

## Output T2.2

# Pre-feasibility Study (Slovakia)

WP T2: Project main output

September, 2022

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



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#### **DOCUMENT CONTROL SHEET**

Project reference	
Full title of the project	Innovative model to drive energy security and diversity in the Danube Region via combination of bioenergy with surplus renewable energy
Acronym	DanuP-2-Gas
Programme priority	Priority 3
Programme priority specific objective	SO 3.2 Improve energy security and energy efficiency
Duration	01.07.2020 – 31.12.2022
Project website	www.interreg-danube.eu/danup-2-gas
Project coordinator	TZE

#### **Short Description**

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

Document Details	
Title of document	Pre-feasibility Report (Country)
Action	WP T2 Transnational Infrastructure and Biomass assessment & Pre-feasibility Studies
Deliverable	Output T2.2
Delivery date	September 2022

Version	Date	Author	Organization	Description
$\lor$ 1	15.9.2022	Dominika Fukerova	NARA-SK	l <sup>st</sup> version



#### **IMPRINT**

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- ERDF PP1 Energy AGency of Savinjska, Koroška and Šaleška Region (SI)
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- IPA PP1 Regional Agency for Socio Economic Development Banat Ltd (RS)

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## **1. METHODOLOGY**

For the purpose of this document, the main tool used was the Optimalisation tool (https://www.danup2gas.eu/optimizationtool) and the Atlas of renewable energy, both created during the course of the DanuP-2-Gas project. The objective is to assess the current and theoretical conditions in Slovakia for the investment into Power-to-Gas (P2G) hub. The P2G hubs are configured as either a part of existing renewable or industrial plant, or a greenfield location. In each of these three cases we explore the potential with current prices of gas and 10 times higher gas prices. Each of these cases is then further explored with the amount of 0% subsidy or 50% subsidy. This results in 12 different (3x2x2=12) situations that are presented in this document with further specifications, comments and assessment.

The sources of data used for the Optimalisation tool is the Infrastructure and Biomass tables and reports conducted during the course of the DanuP-2-Gas project. The data is as accurate as the sources of available sources were and may not be 100% exact. For further exploration of the possibilities, more options are available, such as adding the existing market options for Hydrogen, Oxygen, Biochar and Methane. In the presented study cases, these were set to zero.

### **2. CASE STUDIES**

For the purpose of this prefeasibility study, 3 different case scenarios were evaluated, all of them further divided with more theoretical options. The first case is a P2G hub located next to an existing renewable plant (REP) Biomass plant Bučina in Zvolen. This biomass plant produces around 30000 MWh of electricity and heat yearly.

The second case of P2G hub is located next to an existing Industrial plant (IP) Chemosvit with the power of almost 12 MW and consumtion of over 60 000 mWh of electric power.

The third case is a greenfield location in the region of Gemer Malohont, near the village Jesenské, where the region has potential for such investment. There is several biomass sources around and few photovoltaic plants.



## **3. RESULTS**

For each one of case studies (IP, REP and GF), two types of gas prices and subsidies are considered. The considered cases are summarized in *Table 1*.

Table 1:

	Conservat	ive prices of	fmethane	10 × Higher prices of methane			
	REP	IP	GF	REP	IP	GF	
No subsidy	No investme nt, Fig. 1	No investme nt, Fig. 5	No investme nt, Fig. 9	Possible investmen ts, Fig. 3	Possible investmen ts, Fig. 7	Possible investmen ts, Fig. 11	
Subsidy of 50 %	No investme nt, Fig. 2	No investme nt, Fig. 6	No investme nt, Fig. 10	Possible investmen ts, Fig. 4	Possible investmen ts, Fig. 8	Possible investmen ts, Fig. 12	

Every solution from Table 1 is obtained using the simulation period of one complete year and electrical consumption/production sampling of 24h. The maximum investment is set to 1 000 000 000 and maximum payoff period to 20years. The market options for hydrogen, oxygen, methane and biochar are set to 0. As seen from the Table 1, the only feasible options for P2G hub in Slovakia are with an increased gas price. With the current gas prices, none of the three locations are economically viable to be extended with the P2G hub. The concrete cases are each commented under the selected Figures.



#### <u>REP</u>

Inves	tment specifications				
	Element	Cost		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	€	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
Processes	Carbon capture plant	0,00	€	0,000000	mol/s
	Gasification + water gas shift plant	0,00	€	0,000000	kg/s
	Methanation reactor	0,00	€	0,000000	mol/s
-	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,00	€	0,000000	mol/s
	Precipitation collector	0,00	€	0,00	m²
	Heat exchanger	0,00	€	0,00	kW
	Gas compressor station	0,00	€	0,0000	kWe
	Total for processes	0,00	€		
	Dry biomass storage	0,00	€	0,00	kg
	Wet biomass storage	0,00	€	0,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
s	Hydrogen storage tank	0,00	€	0,00	kg
E.	Oxygen storage tank	0,00	€	0,00	kg
55	Methane storage tank	0,00	£	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m³
	Total for storages	0,00	€		
2 번	Electrical connection	0,00	€	0,00	MW
e me	Gas connection	0,00	€	0,00	MW
lang	Water connection	0,00	€	0,00	m³/h
3 5	Total for connections	0,00	€		
	Total investment	0,00	€	]	
	Payoff period	n/a	vears	]	

Operati	onal costs for selected period				
		Cost		Amount	_
	Produced by REP	6 156 573,30	€	31 304,61	MWh
Electrical energy	Consumed by IP	0,00	€	0,00	MWh
	Net consumption without investment	-6 156 573,30	€	-31 304,61	MWh
B	Mean peak power without investment	0,00	€	0,00	MW
i.	Consumed by P2G	0,00	€	0,00	MWh
B	Net consumption with investment	-6 156 573,30	€	-31 304,61	MWh
	Mean peak power with investment	0,00	€	0,00	MW
	Produced by REP	0,00	€	0,00	MWh
	Produced IP	0,00	€	0,00	MWh
Heat	Net production without investment	0,00	€	0,00	MWh
_	Consumed by P2G	0,00	€	0,00	MWh
	Net production with investment	0,00	€	0,00	MWh
Gas (methane) to/from the grid	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 from the grid consumed by P2G	0,00	€	0,00	m³
	Collected precipitation consumed by P2G	n/a	€	0,00	m³
~	Dry biomass bought	0,00	€	0,00	t
srial	Wet biomass bought	0,00	€	0,00	t
lat p	Biochar bought	0,00	€	0,00	t
E	Total cost of input materials	0,00	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
<u> </u>	Oxygen sold (in bottles)	0,00	€	0,00	t
iltio ale:	Methane sold (in bottles)	0,00	€	0,00	t
Add	Biochar sold	0,00	€	0,00	t
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	€	0,00	t
8	Residue from wet anaerobic digester	0,00	€	0,00	t
sidu	Tar from gasification + water gas shift plar	0,00	€	0,00	t
Be	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	-6 156 573,30	€		
	Total operational cost with investment	-6 156 573,30	€		
	Savings with introduction of P2G	0.00	•		

**Fig. 1** Results for optimal P2G hub next to REP with conservative prices of methane and no subsidy (Results sheet of the Optimization tool)

With the current prices of methane, it is not economically feasible to invest in the P2G near this biomass plant.



	Element	Cost		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	£	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	€	0,000000	mol/s
	Gasification + water gas shift plant	0,00	€	0,000000	kg/s
	Methanation reactor	0,00	€	0,000000	mol/s
	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,00	€	0,000000	mol/s
	Precipitation collector	0,00	€	0,00	m²
	Heat exchanger	0,00	£	0,00	kW
	Gas compressor station	0,00	€	0,0000	kWe
	Total for processes	0,00	€		
	Dry biomass storage	0,00	€	0,00	kg
	Wet biomass storage	0,00	€	0,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
	Hydrogen storage tank	0,00	€	0,00	kg
	Oxygen storage tank	0,00	€	0,00	kg
	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	£	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
	Total for storages	0,00	€		
Ħ	Electrical connection	0,00	€	0,00	MW
e	Gas connection	0,00	€	0,00	MW
Ę	Water connection	0,00	€	0,00	m <sup>3</sup> /h
5	Total for connections	0,00	€		
	Total investment	0,00	€	]	
	Payoff period	n/a	vears		

		Cost	_	Amount	
	Produced by REP	6 156 573,30	€	31 304,61	MWh
Residues Additional Input RM Gas (methane) Heat Electrical energy sales materials to from the grid Heat	Consumed by IP	0,00	€	0,00	MWh
	Net consumption without investment	-6 156 573,30	€	-31 304,61	MWh
	Mean peak power without investment	0,00	€	0,00	MW
Gtric	Consumed by P2G	0,00	€	0,00	MWh
E	Net consumption with investment	-6 156 573,30	€	-31 304,61	MWh
	Mean peak power with investment	0,00	€	0,00	MW
	Produced by REP	0,00	€	0,00	MWh
Additional Input Gas (methane) Additional Input Residues sales are to/from the grid Heat to/from to/fr	Produced IP	0,00	€	0,00	MWh
	Net production without investment	0,00	€	0,00	MWh
	Consumed by P2G	0,00	€	0,00	MWh
	Net production with investment	0,00	€	0,00	MWh
Residues Additional Input R Gas (methane) Heat Electrical energy sales materials a to/from the grid Heat	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
fror as	Produced by P2G	0,00	€	0,00	MWh
Ga to/	Net consumption with investment	0,00	€	0,00	MWh
Vator	Water from the grid consumed by P2G	0,00	€	0,00	m <sup>3</sup>
vater	Collected precipitation consumed by P2G	n/a	€	0,00	m <sup>3</sup>
Log by the second s	0,00	t			
in all	Wet biomass bought	CostAmount6 156 573,30€31 304,61MW/0,00€0,00MW/n without investment-6 156 573,30€-31 304,61MW/r without investment-6 156 573,30€-31 304,61MW/r without investment-6 156 573,30€-31 304,61MW/r with investment-6 156 573,30€-31 304,61MW/r with investment-6 156 573,30€-31 304,61MW/r with investment0,00€0,00MW/0,00€0,00€0,00MW/0,00€0,00€0,00MW/0,00€0,00€0,00MW/investment0,00€0,00MW/10 thou investment0,00€0,00MW/n with investment0,00€0,00MW/n with investment0,00€0,00MW/gight0,00€0,00MW/gight0,00€0,001n bottles)0,00€0,00tn bottles)0,00€0,001n bottles)0,00€0,00tn bottles)0,00€0,00tn bottles)0,00€0,00tn bottles)0,00€0,00tn bottles)0,00€0,00tn bottles)0,00€0,00t <td>t</td>	t		
at at	Biochar bought		t		
5	Total cost of input materials	0,00	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
Residues Additional Input Gas (methane) sales materials Later Gas (methane) Heat Electrical energy sales	Oxygen sold (in bottles)	0,00	€	0,00	t
	Methane sold (in bottles)	0,00	€	0,00	t
S	Biochar sold	CostAmounted by REP6 156 573,30€31 304,61ned by IP0,00€0,00isumption without investment-6 156 573,30€-31 304,61ned by PZG0,00€0,00samption with investment-6 156 573,30€-31 304,61ned by PZG0,000€0,000eak power with investment-6 156 573,30€-31 304,61eak power with investment0,000€0,000ed by PZG0,000€0,000ed precipitation consumed by P2Gn/ai€0,000en sold (in bottles)0,000€0,000en sold (in bottles)0,000€0,000er from dry anaerobic digester0,000€0,000er from dry anaerobic digester0,000€0,000er for dry anaerobic digester0,000€0,000er for dry anaerobic digester0,000€0,000erational cost without investment-6 156 573,30€erational cost without investment-6	t		
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	£	0,00	t
S	Residue from wet anaerobic digester	0,00	€	0,00	t
sidu	Tar from gasification + water gas shift plar	0,00	€	0,00	t
Residues Acational input cast (instraints) Heat Ele	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	-6 156 573,30	€		
	Total operational cost with investment	-6 156 573,30	€		
	Savings with introduction of P2G	0.00	€		

**Fig. 2** Results for optimal P2G hub next to REP with conservative prices of methane and 50% subsidy (Results sheet of the Optimization tool)

The investment is not economically viable neither with the subsidy of 50%. With the current prices of methane and no existing market for hydrogen, oxygen and biochar, the Optimalisation tool suggest not to invest into any component of P2G hub,



	Element	Cost		Size	
_	Dry anaerobic digestor	2 430 555.56	£	0.115741	kg/s
	Wet anaerobic digestor	2 430 555.56	£	0.115741	kg/s
	Dry biomass to biochar plant	0.00	€	0.000000	kg/s
	Wet biomass to biochar plant	0.00	€	0.000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	€	0,000000	mol/s
	Gasification + water gas shift plant	13 888,89	€	0,013889	kg/s
Ē	Methanation reactor	3 187 395,34	€	7,499754	mol/s
•	Electrolyser	11 364 755,71	€	4 545,90	kW
	Demineralizer	1 236,87	€	12,368668	mol/s
	Precipitation collector	2 000,00	€	1 000,00	m²
	Heat exchanger	226 658,54	€	2 266,59	kW
	Gas compressor station	48 247,28	€	60,3091	kWe
	Total for processes	19 705 293,74	€		
	Dry biomass storage	100 000,00	€	10 000,00	kg
	Wet biomass storage	50 000,00	€	10 000,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
9	Hydrogen storage tank	0,00	€	0,00	kg
8	Oxygen storage tank	0,00	€	0,00	kg
ñ	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	£	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
	Total for storages	150 000,00	€	1000	
t	Electrical connection	317 232,32	€	5,29	MW
eme	Gas connection	134 954,35	€	6,04	MW
lang	Water connection	24,74	€	0,80	m <sup>3</sup> /h
er	Total for connections	452 211,41	€		
	Total investment	20 307 505,14	€		
	Payoff period	5.11	vears		

Operati	onal costs for selected period				
		Cost		Amount	
	Produced by REP	6 156 573,30	€	31 304,61	MWh
Residues Additional Input Gas (methane) Heat Electrical energy sales materials Loyfrom the grid Heat	Consumed by IP	0,00	€	0,00	MWh
	Net consumption without investment	-6 156 573,30	€	-31 304,61	MWh
	Mean peak power without investment	0,00	€	0,00	MW
	Consumed by P2G	25 470 420,09	€	93 986,79	MWh
Ele	Net consumption with investment	16 986 870,78	€	62 682,18	MWh
Residues Additional Input & Gas (methane) Heat Electrical energy and sales materials à to/from the grid Heat Electrical energy	Mean peak power with investment	28 258,66	€	7,16	MW
	Produced by REP	0,00	€	0,00	MWh
methane) Heat	Produced IP	0,00	€	0,00	MWh
	Net production without investment	0,00	£	0,00	MWh
	Consumed by P2G	0,00	€	-19 315,90	MWh
	Net production with investment	0,00	€	19 315,90	MWh
a P	Produced by REP	0,00	€	0,00	MWh
Gas (methane) to/from the gri	Consumed by IP	0,00	€	0,00	MWh
	Net consumption without investment	0,00	£	0,00	MWh
	Produced by P2G	212 555 428,07	€	52 886,76	MWh
	Net consumption with investment	-212 555 428,07	€	-52 886,76	MWh
Water	Water from the grid consumed by P2G	7 787,40	£	6 425,78	m³
	Collected precipitation consumed by P2G	n/a	€	774,57	m <sup>3</sup>
10	Dry biomass bought	97 084,91	€	3 650,00	t
rial;	Wet biomass bought	0,00	€	3 650,00	t
Additional Input & Gas (methane) sales materials at to/from the grid	Biochar bought	0,00	€	0,00	t
	Total cost of input materials	97 084,91	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
	Oxygen sold (in bottles)	0,00	€	0,00	t
Residues Additional Input & Gas (methane) asiles materials to/from the grid to/from the grid Additional Electrical energy	Methane sold (in bottles)	0,00	£	0,00	t
Add	Biochar sold	0,00	£	0,00	t
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	£	109,50	t
5	Residue from wet anaerobic digester	0,00	€	547,50	t
sidu	Tar from gasification + water gas shift plan	0,00	€	43,80	t
Re	CO2 emitted	0,00	£	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	-6 156 573,30	€		
	Total operational cost with investment	-195 435 426,32	€		
	Savings with introduction of P2G	189 278 853.02	€		

**Fig. 3** Results for optimal P2G hub next to REP with 10× higher prices of methane and no subsidy (Results sheet of the Optimization tool)

The situation changes with the (10×) higher prices of methane. In this scenario it is already feasible to invest into wet and dry anaerobic digestor, gasification + water gas shift plant, electrolyser, methanation reactor, heat exchanger gas compressor station and storages for wet and dry biomass, biochar storage and water storage tank. This is an investment of over 20 000 000€ with no subsidy and payoff period 5,11 years. The total savings with the introduction of P2G would be 189 278 853,02€.



	Flement	Cost		Size	
	Dry anaerobic digestor	1 215 277 78	f	0 1157/1	kale
	Wet anaerobic digestor	1 215 277,78	f	0,115741	ka/s
	Dev biomass to biochar plant	12132/1,/8	t F	0,115741	kg/s
	Wet biomass to biochar plant	0,00	e e	0,000000	ka/s
	Combined best and power (CHP)	0,00	e e	0,000000	kWo
	Carbon capture plant	0,00	e e	0,00	mol/s
ses	Carification L water and chift plant	6 044 44	• •	0,000000	kala
000	Mothapation reactor	1 502 607 67	e e	7 400754	mol/c
ď.	Flactrolycor	5 692 277 96	e e	7,499734	LW S
	Demineralizer	5 082 577,80	t F	12 269669	mol/s
	Precipitation collector	1 000 00	e e	1 000 00	m <sup>2</sup>
	Heat exchanger	113 329 27	e	2 266 59	EW.
	Gas compressor station	24 123 54	e e	60 3091	kWe
	Total for processes	9 852 646 87	e e	00,0001	KIVC.
	Dry biomass storage	50,000,00	£	10 000 00	ka
	Wet biomass storage	25 000 00	£	10 000 00	ka
	Biochar storage	0.00	£	0.00	kø
	Biogas storage	0.00	£	0.00	kg
2	Hydrogen storage tank	0,00	£	0.00	kg
ĕ	Oxygen storage tank	0.00	£	0.00	kg
ŝ	Methane storage tank	0.00	£	0.00	kg
	Syngas storage tank	0.00	£	0.00	kg
	Carbon dioxide storage tank	0.00	£	0.00	kg
	Water storage tank	0.00	£	0.00	m <sup>3</sup>
	Total for storages	75 000.00	£	-,	
Ħ	Electrical connection	317 232.32	€	5.29	MW
BE	Gas connection	134 954.35	€	6.04	MW
ange	Water connection	24,74	£	0.80	m³/h
e	Total for connections	452 211.41	€		
	Total investment	10 379 858.28	€	1	
	Payoff period	5.06	vears	1	

Operation	onal costs for selected period				
		Cost		Amount	
	Produced by REP	6 156 573,30	€	31 304,61	MWh
20	Consumed by IP	0,00	€	0,00	MWh
ueu	Net consumption without investment	-6 156 573,30	€	-31 304,61	MWh
8	Mean peak power without investment	0,00	€	0,00	MW
Ē	Consumed by P2G	25 470 420,09	€	93 986,79	MWh
E	Net consumption with investment	16 986 870,78	€	62 682,18	MWh
	Mean peak power with investment	28 258,66	€	7,16	MW
	Produced by REP	0,00	€	0,00	MWh
	Produced IP	0,00	€	0,00	MWh
Hea	Net production without investment	0,00	€	0,00	MWh
-	Consumed by P2G	0,00	€	-19 315,90	MWh
	Net production with investment	0,00	€	19 315,90	MWh
@₽	Produced by REP	0,00	€	0,00	MWh
e gi	Consumed by IP	0,00	€	0,00	MWh
a et	Net consumption without investment	0,00	€	0,00	MWh
as (r	Produced by P2G	212 555 428,07	€	52 886,76	MWh
ţ ö	Net consumption with investment	-212 555 428,07	€	-52 886,76	MWh
Water	Water from the grid consumed by P2G	7 787,40	€	6 425,78	m³
water	Collected precipitation consumed by P2G	n/a	€	774,57	m³
Ś	Dry biomass bought	97 084,91	€	3 650,00	t
ij et	Wet biomass bought	0,00	€	3 650,00	t
ing in	Biochar bought	0,00	€	0,00	t
-	Total cost of input materials	97 084,91	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
	Oxygen sold (in bottles)	0,00	€	0,00	t
ale:	Methane sold (in bottles)	0,00	€	0,00	t
Ado	Biochar sold	0,00	€	0,00	t
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	€	109,50	t
8	Residue from wet anaerobic digester	0,00	€	547,50	t
sidu	Tar from gasification + water gas shift plar	0,00	€	43,80	t
Re	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	-6 156 573,30	€		
	Total operational cost with investment	-195 435 426,32	€		
	Savings with introduction of P2G	189 278 853,02	€		

**Fig. 4** Results for optimal P2G hub next to REP with 10× higher prices of methane and 50% subsidy (Results sheet of the Optimization tool)

The situation is similar than in Figure 3, only the subsidy makes the whole investment smaller and the payoff period shorter. The amount of produced biomethane is over 50 000 mWh per year and the total savings are over 189 000 000 EUR.



#### PROJECT WEBSITES - UNIS - TO SECTION

#### IP

	Element	Cost		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	€	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	€	0,000000	mol/s
2	Gasification + water gas shift plant	0,00	€	0,000000	kg/s
2	Methanation reactor	0,00	€	0,000000	mol/s
-	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,00	€	0,000000	mol/s
	Precipitation collector	0,00	€	0,00	m <sup>2</sup>
	Heat exchanger	0,00	€	0,00	kW
	Gas compressor station	0,00	€	0,0000	kWe
	Total for processes	0,00	€		
	Dry biomass storage	0,00	€	0,00	kg
	Wet biomass storage	0,00	€	0,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
9	Hydrogen storage tank	0,00	€	0,00	kg
f	Oxygen storage tank	0,00	€	0,00	kg
ñ	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
	Total for storages	0,00	£		
ŧ	Electrical connection	0,00	€	0,00	MW
eme	Gas connection	0,00	€	0,00	MW
ang	Water connection	0,00	€	0,00	m <sup>3</sup> /h
en en	Total for connections	0,00	€		
	Total investment	0,00	€		
	Payoff period	n/a	years		

Operat	ional costs for selected period				
		Cost		Amount	
	Produced by REP	0,00	€	0,00	MWh
nergy	Consumed by IP	16 277 764,05	€	60 065,55	MWh
	Net consumption without investment	16 277 764,05	€	60 065,55	MWh
Gal	Mean peak power without investment	27 078,87	€	6,86	MW
strie	Consumed by P2G	0,00	€	0,00	MWh
Ele	Net consumption with investment	16 277 764,05	€	60 065,55	MWh
	Mean peak power with investment	27 078,87	€	6,86	MW
	Produced by REP	0,00	€	0,00	MWh
	Produced IP	0,00	€	32,50	MWh
lear	Net production without investment	0,00	€	32,50	MWh
-	Consumed by P2G	0,00	€	0,00	MWh
	Net production with investment	0,00	€	32,50	MWh
e Pi	Produced by REP	0,00	€	0,00	MWh
lan.	Consumed by IP	0,00	€	0,00	MWh
n th	Net consumption without investment	0,00	€	0,00	MWh
fror	Produced by P2G	0,00	€	0,00	MWh
Ga to/	Net consumption with investment	0,00	€	0,00	MWh
	Water from the grid consumed by P2G	0,00	€	0,00	m <sup>3</sup>
water	Collected precipitation consumed by P2G	n/a	€	0,00	m <sup>3</sup>
	Dry biomass bought	0,00	€	0,00	t
rials	Wet biomass bought	0,00	€	0,00	t
Inp	Biochar bought	0,00	€	0,00	t
E	Total cost of input materials	0,00	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
e .	Oxygen sold (in bottles)	0,00	€	0,00	t
ales	Methane sold (in bottles)	0,00	€	0,00	t
Add	Biochar sold	0,00	€	0,00	t
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	€	0,00	t
6S	Residue from wet anaerobic digester	0,00	€	0,00	t
sidu	Tar from gasification + water gas shift plant	0,00	€	0,00	t
Res	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	16 304 842,92	€		
	Total operational cost with investment	16 304 842.92	€		
	Savings with introduction of P2G	0.00	£		

**Fig. 5** Results for optimal P2G hub next to IP with conservative prices of methane and no subsidy (Results sheet of the Optimization tool)

In the case of current prices of methane and no subsidy, the investment into P2G next to an existing Industrial plant seems not to be feasible.



	Element	Cost		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	£	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	£	0,000000	mol/s
	Gasification + water gas shift plant	0,00	€	0,000000	kg/s
	Methanation reactor	0,00	€	0,000000	mol/s
	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,00	€	0,000000	mol/s
	Precipitation collector	0,00	£	0,00	m²
	Heat exchanger	0,00	£	0,00	kW
	Gas compressor station	0,00	€	0,0000	kWe
_	Total for processes	0,00	€		
	Dry biomass storage	0,00	£	0,00	kg
	Wet biomass storage	0,00	€	0,00	kg
	Biochar storage	0,00	£	0,00	kg
	Biogas storage	0,00	£	0,00	kg
1	Hydrogen storage tank	0,00	€	0,00	kg
	Oxygen storage tank	0,00	€	0,00	kg
1	Methane storage tank	0,00	£	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	£	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
_	Total for storages	0,00	€		
int	Electrical connection	0,00	£	0,00	MW
eme	Gas connection	0,00	€	0,00	MW
lang	Water connection	0,00	£	0,00	m <sup>3</sup> /h
a	Total for connections	0,00	€		
	Total investment	0,00	€		
	Payoff period	n/a	years		

Operat	ional costs for selected period				
		Cost		Amount	
	Produced by REP	0,00	€	0,00	MWh
nengy	Consumed by IP	16 277 764,05	e	60 065,55	MWh
	Net consumption without investment	16 277 764,05	¢	60 065,55	MWh
a a	Mean peak power without investment	27 078,87	¢	6,86	MW
ctri	Consumed by P2G	0,00	e	0,00	MWh
E	Net consumption with investment	16 277 764,05	e	60 065,55	MWh
	Mean peak power with investment	27 078,87	e	6,86	MW
	Produced by REP	0,00	e	0,00	MWh
	Produced IP	0,00	¢	32,50	MWh
feat	Net production without investment	0,00	¢	32,50	MWh
÷.	Consumed by P2G	0,00	¢	0,00	MWh
	Net production with investment	0,00	e	32,50	MWh
- P	Produced by REP	0,00	€	0,00	MWh
egr	Consumed by IP	0,00	¢	0,00	MWh
u th	Net consumption without investment	0,00	¢	0,00	MWh
fror	Produced by P2G	0,00	¢	0,00	MWh
to/ 6	Net consumption with investment	0,00	e	0,00	MWh
Weter	Water from the grid consumed by P2G	0,00	e	0,00	m³
water	Collected precipitation consumed by P2G	n/a t	e	0,00	m <sup>3</sup>
10	Dry biomass bought	0,00	€	0,00	t
rials	Wet biomass bought	0,00	¢	0,00	t
ate l	Biochar bought	0,00	¢	0,00	t
E	Total cost of input materials	0,00	e		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
	Oxygen sold (in bottles)	0,00	¢	0,00	t
ales	Methane sold (in bottles)	0,00	¢	0,00	t
Add	Biochar sold	0,00	¢	0,00	t
	Total revenue from additional sales	0,00	e		
	Residue from dry anaerobic digester	0,00	¢	0,00	t
5	Residue from wet anaerobic digester	0,00	e	0,00	t
idu	Tar from gasification + water gas shift plan	0,00	¢	0,00	t
Res	CO2 emitted	0,00	¢	0,00	t
	Total cost of residues	0,00	e		
	Total operational cost without investment	16 304 842,92	e		
	Total operational cost with investment	16 304 842,92	e		
	Savings with introduction of P2G	0.00	•		

**Fig. 6** Results for optimal P2G hub next to IP with conservative prices of methane and 50% subsidy (Results sheet of the Optimization tool)

The result from the calculation of possible investment to P2G hub next to an existing industrial plant shows that with the current prices of methane and zero subsidy it is no feasible.



Inve	tment specifications				Operati	onal costs for selected period	
	Element	Cost	Size				Cost
	Dry anaerobic digestor	2 430 555,56 €	0,115741	kg/s		Produced by REP	0,00 €
	Wet anaerobic digestor	2 430 555,56 €	0,115741	kg/s	20	Consumed by IP	16 277 764,05 €
	Dry biomass to biochar plant	0,00 €	0,000000	kg/s	ueu	Net consumption without investment	16 277 764,05 €
	Wet biomass to biochar plant	0,00 €	0,000000	kg/s	a a	Mean peak power without investment	27 078,87 €
	Combined heat and power (CHP)	0,00 €	0,00	kWe	stric	Consumed by P2G	25 470 420,09 €
	Carbon capture plant	0,00 €	0,000000	mol/s	Ele	Net consumption with investment	41 748 184,14 €
asse	Gasification + water gas shift plant	13 888,89 €	0,013889	kg/s		Mean peak power with investment	69 450,33 €
Loce	Methanation reactor	3 187 395,34 €	7,499754	mol/s		Produced by REP	0,00 €
~	Electrolyser	11 364 755,71 €	4 545,90	kW		Produced IP	0,00 €
	Demineralizer	1 236,87 €	12,368668	mol/s	lear	Net production without investment	0,00 €
	Precipitation collector	2 000,00 €	1 000,00	m <sup>2</sup>	-	Consumed by P2G	0,00 €
	Heat exchanger	226 658,54 €	2 266,59	kW		Net production with investment	0,00 €
	Gas compressor station	48 247,28 €	60,3091	kWe	(i)	Produced by REP	0,00 €
	Total for processes	19 705 293,74 €			the	Consumed by IP	0,00 €
	Dry biomass storage	100 000,00 €	10 000,00	kg	rom	Net consumption without investment	0,00 €
	Wet biomass storage	50 000,00 €	10 000,00	kg	s (r	Produced by P2G	212 555 428,07 €
	Biochar storage	0,00 €	0,00	kg	Ga	Net consumption with investment	-212 555 428,07 €
	Biogas storage	0,00 €	0,00	kg	Water	Water from the grid consumed by P2G	7 787,40 €
se	Hydrogen storage tank	0,00 €	0,00	kg	water	Collected precipitation consumed by P2G	n/a €
orag	Oxygen storage tank	0,00 €	0,00	kg	v)	Dry biomass bought	65 218,14 €
st	Methane storage tank	0,00 €	0,00	kg	ti dt	Wet biomass bought	254 668,57 €
	Syngas storage tank	0,00 €	0,00	kg	Inp	Biochar bought	0,00 €
	Carbon dioxide storage tank	0,00 €	0,00	kg	<u>د</u>	Total cost of input materials	319 886,71 €
	Water storage tank	0,00 €	0,00	m <sup>3</sup>		Hydrogen sold (in bottles)	0,00 €
	Total for storages	150 000,00 €				Oxygen sold (in bottles)	0,00 €
a te	Electrical connection	337 440,20 €	5,62	MW	ale	Methane sold (in bottles)	0,00 €
enic	Gas connection	0,00 €	0,00	MW	Add	Biochar sold	0,00 €
Iang	Water connection	24,74 €	0,80	m³/h		Total revenue from additional sales	0,00 €
S P	Total for connections	337 464,93 €				Residue from dry anaerobic digester	0,00 €
	Total investment	20 192 758,67 €			8	Residue from wet anaerobic digester	0,00 €
	Payoff period	5,11 yea	rs		sidu	Tar from gasification + water gas shift pla	0,00 €
					Re	CO2 emitted	0,00 €
						Total cost of residues	0,00 €
						Total operational cost without investment	16 304 842,92 €
						Total operational cost with investment	-170 410 119,50 €
						Savings with introduction of P2G	186 714 962,41 €

Fig. 7 Results for optimal P2G hub next to IP with 10× higher prices of methane and no subsidy (Results sheet of the Optimization tool)

The Optimalisation tool suggest to invest in multiple components when the prices of methane go higher. The investment shown above consists of dry and wet anaerobic digestors, gasification + water gas shift plant, methanation reactor, electrolyser, demineraliser, precipitation collector, heat exchanger, gas compressor station, together with dry and wet biomass storages, biochar storage and water storage tank. It is an investment over 20 000 000 and the payoff period is 5,11 years and the P2G hub would produce over 50 000 mWh of biomethane yearly. The total savings would be around 186 714 962 EUR per year.

0,00 MWh

60 065,55 MWh

60 065,55 MWh

93 986.79 MWh 154 052,34 MWh

6.86 MW

17,59 MW

0,00 MWh

32.50 MWh

32,50 MWh

0,00 MWh

0,00 MWh

0.00 MWh 52 886,76 MWh

-52 886,76 MWh

6 425,78 m 774,57 m<sup>3</sup>

3 650,00 t

3 650,00 t

0,00 t

0,00 t

0.00 t

0,00 t

0,00 t

109.50 t

547 50 1

43,80 t

0,00 t

-19 315,90 MWh 19 348,40 MWh



	Element	Cost		Size	
	Dry anaerobic digestor	1 215 277.78	€	0.115741	kg/s
	Wet anaerobic digestor	1 215 277,78	€	0,115741	kg/s
	Dry biomass to biochar plant	0,00	€	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	€	0,000000	mol/s
ssses	Gasification + water gas shift plant	6 944,44	€	0,013889	kg/s
ĕ	Methanation reactor	1 593 697,67	€	7,499754	mol/s
<b>-</b>	Electrolyser	5 682 377,86	€	4 545,90	kW
	Demineralizer	618,43	€	12,368668	mol/s
	Precipitation collector	1 000,00	€	1 000,00	m²
	Heat exchanger	113 329,27	€	2 266,59	kW
	Gas compressor station	24 123,64	€	60,3091	kWe
	Total for processes	9 852 646,87	€		
	Dry biomass storage	50 000,00	€	10 000,00	kg
	Wet biomass storage	25 000,00	€	10 000,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
S	Hydrogen storage tank	0,00	€	0,00	kg
E.	Oxygen storage tank	0,00	€	0,00	kg
5	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
	Total for storages	75 000,00	€		
ŧ	Electrical connection	337 440,20	€	5,62	MW
eme	Gas connection	0,00	€	0,00	MW
ang	Water connection	24,74	€	0,80	m³/h
e	Total for connections	337 464,93	€		
	Total investment	10 265 111,80	€	]	
	Payoff period	5.06	vears		

Operati	onal costs for selected period				
		Cost		Amount	
	Produced by REP	0,00	€	0,00	MWh
≳	Consumed by IP	16 277 764,05	€	60 065,55	MWh
nen	Net consumption without investment	16 277 764,05	€	60 065,55	MWh
<u>9</u>	Mean peak power without investment	27 078,87	€	6,86	MW
Ŭ,	Consumed by P2G	25 470 420,09	€	93 986,79	MWh
E	Net consumption with investment	41 748 184,14	€	154 052,34	MWh
	Mean peak power with investment	69 450,33	€	17,59	MW
	Produced by REP	0,00	€	0,00	MWh
	Produced IP	0,00	€	32,50	MWh
feat	Net production without investment	0,00	€	32,50	MWh
-	Consumed by P2G	0,00	€	-19 315,90	MWh
	Net production with investment	0,00	€	19 348,40	MWh
œ₽	Produced by REP	0,00	€	0,00	MWh
egr	Consumed by IP	0,00	€	0,00	MWh
th def	Net consumption without investment	0,00	€	0,00	MWh
fror (r	Produced by P2G	212 555 428,07	€	52 886,76	MWh
ĝ õ	Net consumption with investment	-212 555 428,07	€	-52 886,76	MWh
Water	Water from the grid consumed by P2G	7 787,40	€	6 425,78	m³
water	Collected precipitation consumed by P2G	n/a	€	774,57	m³
\$	Dry biomass bought	65 218,14	€	3 650,00	t
rial of	Wet biomass bought	254 668,57	€	3 650,00	t
igt in	Biochar bought	0,00	€	0,00	t
-	Total cost of input materials	319 886,71	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
	Oxygen sold (in bottles)	0,00	€	0,00	t
ale litio	Methane sold (in bottles)	0,00	€	0,00	t
Ado	Biochar sold	0,00	€	0,00	t
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	€	109,50	t
8	Residue from wet anaerobic digester	0,00	€	547,50	t
sidu	Tar from gasification + water gas shift plar	0,00	€	43,80	t
a B	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	16 304 842,92	€		
	Total operational cost with investment	-170 410 119,50	€		
	Savings with introduction of P2G	186 714 962,41	€		

**Fig.8** Results for optimal P2G hub next to IP with 10× higher prices of methane and 50% subsidy (Results sheet of the Optimization tool)

The result of simulation with higher prices of methane and 50% subsidy resulted in similar investment suggestion to the Fig. 7. The main difference is the amount of total investment (over 10 000 000) and payoff period 5,06 years.



#### <u>GF</u>

	Element	Cost		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	€	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
s	Carbon capture plant	0,00	€	0,000000	mol/s
esse	Gasification + water gas shift plant	0,00	€	0,000000	kg/s
Loc	Methanation reactor	0,00	€	0,000000	mol/s
-	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,00	€	0,000000	mol/s
	Precipitation collector	0,00	€	0,00	m²
	Heat exchanger	0,00	€	0,00	kW
	Gas compressor station	0,00	€	0,0000	kWe
	Total for processes	0,00	€		
	Dry biomass storage	0,00	€	0,00	kg
	Wet biomass storage	0,00	€	0,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
sa	Hydrogen storage tank	0,00	€	0,00	kg
orag	Oxygen storage tank	0,00	€	0,00	kg
St	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
	Total for storages	0,00	€		
ŧ	Electrical connection	0,00	€	0,00	MW
E	Gas connection	0,00	€	0,00	MW
1 Per	Water connection	0,00	€	0,00	m <sup>3</sup> /h
5 8	Total for connections	0,00	€		
	Total investment	0,00	€		
	Payoff period	n/a	vears		

Operat	ional costs for selected period				
		Cost		Amount	
	Produced by REP	0,00	€	0,00	MWh
ctrical energy	Consumed by IP	0,00	€	0,00	MWh
	Net consumption without investment	0,00	€	0,00	MWh
	Mean peak power without investment	0,00	€	0,00	MW
	Consumed by P2G	0,00	€	0,00	MWh
Ele	Net consumption with investment	0,00	€	0,00	MWh
	Mean peak power with investment	0,00	€	0,00	MW
	Produced by REP	0,00	€	0,00	MWh
	Produced IP	0,00	€	0,00	MWh
lea	Net production without investment	0,00	€	0,00	MWh
-	Consumed by P2G	0,00	€	0,00	MWh
	Net production with investment	0,00	€	0,00	MWh
π₽	Produced by REP	0,00	€	0,00	MWh
egr	Consumed by IP	0,00	€	0,00	MWh
n th	Net consumption without investment	0,00	€	0,00	MWh
fror	Produced by P2G	0,00	€	0,00	MWh
to 0	Net consumption with investment	0,00	€	0,00	MWh
	Water from the grid consumed by P2G	0,00	€	0,00	m <sup>3</sup>
water	Collected precipitation consumed by P2G	n/a	€	0,00	m <sup>3</sup>
5	Dry biomass bought	0,00	€	0,00	t
out	Wet biomass bought	0,00	€	0,00	t
ling ling	Biochar bought	0,00	£	0,00	t
5	Total cost of input materials	0,00	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
	Oxygen sold (in bottles)	0,00	€	0,00	t
litio	Methane sold (in bottles)	0,00	€	0,00	t
Add	Biochar sold	0,00	€	0,00	t
	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	€	0,00	t
S	Residue from wet anaerobic digester	0,00	€	0,00	t
sidu	Tar from gasification + water gas shift plan	0,00	€	0,00	t
Re	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	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 optimal P2G hub next to GF with conservative prices of methane and no subsidy (Results sheet of the Optimization tool)

With the current prices of methane, it is not economically feasible to invest into P2G hub in the selected Greenfield location. The prices of biomass sources, transportation, grid connections and components themselves are too high to be so that they can be repaid by only selling biomethane for the current market price. Maybe with the additional market possibility for hydrogen or biochar, the situation would be different.



	Flement	Cost		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	£	0,000000	kg/s
	Wet biomass to biochar plant	0.00	£	0,000000	kg/s
	Combined heat and power (CHP)	0.00	£	0.00	kWe
	Carbon capture plant	0.00	£	0.000000	mol/s
	Gasification + water gas shift plant	0.00	£	0.000000	kg/s
	Methanation reactor	0.00	£	0.000000	mol/s
	Electrolyser	0,00	€	0.00	kW
	Demineralizer	0,00	€	0,000000	mol/s
	Precipitation collector	0,00	£	0,00	m²
	Heat exchanger	0,00	€	0,00	kW
	Gas compressor station	0,00	£	0,0000	kWe
	Total for processes	0,00	€		
	Dry biomass storage	0,00	€	0,00	kg
	Wet biomass storage	0,00	€	0,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
	Hydrogen storage tank	0,00	€	0,00	kg
P	Oxygen storage tank	0,00	€	0,00	kg
1	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m <sup>3</sup>
	Total for storages	0,00	€		_
ŧ	Electrical connection	0,00	€	0,00	MW
eme	Gas connection	0,00	€	0,00	MW
lang	Water connection	0,00	€	0,00	m³/h
a	Total for connections	0,00	€		
	Total investment	0,00	€		
	Payoff period	n/a	years		

Operati	ional costs for selected period				
		Cost		Amount	
	Produced by REP	0,00	€	0,00	MWh
nergy	Consumed by IP	0,00	€	0,00	MWh
	Net consumption without investment	0,00	€	0,00	MWh
9	Mean peak power without investment	0,00	€	0,00	MW
GT.	Consumed by P2G	0,00	€	0,00	MWh
B	Net consumption with investment	0,00	€	0,00	MWh
	Mean peak power with investment	0,00	€	0,00	MW
	Produced by REP	0,00	€	0,00	MWh
	Produced IP	0,00	€	0,00	MWh
lea	Net production without investment	0,00	€	0,00	MWh
-	Consumed by P2G	0,00	£	0,00	MWh
	Net production with investment	0,00	€	0,00	MWh
@₽	Produced by REP	0,00	€	0,00	MWh
egr	Consumed by IP	0,00	€	0,00	MWh
n th	Net consumption without investment	0,00	€	0,00	MWh
fror fr	Produced by P2G	0,00	€	0,00	MWh
to 6	Net consumption with investment	0,00	€	0,00	MWh
Water	Water from the grid consumed by P2G	0,00	€	0,00	m³
water	Collected precipitation consumed by P2G	n/a	€	0,00	m³
5	Dry biomass bought	0,00	€	0,00	t
ut out	Wet biomass bought	0,00	€	0,00	t
at at	Biochar bought	0,00	€	0,00	t
-	Total cost of input materials	0,00	€		
	Hydrogen sold (in bottles)	0,00	€	0,00	t
	Oxygen sold (in bottles)	0,00	€	0,00	t
ale	Methane sold (in bottles)	0,00	€	0,00	t
Add	Biochar sold	0,00	€	0,00	t
22	Total revenue from additional sales	0,00	€		
	Residue from dry anaerobic digester	0,00	€	0,00	t
S	Residue from wet anaerobic digester	0,00	€	0,00	t
idu	Tar from gasification + water gas shift plan	0,00	€	0,00	t
Be	CO2 emitted	0,00	€	0,00	t
	Total cost of residues	0,00	€		
	Total operational cost without investment	0,00	€		
	Total operational cost with investment	0,00	€		
	Savings with introduction of P2G	0,00	€		

**Fig. 10** Results for optimal P2G hub next to GF with conservative prices of methane and 50% subsidy (Results sheet of the Optimization tool)

The situation is the same than in Figure 9 even with the subsidy of 50% for the components of P2G hub. No investment is suggested by Optimalisation tool.



	Element	Cost		Size	
ss es	Dry anaerobic digestor	2 430 555,56	€	0,115741	kg/s
	Wet anaerobic digestor	2 430 555,56	€	0,115741	kg/s
	Dry biomass to biochar plant	0,00	€	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	€	0,000000	mol/s
	Gasification + water gas shift plant	13 888,89	€	0,013889	kg/s
Loc	Methanation reactor	3 187 395,34	€	7,499754	mol/s
	Electrolyser	11 364 755,71	€	4 545,90	kW
	Demineralizer	1 236,87	€	12,368668	mol/s
	Precipitation collector	2 000,00	€	1 000,00	m²
	Heat exchanger	226 658,54	€	2 266,59	kW
	Gas compressor station	48 247,28	€	60,3091	kWe
	Total for processes	19 705 293,74	€		
	Dry biomass storage	100 000,00	€	10 000,00	kg
	Wet biomass storage	50 000,00	€	10 000,00	kg
	Biochar storage	0,00	€	0,00	kg
Storages	Biogas storage	0,00	€	0,00	kg
	Hydrogen storage tank	0,00	€	0,00	kg
	Oxygen storage tank	0,00	€	0,00	kg
	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m³
	Total for storages	150 000,00	€		
connections enlargement	Electrical connection	644 232,32	€	10,74	MW
	Gas connection	2 808 861,00	€	6,04	MW
	Water connection	0,00	€	0,80	m³/h
	Total for connections	3 453 093,32	€		
	Total investment	23 308 387,06	€	]	
	Payoff period	5,13	vears		

Operational costs for selected period						
		Cost		Amount		
٨.	Produced by REP	0,00	€	0,00	MWh	
	Consumed by IP	0,00	€	0,00	MWh	
heu	Net consumption without investment	0,00	€	0,00	MWh	
Electrical e	Mean peak power without investment	0,00	€	0,00	MW	
	Consumed by P2G	25 470 420,09	€	93 986,79	MWh	
	Net consumption with investment	25 470 420,09	€	93 986,79	MWh	
	Mean peak power with investment	42 371,46	€	10,73	MW	
	Produced by REP	0,00	€	0,00	MWh	
	Produced IP	0,00	€	0,00	MWh	
Feat	Net production without investment	0,00	€	0,00	MWh	
-	Consumed by P2G	0,00	£	-19 315,90	MWh	
	Net production with investment	0,00	€	19 315,90	MWh	
a P	Produced by REP	0,00	€	0,00	MWh	
egr	Consumed by IP	0,00	€	0,00	MWh	
n th	Net consumption without investment	0,00	€	0,00	MWh	
as (r	Produced by P2G	212 555 428,07	€	52 886,76	MWh	
Gi to/	Net consumption with investment	-212 555 428,07	€	-52 886,76	MWh	
Water	Water from the grid consumed by P2G	7 775,19	€	6 425,78	m <sup>3</sup>	
water	Collected precipitation consumed by P2G	n/a	€	774,57	m <sup>3</sup>	
10	Dry biomass bought	127 281,18	€	3 650,00	t	
rial or	Wet biomass bought	67 575,99	€	3 650,00	t	
int in	Biochar bought	0,00	€	0,00	t	
E	Total cost of input materials	194 857,17	€			
	Hydrogen sold (in bottles)	0,00	€	0,00	t	
	Oxygen sold (in bottles)	0,00	€	0,00	t	
Addition	Methane sold (in bottles)	0,00	£	0,00	t	
	Biochar sold	0,00	€	0,00	t	
	Total revenue from additional sales	0,00	€			
	Residue from dry anaerobic digester	0,00	€	109,50	t	
S	Residue from wet anaerobic digester	0,00	€	547,50	t	
Residu	Tar from gasification + water gas shift plan	0,00	€	43,80	t	
	CO2 emitted	0,00	€	0,00	t	
	Total cost of residues	0,00	€			
	Total operational cost without investment	0,00	€			
	Total operational cost with investment	-186 840 004,17	€			
	Savings with introduction of P2G	186 840 004,17	€			

# **Fig. 11** Results for optimal P2G hub next to GF with 10× higher prices of methane and no subsidy (Results sheet of the Optimization tool)

With the higher prices of methane, the production of biomethane and building a P2G in a greenfield location starts to be feasible. The Optimisation tool suggests to invest into both dry and wet digestors and biomass storages, methanation reactor, gasification and water gas shift, electrolyser and other components, see the result sheet. The total production of biomethane would be over 50 000 mWh yearly and with the existing market for hydrogen it could be another output. The total investment would be over 23 000 000 EUR and payoff period 5, 13 years.



	Element	Cost		Size	
	Dry anaerobic digestor	1 215 277,78	€	0,115741	kg/s
	Wet anaerobic digestor	1 215 277,78	€	0,115741	kg/s
	Dry biomass to biochar plant	0,00	€	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Combined heat and power (CHP)	0,00	€	0,00	kWe
	Carbon capture plant	0,00	€	0,000000	mol/s
ssses	Gasification + water gas shift plant	6 944,44	€	0,013889	kg/s
ũ	Methanation reactor	1 593 697,67	€	7,499754	mol/s
-	Electrolyser	5 682 377,86	€	4 545,90	kW
	Demineralizer	618,43	€	12,368668	mol/s
	Precipitation collector	1 000,00	€	1 000,00	m²
	Heat exchanger	113 329,27	€	2 266,59	kW
	Gas compressor station	24 123,64	€	60,3091	kWe
	Total for processes	9 852 646,87	€		
	Dry biomass storage	50 000,00	€	10 000,00	kg
	Wet biomass storage	25 000,00	€	10 000,00	kg
	Biochar storage	0,00	€	0,00	kg
	Biogas storage	0,00	€	0,00	kg
Sa	Hydrogen storage tank	0,00	€	0,00	kg
2 Const	Oxygen storage tank	0,00	€	0,00	kg
5	Methane storage tank	0,00	€	0,00	kg
	Syngas storage tank	0,00	€	0,00	kg
	Carbon dioxide storage tank	0,00	€	0,00	kg
	Water storage tank	0,00	€	0,00	m³
	Total for storages	75 000,00	€		
enlargement	Electrical connection	644 232,32	€	10,74	MW
	Gas connection	2 808 861,00	€	6,04	MW
	Water connection	0,00	€	0,80	m <sup>3</sup> /h
	Total for connections	3 453 093,32	€		
	Total investment	13 380 740.19	£		

Produced by REPCostAmountNet consumption without investment0,00€0,00NWhNet consumption without investment0,00€0,00NWhMean peak power without investment0,00€0,00NWhConsumed by P2G25 470 420,09€93 986,79NWhNet consumption withinvestment225 770 420,09€0,00NWhNet peak power with investment24 271,46€0,00NWhProduced by REP0,00€0,00NWhNet production without investment0,00€0,00NWhNet production without investment0,00€0,00NWhNet production withinvestment0,00€0,00NWhNet production withinvestment0,00€0,00NWhNet consumption without investment0,00€0,00NWhNet consumption withinvestment-212 555 428,07€0,00NWhNet consumption withinvestment-212 555 428,07€64 25,70m <sup>3</sup> Net consumption withinvestment-212 555 428,07€36 50,001Net consumption withinvestment0,00€0,00€0,00Net consumption withinvestment-212 555 428,07€36 50,001Net consumption withinvestment-212 555 428,07€36 50,001Net consumption withinvestment0,00€0,00€0,00Net consumption withinvestment <td< th=""><th colspan="7">Operational costs for selected period</th></td<>	Operational costs for selected period						
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           Mean peak power without investment         25 470 420,09         €         93 986,79         MWh           Mean peak power with investment         22 54 70 420,09         €         93 986,79         MWh           Mean peak power with investment         42 371,46         €         10,73         MW           Produced by REP         0,00         €         0,00         MWh           Produced by P2G         0,00         €         0,00         MWh           Net production with investment         0,00         €         0,00         MWh           Net produced by P2G         0,00         €         0,00         MWh           Net produced by P2G         0,00         €         0,00         MWh           Net consumption without investment         0,00         €         0,00         MWh           Net consumption without investment         -212 555 428,07         €         52 886,76         MWh           Vater from the grid consumed by P2G         7775,19			Cost		Amount		
Second Participation         Consumed by IP         0,00         C         0,00         MWh           Net consumption without investment         0,00         C         0,00         MWh           Mean peak power without investment         0,00         C         0,00         MWh           Mean peak power with investment         25 470 420,09         C         93 986,79         MWh           Net consumption with investment         42 371,46         C         10,73         MW           Produced by REP         0,00         C         0,00         MWh           Net production with investment         0,00         C         0,00         MWh           Net consumption with investment         0,00         C         0,00         MWh           Net consumption without investment         0,00         C         0,00         MWh           Net consumption with investment         -212 555 428,07         C         52 886,76         MWh           Ne	nergy	Produced by REP	0,00	€	0,00	MWh	
Net consumption without investment         0,00         €         0,00         MWh           Mean peak power without investment         0,00         €         0,00         MWh           Consumed by P2G         25 470 420,09         €         93 986,79         MWh           Mean peak power with investment         25 470 420,09         €         93 986,79         MWh           Mean peak power with investment         42 371,46         €         10,73         MW           Mean peak power with investment         42 371,46         €         0,00         MWh           Produced IP         0,00         €         0,00         MWh           Net production without investment         0,00         €         0,00         MWh           Produced by P2G         0,00         €         0,00         MWh           Produced by REP         0,00         €         0,00         MWh           Net production with investment         0,00         €         0,00         MWh           Net consumption withinvestment         -212 555 428,07         €         52 886,76         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Net consumption with investment		Consumed by IP	0,00	€	0,00	MWh	
Bit Part Pack power without investment         0,00         C         0,00         NW           Consumed by P2G         25 470 420,09         C         93 986,79         MWh           Net consumption with investment         25 470 420,09         C         93 986,79         MWh           Net consumption with investment         25 470 420,09         C         93 986,79         MWh           Produced by REP         0,00         C         0,00         MWh           Produced IP         0,00         C         0,00         MWh           Net production without investment         0,00         C         0,00         MWh           Net production with investment         0,00         C         0,00         MWh           Net production with investment         0,00         C         0,00         MWh           Produced by REP         0,00         C         0,00         MWh           Consumed by P2G         212 555 428,07         C         52 886,76         MWh           Vect consumption with investment         -212 555 428,07         C         52 886,76         MWh           Water         Consumed by P2G         777,51         C         64 25,78         m <sup>3</sup> Ory biomass bought         1		Net consumption without investment	0,00	€	0,00	MWh	
Upper Produced by P2G         25 470 420,09         €         93 986,79         MWh           Met consumption with investment         25 470 420,09         €         93 986,79         MWh           Mean peak power with investment         42 371,46         €         10,73         MW           Produced by REP         0,000         €         0,000         MWh           Produced by P2G         0,000         €         0,000         MWh           Net production without investment         0,000         €         0,000         MWh           Net produced by P2G         0,000         €         0,000         MWh           Net produced by P2G         0,000         €         0,000         MWh           Net produced by REP         0,000         €         0,000         MWh           Net consumption without investment         0,000         €         0,000         MWh           Valued by P2G         212 555 428,07         €         52 886,76         MWh           Water         Water from the grid consumed by P2G         775,19         €         64 25,78         M"h           Valued by by biomass bought         67 575,99         €         3650,00         t         1000         t	a a	Mean peak power without investment	0,00	€	0,00	MW	
Bit on sumption with investment         25 470 420.09         €         93 986.79         MWh           Mean peak power with investment         42 371.46         €         10.73         MW           Produced by REP         0,00         €         0,00         MWh           Produced IP         0,00         €         0,00         MWh           Net production without investment         0,00         €         0,00         MWh           Net production with investment         0,00         €         0,00         MWh           Net production with investment         0,00         €         0,00         MWh           Net production with investment         0,00         €         0,00         MWh           Consumed by IP         0,00         €         0,00         MWh           Net consumption without investment         -212 555 428,07         €         52 886,76         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Net consumption with out summed by P2G         775,19         €         64 25,78         m³           Dry biomass bought         127 281,18         €         3650,00         t           Vet biomass bought         6,75	Gtri	Consumed by P2G	25 470 420,09	€	93 986,79	MWh	
Mean peak power with investment         42 371.46         €         10.73         MW           Produced by REP         0,00         €         0,00         MW/h           Produced by REP         0,00         €         0,00         MW/h           Produced by REP         0,00         €         0,00         MW/h           Consumed by P2G         0,00         €         0,00         MW/h           Consumed by P2G         0,00         €         0,00         MW/h           Produced by REP         0,00         €         0,00         MW/h           Consumed by IP         0,00         €         0,00         MW/h           Net consumption without investment         0,00         €         0,00         MW/h           Net consumption withinvestment         -212 555 428,07         €         52 886,76         MW/h           Net consumption withinvestment         -212 555 428,07         €         52 886,76         MW/h           Water         from ter grid consumed by P2G         n775,19         €         64 25,78         M <sup>3</sup> Orybiomass bought         127 281,18         €         3 650,00         t         1           Total cost of ingut materials         194 857,17	E	Net consumption with investment	25 470 420,09	€	93 986,79	MWh	
Produced by REP         0,00         €         0,00         MWh           Produced IP         0,00         €         0,00         MWh           Net production without investment         0,00         €         0,00         MWh           Net production with investment         0,00         €         19 315,90         MWh           Produced by REP         0,00         €         0,00         MWh           Produced by REP         0,00         €         0,00         MWh           Net consumption without investment         0,00         €         0,00         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Water from the grid consumed by P2G         7775,19         €         6425,78         m <sup>3</sup> Dry biomass bought         127 281,18         €         3650,00         t           Wet biomass bought         127 281,18         €         3650,00         t           Total cost of input materials         194 857,17         €         0,00         t           Wet biomass bought         0,00         €         0,00         t         0,00         t           Total cost of input materials         194 857,17		Mean peak power with investment	42 371,46	€	10,73	MW	
Produced IP         0,00         €         0,00         MWh           Net production without investment         0,00         €         0,00         MWh           Consumed by P2G         0,00         €         19 315,90         MWh           Orguna of the production with investment         0,00         €         0,00         MWh           Orguna of the production with investment         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         212 555 428,07         €         52 886,76         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Water         Water from the grid consumed by P2G         7.775,19         €         6 425,78         m³           Collected precipitation consumed by P2G         7.775,19         €         6 425,78         m³           Dry biomass bought         107 75,79         €         3 650,00         t           Biochar bought         0,00         €         0,00         t           Oxgen soid (in bottles)		Produced by REP	0,00	€	0,00	MWh	
Perform         Net production without investment         0,00         €         0,00         MWh           Consumed by P2G         0,00         €         .19 315,90         MWh           Net 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           Net consumption without investment         0,00         €         0,00         MWh           Value of by P2G         212 555 428,07         €         52 886,76         MWh           Water         Value onsumption with investment         -212 555 428,07         €         42 57,8         m³           Dy biomass bought         127 281,18         €         45 50,00         t         t           Mater         Water from the grid consumed by P2G         777,519         €         6         425,78         m³           Dy biomass bought         127 281,18         €         3 550,00         t         t           Total cost of input materials         194 857,17         €         -         0,00         t           Oxgen sold (in bottles)         0,00         €	_	Produced IP	0,00	€	0,00	MWh	
Consumed by P2G         0,00         €         -19 315,90         MWh           Net production with investment         0,00         €         19 315,90         MWh           Produced by REP         0,00         €         0,00         MWh           Produced by REP         0,00         €         0,00         MWh           Net consumption without investment         0,00         €         0,00         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Water         Water from the grid consumed by P2G         775,19         €         64 25,78         m³           Dry biomass bought         67 575,99         €         3 650,00         t         Biochar bought         0,00         €         0,00         t           Total cost of input materials         194 857,17         €            0,00         t            Methane sold (in bottles)         0,000         €         0,000         €	ea	Net production without investment	0,00	€	0,00	MWh	
Net production with investment         0.00         €         19 315.90         MWh           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         212 555 428.07         €         52 886.76         MWh           Net consumption with investment         -212 555 428.07         €         64 52.78         m <sup>3</sup> Water         Outleted precipitation consumed by P2G         7775.19         €         64 52.78         m <sup>3</sup> Dry biomass bought         127 281,18         €         3 650,00         t           Wet biomass bought         127 781,18         €         3 650,00         t           Biochar bought         0.00         €         0.00         t           Oxygen sold (in bottles)         0.00         €         0.00         t           Oxygen sold (in bottles)         0.00         €         0.00         t           Methane sold (in bottles)         0.00         €         0.00         t           Oxygen sold (in bottles)         0.00         €	-	Consumed by P2G	0,00	€	-19 315,90	MWh	
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           Net consumption without investment         2,00         F         0,00         MWh           Water         Ret consumption with investment         -212 555 428,07         €         -52 886,76         MWh           Water         Water from the grid consumed by P2G         7.775,19         €         6 425,78         m³           Objected         Dry biomass bought         127 281,18         €         3 650,00         t           Biochar bought         0,00         €         0,00         t         0,00         t           Yotigen sold (in bottles)         0,00         €         0,00         t         0,00         t           Biochar sold         0,00         €         0,00         €         0,00         t           Biochar sold (in bottles)         0,00         €         0,00         t         1           Oxygen sold (in bottles)         0,00         €         0,00         t         1           Biochar sold         0,00<		Net production with investment	0,00	€	19 315,90	MWh	
group         Consumed by IP         0,00         €         0,00         MWh           Net consumption without investment         0,00         €         0,00         MWh           Produced by P2G         212 555 428,07         €         52 886,76         MWh           Net consumption with investment         -212 555 428,07         €         52 886,76         MWh           Water         Water from the grid consumed by P2G         7775,19         €         6 425,78         m <sup>3</sup> Dry biomass bought         127 281,18         €         3 650,00         t           Biochar bought         0,00         €         0,00         t           Total cost of input materials         194 857,17         €         4           Hydrogen sold (in bottles)         0,00         €         0,00         t           Oxgen sold (in bottles)         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         t           Residue from dry anaerobic digester         0,00         €         547,50         t           Residue from wet anaerobic digester         0,00         €         60,00         t           Tar from gasification + water gas shift plan	<u>.</u>	Produced by REP	0,00	€	0,00	MWh	
Bit op 1         Net consumption without investment         0,00         €         0,00         MWh           Produced by P2G         212 555 428,07         €         52 88,76         MWh           Net consumption with investment         -212 555 428,07         €         52 88,76         MWh           Water         Variable for the grid consumed by P2G         775,19         €         64 425,78         m³           Dry biomass bought         127 281,18         €         3 650,00         t           Use biomass bought         67 575,99         €         3 650,00         t           Variable biochar bought         0,00         €         0,00         t           Total cost of input materials         194 857,17         €         0,00         t           Mydrogen sold (in bottles)         0,00         €         0,00         t           Oxgen sold (in bottles)         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         t           Residue from dry anaerobic digester         0,00         €         109,50         t           Residue from dry anaerobic digester         0,00         €         0,00         t           Cola per	egr	Consumed by IP	0,00	€	0,00	MWh	
Openant         Produced by P2G         212 555 428,07         €         52 886,76         MWh           Water         Net consumption with investment         -212 555 428,07         €         -52 886,76         MWh           Water         Water from the grid consumed by P2G         7775,19         €         6425,78         m³           Object         Dry biomass bought         127 281,18         €         3 650,00         t           Biochar bought         0,00         €         0,00         t         0,00         t           Yet biomass bought         194 857,17         €         6,000         t         0,00         t           Biochar bought         0,00         €         0,000         €         0,000         t           Oxygen sold (in bottles)         0,000         €         0,000         t         0,000         t           Methane sold (in bottles)         0,000         €         0,000         t         0,000         t           Total revenue from dry anaerobic digester         0,000         €         109,50         t           Residue from dry anaerobic digester         0,000         €         0,000         t           Co2 emitted         0,000         € <td< td=""><td>n th</td><td>Net consumption without investment</td><td>0,00</td><td>€</td><td>0,00</td><td>MWh</td></td<>	n th	Net consumption without investment	0,00	€	0,00	MWh	
10         20         Net consumption with investment         -212 555 428,07         €         -52 886,76         MWh           Water         Water from the grid consumed by P2G         7.75,19         €         6 425,78         m³           Collected precipitation consumed by P2G         n/a         €         774,57         m³           Dry biomass bought         127 281,18         €         3 650,00         t           Wet biomass bought         67 57,59         €         3 650,00         t           Biochar bought         67 57,59         €         3 650,00         t           Hydrogen sold (in bottles)         0,00         €         0,00         t           Oxygen sold (in bottles)         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         t           Biochar sold         0,00         €         0,00         t           Biochar sold (in bottles)         0,00         €         0,00         t           Total revenue from additional sales         0,00         €         109,50         t           Residue from dy anaerobic digester         0,00         €         547,50         t           Tar from gasifica	fror	Produced by P2G	212 555 428,07	€	52 886,76	MWh	
Water from the grid consumed by P2G         7 775,19         €         6 425,78         m³           Collected precipitation consumed by P2G         n/a         €         774,57         m³           Dry biomass bought         127 281,18         €         3 650,00         t           Bry biomass bought         127 281,18         €         3 650,00         t           Bry biomass bought         0,00         €         0,00         t           Total cost of input materials         194 857,17         €            Hydrogen sold (in bottles)         0,00         €         0,00         t           Oxgen sold (in bottles)         0,00         €         0,00         t           Biochar sold         0,00         €         0,00         t           Biochar sold         0,00         €         0,00         t           Biochar sold (in bottles)         0,00         €         0,00         t           Biochar sold (in bottles)         0,00         €         0,00         t           Total revenue from additional sales         0,00         €         109,50         t           Residue from dry anaerobic digester         0,00         €         547,50         t	6i to/	Net consumption with investment	-212 555 428,07	€	-52 886,76	MWh	
Visite         Collected precipitation consumed by P2G         n/a         Collected precipitation to the precipitation consumed by P2G         127 281,18         Collected precipitation to	Water	Water from the grid consumed by P2G	7 775,19	€	6 425,78	m <sup>3</sup>	
Bit Shows         Bit Shows         State         State <thstate< th=""></thstate<>	water	Collected precipitation consumed by P2G	n/a	€	774,57	m³	
Total cost of input materials         67 575,99         €         3 650,00         t           Biochar bought         0,00         €         0,00         t         t           Total cost of input materials         194 857,17         €         C         C           Wet biomass bought         0,00         €         0,00         t         t           Viggen sold (in bottles)         0,00         €         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         €         0,00         t           Biochar sold         0,00         €         0,00         €         0,00         t           Total revenue from additional sales         0,00         €         0,00         t         t           Residue from dry anaerobic digester         0,00         €         109,50         t           CO2 emitted         0,00         €         0,00         €         43,80         t           CO2 emitted         0,00         €         0,00         €         0,00         €           Total cost of residues         0,00         €         €         0,00         €	10	Dry biomass bought	127 281,18	€	3 650,00	t	
Image: Properties         Biochar bought         0,00         €         0,00         t           Total cost of input materials         194 857,17         €               0,00         t          0,00         t           0,00         t           0,00         t          0,00         t           0,00         t           0,00         t            0,00         t	rial	Wet biomass bought	67 575,99	€	3 650,00	t	
Image: constraint of the second se	Inp	Biochar bought	0,00	€	0,00	t	
Hydrogen sold (in bottles)         0,00         €         0,00         t           Oxgen sold (in bottles)         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         t           Total revenue from additional sales         0,00         €         0,00         t           Residue from dry anaerobic digester         0,00         €         109,50         t           Tar from gasification + water gas shift plan         0,00         €         6,000         t           Total operational cost without investment         0,00         €         0,00         t	-	Total cost of input materials	194 857,17	€			
Total operational cost without investment         0,00         €         0,00         t           0xygen sold (in bottles)         0,00         €         0,00         t           Methane sold (in bottles)         0,00         €         0,00         t           Biochar sold         0,00         €         0,00         t           Total revenue from additional sales         0,00         €         109,50         t           Residue from wet anaerobic digester         0,00         €         547,50         t           Tar from gasification + water gas shift plan         0,00         €         43,80         t           Total operational cost without investment         0,00         €         43,80         t		Hydrogen sold (in bottles)	0,00	€	0,00	t	
Open of boot boot boot boot boot boot boot b	2	Oxygen sold (in bottles)	0,00	£	0,00	t	
No     Biochar sold     0,00     €     0,00     t       Total revenue from additional sales     0,00     €       Residue from dry anaerobic digester     0,00     €       Total revenue from additional sales     0,00     €       Total revenue from additional sales     0,00     €       Total revenue from dry anaerobic digester     0,00     €       Total revenue from wet anaerobic digester     0,00     €       Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2"       Total operational cost without investment     Colspan="2"       Total operational cost without investment     Colspan="2"	litio	Methane sold (in bottles)	0,00	€	0,00	t	
Total revenue from additional sales     0,00     €       Residue from dry anaerobic digester     0,00     €     109,50     t       Residue from wet anaerobic digester     0,00     €     547,50     t       Tar from gasification + water gas shift plan     0,00     €     43,80     t       Co2 emitted     0,00     €     0,00     €       Total cost of residues     0,00     €     €       Total operational cost without investment     0,00     €	Add	Biochar sold	0,00	€	0,00	t	
Residue from dry anaerobic digester         0,00         €         109,50         t           Residue from wet anaerobic digester         0,00         €         547,50         t           Tar from gasification + water gas shift plan         0,00         €         43,80         t           CO2 emitted         0,00         €         0,00         €         0,00         t           Total cost of residues         0,00         €         6         0,00         €         0,00         €		Total revenue from additional sales	0,00	€			
generalized     Residue from wet anaerobic digester     0,00     €     547,50     t       Tar from gasification + water gas shift plan     0,00     €     43,80     t       CO2 emitted     0,00     €     0,00     €       Total cost of residues     0,00     €     6		Residue from dry anaerobic digester	0,00	€	109,50	t	
Tar from gasification + water gas shift plan     0,00     €     43,80     t       CO2 emitted     0,00     €     0,00     t       Total cost of residues     0,00     €       Total operational cost without investment     0,00     €	8	Residue from wet anaerobic digester	0,00	€	547,50	t	
<sup>b</sup> / <sub>2</sub> <sup>b</sup> / <sub>2</sub> <sup>c</sup> / <sub>2</sub> co2 emitted <sup>c</sup> / <sub>2</sub> on 0 € <sup>c</sup> / <sub>2</sub> <sup></sup>	Residue	Tar from gasification + water gas shift plan	0,00	€	43,80	t	
Total cost of residues     0,00 €       Total operational cost without investment     0,00 €       Total operational cost without investment     0,00 €		CO2 emitted	0,00	€	0,00	t	
Total operational cost without investment     0,00 €       Total operational cost with investment     100 000 17 C		Total cost of residues	0,00	€			
Tetel		Total operational cost without investment	0,00	€			
Total operational cost with investment -186 840 004,17 €		Total operational cost with investment	-186 840 004,17	€			
Savings with introduction of P2G 186 840 004,17 €		Savings with introduction of P2G	186 840 004,17	€			

**Fig.12** Results for optimal P2G hub next to GF with 10× higher prices of methane and 50% subsidy (Results sheet of the Optimization tool)

The result is similar than in the figure 11, only with a shorter payoff period.



## **4. CONCLUSIONS**

As seen from the calculations shown above, the Slovak territorial perspectives for introducing the P2G hub with the current prices of methane does not seem economically profitable. Zero investment possibilities were shown for the situations of investing to P2G next to Renewable energy source, Industrial plant and also building it on the greenfield location. The same result was shown when adding a 50% subsidy.

Economically viable calculations started to appear when higher prices of methane were simulated. In all three cases, both for situations with and without subsidy, investments into different P2G components were suggested. The major change for the calculations with subsidy was shorter payoff period.

However, the results may change if the actual existing market possibilities for hydrogen, oxygen, methane and biochar were added. The market with hydrogen is slowly being introduced to Slovakia and we believe that in few years this commodity will be highly demanded. For this reason, we would suggest to potential investors to at least include hydrogen market possibilities into the calculation, maybe also biochar. When simulating calculations with biochar, possible investment appeared also for the current prices of methane.

We would also suggest to revise the data downloaded from the Atlas, since in time the data may change or the potential investor have better overview for a current price for certain infrastructure case. In any case a detailed study of the distribution system operators is needed when the P2G would be connected to the grid and conclusions from this study may be applied into the Optimisation tool.