CONCERTO COMMUNITIES IN EU DEALING WITH OPTIMAL THERMAL AND ELECTRICAL EFFICIENCY OF BUILDINGS AND DISTRICTS, BASED ON MICROGRIDS

WP 3.3. - Del 3.3.2.

Detailed design specifications of Szentendre energy systems

Final version

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Index

LIST OF ABBREVIATIONS

RES	Renewable energy sources
RUE	Rational Use of Energy
DHW	Domestic hot water
CHP	Combined heat and power (cogeneration)
HP	Heat Pump
PV	Photovoltaic
BIPV	Building Integrated Photovoltaic
FF	Fill factor
CP	Community Parameters
BP	Building Parameters
DA	Dissemination Activities
DC	Direct Current
AC	Alternating Current

1. Introduction

Detailed design specifications of Szentendre energy systems in this document will be based on the planned renewable energy generation measures of Concerto area in Szentendre. Site map of the Concerto area can be seen on Figure 1.1.

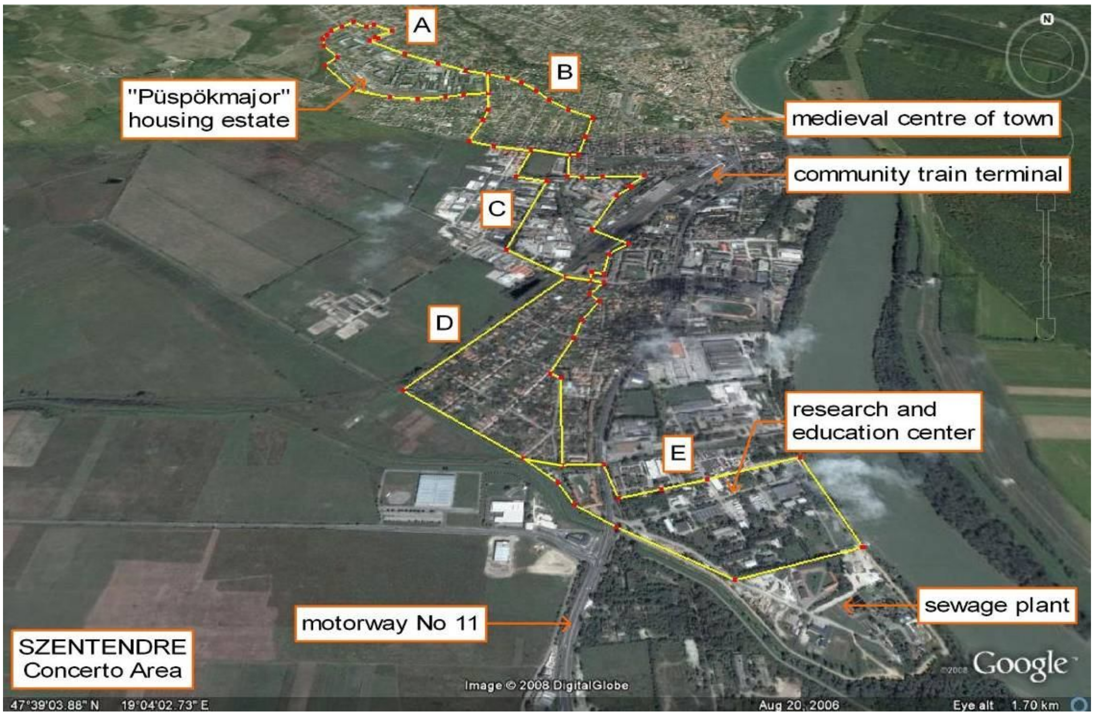

Figure 1.1: PIME'S area in Szentendre, Hungary

The description of the PIME'S areas in Szentendre can be found in Table 1.1.

Table 1.1: Description of the PIME'S area in Szentendre, Hungary

Area	**Name**	**Description**
A	"Püspökmajor" housing estate	Residential area and district heating center, buildings under refurbishment
B	Family house area	Residential area
C	Industrial area	Industrial area, local heat centre and office under refurbishment
D	"Pannónia" estate	Residential area
E	Research and Education Centre	Industrial area, offices and labs, office partly heated by sewage plant to be constructed

Figure 1.2 shows the residential area A of Szentendre.

Figure 1.2: Air shot of residential area A in Szentendre.

Figure 1.3 shows the satellite photo of the site of the City Service Company in area C.

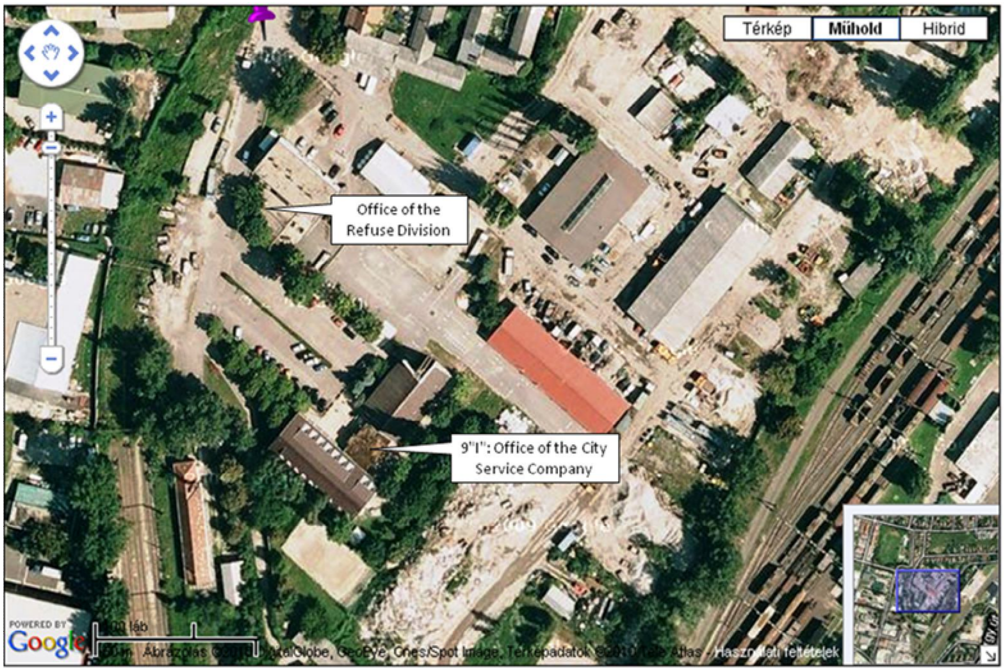

Figure 1.3: Satellite photo of the industrial area / Central Site of the City Service Company (located in area C)

Figure 1.4 shows the Research and Education Centre and the neighbour sewage plant in area E, which will provide green energy based on sewage heat and gas.

Figure 1.4: Satellite photo of the Research and Education Centre and the sewage plant (located in area E)

The energy system of Szentendre demonstration sites consists of 3 CHPs, which dimensioned for the local opportunities (eg. biogas) and demand needs as well as for the favourable size (ORC system).

This system is supplemented by the solar thermal system, where the seasonable storage is not really enforceable, so the installation of it is questionable based on the research. On the site of ÉMI the solar collector helps to meet the higher temperature needs, because the heat pump is effective at low temperature.

The system is supplemented by diversificately located PV systems, which will probably expand as time goes by and as the specific price of the systems decreases. The adhere of a wind power plant to the system on the Danube bank west from the estate is also argued, but it exceeds the time and the budget scope of the current project.

The planning is hindered by the fact that the appearance of the METÁR is delayed, so there is no possibility to start the economic planning of the receiving of green power and the accurate calculations of returns, thus making difficult the realisation of investors.

The building of the system has been begun on the site of ÉMI and the completion is scheduled by the end of 2013. The bases of the planning are presented in detail in the case study chapters of Deliverables 2.4.3 and 2.4.5. Here the main specifications are presented in English and the detailed plans are attached. The planning of the VSZ Zrt. and the ORC gas engine will be tendered by the second half of 2012 and early 2013.

2. Integration of sewage based heat pump system with biogas engine located at the ÉMI site (area E)

2.1. History

The engineering plan documentation titled „The gas engine and heat pump operated heat and cold energy producing and supplying centre to be established in the ÉMI area of the Szentendre industrial park" was issued in July 2011. Based on the request of the client, it has been modified several times, mainly in order to decrease implementation costs.

In September 2011 the client decided to separate the implementation into two steps because of the changes in prices caused by the economic crisis and the reduction of financial resources.

The system to be built in the first step will probably operate permanently. The realization of the second step is uncertain, but after the implementation of the first according to our plans, from an engineering point of view the second step can be easily connected to it. The new schedule influences the implementation plans of electricity transmission, control technology and the heat and cold energy pipeline, but it does not influence those of building engineering, biogas and treated sewage technology.

In the second step the HFES1-2 pumps need to be replaced and the cold energy pipeline has to be expanded to ensure cold energy supply.

The independently operable facility, established according to plan, is capable of meeting the planned heat and cooling demand in the first step.

The facility to be implemented in the first step is capable:

In the winter period: to supply max. 600 kW heat energy (with the parallel operation of the HS1-2 heat pump and the GM biogas engine; in the case of breakdown of the biggest unit: to supply min. 230 kW).

In the transitional period: to supply min. 100 kW cooling and max. 500 kW heating energy depending on the heat pump chosen for operation; or max. 370 kW cooling and min. 230 kW heating energy.

In the summer period: to supply max. 470 kW cooling energy (with the operation of the HS1-2 heat pump; in the case of breakdown of the biggest unit: to supply min. 100 kW).

2.2. Introduction

The gas engine and heat pump operated heat and cold energy producing and supplying centre to be established in the ÉMI area of the Szentendre industrial park will provide an office building to be erected with complete heat and cold energy supply on a renewable basis.

Figure 2.1: Air shot and planned buildings and facilities of the Szentendre industrial park.

One of the financial resources of the technical solution is won in the Concerto program and ÉMI has undertaken the implementation, which is separated into two steps.

Initial basic data according to the pre-feasibility study of METeOR Bt.

Heat and cold energy consumers:

Consumer object	Heating [kW]	Cooling[kW]
ÉMI	224	200
CAMPUS	600	536

Hall (laboratory)	371	436
ÉMI office building	644	595
Altogether:	1,839	1,767

In the first step of the implementation the substation can provide ~470 kW cold energy and ~600 kW heat energy at 5/12 °C and 45/35 °C respectively.

The renewable energy source is treated sewage water from the nearby Szentendrei sewage treatment plant (SZSZT) owned by the Duna Menti Regionális Vízmű Zrt. (DMRV), from which the source-side energy for the heat pumps can be provided through a separating heat exchanger.

The fuel for the biogas engine is the biogas generated in the maturing containers of the sewage treatment plant. According to DMRV the amount of sewage water at night is not enough for the maximum nominal output of the energy centre in its eventual form. However, the amount of sewage water at night needed to feed the heat and cold energy facilities supplying the office building to be erected in the first step is available at the moment. DMRV also said that in the near future after the installation and connection of sewage systems in the neighbouring villages, the amount of sewage water to be treated - the heat source - will increase. It means that the amount of sewage water available at night as a heat source will also be on the rise. In the case of increasing heat and cold energy demand, this additional heat source can also be taken into consideration.

In the energy centre heat and cold energy is generated by a 100 kW and a 370 kW output heat pump and a 130 kW output biogas engine to be installed in the firs step. In the second step two 770 kW output heat pumps will be installed, raising the nominal maximum output of the heat center to 2010 kW. The total output of the heating system will be defined by the future consumer demand (excluding the office building).

The size and diameters of the pipelines in the energy centre are planned according to the heat output after the implementation of the second step. For the heat pumps to be installed in the second step the suitable pipeline connecting joins will be shaped both on the source and the consumer side.

If the sewage water demand of the energy centre, expanding parallel with the growing heat and cold energy demand, increases faster or on a larger scale than the expansion of the sewage treatment plant, installation of another facility (e.g. a natural gas-fired hot water boiler) will be necessary to provide the heat and cold energy output needed.

IMPORTANT!

The parts of the energy centre will be chosen in a public procurement procedure, so the facilities and their sizes can change according to and after the result of the procedure!!!

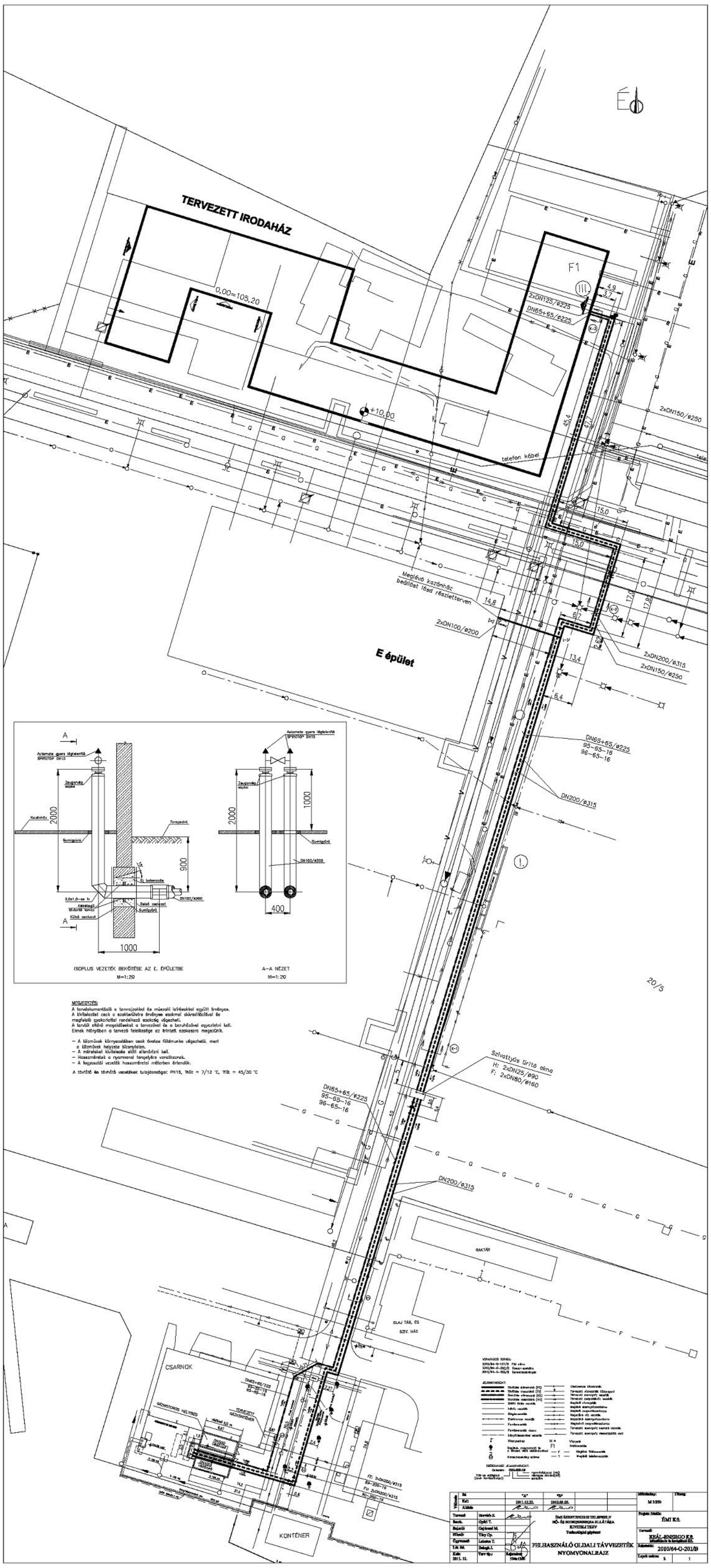

Figure 2.2: Design of the new pipelines at the user side.

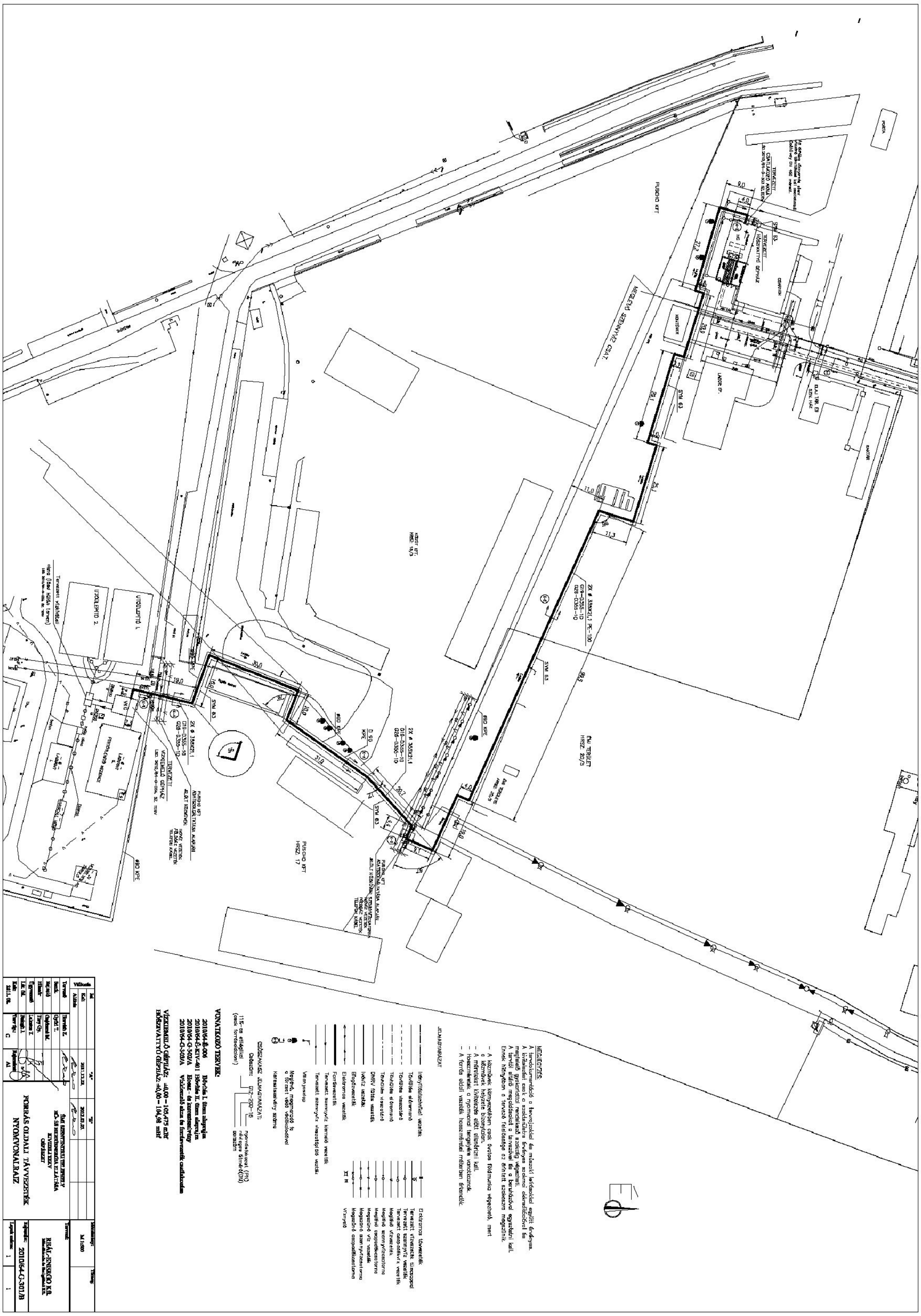

Figure 2.3: Design of the new pipelines at the source side.

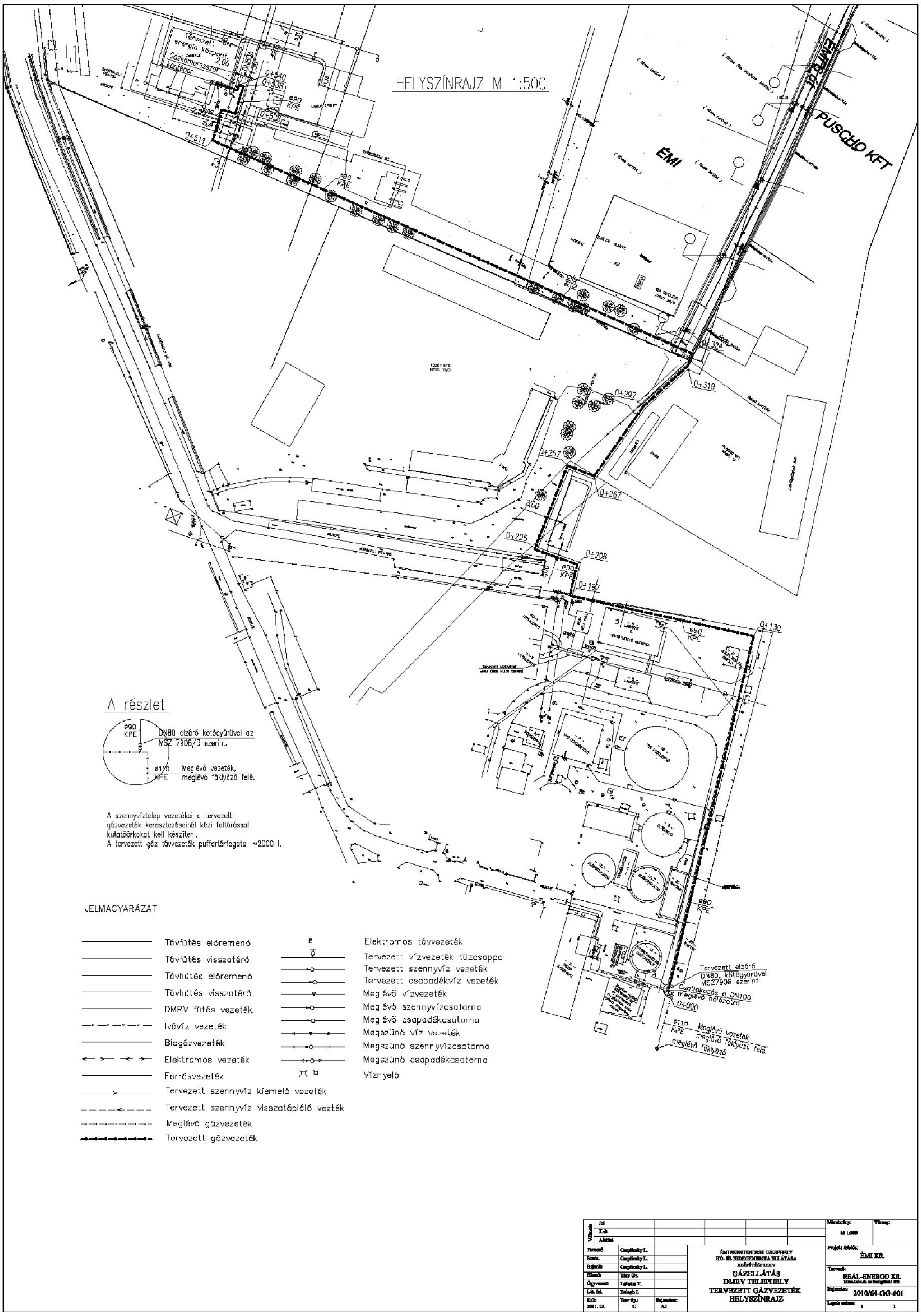

Figure 2.4: Design of the new gas pipeline.

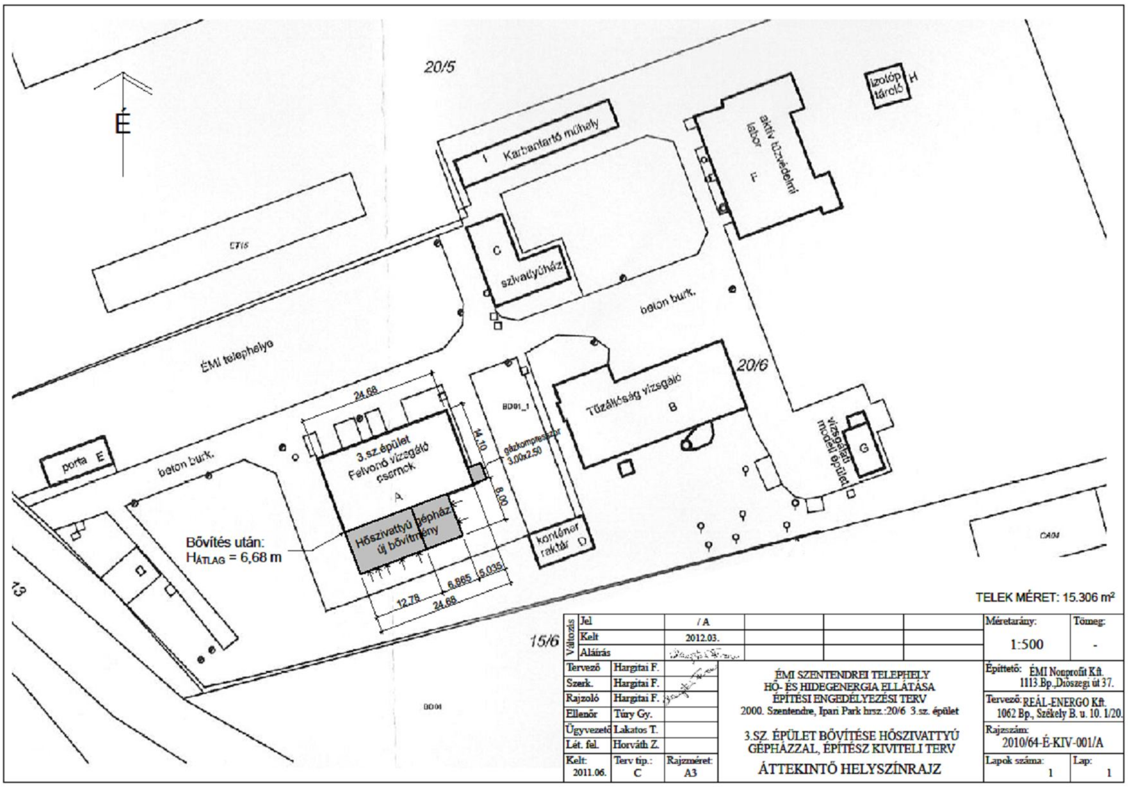

Figure 2.5: Design of the site for new building for heat pumps.

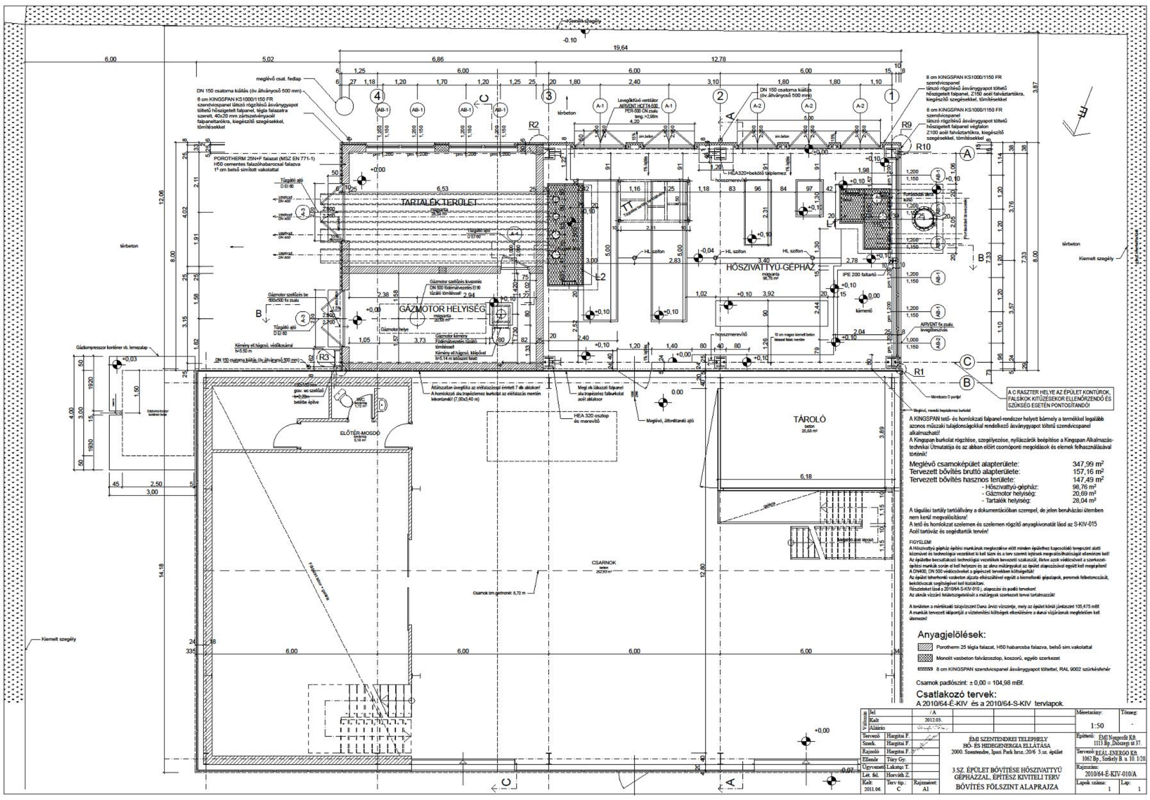

Figure 2.6: Design of the new building for heat pumps.

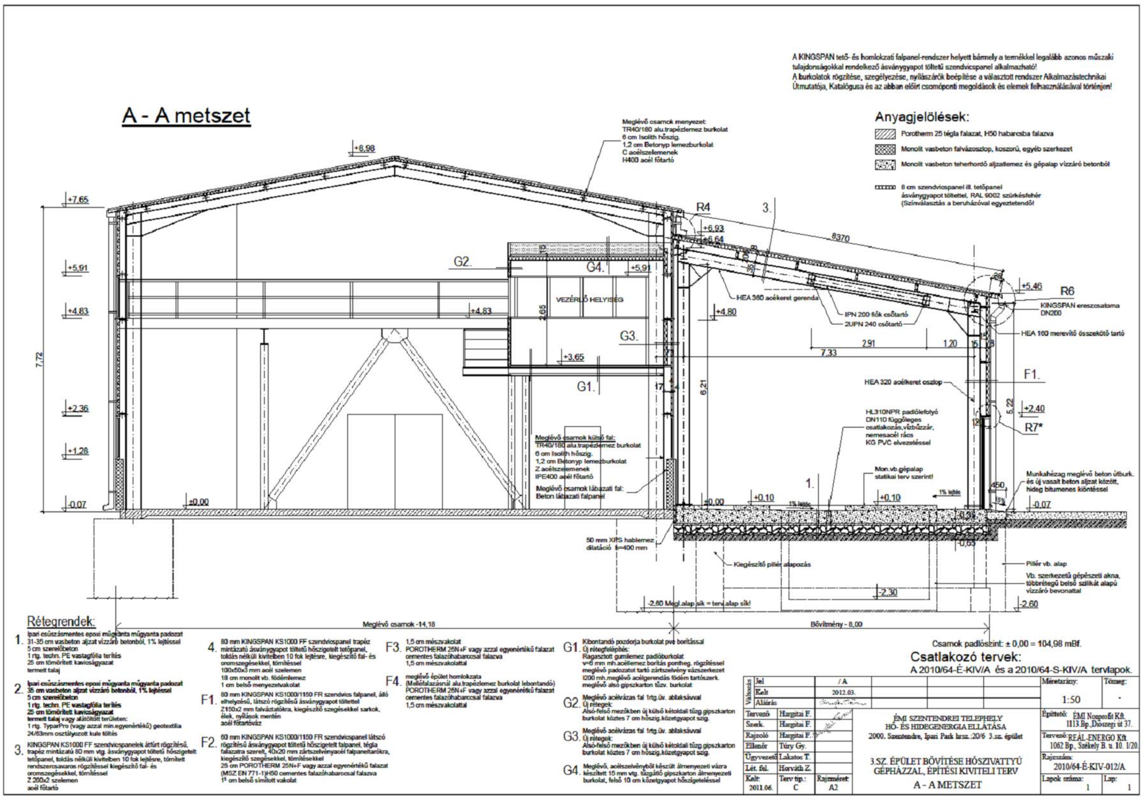

Figure 2.7: Cross section design of the new building for heat pumps

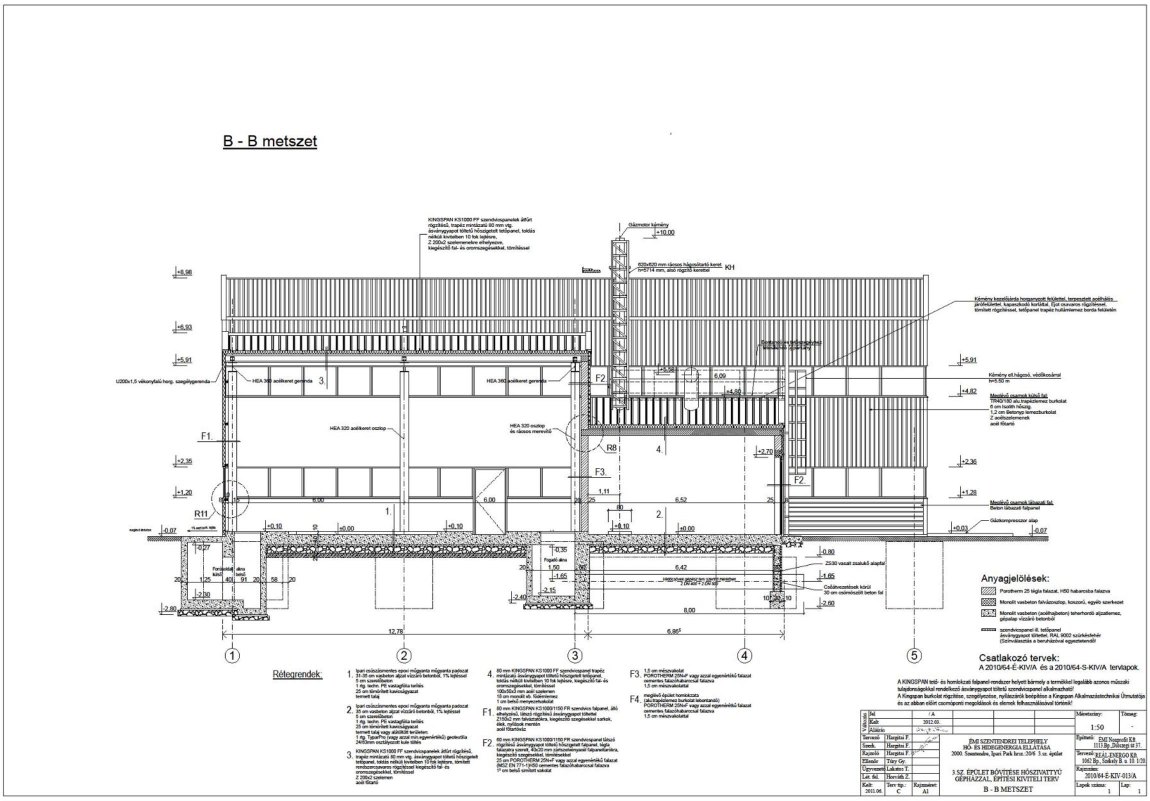

Figure 2.8: Cross section design of the new building for heat pumps

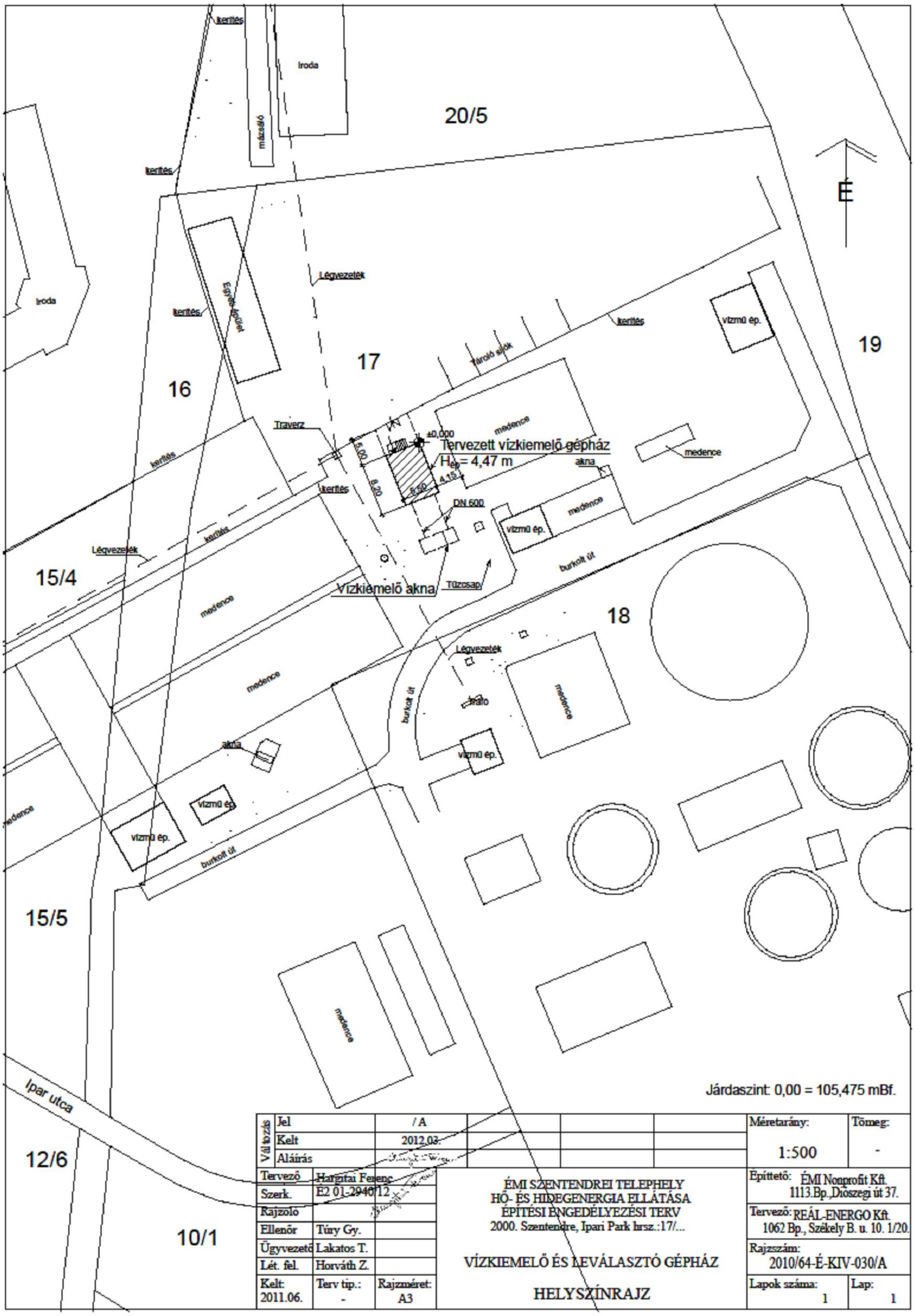

Figure 2.9: Design of the site for building for water lifter.

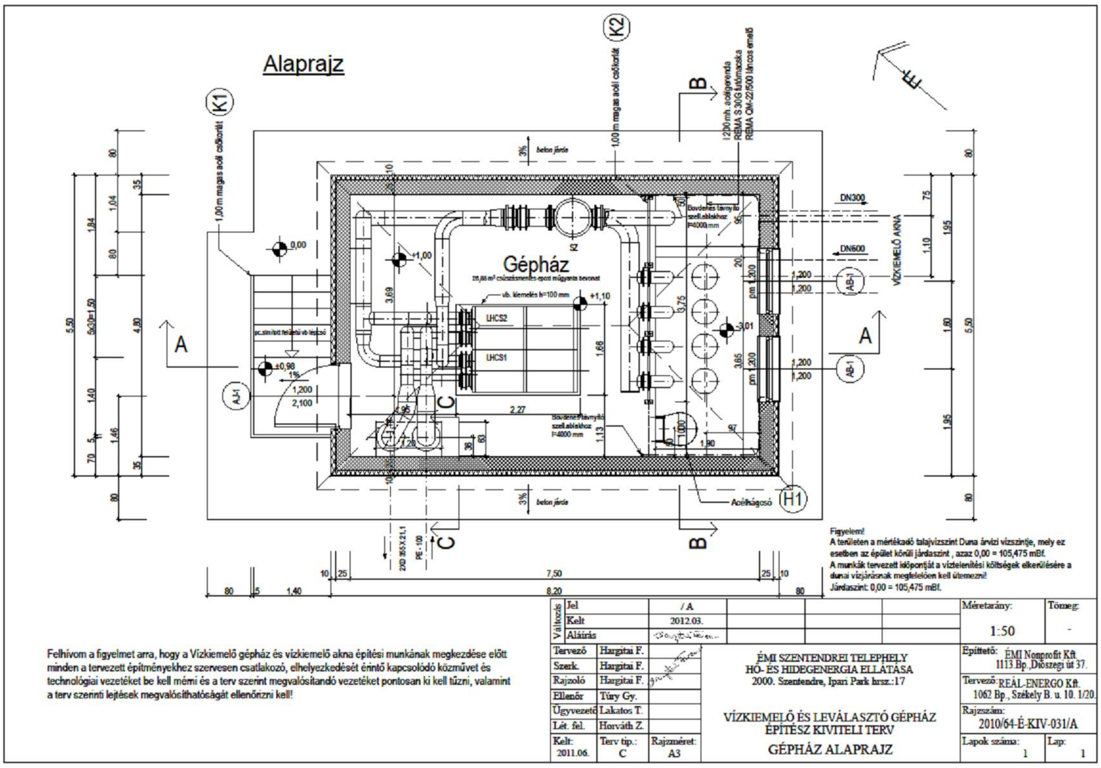

Figure 2.10: Design of the building for water lifter

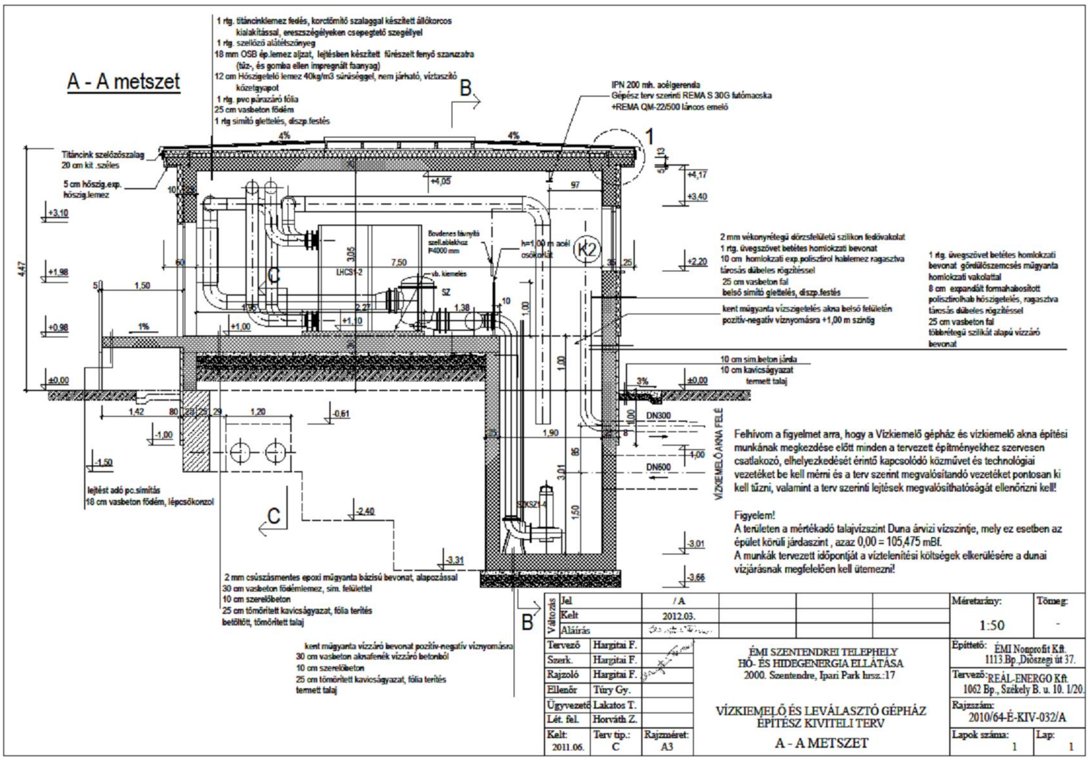

Figure 2.11: Cross section design of the building for water lifter.

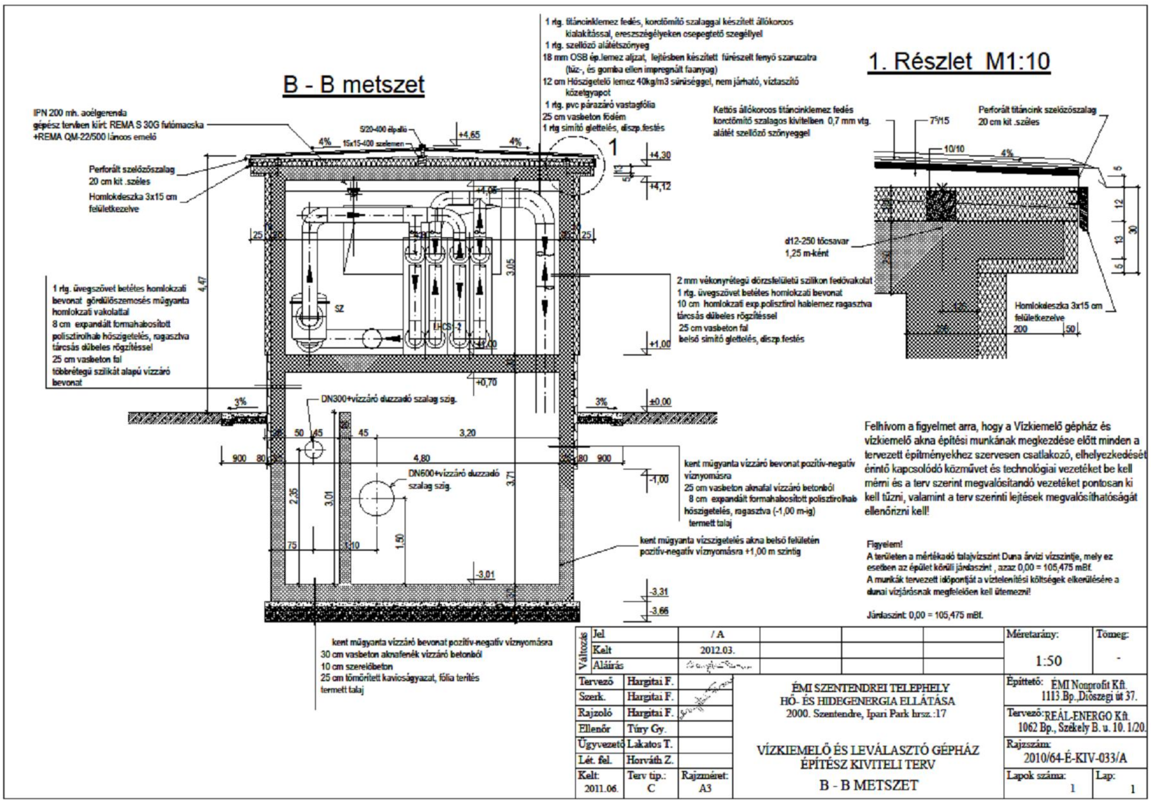

Figure 2.12: Cross section design of the building for water lifter.

2.3. Items to be installed in the first step

2.3.1. SZKS1÷2 sewage water-lifting submersible pump with built-in frequency converter

Type:	KSB Amarex KRTK 150-315/234UG or similar,
Amount:	2 pieces
Nominal flow rate:	~109.6÷77.1-m3/h,
Nominal delivery head:	~30÷22 m,
Max. output:	~15.2 kW,
Supply voltage:	3x400 V,
Connection size:	DN 200,
Nominal pressure rating:	PN 16,
Fluid:	sewage water,
Fluid temperature:	max. 30 °C.

2.3.2. FOKS1÷2 source-side circulation pump with built-in frequency converter

Type:	GRUNDFOS CLM 200-300-37.0 or similar,
Amount:	2 pieces
Nominal flow rate:	~438.5÷308.4 m3/h in the second step,
Nominal delivery head:	~19.6÷9.7 m in the second step,
Nominal flow rate:	~307÷154 m3/h in the first step,
Nominal delivery head:	~21.3÷11 m in the first step,
Max. output:	~28.8 kW,
Supply voltage:	3x400 V,
Connection size:	DN 250/200,
Nominal pressure rating:	PN 16,
Fluid:	glycolised water,
Fluid temperature:	max. 30 °C.

2.3.3. HSFOS1 and HS1 heat pump and source-side circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 65-180/2-S or similar,
Amount:	1 piece,
Nominal flow rate:	~20.6÷13.4 m3/h,
Nominal delivery head:	~6.6÷2.8 m,
Max. output:	~0.6 kW,
Supply voltage:	3x400 V,
Connection size:	DN 65/65,
Nominal pressure rating:	PN 16,
Fluid:	glycolised water,
Fluid temperature max./min.:	30/7 °C.

2.3.4. HSFOS2 and HS2 heat pump and source-side circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 100-110/4 or similar,
Amount:	1 piece,
Nominal flow rate:	~75.4÷49.2 m3/h,
Nominal delivery head:	~7.3÷3.1 m,
Max. output:	~2.6 kW,
Supply voltage:	3x400 V,
Connection size:	DN 100/100,
Nominal pressure rating:	PN 16,
Fluid:	glycolised water,
Fluid temperature max./min.:	30/7 °C.

2.3.5. HSFES1 and HS1 heat pump and source-side circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 50-180/2-S or similar,
Amount:	1 piece,
Nominal flow rate:	~16.1÷11.0 m3/h,
Nominal delivery head:	~4.1÷1.9 m,
Max. output:	~0.3 kW,
Supply voltage:	3x400 V,
Connection size:	DN 50/50,
Nominal pressure rating:	PN 16,
Fluid:	pipeline water,
Fluid temperature max./min.:	45/5 °C.

2.3.6. HSFES2 and HS2 and heat pump and source-side circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 100-90/4 or similar,

Amount:	1 piece,
Nominal flow rate:	~59.2÷40.2 m3/h,
Nominal delivery head:	~5.0÷2.5 m,
Max. output:	~1.4 kW,
Supply voltage:	3x400 V,
Connection size:	DN 100/100,
Nominal pressure rating:	PN 16,
Fluid:	pipeline water,
Fluid temperature max./min.:	45/5 °C.

2.3.7. HKS1-2 consumer side cooling circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 32-380/2 or similar,
Amount:	2 pieces,
Nominal flow rate:	~16.1 m3/h,
Nominal delivery head:	~25.6 m,
Nominal output:	~1.9 kW,
Supply voltage:	3x400 V,
Connection size:	DN 32,
Nominal pressure rating:	PN 16,
Fluid:	pipeline water,
Fluid temperature:	max. 5 °C.

2.3.8. HKS/FKS1-2 consumer side cooling/heating circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 125-160/4 or similar,
Amount:	2 pieces,
Nominal flow rate:	~172÷51.6 m3/h,
Nominal delivery head:	~9.5÷7.1 m,

Max. output:	~9.5 kW,
Supply voltage:	3x400 V,
Connection size:	DN 100,
Nominal pressure rating:	PN 16,
Fluid:	pipeline water,
Fluid temperature max./min.:	45/5 °C.

2.3.9. GKS gas engine circulation circle pump

Type:	GRUNDFOS TPE 40-270/2 or similar,
Amount:	1 piece,
Nominal flow rate:	~5.6 m3/h,
Nominal delivery head:	~11.5 m,
Max. output:	~0.3 kW,
Supply voltage:	3x400 V,
Connection size:	DN 40/40,
Nominal pressure rating:	PN 16,
Fluid:	gas engine cooling water,
Fluid temperature:	max. 70 °C.

2.3.10. GHKS gas engine heat exchanger circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 40-180/2-S or similar,
Amount:	1 piece,
Nominal flow rate:	~11.7 m3/h,
Nominal delivery head:	~9.7 m,
Max. output:	~0.5 kW,
Supply voltage:	3x400 V,
Connection size:	DN 50/50,
Nominal pressure rating:	PN 16,

Fluid:	pipeline water,
Fluid temperature:	max. 45 °C.

2.3.11. KHKS forced cooling heat exchanger circulation pump with built-in frequency converter

Type:	GRUNDFOS TPE 65-180/2-S or similar,
Amount:	1 piece,
Nominal flow rate:	~22.0 m3/h,
Nominal delivery head:	~6.7 m,
Max. output:	~0.7 kW,
Supply voltage:	3x400 V,
Connection size:	DN 65/65,
Nominal pressure rating:	PN 16,
Fluid:	glycolised water,
Fluid temperature:	max. 30 °C.

2.3.12. HS1 heat pump with compressor

Type:	Climaventa S.p.A. NECS-WN 0352, or similar,	
Amount:	1 piece,	
Nominal pressure rating:	PN 16,	
Connection size:	DN 65/65,	
Operation mode:	heating	cooling,
Heat output:	~100 kW	~94 kW,
Electric power consumption:	~23 kW	~27 kW,
Source side glycolised water flow rate:	~13 t/h	~21 t/h,
Consumer side flow rate:	~11 t/h	~16 t/h,
Source side temperature in/out:	7/2 °C	30/35 °C,
Consumer side temperature in/out:	37/45 °C	10/5 °C,
Source side loss hight:	~16 kPa	~37 kPa,

Consumer side loss hight:	~10 kPa	~21 kPa.

2.3.13. HS2 heat pump with compressor

Type:	Climaventa S.p.A. NECS- 1204, or similar,	
Amount:	1 piece,	
Nominal pressure rating:	PN 16,	
Connection size:	DN 65/65,	
Operation mode:	heating	cooling,
Heat output:	~370 kW	~344 kW,
Electric power consumption:	~85 kW	~100 kW,
Source side glycolised water flow rate:	~49 t/h	~75 t/h,
Consumer side flow rate:	~40 t/h	~59 t/h,
Source side temperature in/out:	7/2 °C	30/35 °C,
Consumer side temperature in/out:	37/45 °C	10/5 °C,
Source side loss hight:	~18 kPa	~43 kPa,
Consumer side loss hight:	~11 kPa	~25 kPa.

2.3.14. GM gas engine

Type:	ENER-G 80B (MERCEDES), or similar,
Fuel:	biogas (min. 60 % CH_4, max. 0,1 % S content),
Amount:	1 piece,
Gas output:	~260 kW,
Thermal output:	~130 kW,
Electricity output:	~80 kW,
Efficiency min.:	~80 %,
Water temperature:	70/90 °C,
Electrical voltage:	0.4 kV,
Noise level from 1 m:	65 dB(A).

2.3.15. K gas engine chimney

Type:	EDILMAT ASTRA, or similar,
Amount:	1 piece,
Design:	self-supporting, double-walled, preinsulated, with standard kit
Material:	stainless steel
Diameter:	Ø 200/ Ø300 mm,
Height:	~10 m.

2.3.16. FOHV standing cylinder, source side hydraulic converter with instrument and drain stubs and supporting structure

Type:	Flamco FlexBalance F300, or similar,	
Amount:	1 piece, ~1.8 m3	
Nominal pressure rating:	PN 16,	
Connection size:	4×DN 300,	
Operation mode:	heating	cooling,
Source side flow rate:	~96.1-310 t/h	~109-440 t/h,
Temperature in/out:	7/2 °C	30/35 °C,

2.3.17. FHV standing cylinder, heating hydraulic converter, with instrument and drain stubs and supporting structure

Type:	Flamco FlexBalance F200, or similar,
Amount:	1 piece, ~0.8 m3
Nominal pressure rating:	PN 16,
Connection size:	4×DN 200,
Max. transferred thermal output:	~2,000 kW,

Consumer side flow rate:	~52.2-172 t/h,
Temperature in/out:	45/35 °C.

2.3.18. HHV standing cylinder, cooling hydraulic converter, with instrument and drain stubs and supporting structure

Type:	Flamco FlexBalance F250, or similar,
Amount:	1 piece, ~1.8 m3
Nominal pressure rating:	PN 16,
Connection size:	×DN 250,
Max. transferred thermal output:	~1,800 kW,
Consumer side flow rate:	~53,7-235 t/h
Temperature in/out:	5/12 °C

2.3.19. SZLHCS1÷2 sewage water separating heat exchanger in heating or cooling source operation mode

Type:	ALFA-LAVAL T20-PFG or similar,	
Amount:	2 pieces,	
Output:	2,000 kW	
	1st side	2nd side
Incoming Fluid:	9, or 22 °C	2, or 35 °C,
Outgoing Fluid:	4, or 28 °C	7, or 30 °C,
Fluid:	treated sewage water	water+11 % glycol,
Flow rate (cooling):	~109-439 t/h	~109-439 t/h,
Flow rate (heating):	~96.1-308 t/h	~96.1-308 t/h,
Pressure drop (cooling):	0.5 bar	0.5 bar,
Connection size:	DN 200	DN 200,
Nominal pressure rating:	PN 10	PN 10.

2.3.20. KHHCS forced cooling heat exchanger

Type:	SONDEX S8a-IT10-30-TLA-LIQUID, or similar,	
Amount:	1 piece,	
Output:	130 kW	
	Warm side	Cool side
Incoming Fluid:	90 °C	30 °C,
Outgoing Fluid:	70 °C	35 °C,
Fluid:	district heating water	water+11 % glycol,
Flow rate:	~5.6 t/h	~22 t/h,
Pressure drop:	0.5 bar	0.5 bar,
Connection size:	DN 32	DN 32,
Nominal pressure rating:	PN 10	PN10.

2.3.21. GLHCS gas engine separating heat exchanger

Type:	SONDEX S8a-IT10-30-TLA-LIQUID, or similar,	
Amount:	1 piece,	
Output:	130 kW	
	Warm side	Cool side
Incoming Fluid:	90 °C	35 °C,
Outgoing Fluid:	70 °C	40°C,
Fluid:	district heating water	district heat. water,
Flow rate:	~5.6 t/h	~11 t/h,
Pressure drop:	0,5 bar	0.5 bar,
Connection size:	DN 32	DN 32,
Nominal pressure rating:	PN 10	PN 10.

2.3.22. FOTÁT source side expansion tank

Type:	Flexcon C600 Ø790-1538 art. no.:17162, or similar,

Amount:	1 piece,
Nominal pressure rating:	PN 6,
Fluid:	water+11 % glycol,
System volume:	~64.5 m3,
Medium fluid temperature:	4.5 °C, 32.5 °C,
Cold pressure of system Pr=:	2.0 bar(a)
Allowed pressure of system Pmeg=:	4.5 bar(a)

2.3.23. FTÁT district heating expansion tank

Type:	Flexcon C600 Ø790-1538 art. no.:17162, or similar,
Amount:	1 piece
Nominal pressure rating:	PN 6,
Fluid:	district heating soft water,
System volume:	~34 m3,
Medium fluid temperature:	40 °C,
Cold pressure of system Pr=:	2.0 bar(a),
Allowed pressure of system Pmeg=:	4.5 bar(a).

2.3.24. HTÁT district cooling expansion tank

Type:	Flexcon C110 Ø484-786 art. no.:17112, or similar,
Amount:	1 piece,
Nominal pressure rating:	PN 6,
Fluid:	district heating soft water,
System volume:	~53 m3,
Medium fluid temperature:	8 °C,
Cold pressure of system Pr=:	2.0 bar(a),
Allowed pressure of system Pmeg=:	4.5 bar(a).

2.3.25. SZESZ sewage water filter

Type:	BWT BOLL 6.18-DN 300 (Mayer Kft.), or similar,	
Amount:	1 piece,	
Nominal pressure rating:	PN 16,	
Connection size:	DN 300,	
Fluid:	treated sewage water,	
Filtering fineness:	500 µm,	
Operation pressure:	2.5-5.5 bar,	
Max. loss hight:	6 m,	
Operation mode:	heating	cooling,
Filter output:	~96.1-310 t/h	~109-440 t/h,
Temperature in/out:	~12 °C	~22 °C.

2.3.26. SZESZ sewage water filter operating compressor

Type: BOGE SRD-SBD-RM series compressor with air-cooling and piston, or similar,

Amount:	1 piece,
Nominal pressure rating:	PN 10,
Operation pressure:	6 bar(t),
Max. operation temperature:	40 °C,
Flow rate:	180 l/p,
Volume of storage tank:	~25 l.

2.3.27. AISZ1-4 engine-driven flow reversing valve

Type:	ARI-ZESA, or similar,
Amount:	4 pieces,
Nominal pressure rating:	PN 16,
Connection size:	DN 250,

Flow rate:	~96.1-440 t/h,
Fluid temperature:	2-35 °C,
Opening/closing time:	~60 s.
Fluid:	glycolised water,

2.3.28. FVSZ1 three-way, engine-driven control valve for the HS1 heat pump

Type:	HONEYWELL V5329A/V5050, or similar,
Amount:	1 piece
Nominal pressure rating:	PN 16,
Connection size:	DN 40,
Flow characteristics Kvs:	~25 m3/h,
Flow rate:	11-16 t/h,
Fluid temperature:	2-45 °C.

2.3.29. FVSZ2 three-way, engine-driven control valve for the HS2 heat pump

Type:	HONEYWELL V5329A/V5050, or similar,
Amount:	1 piece
Nominal pressure rating:	PN 16,
Connection size:	DN 80,
Flow characteristics Kvs:	~100 m3/h,
Flow rate:	40-59 t/h,
Fluid temperature:	2-45 °C.

2.3.30. VL twin-column water softener with VE chemical feeder

Type:	Hidrofilt HF-300 Na-A/V DF2, or similar,
Fluid:	mains water,
Flow output:	~2.7 m3/h,
System:	flow through,

Operation:	automatic,
Total capacity btw. reclamations:	~250 nk° × m3/column,
Operation pressure:	2.5-6 bar(t),
Operation temperature:	5-35 °C,
Nominal pressure rating:	PN 6,
Chemical feeder max. output:	~0.3 l/h

2.3.31. Gas engine ventilator with speed regulator and fixed damper

Type:	AIRVENT HCFT 4-400, or similar,
Amount:	1 piece,
Flow rate:	~2,300 m3/h,
Pressure rise:	~60 Pa,
Max. operation temperature:	40 °C,
Hourly ventilation:	~19 x
Max. sound pressure level:	55 dB(A).

2.3.32. Energy centre ventilator with speed regulator and exhaust damper

Type:	AIRVENT HCFT 4-500, or similar,
Amount:	1 piece,
Flow rate:	~5,000 m3/h,
Pressure rise:	~150 Pa,
Max. operation temperature:	40 °C,
Hourly ventilation:	~8.8 x
Max. sound pressure level:	55 dB(A).

2.4. Description of the technology

In the first step the water-lifting engine house, the heating/cooling and extra pipelines and the energy centre will be completed. In the energy centre heat energy will be generated by the GM biogas engine and the HS1-2 heat pumps. Biogas, used as fuel for the biogas engine, will be provided by the fermenter towers of the sewage treatment plant and will be transferred through the planned pipeline. The two HS1-2 heat pumps and the GM gas engine will be installed into the building which is going to be constructed in the first step.

In the second step the HS3÷4 heat pumps together with the HSFOS3-4 source-side and the HSFES3-4 consumer-side pumps will be implemented. At the same time the HKS1-2 pumps are going to be replaced, the cold energy pipeline will be expanded and the FVSZ3-4 fittings installed.

Output details:

- GM (1st step) heat output: ~130 kW, electricity output: 80 kWe.
- HS1 (1st step) heat output: ~100 kW; cooling output: ~94 kW.
- HS2 (1st step) heat output: ~370 kW; cooling output: ~344 kW.
- HS3÷4 (2nd step) heat output: ~770 kW; cooling output: ~740 kW.

Heat and cold energy for district heating and cooling will both be generated by the heat pumps (the gas engine will also take part in heat production), because they are equally capable of heat and cold energy generation.

The heat pumps will utilize heat from the water source at 5 °C temperature level. In the heating season in winter, the source-side water cools the treated sewage water (through a heat exchanger), while in the cooling season in summer, it heats it.

2.4.1. Operation modes:

The heat pumps operate parallel in heating and cooling mode both on the source and on the consumer side.

In the heating season the gas engine (130 kW) and the two heat pumps (heating 100 kW, 370 kW) supply heat according to demand through the DN200 size pipeline.

In the transitional period up to ~94 kW cooling demand the HS1 heat pump supplies cold energy through the DN65 size pipeline. In this period heating is supplied by the GM 130 kW output gas engine and the bigger, 370 kW performance HS2 heat pump through the DN200 size pipeline. When the cooling demand goes above ~94 kW, after switching over the cooling pipelines, the HS2, ~344 kW heat pump supplies cooling through the DN200 size pipeline. The DN65 size pipeline gets out of operation.

Outside the heating season the GM gas engine works in forced cooling operation mode, while the HS1-2 heat pumps provide cooling energy to the consumers through the DN200 size pipeline. After the second step of its realization and the expansion of the DN65 size pipeline, the energy centre will be capable of bigger parallel heating/cooling output than mentioned above.

The heat generated by the biogas engine is also planned to be fed into the district heating system. The water coming out of the gas engine feeds its heat into the heat pump side of the FHV heating hydraulic converter through the GLHCS gas engine separating heat exchanger. The gas engine, in terms of the heating system, is connected in parallel with the heat pumps. A possible connection (stub) is designed for a hot water boiler, which can be used as a spare heat source, and which is situated in the nearby ÉMI hall boiler house.

2.4.2. Heat and cold energy generation and output with heat pumps

The gas engine supplies heat for the district heating system, while the heat pumps are equally capable of heat and cold energy generation. Heat or cold energy output is realized through the DN 200 size district heating/cooling pipeline, or in the transitional period, through the DN65 size district cooling pipeline.

The heat pumps change the temperature of the source-side water by 5 °C. In the heating season in winter, the source-side water cools the treated sewage water through a heat exchanger, while in the cooling season in summer, it heats it.

Conversion between heating and cooling operation mode in the heat pumps happens by inside switchover: reversing the cycle in the heat pump. At the switchover the operation of the facility, in terms of the source side, stays the same, but on the consumer side it provides heat reduction necessary for cooling, instead of heat energy supply.

Heat energy extracted from the low temperature source water (treated sewage water from the HCS), on a higher temperature level, can be used to heat water in the district heating system on the consumer side. In cooling operation mode the higher temperature water is put in from the cooling network on the consumer side of the HS, and heat reduction happens through the warming up of the source-side water.

2.4.3. HS1-2 heat pumps, source side

So-called source-side feeding of the heat pumps in both heating and cooling operation mode happens by using the SZLHCS1÷2 sewage water separating heat exchangers and the FOHV source-side common hydraulic converter. The source-side water transfers heat energy usable for district heating extracted from/to the sewage water or the heat extracted from the cooling system from/to the other side of the heat exchangers.

2.4.4. HS1-2 heat pumps, consumer side

Water coming from the HS1-2 heat pumps flows into the FHV heating, or the HHV cooling hydraulic converter, depending on the heating or cooling operation mode. From these water is circulated by the HKS/FKS1-2 heating or the HKS1-2 cooling circulation pumps towards the consumers. The FKS1-2 and the HKS1-2 circulation pumps transfer variable flow rate water. The speed control signal lead is the temperature of the return water from the heating/cooling system.

2.4.5. GM gas engine heat generation

Heat from the GM gas engine is planned to be fed into the district heating system. Water coming from the gas engine feeds its heat into the closer side of the FHV heating hydraulic converter through the GLHCS gas engine separating heat exchanger. The gas engine, in terms of heating, is connected in parallel with the heat pumps. The cooling water of the gas engine is circulated by the GKS gas engine circulation pump. The gas engine circulation pump is built in the return line of the gas engine and works with variable flow rate.

If the demand of the district heating system is lower than the heat output of the gas engine, but the gas engine needs to be operated with invariable performance, the surplus heat has to be taken out by forced cooling. The KHHCS forced cooling heat exchanger is installed between the GM gas engine and the GLHCS gas engine separating heat exchanger.

The flue gas from the gas engine is planned to be removed by a self-supporting, double-walled, preinsulated, ~10 m tall stainless steel chimney: K.

2.4.6. The water-lifting and separating engine house

On the DMRV site a (gross) 5.5 × 7.5 m, 41.25 m² size building will be constructed. It is going to contain two sewage water pumps in the first step, and another two in the second step, a continuously operating, automatic filter and also two separating heat exchangers.

The treated sewage water needed for the operation is planned to be transferred by connecting to a DN600 size pipeline coming from the sedimentation tanks.

The continuously operating, automatic filter filters the treated sewage water before it comes into the LHCS1-2 separating heat exchangers. The filtered water, flowing continuously from the SZESZ sewage water filter through a DN40 size pipeline, is fed back to the DN300 size pipeline coming from the LHCS1-2 separating heat exchangers.

2.5. Installation

The water-lifting and separating engine house is going to be installed on the DMRV site, while the heat and cold energy generating centre will be situated on the site of ÉMI.

The sewage water needed for the operation of the system will be taken out in the pump engine house on the DMRV site. According to information from DMRV, water coming out of the pre-sedimentation tanks is mechanically filtered, but is not treated biologically. In order to avoid biologically contaminated water to get into the energy generating centre to be installed, the DMRV and ÉMI systems will be separated by a separating heat exchanger. To avoid the blocking of the heat exchanger, a continuously operating filter is planned to be installed. It is also necessary to circulate glycolised water against freezing up.

The sewage water filtering facility and the separating heat exchanger will be installed in the engine house on the DMRV site. The treated sewage water is going to be put back into the

DMRV techologies after the heat exchange, because in this way it is unnecessary to establish a separate disinfection technology and money can be saved.

The sewage water lifting submersible pump facilities, the continuously operating filter and the separating heat exchangers will be installed in the pump engine house. The water flowing through the separating heat exchanger is going to be pumped to the heat pump energy generating engine house through a pipeline laid in the ground.

The VL water softener and the VE chemical feeder, which fill up the district heating and cold energy supply system and provide make-up water, will be installed on the north wall of the heat pump engine house.

In the first step, the FOTÁT, HTÁT and FTÁT expansion tanks are planned to be fixed on the base of the HS3 heat pump. In the second step these tanks will be placed on a steel structure stand.

The HS1-2 heat pumps (first step) and the HS3-4 heat pumps (second step) will be installed opposite the doors on the south facade of the building. The doors make it possible to clean and maintain the heat exchangers built in the heat pumps.

The FHV and the HHV hydraulic converters are going to be placed ~1960 mm far from the north wall of the engine house.

The HSFE1-2 circulation pumps will be installed near the pillars between the heat pumps and the doors on the facade, and also near the heat pumps and the FHV and HHV hydraulic converters.

The HKS/FKS1-2 and HKS1-2 consumer side cooling/heating circulation pumps, which are installed near the FHV and HHV hydraulic converters, will circulate the district heating and cooling energy.

The GM gas engine will be placed in a separate, noise-insulated room. Biogas will be fed into it through a gas pipeline coming from the DMRV gas container. Along the walls, the GKS, KHKS and GHKS circulation pumps will be installed. The GLHCS, KHHCS heat exchangers and the K chimney will also be placed here.

The heat pump heat and cold energy supply system is going to be monitored and controlled based on the set parameters by the PLC placed in the control room.

In case of suspended or terminated biogas supply it is necessary to provide the buildings with heat and cold energy. That is why a room planned next to that of the gas engine will be left empty, where a 2 MW heat output natural gas-fired boiler can be installed if needed.

3. Specification of the CHP unit based on wood gasification at the site of VSZ zRt (area C)

3.1. Geometrical and thermal performance data of the buildings

Several buildings can be found at the premise of VSz Zrt. (9 Szabadkai Street, Szentendre), all of which are heated from the boiler house in the main building, via a heating pipe network. The pipe network was constructed in the 1970-ies, with the pipes laid in concrete ducts and insulated afterwards as was usual at that time. A gas heating alternative was also installed as a reserve because of the drop-outs of the ailing heat delivery pipe network. A photo of the main building can be seen in Figure 3.1.

Figure 3.1: The photo of the main building

The tendering of the system refurbishment has been started and evaluated, the tender documents and the design drawings are attached and can be downloaded from the project website.

The power and heat outputs of the CHP unit for installation to the premise (headquarters) of VSz Zrt. (9 Szabadkai Street, Szentendre) based on the heating duration curve, the data of power demand and the ratio of the power and heat demand.

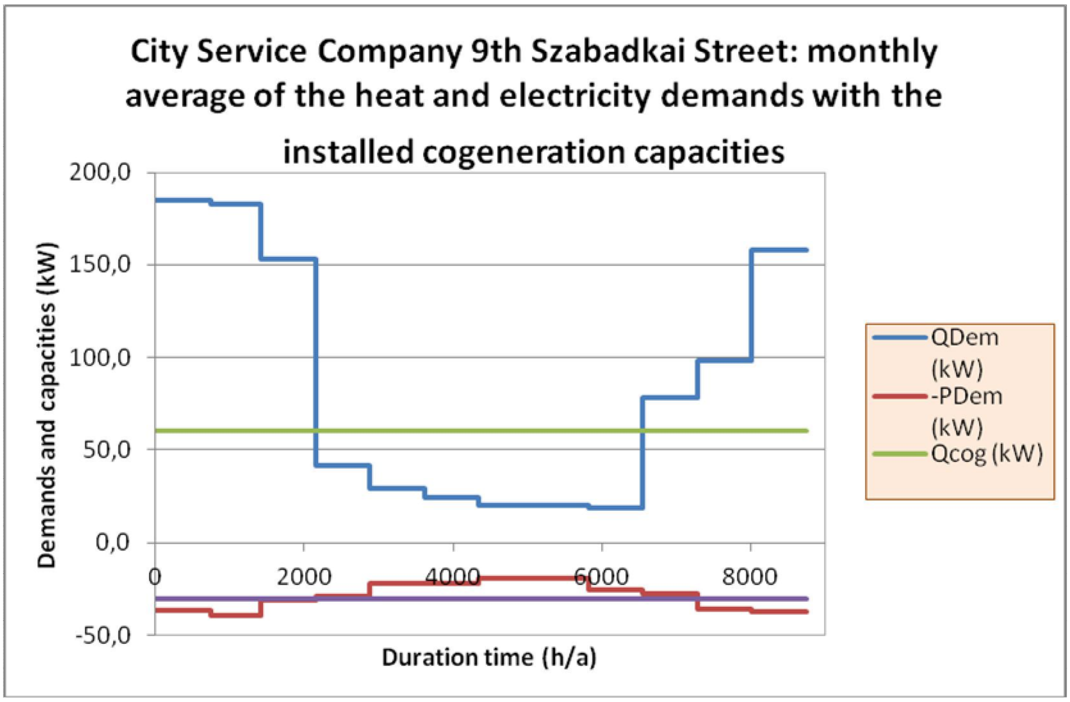

Figure 3.2: Monthly average energy demands at VSZRT.

3.2. The main equipment and basic technical data of a CHP unit based on wood gasification

- Wood gasification reactor ("downdraft" or „updraft" type):
  - input: wood chips (35-45% moisture content)
  - output/product: gas (H_i= 4.8 - 6.8 MJ/gasNm^3)

- Gas cleaning cyclone (removing larger airborne particulate matters)

- Gas/water heat exchanger (gas cooler)

- Gas cleaning bag filter (removing smaller diameter contaminating particles)

- Gas engine (internal combustion engine):
  - power output: 30 kW_e
  - heat output: 60 kW_{th}

- Control box (Monitoring/control system)

- Auxiliary equipment:
  - gas tank
  - wood chips storage
  - wood chips feeder

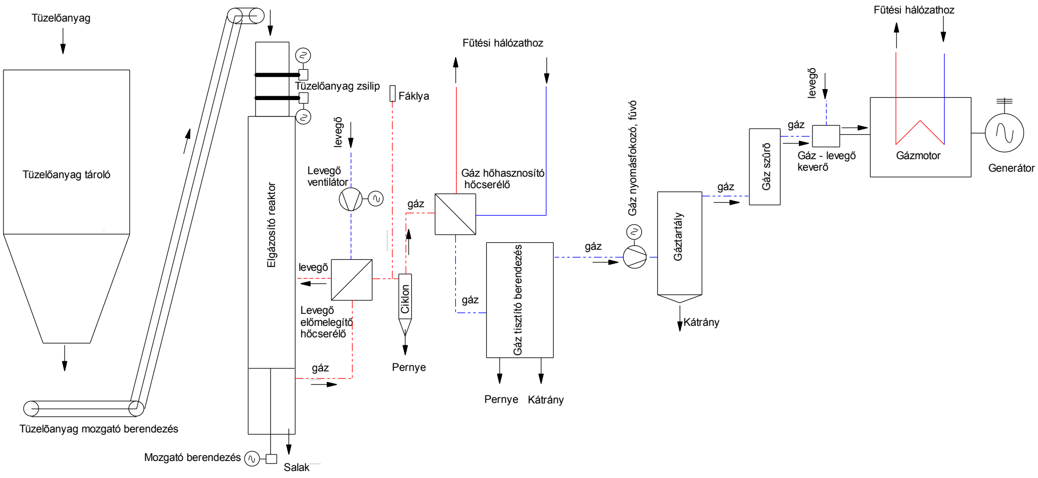

Figure 3.3: Schematic flow diagram

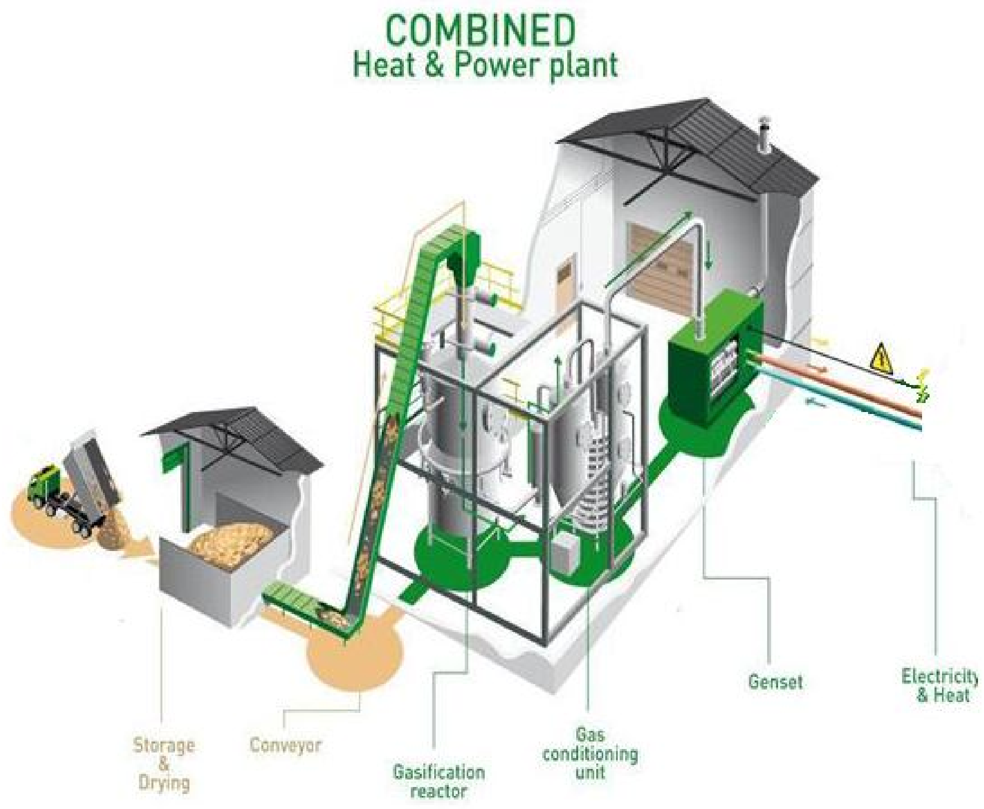

Figure 3.4: Lay-out scheme

Space requirement (ground floor area):

- complete technology: 70 m^2
- additional space (for wood chips supplier truck): 40 m^2

Energy data:

- Wood chips demand: 370 t/a
- Reactor gas to fuel the gas engine: 3,062 GJ/a
- Useful heat production: 1,190 GJ/a
- Electricity production: 215 MWh/a

3.3. Air pollution

Hungarian law has prescriptions in this respect only for equipment of 140 kW fuel input and over. Despite this, it is expedient to comply with the rules for equipment of over 140 kW fuel input. The prescriptions are contained in Point 54 of Attachment 6 of the ministry decree 14/2001. (V.9.) of KöM-EüM-FVM on "limit values of air pollution, emission limit values of stationery air polluting point sources", as follows.

"54. Bio gas and landfill gas fuelled stationery gas engines

The rules relate to stationery Otto type, four stroke, internal combustion gas engines with electric ignition, on bio gas and landfill gas fuel and of a fuel input of 140 kW_{th} or over.

Technology	Limit values of emissions [mg/m^3] (concentration of air polluting materials)		
	Nitrogen oxides (in NO_{2eq})	Carbon monoxide	Total of organic materials in C (expect methane)
Stationery gas engines on bio gas or landfill gas fuel	600	700	150

Remark: The emission limit values for all air polluting materials exiting from the technology are related to a dry exhaust gas with 5 $\%_{vol}$ O_2, at a temperature of 273 K and a pressure of 101.3 kPa."

The limit values above can be observed when using wood chips. This has to be proved by calculations in the environment protection chapter of the licensing plan of the CHP installation.

3.4. Noise impacts

The technology to be installed emits noise to the environment. The noisiest element of the small power plant is the gas engine. Its sound pressure level at 1 m distance from the gas engine is 85 dB(A). In order to reduce noise, the gas engine has to be contained in a compartment with acoustic insulation, which abates noise by, at least, 30 dB(A). All major equipment of the CHP technology will be placed in one building with a boundary surface construction that reduces noise also, at least by 30 dB(A). Out of further components of the CHP, the actuating equipment in the fuel storage and the fuel forwarding conveyor emit noise. The sound pressure level of these components at a 1 m distance from the components is not more than 35 dB(A).

The selected location site is within an industrial zone but a residential zone is in a distance of 150 m. The latter is to be protected from noise, where the permitted noise level values are prescribed by No 1 attachment of the ministry decree 27/2008. (XII.3.) of KvVM-EüM on "determination of limit values for noise and vibration burden of the environment". All potential locations belong to Class No 2, that is "Residential area (small town, green suburb, rural, built-up area), and the area of educational institutes, cemeteries and green belts as special areas".

The limit values for these are:

		Limit values (LTH) for LAM evaluation level (dB)	
		Day-time 06- 22 h	Night-time 22-06 h
2	"Residential area (small town, green suburb, rural, built-up area), and the area of educational institutes, cemeteries and green belts as special areas	50	40

The investment will include the following operations and works:

- Construction works
  - Erection of the technology building with proper bases
  - Construction of the fuel storage
  - Concrete bed for the truck docking bay
  - Building engineering works
  - Construction of the air supply system for ventilation, the gasification reactor and the gas engine, with noise abatement
  - Construction of the sewerage system

- Installation of the CHP technology system
  - Installation of the gasification reactor

    - Installation of the gas cleaning cyclone
    - Installation of the gas cooler
    - Installation of the bag filter, fly ash separator
    - Installation of the gas engine
    - Construction of engineering pipe system
    - Installation of cabinets of power transmission and automatics
    - Connection of electric equipment and motors
    - Installation of electric cable system
    - Installation of cable system for the automatics
    - Installation of components of automatics and their connection to the network system

- Installation of equipment for power feed out
    - Installation of low voltage (0.4 kV) equipment, circuit breakers and protection devices
    - In house cabling
    - Cable installation and connection to the existing low voltage (0.4 kV) cupboard

- Installation of equipment for heat supply
    - Construction of heating pipes to the boiler house and their connections

- Equipment of the outside fuel storage
    - Installation of fuel actuating equipment
    - Installation of fuel feeding (conveyor)

- Installation of monitoring/control system
    - Installation of computer (PLC) for monitoring/control
    - Connection/interface of major CHP equipment to the PLC
    - Connection/interface of further equipment and sub-systems to the PLC
    - Preparation of monitoring software
    - Installation of a work station

- Installation of fire alarm

3.5. Estimated project cost

Planning/designing, permitting	6 364 €
Technical supervision, putting into operation	6 364 €
Construction works	44 364 €
Installation of the CHP technology system	54 545 €
Installation of equipment for power feed out	10 909 €
Installation of equipment for heat supply	7 273 €
Equipment of the outside fuel storage	16 364 €
Installation of monitoring/control system	29 091 €
Overall costs	175 273 €

4. Design conception of the ORC cycle CHP energy system in Püspökmajor (area A)

4.1. Introduction

The supply of heat to the Szentendre district heating system in Püspökmajor (area A) is based 100% on natural gas as fuel. In the heating plant (see location in Figure 4.1: Satellite photo of the Heat centre area of the the Püspökmajor area (A).Figure 4.1), heat is generated by three hot water boilers of a combined capacity over 17 MW and by a JMS 612 type Jenbacher made gas engine with a heating capacity of about 1.6 MW. However, the actual available capacity of the gas engine is less than this because the engine is stopped for 3.5-4.5 hours a day in the night time, due to the unfavourable power feed-in tariff.

Figure 4.1: Satellite photo of the Heat centre area of the the Püspökmajor area (A).

Almost 90% of the heat supplied by the district heating system covers residential space heating and DHW demand and the extrapolated peak heat demand of the district heating system at an average daily outdoor temperature of -15 °C is 8.6 MW in the heating plant.

The heating plant covers not only the heat demand of the district heating system but also the heat demand of a swimming pool built in its close vicinity and, in summer, the cooling demand of this swimming pool, by way of an adsorption chiller driven by district heat.

In the last year it appeared that the favourable economic conditions of gas engine based heat and power generation would stabilise up until 2015 but the government is to reduce radically the support for cogenerated power from January this year what, naturally, has an adverse effect on the economic viability of cogenerated heat.

The rate of the proposed reduction of support is such that it questions the profitability of cogenerated heat against heat produced in natural gas fired hot water boilers. By the drop of combined heat and power generation due to these changes, the savings in primary energy achieved in the previous decade may disappear and its "remaking" becomes a task, that would be solved by wide spread use of renewables, mostly bio mass, in energy production and by the reduction of energy demand of buildings due to improvements to their energy performance, according to plans of the government communicated so far. Specific forms and conditions of incentives to this end are not known yet.

The proposals for development of heat generation in the district heating of Szentendre had to be worked out in a situation where the details of the concept for the national and European energy policy and energy strategy are not worked out.

For the basic goal, it had to be considered that the share of energy production based on fossil fuels (natural gas) has to be reduced for environmental and economic reasons, what is forced out faster than expected by changes in regulations outlined above. According to our knowledge at present, the extension of the heating market cannot realistically be reckoned with in the near future, and even some drop in demand may occur due to an upswing in building upgrading.

Due to these considerations an ORC type CHP unit has been chosen to be settled. The ORC small power plant will be connected to the existing heating plant both for power and heat. The heat generated will be used in the district heating system of the heating plant, replacing natural gas use. The power generated will be fed into the grid also via the heating plant. For this the cables for the existing gas engine will be used.

Széchenyi Square, on the border to Radnóti Miklós Street and Pomázi Street is appropriate as a site for the new plant construction. The site is shown by Figure 4.2. The area marked in the figure has a size of 60 x 60 meters, and the track length of the pipes to be laid down toward the heating plant, between the two buildings, is about 300 m.

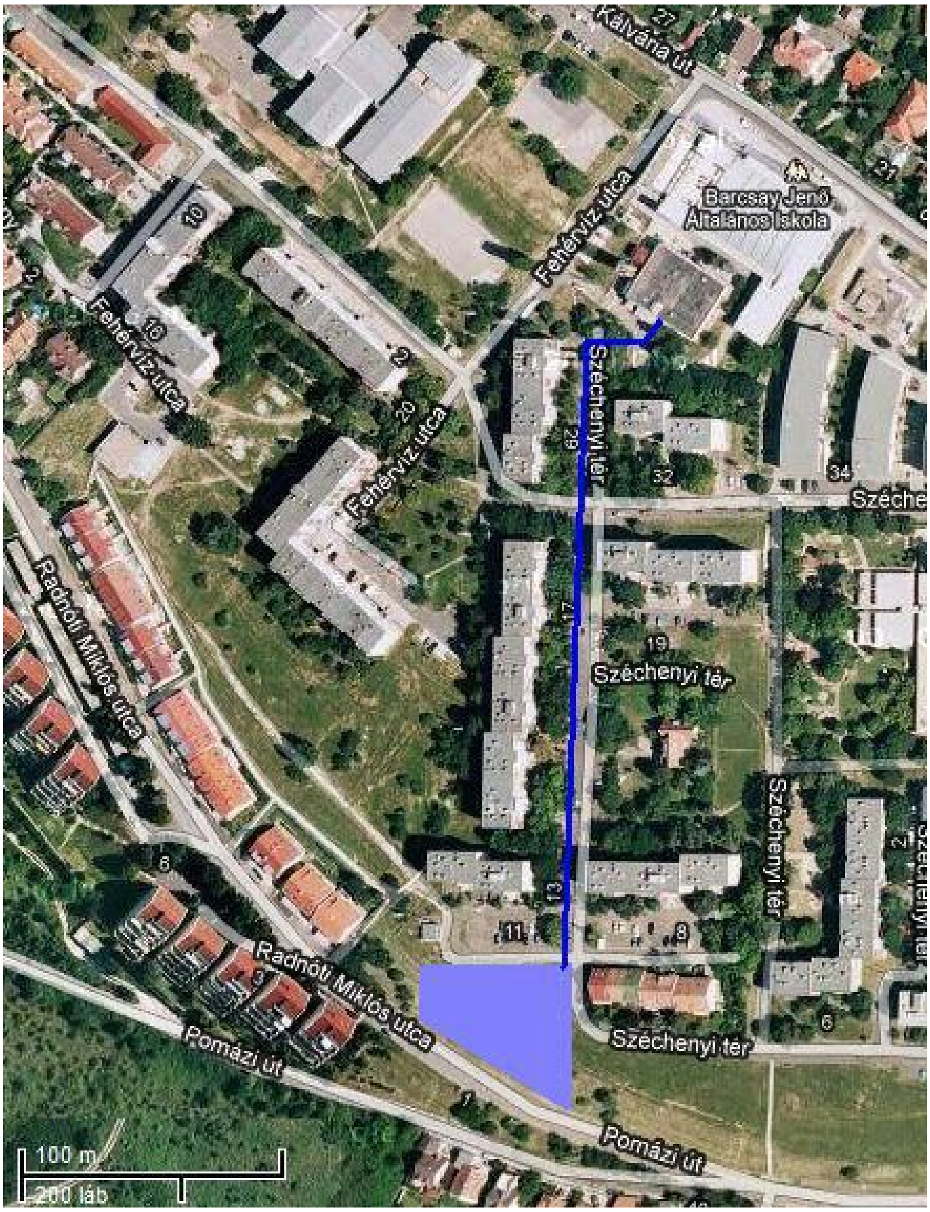

Figure 4.2: The planned site of the new ORC plant construction and the connecting pipeline track to the district heating plant.

The aerial photos show that the planned project would be implemented in a relatively densely built-up area of the city, so efforts have to be made that the operation of the future small power plant should cause minimum annoyance to the public. For this reason, the proposal of the Municipality to put the facility underground, as much as possible, has to be given due consideration.

The planned location is situated by a road of moderate traffic. This fact was an important aspect for choosing the possible site for the new plant. Supply of wood chips, to meet the 25 t/d wood chip requirement, means that 2 trucks of 20 t net load has to be received daily, four days a week. It is, at present, a public area in the possession of the Municipality. There are residential buildings in its vicinity but the topographic situation provides the best condition for underground construction.

4.2. Description of the ORC cycle CHP energy system

The main elements of an ORC cycle small power plant with thermo oil boiler system are:

- Thermo oil boiler system
  - Boiler
  - Fuel storage and feeder
  - Flue gas cleaner, fly ash precipitator
  - Ash remover
  - Circulating pump
  - Power transmission and automatics cabinet
- ORC cycle unit
  - Pre-heater
  - Stem generating evaporator
  - Turbine-generator
  - Condenser
  - Circulating pump
  - Power transmission and automatics cabinet
- Power feed out equipment
  - Medium voltage equipment
  - Transformer
  - Cables
- Equipment for connections to district heating
  - District heating pipes (DN 100)
  - Circulating pump
- Outside fuel storage
  - Fuel storage
  - Fuel actuating equipment

Technical data:

- ORC
  - heat capacity (kWth): 1 901
  - power capacity (kWe): 384
- Thermo oil boiler
  - output capacity = heating capacity (kWth): 2 285
  - input capacity = fuel input requirement (kWth): 2 640
  - fuel (wood chips, Hi=10,4 MJ/kg) demand (kg/h): 917
- Space requirement of the total system
  - building: 30 x 20 m = 600 m2
  - fuel storage: 150 m2

Energy data:

- Yearly biomass consumption: 70,134 GJ/a = 5,844 t/a
- Heat produced: 49,561 GJ/a
- Electriciy:
  - produced: 3,095 MWh/a
  - sold: 2,920 MWh/a

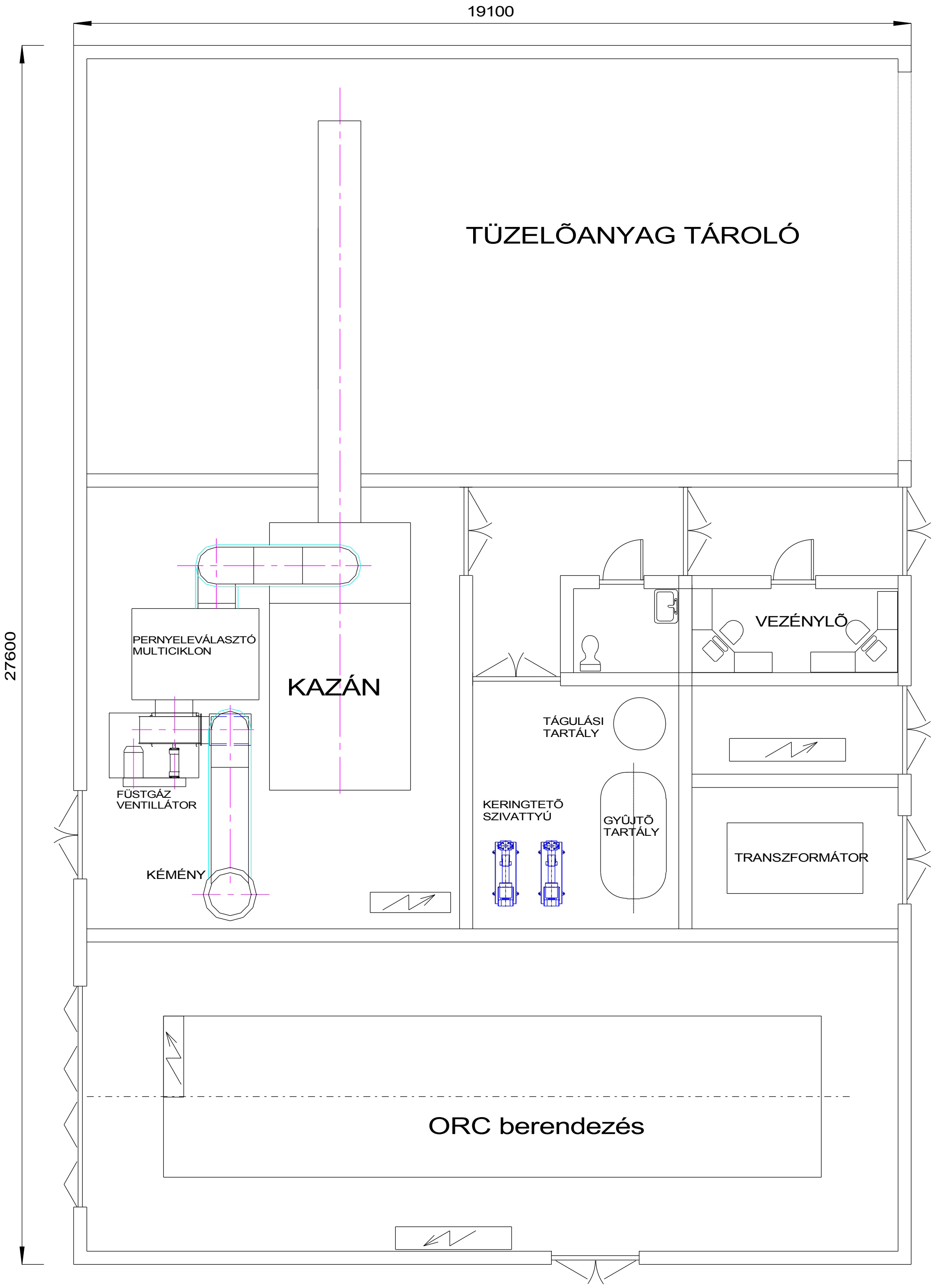

Figure 4.3: Space requirement of ORC unit with thermo oil boiler and fuel storage

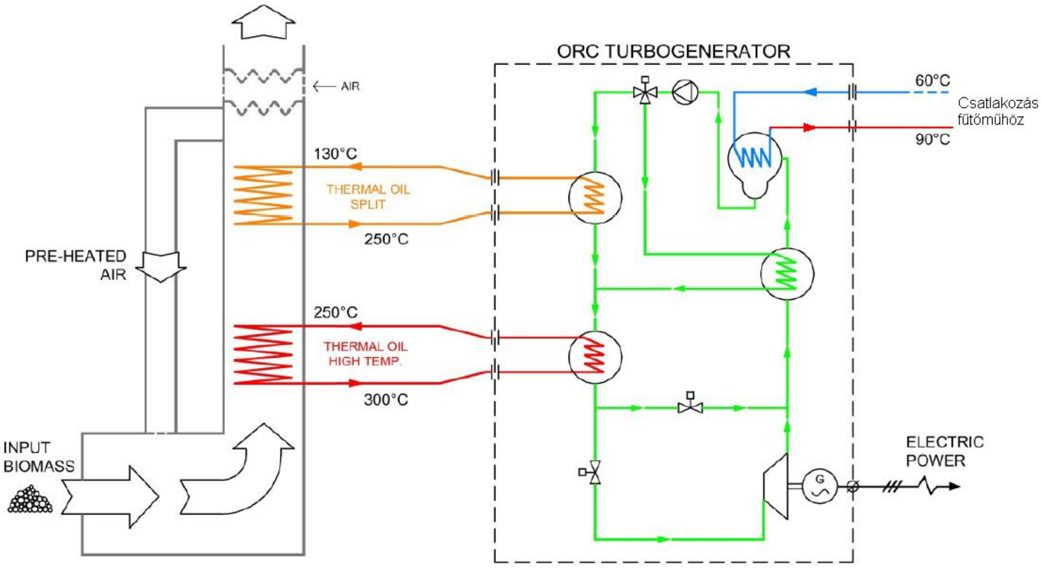

Figure 4.4: Simplified scheme of ORC small power plant

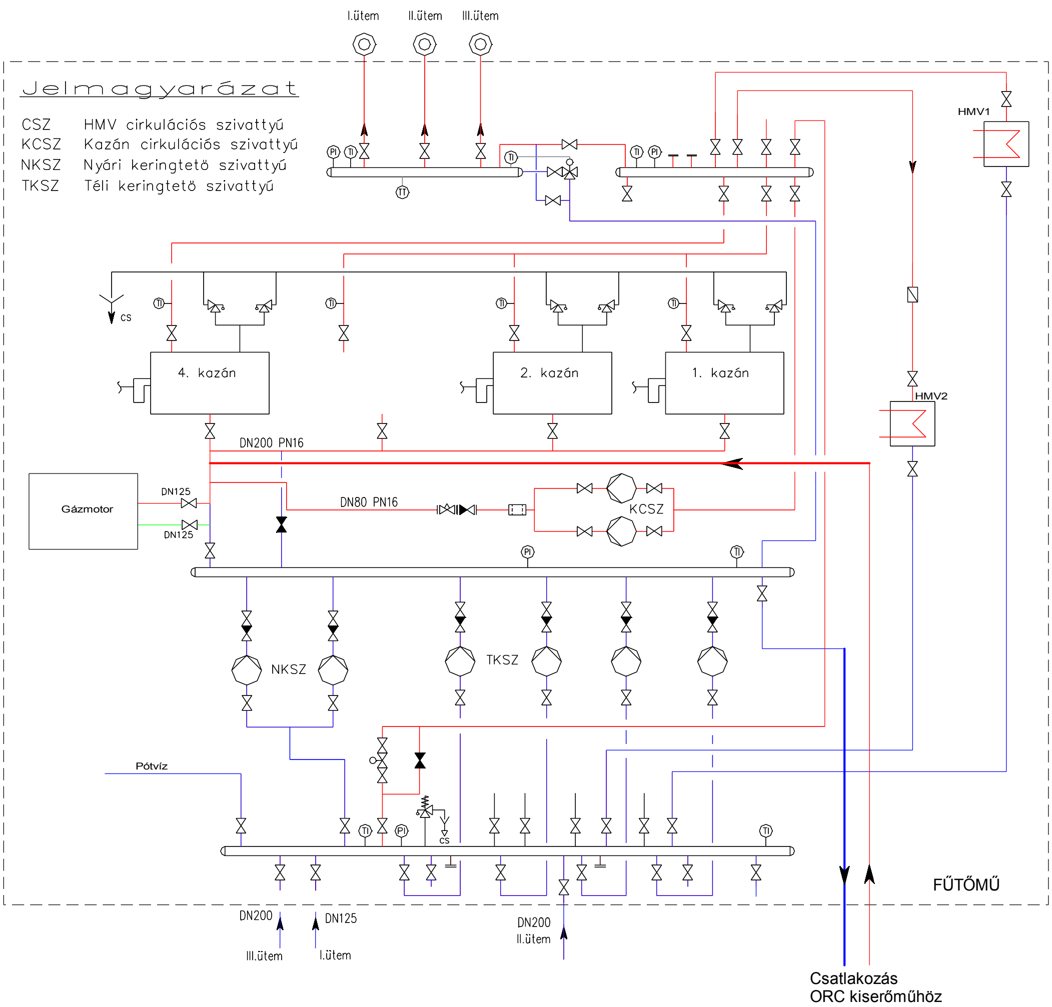

Figure 4.5: Simplified scheme of existing DH plant with ORC unit connecting point

4.3. Air pollution

The only point of pollution discharge to the atmosphere of the technology applied is the stack of the boiler.

The air polluting impurities form in the boiler during the combustion of the wood chip fuel used.

Regulations for the boiler to be installed are contained in the ministerial decree 23/2001. (XI. 13.) KöM "for technology emission limits of air pollutants from combustion equipment of an input heat capacity of 140 kWth or larger and less than 50 MWth". The limit values are included in Annex 1 of the decree as follows:

Air pollutant	Emission limit [mg/m3]
Particles	150
Carbon monoxide (CO)	250
Nitrogen oxides (NO2 equivalent)	650(1)
Sulphur-dioxide and -trioxide(SO2 equivalent)	2000(2)
Unburned fossil carbon compounds (in C equivalent) metered by flame ionised detector for solid bio mass fuels	50

Remarks:

For inland lignite max. 300 mg/m3 (heat content < 7000 kJ/kg). For fluid combustion boilers 200 mg/m3.

For brown coal firing 3000 mg/m3. For imported coal firing 400 mg/m3. For wood, wood chips and solid biomass fuel firing 1000 mg/m3.

4.4. Noise emission

The equipment to be installed will emit noise toward its environment. The noisiest part of the ORC instalment is the turbine. The sound pressure level is 95 dB(A) 1 m away from the branch. Out of the parts of the boiler the ventilators are the noisiest. The sound pressure levels of the combustion air and flue gas ventilators are 75 dB(A) at a distance of 1 m.

In the surroundings of all the potential sites of the small power plant either residential area or a school can be found. These are areas to be protected from noise, the maximum of permitted noise is determined in the No 1 attachment of the ministry decree 27/2008. (XII.3.) of KvVM-EüM on "determination of limit values for noise and vibration burden of the environment". All potential locations refer to the No 2 class, that is "Residential area (small town, green suburb, rural, built-up area), and the area of educational institutes, cemeteries and green belts as special areas".

The limit values are:

		Limit values (LTH) for LAM evaluation level (dB)	
		Day-time 06- 22 h	Night-time 22-06 h
2	"Residential area (small town, green suburb, rural, built-up area), and the area of educational institutes, cemeteries and green belts as special areas	50	40

The investment will include the following operations and works:

- Construction works
  - Construction of the technology building with bases for machinery
  - Construction of fuel storage
  - Concrete bed for the truck docking bay
- Building engineering works
  - Construction of communal water and waste water systems
  - Construction of the ventilation and boiler air supply systems with noise abatement
  - Construction of room heating and air conditioning
- Construction of thermo oil boiler system
  - Erection of the boiler
  - Construction of the fuel storage and fuel feeding system
  - Installation of flue gas cleaning and fly ash precipitation
  - Construction of stack
  - Installation of ash remover
  - Installation of circulating pumps
  - Construction of engineering pipe network
  - Installation of cabinets of power transmission and automatics
  - Connection of electric equipment and motors
  - Installation of electric cables
  - Installation of cables for control automatics
  - Installation and connection to the network of automatics parts
- Installation of the ORC equipment and mounting its units
  - Pre-heater
  - Evaporator
  - Turbine-generator
  - Condenser
  - Circulating pump
  - Installation of cabinets of power transmission and automatics
  - Construction of pipe network and connection of equipment
  - Installation of electric cables and connection of electric equipment
  - Installation of cables for control automatics and connection of automatics parts
- Installation of equipment for power feed-out
  - Installation of medium voltage equipment, circuit breakers and protection devices

- Installation of transformer
- Cabling
- Installation of a cable to the heating plant and its connection to the existing medium voltage cabinet

➢ Installation of district heating connections
- Construction of district heating pipes to the heating plant and connection of the pipes
- Installation of circulating pumps

➢ Equipment of outside fuel storage
- Installation of fuel actuating equipment

➢ Installation of monitoring system
- Installation of computer (PLC) for monitoring
- Connection of the boiler and of the ORC to the PLC for monitoring
- Connection of further equipment and sub-systems to the monitoring PLC
- Preparation of monitoring software
- Installation of a working station
- Installation of communication cable to the heating plant
- Installation of fire alarm equipment

4.5. Estimated project cost

Planning, permitting	120 000 €
Technical supervision, putting into operation	80 000 €
Building construction work	500 000 €
Thermo oil boiler system	757 917 €
ORC equipment	944 000 €
Power feed-out	109 091 €
District heating pipe connections	64 727 €
Outer fuel storage equipment	92 517 €
Monitoring system	167 273 €
Overall costs	2 835 525 €

5. Photovoltaic energy systems in Szentendre Concerto area

In Szentendre there are 4 buildings that will have a BIPV installation with a total power of 37.3 kW_p, and a total generated electrical energy of 38740-44550 kWh. Three buildings will be refurbished and one is a new construction. These buildings are the Kindergarten in Püspökmajor (area A), a residential building in Hamvas street of Püspökmajor (area A), the office building of VSZ Zrt. (area C) and a new office building of ÉMI (area E).

5.1. Refurbishment projects

Three demonstration building of PIME'S project will be refurbished incorporating the application of BIPV. These are the Kindergarten of Püspökmajor area, the Residential Building in Hamvas street of Püspökmajor area, and the office building of VSZ Zrt. The planned BIPV system concepts will be introduced in the following pages.

5.1.1. Kindergarten of Püspökmajor (area A)

Figure 5.1: Kindergarten before refurbushment

In the kindergarten building a BIPV system with a total area of about $50m^2$ and total power of 7.1 kW_p will be installed. The estimated total yearly generated electrical energy is 7710-9050 kWh.

The BIPV modules will be placed in three different parts of the building showing different BIPV solutions.

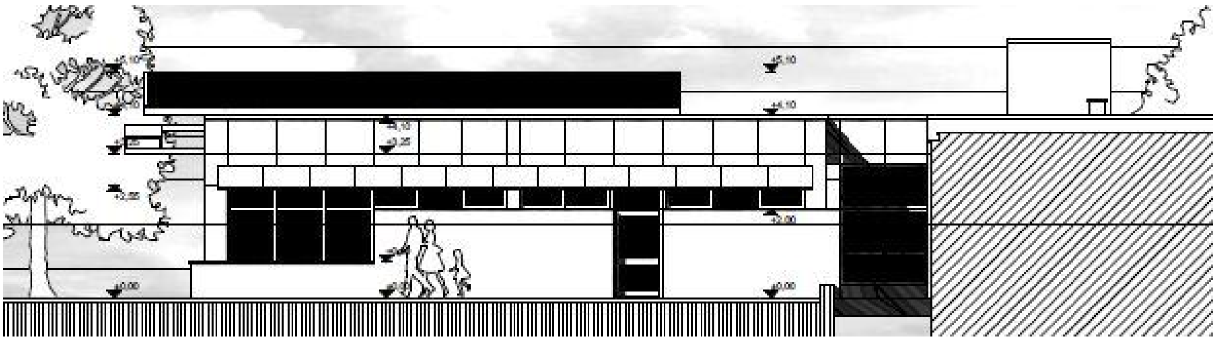

Figure 5.2: South facade of kindergarten.

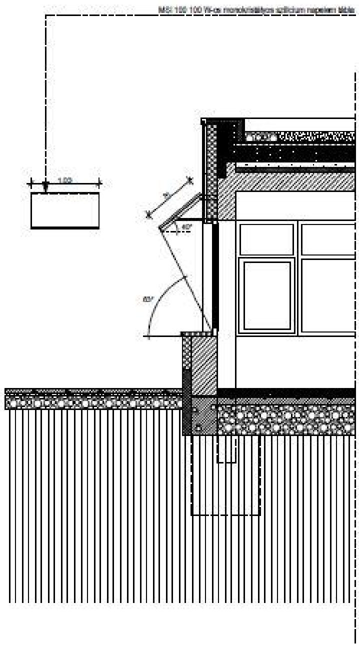

Figure 5.3: South facade BIPV penthouse

One part of the system will function as a penthouse mounted in a fix way on the south façade. It will consist of 10 pieces of 190 W_p Kyocera KD multicrystalline Si PV module (1.3m^2 area), with a total area of 13m^2 and total power of 1.9 kW_p. The mounting to the building will be solved by a standardized iron structure ensuring a tilt of 40^o for the PV modules. The estimated yearly generated electrical energy is 2085-2450 kWh.

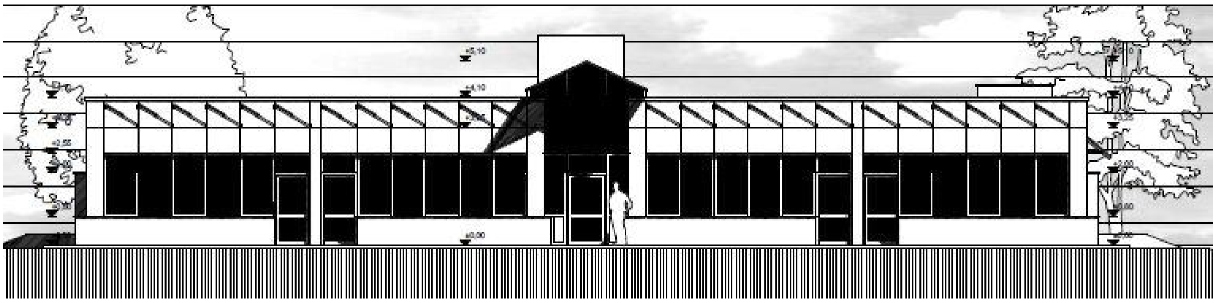

Figure 5.4: Western facade.

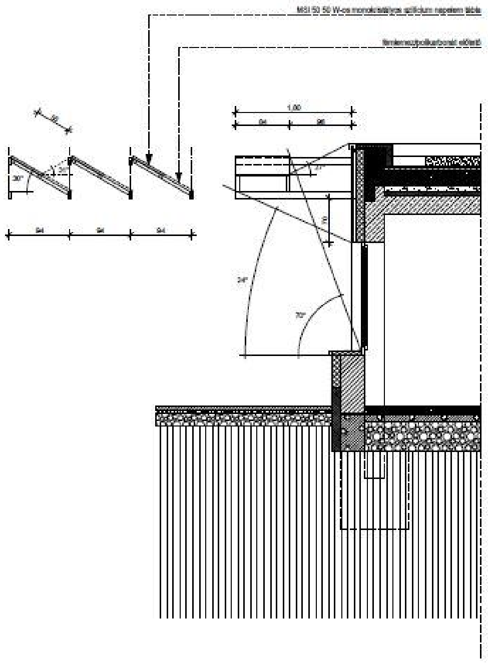

Figure 5.5: Western facade BIPV

The second part of the BIPV system will function as a fix shade above the windows of the western façade. These PVs will face to the south with a tilt of 30°. The mounting of the system will be solved by wooden support system with load assuring no thermal bridge. 24 pieces of S-energy SM 70 (0.56m^2) multicristalline Si PV modules will be used with a total area of 13.44m^2 and a total power of 1.68 kW$_p$. The estimated yearly generated electrical energy is 1825-2140 kWh.

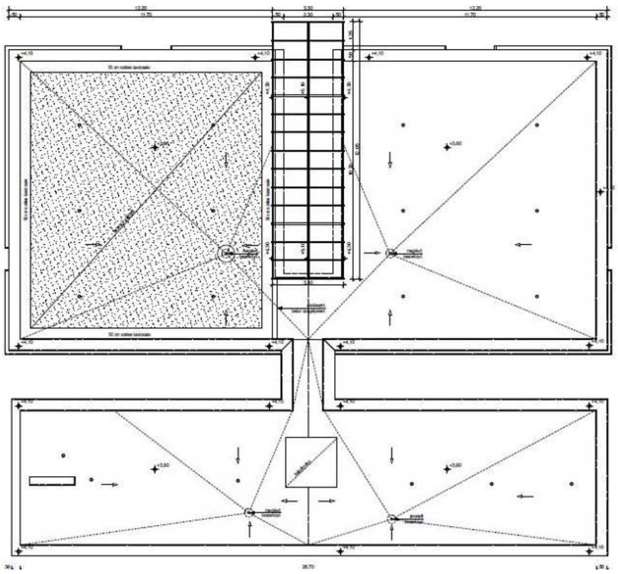

Figure 5.6: Top view of the flat roof

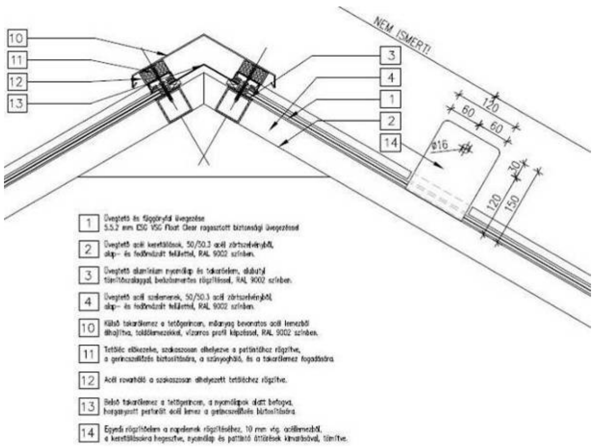

Figure 5.7: BIPV connection in the skylight

The third part of the BIPV system will function as a fix (optionally semitransparent) shade in summer as a part of the south face of the new lighting roof (tilt: 35^o), however due to a simple mobile solution it will let the sunshine in through the glazing in wintertime. The total area of these crystalline Si modules will be about $24m^2$ with a total power of 3.5 kW_p. The estimated yearly generated electrical energy is 3800-4460 kWh.

The inverters of the grid connected system have 95.4% efficiency and it will feed the generated electrical energy into the grid.

5.1.2. Residential building – block of flats in Hamvas street of Püspökmajor (area A)

Figure 5.8: Residential area of Püspökmajor.

The residential building of Püspökmajor will demonstrate two kinds of PV mounting technique in its BIPV system. The whole system is designed to have 6 kW_p maximum power in total. The total yearly generated electrical energy can be estimated to 5800-6810 kWh.

The Southern façade edge wall of the building will support about a fixed $60m^2$ PV beside the upper part of the wall. From an energetic point of view the thin film PV is a better solution here, since it is less sensitive to rarely possible shadows and the incidence of the sunlight. With an example of thin film PV this area gives about 3.7 kW_p. The estimated yearly generated electrical energy is 3210-3770 kWh.

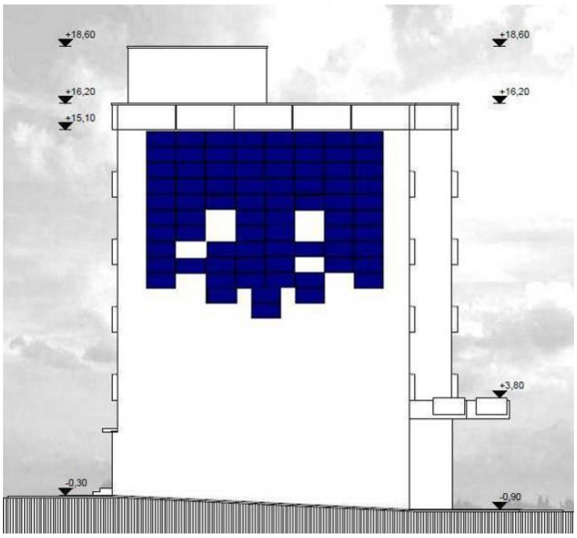

Figure 5.9: Example of a 60m^2 BIPV matrix on the south gable

On the eastern part of the flat roof further PV modules can be placed. Crystalline solar modules are suggested on the roof with a loaded fix console mounting technology. Taking multicrystalline module (190 W_p, 1.3m^2) we design about 12 pieces only above the balconies (using their planned metal structure), which results in 2.3 kW_p and 15.6m^2. The estimated yearly generated electrical energy is 2590-3040 kWh.

Figure 5.10: Eastern facade of Residential building in Hamvas street

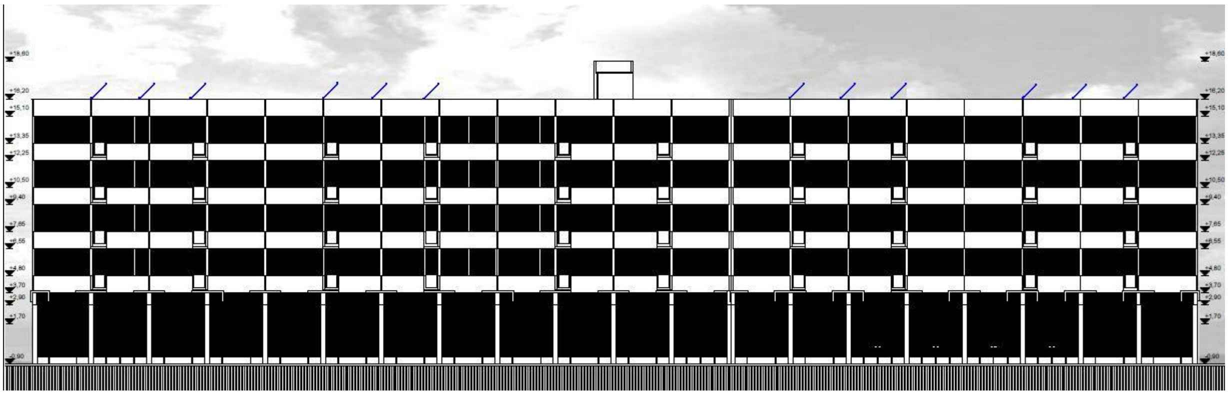

Figure 5.11: PVs on the eastern edge of the roof.

The whole system will be a grid connected system connecting through inverters with efficiency of 98%.

5.1.3. VSZ Zrt. Head office building (area C)

The office building of Városi Szolgáltató Zrt. planned a PV system, which has two separate parts. The total power of the system is 10.3 kW. The whole system is designed to have 6 kW_p maximum power in total. The total yearly generated electrical energy can be estimated to 11160-12160 kWh.

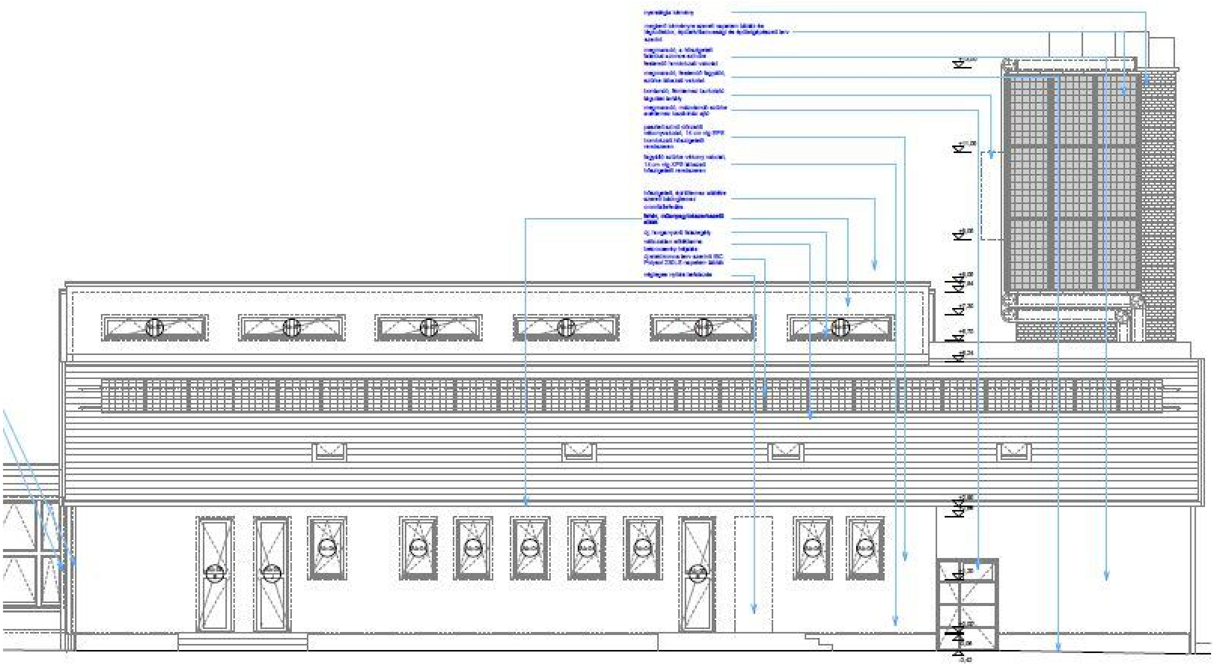

Figure 5.12: Southeast facade of VSZ Zrt. office

One part of the system consists of normal PV modules fixed on the southeast facing pitched roof. It will use 36 pieces of IBC Polysol 230LS multicrystalline Si solar modules in three strings. The total power of this part of the PV system is 8.3 kW_p. Due to the necessary sunshine duration the row of high trees alongside the building has to be cut and changed to other kind of trees with lower foliage. The total generated electrical energy of this part of the PV system will be fed into the grid. Its annual generated energy is estimated to 9080-9715 kWh.

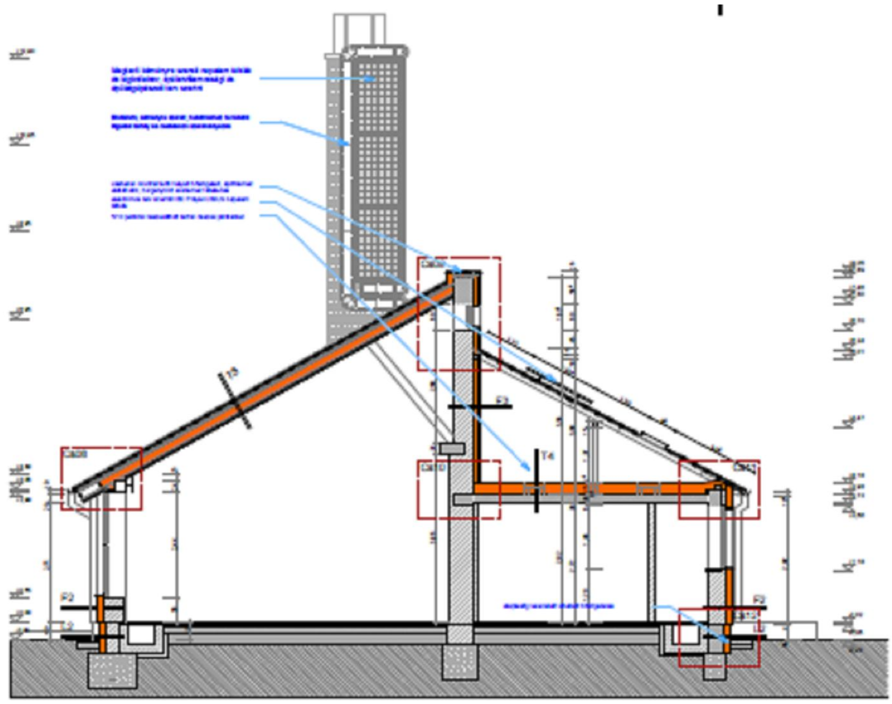

Figure 5.13Cross section and southwest wall of chimney

The other part of the PV system is placed fixed on the southeast and southwest facing walls of the chimney. Behind the solar modules solar thermal air collectors are applied to lead away the generated heat and to utilize it as a fresh air heater inside the building. The total power of the PV modules is about 2 kW_p, and it will have an own inverter. The estimated yearly generated energy is 1560-1830 kWh for the SE façade and 515-605 kWh for the SW façade, so 2075-2440 kWh in total.

The system can not be used as an off-grid PV system. The efficiency of the inverters is 96.3%.

5.2. New office building of ÉMI (area E)

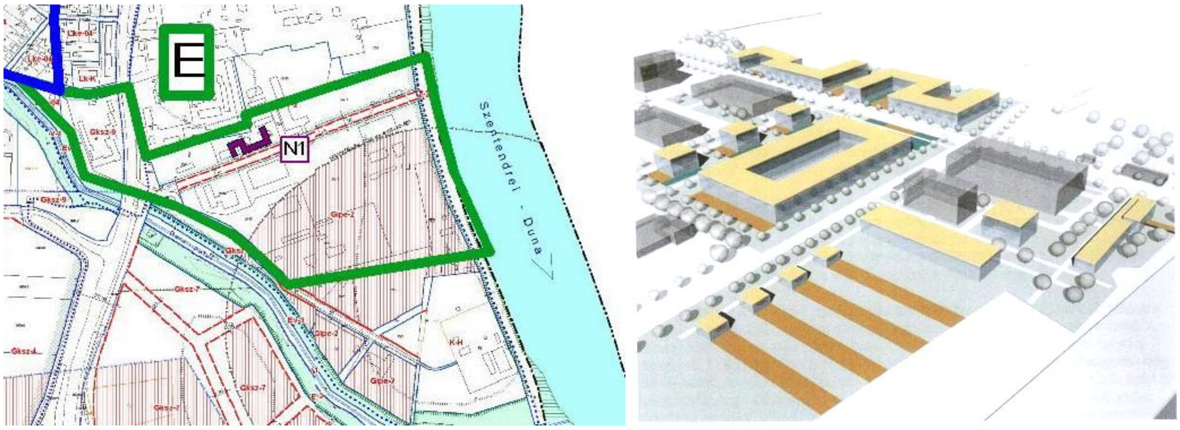

Figure 5.14: Location of the new office building of ÉMI.

ÉMI Nonprofit Kft. will build a new office building in Szentendre, which will demonstrate several types of BIPV. The total nominal power of the PV system is at least 13.9 kW_p. The total yearly generated electrical energy can be estimated to 14070-16530 kWh.

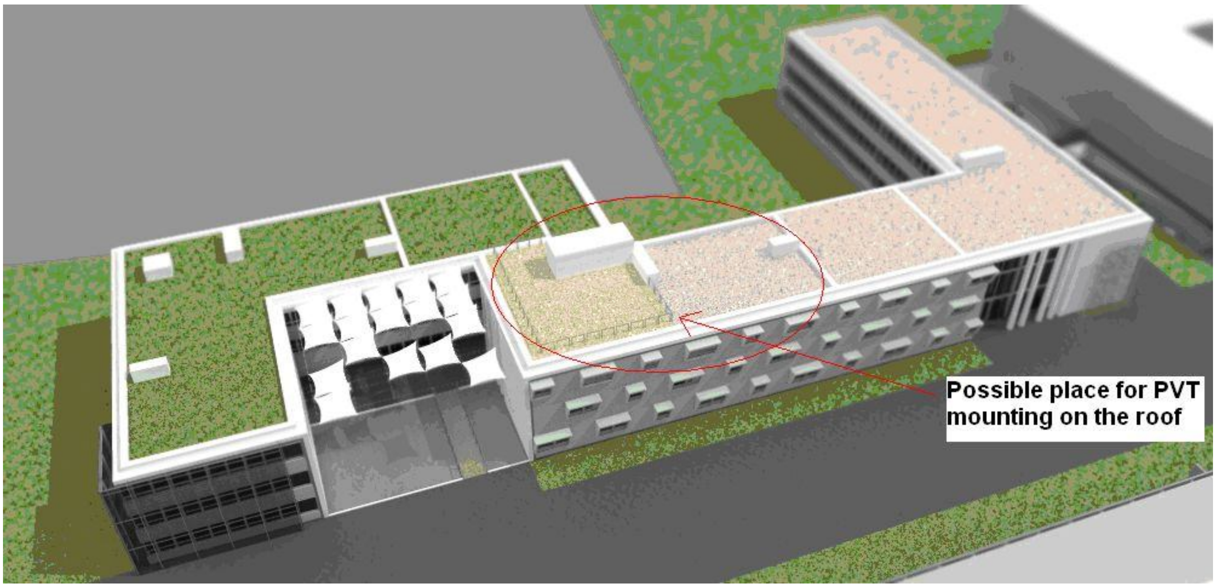

Figure 5.15: 3D model of the new office building.

On the flat roof of the new constructing ÉMI office building a fixed hybrid PVT system will be placed. The innovative PVT modules produce electrical power (190 W_p) and thermal power (460 W_{th}) in one single unit (1.4m^2). This module applies crystalline Si solar cells and under it a solar thermal collector. The total area will be about 66m^2, with a total electrical power of 9.1 kW_p and thermal power of 22.1 kW_{th}. The PVT modules will be mounted on the flat roof by mounting structure, which set the tilt of the modules close to the optimal one. The PVT modules will be grouped into 3 groups, and they automatically connect through inverters to the one-phase UPS unit, which ensures the uninterrupted electrical energy for the weak current security and safety devices independently from the grid. The UPS unit also connects to the grid, so the whole system is a hybrid (or combined) PV system. The yearly generated energy of this system can be estimated to 10250-12040 kWh.

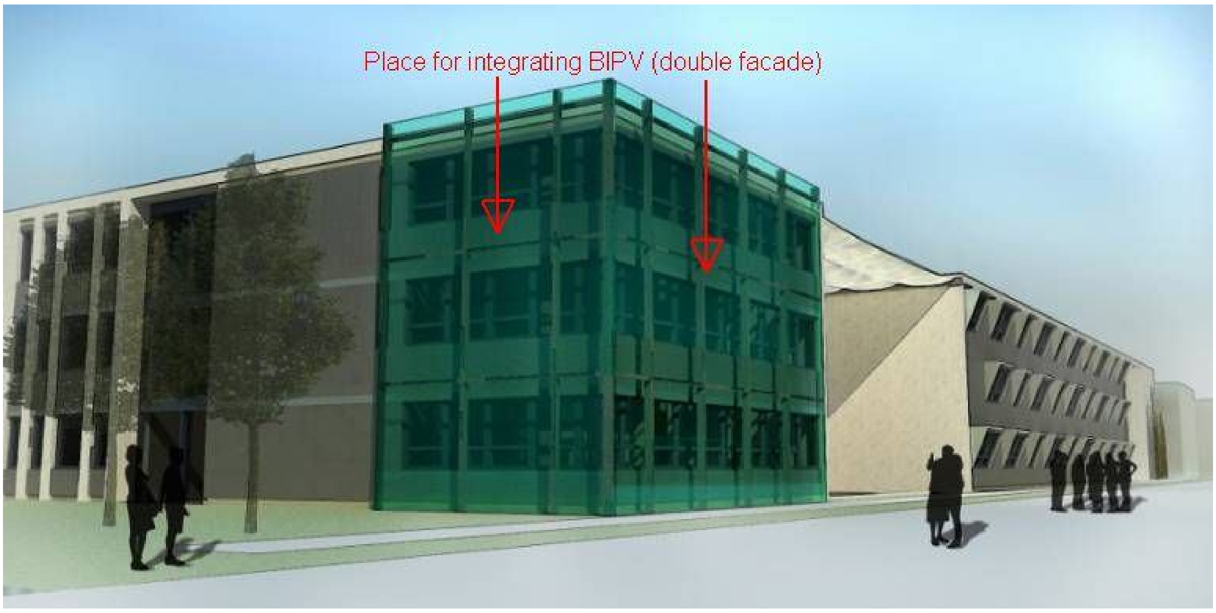

Figure 5.16: Southern and western façade of new office building.

On the southern and western façade of the office building a double façade has been designed, which has a glazed outer shell. This glazing can be used also for BIPV purposes, since the thin-film PV can be used as a semitransparent glazing as a building element. A system with a total maximum power of 3.3 kW_p on the southern façade and a 1.5 kW_p on the western façade can be applied. The estimated yearly generated energy is 2860-3360 kWh for the southern façade and 960-1130 kWh for the western façade, so 3820-4490 kWh in total.

The inverters of this system has an efficiency of 98%.