Bioenergy: saint or sinner?

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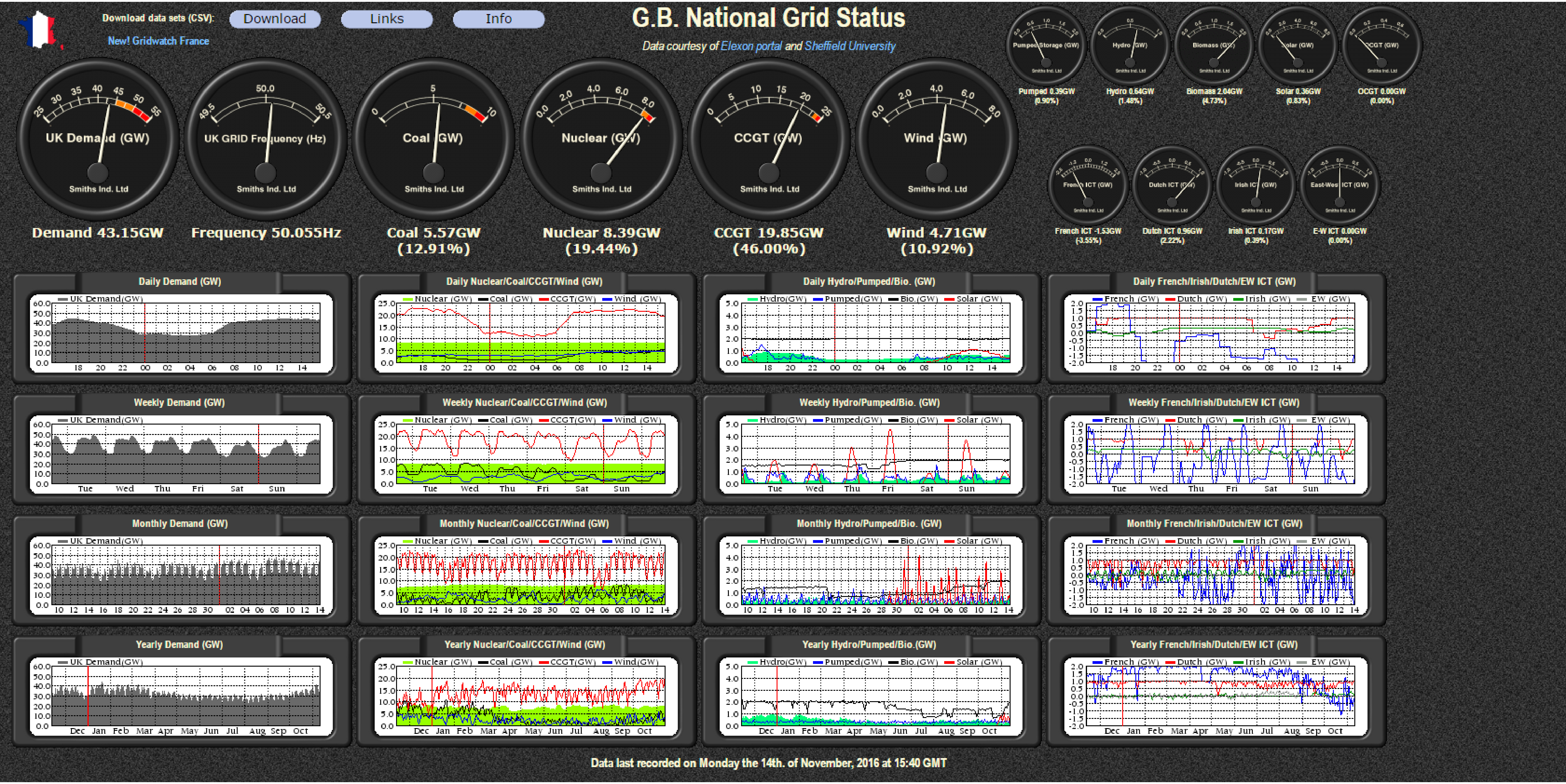
UNIVERSITY OF BATH

SUPERGEN Bioenergy Hub


Download data sets (CSV):
Download
Links
Info
New! Gridwatch France
G.B. National Grid Status
Data courtesy of Elexon portal and Sheffield University
Pumped 0.39GW (0.90%)
Hydro 0.64GW (1.48%)
Biomass 2.04GW (4.73%)
Solar 0.36GW (0.83%)
OCGT 0.00GW (0.00%)
UK Demand (GW)
UK GRID Frequency (Hz)
Coal (GW)
Nuclear (GW)
CCGT (GW)
Wind (GW)
Smiths Ind. Ltd
Demand 43.15GW
Frequency 50.055Hz
Coal 5.57GW (12.91%)
Nuclear 8.39GW (19.44%)
CCGT 19.85GW (46.00%)
Wind 4.71GW (10.92%)
French ICT -1.53GW (-3.55%)
Dutch ICT 0.96GW (2.22%)
Irish ICT 0.17GW (0.39%)
E-W ICT 0.00GW (0.00%)
Daily Demand (GW)
Daily Nuclear/Coal/CCGT/Wind (GW)
Daily Hydro/Pumped/Bio. (GW)
Daily French/Irish/Dutch/EW ICT (GW)
Weekly Demand (GW)
Weekly Nuclear/Coal/CCGT/Wind (GW)
Weekly Hydro/Pumped/Bio. (GW)
Weekly French/Irish/Dutch/EW ICT (GW)
Monthly Demand (GW)
Monthly Nuclear/Coal/CCGT/Wind (GW)
Monthly Hydro/Pumped/Bio. (GW)
Monthly French/Irish/Dutch/EW ICT (GW)
Yearly Demand (GW)
Yearly Nuclear/Coal/CCGT/Wind (GW)
Yearly Hydro/Pumped/Bio.(GW)
Yearly French/Irish/Dutch/EW ICT (GW)
UK Demand(GW)
Nuclear (GW) Coal (GW) CCGT(GW) Wind (GW)
Hydro(GW) Pumped(GW) Bio.(GW) Solar (GW)
French (GW) Dutch (GW) Irish (GW) EW (GW)
Data last recorded on Monday the 14th. of November, 2016 at 15:40 GMT

Biomass energy: "'**confident' renewables**: the
technical unc
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"Biofuels cou
carbon-neut
(Mitchell and

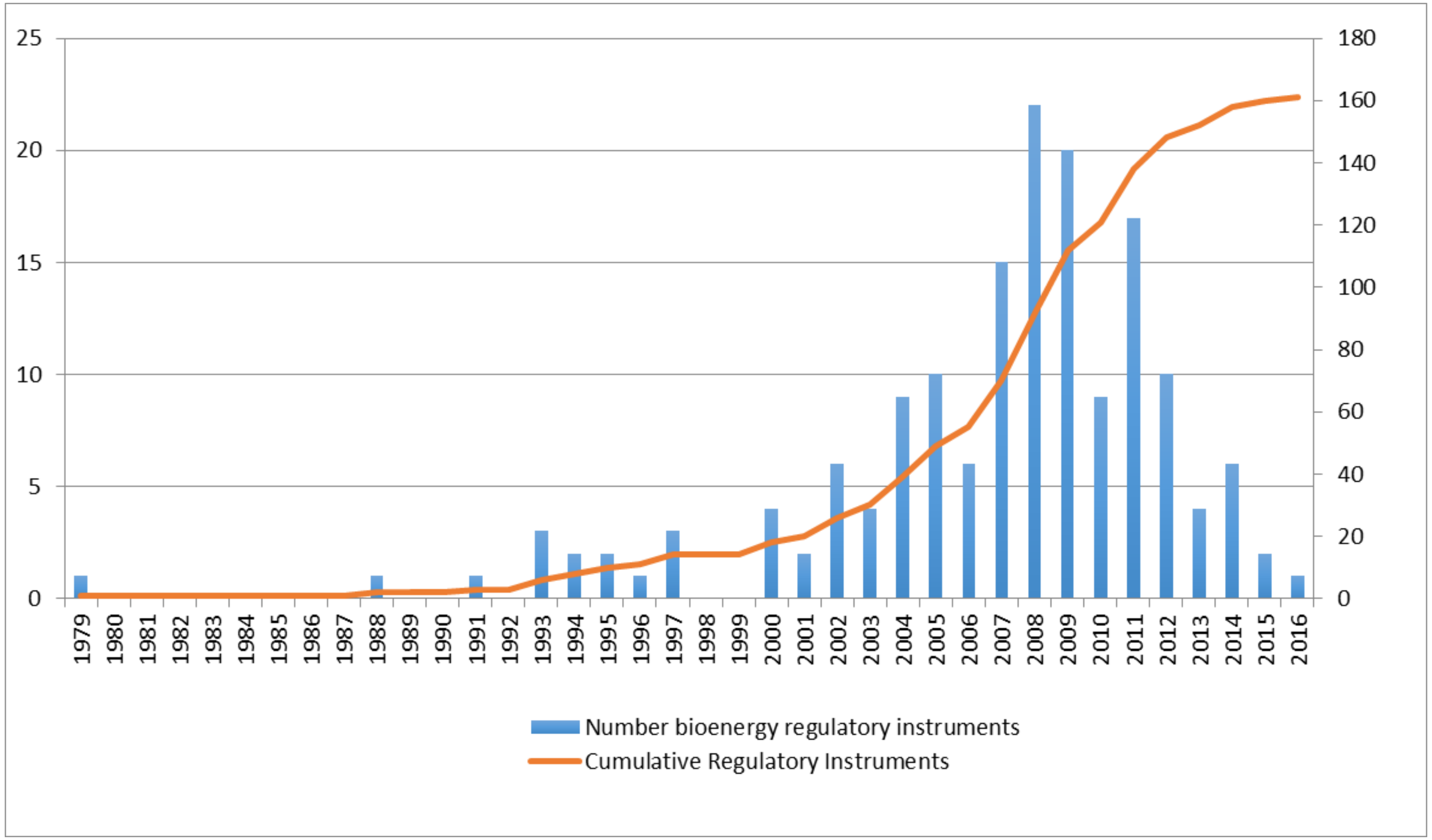
Biofuels: "**Ca**
2005); offer "
2003)


TELL THE GOVERNMENT
TO CHOOSE THE RIGHT
BIOFUEL
OR THE
ORANG-UTAN
GETS IT


news
ELS
Every little hurts
Don't be fooled
bio-fuels

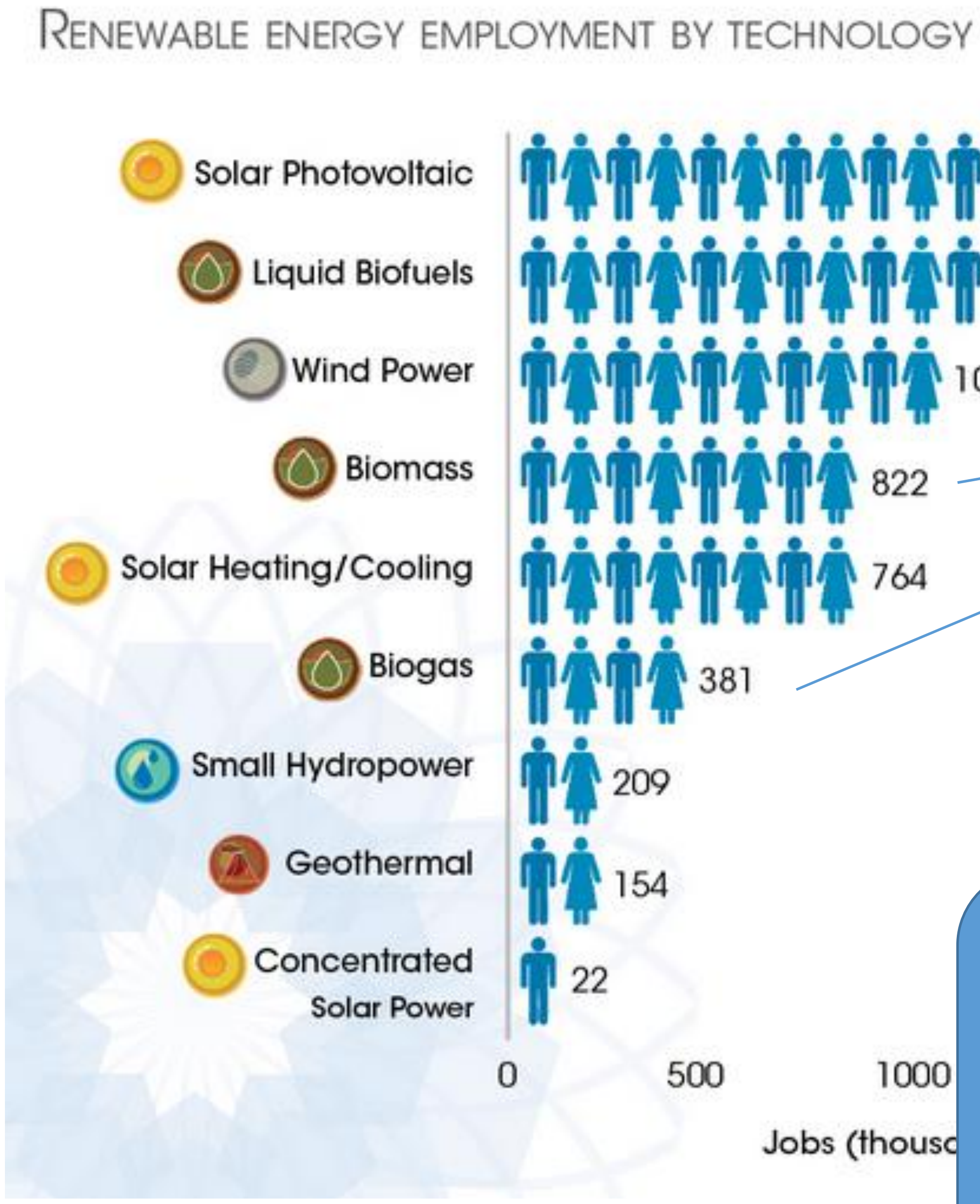
Algae

Global Bioenergy Regulatory instruments



Based on IRENA 2016 data

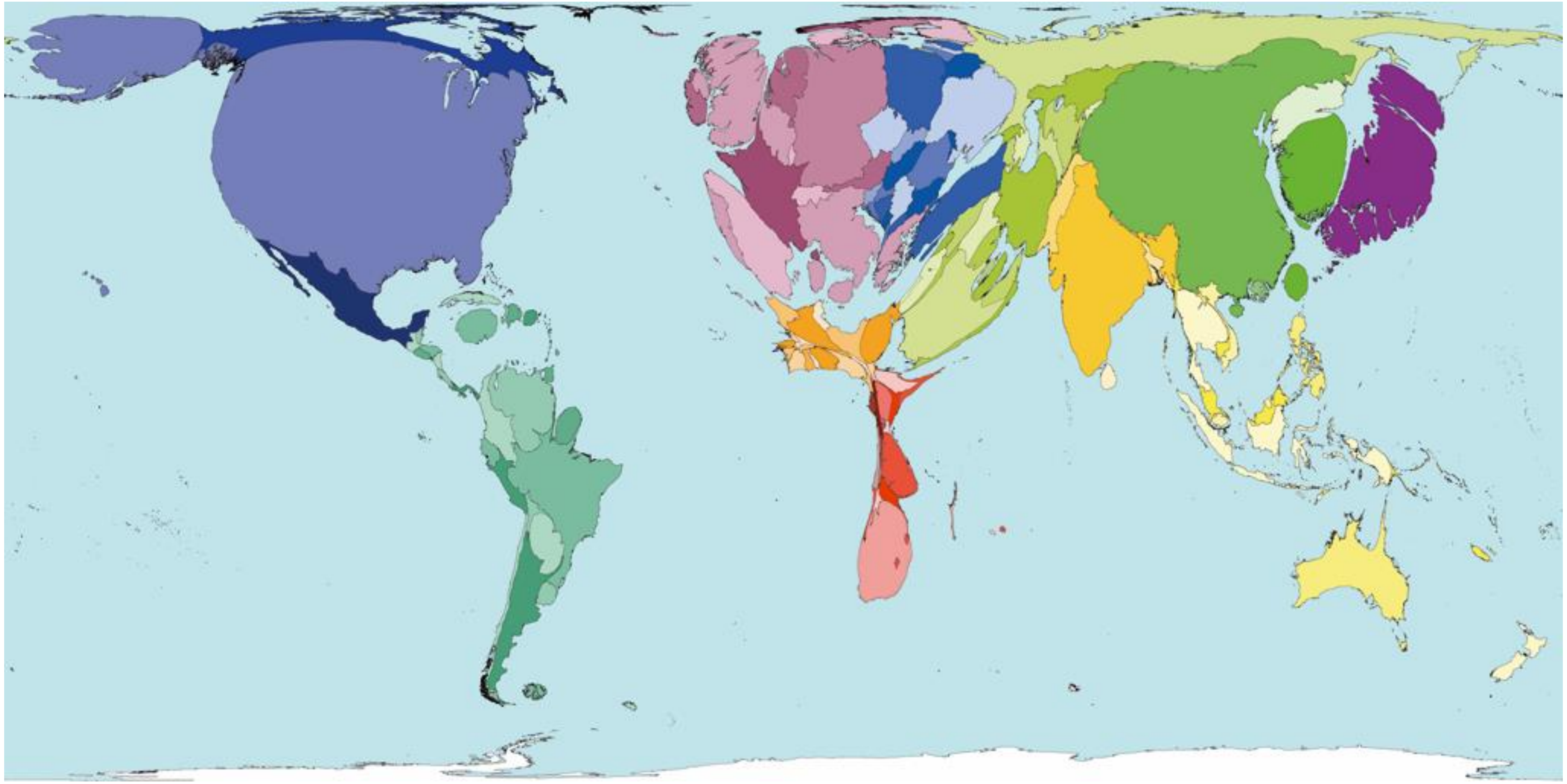
http://www.iea.org/policiesandmeasures/renewableenergy/



Bioenergy total = 2991

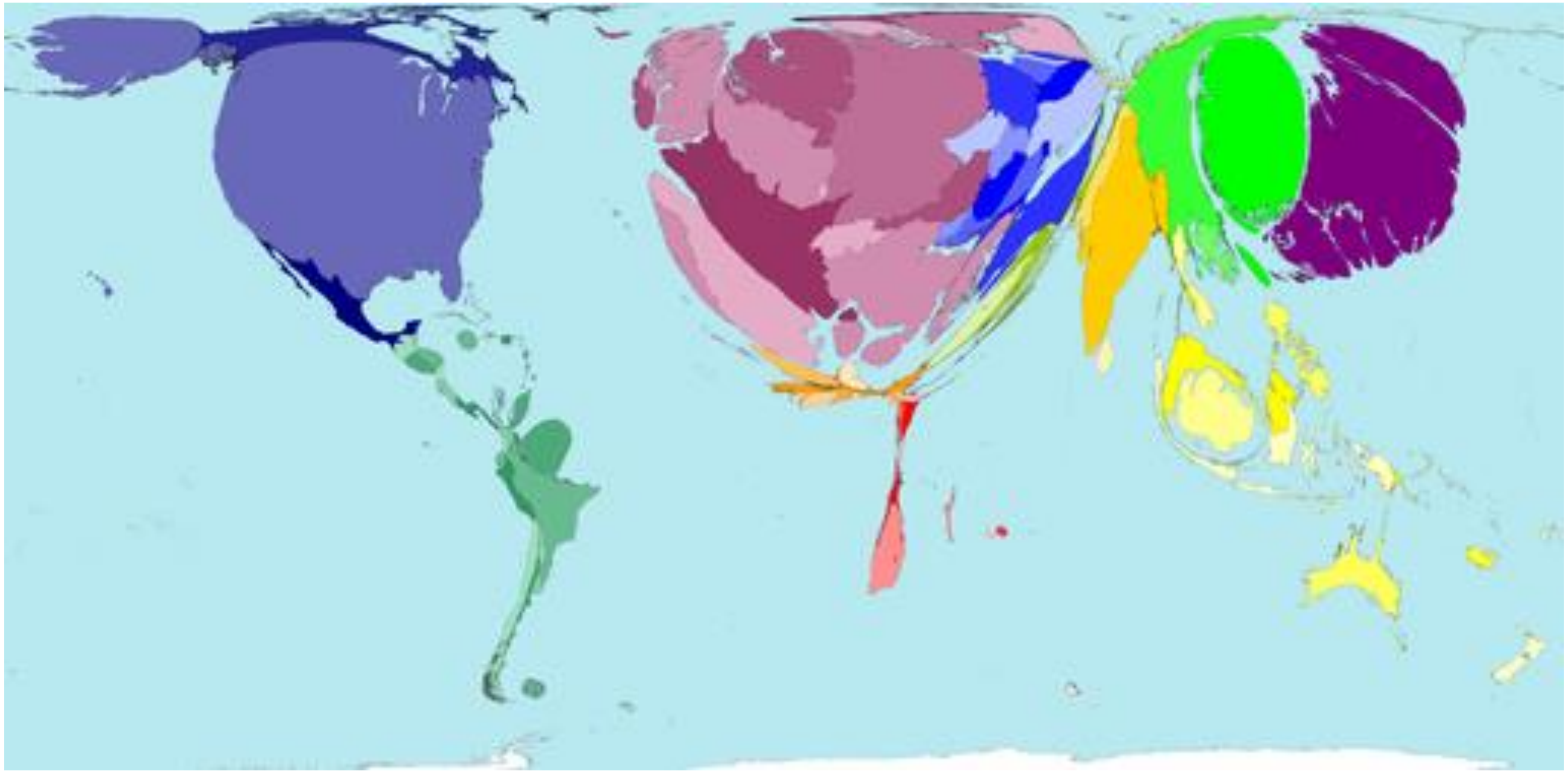
Bioenergy is the largest global source of renewable energy, and contributes an estimated 10% of global primary energy production, in particular as a direct source of industrial and domestic heat.

World Mapper: GHGs



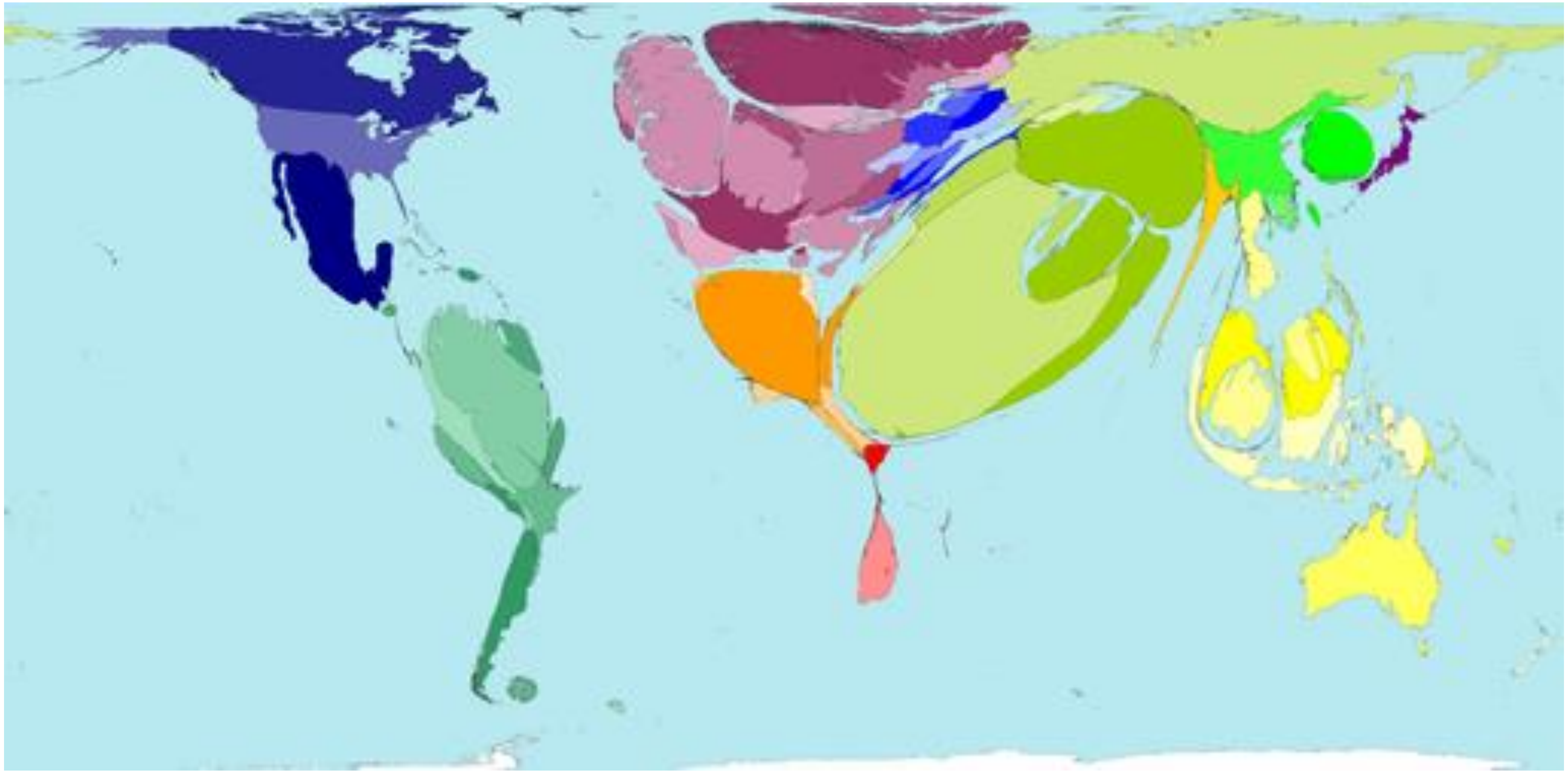
http://www.worldmapper.org/

World Mapper: Fuel imports



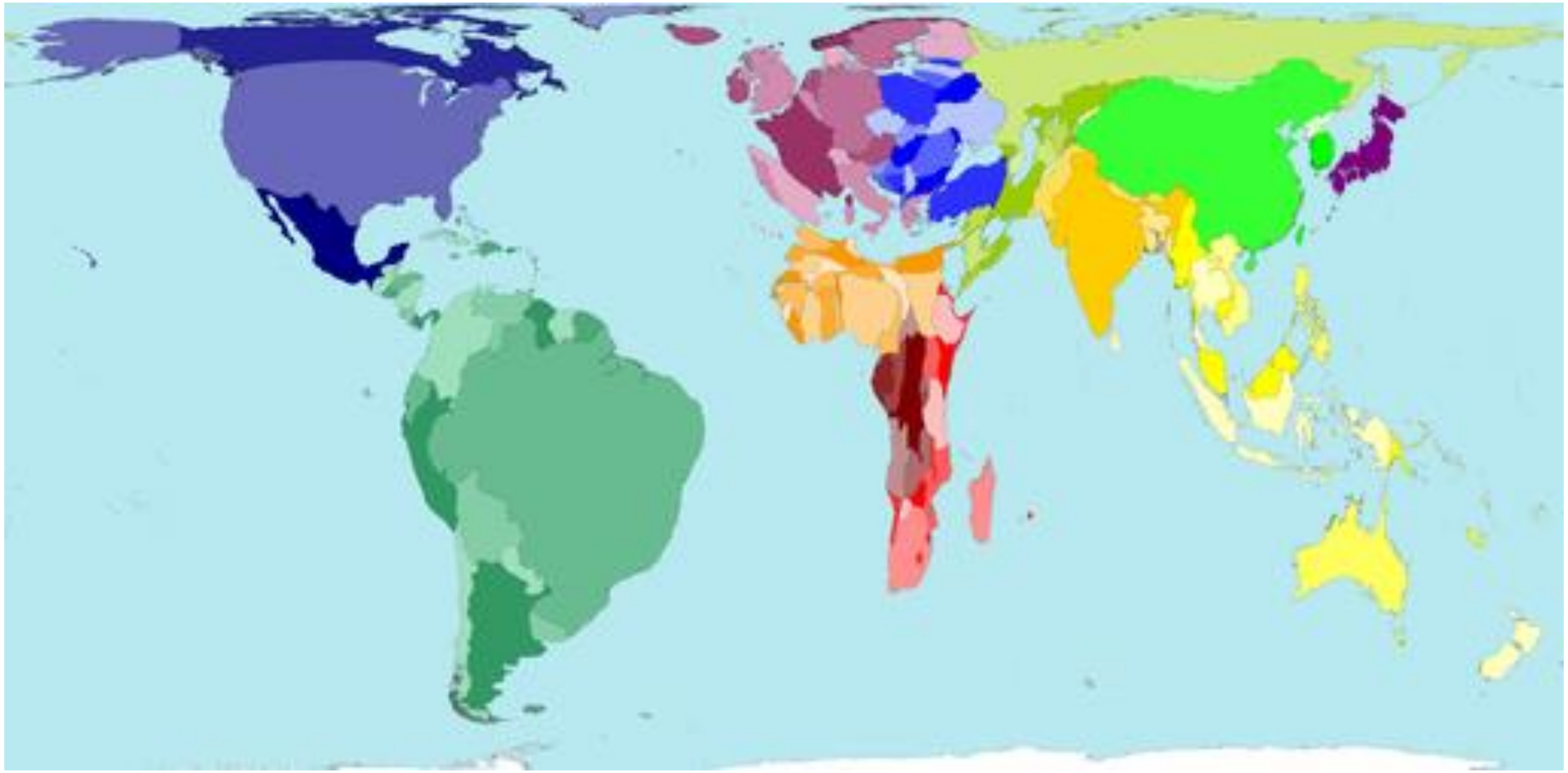
http://www.worldmapper.org/

World Mapper: Fuel exports



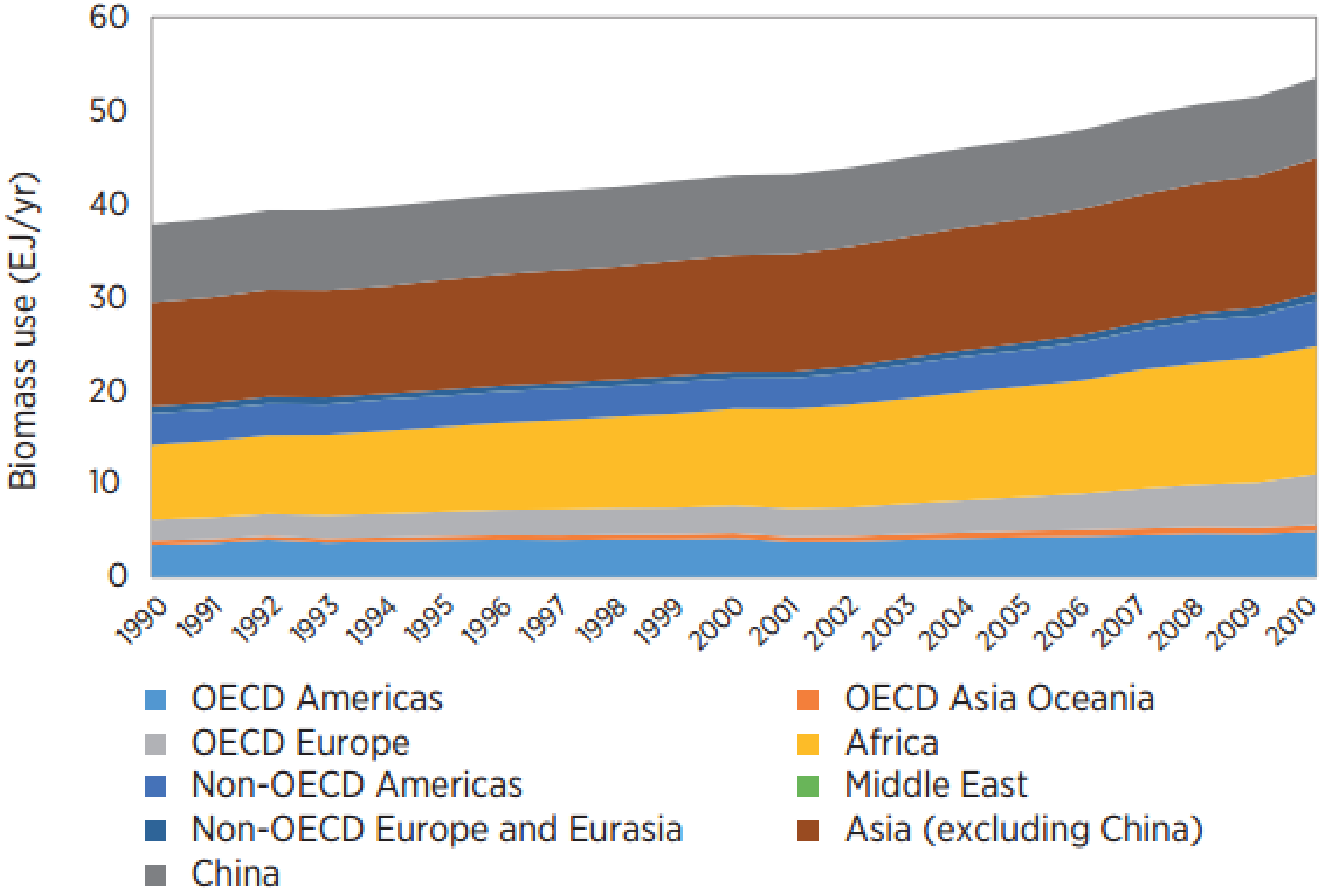
http://www.worldmapper.org/

World Mapper: Biocapacity



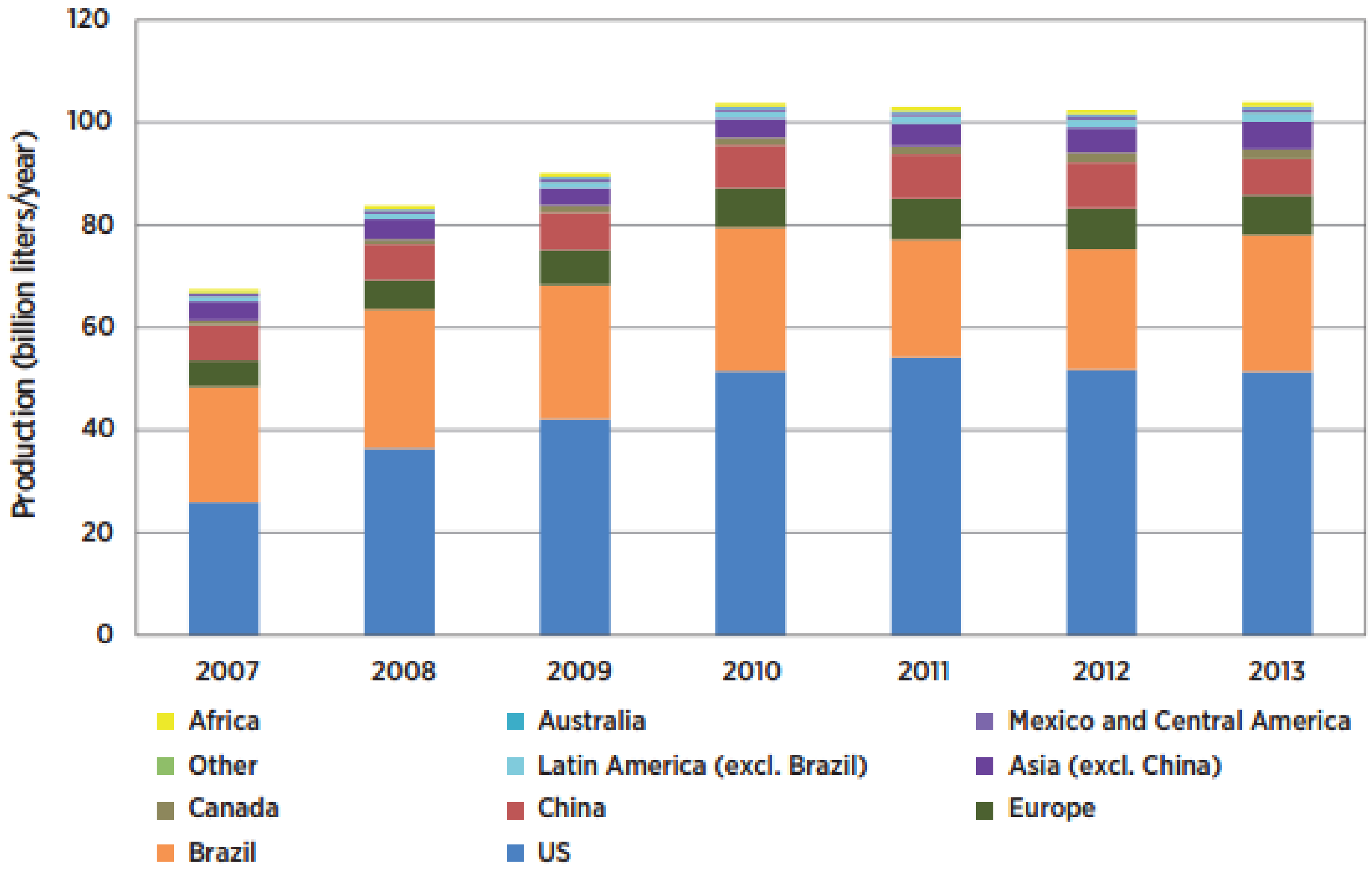
http://www.worldmapper.org/

Development of global biomass use



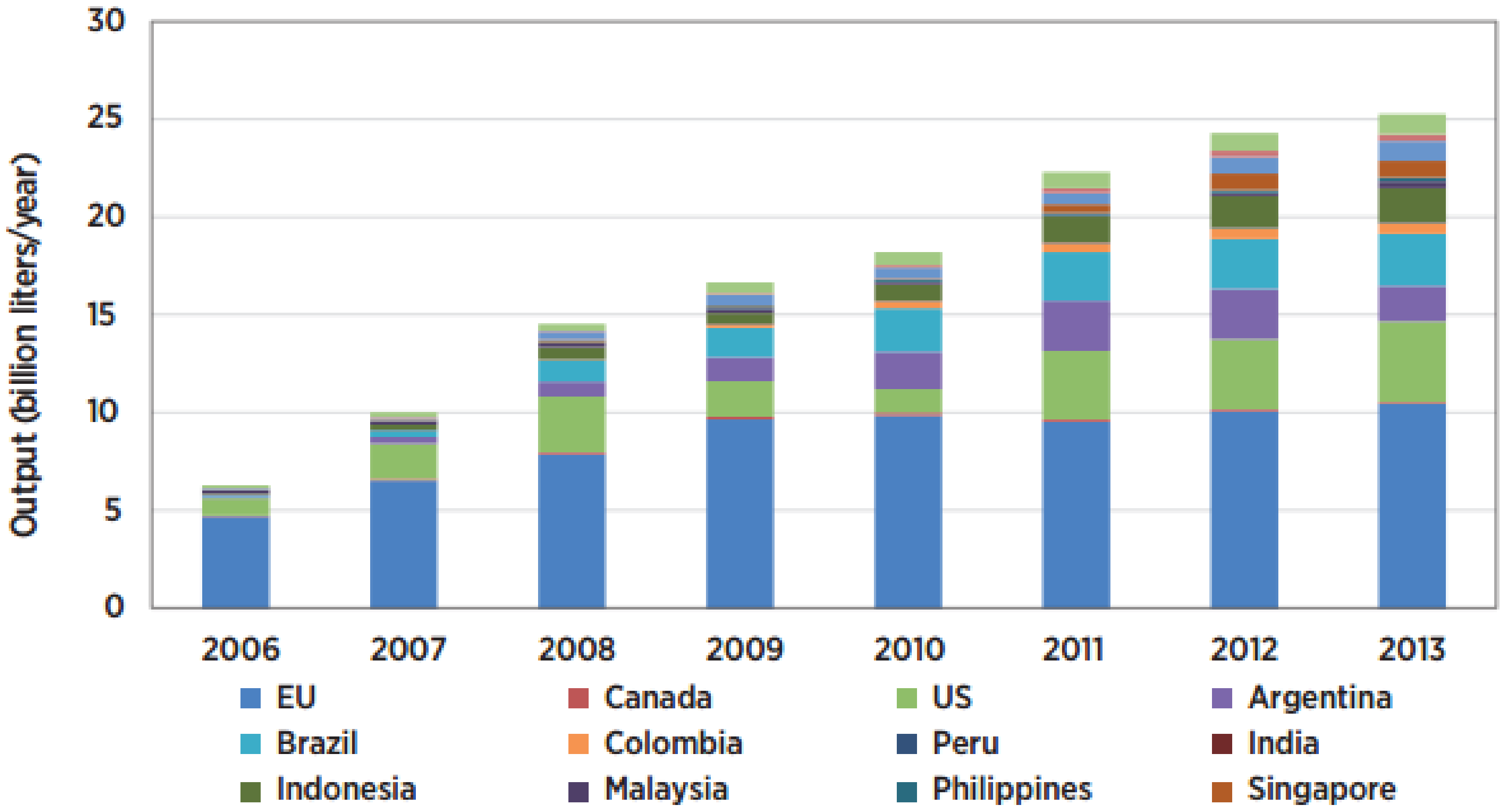
IRENA, 2014

Global ethanol production (2007 – 2013)



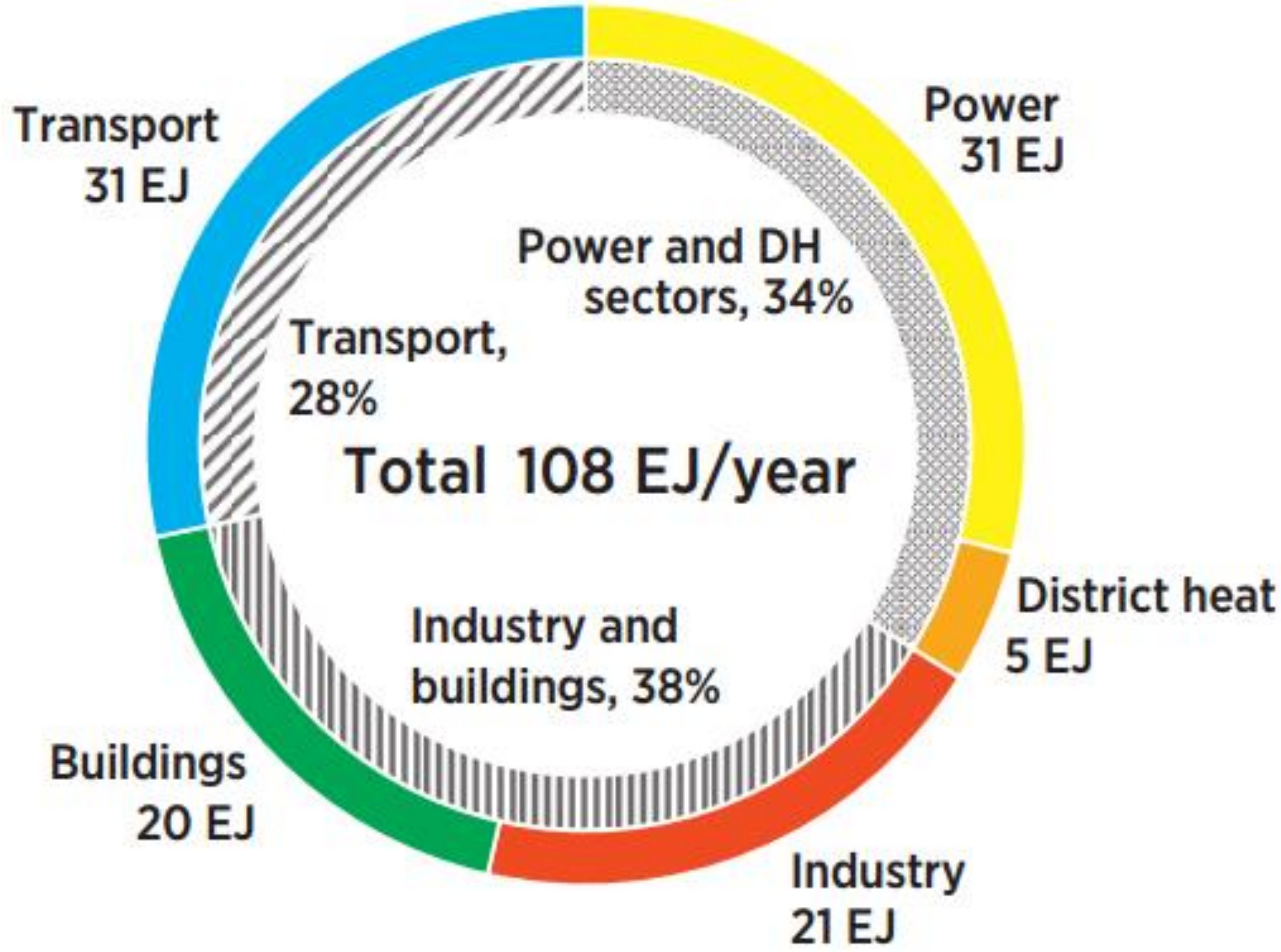
IRENA, 2014

Global biodiesel production (2006 – 2013)

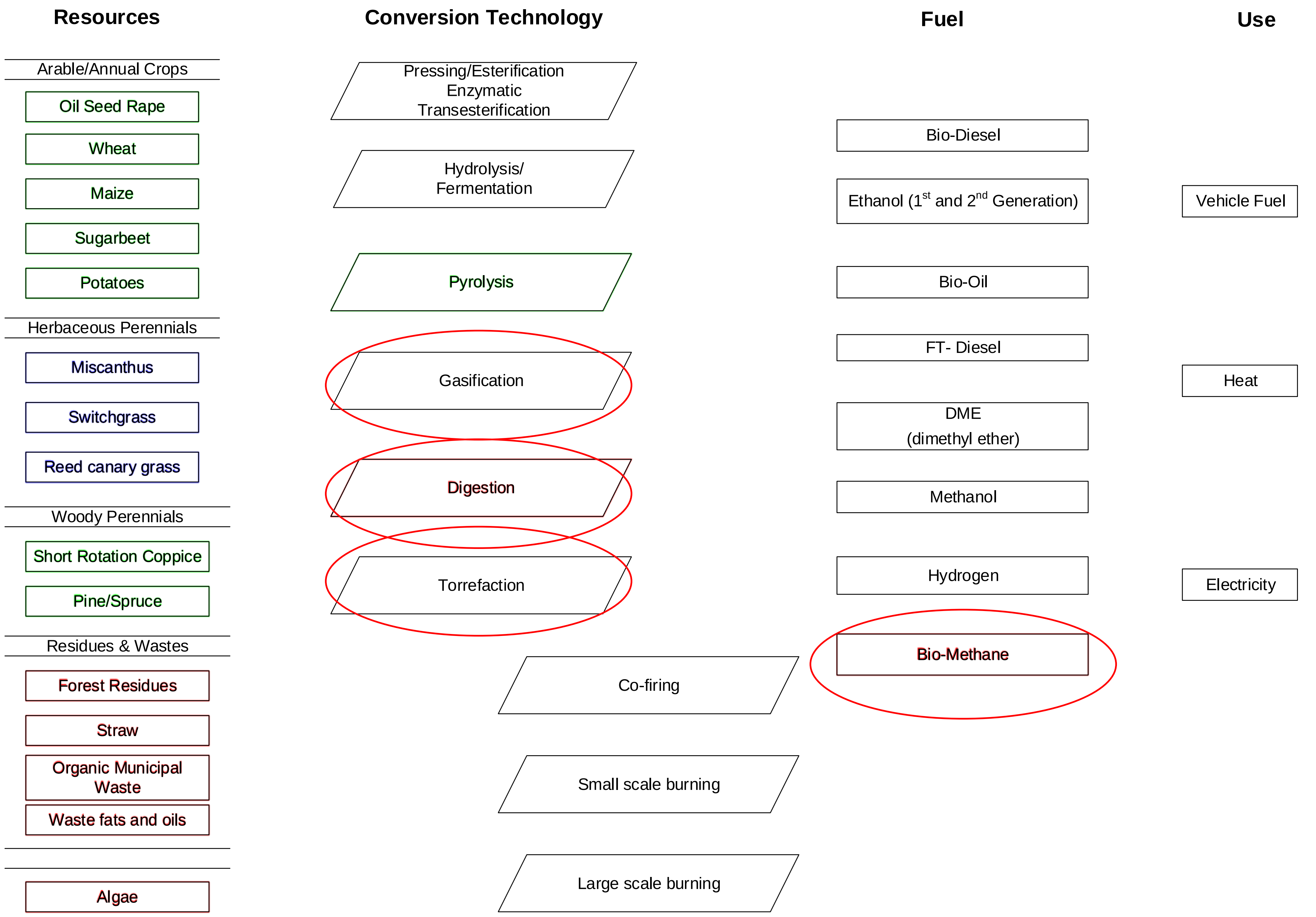


IRENA, 2014

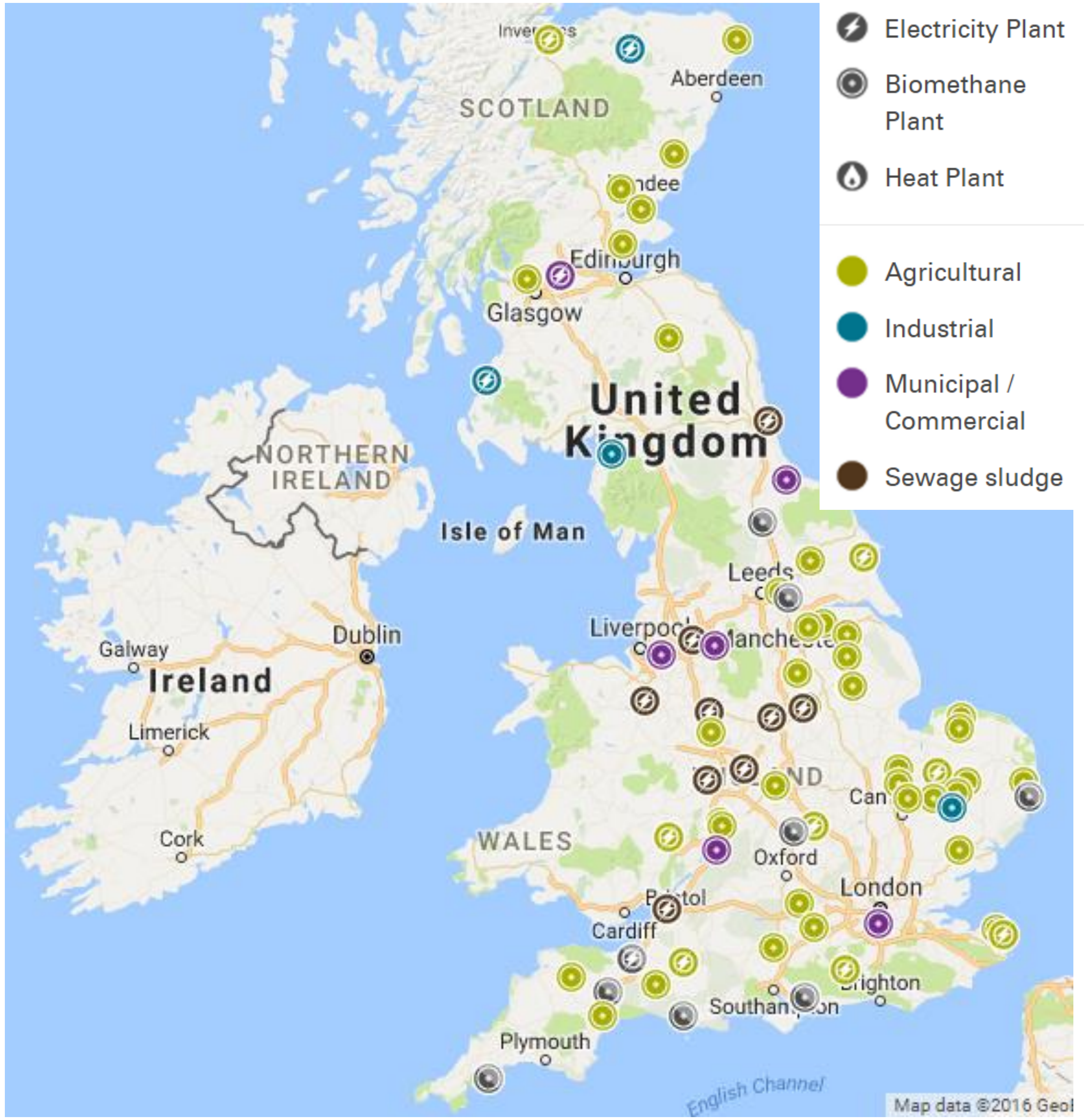
Proposed breakdown of total biomass demand (2030)



IRENA, 2014


Resources
Conversion Technology
Fuel
Use
Arable/Annual Crops
Oil Seed Rape
Wheat
Maize
Sugarbeet
Potatoes
Herbaceous Perennials
Miscanthus
Switchgrass
Reed canary grass
Woody Perennials
Short Rotation Coppice
Pine/Spruce
Residues & Wastes
Forest Residues
Straw
Organic Municipal Waste
Waste fats and oils
Algae
Pressing/Esterification Enzymatic Transesterification
Hydrolysis/ Fermentation
Pyrolysis
Gasification
Digestion
Torrefaction
Co-firing
Small scale burning
Large scale burning
Bio-Diesel
Ethanol (1st and 2nd Generation)
Bio-Oil
FT- Diesel
DME (dimethyl ether)
Methanol
Hydrogen
Bio-Methane
Vehicle Fuel
Heat
Electricity

Biomethane – Market Overview



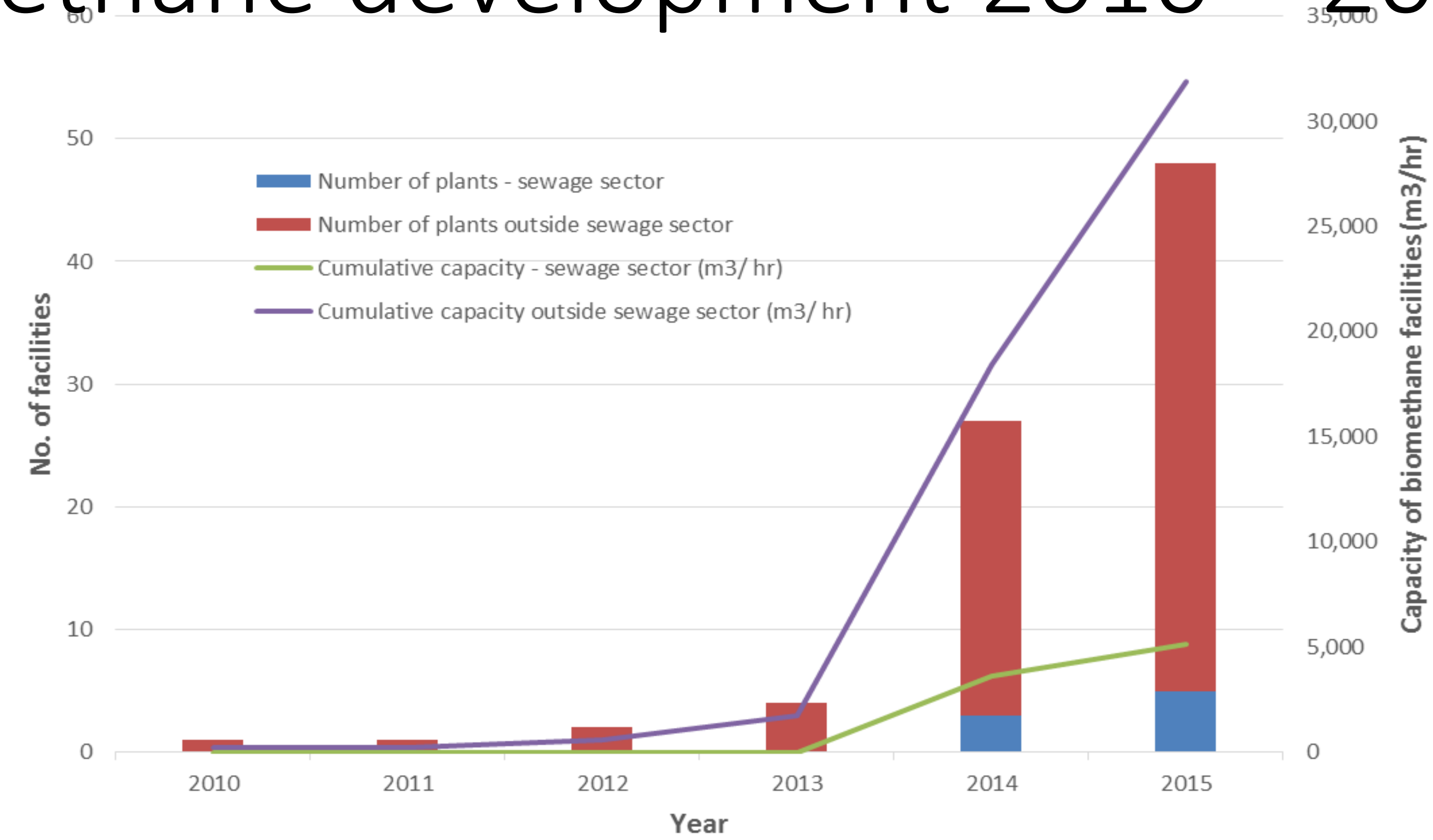
Nearly 80 biomethane facilities now operating in the UK.

In 2012 there was only 1.

Geographically spread across the country.

Demonstrates the importance in assessing the policies that have led to this development and what the implications are going forward.

Biomethane development 2010 – 2015



- Rapid development in last 5 years, particularly in the agricultural sector

Sustainability Criteria – Key Points

RO	RHI	FIT
GHG criteria April 2014	GHG criteria Oct 2015	Proposed for new sites
Land criteria April 2015	Land criteria Oct 2015	Limits on crop use for new sites
Mostly solid biomass	2016 consultation	Unlikely to affect many sites
No proposals to restrict crop use	Limits on crop use for new sites	2016 consultation

Sustainability Criteria introduced – all biomethane facilities need to meet strict GHG criteria.

Some methodological issues with the GHG criteria

Some policy anomalies exist, particularly between different support schemes and the fossil fuel comparator.

Fossil Fuel Comparator

- Both RO and RHI require 60% GHG savings
  - RO: 79.2g CO2 eq/MJ electricity
  - RHI: 34.8gCO2 eq/MJ biomethane

  - 60% GHG saving compared with fossil criteria

Restrictions on the use of crops

ofgem e-serve Making a positive difference for energy consumers

Non-Domestic Renewable Heat Incentive (RHI)

Sustainability Self-Reporting Guidance (version 1)

www.ofgem.gov.uk

Non-Domestic

Publication date:	5 October 2015
Contact:	RHI Operations Team
Tel:	**0845 200 2122**
Email:	RHI.enquiry@ofgem.gov.uk

Biomass Sustainability Criteria

Severely limits what feedstocks can be used and how AD plants are operated.

GHG measurement and mitigation now crucial for future of biomethane.

Department of Energy & Climate Change

3rd March 2016

The Renewable Heat Incentive: A reformed and refocused scheme

RHI Consultation

- Limits use of crops (50%)
- Introduces concept of ‘carbon cost effectiveness’

Proposed reforms to the existing Domestic and Non-Domestic Renewable Heat Incentive schemes

3rd March 2016 – URN: 16D/012

Department of Energy & Climate Change

26th May 2016

Review of support for Anaerobic Digestion and micro-Combined Heat and Power under the Feed-in Tariffs scheme

FIT Consultation

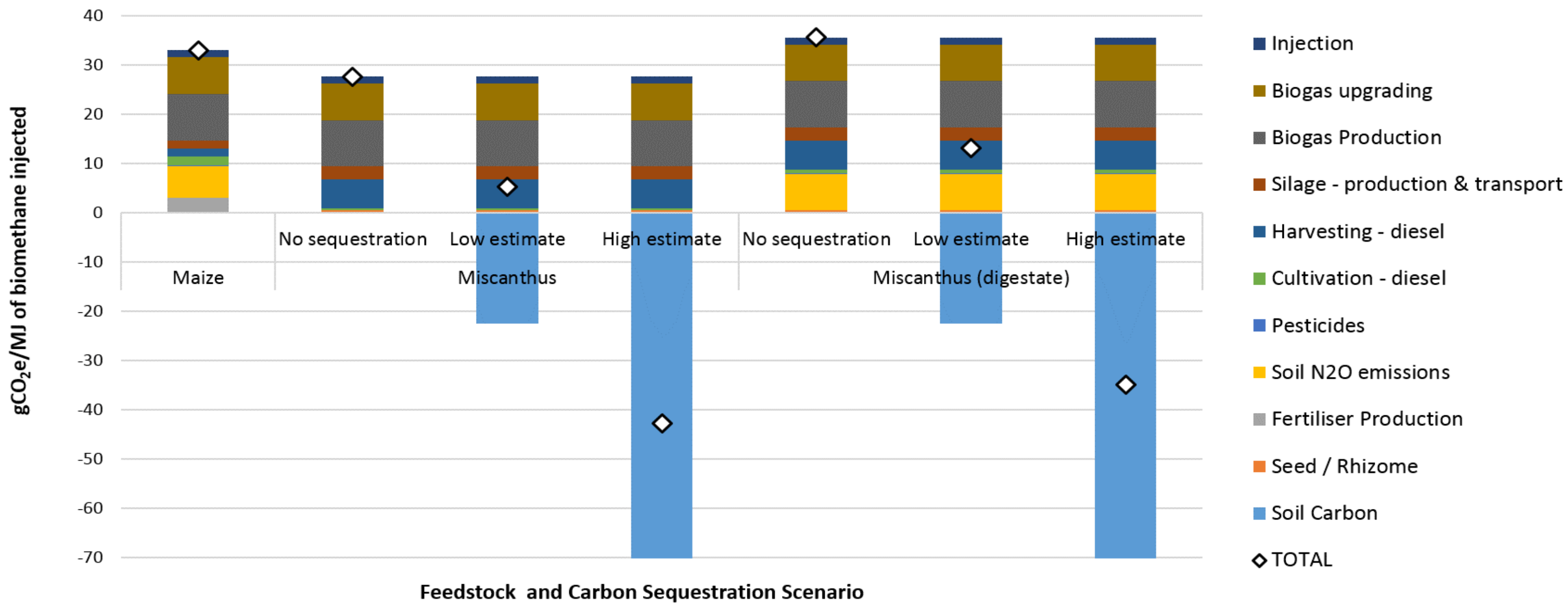
- Introduces BSC for FIT
- Same proposals as the RHI

26 May 2016

Change of focus: from “how much renewable energy can we produce” to “how many tonnes of carbon can we save”

How we account for that is therefore key

Alternatives to Annual Crops



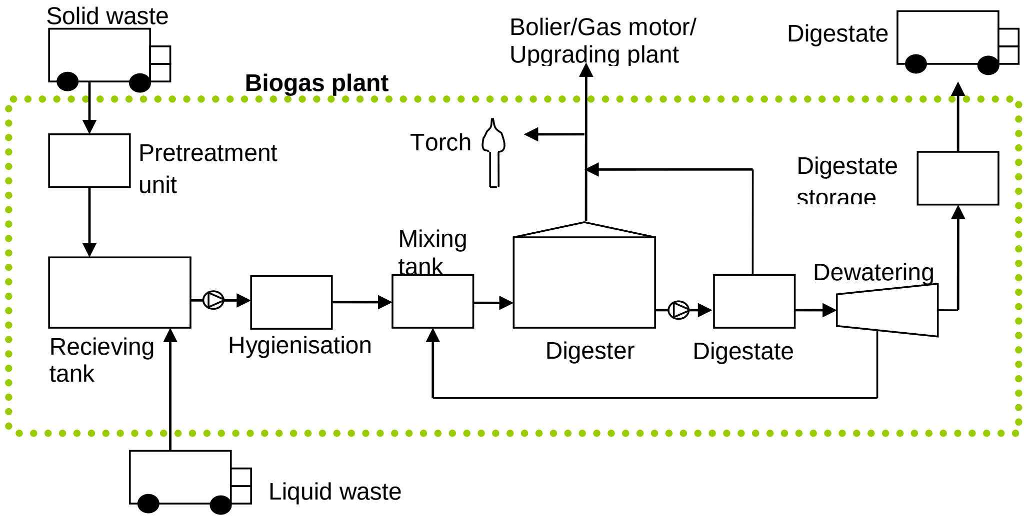
- Recent study between Rothamsted and Bath assessed the use of Miscanthus as an alternative feedstock for anaerobic digestion.
- Miscanthus offers potential for GHG savings in comparison to maize, however it requires more land due to lower biogas yields.
- Additional benefits of Miscanthus may include soil carbon sequestration

Typical emissions from biomethane

Emission source	Rank	% Contribution	Uncertainty
Seeds	10	<1%	Low
Pesticides	9	~1%	Low
Fertiliser Production	3	19%	Medium
Diesel use in cultivation	4	9%	Low
Emissions from fertiliser application	1	26%	**High**
Diesel use in harvesting	6	8%	Low
Transport	8	3%	Low
Silage losses	7	4%	Medium
Grid electricity use	5	9%	Low
Methane loss	2	21%	**High**

- A review of GHG emissions from 8 crop-based biomethane facilities shows that emissions from fertiliser use and methane loss are the largest sources, but they are also the most uncertain due to difficulties in measurement.
- More research is therefore required on these emission sources.

Methane emissions measurement



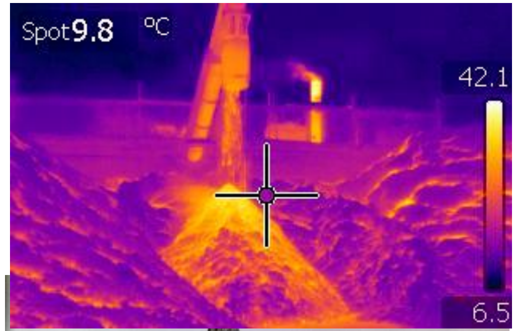
- Field trials conducted on 4 biogas sites
- Developing suggested methodology for biomethane operators and an industry best-practice guideline

Methane emission measurement

- Completed methane leakage measurements at 4 sites in the UK
- Biomethane facility using agricultural crops
- Small-scale farm biogas CHP
- Food processing waste electricity
- Large-scale sewage treatment electricity
- Measurements taken at source point at all accessible points across each site
- First study of its kind undertake in the UK – has generated interest in policy / industry

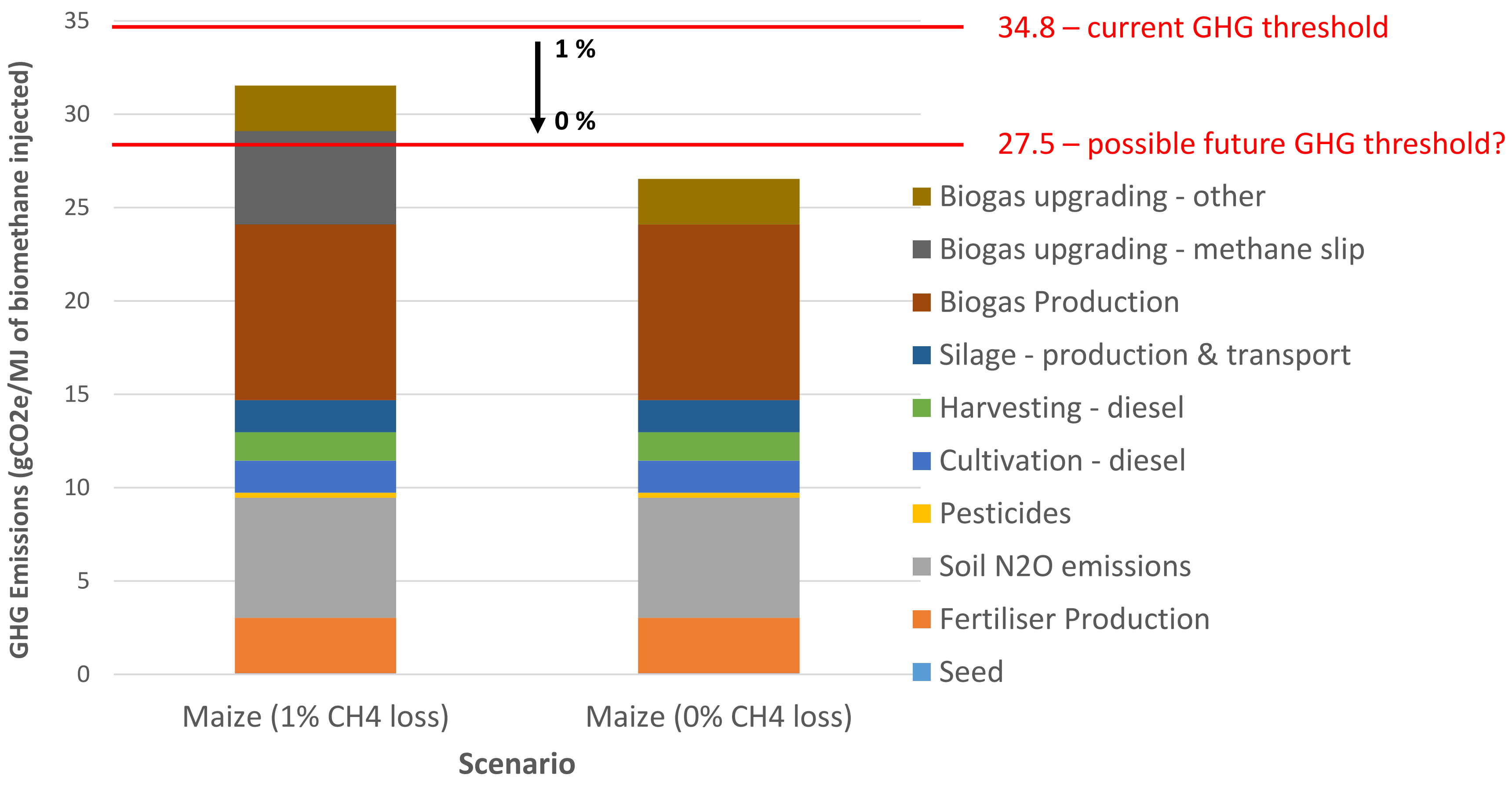
Stage of Production	% loss of total production
Biogas production	0.63
CHP engine ^	2.76
Biogas upgrading *	0.71
Biomass sustainability criteria "	0.24

^ CHP engine outside scope of sustainability criteria
* only 1 biomethane site
" includes upgrading but digestate storage and CHP exhaust outside reporting scope

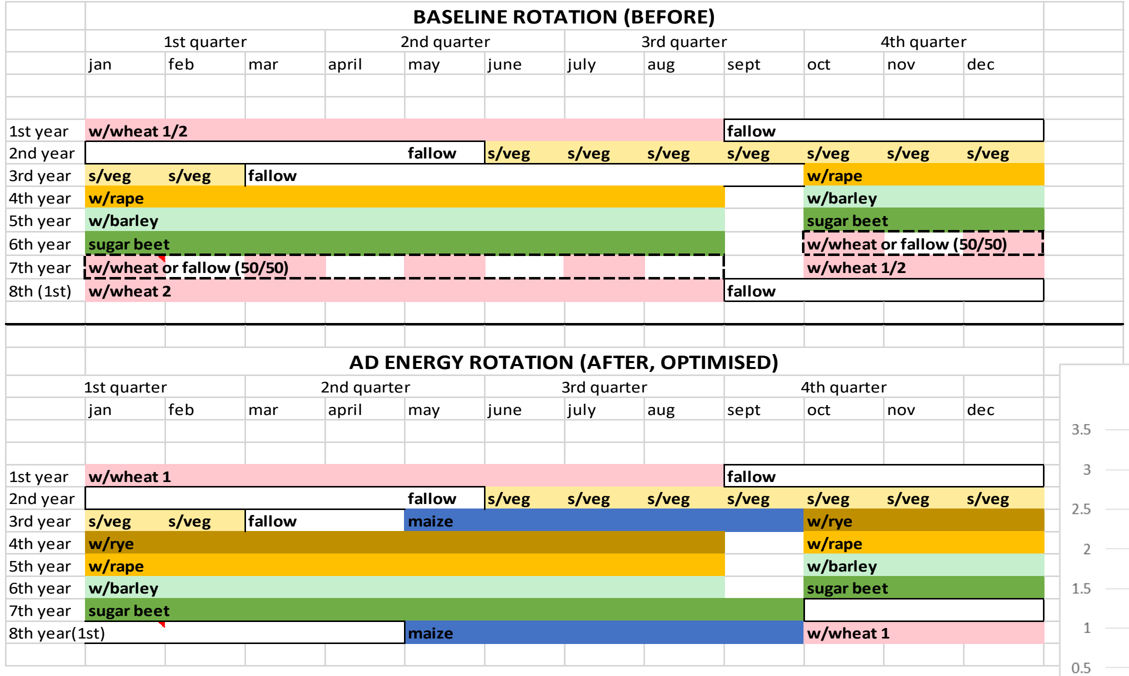


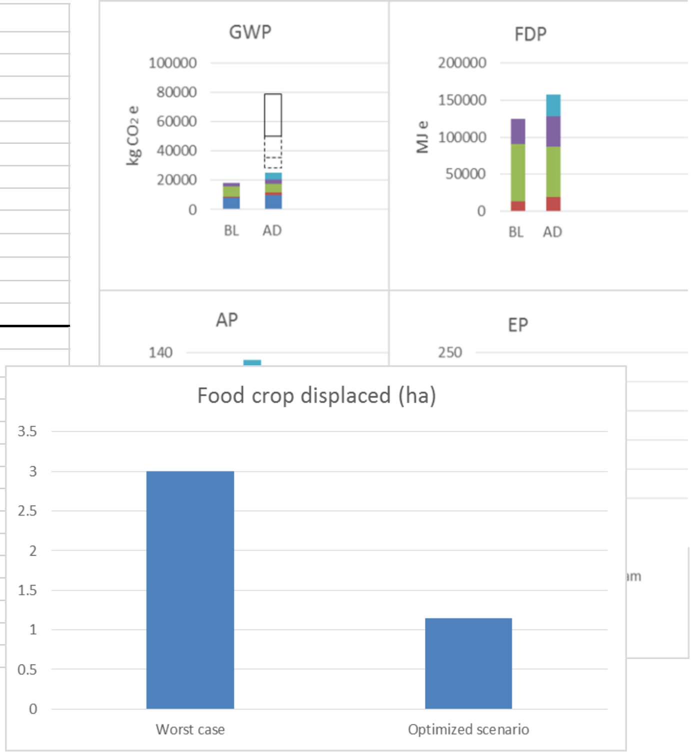
GHG Results – Biomethane (Maize)

- Anything over the GHG threshold will not receive RHI payment
- In future, the threshold may reduce to comparison with natural gas or LNG which would be lower
- Hence managing methane slip from upgrading offers a way to reduce GHG emissions



Crop rotations and land use change





- How farmers manage their land is crucial to the relative impact of cultivating energy crops.
- Ongoing work in collaboration with Bath, Future Biogas and Bangor is assessing how crop rotations play a role in optimising land use to minimise environmental impacts.

Torrefaction: case studies

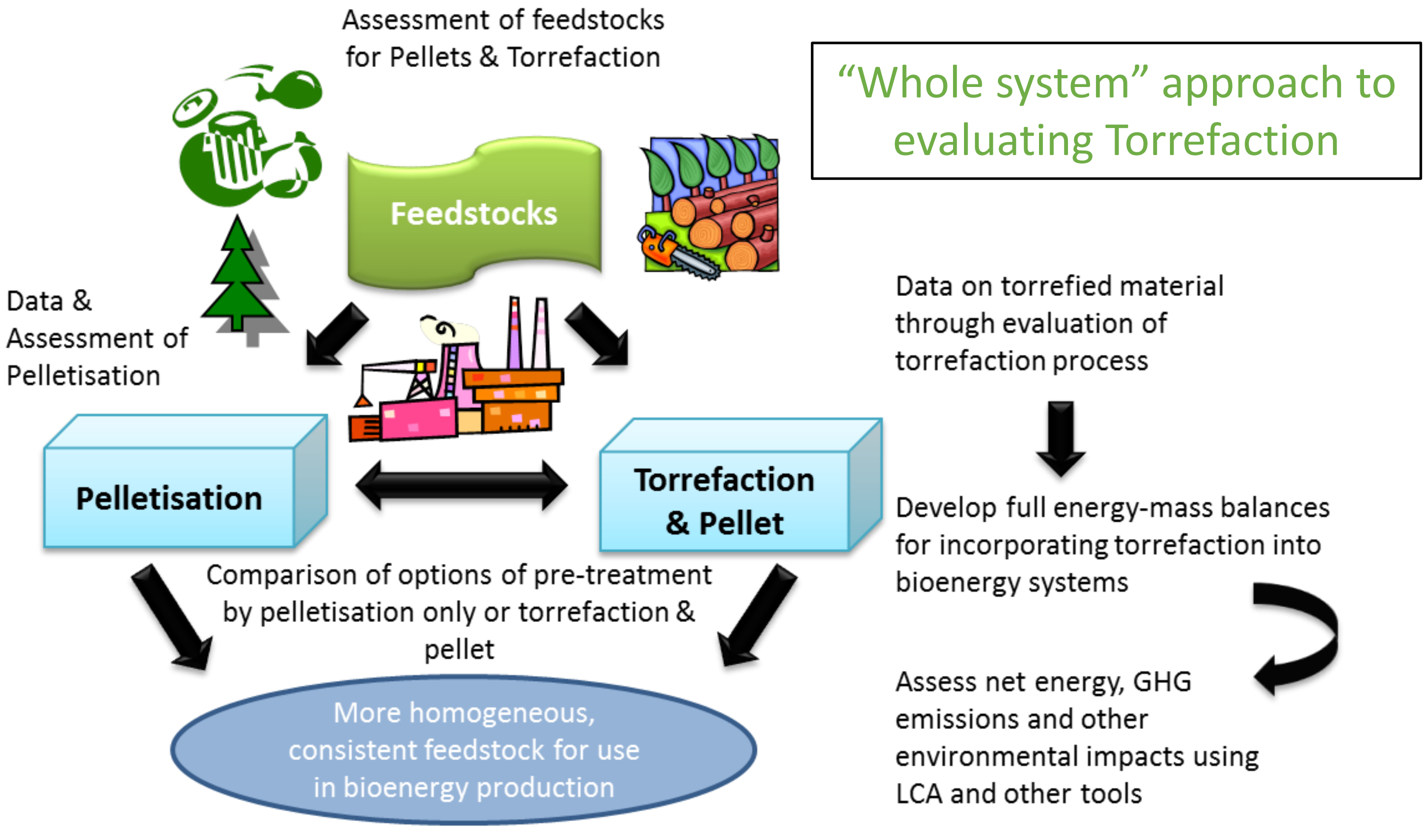
Case studies:

1) Comparative LCA of Torrefied Pellets with Conventional Wood Pellets
2) Torrefaction of North American Pine and life cycle GHG emissions

Future work:

Comparison of torrefied briquettes with alternative biomass feedstocks for domestic use

Torrefaction integrated assessment



- Evaluation of Torrefaction & Pelletisation in a whole system context
- Life cycle assessment of pre-treatment options
- Techno-economic analysis
- Policy mechanisms and assess rationale for support

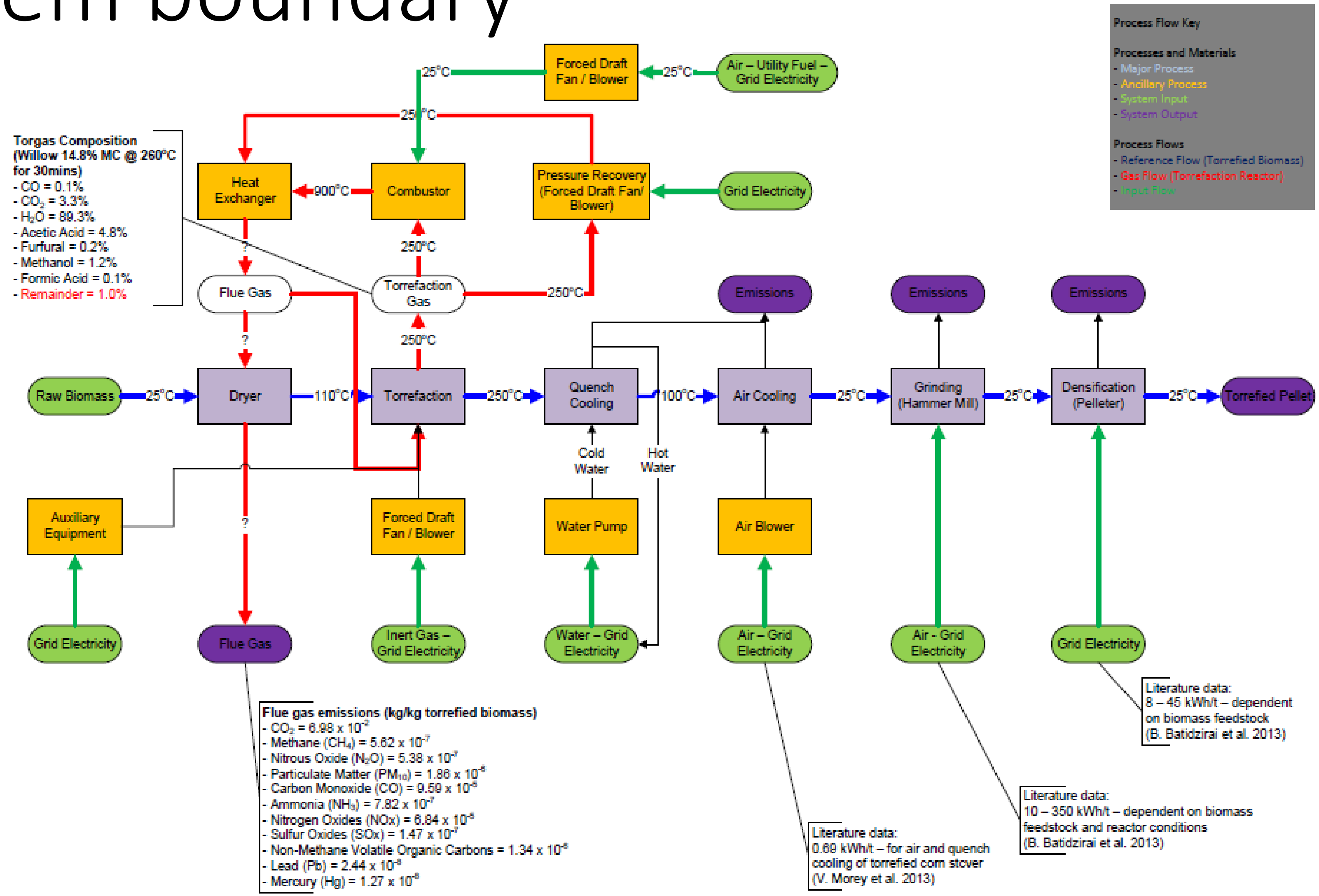
Adams, P.W.R., Shirley, J.E.J. & McManus, M.C., 2015

Physical properties

Parameter	Wood Chips	Wood Pellets (WP)	Torrefied Wood	Torrefied Pellets (TP)	Coal
Moisture content (MC) (wt.%)	30-50	7-10	3	1-5	10-15
Lower Calorific Value (CV) (MJ/kg)	9-12	15-16	19-23	20-24	23-28
Bulk Density (kg/m^3)	250-300	550-700	180-300	750-850	800-850
Grindability (kWh/t)	237	237	23-78	23-78	12
Hygroscopic nature	Hydrophilic	Hydrophilic	Hydrophobic	Hydrophobic	Hydrophobic
Biological Degradation	Yes	Yes	No	No	No
Milling Requirements	Special	Special	Classic	Classic	Classic

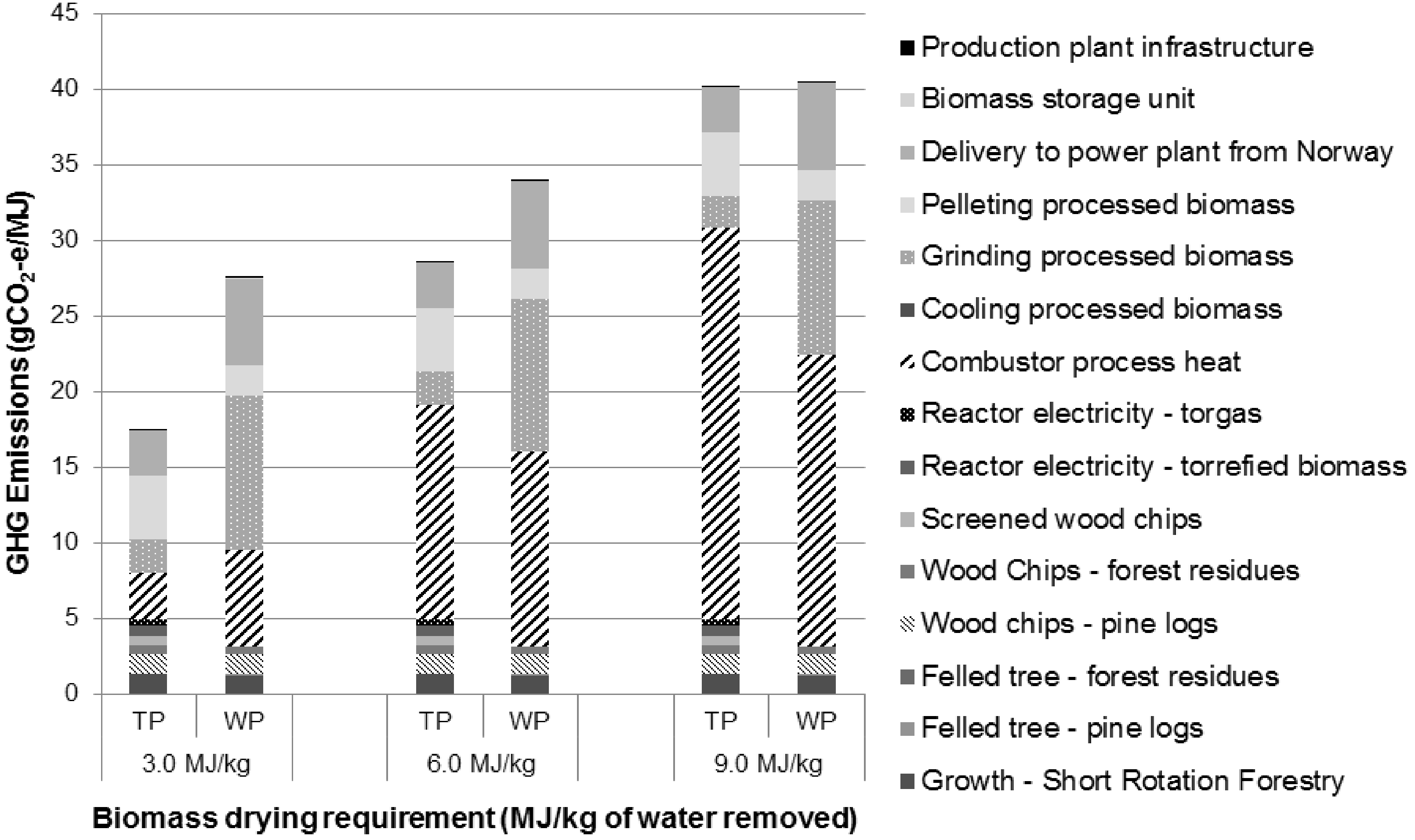
Adams, P.W.R., Shirley, J.E.J. & McManus, M.C., 2015

System boundary



Adams, P.W.R., Shirley, J.E.J. & McManus, M.C., 2015

Torrefied Pellets – GHG results

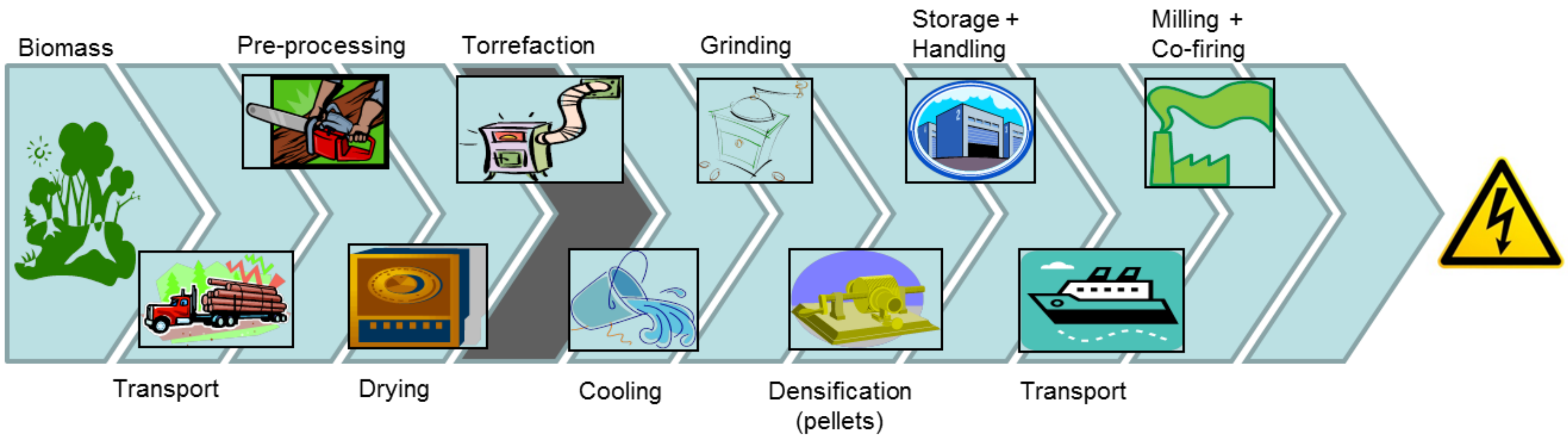


Climate change impacts (gCO_2e per MJ) delivered of TP/WP bioenergy chains for varying biomass drying requirements

Adams, P.W.R., Shirley, J.E.J. & McManus, M.C., 2015

North American Pine Torrefaction

- Experimental work on the torrefaction of North American Pine at four different torrefaction conditions: 250^C (30 mins), 270^C (30 mins), 270^C (60 mins), 290^C (30 mins)
- Modelled torrefaction supply chain against conventional wood pellets imported from North America
- Used LCA to model GHG emissions and calculate in accordance with RED methodology



McNamee, P., Adams, P.W., McManus, M.C., Dooley, B., Darvell, L. I., Williams, A. & Jones, J. M. , 2016

Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions per MJ of electricity delivered for 4 different torrefied pellets (TP) and conventional wood pellets (WP) using wood chips (WC) or natural gas (NG) as utility fuel. *For wood pellets = drying only

McNamee, P., Adams, P.W., McManus, M.C., Dooley, B., Darvell, L. I., Williams, A. & Jones, J. M. , 2016

Conclusions

- Can have GHG benefits; but optimal solutions need to be found in every situation
- A global view is required
- Consequential life cycle thinking benefits engineering, scientists, policy makers and industrialists

- Thanks to: SERT team, especially Paul Adams.

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