INVESTMENT SPECIFICATION FOR THE INTEGRATION OF AN ENERGY STORAGE IN HUC OF LENDAVA

D.T2.1.5

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Title	INVESTMENT SPECIFICATION FOR THE INTEGRATION OF AN ENERGY STORAGE IN HUC OF LENDAVA (SI)
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Summary

1. INTRODUCTION

This investment specification document (pre-investment concept) includes all the aspects to be evaluated before starting with investments and procurement procedures, including also the aspects already included in preliminary project design steps incl. energy audit where available. Each pilot fills in this document to ensure that all relevant aspects will be considered in the procurement of the identified storage solution.

The investment specification is linked and should include the outcomes and contributions of other documents and project results (see also Figure 1 below):

- Deployment desk outcomes, including expectations of stakeholders supporting the pilots (A.T1.1);
- Feasibility study of the pilot (A.T1.2);
- Results of the application of the Energy Management System (EMS) tools in the storage planning and design (A.T3.1);
- Monitoring of Key Performance indicators (KPIs) specified for pre-investment stage (paragraph 2 of template for the HUC pilot action report, D.T2.2.1);
- Existing preliminary projects of reference for the pilot investment;
- Existing energy audit / analysis of consumption for pilots.

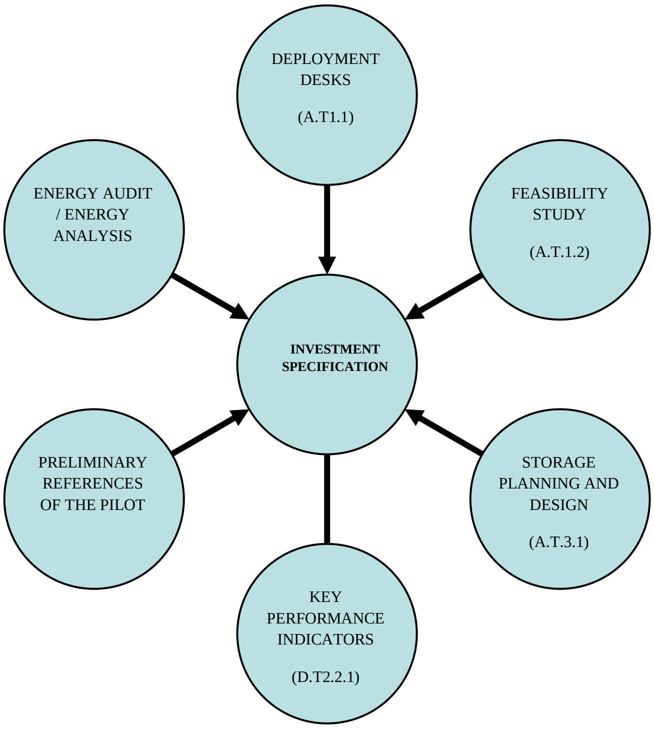

Figure 1: *Interrelations between the elements for consideration in the pre-investment concept*

The main aim of the pilot project is the replacement of the existing Oil-Fired Boiler in Lendava Library (public building) with a renewable energy source. The building will be connected to the existing geothermal district heating network to increase the share of Thwe public sector.

Lendava Library will be the last connection in the geothermal district heating network and the supply is not stable - the supply medium temperature will/cannot be constant. This was the main reason, why the owner did not change the fossil fuel in this building yet - the storage selection in the pilot is crucial, to change into RES. The properly selected storage will in this case ensure the stable supply for end users.

An innovative solution of energy storing system will be installed in the basement of Lendava Library to increase the level of energy efficiency in public buildings (related to the higher efficiency of the heating system). Paraffin cells are modern and innovative buffer storages that have been developed to efficiently store heat and cold generated from small irregular energy sources such as solar energy, heat pumps etc. Thermal energy storage technologies and geothermal district heating systems have the potential to play a significant role in the transition towards 100% renewable energy systems through increasing system flexibility and overall efficiency and thus reduce CO_2 emissions and increase domestic energy security and additionally reduce the costs of heating. The advantage of paraffin used storages compared to regular water storages: requires less space, which is very important in case of Lendava Library.

The building was restored several times. In 1996, the roof was restored. The renovation included the replacement of the roof structure, the replacement of the roofing and the installation of 15 cm thick thermal insulation. The next major renovation was made in 2005, when the basement was completely renovated. The windows are wooden, boxed versions. The building is a cultural heritage and is under the protection of monuments. This means that investments/renovation on the building are limited or under control. The Library employs 10 people, the average daily number of Library visitors is around 45.

Due to the above-mentioned challenges, however, there is a need to catch up in terms of energy efficiency and the use of renewable energy sources, especially in these districts with its listed buildings concerning historic monument and landscape protection. The project in question can and should therefore serve as an innovative best-practice example over the next few years and as a model for simplified technical and, above all, economic implementation in protected historic monuments and landscapes. It will lead to a significant increase in the proportion of renewable energy sources use in historic urban centres.

As a result of the connection to RES and newly implemented storage in accordance with the newly implemented control and EMS system, the following positive effects can be achieved:

- Increasing the energy efficiency of the system by changing the heating system from energy un-efficient (old Oil-Fired boiler) to efficient (DHS) → min. primary energy savings → CO_2 saving through lower final energy consumption
- Lower pollutant emissions by changing from fossil to renewable energy source (carbon dioxide - CO_2, carbon monoxide - CO, dust and other greenhouse gas emissions as NOx and CxHy)
- Exploitation of local renewable energy – geothermal energy
- Extension of maintenance intervals → lower maintenance costs (no maintenance on heating system and low maintenance cost on storage)

2. INITIAL SITUATION AND CONTEXT

2.1. Localization of the storage

The storage will be installed in the Public Library of Lendava in Pomurje Region. Geographical position of Lendava is in the eastern part of Slovenia near Slovenian-Hungarian and Slovenian-Croatian border. The unique position of the town at the foothills of picturesque vineyards originates from its rich historical role and a profuse cultural image, contributed by inhabitants with diverse ethnic definition. In Lendava members of different nationalities live closely together; Slovenes, Hungarians, Croats and other nationalities. Based on the city's cultural tradition there is a multicultural centre which defines the city and also municipality. The unique position is defining Lendava in its culture, languages and the way of thinking and living. Based on the city's cultural tradition, rich history, multicultural aspect Lendava is a typical example, where United Europe project easily finds its place.

The Lendava Library is located in the centrum of the town near the Evangelical Church and the Lendava Town Hall, where the municipal administration is located.

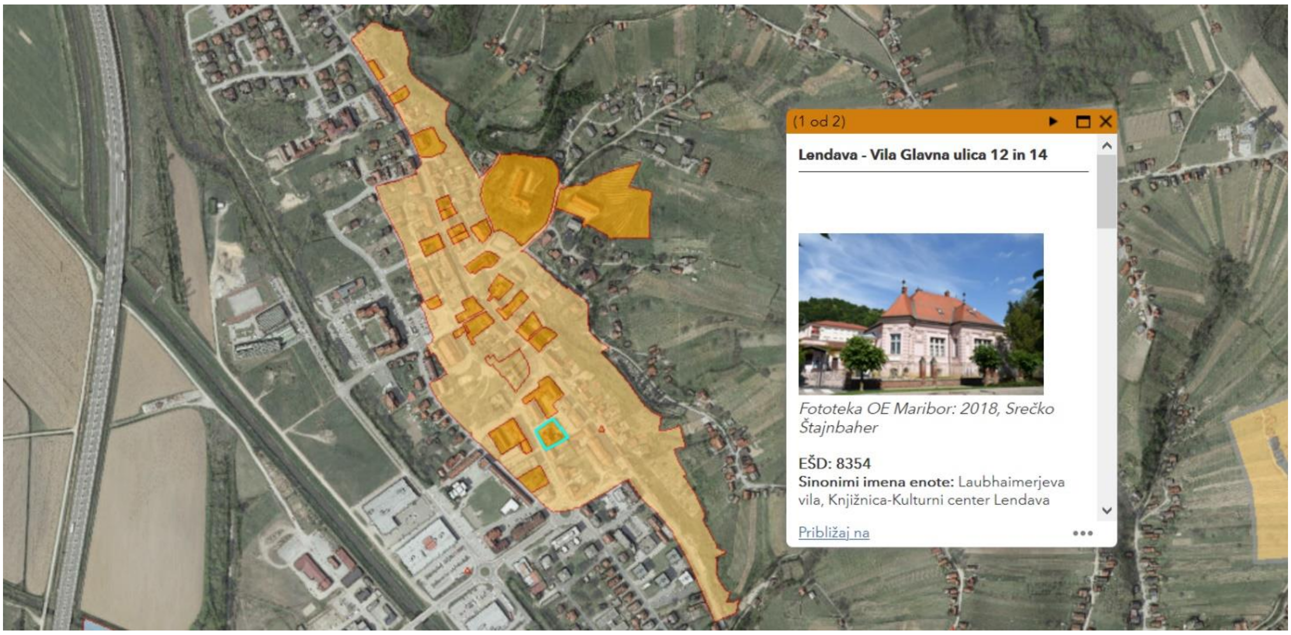

Figure 2: *The location of Public Library in Lendava*[1]

The building of Lendava Public Library is located in the Oskar Laubhaimer's neo-baroque villa built in 1906. The building was restored several times. In 1996, the roof was restored. The renovation included the replacement of the roof structure, the replacement of the roofing and the installation of 15 cm thick thermal insulation. The next major renovation was made in 2005, when the basement was completely renovated. The windows are wooden, boxed versions. The building is a cultural heritage and is under the protection of monuments. This means that investments/renovation on the building are limited or under control. The Library employs 10 people, the average daily number of Library visitors is around 45.

[1] https://gisportal.gov.si/portal/apps/webappviewer/index.html?id=df5b0c8a300145fda417eda6b0c2b52b

Figure 3: *Lendava Library - Oskar Laubhaimer's neo-baroque villa built in 1906*

In the building the storage will be installed in the basement of the building where currently the heating oil tanks are storred. The PCM storage tanks will be connected to the existing geothermal district heating network to increase the share of renewables in public sector. Lendava Library will be the last connection in the geothermal district heating network.

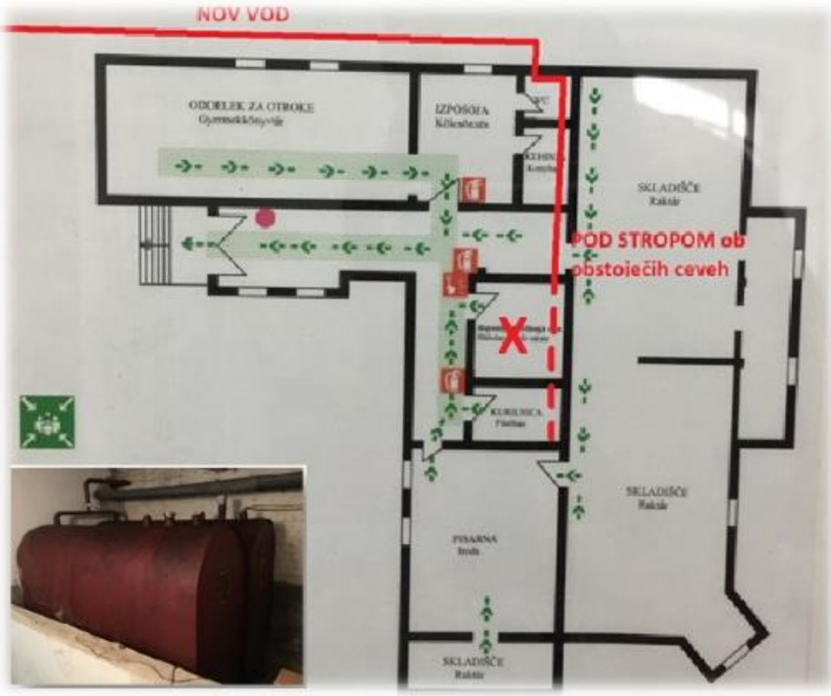

Figure 4: *Location oft the new storage in the basement of Lendava Library*

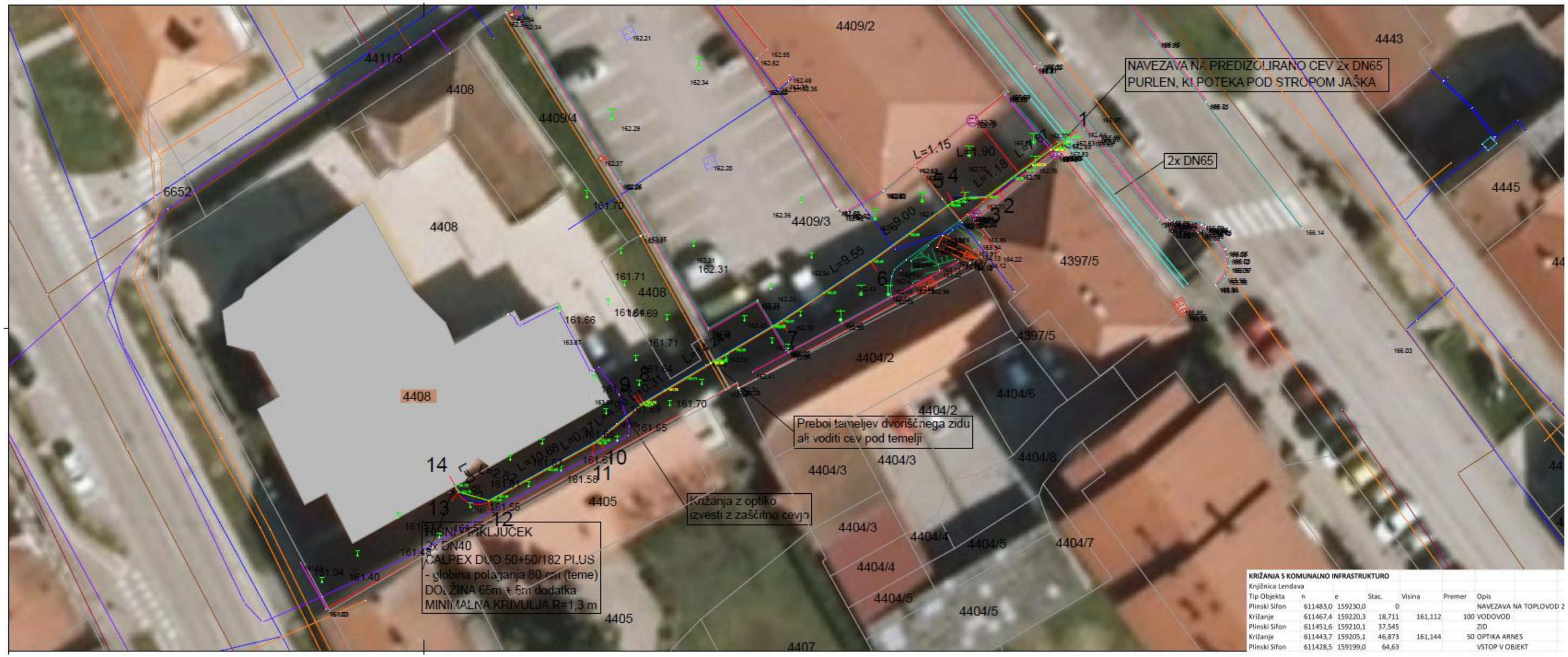

Figure 5: *Location of the new geothermal pipeline*

2.2. Actual energy users and building parameters that the storage will serve

District Heating System Description

In Lendava Petrol Geoterm d.o.o. built a district heating system with geothermal energy (geothermal energetic source) on the basis of Mining Act (Official Gazette of the Republic of Slovenia no. 56/99 and 46/04). After the construction of entire district heating system with geothermal energy system, this is the first system of its kind in Slovenia.

The principle of operation of the district heating system is as follows: thermal water is pumping from aquifer with the production well, transfer heat through heat exchangers to consumers and then cooled water is injected back into the aquifer.

The entire area of district heating with geothermal energy with all consumers, production and (re)injection well is shown in Figure 6.

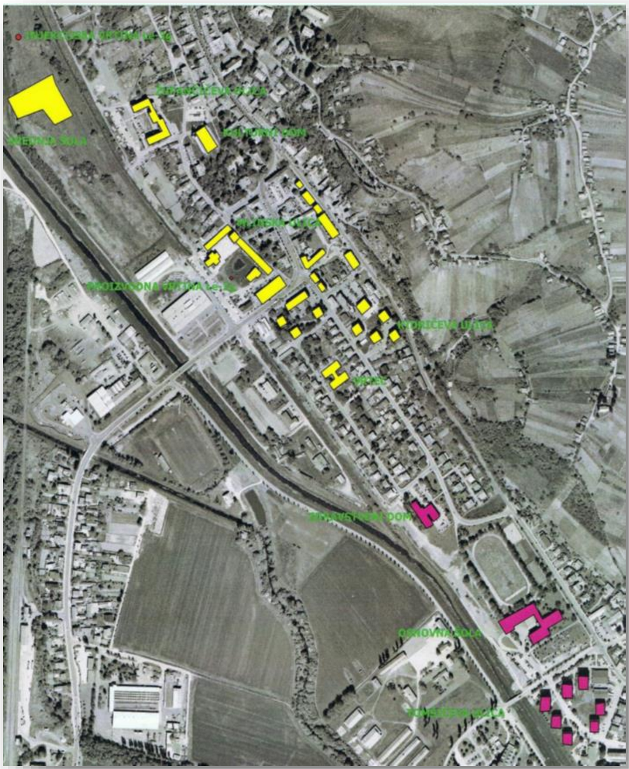

Figure 6: *Area of district heating with geothermal energy with all consumers, production and (re)injection well*

Facilities, connected to the district heating system, are built in different time periods and are poorly isolated. Annual specific heat varies between 28 and 170 kWh/m². For the rational use of heat, most of the facilities should be renovated.

In some existing facilities, hot-water boilers on standard fuels are installed. They are used as reserve for operation at extremely low temperature and in the events of the district heating system failures.

The total installed heat power of the district heating system is 6.65 MWt with total heating area of 65,000 m². Consumers connected to the district heating system are residential (residential blocks), business (shops and business facilities) and educational (school and gym). All consumers have built-in calorimeters to measure heat supplied by the heat distributor.

Annually the heat consumption of all consumers comes approximately at 5.000 MWh, which means about 1.500 tons of CO_2 less greenhouse gas emissions, than in the case if the heat would be provided by incineration of 600.000 litres of extra light heating oil.

The characteristic of the Lendava district heating system are gathered in the table below.

Table 1: *Basic information of Lendava district heating system*

District heating system (DH)	Yes operating
Flow temperature (in case of DH)	66ºC
Total installed power (of heat power plant)	7 MW
Estimations of total installed power in individual systems	6.65 MW
Type of heat production	thermal water, gas boiler, heat pump
Energy source	Geothermal energy
Annually sold heat to households	18,000 GJ
Annually sold heat to industry	/
Share of heat loss in the DH	7 %
Total flat (heated) area surface	260,539 m^2
Flat (heated) area surface on DH	65,000 m^2
Flat (heated) area surface out of DH	195,539 m^2
Share of Flat (heated) area surface on DH (m^2)	25 %
Share of Flat (heated) area surface out of DH	75 %
Estimated specific heat load per square meter (in average)	3.333 W/m^2

Destrict Heating Existing Facilities

The first phase of district heating in Lendava, with exploitation of geothermal energy, started with a well and boiler room for the needs of hotel Elizabeta and business facilities in Mlinska Street in Lendava. In boiler room the heat exchanger with power of 435 kW is operating with temperature difference around 10 °C and a regime 50/40 °C.

In second phase, the well was rehabilitated and a pumping-transport water system was made with partially implemented hot water system to the Secondary school, the block in Župančičeva Street and the Cultural home. Gas boiler room with power of 2.6 MW was completed and an additional heat exchanger for covering peaks and reserve was installed.

In the system was used the existing heating system of Mlinska Street, the regulation and connection of residential blocks in Square Ljudske pravice and Krajnčeva Street in Lendava was made. At the same time, the heating of the Secondary school in Lendava was made.

Residential settlements - residential blocks (Kranjčeva TLP, Župančičeva in Tomšičeva) with a total power of 4.54 MW, connected on district heating system, are older and inappropriately isolated. Temperature heating regime is 60/40 °C.

Residential settlement Krajnčeva includes residential blocks and business facilities (Administrative office, companies ...).

Residential settlement Župančičeva was built in 1980. Heating is conducted through heat exchanger from boiler room. In the building pipeline for thermal water and return of the DN 150 were made. The distribution station is set in basement entrance 1 and had installed distribution board with connection, automatic and pumps for each entrance in the building.

Residential settlement Tomšičeva Street was built 1978 with poor isolation. In existing boiler room two hot-water boilers were installed. The newer boiler has a heat power of 700 kW and older boiler has heat power of 1,500 kW. Heating with geothermal energy was performed.

The Secondary school was built in 2004 and is quite well isolated. The installed heat power is 480 kW. The heat exchanger is used for heating and as a reserve they use hot-water gas boiler Buderus. The system is designed in a way that the thermal water is heated by a system which, if necessary, is warmed up by a hot-water gas boiler.

The Cultural home is newer building, already designed for low temperature regime of 50/40 °C. For heating, a Buderus hot-water boiler with heat power 270 kW is used. After the connection to the thermal water system, the boiler is needed for warming up the system at extremely low temperatures and for reserve.

The Elementary school was built in 1968. In 2004 windows were partially changed and in 2008 the renovation of whole building furniture and isolation of building was carried out. The heating of the building is made from hot water system, which leads to Tomšičeva Street. In boiler room were installed two hot-water boilers with power of 2 x 580 kW and for preparation of hot sanitary water a hot-water boiler with power 28 kW. All boilers use heating oil.

A Health Centre was built in 1975. Building is quite well isolated, if we look a year of construction. Connection on heating system is carried out from hot water system, which leads to Tomšičeva Street.

The building of Lendava Library will be the last connection in the geothermal district heating network and the supply is not stable - the temperatures will/cannot be constant. This was the main reason, why they didn´t changed the fossil fuel in this building yet - the storage selection in the pilot is crucial, to change into RES. The properly selected storage will in this case ensure the stable supply for end users.

Description of building energy parameters

The geothermal district heating network will be connected through the PCM storage tanks to the Lendava Library and will be the last connection in the geothermal district heating network. Lendava Library is one of the biggest public buildings in Lendava and is still heated by fossil fuel – residual fuel oil.

Table 2: *Energy consumption of main public buildings in Lendava municipality*

Public building	Heated area	Heating method	Heating source	Heat consumption	Specific heat energy consumption	Electric energy consumption
	m²	/	/	kWh	kWh/m²	kWh
Primary school Lendava I	7503	thermal substation	geothermal energy	477.964	64	132.680
Primary school Lendava II	828	individual boiler	heating oil	128.125	155	20.970
Primary school Lendava – Petišovci	259	individual boiler	heating oil	70.623	273	3.542
Primary school Genterovci	1.905	individual boiler	LPG	316.000	166	24.302
Kindergarten Lendava	981	central heat. station	geothermal energy	143.000	146	49.400
Public Library Lendava	596	Individual boiler	heating oil	84.351	142	32.653
Theater - concert hall	2.082	thermal substation	geothermal energy	319.002	153	93.693
Castle - Lendava Museum	320	individual boiler	natural gas	61.313	192	13.758
Lendava Health Center	2.075	individual boiler	heating oil	348.750	168	123.000
City hall Lendava	767	individual boiler	natural gas	88.630	116	54.271

The current average annual heat consumption is 84.351 kWh on a heated area of 596 m². Figure 7 shows the existing inefficient old heating oil boiler and the heating oil storage tank. Together with the electric consumption (32.653 kWh), they have an annual energy consumption of 196 kWh per square meter. Lendava Library produce annually 23,5 tons of CO_2 related to space heating. The connection to the existing geothermal network would reduce this amount to zero.

Existing boiler plant Description

Figure 7: *Existing inefficient old heating oil boiler*

The heating temperature in the building is regulated by an outdoor temperature sensor. In the rooms are radiators, which are not equipped with thermostatic valves.

Table 3: *Key characteristics of the existing boiler plant*

Boiler plant		
Cast-iron boiler	BUDERUS	
Type	Logano G215	
Power	71 - 85	[kW]
Dimensions	1027/920/695	mm
Net weight	317	kg
The amount of water in the boiler	85	l
The amount of flue gases	101,4	l
Flue gas temperature	160-180	°C
Maximum flow temperature	110	°C
Maximum working pressure	4	bar
Burner type	Gulliver RG2	
Used heating oil (2017/18)	8.452	l

The secondary source of heating In Lendava Library is the electric power for the operation of two Mitsubishi MX2 air conditioners (power of 10,5 kW). Heating with the secondary source may be considered during a transitional period when the rooms are heated by the specified air conditioners. The estimated electricity consumption for heating during the transition period is 25.000 kWh, but will not be included in the following calculations related to savings/costs/consumption.

2.3. Actual energy use and energy balance

The energy data from tables 4, 5 and 6 are taken from the energy accounting software E2 manager. The building of Lendava Library is still heated by fossil fuel – residual fuel oil. Based on the actual *Local Energy Concept of Lendava Municipality* (data taken on the current average annual heat consumption is 84.351 kWh on a heated area of 596 m². Together with the electric consumption (32.653 kWh), it has an annual energy consumption of 196 kWh per square meter. Lendava Library produce annually 23,5 tons of CO_2 related to space heating. The connection to the existing geothermal network could reduce this amount to zero.

Table 4: *Heating oil consumption in Lendava Library*[2]

	Consumption in litres				Growth rate in %		Average annual growth in %
Year	**2016**	**2017**	**2018**	**2019**	**2016/2018**	**2016/2019**	**2016/2019**
January		3.000					
February			4.900				
March				1.800			
April	1.000	1.502			50,20		
May				1.000			
October	2.501	2.000	2.900	2.205	-20,00	-11,80	-4,11
December	2.200	2.232		1.500	1,50	-31,80	-11,99
TOTAL	**5.701**	**8.734**	**7.800**	**6.505**	**53,20**	**14,10**	**4,50**

Table 5: *Electricity consumption in Lendava Library*

	Consumption in litres				Growth rate in %			Average annual growth in %
Year	**2016**	**2017**	**2018**	**2019**	**2016/2017**	**2017/2018**	**2018/2019**	**2016/2019**
January	3.285	6.988	3.549	3.462	112,70	-49,20	-2,50	1,76
February	3.204	3.076	3.284	3.161	-4,00	6,80	-3,70	-0,45
March	3.442	3.483	3.650	3.502	1,20	4,80	-4,10	0,58
April	3.128	3.072	3.336	3.372	-1,80	8,60	1,10	2,54
May	3.324	3.258	3.430	3.478	-2,00	5,30	1,40	1,52
June	3.280	3.435	3.403	3.914	4,70	-0,90	15,00	6,07
July	3.446	3.912	3.358	3.939	13,50	-14,20	17,30	4,56
August	3.204	3.989	3.966	3.981	24,50	-0,60	0,40	7,51
September	3.445	3.499	3.451	3.526	1,60	-1,40	2,20	0,78

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October	3.293	3.483	3.582	3.616	5,80	2,80	0,90	3,17
November	3.346	3.393	3.407	3.449	1,40	0,40	1,20	1.02
December	3.526	3.439	3.297	3.404	-2,50	-4,10	3,20	-1,17
TOTAL	**39.923**	**45.027**	**41.713**	**42.804**	**12,78**	**-7,36**	**2,62**	**2,35**

Table 6: *Electricity and heat consumption of Lendava Library*

	Consumption in kWh			Share in %	
Year	Electric energy	Heating oil	Total	Electric energy	Heating oil
2016	39.923	57.352	97.275	41,04	58,96
2017	45.027	78.468	123.495	36,46	63,54
2018	41.713	87.864	129.557	32,19	67,81
2019	42.804	65.440	108.244	39,54	60,46

Due to the data from E2 manager the average library consumption per year is about 61.000 kWh per year.

The share of consumption in the coldest month in january is 17% (source: Recknagel - Sprenger, Heizkosten) and therefore the consumption is at least 10.370 kWh.

The daily consumption in the coldest month is thus rounded for 30 days: 346 kWh

The average power of the boiler, which is connected to the pipes and radiators, is 45 kW (150 W/m²), which means that the boiler operates 7,69 hours per day.

The maximum power of the boiler is 70 kW, which means that the boiler would operate 4,94 hours per day.

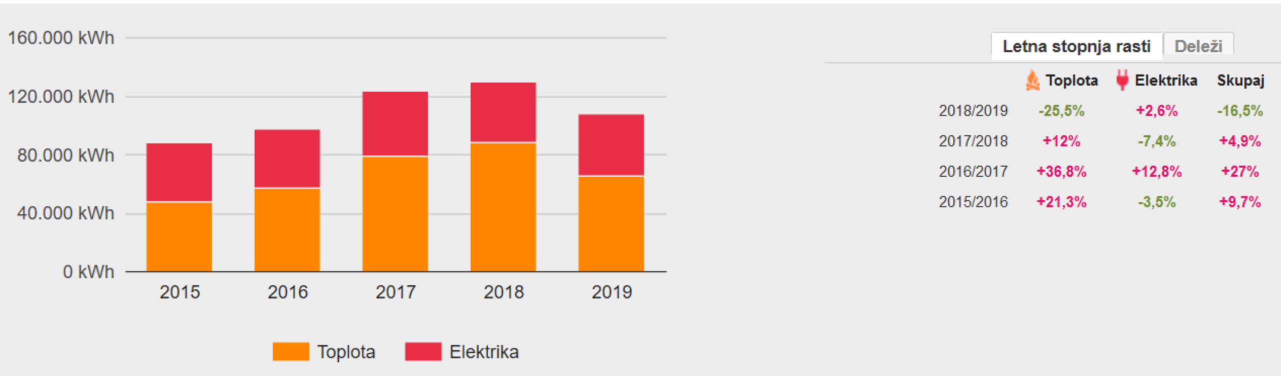

Figure 8: *Electricity (in red) and heat consumption (in orange) of Lendava Library per years*

Regarding the *system operating instructions* for the **district heating system** in the geographical area of the Municipality of Lendava the following regulation have to be considered to define the temperature diagram for the hot water (2C) system for buildings: Official Gazette of the Republic of Slovenia no. 3/2018 (12 January 2018). From the diagram in Figure 9 we can see that the maximum flow temperature of the system is 65°C and at outside temperature of -10°C this temperature drops to 60°C and less.

At outside temperature of 5°C, the distributor provides 50°C temperature. As the tolerance is ± 3°C, a temperature of 47°C can be expected.

Regarding the the data above and due to the additional temperature drop of 2-5°C, we can expect a maximum of 45°C on the secondary side.

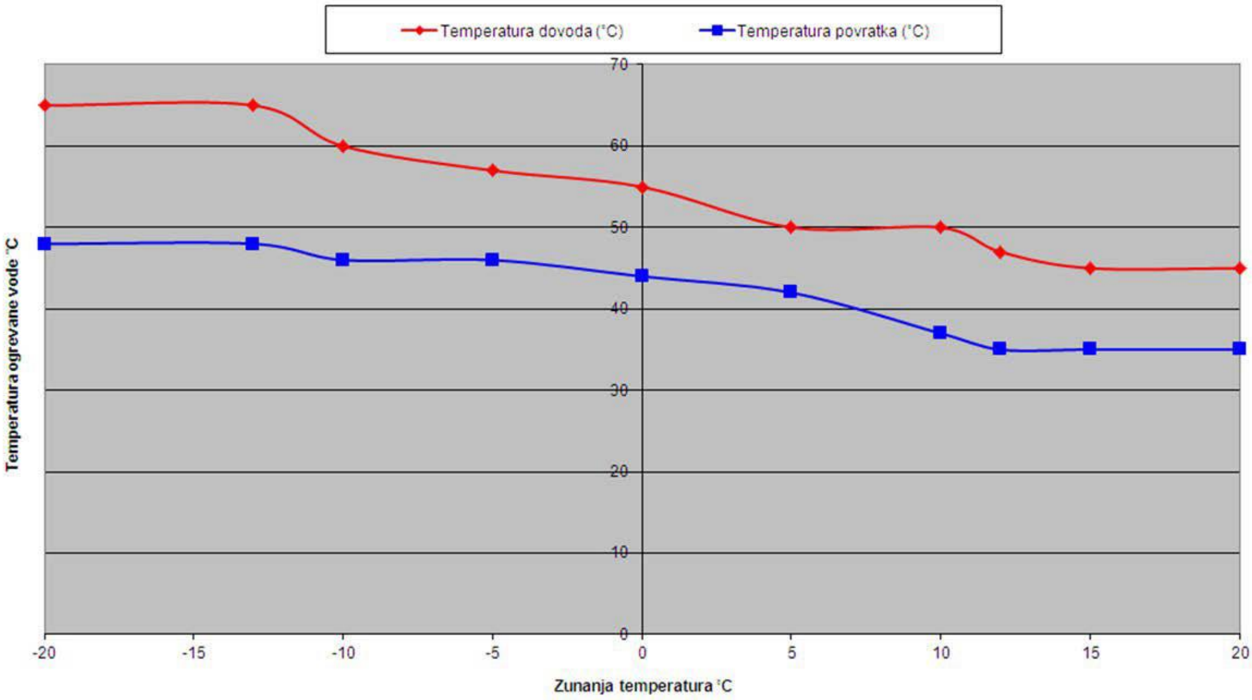

Figure 9: Temperature diagram of hot water (2C) district heating system 2

(in red the inlet temperature and in blue the outlet temperature)

Footnotes:

- The permissible deviation of the heated water temperature at each consumption point is ± 3°C;
- The flow temperature depends on the day/night mode, on the outside temperatures and on the return temperatures. The “day mode” is valid from 5.30 am till 9 pm and the “night mode” from 9 pm till 5.30 am;
- If the return temperature is higher than the reference temperature, the flow temperature is reduced by the same value;
- The flow temperature in ”night mode” depends on the outdoor temperature and is equal to (± 3°C) the return temperature in “day mode”;
- Heating stations must be manufactured in accordance with the requirements of the district heating network operator.

3. CONSTRAINTS AND REFERENCE STANDARDS

3.1. Technical standards

At the national level in Slovenia there are no specific standards for **thermal storages**.

In accordance with the Slovenian Decree on the Classification of Facilities[3] (Official Gazette of the Republic of Slovenia, no. 37/18, according to Annex 2) the installation of a thermal substation is classified as an intervention "Maintenance of facilities" for a number of works: installation of devices and installations in, on and next to the facility. This includes also: the installation of new appliances and related installations for heating, cooling, ventilation, domestic hot water and lighting, including the use of renewable energy sources. A building permit is not required for this type of construction work. It is necessary to obtain project conditions and opinions on the PZI (project for the implementation).

The *system operating instructions* for the **district heating system** in the geographical area of the Municipality of Lendava the following regulation have to be considered to define the temperature diagram for the hot water (2C) system for buildings: Official Gazette of the Republic of Slovenia no. 3/2018[4] (12 of January 2018).

The **heating pipeline** must be planned in accordance with the system instructions of the thermal energy distributor, therefore the facilities of the planned main pipelines and connections are classified as demanding facilities in accordance with the regulation on the classification of facilities, Official Gazette of the Republic of Slovenia no. 37/2018[5] (1 of June 2018).

3.2. Building, monument and heritage protection regulation

HUCs are in Slovenia subject to the building and spatial planning laws of the local community and the Slovenian Preservation of Cultural Heritage Act.

Today the Institute for the Protection of Cultural Heritage of Slovenia (Zavod za varstvo kulturne dediščine Republike Slovenije[6]) brings together art historians, archaeologists, architects, ethnologists, historians, landscape architects, sculptors, painters and many other experts, who work in the Institute's Cultural Heritage Service with the seven regional offices located across Slovenia and in its Conservation Centre with its Restoration and the Preventive Archaeology Centres. In 1999 the new Law on Cultural Heritage Protection clearly defined the administrative and professional functions of protection, especially in binding the rights and obligations of heritage owners to a legal document. In 2008 the Preservation of Cultural Heritage Act was adopted, which includes movable as well as non-movable and intangible cultural heritage, defining the tasks to be performed by public services concerning the preservation of cultural heritage and its executants.[7]

Based on the *Register of Slovene Cultural Heritage*[8], which is under the jurisdiction of Ministry of Culture, the Lendava Library is classified as Profane Building. In 2018, based on the Local Self-Government Act[9] (Official Gazette of the Republic of Slovenia, no. 94/07, 76/08, 79/09, 51/10 and 84/17) and the Cultural Heritage Protection Act – ZVKD-1[10] (Official Gazette of the Republic of Slovenia, no. 16/08), the

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[3] https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/2018-01-1900#

[4] https://www.uradni-list.si/glasilo-uradni-list-rs/celotno-kazalo/20183

[5] https://www.uradni-list.si/glasilo-uradni-list-rs/celotno-kazalo/201837

[6] https://www.zvkds.si/sl

[7] https://www.culture.si/en/Heritage_preservation_and_restoration_in_Slovenia

[8] https://gisportal.gov.si/portal/apps/webappviewer/index.html?id=df5b0c8a300145fda417eda6b0c2b52b

[9] https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/82670

[10] https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina?urlid=19997&stevilka=287

Municipality of Lendava has adopted (2018) an *Ordinance on the proclamation of cultural monuments of local importance in the area of the Municipality of Lendava*[11].

Figure 10: *The Public Library in Lendava in the Register of Slovene Cultural Heritage*

In 2016, The Ministry of Culture in cooperation with the Ministry of Infrastructure published a *Guidelines for energy renovation of cultural heritage buildings*[12]:

"…CONNECTION TO DISTRICT HEATING

In places where a district heating system is established for heating, it is necessary to connect to such a system. The district heating system is the most environmentally acceptable method of heating. District heating is a method of heating in which heat is transferred from a larger source to consumers via a pipe network. Easy connection to the system, lower energy costs, environmental friendliness and additional benefits when connected are just some of the benefits of district heating. …"

Necessary documents for implementation of the pilot:

(1) It is necessary to obtain project conditions and opinions from different experts/institutions (municipal administration, public utility service provider for drinking water supply, public utility company for sewer services, IT provider, telephony operator, electricity operator, services related to the protection of cultural heritage, housing service companies, DHS operator, etc.)

(2) It is necessary to prepare the *Project for the implementation* document (PZI)

(3) An official building permit is NOT required for this type of construction work!

[11] https://gis.gov.si/MK_eVRDpredpis/p1904_1.pdf

[12] http://www.energetika-portal.si/fileadmin/dokumenti/podrocja/energetika/javne_stavbe/smernice_kd_23.2.2017.pdf

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Ime enote:	**Lendava – Vila Glavna ulica 12 in 14**
Lokacija:	parc. št.: 4408 k.o. Lendava
Utemeljitev razglasitve	Pritlična neobaročna vila kvadratnega tlorisa ima štiri vogalne stolpiče. Fasada je členjena z bogato okrašenimi baročnimi kartušami in maltastimi šivanimi robovi. Kvalitetni so dekorativni zaključki žlebov in dimnikov. Notranjščino krasi bogata stropna štukatura z rastlinsko in cvetlično ornamentiko v obliki girland. Glasbeni salon je okrašen s figuralnimi motivi. Kvalitetni so tudi talni mozaiki in parket. Pomemben sestavni del celotne arhitekture predstavlja manjša dvoriščna stavba, v kateri so bili prostori notariata. Izpostaviti velja tudi umetelno oblikovano dvoriščno ograjo. Nekdanja vila notarja Oskarja Laubhaimerja je bila zgrajena leta 1906 in predstavlja kvaliteten primer historicistične enodružinske vile z vrtom, v kateri danes domuje knjižnica.
Opis varstvenega režima:	Za spomenik velja varstveni režim, ki določa: – varovanje kulturnih, arhitekturnih, umetniških in ambientalnih vrednot v celoti, njihovi izvirnosti in neokrnjenosti ter varovanje vseh vedut na spomenik; – vsaka raba in vsi posegi v spomenik morajo biti podrejeni ohranjanju in varovanju spomeniških lastnosti; – strokovno vzdrževanje in obnavljanje vseh neokrnjenih prvin arhitekture po načelu ohranjanja izvirne tlorisne zasnove, gabaritov, lege, pojavnosti, materialov, poslikav in okrasja; – omogočanje predstavitve celote in posameznih zaščitenih elementov ter dostopnost javnosti v meri, ki ne ogroža varovanja spomenika in ne moti v njem odvijajoče se dejavnosti; – na spomenik in ob njem je prepovedano postavljati nosilce infrastrukture in reklam.

Figure 11: *Extract from the municipal ordinance on the proclamation of cultural monuments of local importance in the area of the Municipality of Lendava (Lendava Library)*

The *Ordinance on the proclamation of cultural monuments of local importance in the area of the Municipality of Lendava* prescribes the protection regime description for the building Lendava Library:

- ✓ *protection of cultural, architectural, artistic and ambient values in their entirety, their originality and integrity, and protection of all views of the monument;*
- ✓ *any use and all interventions in the monument must be subject to the preservation and protection of monumental properties;*
- ✓ *professional maintenance and restoration of all intact elements of architecture according to the principle of preserving the original floor plan, dimensions, position, appearance, materials, paintings and decoration;*
- ✓ *enabling the presentation of the whole and individual protected elements and accessibility to the public to the extent that it does not endanger the protection of the monument and does not interfere with the activities taking place in it;*
- ✓ *it is forbidden to place infrastructure and advertisements on and next to the monument.*

4. STORAGE DESCRIPTION AND REQUIREMENTS

4.1. Product technical specifications

4.1.1. Storage and DH connection technical requirements

In the existing heating oil boiler room, an indirect heat station will be installed for the purpose of heating. To reduce the peak heat load, a PCM (phase change material) storage tank (change of liquid and solid phase) will be installed, which will enable the storage of thermal energy at a selected temperature potential of around 50°C. The existing hot water distribution from the neighboring Kranjčeva street, which already supplies house numbers 2, 4, 6, will be used for connection to district heating in the municipality of Lendava. The power of the planned heating substation will be 70 kW. The length of the new connection to the heating pipeline is 65 m.

It is planned to install an indirect heat substation with a low primary regime, below 60°C at the flow. The substation must be richly dimensioned for the lowest possible temperature drops between the primary and secondary. The Lendava library building is currently heated with heating oil.

A connection in the shaft next to the apartment block is planned. The estimated thermal power for heating of 600 m^2 is 72 kW at 120 W/m^2.

The boiler room will first remain in its function in case of low outside temperatures. When the building is partially renovated, it can be completely dismantled. The decision is up to the user.

To the flow and return flow from the boiler, the flow and return flow from the district heating will be connected, which will be brought to the interior of the building.

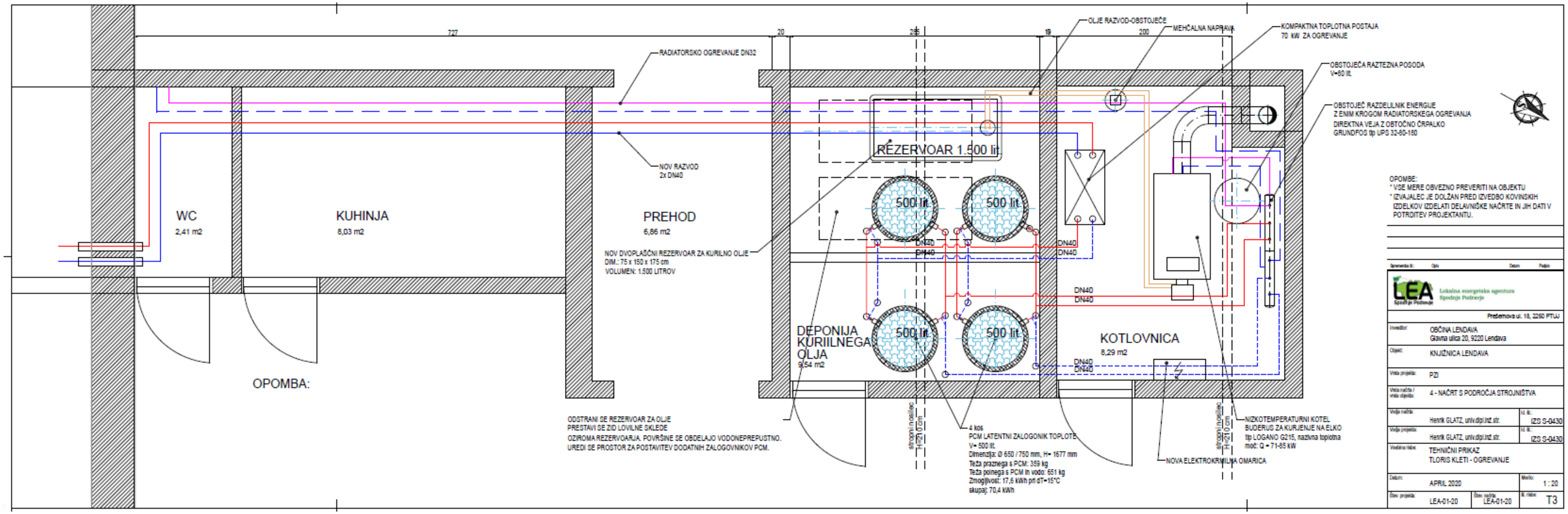

Figure 12: *Floor plan of the planned newly installed 4 PCM storages in accordance with the newly implemented control and EMS syste*

4.1.2. Selection of the storage system

In case of Lendava library, we are limited by the operating temperature of the district heating, which is low, and with the required indirect connection to the heating system, the flow temperature will be further reduced by 5°C, if we take into account the losses of pipelines. In energy terms, the PCM storage tank used is already a proven technology in some countries in EU. This solution of course cannot be regarded as the most cost-effective solution compared with other storage technologies (for example: water buffer tanks), but due to the additional problems with lack of space in the Lendava Library (e.g. the problem of low basement height) and due to the several positive effects of paraffin based latent storages, this is the appropriate solution.

Latent paraffin storage tanks consist of a classic heating water storage tank filled with balls that have a paraffin filler (PCM). At a temperature withdrawal of 45/30°C, energy can be absorbed during the day, distributed overnight and in the morning.

At a crystallization temperature of 42°C, 17,6 kWh of thermal energy can be stored in a 500 liter storage tank at a differential temperature of dT = 15°C. In four storage tanks 70,4 kWh of heat for heating and thus reduce the peak load of the indirect heating station. With a heat demand of 45 kW, the amount of stored heat would be sufficient for 1,56 hours of operation without removal from the district heating. With the correct establishment of the operation of the system, we can reduce the connection power of the heating station, as the peak loads are covered by the storage tanks. Using a storage tank can reduce our peak removal power by at least 30%.

Table 7: *Characteristic values of the new PCM storage tank*

PCM latent storage tank with paraffin wax beads	
Rated pressure	3 bar, test pressure 4.5 bar
Height	1693 mm
Diameter	749 mm
Boiling point	1851 mm
Number of PCM beads	624
Empty weight	134 kg
Storage capacity	17.6 kWh / 15°C
Temp. of crystallization	45°C on request
Volume	500 lit.

If we would use 800 liter storage tanks, it is possible to store 26,9 kWh of energy.

The pilot is an innovative investment at national level, such installation has not yet been built anywhere in Slovenia and in this case the pre-investment report will give us clear technical overview/specifications. Clear is that heat exchanger will be installed and temperature sensors will measure the starting and final temperatures. In any case - the investment can serve as an example of good practice in the project area – example of innovative solution of storing renewable energy in an effective way. After the investment an effective monitoring report will be prepared using energy management tool developed to see the results of the investment (CO_2 savings, kWh savings, cost savings, etc.).

Figure 13: *Example of a phase change energy storage tank*[13]

4.2. Conditions for connection to the district heating system

The Lendava district heating system is managed by the company PETROL d.d. The following are the general and technical conditions for the construction of the Lendava district heating extension.

Terms and conditions:

1. The connection can be made at the location Kranjčeva 6, which is owned by the residents and managed by the Stanovanjsko podjetje Lendava ("Lendava Housing Company") - it is necessary to obtain their consent;
2. The reserve location for connection is the common consumption point of the boiler room at Kranjčeva 8;
3. It is necessary to follow the *System Operating Instructions* for the heat distribution system in the geographical area of the Municipality of Lendava (Official Gazette of the Republic of Slovenia No. 3/2018) and all instructions given by the representative of Petrol d.d. in the field regarding the construction of the heating station and connection to the heating pipeline;
4. Drawing of existing pipelines must be ordered before the start of construction;
5. Before filling the connecting pipeline and before connecting the heating station to the district heating system, it is necessary to inform the representative of Petrol d.d.;
6. In the project for implementation, it is necessary to show the installation of the indirect heating station and the connection to the internal installation in accordance with the System operating instructions.

[13] Source: https://www.jekusol.de/

Figure 14: Existing distrct heating pipeline under the pavement at Kranjčeva street – new connection location

Technical conditions:

1. Separate heating system via indirect heating station for the heating (System Operating Instructions) for the heat distribution system in the geographical area of the Municipality of Lendava (Official Gazette of the RS No. 3/2018), which applies to the common consumption point Kranjčeva 8;
2. Separate preparation of hot sanitary water through an indirect heating station is not feasible;
3. Intended installation of an indirect heating station;
4. Internet access and enabled remote control and monitoring of the secondary heating system;
5. Enabled remote monitoring of heat consumption.

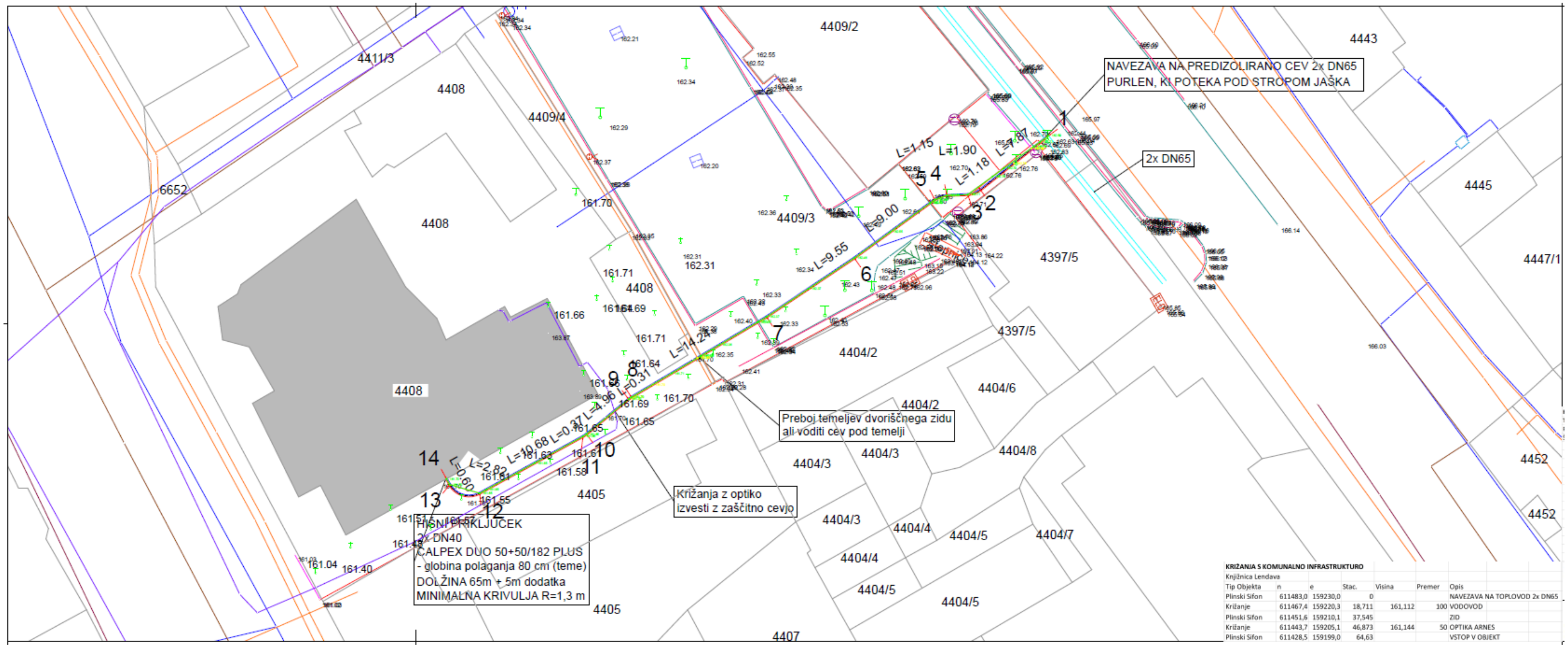

Figure 15: *The new connection between the Lendava library and geothermal district heating*

4.3. Performance requirements

The current average annual heat consumption of the Lendava Library is 84.351 kWh on a heated area of 596 m². Together with the electric consumption (32.653 kWh), it has an annual energy consumption of 196 kWh per square meter.

In the existing boiler room where the old oil-fired boiler is located, an indirect heat station will be installed for the purpose of heating. To reduce the peak heat load, a PCM (phase change material - change of liquid/solid phase) storage tank will be installed, which will enable the storage of thermal energy at a selected temperature potential of around 50°C. The existing hot water distribution from the neighboring Kranjčeva street, which already supplies multi-residential buildings with numbers 2, 4, 6, will be used for connection to the existing geothermal district heating. The power of the planned heating substation will be 70 kW. The length of the new connection to the heating pipeline is 65 m.

The storage tanks will be filled with paraffin cells. Paraffin cells are innovative buffer storages that have been developed to efficiently store heat and cold generated from small irregular energy sources such as solar energy, heat pumps etc. Thermal energy storage technologies and geothermal district heating systems have the potential to play a significant role in the transition towards 100% renewable energy systems through increasing system flexibility and overall efficiency and thus reduce CO_2 emissions, increase domestic energy security and additionally reduce the costs of heating. There are several advantages of latent paraffin-based storages against the “usual” thermal heat storages: Require less space – smaller dimensions; Less temperature loss; Less reactivity with the environment and less likelihood of leakage as it changes phases; Better heat transfer performances=higher efficiency=lower heating costs.

In addition to the storage, the required peripheral components such as piping, expansion system, grid pump, heat meter and control/EMS system with visualisation and data recording will be newly installed or renewed, respectively.

HEATING STATION

To achieve optimal heating results, it is necessary to install the optimal size of the heating station with first-class control and regulation equipment. Compact modern heating stations have low heat losses and high energy transfer efficiency with extremely small temperature drops in the transfer from the primary high-pressure part to the secondary heating system. The planned heating station is of the indirect type of compact design with a secondary circuit for heating the building for the temperature regime:

- primary 60°C / 50°C
- secondary 55°C / 45°C at T_{out} = - 16°C

The heating station is designed as a compact heating station, mounted on a steel frame and with all electrical connections. The elements and pipe connections are insulated as much as possible. It consists of a primary and a secondary part. It will be connected to the hot water network (2C) Lendava and implemented in accordance with the technical conditions for connection to the distribution network.

Design parameters for dimensioning of heating stations:

HEATING AND VENTILATION OF THE FACILITY

- primary temperature regime: 65°C at an outdoor temperature of -13°C
- temperature regime on the secondary: max. 55/45°C

The thermal needs of the building were not calculated, as the investor did not provide funds for calculations in accordance with SIST EN 12831-2004. The existing power of the boiler is 80 kW.

The design temperature is -13°C for the planned facility (Lendava).

The elements of the primary heating station must be designed for temp. up to 70°C and PN 6.

The heating station will be installed in the existing boiler room in the basement of the building. Heating water flows in the primary part of the heating station and hot water in the secondary part of the customer.

The maximum available pressure drop in the primary part of the heating station is 35 - 40 kPa.

The heating station is located in the boiler room next to the boiler in the basement of the building. The pipelines enter the building in the toilet area, where insulated pipelines run under the ceiling to the boiler room area.

Two air pots with automatic vents are provided at the highest point. Entrance to the boiler room or. thermal indirect substation is through a single door 90x200 cm, directly from the connecting corridor. The door is metal and opens outwards.

PRIMARY PART (HEATING STATION)

The heating station connected to the primary distribution network must enable connection to the distributor's remote monitoring system. The required remote controle parameters are:

- measurement of parameters of billing heat meter: temperature, energy, power, flow;
- temperature measurement of the heating station: return primary, supply and return secondary outdoor temperatures, temperatures in the heating water accumulator;
- indication of the operation and failure of the circulation pumps and the opening / closing of the motor drives;
- pressure measurements in the secondary part of the heating system;
- open position measurements of primary motor drives;
- two-way communication of setting parameters of local regulation (time and temperature settings of heating control parameters) and electronic continuous limitation of current power and flow using a communication protocol compatible with the existing remote controle system of the distributor

SECONDARY PART (DISTRIBUTION STATION)

Heat exchanger

The surface of the heat exchanger is dimensioned to the maximum power of the customer's heating devices at the selected heating water temperature on the primary and secondary side of the heat exchanger.

The following measurements are shown:

- primary supply temperature in °C;
- primary return temperature in °C;
- reference and actual supply temperature on the secondary side in °C;
- secondary return temperature °C;
- outdoor temperature in °C;
- primary supply pressure in bars;

- secondary return pressure in bars;
- return pressure to the secondary in bars;
- data from the heat meter: power, energy, current flow, cumulative flow, supply and return temperatures.

The following states are displayed:

- control valve activity;
- mode of operation of the controller (manual, automatic, antifreeze, DHW, complete stop);
- time and date of the controller;
- indication of return temperature, power and / or flow limiting activity.

4.3.1. Selection of the heating station

The following indirect substation is suitable for the thermal needs of the Lendava library building:

GIAFLEX heating station with a nominal heating power of 70kW with the following data:

- version: freestanding
- power source: district heating
- connection power: 70kW
- primary: hot water 60/50 ° C, (max. 100 ° C) PN16 DN50
- secondary: 55 / 45 ° C, PN10 DN50
- medium: primary - hot prepared (softened); water secondary - sanitary water
- max. pressure drop-on the primary side: 35kPa

The station consists of the following elements:

- heat exchanger of plate solder version, stainless steel plate 1.4404 (AISI 316), connected with copper solder and welded or flange connections type Alfa Laval CB60-60L

PRIMARY:

- control bypass valve with flange connections, gray cast iron housing, Samson 3213 with actuator 5857-230-10 / 3T / 230V, max. medium temperature 130°C

  PN16 DN32

  kvs = 16 m^3/h

  dp = 14 kPa

- heat exchanger of plate solder design, stainless steel plate 1.4404 (AISI 316), connected with copper solder and welded or flange connections type Alfa Laval CB60-60L **; max. temp. 225°C

  Q = 70kW; PN25,

  primary: 60/50°C Dp = 15kPa

  secondary: 55/45 ° C Dp = 10kPa

- removable insulation for heating made of polyurethane with ABS coating

- threaded ball valve, material stainless steel (also suitable for DHW), max. temp. medium 110 ° C. PN10 DN50 (2")
- manometer together with U-elbow and manometer tap, diameter 80mm range 0-16bar
- thermometer diameter 80mm 0-120°C
- dirt trap with flange connection, gray cast iron, sieve fineness max. 0.8mm, with magnetic insert, max. temperature 150°C DN50 PN16
- pipe temperature sensor Samson 5277-2, temp. range-10… 150°C, max. temp. medium 200°C
- drain tap with nozzle for flexible hose, max. temp. medium 150°C PN16 DN25

SECONDARY:

- threaded ball valve, material stainless steel (also suitable for DHW), max. temp. medium 110°C. PN10 DN50 (2")
- dirt trap with flange connection, gray cast iron, sieve fineness max. 0.8mm, with magnetic insert, max. temperature 150°C DN50 PN16
- thermometer diameter 80mm 0-120°C
- manometer together with U-elbow and manometer tap, diameter 80mm range 0-10bar
- pipe temperature sensor Samson 5277-2, temp. range-10… 150°C, max. temp. medium 200°C
- drain tap with nozzle for flexible hose, max. temp. medium 150°C PN16 DN25

SYSTEM PROTECTION

- Safety valve DN20 / 25 Gerhard Götze type 651mHNK for hot water system, temperatures up to 120°C, in accordance with DIN 4751/2 (1993), TRD 721, DIN EN 12828, DIN EN ISO 4126-1, PED 97/23 / EC. opening pressure: 3 bar (n) outlet coefficient: alpha = 0.3
- Cap valve (or ball valve with shut-off valve) for protection against unauthorized closing of expansion vessel DN25 (1") PN16
- Zilmet expansion tank type Cal Pro 105L for heating systems, cold rolled steel housing, SBR rubber membrane. Max. temperature 99°C, max. pressure 6bar, connection 3/4 "volume 105l.

HEAT ENERGY METER

- Heat meter, set with built-in set and calculation unit and two temperature sensors, together with Mbus card and 230V mains power supply, product Allmess type CF Echo II, PN16 DN25, L = 260mm Vnom = 6m³/h Vmin = 0,060 m³/h
- Intermediate piece of pipe, the dimensions of which correspond to the dimensions of the heat meter, for installation during the trial operation instead of the heat meter, with Dutch / flanges. The meter must allow data to be transmitted to the distributor.

ELECTRONIC CONTROLLER

- Digital electronic controller for flow temperature control depending on the outside temperature Samson 5573. Two three-point outputs. Mbus card for connection to the calorimeter and the possibility of continuous power limitation. Possible choice of different standard machine schemes, which include heating, DHW preparation and utilization of other energy sources. Includes electrical cabinet with regulator, cabling, surge protection and grounding. All elements are electrically connected and ready for connection to the 230 or 380 V ~ mains.

- external temperature sensor Samson 5227-2 temp. range -35…85°C
- TTL / RS485 signal converter, together with surge protection without Samson SA5000 signal conversion

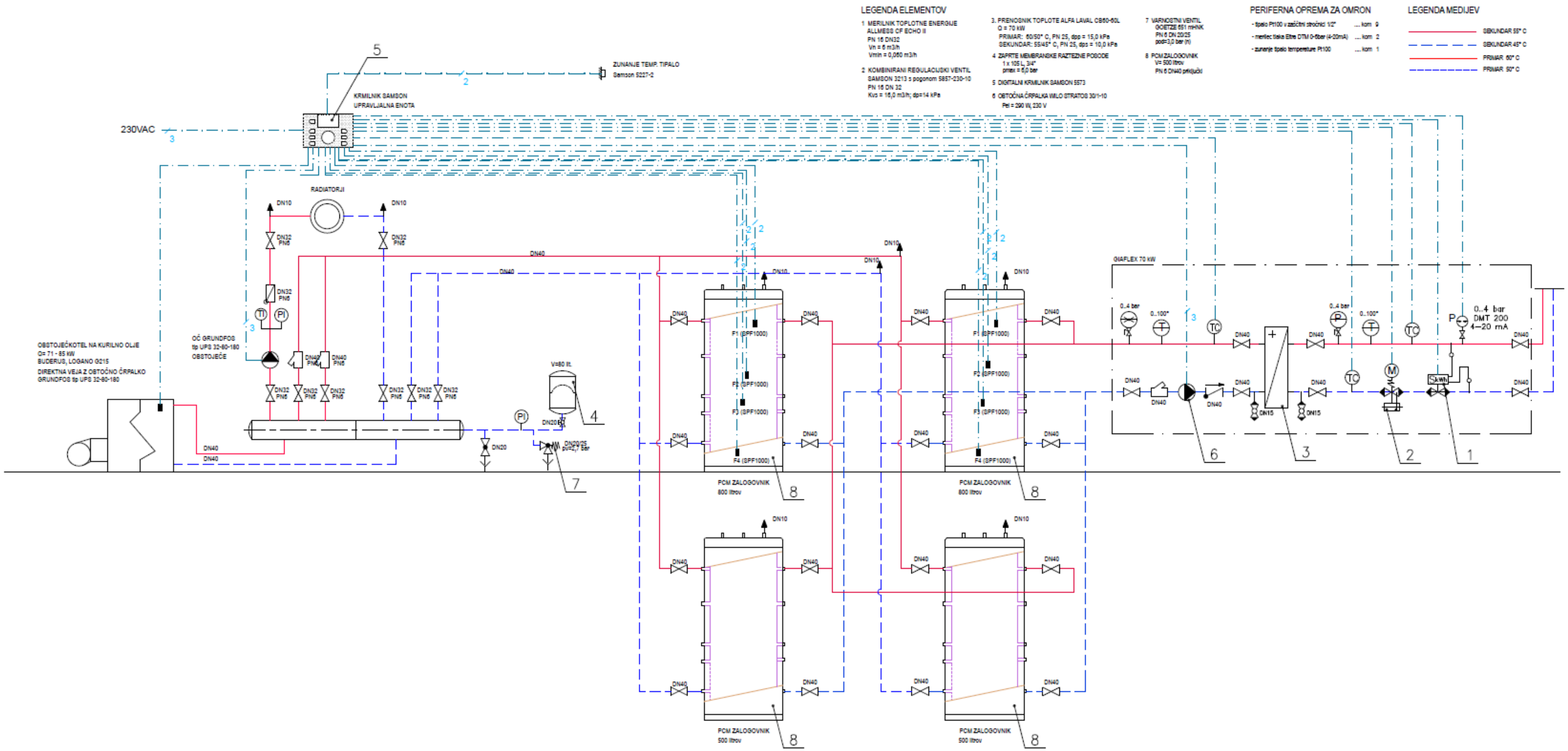

Figure 16: *Scheme of planned newly installed 4 PCM storages in accordance with the newly implemented control and EMS system*

4.4. Minimum project targets

By referring to the accomplished deliverable DT1.2.3 Feasibility study for implementing energy storages in Lendava (SI) with the following citation: "*As a result of the connection to RES and newly implemented storage in accordance with the newly implemented control and EMS system, the following positive effects can be achieved:*

- *Increasing the energy efficiency of the system by changing the heating system from energy un-efficient (old Oil-Fired boiler) to efficient (DHS) → significant primary energy savings → CO_2 saving through lower final energy consumption*
- *Lower pollutant emissions by changing from fossil to renewable energy source (carbon dioxide - CO_2, carbon monoxide - CO, dust and other greenhouse gas emissions as NOx and CxHy)*
- *Exploitation of local renewable energy – geothermal energy*
- *Extension of maintenance intervals → lower maintenance costs (no maintenance on heating system and low maintenance cost on storage)*

By referring to the application form of the STORE4HUC project, the following minimum project targets must be achieved on Lendava Pilot:

1. *Reduction of energy consumption/share of fossil fuels: 60 MWh (current consumption of heating oil in Lendava Library);*
2. *Reduction of CO_2 Emissions Pollution: 16,8 tons of CO_2 (geothermal energy has an CO_2 emission factor of "0");*
3. *Exploitation of renewable energy – geothermal energy: 57 MWh (savings related to energy storing included)*
4. *Increase of energy efficiency: 5,5% or 3 MWh (boiler efficiency)*
5. *Implementation and presentation of an innovative way of energy storing*
6. *Integration of political decision makers/public sector in the development and implementation process of the pilot project – as a basis for further promotion of the project to other sectors and integration of measures into the policies*

Table 8: *Theoretical fuel and pollutant savings*

Parameters	before	after	difference
energy savings			
Fuel energy used	kWh	kWh	%
	84.351[14]	79.711	- 5,5
savings of fossil fuels			
Fossil fuel used	kWh	kWh	%
	84.351	0	- 100
reduction of pollution			
	kg/a		
CO_2-equivalent emissions[15]	26.148,81		
CO_2-standard emission factor	23.533,92		
SO_2	36,44		
CO	13,66		
NO_x	12,15		
Dust	1,53		
CxHy	1,82		

In addition, a related new Energy Management System allows a higher control of the overall DH. The following investigation results are commenting the other key performance indicators (KPIs) defined in the already completed deliverable D.T2.1.1 Urban Key Performance indicators & its implication on participating HUC via comparative analysis:

The Key Performance Indicators have been developed to evaluate and monitor the effectiveness of pilot actions, assessing technical, economic and environmental aspects. A set of them has been identified giving to STORE4HUC PPs a consolidated tool for monitoring the successfulness of the pilots and to evaluate the potential impacts and benefits of their replicability in historical urban centres.

For each KPI a description sheet has been defined. These sheets contain a short introduction to the KPI, the field of applicability and the definition of the calculation method. Each monitored indicator (KPI) must be evaluated at different stages of the HUC pilot actions, according to the contents and timeline included in D.T2.2.1 (template for HUC action report).

4.4.1. KEY PERFORMANCE INDICATORS (KPIs)

This paragraph reports on the KPIs identified to evaluate the impacts of the pilot actions on different aspects and benefits foreseen by the implementation of energy storages in HUCs.
KPIs are classified in 2 different categories:

- **Pilot specific KPIs**, specifically aimed to measure the performance and evaluate the results of the storage investment and the direct benefits of its application, coupled with a suitable control algorithm for their energy management. Each PP must identify its pilot specific KPIs, depending on the features of its pilot investment

[14] Source: Local Energy Concept of Lendava Municipality, 2012

[15] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjrwtreu4bqAhVMQMAKHUJPCWgQFjADegQIBRAB&url=http%3A%2F%2Fwww.covenantofmayors.eu%2FIMG%2Fpdf%2Ftechnical_annex_en.pdf&usg=AOvVaw292jg4vxVp9v9b5BH6WRZj

- **Urban KPIs**, identified to measure or evaluate the benefits of the pilot action at urban level or other intermediate levels (for example: municipal properties). All PPs are required to monitor these common urban KPIs.

In order to understand the meaning of the implemented indicators, a short introduction to the definition of the parameters referred to energy consumption is necessary.

In the following indicators these parameters have been defined:

- $E_{c,i}$: i-th thermal/electrical energy consumption of the pilot system, supplied by external source for one year [kWh]
- $E_{c,tot} = \sum E_{c,i}$: total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year [kWh]
- $E_{self\text{-}RES,i}$: i-th consumed energy from self-production of local RES system in a year [kWh]
- $E_{self\text{-}RES} = \sum E_{self\text{-}RES,i}$: total consumed energy from self-production of local RES systems in a year [kWh]
- $E_{TOT} = E_{c,tot} + E_{self\text{-}RES}$: total thermal/electrical energy consumption of the pilot system for one year [kWh]

Moreover, to evaluate these indicators and compare the calculated values during the reporting period, a fixed set of conditions is defined in order to adjust the calculated values from their actual conditions to the common fixed set of conditions.
The adjustment terms are defined from identifiable physical facts about the energy governing characteristics of equipment/system. Two types of adjustments are possible:

- Routine Adjustments – for any energy-governing factors, expected to change routinely during the period of calculation of the indicator, such as weather conditions, annual lift runs, hours of utilisation of the system.
- Non-Routine Adjustment - for those energy-governing factors which are not usually expected to change, such as the facility size, the heated volume or the use of the system.

Table 9: *Complete list of KPI´s*

Indicator	Category	Description	Measurement Unit
KPI_1: External energy needs of the pilot system	Pilot specific KPI	Energy consumption supplied by external sources	[kWh]
KPI_2: External energy cost of the pilot system	Pilot specific KPI	Cost of the energy supplied by external sources	[€]
KPI_3: Average yearly CO_2 abatement	Pilot specific / Urban KPI	CO_2 emissions	[t CO_2]
KPI_4: Autarky rate	Pilot specific / Urban KPI	Energy self-sufficiency	[%]
KPI_5: Use of energy from RES	Pilot specific / Urban KPI	RES self-consumed energy, associated to storage	[kWh]
KPI_6: Security of energy supply	Pilot specific KPI	Hours without service interruptions/discomforts	[-]
KPI_7: Power peak	Pilot specific KPI	Average power peak	[kW]
KPI_8: Profitability	Pilot specific KPI	Net Present Value / Investment	[-]
KPI_9: Stimulation of the local economy	Urban KPI	New jobs created calculated through estimation of investment and replicability potential	[-]

KPI1: External energy needs of the pilot system

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Energy consumption supplied by external sources
Input parameters & Calculation	Calculation method: 1. Total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year $\mathbf{E_{c,tot}}$ [kWh] 2. Calculation of Key Performance Indicator: $\mathbf{KPI_1 = E_{c,tot}}$
Measurement Unit	[kWh]
References	Efficiency Valuation Organization, *International Performance Measurement and Verification Protocol*, 2017

Status quo:

$\mathbf{KPI_1 = E_{c,tot}}$ = 84.350,9 [kWh]

Background and assumptions:

- Average consumed extra light heating oil by old boiler in last years by *Local Energy Concept of Municipality of Lendava*: 8.452 [l]
- Lower heating value (LHV): 9,98 [kWh/l]
- Electrical energy consumption not considered, as electrical energy is only used as auxiliary energy for circulating pumps, for instance, and amounts to only a very small proportion of the total energy consumption.

Target (prediction):

$\mathbf{KPI_1 = E_{c,tot}}$ = 80.133,3 [kWh]

Background and assumptions:

- Predicted savings (related to more energy efficient heating system) with planned measures: 5,0 [%]

KPI2: External energy cost of the pilot system

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Cost of the energy supplied by external sources
Input parameters & Calculation	Calculation method: 1. External thermal/electrical energy cost[1] $\mathbf{C_E}$ [€], as function of yearly energy profile of each external energy source 2. Thermal/electrical energy consumption profile of the pilot system, supplied by external sources for one year $\mathbf{E_{c,tot}}$ [kWh] 3. External thermal/electrical cost of peak power taken from external sources $\mathbf{C_P}$ [€], which also includes the contracted power delivery with the external source 4. Sequence of peak powers absorbed from the external sources on yearly basis $\mathbf{P_{peak}}$ [kW] 5. Calculation of Key Performance Indicator: $\mathbf{KPI_2 = \Sigma\, [C_E(E_{c,i}) + C_P(P_{peak})]}$
Measurement Unit	[€](tax included)
References	-

[1] This cost must include all expenses related to energy purchasing, energy distribution and transportation, energy meter management, system charges and taxes.

Status quo:

$\mathbf{KPI_2 = \Sigma\, [C_E(E_{c,i}) + C_P(P_{peak})]}$ = 8.460,45 [€]

Background and assumptions:

- Extra light heating oil is the primary energy source for the local heating network. Therefore, there is no peak load boiler or similar → $\mathbf{C_P}$ and $\mathbf{P_{peak}}$ are zero.
- Average consumed extra light heating oil by old boiler in last years by *Local Energy Concept of Municipality of Lendava*: 8.452 [l]
- Extra light heating oil price[16] in business year 2019: 1,001 [€/l] or 0,0828 [€/kWh]
  - Average price; includes delivery and all taxes (excise duty, environmental tax, RES and RUE tax, etc.)

[16] https://www.statista.com/statistics/597582/heating-oil-price-slovenia/

<u>**Target (prediction):**</u>

$KPI_2 = \Sigma [C_E(E_{c,i}) + C_P(P_{peak})]$ = 5.272,93 [€]

Background and assumptions:

- Also, in future there is no peak load boiler or similar planned → **C_P** and **P_{peak}** are zero.
- Predicted price from geothermal district heating system[17] without tax (22%): 22,85264 [€/$MWh_{(VC\text{ - variable cost})}$] and 3.517,12707 [€/MW/$month_{(FC\text{ - fixed cost})}$]
  - Represents the heat energy price for the business year 2020 and according to the district heating system operator the price will stay constant for the next few years.
  - The standard VAT (Value Added Tax) rate in Slovenia is 22 % and 9,5 % reduced rate – latter applies to goods and services specially defined by the VAT Act.
  - The estimated thermal power for heating of 600 m^2 is 72 kW at 120 W/m^2.

[17] Source: https://www.petrol.si/binaries/content/assets/www/2018/pages/za-dom/energenti/daljinsko-ogrevanje/lendava/tarifna-skupina.pdf

KPI_3: Yearly CO_2 emissions

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	CO_2 emissions
Input parameters & Calculation	Calculation method: 1. Total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year $\mathbf{E_{c,tot}}$ [kWh] 2. CO_2 emission factor to be applied to the energy source **EF** [t CO_2/kWh], e.g IPCC emission factors 3. Calculation of Key Performance Indicator: $\mathbf{KPI_3 = E_{c,tot} \times EF}$
Measurement Unit	[t CO_2]
References	Covenant of Mayor: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf

Status quo:

$\mathbf{KPI_3 = E_{c,tot} \times EF}$ = 84.350,9 kWh × 0,000279 t CO_2/kWh = 23,53 [t CO_2]

Background and assumptions:

- **EF** for Residental Fuel Oil = 0,279 [t CO_2/MWh]
- $\mathbf{E_{c,tot}}$ = 84,3509 [MWh]

Target (prediction):

$\mathbf{KPI_3 = E_{c,tot} \times EF}$ = 80.133,3 kWh × 0 t CO_2/kWh = 0 [t CO_2]

Background and assumptions:

- **EF** for Geothermal = 0 [t CO_2/MWh]
- $\mathbf{E_{c,tot}}$ = 80,1333 [MWh]

KPI4: Autarky rate

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Energy self-sufficiency
Input parameters & Calculation	Calculation method: 1. Consumed energy from self-production of local RES system in a year $\mathbf{E_{self\text{-}RES}}$ [kWh] 2. Total thermal/electrical energy consumption of the pilot system for one year $\mathbf{E_{TOT}}$ [kWh] 3. Calculation of Key Performance Indicator: $\mathbf{KPI_4 = [E_{self\text{-}RES}/ E_{TOT}] \times 100\ \%}$
Measurement Unit	[%]
References	Deliverable D.T3.2.4 “Validation report and establishment of the autarky rate tool & the checklist”

Status quo:

$\mathbf{KPI_4 = [E_{self\text{-}RES}/E_{TOT}] \times 100\ \% = 0\ [\%]}$

Background and assumptions:

- There is no self-production of a local RES system for the heating plant → $E_{self\text{-}RES}$ is zero. The only (external) energy source is the geothermal energy, provided 100% by the district heating system operator → $E_{TOT} = E_{c,tot}$.

Target (prediction):

$\mathbf{KPI_4 = [E_{self\text{-}RES}/E_{TOT}] \times 100\ \% = 0\ [\%]}$

Background and assumptions:

- Also, in future there is no self-production of a local RES system planned.

KPI5: Use of energy from RES

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Consumed energy from self-production of local RES systems in a year
Input parameters & Calculation	Calculation method: 1. Consumed energy produced by local RES systems in a year $E_{self\text{-}RES}$ [kWh] 2. Calculation of Key Performance Indicator: $KPI_5 = E_{self\text{-}RES}$
Measurement Unit	[kWh]
References	-

Status quo:

$KPI_5 = E_{self\text{-}RES} = 0$ [kWh]

Background and assumptions:

- **See KPI_4.**

Target (prediction):

$KPI_5 = E_{self\text{-}RES} = 0$ [kWh]

Background and assumptions:

- **See KPI_4.**

KPI6: Security of energy supply

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Percentage of time without interruptions/discomforts in terms of operation of local energy consumption system without service interruptions/discomforts
Input parameters & Calculation	Calculation method: 1. Number of hours without interruptions/discomforts on yearly basis $\mathbf{N_{no\_interrupt}}$ [h] 2. Total number of hours of local energy consumption systems operation on yearly basis $\mathbf{N_{tot}}$ [h] 3. Calculation of Key Performance Indicator: $\mathbf{KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \%}$
Measurement Unit	[%]
References	-

Status quo:

$\mathbf{KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \% = 99{,}00\ [\%]}$

Background and assumptions:

- N_{tot} = 8.760 [h]
  - The heating plant is operated the whole year.
- $\mathbf{N_{no\_interrupt}}$ = 8.672,4 [h]
  - The $N_{no\_interrupt}$ was derived from the experiences of the users. It was assumed that there were 87,6 [h] with interruptions, related to regular maintenance works.

Target (prediction):

$\mathbf{KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \% = 100\ [\%]}$

Background and assumptions:

- Based on the planned measures and the implementation of the storage, it is assumed that no interruptions/discomforts or under-temperatures of the network will occur in the future.

KPI7: Peak power

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Average yearly peak power delivered from external energy sources
Input parameters & Calculation	Calculation method: 1. Array of monthly peak powers delivered from external energy sources $\mathbf{P_{peak,month}}$ [kW], where *month* goes from January to December [$P_{peak,January}$, $P_{peak,February}$, … , $P_{peak,December}$] 2. Calculation of Key Performance Indicator: $$KPI_7 = \frac{1}{12} * \sum_{month=January}^{December} P_{peak,month}$$
Measurement Unit	[kW]
References	-

Status quo:

Q = 71- 85 kW (Boiler LOGANO G215 BUDERUS**)**

Q = 70 kW (New heat station GIAFLEX**)**

KPI_7 = 22,25 [kW] (Calculation of Key Performance Indicator**)**

Background and assumptions:

	Average	[kW]	Peak	[kW]
$P_{peak,January}$	45	[kW]	64	[kW]
$P_{peak,February}$	33	[kW]	47	[kW]
$P_{peak,March}$	23	[kW]	32	[kW]
$P_{peak,April}$	12	[kW]	17	[kW]
$P_{peak,May}$	3	[kW]	4	[kW]
$P_{peak,June}$	0	[kW]	0	[kW]
$P_{peak,July}$	0	[kW]	0	[kW]
$P_{peak,Augus}$	0	[kW]	0	[kW]
$P_{peak,September}$	4	[kW]	6	[kW]
$P_{peak,October}$	11	[kW]	16	[kW]
$P_{peak,November}$	21	[kW]	30	[kW]
$P_{peak,December}$	36	[kW]	51	[kW]

- $P_{peak,month}$ for each month are derived from software RETScreen, Canada, data for one year[18]. (Location data: Murska Sobota).

<u>**Target (prediction):**</u>

Q = 47 kW (maximum heat output of the new GIAFLEX indirect heat station when installing PCM storage tanks)

KPI_7 = 16,5 [kW] (Calculation of Key Performance Indicator)

Background and assumptions:

- In the future, only a heat station with the support of heat accumulators will operate.
- However, the existing boiler will only serve as a backup in the event of a district heating failure.
- From the results of the predicted condition, we can see that the installation of heat accumulators will reduce the peak load from 64 kW to 47 kW.
- The above calculations are made on the assumption that the entire building has a heating area of 600 m². In the case of heating ½ the building (library only), all values written below are halved.

Assuming the max power of the boiler in operation leads to following $P_{peak,month}$:

	Average	[kW]	Peak	[kW]
$P_{peak,January}$	45	[kW]	47	[kW]
$P_{peak,February}$	33	[kW]	34	[kW]
$P_{peak,March}$	23	[kW]	24	[kW]
$P_{peak,April}$	12	[kW]	13	[kW]
$P_{peak,May}$	3	[kW]	3	[kW]
$P_{peak,June}$	0	[kW]	0	[kW]
$P_{peak,July}$	0	[kW]	0	[kW]
$P_{peak,Augus}$	0	[kW]	0	[kW]
$P_{peak,September}$	4	[kW]	5	[kW]
$P_{peak,October}$	11	[kW]	12	[kW]
$P_{peak,November}$	21	[kW]	22	[kW]
$P_{peak,December}$	36	[kW]	38	[kW]

[18] Source: https://www.nrcan.gc.ca/maps-tools-publications/tools/data-analysis-software-modelling/retscreen/7465

KPI8: Profitability

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	No
RES system	Yes

Description	Net Present Value / Investment
Input parameters & Calculation	Calculation method: 1. Calculation of Net Present Value: $NPV = -I_0 + \sum_{t=0}^{t} [\frac{R_t}{(1+i)^t}]$ NPV = Net Present Value [€] I_0 = investment [€] R_t = Net cash inflow-outflows during a single period t [€] t = numbers of time periods i = discount rate or return that could be earned in an alternative investment 2. Calculation of Key Performance: **KPI_8 = NPV / I_0**
Measurement Unit	[-]
References	-

Status quo:

Not applicable.

Target (prediction):

KPI8 = NPV / I0 = 1.49 [-]

Background and assumptions:

- I0 = 96.356,99 [€]
  - Estimated costs of planned measures on the basis of the offers obtained from vendors.
- Rt = 3.825,04 [€]
  - Difference between net cash outflow (cost for energy before investment) and net cash outflow (cost for energy after investment)
  - assumed to be constant over the entire period
- t = 15 [a]

- the number of time periods is assumed to be 15 years according to the technical life of the pilot (defined in KPI9)

- i = 0 [%]
  - internal rate
- NPV = 144.169,94 € [€]
  - Net Present Value after t time periods

KPI9: Stimulation of the local economy

Applicability for objects of assessment

Pilot specific KPI	-
Urban KPI	-
Thermal energy storage	X
Electric energy storage	-
Only energy storage integrated by RES system	-

Description	New jobs created calculated through valuation of investment and its maintenance and operational costs
Input parameters & Calculation	Calculation method: 1. Total cumulated expense of the storage installed, calculated as the Investment (*CAPEX* [€]) + associated Operation&Maintenance costs ($OPEX$ [€], evaluated on the system technical life: 20 years for electric pilot and 15 years for thermal pilot) 2. Constant K [€], equal to 200.000 €, that represents an empirical factor calculated as the ratio between a generic Company turnover and the number of company employees 3. *r*, equal to the number of the same storage solutions potentially installed in the district/region, considering a mid-term perspective of 5 years after the end of the pilot project. At the pre-investment stage consider this parameter equal to 1 4. Calculation of Key Perfomance Indicator: $KPI_9 = (CAPEX+OPEX) * r / K$
Measurement Unit	-
References	-

Status quo:

Not applicable.

Target (prediction):

$KPI_9 = (CAPEX+OPEX) * r / K = 0,48$ **[-]**

Background and assumptions:

- *CAPEX* = 96.356,99 [€]
  - Estimated costs of planned measures on the basis of the offers obtained from vendors
- *OPEX = 0 [€]*
  - In case of our pilot the Operation and Maintenance costs are not calculated, because it is about reducing the cost of energy supplied from external distributer

4.5. Life cycle costs

In the calculation of Life cycle costs by our pilot the total investment cost of 96.356,99 € may be taken into account. Annual savings, from an economic point of view is 3.187,53 €. If we look from a strictly economic point of view, the payback period of the investment will be done after 30 years. Compared to everything else related to the pilot, we should not neglect other effects and added value of impact of the pilot, which are not given or are difficult to evaluate from an economic point of view; such as CO_2 savings, cleaner air around the building / city center, etc.

In case of our pilot the Operation and Maintainance costs are not calculated, because it is about reducing the cost of energy supplied from external distributer.

4.6. Process related specifications

4.6.1. Timeframe

In Table 10 the work plan is shown. It includes management aspects, the realisation of construction work, the implementation of the storage and the monitoring process. In addition, dissemination activites are foreseen after the completion of the work.

Table 10: *Timetable of pilot in Lendava*

No.	Pilot Work packages / Date	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021
	1 Project Management														
1.1	Start of the project	X													
1.2	Project coordination	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1.3	Preparation of project documentation	X	X	X	X	X	X	X							
1.4	End of the project (formal)														X
	2 Project implementation / Construction works														
2.1	Public pocurement process						X	X							
2.2	Construction works - Pipeline								X						
2.3	Work on DH substation / storage								X	X					
	3 Monitoring														
3.1	Instalation and testing of monitoring equipment								X	X					
3.2	Ongoing monitoring									X	X	X	X	X	X
	4 Dissemination														
4.1	Articles in local/national media										X	X			
4.2	Implementation of workshop with interested stakeholders										X	X	X	X	
4.3	Ongoing dissemination activities										X	X	X	X	X

4.6.2. Environmental management

The current average annual heat consumption of the Lendava Library is 84.351 kWh on a heated area of 596 m^2. Together with the electric consumption (32.653 kWh), they have an annual energy consumption of 196 kWh per square meter. Lendava Library produce annually 23,5 tons of CO_2 related to space heating. The connection to the existing geothermal network could reduce this amount to zero.

In the existing boiler where the old oil-fired boiler is located, an indirect heat station will be installed for the purpose of heating. To reduce the peak heat load, a PCM (phase change material - change of liquid/solid phase) storage tank will be installed, which will enable the storage of thermal energy at a selected temperature potential of around 50°C. The existing hot water distribution from the neighboring Kranjčeva street, which already supplies multi-residential buildings with numbers 2, 4, 6, will be used for connection to the existing geothermal district heating. The power of the planned heating substation will be 70 kW. The length of the new connection to the heating pipeline is 65 m.

The storage tanks will be filled with paraffin cells. Paraffin cells are innovative buffer storages that have been developed to efficiently store heat and cold generated from small irregular energy sources such as solar energy, heat pumps etc. Thermal energy storage technologies and geothermal district heating systems have the potential to play a significant role in the transition towards 100% renewable energy systems through increasing system flexibility and overall efficiency and thus reduce CO_2 emissions and increase domestic energy security, additional reduce the costs of heating. There are several advantages of latent paraffin-based storages against the "usual" thermal heat storages: Require less space – smaller dimensions; Less temperature loss; Less reactivity with the environment and less likelihood of leakage as it changes phases; Better heat transfer performances=higher efficiency=lower heating costs.

As a result of the connection to RES and newly implemented storage in accordance with the newly implemented control and EMS system, the following positive effects can be achieved:

- Increasing the energy efficiency of the system by changing the heating system from energy un-efficient (old Oil-Fired boiler) to efficient (DHS) → significant primary energy savings → CO_2 saving through lower final energy consumption
- Lower pollutant emissions by changing from fossil to renewable energy source (carbon dioxide - CO_2, carbon monoxide - CO, dust and other greenhouse gas emissions as NOx and CxHy)
- Exploitation of local renewable energy – geothermal energy
- Extension of maintenance intervals → lower maintenance costs (no maintenance on heating system and low maintenance cost on storage)

Table 11: *Calculated fuel and pollutant savings*

Parameters	before	after	difference
energy savings			
Fuel energy used	kWh	kWh	%
	84.351[19]	79.711	- 5,5
savings of fossil fuels			
Fossil fuel used	kWh	kWh	%
	84.351	0	- 100
reduction of pollution			
	kg/a		
CO_2-equivalent emissions[20]	26.148,81		
CO_2-standard emission factor	23.533,92		
SO_2	36,44		
CO	13,66		
NO_x	12,15		
Dust	1,53		
CxHy	1,82		

4.6.3. Security and protection

SYSTEM PROTECTION (HEATING STATION)

- Safety valve DN20/25 Gerhard Götze type 651mHNK for hot water system, temperatures up to 120˚C, in accordance with DIN 4751/2 (1993), TRD 721, DIN EN 12828, DIN EN ISO 4126-1, PED 97/23 / EC. opening pressure: 3 bar (n) outlet coefficient: alpha = 0.3
- Cap valve (or ball valve with shut-off valve) for protection against unauthorized closing of expansion vessel DN25 (1") PN16
- Zilmet expansion tank type Cal Pro 105L for heating systems, cold rolled steel housing, SBR rubber membrane. Max. temperature 99˚C, max. pressure 6bar, connection 3/4 "volume 105l.

PROTECTION AGAINST ELECTRIC SHOCK

In accordance with the SIST HD 60364-4-41: 2007 standard, the basic rule of protection against electric shock applies that dangerous live parts must not be touched and that touching conductive parts must not become dangerous live parts under normal conditions or during the first failure.

According to the standard, the following protective measures are provided:

- basic protection (protection against direct contact) as a protective measure in normal conditions,

[19] Source: Local Energy Concept of Lendava Municipality, 2012

[20] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjrwtreu4bqAhVMQMAKHUJPCWgQFjADegQIBRAB&url=http%3A%2F%2Fwww.covenantofmayors.eu%2FIMG%2Fpdf%2Ftechnical_annex_en.pdf&usg=AOvVaw292jg4vxVp9v9b5BH6WRZj

- failure protection (indirect contact protection) as a protective measure in the event of a first failure.

Protection must include:

- an appropriate combination of a basic protection measure by an independent failure protection measure, or
- an appropriate measure to ensure such protection in normal operation as well as in the event of failure.

In general, the following safeguards may apply:

- automatic power off,
- double or reinforced insulation,
- electrical isolation to supply one consumer,
- low voltage (SELV and PELV)

Certain safeguards (e.g. use of barriers and placement out of reach, non-conductive environment, local equipotential bonding without earth connection, electrical isolation for power supply more than one consumer, ...) may only be used if the installation is under the supervision of a professional or trained staff so that inadmissible changes are not possible.

If certain conditions of the safeguard measure cannot be met, additional measures should be so that the same level of security is ensured through all protection.

OVERCURRENT PROTECTION

The SIST IEC 60364-4-43: 2009 standard deals with requirements for the protection of live conductors before the effects of overcurrents. The standard describes how live conductors are protected by one or more devices for automatic disconnection of power supply in case of overload and short circuit.

Protective devices must ensure that any overcurrent of the circuit conductors is disconnected before such a current could cause a hazard and damage the insulation due to thermal or mechanical effects, joint, terminal or material around conductors.

The size of the protective (disconnecting) device that protects the conductors from overload and short circuit is determined by the conical current and the selectivity of the protection.

Protective devices must be of the following types:

- Devices that provide protection against overload and short-circuit current:
  - a) circuit breakers with short-circuit tripping overload,
  - b) circuit breakers combined with fuses,
  - c) fuses with gG characteristics
- Devices that only offer overload protection
  - a) protection devices with inverse (inversely proportional) time delay (note: fuses of type aM do not protect against overload)
- Devices that offer only short-circuit protection

As such, it should only be installed where overload protection is provided by other measures.

- a) circuit breakers with only short-circuit trip,
- b) fuses of types gM, aM.

PROTECTION AGAINST SHORT-CIRCUIT CURRENTS

The standard only takes into account the case of a short circuit between conductors belonging to the same circuit.

The expected short-circuit current must be determined at each suitable installation point. This can be done by calculation or by measurement.

The expected short-circuit current at the supply point can be given by the supplier.

A device that provides short-circuit protection must be installed at a point where the cross-section of the conductors is reduced or the current carrying capacity of the conductors is reduced due to other changes.

There shall be no branch circuits or sockets in the part of the conductor between the point of reduction of the cross-section or other change and the position of the protective device and this part of the conductor:

- should not exceed 3m and
- it must be installed in such a way that the risk of short circuit is reduced to a minimum,
- must not be placed near flammable material.

For cables and insulated conductors, all short-circuit currents occurring at any point in the circuit must be switched off for a period not exceeding that in which the permissible conductor insulation temperature limit is exceeded.

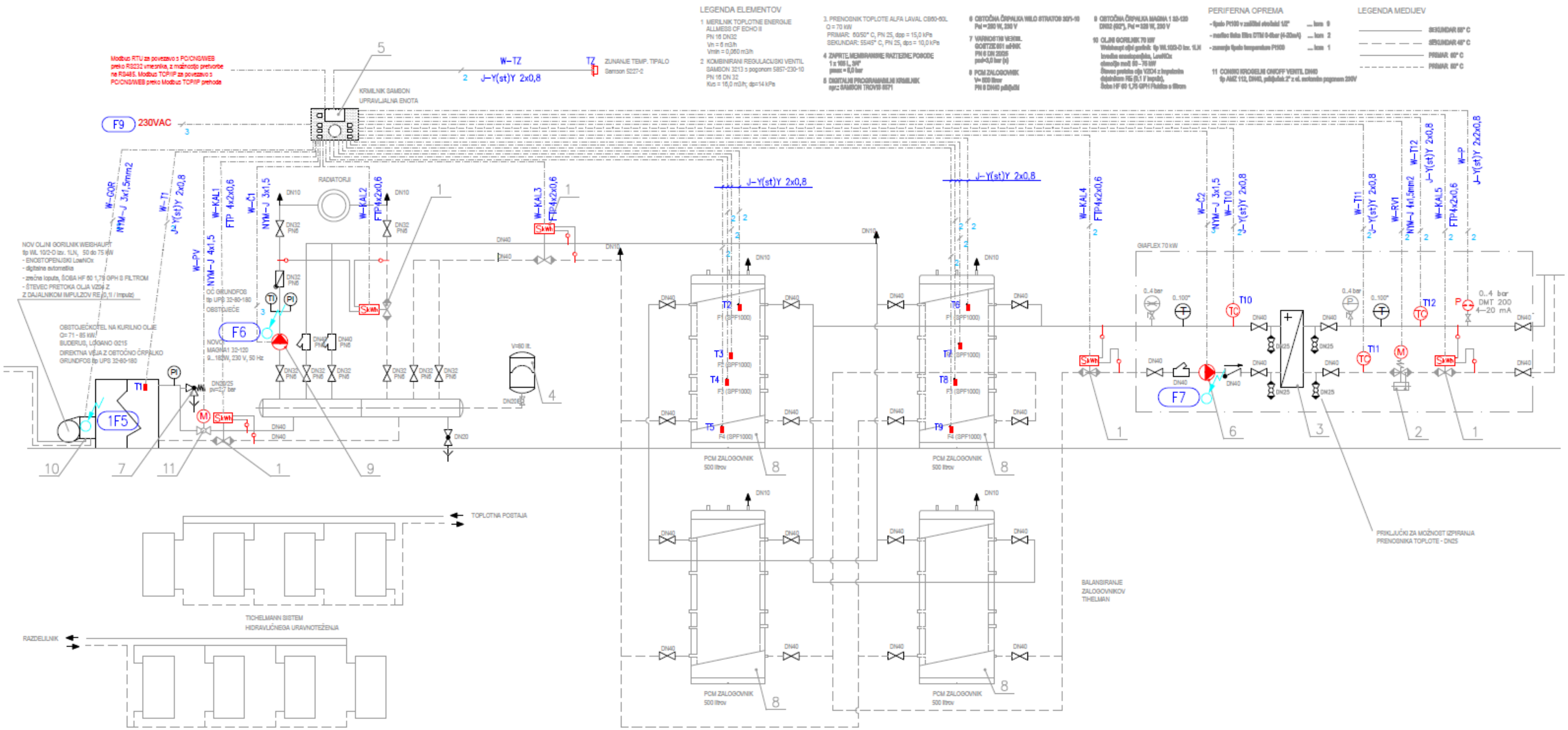

Figure 17: *The plan of electrical installation and electrical equipment*

5. RISK ASSESSMENT

5.1. Risk assessment for the work execution phase

In the work execution phase, there are the following risk, which may occur during the execution of works and they can be determined in three levels of risk factors: 1 (low risk), 2 (medium risk) and 3 (high risk).

RA1: The first factor is related to the risk of obtaining documentation. This happens mostly with project and investment documentation, environmental documentation, planning documentation, technical documentation, etc. Risk factors are related to the volume and value of the investment, investment complexity, location of the investment, legislation in the field of the investment in question, etc. in the case of a demanding project that requires extensive documentation. The project receives a risk factor of 2.

RA2: The second factor is related to the risk of obtaining approval. Factors that affect the risks associated with obtaining approval are: criteria and conditions for construction of buildings, risks arising from spatial planning documentation, land ownership, type of construction and other works, as well as the purpose of use of the building, place of investment, etc. an investment requires a large number of approvals, it carries a higher risk (3), while in the case of a smaller number of approvals, a lower risk (1). The project receives a risk factor of 2.

RA3: The third factor is related to the risk of performing the works. Factors influencing the risks associated with the execution of works are: geologically, geomechanically and spatially demanding construction site, structurally demanding facility, a large number of subcontractors, reliability of the contractor, financial stability of the client. In the case of a demanding project and the terrain of the building, a large number of subcontractors, uncertainty, the client - the risk receives a risk factor of 3. The project receives a risk factor of 1.

RA4: The fourth factor is related to the risk of successful completion of works. Factors influencing the risk are: type of works (environmental impacts of the facility, facility over which supervision / monitoring is prescribed), experience of the contractor (whether the construction is in accordance with the technical and project documentation, fulfillment of the contractor's obligations) and investor experience (obligations investors: supervision of test work, technical inspection, maintenance, etc.). In case the investor and the contractor do not fulfill their obligations - the risk gets a risk factor of 3. The project gets a risk factor of 2.

RA5: The fifth factor is related to the risk assessment of investment financing. If the investor has contracted financing of the investment and if the investor has sufficient financial resources to be able to compensate for the loss of funds, the risk has a risk factor of 1. Otherwise - the risk factor is 3. The project receives a risk factor of 1.

5.2. Risk assessment for the operational phase

In the work operational phase, there are the following risk, which may occur during the execution of works and they can be determined in three levels of risk factors: 1 (low risk), 2 (medium risk) and 3 (high risk).

RA6: The sixth risk is related to the reliability of electricity supply. A power blackout or power outage is the loss of the electrical power network supply to an end user. The project gets a risk factor of 1.

In 2017, Slovenia had 3618 MW of total installed electricity capacity, 688 MW of which was provided by the Krško nuclear power plant (NPP) and the rest by hydro (1347 MW), thermal (1332 MW) and other (252 MW) power plants facilities (see Table 4). Total gross electricity production in 2017 amounted to 16326 GW·h, of which 6285 GW·h was produced from nuclear, 4141 GW·h from hydro, 5610 GW·h from thermal and 290 GW·h from solar and wind power plants. Slovenia has fairly diversified primary sources for electricity production.[21]

Based on the informations from Elektro Maribor d.d. (electricity distributor in Lendava) in year 2018, there were a large number (27) of days with extraordinary weather conditions, which were not as intense as in 2017 (windstorm) or 2014 (ice break). Due to this and due to intensive investments in the robustness and advancedness of the network, the quality of electricity supply in 2018 was one of the highest in recent years. Taking into account all causes, own and foreign and force majeure, in 2018 the annual rate of uninterrupted power supply was 99,985%.

RA7: The seventh risk is related to the reliability of the geothermal district heating system in Lendava. This risk is evaluated based in terms of system failures. The risk factor has been set based on the monitoring of the local heat provider (Petrol Geo d.d.). In years after 2007 there were none disconnections/failures (highly reliable supply). The project gets a risk factor of 1.

RA8: The eighth factor is related to the capacity of the geothermal bouthole/well drop/temperatues drop. A doublet scheme is operational in Lendava downtown. In north-eastern Slovenia the localities are the most vulnerable to overexploitation of thermal water as most users capture water from the same aquifer. The problem has yet to be tackled with needed care. In this sense it is unfortunate that the Murska Sobota municipality has not completed the extension project for the DH system there with inclusion of previously drilled two boreholes in the northern parts of town (Rman et al., 2012). Thermal capacity of the new doublet could reach 4 MWt and geothermal energy use 8.8 GWh/year. It could have been the second doublet system operating in the country provided it becomes active at all in future. When speaking about geothermal district heating, only one plant is considered in Slovenia at present, in Lendava, where several public buildings (school, kindergarten, etc.) and blocks of flats are heated under the Petrol Geo d.o.o. authority. Namely, in Murska Sobota the residential areas and a theater under Komunala authority are not heated geothermally anymore (due to unfavorable concessions fees introduced), nor at Benedikt in a small scale for few public buildings, both since 1st Jan. 2016. The future of geothermal district heating there remains uncertain. However, following the explanations the project gets a risk factor of 1.

Related to the last risk: The Interreg project DARLINGe, running between 2016 and 2019, significantly contributed to a better resource assessment of eastern and northeastern Slovenia. A harmonized geological 3D model was extended to Croatia, a benchmarking assessment was performed at new sites and a numerical model focused on reinjection possibilities is being built. Main results will be available in summer of 2019. The effects of current thermal water abstraction on the hydraulic state of the Mura Fm. aquifer were simulated by a regional mathematical model of groundwater flow enabling calculation of

[21] Source: https://cnpp.iaea.org/countryprofiles/Slovenia/Slovenia.htm

different development scenarios, predictions and control of impacts (Nádor et al., 2012, Rman et al., 2015; Tóth et al., 2016). Trends in geothermal are focused on enhancing the cascade direct use, lowering the outlet thermal water temperature, promoting higher efficiency of installed capacity for direct use, effective problem solutions, regarding thermal water scaling and degassing, as well as performing new research for potential geothermal sites and implementation of doublets. As the number of users increases, interference between them has already been noticed. Besides, increased demand for thermal water from the same aquifers causes negative quantitative trends, and potential disputes between nearby users. Almost all thermal water users now have an operating production monitoring established and from now on resource assessment and state evaluation will be much more reliable to plan the measures which are really needed to reach both, environmental and energy goals. Reinjection should become nationally supported to preserve the existent capacities of thermal water, and many activities are now being taken also from the user's side to raise funds from its establishment.[22]

Strengths	Weaknesses
- Geothermal energy is generally considered as environmentally friendly - No significant amounts of pollution - Increased energy efficiency (primary energy savings due to higher efficiency of district heating) - Higher customer satisfaction (from fossil to RES) - Requires less space for storage due to increased energy capacity of an innovative storage (paraffin-based) - Lower maintenance costs (district heating system) - Fully implemented in local energy strategies/Action plans (Local Energy Concept and SEAP) - Experience of executing companies	- Time-consuming planning process due to implementation in a HUC and using an innovative storage solution - Time-consuming implementing process due to implementation in a HUC and using an innovative storage solution - Higher investment costs due to implementation in a HUC - Higher initial investment costs due to implementation an innovative storage solution (paraffin-based storage)
Opportunities	**Threats**
- Export concept to other HUCs in Slovenia and Europe - Best-practice in terms of implementing innovative storages in HUCs with no pollution - Increasing energy efficiency and share of RES in HUCs	- Additional permits due to monument and local image protection laws related to Cultural Heritage Protection (Institute for the Protection of Cultural Heritage of Slovenia) - Finding a suitable product on the market

Figure 18: *SWOT analysis for pilot in Lendava*

[22] Source: Geothermal Energy Use, Country Update for Slovenia, Geological Survey of Slovenia

6. PROCUREMENT PROCEDURE

6.1. Type of tendering procedure

In Slovenia, relevant procurement procedures are depending on who is investing and on the contract value according to the Slovenian Public Procurement Act - ZJN-3[23] (Official Gazette of the Republic of Slovenia no. 91/15 and 14/18). Direct purchase is allowed for supplies and services contracts valued below EUR 20.000 and work contracts below EUR 40.000. All contracts above these thresholds must be posted on the Slovenian Public Procurement portal. For so-called 'low-value' contracts i.e. supplies and services between EUR 20.000 and EUR 40.000 and public work contracts between EUR 40.000 and EUR 80.000 in value, simplified procedures may be applied. Contracts above the 'low-value' limits must be procured using standard procedures, i.e. open, restricted, and negotiating procedures with or without publicised terms of the contract, and competitive dialogue. Due to the coronavirus pandemic in 2020 there were new rules and the EUR 40.000 limit was increased for 100% to EUR 80.000. In this case in Lendava pilot (under EUR 80.000) there were not obliged to post the project on the Slovenian Public Procurement portal. The procurer made with a help of an expert an inventory of materials / services on the basis of price verification (references, web analytics) and collected 3 bids / offers.

6.2. Eligibility criteria for the procurer

The bidder should submit a completed bid list and cost estimate based on the prepared list of projects/materials/services and sent to the procurer.

6.3. Minimum technical specifications

Related data can be found in the accomplished deliverable D.T1.2.4 Feasibility study for implementing energy storages in Lendava (SI).

6.4. Procedure and award criteria and scores

The selection criteria in case of Lendava pilot based on the current Slovenian Public Procurement Act (pandemic exceptions included and taken into account) is 100% the price.

[23] http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO7086