

Innovative feedstock for biomethane production

Prepared by:
Myrsini Christou

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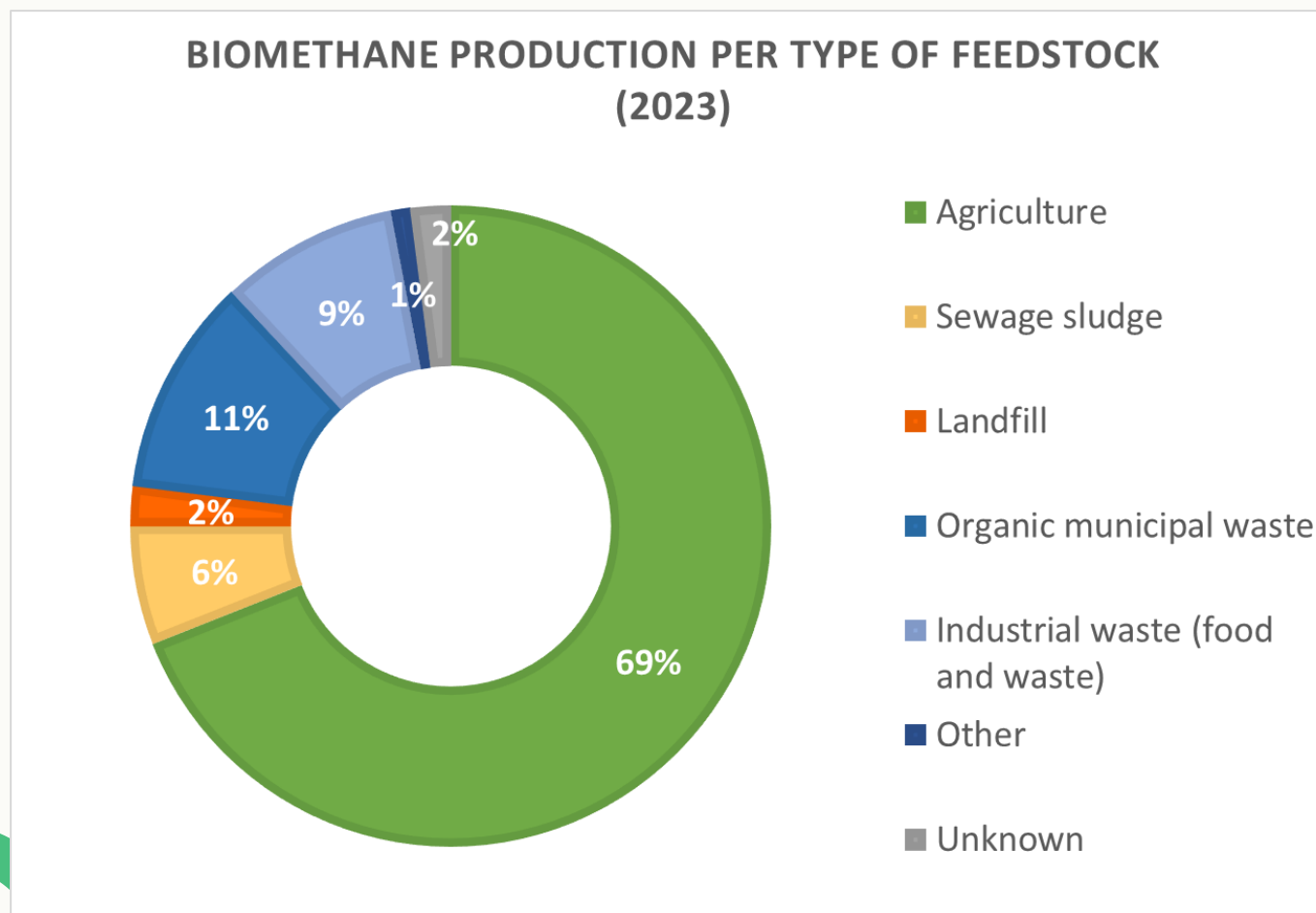


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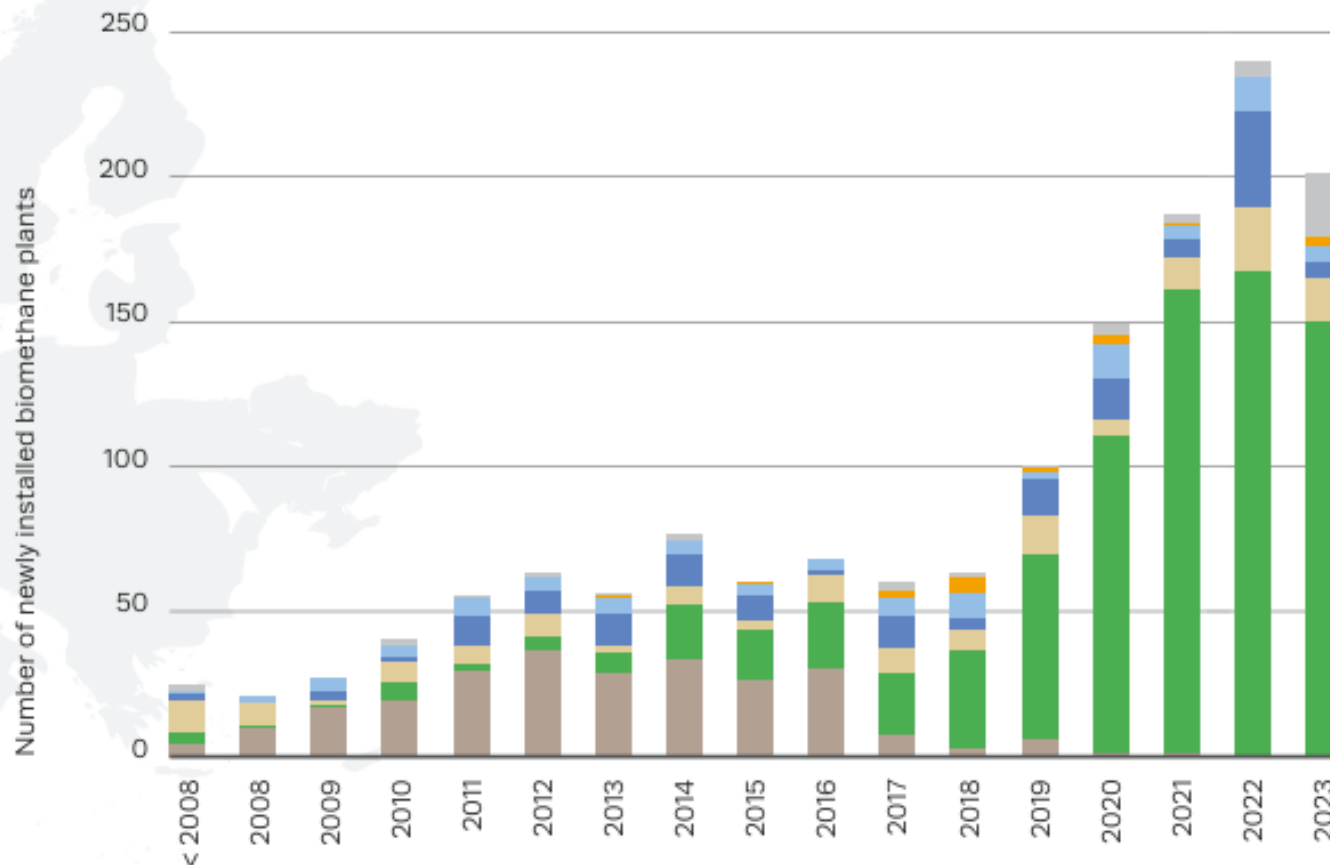
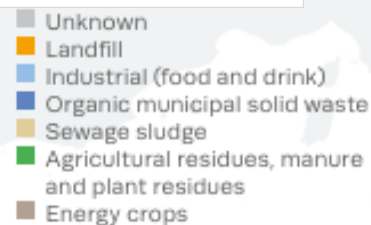
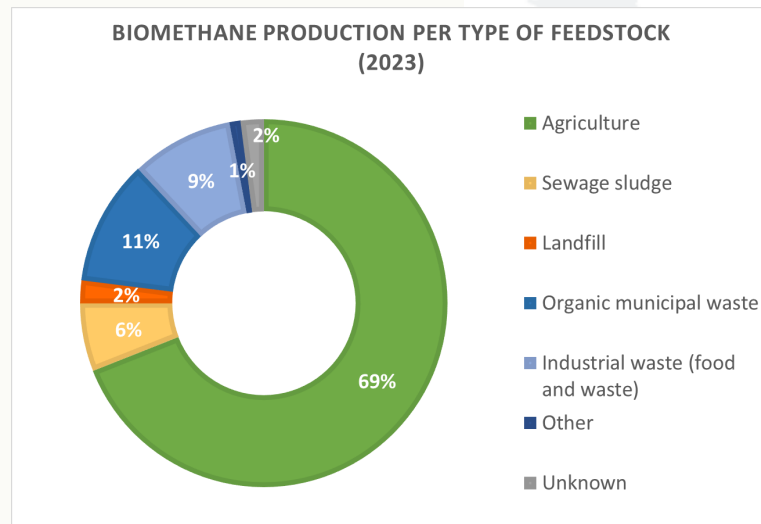
- Feedstock for biomethane production in Europe
- R&I in growing crops
- Conclusions



Feedstock for biomethane production in Europe

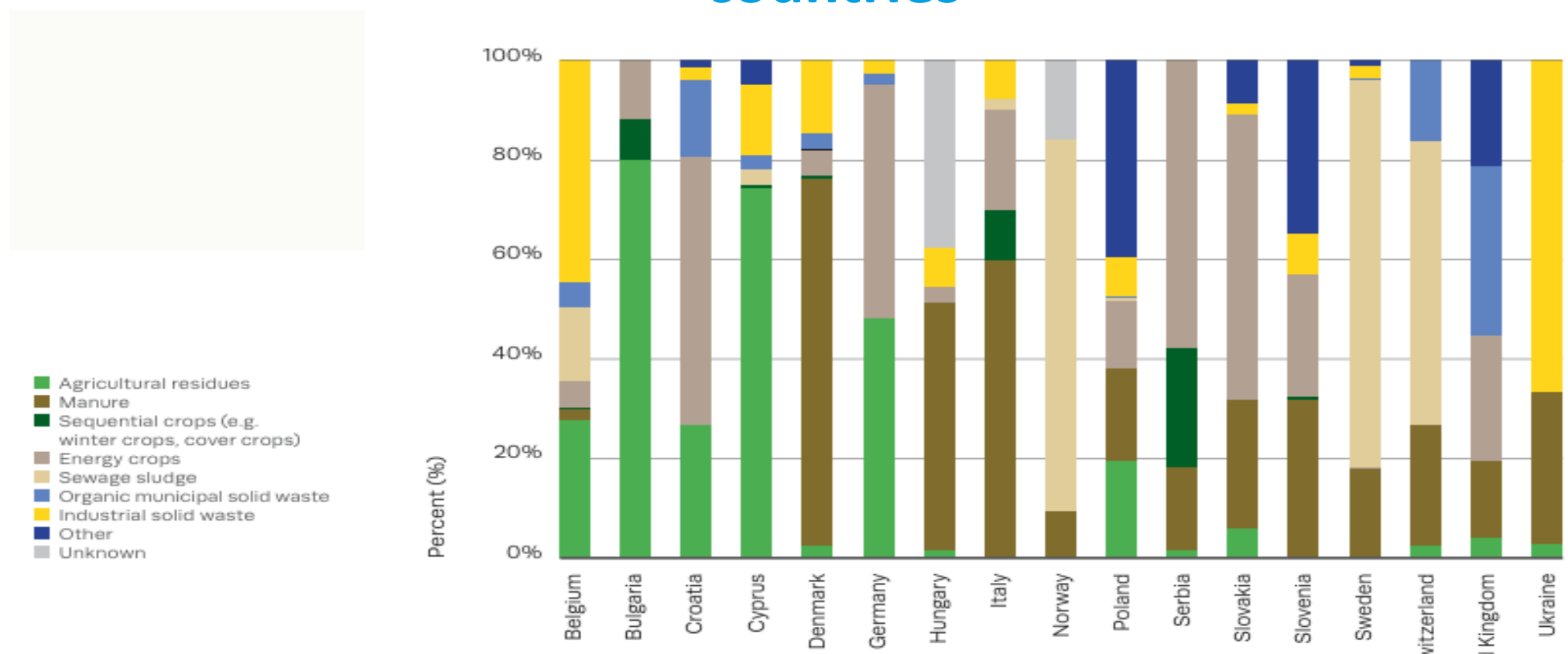


Feedstock for biomethane production in Europe



- A clear trend towards agricultural residues and -to a lesser extend- organic municipal solid waste, sewage sludge and industrial waste.
- Monocrops (maize mostly in Germany) are gradually withdrawn from 2017 onwards

Feedstock types for biogas production in selected European countries



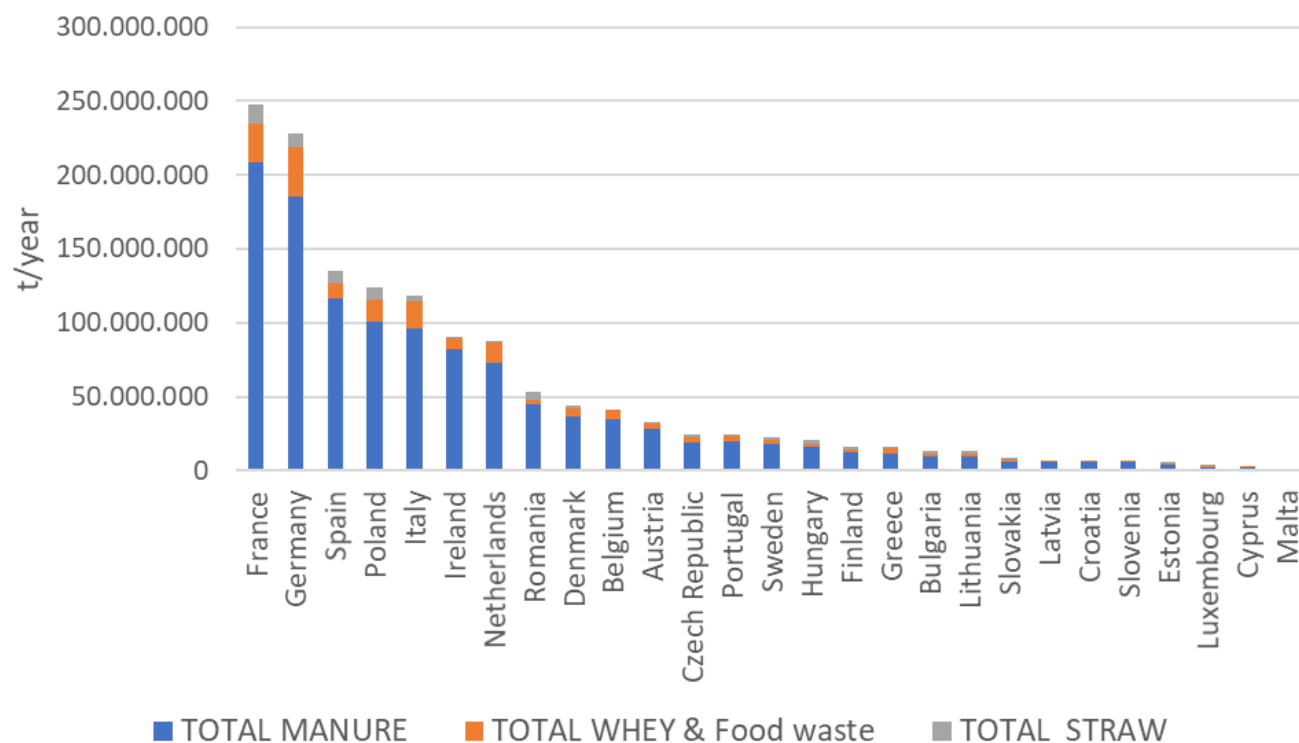
- High country variation
- In several countries, there is one dominant feedstock type

Feedstock types for biomethane production in EU

2022	POTENTIAL BIOMETHANE FOR GAS NETWORK bcm/year	BIOMETHANE ENERGY CONTENT TWh/y
European Union - 27 countries	39.71	382.89
Bovine	7.87	75.88
Dairy cows	5.77	55.59
Sheeps	1.3	12.58
Goats	0.25	2.4
Swine/pigs	1.97	18.99
TOTAL MANURE	17.16	165.44
Wheat straw	10.07	97.07
Oat straw	1.15	11.12
Barley	4.5	43.4
Rye	0.85	8.19
TOTAL STRAW	16.57	159.78
Whey/milk	1.58	15.22
Bio-food waste	4.4	42.45
TOTAL FOOD WASTE	5.98	57.67

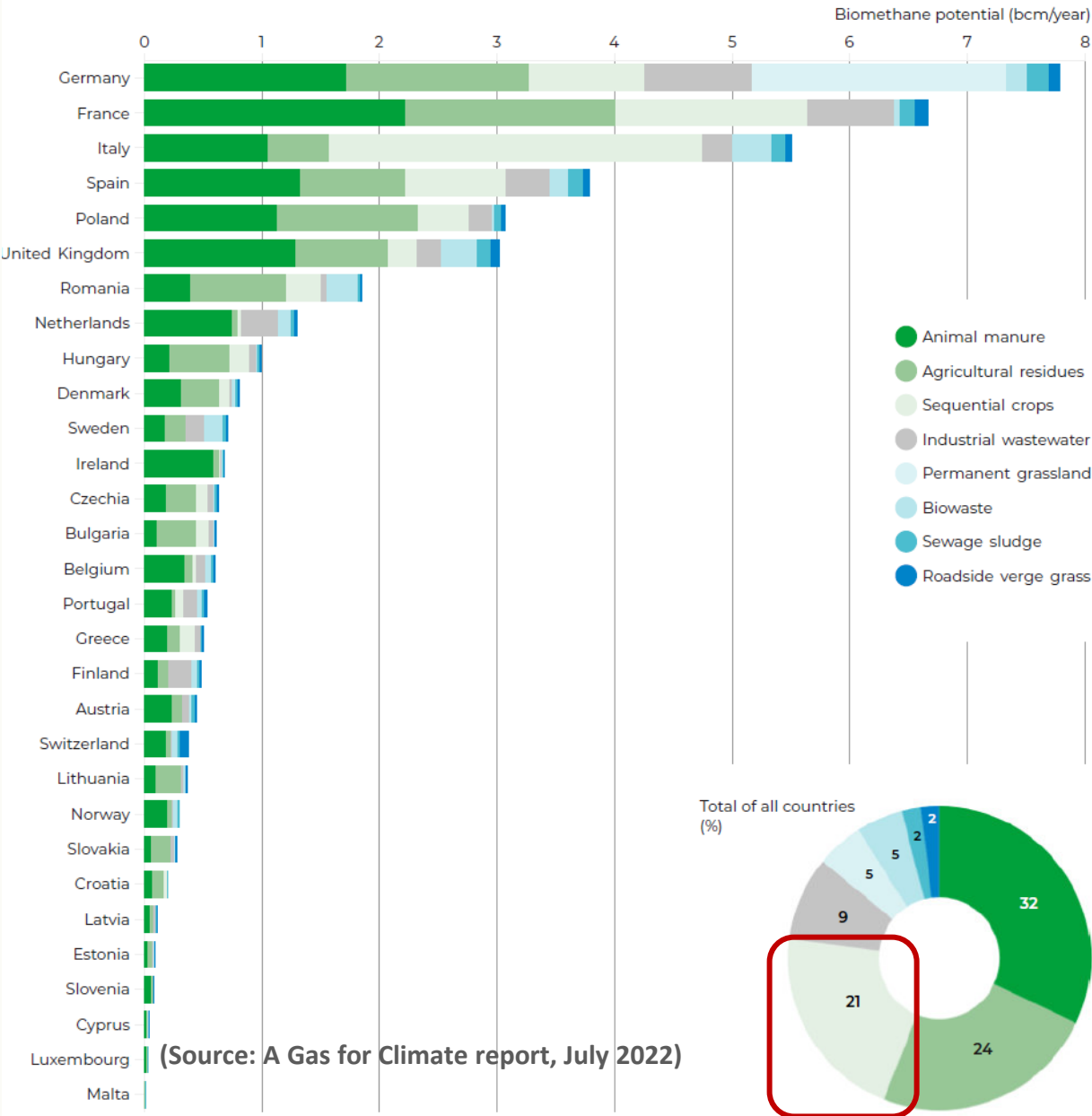
Feedstock types for biomethane production in EU

BIOMASS POTENTIAL PER FEEDSTOCK TYPE

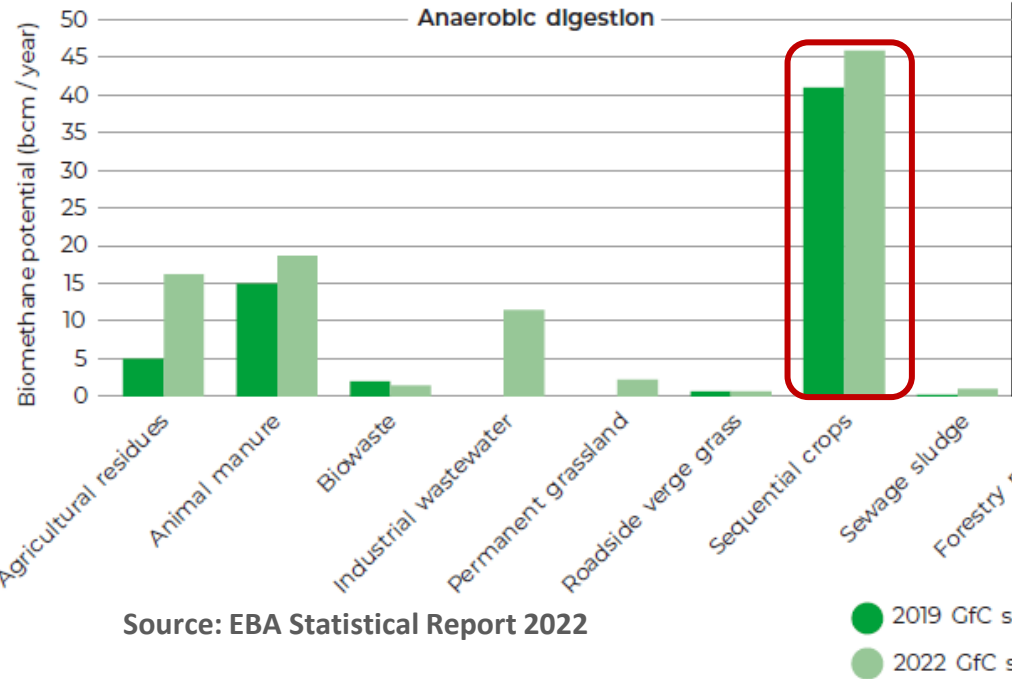


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Anaerobic digestion potential in 2030 per feedstock and country

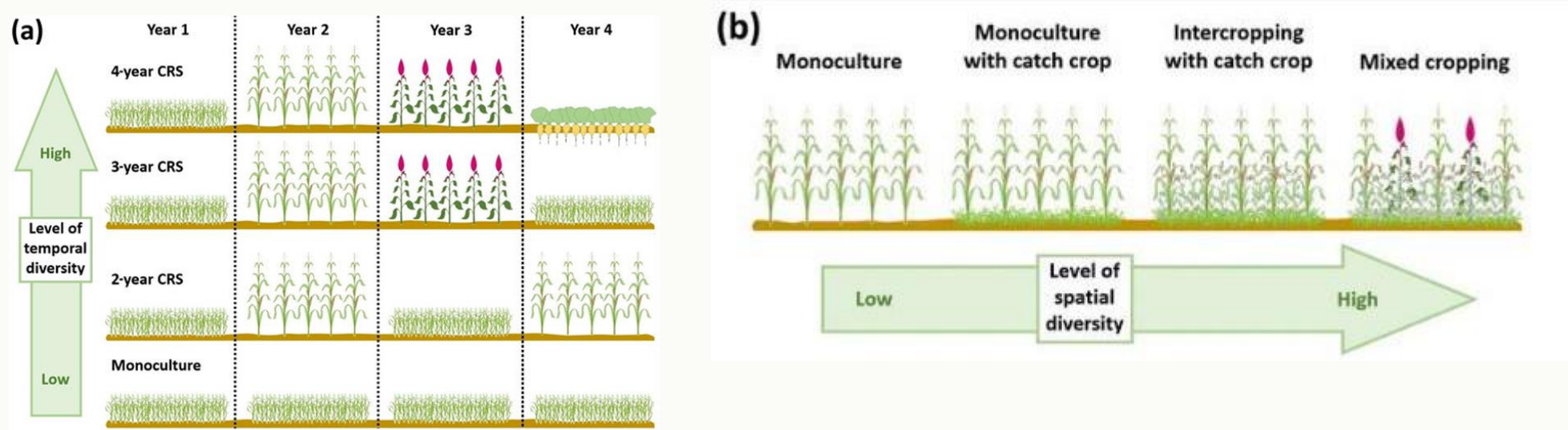


Biomethane potential in 2050 per technology and feedstock



R&I in growing crops

- ➔ Sequential cropping (a) (double, triple etc; i.e BIOGASDONERIGHT concept, projects BECOOL, BIKE, Icarus, intercropping (b) (row, patch, strip, etc)

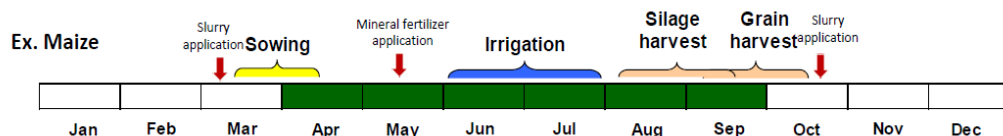


- ➔ Minimal/low tillage
- ➔ Growing perennial crops
- ➔ Growing crops (annual, perennial) on marginal lands (i.e projects MAGIC, MIDAS) for land phytoremediation (i.e projects GOLD, PHY2CLIMATE, CERESIS, FORTE, GRACE)

The BiogasDoneRight concept

Conventional Agriculture

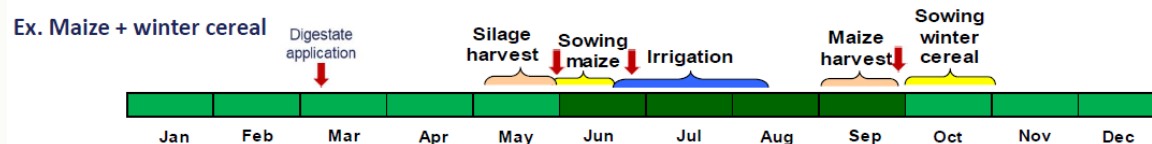
- Dairy farm, crop production to feed/food
- Arable crops, one-two crops per year (mainly maize)
- Fertilisation based on livestock manure + mineral



- ✓ Soil covered **6 months** per year
- ✓ Total above ground biomass around **23 DM t/ha/year (grain 13)**
- ✓ Irrigation: **necessary**
- ✓ Herbicides: **necessary**
- ✓ Soil tillage: **heavy (ploughing)**
- ✓ Organic matter level in soil: **steady or slightly down**

BiogasDoneRight® concept

- Dairy farm, crop production to feed/food/energy
- Arable/no till crops, two crops per year (several)
- Fertilisation based on digestate



- ✓ Soil covered **12 months** per year
- ✓ Total above ground biomass around **30 DM t/ha/year (maize 18 + triticale 12)**
- ✓ Irrigation: **necessary**
- ✓ Herbicides: **reduced** (especially if agricultural work happens quickly)
- ✓ Soil tillage: **reduced**
- ✓ Organic matter level in soil: **increasing**

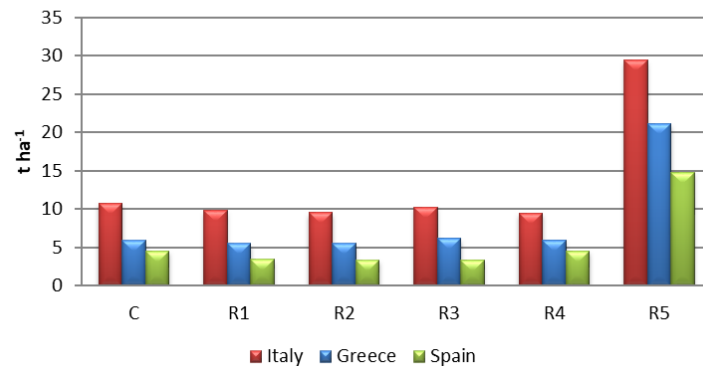
The BECOOL project

The integrated cropping systems including food and lignocellulosic crops are:

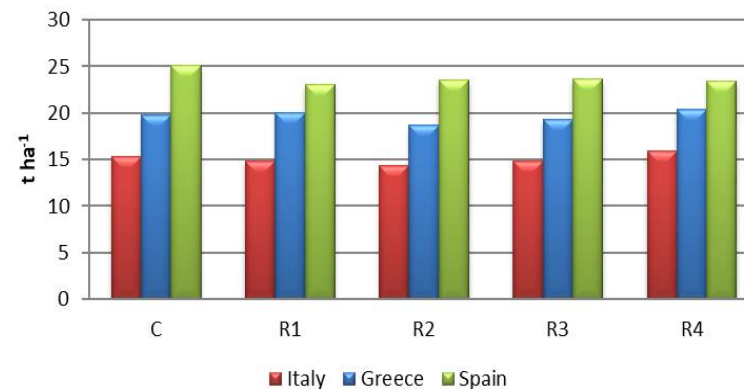
green: food crop
orange: energy legume
blue: energy crop

	2017												2018												2019												2020												2021											
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S																		
C	Maize												Wheat												Maize																																			
R1	Maize												Sunn Hemp						Wheat						Sunn Hemp												Maize												Sunn Hemp											
R2	Maize												Fiber sorghum						Wheat						Sunn Hemp												Maize												Fiber sorghum											
R3	Maize												Kenaf						Wheat						Sunn Hemp												Maize												Kenaf											
R4	Maize												Hemp						Wheat						Sunn Hemp												Maize												Hemp											
R5				Sunn Hemp			Wheat						Sunn Hen						Wheat						Sunn Hen						Wheat						Sunn Hen						Wheat						Sunn Hen											

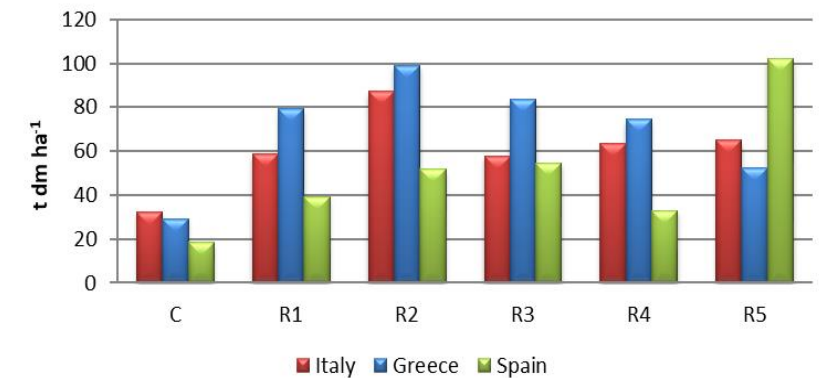
Wheat grain yields



Maize grain yields



Biomass yields

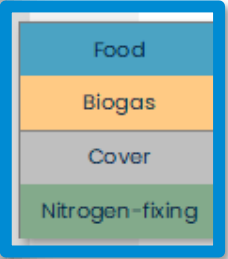
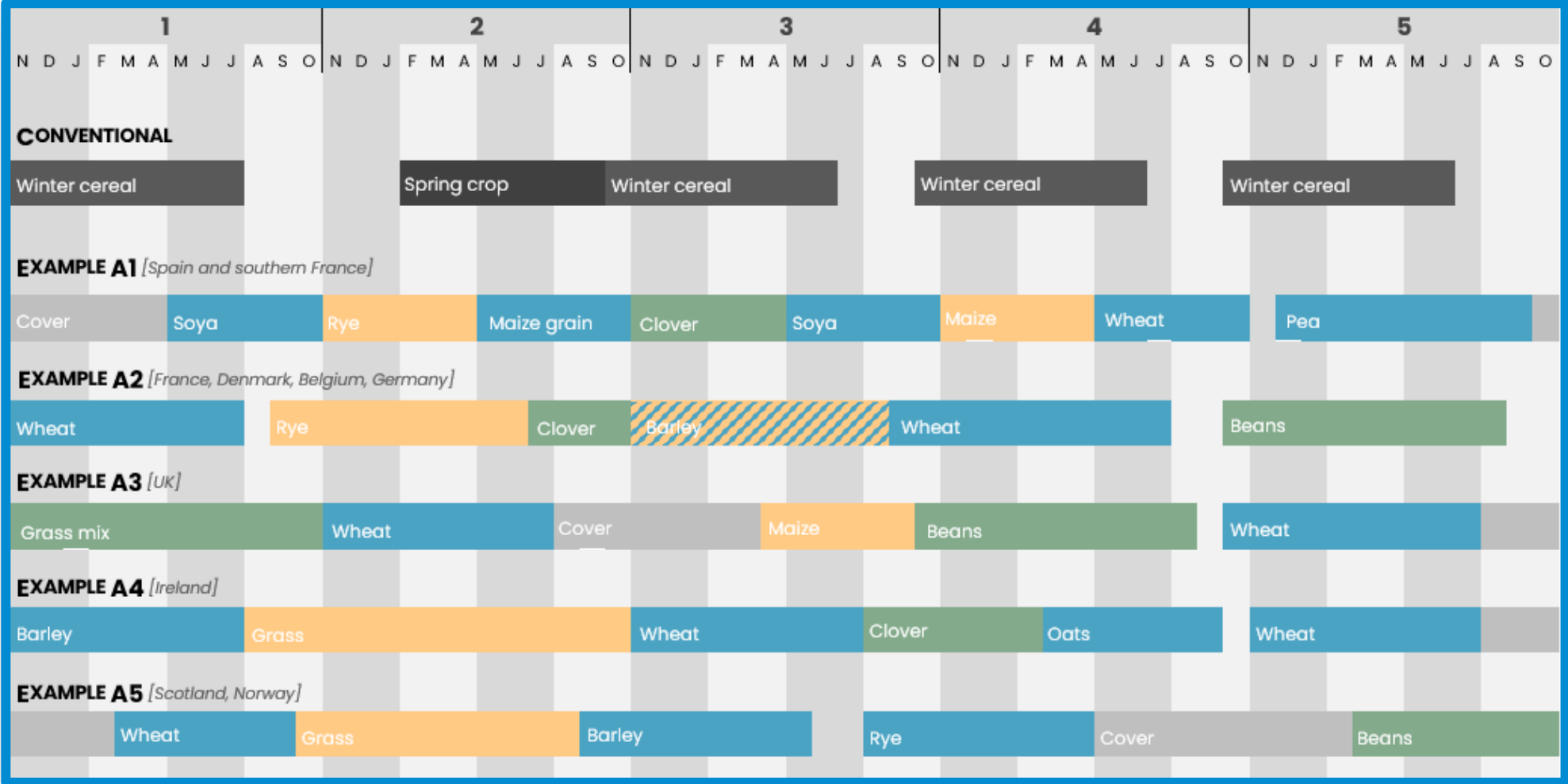


- Wheat and maize grain yields were not affected by the rotations in all environments
- Rotations with fiber sorghum, kenaf and hemp resulted in highest biomass yields in all environments

Developed potential crop rotations for each European environmental zone

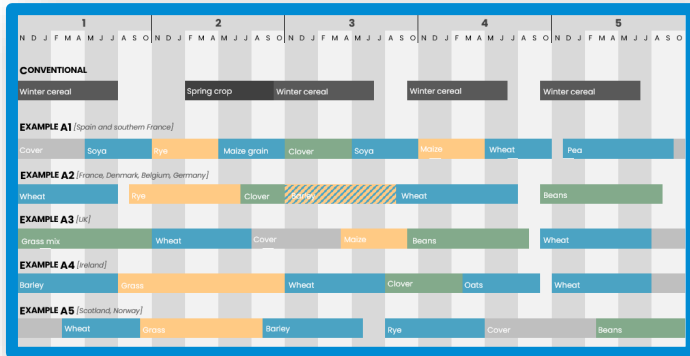


Atlantic



Developed potential crop rotations for each European environmental zone

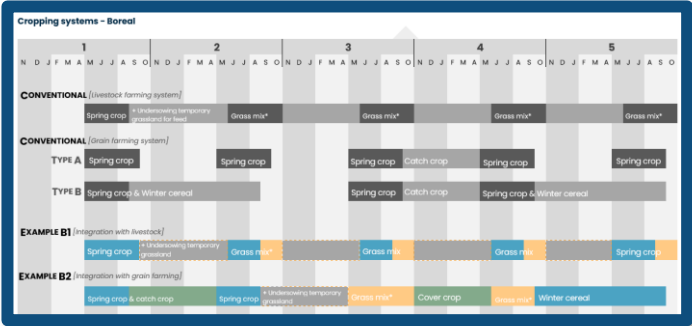
Atlantic



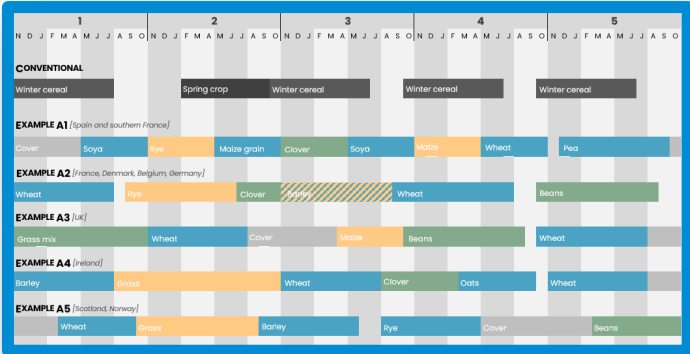
Country	Total arable land (ha)	Proportion of land within the Atlantic biogeographical region (%)	Crop rotation assumed	Average annual biomass grown for AD (tonnes)	Biomethane max potential per year (bcm)
Belgium	870,420	50%	2	1,175,067	0.3
Denmark	2,357,950	30%	2	1,909,940	0.6
France	18,044,450	50%	1 ^(10%) & 2 ^(90%)	26,976,453	8.7
Germany	11,657,900	20%	2	6,295,266	1.9
Ireland	434,940	100%	4	1,043,856	0.2
Netherlands	1,003,450	100%	2	2,709,315	0.8
Spain	11,732,660	10%	1	6,570,290	2.1
<i>Non-EU</i>					
Norway	804,310	15%	5	193,034	0.0
UK	5,857,460	100%	3 ^(50%) & 5 ^(50%)	12,886,412	3.4

Developed potential crop rotations for each European environmental zone

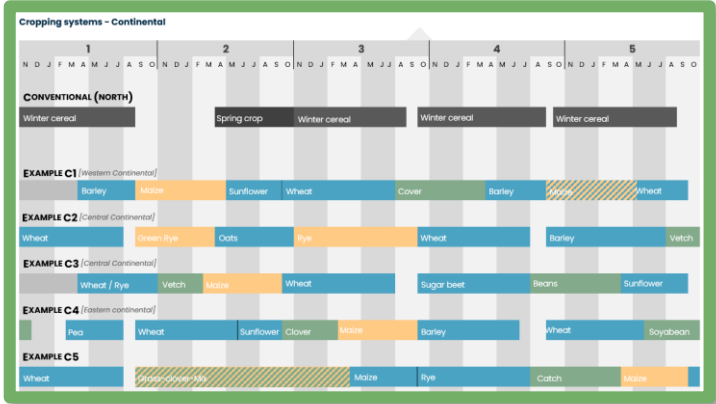
Boreal



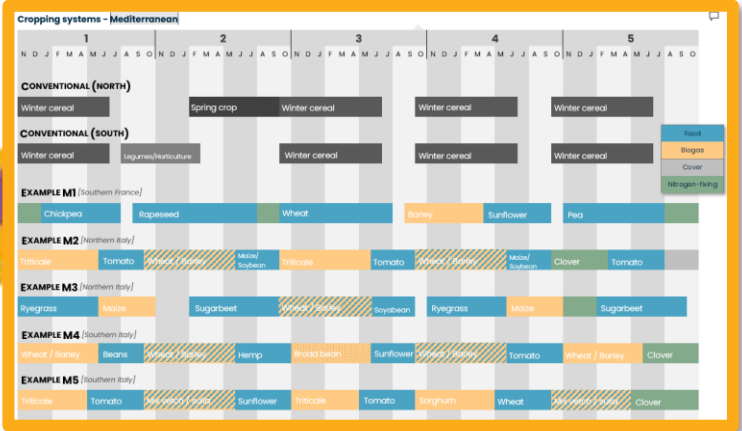
Atlantic



Continental



Mediterranean



Comparison with other estimates



Article

The Role of Sequential Cropping and Biogasdoneright™ in Enhancing the Sustainability of Agricultural Systems in Europe

Francesca Magnolo^{1,*}, Hansen Dekker², Mickel Devote³, Guido Beetz⁴, Lovella Rossi^{5,6}, Erik Meers⁴ and Stjepan Špešman¹

¹ Department of Agricultural Economics, Faculty of Bioscience Engineering, Ghent University, Coupure links 671, 9000 Ghent, Belgium; agronomy@ugent.be (F.M.); hansen.dekker@ugent.be (H.D.); mickel.devote@ugent.be (M.D.); guido.beetz@ugent.be (G.B.); lovella.rossi@ugent.be (L.R.); erik.meers@ugent.be (E.M.); stjepan.spesman@ugent.be (S.Š.)

² European Biogas Association, Rue d'Enghien 45, 1050 Brussels, Belgium; hansen.dekker@ebpa.eu (H.D.)

³ CIB - Consorzio Interuniversitario per la Bioeconomia, 20090 Lodi, Italy; mickel.devote@cib-eu.org (M.D.)

⁴ Ghent University, Coupure links 671, 9000 Ghent, Belgium; erik.meers@ugent.be (E.M.); stjepan.spesman@ugent.be (S.Š.)

⁵ Department of Agricultural Economics, Faculty of Bioscience Engineering, Ghent University, Coupure links 671, 9000 Ghent, Belgium; lovella.rossi@ugent.be (L.R.)

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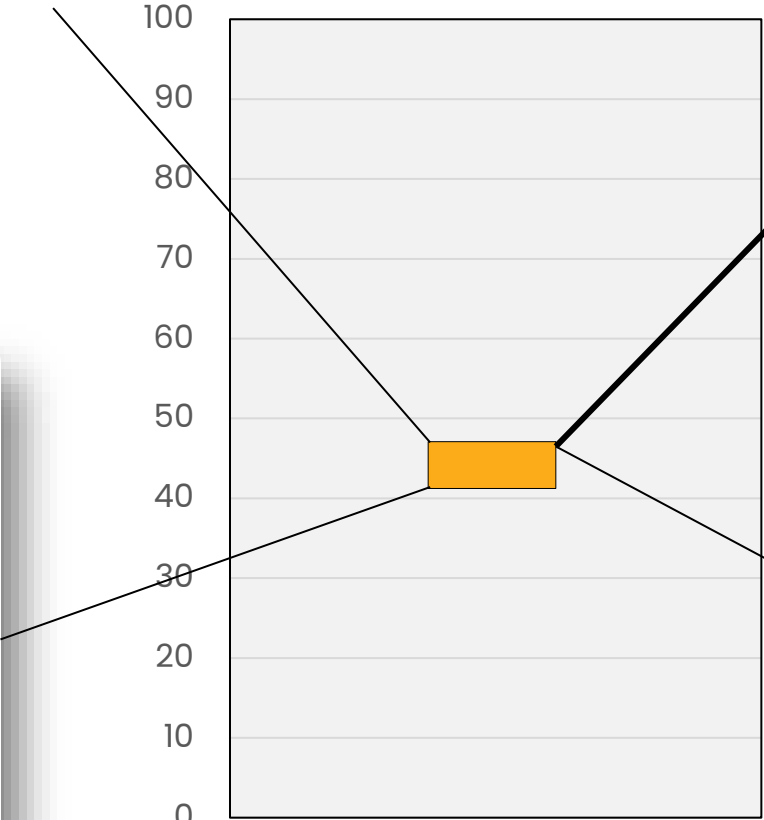
Abstract: Sequential cropping in the Biogasdoneright™ (BDR™) system in Italy has recently gained attention to combine food and renewable energy production in a sustainable way, as well as for carbon sequestration. However, little is known on the potential to expand the practice to other regions of Europe. In this paper, sequential crop calendars were developed for different EU climate regions, and the EU biogasdoneright potential of the associated, integrated (BDR) or sequential crops was estimated for a *Cerealia*, *Leguminosae* and a *Mineralis*, *Leguminosae* scenario, assuming different percentages of primary crop land dedicated to the practice and biogas yields. A total EU biogasdoneright potential of 46 bcm/yr and 307 bcm/yr was estimated from the BDR of sequential crops in the two scenarios, respectively, and the Continental region registered the highest potential compared to the other regions. The additional benefits of the combination of sequential cropping with other agricultural conservation practices and nitrogen use included in BDR™ systems were also discussed. In conclusion, the paper shows that with appropriate innovations in crop management, sequential cropping could be applied in different agricultural regions of Europe, contributing to climate and renewable energy targets.

Keywords: Biogasdoneright™; biogasdoneright; carbon sequestration; circular bioeconomy; sequential cropping

1. Introduction

Agriculture is at the heart of the most important global challenges mankind is currently facing and will face in the future, including food security, environmental degradation, economic development and climate change [1]. Agriculture is highly exposed to climate change, as its activities directly depend on climatic conditions [2]. At the same time, the agricultural sector itself is responsible for direct GHG emissions, such as nitrous oxide emissions from soils, fertilizer application and livestock farming, as well as indirect GHG emissions from land use changes, such as land clearing and deforestation, and agricultural practices that also help mitigate climate change by sequestering carbon. The magnitude of the net effect is uncertain, as land use changes that are directly or indirectly related to the food system can have both positive and negative impacts on the climate [3]. In order to reach the climate-neutral goal and cut European GHG emissions by 50% by 2030 [4], while still circular bioeconomy [5], agricultural practices need to increasingly take on tackling climate change while concurrently providing food.

Max
46 bcm
Magnolo et al. (2021)



Min
40 bcm
Dale et al. (2020)

Deliverable
44-46 bcm
BIP (2023)

Teaming up to achieve 35 bcm of sustainable biomethane by 2030

Biomethane Industrial Partnership

Biomethane potential from the deployment of novel cropping systems across Europe

Biomethane production potentials in the EU

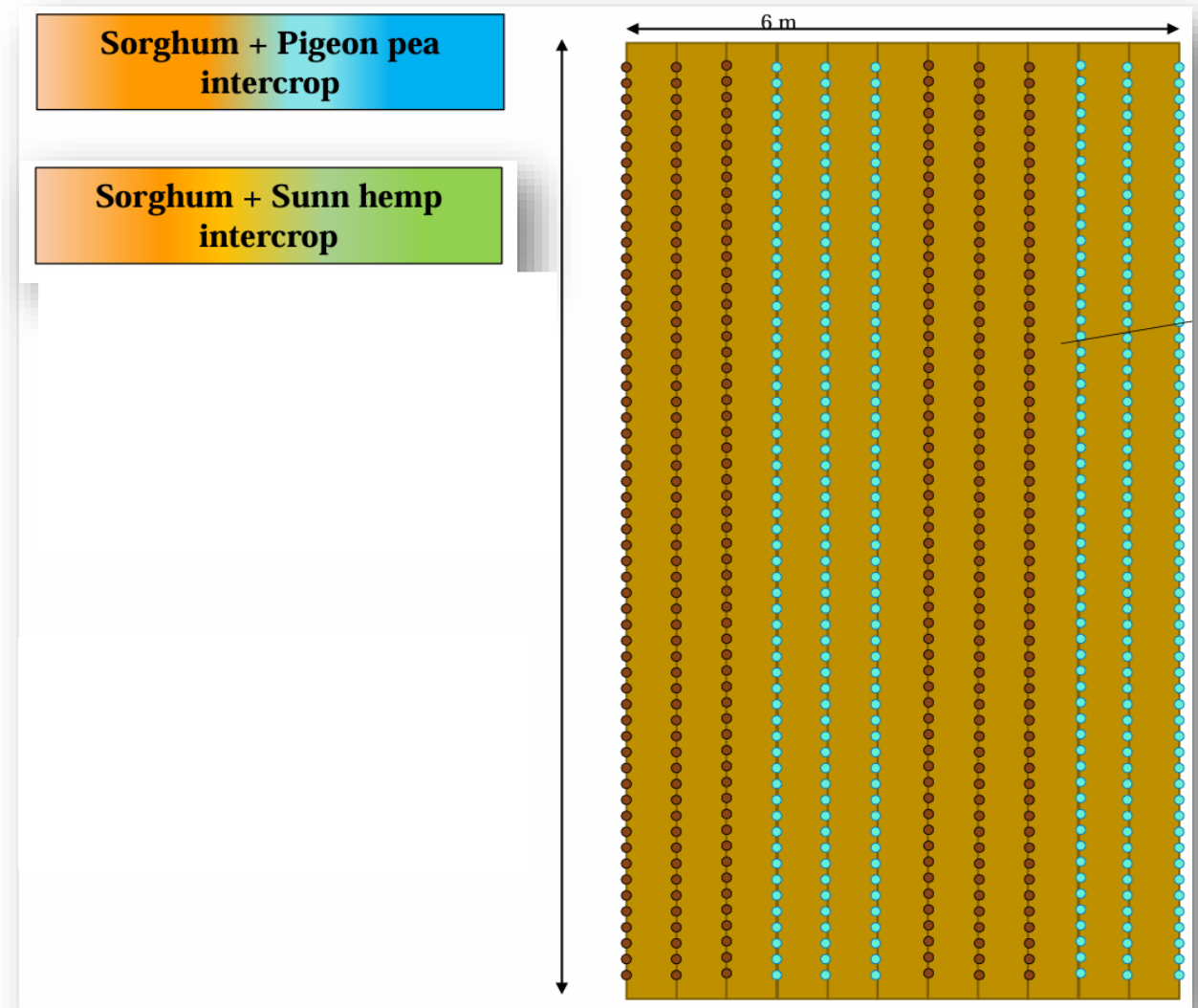
Feasibility of REPowerEU 2030 targets, production potentials in the Member States and outlook to 2050

A Gas for Climate report
July 2022

46 bcm
Gas for Climate (2022)

Mixed cropping

- to maximize biomass production (both in quantitative and qualitative terms) for conversion into SAF with:
 - ✓ intercropping systems of sorghum and legumes (sunn hemp and pigeon pea)
 - ✓ biostimulants on crop growth and production.
- Crop systems
 - ✓ Sorghum monocrop
 - ✓ Sunn hemp monocrop
 - ✓ Pigeon pea monocrop
 - ✓ Sorghum + sunn hemp intercrop
 - ✓ Sorghum + pigeon pea intercrop



Advantages	Disadvantages
Enhanced soil fertility and higher yields.	Required higher levels of farm organization and farmer skills.
Improved soil structure and maintenance of long-term productivity and organic matter	Increased need of diversified agricultural equipment and agricultural supplies.
Longer period of land cover with subsequent lower erosion.	Reduced land availability for the most profitable crop.
Reduced use of agricultural inputs such as agrochemicals and synthetic fertilizers.	Unfamiliarity of farmers with several crop rotations', cultural and management requirements.
Diversified production with greater market opportunities and lower economic and climatic risks.	The fact of having to keep scheduled crop sequences leaves no choice to farmers to select crops contingently.
Increased biodiversity and less monotony of the landscape.	
Time-diluted farming activities.	

Source: Zegada-Lizarazu and Monti . Energy crops in rotation. A review. Biomass and bioenergy 35 (2011), 12-25.

Other feedstock choices: Digestate

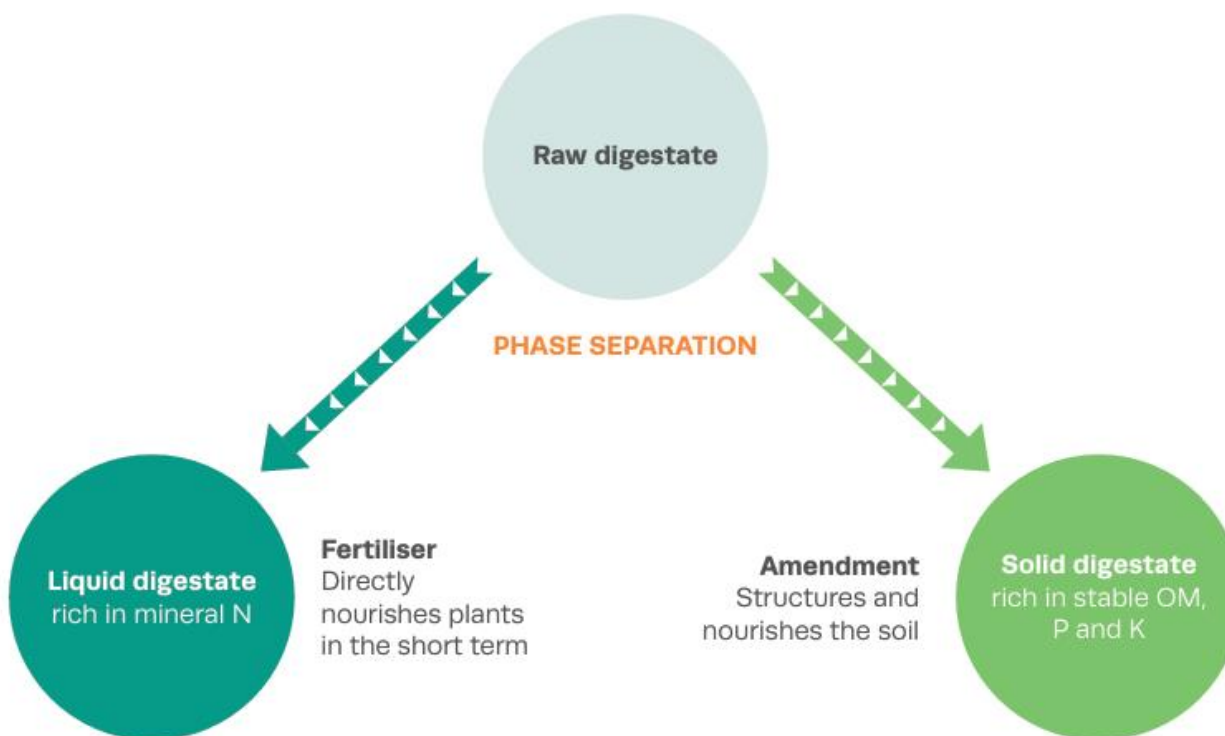
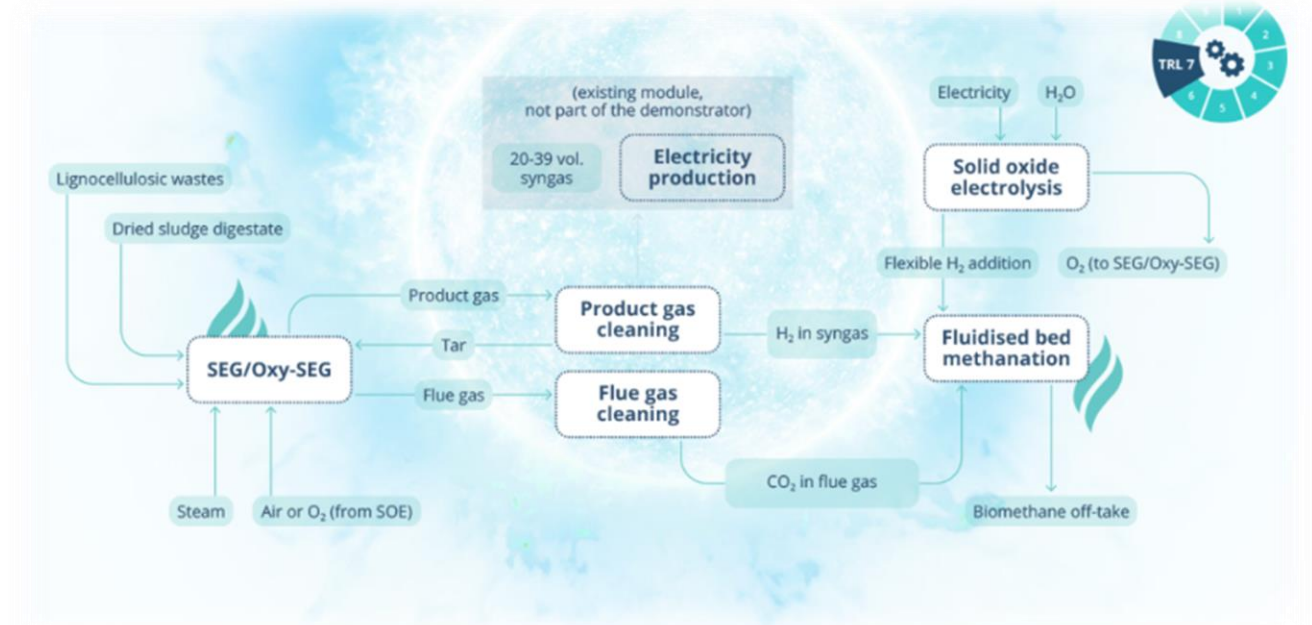
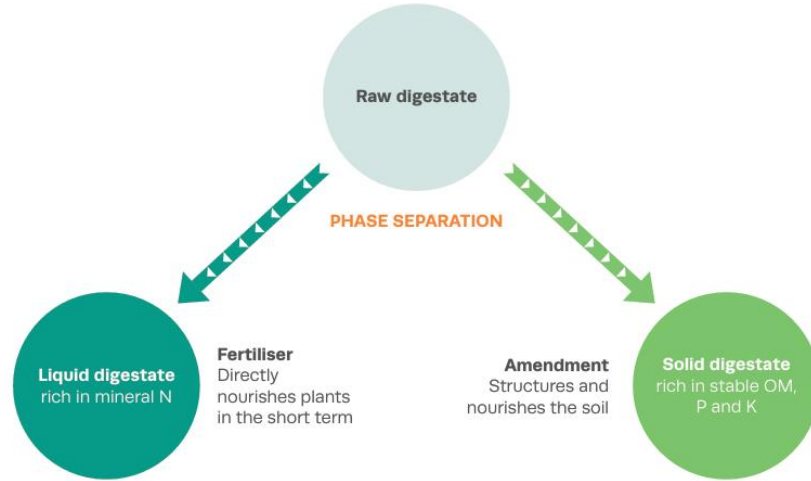


Table 1: Total digestate production volumes [Mt dry matter (DM)] and nutrient content (Mt) in 2022, 2030 and 2050

Parameter	2022	2030	2050
Total digestate production (Mt DM/year)	31	75	177
Nutrient content (Mt)			
Nitrogen (TKN)	1.7	4.1	9.7
Phosphorous (P)	0.3	0.7	1.7
Potassium (K)	0.2	0.4	0.8

Total nutrient demand in Europe: 11.1 Mt nitrogen, 2.8 Mt phosphorous and 3.1 Mt potassium per year.

Other feedstock choices: Digestate



- When digestate spreading has to be limited (for zones in N surplus)
 - if the biogas plant is located in an urban area away from fields
 - if derived from waste water treatment plants and needs further processing
- technology options are considered to use it as feedstock for additional biomethane.

In HYFUELUP project, an alternative biomethane production pathway will be demonstrated that includes the flexible conversion of low-grade feedstocks via sorption-enhanced **gasification coupled with syngas or flue gas clean-up**, followed by **fluidised-bed methanation** of either syngas or flue gas with the dynamic addition of hydrogen.

Conclusions

- ✓ A clear trend towards:
 - agricultural residues, manure and plant residues for biomethane production
 - AD-based biomethane at present, gasification expected to progress fast from 2030 to 2050
- ✓ Expansion and improvement of separate waste collection systems can result in increased availability of food waste.
- ✓ Mobilization of currently underutilized industrial wastewater streams, agricultural residues and manure can contribute to a sufficient and sustainable supply of feedstock
- ✓ R+I needs also vary across technologies and countries
 - On feedstock: focus on
 - sequential cropping, minimum tillage,
 - use of marginal lands, perennial crops
 - Other alternative options (i.e digestate)
- ✓ Introduction and scaling-up of sequential cropping as a sustainable agricultural practice, can assure additional feedstock.
- ✓ Technological progress in gasification processes, enabling the use of a wider range of feedstocks

Thank you very much!



Stay tuned!

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 info@greenmeup-project.eu

 [Myrsini Christou mchrist@cres.gr](mailto:Myrsini.Christou@mchrist@cres.gr)



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