
14:00	Close	



Exhibitors

- Goodrich
- Dynex Semiconductor
- International Rectifier
- Emerson - Control Techniques
- University of Nottingham
- GE Energy (Converteam)
- Rolls-Royce
- UKESF
- E3 Academy
- NMI