CHANIA2023

10th International Conference on Sustainable Solid Waste Management

21-24 JUNE

ANALYSIS OF POSSIBILITIES OF OBTAINING POSITIVE ENERGY BALANCE IN ANAEROBIC DIGESTION SYSTEMS WITH HYDRODYNAMIC DISINTEGRATION

Monika Żubrowska-Sudoł, **Katarzyna Sytek-Szmeichel**,
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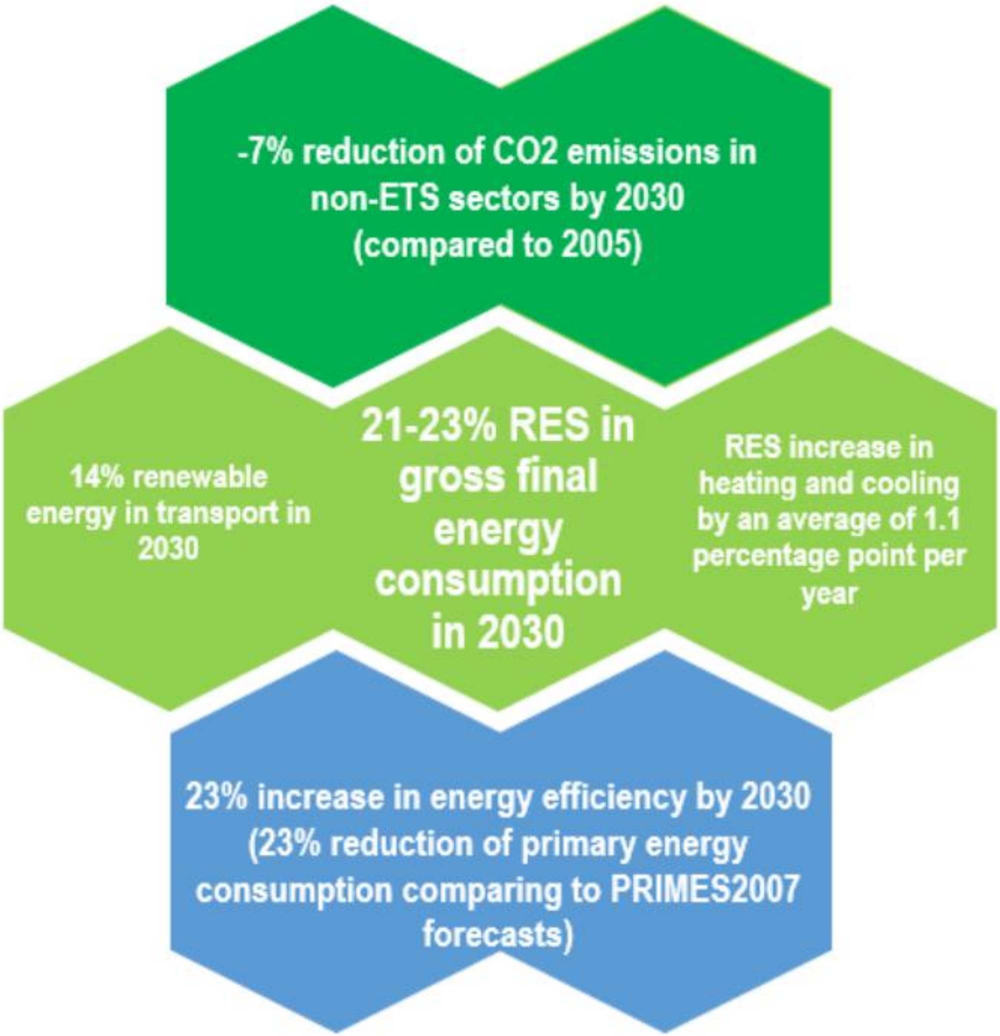
„Development of a technology for preparation substrates used in methane co-fermentation by disintegration methods"
(DEZMETAN) No.: POIR.04.01.02-00-0022/17

European Funds Smart Growth

The National Centre for Research and Development

European Union European Regional Development Fund

POLAND'S NATIONAL ENERGY AND CLIMATE PLAN FOR THE YEARS 2021-2030

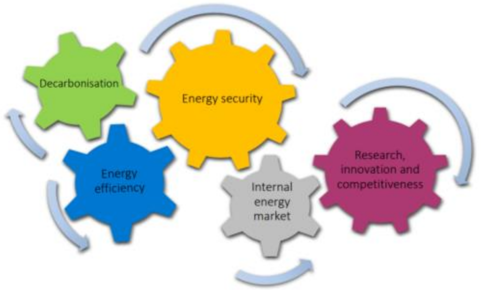


The five dimensions of the Energy Union

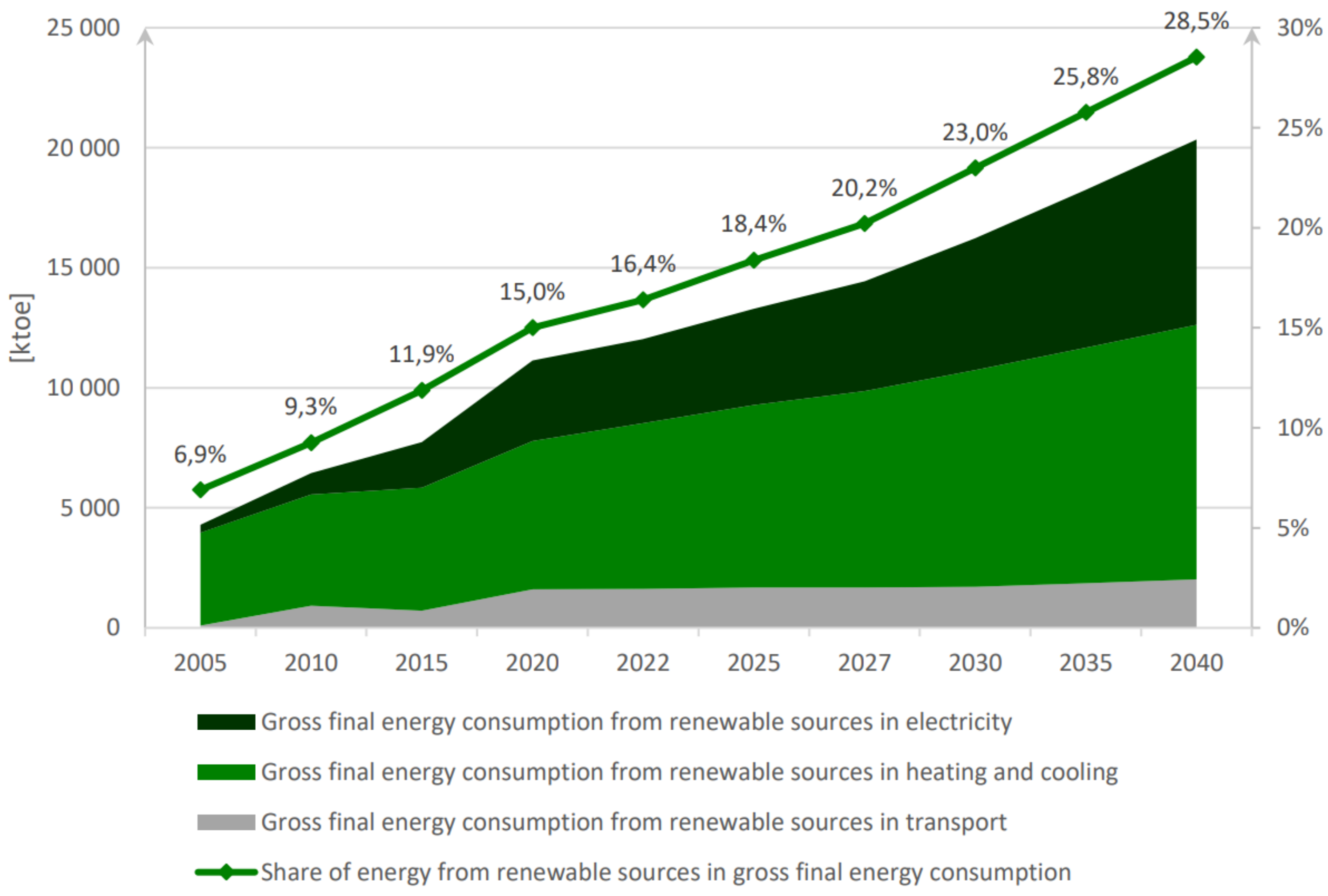
Poland's climate and energy targets until 2030

POLAND'S NATIONAL ENERGY AND CLIMATE PLAN FOR THE YEARS 2021-2030

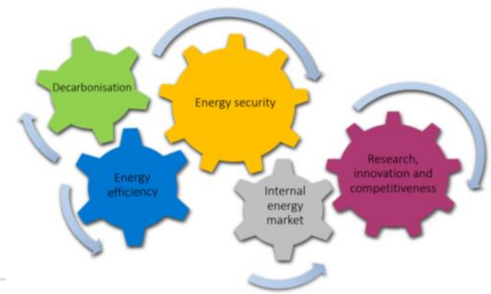
Renewable Sources development



The five dimensions of the Energy Union

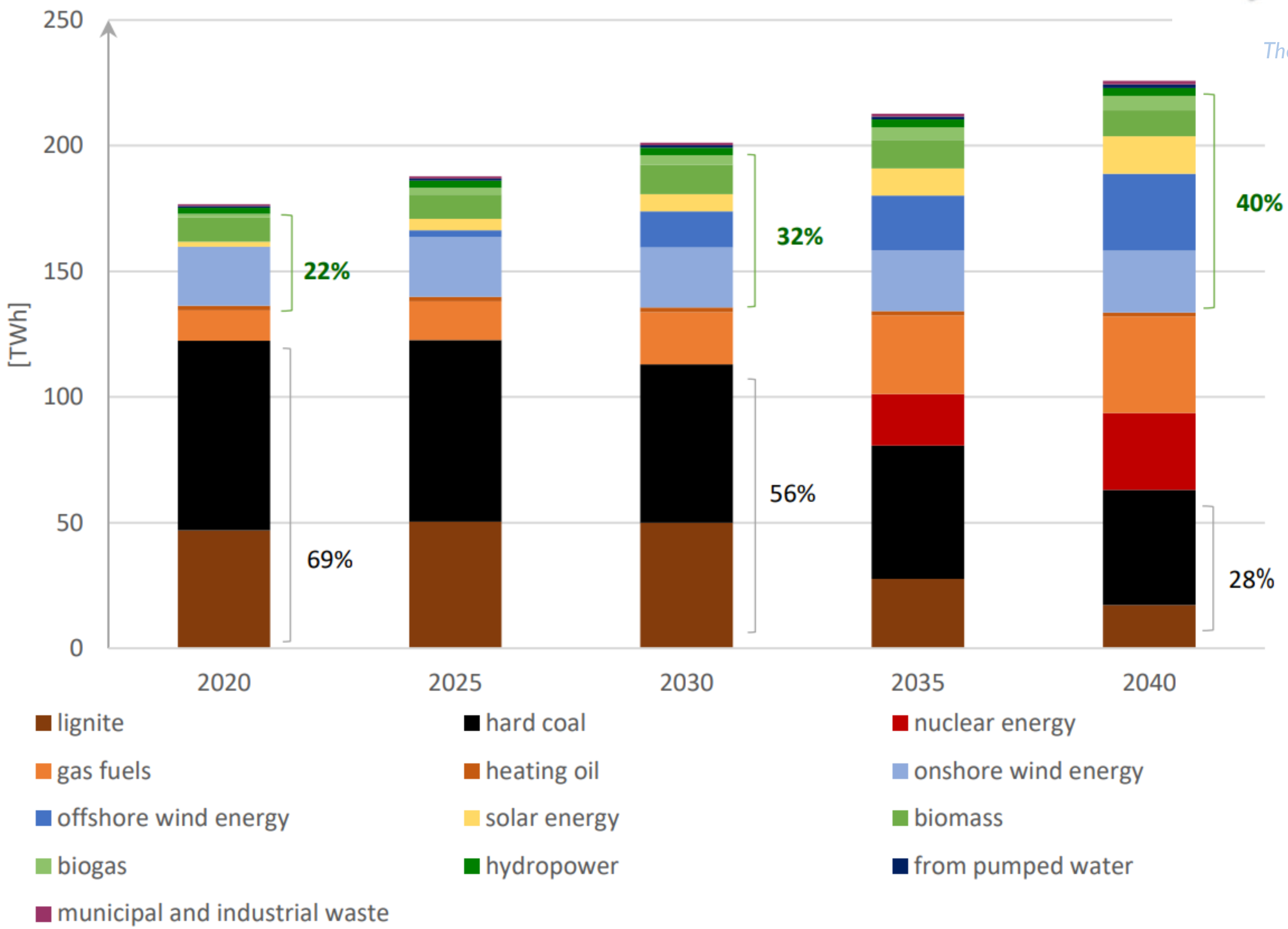


POLAND'S NATIONAL ENERGY AND CLIMATE PLAN FOR THE YEARS 2021-2030



The five dimensions of the Energy Union

Structure of electricity production



RESEARCH PROBLEM

How to increase biogas production?

Pretreatment

e.g. disintegration process

ENERGY
(mechanical, thermal, chemical)

increasing the availability of the substrate for microorganisms involved in the anaerobic digestion process

Co-digestion process

Substrate
(e.g. sewage sludge)

+

Co-substrate
characterized by a high methane production potential

increase of calorific value of substrates entering the anaerobic digester

energies

MDPI

Article

Energy-Positive Disintegration of Waste Activated Sludge—Full Scale Study

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Abstract: This study aimed to evaluate the effects of mechanical disintegration of waste activated sludge (WAS) on full scale anaerobic digestion, considering the possibility of obtaining a positive energy balance. The results showed that an increase in energy density (ε_L) used in disintegration was accompanied by an increase in the release of organic compounds from sludge (SCOD increased from 211 ± 125 mg O_2/L for ε_L = 0 kJ/L to 6292 ± 2860 mgO_2/L for ε_L = 180 kJ/L). Some of them were volatile fatty acids. The percentage share of WAS subject to disintegration was also documented as a crucial parameter affecting the efficiency of biogas production. An increase in the value of this parameter from 25% to 100%, even at much lower ε_L used in disintegration (therefore with much smaller amounts of organic compounds released from sludge flocs) resulted in an increase in biogas

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

ELSEVIER

Effect of hydrodynamic disintegration on the solubilisation and bioavailability of thickened excess sludge

Agnieszka Garlicka*, Monika Zubrowska-Sudol

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ARTICLE INFO

Keywords:
Bioavailability
COD solubilisation
Hydrolysis
Hydrodynamic disintegration
Thickened excess sludge
Wastewater engineering

ABSTRACT

The main objective of the study was the verification whether conducting the hydrodynami[c] of thickened excess sludge (TES) before the anaerobic hydrolysis (AH) can cause an increa[se] the hydrolysis process, and therefore a reduction in its duration, or allow for complete [...] before the anaerobic digestion (AD). For this purpose, the HD (conducted in five levels o[f] 140, 280, 420, 560 and 700 kJ/L) of TES was carried out, and then all sludges (before and were subjected to the AH. The obtained results confirmed that the process of HD can be a

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Thermal Science and Engineering Progress

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ELSEVIER

The effects of mechanical sludge disintegration to enhance full-scale anaerobic digestion of municipal sludge

Monika Zubrowska-Sudol[a,*], Jolanta Podedworna[a], Katarzyna Sytek-Szmeichel[a], Agnieszka Bisak[a], Piotr Krawczyk[b], Agnieszka Garlicka[a]

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ARTICLE INFO

Keywords:
Anaerobic digestion
Mechanical disintegration
Waste activated sludge
Biogas production

ABSTRACT

The main goal of the study was to evaluate the effects of mechanical sludge disintegration in enhancing full-scale anaerobic digestion of municipal sludge. Batch disintegration tests and lab dewatering tests were performed to determine the release of organic compounds and to assess the impact of disintegration of excess sludge before the fermentation process of mixed sludge on the dewaterability of post fermented sludge, respectively. In the study, a disc disintegrator driven by a motor with a power of 30 kW, revolutions n = 2950 rpm, was used. It was shown that increased amounts of organic compounds were released from the sludge along with an increase in energy consumed in the disintegration. A part of the organic compounds were volatile fatty acids (VFAs). The highest share of VFAs in the released organic compounds (COD:VFA in the range of 6.6 ÷ 8.2) was obtained by performing disintegration at an energy density of 140 kJ/L. It was also documented that the introduction of excess sludge disintegration prior to the fermentation tank resulted in a significant increase in biogas production (by an average of 33.9%) and in an increase in volatile total solids reduction in the fermented sludge (by an average of 22.7%). Such a surplus of produced biogas would allow to produce ca. 1600 kWh/d net electricity and 7.5 GJ/d (2080 kWh/d) of heat. Moreover, it was documented that the share of disintegrated waste activated sludge in the mixed sludge subjected to the fermentation process could favourably influence the efficiency of post-fermented sludge dewatering.

Bioresource Technology 360 (2022) 127622

Contents lists available at ScienceDirect

Bioresource Technology

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

ELSEVIER

Disintegration of waste sludge as an element bio-circular economy in waste water treatment plant towards carbon recovery for biological nutrient removal

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HIGHLIGHTS

- Biocircular economy of excess sludge via disintegration process was investigated.
- Disintegrated excess sludge as a source of C to increase N and P removal was used.
- N and P removal depended on energy densities at which C was produced.
- Increase of combined N and P removal was obtained at 70 kJ/L and 210 kJ/L.
- Decline in efficiency of N and COD removal was observed at 280 kJ/L.

GRAPHICAL ABSTRACT

ARTICLE INFO

Keywords:
Excess sludge

ABSTRACT

The goal of the study was to evaluate the possibility of use of disintegrated excess sludge to enhance combined biological nutrient removal from wastewater. In the experiment lasting 295 days four runs were performed.

RESEARCH PAPER

Water

CLEAN Soil Air Water

www.clean-journal.com

Influence of Hydrodynamic Disintegration on the Release of Organic and Nutrient Compounds From Activated Sludge

Justyna Walczak, Monika Zubrowska-Sudol, and Paula Piechna*

The aim of the research is to assess the release of organic compounds and nutrients to liquid phase as a result of hydrodynamic disintegration (HD) of sludge. Six batch disintegration tests are conducted. The scope is a complex analysis of the release of organic compounds (soluble chemical oxygen demand [SCOD], volatile fatty acids [VFA]) and nutrients (soluble total nitrogen [STN], NO_3^--N, NO_2^--N, NH_4^+-N, soluble total phosphorus [STP], PO_4^{3-}-P) depending on the energy density (ε_L) used during the HD process (70–350 kJ L^{-1}). It is shown that an increase in ε_L is correlated with an increase in the disintegration degree (DD). This results in an increase in both the SCOD (including VFA) and in the soluble nutrient concentration (STN and STP). The value of ε_L at which HD is conducted, also has an influence on the percentage share of VFA in soluble organic compounds released from activated sludge flocs and on the relationship between the SCOD/STN and SCOD/STP ratio. It is also shown that ε_L and the total solids concentration of disintegrated sludge have an influence on the costs of organic compounds acquired by the HD method. Low costs are obtained for ε_L = 350 kJ L^{-1} (0.7–2.2 € kg^{-1} SCOD and 12.8–23.6 € kg^{-1} VFA), and for relatively high total solids (TS) concentrations (TS > 4%) (1.5–1.9 € kg^{-1} SCOD for ε_L = 70 kJ kg^{-1} and 0.7–0.8 € kg^{-1} SCOD for ε_L = 350 kJ L^{-1}).

production and to percentage reduction o[f] volatile total solids (VTS).[2,3] Moreover, disintegration can improve sludge dewa[...] terability.[4] Sludge disintegration is als[o] referred to as a method of obtaining a[n] alternative carbon source for intensifying nutrient removal from wastewater.[5-7]

There are many ways of conducting sludge disintegration, and they differ by the source of energy entering the system, fo[r] example, mechanical (ultrasound, bal[l] mills, homogenization, pressure methods, hydrodynamic disintegration [HD]),[...] physical (high temperature),[12] chemical (hydrolysis, ozone treatment),[13] and bio[...] logical.[14] A combination of two or more methods is also used.[15] In practice, the choice of disintegration method is dictated by the required disintegration efficiency and, alternatively, by the investment and operational costs of the system. In order to conduct a comparison of energy inputs, parameters were introduced in the disinte[...] gration process, called: energy density

energies

MDPI

Article

Effects of Thickened Excess Sludge Pre-Treatment Using Hydrodynamic Cavitation for Anaerobic Digestion

Agnieszka Garlicka [1,*], Monika Zubrowska-Sudol [1], Katarzyna Umiejewska [1], Otton Roubinek [2], Jacek Palige [2] and Andrzej Chmielewski [2]

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2 Institute of Nuclear Chemistry and Technology, 16 Dorodna St., 03-195 Warsaw, Poland; o.roubinek@ichtj.waw.pl (O.R.); j.palige@ichtj.waw.pl (J.P.); a.chmielewski@ichtj.waw.pl (A.C.)
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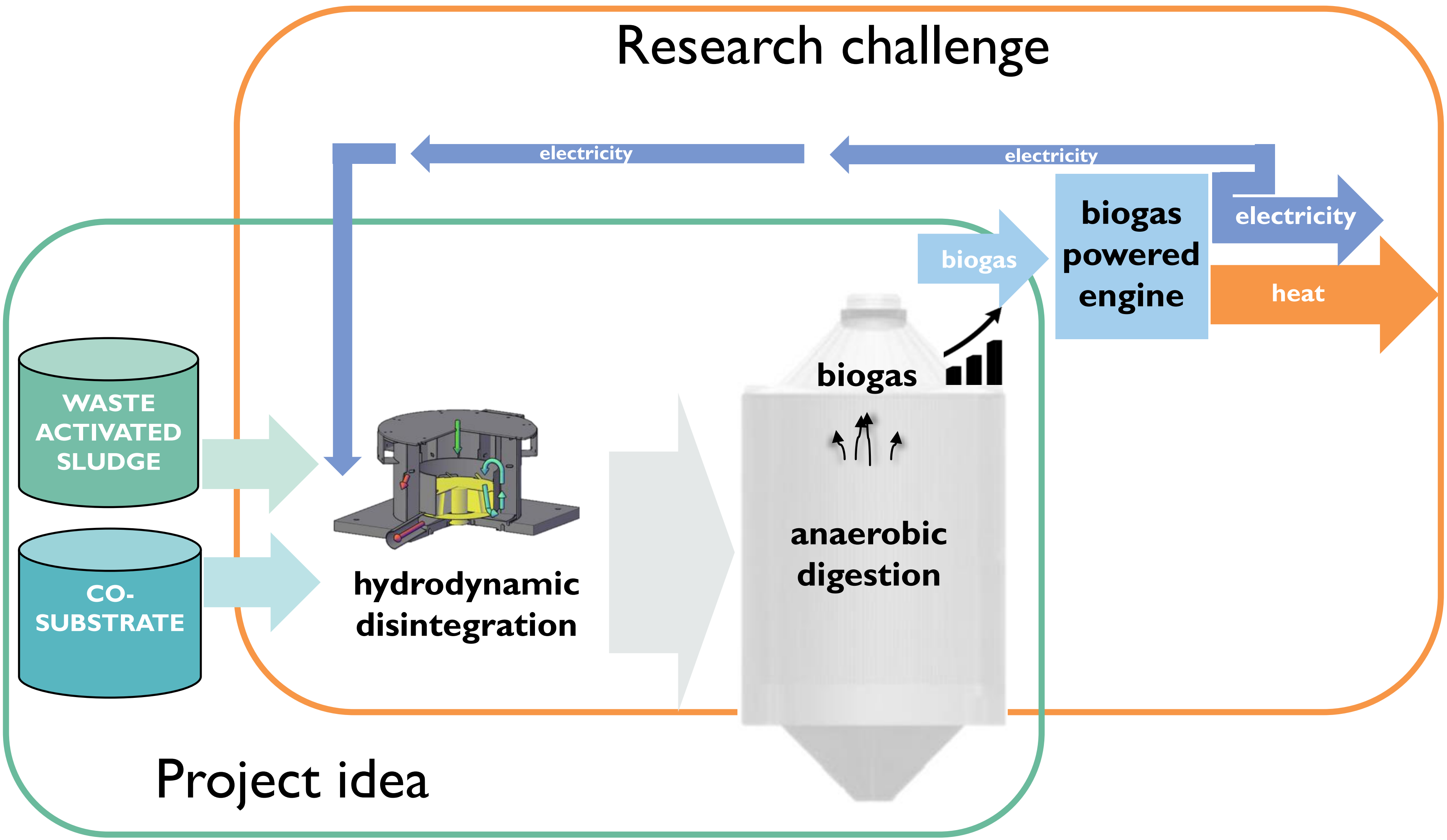
Received: 17 April 2020; Accepted: 12 May 2020; Published: 14 May 2020

check for updates

Abstract: The main purpose of this study was the assessment of the possibility of increasing the production of biogas through the pre-treatment of thickened excess sludge (TES) by means of the hydrodynamic cavitation (HC) conducted at different levels of energy density

…excess biogas obtained due to the disintegration process would allow for producing an amount of electricity higher than that used for pre-treatment method



„Development of a technology for preparation substrates used in methane co-fermentation by disintegration methods" (DEZMETAN) No.: POIR.04.01.02-00-0022/17

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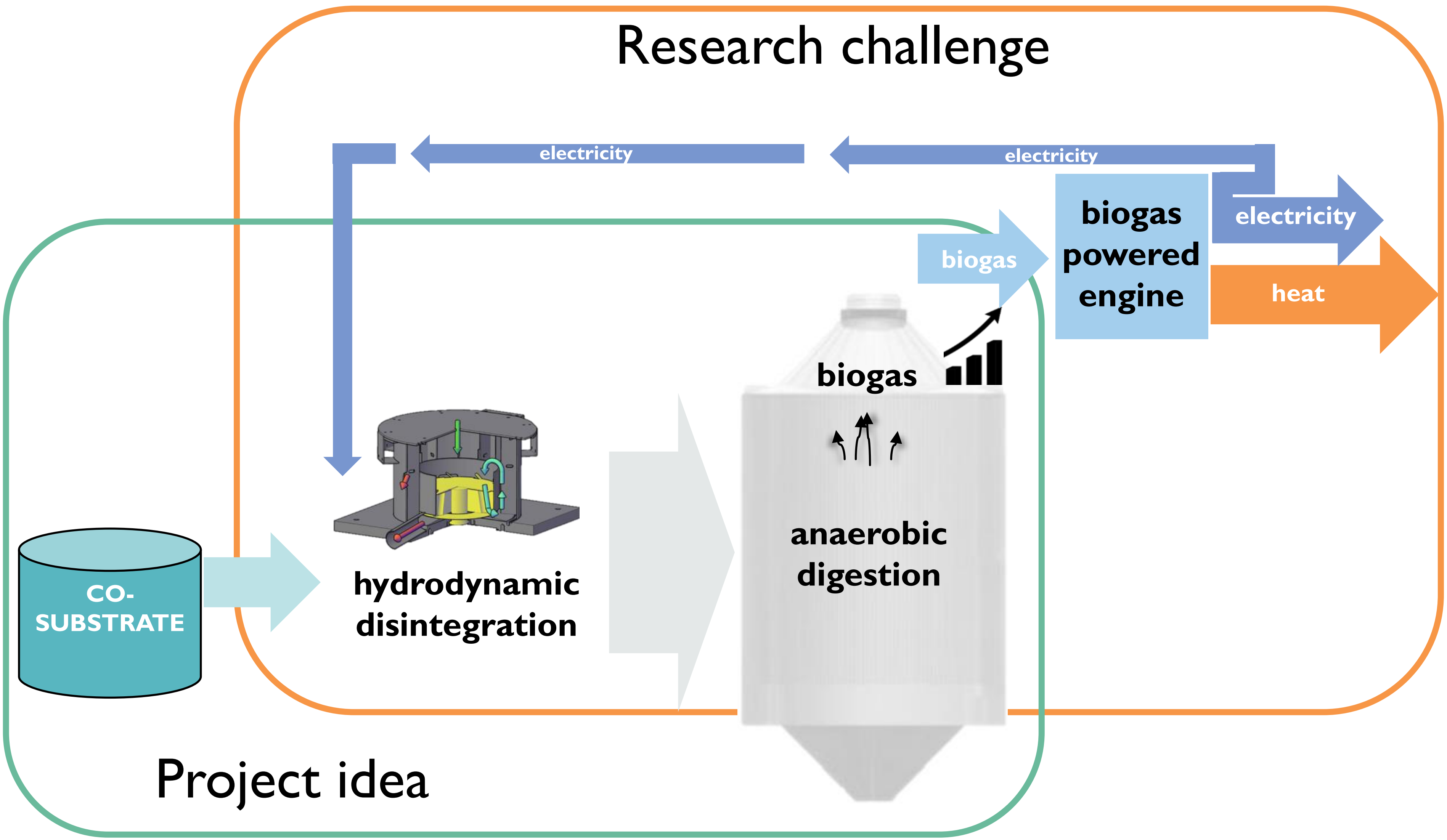

„Development of a technology for preparation substrates used in methane co-fermentation by disintegration methods"
(DEZMETAN) No.: POIR.04.01.02-00-0022/17

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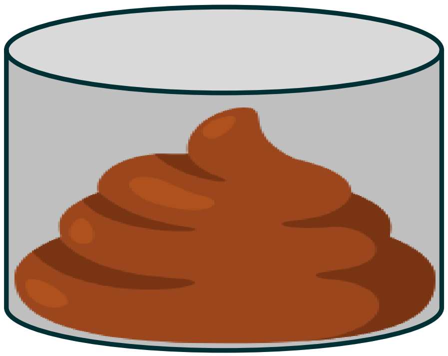
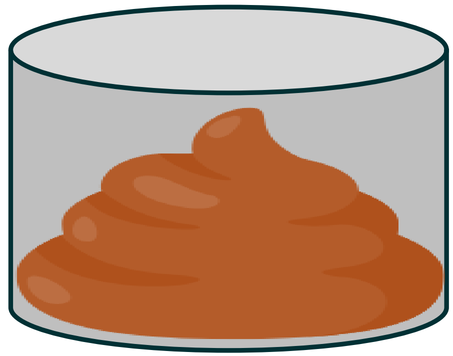
Unia Europejska Europejski Fundusz Rozwoju Regionalnego

AIM

Analysis of the possibility of increasing the methane potential of selected co-substrates and obtaining a positive energy balance via hydrodynamic disintegration pre-treatment.

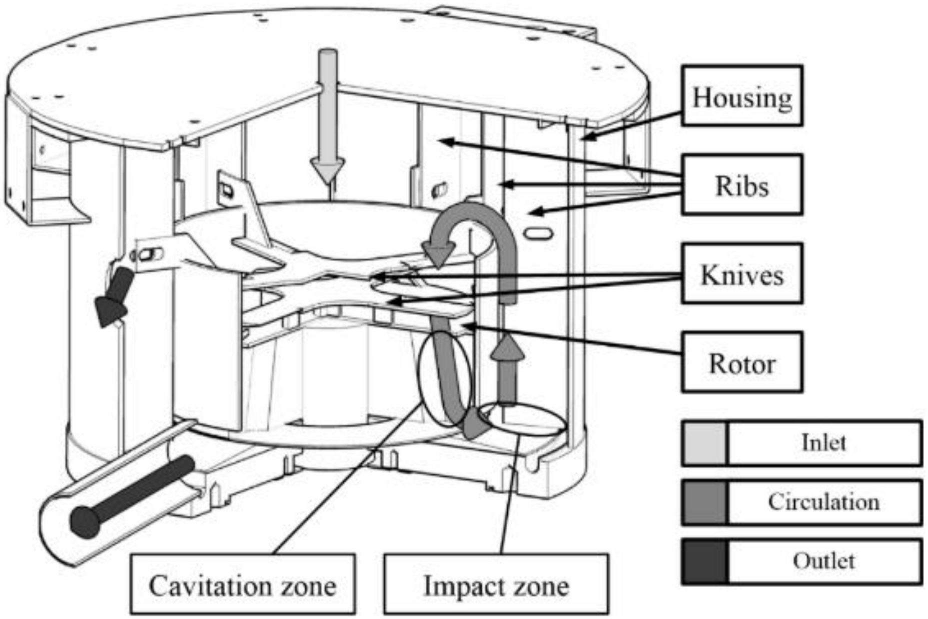
METODS

CO-SUBSTRATE

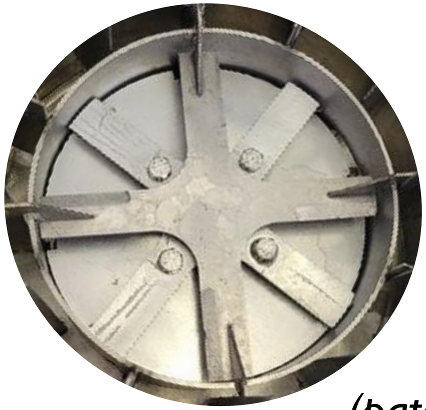
Cow manure CM **TS = 6.91 – 8.21 %**	**Pig manure PM** **TS = 2.87 - 10.8 %**	**Maize silage MS** **TS = 8.72 – 10.9 %**
		
Remains of fruits RF **TS = 22.7 – 30.9 %**	**Beetroot pulp BP** **TS = 9. 16 – 19.4 %**	**Beetroot pulp in the form of pellets BPP** **TS = 87.6 – 94.0 %**
		

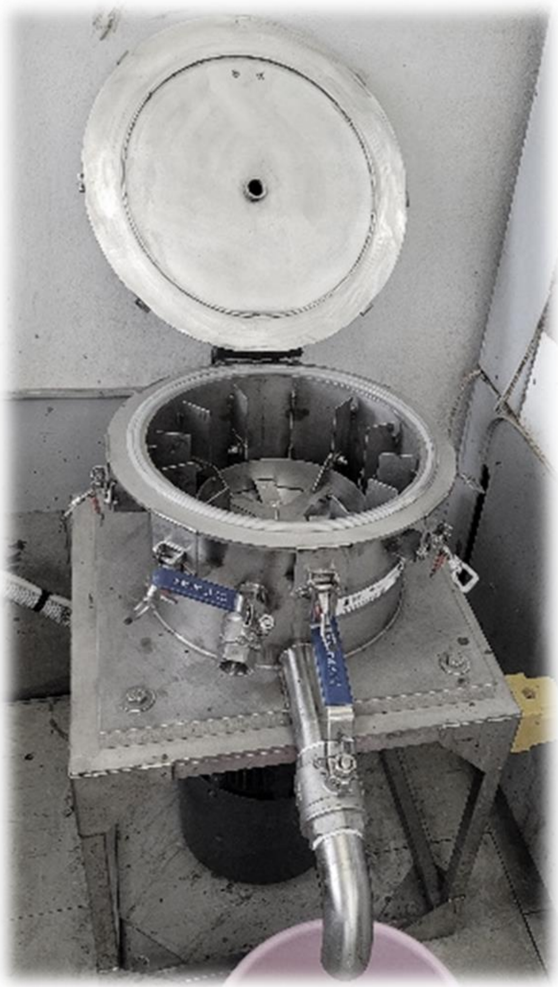
HYDRODYNAMIC DISINTEGRATION

Disintegration apparatus

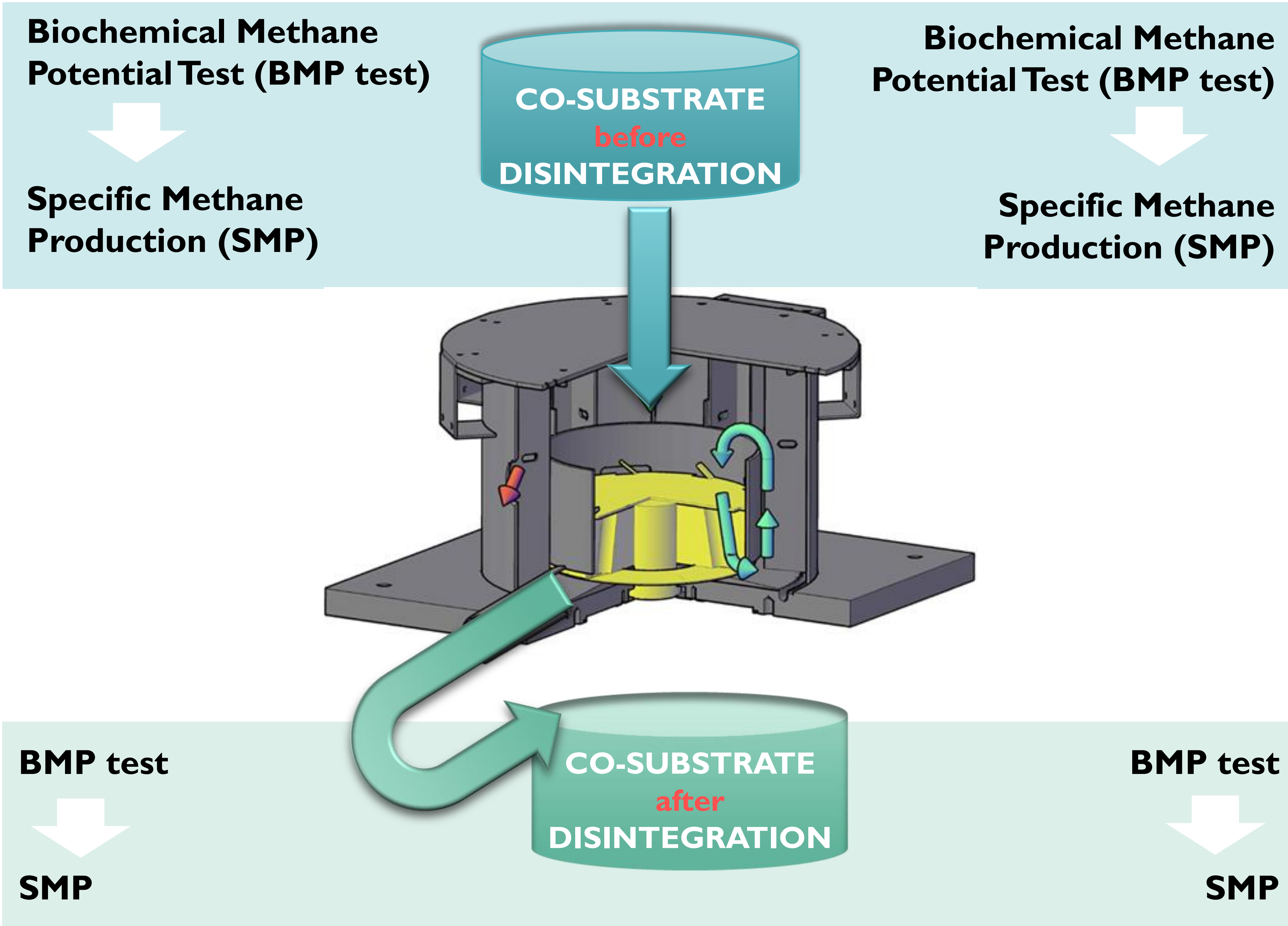


- Motor power: 5.5 kW
- Rotor revolution: 3000/min
- Volume of tank: 13 L





hydrodynamic disintegrator
(patent application WP-84/JW 13766118)


Biochemical Methane Potential Test (BMP test)
Specific Methane Production (SMP)
CO-SUBSTRATE
before
DISINTEGRATION
Biochemical Methane Potential Test (BMP test)
Specific Methane Production (SMP)
BMP test
SMP
CO-SUBSTRATE
after
DISINTEGRATION
BMP test
SMP

diluted to TS ≈ 5 % (MS, RF, BP, BPP)

Biochemical Methane Potential Test (BMP test)

⇩

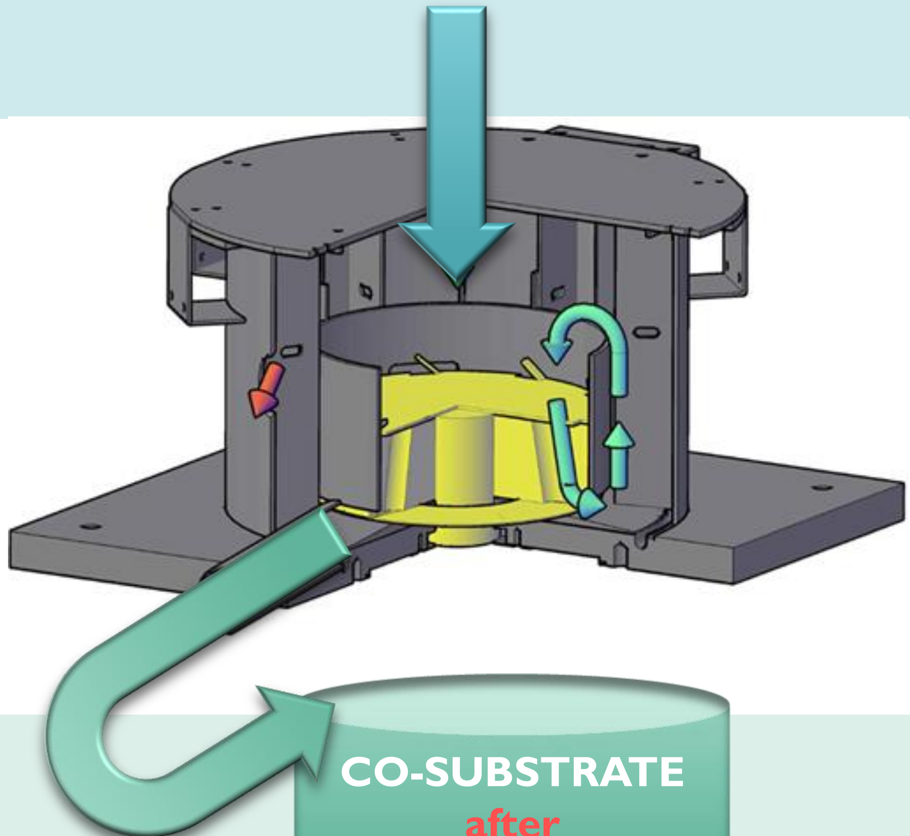
Specific Methane Production (SMP)

CO-SUBSTRATE before DISINTEGRATION

Biochemical Methane Potential Test (BMP test)

⇩

Specific Methane Production (SMP)



BMP test

⇩

SMP

CO-SUBSTRATE after DISINTEGRATION

BMP test

⇩

SMP

diluted to TS ≈ 5 % (MS, RF, BP, BPP)

Biochemical Methane Potential Test (BMP test)

⇓

Specific Methane Production (SMP)

CO-SUBSTRATE before DISINTEGRATION

Biochemical Methane Potential Test (BMP test)

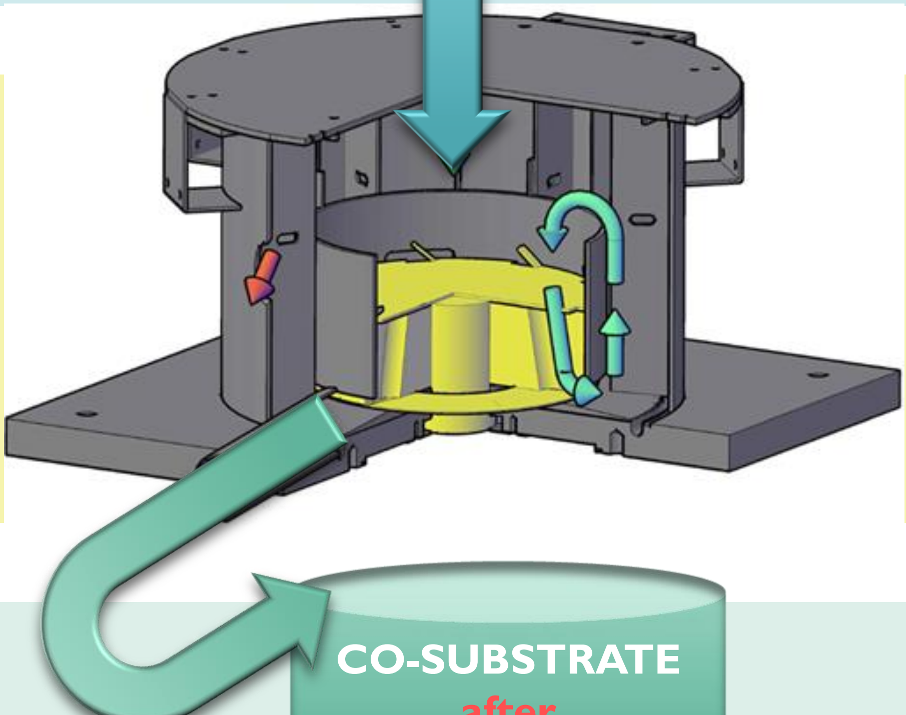
⇓

Specific Methane Production (SMP)

SERIES 1

Energy density ε_L:

35 – 140 kJ/L



SERIES 2

Energy density ε_L:

10 – 35 kJ/L

BMP test

⇓

SMP

CO-SUBSTRATE after DISINTEGRATION

BMP test

⇓

SMP

Biochemical methane potential tests (BMP)

- constant temperature of 37°C
- initial organic loading rate 5 $gVTS_{\text{of introduced substrate}}/L$
- each assay was performed in three repetitions

Automatic Methane Potential Test System
(*AMPTS II - Bioprocess Control Sweden*)

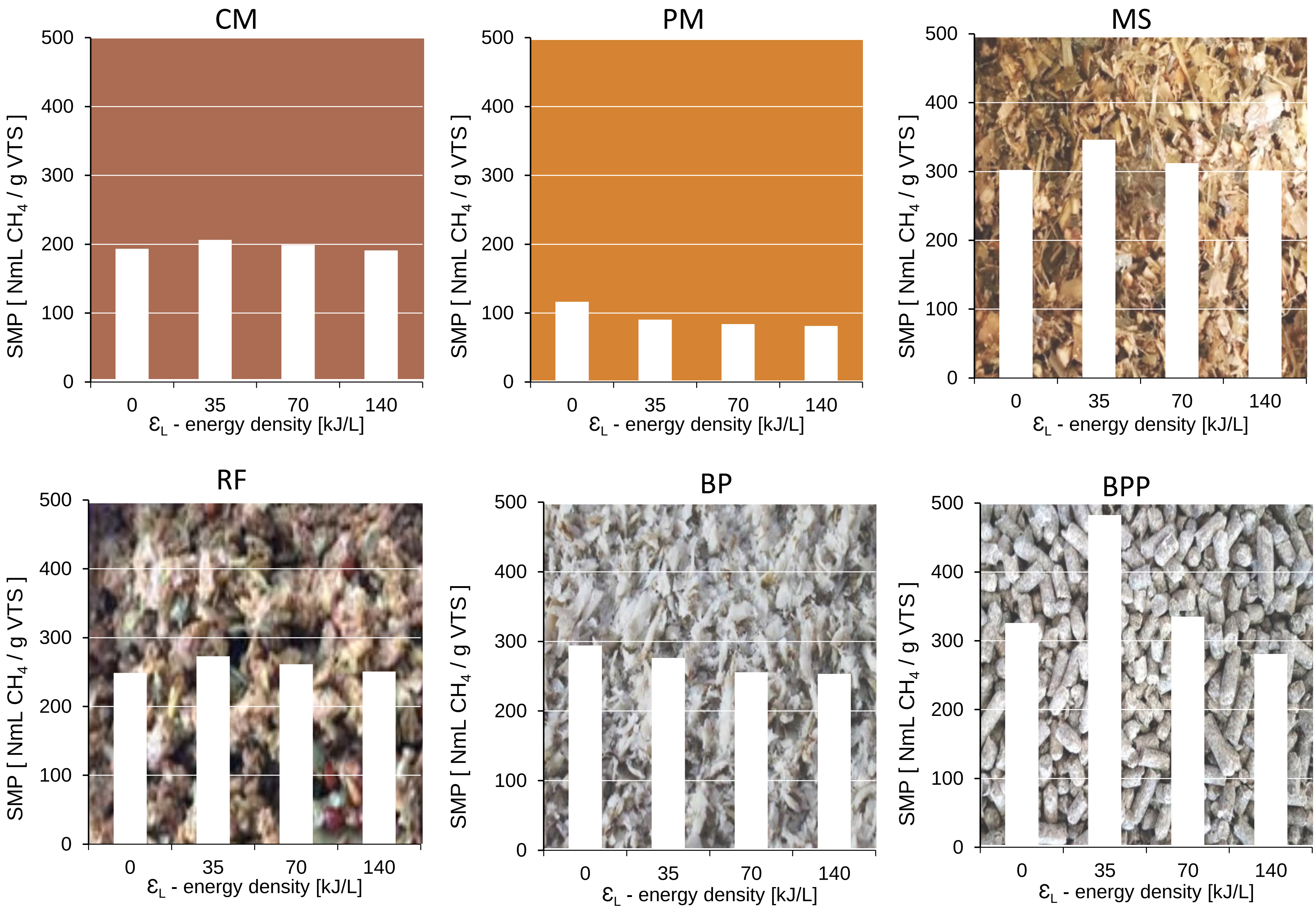
Specific Methane Production (SMP)

Holliger,C., Alves,M., Andrade,D., Angelidaki,I., Astals,S., Baier,U., Ebertseder,F. et al.: Towards a standardization of biomethane potential tests. Water Science and Technology 74(11), 2515-2522 (2016)

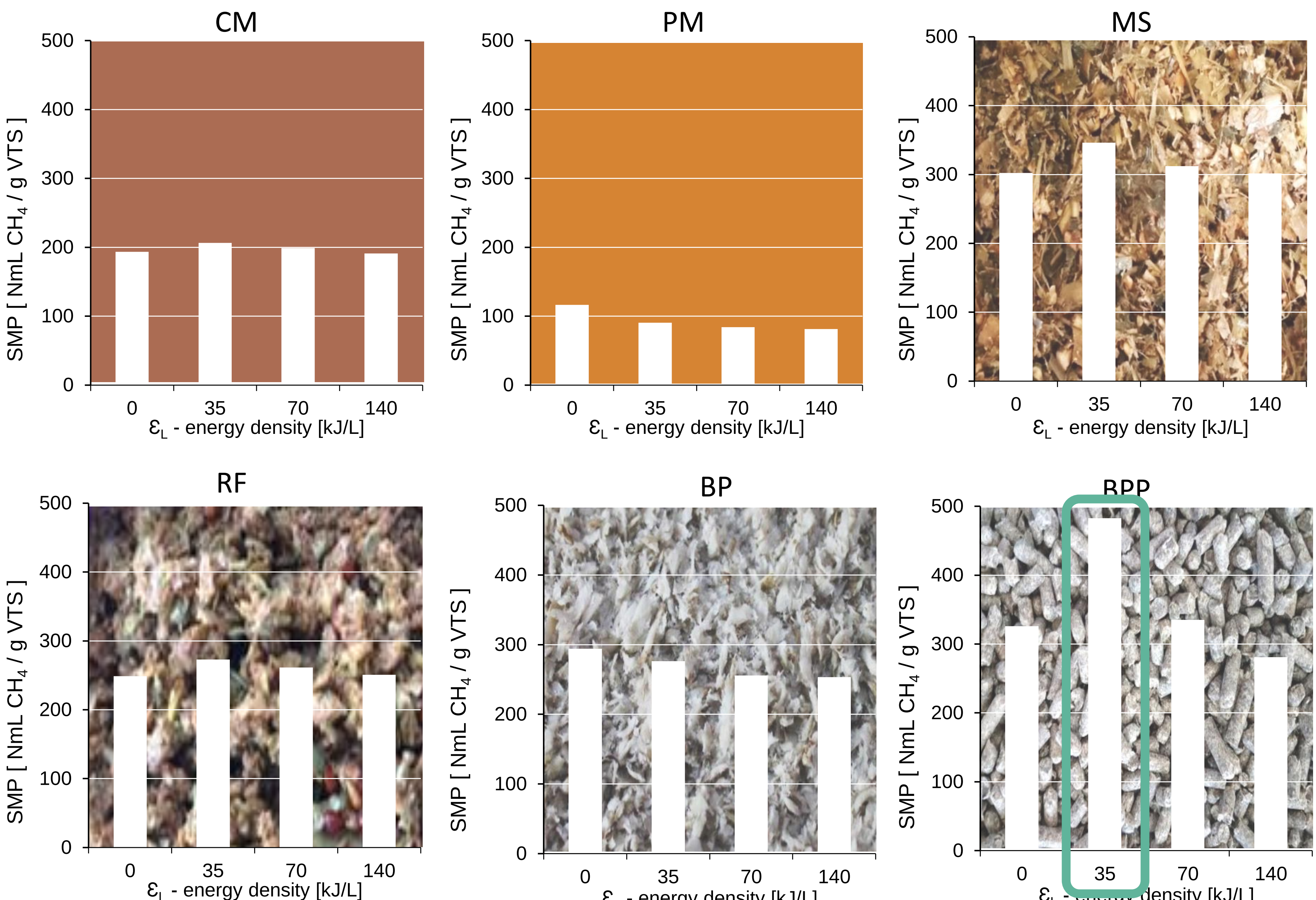
Zielinski M., Debowski M., Kisielewska M., Nowicka A., Rokicka M., Szwarc K.: Comparison of Ultrasonic and Hydrothermal Cavitation Pretreatments of Cattle Manure Mixed with Straw Wheat on Fermentative Biogas Production. Waste Biomass Valor 10, 747-754 (2019)

RESULTS

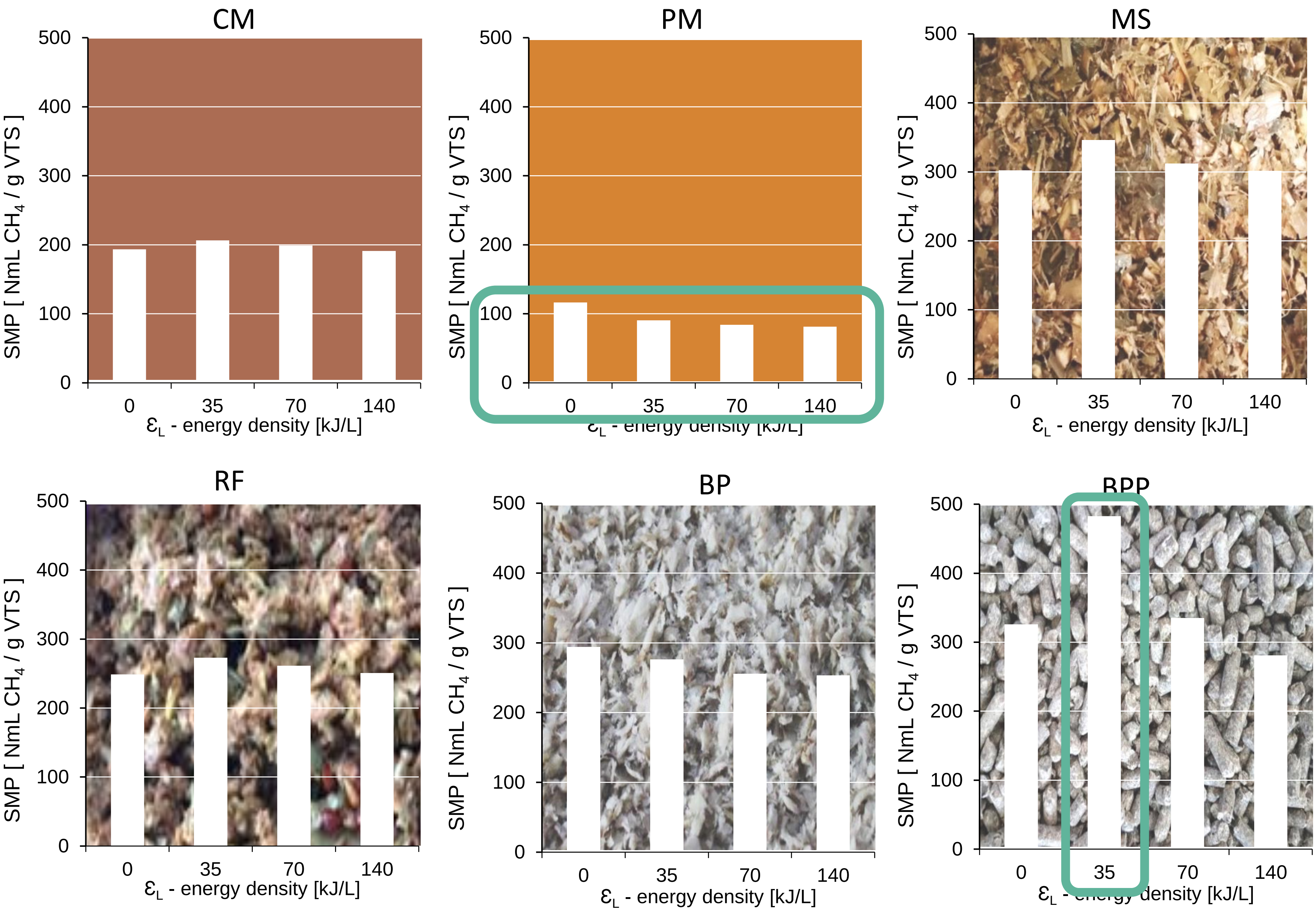
SPECIFIC METHANE PRODUCTION – SERIES I



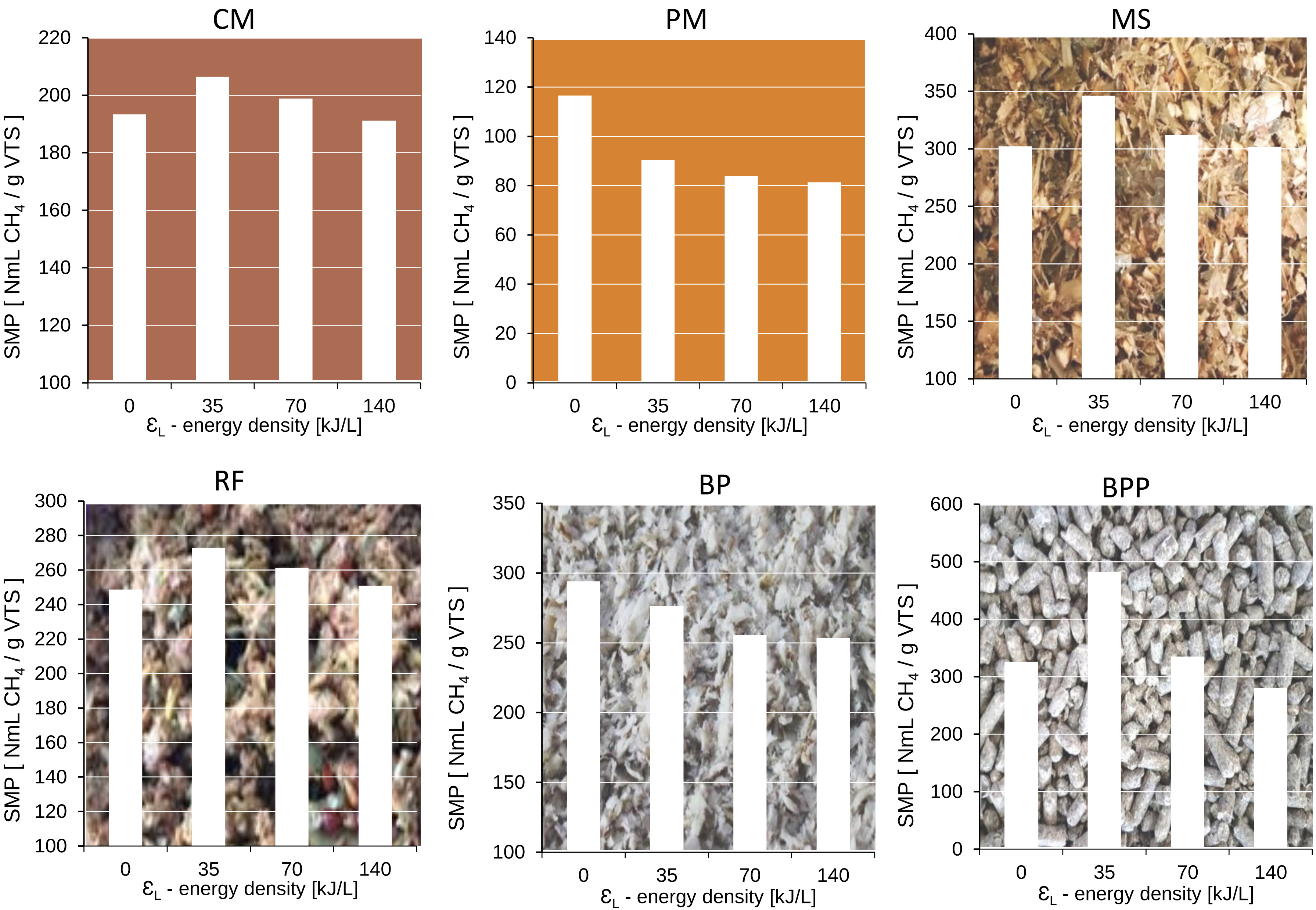
SPECIFIC METHANE PRODUCTION – SERIES 1



SPECIFIC METHANE PRODUCTION – SERIES 1



SPECIFIC METHANE PRODUCTION – SERIES I



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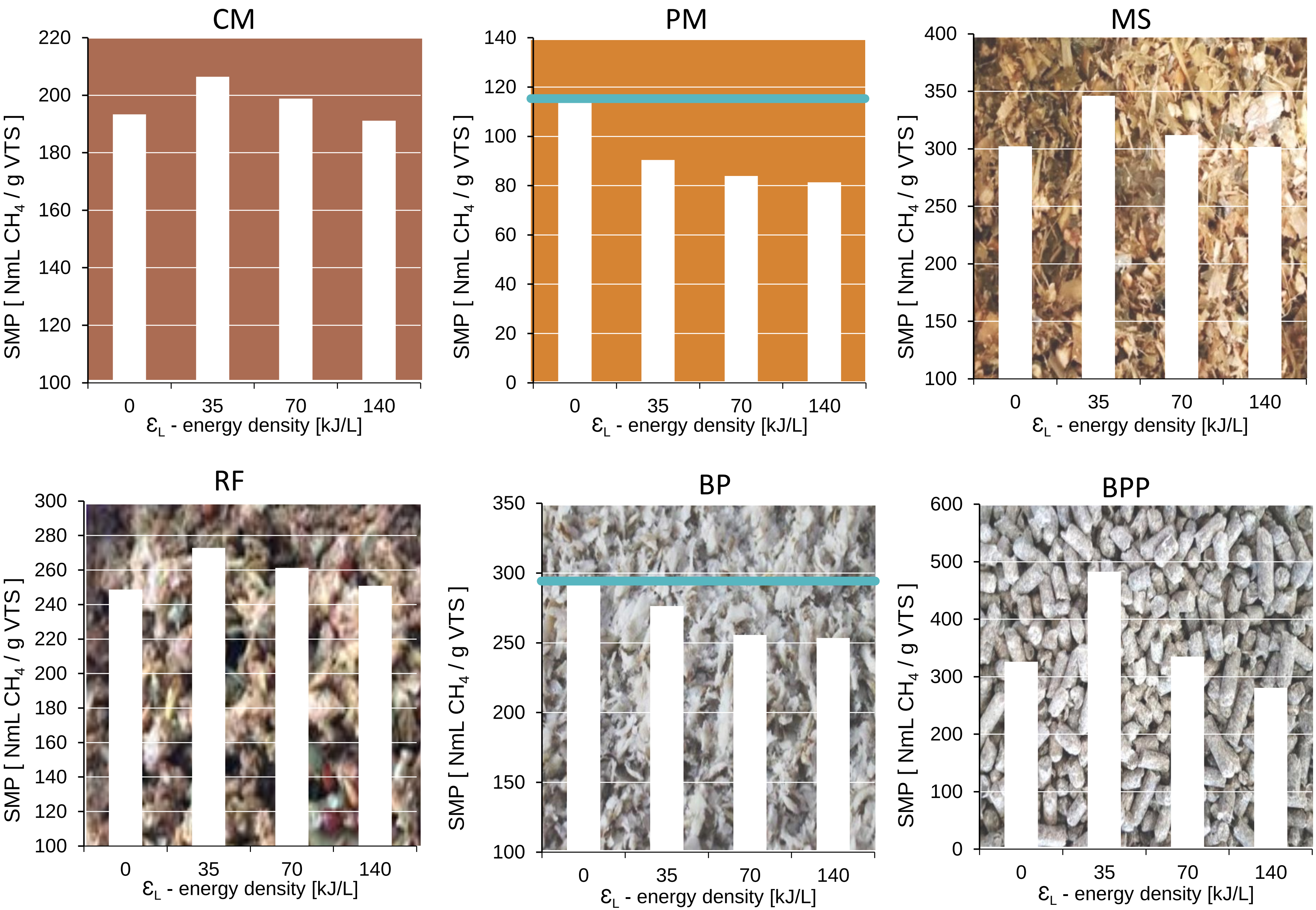

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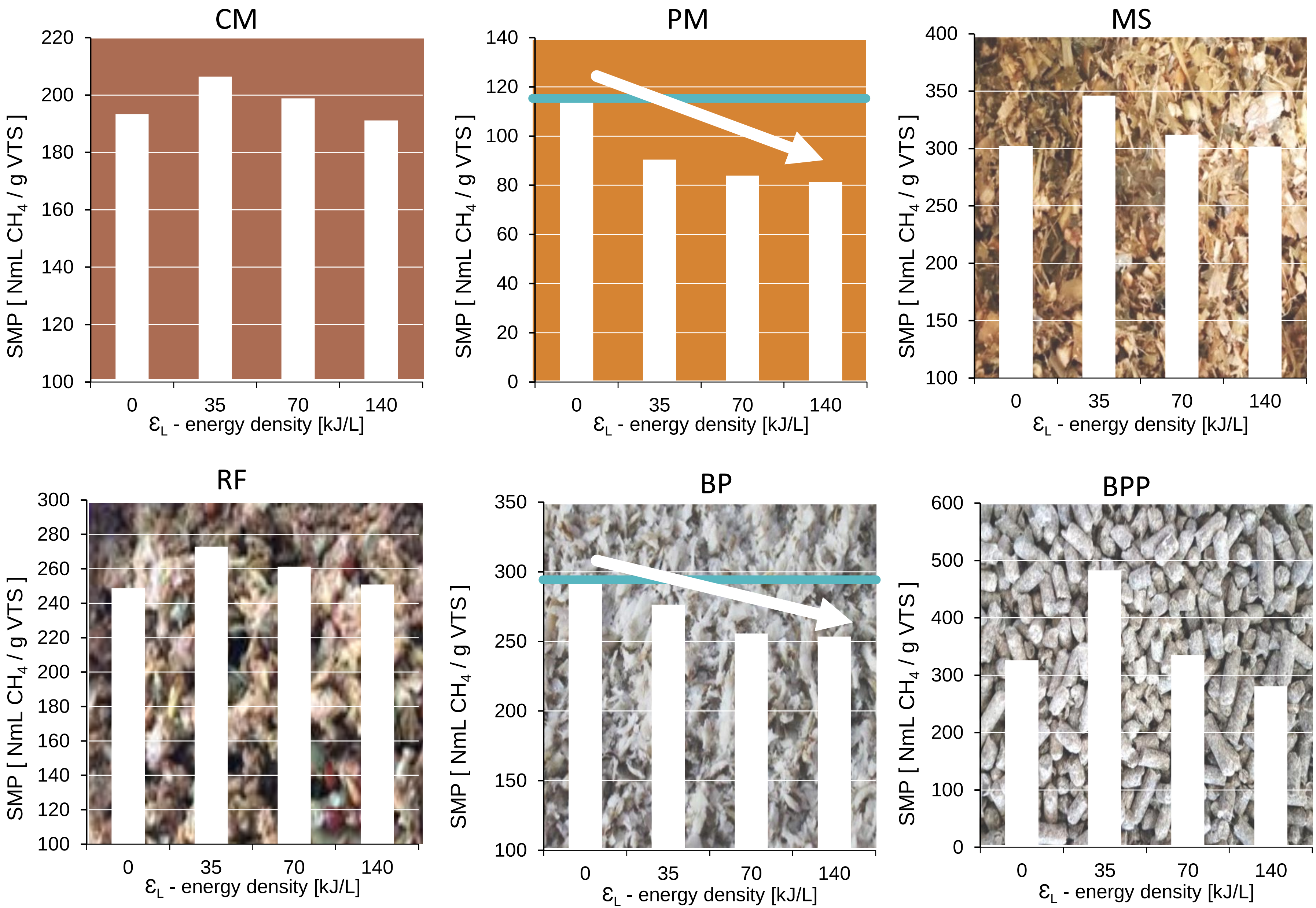

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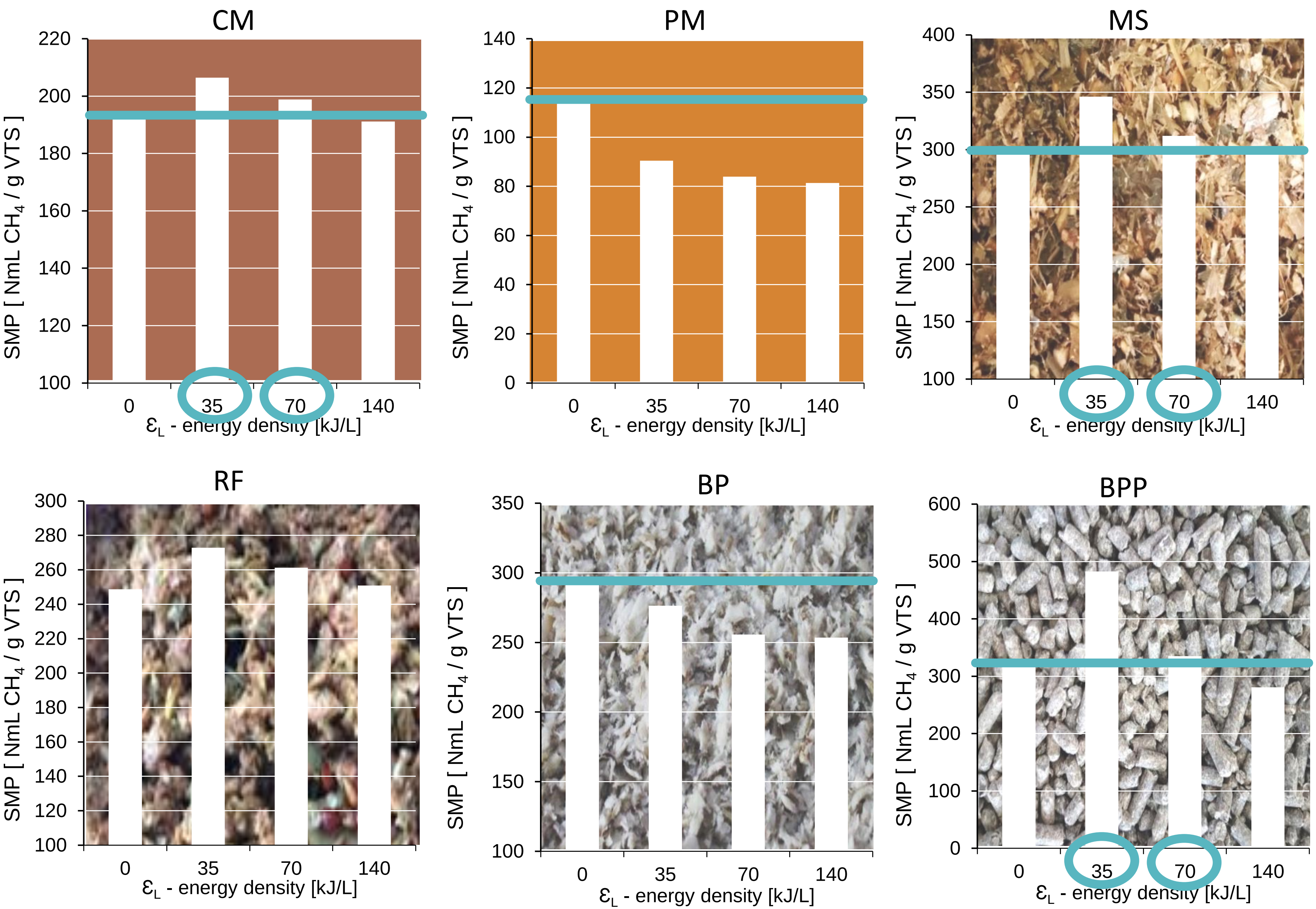

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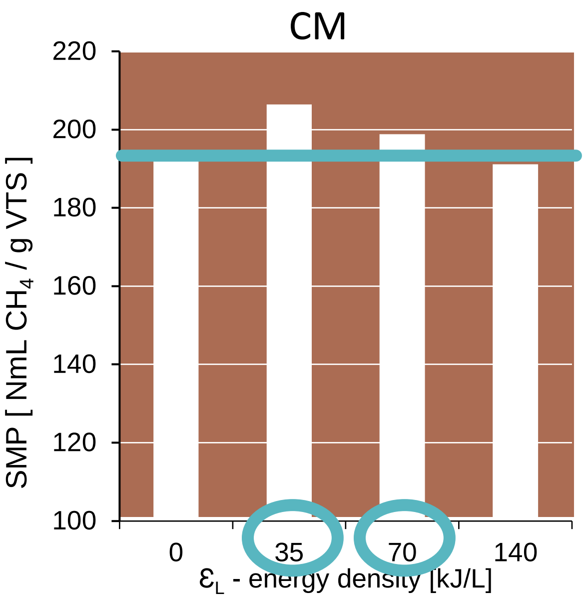

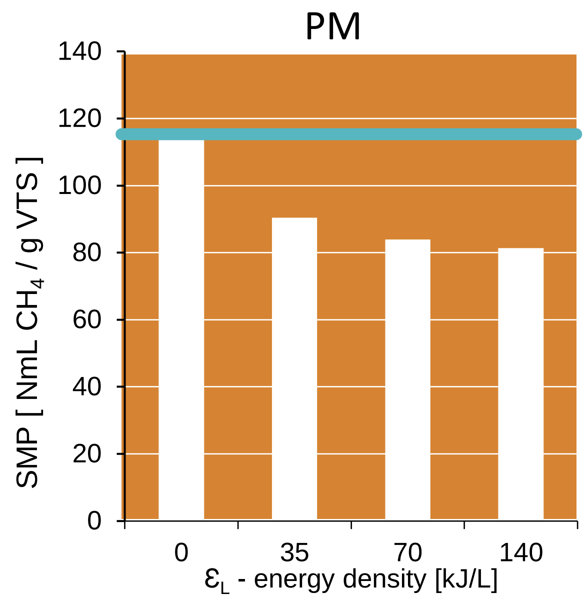

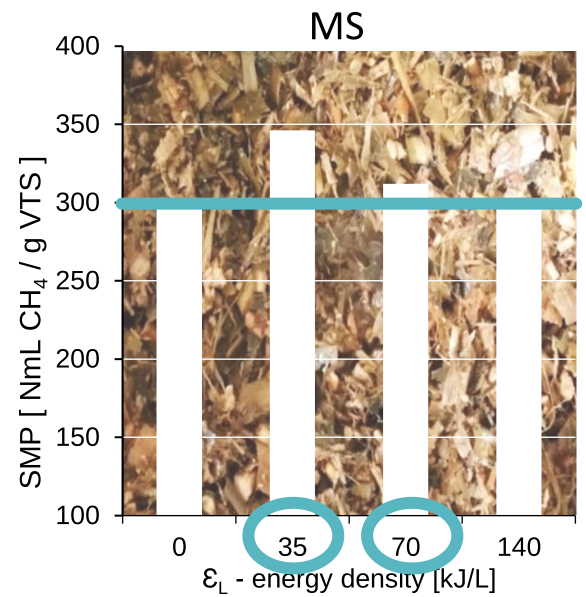

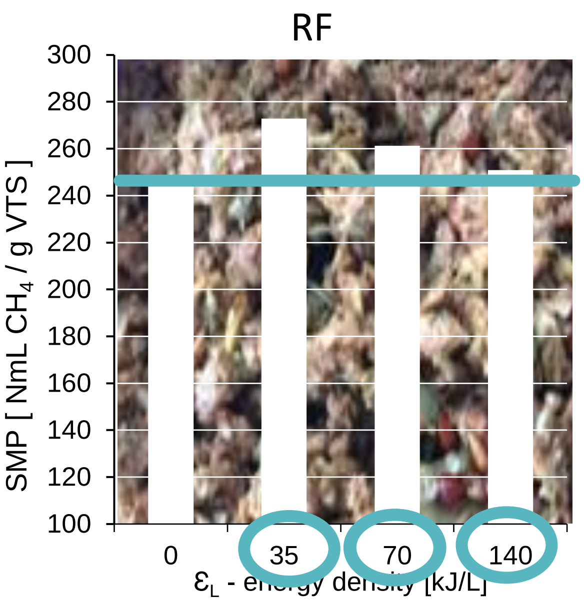

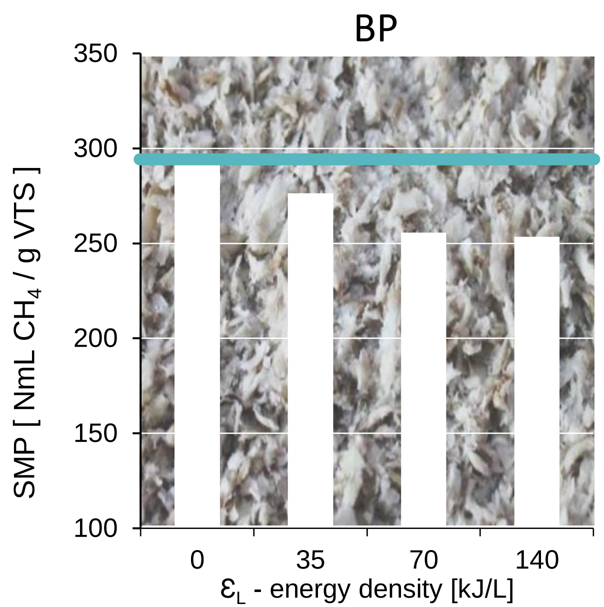

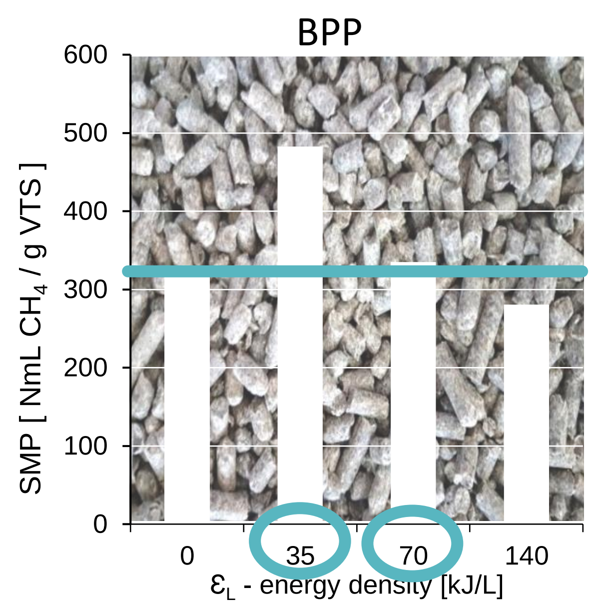

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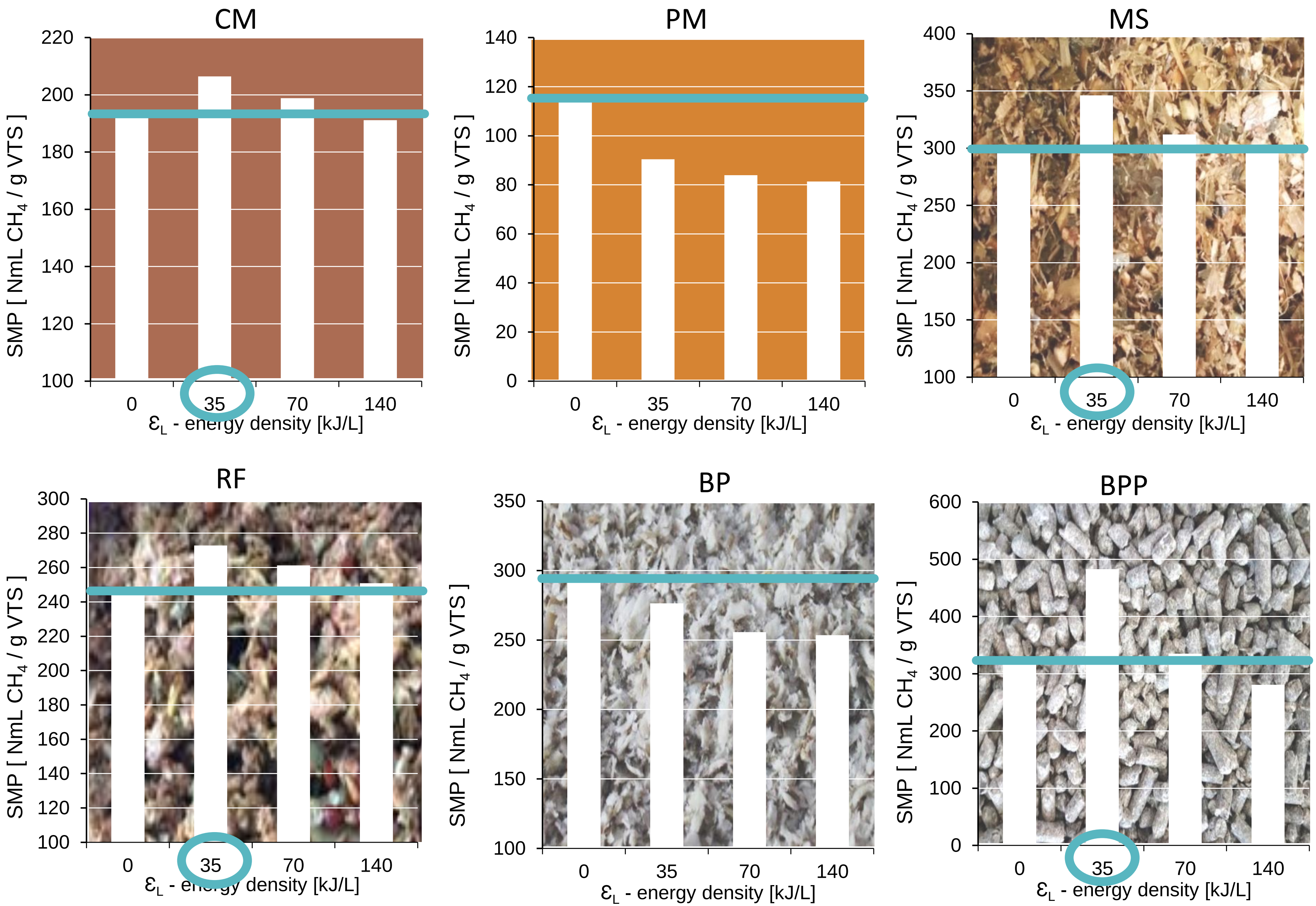
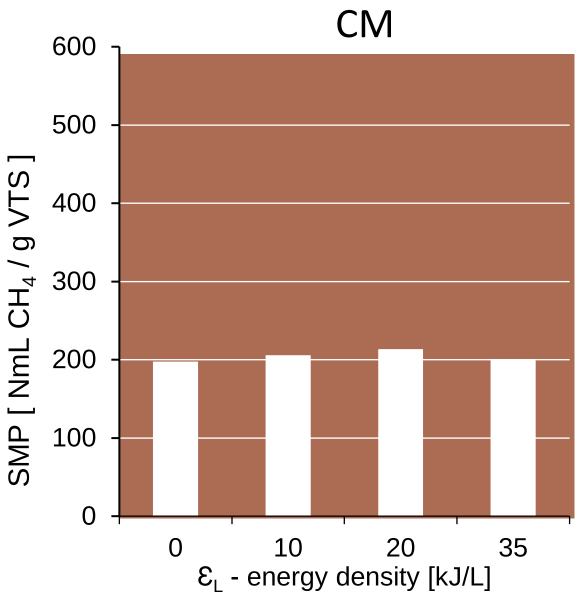
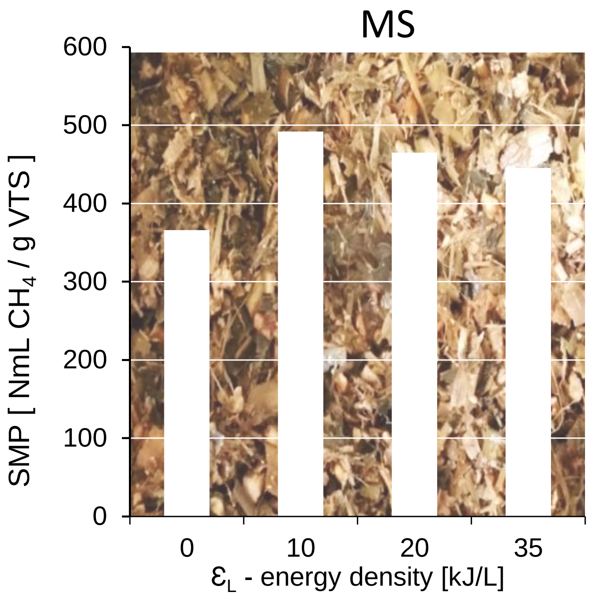
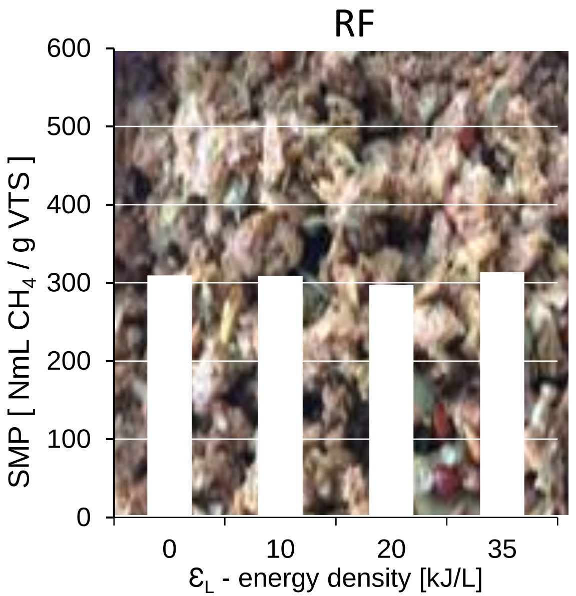
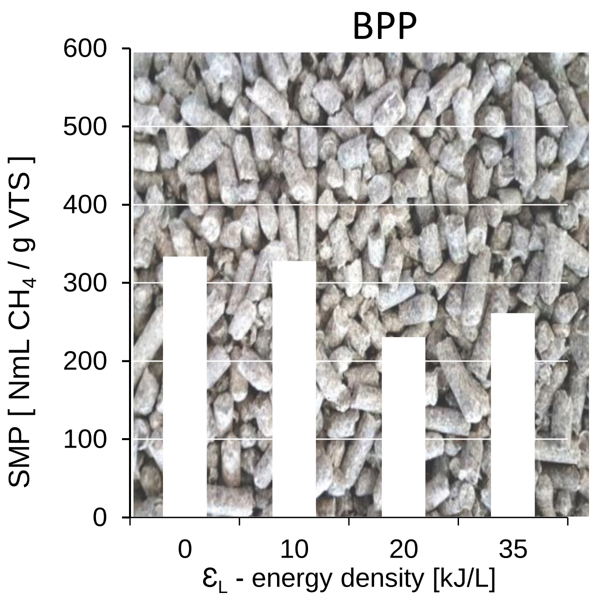


SPECIFIC METHANE PRODUCTION – SERIES 2

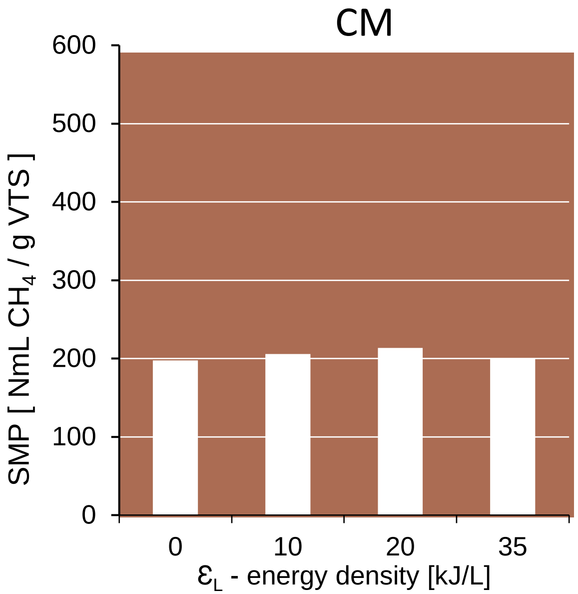


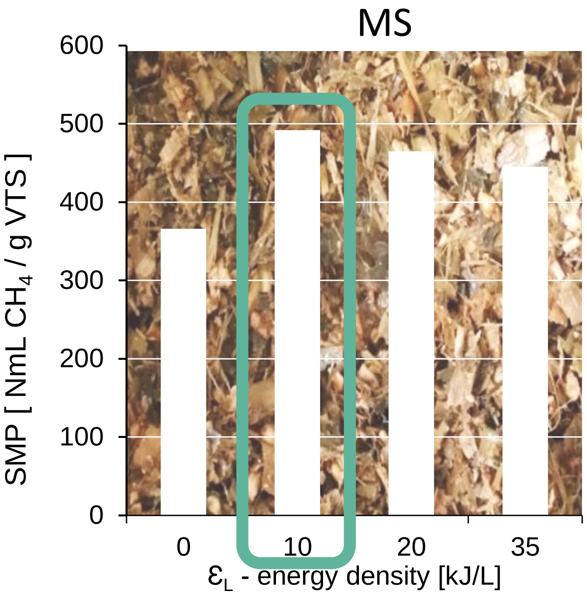


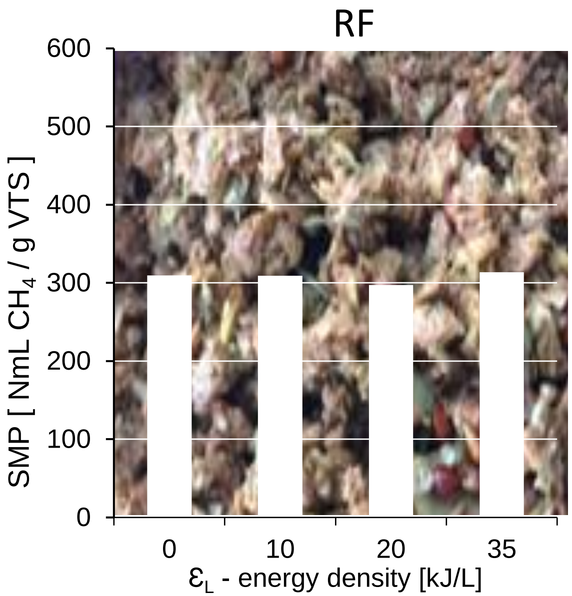


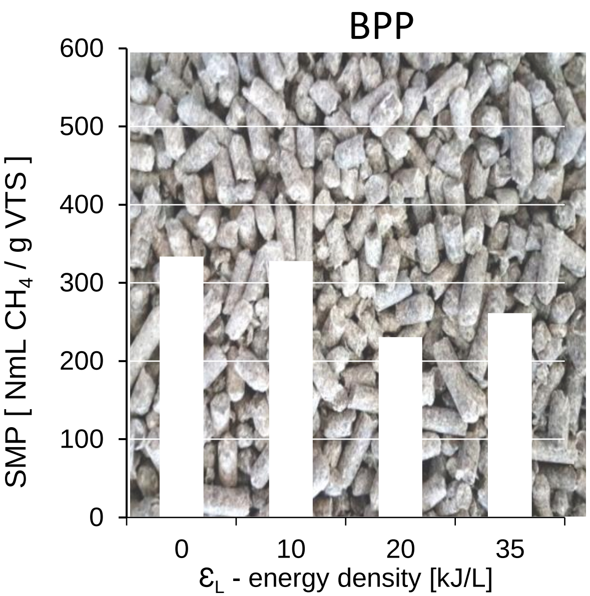


SPECIFIC METHANE PRODUCTION – SERIES 2

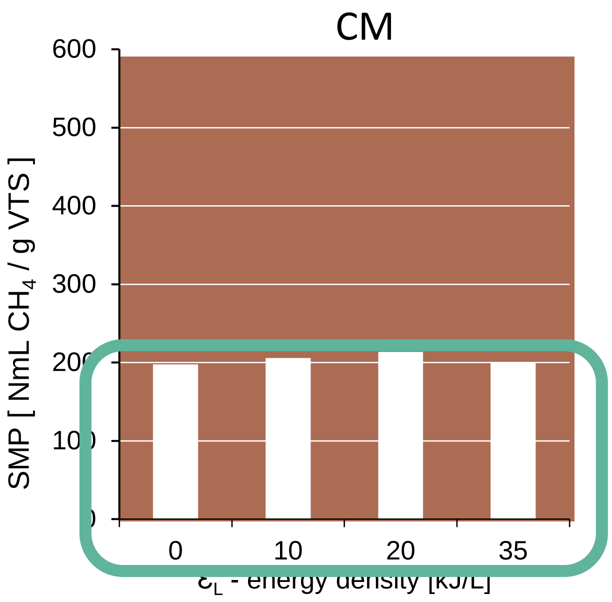


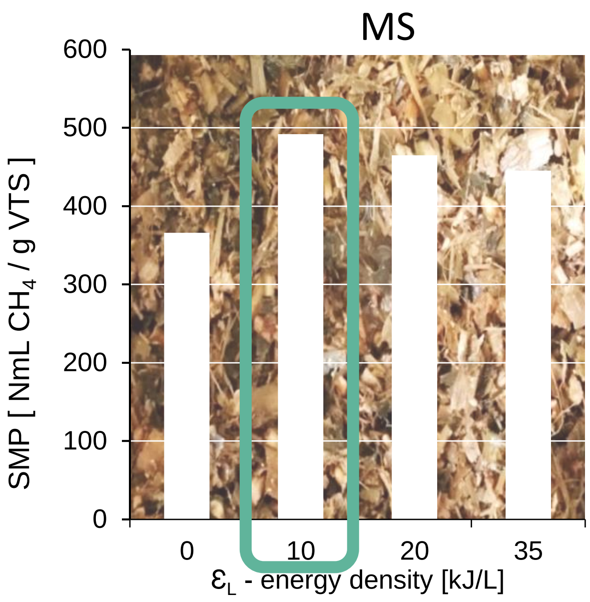


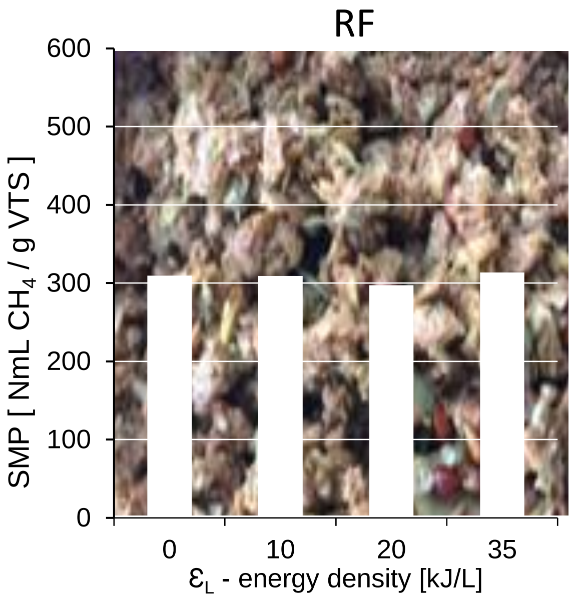


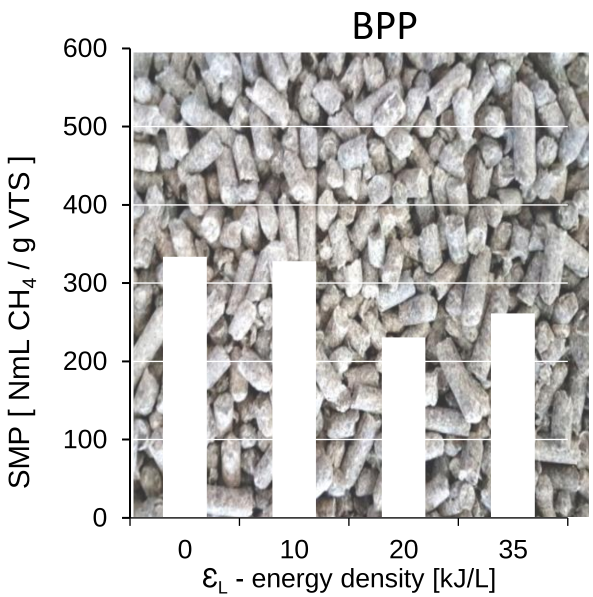


SPECIFIC METHANE PRODUCTION – SERIES 2

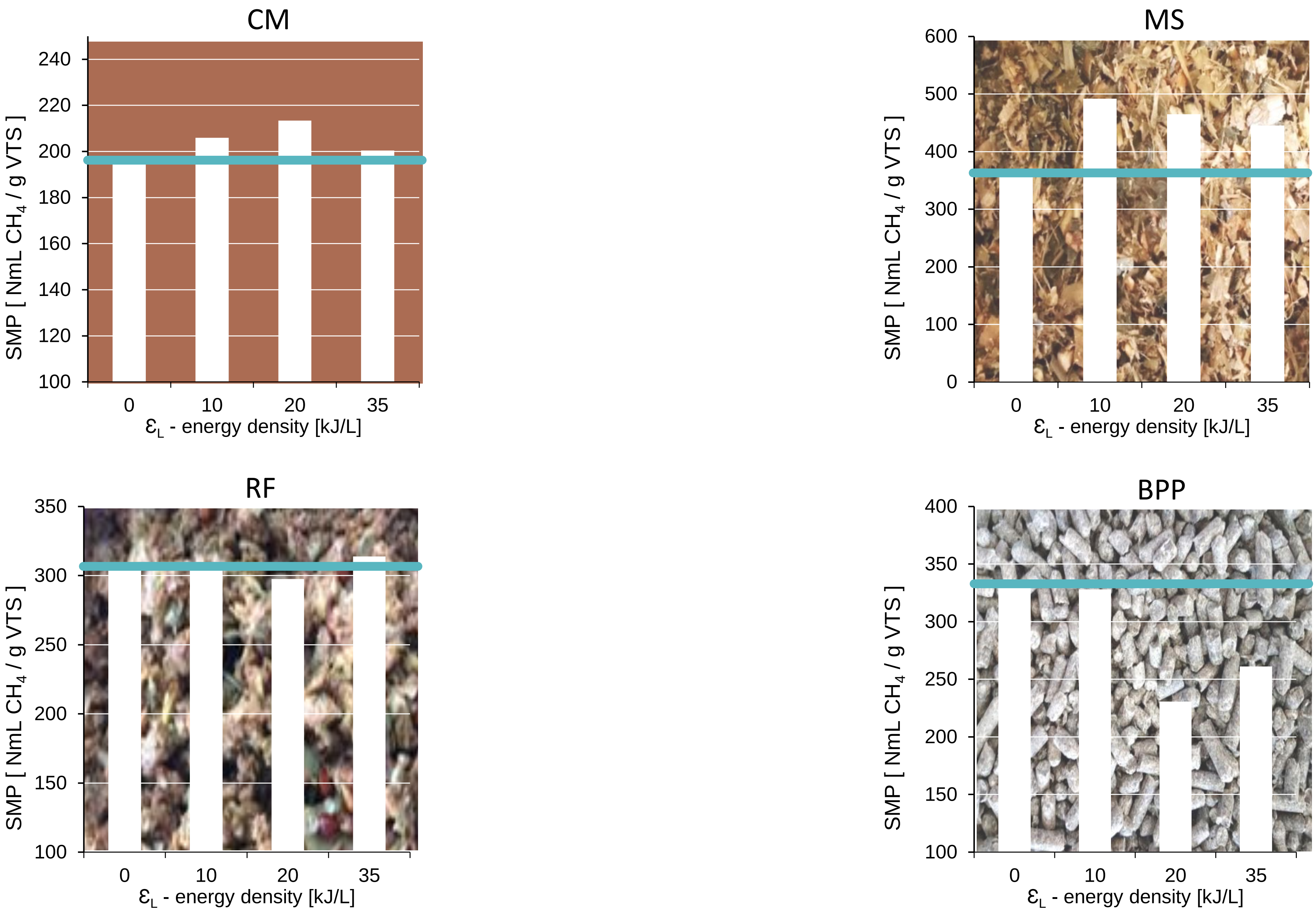




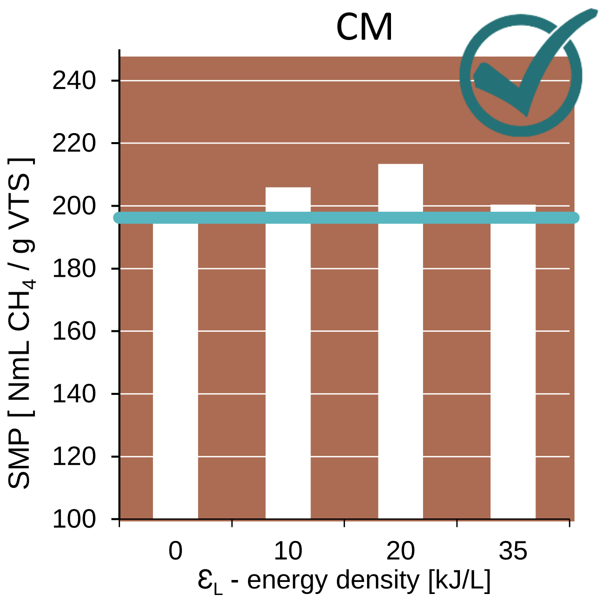


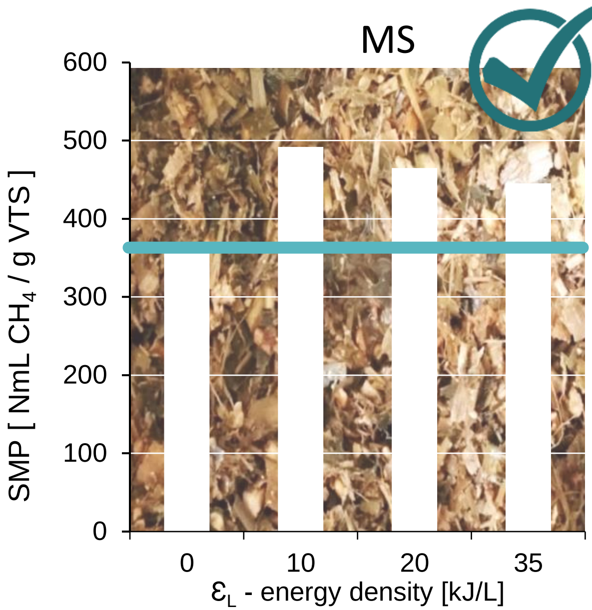


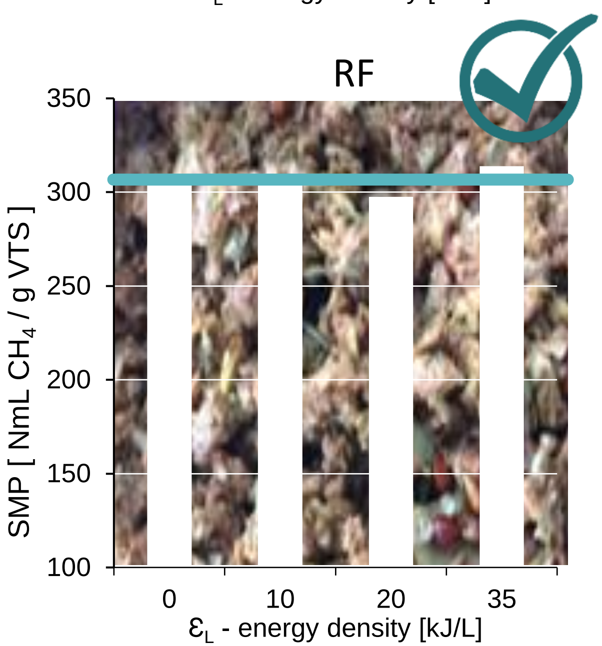
SPECIFIC METHANE PRODUCTION – SERIES 2

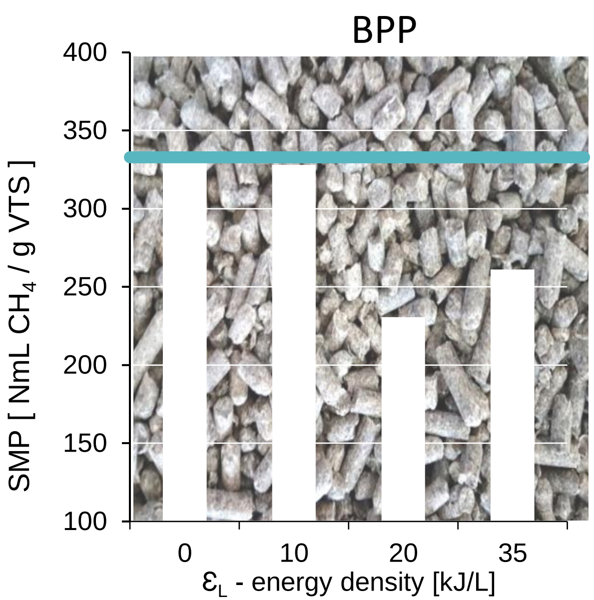


SPECIFIC METHANE PRODUCTION – SERIES 2

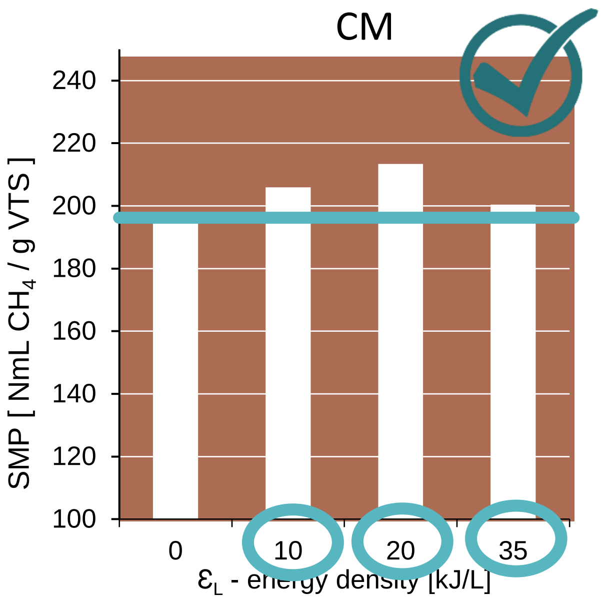


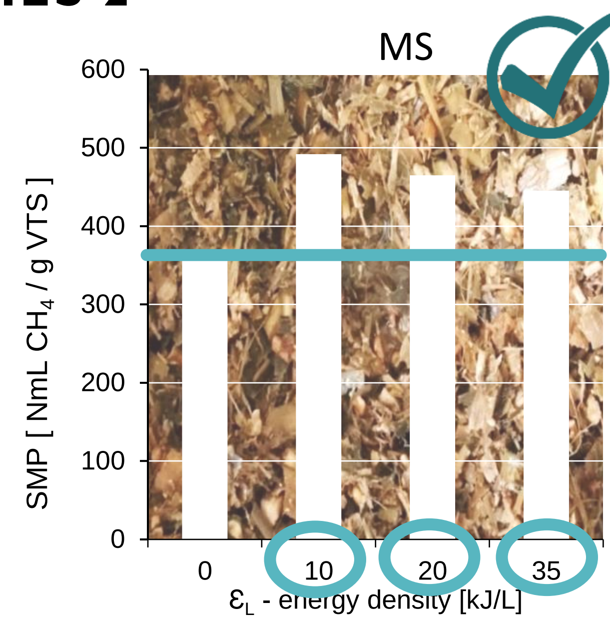


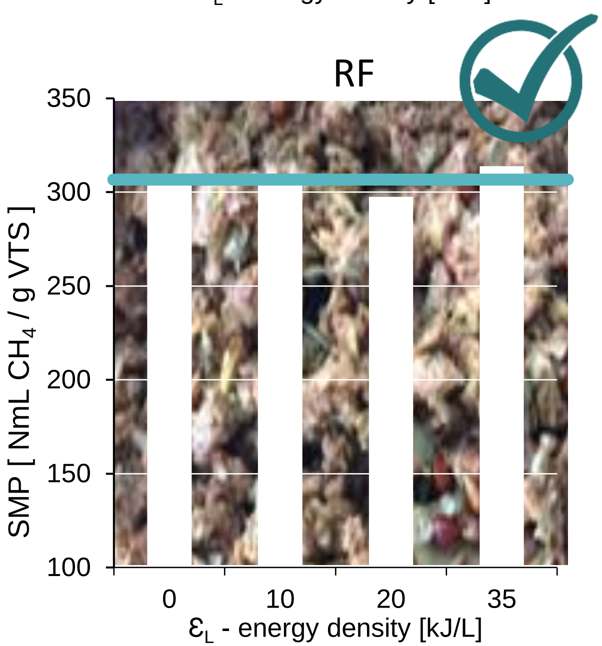


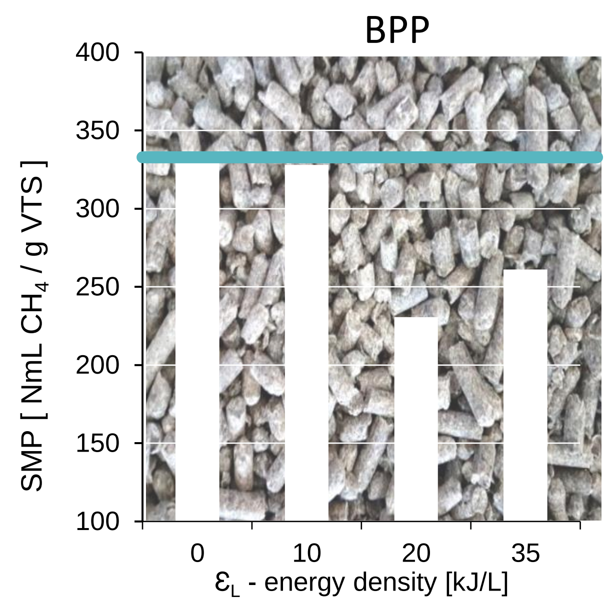


SPECIFIC METHANE PRODUCTION – SERIES 2

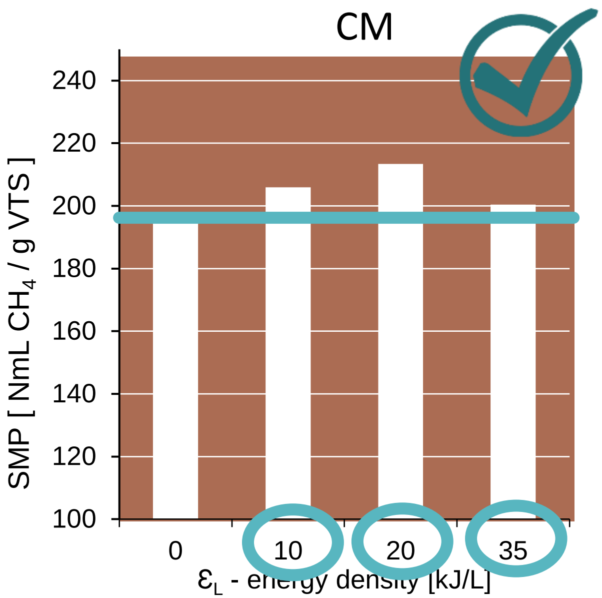


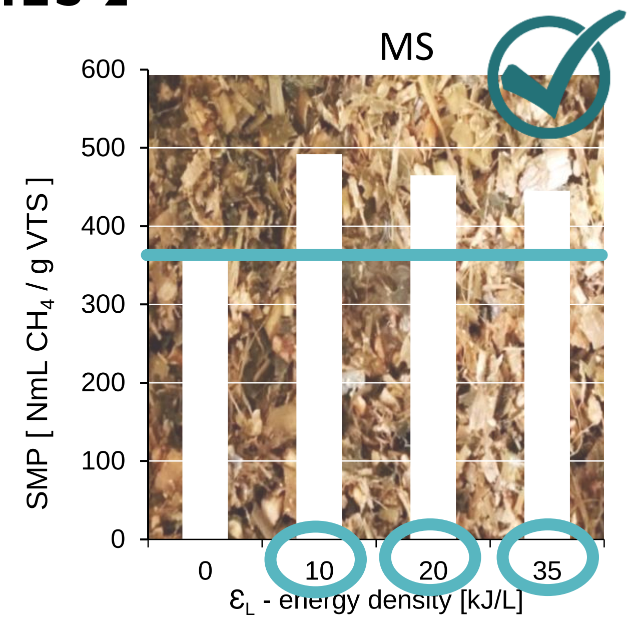


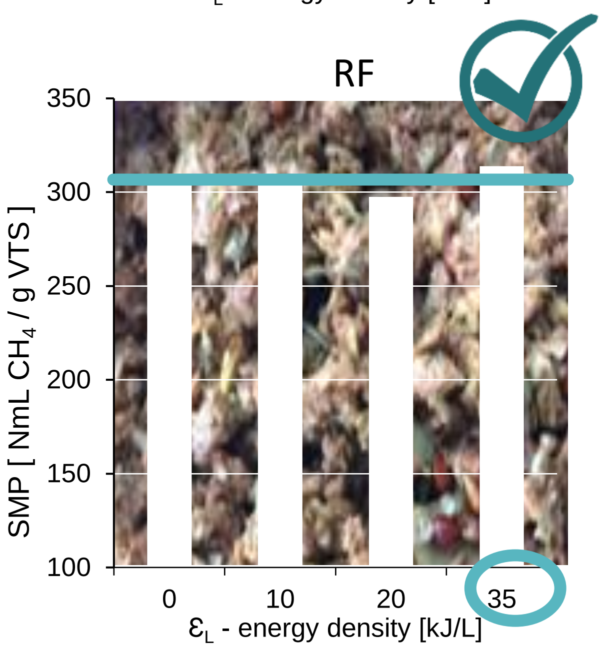


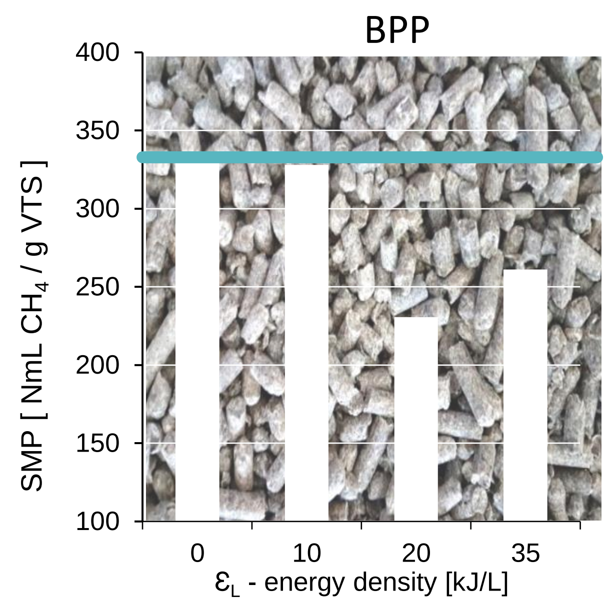


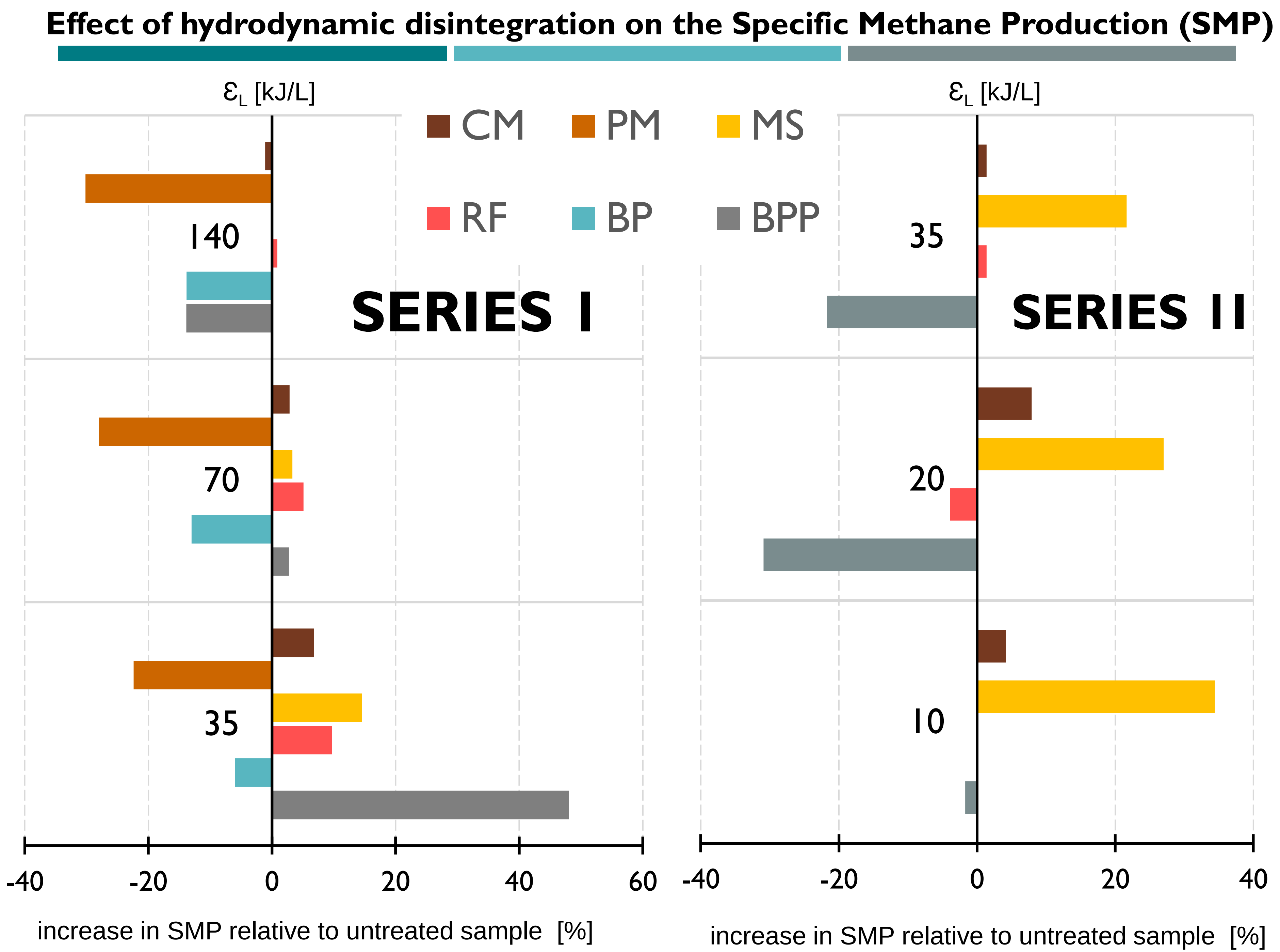
SPECIFIC METHANE PRODUCTION – SERIES 2



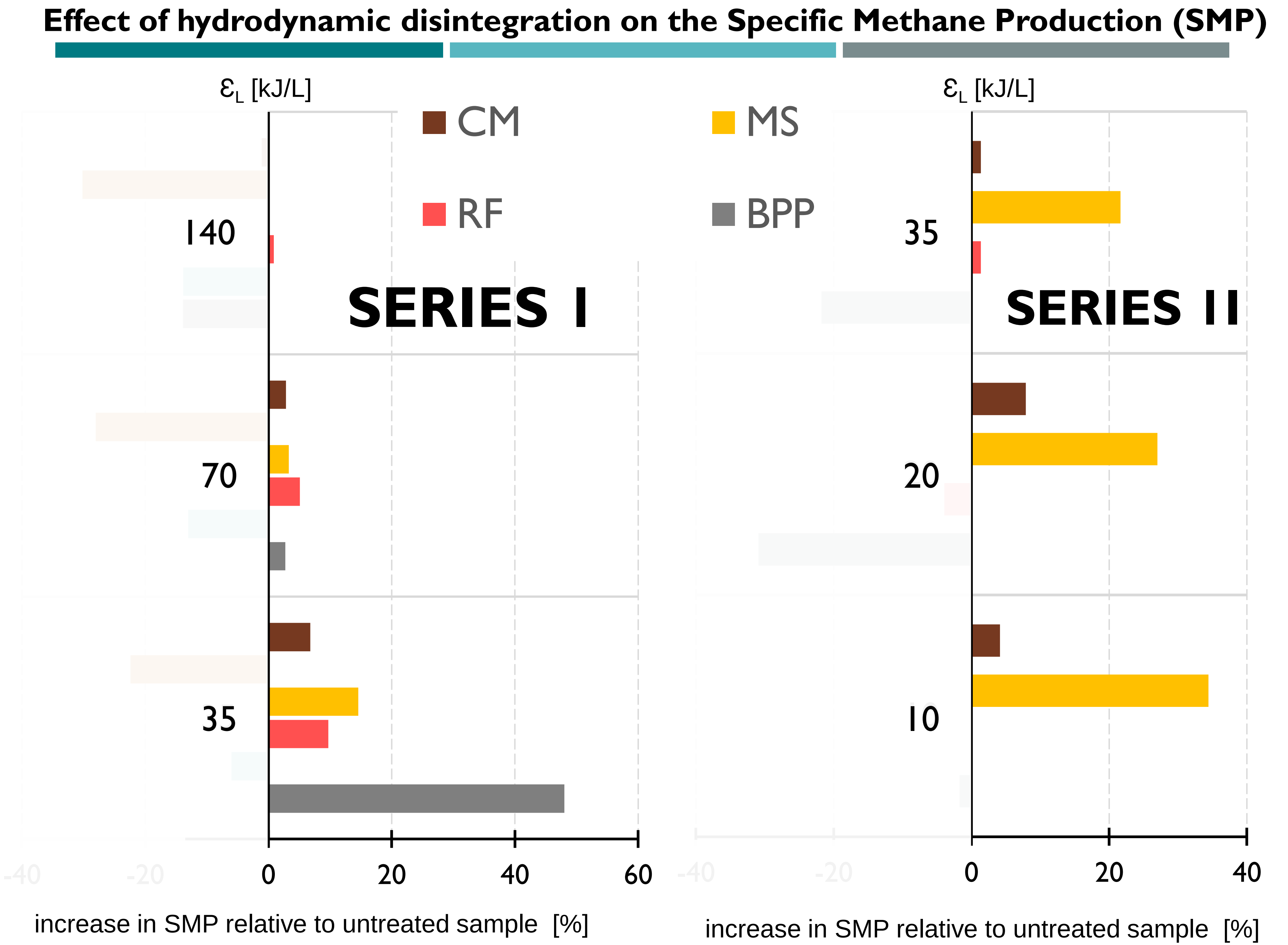








Effect of hydrodynamic disintegration on the Specific Methane Production (SMP)
ε_L [kJ/L]
CM
PM
MS
RF
BP
BPP
SERIES I
140
70
35
-40
-20
0
20
40
60
increase in SMP relative to untreated sample [%]
ε_L [kJ/L]
SERIES II
35
20
10
-40
-20
0
20
40
increase in SMP relative to untreated sample [%]



Effect of hydrodynamic disintegration on the Specific Methane Production (SMP)
ε_L [kJ/L]
CM
MS
RF
BPP
SERIES I
SERIES II
140
70
35
35
20
10
-40
-20
0
20
40
60
-40
-20
0
20
40
increase in SMP relative to untreated sample [%]
increase in SMP relative to untreated sample [%]

Energy balance

Parameter	unit	CM - Cow Manure								MS - Mazie Silage							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	3,86	4,10	3,95	3,79	3,95	4,11	4,25	3,99	3,12	3,45	3,11	3,00	7,29	9,81	9,27	8,87
Electricity[2]	Wh	1,54	1,64	1,58	1,51	1,58	1,64	1,70	1,60	1,25	1,38	1,25	1,20	2,92	3,92	3,71	3,55
Extra electricity[3]	Wh		0,10	0,04	-0,03		0,06	0,12	0,02		0,13	0,00	-0,04		1,01	0,79	0,63
Energy applied for HD	Wh		0,26	0,52	1,04		0,09	0,18	0,32		0,23	0,42			0,17	0,31	0,58
Net energy production	Wh		-0,16	-0,48			-0,03	-0,05	-0,30		-0,10	-0,42			0,84	0,48	0,05
Relative energy profit	%														599	253	108

Parameter	unit	RF - Remains of Fruits								BPP - Beetroot Pulp in the form of Pellets							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	2,48	2,70	2,63	2,52	6,12	6,17	5,92	6,25	6,51	9,61	6,65	5,60	6,65	6,66	4,60	5,21
Electricity[2]	Wh	0,99	1,08	1,05	1,01	2,45	2,47	2,37	2,50	2,60	3,84	2,66	2,24	2,66	2,66	1,84	2,08
Extra electricity[3]	Wh		0,09	0,06	0,02		0,02	-0,08	0,05		1,24	0,06	-0,36		0,00	-0,82	-0,58
Energy applied for HD	Wh		0,20	0,39	0,78		0,10		0,38		0,41	0,82					
Net energy production	Wh		-0,11	-0,33	-0,77		-0,09		-0,33		0,83	-0,76					
Relative energy profit	%										303						

[1]Methane energy content calculated by assuming methane calorific value equal to 36 MJ/m^3;
[2]Electricity calculated by assuming electrical efficiency of engine equal to 40%;
[3]Extra electricity = electricity dez.—electricity untreated, (Wh): Electricity dez., amount of electricity produced in a disintegrated sample at a predefined energy density level (Wh); Electricity untreated, amount of electricity produced in an untreated sample (Wh).

Energy balance

Parameter	unit	CM - Cow Manure								MS - Mazie Silage							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	3,86	4,10	3,95	3,79	3,95	4,11	4,25	3,99	3,12	3,45	3,11	3,00	7,29	9,81	9,27	8,87
Electricity[2]	Wh	1,54	1,64	1,58	1,51	1,58	1,64	1,70	1,60	1,25	1,38	1,25	1,20	2,92	3,92	3,71	3,55
Extra electricity[3]	Wh		0,10	0,04	-0,03		0,06	0,12	0,02		0,13	0,00	-0,04		1,01	0,79	0,63
Energy applied for HD	Wh		0,26	0,52	1,04		0,09	0,18	0,32		0,23	0,42			0,17	0,31	0,58
Net energy production	Wh		-0,16	-0,48			-0,03	-0,05	-0,30		-0,10	-0,42			0,84	0,48	0,05
Relative energy profit	%														599	253	108

Parameter	unit	RF - Remains of Fruits								BPP - Beetroot Pulp in the form of Pellets							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	2,48	2,70	2,63	2,52	6,12	6,17	5,92	6,25	6,51	9,61	6,65	5,60	6,65	6,66	4,60	5,21
Electricity[2]	Wh	0,99	1,08	1,05	1,01	2,45	2,47	2,37	2,50	2,60	3,84	2,66	2,24	2,66	2,66	1,84	2,08
Extra electricity[3]	Wh		0,09	0,06	0,02		0,02	-0,08	0,05		1,24	0,06	-0,36		0,00	-0,82	-0,58
Energy applied for HD	Wh		0,20	0,39	0,78		0,10		0,38		0,41	0,82					
Net energy production	Wh		-0,11	-0,33	-0,77		-0,09		-0,33		0,83	-0,76					
Relative energy profit	%										303						

[1]Methane energy content calculated by assuming methane calorific value equal to 36 MJ/m^3;
[2]Electricity calculated by assuming electrical efficiency of engine equal to 40%;
[3]Extra electricity = electricity dez.—electricity untreated, (Wh): Electricity dez., amount of electricity produced in a disintegrated sample at a predefined energy density level (Wh); Electricity untreated, amount of electricity produced in an untreated sample (Wh).

Energy balance

Parameter	unit	CM - Cow Manure								MS - Mazie Silage							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	3,86	4,10	3,95	3,79	3,95	4,11	4,25	3,99	3,12	3,45	3,11	3,00	7,29	9,81	9,27	8,87
Electricity[2]	Wh	1,54	1,64	1,58	1,51	1,58	1,64	1,70	1,60	1,25	1,38	1,25	1,20	2,92	3,92	3,71	3,55
Extra electricity[3]	Wh		0,10	0,04	-0,03		0,06	0,12	0,02		0,13	0,00	-0,04		1,01	0,79	0,63
Energy applied for HD	Wh		0,26	0,52	1,04		0,09	0,18	0,32		0,23	0,42			0,17	0,31	0,58
Net energy production	Wh		-0,16	-0,48			-0,03	-0,05	-0,30		-0,10	-0,42			0,84	0,48	0,05
Relative energy profit	%														599	253	108

Parameter	unit	RF - Remains of Fruits								BPP - Beetroot Pulp in the form of Pellets							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	2,48	2,70	2,63	2,52	6,12	6,17	5,92	6,25	6,51	9,61	6,65	5,60	6,65	6,66	4,60	5,21
Electricity[2]	Wh	0,99	1,08	1,05	1,01	2,45	2,47	2,37	2,50	2,60	3,84	2,66	2,24	2,66	2,66	1,84	2,08
Extra electricity[3]	Wh		0,09	0,06	0,02		0,02	-0,08	0,05		1,24	0,06	-0,36		0,00	-0,82	-0,58
Energy applied for HD	Wh		0,20	0,39	0,78		0,10		0,38		0,41	0,82					
Net energy production	Wh		-0,11	-0,33	-0,77		-0,09		-0,33		0,83	-0,76					
Relative energy profit	%										303						

[1]Methane energy content calculated by assuming methane calorific value equal to 36 MJ/m^3;
[2]Electricity calculated by assuming electrical efficiency of engine equal to 40%;
[3]Extra electricity = electricity dez.—electricity untreated, (Wh): Electricity dez., amount of electricity produced in a disintegrated sample at a predefined energy density level (Wh); Electricity untreated, amount of electricity produced in an untreated sample (Wh).

Energy balance

Parameter	unit	CM - Cow Manure								MS - Mazie Silage							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	3,86	4,10	3,95	3,79	3,95	4,11	4,25	3,99	3,12	3,45	3,11	3,00	7,29	9,81	9,27	8,87
Electricity[2]	Wh	1,54	1,64	1,58	1,51	1,58	1,64	1,70	1,60	1,25	1,38	1,25	1,20	2,92	3,92	3,71	3,55
Extra electricity[3]	Wh		0,10	0,04	-0,03		0,06	0,12	0,02		0,13	0,00	-0,04		1,01	0,79	0,63
Energy applied for HD	Wh		0,26	0,52	1,04		0,09	0,18	0,32		0,23	0,42			0,17	0,31	0,58
Net energy production	Wh		-0,16	-0,48			-0,03	-0,05	-0,30		-0,10	-0,42			0,84	0,48	0,05
Relative energy profit	%														599	253	108

Parameter	unit	RF - Remains of Fruits								BPP - Beetroot Pulp in the form of Pellets							
		Series 1				Series 2				Series 1				Series 2			
		0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L	0	35 kJ/L	70 kJ/L	140 kJ/L	0	10 kJ/L	20 kJ/L	35 kJ/L
Methane energy content[1]	Wh	2,48	2,70	2,63	2,52	6,12	6,17	5,92	6,25	6,51	9,61	6,65	5,60	6,65	6,66	4,60	5,21
Electricity[2]	Wh	0,99	1,08	1,05	1,01	2,45	2,47	2,37	2,50	2,60	3,84	2,66	2,24	2,66	2,66	1,84	2,08
Extra electricity[3]	Wh		0,09	0,06	0,02		0,02	-0,08	0,05		1,24	0,06	-0,36		0,00	-0,82	-0,58
Energy applied for HD	Wh		0,20	0,39	0,78		0,10		0,38		0,41	0,82					
Net energy production	Wh		-0,11	-0,33	-0,77		-0,09		-0,33		0,83	-0,76					
Relative energy profit	%										303						

[1]Methane energy content calculated by assuming methane calorific value equal to 36 MJ/m^3;
[2]Electricity calculated by assuming electrical efficiency of engine equal to 40%;
[3]Extra electricity = electricity dez.—electricity untreated, (Wh): Electricity dez., amount of electricity produced in a disintegrated sample at a predefined energy density level (Wh); Electricity untreated, amount of electricity produced in an untreated sample (Wh).

CONCLUSIONS

Hydrodynamic disintegration as pre-treatment of substrates subject to the anaerobic digestion process allows for increasing the amount of produced methane while obtaining a positive energy balance.

Implementation works should be preceded with tests aimed at the selection of:

- substrate/substrates subject to pre-treatment

~~cow manure~~ pig manure **maize silage** remains of fruits

~~beetroot pulp~~ **beetroot pulp in the form of pellets**

- parameters of the disintegration process (including the amount of energy supplied in the process)

10 kJ/L **20 kJ/L** **35 kJ/L** 70 kJ/L 140 kJ/L

Warsaw University of Technology

Faculty of Building Services, Hydro and Environmental Engineering

WARSAW UNIVERSITY OF TECHNOLOGY

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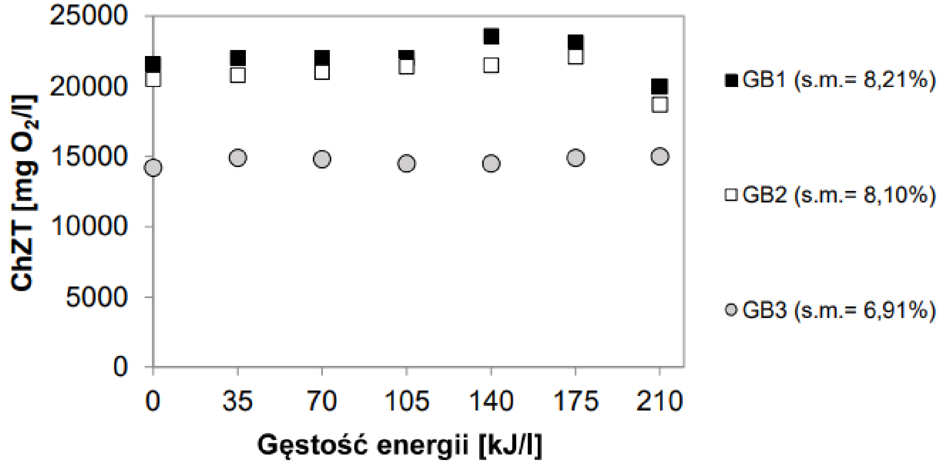
Development of a technology for preparation substrates used in methane co-fermentation by disintegration methods (DEZMETAN) No.: POIR.04.01.02-00-0022/17

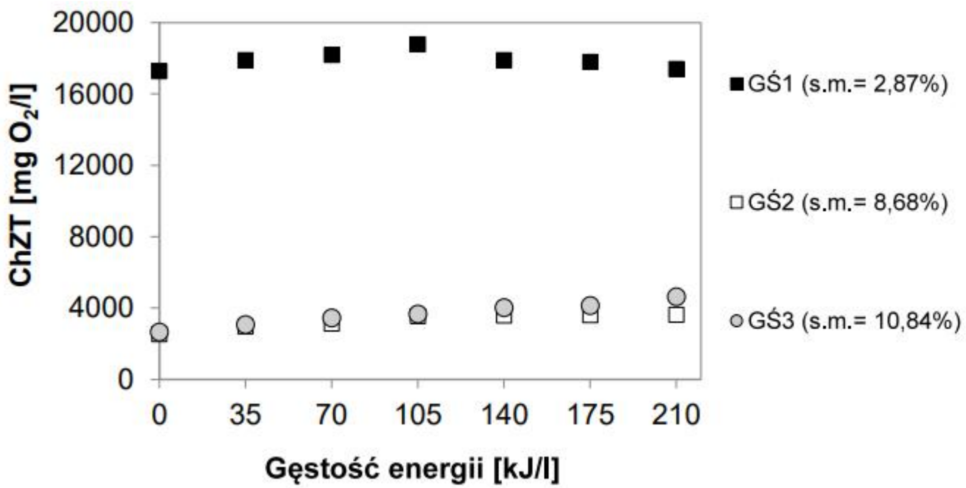
European Funds Smart Growth

The National Centre for Research and Development

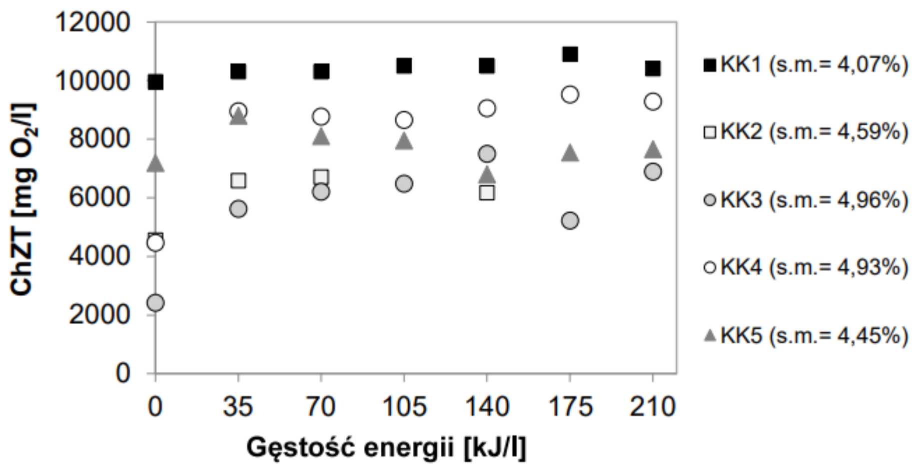
European Union European Regional Development Fund



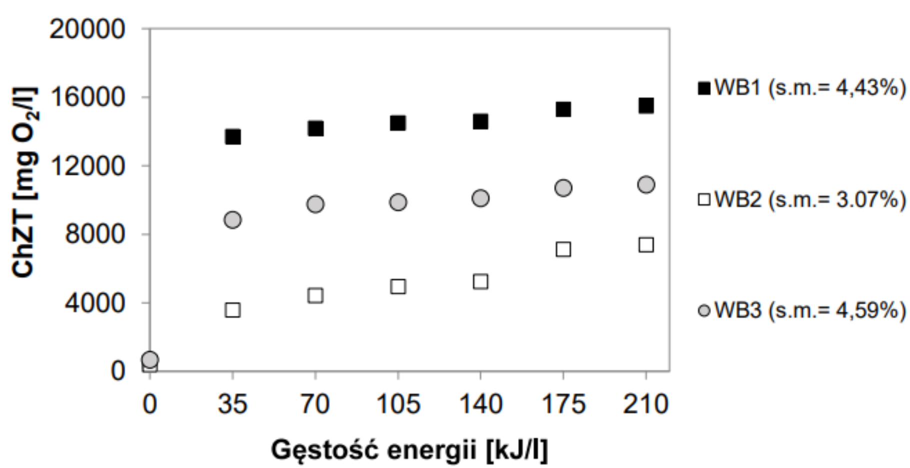
Rys. 4.4.27. Wartość rozpuszczonego ChZT gnojowicy bydlęcej w zależności od gęstości energii zużytej w procesie hydrodynamicznej dezintegracji.



Rys. 4.4.28. Wartość rozpuszczonego ChZT gnojowicy świńskiej w zależności od gęstości energii zużytej w procesie hydrodynamicznej dezintegracji.



Rys. 4.4.30. Wartość rozpuszczonego ChZT kiszonki kukurydzy w zależności od gęstości energii zużytej w procesie hydrodynamicznej dezintegracji.



Rys. 4.4.31. Wartość rozpuszczonego ChZT wysłodków buraczanych w zależności od gęstości energii zużytej w procesie hydrodynamicznej dezintegracji.