How biogas solutions can make our planet great again

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Biogas Research Centre Conference, June 4th, 2020 (online)

MAKE OUR PLANET GREAT AGAIN

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French president's climate talent search nabs 18 foreign scientists

By Elisabeth Pain | Dec. 11, 2017, 2:00 PM

Science Magazine. Dec 2017.

- 42 French laureates (18 + 14 + 12; 2 declined)
- France: Many spin-offs
- 13 German laureates

Carbon management & Bioresources strategies for scoping the transition towards low fossil carbon

CAMBIOSCOP

Carbon management towards low fossil carbon use

2018 - 2023

MAKE OUR PLANET GREAT AGAIN

1

Which planet?

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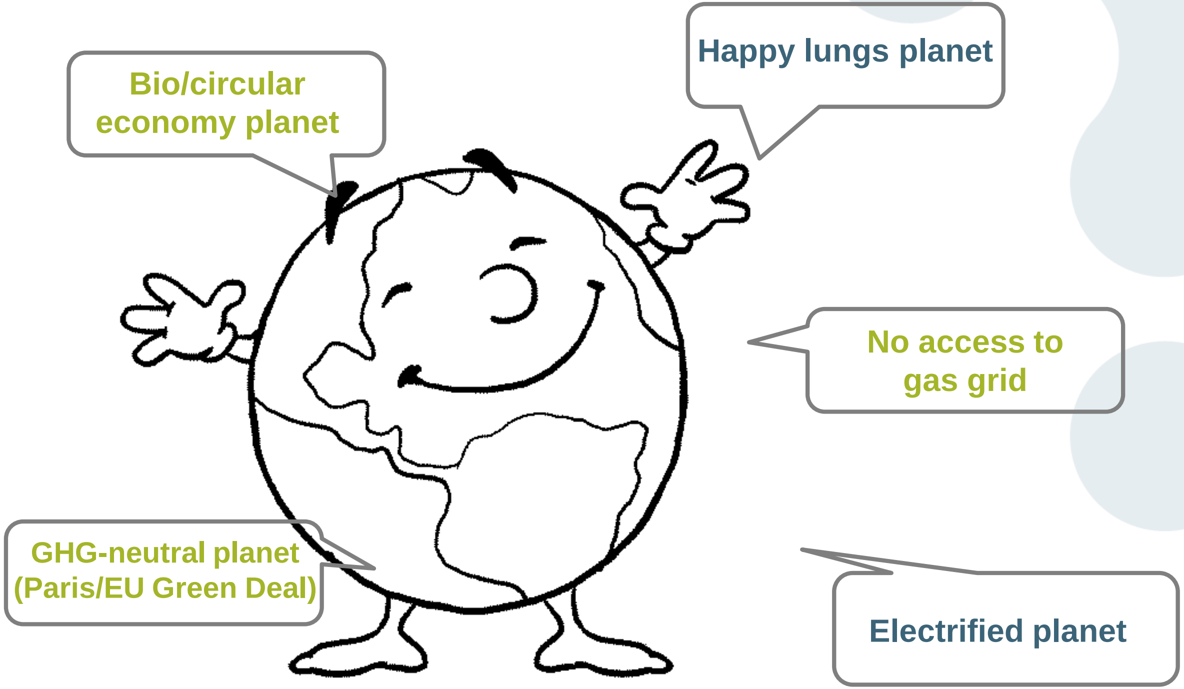
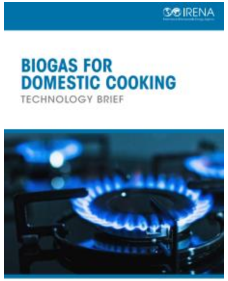
Which planet?



Which planet?

Only 60% of the World has access to clean fuels for cooking
https://ourworldindata.org/indoor-air-pollution



Source: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Dec/IRENA_Biogas_for_domestic_cooking_2017.pdf

World Health Organization | Health Topics | Countries | Newsroom | Emergencies

8 May 2018

Key facts

- **Around 3 billion people cook using polluting open fires or simple stoves fuelled by kerosene, biomass (wood, animal dung and crop waste) and coal.**
- **Each year, close to 4 million people die prematurely from illness attributable to household air pollution from inefficient cooking practices using polluting stoves paired with solid fuels and kerosene.**
- **Household air pollution causes noncommunicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer.**
- **Close to half of deaths due to pneumonia among children under 5 years of age are caused by particulate matter (soot) inhaled from household air pollution.**

Indoor air pollution and household energy: the forgotten 3 billion

Around 3 billion people still cook using solid fuels (such as wood, crop wastes, charcoal, coal and dung) and kerosene in open fires and inefficient stoves. Most of these people are poor, and live in low- and middle-income countries.

These cooking practices are inefficient, and use fuels and technologies that produce high levels of household air pollution with a range of health-damaging pollutants, including small soot particles that penetrate deep into the lungs. In poorly ventilated dwellings, indoor smoke can be 100 times higher than acceptable levels for fine particles. Exposure is particularly high among women and young children, who spend the most time near the domestic hearth.

Impacts on health

3.8 million people a year die prematurely from illness attributable to the household air pollution caused by the inefficient use of solid fuels and kerosene for cooking. Among these 3.8 million deaths:

- 27% are due to pneumonia
- 18% from stroke
- 27% from ischaemic heart disease
- 20% from chronic obstructive pulmonary disease (COPD)
- 8% from lung cancer.

Source: https://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health

So much to say …

- Storable and versatile source of C
- Mitigation technology for GHG in agriculture / manure management
- Bio-/circular economy: ca. 40% of the initial C is returned back to soils (potentially more reluctant to degradation) and N completely preserved (and in a form more available to plants)
- Links agricultural (feedstock supplier) & urban areas (key user)
- …

Outline

- WHY
- WHEN
- HOW

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Why?

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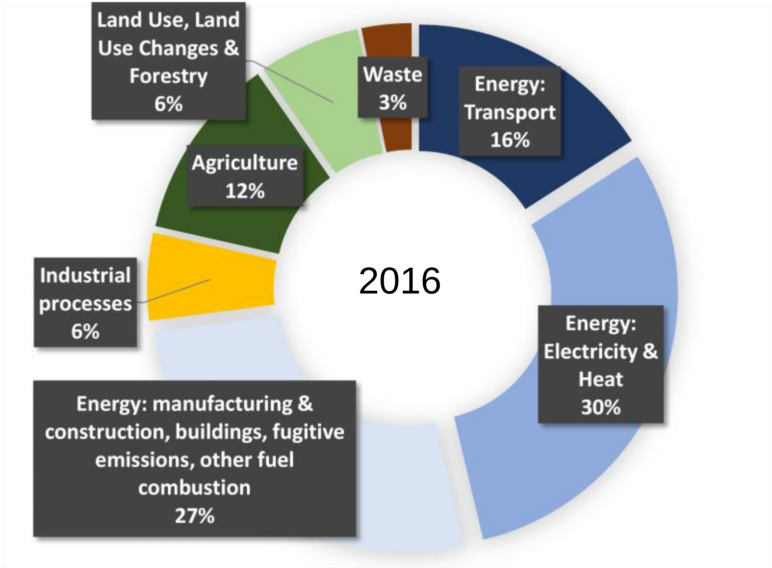
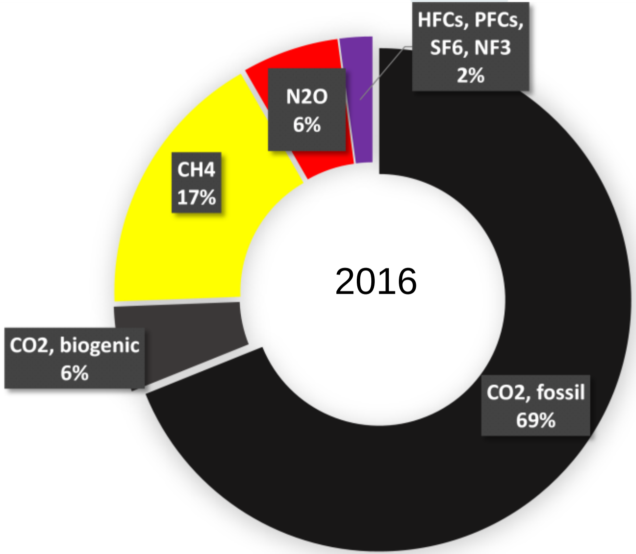
Towards GHG neutrality?

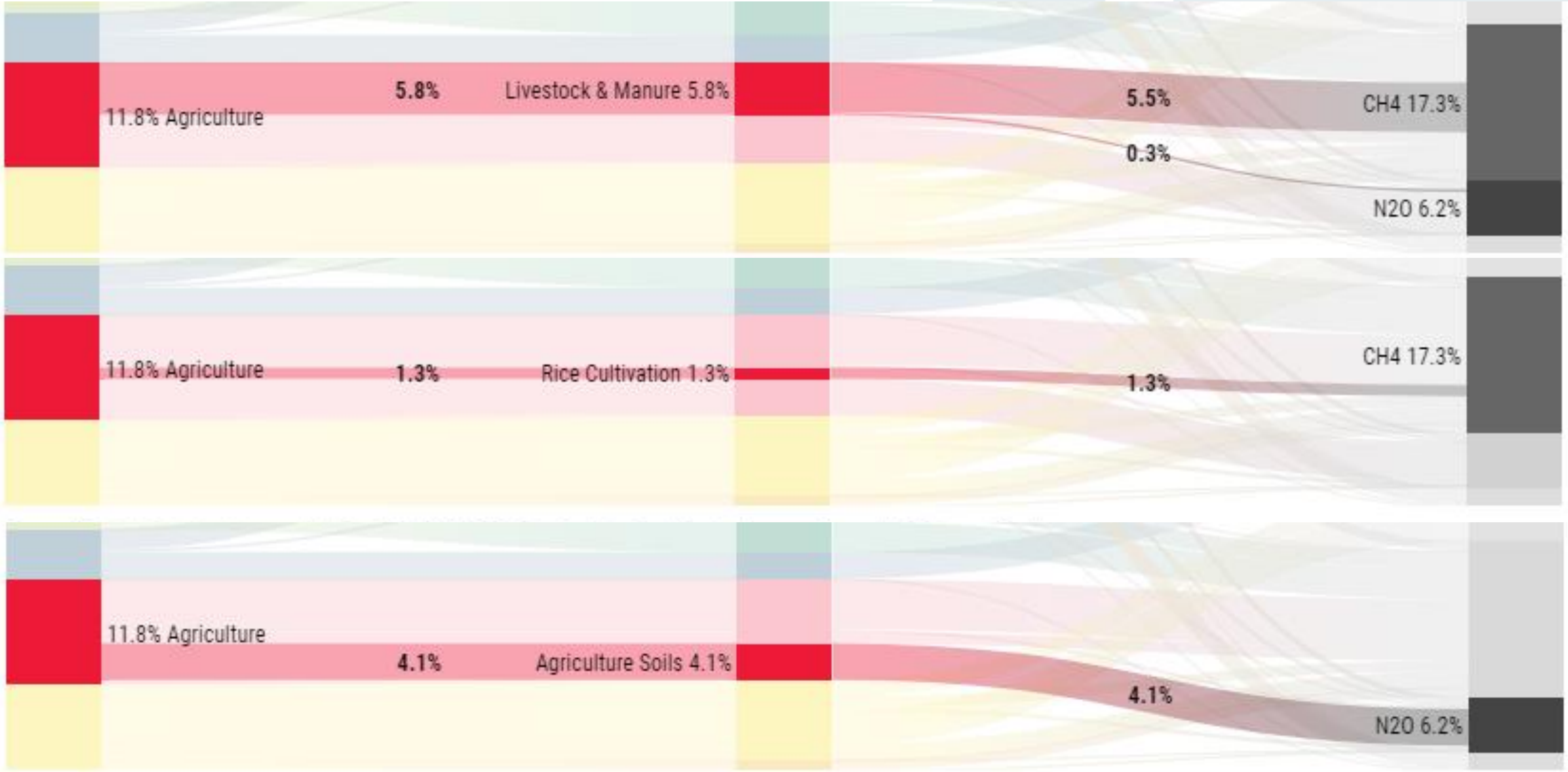
- **Global GHG are due to only 5 sectors of activity**





Source: own figures, made from data retrieved from https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016

Zooming on agriculture



Source: Climate Watch, based on raw data from IEA (2018), CO2 Emissions from Fuel Combustion, www.iea.org/statistics; modified by WRI.

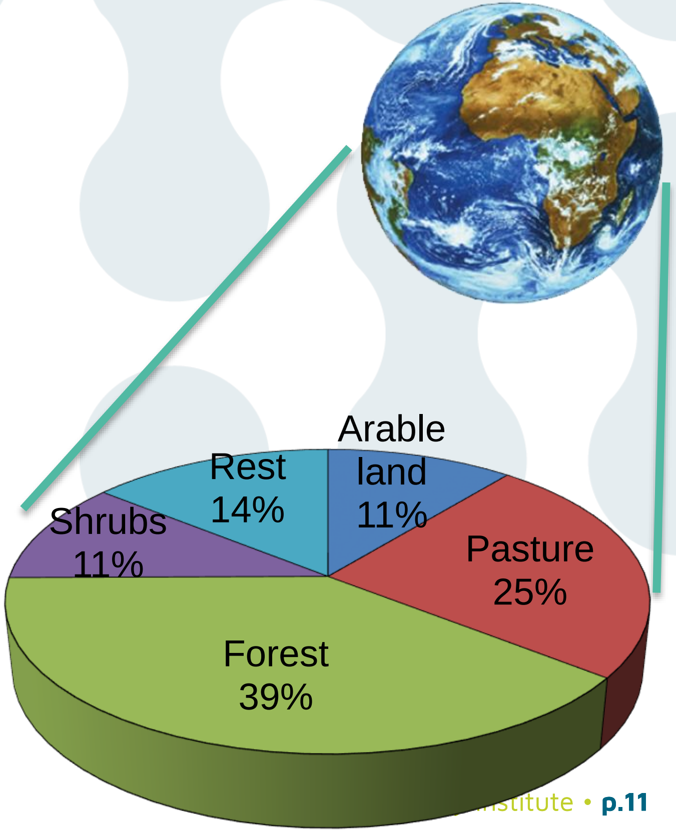
WORLD RESOURCES INSTITUTE

https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016

Global outlook on land use (today)

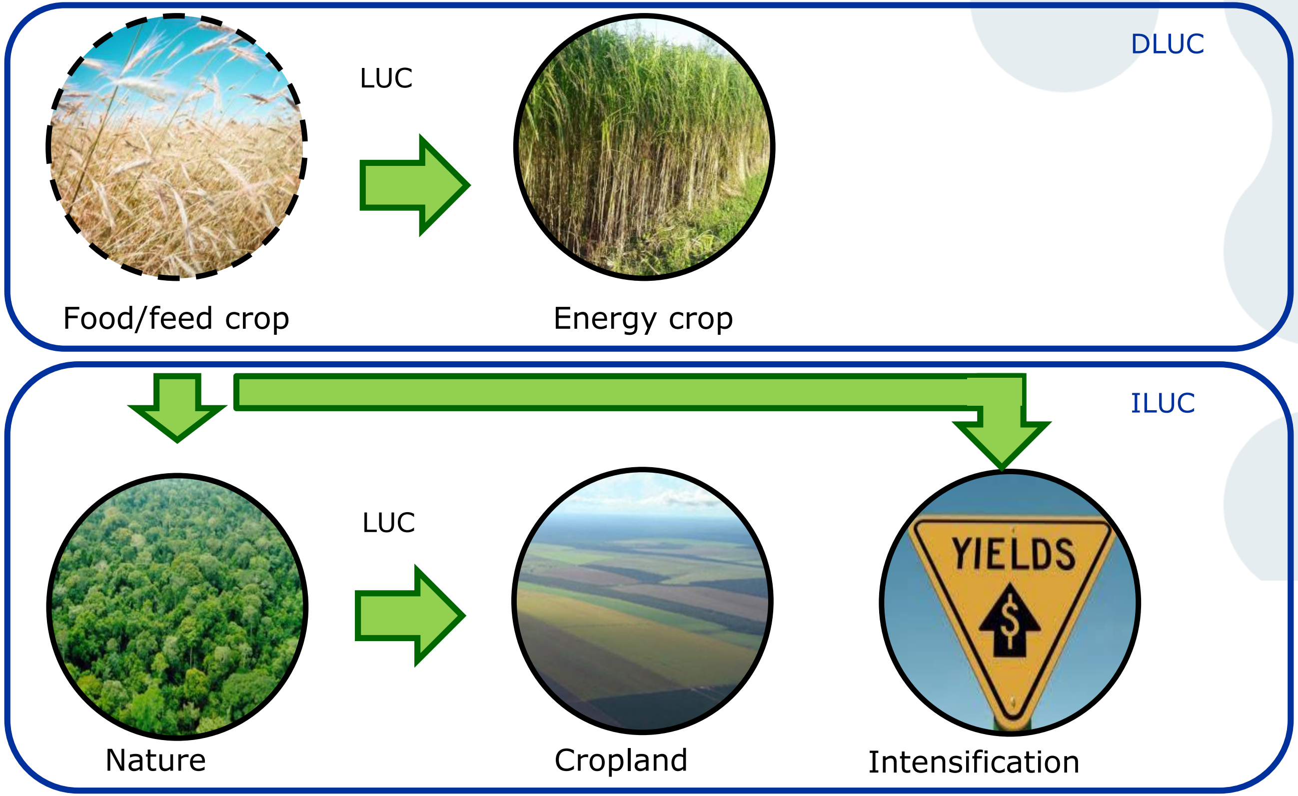
12.5 Gha of land area on Earth*:

- **4.5 Gha agricultural land**
  - 1.4 Gha arable land;
  - 3.1 Gha pastures
- **4.9 Gha forest**
  - ~1.6 Gha primary forest;
  - ~ 0.3 Gha plantations;
  - ~ 2.9 Gha naturally regenerated;
- **3.1 Gha other land**
  - 1.7 Gha uncultivable (permanent snow, water);
  - 0.08 Gha rest (urban)
  - 1.4 Gha shrub



*(*Excludes Antarctica; FAOSTAT, retrieved in 2020 (data for 2017; MODIS data); FAO 2010; Kampman et al. 2008; Kok et al. 2008); Inconsistencies due to rounding*

Land use changes




COMMENT · 27 MARCH 2019

Why the US–China trade war spells disaster for the Amazon

An analysis of global soya-bean production forecasts massive deforestation in Brazil – stakeholders must act fast to prevent it, warn Richard Fuchs and colleagues.

Peter Alexander, Calum Brown, Frances Cossar, Roslyn C. Henry & Mark Rounsevell
Richard Fuchs ,

Fields of soya beans (left) sit alongside untouched natural forest in the Cerrado ecoregion of Brazil. Credit: Marizilda Cruppe/Greenpeace

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doi: 10.1038/d41586-019-00896-2

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When?

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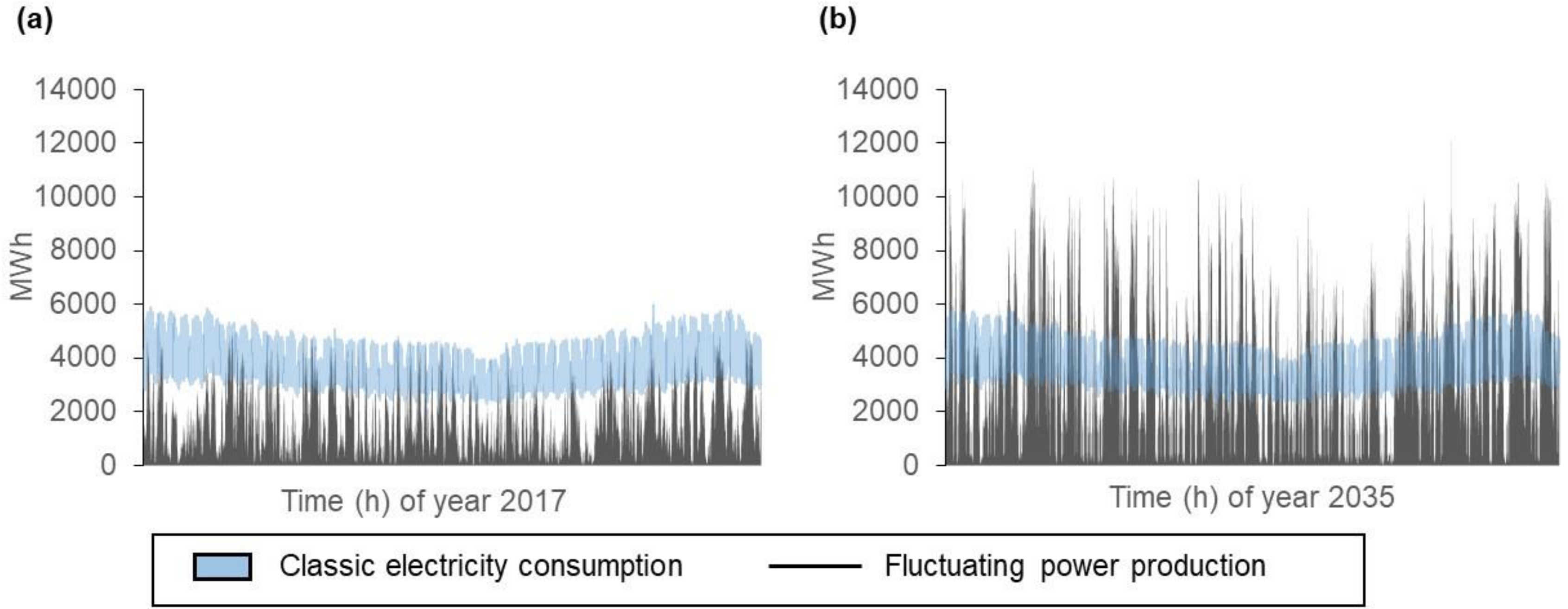
Towards more decarbonized (/fluctuating) power



Source: Hamelin et al. Re-submitted to RSER April 2020 - Harnessing the full potential of biomethane towards tomorrow's bioeconomy: a national case study coupling sustainable agricultural intensification, emerging biogas technologies and energy system analysis

4

How?

(A double-edged sword?)

(Case study: external C co-substrates to boost manure-based biogas)

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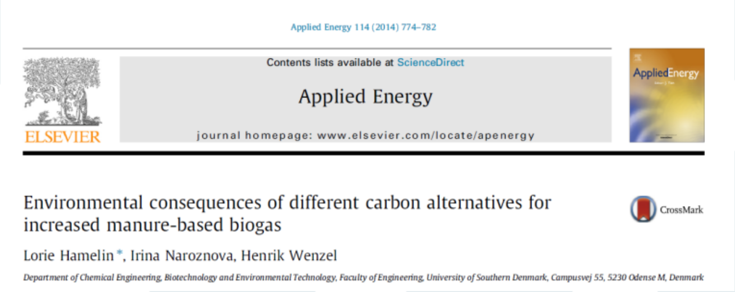
Case study example - Aim

Goal: investigating environmental consequences of different co-substrate strategies for drastic increase in manure-biogas


Applied Energy 114 (2014) 774–782

Contents lists available at ScienceDirect

Applied Energy

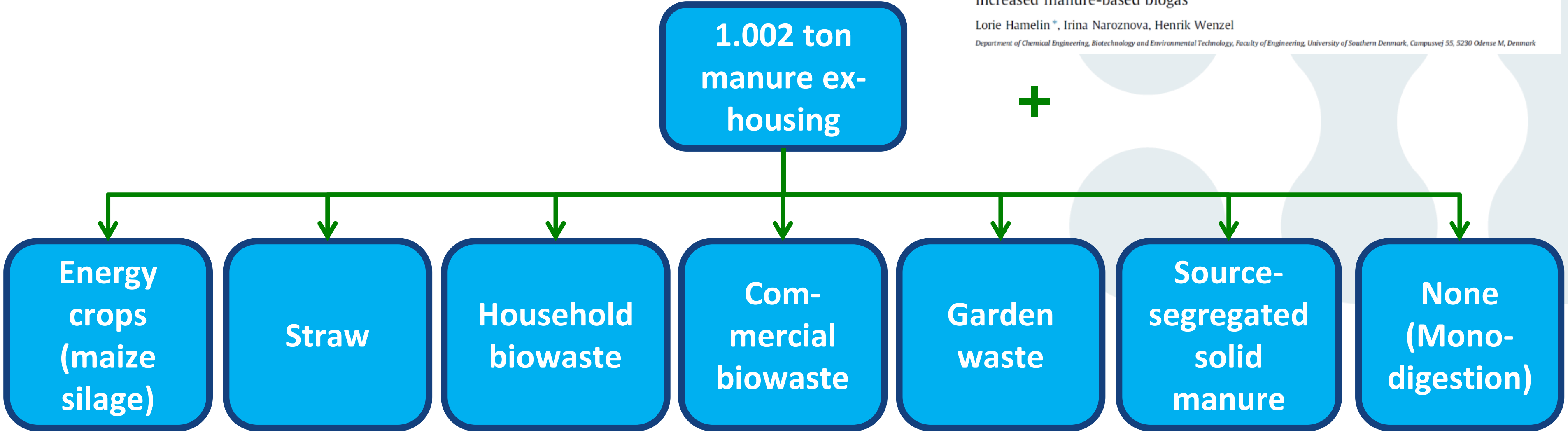
journal homepage: www.elsevier.com/locate/apenergy

Environmental consequences of different carbon alternatives for increased manure-based biogas

Lorie Hamelin*, Irina Naroznova, Henrik Wenzel

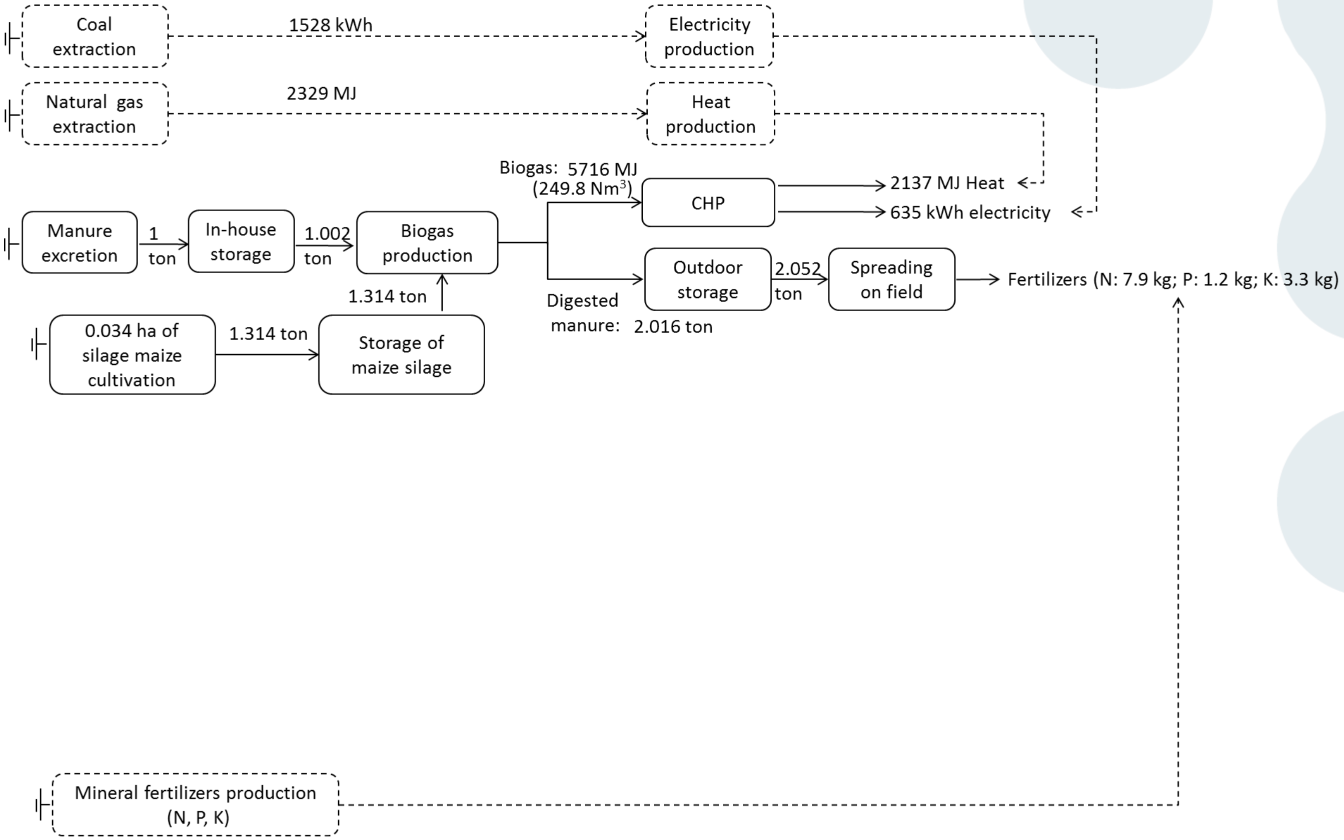
Department of Chemical Engineering, Biotechnology and Environmental Technology, Faculty of Engineering, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark

FU: 1 tonne manure ex-animal

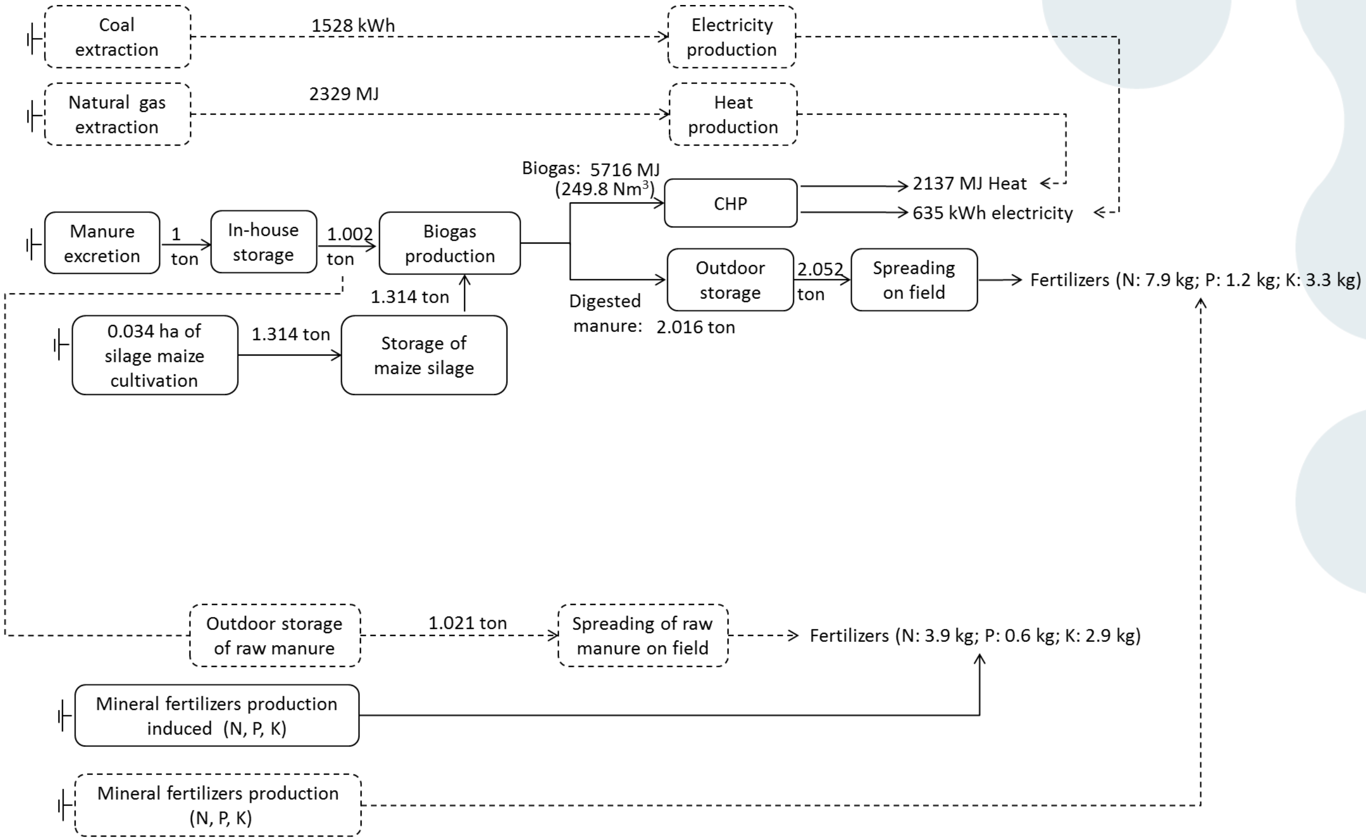


=>: 7 baseline scenarios

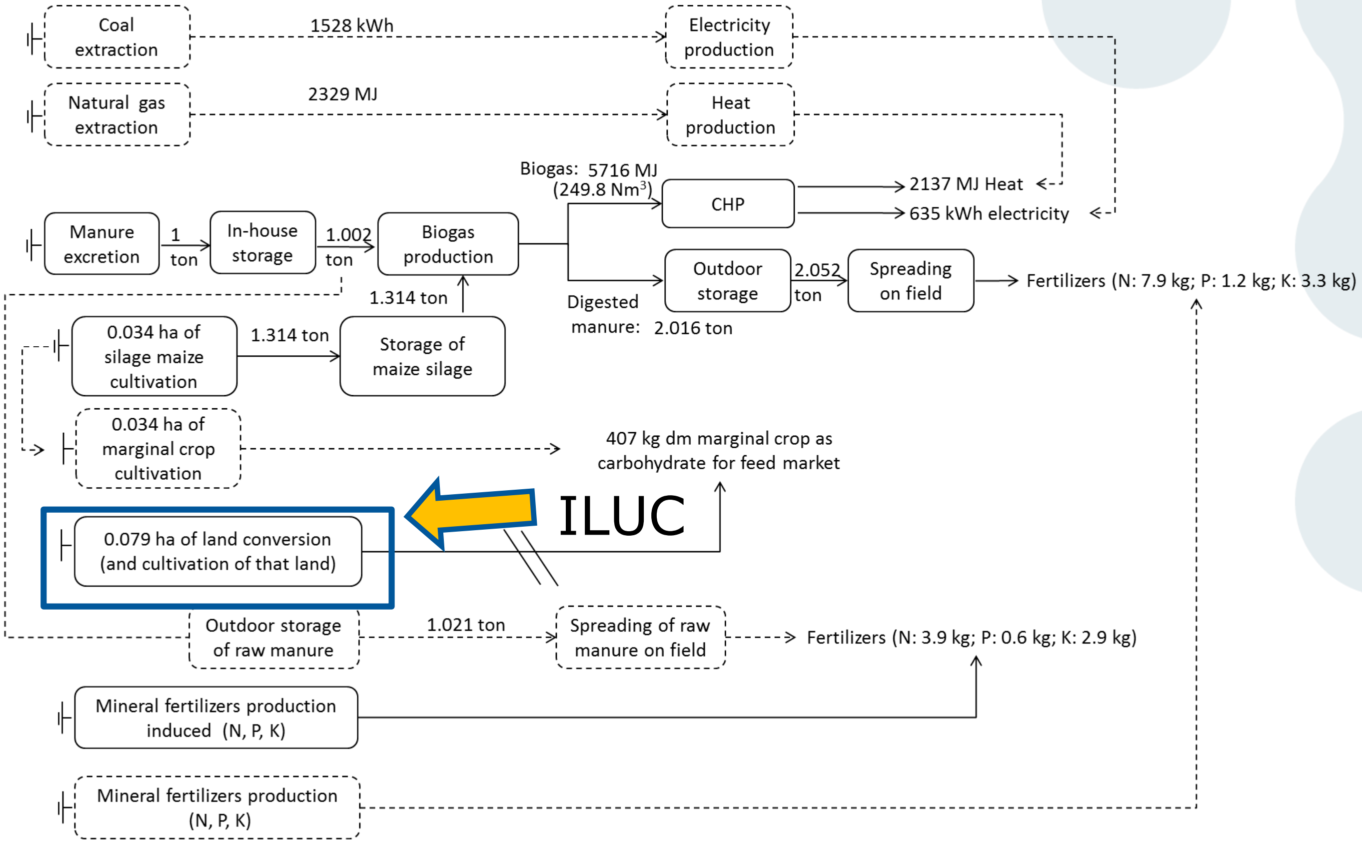
LCA System Boundary. Energy crop case (maize silage)



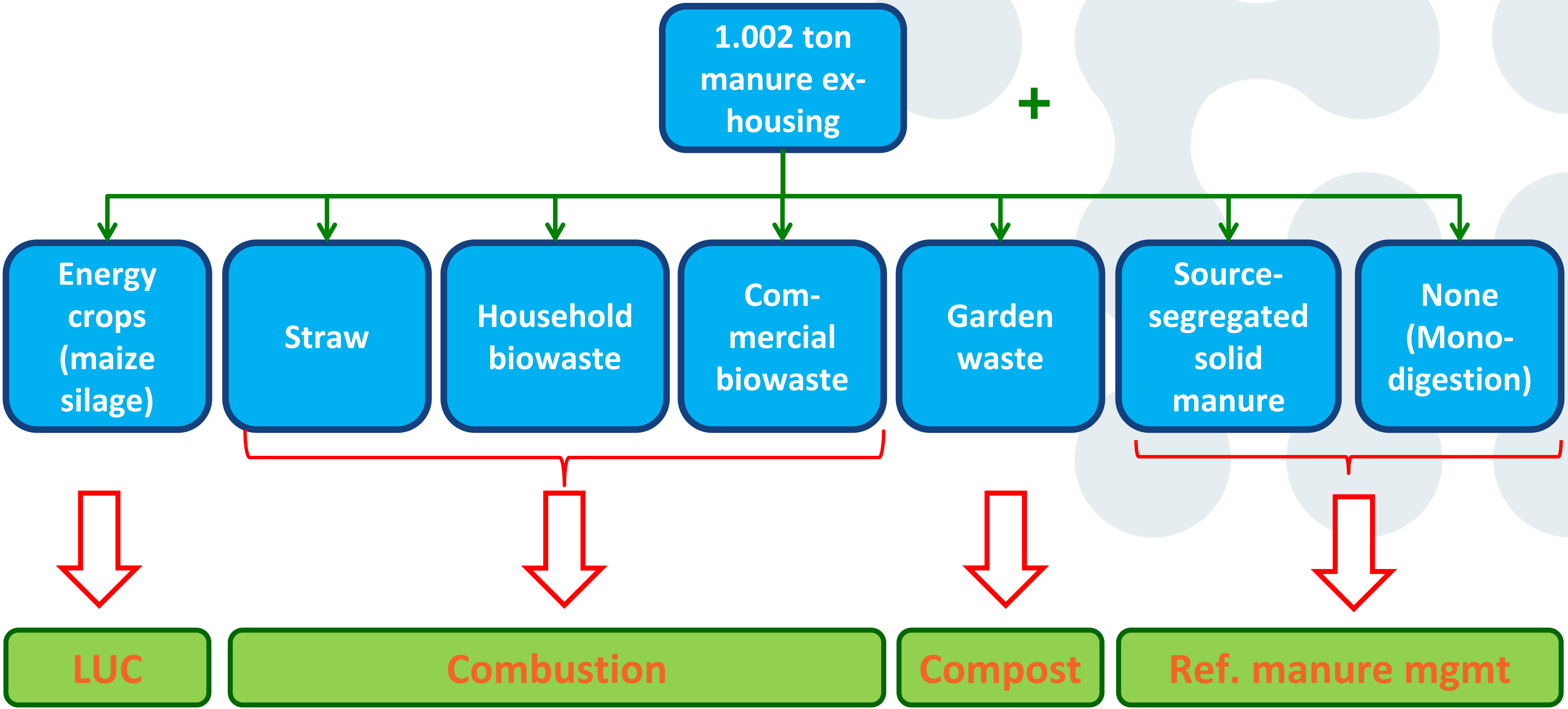
LCA System Boundary. Energy crop case (maize silage)



LCA System Boundary. Energy crop case (maize silage)

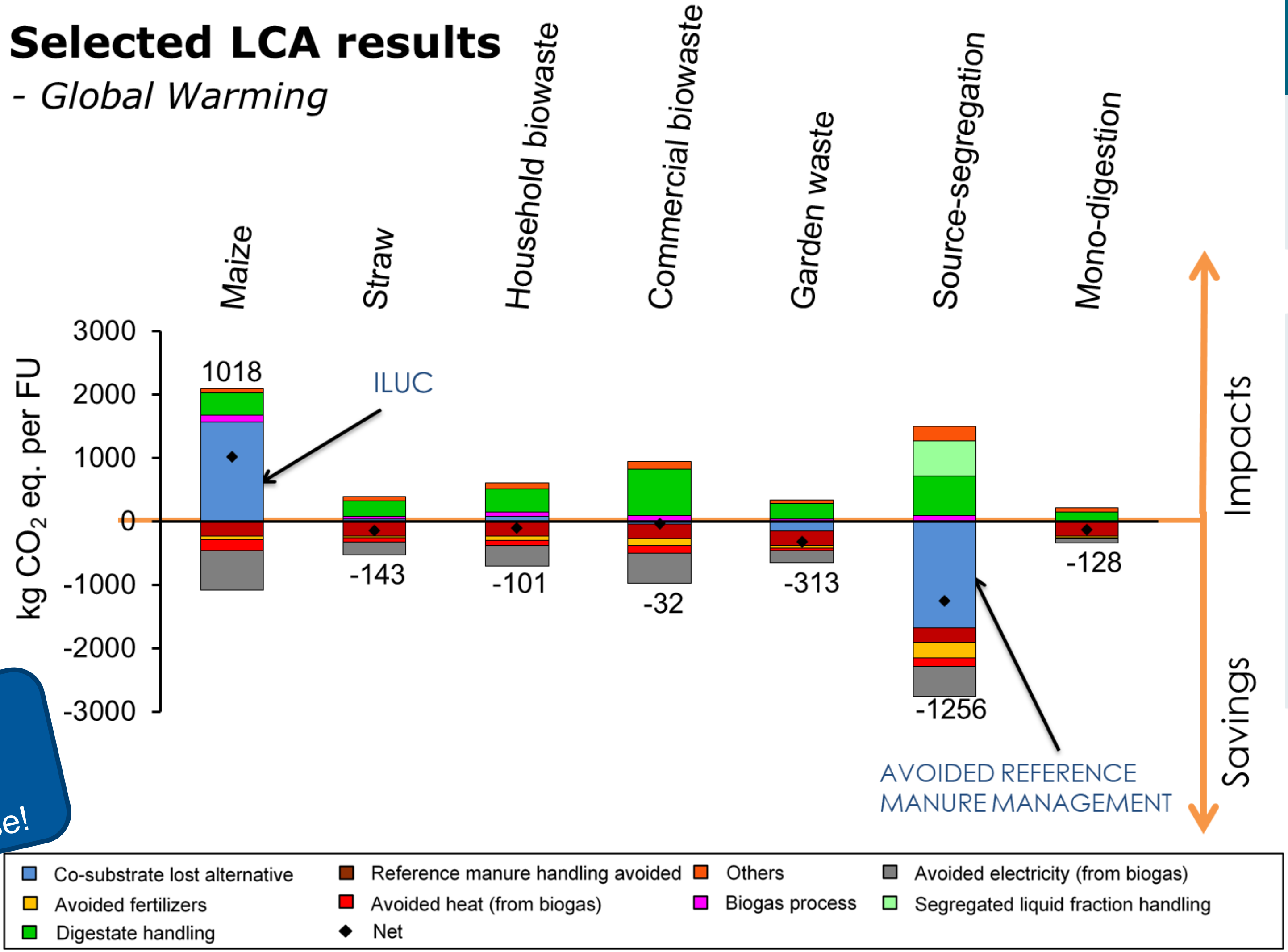


Lost Alternatives



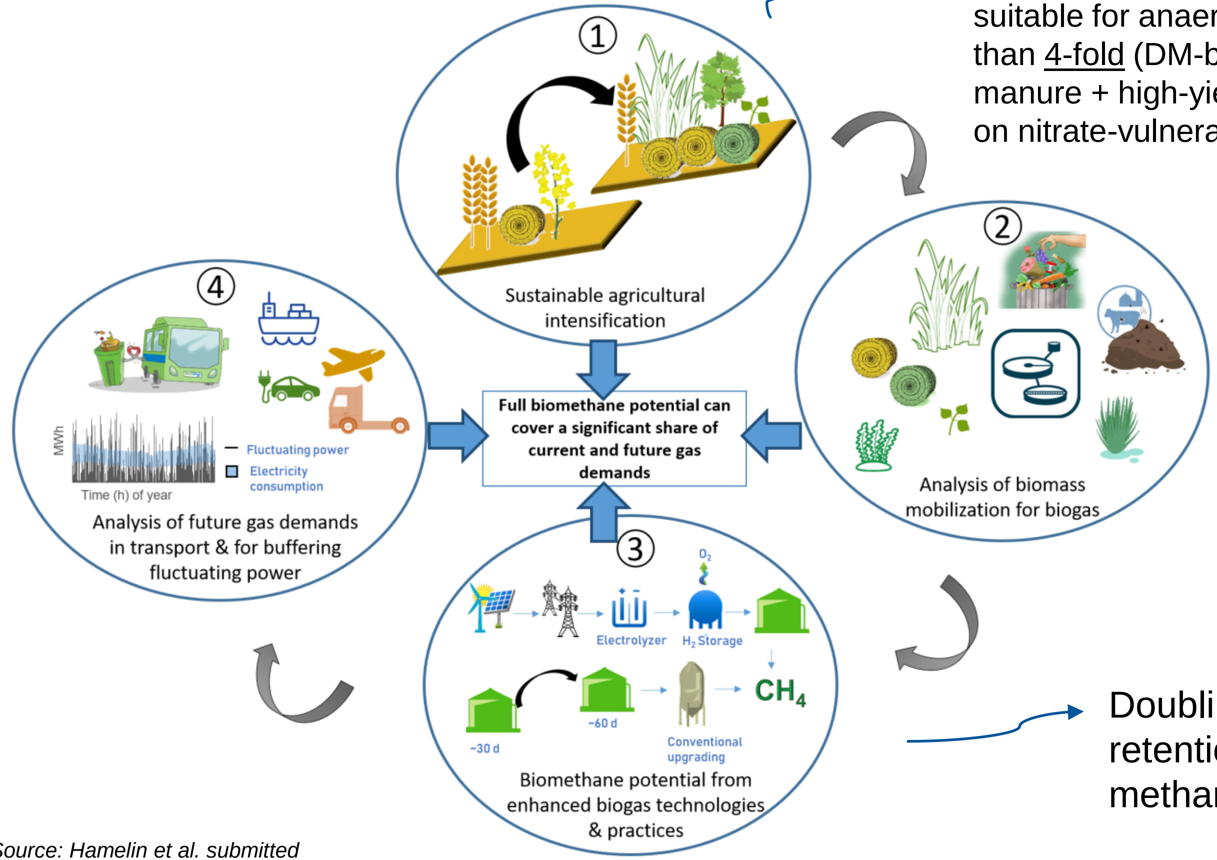
Selected LCA results

- Global Warming



Note: this is of course just part of the story (upstream). It tells nothing on biogas use!

Case 2: towards more biogas with sustainable intensification and "better" biogas technologies



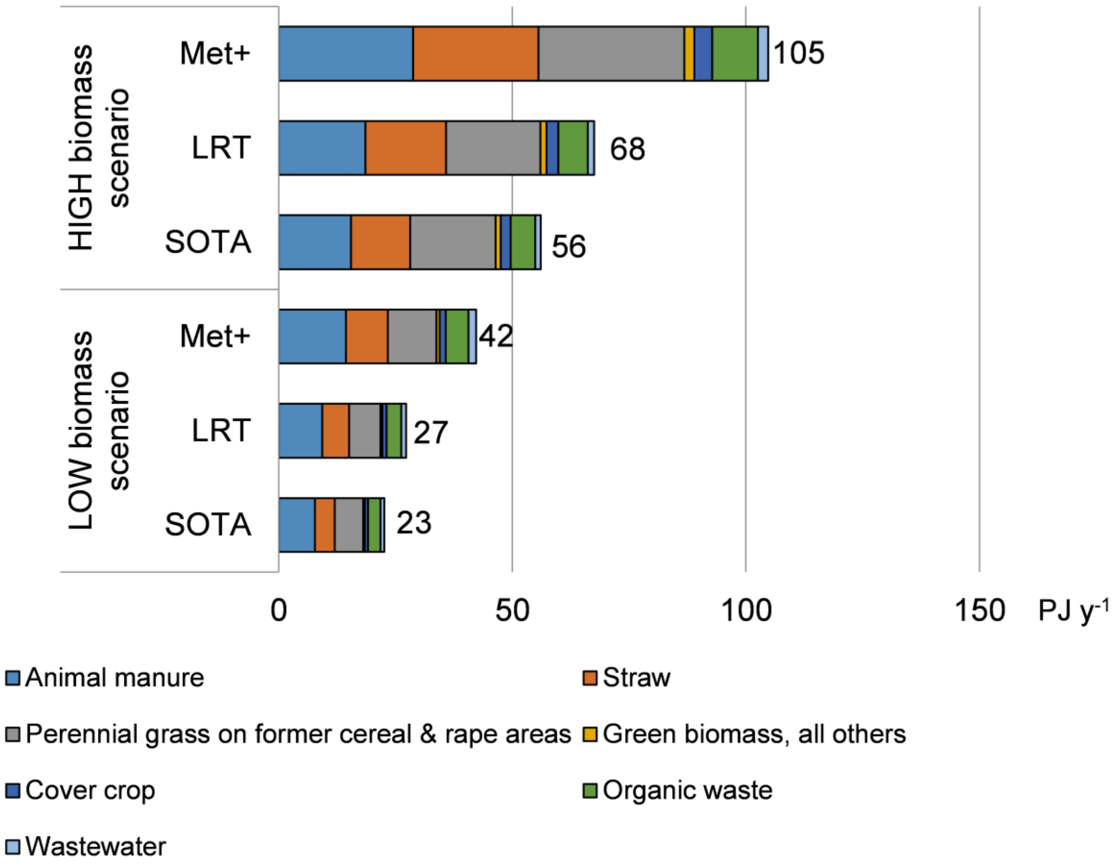
Through SI measures, the supply of agricultural biomass suitable for anaerobic digestion can be increased more than 4-fold (DM-base). Most significant: harnessing more manure + high-yielding perennial grasses where cereals on nitrate-vulnerable lands

Low – High ranges, stream by stream

Doubling retention time; methanation

Source: Hamelin et al. submitted

Case 2: key results



- For all 6 scenarios, more than 80% of potential is ensured by three major resources: animal manure, straw and perennial grass (grown on converted cereal and rapeseed areas).
- Moving from SOTA to a LRT biogas production (doubling the retention time) brings an increased methane production of 20% (energy-wise), while this increase is 87% if methanation is added to the LRT biogas production (Met+ scenario)
- Much higher amount of biogas can be produced (15 PJ today), if large deployment is made a strategic choice

5

Perspectives

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In a low fossil C future, Carbon is scarce

Comparison of food and energy

Harvested (and used) biomass "today" (year 2000)	≈ 230 EJ/year
World average food intake: 2798 kcal/pers/day (26 EJ/y)	*≈ 150 EJ/year*
Fossil energy consumption 2016	≈ 550 EJ/year
Fossil energy consumption 2050	≈ 600 - 1000 EJ/year
Biomass for full fossil substitution today	≈ 780 EJ/year

→ we need more than **3 times as much** biomass as what is harvested "today" (useful harvest) for full fossil substitution "today"

Can agricultural yield increases reduce the gap?

Yield increase in agriculture	≈ 1.2% per year
Global demand increase for cereals/veg. oil/ sugar	≈ 1.4/4.4/1.8% per year

Conclusion: Demand is rising faster than yield, so expansion unavoidable!

Is CH_4 mitigation of lower « urgency »?

- **Towards WB 2°C:**

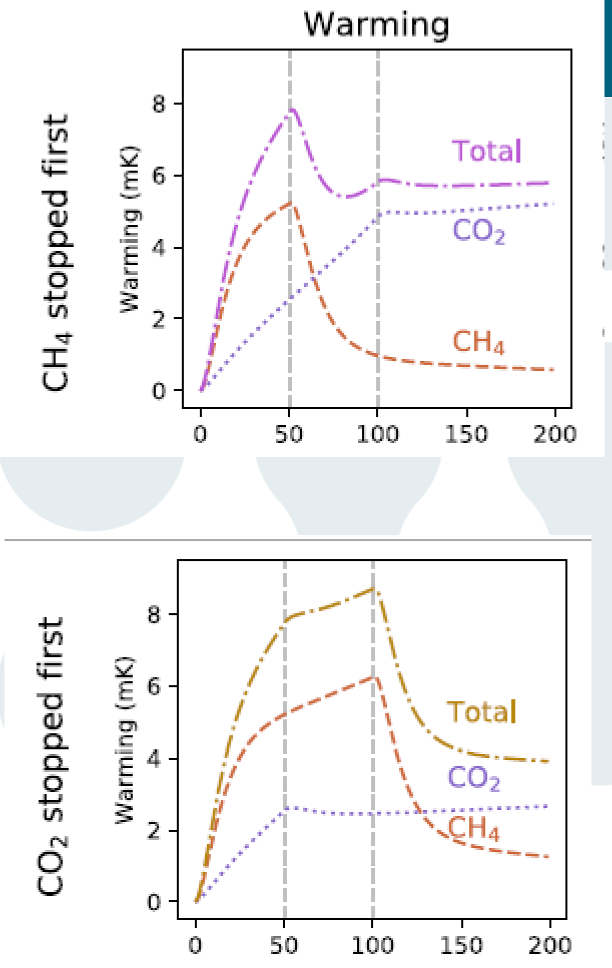
CH_4 is a short-lived GHG (12.4y); Lynch et al. (2020) demonstrate that delaying action on CH_4 does not have as significant an impact on long-term temperature as delaying action on CO_2 (concept of « warming equivalent »; GWP*)

Environmental Research Letters

LETTER • OPEN ACCESS

Demonstrating GWP*: a means of reporting warming-equivalent emissions that captures the contrasting impacts of short- and long-lived climate pollutants

To cite this article: John Lynch *et al* 2020 *Environ. Res. Lett.* **15** 044023

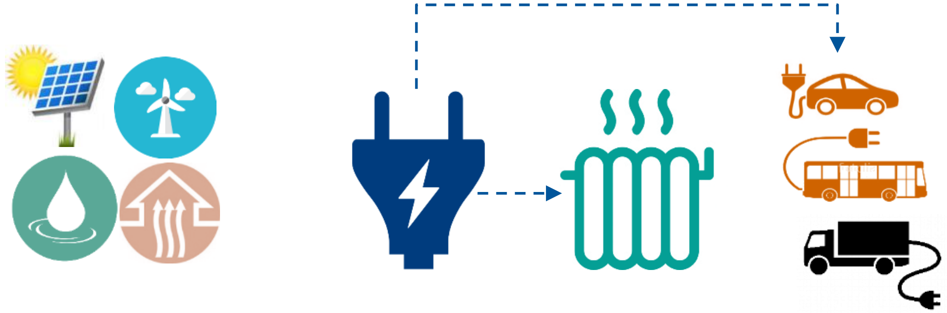


Source: Lynch et al. (2020), ERL, V15, No4
https://iopscience.iop.org/article/10.1088/1748-9326/ab6d7e

Decarbonization in 2050 ?

- Misleading terminology; Carbon is after all the basis of life on Earth

- Not about C, but about fossil C



Not all services can be immediately electrified!

- Where can we then get C come from?

6

Cambioscop

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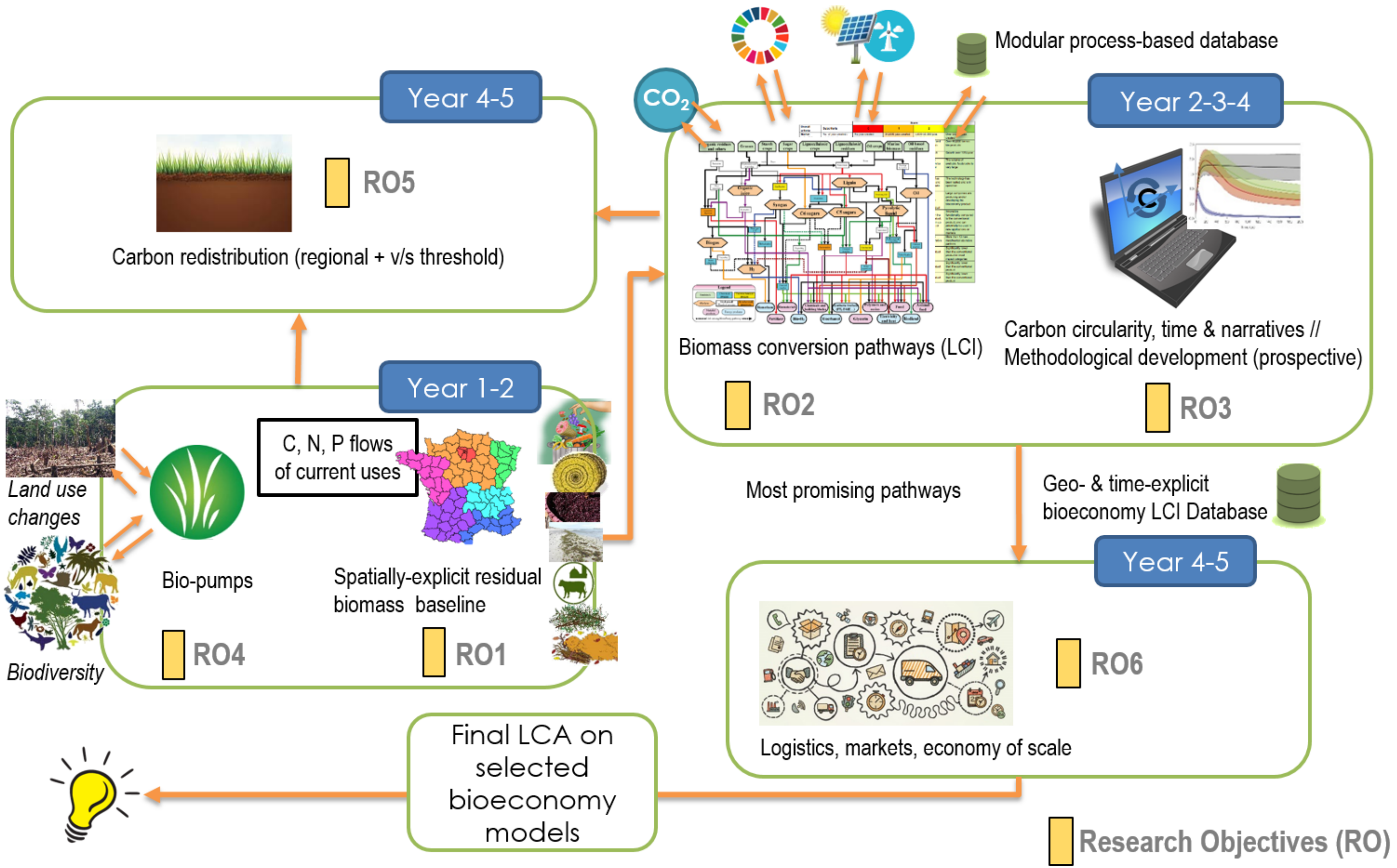
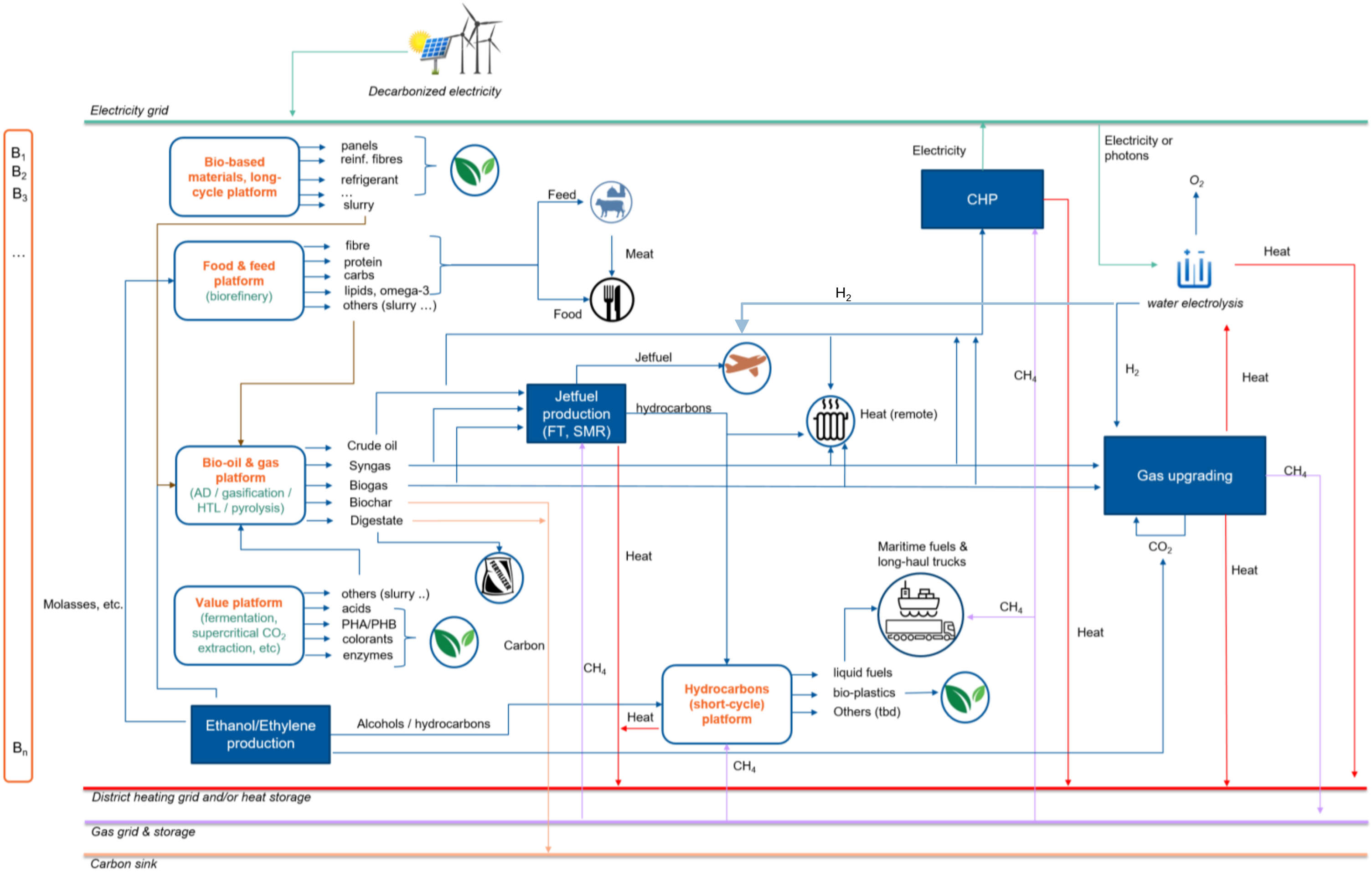
Six Research objectives



Without considering biomass in isolation

Of course, not only about C (nor CO_2)



Thanks for your attention

CAMBIOSCOP

Carbon management towards low fossil carbon use

https://cambioscop.cnrs.fr/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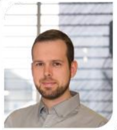
Pimchanok Su-Ungkavartin, PhD Student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Additional material

IPCC's SRCCL (chapter 6)

- **A missed opportunity for biogas/digestate and soil improvement: Biogas addressed within "improved livestock management" (manure mgmt. for local biogas production to replace traditional biomass use) only**

Table 6.54 Summary of direction and size of impact of land management options in agriculture on mitigation, adaptation, desertification, land degradation and food security

Integrated response option	Mitigation	Adaptation	Desertification	Land degradation	Food security	Context and evidence base for magnitude of effect
Increased food productivity						These estimates assume that increased food production is implemented sustainably (e.g. through sustainable intensification: Garnett et al. 2013b; Pretty et al. 2018) rather than through increasing external inputs, which can have a range of negative impacts. Mitigation: ***Large benefits*** (Table 6.13). Adaptation: ***Large benefits*** (Chapter 2; Table 6.21; Campbell et al. 2014). Desertification: ***Large benefits*** (Chapter 3; Table 6.29; Dai 2010). Land degradation: ***Large benefits*** (Chapter 4; Table 6.37; Clay et al., 1995). Food security: ***Large benefits*** (Chapter 5; Table 6.45; Godfray et al. 2010b; Tilman et al. 2011; Godfray and Garnett 2014).
Improved cropland management						Mitigation: ***Moderate benefits*** by reducing greenhouse gas emissions and creating soil carbon sinks (Chapter 2; Table 6.13; Smith et al. 2008, 2014a). Adaptation: ***Large benefits*** by improving the resilience of food crop production systems to future climate change (Chapter 2; Table 6.21; Porter et al. 2014). Desertification: ***Large benefits*** by improving sustainable use of land in dry areas (Chapter 3; Table 6.29; Bryan et al. 2009b; Chen et al. 2010). Land degradation: ***Large benefits*** by forming a major component of sustainable land management (Chapter 4; Table 6.37; Labrière et al. 2015). Food security: ***Large benefits*** by improving agricultural productivity for food production (Chapter 5; Table 6.45; Porter et al. 2014).
Improved grazing land management						Mitigation: ***Moderate benefits*** by increasing soil carbon sinks and reducing greenhouse gas emissions (Chapter 2; Table 6.13; Herrero et al. 2016). Adaptation: ***Moderate benefits*** by improving the resilience of grazing lands to future climate change (Chapter 2; Table 6.21; Porter et al. 2014). Desertification: ***Moderate benefits*** by tackling overgrazing in dry areas to reduce desertification (Chapter 3; Table 6.29; Archer et al. 2011). Land degradation: ***Large benefits*** by optimising stocking density to reduce land degradation (Chapter 4; Table 6.37; Table 6.45; Tighe et al. 2012). Food security: ***Large benefits*** by improving livestock sector productivity to increase food production (Chapter 5; Table 6.45; Herrero et al. 2016).
Improved livestock management						Mitigation: ***Moderate benefits*** by reducing greenhouse gas emissions, particularly from enteric methane and manure management (Chapter 2; Table 6.13; Smith et al. 2008, 2014a). Adaptation: ***Moderate benefits*** by improving resilience of livestock production systems to climate change (Chapter 2; Table 6.21; Porter et al. 2014). Desertification: ***Moderate benefits*** by tackling overgrazing in dry areas (Chapter 3; Table 6.29; Archer et al. 2011). Land degradation: ***Large benefits*** by reducing overstocking which can reduce land degradation (Chapter 4; Table 6.37; Table 6.45; Tighe et al. 2012). Food security: ***Large benefits*** by improving livestock sector productivity to increase food production (Chapter 5; Table 6.45; Herrero et al. 2016).
Agroforestry						Mitigation: ***Moderate benefits*** by increasing carbon sinks in vegetation and soils (Chapter 2; Table 6.13; Delgado 2010; Mbow et al. 2014a; Griscom et al. 2017a). Adaptation: ***Large benefits*** by improving the resilience of agricultural lands to climate change (Chapter 2; Table 6.21; Mbow et al. 2014a). Desertification: ***Large benefits*** through e.g. provides perennial vegetation in dry areas (Chapter 3; Table 6.29; Nair et al. 2010; Lal 2001a). Land degradation: ***Large benefits*** by stabilising soils through perennial

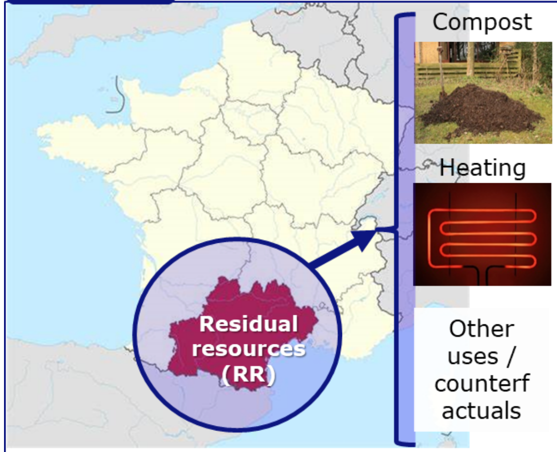
Table 6.53 Key for criteria used to define magnitude of impact of each integrated response option

	Mitigation	Adaptation	Desertification	Land Degradation	Food
Large positive	More than 3 $GtCO_2$-eq yr^{-1}	Positively impacts more than around 25 million people	Positively impacts more than around 3 million km^2	Positively impacts more than around 3 million km^2	Positively impacts more than around 100 million people
Moderate positive	0.3 to 3 $GtCO_2$-eq	1 million to 25 million	0.5 to 3 million km^2	0.5 to 3 million km^2	1 million to 100 million
Small positive	>0	Under 1 million	>0	>0	Under 1 million
Negligible	0	No effect	No effect	No effect	No effect
Small negative	<0	Under 1 million	<0	<0	Under 1 million
Moderate negative	-0.3 to -3 $GtCO_2$-eq	1 million to 25 million	0.5 to 3 million km^2	0.5 to 3 million km^2	1 million to 100 million
Large negative	More than -3 $GtCO_2$-eq yr^{-1}	Negatively impacts more than around 25 million people	Negatively impacts more than around 3 million km^2	Negatively impacts more than around 3 million km^2	Negatively impacts more than around 100 million people

A local bioeconomy study on non-fossil CH_4 to supply the CH_4 demand in the Occitanie region: AD vs Gasification

Concetta Lodato

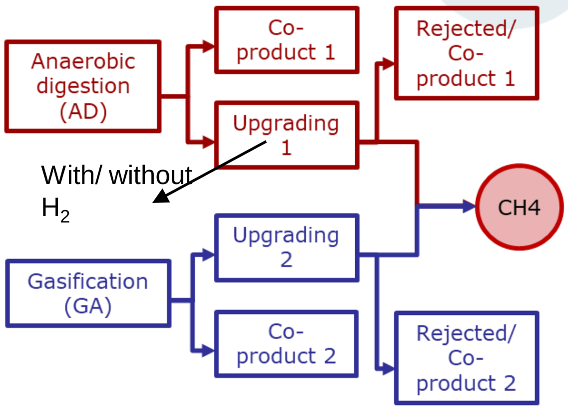
STAGE 1



Identification of:

- **Residual resources (RR) available** in Occitanie region based on technical reports
- **Current uses** of RR
- Effects of diverting the RR from their current use/function to bio-based gas production (**counterfactual**)

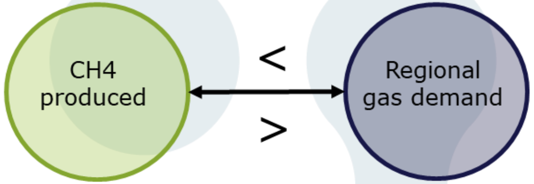
STAGE 2



Analysis of the bio-based gas production (focus on CH4):

- **Technology pathway** (anaerobic digestion, AD, and/or gasification, GA)
- **Technology upgrading** for CH4 maximization
- **Management of co-products and rejected**

STAGE 3



Determination of the **two hypotheses based on the regional gas demand** (current and future):

- The supply of bio-based gas > regional gas demand
- The supply of bio-based gas < regional gas demand

A LCI database with 41 biomass streams structured into 10 biomass categories

Where we grow food today and what do we grow?

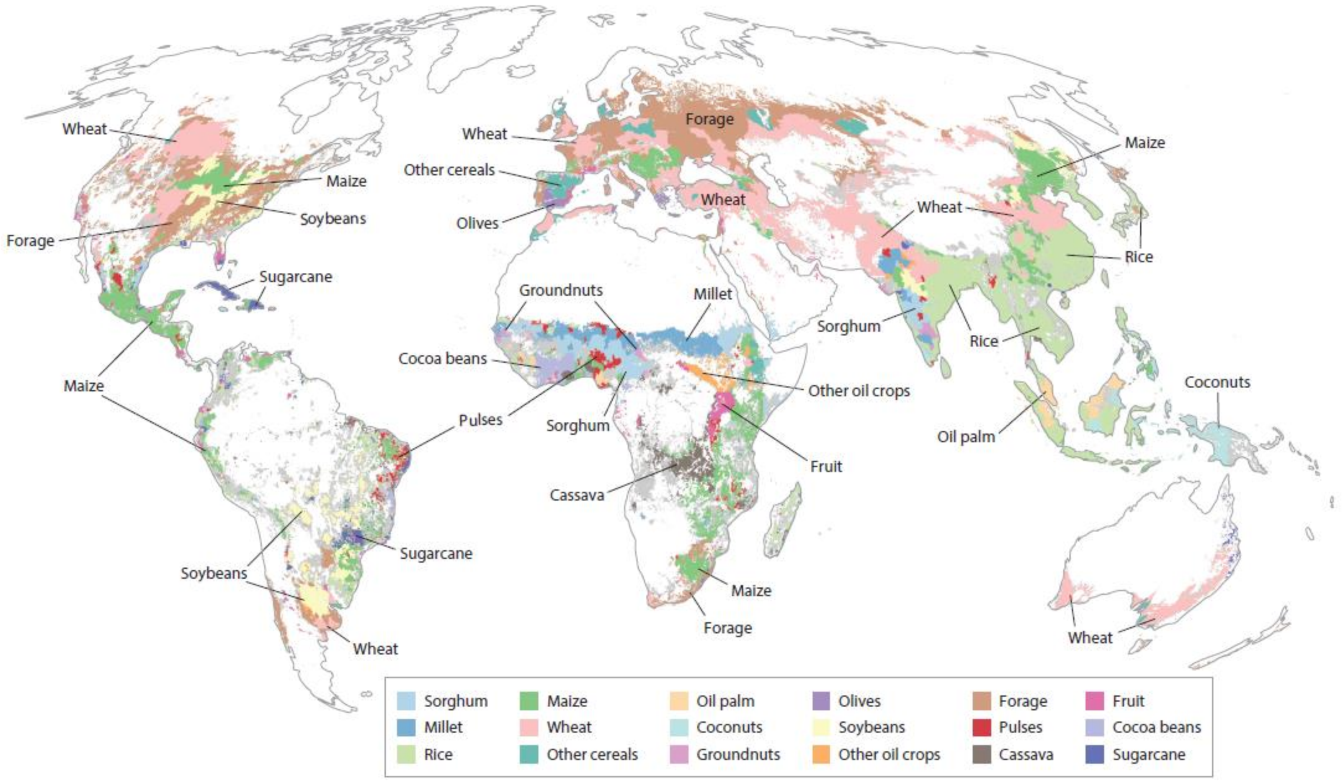


Figure 6

Crop belts of the world (circa year 2000). We show the dominant crop or crop group, derived from a geospatial database of 175 individual crops (**http://www.earthstat.org**). For clarity, not all regionally important crops are indicated. For example, bananas and plantains in Africa are labeled as fruit.

Ramankutty et al. (2018). doi.org/10.1146/annurev-arplant-042817-040256