

FEASIBILITY STUDY FOR IMPLEMENTING ENERGY STORAGES IN LENDAVA (SI)

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1. Introduction

In the course of the project Store4HUC, a feasibility study is carried out for every pilot region (IT, AT, CRO, SI). A feasibility study is simply an assessment of the practicality of a proposed plan or project. It takes all relevant factors into account—including economic, technical, legal, and scheduling considerations—to ascertain the likelihood of completing the project successfully and is therefore used to discern the pros and cons of undertaking a project before a lot of time and money is invested into it. As the name implies, the study deals with the question, if the project/pilot is feasible or not. The main goals can be defined as follows:¹

- To understand thoroughly all aspects of a project, concept, or plan;
- To become aware of any potential problems that could occur while implementing the project;
- To determine if, after considering all significant factors, the project is viable – that is, worth undertaking.

This document deals with the feasibility study of the Store4HUC pilot in Lendava. The feasibility studies should outline the constraints and solutions from various aspects (technical, economic, monumental protection, status quo of HUC, ensure further implementation actions, etc.) to implement the pilot at the historical sites. The main target of the study is to enable a decision making about the pilot (“go” or “no-go” decision). A further target is to inform all relevant stakeholders and to get a first feedback from them. In contrast to the pre-investment concept, which will be carried out in D.T2.1.5, the feasibility study focuses on first rough analysis and plausibility checks. If the feasibility study leads to a positive result, the pre-investment-concept will be carried out as the next step, where all specifications of the pilot for the application of the building permit will be specified. Therefore, the pre-investment concept has to be much more detailed than the feasibility study, but nevertheless all major impacts are already considered in the feasibility study, to enable the evaluation of the pilot.

To clarify the vision of the pilot, the mission statements according to the UNESCO-rules/conservation rules, the sustainability criteria, the environmental friendliness, the moderns and the legislation are defined in the second chapter. Based on the mission statements, strategies, targets and operative actions are deduced for the pilot. To classify the meaning of the pilot for the proposed HUC, the status quo is described in chapter three, dealing with questions like: “Are there already any other best practice examples on RES and EE?”, “How great is the willingness of the city/region for innovations like this?” or “What are the constraints, benefits, changes and barriers?”, and so on.

In chapter four, the main factors for the assessment of the pilot are discussed. It starts with the technical specifications of the pilot like “what is planned?”, “which type of storage will be used?”, “why is this type of storage considered as the best option?”, “what other installations are planned?”, etc. From the economic perspective, the estimated costs (investment, operation) as well as the expected savings are explained. A first finance plan shows how the pilot will be financed and the next steps are planned. Moreover, a SWOT analysis is carried out, to show the strengths, weaknesses, opportunities and threats of the pilot. Based on this information, the assessment of the practicality of a proposed pilot can be carried out.

¹Kenton, Will (11.08.2019): Feasibility Study. URL: “<https://www.investopedia.com/terms/f/feasibility-study.asp> [10.10.2019].

2. Mission Statements

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 renewables in 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.

Figure 1 shows the location of Lendava Library - it 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.



Figure 1: *Lendava Library - Oskar Laubhaimer's neo-baroque villa built in 1906*

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.



2.1. According to the European and international guidelines and recommendations on conservation and rehabilitation of historic monuments and sites

Goals and actions to be achieved by this project are in accordance and in respect with key ethical and technical guidance and recommendations on heritage interventions brought by most relevant European and international institutions that deal with heritage protection and conservation such as UNESCO, European Commission, Architects' Council of Europe and above all ICOMOS - International Council on Monuments and Sites, the only global non-governmental organisation dedicated to promoting the theory, methodology, and scientific techniques to the conservation of heritage. All those international charters for the conservation and restoration of monuments, starting from *The Venice Charter (1964)* up to more recent *The Valletta Principles for the Safeguarding and Management of Historic Cities, Towns and Urban Areas (2011)*, *The Paris Declaration On heritage as a driver of development (2011)* and most recent documents delivered in the framework of the European Year of Cultural Heritage 2018; *Leeuwarden declaration on adaptive re-use of the built heritage: preserving and enhancing the values of our built heritage for future generations and European Quality Principles for Cultural Heritage Interventions* insist on the following:

- investments in cultural heritage that are bringing benefits across the four areas of sustainable development: economy, culture, society and the environment;
- re-use of heritage monuments that will make them sustainable and comfortable for modern use and in that way will bring to prolongation of their life;
- on multidisciplinary usage of knowledge and skills from different disciplines;
- on using a new solution to emphasise and strengthen cultural values and give added value to a monument or site;
- on bringing new functions to heritage monument that respond to community needs;
- on reuse of heritage sites that can generate new social dynamics in their surrounding areas and thereby contribute to urban regeneration;
- on smart renovation and transformation of heritage sites that can find new, mixed or extended uses.

2.2. According to sustainability criteria

The planned pilot project is in accordance with the current valid *Local Energy Concept of the Municipality of Lendava (2012)* and the current valid *Sustainable Energy Action Plan of the Municipality of Lendava - SEAP (2012)*. The main summaries of the aforementioned strategies are summarized below:

(1) *Local Energy Concept of the Municipality of Lendava (2012)*

The *Local Energy Concept (LEC)* of the municipality is a study that is a prerequisite for integrated development and long-term planning and management of energy policy at the municipal level. The energy concept systematically forms a basic database on the supply and use of all types of energy in the municipality. It covers the ways in which we can implement community-specific solutions for efficient, economical and environmentally friendly energy services in households, tertiary sector, companies and public institutions. The document also gives us concrete effects that the local community can achieve by implementing activities from LEC.

The *Local Energy Concept* therefore represents for the local community the basic document and strategy of supply, energy use, introduction of renewable energy sources and measures to reduce energy use and increase energy efficiency in the entire local community with the following goals:



- ✓ reduction of costs for energy consumption and maintenance of energy devices in public buildings and institutions such as schools, kindergartens, health centres, homes for the elderly, etc. and managing these costs;
- ✓ introduction of renewable energy sources in areas where this is reasonable, technically feasible, geographically feasible and economically justified;
- ✓ introduction of energy efficiency in public buildings, public companies and public institutions;
- ✓ promoting energy efficiency in the private sector (industry and services);
- ✓ ensuring the highest possible level of sustainable transport, and reducing the negative effects of transport on the environment;
- ✓ introduction of district heating, cogeneration and three-generation systems, where possible and economically justified;
- ✓ reducing the use of non-renewable resources to an acceptable level;
- ✓ conducting energy audits of public buildings, companies and residential buildings;
- ✓ introduction of energy accounting, energy monitoring and management, including preventive energy maintenance of devices and systems for the provision and use of energy in public buildings, institutions and companies;
- ✓ reducing the final energy consumption of all consumers in the local community, including public lighting;
- ✓ promoting, educating and raising the awareness of institutions employed in the public sector, citizens, pupils, students and others in the direction of efficient energy use, energy efficiency and renewable energy sources;
- ✓ Involvement of all actors in the local community in joint efforts to increase energy efficiency and the use of renewable energy sources;
- ✓ Meeting the objectives set out in the national action plans “AN-URE”, “AN-OVE”, “AN-sNES”, “OP EKP 2014-2020” and the *Long-term strategy for promoting energy renovation of buildings*;
- ✓ compliance with the objectives of the operational programs for the protection of ambient air against PM10 pollution (OP PM10) and the reduction of greenhouse gas emissions (OP GHG);
- ✓ fulfillment of international commitments from the EU Directives in the field of RUE and RES.

The pilot project in the frame of Store4HUC project within the *Local Energy Agency of the Municipality of Lendava* Action Plan is mainly in accordance with measure no. 43:

- ✓ Promotion of geothermal district heating in Lendava

(2) *Sustainable Energy Action Plan* - Municipality of Lendava (2012)

The aim of the preparation and implementation of the *Sustainable Energy Action Plan of the Municipality of Lendava* is to create a basic document for the energy strategy related to the harmonized energy and environmental policy of the municipality, which is the basis for energy activities in the municipality. The mentioned project is especially important for the preparation of the implementation of concrete measures, both in the field of efficient energy use, introduction or greater use of local renewable energy sources, as well as decentralized energy supply.

In 2011, the Municipality of Lendava joined the Global Covenant of Mayors initiative and set up a goal to reduce the CO₂ emissions in the municipality. The agreement is a good starting point for the participating municipalities, which have committed themselves to achieving and exceeding the goals of the European Union's climate and energy policy in reducing CO₂ emissions by improving energy efficiency and producing and using cleaner energy.



The *Sustainable Energy Action Plan of the Municipality of Lendava* determines the measures and necessary activities of the local community to achieve the goal of reducing CO₂ emissions by 36,19% by 2020, compared to the selected reference year 2001.

The pilot project in the frame of Store4HUC project within the *Sustainable Energy Action Plan of the Municipality of Lendava* Action Plan is mainly in accordance with measure no. 11:

- ✓ Complementary heating of buildings with geothermal energy from the Lendava well

2.3. According to environmental friendliness

The Lendava pilot follows the latest common **EU energy goals and environmental objectives**:

Overall goals of the EU energy policies framework

EU Directive 2018/2001/EU of the European Parliament and of the council of 11 December 2018 on the promotion of the use of energy from renewable sources. Each Member Country defines its own special goals in the National energy and climate plan (NECP).

2030 Framework for Climate and Energy

- a 40% cut in greenhouse gas emissions compared to 1990 levels
- at least a 27% share of renewable energy consumption
- indicative target for an improvement in energy efficiency at EU level of at least 27% (compared to projections), to be reviewed by 2020 (with an EU level of 30% in mind)
- support the completion of the internal energy market by achieving the existing electricity interconnection target of 10% by 2020, with a view to reaching 15% by 2030 long-term 2050 greenhouse gas reductions target
- reducing EU GHG emissions by 80%

EU Strategy for Heating and Cooling

Revised Renewable Energy Directive (RED II)

- Member States will endeavour to achieve an annual increase of 1% in the share of renewable energy in the heating and cooling supply
- yearly increase of the share of RES in heating and cooling of 2 percentage points in the next decade

2010/31/EU on energy performance of buildings

- ✓ new and existing buildings undergoing major renovation: “nearly zero-energy” by the end of 2018, and all new private buildings by 2020

EU Directive 2012/27/EU on energy efficiency

- ✓ energy efficiency obligation schemes to achieve new savings each year of 1.5% of the annual energy sales to final customers



EU Strategy for environmental objectives

Water Framework Directive (2000/60/EC)

- ✓ available groundwater resource is not exceeded by the long-term annual average rate of abstraction (no overexploitation), whereas the good quality status means that there are no effects of saline or other intrusions

Groundwater Directive 2006/118/EC

- ✓ authorize the reinjection into the same aquifer of used geothermal water as long as it does not compromise the environmental objectives

Environmental-related EU legislations

- ✓ projects likely to have significant effects on the environment are subjected to an environmental assessment prior to their approval or authorisation

On national level, the Lendava pilot follows the latest Slovenian legislation/strategies/requirements related to environment protection:

- ✓ *Environmental Protection Act*² (ZVO-1-UPB1), Official Gazette of the Republic of Slovenia no. 39/06 - 49/06, 66/06, 33/07, 57/08, 70/08, 108/09, 108/09, 48/12, 57/12, 92/13, 56/15, 102/15, 30/16, 61/17 - GZ, 21/18 and 84/18
- ✓ *Guidelines on the promotion of efficient energy use and the use of renewable energy sources*,³ Official Gazette of the Republic of Slovenia no. 89/2008
- ✓ *Guidelines on the efficient use of energy in buildings*⁴, Official Gazette of the Republic of Slovenia no. 52/10 and 61/17
- ✓ *National energy efficiency Action Plan 2014-2020*⁵ (AN URE 2020)
- ✓ *National Renewable Energy Action Plan 2010-2020*⁶ (NREAP)

On local level, the Lendava pilot follows the latest *Action plan for improving the quality of the environment and the sustainable footprint of the Lendava municipality*⁷ (prepared in 2013) and especially the section related to the improvement of air quality (Identified problem no. 3: *Emissions of small-scale stoves*; Measure: *Development of geothermal and environmentally friendly heating*; Action responsibility: *Building owners*).

² <https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/72890>

³ <https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina?urlid=200925&objava=1069>

⁴ <http://www.pisrs.si/Pis.web/pregledPredpisa?id=PRAV10043>

⁵

https://www.google.si/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKewjtsePUqqnrAhUw_SoKHY7EBaUQFjAAegQIAxAB&url=https%3A%2F%2Fwww.energetika-portal.si%2Ffileadmin%2Fdokumenti%2Fpublikacije%2Fan_ure%2Fneap_slo_2014-2020_eng.pdf&usq=AOvVaw3R8yCmEmnG_SpWf_90tvJu

⁶

https://www.google.si/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKewjtsePUqqnrAhUw_SoKHY7EBaUQFjALegQIAhAB&url=https%3A%2F%2Fs3platform.jrc.ec.europa.eu%2Fdocuments%2F20182%2F96176%2Fnational_renewable_energy_action_plan_slovenia_en.pdf%2Fb4a26cf1-8a03-480f-8adb-bcd0491648f6&usq=AOvVaw36UYUu1GZqYH33ONquavUP

⁷ Source: https://www.lendava.si/sites/default/files/akcijski_nacrt_1.jpg



2.4. According to modernes / state-of-the-art

An innovative solution of energy storing system will be installed in 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 CO₂ emissions, 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 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 (CO₂ savings, kWh savings, cost savings, etc.).

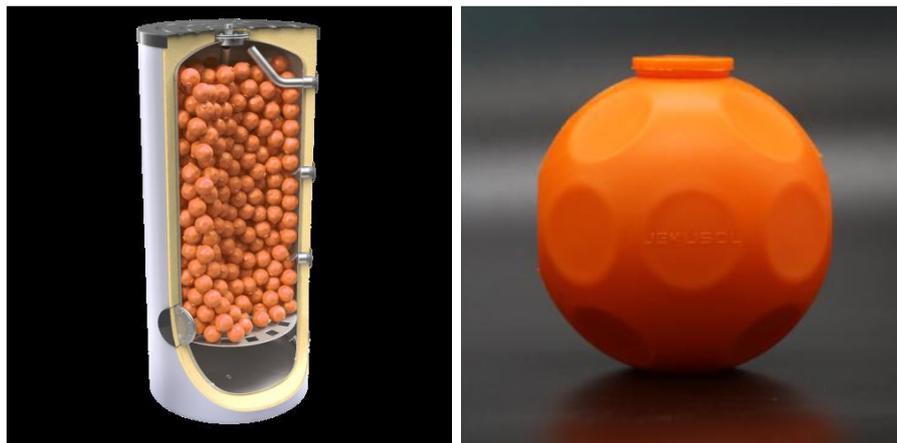


Figure 2: Example of a phase change energy storage tank ⁸

⁸ Source: <https://www.jekusol.de/>



2.5. According to legislation

Renewables in general have in EU a well articulated role in the clean energy transition in the EU climate and energy framework package, which goals and performance is thoroughly and continuously monitored and amended by the European Commission and relevant organizations. Among renewables geothermal energy and its application for heating purposes is also relatively well positioned: the RES directive paves the pathway for the development of geothermal energy in general. Art. 13 and 23 of the RES / REDII directive, as well as EU Directives on the energy performance of buildings and on energy efficiency promote geothermal (district) heating.

Environmental-related EU legislations are not geothermal specific, they rather ensure that plans, programmes and projects likely to have significant effects on the environment are subjected to an environmental assessment prior to their approval or authorisation (Directive 2011/92/EU on Environmental Impact Assessment), not threatening the habitats (Directive 92/43 on the conservation of natural habitats and of wild fauna and flora), and establish the 'polluter-pays' principle to prevent and remedy environmental damages (Directive 2004/35/EC on environmental liability). According to the EIA Directive, the national authority determines whether and which geothermal projects should be subject to an environmental impact assessment.

The new strategy, the Energy Concept of Slovenia⁹ (EKS) and the Long-Term Development Strategy of Slovenia until 2050 are under preparation at the moment. EKSs give directions and vision of Slovenia's energy policy, which will be determined in the more concrete form of measures in future action plans. Its headline targets by 2020 are the reduction of greenhouse gas (GHG) emissions by at least 13%, have 25% share of RES in the gross final energy consumption and reach 23% primary energy savings by 20% compared to the level of the year 1990.

The key measures of the current EKS are:

- ✓ Increasing energy efficiency,
- ✓ Raising awareness among consumers and providers of sustainable supply and energy management,
- ✓ Supporting the development of knowledge in the area of sustainable energy supply and energy management,
- ✓ Abandoning fossil resources and gradually switching to renewable and low carbon sources,
- ✓ Introduction of advanced energy systems and services.

In buildings, the current 40% share of the final energy consumption will be reduced by 30% by 2030 compared to 2005 due to new standards and consequently better energy efficiency of buildings, and at least two thirds of the energy consumption will be from RES.

In 2017 the Slovenian NREAP 2010-2020¹⁰ was updated. The renewed goal for the share of RES for heating and cooling increased to 34.5%, with overall share of RES in all three sectors (electricity, heating and cooling and transport) staying at 25%. The renewed share of electricity dropped from 39.3% to 38.6%. Most of the renewable energy from RES is derived from wood and wood biomass.

In accordance with the Slovenian Decree on the Classification of Facilities¹¹ (*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

⁹ <https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/energetski-koncept-slovenije/>

¹⁰ <https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/akcijski-nacrt-za-obnovljivo-energijo/>

¹¹ <https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/2018-01-1900#>

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).



Figure 3: The Public Library in Lendava in the Register of Slovene Cultural Heritage

Based on the *Register of Slovene Cultural Heritage*¹², 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 Act¹³ (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-1¹⁴ (Official Gazette of the Republic of Slovenia, no. 16/08), the Municipality of Lendava has adopted an *Ordinance on the proclamation of cultural monuments of local importance in the area of the Municipality of Lendava*¹⁵.

¹² <https://gisportal.gov.si/portal/apps/webappviewer/index.html?id=df5b0c8a300145fda417eda6b0c2b52b>

¹³ <https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/82670>

¹⁴ <https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina?urlid=19997&stevilka=287>

¹⁵ https://gis.gov.si/MK_eVRDpredpis/p1904_1.pdf



Table 1: Extract from the municipal ordinance on the proclamation of cultural monuments of local importance in the area of the Municipality of Lendava (Lendava Library)

EŠD	8354
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 izvornosti 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 izvorne tlorisne zasnove, gabaritov, lege, pojavnosti, materialov, poslikav in okrasja; – omogočanje predstavitve celote in posameznih zaščiteneh 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.

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.*

3. Status quo of the proposed HUC

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 4.

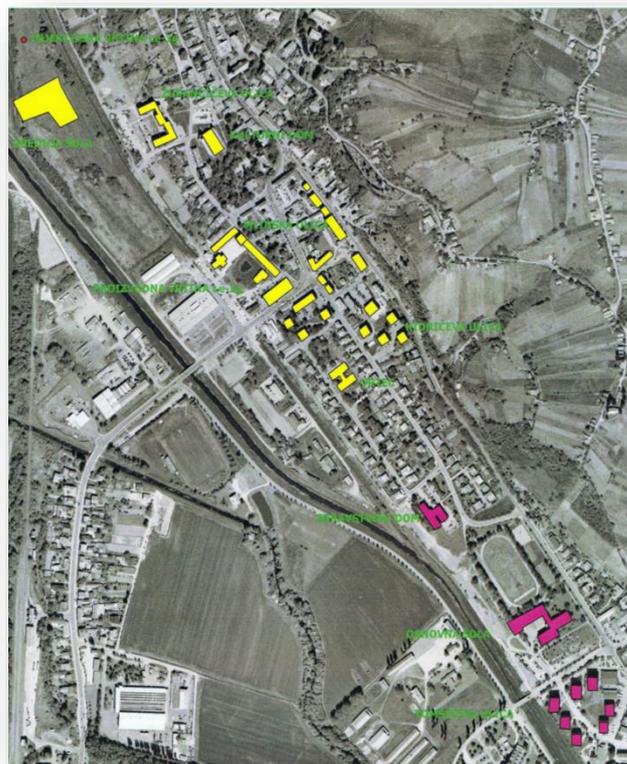


Figure 4: Area of district heating with geothermal energy with all consumers, production and (re)injection well

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 CO₂ 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 characteristics of the Lendava district heating system are gathered in the table below.

Table 2: Basic information of Lendava district heating system

District heating system (DH)	Yes operating
Flow temperature (in case of DH)	66°C
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 (%)	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

The Covenant of Mayors is a European movement, with the participation of local and regional authorities, who have voluntarily committed themselves to increase energy efficiency and use of renewable energy sources in their areas. The signatories to the Convention bind themselves to meet and exceed the European Union goal of 20% reduction in CO₂ emissions by 2020.¹⁶

¹⁶ <https://www.covenantofmayors.eu/>



The Municipality of Lendava acceded on 29th of May 2011, as the eighth municipality in Slovenia and as third municipality of Pomurje region, to the Covenant of Mayors. With this signing, the municipality has bound itself to prepare an Action plan for Sustainable Energy (hereinafter: ANTE or Action Plan), which sets out measures and activities necessary to achieve the ultimate goal, which is the reduction of CO₂ by 20% by 2020, according to the reference year 2004.

The long-term vision of the municipality remains the same even after 2020: to reduce the need for conventional transport, increasing interest in alternative transportation options, increasing the interest of local people to cycle, the introduction of measures to reduce the attractiveness of car travel, the implementation of local marketing campaign to promote the use of alternative means of transport and reduce emissions of cars owned by the municipal administration. In the field of energy consumption the municipality intends to improve the situation in the field of use of renewable energy, energy efficiency and district heating. Heating systems outside town of Lendava mainly use as an energy fuel oil, while the town itself is heated by geothermal energy. Renewable sources of energy with a little influence on the environment, facilitate the production of energy with a relatively small CO₂ emissions. With the continued construction of biogas plants that use cogeneration (production of electricity and heat) we hope to achieve very good results in protecting the environment of the local communities. District heating systems (geothermal) are planned to be implemented in future years because of the low environmental impact in the sense of CO₂ emissions.¹⁸

Table 3: 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
	m ²	/	/	kWh	kWh/m ²	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 building of Lendava Library is still heated by fossil fuel - residual fuel oil. 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 produces annually 23,5 tons of CO₂ related to space heating. The connection to the existing geothermal network would reduce

¹⁸ Source: Sustainable Energy Action Plan of Lendava Municipality, 2012

this amount to zero. Figure 6 shows the existing inefficient old heating oil boiler and the heating oil storage tank.



Figure 6: Existing inefficient old heating oil boiler and the heating oil storage tank



4. Short specification / description of the pilot

In Lendava the company Lendava Petrol Geoterm d.o.o. (Infrastructure provider and energy distributor) built in 2003 a district heating system with geothermal energy. The building of Lendava Library is located in the Oskar Laubhaimer's neo-baroque villa built in 1906 and it is still heated by fossil fuel - residual fuel oil. In the frame of the project the installation of a paraffin-based latent heat storage is planned in the local library building. Moreover, the library will be connected to the geothermal grid. The pilot of a paraffin-based latent storage in connection with a geothermal district heating system is a highly innovative investment in Slovenia because no similar installation has yet been built anywhere else in Slovenia. Therefore, the installation can be a very good best practice example for the region.

4.1. Technical specification

The current average annual heat consumption of the Lendava Library is 84.351 kWh on a heated area of 596 m². Together with the electricity 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 CO₂ 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.

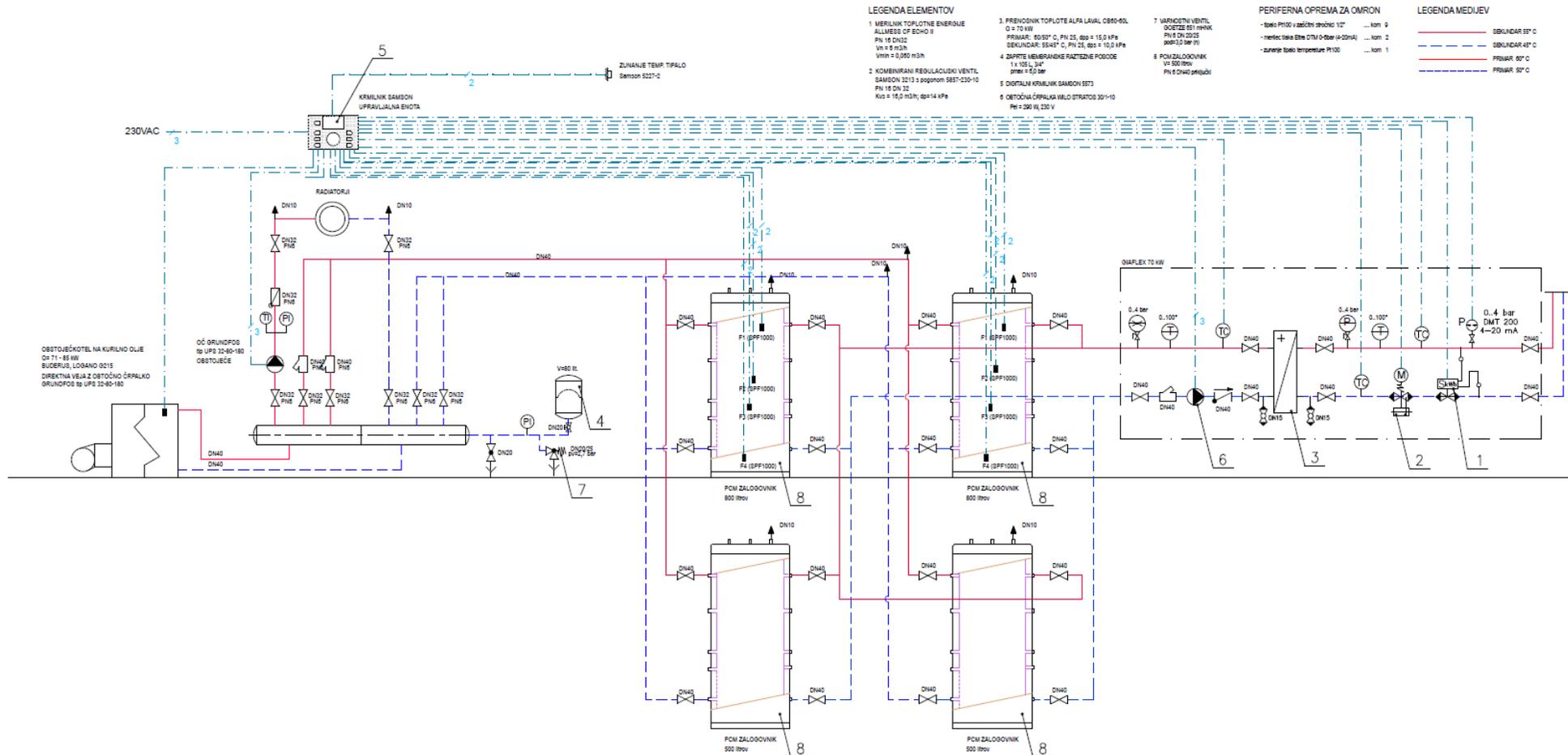


Figure 7: Plan of newly installed storage in accordance with the newly implemented control and EMS system



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 inefficient (old Oil-Fired boiler) to efficient (DHS) → significant primary energy savings → CO₂ saving through lower final energy consumption
- Lower pollutant emissions by changing from fossil to renewable energy source (carbon dioxide - CO₂, carbon monoxide - CO, dust and other greenhouse gas emissions as NO_x and C_xH_y)
- 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 4: 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.

4.2. Economical specification

With this pilot investment we will achieve: 1. Connection of the building (Lendava Library) to the existing geothermal pipeline/distribution network - to use it for space heating (65 m of new pipeline, heat exchanger, thermal regulation system, construction works, etc.); 2. Installation of an innovative energy storing system with paraffin-based latent storages (4 pieces; volume 500 litres).

The total investment for the project is about EUR 100.000,00, including the preparation and construction works for the new pipeline (construction and assembly work), the planning and installation process of a district heating substation with included storage system, the peripheral regulation and electrical equipment and the construction costs for boiler room preparation. The estimated costs of the planned measures are in section 4.4 (Financing plan). The total for the entire work has been calculated on the basis of the elementary prices taken from the regional price list for public works, as well as unit prices determined through specific analyses based on market cost assessments.

In energy terms, the PCM storage tank used is already a proven technology in some countries in the 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 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 (mentioned in section 4.1), this was the appropriate solution. In addition, we are limited by



the operating temperature of the geothermal district heating, which is low (about 50°C), 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 this case an optimal “energy” solution was required.

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 economic effects can be achieved:

- Increasing the energy efficiency of the system by changing the heating system from energy inefficient (old Oil-Fired boiler) to efficient (DHS) → significant primary energy savings → CO₂ saving through lower final energy consumption
- Extension of maintenance intervals → lower maintenance costs (no maintenance on heating system and low maintenance cost on storage)
- Increasing the service life of the plant components.



Table 5: 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		



4.3. SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> - 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 	<ul style="list-style-type: none"> - 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 of an innovative storage solution (paraffin-based storage)
Opportunities	Threats
<ul style="list-style-type: none"> - 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 	<ul style="list-style-type: none"> - 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 8: SWOT analysis

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=2ahUKewjrtreu4bqAhVMQMAKHUJPCWgQFjADe_gQJBRAB&url=http%3A%2F%2Fwww.covenantofmayors.eu%2FIMG%2Fpdf%2Ftechnical_annex_en.pdf&usq=AOvVaw292jg4vxVp9v9b5BH6WRZj



4.4. Financing plan

Table 6 shows an indicative costs breakdown of the planned measures.

Table 6: *Estimated costs of the planned measures*

Cost position	Costs [€]
1 New pipeline (construction and assembly work)	75.000,00
2 Paraffin based latent storages	25.000,00
Total incl. VAT	100.000,00



4.5. Legal framework conditions

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 Slovenije²¹) 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.²²

In 2016, The Ministry of Culture in cooperation with the Ministry of Infrastructure published a *Guidelines for energy renovation of cultural heritage buildings*²³:

“...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!

²¹ <https://www.zvkds.si/sl>

²² https://www.culture.si/en/Heritage_preservation_and_restoration_in_Slovenia

²³ http://www.energetika-portal.si/fileadmin/dokumenti/podrocja/energetika/javne_stavbe/smernice_kd_23.2.2017.pdf



4.6. Action plan / roadmap

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														
1.2	Project coordination														
1.3	Preparation of project documentation														
1.4	End of the project (formal)														
2 Project implementation / Construction works															
2.1	Public procurement process														
2.2	Construction works - Pipeline														
2.3	Work on DH substation / storage														
3 Monitoring															
3.1	Installation and testing of monitoring equipment														
3.2	Ongoing monitoring														
4 Dissemination															
4.1	Articles in local/national media														
4.2	Implementation of workshop with interested stakeholders														
4.3	Ongoing dissemination activities														

Figure 9: Timetable regarding the project implementation



5. Collected feedback / summary

The investment in a pilot energy storage system in Lendava will be the first in the region and on the national level. The storage, which will be installed in the cultural and historic protected building of Public library of Lendava, will represent a decentralized system of thermal energy improvement in the system with paraffin - latent storages. Municipality of Lendava is one of the two Slovenian municipalities that has geothermal district heating. In parallel, the municipality also works on energy efficiency, where there are restrictions on cultural and historical protected structures. Pilot paraffin-based latent storages in connection with geothermal district heating system in Lendava is an innovative investment at the national level, such installation has not yet been built anywhere in Slovenia. The investment can serve as an example of a good practice in the project area; example of innovative solution of storing renewable energy in an effective way.