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Bioenergy

Biomass and bioenergy: a vital component of the UK's green economy?

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We work with academia, industry, government and societal stakeholders to develop sustainable bioenergy systems that support the UK's transition to an affordable, resilient, low-carbon energy future.

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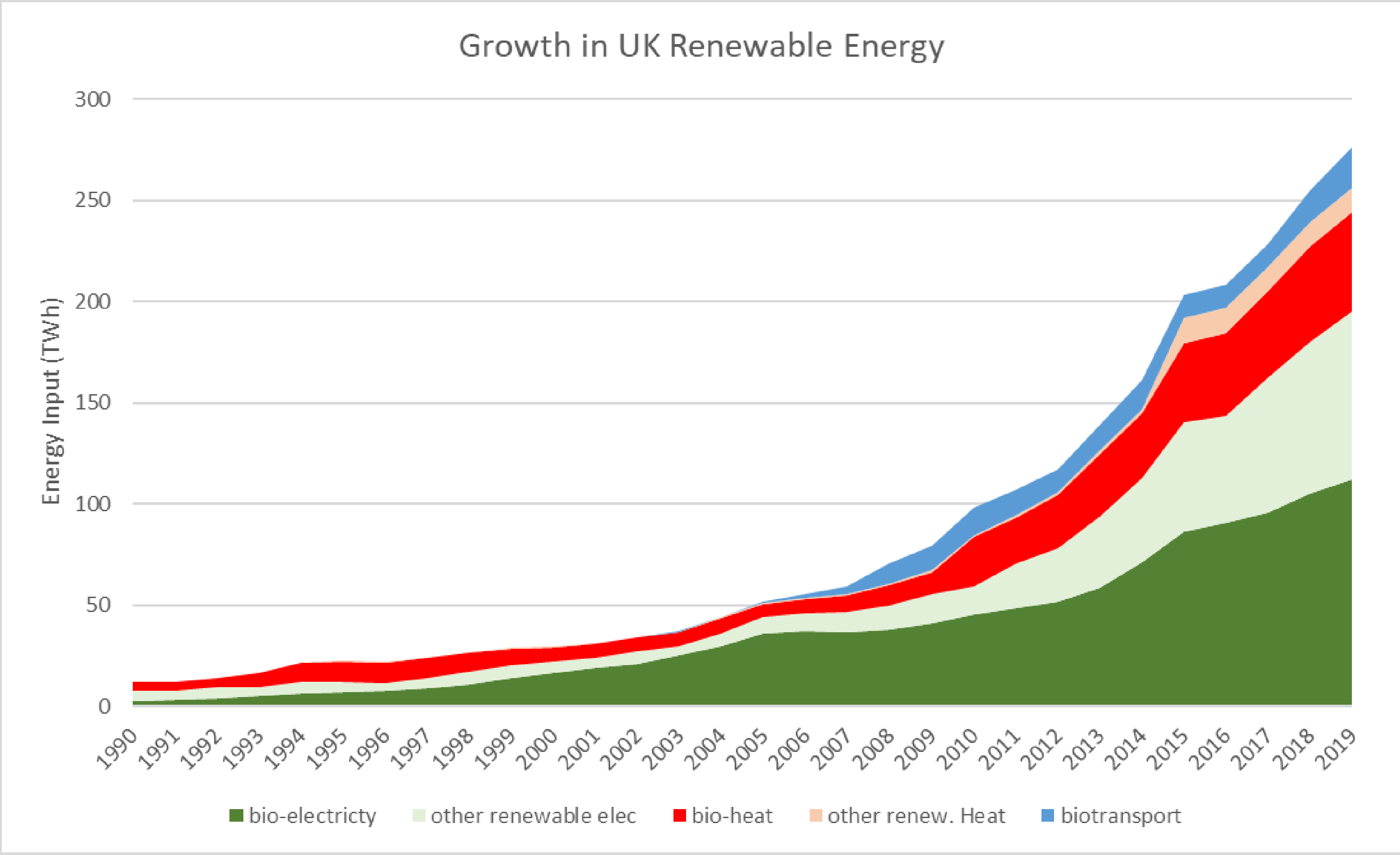
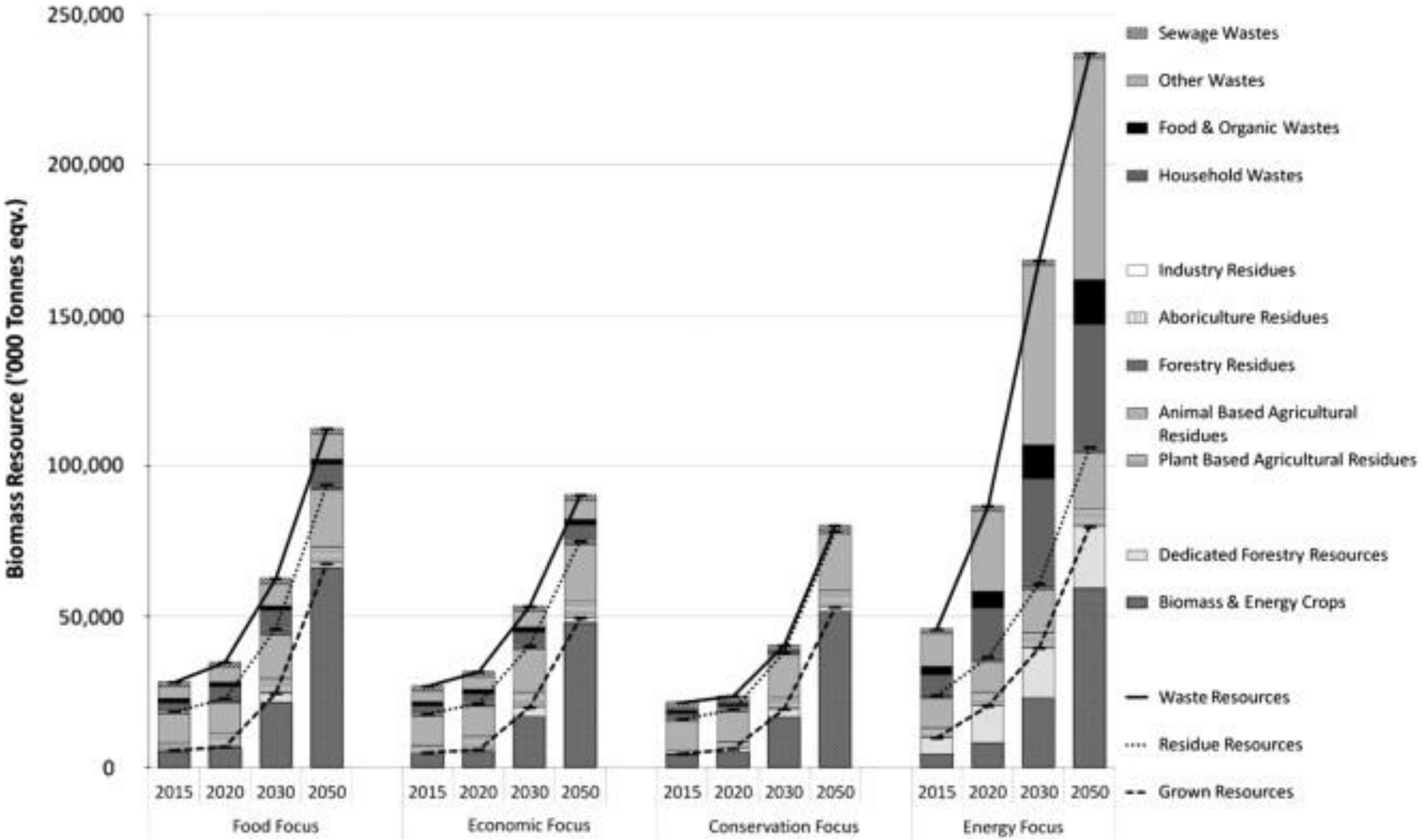
Role of bioenergy in UK decarbonisation to date



https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2020

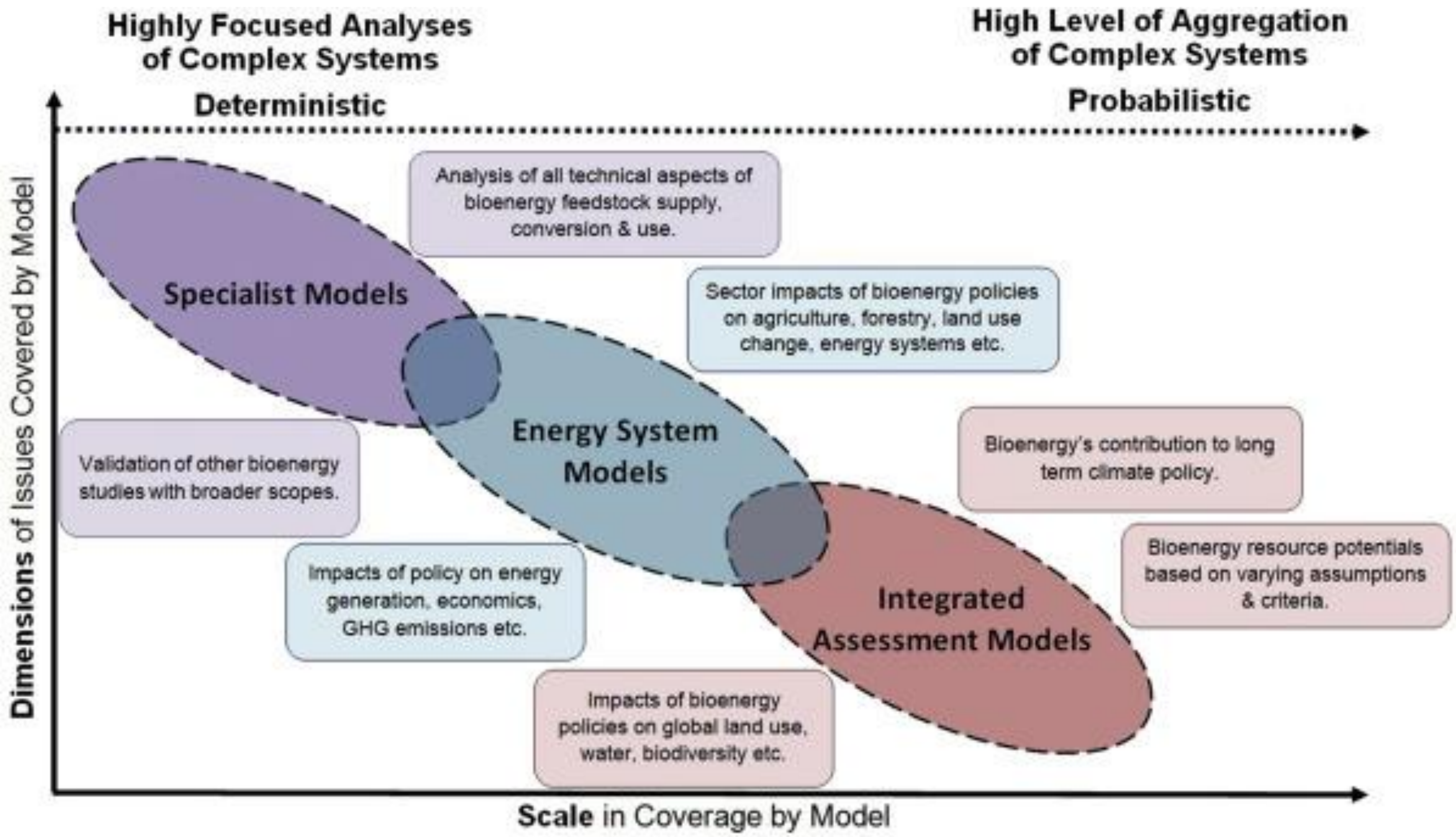
Peter Coleman, BEIS

Potential of bioenergy in future UK energy supply

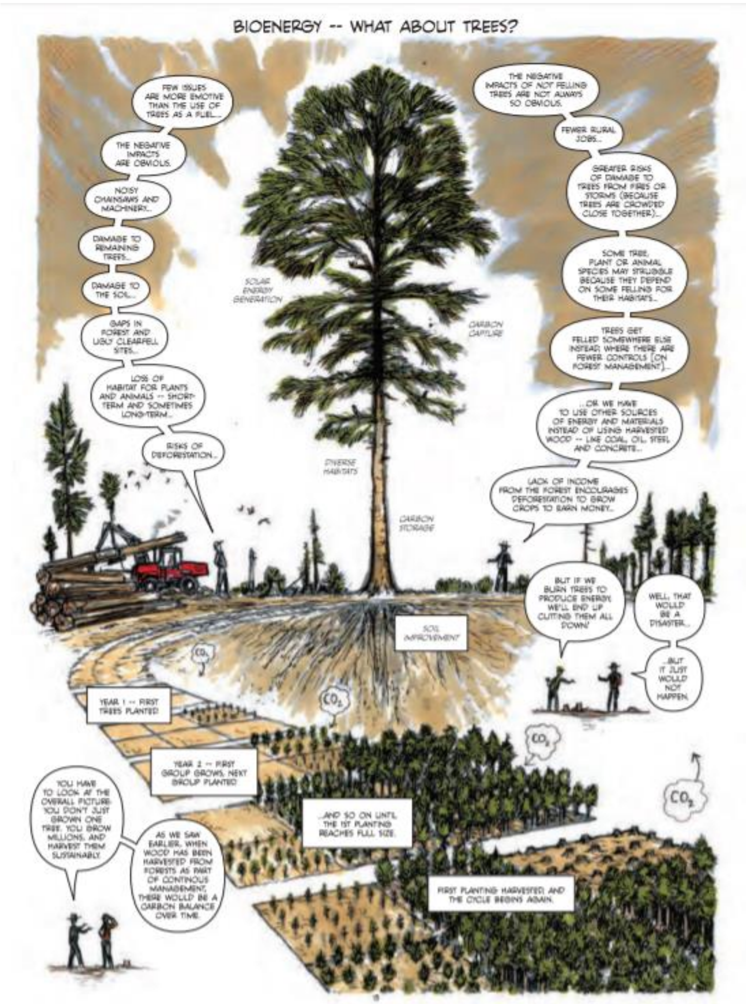


Welfle, Gilbert & Thornley,Securing a bioenergy future without imports, Energy Policy, Volume 68, 2014, Pages 1-14, https://doi.org/10.1016/j.enpol.2013.11.079.

The power(?) of models



How does using trees reduce carbon emissions?



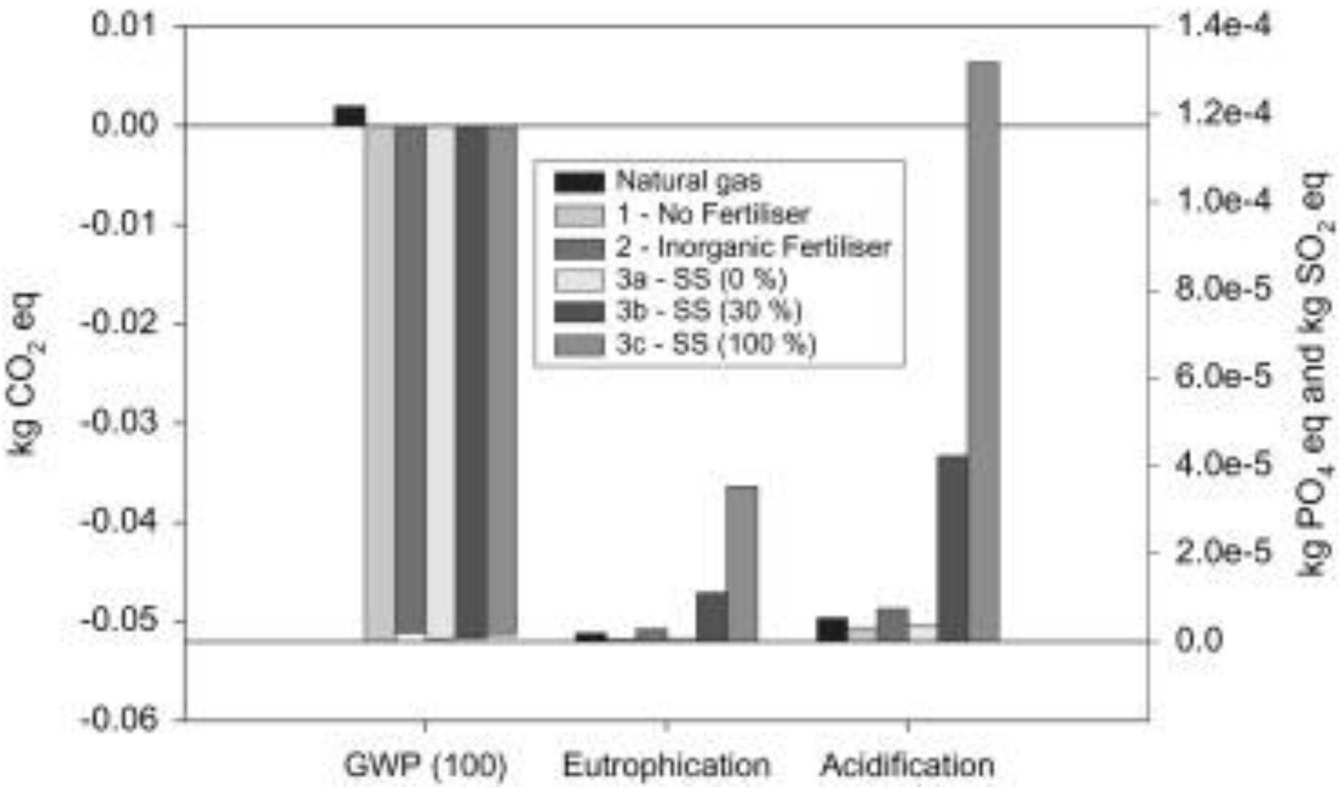
https://www.supergen-bioenergy.net/comic/

- Carbon sequestration during growth
- Combustion returns (relatively) recently sequestered CO2 to atmosphere
- Supply chain emissions usually low unless intensive farming or land-use change
- Sequestration fastest in earliest phases
- Main product from trees is saw-log timber (high value)
- Management of trees requires thinning
- Trees use land and need to provide a return to the land-owner

Conditions for significant carbon reductions

Sustainable growth (low input and land-use change) removing atmospheric carbon dioxide → Low supply chain emissions → Displacing carbon intensive incumbents

Low input



Gilbert, Thornley, & Riche, The influence of organic and inorganic fertiliser application rates on UK biomass crop sustainability

, Biomass and Bioenergy, vol 35, 2011

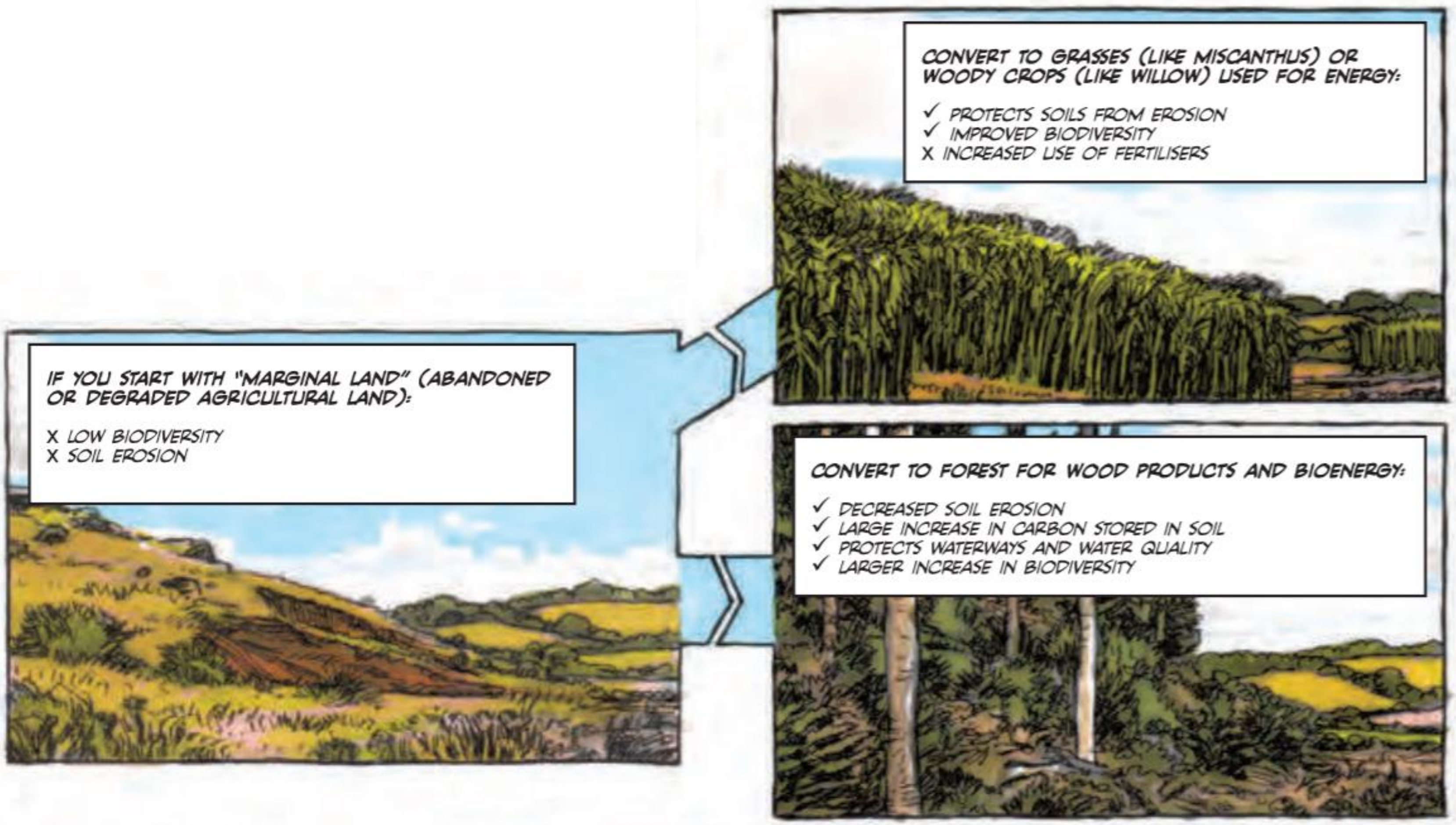
Land-use change

Biodiesel Type	% GHG saving assuming land converted from cropland (a)	% GHG saving assuming land converted from forestland (b)	% GHG saving assuming land converted from grassland (c)	Payback time (years) (a)	Payback time (years) (b)	Payback time (years) (c)
Soy (Brazil)	9	-2550	-699	0	5503	1523
Soy (Argentina)	44	-1134	-109	0	533	69
Palm (Malaysia)	48	-135	-12	0	77	25
Palm (Indonesia)	48	-185	-84	0	98	55
Rapeseed (UK)	36	-569	-123	0	335	88
UCO (UK)	85	85	85	0	0	0
Sugarcane (Br)	72	-299	-30	0	103	28
Soy (US)	27	-1143	-100	0	875	95

Upham, Thornley, Tomei & Boucher, Substitutable biodiesel feedstocks for the UK: a review of sustainability issues with reference to the UK RTFO

BIOENERGY -- LAND USE CHANGE

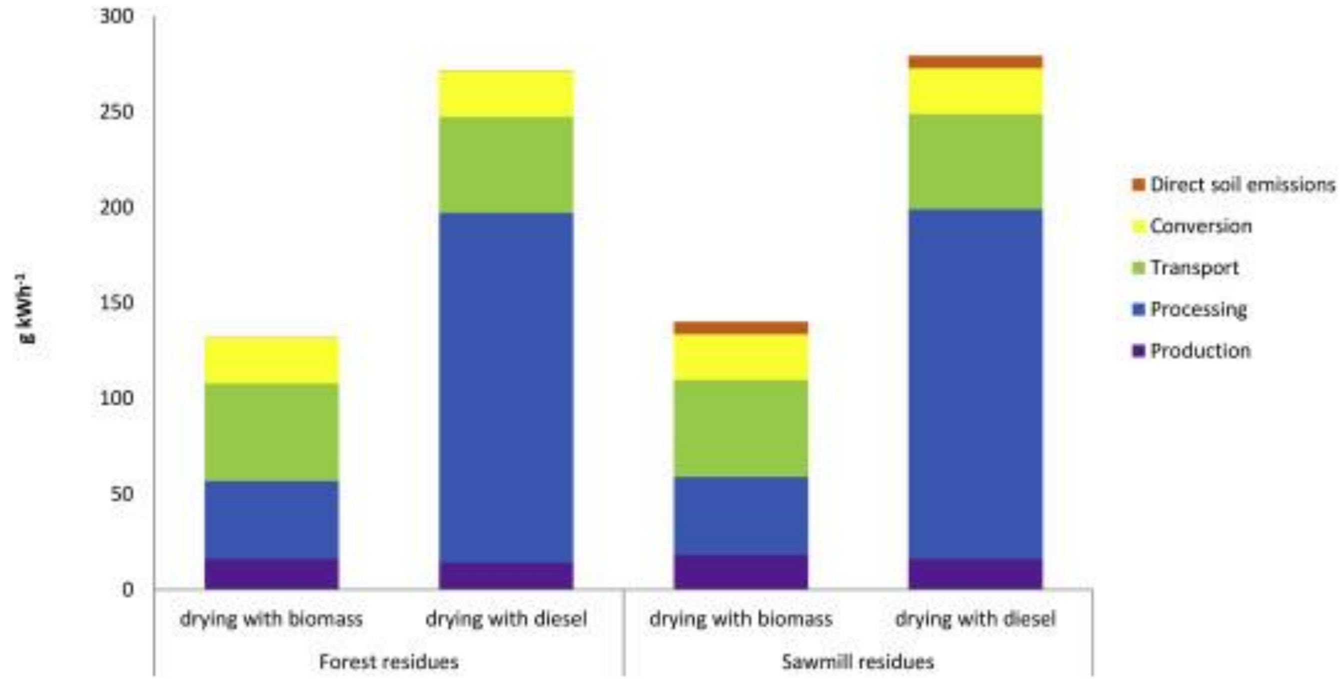
BIOMASS PRODUCTION CHANGES THE WAY LAND IS USED, AND THIS CAN HAVE POSITIVE AND NEGATIVE IMPACTS - DEPENDING ON WHERE YOU START AND WHERE YOU FINISH.


IF YOU START WITH "MARGINAL LAND" (ABANDONED OR DEGRADED AGRICULTURAL LAND):
X LOW BIODIVERSITY
X SOIL EROSION
CONVERT TO GRASSES (LIKE MISCANTHUS) OR WOODY CROPS (LIKE WILLOW) USED FOR ENERGY:
✓ PROTECTS SOILS FROM EROSION
✓ IMPROVED BIODIVERSITY
X INCREASED USE OF FERTILISERS
CONVERT TO FOREST FOR WOOD PRODUCTS AND BIOENERGY:
✓ DECREASED SOIL EROSION
✓ LARGE INCREASE IN CARBON STORED IN SOIL
✓ PROTECTS WATERWAYS AND WATER QUALITY
✓ LARGER INCREASE IN BIODIVERSITY

[Title]

AS WELL AS THE ABOVE, WE ALSO HAVE TO BE CAREFUL THAT A CHANGE IN ONE PLACE DOESN'T CAUSE A CHANGE SOMEWHERE ELSE -- OFTEN FAR AWAY.
THIS IS TERMED 'INDIRECT LAND USE CHANGE (ILUC).
GO ON, SHOO! YOU'RE NOT WANTED AROUND HERE ANY MORE!
HEY! OVER HERE! GOOD NEW GRAZING LAND!
BIOENERGY CROP
16

Supply chain emissions



Röder , Whittaker & Thornley, How certain are greenhouse gas reductions from bioenergy? Life-cycle assessment and uncertainty analysis of wood pellet-to-electricity supply chains from forest residues, Biomass and Bioenergy, 79, 2015

Displacing carbon-intensive incumbents

BIOMASS AND BIOENERGY 81 (2015) 35–43

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BIOMASS & BIOENERGY

Research Paper

Maximizing the greenhouse gas reductions from biomass: The role of life cycle assessment

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ABSTRACT

Biomass can deliver significant greenhouse gas reductions in electricity, heat and transport fuel supply. However, our biomass resource is limited and should be used to deliver the most strategic and significant impacts. The relative greenhouse gas reduction merits of different bioenergy systems (for electricity, heat, chemical and biochar production) were examined on a common, scientific basis using consistent life cycle assessment methodology, scope of system and assumptions. The results show that bioenergy delivers substantial and cost-effective greenhouse gas reductions. Large scale electricity systems deliver the largest absolute reductions in greenhouse gases per unit of energy generated, while medium scale wood chip district heating boilers result in the highest level of greenhouse gas reductions per unit of harvested biomass. However, ammonia and biochar systems deliver the most cost effective carbon reductions, while biochar systems poten-

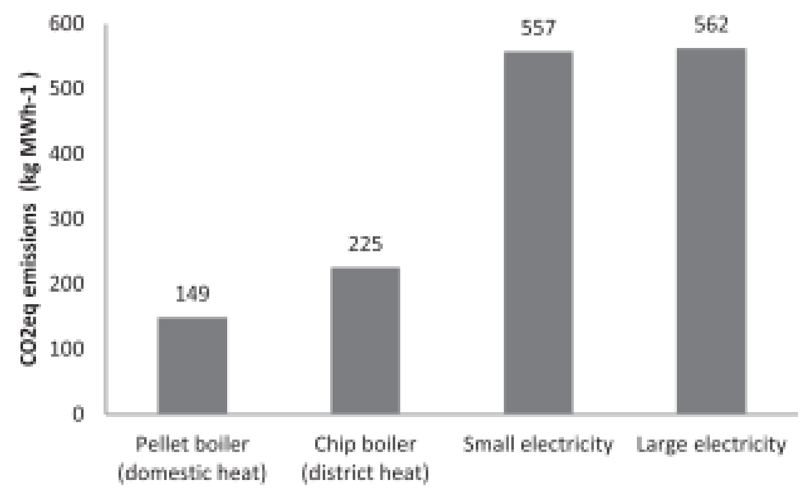

Fig. 2 – Absolute greenhouse gas savings per unit of energy delivered.

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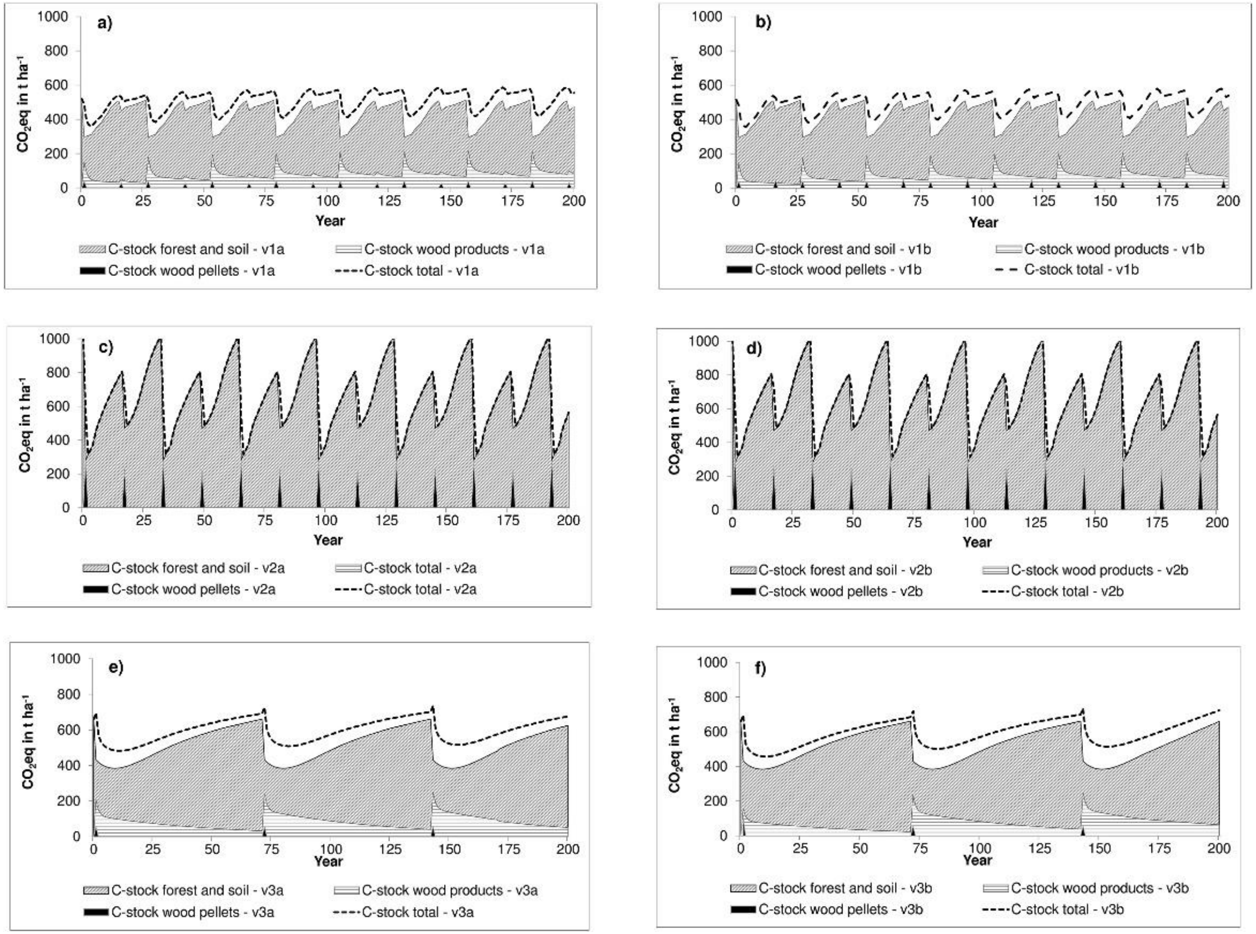
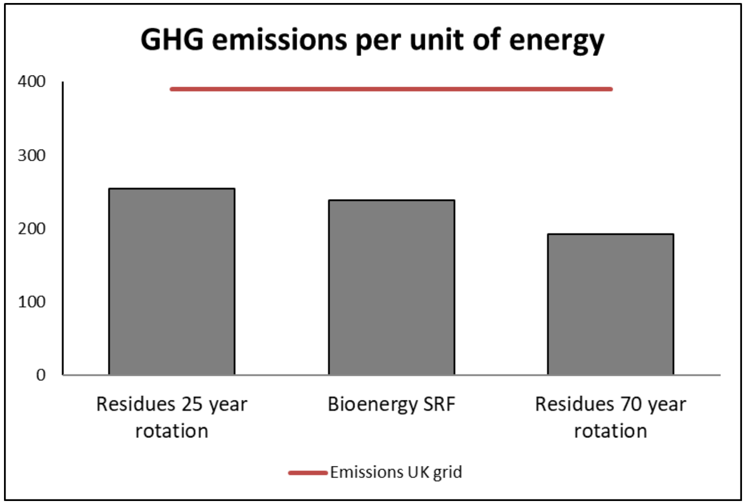
Carbon debt? Depends on start and end-points



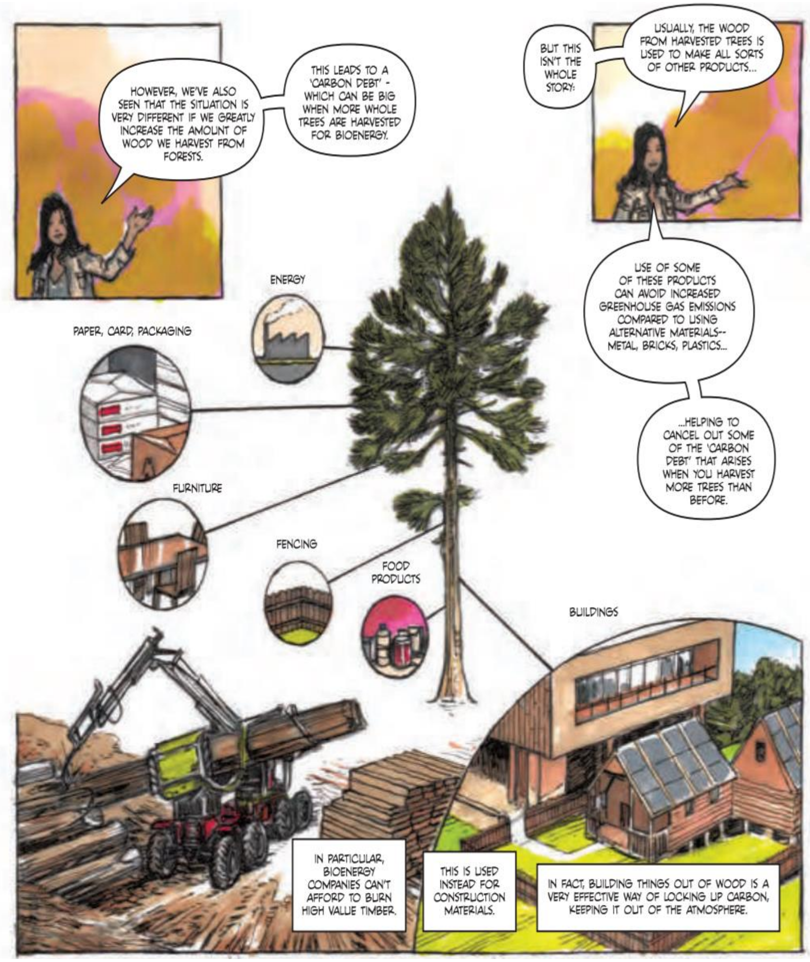
Roeder et al., Understanding the timing and variation of greenhouse gas emissions of forest bioenergy systems, Biomass and Bioenergy, February 2019

Allocating carbon emissions

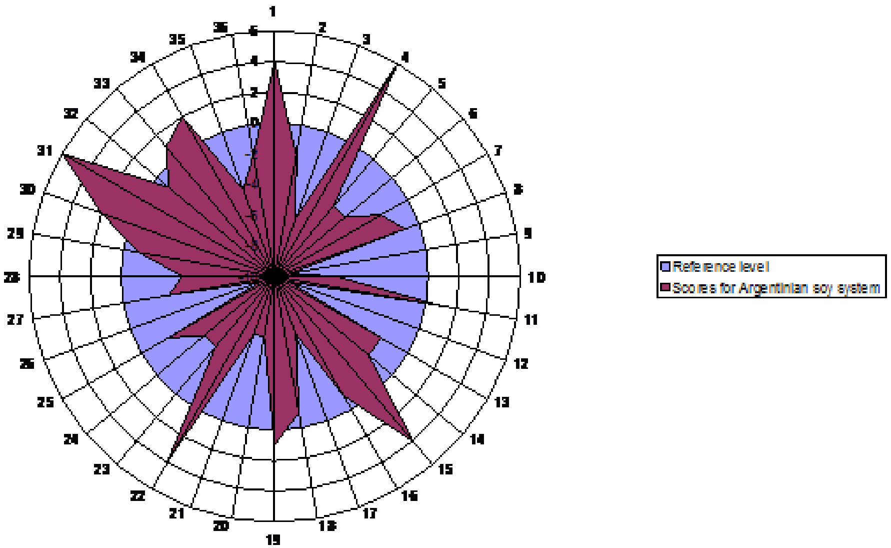


- Emission intensity of bioenergy (supply chain emissions only)
- Emission reductions compared to emission intensity of UK grid (40-60%)

Röder M, et al. Understanding the timing and variation of greenhouse gas emissions of forest bioenergy systems. Biomass and Bioenergy 2019; 121:99-114.



Sustainability beyond carbon



Thornley & Gilbert, "Biofuels: Balancing risks and rewards", Interface Focus, 2013

Coffee production

Cases	Bioenergy / Reference scenarios	Climate Change	PM form.	Fo-Dep	POF	Human-Tox	Te-Ecotox.	FW-Ecotox	FWater-EU	Te-Acidf.	Metal-Dep
Bioenergy 1 / Reference 1: Replacement of diesel/grid electricity and coffee stems cookstoves with bioelectricity from coffee stems gasification-electricity only system											
A1	**B:** 100% Bioelectricity + LPG Cookstove **C:** Diesel electricity + CS Cookstove	-48%	-98%	-36%	-92%	-76%	-76%	-78%	-78%	-89%	-75%
A2	**B:** 100% Bioelectricity + Elect Cookstove **C:** Diesel electricity + CS Cookstove	-86%	-98%	-85%	-73%	-34%	364%	-54%	-44%	-93%	24%
A3	**B:** 100% Bioelectricity + LPG Cookstove **C:** Grid electricity + CS Cookstove	68%	-97%	642%	-85%	-69%	-81%	12%	-77%	-26%	116%
A4	**B:** 100% Bioelectricity + Elect Cookstove **C:** Grid electricity + CS Cookstove	-56%	-98%	73%	-52%	-15%	264%	131%	-41%	-58%	950%
Bioenergy 2/Reference 2: Replacement of diesel/grid electricity, coal/diesel heat and coffee stems cookstoves with bioelectricity and bioheat from coffee stems gasification-CHP system											
B1	**B:** 71%Bioelectricity+29%Bioheat+LPG Stove **C:** Diesel electricity + Coal heat + CS Stove	-72%	-98%	-56%	-93%	-89%	-80%	-90%	-86%	-92%	-82%
B2	**B:** 71%Bioelectricity+29% Bioheat +LPG Stove **C:** Diesel electricity + Diesel heat + CS Stove	-55%	-97%	-46%	-92%	-78%	-78%	-79%	-80%	-89%	-77%
B3	**B:** 71%Bioelectricity+29% Bioheat +LPG Stove **C:** Grid electricity + Coal heat + CS Stove	-56%	-97%	18%	-88%	-87%	-84%	-85%	-85%	-81%	-47%
B4	**B:** 71%Bioelectricity+29% Bioheat +LPG Stove **C:** Grid electricity + Diesel heat + CS Stove	11%	-97%	129%	-86%	-71%	-83%	-14%	-79%	-41%	27%
Original Bioenergy/Reference 3: Replacement of diesel/grid electricity and coffee stems combustion in industrial stoves with bioelectricity and bioheat from coffee stems gasification-CHP											
C1	**B:** 71% Bioelectricity + 29% Bioheat **C:** Diesel electricity + CS combustion (drying)	-98%	-99%	-98.5%	-92%	-66%	-29%	-97%	16%	-98.5%	-93%
C2	**B:** 71% Bioelectricity + 29% Bioheat **C:** Grid electricity + CS combustion (for drying)	-91%	-90%	-85%	-31%	-32%	-66%	-88%	56%	-84%	-74.5%

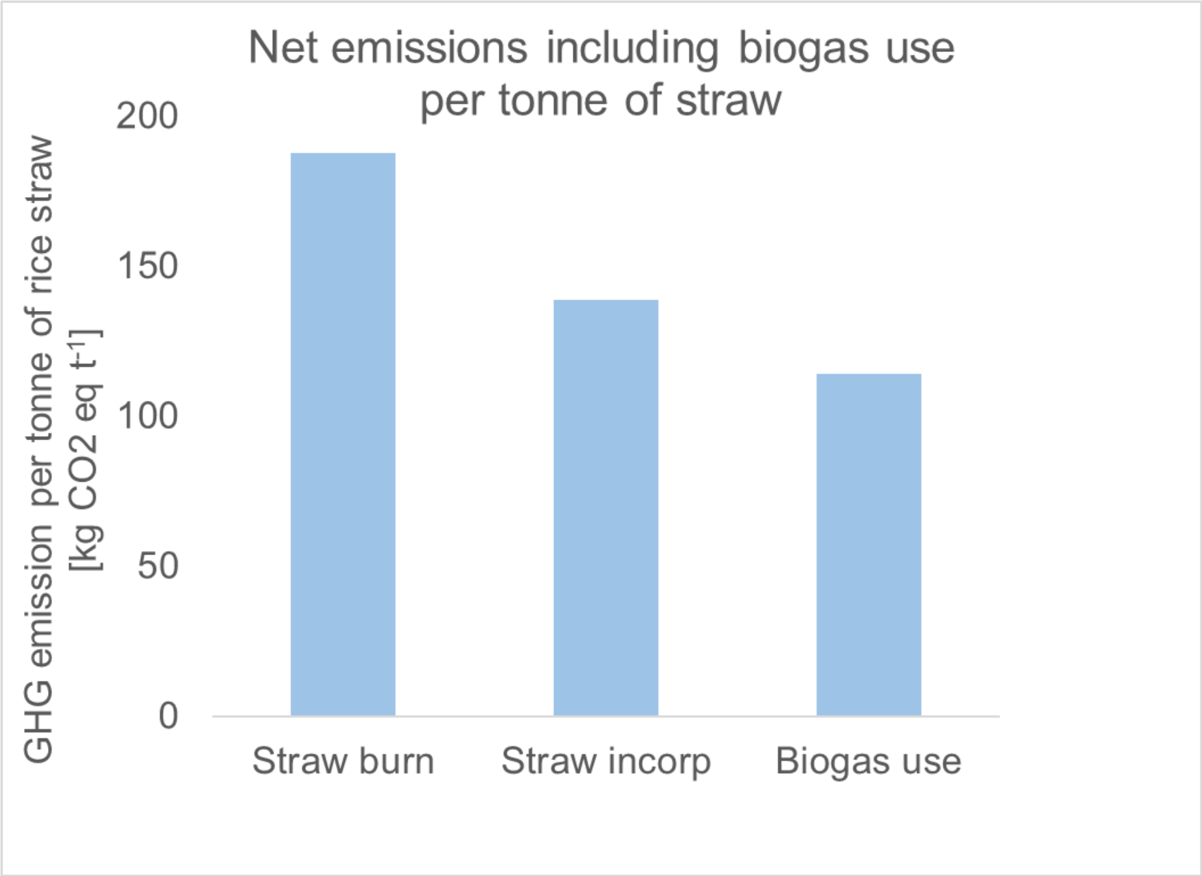
High net positive effect: X ≤ -50%	**High net negative effect: X ≥ 50%**
Low net positive effect: -50% < X < 0%	**Low net negative effect: 0 < X < 50%**

Freites, Thornley & Roeder, Environmental trade-offs associated with bioenergy from agri-residues in sub-tropical regions: A case study of the Colombian coffee sector, Biomass and Bioenergy, 2020

Rice straw to energy

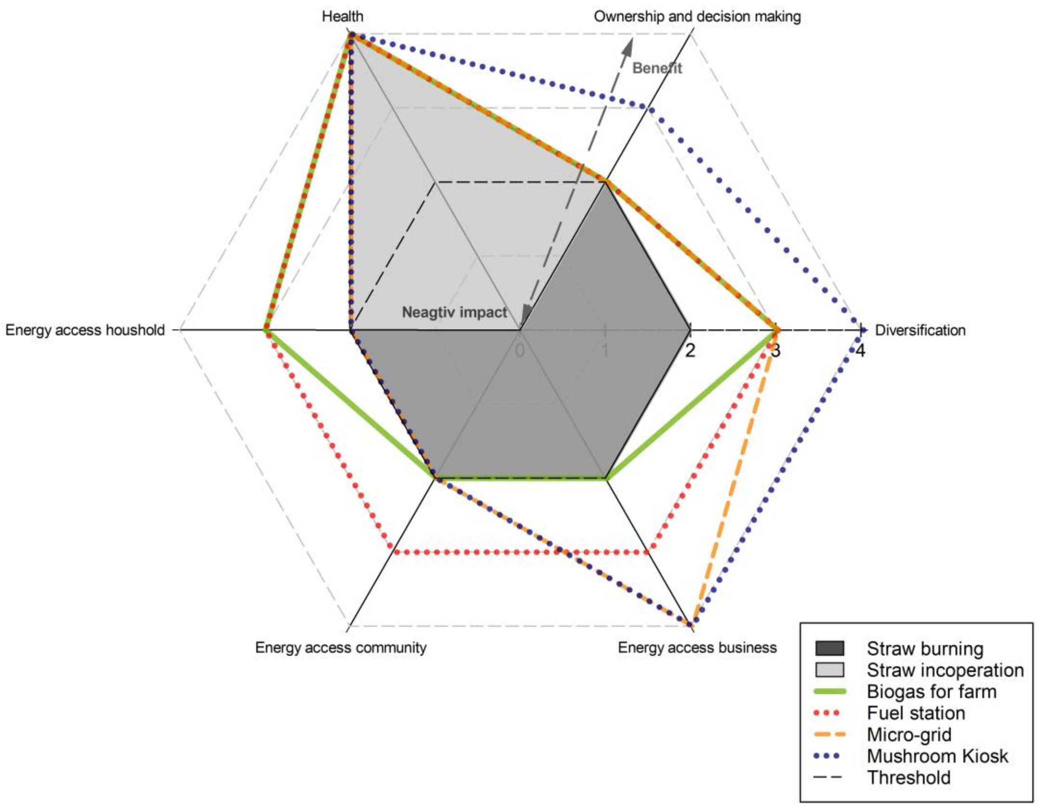
- Biogas pilot facility in the Philippines
- Provide a low-cost technology adapted to the needs of the location to manage rice straw, support energy access and socio-economic empowerment
- Test solutions for technical barriers (straw collection, handling, AD operations)
- Develop business models (Röder, M., et al., (2020). (Stop) burning for biogas. Enabling positive sustainability trade-offs with business models for biogas from rice straw. Biomass and Bioenergy, 138, 105598.)
- **Assess environmental performance of biogas system**

Rice straw bioenergy emissions including use



- (Röder, M., et al., (2020). (Stop) burning for biogas. Enabling positive sustainability trade-offs with business models for biogas from rice straw. Biomass and Bioenergy, 138, 105598.)

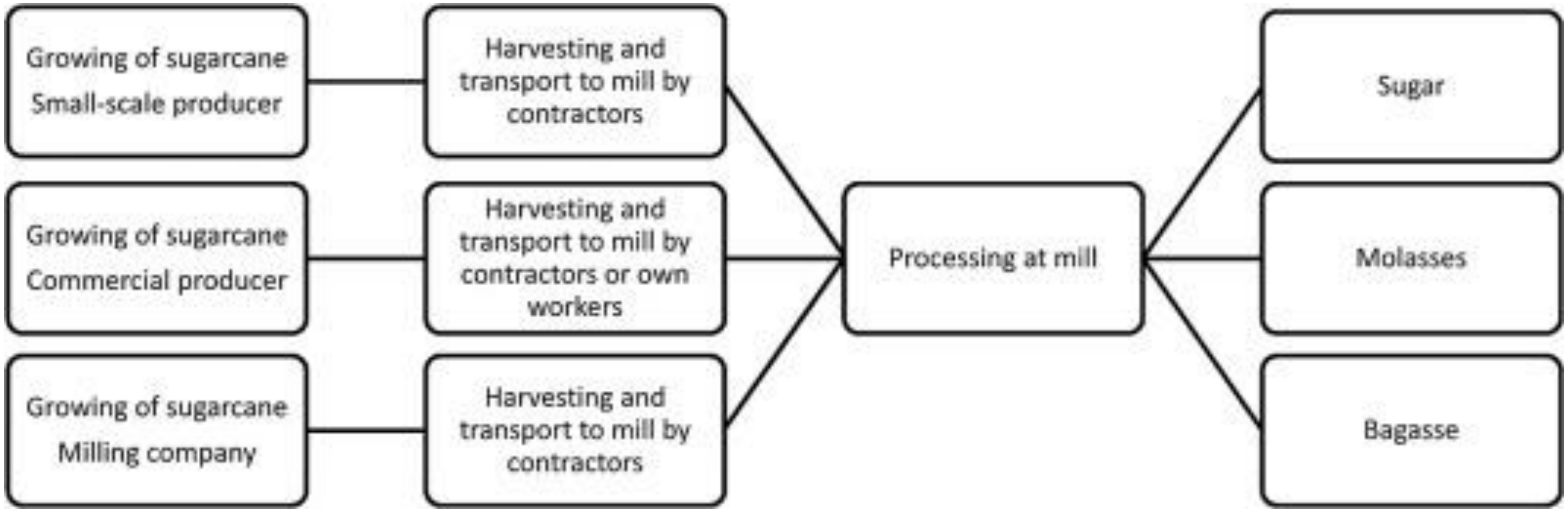
Rice straw bioenergy socio-economic trade-offs of different business models



- Change of business model changes implications of different criteria
- Biogas business models socio-economic more beneficial than current agricultural and post-harvest practices

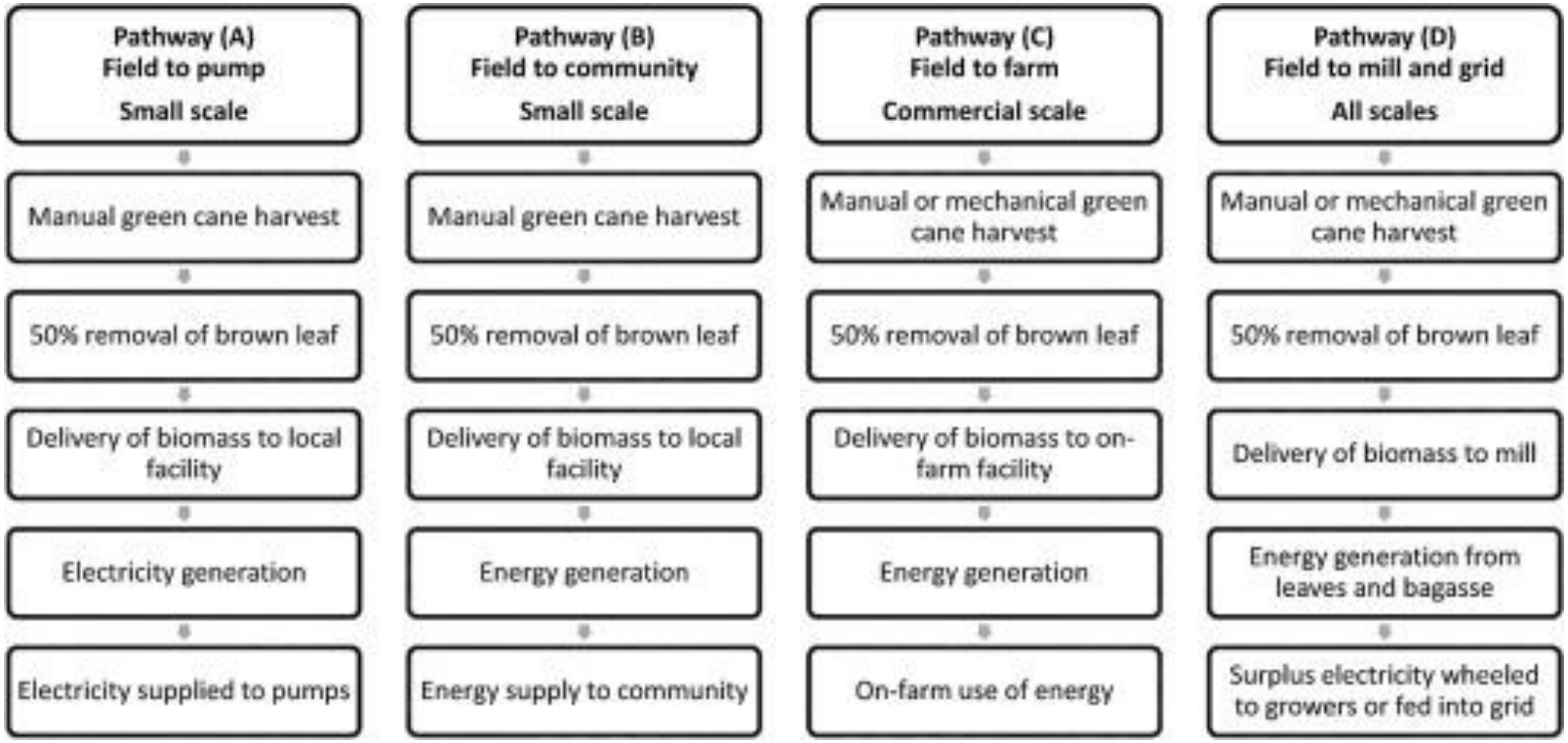
- (Röder, M., et al., (2020). (Stop) burning for biogas. Enabling positive sustainability trade-offs with business models for biogas from rice straw. Biomass and Bioenergy, 138, 105598.)

Sugar cane production



Röder, M., Stolz, N. & Thornley, P., Sweet energy – Bioenergy integration pathways for sugarcane residues. A case study of Nkomazi, District of Mpulmalanga, South Africa, Renewable Energy, vol 113, 2017

Sugar cane residues to bioenergy



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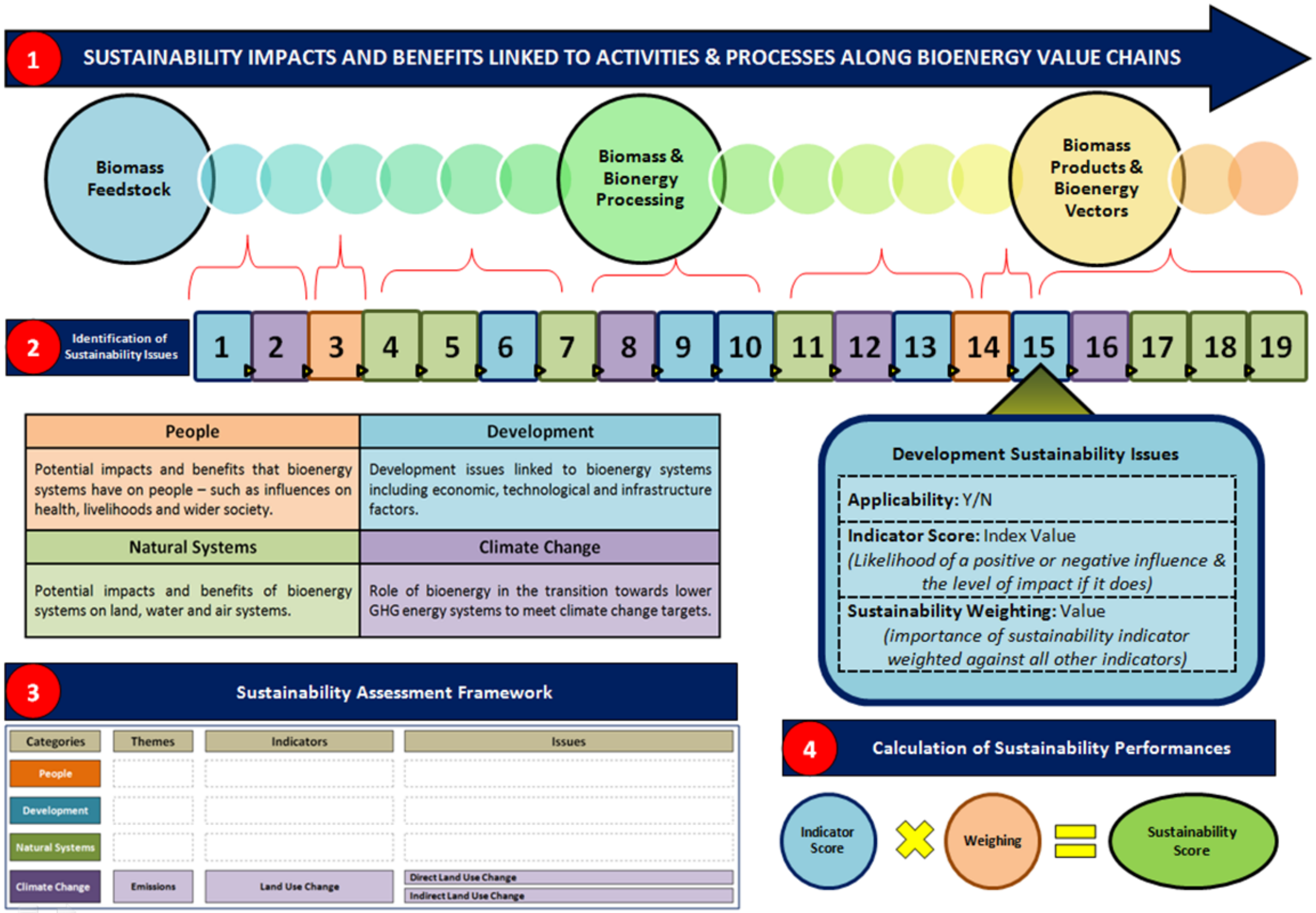
Sugarcane bioenergy impacts

	Pathway A)	Pathway B)	Pathway C)	Pathway D)
Environmental				
Reducing agricultural emissions	🙂	🙂	🙂	🙂
Dealing with residues and wastes	🙂	🙂	🙂	🙂
Renewable energy	🙂	🙂	🙂	🙂
Reducing health impacts from traditional biomass use	🙁	😐	🙁	🙁
Agronomic benefits	🙂	🙂	🙂	🙂
Economic				
Economic development	🙂	🙂	🙂	🙂
Create employment	🙂	🙂	🙂	🙂
Increased cost (labour and logistics)	🙁	🙁	🙁	🙁
Fits into existing infrastructure	🙁	🙁	🙁	🙂
Operational complexity	🙁	🙁	🙂	🙂
Energy security domestic	😐	😐	😐	🙂
Energy security local	🙂	🙂	🙂	😐
Access to investment	🙁	🙁	😐	😐
Social				
Empowerment of local population	🙂	🙂	😐	🙁
Justice and equality of electricity supply	😐	🙂	😐	🙁
Decentralised energy infrastructure	🙂	🙂	🙂	🙁
Horizontal supply chains	😐	🙂	😐	🙁
Supporting ownership rights and equality in decision making	😐	🙂	😐	🙁
Policy				
Supporting policy framework	🙁	🙁	🙁	😐
Crime and mismanagement	🙁	🙁	😐	😐

Röder, M., Stolz, N. & Thornley, P., Sweet energy – Bioenergy integration pathways for sugarcane residues. A case study of Nkomazi, District of Mpulmalanga, South Africa, Renewable Energy, vol 113, 2017

Measuring sustainability in SGBH



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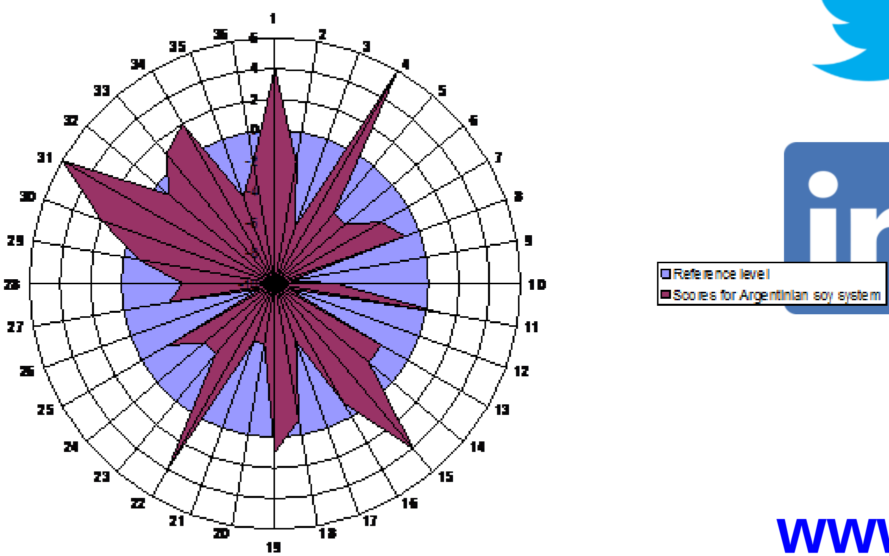
Sustainable?



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