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EXPRESS

Regional Context Assessment: **Energy sector of Međimurje County**

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*Adria Innovation Harbour (On behalf of Public Institution for the Development of
the Međimurje County REDEA)*

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Outline of the presentation

- Introduction
- Flowchart of the energy assessment of the Međimurje County
- Structure of the Međimurje County energy system
- Overview of the current state of primary energy production for the Međimurje County
- Overview of the current state of energy demand for Međimurje County
- Base scenario: resulting estimation of self-sufficiency (EnergyPLAN) + comparison with Republic of Croatia
- The potential of using renewable energy sources in Međimurje County for far-future scenarios
- Near-future scenario
- Far-future scenarios: structure and three cases: S-Elec, S-H2/SNG and S-Biogas
- Survey on public perspective on energy self-sufficiency and the use and representation of renewable energy sources and energy efficiency measures

Introduction

European Union is heavily dependent on imports of energy, particularly oil and natural gas

- (-) Issues related to security of supply and fluctuating energy costs
- (+) Increasing share of renewable energy and energy self-sufficiency

In the EXPRESS project, eight partners from 8 different European Union countries are participating.

- The Croatian partner is the Public Institution for the Development of Međimurje County (REDEA)

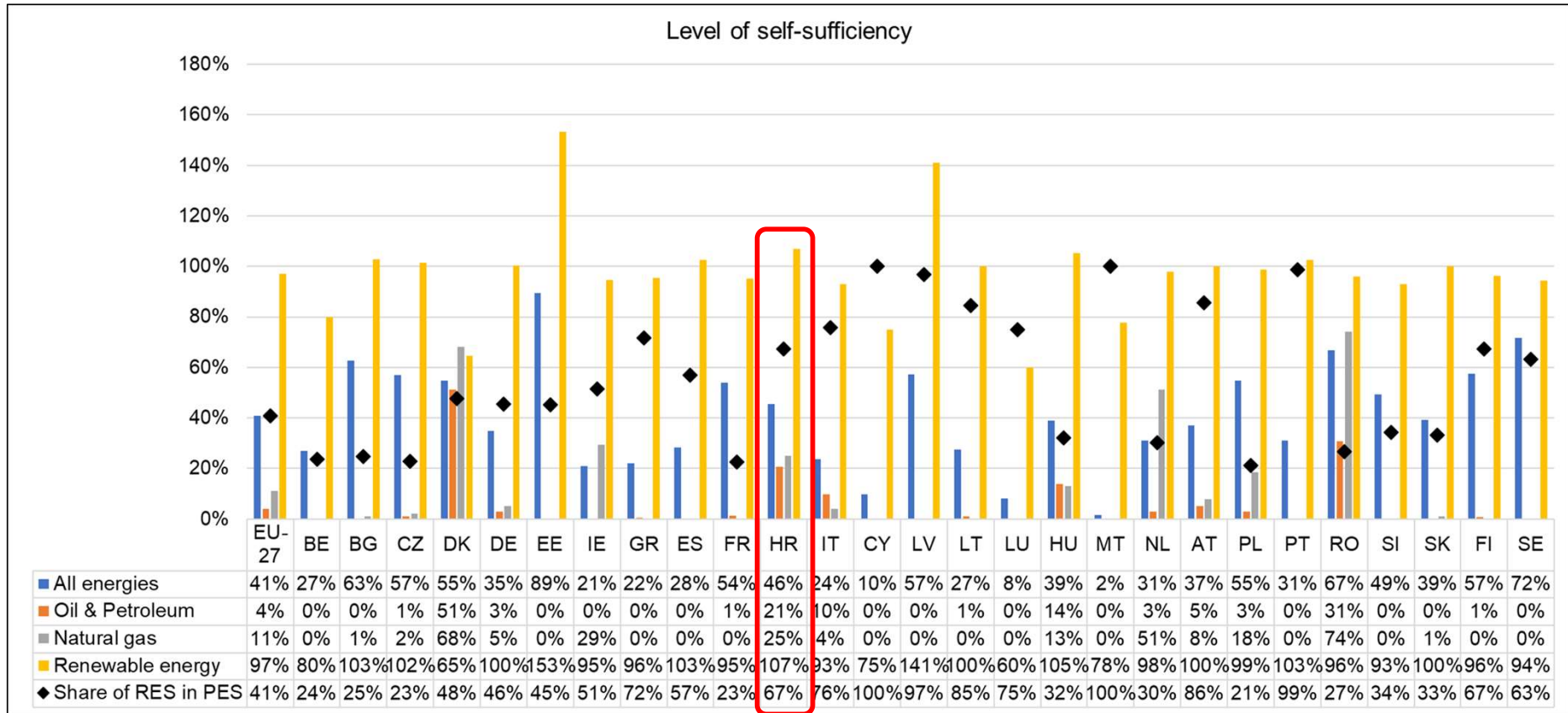
MEĐIMURJE COUNTY

Population	105,250 (as of 2021)
Area	729.58 km ²
Population Density	156 residents per km ²
Administrative Division	Three cities and 22 municipalities
Number of settlements	131
County Status	Obtained in 1992



Introduction

Level of self-sufficiency in EU-27?



Flowchart of the energy assessment of the Međimurje County

Development of base scenario for Međimurje County:

- Definition of the structure of the energy system
- Overview of the current state of primary energy production for the Međimurje County
- Overview of the current state of energy demand for Međimurje County

Simulation of base scenario for Međimurje County:

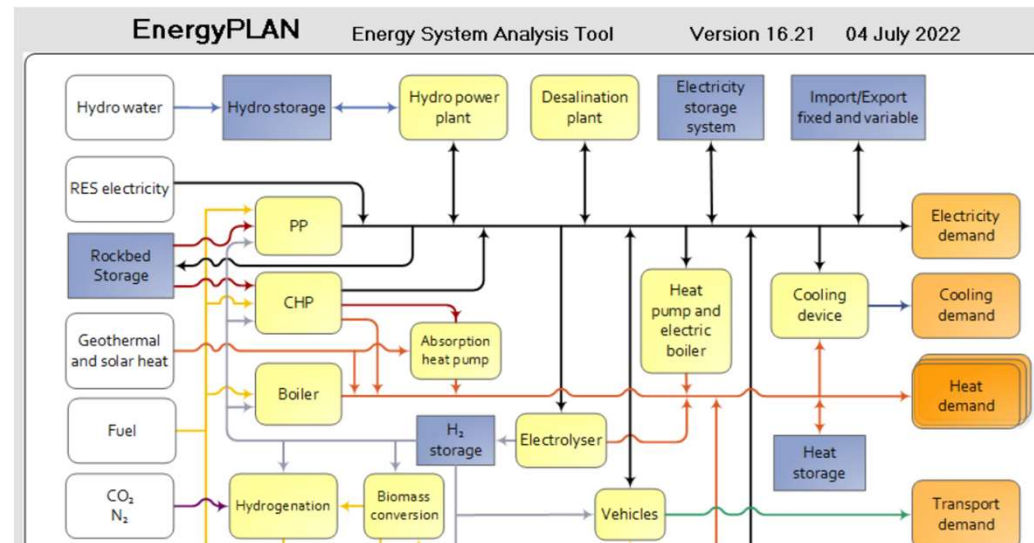
- Model developed in EnergyPLAN modelling software
- One-Year simulation with hourly time resolution
- Analysis of results

Development of near-future energy scenario for Međimurje County:

- Modification of base scenario by adding already planned and near-realization renewable energy projects
- Target: 2030

Development of far-future energy scenarios for Međimurje County:

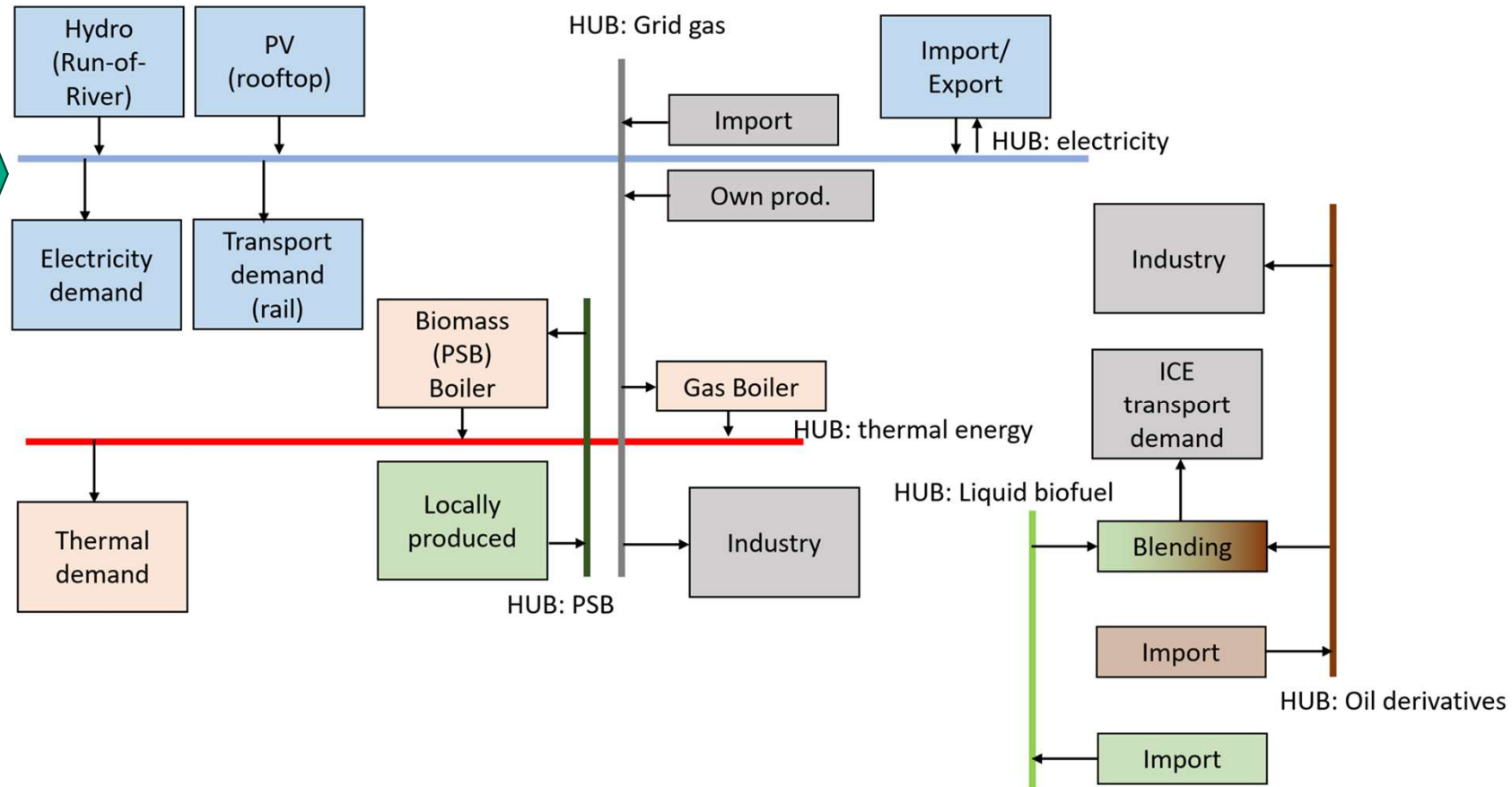
- estimation of RES potential
- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- Extensive biogas (S-Biogas)
- Target: 2050



Structure of the Međimurje County reference energy system (base scenario)

Development of base scenario for Međimurje County:

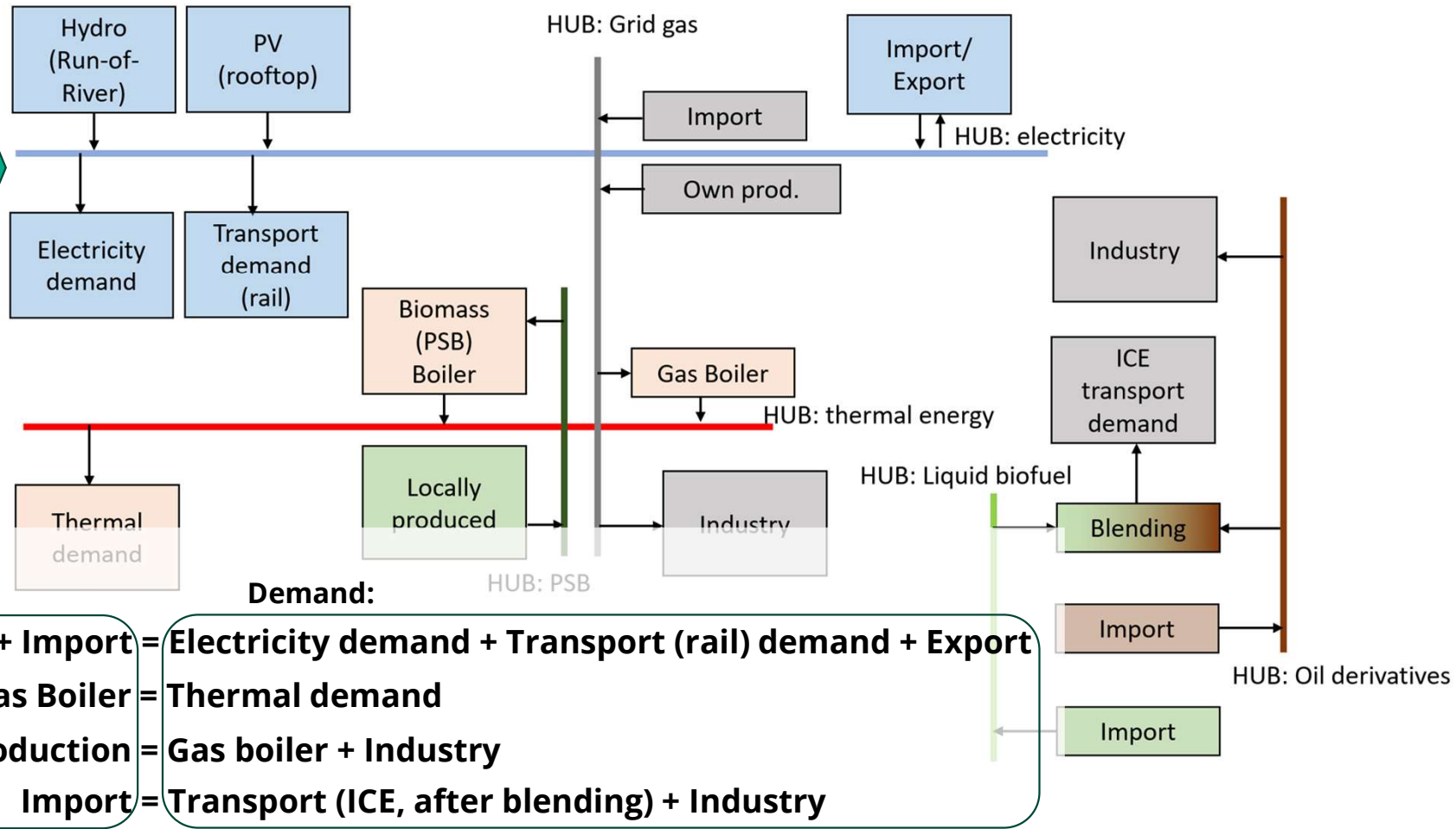
- Definition of the structure of the energy system
- Overview of the current state of primary energy production for the Međimurje County
- Overview of the current state of energy demand for Međimurje County



Structure of the Međimurje County reference energy system (base scenario)

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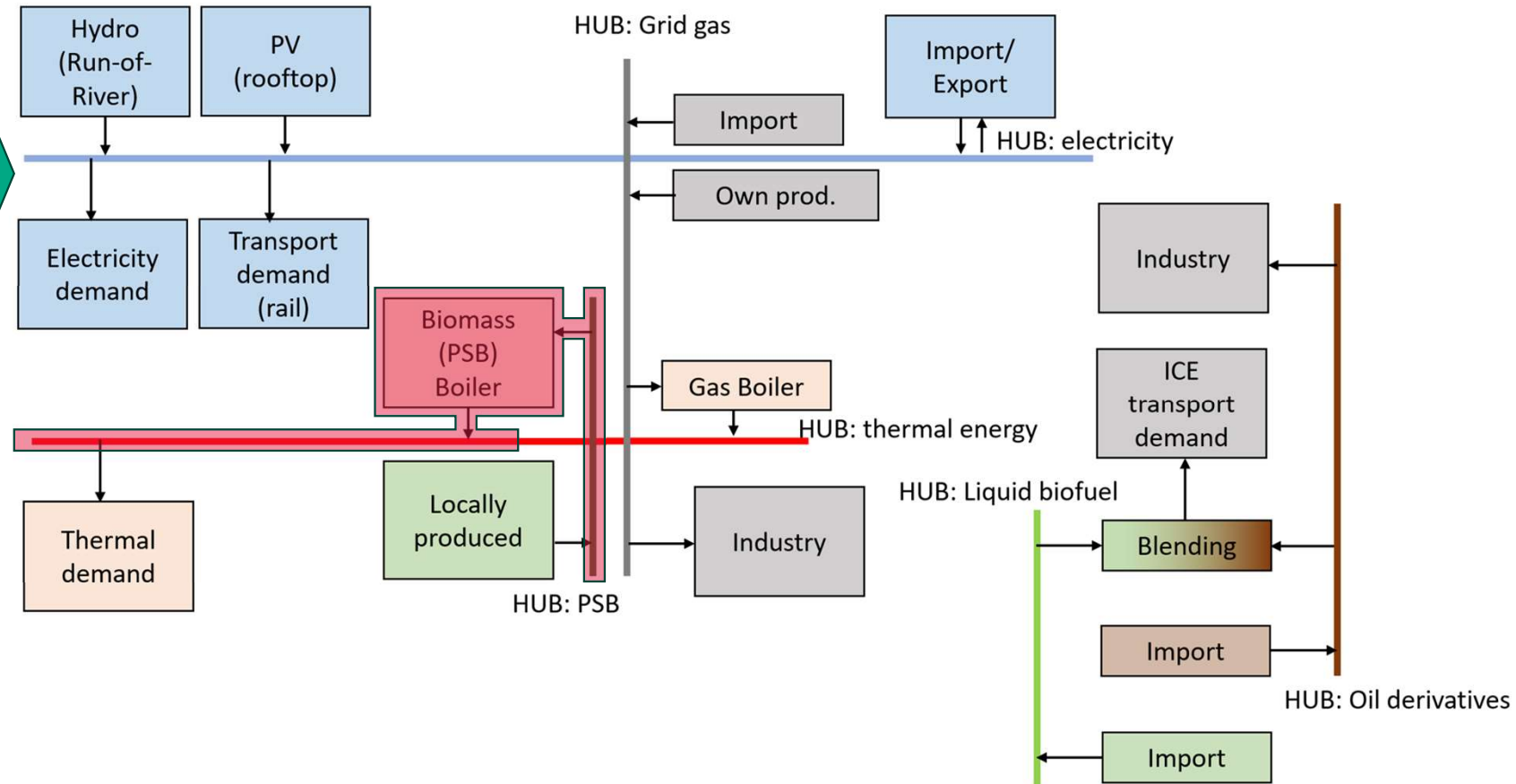
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Structure of the Međimurje County reference energy system (base scenario)

Development of base scenario for Međimurje County:

- Definition of the structure of the energy system
- Overview of the current state of primary energy production for the Međimurje County
- Overview of the current state of energy demand for Međimurje County



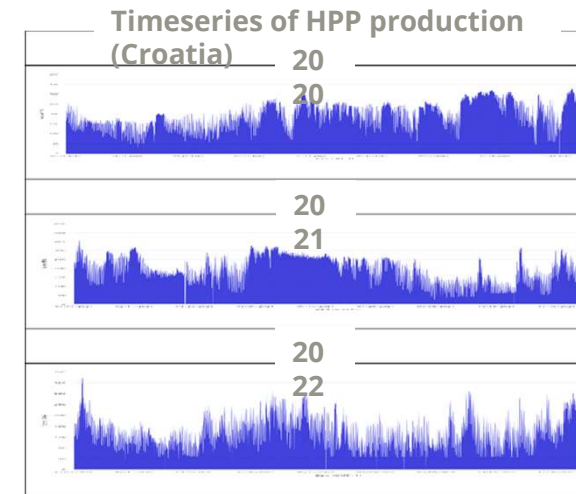
Overview of the current state of primary energy production for the Međimurje County

Development of base scenario for Međimurje County:

- Definition of the structure of the energy system
- **Overview of the current state of primary energy production for the Međimurje County**
- Overview of the current state of energy demand for Međimurje County

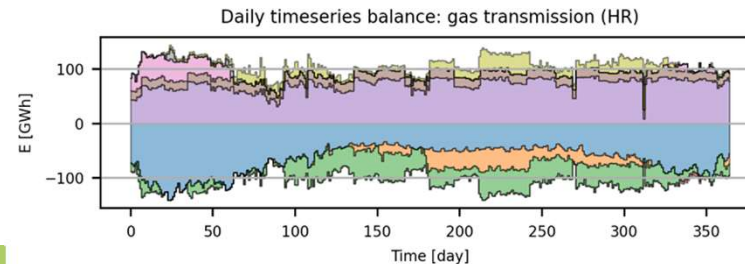
- Renewable energy sources: **hydro**, biomass, solar PV and geothermal (primary energy supply)

Year	HPP Čakovec		HPP Dubrava	
	Production in GWh	Capacity factor [-]	Production in GWh	Capacity factor [-]
2017	321,9	0,475	329,5	0,461
2018	404,8	0,597	401,5	0,579
2019	385,5	0,568	394,4	0,552
2020	446,2	0,658	458,7	0,638
2021	407,5	0,601	402,1	0,583
average	393,2	0,580	397,2	0,563



Source: ENTSO-E

- Natural gas



- Final Consumers and Distribution (HR)
- UGS Croatia
- Dravaszerdahely
- Rogatec
- Croatia LNG
- Production (HR)
- UGS Croatia
- Dravaszerdahely
- Rogatec

75% of natural gas is from the import (mostly from the LNG terminal)

Overview of the current state of primary energy production for the Međimurje County

Development of base scenario for Međimurje County:

- Definition of the structure of the energy system
- **Overview of the current state of primary energy production for the Međimurje County**
- Overview of the current state of energy demand for Međimurje County

Category	Sub-category	Estimation	Note
Renewable energy	Hydro	790 GWh	Refers to 5-Year average production from two HPP's
	Solar PV	2 MW of installed capacity	Based on OIE-KPP
	Biomass	Fully sourced locally, 100% self-sufficient	This refers to primary solid biofuels
	Liquid biofuels	-	There are no liquid biofuel plants in Međimurje County
Fossil energy	Natural gas	The assumption is that 25% of domestically used natural gas is locally produced	Data taken from the national value of gas self-sufficiency
	Oil and petroleum products	-	Fully imported from other Counties
	Solid (coal)	-	There are no active coal mines in Republic of Croatia

Overview of the current state of energy demand for Međimurje County

Development of base scenario for Međimurje County:

- Definition of the structure of the energy system
- Overview of the current state of primary energy production for the Međimurje County
- **Overview of the current state of energy demand for Međimurje County**

	Industry	Transport		Other		
		Road	Rail	Service	Households	Agriculture / Forestry
	GWh	GWh	GWh	GWh	GWh	GWh
Electricity	(131)	6	7	(131)	(119)	4
Liquid biofuels	0	26	0	0	0	0
Primary solid biofuel	(31)	0	0	(31)	(76)	0
Fossil Gas	(80)	0	0	(80)	(271)	9
LPG		6,5				
Motor gasoline	0	165	0	0	0	0
Diesel oil	0	446	5	0	0	0

Top-down approach: values as a fraction of the Croatia's national values based on percentage of population

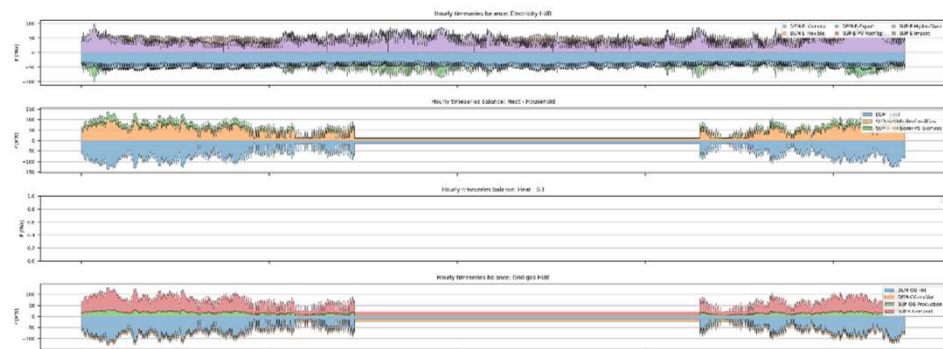
Bottom-up approach: exact values for MC taken from available public data, usually local energy companies (Elektra Čakovec, Međimurje plin)

Base scenario: resulting energy balance (EnergyPLAN)

Simulation of base scenario for Međimurje County:

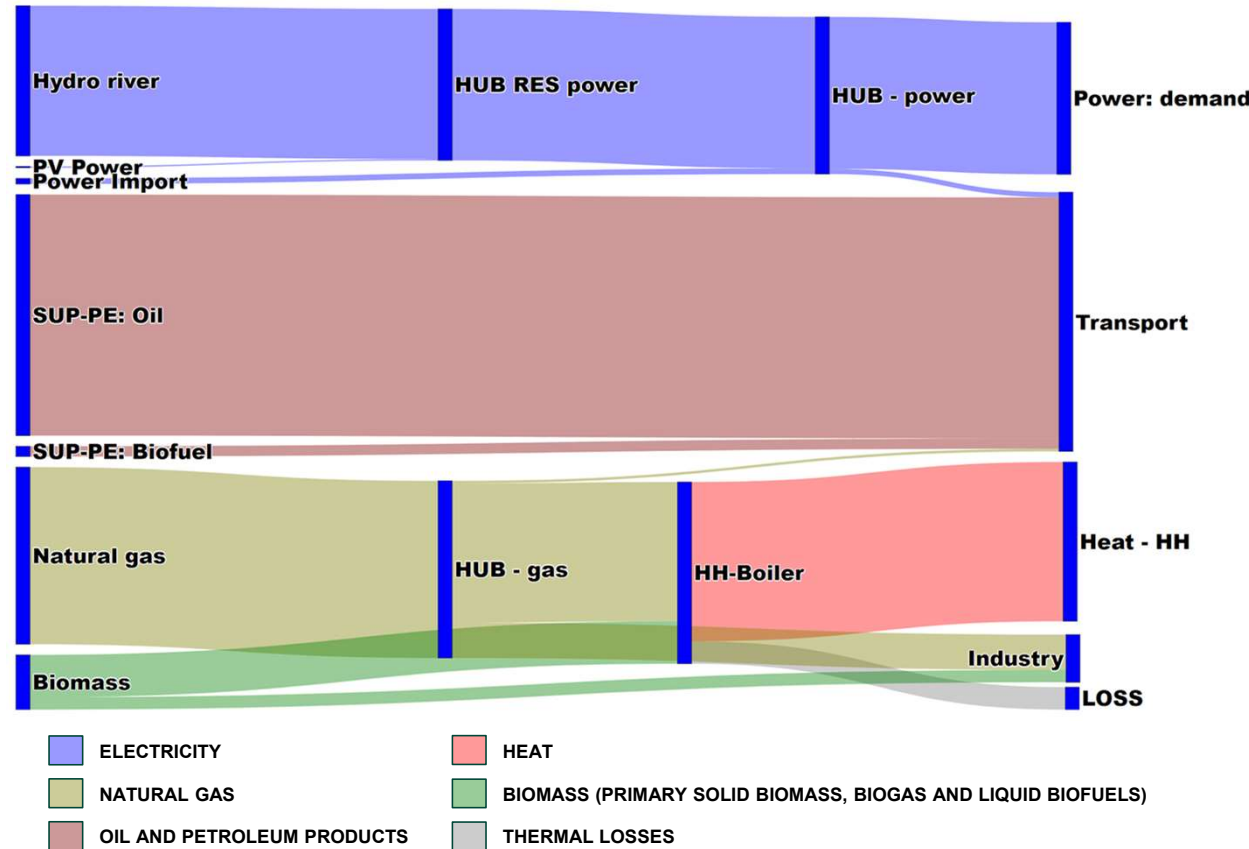
- Model developed in EnergyPLAN modelling software
- One-Year simulation with hourly time resolution
- Analysis of results

Hourly values of electricity, heat and grid gas balance throughout the Year



Međimurje County base scenario

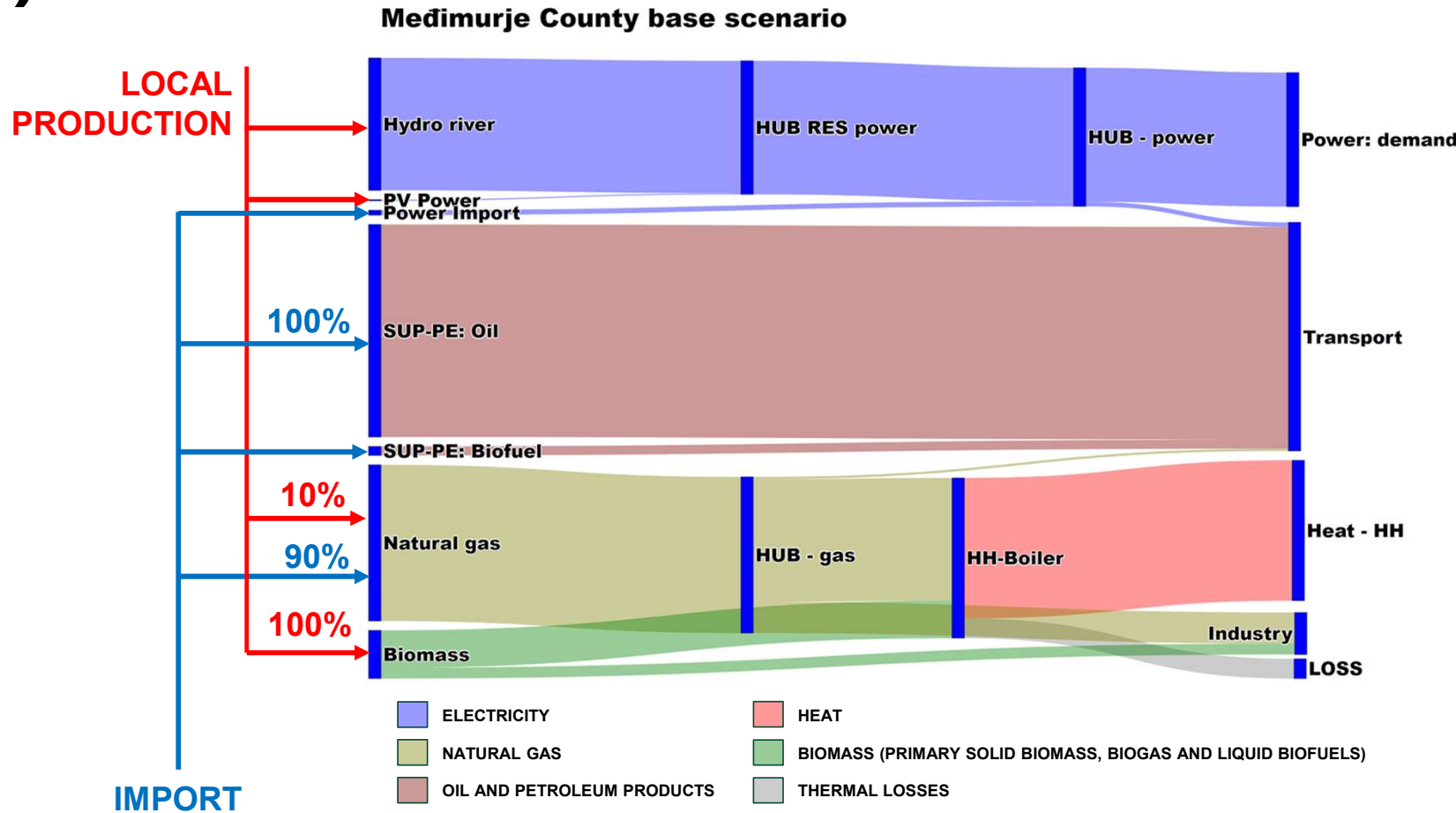
Yearly energy flow diagram



Base scenario: resulting energy balance (EnergyPLAN)

Simulation of base scenario for Međimurje County:

- Model developed in EnergyPLAN modelling software
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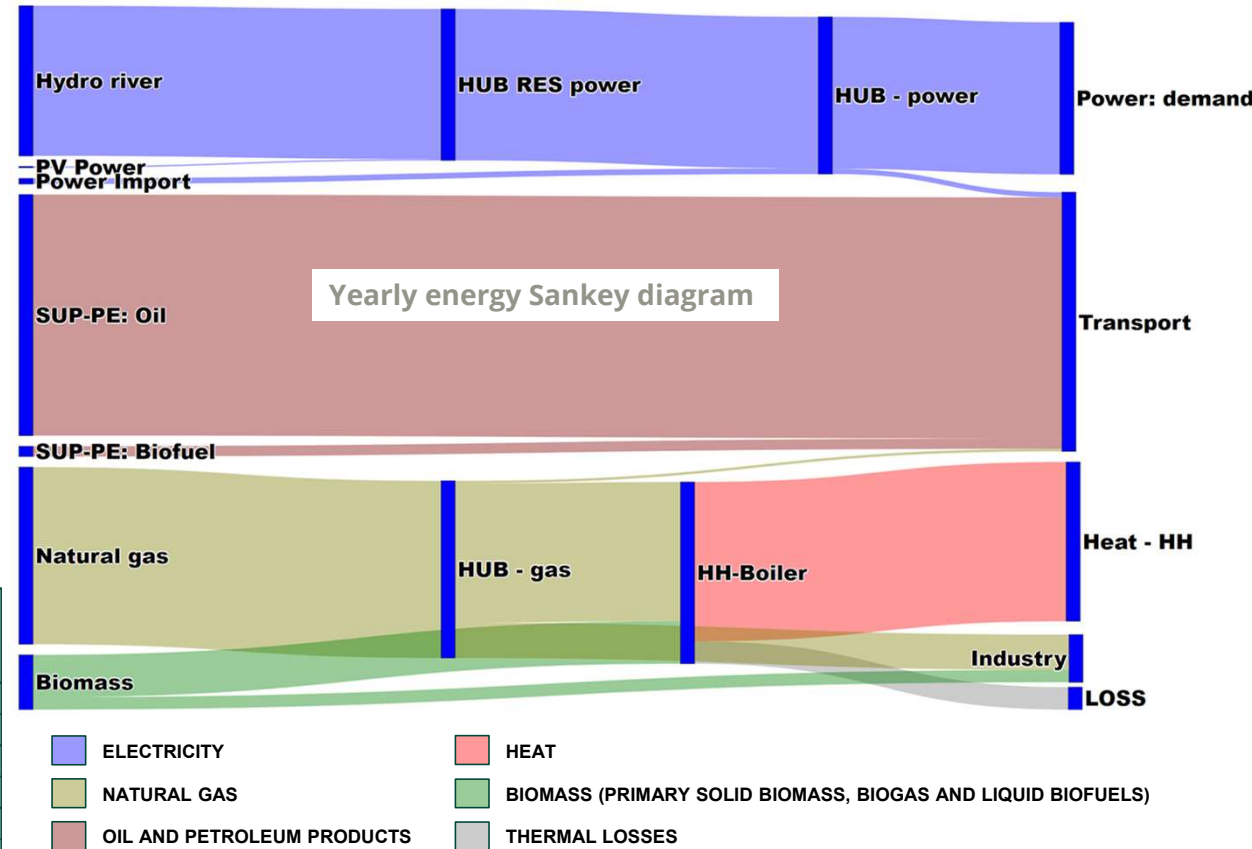


Base scenario: resulting estimation of self-sufficiency (EnergyPLAN)

Simulation of base scenario for Međimurje County:

- Model developed in EnergyPLAN modelling software
- One-Year simulation with hourly time resolution
- Analysis of results

Međimurje County base scenario



$$\text{Level of self sufficiency} = \frac{\text{Locally produced}}{\text{Local demand}} = 37\%$$

Type of energy	Locally produced	Import	Export	Net import	Local demand	Level of self-sufficiency
	(a)	(b)	(c)	(d) = (b) - (c)	(e)	(a)/(e)
	GWh	GWh	GWh	GWh	GWh	%
Electricity	383	63	49,16	14	397	96
PSB	94	0	0	0	94	100
GridGas (GG)	108	332	0	332	440	25
Petroleum products	0	611	0	611	611	0
Liquid biofuels	0	26	0	26	26	0
Total	584	1033	49	984	1568	37

Base scenario: resulting estimation of self-sufficiency (EnergyPLAN), comparison with Republic of Croatia

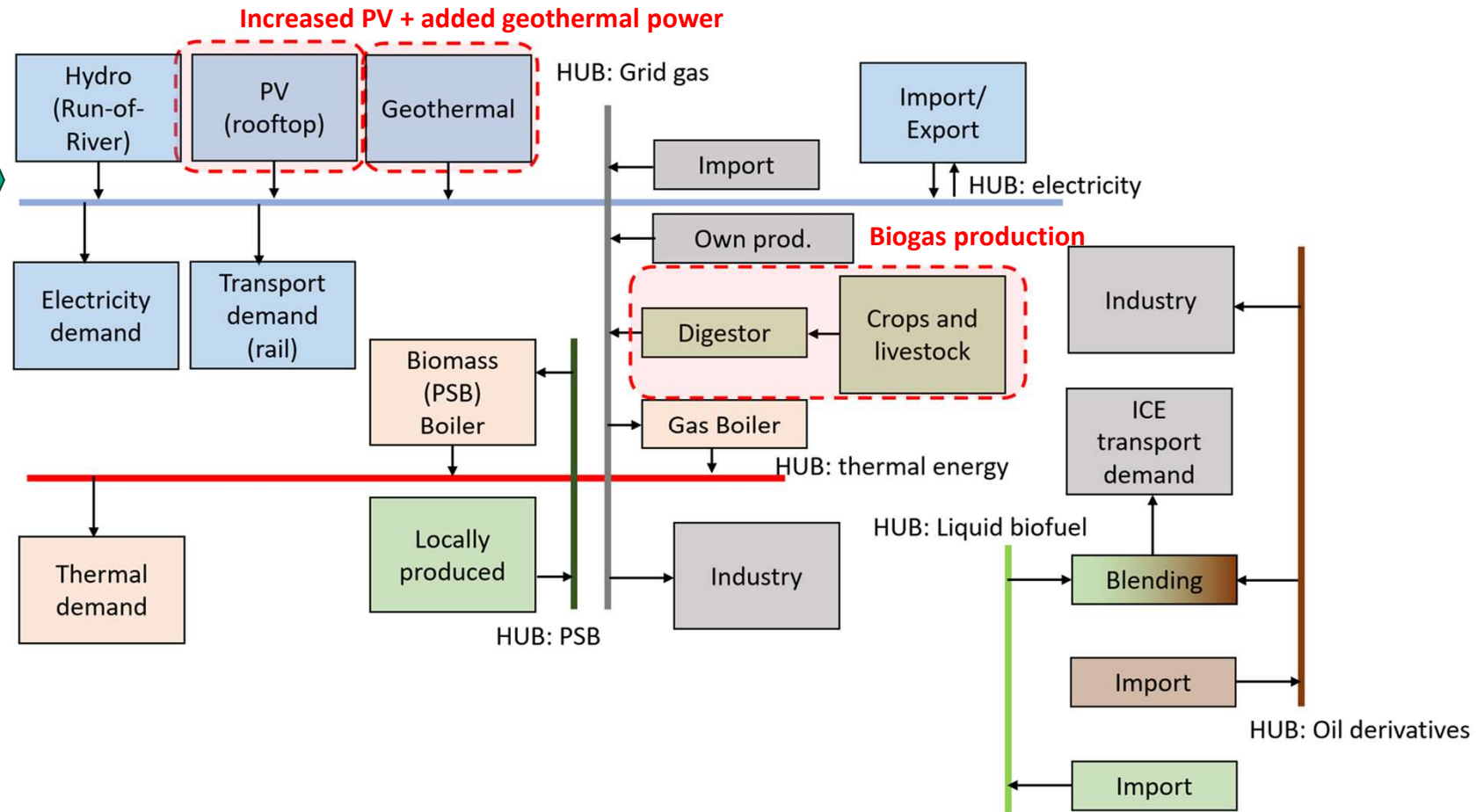
According to the results of the base scenario, the level of self-sufficiency for Međimurje County is **37%**, which is lower than **47%** for Republic of Croatia. The reasons for that are:

- Croatia still **has 20% of own production of oil and oil derivatives, while at the same time oil and oil derivatives are the largest individual type of energy** used in final consumption
- Međimurje County has **larger share of natural gas in heating than Republic of Croatia;** Croatian's levels are at 40%, while for the Međimurje County natural gas accounts for 78% (271 GWh is natural gas, 76 GWh is primary solid biofuel)
- In terms of self-sufficiency of electricity, Međimurje County is **better positioned than Croatia,** since HPP's already cover for 96% of electricity demand, while for Croatia this percentage for a 5-year average is around 75%

The structure of the near-future energy system for Međimurje County (target <2030)

Simulation of near-future scenario for Međimurje County:

- Model developed in EnergyPLAN modelling software
- One-Year simulation with hourly time resolution
- Analysis of results



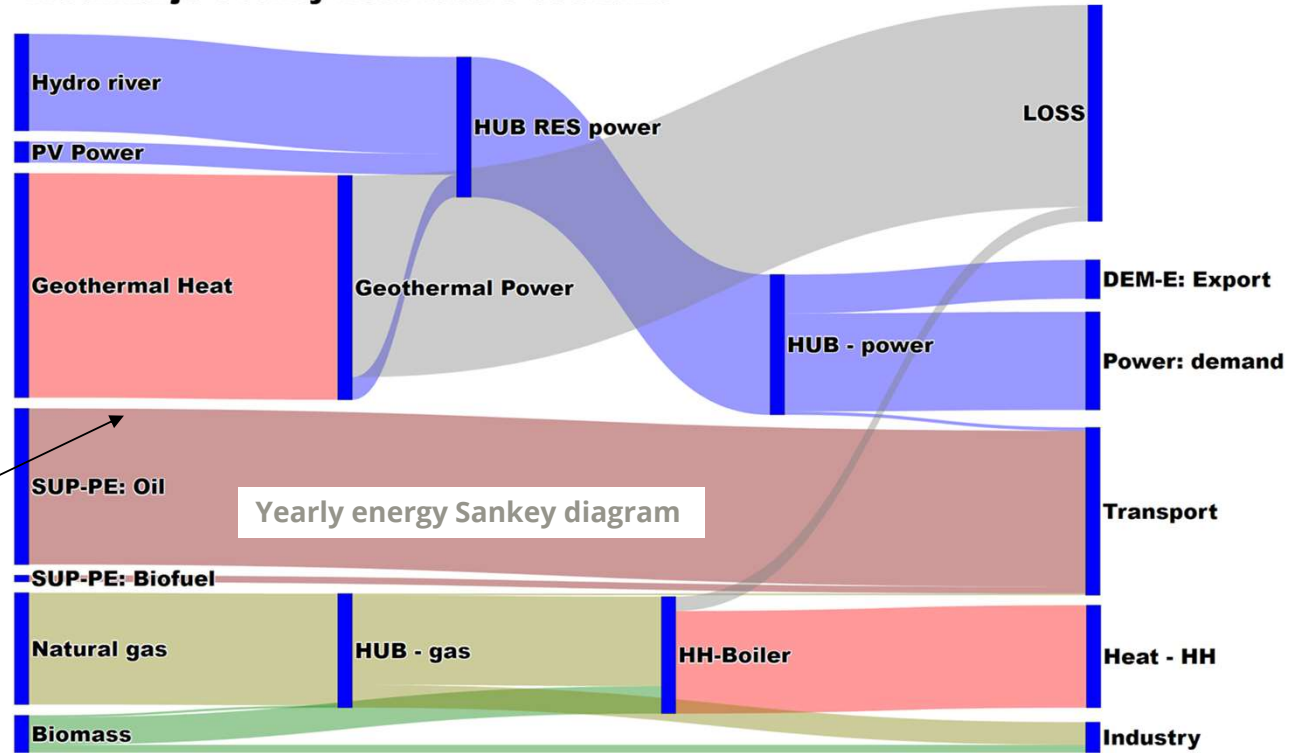
Near-future scenario: resulting energy balance (EnergyPLAN)

Simulation of near-future scenario for Međimurje County:

- Model developed in EnergyPLAN modelling software
- One-Year simulation with hourly time resolution
- Analysis of results

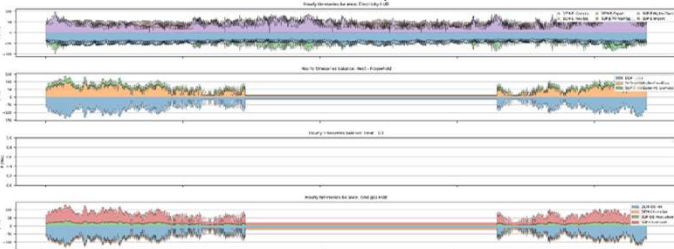
Level of self-sufficiency increased by 10% (from 37% to 47 %) due to increased production of electricity

Međimurje County near future scenario



- | | |
|---|--|
| ■ ELECTRICITY | ■ HEAT |
| ■ NATURAL GAS | ■ BIOMASS (PRIMARY SOLID BIOMASS, BIOGAS AND LIQUID BIOFUELS) |
| ■ OIL AND PETROLEUM PRODUCTS | ■ THERMAL LOSSES |

Hourly values of electricity, heat and grid gas balance throughout the Year

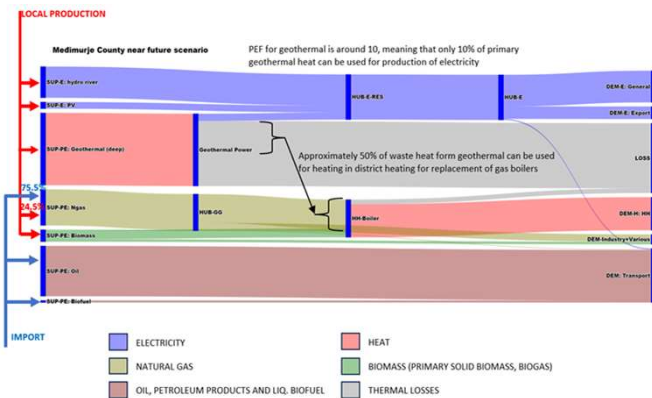


Near-future scenario: resulting energy balance (EnergyPLAN)

Simulation of near-future scenario for Međimurje County:

- Model developed in EnergyPLAN modelling software
- One-Year simulation with hourly time resolution
- Analysis of results

- Level of self-sufficiency increased by 10% (from 37% to 47 %) due to increased production of electricity, which is now 134% self-sufficient
- Further increase requires bigger changes in the structure of the energy system
- There are many possible pathways how to change the system to be more self-sufficient, but choice of the particular technology depends on availability of local resources



Type of energy	Locally produced	Import	Export	Net import	Local demand	Level of self-sufficiency
	(a)	(b)	(c)	(d) = (b) - (c)	(e)	(a)/(e)
	GWh	GWh	GWh	GWh	GWh	%
Electricity	532	13	148	-135	397	134
PSB	94	0	0	0	94	100
GridGas (GG)	114	326	0	326	440	26
Petroleum products	0	611	0	611	611	0
Liquid biofuels	0	26	0	26	26	0
Total	740	976	148	828	1568	47

The potential of using renewable energy sources in Međimurje County for far-future scenarios

The following renewable energy sources are recognized as being locally available:

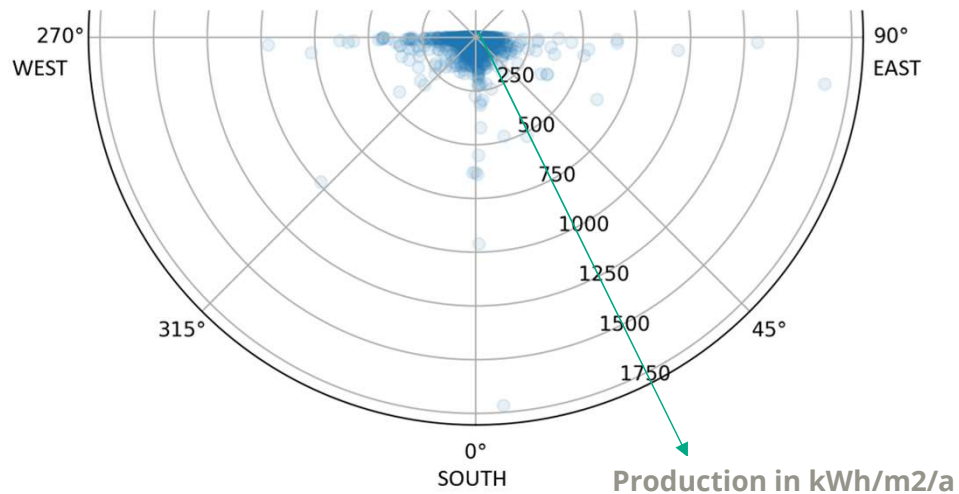
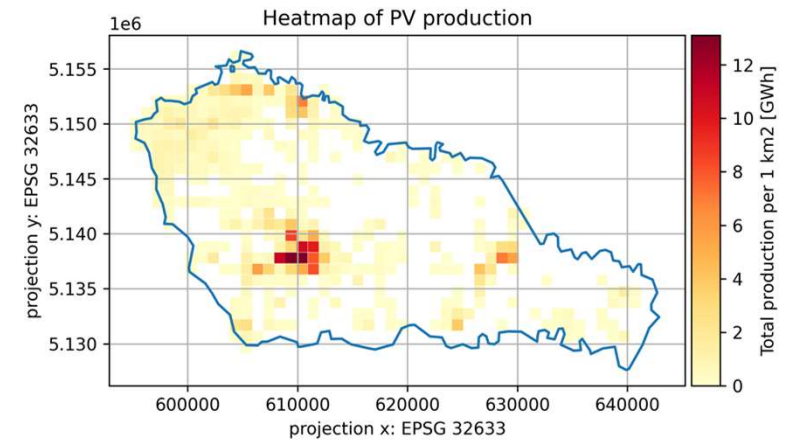
- Rooftop PV
- Standalone PV (2-axis tracker)
- Production of biogas
- Deep geothermal energy
- Ground source heat pumps

The potential of using renewable energy sources in Međimurje County: rooftop PV

Development of far-future energy scenarios for Međimurje County:

- estimation of RES potential

- Rooftop PV
 - All buildings in Međimurje County are mapped by surface and roof orientation
 - Estimation: 40% of available roof can be, in average, used for mounting PV's



Installed peak power of PV panels	MWp-e	318
Installed net power of solar PV (14% loss)	MWp-e	273
Produced energy	GWh-e	332
Capacity factor based on installed net power of solar PV	%	13

The potential of using renewable energy sources in Međimurje County: biogas production

Development of far-future energy scenarios for Međimurje County:

- renewable sources potential

- Production of biogas from animal farming

	Number of units	feedstock/manure production per 100 units	conversion rate	gross production per 100 units	net production per 100 units	Total potential for Međimurje County	Total potential for Međimurje County
	(a)	(b)	(c)	(d) = (b)*1000*(c)	(e) = (d)·66%	(f) = (a)/100·(e)·365/1000	(g) = (f)·6/1000
	-	t/day	m ³ /kg	m ³ /day	m ³ /day	1000m ³ /Year	GWh/Year
Cattle	9734	7,7	0,390	3003	1982	70418	423
Milk cow	2532	6,25	0,390	2438	1609	14868	89
Sheep	666	0,38	0,258	98	65	157	1
Goat	3740	0,38	0,258	98	65	883	5
Pig	43266	0,5	0,272	136	90	14175	85
Broiler chicken	2706356	0,0036	0,200	1	0	4694	28
Laying hen	52071	0,0125	0,200	3	2	314	2
Total						105509	633

In order to make biogas production economically feasible, farm has to be sufficiently large.

Since farms are usually small in size with small number of units, the rough estimate is that only 10% of the total potential can be economically achieved

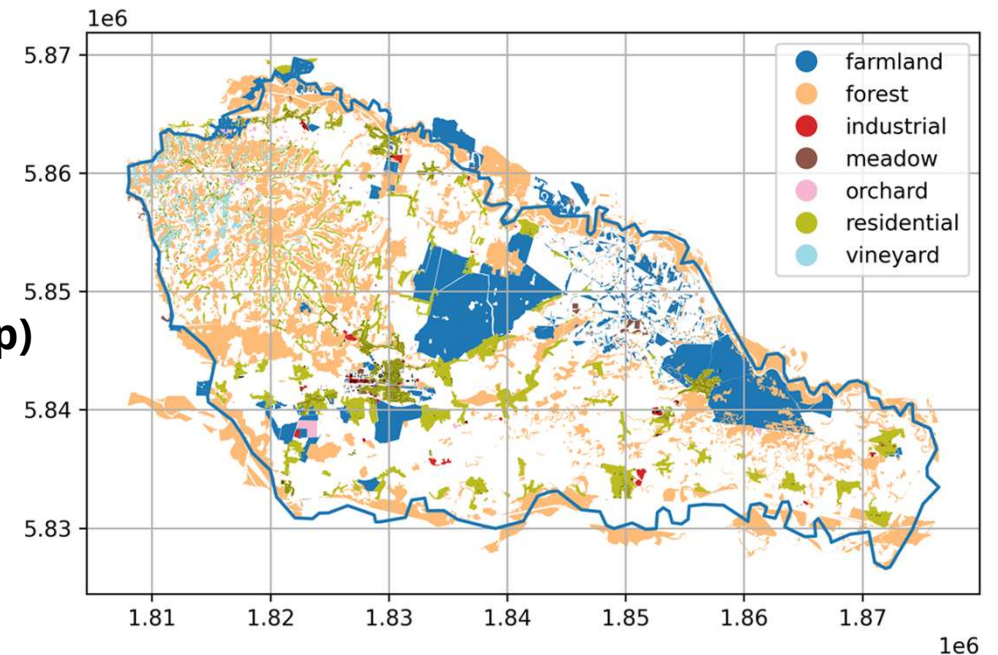
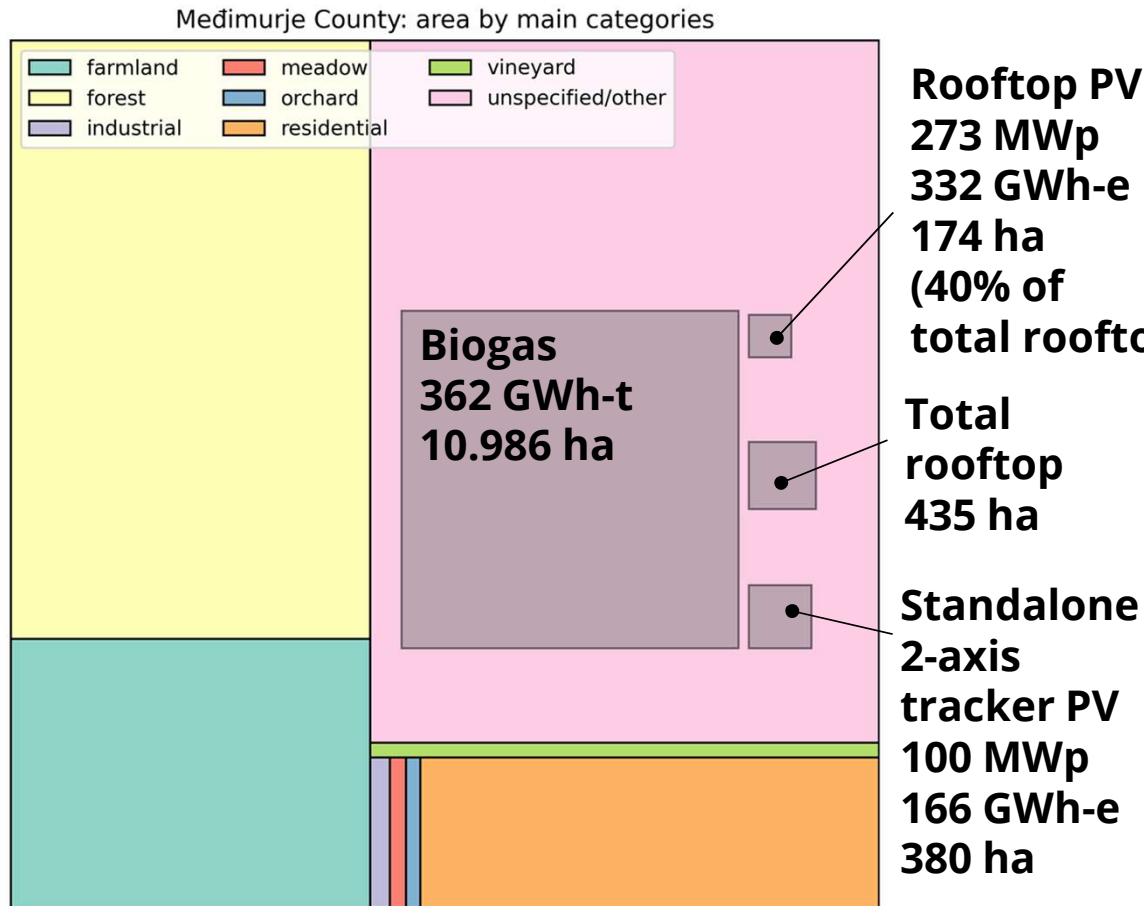
The potential of using renewable energy sources in Međimurje County: geothermal energy

Development of far-future energy scenarios for Međimurje County:

- renewable sources potential

- Deep geothermal energy
 - Currently there is one exploitation field Draškovec AATG and three investigation fields, one with a concession, Merhatovec, and two in the tendering process, Međimurje-5 and Kotoriba
 - Total potential is estimated at 20 MW-electric
- Ground source heat pumps
 - Unconfined aquifers, consisting mainly from gravel and sand, as the best type of soil from the energy point of view will have highest coefficient of performance, are more likely to occur in the vicinity of rivers Mura and Drava

The potential of using renewable energy sources in Međimurje County: landuse for biogas and PV

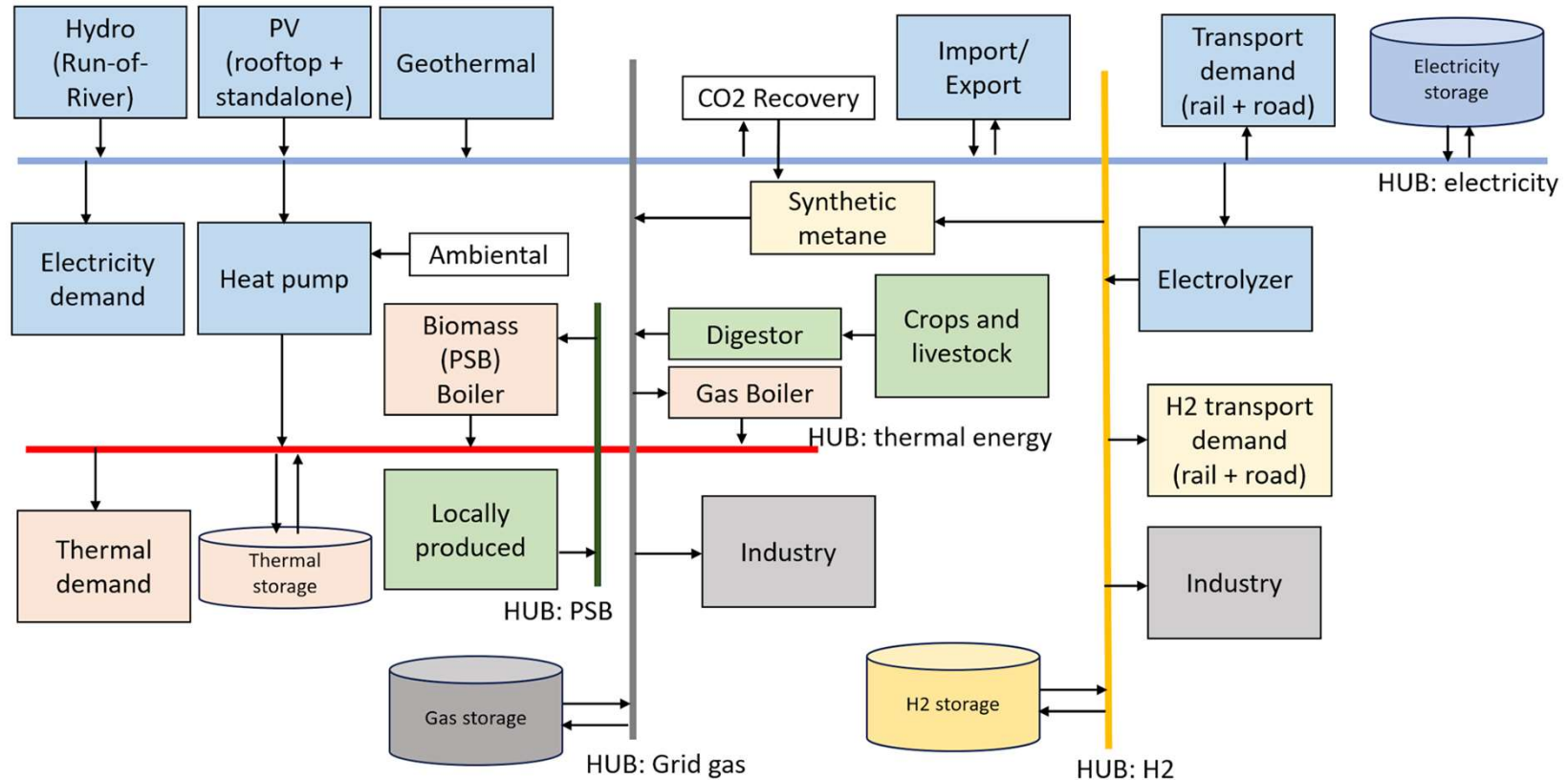


**source of GIS data is OpenStreetMap, which is an opensource database, therefore not all farmland area is being mapped in this picture.*

The structure of the far-future energy system for Međimurje County (target 2050)

Development of far-future energy scenarios for Međimurje County:

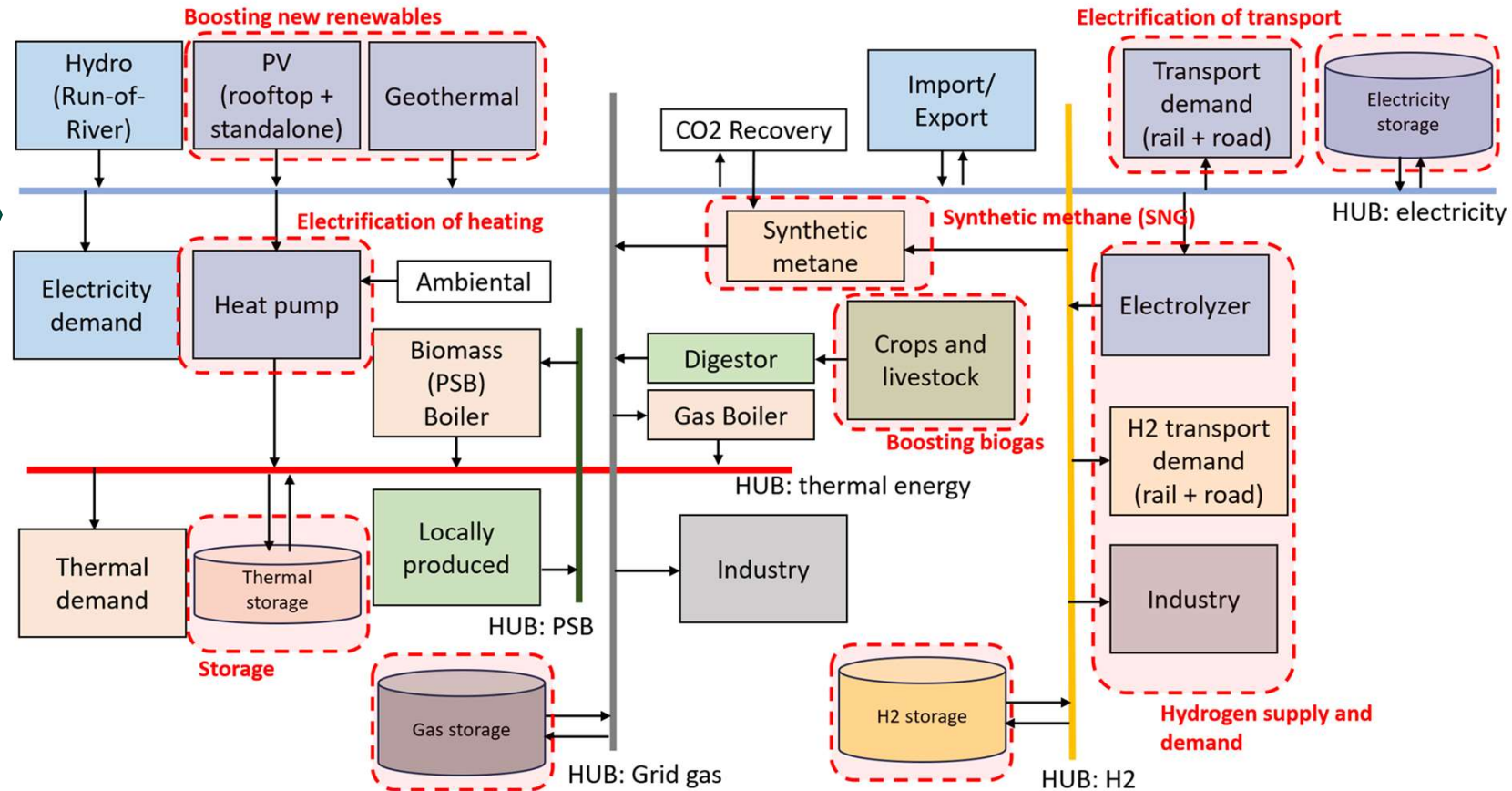
- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- Extensive biogas (S-Biogas)
- Target: 2050



The structure of the far-future energy system for Međimurje County (main features)

Development of far-future energy scenarios for Međimurje County:

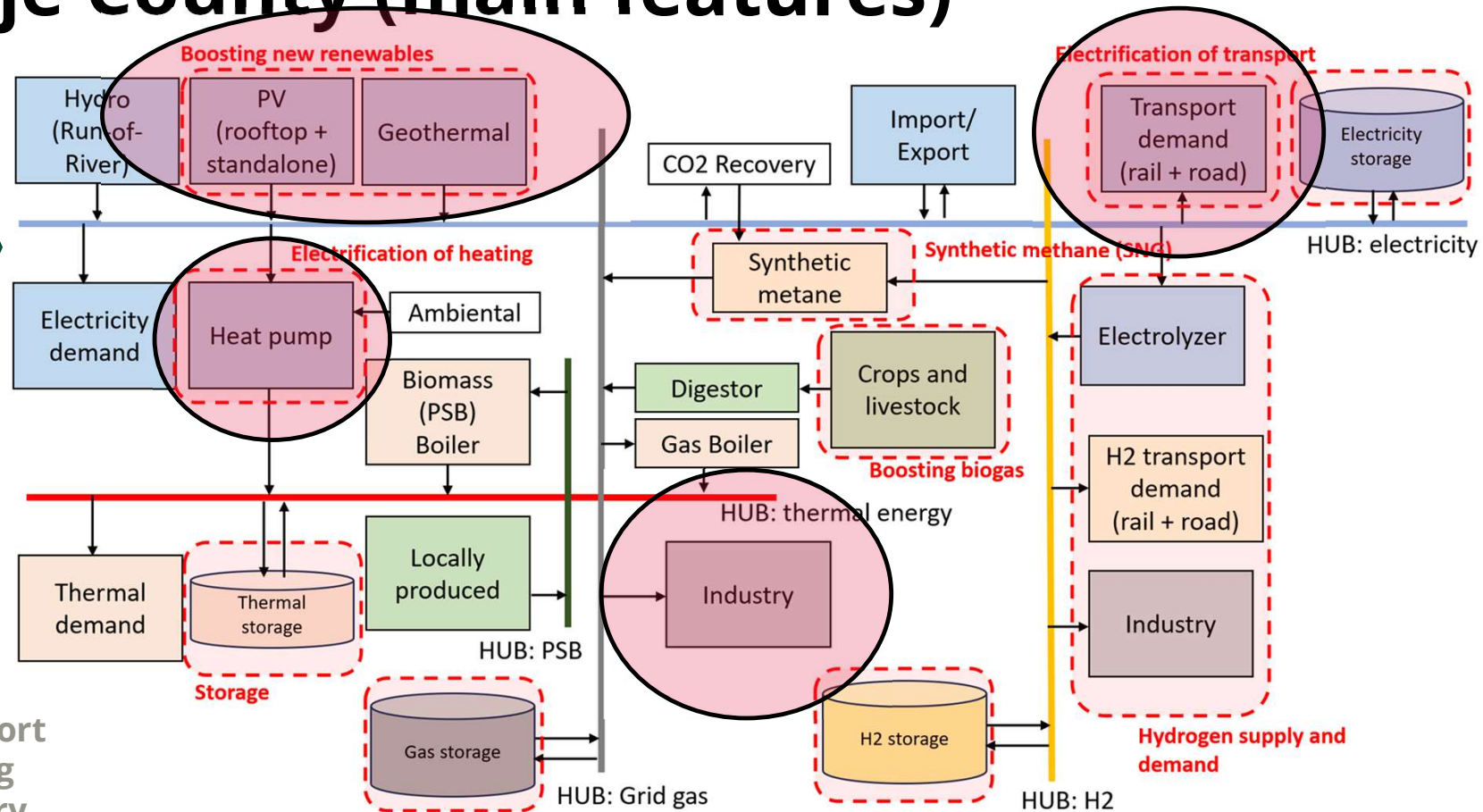
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The structure of the far-future energy system for Međimurje County (main features)

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- Target: 2050



S-ELEC

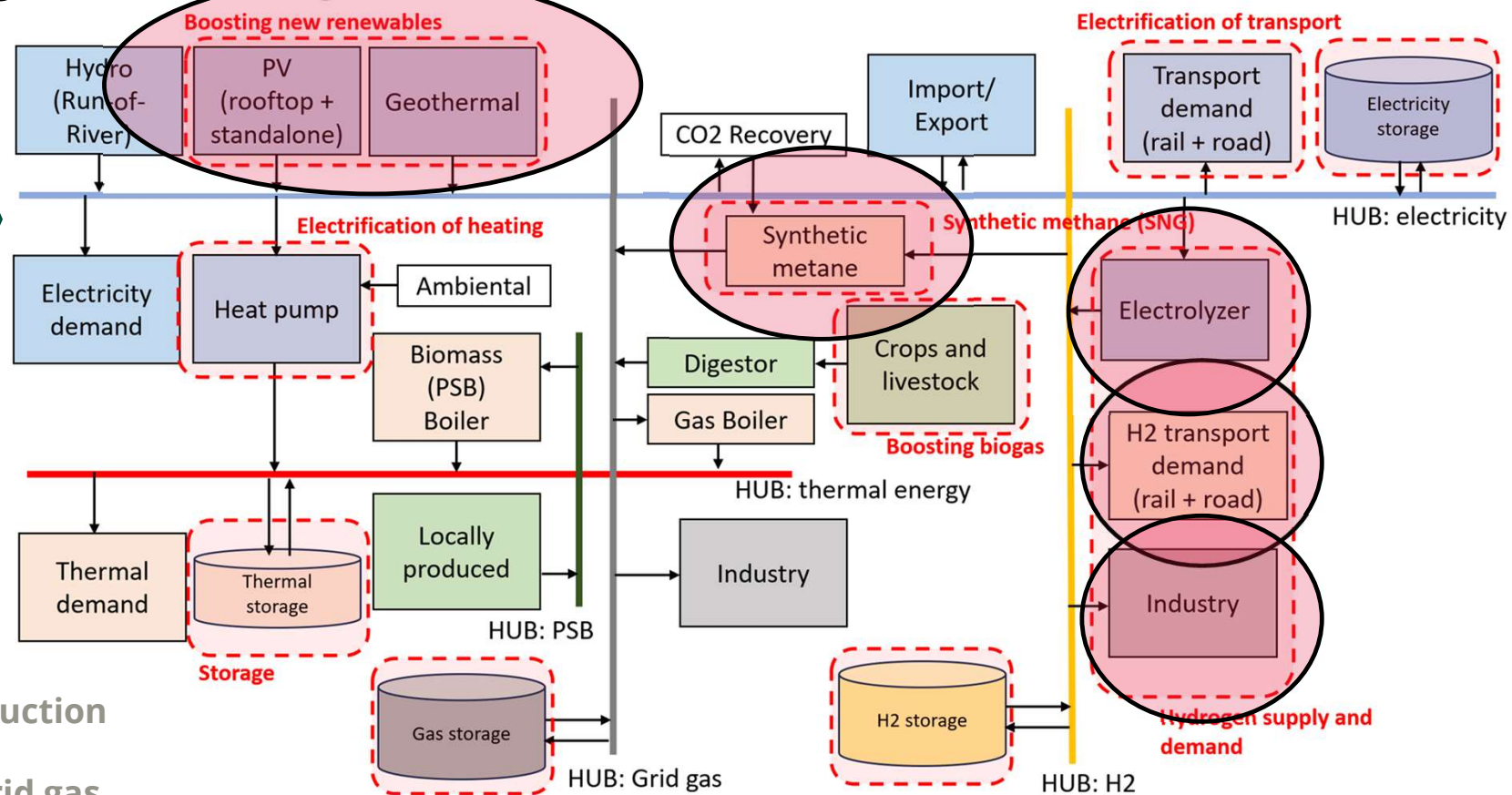
Main features:

1. electrification of transport
2. electrification of heating
3. electrification of industry
4. boosting up renewables (primary source)

The structure of the far-future energy system for Međimurje County (main features)

Development of far-future energy scenarios for Međimurje County:

- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- Extensive biogas (S-Biogas)
- Target: 2050



S-H2/SNG

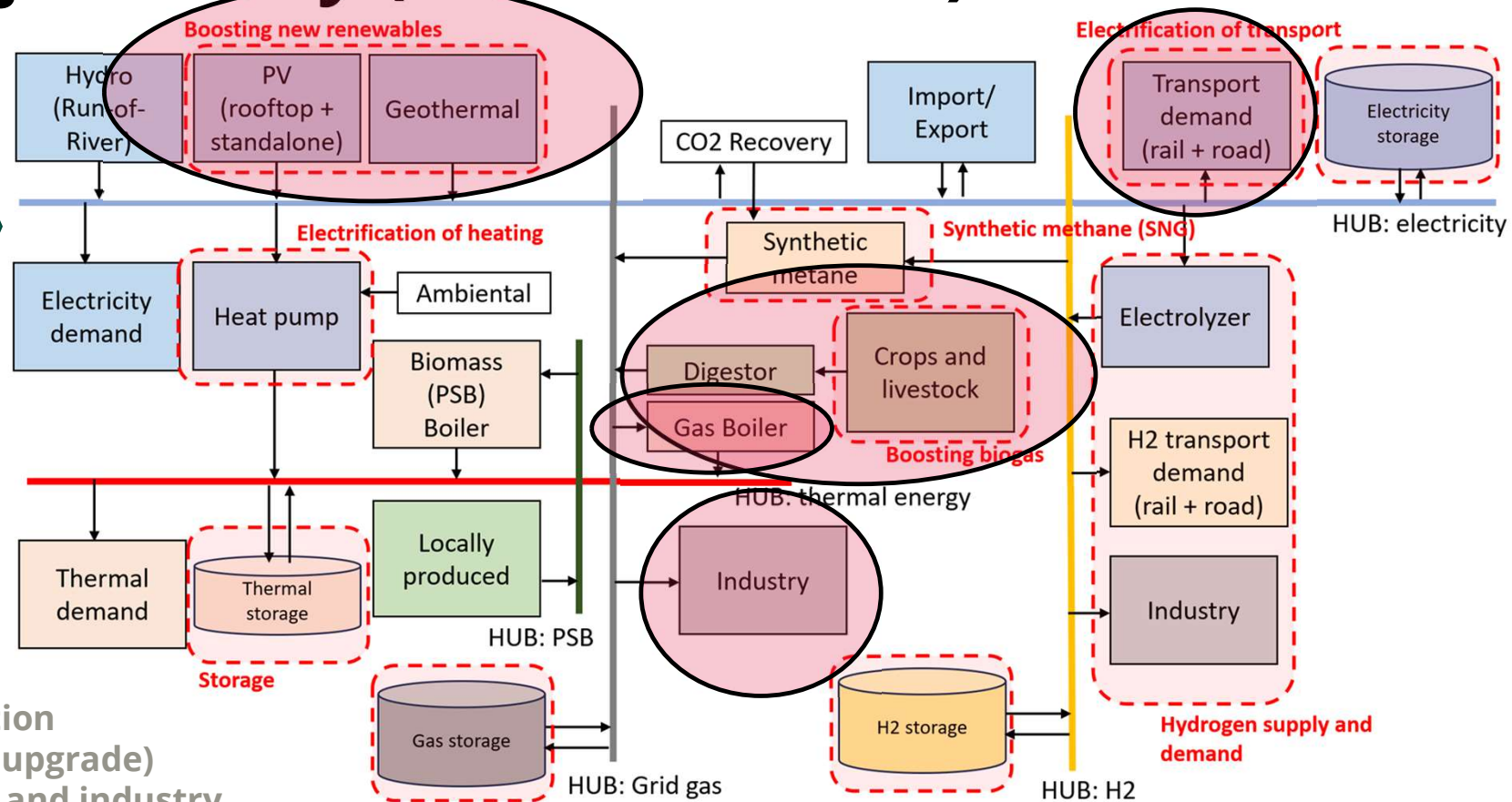
Main features:

1. boosting hydrogen production
2. hydrogen in transport
3. synthetic methane to grid gas
4. hydrogen in industry
5. boosting up renewables (primary source)

The structure of the far-future energy system for Međimurje County (main features)

Development of far-future energy scenarios for Međimurje County:

- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- Extensive biogas (S-Biogas)
- Target: 2050



S-Biomass

Main features:

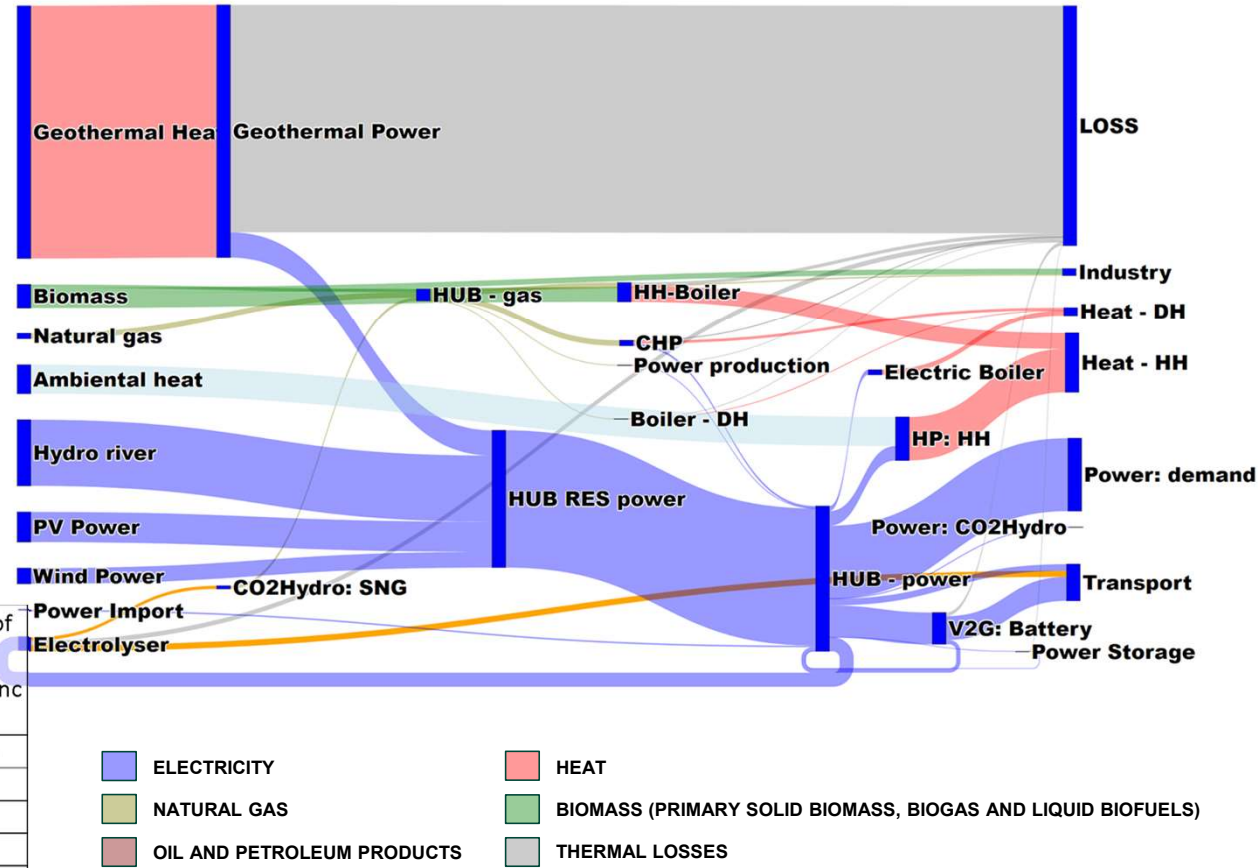
1. boosting biogas production
2. biogas to grid gas (after upgrade)
3. keep grid gas in heating and industry
4. electricity in transport
5. boosting up renewables + biogas (primary source)

Far-future scenario S-ELEC

Development of far-future energy scenarios for Međimurje County:

- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- Extensive biogas (S-Biogas)
- Target: 2050

Međimurje County far future scenario: S-Elec



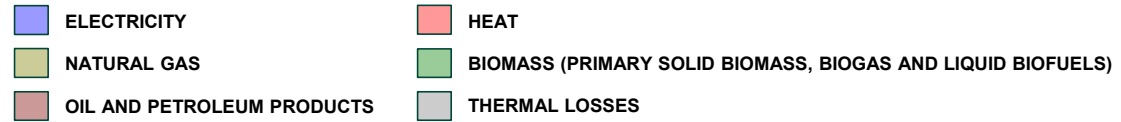
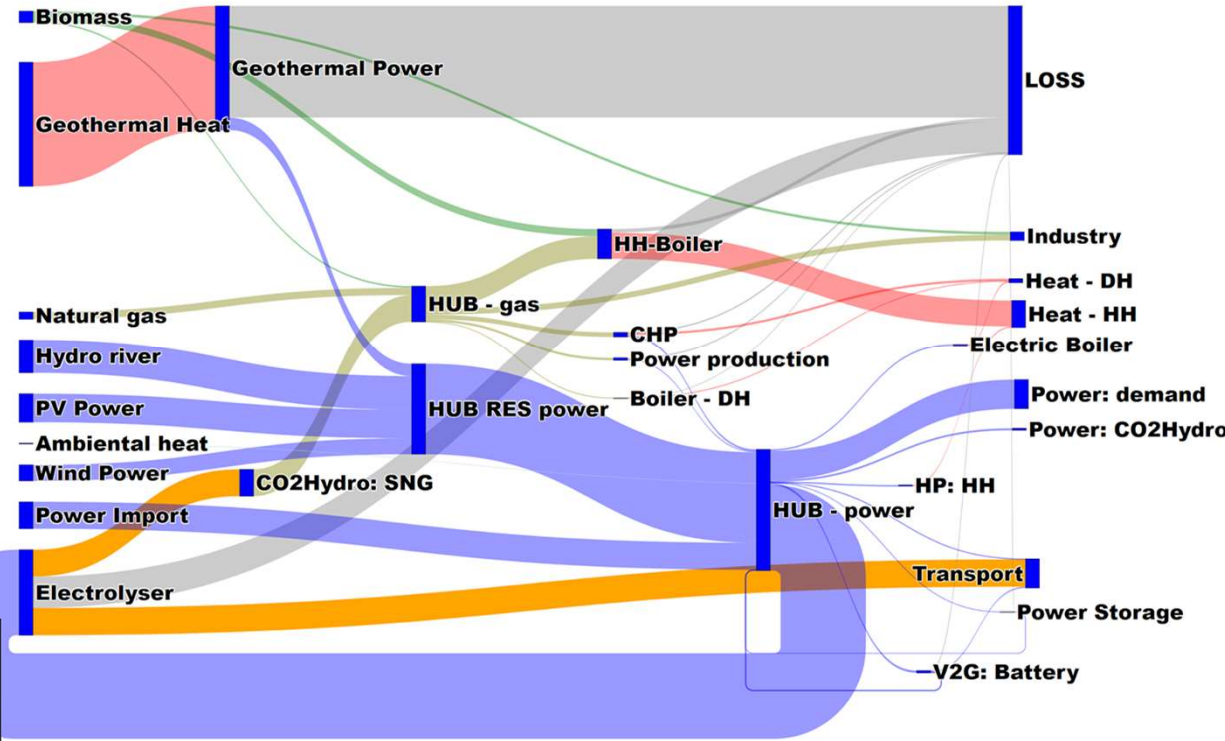
Type of energy	Locally produced	Import	Export	Net import	Local demand	Level of self-sufficiency
	(a)	(b)	(c)	(d) = (b) - (c)	(e)	(a)/(e)
	GWh	GWh	GWh	GWh	GWh	%
Electricity	797	7	0	7	805	99
PSB	68	0	0	0	68	100
GridGas (GG)	38	33	9	25	82	46
Petroleum products	0	0	0	0	0	0
Liquid biofuels	0	0	0	0	0	0
Total	903	41	9	32	954	95

Far-future scenario S-H2/SNG

Development of far-future energy scenarios for Međimurje County:

- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- Extensive biogas (S-Biogas)
- Target: 2050

Međimurje County far future scenario: S-H2/SNG



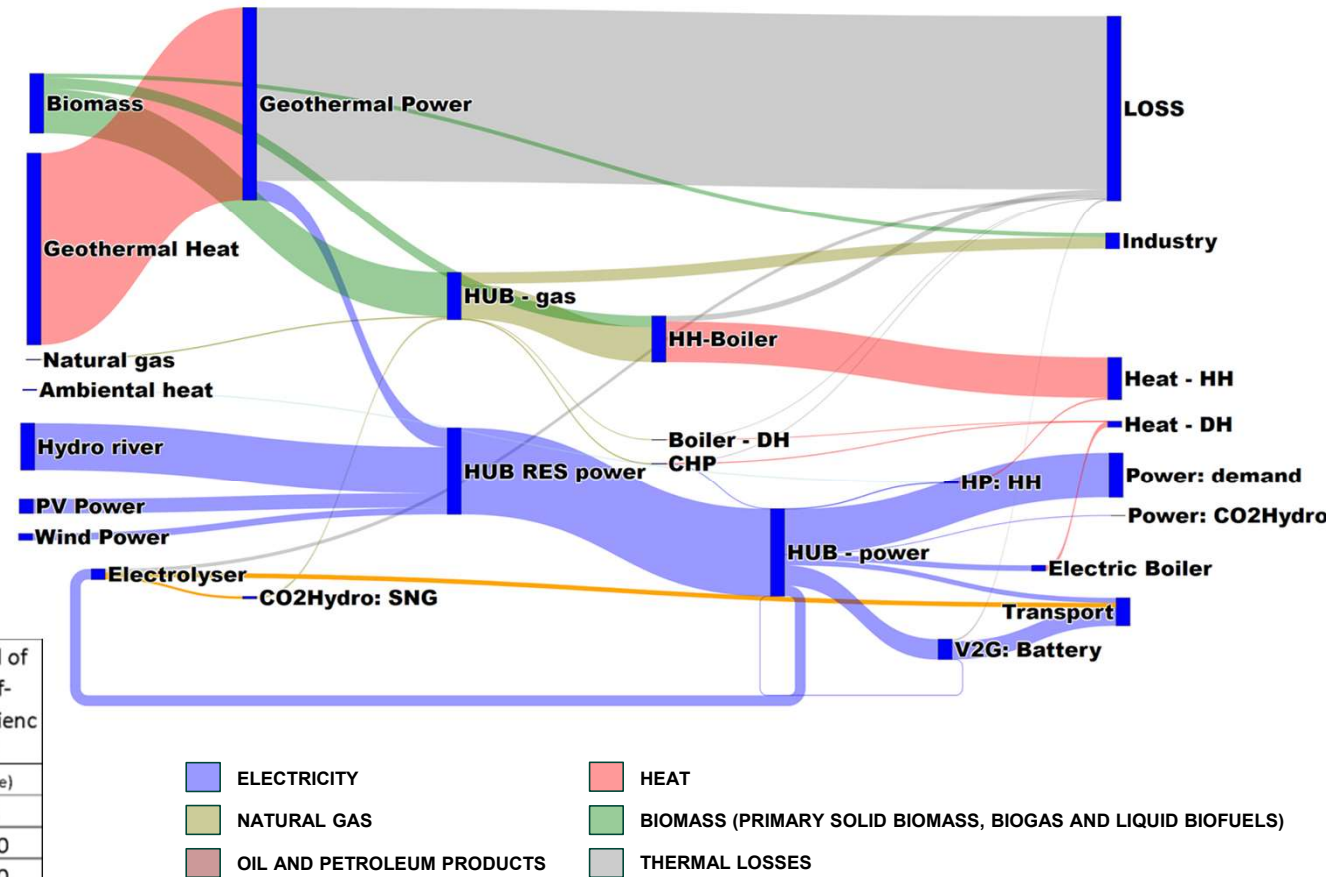
Type of energy	Locally produced	Import	Export	Net import	Local demand	Level of self-sufficiency
	(a)	(b)	(c)	(d) = (b) - (c)	(e)	(a)/(e)
	GWh	GWh	GWh	GWh	GWh	%
Electricity	1072	300	0	300	1372	78
PSB	72	0	0	0	72	100
GridGas (GG)	323	116	64	52	413	78
Petroleum products	0	0	0	0	0	0
Liquid biofuels	0	0	0	0	0	0
Total	1466	417	64	353	1857	79

Far-future scenario S-Biogas

Development of far-future energy scenarios for Međimurje County:

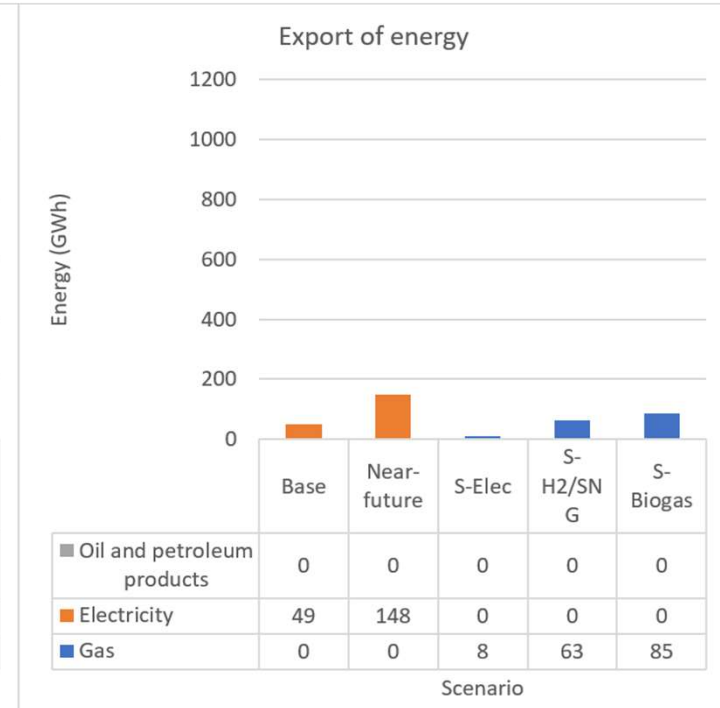
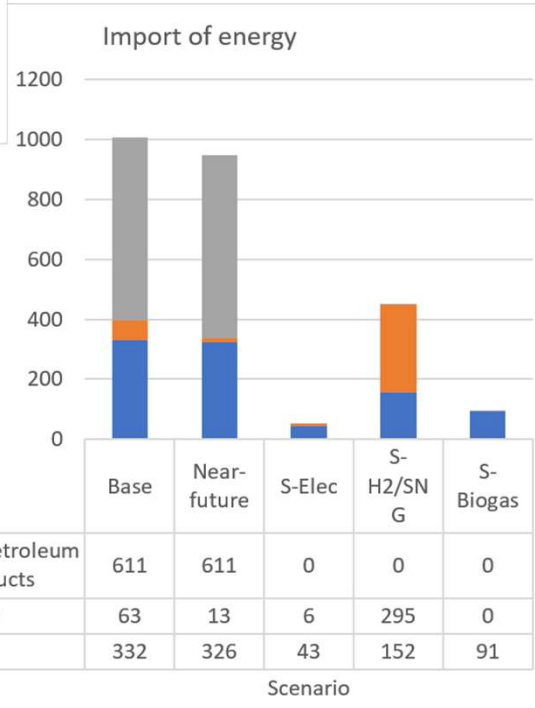
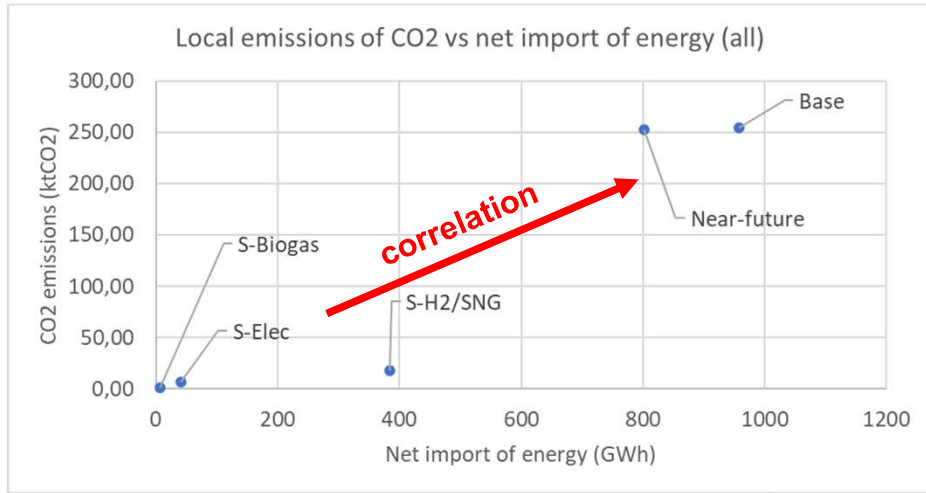
- Extensive electrification (S-ELEC)
- Hydrogen/Synthetic Natural Gas (S-H2/SNG)
- **Extensive biogas (S-Biogas)**
- Target: 2050

Međimurje County far future scenario: S-Biogas



Type of energy	Locally produced	Import	Export	Net import	Local demand	Level of self-sufficiency
	(a)	(b)	(c)	(d) = (b) - (c)	(e)	(a)/(e)
	GWh	GWh	GWh	GWh	GWh	%
Electricity	638	0	0	0	638	100
PSB	72	0	0	0	72	100
GridGas (GG)	344	93	85	8	353	98
Petroleum products	0	0	0	0	0	0
Liquid biofuels	0	0	0	0	0	0
Total	1054	93	85	8	1063	99

Comparative analysis of all scenarios



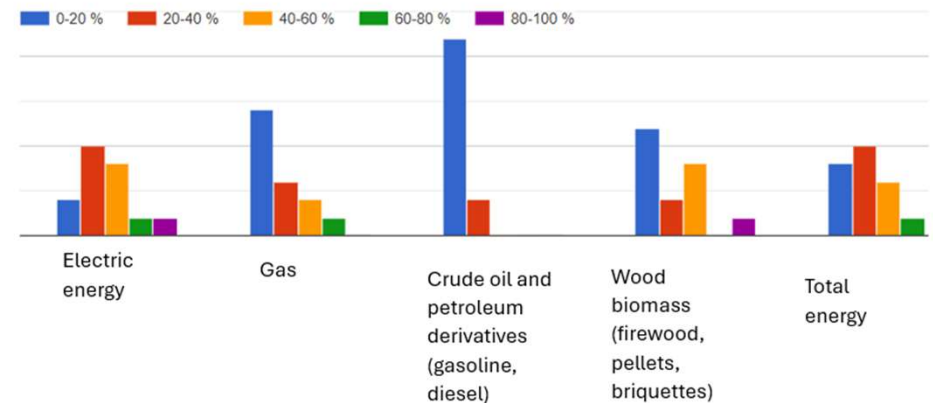
SWOT analysis for energy sector of Međimurje County

<p><u>Strengths</u></p> <p>100% of households and non-households have access to electricity.</p> <p>78% of households and 72% of entrepreneurships have access to a gas network.</p> <p>Large share of electricity produced locally in hydroelectric power plants with moderate to high-capacity factors.</p> <p>Strong agriculture related to both crop and livestock farming.</p>	<p><u>Weaknesses</u></p> <p>Transport sector is fully relying on fossil oil derivatives (like in the rest of the Republic of Croatia). Fossil oil derivatives in Međimurje County are fully relying on import. Public transportation is very weak and inadequate.</p> <p>Fossil gas is extensively used for heating.</p> <p>Extensive use of fossil gas in industry sector.</p>
<p><u>Opportunities</u></p> <p>Electrification of heating to reduce dependency on fossil gas.</p> <p>Electrification of transport to reduce dependency on oil derivatives.</p> <p>Installation of new biogas production facilities for utilisation of biogas potential in decarbonization of grid gas. Installation of biorefineries for production of liquid biofuels and biogas.</p> <p>Installation of new renewable energy sources (rooftop and standalone PV and geothermal).</p>	<p><u>Threats</u></p> <p>Climate-change related decline in hydroelectric power plant production due to river water level drop and reduced rainfalls.</p> <p>Further decline in oil and gas production in the Republic of Croatia.</p> <p>Financial burden for energy storage systems for local balancing of intermittent renewable energy sources.</p>

Survey on public perspective on energy self-sufficiency and the use and representation of renewable energy sources and energy efficiency measures

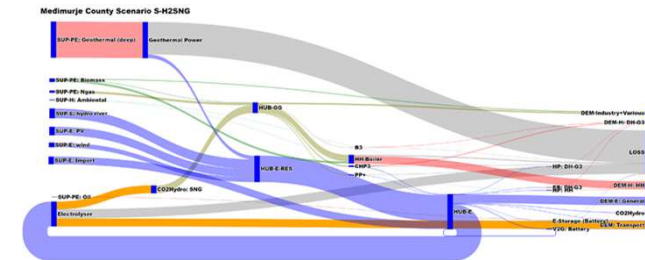
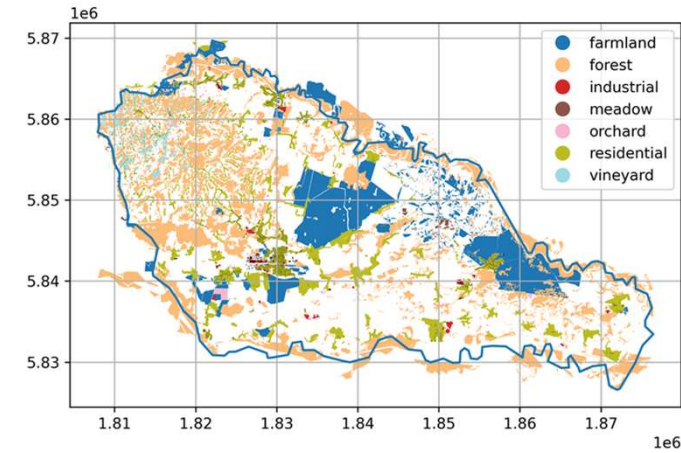
- Survey was divided between physical persons and legal entities
- 73% of physical persons and 88% of legal entities are aware of the term “Energy self-sufficiency” and majority of them are correctly assuming the high level of Croatia’s import dependency on crude oil, gas and electricity
- 88% of physical persons and 100% of legal entities think that Croatia should have greater coverage of energy consumption with own production
- 46% of physical persons and 66% of legal entities intend to invest in measures to increase the energy efficiency within the next two years

17. According to your knowledge or opinion, what is the coverage of consumption by own energy production in the Republic of Croatia? Please evaluate separately for each listed type of energy source.



Conclusions

- Primary energy production of Međimurje County is dominated by the **hydroelectric power plants** and **primary solid biofuel**, while **natural gas and oil derivatives are mainly of fully imported**
- **Međimurje County is currently 37% self-sufficient**, with high shares of self-sufficiency for electricity and primary solid biofuels, and low or extremely low values of self-sufficiency for natural gas and liquid biofuels
- Far-future scenarios have been developed: all three scenarios managed to increase the **level of self-sufficiency in the range between 79-99%**, with **best results achieved in Biogas scenario**
- The performed SWOT analysis indicate great opportunity for Međimurje County to increase the level of self-sufficiency with **local biogas production** and **electrification of transport**
- Results of the survey show that **majority of public is aware of the term energy self-sufficiency** and think that level of self-sufficiency **should be increased**; majority of public is **open** towards renewables and increasing energy efficiency

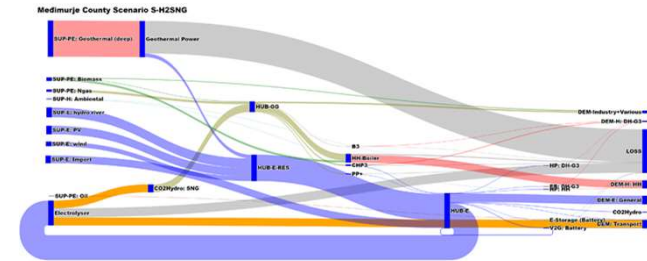
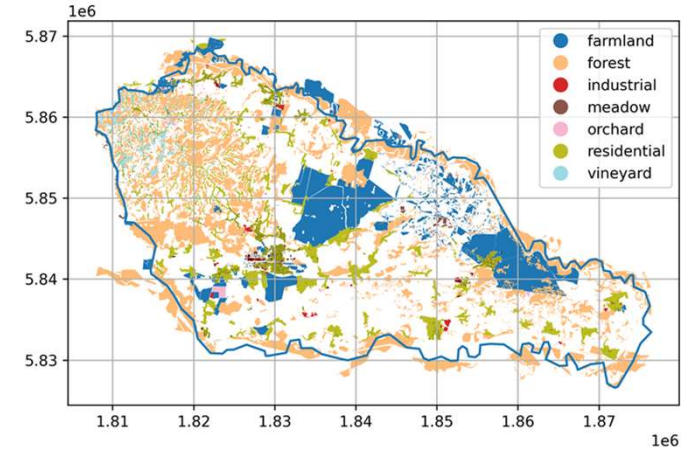


Perspektiva javnosti o energetskej samodostatnosti te korištenju i zastupljenosti obnovljivih izvora energije i mjera energetske efikasnosti

Thank you!

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Time for questions



Perspektiva javnosti o energetskejoj samodostatnosti te korištenju i zastupljenosti obnovljivih izvora energije i mjera energetske efikasnosti

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