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## DanuP-2-Gas

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# Studija predizvodljivosti P2G čvorišta za Hrvatsku



Nacionalna DanuP2Gas radionica za Hrvatsku, Zagreb, 24.11.2022.



Sveučilište u Zagrebu Fakultet elektrotehnike i računarstva, Laboratorij za sustave obnovljivih izvora energije



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# Studija predizvodljivosti P2G čvorišta za Hrvatsku

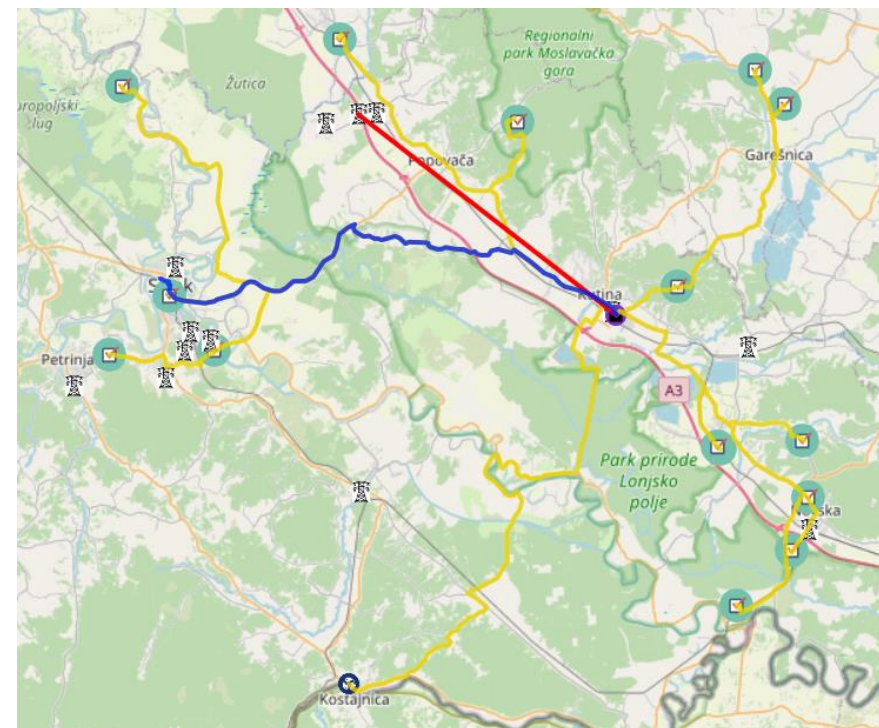
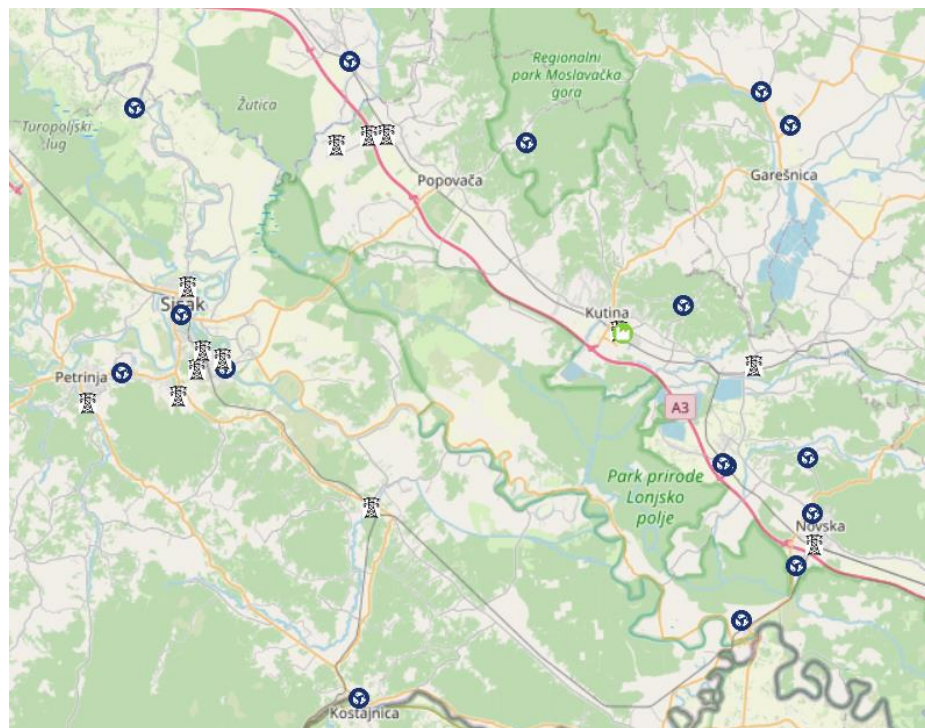
- 3 glavna slučaja:
  - P2G + IP – Petrokemija Kutina
  - P2G + REP – Tvornica Ulja Čepin
  - Samostalni P2G – Karlovac
- Varijacije cijene plina i iznosa subvencije

Subvencija [%] / Cijena plina	1x (trenutna)	10x uvećanje
0%	A	C
50%	B	D





# Rezultati: P2G + IP – Petrokemija Kutina







# Rezultati: P2G + IP – Petrokemija Kutina

Interreg Danube Transnational Programme DanuP-2-Gas			
RESULTS			

Investment specifications			
Element	Cost	Size	
Processes	Dry anaerobic digester	2.443.910,26 €	0,116377 kg/s
	Wet anaerobic digester	2.443.910,26 €	0,116377 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 kW
	Carbon capture plant	0,00 €	0,000000 mol/s
	Gasification + water gas shift plant	14.028,80 €	0,014029 kg/s
	Methanation reactor	3.205.426,05 €	7,542179 mol/s
	Electrolyser	11.430.026,35 €	4.572,01 kW
	Deminerallizer	1.156,05 €	11,560518 mol/s
Storages	Precipitation collector	2.000,00 €	1.000,00 m <sup>2</sup>
	Heat exchanger	227.944,10 €	2.279,44 kW
	Gas compressor station	202.112,95 €	252,6412 kW
	Total for processes	19.970.514,82 €	
	Dry biomass storage	100.000,00 €	10.000,00 kg
	Wet biomass storage	50.000,00 €	10.000,00 kg
Connections and engagements	Biochar storage	15.000,00 €	1.000,00 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	165.000,00 €	
	Electrical connection	0,00 €	0,00 MW
	Gas connection	0,00 €	0,00 MW
	Water connection	23,12 €	0,75 m <sup>3</sup> /h
	Total for connections	23,12 €	
	Total investment	20.135.537,94 €	
	Payoff period	7,10 years	

Operational costs for selected period			
	Cost	Amount	
Electrical energy	Produced by REP	0,00 €	0,00 MWh
	Consumed by IP	34.259.995,00 €	102.200,00 MWh
	Net consumption without investment	34.259.995,00 €	102.200,00 MWh
	Net consumption with investment	62.903.114,26 €	187.644,46 MWh
	Mean peak power with investment	899.749,02 €	21,42 MW
Heat	Produced by REP	0,00 €	0,00 MWh
	Produced by IP	0,00 €	678.900,00 MWh
	Net production without investment	0,00 €	678.900,00 MWh
	Net production with investment	0,00 €	696.196,91 MWh
	Total for processes	899.749,02 €	21,42 MW
Gas (methane) to/from the grid	Produced by REP	0,00 €	0,00 MWh
	Consumed by IP	4.916.743.244,83 €	6.057.529,54 MWh
	Net consumption without investment	4.916.743.244,83 €	6.057.529,54 MWh
	Net consumption with investment	4.877.092.883,32 €	6.010.096,50 MWh
	Total for processes	4.877.092.883,32 €	6.010.096,50 MWh
Water	Water from the grid consumed by P2G	648,02 €	5.445,57 m <sup>3</sup>
	Collected precipitation consumed by P2G	n/a	867,19 m <sup>3</sup>
	Dry biomass bought	24.859,02 €	3.650,00 t
	Wet biomass bought	27.995,44 €	2.962,00 t
	Biogas bought	0,00 €	0,00 t
Input materials	Total cost of input materials	52.834,46 €	
	Hydrogen sold (in bottles)	0,00 €	0,00 t
	Oxygen sold (in bottles)	25.550,00 €	365,00 t
	Methane sold (in bottles)	0,00 €	0,00 t
	Biogas sold	21.960,00 €	183,00 t
Additional sales	Total revenue from additional sales	47.510,00 €	
	Residue from dry anaerobic digester	0,00 €	109,50 t
	Residue from wet anaerobic digester	0,00 €	444,30 t
	Tar from gasification + water gas shift plant	0,00 €	22,06 t
	CO2 emitted	0,00 €	0,00 t
Residues	Total cost of residues	0,00 €	
	Total operational cost without investment	4.951.493.239,83 €	
	Total operational cost with investment	4.940.901.719,08 €	
	Savings with introduction of P2G	10.591.520,75 €	

Interreg Danube Transnational Programme DanuP-2-Gas			
RESULTS			

Investment specifications			
Element	Cost	Size	
Processes	Dry anaerobic digester	0,00 €	0,000000 kg/s
	Wet anaerobic digester	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)	30.000.000,00 €	10.000,00 kW
	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
	Deminerallizer	0,00 €	0,000000 mol/s
Storages	Precipitation collector	0,00 €	0,00 m <sup>2</sup>
	Heat exchanger	1.250.000,00 €	12.500,00 kW
	Gas compressor station	0,00 €	0,0000 kW
	Total for processes	31.250.000,00 €	
	Dry biomass storage	0,00 €	0,00 kg
	Wet biomass storage	0,00 €	0,00 kg
Connections and engagements	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 €	
	Electrical connection	0,00 €	0,00 MW
	Gas connection	0,00 €	0,00 MW
	Water connection	0,00 €	0,00 m <sup>3</sup> /h
	Total for connections	0,00 €	
	Total investment	31.250.000,00 €	
	Payoff period	10,44 years	

Operational costs for selected period			
	Cost	Amount	
Electrical energy	Produced by REP	0,00 €	0,00 MWh
	Consumed by IP	34.259.995,00 €	102.200,00 MWh
	Net consumption without investment	34.259.995,00 €	102.200,00 MWh
	Net consumption with investment	4.894.285,00 €	14.600,00 MWh
	Mean peak power with investment	70.000,00 €	1,67 MW
Heat	Produced by REP	0,00 €	0,00 MWh
	Produced by IP	0,00 €	678.900,00 MWh
	Net production without investment	0,00 €	678.900,00 MWh
	Net production with investment	0,00 €	788.400,00 MWh
	Total for processes	788.400,00 €	21,42 MW
Gas (methane) to/from the grid	Produced by REP	0,00 €	0,00 MWh
	Consumed by IP	558.309.253,75 €	6.057.529,54 MWh
	Net consumption without investment	558.309.253,75 €	6.057.529,54 MWh
	Net consumption with investment	578.620.159,64 €	6.277.898,29 MWh
	Total for processes	578.620.159,64 €	6.277.898,29 MWh
Water	Water from the grid consumed by P2G	0,00 €	0,00 m <sup>3</sup>
	Collected precipitation consumed by P2G	n/a	867,19 m <sup>3</sup>
	Dry biomass bought	0,00 €	0,00 t
	Wet biomass bought	0,00 €	0,00 t
	Biogas bought	0,00 €	0,00 t
Input materials	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
	Methane sold (in bottles)	0,00 €	0,00 t
	Biogas sold	0,00 €	0,00 t
Additional sales	Total revenue from additional sales	0,00 €	
	Residue from dry anaerobic digester	0,00 €	0,00 t
	Residue from wet anaerobic digester	0,00 €	0,00 t
	Tar from gasification + water gas shift plant	0,00 €	0,00 t
	CO2 emitted	2.168.100,00 €	43.362,00 t
Residues	Total cost of residues	2.168.100,00 €	
	Total operational cost without investment	593.059.248,75 €	
	Total operational cost with investment	585.752.544,64 €	
	Savings with introduction of P2G	7.306.704,11 €	





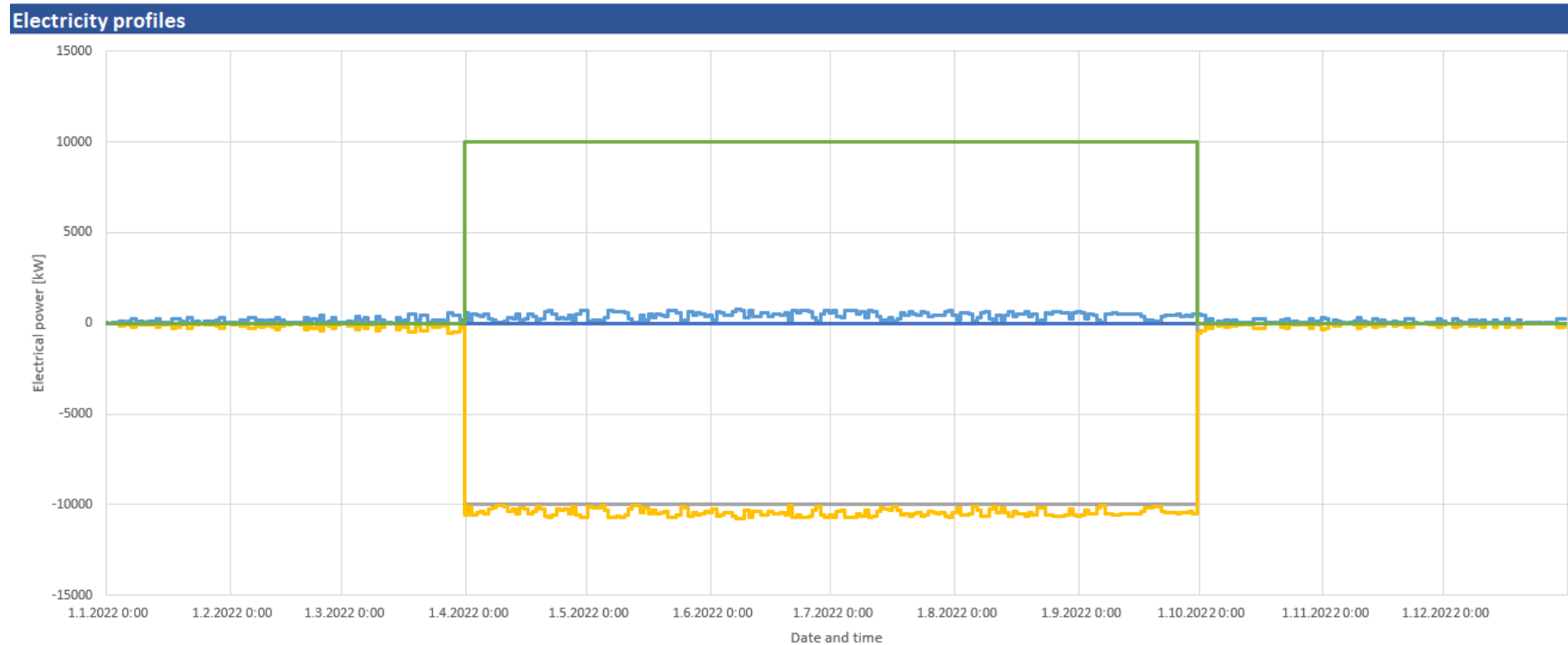
## Rezultati: P2G + IP – Petrokemija Kutina

Subvencija [%] / Cijena plina	1x (trenutna)	10x uvećanje
0%	Investicija u CHP	Kontinuirana proizvodnja biometana
50%	Investicija u CHP	Kontinuirana proizvodnja biometana





# Rezultati: P2G + REP – Sunčana Elektrana TUČ







## Rezultati: P2G + REP

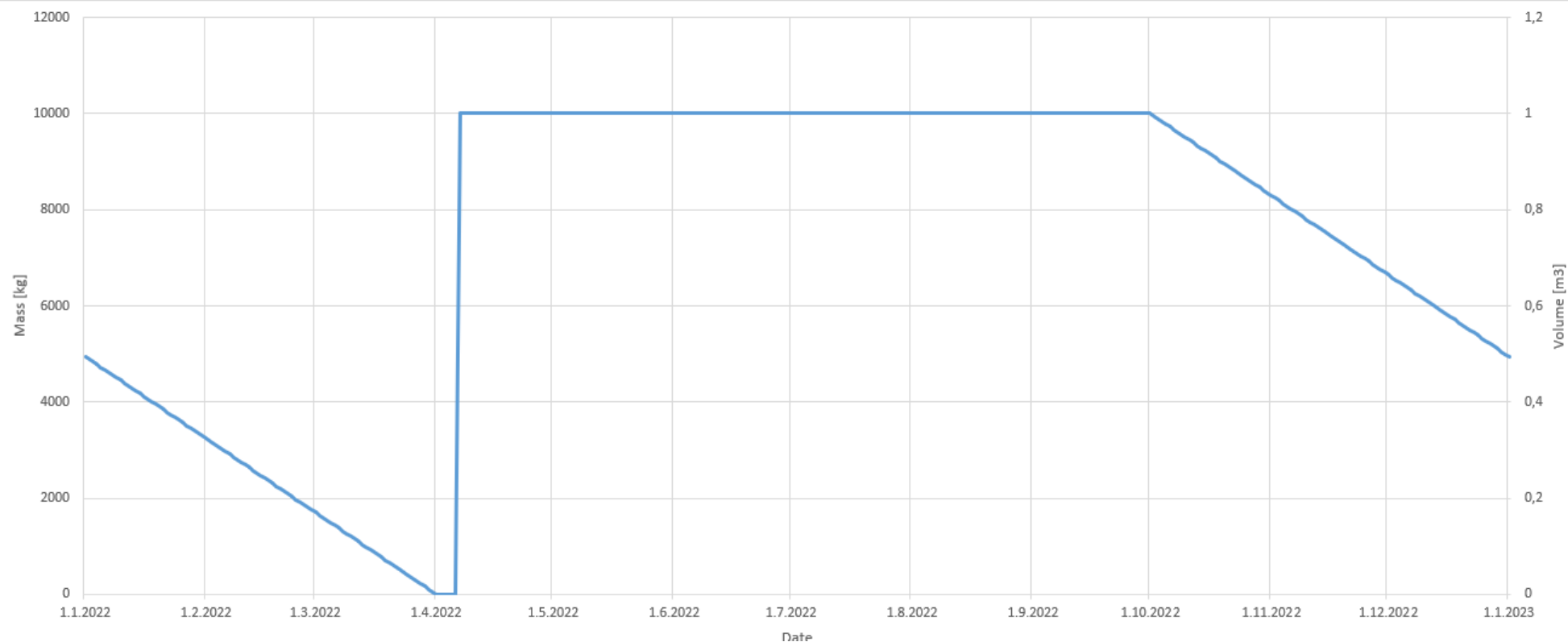
Subvencija [%] / Cijena plina	1x (trenutna)	10x uvećanje
0%	Bez investicije	Periodička proizvodnja biometana (rad zimi)
50%	Investicija u CHP (rad ljeti)	Periodička proizvodnja biometana (rad zimi)





# Rezultati: P2G - GF – Karlovac

Storages - mass profiles







## Rezultati: Samostalni P2G

Subvencija [%] / Cijena plina	1x (trenutna)	10x uvećanje
0%	Bez investicije	Periodička proizvodnja biometana (rad zimi)
50%	Investicija u CHP (rad ljeti)	Periodička proizvodnja biometana (rad zimi)





# Studija predizvodljivosti

Output T2.2

## Pre-feasibility Study (Croatia)

WP T2: Project main output

August, 2022

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

### 3.4 RESULTS WITH INCREASED GAS PRICES WITHOUT SUBSIDIES

Since gas prices are increasing rapidly in last years, scenarios with gas price increase are observed. For the next 6 scenarios (Figures 7 to 12), 10x increase in gas price is used in the OT. Such an abrupt change is made to explore the optimal investment cases that occur when the gas prices outweigh the electricity prices.

Figures 7 to 9 show scenarios for IP, REP and GF without subsidy and Figures 10 to 12 show scenarios with 50% subsidy on the investment cost.

Results show that after this significant gas price increase, biomethane production becomes economically profitable.

Investment specifications		
Item	Cost	Unit
City anaerobic digester	2,444,510.29 €	0.220077 kg/h
Wet anaerobic digester	2,444,510.29 €	0.220077 kg/h
City biomass to biogas plant	0.00 €	0.000000 kg/h
Wet biomass to biogas plant	0.00 €	0.000000 kg/h
Combined heat and power (CHP)	0.00 €	0.00 Value
Carbon capture plant	0.00 €	0.000000 m <sup>3</sup> /h
Distillation + water gas shift plant	14,038.40 €	0.000074 kg/h
Dehydration module	1,020,420.00 €	2,042,070 m <sup>3</sup> /h
Electrolyser	11,450,020.39 €	4,571.01 m <sup>3</sup> /h
Dehumidifier	1,120.00 €	11,580.00 m <sup>3</sup> /h
Preheating collector	2,900.00 €	1,000.00 m <sup>2</sup>
Heat exchanger	227,844.10 €	2.275 m <sup>2</sup> m <sup>3</sup> /h
Gas compressor station	882,112.00 €	320,000.00 m <sup>3</sup> /h
<b>Total for processes</b>	<b>19,979,514.60 €</b>	
City biomass storage	100,000.00 €	10,000.00 kg
Wet biomass storage	50,000.00 €	10,000.00 kg
Biogas storage	10,000.00 €	1,000.00 kg
Biogas storage tank	0.00 €	0.00 kg
Biogas storage tank	0.00 €	0.00 kg
Methane storage tank	0.00 €	0.00 kg
Carbon 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>
<b>Total for storage</b>	<b>160,000.00 €</b>	
Strawberry connection	0.00 €	0.00 m <sup>3</sup> /h
Gas connection	0.00 €	0.00 m <sup>3</sup> /h
Water connection	22.12 €	0.75 m <sup>3</sup> /h
<b>Total for connection</b>	<b>22.12 €</b>	
<b>Total investment</b>	<b>20,159,536.74 €</b>	
Payoff period	7.45 years	

Operational costs for selected period		
Item	Cost	Amount
Produced by REP	0.00 €	0.00 MWh
Consumed by IP	34,220,000.00 €	102,200.00 MWh
Net consumption without investment	34,220,000.00 €	102,200.00 MWh
Wet feed power without investment	400,000.00 €	10.00 MWh
Consumed by P2G	28,843,128.24 €	80,444.40 MWh
<b>Net consumption with investment</b>	<b>62,863,128.24 €</b>	<b>192,644.40 MWh</b>
<b>Wet feed power with investment</b>	<b>400,000.00 €</b>	<b>10.00 MWh</b>
Produced by REP	0.00 €	0.00 MWh
Produced by IP	0.00 €	0.00 MWh
Net production without investment	0.00 €	0.00 MWh
Consumed by P2G	0.00 €	0.00 MWh
<b>Net production with investment</b>	<b>0.00 €</b>	<b>0.00 MWh</b>
Produced by REP	0.00 €	0.00 MWh
Consumed by IP	4,918,743,244.91 €	6,917,829.34 MWh
Net consumption without investment	4,918,743,244.91 €	6,917,829.34 MWh
Produced by P2G	34,420,070.97 €	47,452.04 MWh
<b>Net consumption with investment</b>	<b>4,953,163,315.88 €</b>	<b>7,065,281.38 MWh</b>
Wet feed power with investment	400,000.00 €	10.00 MWh
Consumed by P2G	28,843,128.24 €	80,444.40 MWh
Wet biomass bought	27,900.00 €	2,790.00 MWh
Wet biomass bought	27,900.00 €	2,790.00 MWh
Wet biomass bought	27,900.00 €	2,790.00 MWh
<b>Total cost of input materials</b>	<b>53,850.00 €</b>	<b>5,385.00 MWh</b>
Phosphate used in biogas	0.00 €	0.00 MWh
Phosphate used in biogas	25,000.00 €	250.00 MWh
Methane used in biogas	0.00 €	0.00 MWh
Residue used	22,000.00 €	220.00 MWh
<b>Total revenue from additional sales</b>	<b>47,000.00 €</b>	<b>470.00 MWh</b>
Residue from anaerobic digester	0.00 €	0.00 MWh
Residue from wet anaerobic digester	0.00 €	0.00 MWh
The form production + water gas shift	22,000.00 €	220.00 MWh
CO <sub>2</sub> credit	0.00 €	0.00 MWh
<b>Total cost of residues</b>	<b>0.00 €</b>	<b>0.00 MWh</b>
<b>Total operational cost without investment</b>	<b>4,953,163,315.88 €</b>	<b>7,065,281.38 MWh</b>
<b>Total operational cost with investment</b>	<b>4,953,163,315.88 €</b>	<b>7,065,281.38 MWh</b>
<b>Savings with investment of P2G</b>	<b>19,979,514.60 €</b>	<b>19,979,514.60 MWh</b>

Fig. 7 Results for optimal P2G hub next to IP with higher prices of methane and no subsidy

P2G hub next to IP with large methane consumption can be highly profitable with increased gas prices. Optimal result for this scenario is producing as much biomethane as it is possible with constraints of the OT to fulfil the IP's needs for gas. In this scenario, both wet and dry biomass inputs are limited to 10 tonnes per day and that is the amount of dry biomass bought each day by the P2G hub. Wet biomass sources which are more

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





# Hvala na pažnji

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LARES

