European Commission

EUROPEAN PIGMEAT REFLECTION GROUP

An overview of biogas from pigmeat farming

Sergio Piccinini
CRPA

4° Meeting
Environment and climate challenges (part II)

VIDEOCONFERENCE
12 September 2022

CRPA – Centro Ricerche Produzioni Animali
Research Center on Animal Production

- Agriculture and farm management
- Animal productions
- **Environment & Energy**
- Results dissemination
- **CRPA Lab**

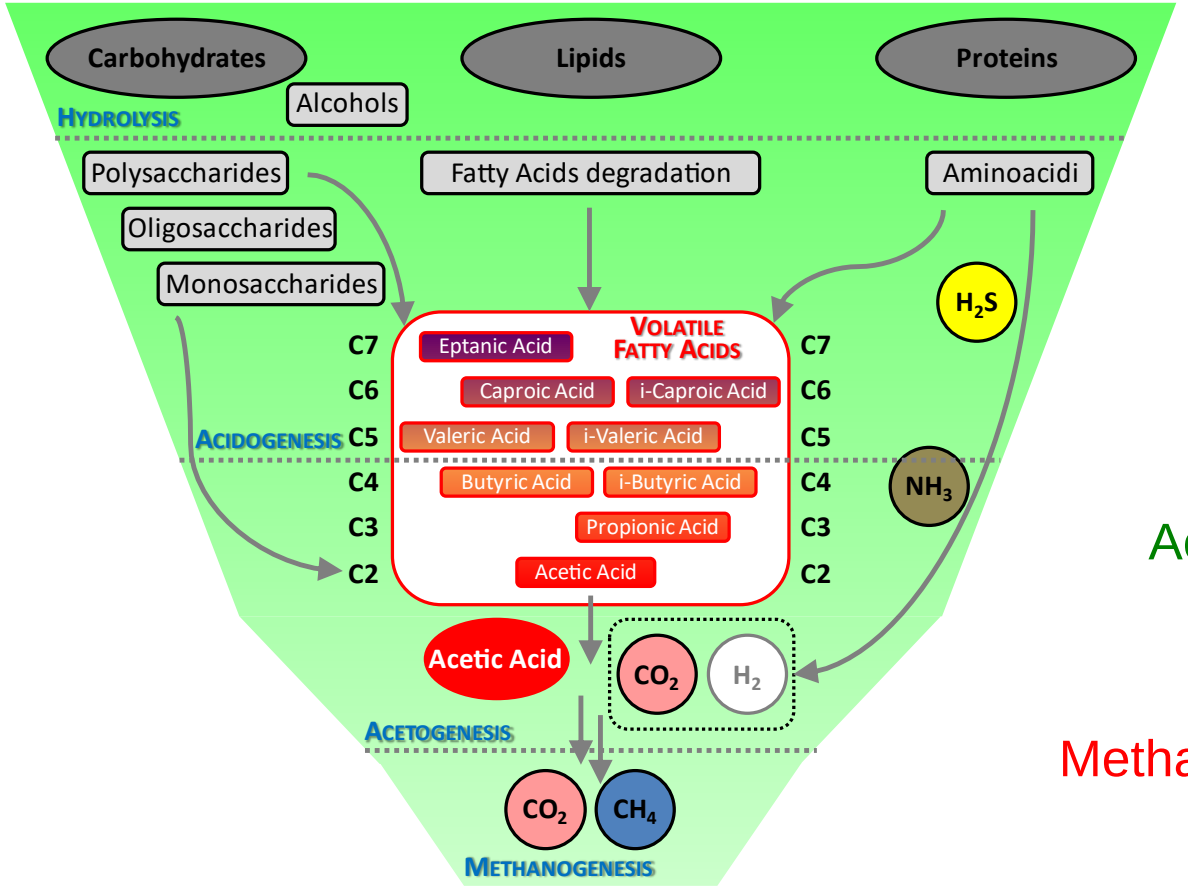
ENVIRONMENT & ENERGY LAB

- Biomass, biowaste and agroindustrial by-products characterization for their valorization in biogas and organic fertilizers

- Biochemical Methane Potential (BMP) *batch test* and *continuous anaerobic digestion tests* in pilot scale reactors

- Biomass management techniques:
  - *Pre-treatment* to increase the energy yield
  - Post-anaerobic digestion techniques for nutrients reduction and recovery
  - Chemico-physical analysis on biomass, NIR analysis on organic substrates and soil, olfactometric analysis (odours)

Anaerobic digestion



Hydrolysis carbohydrates, fats and proteins are reduced in monosaccharides, fatty acids and aminoacids by exo-enzymes

Acidogenesis Monomers are coverted in H_2, CO_2, volatile fatty acids and alcohols through fermentation

Acetogenesis H_2, CO_2, and volatile fatty acids are partially transformed in acetic acid

Methanogenesis H_2, CO_2, acetic acid are converted in CH_4 e CO_2

Biomass for biogas production

ANIMAL MANURE

Biomass for biogas production

AGROINDUSTRIAL BYPRODUCTS

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Biomass for biogas production

AGRICULTURAL RESIDUES

AGROINDUSTRIAL BYPRODUCTS

ANIMAL MANURE

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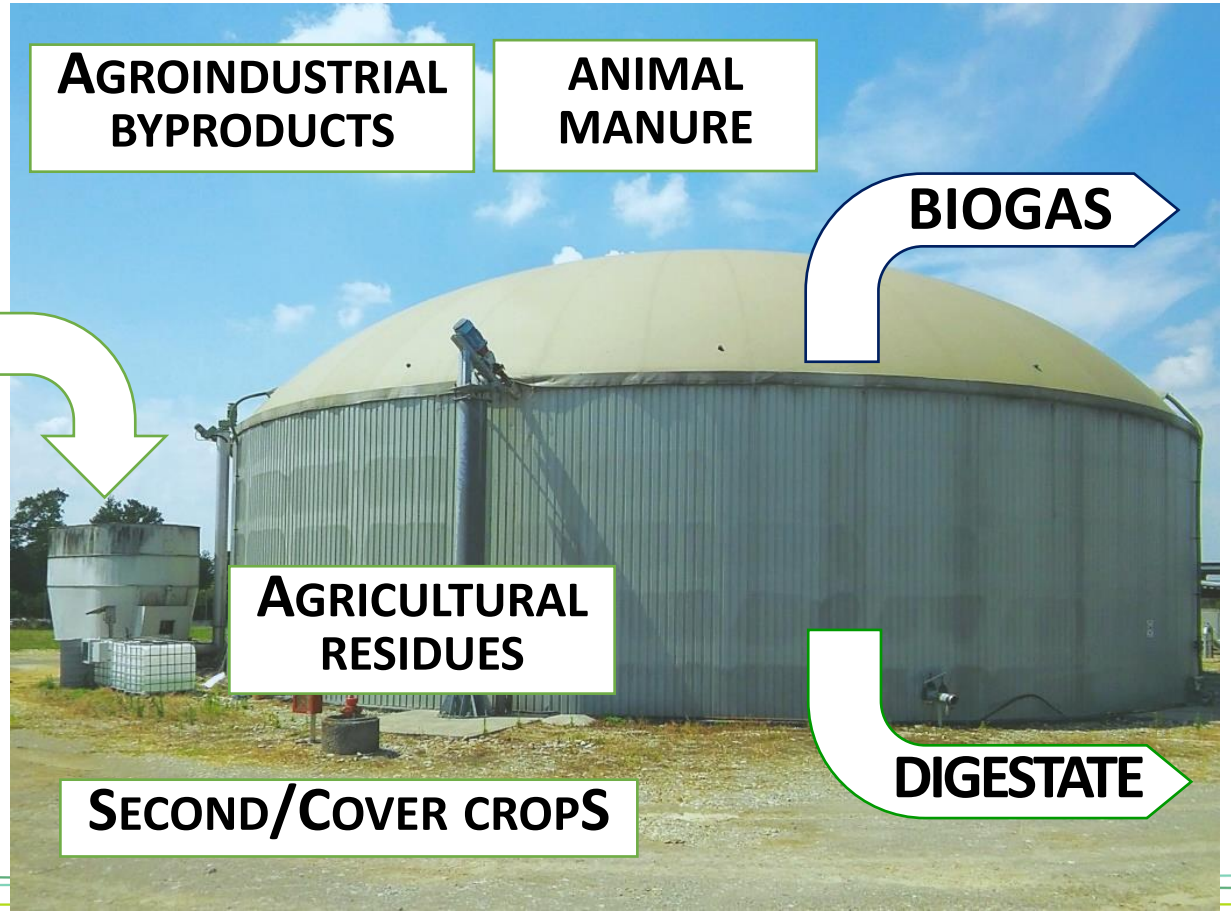
Biomass for biogas production

SECOND/COVER CROPS



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Advantages and concerns for different substrates

Substrate	Propension to anaerobic digestion	Concerns
Pig slurry	**Very good**	Dry matter and organic matter content variable in function of the breeding type
Bovine slurry	**Very good**	Dry matter content related to breeding type
Poultry manure	**Very good**	Nitrogen content, H_2S production, sediment production
Cereal straw	**Slow**	Dissolving, shredding, crusts
Cornstalk	**Good for green ones, slow for dry**	Dissolving, shredding, crusts
Tomato peels	**Good**	Low biodegradability, seasonality
Fruits and vegetables transformation waste	**Very good**	Acidity, humidity, seasonality, seed sedimentation, odours
Grape pomace	**Medium-low**	Low biodegradability of lignocellulolisic content
Olive pomace	**Very good**	Seasonality, pits sedimentations, balance C/N ratio needed
Citrus paste	**Good**	Seasonality, acidity, balance C/N ratio needed
Slaughterhouse waste	**Good**	Shredding, nitrogen, fats, odours, lipids
Whey and derived products	**Very good**	Acidity, humidity, balance C/N ratio needed

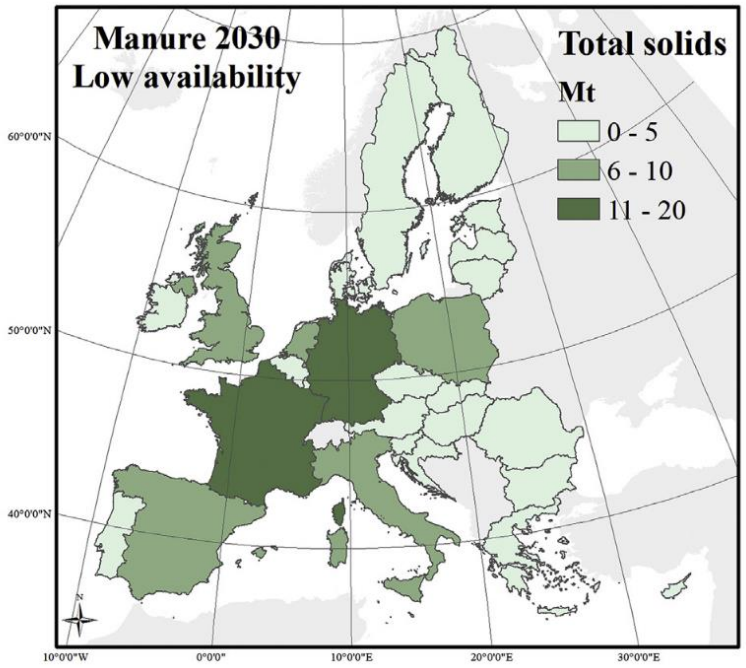
PIG SLURRY

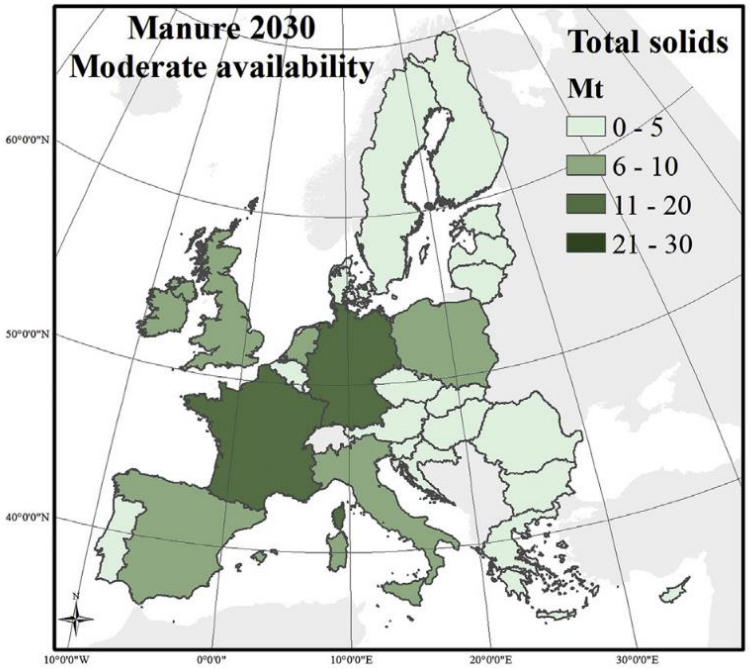
FACTORS AFFECTING QUANTITY' AND QUALITY OF SLURRY INPUT IN THE BIOGAS PROCESS PRODUCTION:

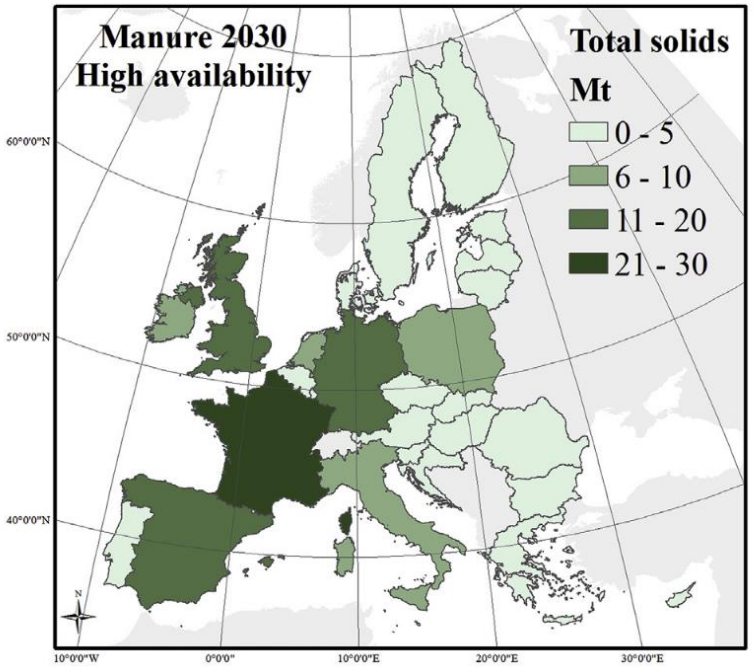
- **age of the animals, «age» of the manure**
- **animal feeding**
- **breeding type and manure management**

From «old» to «fresh» slurry up to 40% more biomethane

Manure distribution in EU







- Total potential quantities of TS from manure (cattle, pig and poultry) forecasted for the year 2030 in the EU member states were estimated to range from **83 to 122 Mt y^{-1}** depending on the applied biomass availability scenario used.
- The potential from **pig manure** (represented in TS) was **18-23 Mt y^{-1}**.

Source: Meyer et al. - Future European biogas: Animal manure, straw and grass potentials for a sustainable European biogas production - Biomass and Bioenergy 111 (2018) 154-164,

EU energy potential from AD of manure

The Energy potential from anaerobic digestion of animal manure in the member state of the European Union in 2030

(1PJ=Peta Joule=10^{15}Joule=0.278 TWh)

Source: Meyer et al. - Future European biogas: Animal manure, straw and grass potentials for a sustainable European biogas production - Biomass and Bioenergy 111 (2018) 154-164,

PJ	Cattle manure			Pig manure			Poultry manure		
	High availability	Moderate availability	Low availability	High availability	Moderate availability	Low availability	High availability	Moderate availability	Low availability
Austria	9	7	6	3	3	2	1	1	1
Belgium	10	9	7	7	6	5	3	3	2
Bulgaria	4	3	3	1	1	1	>1	>1	>1
Croatia	2	2	2	1	1	1	>1	>1	>1
Cyprus	>1	>1	>1	1	1	1	>1	>1	>1
Czech Republic	6	5	4	>1	>1	>1	1	1	1
Denmark	8	7	6	2	1	1	1	1	1
Estonia	1	1	1	8	7	6	>1	>1	>1
Finland	4	3	3	>1	>1	>1	1	1	1
France	78	67	56	152	135	118	12	10	9
Germany	57	49	41	153	136	119	9	8	7
Greece	3	2	2	1	1	1	1	1	1
Hungary	4	3	3	>1	>1	>1	2	2	1
Ireland	23	19	16	14	12	11	1	1	1
Italy	29	25	21	29	26	23	7	7	6
Latvia	2	2	2	1	1	1	>1	>1	>1
Lithuania	4	4	3	4	3	3	>1	>1	>1
Luxembourg	1	1	1	>1	>1	>1	0	0	0
Malta	>1	>1	>1	1	1	1	>1	>1	>1
Netherlands	22	19	16	14	12	11	6	5	4
Poland	29	25	21	>1	>1	>1	10	9	8
Portugal	6	5	5	1	1	1	2	2	2
Romania	14	12	10	>1	>1	>1	2	2	2
Slovakia	2	2	2	>1	>1	>1	0	0	0
Slovenia	2	2	1	>1	>1	>1	>1	>1	>1
Spain	27	23	19	11	10	9	8	7	6
Sweden	6	5	4	11	10	9	1	1	1
United Kingdom	36	31	26	2	2	1	11	10	8
EU28	389	333	278	416	369	323	80	71	62

116 – 90 TWh

European context

- The biogas/biomethane chain is strongly represented in Europe with more than 18,700 biogas plants, with an annual production of about 15 billion m^3 CH_4 equivalent and 159 TWh of energy produced , and 880 biomethane plants, with an annual production of about 3 billion m^3 CH_4, about 32 TWh energy, (European Biogas Association-EBA, Statistical Report 2021).
- The potential biogas and biomethane production calculated for 2030 could reach up to 42 billion m^3, equivalent to 467 TWh (EBA,Statistical Report 2021).
- The International Energy Agency (IEA) calculates Europe's overall biomethane potential as 125 billion m^3 or 1,326 TWh, representing 166 GW of production capacity. According to the IEA, this potential is reachable by 2040.
- the REPowerEU plan of the EC: increase biomethane production to 35 billion m^3 by 2030.

Number of biogas and biomethane plants in Europe

(EBA STATISTICAL REPORT 2021)

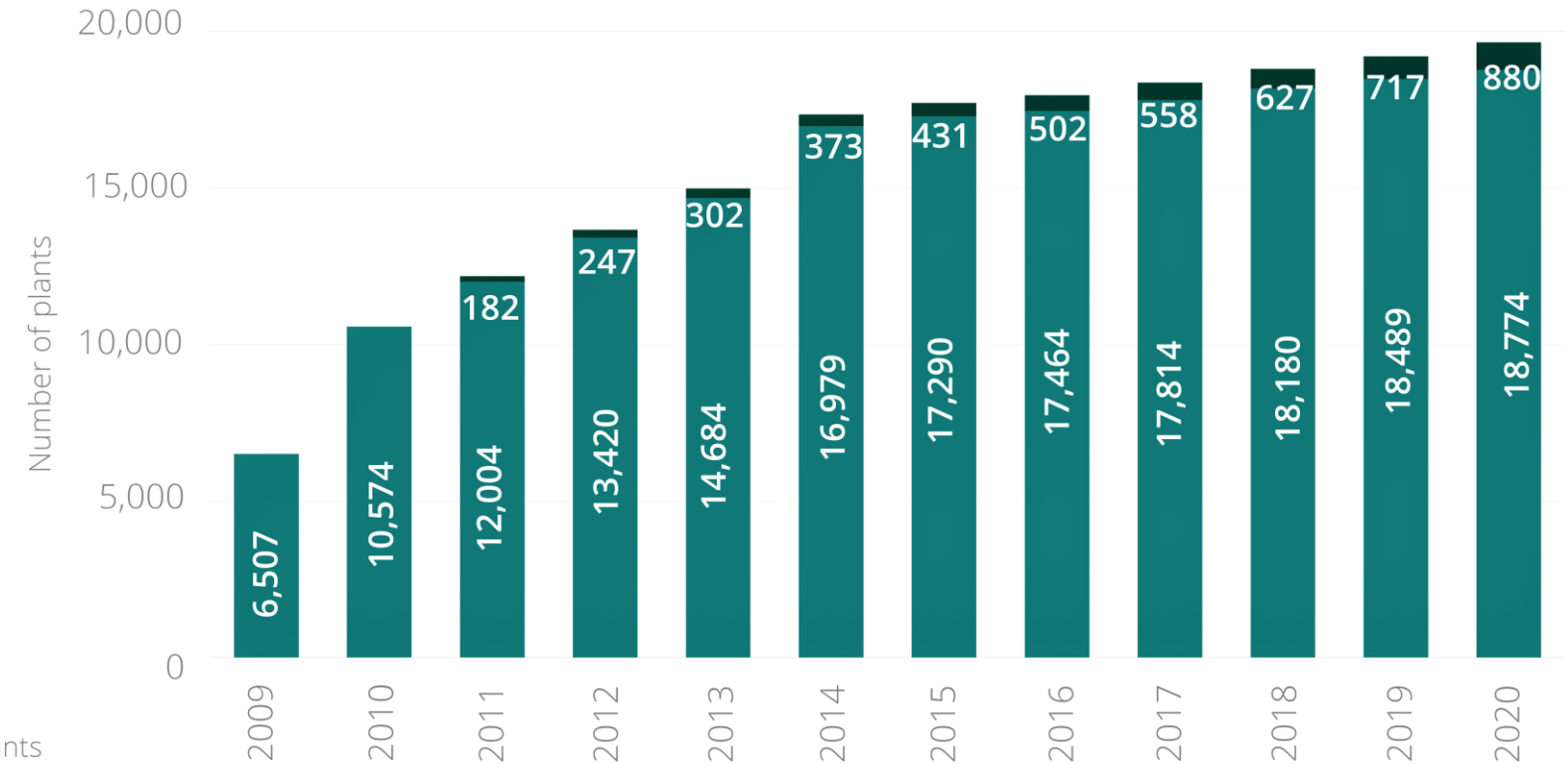


Figure 2.10:
Combined number of bio-methane and biogas plants in Europe

Biogas and Biomethane production per plant tipe

(EBA STATISTICAL REPORT 2021)

Figure 2.8:
Percentage of European biogas production per plant type in 2020

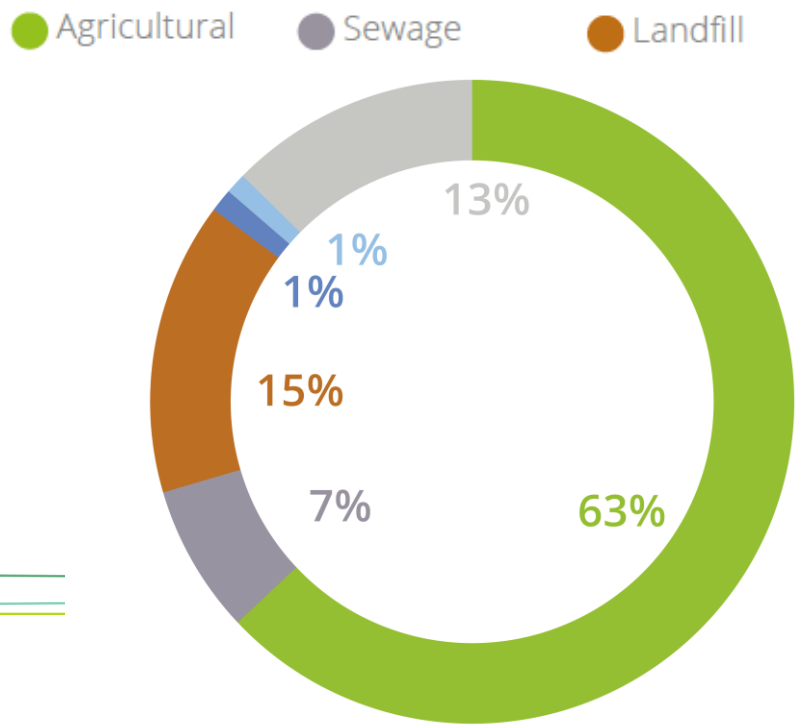
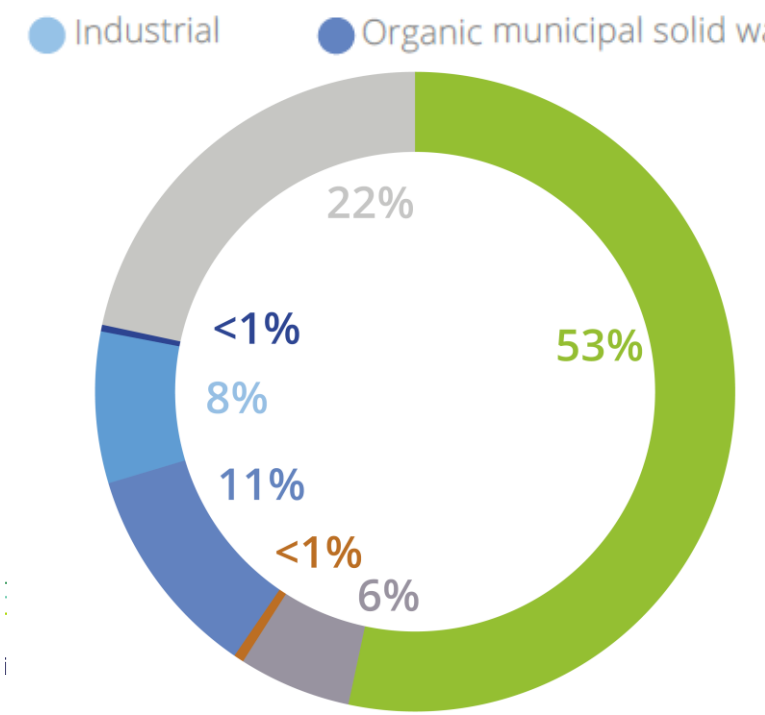


Figure 2.9:
Percentage of European biomethane production per plant type in 2020



Agricultural Biogas = 63%

Agricultural Biomethane = 53%

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Biogas and biomethane production potential calculated per feedstock type in the various studies (TWh)

Calculated potential per feedstock type by various studies (TWh)						
	GfC	IEA	Cerre	UGhent	EBA working group wastewater	**Average**
Sequential crops	434	456	/	487	/	**459**
Agricultural residues	53		537	/	/	**295**
Manure	159	393	185	/	/	**246**
Food waste	21	216	/	/	/	**119**
Industrial wastewater	/	/	/	/	142	**142**
Sewage sludge	2	57	/	/	/	**30**
Gasification	350	204	594	/	/	**383**
Total	**1,020**	**1,326**	**1,316**	**487**	**142**	**1,673**

Table 3.2:
Biogas and biomethane production potential calculated per feedstock type in the various studies (TWh)

(EBA STATISTICAL REPORT 2021)

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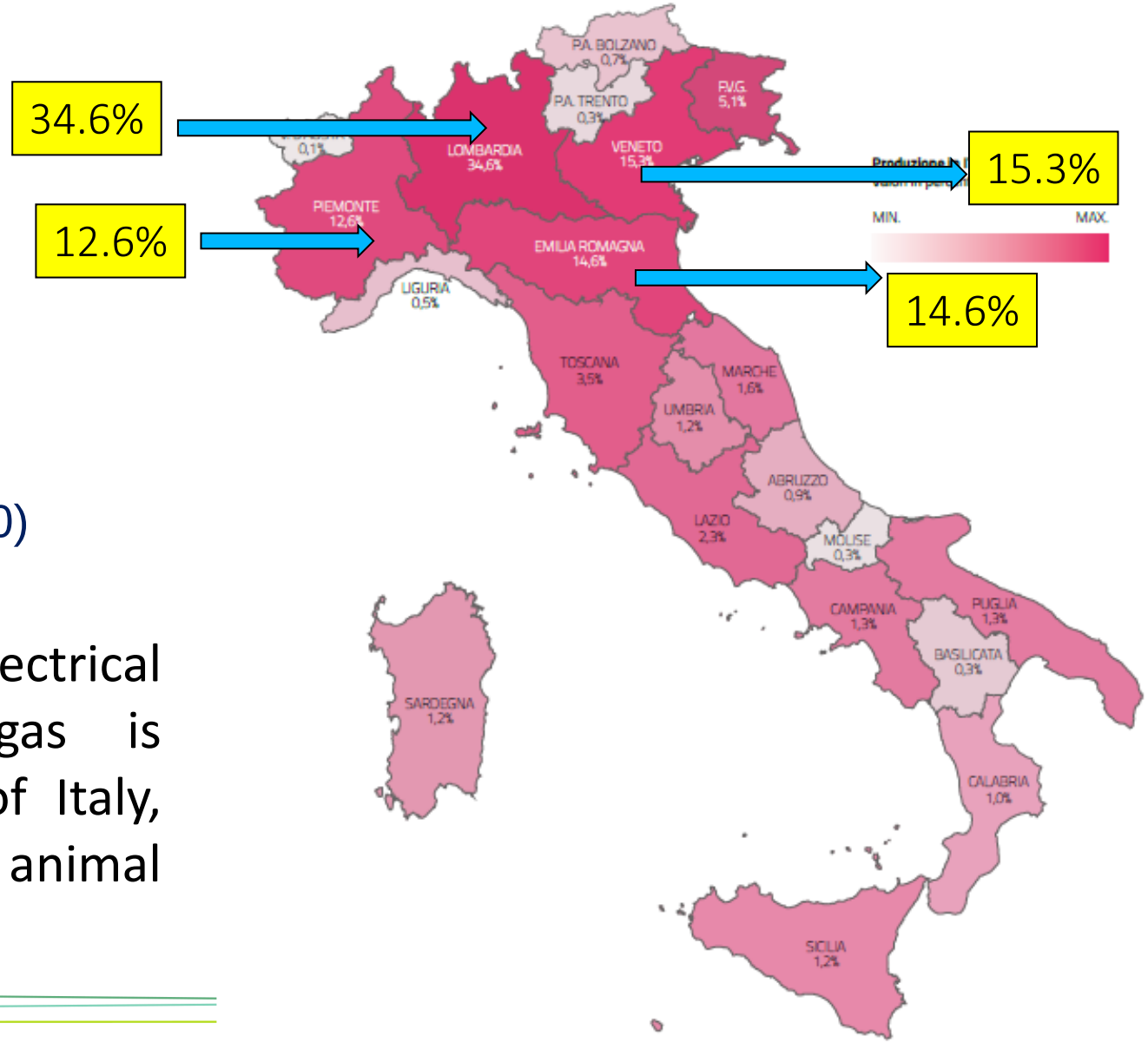
Italian context

- In the **Biogas** sector, Italy ranks the 4° place after Germany, China and USA, with 2200 operating plants, of which 1730 in the agri sector and 470 in the biowaste/sludge sector, with a total of 1450 MWel installed (1000 MWel from agri sector: source GSE).
- In the **Biomethane** sector Italy is under development, in fact in April 2022 about 30 plants are operating and/or starting to operate, with a total production of **284 Mm^3 /y** (source: Italian Biogas Consortium - CIB)
- The developing potential of the biogas and biomethane supply chain in the short/mid term is consistent; CIB estimates **8-10 Gm^3/y production potential**, equal to the 11-13% of the current gas consumption in Italy and higher than the current national production

Regional distribution of biogas production, 2020

(Source GSE, Statistical report 2020)

The 83,4% of the italian total electrical energy production from biogas is furnished by northern regions of Italy, where there is about 80% of animal production.



Potential of biogas/biomethane sector in Italy

Biomasses	Quantity
Animal manure	130 (Mt/y)
Agroindustrial by-products	5 (Mt/y)
Sewage sludge	3.5 (Mt/y)
Municipal biowaste	10 (Mt/y)
Agricultural residues	8.5 (Mt/y)
Second and cover crops	400,000 (ha)

BIOGAS

upgrading

~ 14 M ton CO_2 per year

8 billion Sm^3CH_4/year

Digestate: ~5 M ton CO_2 per year, to be stored permenently in the soil

Of which **3 billions** Sm^3CH_4/year already produced

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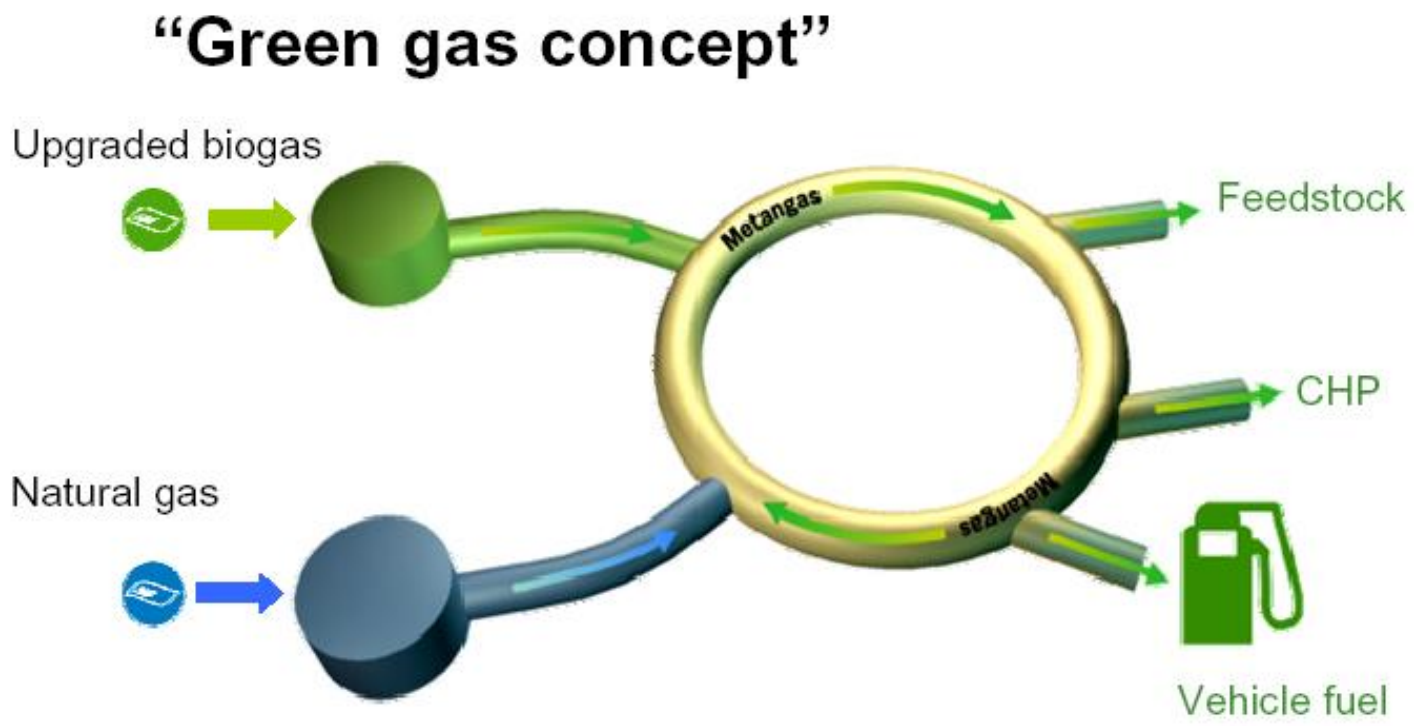
Biogas/biomethane can help decarbonising the energetic consumption



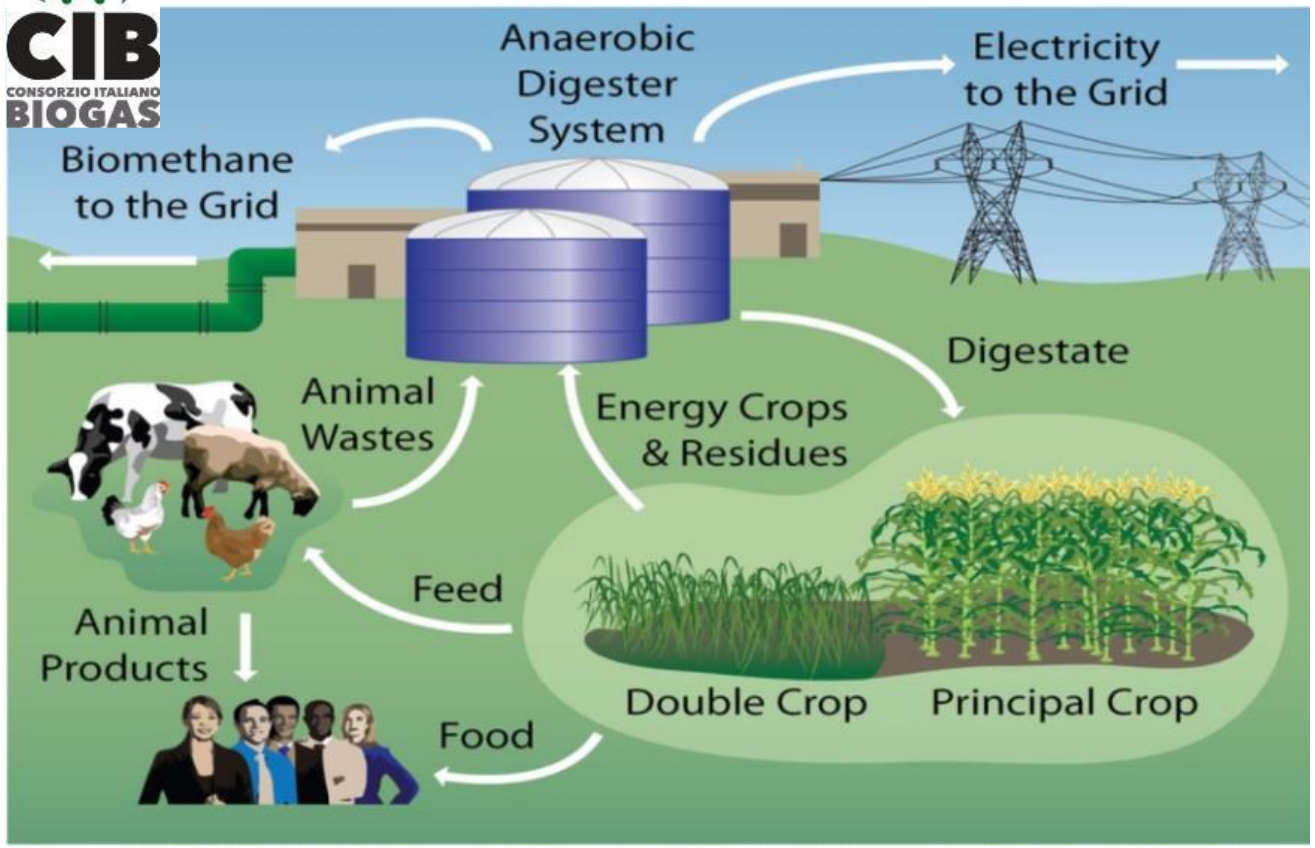
Electricity from RES

Heat from RES

RES for transportation

*RES: renewable energy sources

Sustainable agriculture: BiogasDoneRight Model

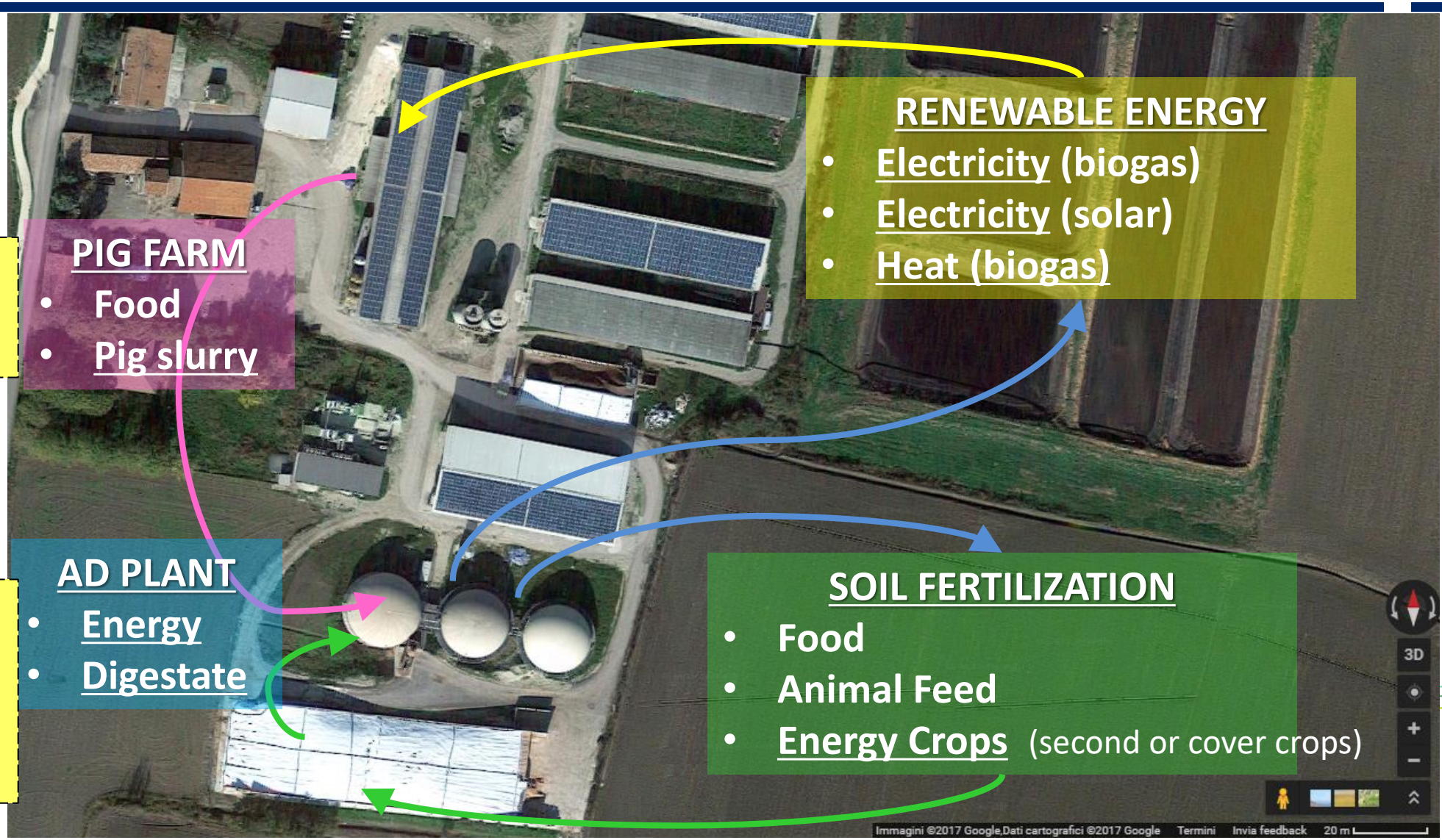


1. Valorization of livestock manure, agricultural residues and agroindustrial byproducts;
2. Production of «EXTRA CARBON» thanks to the inclusion of «SECOND CROP» or «COVER CROP»
3. Increase of CARBON STOCK in the soil (return of digestate and increase in roots production);
4. Reduction of chemical fertilizers and optimization of the nutrient recycling and hydraulic resources (fertigation and digestate);
5. Adoption of advanced farming techniques (precision farming, minimun tillage, strip tillage,…).

Circular Economy: Pig farm and biogas plant

PIG FARM
About 11,000 fattening pigs
(heavy pig for Parma ham)

AD PLANT
Temperature: 42-43°C
Digestion volume: 1400 m^3 x 3
HRT: 30-35 days
CHP : 725 kWe



LCA analysis
Life Cycle Assessment

Sow and piglet breeding

Weaned piglet

Fattening pig breeding

Heavy pig (>160 Kg)

Input

PIG FARM: BREEDING+FATTENING
800 sows + 9500 fattening pigs

Output

livestock emissions

Manure management and storage emissions

Output

Manure and livestock emissions

Input

Anaerobic plant

Biogas

Output

Digestate emissions,
Emissions for biogas leakage
Crop cultivation emissions

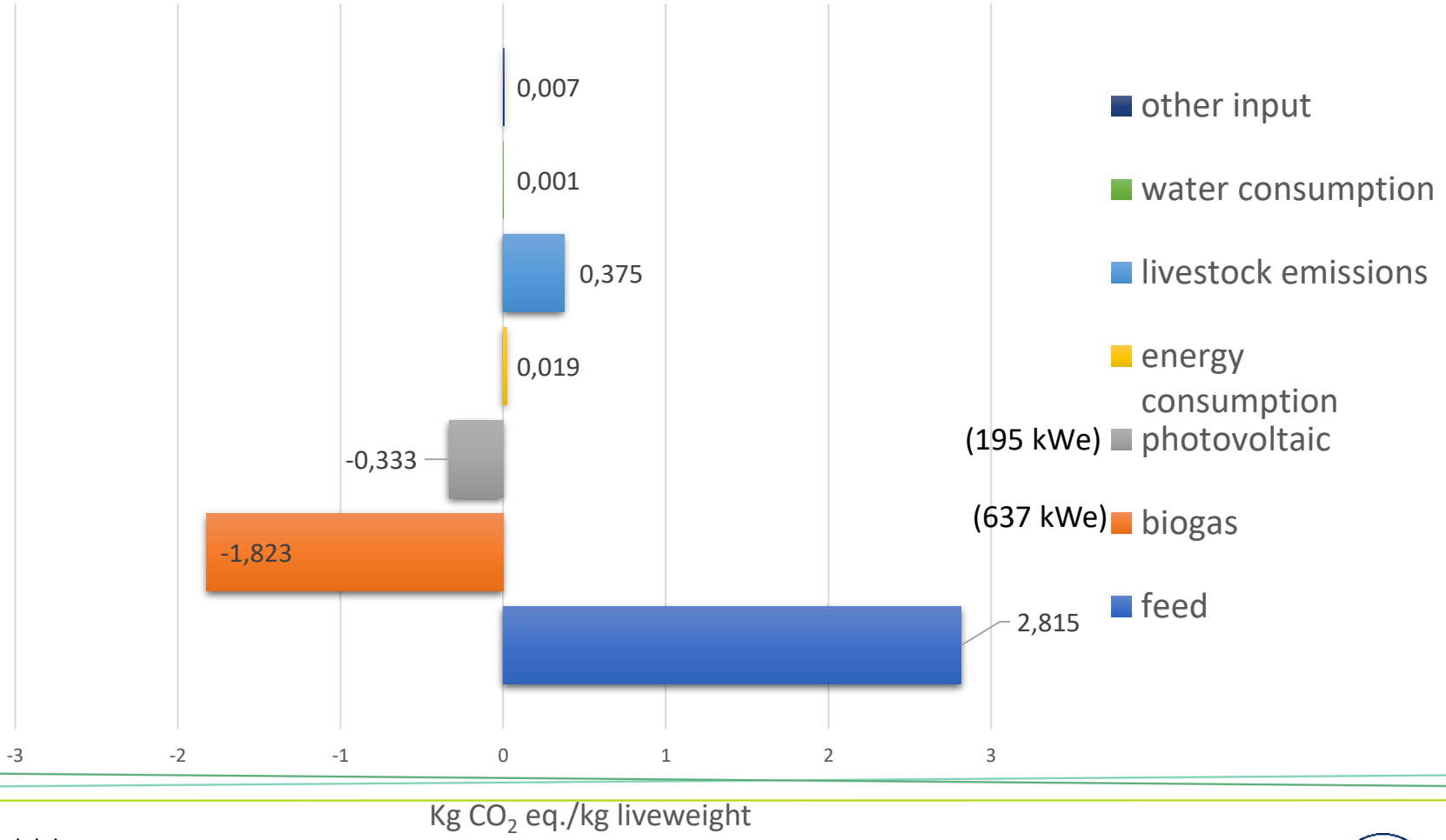
avoided

Carbon footprint of pig production

Carbon Footprint (CF) represents the global warming potential (GWP) caused by GreenHouse Gas emissions throughout life cycle of product

1.06 Kg CO_2 eq./kg liveweight <u>with</u> renewable energy

5.08 Kg CO_2 eq./kg liveweight <u>without</u> renewable energy



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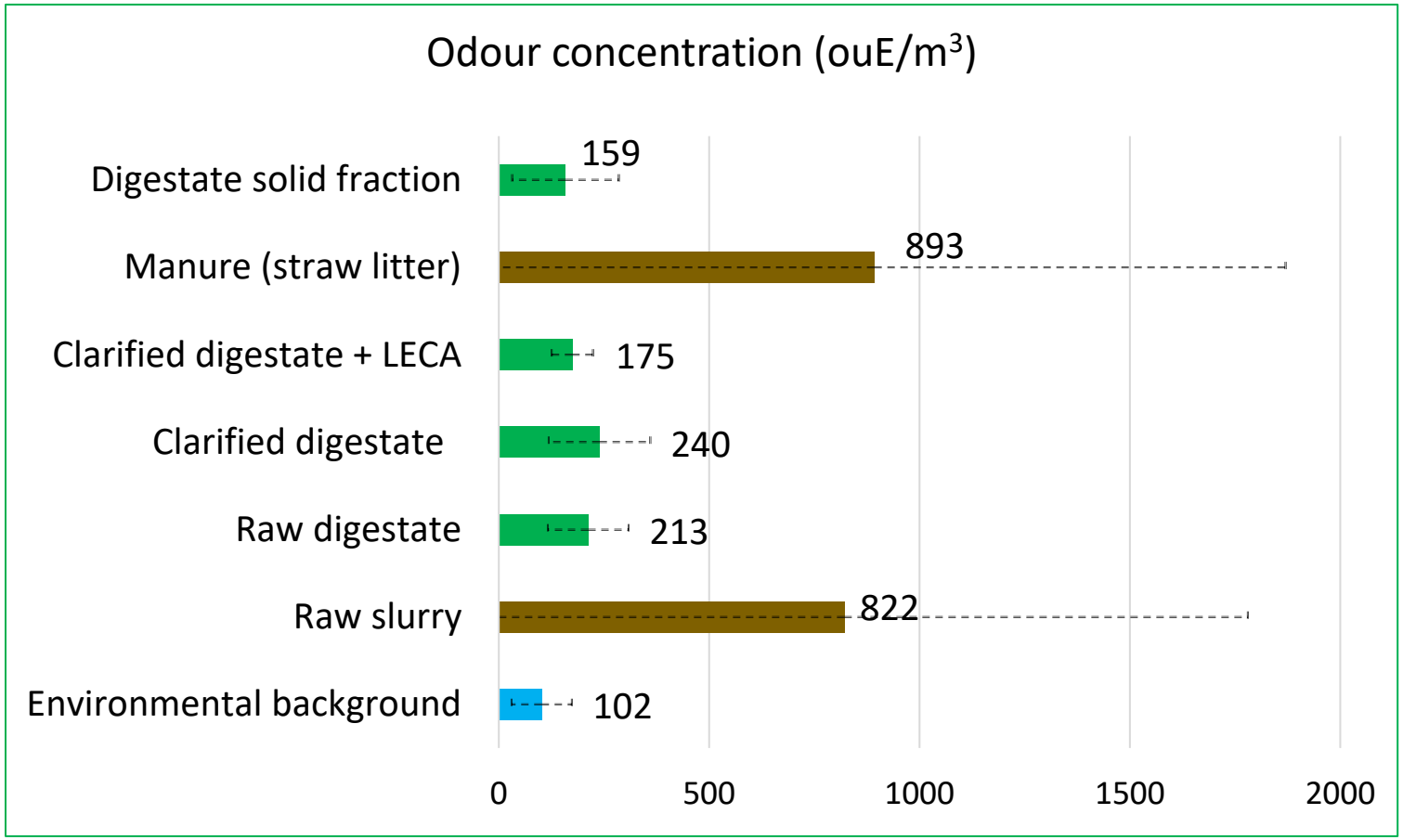
Olfactory impact reduction

Results of OG Digestate&Emissions



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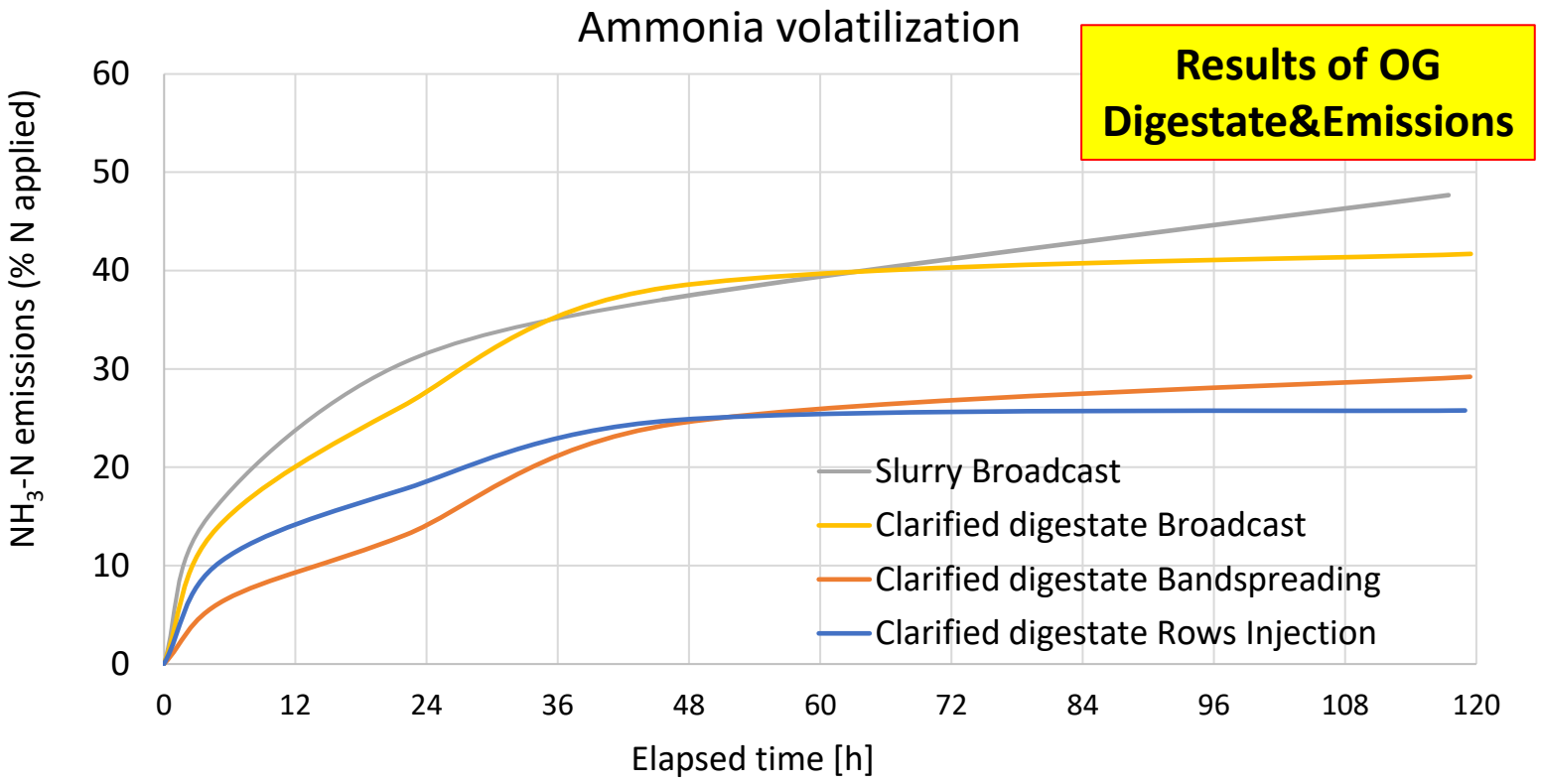
Digestate in agronomic utilization

- Ammonia nitrogen makes digestate similar to a rapid effect fertilizer
- Nitrogen and its fertilizing power should not be lost!
- Superficial distribution by scattering can loose ~50-60% of the available nitrogen

Distrubution of the digestate in the **right time** and with **good agronomic techniques**



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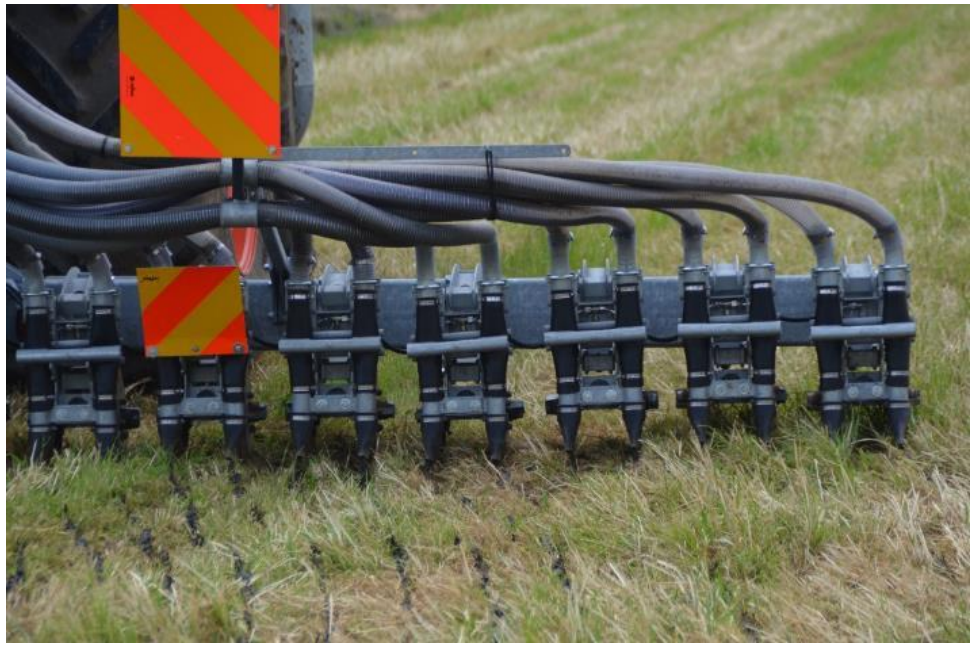
Best techniques for effluent distribution

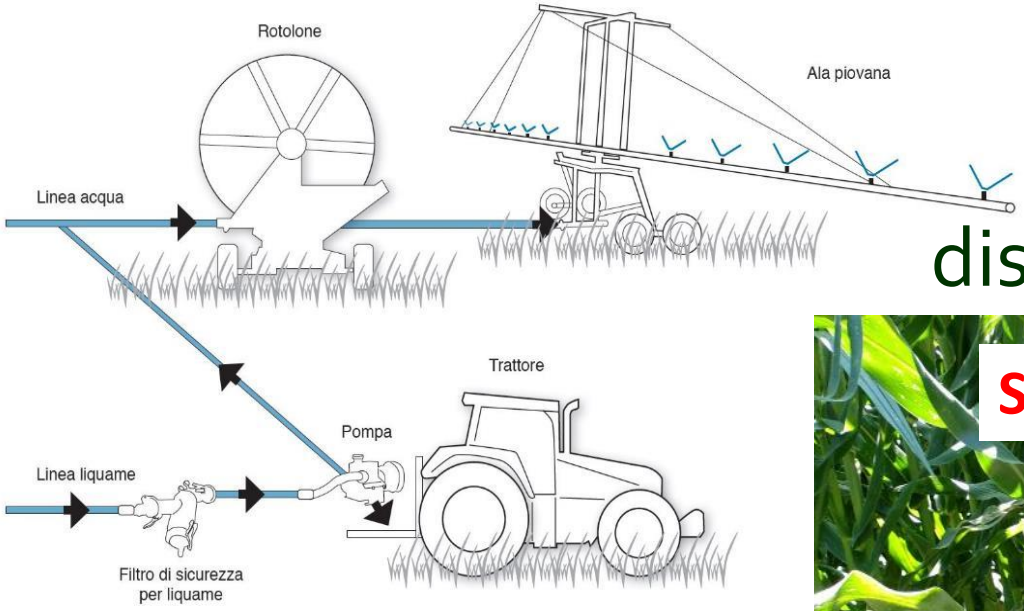
Bandspreading

Open rows injection

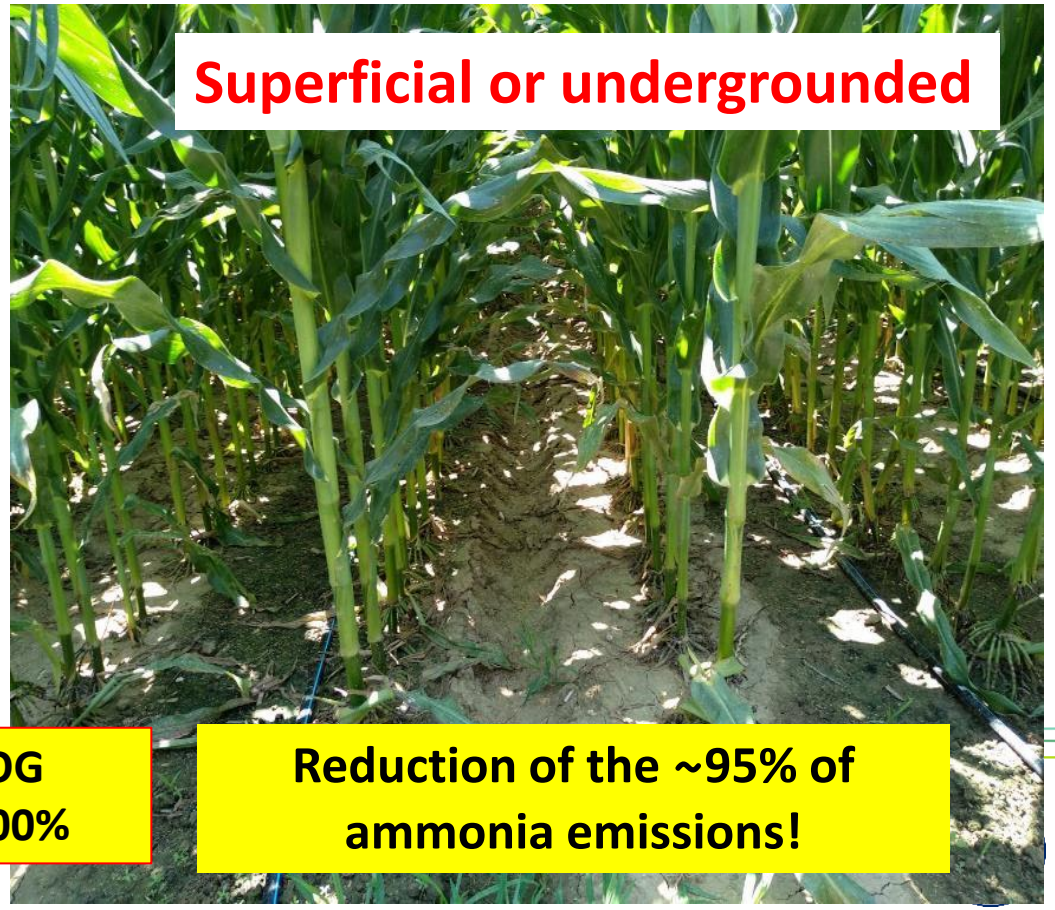


Fertigation with digestate

Water and digestate distribution with **drip lines** put between corn spacing



Water and digestate distribution with drip lines



Results of OG Digestate_100%

Reduction of the ~95% of ammonia emissions!

Conclusions

- ✓ Biomethane is a sustainable biofuel and it is important for the decarbonization of the European economy and for Europe's energy transition;
- ✓ The anaerobic digestion process increases the sustainability of European agriculture, reducing GHG emissions and reducing the odours in livestock manure and organic waste management; different techniques for reduction of the ammonia emissions are also available;
- ✓ The digestatate is a very good organic fertilizer that can significantly replace chemical ones; different tools for field distribution, allowing to minimize the GHG emissions and to preserve the fertilizing value, are available; moreover, it contributes to stock and increase the carbon in the soil;
- ✓ Biogas/Biomethane is a really important support for the agricultural sector to the ecological transition of the European countries.

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Sergio Piccinini

s.piccinini@crpa.it