

# <u>Output T2.2</u>

# Pre-feasibility Study (Hungary)

WP T2: Project main output

June 20, 2022

THE PROJECT IMPLEMENTED UNDER THE INTERREG DTP PROGRAMME IS CO-FUNDED BY EUROPEAN UNION FUNDS (ERDF, IPA). www.interreg-danube.eu/danup-2-gas



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

BLANK PAGE



# 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

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



## EPROPERTOWERED ESTIMATION CONTRACTOR

	assessment & Pre-feasibility Studies
Deliverable	Output T2.2
Delivery date	June 20, 2022

Version	Date	Author	Organization	Description
√1				1 <sup>st</sup> version



# IMPRINT

This document is issued by the consortium formed for the implementation of the DanuP-2-Gas project by the following partners:

- LP Technology Centre Energy University of Applied Sciences Landshut (DE)
- ERDF PP1 Energy AGency of Savinjska, Koroška and Šaleška Region (SI)
- ERDF PP2 Tolna County Development Agency Nonprofit Public Ltd.(HU)
- ERDF PP3 Energy Institute at the Johannes Kepler University Linz (AT)
- ERDF PP4 Black Sea Energy Research Centre (BG)
- ERDF PP5 URBASOFIA SRL (RO)
- ERDF PP6 Deggendorf Institute of Technology (DE)
- ERDF PP7 National Recycling Agency of Slovakia (SK)
- ERDF PP8 Institute of Technology and Business in České Budějovice (CZ)
- ERDF PP9 MAHART-Freeport Co. Ltd (HU)
- ERDF PP10 International Centre for Sustainable Development of Energy,
   Water and Environment Systems (HR)
- ERDF PP11 Energy Institute Hrvoje Požar (HR)
- ERDF PP12 University of Zagreb Faculty of Electrical Engineering and Computing (HR)
- IPA PP1 Regional Agency for Socio Economic Development Banat Ltd (RS)

Responsible Partner for the compilation of this document

LP Technology Centre Energy - University of Applied Sciences Landshut (DE)



# PROJECT WORSTTES - User ------

ERDF PP1 Energy Agency of Savinjska, Koroška and Šaleška Region (SI)

# BLANK PAGE



# CONTENT

1.	MET	HOD	OLOGY	10
2.	Case	Stuc	lies	11
2	.1	P2G	hub as a green field project (Green field); Kaposvár	11
	2.1.1	L	Transportation	12
	2.1.2	2	Physical constants	13
	2.1.3	3	RE access	14
	2.1.4	Ļ	Power and gas grid access	15
2	.2	P2G	hub at an industrial plant (IP) – TVK, Tiszaújváros	17
	2.2.1	L	Transportation	19
	2.2.2	2	Amount and price of biomass	20
	2.2.3	3	RE access	20
	2.2.4	Ļ	Power and gas grid access	21
	2.2.5	5	Physical constants	23
2	.3	REP	<ul> <li>PV location characteristics (P2G hub at a renewable energy plant (REP)</li> </ul>	25
	2.3.1	L	Characteristics of the setup	26
	2.3.2	<u>)</u>	Status Quo of Solar Power generation in Hungary	30
2	.4	Exist	ting P2G pilot project in hungary	31
3.	Resu	ılts		33
3	.1	Gree	en Field	33
	3.1.1	L	Results with subsidies	33
	3.1.2	<u>)</u>	Results without Subsidies	35
3	.2	IP		37
	3.2.1	L	Results with subsidies	37
	3.2.2	<u>)</u>	Results without subsidies	40
3	.3	REP.		43
	3.3.1	L	Results with subsidies	43
	3.3.2	<u>)</u>	Results without subsidies	45
			Project co-funded by the European Union funds (ERDF, IPA)	

www.interreg-danube.eu/danup-2-gas





Version	Date	Author	Organizatio n	Description
V1	27.09.2021	Kiril Raytchev	BSERC	Initial version
v2	22.02.2022	Kiril Raytchev	BSERC	Reflecting Optimization tool current specification
v3	15.03.2022	Kiril Raytchev	BSERC	Replacing pay-off period analysis with gas price deviation one.



# 1. METHODOLOGY

The main input for the study was the results tables generated by the DanuP2G Optimilization Tool (OT). The inputs to OT were mainly the previously submitted Infrastructure report and table and the Biomass report and table. Other supplementary and explanatory information is also provided in the study, given that these may be internet sources, these sources are indicated in the relevant section.

The Optimilization Tool (OT) is ready for all 18 cases, according to the work package.

More precisely the following three cases:

- P2G hub as a green field project (Green field);
- P2G hub at an industrial plant (IP);
- P2G hub at a renewable energy plant (REP);

For each of these three cases (IP, REP, and Green field) the results include an investigation of:

- Natural gas price
  - o current price
  - o 5 times the current price
  - o 10 time the current price
- with and without subsidies of 50%.



# 2. CASE STUDIES

# 2.1 P2G HUB AS A GREEN FIELD PROJECT (GREEN FIELD); KAPOSVÁR

The city of Kaposvár, capital of Somogy county in Southern-west Hungary is a possible location for a greenfield investment<sup>1</sup>.

The term greenfield stands for investments implemented on fields that has been, literally, green. The word green also mean new, alluding to new construction projects. Instead of buying an existing facility, a new venture is begun by constructing new facilities. Construction projects may include more than just a facility. They also entail, rather lean on the entire public utility infrastructure.

The economy of Kaposvár has implemented tremendous development in recent years. The economic strategy of the city, the attractive environment for investors and the supportive attitude of the municipality resulted several traditional manufacturing companies expanding their production capacity, as well as industrial companies appear in the industrial parks of the city and announce new investments. Examining the transport geography of Kaposvár, its road and railway connections effectively contribute to the provision of passenger and freight traffic in the area.

Kaposvár is the dominant economic location of Somogy county and Southern Transdanubia, the production and commercial centre, the engine of development. Considering its industrial structure, two distinct lines can be observed. Food plants with a long history and strategic importance, as well as the electrical and machinery

<sup>&</sup>lt;sup>1</sup><u>Understanding Greenfield vs. Brownfield Investments (investopedia.com)</u>



industries investments have been made or are in the process of being made. Jobs are successful providing the city's education system with a skilled workforce as a basis for its operation task. Major achievements in this area are the soon-to-be-built Science Park, as well as the local units of notorious higher education institutions (University of Óbuda, Hungarian University of Agricultural and Life Sciences). The iFood Cluster gathers the outstanding actors of the food and agricultural industry in the region.

# 2.1.1 TRANSPORTATION

The regional relations of Somogy county are twofold: the northern and western edges of the county have adequate accessibility and infrastructural background, while the inner areas, mainly eastern and southern parts have more closed transport links. Kaposvár has good road access, on M7 or M6 motorways from Budapest, 48 km from the M7 motorway, on the M67 motorway from Balatonszemes. I can be reached from Dunaföldvár on the main road 61. From the centre of the region, Pécs, it can be reached on the main road 66, from Nagykanizsa and Dombóvár on the main road 61.

During the spring of 2023, the existing main road 67 bypassing Kaposfüred will be improved with a 2x2 lane road, with a design speed of 110 km / h. The planned M9 motorway between Szekszárd and Kaposvár is in the most advanced planning phase. The railway connection of the city is also ensured, on the railway line 40 (Budapest-Dombóvár-Pécs) to Dombóvár, then from there on the railway line 41 (Dombóvár – Gyékényes). Railway line 41 is after Kaposvár had 3 southern branches, however these were eliminated aggravating the situation of underdeveloped southeastern districts.

Direct rail connections of Kaposvár:



- Line 35: Kaposvár-Siófok, 100 km, single
  - 100 km, single-track, non-electrified side line
- Line 36: Kaposvár-Fonyód, 54 km, single-track, non-electrified side line
- Line 41: Dombóvár-Gyékényes, 101 km, single-track, electrified main line

As mentioned, there are several industrial zones around the city with plenty of manufacturing companies as potential users of the P2G hub in case the project was implemented as a greenfield investment near Kaposvár. Greenfield industrial investments are being implemented currently too. Industrial parks:

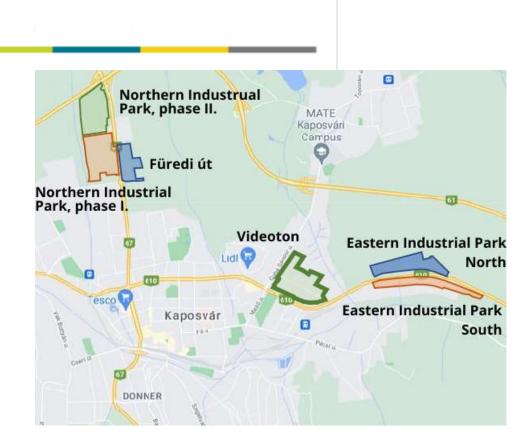
- Eastern Industrial Park (north and south)
- Videoton Industrial Park
- Northern Industrial Park (implemented as a greenfield project in four phases)
- Eastern side of Füredi út

# 2.1.2 PHYSICAL CONSTANTS

As shown in the figure below, the city is bordered by large green fields, potential locations of a P2G hub for Kaposvár<sup>2</sup>.

<sup>&</sup>lt;sup>2</sup> Kaposvár Pre-feasibility study





1. Figure: Kaposvar Industrial Parks

Source: Own editing

# 2.1.3 RE ACCESS

From the Eastern Industrial Park to the north, there is the largest solarplant of the country. It is a 100 megawatt solar power plant<sup>3</sup>. It is currently the largest solar power plant in Central Europe, four times the size of the one in Kapuvár, which was previously considered to be the largest similar facility in Hungary.

The amount of energy produced by the solar park almost meets the annual energy needs of the entire population of Kaposvár. The solar power plant was built by the

<sup>&</sup>lt;sup>3</sup> Óriási napelempark készült el Kaposvár határában - Műszaki Magazin (muszakimagazin.hu)



National Machinery Import and Export Corporation (CMC), a design company owned by China's state-owned company, China General Technology Group. Construction of the solar park began in June 2019 and was completed in 2021.

Due to such projects, the amount of solar capacity in Hungary is growing rapidly. This is confirmed by the fact that while in 2019 the total capacity of domestic solar systems was 1277 MW, by the end of 2020 this number had already reached 2000 MW. The Kaposvár solar park connected to the grid in 2021 represents an additional 5% increase at the beginning of the year compared to 2020. This is a very good starting point, as the main goal of Hungary's National Renewable Action Plan is to be able to cover 14.65% of the country's electricity needs from renewable sources by 2022.

# 2.1.4 POWER AND GAS GRID ACCESS

# Amount and price of biomass

Biomass is available almost anywhere in the country at varying prices, but the average price is 42 EUR/tonne.

Optimization tool setup and input parameters

- Grid investment prices:
  - Electrical grid:
    - Unit cost for electrical transmission grid connection 2,55 €/kW
       km
    - Unit cost for electrical distribution grid connection 4,27 €/kW km
    - Capacity cost for electrical transmission grid connection 122
       €/kW



Capacity cost for electrical distribution grid connection 1,63
 €/kW

• Gas grid:

- Unit cost for gas transmission grid connection 90 €/kW km
- Unit cost for gas distribution grid connection 67 €/kW km
- Capacity cost for gas transmission grid connection 0,6 €/kW
- Capacity cost for gas distribution grid connection 0,53 €/kW

## o Water grid

- Unit cost for water grid connection 4,02 €/kW km
- Capacity cost for water grid connection 1,48 €/kW



# 2.2 P2G HUB AT AN INDUSTRIAL PLANT (IP) – TVK, TISZAÚJVÁROS

In Tiszaújváros the Tisza Chemical Combine Public Limited Company (TVK Plc. Or TVK) is one of the largest chemical companies in Hungary in terms of turnover. For more than four decades, TVK has been producing raw materials in competitive quality for the plastics processing industry, from which have become consumer and industrial goods an integral part of our daily lives. TVK's shares can be traded on the Budapest Stock Exchange and the over-the-counter trading system (IOB) of the London Stock Exchange.

TVK and Slovnaft a.s. in Bratislava - as part of the integrated MOL Downstream division - are the leader in the petrochemical industry in the Central European region. These two companies are among the top ten players in the polymer market in Europe in terms of joint production capacity. The production of TVK and its Slovakian partner are optimally synchronized by the MOL Group furthermore they are utilized the benefits of integrated polymer sales within the MOL Group.

# PRIORITY OBJECTIVES

- Safe operation of plants
- Continuous increase of efficiency
- Implementation of strategic development projects
- Maintain strict control of costs and investments
- Strengthening integrated operations in the Downstream division of MOL Group.





2. Figure:TVK, Tiszaújváros

Source: <u>Debrecen hírei, debreceni hírek | Debrecen és Hajdú-Bihar megye hírei -</u> Dehir.hu

Main activity:

It primarily serves European plastics processing companies with competitive, highquality polymer products. In addition to main profile, it also sells olefins and other chemical feedstocks to the region's chemical and oil refining industries, including MOL.

The main products of the olefin plants are ethylene and propylene, which are processed into polyethylene and polypropylene in polymer plants. Some of the ethylene produced in the olefin plants is sold to BorsodChem Zrt. under a long-term contract.

TVK is committed to sustainable development. Its environmental performance:



- The waste collection and storage method developed through the implementation of the Central Waste Yard is to the satisfaction of both our business units and our contracted partners. There were no comments or complaints from the public.
- By increasing energy efficiency, reducing specific carbon dioxide emissions, implementing leading technological improvements, optimising energy supply and production, and optimising the availability of demand and service assets, we have achieved specific emissions of 0.989 tonnes CO2/t HVC at the level of the TEC.
- In the course of uniform environmental licensing procedures, permit documentation for review documentation has been compiled and submitted to the EMI-CERC.

The plant is currently expanding, looking for opportunities. MOL Petrolkémia Zrt. and McDermott International Inc. have signed an agreement for basic design, technology license, catalyst and Front End Engineering Design (FEED) for olefin conversion technology (OCT) investment, which will be part of MOL's petrochemical complex in Tiszaújváros, in Hungary. From refinery and olefin plant feedstocks, the new plant will produce a polymer feedstock, propylene, with a capacity of 100,000 tons / year, using the OCT and CDHydro Isobutene Removal process owned by Lummus. The plant will also produce an isobutene-rich fraction.

# 2.2.1 TRANSPORTATION

It is a settlement located 35 km from Miskolc, at the mouth of the Sajó Tisza; It is located right next to the main road 35 from Nyékládháza to Debrecen, and is connected to Mezőcsát by the 3313 road. A small part of its administrative area is



located on the other side of the Tisza, on the left bank, but that part of the area can be considered uninhabited.

Rail connections of Tiszaújváros:

Line 89: Tiszaújváros–Nyékládháza

Road connections of Tiszaújváros:

Line 35, near Miskolc

Water connections of Tiszaújváros:

through the Tisza River (2<sup>nd</sup> largest river in Hungary)

# 2.2.2 AMOUNT AND PRICE OF BIOMASS

Tisza BioTerm Kft., owned by Sinergy Kft. The project was implemented with the support of the European Union and the New Széchenyi Plan for HUF 65 million in 2013.

Biomass is available almost anywhere in the country at varying prices, but the average price is 42 EUR/tonne.

# 2.2.3 RE ACCESS

The number of sunny hours suitable for energy production in the region of Northern Hungary is 1100-1200 moves around. World market prices for solar panels have fallen sharply in recent years, as a result the interest of domestic investors in solar parks and solar power plants (PV) has increased significantly. In the last few years, a more or less powerful solar power plant has been built in many settlements of the country. In Borsod-Abaúj-Zemplén county, several solar power plant investment projects are under implementation, these are the solar power plant project in Felsőzsolca, which

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



is being implemented in the investment of MVM Zrt. one of the most powerful PV parks in Hungary.

In the case of Tiszaújváros as well, the implementation of a solar power plant investment with a capacity of at least 6 MW was justified, which allows approx. 4,000 MWh of electricity generation and approx. 3 200 t CO2 emission reductions are achievable. In selecting the location of the investment, it had to be taken into account that: approximately 7-8 hectares of solar power is required in this power range. Since the in the vast majority of solar power plants, it is advisable to connect to the 20 kV network. to install the power plant near a pipeline or substation. Also, it was an important consideration to do so, if possible, the power plant should be located in a brownfield area (eg in an abandoned industrial area). MOL has launched a 3 MW solar power plant on the site of MOL Petrolkémia Zrt. (Formerly TVK) which was already operational at the end of 2018.<sup>4</sup>

China-based Unisun Energy Group has built an 11.6-megawatt solar power plant in Tiszaszőlős. According to their plans, the capacity of the solar power plant installed in the settlement near Lake Tisza can be expanded to at least 50 MW later in several phases. In total, the Chinese company is involved in more than 1 GW of photovoltaic projects worldwide.

# 2.2.4 POWER AND GAS GRID ACCESS

Tisza II is a thermal power plant in Tiszaújváros. It consists of 4 units of 215 MW (power plant unit) with a total nominal capacity of 860 MW. It has hydrocarbon-fired boilers: the thermal power plant fires natural gas and heating oil, and even in 1982 it was

<sup>&</sup>lt;sup>4</sup> Tiszaújváros Sustainable Energy And Climate Action Plan (SECAP)



made suitable for firing high-inert natural gas. The power plant covers an area of more than 130 hectares, has its own water extraction and water treatment plant, an oil storage facility with a capacity of more than 80,000 tons, and its own internal industrial track.



3. Figure: Utilities in the area

# Source<sup>5</sup>: <u>https://ekozmu.e-</u>

epites.hu/alkalmazas/lakossag/menu/terkep/tajekoztatas/kozmuterkep

Financial data from the TVK:

- Total fixed assets 140.862 million forints
- All current assets 75.362 million forints

Operational prices and parameters

<sup>&</sup>lt;sup>5</sup> yellow = hydrocarbons, pink = district heating, red = electricity, blue = water supply, brown = drainage



- Total operating income 401.695 million forints
- Total operating expenses 364.766 million forints

## Investment prices

- All sources 216.224 million forints
- 2.2.5 PHYSICAL CONSTANTS

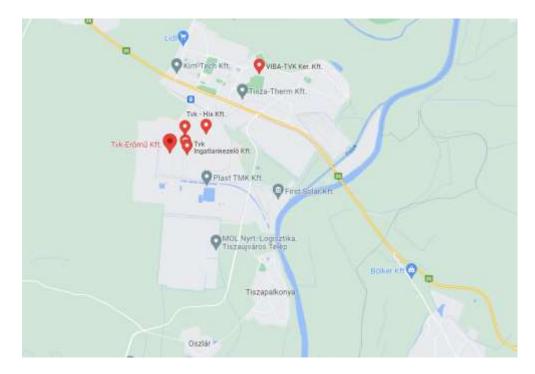
The registered office of the Company is Tiszaújváros (H-3581 Tiszaújváros, TVK-Ipartelep, TVK Central Office Building, building 2119/3)

Tiszaújváros is an industrial city in northern Hungary, in Borsod-Abaúj-Zemplén county. The center of the Tiszaújváros district. It is the fifth most populated town in the county after the county seat. Tiszaújváros has a favorable geographical location. The area is a plain and terraced river valley according to its topography. The city is located in northern Hungary on the eastern edge of the Bükk region, in the area enclosed by the Sajó estuary, the second largest river in Hungary, the largest river in the counties of Tisza and Borsod-Abaúj-Zemplén. Its area of 46.04 km<sup>2</sup>. Tiszaújváros plays a connecting role between three big cities, Miskolc, Debrecen and Nyíregyháza. The establishment of the industrial base began in 1953 with the construction of a 200 MW coal-fired thermal power plant on the border of Tiszapalkonya. With the services of the thermal power plant, electricity and industrial steam, it established the existence of large industrial plants to be built later (eq Tiszai Vegyi Kombinát, Tiszai Refinery, Olefin Factory, Tisza II Thermal Power Plant). The first operating unit of the Tisza Chemical Plant, the gas plant, was put into operation in 1959, the paint factory started operating in 1961 and the fertilizer factory in 1964. The olefin program has given new impetus to the development of the industry. Petrochemical activity began in 1970 with the commissioning of the first polyethylene plant. The major



investment of the Tisza Power Plant, the construction of the Tisza Thermal Power Plant, began in 1971, and was originally planned to be the largest power plant in the country at 2,000 MW, but was built at only 860 MW due to the 1973 oil crisis, making it the third largest power plant in Hungary. It was handed over on September 7, 1979. Construction of the Tisza Petroleum Company (TIFO) began in 1973, and oil refining began in November 1980. In addition to the three factory complexes, the municipality of Tiszaújváros established the 140-hectare Tiszaújváros Industrial Park with a greenfield investment in 1997. The industrial park with full infrastructure has created favourable conditions for industrial and commercial companies. The settled businesses employ more than 10,000 people in the industrial park.

The closing headcount of the TVK Group employees on 31 December 2014 was 981.



4. Figure: Tiszaújváros map

# Source: google.com/maps

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



# 2.3 REP – PV LOCATION CHARACTERISTICS (P2G HUB AT A RENEWABLE ENERGY PLANT (REP)

In the case of renewable resources, we have a wide range of options to choose from, given that increasing and integrating solar power generation into the grid is one of the most important goals and challenges for the Hungarian energy system in the coming decades, so the calculations were run with solar PV.

Considering that in the next decades solar resources will be available in almost all parts of the country with similar conditions, not a specific location was chosen, but a general hypothetical investment location, which could be located near any solar park in the country.





5. Figure: The biggest solar park (100 MW) in Kaposvar, Hungary

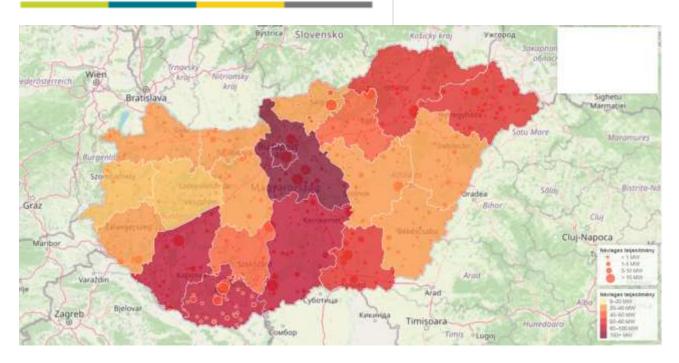
Source: Elkészült Kaposvár giganapelemparkja, februártól indul a termelés | Kaposvár Most.hu (kaposvarmost.hu)

# 2.3.1 CHARACTERISTICS OF THE SETUP

Availability and cost of resources:

The availability of solar power plants in many areas of the country, even on a larger scale, means that entry costs can be almost identical in this respect, so other factors may be the main determinant for the choice of a site.





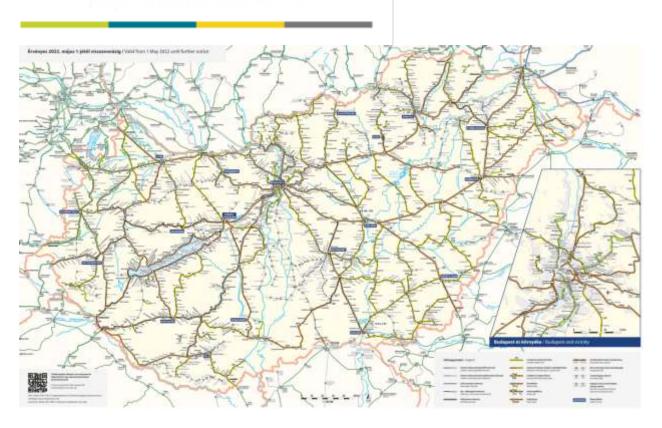
6. Figure: Solar field map of Hungary (nominal power)

# Source: SolarMap - Interaktív térkép

# Transportation:

Given that a location with no general precise location was chosen for the analysis, it can be said that rail transport in Hungary has a network with a high density and good accessibility along the main lines.



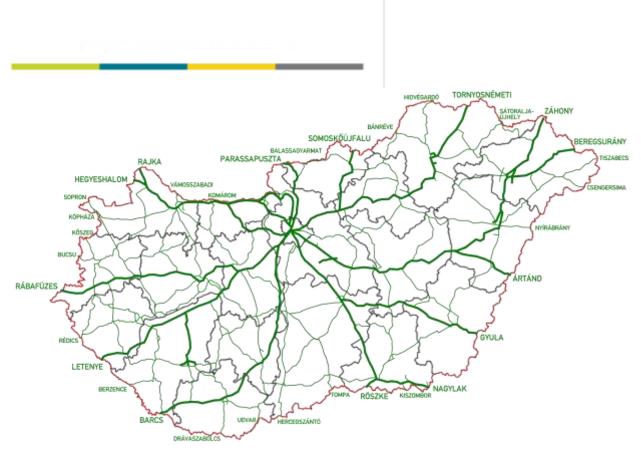


7. Figure: Main lines of the Hungarian railway network

## Source: Térképek | MÁV-csoport (mavcsoport.hu)

In terms of road accessibility, the Hungarian road network is as dense as the rail network, the quality of the network along the main routes has improved a lot in recent years, while the most recent years have seen the most extensive upgrading or major renewal works on the secondary lines, which will be typical in the decade to 2020.





8. Figure: Main routes of the road network in Hungary

Source: Magyarország főútjai – Wikipédia (wikipedia.org)

Amount and price of biomass:

Biomass is available almost anywhere in the country at varying prices, but the average price is 42 EUR/tonne.

RE access:

Given that no specific location has been chosen, access to renewable energy sources is flexible and can be adapted to the site.

Power and gas grid access:

The average distance between connection points in the country is 12 km for electricity and 10 km for gas.



Optimization tool setup and input parameters

- Grid investment prices:
  - Electrical grid:
    - Unit cost for electrical transmission grid connection 2,55 €/kW
       km
    - Unit cost for electrical distribution grid connection 4,27 €/kW km
    - Capacity cost for electrical transmission grid connection 122
       €/kW
    - Capacity cost for electrical distribution grid connection 1,63
       €/kW
  - o Gas grid:
    - Unit cost for gas transmission grid connection 90 €/kW km
    - Unit cost for gas distribution grid connection 67 €/kW km
    - Capacity cost for gas transmission grid connection 0,6 €/kW
    - Capacity cost for gas distribution grid connection 0,53 €/kW
  - o Water grid
    - Unit cost for water grid connection 4,02 €/kW km
    - Capacity cost for water grid connection 1,48 €/kW

# 2.3.2 STATUS QUO OF SOLAR POWER GENERATION IN HUNGARY

After the extremes of March, electricity prices in April were €80-100/MWh lower on the day-ahead markets, with prices fluctuating between €200-250 on the domestic exchange. The price moderation was due to a correction in gas prices and higher



renewable generation, according to the April electricity market report of the Hungarian Energy and Utilities Regulatory Office.<sup>6</sup>

In April 2022, aggregate consumption in the five largest European markets was 2% lower than in the same period of the previous year. Consumption in the Central European region fell by more than this, by 3.2%.

Renewable generation has been growing dynamically, reaching a daily maximum of 1806 MW on 13 April, an absolute record, far exceeding the 1407 MW recorded in August last year.

# 2.4 EXISTING P2G PILOT PROJECT IN HUNGARY

There is also a very significant Power-2-Gas related pilot project currently running in Hungary, the Akvamarin project.

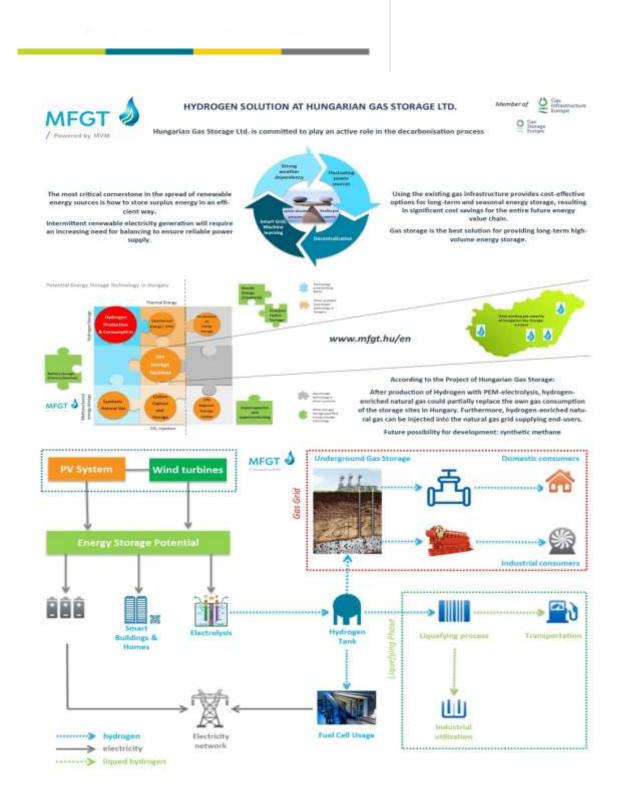
In February 2021, Hungarian Natural Gas Storage Ltd. launched its innovative R&D pilot project, Akvamarin, which will establish a hydrogen production and blending technology at its underground gas storage facility in Kardoskút. The project is a response to the European Union's European Green Deal and aims to sell to consumers and replace the use of own gas. FGSZ Natural Gas Transmission Ltd. is a joint venture of MFGT Zrt.

FGSZ is pleased to be associated with the testing of the transmissibility of the hydrogen gas produced by the project in the transmission system, based on its knowledge, extensive technological background and legal knowledge, as part of a cooperation agreement. The project is expected to be completed by early 2023<sup>7</sup>.

<sup>&</sup>lt;sup>6</sup> www.mekh.hu/csucsot-dontott-a-hazai-naperomuvi-termeles-aprilisban

<sup>&</sup>lt;sup>7</sup> Akvamarin projekt alapkőletétel (mfgt.hu)





9. Figure: Schematic diagram of the project

Source: Akvamarin (mfqt.hu)

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



# 3. RESULTS

# 3.1 GREEN FIELD

From Figure 4 to Figure 9, we can see cases where a P2G hub could be developed as a greenfield investment, but the calculation shows that such an investment cannot be economically feasible in Hungary, even with 50% subsidy and 10x gas price increase.

# 3.1.1 RESULTS WITH SUBSIDIES

	Element	Price		Stre	11.
	Dry anaerobic digestor	0,00	€	0,000000	kg/s
	Wet anaerobic digestor	0,00	£	0,000000	kg/s
	Dry biomass to blochar plant	0,00	e	0,000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
ī	Biogas separator	0,00	£	0,000000	kg/s
	Gassfication + water gas shift plant	0,00	e	0,000000	kg/s
Processes	Combined heat and power (CHP)	0,00	€	0,000000	kg/s
3	Carbon capture plant	0,00	€.	0,000000	mol/s
-	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,00	€	0,000000	mol/i
	Precipitation collector	0,00	£	0,00	mī
	Methanation reactor	0,00	€	0,000000	mal/s
	Heat exchanger	0,00	€	0,0000	kW .
	Total for processes	0,00	£		
	Dry biomass storage	0,00	€	D.0000	kg
	Wet biomass storage	0,00	€	0,0000	kg
	Biochar storage	0,00	£	0,0000	kg.
1	Water storage tank	0,00	€	0.0000	mal
Shuring me	Oxygen storage tank	0,00	¢	0,0000	mal
01	Hydrogen storage tank	0,00	€	0,0000	mal
	Carbon dioxide storage tank	0,00	€	0.0000	mai
	Methane storage tank	0,00	€	0,0000	mol
	Total for storages	0,00	6		
2.2	Electrical connection	0,00	€	0,00	MW
connections with general	Gas connection	0,00	¢	0,00	MW
Connections	Water connection	0,00	€	0,00	$m^{1}/h$
0.8	Total for connections	0,00	£		
	Total investment	0,00	•		
	Payoff period	n/a	years		

		Price	Amount
	Produced by REP	0,00 €	0,00 MWH
19-10	Consumed by IP	0,00 €	0,00 MWh
8	Net consumption without investment	0,00 €	0.00 MWh
and a	Peak power without investment	0,00 €	0,00 kW
ŝ	Consumed by P2G	0,00 €	0,00 MWh
ď.	Net consumption with investment	0,00 €	0.00 MWh
rputs American Methania Heart Electrical energy	Peak power with investment	0,00 €	0,00 kW
	Produced by REP	0,00 €	0,00 MWh
225	Produced IP	0,00 €	0.00 MWh
Han	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
8	Produced by REP	0,00 €	0,00 MWh
	Consumed by IP	0,00 €	0,00 MWh
3	Net consumption without investment	0,00 €	0,00 MWh
auruaw Water	Produced by P2G	0,00 €	0,00 MWH
	Net consumption with investment	0,00 €	0,00 MWh
Vater	Water consumed by P2G	0,00 €	0,00 m <sup>9</sup>
25	Dry blomass bought	0,00 €	0,00 t
2	Wet biomass bought	0,00 €	0,00 1
ä.	Biochar bought	0,00 €	6,00 t
8	Blocher sold	0.00 €	0,00 t
4	Hydrogen sold	0,00 €	0,00 1
0	CO2 emitted	0,00,€	0,00 kg
Watter W Stridui Sandaro Fi	Total operational cost without investment	0,00 €	
	Total operational cost with investment	0,00 €	
	Savings with introduction of P2G	0.00 €	

Construction of the

10. Figure: Results for GF with real gas prices of methane and 50% subsidy

Source: Optimilization Tool v1.1



	Element	Price	5	ice .
	Dry anaerobic digestor	0,00	£	0,000000 kg/s
	Wet anaerobic digestor	0,00	e	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
	Biogas separator	0,00	e	0.000000 kg/s
12	Gasification + water gas shift plant	0,00	£	0,000000 kg/s
Processo	Combined heat and power (CHP)	0,00	£	0,000000-kg/s
Tap	Carbon capture plant	0,00	e	0,000000 mol/s
0	Electrolyser	0,00	€.	0,00 kW
	Demineralizer	0,00	¢	0,000000 mol/s
	Precipitation collector	0,00	e	0,00 m <sup>2</sup>
	Methanation reactor	0,00	£	8,600000 mol/i
	Heat exchanger	0,00	¢	0,0000 kW
	Total for processes	0,00	¢	
	Dry biomass storage	6,00	£	0.0000 kg
	Wet biomass storage	0,00	e	0,0000 kg
	Biochar storage	0,00	£	0.0000 kg
1	Water storage tank	0,00	¢	0.0000 mail
to Bearing	Oxygen storage tank	0,00	e	0,0000 mol
4	Hydrogen storage tank	0,00	£	0,0000 mol
	Carbon dioxide storage tank	0.00	e	0.0000 mol
	Methane storage tank	0,00	¢	0.0000 mel
	Total for storages	0,00	E	
ΕE	Electrical connection	0.00	¢	0,00 MW
88	Gas connection	0,60	£	0,00 MW
8.2	Water connection	0,00	£	0,00 m³/h
್	Total for connections	0,00	€ .	
	Total investment	0,00	¢	
	Payoff period	n/a	years	

	2	Consumed by IP	0,00	6	0.00 MWH
	2	Net consumption without investment	0,00	¢	0,00 MWh
	3	Peak power without investment	0,00	£	0,00 kW
	8	Consumed by P2G	0,00	¢	0.00 MWh
	Methane Haat Bethe	Net consumption with investment	0,00	¢	0.00 MWh
1.005		Peak power with investment	0,00	£	0,00 KW
		Produced by REP	0,00	¢	0,00 MWh
	- 12-0	Produced IP	0,00	6	0,00 MW/h
	1	Net production without investment	0,00	e	0,00 MWh
	100	Consumed by P2G	0,00	e	0,00 MWh
		Net production with investment	0,00	6	0,00 MWh
		Produced by REP	0,00	e	0,00 MWh
	8	Consumed by IP	0,00	e	0,00 MWM
	5	Net consumption without investment	0,00	6	0,00 MWh
	2	Produced by P2G	0,00	¢ :	0,00 MWh
		Net consumption with investment	0,00	6	0,00 MWh
	Water	Water consumed by P2G	0,00	C	0,00 m <sup>9</sup>
	10	Dry biomass bought	0,00	C :	0,00 1
	3	Wet biomess bought	0,00	€	0,00 t
Water spoluj	Biochar bought	0,00	¢	0,00 t	
	12	Brochar sold	0,00	C	0.00 1

0.00 €

0.00 €

0,00 €

0,00 €

0,00 €

0,00 E

#### Operational costs for selected period

Produced by REP

Hydrogen sold

CO2 emitted

Total operational cost without investment

Total operational cost with investment

Savings with introduction of P2G

1 mar 1

0.00 1

0.00 kg

0.00 5767

#### 11. Figure: Results for GF with moderate gas prices of methane and 50% subsidy

	Element	Price	Size		Contraction of the Contraction o	Price	Amount
-	Dry anaerobic digestor	0.00 €	0.000000 kg/s		Produced by REP	0.00 €	0.00 MW
	Wet anaerobic digestor	0.00 €	0.000000 kg/s	1.00	Consumed by IP	0.00 €	0.00 MW
	Dry biomass to blochar plant	0.00 €	0,000000 kg/s	(Luca	Net consumption without investment	0.00 €	0.00 MW
	Wet biomess to biocher plant.	0,00 €	0,000000 kg/s	10	Feak power without investment	0.00 C	0.00 kW
	Biogas separator	0.00 €	0.000000 kg/s	Betreal	Consumed by P26	0.00 K	0.00 MW
2	Gasification + water gas shift plant	0.00 €	0.000000 kg/s	E	Net consumption with investment	0.00 €	0.00 MW
8	Combined heat and power (CHP)	0.00 €	0.000000 kg/s	1.5546.23	Peak power with investment	0.00 €	0.00 kW
ĝ.	Carbon capture plant	0,00 €	6,000000 mol/s		Produced by REP	0.00 €	0.00 MW
*	Electrolyser	11,00 €	0.00 kW	10000	Produced IP	0.00 €	0.00 MW
	Demineralizer	0.00 €	0.000000 mol/s	1	Net production without investment	0.00 ¢	0.00 MW
	Precipitation collector	0.00 €	0.00 m <sup>2</sup>	23 <b>4</b> -03	Consumed by P2G	0.00 €	0.00 MW
	Methanation reactor	0.00 €	0.000000 mol/s		Net production with investment	0.00 €	0.00 MW
	Heat exchanger	0,00 €	0,0000 kW	1.000	Produced by REF	0.00 €	0.00 MW
	Total for processes	0,00 €		겯	Consumed by IP	0.00 €	0.00 MW
	Dry bromess storage	0,00 €	0,0000 kg	Methane	Net consumption without investment	0.00 €	0.00 MW
	Wet biomass storage	0.00 €	0,0000 kg	ž	Produced by P2G	0,00 €	0.00 MW
	Biochar storage	0.00.€	0,0000 kg		Net consumption with Investment	0,00 €	0,00 MW
ε.	Water storage tank	0.00 €	0.0000 mail	Water	Water consumed by P2G	0.00.€	0.00 m <sup>3</sup>
1	Oxygen storage tank	0,00 €	0,0000 mail	52	Dry blomass bought	0,00 €	0,00 t
Star	Hydrogen storage tank	0,00 €	0,0000 mal	sanda	Wet biomais bought	0,00 €	0,00 t
	Carbon dioxide storage tank	0,00 €	0,0000 mol	-	Brochar bought	0,00 €	0.00 t
	Methane storage tank	0.00 €	0,0000 mail	2	Blochar sold	0.00 €	0.00 t
	Total for storages	R.00 K	0.000 C (1.000	outpuce	Hydrogen sold	0.00 €	0.00.1
1.8	Electrical connection	0,00 €	0,00 MW	6	CO2 emitted	0,00 €	0,00 kg
1	des connection	0,00 €	0,00 MW		<b>Total operational cost without investment</b>	0,00 K	
5	Water connection	0.00 €	0.00 m <sup>3</sup> /h		Total operational cost with investment	0,00 €	
1.6	Total for connections	0,00 €			Savings with introduction of P2G	0,00 €	
	Total investment	0,00 €					
	Payoff period	n/a years					

## Source: Optimilization Tool v1.1

#### 12. Figure: Results for GF with high gas prices of methane and 50% subsidy

### Source: Optimilization Tool v1.1

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



# 3.1.2 RESULTS WITHOUT SUBSIDIES

	Element	Price	Siz	e	
	Dry anaerobic digestor	0,00	ε	0,000000	kg/s
	Wet an aerobic digestor	0,00	¢	0,000000	kg/s
	Dry biomess to blocher plant	0.00	c	0,000000	kg/s
	Wet biomass to blochar plant	0,00	c	0,000000	kg/s
	Bioges seperator	0,00	c	0,000000	kg/s
7.5	Gasification + water gas shift plant	0,00	c	0,000000	kg/s
Votesses	Combined heat and power (CHP)	0,00	¢	0,000000	kg/s
200	Carbon capture plant	0.00	c	0,000000	moi/s
~	Electrolyser	0,00	¢	0,00	ksv.
	Demineralizer	0,00	¢	0,000000	mol/s
	Precipitation collector	0,00	٤.	0,00	m <sup>2</sup>
	Methanation reactor	0,00	¢	0,000000	mol/s
	Heat exchanger	0,00	c	0.0000	kw:
	Total for processes	0,00	6	235532	101
	Dry biomess storage	-0,00	c	0,0000	kg -
	Wet biomass storage	0,00	c	0,0000	kg
	Biocher storage	0,00	¢	0,0000	kg
10	Water storage tank	0,00	c.	0,0000	mai.
Storages	Oxygen storage tank	0,00	¢	0,0000	mol
ŝ.	Hydrogen storage tank	0,00	c	0,0000	mol
	Carbon dioxide storage tank	0,00	c	0,0000	moi
	Methane storage tank	0,00	¢	0,0000	mail
	Total for storages	0,00	e	13/25/35	10.045
: :	Electrical connection	0.00	¢	0,00	MW.
E E	Gas connection	0,00	ε	0,00	MW
COMPOSITION I	Water connection	0,00	c.	0,00	m <sup>2</sup> /h
SĒ	Total for connections	0,00	e		
	Total investment	0,00	e.		
	Payoff period	n/a	years		

		Price	Am	ount
	Produced by REP	0,00	¢:	0,00 MW1
Bechical energy	Consumed by iP	0,00	c	0,00 MW1
	Net consumption without investment	0,00	c	0,00 MWH
	Peak power without investment	0,00	¢	0,00 kW
-	Consumed by P2G	0,00	¢	0,00 MW1
÷.	Net consumption with investment	0,00	¢	0,00 MW1
	Peak power with investment	0,00	¢	0,00 kW
_	Produced by REP	0,00	¢	0,00 MWH
121	Produced 1P	0,00	¢	0,00 MWH
걸	Net production without investment	0,00	¢	0,00 MW1
1.2	Consumed by P2G	0,00	c	0,001MW1
	Net production with investment	0,00	¢	0,00 MW1
	Produced by REP	0,00	¢	0,00 MWH
÷.	Consumed by IP	0,00	¢	0,00 MWH
Methane	Net consumption without investment	0,00	c	0,00 MWP
2	Produced by #26	0,00	c	0,00 MW1
_	Net consumption with investment	0,00	¢	0,00 MWH
Water	Water consumed by P2G	0,00	¢:	0,00 m <sup>1</sup>
	Dry blomess bought	0,00	e	0,00 t
tgridu	Wet biomass bought	0,00	c	0,00 1
-	Biochar bought	0,00	c	0,00 t
4	Biochar sold	0,00	¢	0,00 t
outputs	Hydrogen sold	0,00	¢	0,00 t
6	CO2 emitted	0,00	¢	0.00 kg
	Total operational cost without investment	0,00	0	
	Total operational cost with investment	0,00	¢	
	Savings with introduction of P2G	0,00	€	

201

13. Figure: Results for GF with real gas prices of methane and no subsidy

Source: Optimilization Tool v1.1



	Element	Prica	Size	
	Dry anaerobic digestor	0,00.€	0,000000	kg/s
	Wet anaerobic digestor	0,00 €	0,000000	kg/a
	Dry biomass to biochar plant	0.00 €	0,000000	kg/s
	Wet biomass to biochar plant	0.00 €	0,000000	kg/s
	Biogas separator	0.00.€	0,000000	kg/s
2	Gesification + water gas shift plant	0,00.€	0,000000	kg/s
8	Combined heat and power (CHP)	0.00 €	0.000000	kg/s
PL D C D D D D D D D D D D D D D D D D D	Carbon capture plant	0,00 €	0,000000	mol/s
BC-	Electrolyser	0,00 €	0,00	kW.
	Demineraltier	0,00 €	0,000000	moli/a
	Precipitation collector	0.00 €	0,00	m²
	Methanation reactor	0,00 €	0,000000	mol/s
	Heat exchanger	0,00 €	6,0000	kW.
	Total for processes	0,00 €		
	Dry biomass storage	0,00.€	0,0000	kg
	Wet biomass storage	0,00 €	0,0000	kg
	biochar storage	0,00 €	0,0000	kg
t.	Water storage tank	0,00 €	0,0000	mal
BOTHER	Oxygen storage tank	0,00 €	0,0000	mpi
a	Hydrogen storage tank	0.00.€	6,0000	mol
	Carbon dioxide storage tank	0,60 €	0,0000	mol
	Methane storage tank	0,00 €	6,0000	mol
	Total for storages	0,00.6		12.5
*	Electrical connection	0,00 €	0,00	MW
estargeneric	Gas connection	0,00/4	0,00	MW
5	Water connection	8,00 €	0,00	m <sup>2</sup> /h
- 2	Total for connections	0,00 K	-	
	Total investment	0,00 €		
	Payoff period	n/a years		

	tional costs for selected period	Price	Amount
_			
	Produced by REP	0,00 €	0,00 MWh
Bedrical-energy	Consumed by IP	0,00 €	0,00 MWH
£.	Net consumption without investment	0,00 €	0,00 MWh
3	Peak power without investment	0,00 €	0,00 kW
B.	Consumed by P2G	0,00 €	0,00 MWh
Ē	Net consumption with investment	0,00 €	0,00 MWh
	Peak power with investment	0,00 €	0,00'kW
	Produced by REP	0,00 €	0,00 MWh
1	Produced IP	0,00 €	0,00 MWh
10	Net production without investment	0,00 €	0,00 MW/h
	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
2	Consumed by IP	0,00 €	0,00 MWh
Methane	Net consumption without investment	0,00 €	0,00 MWh
Ň.	Produced by P26	0,00 €	0,00 MWh
	Net consumption with investment	0,00 €	0,00 MWh
Vater	Water consumed by P2G	0,00 €	0,00 m <sup>2</sup>
95	Dry biomass bought	0,00 €	0,00(1
inputs	Wet blomass bought	0,00 €	0,00 t
<u>F</u>	Biochar bought	0,00 €	0,00 t
22	Biochar sold	0,00 €	0,00 t
outputs	Hydrogen sold	0,00 €	0,00.t
õ.	CO2 emitted	0,00 €	0,00 kg
	Total operational cost without investment	0,00 €	
	Total operational cost with investment	6,00 €	
	Savings with introduction of P2G	0,00 €	

## 14. Figure: Results for GF with moderate gas prices of methane and no subsidy

## Source: Optimilization Tool v1.1

_	Element	Price	Size		
	Dry anaerobic digestor	0,00	£	0.000000	kg/s
	Wet anaerobic digestor	0,00	€	0,000000	Ng/s
	Dry biomass to biochar plant	0,00	¢	0,000000	kg/s
	Wet biomass to biochar plant	0,00	¢	0,000000	kg/s
	Biogas separator	0,00	¢	0,000000	kg/s
	Gasification + water gas shift plant	0,00	¢	0,000000	kg/s
Property	Combined heat and power (CHP)	0,00	¢	0,000000	kg/s
ĝ.	Carbon capture plant	0.00	¢	0,000000	mol/s
	Electrolyser	0.00	¢	0,00	×w.
	Oemineralizer	0,00	¢	0,000000	miol/s
	Precipitation collector	0.00	€	0,00	m <sup>1</sup>
	Methanation reactor	0,00	6	0,000000	mol/s
	Heat exchanger	0,00	¢	0,0000	kW
	Total for processes	0,00	¢		
	Dry biomess storage	0,00	¢	0,0000	kg .
	Wet biomass storage	0,00	¢	0.0000	kg
	Biochar storage	0,00	¢	0,0000	kg
	Water storage tank	0,00	ε.	6,0000	mol
Shoragen	Oxygen storage tank	0,00	¢	0,0000	mol
2	Hydrogen storage tank	0.00	€	0.0000	mol
	Carbon dioxide storage tank	0,00	¢	0,0000	mol
	Methane storage tank	0,00	¢	0,0000	form
	Total for storages	0,00	¢		1.
5.5	Electrical connection	0,00	¢	0,00	MW
88	Gas connection	0,00	¢	0,00	MW
wing over	Water connection	0,00	¢	0,00	m <sup>1</sup> /h
5 E	Total for connections	0,00	¢		
	Total Investment	0,00	€		

-	and the second	Price.	Amount
	Produced by REP	0,00 €	0,00: MW/h
Electrical energy	Consumed by IP	0,00 €	0,00 MWM
	Net consumption without investment	0,00 €	0,00 MWh
	Peak power without investment	0,00 €	0,00 kW
6	Consumed by P2D	0,00 €	0,00 MWP
8	Net consumption with investment	0,00 €	0,00 MWh
	Peak power with investment	0,00 €	0,00 kW
	Produced by REP	3 00.5	0,00 M/Wh
848	Produced IP	0,00 €	0,00 MWh
1 T	Net production without investment	0,00 €	0,00 MWh
	Consumed by P2G	0,00 €	0,00: MW/
	Net production with investment	0,00 €	0,00 MWh
	Produced by REP	0,00 €	0,00 MWh
8	Consumed by IP	0,00 €	D,00 MWh
Methane	Net consumption without investment	0,00 E	0,00 MWH
5	Produced by P2G	0,00 €	0,00 MWh
	Net consumption with investment	0,00 €	0,00 MWh
Water	Water consumed by P2G	0.00 €	0,00 m <sup>3</sup>
27	Dry biomass bought	0,00 €	0,00 1
though	Wet biomass bought	0,00 €	0,00(t
-	Siochar bought	0,00 €	0,00.1
4	Biocher sold	0,00 €.	0,00 t
Outputs	Hydrogen sold	0,00 €	0,00:1
0	CO2 emiliad	0,00 €	0,00 kg
	<b>Total operational cost without investment</b>	0,00 €	
	Total operational cost with investment	0,00 €	
	Savings with introduction of P2G	0,00 €	

15. Figure: Results for GF with high gas prices of methane and no subsidy

Source: Optimilization Tool v1.1

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

## 98



3.2 IP

The case study of industrial installations produced varying results based on the OT calculations, which are presented below.

	Element	Price	Size	the second s		Price	Amount
	Dry anaerobic digestor	0,00 €	0,000000 kg/s		Produced by REP	0,00 €	0,00 MW
	Wet anaerobic digestor	0,00 €	0.000000 kg/s	<b>b</b>	Consumed by IP	198 000 000,00 €	600 000,00 MW
	Dry biomass to biochar plant	0.00 €	0.000000 kg/1	ASiana	Net consumption without investment	198 000 000.00 €	600 000.00 MW
	Wet biomass to biochar plant	0,00 €	0,000000 kg/s	1	Peak power without investment	438 394,89 €	1 643 797,37 kW
	Biogas separator	0,00 €	0,000000 kg/s	Electrical	Consumed by P2G	0,00 €	0,00 MW
	Gasification + water gas shift plant	0,00 €	0.000000 kg/1	8	Net consumption with investment	198 000 000,00 €	600 000,00 MW
Propesses.	Combined heat and power (CHP)	0,00 €	0,000000 kg/s		Peak power with investment	438 394,89 €	1 643 797,37 kW
8	Carbon capture plant	0,00 €	0.000000 mol/s		Produced by REP	0,00 €	0,00 MW
1	Electrolyser	0,00 €	9,00 kW	153	Produced IP	0,00 €	676 000,00 MW
	Oemineralizer	0,00 €	0,000000 mal/s	Feet	Net production without investment	0,00,€	678 000,00 MW
	Precipitation collector	0,00 €	0,00 m <sup>3</sup>	1.5	Consumed by P2G	0,00 €	0,00 MW
	Methanation reactor	0,00 €	0.000000 mal/s		Net production with investment	0,00 €	676 000,00 MW
	Heat exchanger	0,00 €	0,0000 kW		Produced by REP	0,00,€	0,00 MW
	Total for processes	0,00 €	000000000000000000000000000000000000000	Methane	Consumed by IP	140 364 924,00 €	379 000,00 MW
	Dry biomass storage	0,00 €	0,0000 kg		Net consumption without investment	140 164 924,00 €	179 000,00 MW
	Wet biomass storage	0,00 €	0,0000 kg		Produced by P2G	0,00 €	0,00 MW
	Biochar storage	0,00 €	0,0000 kg		Net consumption with investment	140 364 924,00 €	379 000,00 MW
2	Water storage tank	0,00 €	0,0000 mal	Water	Water consumed by P2G	0,00 €	0,00 m <sup>4</sup>
Sourages	Oxygen storage tank	0,00 €.	10m 0000,0		Dry biomass bought	0,00,€	0,00 1
8	Hydrogen storage tank	0,00 €	0,0000 mol	inputs	Wet biomass booght	0,00 €	0,00 t
	Carbon dioxide storage tank	0,00 €	0,0000 mol	· · · ·	Biochar bought	0,00 €	0,00.1
	Methane storage tank	0,00 €.	0,0000 mol	- 2	Biochar sold	0,00,€	0,00 1
_	Total for storages	0,00 E	10 A 10 A 10 A	Outputs	Hydrogen sold	0,00 €	0,00 t
1.1	Electrical connection	0,00 €	0,00 MW	ő	CO2 emitted	0,00 €	0,00 kg
annet a	Gas connection	Ó,00 €.	0,00 MW		Total operational cost without investment	338 803 318,89 €	
1	Water connection	0,00 €	0,00 m <sup>1</sup> /h		Total operational cost with investment	338 803 318,89 €	
5 8	Total for connections	0,00 €			Savings with introduction of P2G	0,00 €	
	Total investment	0,00 €					
	Payoff period	n/a years	10				CHARGED TO THE

# 3.2.1 RESULTS WITH SUBSIDIES

16. Figure: Results for IP with normal gas prices of methane and 50% subsidy

Source: Optimilization Tool v1.1

In the first case, the calculation in the Optimilization Tool did not show a significant change, assuming normal gas prices and 50% subsidy. In that case, as it is shown in Fig. 16, investment payoff period of 20 years is not enough for any investment in P2G hub.



	Element	Price	Size
	Dry anaerobic digestor	81 633 371,39 €	7,774607 kg/s
	Wet anaerobic digestor	1 560 657,17 €	0,389067 kg/s
	Dry biomass to blochar plant	0,00 €	0.000000 kg/s
	Wet biomass to biochar plant	0,00 €	0,000000 kg/s
	Biogas separator	62 100 995,69 €	7,305999 kg/s
16	Gasification + water gas shift plant	281 762,51 €	0,563526 kg/s
Pro cesses	Combined heat and power (CHP)	0,00 €	0.000006 kg/s
100	Carloon capture plant	0,00 €	0,000000 mol/s
۰.	Electrolyser	180 005 955,47 €	144 004,76 kW
	Demineralizer	4 748 231,80 €	499,813874 mol/s
	Precipitation collector	1 000,00 €	1 000,00 m <sup>T</sup>
	Methanation reactor	19 236 830,30 €	118,380494 mol/
	Heat exchanger	1 419 229,50 €	28 384,5899 kW
	Total for processes	353 288 044,22 €	00000000000000000
	Dry biomass storage	0,00 €	0,0000 kg
	Wet biomass storage	0,00 €	0.0000 kg
	Biochar storage	0,00 €	0,0000 kg
	Water storage tank	0,00 €	0.0000 mol
Stanages	Oxygen storage tank	0,00 €	0.0000 mal
15	Hydrogen storage tank	0,00 €	0.0000 mai
	Carbon dicxide storage tank	0,00 €	0,0000 mpl
	Methane storage tank	0,00 €	0.0000 mol
	Total for storages	0,00 €	0.0 Style Cox
ΞĒ	Electrical connection	185 468,30 €	227,57 MW
88	tlas connection	0,00 €	0,00 MW
Interaction of the local data	Water connection	677,00 €	32,49 m <sup>1</sup> /h
3 5	Total for connections	186 145,30 €	
	Total investment	353 474 189,51 €	1
	Payoff period	20,00 years	

		Price	Amount
	Produced by REP	0,00 €	0,00 MWh
Electrical energy	Consumed by IP	196 000 000,00 €	600 000,00 M/Wh
	Net consumption without investment	198 000 000,00 €	600 000,00 MWh
	Peak power without investment	438-394,89 C	1 043 797,37 kW
6	Consumed by P2G	695 482 967,14 €	2 107 524, 14 MWh
ã.	Net consumption with investment	393 482 967,14 €	2 707 524,14 MWh
2.00	Peak power with investment	1 650 943,04 €	3 930 816,75 kW
	Produced by REP	0,00 €	0,00 MWH
420	Produced IP	0,00 €	678 000,00 MWh
Heart	Net production without investment	0.00 €	678.000,00 MWh
	Consumed by P2G	0,00 €	-227 253,95 MWh
	Net production with investment	0.00 €	905 253,95 MWh
	Produced by REP	0,00 €	0,00 MWh
8	Consumed by IP	534 524 924,00 €	379.000,00 MWh
Viethane	Net consumption without investment	534 524 924,00 €	379 000,00 MWh
2	Produced by P2G	1969 618 262,11 €	1 926 047,13 MWh
	Net consumption with investment	-1582044506,20€	-1 547 047,13 MWh
later	Water consumed by P2G	303 337,88 €	284 106,06 m <sup>3</sup>
10	Dry biomass bought	199 595 960,00 Æ	245 180,00 <sup>(</sup> 1
syndu	Wet biomass bought	21.605.800,00 €	12 175,00 1
-	Biochar bought	0,00 €	0,00 1
4	Biochar sold	11,00/€	0,00 t
Durputs	Hydrogen sold	0,00 4	0,00 T
6	CO2 emitted	0,00 €	0.00 kg
	Total operational cost without investment	712 963 318,89 €	10.000
	Total operational cost with investment	-265 339 498,14 €	
	Savings with introduction of P2G	998 302 817,03 C	

\_\_\_\_\_

17. Figure: Results for IP with moderate gas prices of methane and 50% subsidy

Source: Optimilization Tool v1.1



# In the next case, a P2G hub investment can be made based on the calculation. The result shows that a large economic saving can be achieved by setting up a P2G hub if gas prices increase by a factor of five.

	Element	Price	Sine			Price	Amount
	Dry anaerobic digestor	90164038,21 €	8,587051 kg/s		Produced by REP	0,00 €	0,00 MW
	Wet anaerobic digestor	11 330 703,77 €	1,133670 kg/s	X	Consumed by IP	198 000 000,00 €	600 000,00 MW
	Dry biomess to biochar plant	0,00 €	0,000000 kg/s	19	Net consumption without investment	198 000 000,00 €	600 000,00 MW
	Wet biomass to biochar plant	0,00 €	0,000000 kg/s	ŝ	Peak power without investment	438 394,89 €	1 043 797,37 kW
	Bioges separator	7 699 019,91 €	0,905767 kg/e	8	Consumed by P2G	51 687 775,91 €	33 364,98 MW
	Gasification + water gas shift plant	4 296 257,92 €	8,592516 kg/s		Net consumption with investment	208 350 444,17 €	631 364,98 MW
Processes	Combined heat and power (CHP)	30 223 488,52 €	8,635282 kg/s	1 1 1 1 1	Peak power with investment	2 801 365,53 €	0.669.917,93 kW
	Carbon capture plant	12 793 011,01 €	319,825275 mol/s		Produced by REP	0,00 €	6,00 MW
	Electrolyser	413 478 431,98 €	330 782,75 kW		Produced IP	0,00 C	678 000,00 MV
	Demineralizer	13 142 888,33 €	1 383,461930 mol/s		Net production without investment	0,00 €.	678.000,00 MW
	Precipitation collector	1 000,00 €	1 000,00 m <sup>3</sup>		Consumed by P2G	2 680,20 €	443 369,81 MV
	Methanation reactor	49 299 050,11 €	303,378770 mol/s		Net production with investment	0,00 €	1 121 109,81 MV
	Heat exchanger	3 652 724,47 €	73 054,4894 kW		Produced by REP	0,00 €	0,00 MW
	Total for processes	636 086 614,23 €	110000000000000000000000000000000000000	Methane	Consumed by IP	271 035 600,00 €	100 000,00 MW
	Dry biomass storage	221 481 059,74 €	44 296 211,5483 kg		Net consumption without investment	271 035 600,00 €	100 000,00 MW
	Wet biomass storage	11 227 077,40 €	4 490 830,9583 kg		Produced by P2G	364 964 082,13 €	178 358,04 MW
	Biochar storage	52 089 814,23 €	6 945 30IL5644 kg		Net consumption with investment	-160 119 672,69 €	-70.358,04 MW
÷.	Water storage tank	0,00 €	0,0000 mol	Water	Water consumed by P2G	102 693,22 €	78 994,79 m <sup>1</sup>
Storages	Oxygen storage tank	0,00 €	0.0000 mol	22	Dry biomass bought	321 866 334,90 €	197.487,45 t
8.	Hydrogen storage tank	0,00 €	0,0000 mol	the strategy of the strategy o	Wet biomass bought	21 605 800,00 €	12 175,00 t
	Carbon dioxide storage tank	33 159 484,55 €	82 895 711.3641 mol		Biochar bought	0,00 €	6,00 t
	Methane storage tank	45 429 462,30 €	151 431 541,0056 mol	臣	fliochar sold	0,00 €.	0,00 1
	Total for storages	363 386 898,22 €		outputs	Hydrogen cold	100 891,70,€	13,45 t
	Electrical connection	524 023,08 €	643,70 MW	ő	CO2 emitted	310 548 888,14 €	6 210 977 722,81 kg
terres (	Gas connection	0,00 €	0,00 MW	80.°	Total operational cost without investment	469 473 994,89 €	The state of the second s
uning	Water connection	1.873,89 €	\$9,92 m <sup>8</sup> /h		Total operational cost with investment	83 737 187,30 €	
- 1	Total for connections	526-487,55 €			Savings with introduction of P2G	385 736 807,59 €	
	Total investment	1 000 000 000,00 €					
	Payoff period	20,00 years					diama and

18. Figure: Results for IP with high gas prices of methane and 50% subsidy

# Source: Optimilization Tool v1.1

If we increase the price of natural gas by a factor of ten in the parameters of the calculation, even the pre-production of hydrogen becomes an economically viable option. The investment costs of the resulting plant are lower than those of the previous calculation.



# 3.2.2 RESULTS WITHOUT SUBSIDIES

	Element	Price	Size	A Second Second		Price	Amount
	Dry anaerobic digestor	155 062 764 15 €	7,383941/kg/s		Produced by REP.	0,00 €	0,00 MW
	Wet anaerobic digestor	31 360 493,19 €	1,568025 kg/s	2	Consumed by IP	198 000 000,00 €	600 000,00 MW
	Dry biomass to biochar plant	0,00 €	0,000000 kg/s	ē	Net consumption without investment	198 000 000,00 €	600-000,00 MW
	Wet biomass to biochar plant	0,09,€	0,000000 kg/s	ettio	Peak power without investment	438 394,89 €	1 043 797,37 kW
	Biogas separator	16 088 425,10 €	2,122849 kg/k		Consumed by P2G	14 664 471,91 €	19 211,52 MW
-11	Gasification + water gas shift plant	1 325 876,40 €	1,325876 kg/s		Net consumption with investment	204 339 933,02 €	619 211,92 MW
1	Combined heat and power (CHP)	55 799 767,34 €	7,899967 kg/s	110305	Peak power with investment	814 631,71 €	1 939 598.11 kW
di l	Carbon capture plant	0,00/4	0,000000 mol/s		Produced by REP	0,00 €	0,00 MW
1	Electrolyser	107 836 578,82 €	43 134,63 kW	12.000	Produced IP	0,00;€	678 000,00 MW
	Demineralizer	3 255 780,01 €	171.356843 mol/s	Hoat	Net production without investment	0,00 €	678 000,00 MW
	Precipitation collector	2 000,00 €	1.000,00 m <sup>2</sup>		Consumed by P2G	0,00 €	-95 082,07 MW
	Methanation reactor	12 362 136,19 €	38,652727 mol/s		Net production with investment	0,00:€	773 082,07 MW
	Heat exchanger	6 683 371,88 €	66 833,7188 kW		Produced by REP	0,00 €	0,00 MW
	Total for processes	409 477 193,08 €		Methane	Consumed by IP	37 035 600,00 €	100 000,00 MW
	Dry biomass storage	290 189 812,35 €	29 018 981,2361 kg		Net consumption without investment	37 035 000.00 €	100-000,00 MW
	Wet biomais storage	14 576 932,50 €	2 915 386,4998 kg		Produced by FZG	17581 095,61 €	86 301,37 MW
	Biochar storage	26 440 796,06 €	1 762 719,7371 kg		Net consumption with investment	5 073 369,86 €	13 698,63 MW
:	Water storage tank	0,00.€	0.0000 mal	Water	Water consumed by P2G	23 531,78 €	18 101,37 m <sup>8</sup>
1	Oxygen storage tank	0,00 €	0,0000 mel	2	Dry biomass bought	67.469.077,46.€	41 537,92 1
200	Hydrogen storage tank	0,00 €	0,0000 mol	studiu	Wet biomass bought	20 870 052,71 €	11 836,57 t
	Carbon dioxide storage tank	0,00 €	0.0000 mal	-	Blochar bought	0,00 €	0,00 t
	Methane storage tank	29 205 717,59 €	48 676 195,9803 mal	원	Biochar sold	0,00 €	0,00 t
_	Total for storages	360 413 258,50 4		Outputs	Hydrogen sold	97 500,00 €	13,00 t
£ π.	Electrical connection	271 165,96 €	141.82 MW	6	CO2 emitted	68 255 712,83.€	1 365 114 256,60 kg
1	Gas connection	0,00.€	0,00 MW	100	Total operational cost without investment	235 473 994,89 €	
i in	Water connection	464,29 €	11,14 m <sup>1</sup> /h		Total operational cost with investment	230 237 383,21 €	
5 \$	Total for connections	231 630,16 €			Savings with introduction of P2G	5 236 611,69 €	
	Total investment	770 122 081,75 €					
	Payoff period	20,00 years					

19. Figure: Results for IP with normal gas prices of methane and no subsidy

## Source: Optimilization Tool v1.1

For the cases without aid, the first calculation was run with a normal gas price, for which the above result was obtained. The result shows that the first version of the unsubsidised cases already includes the production of hydrogen within the resulting P2G hub.



11.20	Element	Price		Size	_
	Dry anaerobic digestor	174 431 496,58	€	8,306262	kg/s
	Wet anaerobic digestor	10 498 085,46	6	0,524904	kg/s
	Dry biomass to blochar plant.	0.00	¢	0,000000	kg/s
	Wet biomass to biochar plant	0,00	£	0,000000	kg/s
	Biogas separator	9 266 894,85	e	6,545311	kg/s
	Gasification + water gas shift plant	64 234,22	6	0,064254	kg/s
PECENSES	Combined heat and power (CHP)	55 268 912,90	€	7,895559	kg/s
1	Carbon capture plant	0,00	€	0,000000	mol/s
	Electrolyser	26 368 171,71	€	10 746,47	KW .
	Demmeraluer	709 705,53	€	37,352922	mol/s
	Precipitation collector	0,00	€	0,00	m <sup>1</sup>
	Methanation reactor	2,872 636,46	¢	4,838681	mol/s
	Heat exchanger	6 679 642,90	€	66 796,4290	₩.
	Total for processes	286 657 780,59	¢		
	Dry biomass storage	33 033 821,39	€	3 303 362,1389	kg
	Wet biomass storage	3 294 520,55	€	638 904,1096	Rg
	Biochar storage	3 150 231,45	¢	210 015,4299	kg
÷	Water storage tank	0,00	¢	0,0000	form
Sounded	Oxygen storage tank	0,00	¢	0,0000	mal
8	Hydrogen storage tank	0,00	£	0,0000	mol
	Carbon dioxide storage tank	0,00	€	0,0000	mol
	Methane storage tank	86 708 050,39	£	144 513 417,3140	mal
	Total for storages	126 186 623,77	€	101001-001-000	
1 2	Electrical connection	138 483,40	£	84,96	ŃW
1 I	Gas connection	0.00	€	0.00	NW
solargement.	Water connection	101,19	€	2,43	m³/h
2.8	Total for connections	138 584,59	£		
	Total investment	412 982 988,95	€		
	Payoff period	20,00	years		

×4193		Price	Amount
Electrical energy	Produced by REP	0,00 €	0,00 MWh
	Consumed by IP	198 000 000,00 €	600 000,00 MWh
	Net consumption without investment	198 000 000.00 €	600 000.00 MWh
	Peak power without investment	438 394,89 €	1 043 797,37 kW
	Consumed by P2G	31 364 900,58 €	98 170,57 MWh
	Net consumption with investment	228 748 268,07 €	693 176,57 MWh
	Peak power with investment	498 714,07 €	1 187 414.46 kW
	Produced by REP	0,00 €	0,00 MWh
	Produced IP	0.00 €	678 000,00 MWh
3	Net production without investment	0,00 E	675 000,00 MWh
	Consumed by P2G	0,00.€	-16 893,18 MWh
	Net production with investment	0.00 €	094 £93.18 MWh
1	Produced by REP	0,00.€	0,00 MWh
8	Consumed by IP	141 035 600,60 €	100.000.00 MWh
Methane	Net consumption without investment	141 035 600,00 €	100 000,00 MW/h
ž.	Produced by P2G	92 456 239,89 €	.90 410,96 MWh
	Net consumption with investment	13 523 361,64 €	9 589,04 MWh
ater	Water consumed by P2G	17 306,01 €	13 696,93 m <sup>3</sup>
	Dry biomass bought	17 032 253,04 €	11 144,41 1
tindu.	Wet biomass bought	6 833 083,16 €	4 367,65 t
-	Biochar brught	0,00 €	0,00 t
ε.	Biochar sold	0,00,€	0,00 t
Outputs	Hydrogen sold	0,00 €	0,00 t
ő –	CO2 emitted	5 053 157,75 4	101 063 155,02 kg
	Total operational cost without investment	339 473 994,89 €	1000000
	Total operational cost with investment	261 600 928,25 4	
	Savings with introduction of P2G	77 873 066.65 €	

## 2 1

#### 20. Figure: Results for IP with moderate prices of methane and no subsidy

#### Source: Optimilization Tool v1.1

	Element	Price		Size	
	Dry anaerobic digestor	147 378 974,22	£	7,018046	iig/s
	Wet anaemble digestor	33 636 840,60	€	1,961842	hg/s
	Dry biomass to biochar plant	0,00	¢	0,000000	kg/s
	Wet biomass to biochar plant	0.00	£	0,000000	kg/s
	Bioges separator	48 846 228,65	€	2,873308	kg/s
	Gasification + water gas shift plant	731 031,85	€	0,791032	kg/s
1	Combined heat and power (CHP)	35 312 007,63	€	7,901715	kg/s
Precesses	Carbon capture plant	0.00	€	0,000000	init/s
	Electrolyser	198 985 040,10	€	79 594,02	kW
	Demineralitier	4 653 188,63	€	244,904665	mol/s
	Precipitation collector	2 000,00	¢	1 000,00	m
	Methanation reactor	19 970 292,60	6	61,447054	mol/s
	Heat exchanger	6 664 851,21	¢	86 848,8121	itW/
	Total for processes	522 200 455,51	€	18:22:000	940-
	Dry biomass storage	24 254 968,33	€	2.425.436.8329	kg
	Wet bromass storage	5 848 561,12	€	1 169 712,2249	4
	Biochar storage	6 757 467,63	€	450 497,8418	kg -
τ.	Water storage tank	0,00	6	0,0000	mal
Saragel	Oxygen storage tank	0,00	¢	0.0000	mal
8	Hydrogen storage tank	0.00	¢	0,0000	mal
	Carbon dioxide storage tank	16416012,46	6	20 520 015,5745	mol
	Methane storage tank	264 862 546,30	¢	441 458 243,8318	mul
	Total for storages	318 139 355,84	£		
8.8	Electrical connection	319 901,12	£	196,26	NW
convertions relargement	Gas connection	D,00	¢	0,00	MW
convertions relargement	Water connection	652,64	€	15,92	m <sup>1</sup> /h
0.1	Total for connections	320 564,56	€		
	Total Investment	840 000 375,91	¢		
	Payoff period	20,00	years		

	Concernation in the life	Price	Amount
2.0	Produced by REP	0.00 €	0.00 MWH
25	Consumed by @	196 000 000.00 K	600 000.00 MWH
2	Net consumption without investment	198 000 000.00 €	600 000,00 MW/
Dectrical emergy	Peak power without investment	438.394,89 €	1 043 797.37 kW
	Consumed by P2G	52 167 832,00 €	136 215,76 MWH
	Net consumption with investment	249 551 199,57 €	756 215, 76 MW/
	Peak power with investment	818 628,45 €	1 949 115.30 kW
	Produced by REP	0.00 €	0,00 MWH
22	Produced IP	0,00.€	678 000,00 MWh
1	Net production without investment	0.00 C	678 000,00 MW/
	Consumed by P2G	10 053,85 €	-22 664,45 MWh
	Net production with investment	0.00 €	701 664,45 MWP
	Produced by REP	11.00 €	0.00 MW/
Ξ.	Consumed by @	271 035 600,00 €	100 000,00 MWH
Mechane	Net consumption without investment	271 035 600.00 €	100 000.00 MWP
÷.	Produced by P20	302 844 125,98 €	148 000,00 MWM
	Net consumption with investment	-98 219 716,54 €	-4E 000,00 MW/h
ister.	Water consumed by P2G	28 700.83 €	22.077,56 m <sup>3</sup>
22	Dry biomass bought	26 501 369,36 K	16 493,15 1
thurts.	Wet biomass bought	11 545 974,71 €	6 968,38 ±
=	Biochar bought	0,00 €	0,00 t
4	Biocher sold	0,00 €	0,00 1
struting	Hydrogen sold	22 500,00 €	3,00 t
0	CO2 emitted	5 057 097,64 €	101 141 956.82 kg
	Total operational cmt without investment	469 473 994,89 €	
	Total operational cost with investment	185 146 459,02 ¥	
	Savings with introduction of P2G	284 827 535.88 €	

diam'r an the

21. Figure: Results for IP with high gas prices of methane and no subsidy

Source: Optimilization Tool v1.1

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



The introduction of P2G at high gas prices (10x) in an industrial plant is calculated to have a huge savings potential. In this case, the production of hydrogen will reappear, albeit in small quantities. The return on investment here is 20 years, as in the other Industrial Plant calculations.



# 3.3 REP

Calculations with renewable energy sources have not led to significant results. The results suggest that an investment in a P2G hub installed next to a solar PV renewable energy source may represent a cost saving, but such an investment, like a greenfield investment, is also not cost-effective in any of the cases studied.

# 3.3.1 RESULTS WITH SUBSIDIES

	Element	Price	Size			Price	Amount
	Dry anaerobic digestor	0,00 €	0,000000 kg/s		Produced by REP	2 522 362,20,€	10 678,00 MWR
-	Wet anaerobic digestor	0,00 €	0.000000 kg/s	20	Consumed by IP	0.00 C	0,00 MWH
	Dry biomass to biocher plant	0,00 €	0,000000 kg/s	dros e	Net consumption without investment	-2 522 362,20 €	-10 678,00 MWh
	Wet biomass to biochar plant	0,00 €	0,000000 kg/s		Peak power without investment	0,00,€	0,00 KW
	Biogas separator	0,00 €	0.000000 kg/s		Consumed by P2G	0.00 C	0,00 MWH
	dissification + water gas shift plant	0,00 €	0,000000 kg/s		Net consumption with investment	0,00 €	-10 678,00 MWP
	Combined heat and power (CHP)	0,00 €	0,000000 kg/s	10000	Peak power with investment	0,00 E	0,00 KW
Proces	Carbon capture plant	0.00 E	0,000000 mol/s		Produced by REP	0.00 C	0,00 MWF
8	Electrolyser	0,00 €.	0,00 kW		Produced IP	0.00 €	0,00 MWH
	Demineralizer	0,00 €	0,000000 mol/s		Net production without investment	0,00 €	0,00 MWI
	Precipitation collector	0,00 €	0.00 m <sup>4</sup>	1.0	Consumed by P2G	0.00 C	0,00 MW
	Methanation reactor	0,00 €	a,000000 mol/s	-	Net production with investment	0.00 €	0.00 MWH
	Heat exchanger	0,00 €	0,0000 kW		Produced by REP	0,00 €	0,00 MWI
	Total for processes	0,00 €		Methane	Consumed by IP	0,00 €	0,00 MW1
	Dry biomass storage	0,00 €	0.0000 kg		Net consumption without investment	0.00 €	0.00 MW
	Wet biomass storage	0,00 €	0,0000 kg		Produced by P2G	0,00 €	0,00 MW/
	Biochar storage	0,00 €	0,0000 kg		Net consumption with investment	0,00 €	0,00 MW1
÷.	Water storage tank	0,00 €	lom 0000.0	Water	Water consumed by P2G	0.00 €	0,00 m <sup>8</sup>
Sharager	Oxygen storage tank	0,00 €	0,0000 mel		Dry biomass bought	0.00 €	0,00 1
4	Hydrogen storage tank	0,00 €	0,0000 mol	studie	Wet biomass bought	0,00 €	0,00 t
	Carbon dioxide storage tank	0,00 €	0.0000 mol	- 24	Biochar bought	0,00 €	0,00 t
	Methane storage tank	0,00 €	0,0000 mei	12	Biochar sold	0.00 €	0,00 t
	Total for storages	0,00 €	in the second second	Shutho	Hydrogen sold	0,00 €	0,00 t
e:E	Electrical connection	0,00 €	-0,00 MW	6	CO2 emitted	0.00 €	0,00 kg
en long envert	Gas connection	0,00 €	0,00 MW		Total operational cost without investment	-2 522 362,20 €	
line i	Water connection	0,00 €	0,00 m <sup>3</sup> /h		Total operational cost with investment	0,00 C	
2.8	Total for connections	0,00 €			Savings with introduction of P2G	-2 522 362,20 €	
	Total investment	0,00 €					
	Payoff period	n/a years					1. A. C.

22. Figure: Results for REP with real gas prices of methane and 50% subsidy

Source: Optimilization Tool v1.1



	Element	Price	Size
	Dry anaerobic digestor	0,00.€	0,000000 kg/s
	Wet anaerobic digestor	0,00 €	0,000000 kg/s
	Dry biomass to biochar plant	0,00 €	0,000000 kg/s
	Wet blomass to blochar plant	0,00 €	0,000000 kg/s
	Biogas separator	0,00,€	0,000000 kg/s
	Gasification + water gas shift plant	0,00 €	0,000000 kg/s
THORSES	Combined heat and power (CHP)	0,00 €	0,000000 kg/s
2	Carbon capture plant	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>
	Methenation reactor	0,00 €	0,000000 mol/s
	Heat exchanger	0,00 €	0,0000 kW
	Total for processes	0,00 €	
	Dry biomass storage	0,00 €	0,0000 kg
	Wet biomass storage	0,00 €	0.0000 kg
	Biochar storage	0,00 €	0,0000 kg
1	Water storage tank	0,00 €	form 0000,0
Souges	Oxygen storage tank	0,00 €	0,0000 mot
8	Hydrogen storage tank	0,00 €	0,0000 mol
	Carbon dioxide storage tank	0,00 €	0.0000 moi
	Methane storage tank.	0,00 €	0,0000 mol
	Total for storages	0,00 €	
E.E	Electrical connection	0,00 €	0.00 MW
on rector re	Gas connection	0,00 €	0,00 MW
unrecters witargament	Water connection	0,00 €	0,00 m²/h
5×8	Total for connections	0,00 E	10.000
	Total investment	0,00 €	
	Payoff period	n/a years	

Operational	costs for selected period

10		Price	Amount	112
	Produced by REP	2.521.653,54 €	10 675,00	MWb;
Bothtal megy	Consumed by IP	0,00 €	0,00	MWh
	Net consumption without investment	-2 521 653,54 €	-10 673,00	MWh
	Peak power without investment	0,00 €	0,00	kW
6	Consumed by P2G	0,00 K	0,00	MW7
ů.	Net consumption with investment	0,00 €	-10 675,00	MWh
	Peak power with investment	0,00 €	0,00	kW.
	Produced by REP	0,00 €	0,00	MWN
125	Produced IP	0,00 €	0,00	MWh
Here a	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
8	Consumed by IP	0,00 €	0,00	MWh
Methane	Net consumption without investment	0,00 €	0,00	MWh
×.	Produced by P26	0,00 €	0,00	MWh
	Net consumption with investment	0,00 €	0,00	MWh
Nater	Water consumed by P2G	0,00 €	0,00	m <sup>e</sup>
M	Dry biomass bought	0,00 €	0,00	t
inputs	Wet biomass bought	0,00 €	0,00	t
-	Riocher bought	0,00 €	0,00	t
8	Biochar sold	0,00 €	0,00	1
Studying	Hydrogen sold	0,00 €	6,00	1
ő	CO2 emitted	0,00 €	0,00	kg
	Total operational cost without investment	-2 521 651,54 €	11	
	Total operational cost with investment	0,00 C		
	Savings with introduction of P2G	-2 521 653,54 €	1.0	

#### 23. Figure: Results for REP with moderate gas prices of methane and 50% subsidy

1.1.1	Itment specifications	Price		Size	
	Dry anaerobic digestor	0,00	¢	0,000000	kg/s
	Wet anaerobic digestor	0,05	€	0,000000	
	Dry biomass to biochar plant	0.00	€	0.000000	kg/s
	Wet biomass to biochar plant	0,00	€	0,000000	kg/s
	Biogas separator	0,05	€	0,000000	hg/s
a i	Gasification + water gas shift plant	0.00	€	0.000000	kg/s
Armonages	Combined heat and power (CHP)	0,05	¢	0,000000	kg/s
8	Carbon capture plant	0,05	€	0.000000	mol/s
•	Electrolyser	0,00	€	0,00	kW
	Demineralizer	0,05	¢	0,000000	mel/s
	Precipitation collector	0,06	€	6,00	m².
	Methanation reactor	0.00	€	0.000000	mol/s
	Heat exchanger	0,05	¢	0,0000	kW/
	Total for processes	0,00	€		
	Dry biomass storage	0.00	•	0,0000	kg
	Wet biomass storage	0,05	€	0,0000	kg
	Biochar storage	0,06	€	0,0000	kg .
2	Water storage tank	0.00	€	0,0000	mol
Somages	Oxygen storage tank	0,05	£	0,0000	not
8	Hydrogen storage tank	0,06	€	0,0000	mol
	Carbon dioxide storage tank	0.00	€	0,0000	mał
	Methane storage tank	0,05	€ .	0,0000	inol
	Total for storages	0,00	€		
Ŧ	Electrical connection	0.00	¢	0,00	NW
ŝ	Gas connection	0,05	£	0,00	MW
rilagened	Water connection	0,00	€	0.00	m <sup>3</sup> /h
-	Total for connections	0,00	•		
	Total investment	0,00	6		

## Source: Optimilization Tool v1.1

		Price	11	Amount	
	Produced by REP	2 521 653,54	€	10675,00	Midth
1	Consumed by IP	0,00	¢	0,00	MWb
Electrical energy	Net consumption without investment	-2 521 653,54	€.	-10 675.00	Mith
÷.	Peak power without investment	0,00	€	0,00	kW
6	Consumed by P2G	0,00	£	0,00	MWh
đ	Net consumption with investment	0,00	€	-10 675.00	Mith
1.00	Peak power with investment	0,00	€	0,00	kW -
	Produced by REP	0,00	£.	0,00	MWh
22	Produced IP	0,00	€	0,00	MWh
10 A	Net production without investment	0,00	€	0,00	MWh
	Consumed by P2G	0,00	¢.	0,00	MWb
	Net production with investment	0,00	•	0,00	Mith
	Produced by REP	0,00	€	0,00	MWh
8	Consumed by IP	0,00	€	0,00	MWb
Machano	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	MWb
Vater	Water consumed by P2G	0,00	¢	0,00	m²
8	Ory biomass bought	0,00	€	0,00	t
sandu	Wet biomass bought	0,00	¢	0,00	t.
2	Riochar bought	0,00	¢	0,00	t
2	Biochar sold	0,00	€	0,00	t
grupurs	Hydrogen sold	0,00	£.	0,00	t
ő	C02 emitted	0,00	¢	0,00	kg
	Total operational cost without investment	-2 521 653,54	€	12.35	
	Total operational cost with investment	0,00	¢		
	Savings with introduction of P2G	-2 521 651,54	¢		

#### 24. Figure: Results for REP with high gas prices of methane and 50% subsidy

Source: Optimilization Tool v1.1

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



# 3.3.2 RESULTS WITHOUT SUBSIDIES

	Element	Price	Size	a the factor	A CONTRACTOR OF	Price	Amount
	Bry anaerobic digestor	0,00 €	0,000000 kg/s		Produced by REP.	2 521 653.54 €	10 675.00 MWR
	Wet anaerobic digestor	0,00 €	0,000000 kg/s	2	Consumed by IP	0,00 €	0,00 MW
	Dry biomass to biochar plant	0.00 K	0,000000 kg/s	Albua	Net consumption without investment	-2 521 653,54 €	-10 675,00 MW/
	Wet blomass to blochar plant	0.00 €	0,000000 kg/s	10	Peak power without investment	0,00 €	0,00 kW
	Biogas separator	0,00 <	0,000000 kg/s	Bethoal	Consumed by P2G	0,00 €	0,00 MW
	Gasification + water gas shift plant	0,00 €	0,000000 kg/s	ň	Net consumption with investment	0,00 €.	-10 675,00 MW/
ī.	Combined heat and power (CHP)	0.00 €	0,000000 kg/s	100,000	Peak power with investment	0,00 €	0,00 kW
Da l	Carbon capture plant	0,00 <	0,000000 mol/s		Produced by REP	0,00 €	0,00 MWP
•	Electrolyser	0,00 €	0.00 kW	112214	Produced IP	0,00 €.	0,00 MW/
	Demineralizer	0.00 €	s\jom 000000,0	·	Net production without investment	0,00 €	0.00 MWP
	Precipitation collector	0,00 €	0,00 m <sup>2</sup>		Consumed by P2G	0,00 €	0,00 MW
	Methanation reactor	0,00 €	0,000000 mol/s		Net production with investment	0,00 €	0,00 MW/
	Heat exchanger	0.00 €	0,0000 kw		Produced by REP	0,00 €	0.00 MW
	Total for processes	0,00 €		E	Consumed by IP	0,00 €	0,00 MW/
	Dry biomass storage	0,00 €	0.0000 kg	Mechane	Net consumption without investment	0,00 €	0,00 MW/
	Wet biomass storage	0,00 €	0,0000 kg		Produced by P2G	0,00 €	0.00 MWP
	Biochar storage	0,00 €	0,0000 kg		Net consumption with investment	0,00 €	0,00 MW
1	Water storage tank	0,00 €	0.0000 mol	Water	Water consumed by P2G	0,00,€	0,00 m <sup>8</sup>
1	Oxygen storage Tank	0,00 €	0,0000 mol		Dry biomass bought	0,00 €	0,00,1
8	Hydrogen storage tank	0,00 €	0,0000 mol	puts	Wet biomass bought	0,00 €	0,00 t
	Carbon dioxide storage tank	0,00 €	0.0000 mol	H.,	Blochar bought	0,00 €	0,00 t
	Methane storage tank.	0,00 €	0,0000 mol	£	Biochar sold	0,00 €	0.00 1
	Total for storages	0,00 €		Outputs	Hydrogen sold	0,00 €	0,00/t
E	Electrical connection	0.00 €	0.00 MW	6	CO2 emitted	0,00.€	0,00 kg
ŝ	Gas connection	0,00 €	0.00 MW		Total operational cost without investment	-2 521 653,54 €	AND ICC
1	Water connection	0,00 €	0.00 m <sup>1</sup> /h		Total operational cost with investment	0,00 €	
erlagene	Total for connections	0,00 K			Savings with introduction of P2G	-2 521 653,54 €	
	Total investment	0,00 €					
	Payoff period	n/a yean					. Phone second

25. Figure: Results for REP with real gas prices of methane and no subsidy

Source: Optimilization Tool v1.1



	Element	Price	5	ize.
	Dry anaerobic digestor	0,00	¢	0,000000 kg/s
	Wet anaerobic digestor	0,00	£	0,000000 kg/s
	Dry biomass to blochar plant	0.00	¢	0,000000 kg/s
	Wet biomass to biochar plant	0,00	e	0,000000 kg/s
	Biogas separator	0,00	£	0,000000 kg/s
	Gasification + water gas shift plant	0,00	¢	0,000000 kg/s
1	Combined heat and power (CHP)	0,00	e	0,000000 kg/s
hooese	Carbon capture plant	0,00	¢	0,000000 mol/s
-	Electrolyser	0,00	¢	0.00 kW
	Demineralizer	0,00	e	0,000000 mol/s
	Precipitation collector	0,00	¢	0,00 m <sup>1</sup>
	Methanation reactor	0,00	¢	0,000000 mol/s
	Heat exchanger	0,00	e	0,0000 kW
	Total for processes	0,00	¢	
	Dry biomass storage	0,00	¢	0,0000 kg
	Wet biomass storage	0,00	e	0,0000 kg
	Biochar storage	0,00	¢	0,0000 kg
2	Water storage tank	0,00	€	0,0000 mol
Stolages	Oxygen storage tank	0,00	¢	0,0000 mol
8	Hydrogen storage tank	0,00	¢	form 0000,0
	Carbon dioxide storage tank	0,00	6	0,0000 mol
	Methane storage tank	0,00	¢	0,0000 mol
	Total for storages	0,00	¢	
8.8	Electrical connection	0,00	6	0.00 MW
	Gas connection	0,00	£	0,00 MW
Connections relations	Water connection	0,00	6	0.00 m3/h
5 - E	Total for connections	0,00	٢.	
	Total investment	0,00	٤	
	Payoff period	n/a	years	

### Operational costs for selected period

	tionine course for selected period	Price	Amount	
_	which has a first which we want to			Taxan et
Electrical energy	Produced by REP	2 521 653,54 6		10000
	Consumed by IP	0,00 €		MWh
	Net consumption without investment	-2.521.653,54.6		
	Peak power without investment	0,00 4	<u>1717</u>	k/w
	Consumed by P2G	0,00 €	0.00	MWh
÷.	Net consumption with investment	0,00 4	-10.675.00	MWh
	Peak power with investment	0,00 6	0,00	kW.
	Produced by REP	0,00	0,00	MWh
	Produced IP	0,00 €	0.00	MWh
Heat	Net production without investment	0,00 6	0,00	MM
	Consumed by P2G	0,00 €	0,00	MM
	Net production with investment	0,00 4	0.00	MWh
	Produced by REP	0,00 6	0,00	MWh
문	Consumed by IP	0,00 €	0,00	MWh
Methane	Net consumption without investment	0,00 €	0.00	MWh
1	Produced by P2G	0,00 6	0,00	MWh
	Net consumption with investment	0,00 €	0,00	MM
Water	Water consumed by P2G	0,00 4	0.00	m
. 11	Dry biomass bought	0,00 6	0,00	t
input:	Wet biomass bought	0,00 €	0,00	t
=	Biochar bought	0,00 4	0.00	1
4	Biochar sold	0,00 6	E 0,00	t
outputs	Hydrogen sold	0,00 €	0,00	t
ő	CO2 envited	0,00 4	0.00	kg
	Total operational cost without investment	-2 521 653,54 6	L	
	Total operational cost with Investment	0,00 6	1	
	Savings with introduction of P2G	-2 521 651,54 6	r	

- Hereiter Ber

#### 26. Figure: Results for REP with moderate gas prices of methane and no subsidy

	Element	Price	Size			Price	Amount
	Dry anaerobic digestor	0,00 €	0.000000 kg/s		Produced by REP	2 571 653,54 €	10 675,00 MWh
	Wet anaerobic digestor	0,00 €	0.000000 kg/s	5	Consumed by IP	0,00 €	0,00 MWb
	Dry biomass to blochar plant	0,00 K	0,000000 kg/s	100	Net consumption without investment	-2.521.651,54 €	-10 675,00 MWh
	Wet biomess to biocher plant	0,00(€	0.000000 kg/s		Peak power without investment	0,00 €	8,00 kW
	Biogen separator	0,00 €	0.000000 kg/s	strical	Consumed by P2G	0,00 €	0,00 MWh
÷.	Gasification + water gas shift plant	0,00 €	0,000000 kg/s		Net consumption with investment	0,00 €	-10 075,00 MWh
Presenter	Combined heat and power (CHP)	0,00 €	0.000000 kg/s		Peak power with investment	0.00 E	0,00 kW
	Carbon capture plant	0,00 €	0.000000 mol/s		Produced by REP	0,00 K	8,00 MWh
	Electrolyue	0,00 €	0,00 kW	1 12	Produced IP	0,00 €	0,00 MWh
	Demineralizer	0,00 €	0,000000 mai/s		Net production without investment	0,00 €	0,00 MWh
	Precipitation collector	0,00 €	0,00 m <sup>2</sup>		Consumed by P2G	0,00 E	0,00 MWh
	Methanation reactor	0,00 €	0.000000 mal/s		Net production with investment	0,00 €	0,00 MWh
	Heat exchanger	0,00 €	0,0000 WW		Produced by REP	0,00 €	0,00 MWh
	Total for processes	0,00 €		ž.	Consumed by IP	0,00 C	0,00 MWh
	Dry biomuss storage	0,00 €	0,0000 kg	Methane	Net consumption without investment	0,00 C	0,00 MWh
	Wet biomasi storage	0,00 €	0,0000 kg	Ň	Produced by P2G	0,00 E	8,00 MWh
	Biother storage	0,00 €	0,0000 kg		Net consumption with investment	0,00 E	0,00 MWh
12	Water storage tank	0,00 €	0,0000 mail	Water	Water consumed by P2G	0,00 €	0,00 m <sup>8</sup>
Shrige	Devgen storage tank	0,00 €	0,0000 mail	20	Dry biomeis bought	0,00 C	0,00 1
- 27	Hydrogen storage tank	0,00 €	0,0000 mail	2 pidu	Wet biomass bought	0,00 K	0,00 t
	Carbon dioxide storage tank	0,00 €	0,0000 mei	-	Biocher bought	0,00 E	0,00 1
	Methane storage tank	0,00 €	0,0000 mpl	5	Biochar sold	0,00 C	D,00 I
	Total for storages	0,00 €	LAW LAND AND A	outputs	Hydrogen sold	0,00 K	0,00 1
5 1	Electrical connection	0,00 €	8,00 MW	ō	CO2 emitted	0.00 E	0,00 kg
8 E	Eas connection	0,00 K	0,00 MW	1412	total operational cost without investment	-2 521 653,54 €	_
Contra P	Water connection	0,00 C	0,00 m <sup>3</sup> /h		Total operational cost with investment	0,00 C	
01	Total for connections	0,00 C			Savings with introduction of P2G	-2 521 653,54 C	
	Total investment	0,00 €					
	Payoff period	n/a years	15				Destaurth

## Source: Optimilization Tool v1.1

27. Figure: Results for REP with high gas prices of methane and no subsidy

Source: Optimilization Tool v1.1

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