

<u>Output T2.2</u> Pre-feasibility Study (Romania)

WP T2: Project main output

May, 2022

Project co-funded by the European Union funds (ERDF, IPA) www.interreg-danube.eu/danup-2-gas



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Short Description

The potential for exploitable organic residue for each participating country listing key aspects such as location, amount, transport options and costs.

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Responsible Partner for the compilation of this document

LP Technology Centre Energy - University of Applied Sciences Landshut (DE) ERDF PP1 Energy Agency of Savinjska, Koroška and Šaleška Region (SI)



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Version	Date	Author	Organization	Description
v1	27.09.2021	Kiril Raytchev	BSERC	Initial version
v2	22.02.2022	Kiril Raytchev	BSERC	Reflecting Optimization tool current specification
v3	15.03.2022	Kiril Raytchev	BSERC	Replacing pay-off period analysis with gas price deviation one.
v3.1	10.03.2022.	M. Šundrica, M. Ban, D. Đurđević, M. Vašak, F. Rukavina, A. Karneluti	UNIZG-FER, SDEWES, EIHP	Selection of prospective locations for the pre-feasibility study for Croatia, manual take- up of data prepared for the Atlas in the optimization solver
v3.2	29.03.2022	M.Vašak, M. Šundrica, F. Rukavina, A. Karneluti	UNIZG-FER	Case studies executed and explained for Croatia with OT version 1

1. METHODOLOGY

Infrastructure and Biomass database given within the Atlas are prerequisite for any use of Optimization tool (OT). After the selection or manual entry of sources, connection points, etc. is done, optimization can be started.

2. CASE STUDIES

The case studies were conducted using data related to biomass and infrastructure from all over the country by combining biomass depots and energy infrastructure elements from nearby counties that correspond to both national historical regions and administrative development regions.

The main regions targeted were Moldova, which corresponds to the North East Development Region; Muntenia South Development Region; Transylvania Central



Development Region but also the Oltenia Region or the western part of the country, the Banat and Crisana regions.

There were also some exceptional cases where elements from the counties of Calarasi and Constanta were chosen, which are not part of the same region but have a very good connectivity in terms of road, rail and water navigation being neighboring.

2.1 SUMMARY

For each one of cases studies (IP, REP and GF), variations of methane prices and subsidies are considered. In the Table 1, case summaries are given:

Table 1. Simulation cases

	Conservativ	e prices of m	nethane	Higher pric	es of methar	ne
	No increase	No increase	No increase	10x winter	10x winter	15x winter
	No increase	No increase	No increase	5x summer	5x summer	10x summer
	IP	REP	GF	IP	REP	GF
No	No	No	No	No	Periodic	Periodic
subsidy	production,	production	production	production	production ^a	production ^b
subsidy	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5	Fig. 6
Subsidy of	No	No	No	Periodic	Continuous	Continuous
50 %	production	production	production	production	production	production ^b
50 /0	Fig. 7	Fig. 8	Fig. 9	Fig. 10	Fig. 11	Fig. 12

^a simulation for period of 01 January to 30 June

^b simulation for period of 01 February to 31 May

2.2 RESULTS WITHOUT SUBSIDIES

Figure 1 shows an investment of almost 58 million euros, with a pay-off period of 20 years while savings amount to 33.7 million euros. The values 0 in the case of the "Net production without investment" tab mean that no consumption is recorded.



	Element	Price		Size		
3	Dry anaerobic digestor	20,091,787.83	¢	0.956752	kg/s	
	Wet enserobic digestor	20,294,266.87	¢	1.034713	kg/s	
	Dry biomass to biochar plant	0.00	¢	8.000000	Ng/s	
	Wet biomess to blocher plant	0.00	¢	0.000000	kg/s	
	Biogas separator	353,728.10	¢	0.020808	kg/s	
3	Gesification + water gas shift plan	114,277.29	¢	0.114277	kg/s	
	Combined heat and power (CHP)	11,564,289.70	¢	1.652041	kg/s	
	Carbon capture plant	0.00	¢	0.00000.0	mol/s	
1	Electrolyser	2,671,585.37	¢	1,068.63	KW	
	Demineralizer	267,445.36	¢	34.076072	mol/s	
	Precipitation collector	2,000.00	c	1,000.00	m ³	
	Methanation reactor	768,550.13	ŧ	2.564770	mol/s	
	Heat exchanger	1,436,504.60	ε	14,365.0460	kW	
	Total for processes	\$7.564.435.25	€			
	Dry biomass storage	0.00	¢	0.0000	kg	
	Wet blomest storage	0.00	¢	0.0000	kg	
	Biochar storage	27,726.97	¢	1,848.4648	4.g	
e i	Water storage tank	20.60	¢	1,010.1119	mol	
	Oxygen storage tank	53.68	¢	134 2061	mol	
1	Hydrogen storage tenk	0.00	¢	0.0000	mol	
	Carbon dioxide storage tank	33.39	¢	41.7401	mol	
	Methane storage tank	0.00	£	0.0000	moï	
- 1	Total for storages	27,834,65	£			
Ε	Electrical connection	0.00	ε	0.00	MW.	
-	Gas connection	0.00	¢	0.00	MW	
Ť.	Water connection	1.83	¢	0.91	m ^x /h	
2	Total for connections	1.83	£			
	Total incontinuent	\$7 587 771 75				

		Price	Amount	
	Produced by REP	0.00 ¢	0.00	MWh
Outputs Inputs (Incritione Neural Incrition energy)	Consumed by IP	122,601,308.27 €	98,340.00	MWh
£ .	Net consumption without investment	122,601,308 22 €	98,540.00	MWh
÷.	Peak power without investment	174,854.85 €	171,426.32	kW
6	Consumed by 92G	-48,210,482.06 €	-95,075.80	MWb
5	Net consumption with investment	3,273,667.04 €	3,464.20	MWh
	Peak power with investment	71,046.10 €	69,653.04	KW
	Produced by REP	0.00 ¢	0.00	MWh
	Produced IP	0.00 €	589,420.00	MWh
3	Net production without investment	0.00 €	589,420.00	NWh
~	Consumed by #2G	0.00 €	-117,377.75	MWh
	Net production with investment	0.00 E	706,797.75	MWh
	Produced by REP	0.00 €	0.00	MWh
2	Consumed by IP	6,304,600,130.00 €	Attount 0.00 98,340.00 171,426.32 -45,075.04 0.00 589,420.00 59,402,301.00 59,402,301.00 59,402,301.00 59,402,301.00 59,402,301.00 59,402,300.00 0,000	MWh
4	Net consumption without investment	6,104,600,130.00 €	5,402,301.00	MWh
8	Produced by P26	446,235.80 €	9,057.12	MWh
_	Net consumption with investment	6,094,365,583.36 ¢	5,393,343.88	MWh
later.	Water consumed by #2G	8,307,58 €	7,837.34	m
	Dry biomass bought	1,195,210.71 €	18,576.05	ε
1	Wet blomass bought	892,000.00 €	32,000.00	£
÷.	Blochar bought	0.00 ¢	0.00	1
2	Biocher sold	0.00 C	0.00	t :
n a	Hydrogen sold	0.00 €	0.00	ε
ē	CO2 emitted	93,819,029.16 ¢	1,876,380,583.27	kg:
	Total operational cost without investment	6,227,376,293.07 €		
	Total operational cost with investment	6.191.625.843.95 €		
	Savings with introduction of P2G	33,750,449.11 €		

Fig. 1 Results for IP with conservative prices of methane and no subsidy

In the case of Figure 2 P2G hub is not economically viable for such set of parameters. Therefore, payoff period is not applicable. All this time the negative value of the "Net Consumption without investment" indicator means that there are positive values of production.



1	Dement	Price		Size	
	Dry anaerobic digestor	0.00	٤	0.000000	Kg/s
	Wet anaerobic digestor	0.00	¢	0.000000	kg/s
Precenter	Dry biomass to blocher plant	0.00	¢	0.000000	kg/s
	Wet biomass to blochar plant	0.00	¢	0.00000.0	kg/s
	Biogas separator	0.00	¢	0.000000.0	kg/s
	Gasification + water gas shift plan	0.00	¢	0.000000	kg/s
	Combined heat and power (CHP)	0.00	¢	0.000000	Rg/S
	Carbon capture plant	0.00	ε	0.000000	mol/s
	Electrolyser	0.00	¢	0.00	RW
	Demineralizer	0.00	£	0.000000	mol/s
	Precipitation collector	0.00	¢	0.00	m ²
	Methanation reactor	0.00	¢	0.000000	mol/s
	Heat exchanger	0.00	¢	0.0000	kW.
	Total for processes	0.00	¢		
	Dry biomass storage	0.00	ε	0.000.0	×g
	Wet blomass storage	0.00	¢	0.0000	kg
	Blochar storage	0.00	¢	0.0000	18
g i	Water storage tank	0.00	¢	0.0000	mol
8	Oxygen storage tank	0.00	¢	0.0000	mol
2	Hydrogen storage tank	0.00	٤	0.0000	mol
	Carbon dioxide storage tank	0.00	t	0.0000	mol
	Methane storage tank	0.00	¢	0.0000	inol
	Total for storages	0.00	•		
Е	Electrical connection	0.00	¢	0.00	MW
100	Gas connection	0.00	ε	0.00	MW
1	Water connection	0.00	¢	0:00	m ¹ /h
2	Total for connections	0.00	¢		
	Totai investment	0.00	¢		
	Paus H period	nia	WARNER		

00000		Price	Amount	
	Produced by REP	6,558,857.45 €	13,000.00	MWh
2	Consumed by IP	0.00 €	0.00	MWh
E.	Net consumption without investment	-6,553,857.45 €	-13,000.00	MWh
ñ	Peak power without investment	0.00 €	0.00	8W
E.	Consumed by P2G	0.00 €	0.00	MWh
-	Net consumption with investment	-6,555,857.45 €	-15,000.00	MWh
-	Peak power with investment	0.00 ¢	0.00	XW.
	Produced by REP	0.00 €	4,000.00	MWh:
7213	Produced IP	0.00 €	0.00	MWh.
12	Net production without investment	0.00 ¢	4,000:00	MWh
	Consumed by #2G	0.00 €	0.00	MWh
	Net production with investment	0.00 €	4,000.00	MWh
	Produced by REP	0.00 ¢	0.00	MWh
	Consumed by IP	0.00 €	0.00	MWh
5	Net consumption without investment	0.00 ¢	0.00	MWh
1	Produced by P2G	0.00 €	0.00	MWh
	Net consumption with investment	0.00 €	0.00	MWh
Water	Water consumed by P2G	0.00 €	0.00	m ³
- 14	Dry biomass bought	0.00 €	0.00	t
1	Wet biomass bought	0.00 €	0.00	τ
	Blochar bought	0.00 €	0;00	ť
10	Biocher sold	0.00 €	0.00	1
8	Hydrogen sold	0.00 ¢	0.00	t
ő	002 emitted	0.00 €	0.00	kg :
	Total operational cost without investment	-6,555,857.45 €		
	Total operational cost with investment	-6.553.857.45 €		
	Savings with introduction of P20	0.00 €		

Fig. 2 Results for REP with conservative prices of methane and no subsidy



ive	stment specifications				Operat	tional costs for selected period		
	Element	Price	Size		0.0		Price	Amount
	Dry anaerobic digestor	0.00 €	0.000000	Ng/S		Produced by REP	0.00 €	0.00 MW?
	Wet anaerobic digestor	0.00 E	0.000000	kg/s	2	Consumed by P	0,00 €	0.00 MW?
	Dry biomass to biochar plant	0.00 ¢	0.000000	kg/s	100	Net consumption without investment	0.00 €	0.00 MW/
	Wet biomass to biochar plant	0.00 ¢	0.000000	kg/s	13	Peak power without investment	0.00 €	0.00 kW
	Bioges separator	0.00 K	0.000000	kg/s	ų.	Consumed by P2G	0.00 E	0.00 MW?
	Gasification + water gas shift plan	0.00 ¢	0.000000	kg/s	12	Net consumption with investment	0.00 €	0.00 MW
1	Combined heat and power (CHP)	0.00 ¢	0.000000	kg/s		Feak power with investment	0.00 €	0.00 kW
2	Carbon capture plant	0.00 ¢	0.000000	mol/s		Produced by REP	0.00 €	0.00 MW
ି	Electrolyser	0.00 E	0.00	RW.	1.00	Produced IP	0.00 €	0.00 MW7
	Demineralizer	0.00 £	0.000000	moi/s	걸	Net production without investment	0,00 €	0.00 MW
	Precipitation collector	0.00 E	0.00	m² .	100	Consumed by P2G	0.00 €	0.00 MW
Total States	Methanation reactor	0.00 E	0.000000	mol/s		Net production with investment	0.00 €	0.00 MW
	Heat exchanger	0.00 ¢	0.0000	ĸW		Produced by REP	0.00 ¢	0.00 MW
_	Total for processes	0.00 €	C13000	1741 (M	. 2	Cansumed by IP	0.00 €	0.00 MW
	Dry biomass storage	0.00 E	0.0000	NE	4	Net consumption without investment	0.00 €	0.00 MW
	Wet biomass storage	0.00 €	0.0000	RE	10	Produced by P2G	0.00 €	0.00 MW
	Blochar storage	0.00 ¢	0.0000	kg		Net consumption with investment	0.00 €	0.00 MW
2	Weter storage tank	0.00 E	0.0000	mol	Water	Water consumed by P2G	0.00 E	0.00 m ³
8	Oxygen storage tank	0.00 £	0.0000	mol		Dry biomass bought	0.00 €	0.00 t
5	Hydrogen storage tank	0.00 £	0.0000	mol	1	Wet blomass bought	0.00 ¢	0.00 t
	Carbon dioxide storage tank	0.00 E	0.0000	moi		Sidcher bought	0:00 €	0.00 t
	Methane storage tank	0.00 €	0.0000	mol	10	Biochar sold	0.00 €	0.00 t
	Total for storages	0.00 E		1000	륲	Hydrogen sold	0,00 ¢	0,00 t
1 2	Electrical connection	0.00 E	0.00	NW	á	CO2 emitted	0.00 E	0.00 kg
	Gas connection	0.00 £	0.00	MW.		Total operational cost without investment	0.00 €	A. 1998
Inter	Water connection	0.00 ¢	0.00	m*/n		Total operational cost with investment	0.00 €	
1	Total for connections	0.00 €	1078			Sevings with introduction of P2G	0.00 €	
	Total investment	0.00 E						
	Payoff period	n/a vears						



As will be the other cases regarding Greenfield type investments, regardless of the price of the gas or the possible subsidy granted, it can be perceived that P2G hubs is not as economically viable as Greenfield investments.



reacheste apeenteactoria	1000			Opera	cional costs for selected period		
flement	Price	Size		Same-		Price	Amount
Dry anaerobic digestor	4,661,939.42 €	0.221969	hg/s		Produced by REP	0.00 C	0.00 MM
Wet anaerobic digestor	\$1,758,445.02 €	5.087922	*g/s	2	Consumed by IP	127,475,997.95 €	302,458.00 M
Dry biomass to biochar plant	0.00 €	0.000000	itg/s		Net consumption without investment	127,475,997.95 €	102,458.00 M
Wet biomess to biocher plant	0.00 €	0.000000	kg/s	TE .	Peak power without investment	181,807.16 €	178,242.32 kt
Biogas separator	6,507,913.68 €	0.382818	ag/s	P.L.L	Consumed by P2G	22,284,373.77 €	-16,005.32 M
Gesification + water gas shift plan	1,046,581.68 C	1.046582	kg/s	-	Net consumption with investment	81,697,782.97 €	86,452.88 M
Combined heat and power (DHP)	16,019,679.15 €	2.288526	ag/s		Peak power with investment	883,937.02 £	866,604.92 K
E Carbon capture plant	0.00 €	0.000000	mol/s		Produced by REP	0.00 E	0.00 M
Electrolyser	24,490,011.42 €	9,796.00	¥W	14	Produced IF	0.00 £	647,571.00 M
Demineralizer	752,490.70 €	39.604774	mol/s	- Here	Net production without investment	0.00 E	647,573.00 M
Precipitation collector	2,000.00 ¢	1,000.00	m		Consumed by P2G	0.00 C	-153,499.13 M
Methenation reactor	18,989,352.35 €	58.428776	mol/s	-	Net production with investment	0,00 E	801,070.15 M
Heat exchanger	2,014,523.66 €	20,145.2366	8W		Produced by REP	0.00 E	0.00 M
Total for processes	136.242.337.09 €			2	Consumed by IP	7,436,530,744.27 €	5,809,914.00 M
Dry biomass storage	0.00 €	0.0000	äg .	atha	Net consumption without investment	7,436,530,744.27 €	5,809,914.00 M
Wet biomass storage	1,018,688.99 €	211,737,7990	kg.	- 1	Produced by P2G	6,233,526.83 €	104,474.60 M
Biochar storage	1,321,406.09 ¢	88,093.7393	kg .		Net consumption with investment	7,302,803,454.92 €	5,705,439.40 M
Water storage tank	173,114.01 ¢	8,655,700.5946	mol	Water	Water consumed by P2G	23,760.72 €	22,415.77 =
Oxygen storage tank	0.00 ¢	0.0000	mol	1.04	Dry biomass bought	42,000.00 €	7,000.00 1
Hydrogen storage tank	21,599,899.96 €	12,705,823.5066	mol	10	Wet blomass bought	3,136,750.00 €	54,300.00 t
Carbon dioxide storage tank	2,344,475.87 £	1,930,594.8334	mot		Biomer bought	0.00 E	0,00 1
Methane storage tank	0.00 €	0.0000	mol	2	Biochar sold	0.00 E	0.00 t
Total for storages	26,497,584.92 €			24	Hydrogen sold	0.00 E	0.00 1
* Electrical connection	0.00 ¢	0.00	MW	ő	CO2 emlitted	114,551,946,45 £	2,291,058,928.98
E Gas connection	0.00 ¢	0.00	MW		Total operational cost without investment	7,564,188,549.38 €	
Water connection	5.15 €	2.57	m ¹ /h		Total operational cost with investment	7.503.139.632.07 €	
Total for connections	5.15 €				Savings with introduction of #2G	61,048,917.31 €	
Total investment	162.719.927.16 €]					
Payoff period	20.00 years	1					

Fig. 4 Results for IP with higher prices of methane and no subsidy

In the case of industrial plants, the scenario that predicts a higher cost of gas causes the investment with a pay-off period of 20 years to increase while savings and operating costs decrease. Even so, owning one is still beyond the reach of the average person.



	Element	Price	Size			Price
	Dry anaerobic digestor	0.00 ¢	0.000000	kg/s	Produced by REP	4,537,285.95 4
	Wet anaerobic digestor	0.00 ¢	0.000000	kg/s >	Consumed by IP	0.00
	Dry biomass to biochar plant	0.00 K	000000.0	kg/s	Net consumption without investment	-4,537,285.93
	Wet blomass to blochar plant	0.00 €	0.000000	kg/s W	Peak power without investment	0.00
	Biogas separator	0.00 <	0.00000.0	kg/s	Consumed by P2G	0.00(4
	Gesification + water gas shift plan	0.00 ¢	0.000000	kg/s ≟	Net consumption with investment	-4,537,285.93 (
100	Combined heat and power (CHP)	0.00 €	0 000000	ig/s	Peak power with investment	0,00,4
8	Carbon capture plant	0.00 ¢	0.000000	mol/s	Produced by REP	0.00 4
۰.	Electrolyser	0.00 €	0.00	kW	Produced IP	0.00 0
	Demineralizer	0.00 €	0.000000	mol/s	Net production without investment	0.00
	Precipitation collector	0.00 €	Ø.00	m ^T	Consumed by P2G	0.00
	Methanation reactor	0.00 ¢	0.000000	mol/s	Net production with investment	0.00
	Heat exchanger	0.00 E	0.0000	EW .	Produced by REP	0.00
	Total for processes	0.00 €	1		Consumed by IP	0.00
	Dry biomass storage	0.00 ¢	0.0000	kg 🛱	Net consumption without investment	0.00 4
	Wet biomass storage	0.00 €	0.0000	ig Š	Produced by P2G	0.00
	Biocher storage	0.00 €	0.0000	kg	Net consumption with investment	0.00
8	Water storage tank	0.00 €	0.0000	mol. Water	Water consumed by P2G	0.00 4
2	Oxygen storage tank	0.00 ¢	0.0000	mol	Dry biomass bought	0.00
6	Hydrogen storage tank	0.00 €	0.0000	mol	Wet biomass bought	0,00
	Carbon dioxide storage tank	B.00 €	0.0000	moi	Biocher bought	0.00.4
	Methane storage tank	D.00 <	6.0000	mol g	Biochar sold	0.00 4
	Total for storages	0.00 €	100000	4	Hydrogen sold	0,00
2.2	Electrical connection	0.00 €	0.00	MW di	002 emitted	0.00
88	Gas connection	0.00 4	0.00	MW.	Total operational cost without investment	-4,537,285.93
13	Water connection	0.00 ¢	0.00	m ³ /h	Total operational cost with investment	-4.537.285.93
0.0	Total for connections	0.00 €			Savings with introduction of P20	0.00
	Total investment	0.00 €				
	Payoff period	n/a year				



The higher gas price in this scenario (Renewable power plant with high gas price) makes the values of electricity produced but also net consumption with or without investment also decrease. The same decrease is registered for the Operational Costs with or without investment.

9,000.00 MWh

0.00 MWh -9.000.00 MWh

0.00 kW

-9,000.00 MWh

0.00 kW

0.00 MWh 0.00 MWh

0.00 MWW

0.00 MWh

0.00 MWh

0.00 MWh

0.00 MWh

0.00 MWh 0.00 MWh

0.00 MWW

0.00 m²

0.00 t

0.00 t

0.00 t

0.00 t

0.00 t

0.00 kg

Clear results

0.00 MWh



	Elemest	Price		Size	
	Dry enserobic digestor	0.00	¢	0.000000	kg/s
	Wet anaerobic digestor	0.00	¢	0.000000	kg/s
	Dry biomass to biochar plant	0.00	ε	0.000000	kg/s
	Wet blomess to blochar plant	0.00	τ	0.000000	kg/s
	Bigges separator	0.00	¢	0.000000	kg/s
	Gasification + water gas shift plan	0.00	ε	0.000000	Ng/s
1	Combined heat and power (CHP)	0.00	ε	0.000000	Ng/s
	Carbon capture plant	0.00	ε	0.000000	mol/s
	Electrolyser	0.00	¢	0.00	KW.
	Demineralizer	0.00	τ	0.000000	moi/s
	Precipitation collector	0.00	¢	0.00	m2
	Methanation reactor	0.00	ε	6.000000	mol/s
	Heat exchanger	0.00	ε	0.0000	RW
	Total for processes	0.00	£.		
1	Dry biomass storage	0.00	¢	0.0000	Kg
	Wet blomass storage	0.00	¢	0.0000	Ng.
	Biochar storage	0.00	¢	0.0000	kg
ġÌ.	Water storage tank	0.00	ε	0.0000	mol
	Oxygen storage tank	0.00	¢	0.0000	mai
8	Hydrogen storage tank	0.00	¢	0.0000	mol
	Carbon dioxide storage tank	0.00	£	0.0000	mol
	Methane storage tank	0.00	¢	0.0000	mol
	Total for storages	0.00	e		
ŧ	Electrical connection	0.00	¢	0.00	MW.
en e	Gas connection	0.00	ε	0.00	MW
ŝ	Water connection	0.00	ε	0.00	m ¹ /m
÷	Total for connections	0.00	£		
-	Total investment	0.00	•		
	Payoff period	n/e	vears		

		Price	Amount	
	Produced by REP	0:00 €	0.00	MWh
Electrical every	Consumed by IP	0.00 E	0.00	MWh
	Net consumption without investment	0.00 E	0.00	MWh
	Peak power without investment	0.00 €	0.00	kW
	Consumed by P2G	0.00 E	0.00	MWh
	Net consumption with investment	6.00 £	0.00	MWh
	Peak power with investment	0.00 £	0.00	kW
	Produced by REP	0.00 €	0.00	MWh
72:1	Produced (P	0.00 €	0.00	MWh
100	Net production without investment	0.00 ¢	0.00	MWh
-	Consumed by #2G	0.00 E	0.00	MWb
	Net production with investment	0.00 ¢	0.00	MWh
ž	Produced by REP	0.00 €	0.00	MWh
	Consumed by IP	0.00 €	0.00	MWh
that	Net consumption without investment	0.00 E	0.00	MWh
1	Produced by P2G	0.00 £	0.00	MWh
	Net consumption with investment	0.00 C	0.00	MWh
later	Water consumed by P2G	0.00 €	0.00	m ³
-	Dry blomass bought	0.00 €	0.00	ť
2	Wet blomass bought	0.00 €	0.00	t .
-	Biochar bought	6.00 ¢	0.00	τ
2	Blocher sold	0.00 ¢	0.00	t
ē.	Hydrogen sold	0.00 €	0.00	ŧ.
6	CO2 emitted	0.00 €	0.00	ka -
	Total operational cost without investment	0.00 €		
	Total operational cost with investment	0.00 €		
	Savings with introduction of P2G	0.00 €	3	

Fig. 6 Results for GF with higher prices of methane and no subsidy

For the Greenfield investment it is the same case as figure 3 – it is not viable.

2.3 RESULTS WITH SUBSIDIES

In Figures 7 to 12, results for the cases with subsidies are depicted. Although subsidies are considered, with conservative prices of methane there is no economical reason of any investment in biomethane production as it is shown in Figures 7 to 9.



- 1	Element	Price		Size	
	Dry anaerobic digestor	20,684,119.77	¢	1.969916	kg/s
- 1	Wet anaerobic digestor	6,289,108.75	ε	0.628913	kg/s
	Dry biomess to blocher plent	0.00	¢	0.000000	kg/s.
- 1	Wet biomass to biochar plant	0.00	ε	0.000005	kg/s
- 3	Biogas separator	3,823,142.37	¢	0.449781	kg/s
. 1	Gasification + water gas shift plan	525,510.53	¢	1.051021	kg/s
1	Combined heat and power (CHP)	6,391,989.01	ε	1.826283	tg/s
Lon	Carbon capture plant	0.00	¢	0.000000	miai/s
	Electrolyser	11,926,013.75	ε	9,540.81	KW/
- 1	Demineralizer	415,992.23	¢	43.782340	mai/s
	Precipitation collector	1,000.00	٤	1,000.00	m ⁴
- 1	Methanation reactor	4,157,045.70	¢	25.581807	mal/s
	Heat exchanger	859,466.27	ε	17,189.3254	kW.
_	Total for processes	55.073.326.37	¢	10.122102-00	20.
	Dry biomass storage	544,378.87	c	108,875.7748	kg
	Wet blomass storage	116,438.36	¢	46,575.3426	kg
	Biochar storage	658,302.66	c	87,785.6877	kg
	Water storage tank	78,700.98	¢	7,870,097 7061	tam
1	Oxygen storage tank	7,888.88	¢	59,444.4007	mal
9	Hydrogen storage tank	1,190,884.76	٤	1,401,040.8912	mai
- (Cerbon dioxide storage tank	0.02	¢	0.0515	mai
- 1	Methane storage tank	0.00	ε	0.0000	mol
	Total for storages	2.596.684.52	6	(2007)	SWALS
11	Electrical connection	0.00	¢	8.00	MW
	Gas connection	0.00	٤	0.00	MW
	Water connection	2.85	¢	2.85	m ³ /h
2. F .	Total for connections	2.85	£		
	Total investment	57,670.013.74	€		
	Daught applied	20.00	LINDER		

		Price	_	Amount	
	Produced by REP	0.00	¢	0.00	MW
2	Consumed by IP	9,331,335.62	¢	7,500.00	MWh
Electrical may	Net consumption without investment	9,331,335.62	¢ .	7,500.00	MWH
	Feak power without investment	13,308.42	¢	13,047.47	kW
	Consumed by P2G	33,133,356,45	¢	32,163.98	MWh
	Net consumption with investment	37,482,461.13	¢	39,663.98	MW
	Peak power with investment	390,775.36	¢	383,112.90	kW
Heat	Produced by REP	0.00	¢	0.00	MW
	Produced IP	0.00	¢	612,479.00	MWh
	Net production without investment	0.00	¢	612,479.00	MW
	Consumed by P2G	0.00	¢	-128,034.54	MWh
	Net production with investment	0.00	¢	740,513.54	MWh
share	Produced by REP	0.00	¢	0.00	MW
	Consumed by IP	5,470,465,600.00	٤.	4,841,120.00	MWH
	Net consumption without investment	5,470,465,600.00	¢	4,841,120.00	MW
\$	Produced by P2G	6,022,440.04	¢ .	122,235.90	NW
	Net consumption with investment	5,332,339,050.19	έ.	4,718,884 10	MW
Nater	Water consumed by #25	26,235.67	¢	24,750.63	mi
14	Dry blomeas bought	1,577,000.00	¢	55,500.00	ŧ
2	Wet biomass bought	548,000.00	¢	17,000.00	t
	Blochar bought	0.00	¢	0.00	t
2	Biochar sold	0.00	¢	0.00	ε
ē.	Hydrogen sold	0.00	¢	0.00	£
6	CO2 emitted	91,418,308.70	٤.	1,828,366,173.94	kg .
	Total operational cost without investment	5,479,810,244.03	•		
	Total operational cost with investment	5,463,581,810,84	•		
	Savings with introduction of P2G	16.228.433.19	£		

Fig. 7 Results for IP with conservative prices of methane and subsidy of 50%

In the scenario in which normal gas costs are stipulated, to which is added a subsidy of 50%, the Industrial Plant type investment is very profitable, the values being almost 10 times higher than in the case of figure 1.



	Element	Price		Size	
	Dry anaerobic digestor	0.00	<	0.000000	kg/s
	Wet anaerobic digestor	0.00	¢	0.000000	kg/s
	Dry biomass to biochar plant	0.00	c	0.000000	kg/s
	Wet biomass to biochar plant	0.00	ε	0.000000	kg/s
	Biogas separator	0.00	¢	0.000000	kg/s
	Gesification + water gas shift plan	0.00	¢	0.000000	kg/s
	Combined heat and power (CHP)	0.00	¢	0.000000	Kg/s
Ē	Carbon capture plant	0.00	ć.	0.000000	mai/s
	Electrolyser	0.00	ε	0.00	KW.
	Demineralizer	0.00	¢	0.000000	mol/s
	Precipitation collector	0.00	¢	0.00	m²
	Methanation reactor	0.00	٤.	0.000000	mol/s
	Heat exchanger	0.00	¢	0.0000	kW
	Total for processes	0.00	•		
	Dry biomass storage	0.00	¢	0.0000	kg :
	Wet biomass storage	0.00	٤.	0.0000	kg
	Biocher storage	0.00	£	0.0000	kg
٥	Water storage tank	0.00	c	0.0000	mai
1	Oxygen storage tank	0.00	¢	0.0000	mai
7	Hydrogen storage tank	0.00	٤	0.0000	mol
	Carbon dioxide storage tank	0.00	¢	0.0000.0	mol
	Methane storage tank	0.06	\$	0.0000	mol
_	Total for storages	0.00	€		
Ŧ.	Electrical connection	0.00	¢	0.00	MW
ŝ	Ges connection	0.00	¢	0.00	MW
n l	Water connection	0.00	\$	0.00	m^2/m
-	Total for connections	0.00	e		
	Total investment	0.00	¢		
	Payoff period	n/a	VEAD		

		Price	Amount	
flectrical immigy	Produced by REP	6,038,037.50 €	12,000.00	MWh
	Consumed by IP	0.00 E	0.00	MWh
	Net consumption without investment	-6,038,037.50 €	-12,000.00	MWh
	Feak power without investment	0.00 ¢	0.00	kW
	Consumed by P2G	0.00 ¢	0.00	MWh
	Net consumption with investment	-6,038,037.50.€	-12,000.00	MWh
	Peak power with investment	0.00 ¢	0.00	kW
Heat	Produced by REP	0.00 ¢	8,000.00	MWh
	Produced IP	0.00 €	0.00	MWh
	Net production without investment	0.00 ¢	8,000.00	MWh
	Consumed by #2G	0.00 ¢	0.00	MWh
	Net production with investment	0.00 ¢	8,000.00	MWh
	Produced by REP	-1,955,471.55 €	10,000.00	MWh
8	Consumed by IP	0.00 €	0.00	MWN
4	Net consumption without investment	1,955,471.55 €	-10,000.00	MWh
2	Produced by P2G	0.00 ¢	0.00	MWh
i	Net consumption with investment	1,955,471.55 €	-10,000.00	MWh
later	Water consumed by P2G	0.00 ¢	0.00	mi
	Dry biomass bought	0.00 £	0.00	t.
	Wet blomass bought	0.00 ¢	0.00	t
-	Biocher bought	0.00 €	0.00	t
12	Biochar sold	0.00 €	0.00	ŧ
#	Hydrogen sold	0.00 ¢	0.00	t ·
a	CO2 emitted	0.00 ¢	0.00	kg
	Total operational cost without investment	-4.082,565.96 €		
	Total operational cost with investment	-4,082,565.96 €		
	Savings with introduction of P2G	0.00 €		



The 50% grant in the case of REP amortizes the operating costs that are similar to those in Figure 2 where the scenario does not provide for a grant. There is also a higher electricity production and a higher consumption than in scenario 5 which translates into higher production.



	Element	Price	_	Size	_
	Dry anaerobic digestor	0.00	٤	0.000000	Rg/s
	Wet anaerobic digestor	0.00	¢	0.000000	kg/s
	Dry biomass to blochar plant	0.00	ε	0.000000	kg/s
	Wet biomass to blochar plant	0.00	٤	0.000000	kg/s
	Biogas separator	0.00	¢	0.000000	8g/3
<u></u>	Gasification + water gas shift plan	0.00	ε	0.000000	kg/s
8	Combined heat and power (CHP)	0.00	٤	0.000000	Hg/s
100	Cerbon cepture plant	0.00	ε	0.000000	mol/s
	Electrolyser	0.00	ε	0.00	RW.
	Demineralizer	0.00	£	0.000000	mol/s
	Precipitation collector	0.00	¢	0.00	m² .
	Methanation reactor	0.00	ε.	0.000000	mot/s
	Heat exchanger	0.00	٤	0.0000	kW
	Total for processes	0.00	£		
	Dry biomass storage	0.00	¢	0.0000	×g
	Wet biomass storage	0.00	٤	0.0000	KE
	Blochar storage	0.00	ε	0.0000	kg
£.	Water storage tank	0.00	¢	0.0000	mol
1	Oxygen storage tank	0.00	٤	0.0000	mol
ñ	Hydrogen storage tenk	0,00	£	0.0000	mol
	Carbon dioxide storage tank	0.00	ε	0.0000	mol
	Methane storage tank	0.00	٤	0.0000	mol
-	Total for storages	0.00	£		
T	Electrical connection	0.00	¢	0.00	MW
W.	Gas connection	0.00	ε	0.00	MW
- International	Water connection	0.00	£	0.00	m ³ /h
1	Total for connections	0.00	¢		
	Total investment	0.00	£		
	Payoff aeviad	n/a	wears		

		Price	Amount	_
	Produced by REP	0.00 €	0.00	MWh
2	Consumed by IP	0,00 €	0.00	MWh
etrical entry	Net consumption without investment	0,00 €	0.00	MWh
	Feak power without investment	0.00 €	0.00	kW
	Consumed by P2G	0.00 €	0.00	MWh
4	Net consumption with investment	0.00 ¢	0.00	MWh
_	Peak power with investment	0,00 €	0.00	ĸW
	Produced by REP	0.00 €	0.00	MWh
10	Produced IP	0.00 €	0.00	MWh
2	Net production without investment	0.00 ¢	0.00	MWb
÷.,	Consumed by P2G	0.00 €	0.00	MWh
	Net production with investment.	0.00 €	0.00	MWh
a	Produced by REP	0.00 €	0.00	MWh
	Consumed by P	0.00 ¢	0.00	MWh
4	Net consumption without investment	0.00 €	0.00	MWh
2	Produced by P2G	0,00 €	0.00	MWh
_	Net consumption with investment	0.00 €	0.00	MWh
later	Water consumed by P2G	0:00 €	0.00	m ^t
14	Dry biomass bought	0.00 €	0.00	t
2	Wet biomass bought	0,00 €	0.00	1
7	biocher bought	0.00 €	0.00	
12	Biochar sold	0.00 ¢	0.00	τ
-	Hydrogen sold	0.00 ¢	0.00	t
ő	CO2 emitted	0.00 €	0.00	KE .
	Total operational cost without investment	0.00 €		
	Total operational cost with investment	0.00 €		
	Savings with introduction of P2G	0.00 €		

Fig. 9 Results for GF with conservative prices of methane and subsidy of 50%

Greenfield investments – not economically viable.



vestment specifications			Opera	tional costs for selected period		
Element	Price	Size	1.0.000		Price	Amoent
Dry anaerobic digestor	25,304,414.00 €	2.409944 kg/s		Produced by REP	0.00 €	0.00 MW
Wet anaerobic digestor	5,549,213.00 €	0.554921 kg/s	25	Consumed by IP	2,565,495,205.48 €	2,062,000.00 MW
Dry biomass to biochar plant	0.00 ¢	0.000000 kg/s	5	Net consumption without investment	2,565,495,205.48 €	2,062,000.00 MW
Wet biomass to blochar plant	0.00 ¢	0.000000 kg/s	R	Peak power without investment	3,658,927.29 €	3,587,165.61 kW
Biogas separator	22,209,538.31 €	2.612887 kg/s	the second se	Consumed by P2G	712,935,521 94 £	752,919.28 MV
Gasification + water gas shift plan	687,547.56 €	1.375095 kg/s	÷	Net consumption with investment	3,278,490,727.42 €	2,814,919.28 MV
Combined heat and power (CHP)	0.00 ¢	0.000000 kg/s		Peak power with investment	10,867,902.63 €	10,654,806.50 kW
Carbon capture plant	0.00 €	0.000000 mol/s		Produced by REP	0.00 €	0.00 MV
Electrolyser	443,091,509.70 €	354,473.21 kW	1.100	Produced IP	0.00 €	647,571.00 MV
Demineralizer	1,683,115.64 €	177.170067 mol/s	10	Net production without investment	0.00 €	647,571.00 MV
Precipitation collector	1,000.00 €	1,000.00 m ²	-	Consumed by P2G	0.00 C	-81,008.81 MV
Methanation reactor	47,325,765.91 €	291.235483 moi/s		Net production with investment	0.00 ¢	728,579.81 M
Heat exchanger	3,492,511.75 €	69,850,2353 kW		Produced by REP	0.00 ¢	0,00 58
Total for processes	549,344,616,48 €			Consumed by IP	13,882,175,818.03 €	10,845,682.00 M
Dry blomass storage	0.00 ¢	0.0000 kg	1	Net consumption without investment	13,882,175,818.03 €	10,845,682,00 M
Wet biomass storage	0.00 €	0.0000 kg	2	Produced by P2G	41,053,377.05 ¢	688,661.70 M
Biocher storage	763,767.12 €	101,835.6364 kg		Net consumption with investment	13,000,647,376.92 €	10,157,020.50 M
Water storage tank	1,714,265.14 €	171,426,513.6548 mol	Water	Water consumed by P2G	106,925 22 K	100,872.85 m
Oxygen storage tank	0.00 ¢	0.0000 mol	-	Dry blomess bought	1,854,000.00 €	76,000.00 t
Hydrogen storage tank	0.00 ¢	0.0000 mot	10	Wet biomess bought	705,000.00 C	17,500.00 t
Carbon dioxide storage tank	15,927,066.16 €	39,817,665.4031 mol	- R	Biochar bought	0.00 €	9.00 t
Methane storage tank	0.00 €	0.0000 mp/	15	Biochar sold	0.00 €	0.00 t
Total for storages	18.405.098.42 €		1	Hydrogen sold	0.00 ¢	0.00 t
= Electrical connection	166,975.14 €	667.90 MW	6	CO2 emitted	0.00 €	0.00 88
E Gas connection	0.00 ¢	0.00 MW		Total operational cost without investment	16,451,325,950.79 €	
g Water connection	11.52 €	11.52 m ¹ /h		Total operational cost with investment	16.292,611,932.19 €	
Total for connections	166,986.65 €			Savings with introduction of P2G	158,718,018.60 €	
Total investment	567,916,701.55 €			MINARYS NUMBER OF COL		
Payoff period	20.00 years					



Although in the scenario in figure 10 the gas prices are higher, the 50% subsidy makes this type of investment profitable even more profitable than in the first scenario (Average gas price and no subsidy)



_	Element	Price		Size
	Dry anaerobic digestor	0.00	5	0.000000 kg/s
	Wet anaerobic digestor	0.00	¢	0.000000 kg/s
	Dry biomass to biochar plant	0.00	£	0.000000 kg/s
	Wet biomass to biochar plant	0.00	¢	0.000000 kg/s
	Bioges separator	0.00	¢	0.000000 kg/s
	Gasification + water gas shift plan	0.00	¢	0.000000 kg/s
8	Combined heat and power (CHP)	0.00	¢	0.000000 kg/s
1	Carbon capture plant	0.00	¢	0.000000 mol/s
	Electrolyser	0.00	ε	0.00 kW
	Demineralizer	0.00	¢	0.000000 mol/s
	Precipitation collector	0.00	ε	0.00 m ²
	Methanation reactor	0.00	¢	0.000000 mol/s
	Heat exchanger	0.00	٤.	0.0000 kW
	Total for processes	0.00	¢	1000000000
	Dry biomass storage	0.00	6	0.0000 kg
	Wet blomass storage	0.00	ε	0.0000 kg
	Blochar storage	0.00	ŧ	0.0000 kg
z :	Water storage tank	0.00	¢	0.0000 mol
1	Oxygen storage tank	0.00	¢	0.0000 mot
5	Hydrogen storage tank	0,00	ε	0.0000 mol
	Carbon dioxide storage tank	0.00	¢	0.0000 mol
	Methane storage tank	0.00	٤	0.0000 mot
_	Total for storages	0,00	€	2014/09/0029
εE	Electrical connection	0.00	¢	0.00 MW
	Gas connection	0.00	\$	0.00 MW
-	Water connection	0.00	¢	0.00 m ³ /h
2.5	Total for connections	0.00	¢	00000000000
	Total investment	0.00	£	
	Payoff period	nla	WHAT	

	1	Price	_	Amount	
crick megy	Froduced by REP	3,119,652.71	٤.	6,200.00	MWh
	Consumed by IP	0.00	¢	0.00	MWh
	Net consumption without investment	-3,119,652.71	¢	-6,200.00	MWh
	Peak power without investment	0.00	¢	0.00	kW
	Consumed by #2G	0.00	¢	0.00	MWh
4	Net consumption with investment	-3,119,652.71	€	-6,200.00	MWh
	Peak power with investment	0.00	£	D.00	kW
	Produced by REP	0.00	£	0.00	MWh
100	Produced IP	0.00	¢ .	0.00	MM
in the	Net production without investment	0.00	ε	0.00	MWh
20	Consumed by #2G	0.00	£	0.00	MWh
	Net production with investment	0.00	¢ .	0.00	MWh
shake	Produced by REP	6.00	ε	0.00	MWh
	Consumed by IP	0.00	¢	0.00	MWh
	Net consumption without investment.	0.00	¢	0.00	MWB
ž	Produced by P2G	0.00	٤.	0.00	MWh
	Net consumption with investment	0:00	ε	0.00	MWh
Nater	Water consumed by P2G	0.00	٤.	0.00	m
	Dry biomass bought	6.00	٤	0.00	t
1	Wet blomass bought	0.00	ε	0.00	t
2	Biocher bought	0:00	6	0.00	¢
z	Biochar sold	0.00	٤	0.00	t
-	Hydrogen sold	0.00	٤.	0.00	t
6	002 emitted	0.00	£	0.00	kg
	Total operational cost without investment	-3,119,652.71	£	11 (1000)	
	Total operational cost with investment	-3.119.652.71	€		
	Savings with introduction of P2G	0.00	•		

Fig. 11 Results for REP with higher prices of methane and subsidy of 50%

In the case of REP, the trend is maintained, the 50% subsidy amortizing the values from the previous scenarios.



	Element	Price		Size	
	Dry anaerobic digestor	B.00	¢	0.000000	kg/s
	Wet anaerobic digestor	0.00	¢	0.000000	kg/s
	Dry biomass to blochar plant	0.00	¢	0.000000	kg/s
	Wet blomass to blocher plent	0.00	ε	6.000000	kg/s
	Biogas separator	0.00	٤	0.000000	kg/s
	Gasification + water gas shift plan	0.00	ε	0.00000.0	kg/s
al a	Combined heat and power (CHP)	0.00	¢	0.000000	kg/s
8	Carbon capture plant	0.00	ε	0.000000	mol/s
-	Electrolyser	0.00	٤	0.00	kW.
	Demineralizer	0.00	¢	0.000000	moi/s
	Precipitation collector	0.00	¢	0.00	m
	Methanation reactor	0.00	¢	0.000000	mpl/s
	Heat exchanger	0.00	٤	0.0000	KW:
_	Total for processes	0.00	•		
	Dry biomass storage	0.00	ε	0.0000	1g
	Wet blomass storage	0.00	¢	0.0000	łg
	Biocher storage	0.00	¢	0.0000	kg .
2	Water storage tank	0.00	¢	0.0000	mol
a a	Oxygen storage tank	0.00	¢	0.0000	mol
8	Hydrogen storage tank	0.00	¢	0.0000	mol
	Carbon dioxide storage tank	0.00	ε	0.0000	mol
	Methane storage tank	0.00	¢	0.0000	mai
	Total for storages	0.00	e		
1 2	Electrical connection	0.00	¢	0.00	MW
	Ges connection	0.00	¢	0.00	MW
1	Water connection	0.00	٤	0.00	m ³ /h
0 5	Total for connections	0.00	e		
	Total investment	0.00	6	1	
	Payoff period	n/a	years.		

11.	- 49	Price	Amount	
Electrical energy	Produced by REP	0.00.€	0.00	MWh
	Consumed by IP	0.00 <	0.00	MWh
	Net consumption without investment	0.00 €	0.00	MWh
	Peak power without investment	0.00 E	0.00	kW
	Consumed by P20	0.00 €	0.00	MWh
	Net consumption with investment	0.00 ¢	0.00	MWh
	Peak power with investment	0.00 €	0.00	kW
Heat	Produced by REP	0.00 ¢	0.00	MWh
	Produced IP	0.00 ¢	0.00	MWh
	Net production without investment	0.00 €	0.00	MWh
	Consumed by #2G	0.00 €	0.00	MWh
	Net production with investment	0.00 <	0.00	MWIN
Methone	Produced by REP	0.00 €	0.00	MWh
	Consumed by IP	0.00 €	0.00	MWh
	Net consumption without investment	0.00 €	0.00	MWh
	Produced by P2G	0.00 €	0.00	MWh
	Net consumption with investment	0.00 €	0.00	MWh
Water	Water consumed by P2G	0.00 €	0.00	m
	Dry blomass bought	0.00 ¢	0.00	τ
hput	Wet biomass bought	0.00 ¢	0.00	t
	Biocher bought	0.00 €	0.00	t
20	Biochar sold	0.00 ¢	0.00	1
orativio	Hydrogen sold	0.00 €	0.00	t
	CO2 emitted	0.00 ¢	0.00	kg.
	Total operational cost without investment	0.00 €		
	Total operational cost with investment	0.00 €		
	Savings with introduction of P2G	0.00 €		

Fig. 12 GF with higher prices of methane and subsidy of 50%

Greenfield investments – not economically viable.



3. CONCLUSIONS

Regarding Romania, it turns out that the most profitable Power to gas hubs can be linked to Industrial Plants, where investments are viable and durable.

In the case of Renewable Energy Plant, as mentioned above, the negative values in terms of energy consumption with or without investment can be translated as production, however they are not economically viable, just as is the case with investments. Greenfiled type in this field.

However, it is shown that these values may fluctuate depending on the price of methane gas or depending on the existence of a certain subsidy and its percentage / value, for this type of investment.

The existence and the percentage of the subsidy can make the difference and prove to be mathematically, economically more important than the fluctuation of the gas price.

P2G investments are not sustainable in all scenarios.

Taking into account the biomass deposits in Romania, the most profitable areas to invest in biomass are the region of Moldova in the northeast of the country but also Muntenia (Calarasi county) and Constanta county in Dobrogea region, where most biomass is agricultural. The center of the country, Transylvania, is not a bad investment option either, where the biomass is mixed, coming from various sources such as livestock, fruit and forest biomass.

Thus, it is noted that the investments in the P2G field are variable, they are not economically viable in each case and they depend a lot on the price of gas, on the biomass capacity. However, an investment can tip the economic balance in a positive way, even if it would not be 50% as in the presented scenarios, but it would be smaller.