UK Investment in Bioenergy
and
Opportunities for Brazil- UK Collaboration

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Bioenergy Champion, BBSRC

October 2014

Outline of talk

- Why bioenergy for the UK?
- The key UK bioenergy players and how research funding is provided
- The BBSRC Sustainable Bioenergy Centre (BSBEC)
- The EPSRC SUPERGEN Bioenergy Hub
- Current issues around industrial biotechnology and bioenergy
- A joint Brazil / UK approach to addressing the Bioenergy Challenge
- The Energy Challenge looking forward

Why industrial biotechnology and bioenergy are important to the UK?

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Sustainability:

- Addressing the issues identified by the UN IPCC since first report in 1990 and the Rio de Janeiro Earth Summit in 1992.
- UK has committed to sourcing 15% of its total energy from renewable sources by 2020[1.]
- UK has a legally binding long-term framework to cut carbon emissions by at least 80% by 2050[2.]
- Maintaining citizens' lifestyles in an era of increasing cost of 'fossil' hydrocarbon sources for both energy (e.g. petrol, diesel, aviation fuel) and feedstock chemicals (e.g. for plastics).

Value to the economy:

- Industrial biotechnology and bioenergy also has considerable value to the UK economy, estimated to be between £4Bn and £12Bn by 2025.

Health:

- Sources of valuable products for improving healthcare (e.g. antibiotics, biopharmaceuticals)

1. The UK Renewable Energy Strategy 2009.
2. Climate Change Act 2008. (against a 1990 baseline)

Key Bioenergy players in the UK

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Government Departments

- Department of Energy and Climate Change (DECC)
- Department for Transport (DfT)
- Department for Environment Food and Rural Affairs (Defra)

UK Bioenergy Strategy 2012

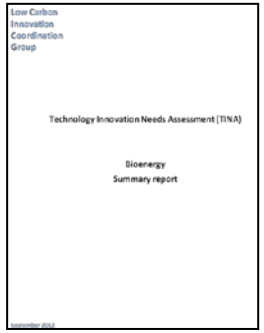
Research Councils

- Biotechnology and Biological Sciences Research Council (BBSRC)
- Engineering and Physical Sciences Research Council (EPSRC)
  - inc. SUPERGEN Bioenergy Hub and coordination of the RC Energy programme
- X-RC Bioenergy Strategy Coordination Group
  - BBSRC, EPSRC, ESRC, NERC, STFC, Innovate UK
- UK Energy Research Centre (UKERC)

Energy Technologies Institute (ETI)

Low Carbon Innovation Coordination Group (LCICG)

- Technology Innovation Needs Assessments (TINA)



LCICG TINA (2012) and Strategic Framework (2014)

UK Research Council Funding

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HM Treasury

Comprehensive Spending Review

Department of Business, Innovation and Skills (BIS)

~ £3 billion budget

RESEARCH COUNCILS UK

AHRC BBSRC ESRC EPSRC

MRC NERC STFC

BBSRC ca. £500M* 2013-2014

*Includes additional capital

What BBSRC does:

- Fund **world-class bioscience research** in UK Universities and Institutes that may well be 10-20 years from full realisation of application.

- Fund **bioscience training and skills.**

- Derive the widest possible **social and economic impact** from our bioscience in industry, policy and public goods through the provision of evidence for policy formation and the support of translational science.

- Promote **public engagement** on bioscience and its application.

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Three major strategic science priorities (Grand Challenges)

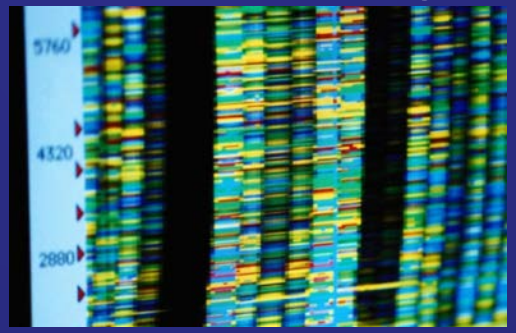
Agriculture & Food Security

Industrial Biotechnology & Bioenergy

Bioscience for Health

Three crucial enabling themes

Enabling innovation



Exploiting New Ways of Working

Partnerships

UK funding

- Fundamental curiosity-led science
- Strategically focused science
- Training
- Knowledge exchange
- Foster international collaboration
- Industrial collaborations
- National Institutes of Bioscience
  - Science parks
  - Industry / academia incubators

Promoting excellent science through peer review

www.bbsrc.ac.uk/funding/funding-index.aspx

Strategic Focus:
IBBE Network and Catalyst model

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EPSRC
Engineering and Physical Sciences Research Council

Innovate UK
Technology Strategy Board

VISION

UK bioscience research delivering new products & processes key to the bioeconomy and driving economic growth for the UK and worldwide

BBSRC NIBB

Network members

Multidisciplinary academics: postgrad to professor

Industry representatives

International connections

Seed funding

Public Outreach

Input to Policy

£18M funding for 13 networks

IB Catalyst

5 year funding programme by BBSRC, EPSRC, and Innovate UK
£45M funding for 2014-15

Scale up and Demonstration

Commercialisation

BBSRC NIBB
(2014-2019)

Total funding = £18M
EPSRC = £1M

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Biorefining

LBNet Lignocellulosic Biorefinery Network
McQueen-Mason - York

AD NETWORK Harnessing Anaerobic Digestion
Banks-Southampton

Biocatalysis

biocatnet
N Turner-Manchester

FoodWasteNet
Charalampopoulos-Reading

P2P
Plants to Products (P2P)
Leak-Bath

Novel Chassis

HVC/Natural Products

Bioprocessing

BioProNET
Smales-Kent

C1net gas fermentation
Minton- Nottingham

PHYCONET
Purton-UCL

High Value Chemicals from Plants
Graham-York

NPRONET
Micklefield - Manchester

Cross Cutting

IBCarb NETWORK
Flitsh-Manchester

Metals IN BIOLOGY
Robinson-Durham

CBMNet
Green - Sheffield

www.bbsrc.ac.uk/bbsrcnibb

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The 13 BBSRC NIBB

- ADNet: Anaerobic Digestion Network
- Biocatnet: Network in Biocatalyst Discovery, Development and Scale-Up
- BioProNET: Bioprocessing Network
- C1NET: Chemicals from C1 Gas
- CBMNet: Crossing biological membranes
- FoodWasteNet: Food Processing Waste and By-Products Utilisation Network
- HVCfP: High Value Chemicals from Plants Network
- IBCarb: Glycoscience Tools for Biotechnology and Bioenergy
- LBNet: Lignocellulosic Biorefinery Network
- Metals in Biology: The elements of Biotechnology and Bioenergy
- NPRONET: Natural Products Discovery and Bioengineering Network
- P2P: A Network of Integrated Technologies: Plants to Products
- PHYCONET: unlocking the IB potential of microalgae

www.bbsrc.ac.uk/bbsrcnibb

International funding

BBSRC grant holders and institute staff can apply for:

Partnering Awards

- Brazil, China, India, Japan, Taiwan and USA
- ‘Other Countries’ and ‘European’ schemes launched 2013
- Aims to benefit BBSRC-funded research:
  - To establish new links
  - Promote exchange of scientists
  - Provide access to facilities
  - Enable UK scientists to access overseas funding
- Partnerships for up to 4 years
- £20k - £50k
- Annual Call: mid September - mid November

International Workshops

- Stimulate joint working in topics important to BBSRC
- Annual Call: mid September - mid November
- Typically up to £10k

Research performance: latest findings

The UK has…

- 0.9% of global population,
- 4.1% of researchers
- 3.2% of R&D expenditure
- 6.4% of global journal articles
- 11.6% of citations,
- 9.5% of downloads
- 15.9% of the world's most highly-cited articles

Source: International Comparative Performance of the UK Research Base – 2013. Elsevier

UK researchers are highly collaborative

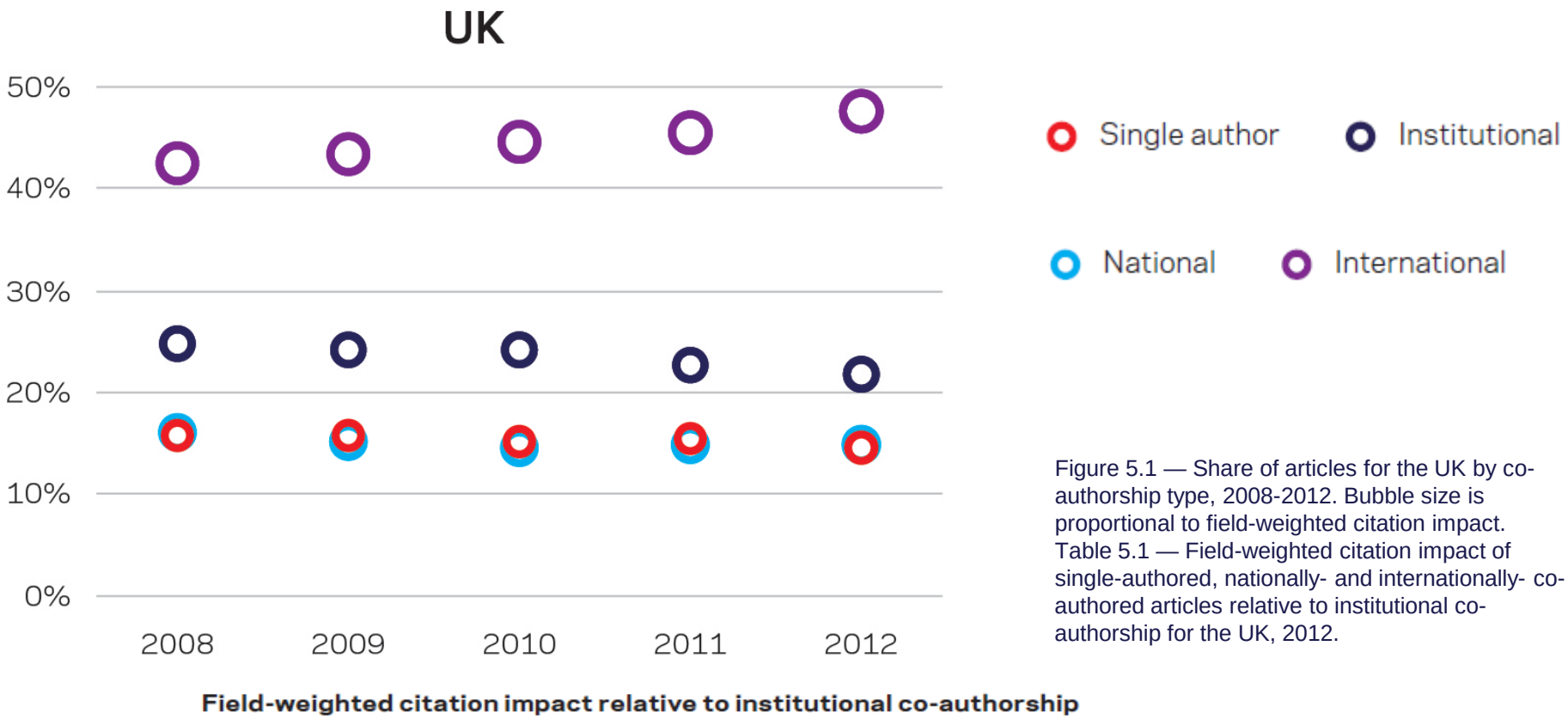
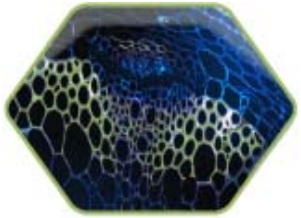
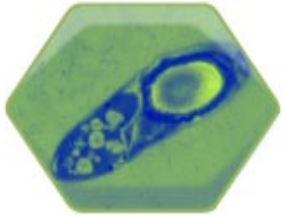


Figure 5.1 — Share of articles for the UK by co-authorship type, 2008-2012. Bubble size is proportional to field-weighted citation impact.
Table 5.1 — Field-weighted citation impact of single-authored, nationally- and internationally- co-authored articles relative to institutional co-authorship for the UK, 2012.

Country	Single author	Institutional	National	International
UK	84%	100%	120%	161%





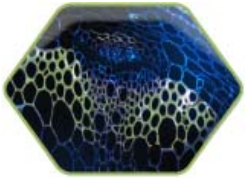
BBSRC Sustainable Bioenergy Centre

Integrated science across chain

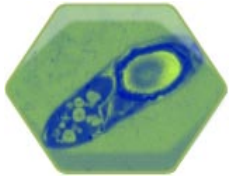
Biomass Growth → Biomass Composition → Biomass Deconstruction → Fermentation → Fuel

ENVIRONMENTAL, SOCIAL, ECONOMIC SUSTAINABILITY

Perennial Bioenergy Crops (BSBEC-BioMASS)
Angela Karp (Rothamsted)
- IBERS
- Imperial College
- University of Cambridge
- Ceres Inc



Cell Wall Sugars
Paul Dupree (Cambridge)
- Newcastle University
- Novozymes A/G



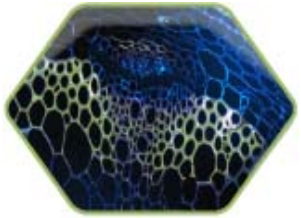
Second Generation, Sustainable, Bacterial Biofuels
Nigel Minton (Nottingham)
- Newcastle University

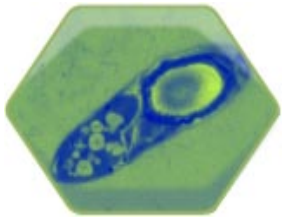
Cell Wall Lignin
Claire Halpin (Dundee)
- University of York
- James Hutton Institute
- RERAD
- Limagrain UK Ltd
- Syngenta
- AgroParisTec – INRA

Marine Wood Borer Enzyme Discovery
Simon McQueen-Mason (York)
- University of Portsmouth
- Novozymes A/G

Lignocellulosic Conversion to Bioethanol
Katherine Smart / Greg Tucker (Nottingham)
- University of Bath
- BP
- Briggs of Burton
- Coors Brewers Ltd
- Ethanol Technology Ltd
- Pursuit Dynamics
- Scottish Whisky Research Institute
- University of Surrey
- Bioethanol Ltd
- British Sugar Ltd
- DSM
- HGCA
- SABMiller

To tackle major barriers of sustainable biofuel production





BBSRC Sustainable Bioenergy Centre

Selected science highlights

- In-depth understanding of the science pipeline towards biofuel production.
- Improved knowledge of critical genetic variation in cereals (wheat and barley), willow and *miscanthus* for obtaining more extracted sugar.
- The xylan shell model to explain how cellulose and hemicelluloses are structurally bound together.
- Novel enzyme discoveries in gribbles and fungi to improve lignocellulose breakdown.
- Discovery of genes that confer tolerance in yeast to fermentation stresses.
- Creation of a *Clostridium* microbe that breaks down cellulose and converts it to butanol.
- A much improved understanding of how English farmers may be motivated to grow energy crops.

BBSRC Sustainable Bioenergy Centre

Additional activities

- Industrial participation
- Building new alliances
- Training
- Capacity and capability building
- Building international relationships
- Public dialogue
- Input to government policy development
- Encouragement and insights from Science and Impact Advisory Board

http://www.bbsrc.ac.uk/research/biotechnology-bioenergy/bsbec/bsbec-index.aspx

SUPERGEN Bioenergy Hub

SGB Hub Aim & Objectives

- **Increasing UK bioenergy to meet strategic targets in a coherent, sustainable and cost-effective manner**
- Focus on thermo-chemical conversion, together with associated issues
- Focal point for sharing and dissemination of scientific knowledge and engineering understanding
- Investigate and develop new approaches to engineering challenges associated with novel technology deployment
- Improve scientific understanding of biomass/conversion
- Whole-systems perspective
- Interdisciplinary: impacts on ecosystems, social responses, economic context; policy

Director: **Dr Patricia Thornley** p.thornley@manchester.ac.uk
Project manager: **Dr Laura O' Keefe** Laura.O'Keefe@manchester.ac.uk
www.supergen-bioenergy.net

SUPERGEN Bioenergy Hub

SGB Hub Projects

1. Emissions from solid biomass
2. Impact of feedstock parameters on airborne emissions
3. Evaluation of substitute natural gas
4. Streamlining the supply chain
5. Carbon uncertainties in the supply chain
6. Gasification integration
7. Torrefaction integrated assessment
8. Carbon capture & storage enabling technologies
9. Bio-oil upgrading
10. Whole systems analysis of novel biofuel technologies
11. Clean energy from rice straw
12. Photocatalytic bioethanol production
13. Increasing energy yield from the integration of anaerobic digestion and pyrolysis
14. Clean energy utilisation from biogas and biomass gasification
15. Development of fast pyrolysis based advanced bioenergy technologies for biofuels
16. Bioenergy value chains – whole systems analysis and optimisation

Current issues around industrial biotechnology and bioenergy

- The food / energy / land use / water nexus.
- Land Use Change.
- Optimisation of wastes and residue streams for manufacturing chemicals and biofuels.
- Translation from research to commercial reality - whole chain scale-up.
- Policy environment.
- Hesitation – fear of doing the ‘wrong thing’ (e.g. ‘best use of biomass’).

Supporting UK-Brazil Collaboration

RCUK-FAPESP MoU

- One way lead agency agreement – applications submitted to RCUK Responsive Mode funding mechanism. Brazilian partners funded by FAPESP.
- Supports collaborative programmes up to £2M.

BBSRC- FAPESP FAPPA Pump-Priming Scheme

- Open to researchers funded by BBSRC and FAPESP
- Up to £35,000 over 2 years for collaborative activities and pump-priming projects.

BBSRC Brazil Partnering Awards

- £20-£50,000 over 1-4 years to support collaborations between BBSRC funded researchers and researchers in, Brazil, China, India, Japan, Taiwan, US and other countries.

International Scientific Interchange Scheme

- Travel grants, up to £5000 of funding available to BBSRC funded researchers to visit other countries to develop collaborations, prepare joint proposals, knowledge exchange.

www.bbsrc.ac.uk/funding/internationalfunding

UK / Brazil research collaborations include:

- Through European Funding networks e.g.: SUNLIBB Framework 7 Programme.
- With Brazil's flagship BIOEN Programme.
- A number of UK universities have signed MoU's with FAPESP.
- With world-leading researchers at UNICAMP and the University of Sao Paulo.

To name but a few……

FAPESP/BBSRC
Joint Bioenergy Call - Intent

The proposed FAPESP / BBSRC programme aims to:

- Advance the excellent scientific relationships developed between UK and Brazilian scientists and encourage new partnerships.
- Advance the scientific area by encouraging deployment of complementary expertise and unique facilities.
- Produce industrially relevant scientific outputs which can be taken up by a global industry.
- Enable a step-change in the BBSRC's strategic partnership with Brazil.

FAPESP/BBSRC
Joint Bioenergy Call - Intent

- Build on the RCUK – FAPESP MoU.
- Focus on **advanced biofuels.**
- Feedstock to product **whole-chain** (including biorefinery) approach.
- Taking into account the social, economic and environmental aspects and **sustainability** of the processes and products that are being developed.
- Building the science to be **adaptable to differing conditions:**
  - not just Brazil and the UK,
  - think Africa.

FAPESP/BBSRC
Joint Bioenergy Call - Science Areas

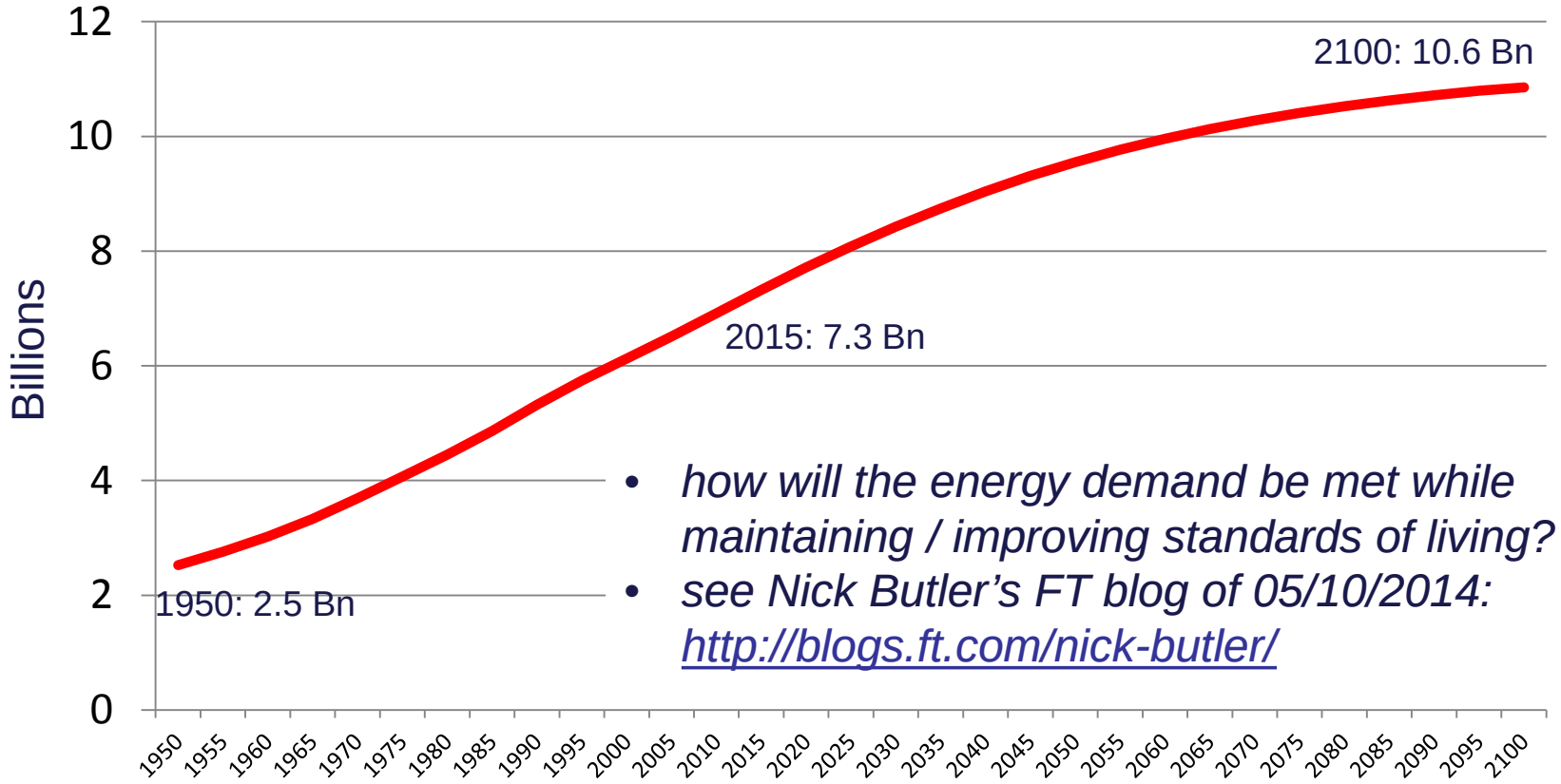
1. **Enzyme design and development** for scaling up processing of lignocellulosic feedstocks from lab to pilot scale with the requirements of further scales in mind. Enzyme discovery can form part of a proposal but should not be the main focus.
2. Optimization of **feedstock attributes** and their effect on production and processing for advanced biofuels and commodity and high value chemicals. This could include new agronomic practices for improving yield, sustainability and the integration of food and bioenergy production.
3. Development of novel **high-yielding fermentative organisms**, able to generate a range of (novel) products but with wide-ranging substrate tolerance and resistance to inhibitors.

FAPESP/BBSRC
Joint Bioenergy Call

- BBSRC will invest in the region of £5 million, with matched funding from FAPESP.
- Grants expected to be for 3-5 years duration.
- Aim to make a formal announcement early in 2015.

- A key will be to optimise outputs from the overall programme; we will aim to **deliver more than the sum of the parts**.
- Successful applicants will be expected to participate in workshops to work together to create a **cohesive programme.**

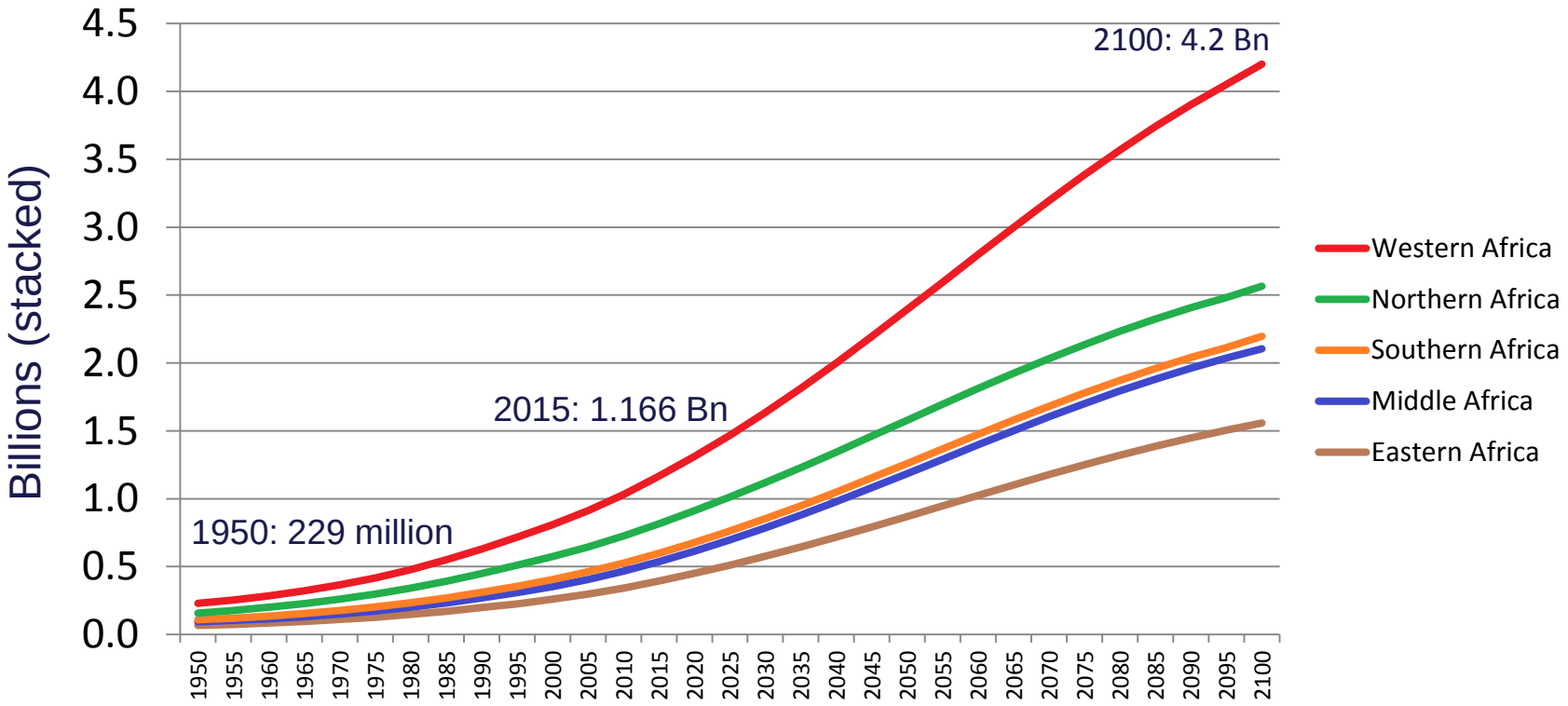
Bioenergy in the Future: World Population (1950-2100)



- *how will the energy demand be met while maintaining / improving standards of living?*
- *see Nick Butler's FT blog of 05/10/2014: http://blogs.ft.com/nick-butler/*

Source: UN, World Population Prospects: The 2012 Revision, http://esa.un.org/unpd/wpp/index.htm October 02, 2014

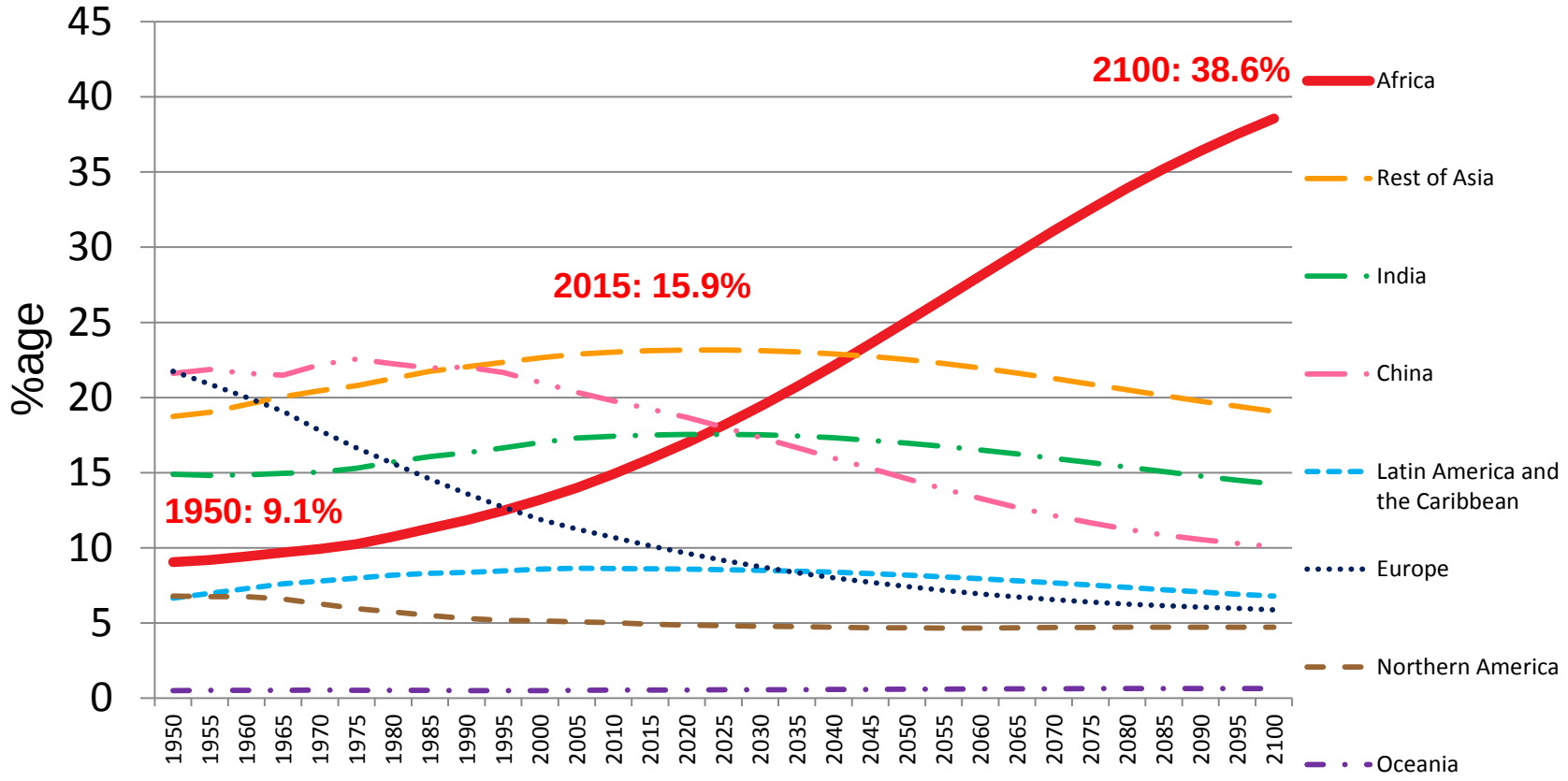
Bioenergy in the Future: Africa Population (1950-2100)



Source: UN, World Population Prospects: The 2012 Revision, http://esa.un.org/unpd/wpp/index.htm October 02, 2014

Bioenergy in the Future:

Population: %age of World (1950-2100)



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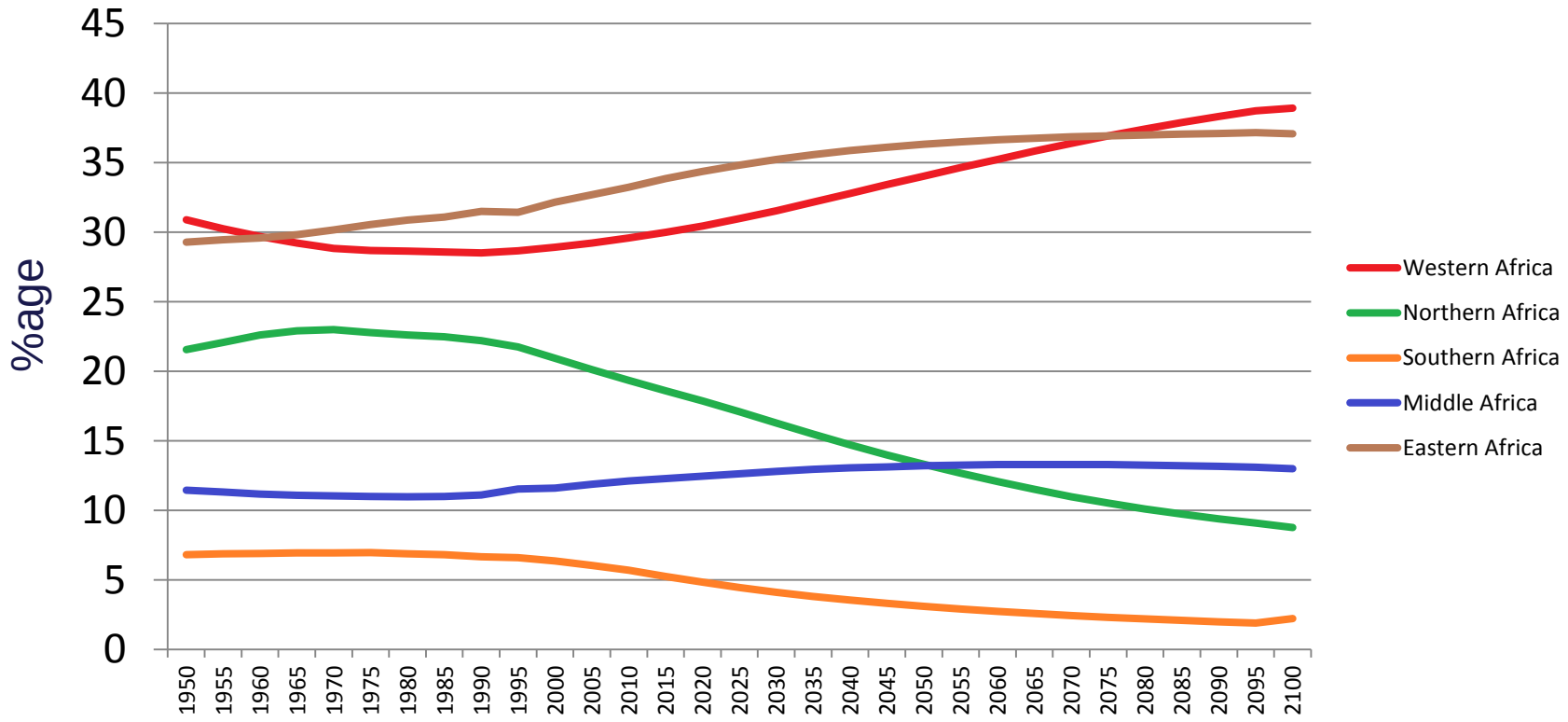
Bioenergy in the Future: Africa Regional %age (1950-2100)



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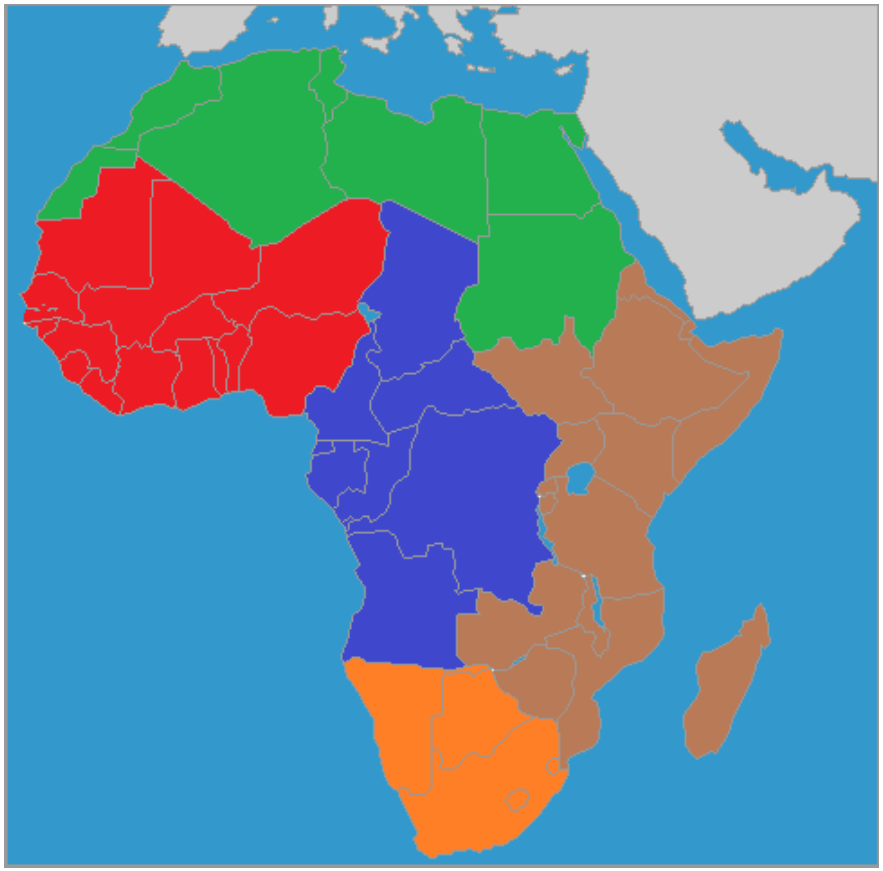
Bioenergy in the Future: Africa Regions



Western Africa

Northern Africa

Southern Africa

Middle Africa

Eastern Africa

UN World Population Prospects: The 2012 Revision http://esa.un.org/unpd/wpp/Excel-Data/country-classification.pdf

A role for bioenergy going forward – the challenge

- Today the true energy demand for Africa is unknown (traditional biomass) and probably substantially unmet.
- African population is rising fast.
- Increasing urbanisation in Africa is likely.
- We should anticipate more energy-intense standards of living in Africa.
- Politics and geographies of oil increasingly difficult.
- Bioenergy can be a part of the solution.
- Ref. IEA Africa Energy Outlook, 13th October 2014: www.worldenergyoutlook.org/africa

A role for bioenergy going forward – the solution

- An integrated multi-disciplinary approach to bioenergy and food production could make a significant contribution to future global wellbeing.
- Combining the skills and experience of Brazil and UK science and implementation could make a real difference in bioenergy.
- Work with local institutions.
- Respect local environments, cultures and practices.
- Work with environmental and social scientists to develop a multi-discipline, integrated approach.

Thank you

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