Interreg
CENTRAL EUROPE
European Union
European Regional Development Fund
STORE4HUC

MID-TERM REPORT OF THE HUC PILOT ACTION IN WEIZ (AT)

D.T 2.2.6

Version 2
06 2020

TITLE AND LOCATION of the PILOT action: Weizberg

REPORTING STAGE (tick on the proper option)

☒ Mid-term

☐ Final

☐ Transnational evaluation

Title	MID-TERM REPORT OF THE HUC PILOT ACTION IN WEIZ (AT)
Deliverable	D.T 2.2.6
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Status	V2
Reviewed by	
Submission	30.06.2020

Content

1. SUMMARY

Even though the Covid-19 pandemic also affects the progress of the pilot in Weiz, as physical meetings with the stakeholders were not possible for some times and some works have been (slightly) delayed, the midterm report can still be very positive as a lot has already been achieved. The construction phase of the storage started in February 2020 and was completed with the installation of the water buffer storage at the end of June 2020. All challenges resulting from the implementation of the extension were excellently mastered by the measures taken. Moreover, the project team successfully applied for a KEM funding for heat storages in order to raise additional funds to finance the project. As the only project in Austria, it was a great achievement for the Austrian Store4HUC team, as well as its local partners and stakeholders, that the storage expansion project in Weizberg received the "KEM Thermal Storage" funding, with the maximum eligible rate of 45% of the investment costs. This can be seen as a strong confirmation of the chosen path of the pilot in Weiz as well as of the importance of the Store4HUC project in general.

The water buffer storage is necessary, because there are currently too high emission loads, there is no emergency boiler and in general the lifetime of the system, energy efficiency and the use of renewable energy sources should be increased. The expected energy savings are calculated with 9 % of biomass fuel, 2 % of grid losses and 12 % electricity reduction. As described in the following chapters, there is a great potential to implement the planned system in other HUCs. The pilot should serve as a lighthouse for other municipalities as biomass district heating systems in the context of historical centres are widespread in Styria, one of 9 counties in Austria. Other regional municipalities have already announced a clear interest on the project results e.g. on the CEBC 2020 conference in Graz on 24-01-20 and via usual communication channels.

Nevertheless, it is challenging to provide a low carbon energy supply in cities in a style of energy storages. Especially in historical urban centres it is very difficult to achieve these results, because interventions in this specific area meet strict architectural protection constraints, involve higher implementation costs and often come in conflict with town planning policies. Therefore, one of the main objectives of the Store4HUC project is also to improve and enrich energy and spatial planning strategies targeting historical city centres by focusing on integration of energy storage systems to enhance the public institutional and utility capabilities.

Moreover, the involvement of all relevant institutions and organizations from the beginning was and is very important for the success of the pilot implementation. These took place at the so-called deployment desk meetings, where all stakeholders come together every few months, as well as at some other informal meetings in between whenever necessary. With this instrument, it was also ensured that all relevant players were reached to share the knowledge and transfer it to other external audiences that are not part of the inner circle. Participation in external events by means of presentations to promote the project results (Rostock, Vienna, Bolzano, Graz) are also important measures within the framework of the stakeholder engagement process. In this context, the energy infrastructure companies Fernwärme Weiz and Energienetze Steiermark are to be increasingly integrated in the future. A cross-fertilization event organised by the Climate Alliance Styria, with contribution of the W.E.I.Z., was also held in Weiz. In addition, at the project's ending, further publicity events are to be implemented locally.

In the next months, the commissioning of the storage will be finished, and the positive effects will be monitored.

2. INTRODUCTION

This document describes the reporting activities of the pilot actions foreseen in the Store4HUC project.

It describes the monitoring activities that the involved PPs will conduct on the pilot implementation and the indicators (KPIs) to be monitored at different stages:

- Intermediate stage (Mid-term report) – September 2020
- Final stage (Final report) – September 2021
- Transnational evaluation stage – November 2021

It also provides (chapter 3) a summary of the aspects to be included at the feasibility study and pre-investment stages, as a memorial for the responsible of pilot actions.

The document in particular has two specific objectives:

- Report on the investment process foreseen for each pilot.
- Monitor other aspects related to the positive impacts and successfulness of pilots, such as:
  - Results of application of operational and monitoring tools.
  - Adaptations of energy and urban policy frames that are needed.
  - Mapping and adaptation of HUC regulations for the authorization of building integration.
  - Energy storage promotion and replication activities.
  - Follow up - recommendations, improvements.
  - Evaluation of the sustainability of the pilot and risk reduction measures.

3. ASPECTS AND KPIs TO BE MONITORED AT DIFFERENT STAGES

Aspects and Urban KPIs	Chapter in the template	Feasibility study	Pre - investment stage	Mid-term report	Final report	Transnat. evaluation
Technical specifications and performance requirements of the identified storage system		X	X			
Strengths, Weaknesses, Opportunities, Threats (SWOT Analysis)		X				
Initial situation: energy consumption, CO_2 emissions and energy costs			X			
Procurement procedure	4.1		X	X	X	
Installation and integration process	4.2		X	X	X	
Impact of the investment on energy and overall costs	4.3		X	X	X	
Energy management	4.4		X	X	X	
Energy and urban policy frames	4.5	X		X	X	X
Stakeholders' involvement	4.6	X		X	X	X
Transferability of the pilot action	4.7	X		X	X	X
Impact of the pilot action	4.8	x		X	X	X
KPI_1 - External energy needs of the pilot system	4.9.1		X		X	X
KPI_2 - External energy costs of the pilot system	4.9.2		X		X	X
KPI_3 - Average yearly CO_2 abatement	4.9.3		X		X	X
KPI_4 - Autarky rate	4.9.4		X		X	X
KPI_5 - Use of energy from RES	4.9.5		X		X	X
KPI_6 -Security of energy supply	4.9.6		X		X	X
KPI_7 - Power peak	4.9.7		X		X	X
KPI_8 - Profitability	4.9.8		X		X	X
KPI_9 - Stimulation of local economy	4.9.9		X		X	X
KPI_{10} - Other pilot specific KPIs	4.9.10		X		X	X

4. PROGRESS REPORT OF THE PILOT ACTION

According to what is described in the former chapters, in the sub-chapters below the progress of the pilot implementation is discussed. For the water puffer storage which is located at the biomass heating plant Weizberg the actual level of development of the investment, according to the activities planned in the application and the timeline of the entire process for each of the following steps are shown for the procurement (tender process), the realization of the storage and auxiliary components, the operation and monitoring of the storage. Additionally, the energy and urban policy frames, the stakeholders' involvement, the transferability of the pilot action and the impact of the pilot actions are discussed.

4.1. Procurement procedure

Type of tendering procedure

In Austria (Weiz), relevant procurement procedures are depending on who is investing according to the national procurement law. The Dorda Brugger Jordis Rechsanwälte webpage provides an overview about relevant laws: For the State (Bund) and public bodies on the central government level, the Federal Public Procurement Law 2006 (Bundesvergabegesetz 2006 – "BVergG 2006") implements Directives 2004/17/EC and 2004/18/EC (aspects on content) as well as Directives 89/665/EEC and 92/13/EEC (review proceedings). First, the BVergG 2006 provides the legal framework for awarding public works, supply and service contracts as well as works and service concessions and contests (the "classic regime"). Second, it contains regulations coordinating the public procurement procedures of entities operating in the water, energy, transport and postal services sector (the "sector regime"). Under both regimes, it covers public tenders above and below the thresholds of Regulation (EC) 2083/2005. Third, the BVergG 2006 comprises procedural provisions relating to the review of the award of public contracts. The BVergG 2006 is also applicable for all aspects on content of public tenders awarded by the nine Austrian Provinces (Bundesländer) and the communities and public bodies governed by them. However, the review proceedings on the regional and local level are exempted from the BvergG 2006 and are subject to nine different provincial laws. These provincial laws do not materially differ from the review proceedings provided for by the BVergG 2006."[1] It is required by law to have open calls across Europe for construction services above the threshold value of €186,000. Below €100,000, service activities such as detailed planning can be assigned directly.

Eligibility criteria and timetable for the procurer

Usually eligibility criteria are related to the particular services, system components and competences requested. Expected skills are chosen via the analysis of provided references. In addition, a so-called competence matrix is used for the documentation of the agreed responsibilities of all involved project stakeholders and their roles for each work package and responsibility for reaching the expected project results. This is also reflected in the invitation of corresponding experts to the deployment desk in Weiz apart from the regular construction team meetings on-site.

In Table 1 the work plan is shown. It includes management aspects, the realisation of construction work and the implementation of the storage. In addition, dissemination activities are foreseen after the completion of the work.

[1] www.dorda.at/publications/austria-public-procurement

Table 1. Timetable pilot Weizberg

Workpackages / MMM.JJ	Mar 20		Apr 20		May 20		June 20		July 20		Aug 20		Sep 20		Oct 20		Nov 20		Dec 20		Jan 21		Feb 21	
Projectmanagement																								
Project start	X	X																						
Project documentation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Projectcontrolling		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
End of projekt																							X	X
Implementation of the building measurments																								
Tenders	X	X	X	X	X	X																		
Implementation of building measurs					X	X	X	X	X	X	X	X	X	X	X	X								
Implementation storage																								
Preperation and planning			X	X	X	X	X	X																
Implementation storage								X	X	X	X													
Dissemination																								
Articles and newspapers																				X				
Workshop with members of biomasse team																	X	X	X	X	X			
Monitoring																								
Ongoing measurements																	X	X	X	X	X	X	X	X

Tender decision-making process

The tender procedure for the thermal storage at pilot Weizberg was prepared and accompanied by DI Johann Haas. Mr. DI Johann Haas has been involved in the activities of the biomass heating plant Weizberg for years. In total there were two separate parts of the tender (See Table 2 for details):

- Construction (boiler room)
- Installation
  - Storage
  - Heating pipes
  - Regulation
  - Electrical installation
  - Emergency heating station and water treatment
  - Planning

Table 2. Investment costs

Costs categories	Costs [€]
Storage	55.633,75
Heating pipes	44.687,49
Regulation	18.961,07
Electrical installation	19.251,60
Emergency heating station and water treatment	15.466,15
Construction costs for boiler room construction according to service specification	116.174,56
Planning and tendering	22.227,90
Total excluding VAT	292.402,53

The tender documents were sent out especially to local companies and companies with whom cooperation had been going on for a longer period of time and who proved to be competent and reliable. In each case 3 offers were received. The following companies were selected, for the construction of the cement building (boiler room), the company Lieb as the cheapest bidder and for the installation, also as the cheapest bidder, the company Haas. As a result, two reliable and long-standing partners could be won and contracted for the construction. The construction is now in progress. Contrary to the original schedule (see Table 1), the entire project (construction and dissemination of the pilot) could be started earlier than planned, especially the tendering and contracting. Due to the Covid-19 pandemic, however, delays have occurred and by June the schedule for the remaining activities can be considered as planned.

4.2. Installation and integration process

The aim of the project is the integration of a central heat storage tank into the existing heating plant of the local heating network in the historic monument and landscape protection zone of Weizberg as well as the implementation of a new control with a fully integrated, intelligent load management with mutual communication of all components.

The boiler of the heating plant is currently operated mainly in the disadvantageous partial or low load range due to the lack of a central heat storage tank. This leads to increased fuel consumption and pollutant emissions (CO, NOx, dust and volatile unburned CnHm emissions). In addition, due to the lack of a central storage tank, the heating network is used as a thermal buffer to absorb the heat supplied by the boilers, particularly in the burnout phase, in order to be able to supply the decentralised hot water storage tanks at the customers' premises. In this way, the heating network is constantly maintained at correspondingly high flow temperatures and unnecessary heat losses of the network (distribution losses) occur.

The innovation of this project takes place on the storage tank as well as on the system level. On the one hand on the system level by the implementation of a new control with a coherent load management of all system components (boiler plant, central storage, network and decentralised storage at the consumers) by mutual communication of these and by access to the control of the decentralised storage at the consumers, and on the other hand on the storage level with the integration of a central heat storage in the historic monument and landscape protection zone.

Only the implementation of the fully integrated, intelligent load management of all system components in interaction with the central heat storage tank and the decentralised heat storage tanks at the customers' premises makes it possible to minimise the disadvantageous operating mode of the boiler plant and prevents the local heating network from being used as a thermal buffer. These planned measures thus increase the flexibility and energy efficiency of the entire biomass heating plant. Essentially, the following positive effects will be achieved:

- Use of the heating network as a thermal buffer is avoided → lower heat losses (distribution losses), optimised fuel utilisation
- Operation of the heating network during the summer months only at certain times when hot water is required and after communication with the decentralised storage → Lower heat losses (distribution losses) and savings on pump energy
- Saving of primary energy (fuel savings) by increasing efficiency → CO2 savings through lower energy expenditure for the provision of the wood chips (production, transport, etc.)
- Lower emissions of pollutants (carbon monoxide (CO), dust, NOx and volatile organic carbon compounds (CnHm))
- Increase of the service life of the plant components → Significant saving of ecological resources, which would result from an early complete renewal of the boiler plant

One of the main reasons for the lack of a storage tank and other measures to increase efficiency is the location of the heating plant in the historic monument and landscape protection zone of Weizberg, where the church and the parish buildings are protected as a historical monument and a protected site. At present, the integration of large heat storage units and other measures for local heating networks in historical districts represents a very great challenge due to the strict conditions imposed by the protection of the townscape and historical monuments. However, especially in these districts, which are protected as historic sites and monuments, there is a backlog demand with regard to energy efficiency and the use of renewable energy sources.

This project will demonstrate a possible solution to this problem by the innovative implementation of a central water buffer storage and a new load management system in the listed town centre of Weizberg. The constructional requirements for compliance with the protection of the townscape and monuments are to be fulfilled by new solution concepts. This project can and should therefore serve as an innovative best-practice facility and as a model for simplified technical and above all economic implementation at other protected sites and lead to a significant increase in the proportion of renewable energy sources in historic city centres.

As with all construction measures at historic monuments and landscapes that are under protection and as already stated often, one of the main challenges for the Weizberg biomass heating plant was to bring this expansion in line with the regulations and requirements of monument protection. Because of these special requirements, an application for KEM subsidies for thermal storage was submitted to raise additional funds. In order to be eligible for funding under the "Thermal Storage" pilot programme, the storage system has to go beyond the usual state of the art (material, size, use over time, etc.) and thus exhibit a high degree of innovation and is technically and economically multipliable. As the only project in Austria, it was a great accomplishment that the storage expansion project at Weizberg received "KEM thermal storage" funding at the maximum eligible rate of 45% of the investment costs.

The building phase started in February 2020. Due to the Covid-19 pandemic the construction work and all planned stakeholder engagement meetings had to stop for some weeks. However, they were completed with the installation of the water buffer storage tank at the end of June 2020. Last work done in this regard is shown in Figure 1. As there were no major problems in the building phase the commissioning of the system has started as planned and should be completed before the start of the heating season. An inauguration ceremony is planned for autumn to officially put the expanded biomass heating plant into operation and thus initiate an energy-efficient and climate-friendly future of energy supply at Weizberg and hopefully at many other historic monuments and landscapes that are under protection.

This project thus demonstrates the use of an already widely tested technology (water buffer storage) for the hardly tested area of application in districts and buildings under monument or site protection. Furthermore, the new load management including mutual communication of all plant components on system level represents an innovative approach. For these reasons, the use of this storage solution goes beyond the state of the art and emphasizes the innovative character of this project.

Figure 1. Last work during the storage installation

4.3. Impact of the investment on energy and overall costs

Concerning the impact of the investment, it is enabled the collection, aggregation and filtering of the energy data and other information that are provided by a wide range of equipment (such as installed meters) and sources mainly responsible for energy production and consumption. The information gathered is afterwards exported to a service layer for enabling peak load reduction, demand shifting, optimum storage exploitation, and consumption forecasting as well as grid flexibility and reliability. Special concern will be attributed to take advantage of the fact that the scale of related building blocks may allow significant optimizations of the local network with lower CAPEX per end-user as well as for better flexibility. The CAPEX is given in Table 2. The maintenance costs OPEX cannot be calculated yet as it is depending on robust monitoring data.

Additional investments are largely due to the implementation of the storage facility in a historic city centre with protected status and listed buildings and the associated difficult and cost-intensive construction requirements. However, these are to be contrasted with the positive environmental effect achieved for protected historical town centres, which is only made possible by this additional investment.

In terms of energy, the water buffer storage is a proven technology and can be considered the most cost-efficient solution compared to other storage technologies due to the high number of charging cycles (almost daily complete charging and discharging of the storage). Additional investment enables positive environmental effects for protected historical town centres and storage technology is still the most energy-efficient solution.

4.4. Energy management

The local heating network and heating plant of the cooperative "Biomasse Heizwerk Weizberg reg. Genossenschaft mbH" was built in 1999. The heat supply of the local heating network with 12 consumers is ensured by two biomass boilers fired with regional wood chips (see Table 3 for details). The largest consumers are a hotel building and the parish of Weizberg. The plant is currently operated without storage and without additional oil or gas boilers as a fail-safe measure. Characteristic values for the heating network and the boiler plant can be found in Table 4 and Table 5. Table 4 also contains a list of available decentralised hot water storage tanks (charging storage tank) at the consumers of the heating network.

Table 3. Consumers of the heating grid

Consumer	Object address	kW
1	Parish building; Weizberg 13; 8160 Weiz	125
2	Hotel; Weizberg 2; 8160 Weiz	330
3	Municipality; VS Weizberg; 8160 Weiz	170
4	Church Weizberg; 8160 Weiz	20
5	Weizberg 13; 8160 Weiz	50
6	Weizberg 7; 8160 Weiz	38
7	Messner house; Weizberg 17; 8160 Weiz	20
8	Schlossgasse 8/10; 8160 Weiz	22
9	Weizbergstrasse 36; 8160 Weiz	25
10	Weizberg 13; 8160 Weiz	30
11	Weizberg 11; 8160 Weiz	28
13	Schlossgasse 7; 8160 Weiz	15
		873

Table 4. Key characteristics of the heating grid

Heating grid				
Energy users	12	[-]		
Grid length	773	[m]		
Connected power	917	[kW]		
Sold heat (2017/18)	1457	[MWh]		
Temperatures	Winter (Oct-Apr)		Summer* (Mai-Sep)	
Flow temperature	81	[°C]	79	[°C]
Return temperature	57	[°C]	58	[°C]
Average temperature difference	24	[°C]	21	[°C]
Decentralised hot water storage				
Consumer 2	750	[Litre]		
Consumer 5	500	[Litre]		
Consumer 6	500	[Litre]		
Consumer 8	500	[Litre]		
Consumer 13	300	[Litre]		

Legend: *) In case of receiving the requested co-financing in Austria DHW will be decentralised

Table 5. Key characteristics of the boiler plant (2 boilers)

Boiler plant		
Power	840	[kW]
Boiler 1	300	[kW]
Boiler 2	540	[kW]
Used biomass (2017/18)	1896,3	[m³]
	417,68	[t]
	22,8	[% humidity]

The high return flow temperatures of the local heating network have optimisation potential. Therefore, optimisation measures (renewal of the heat exchangers, hydraulic balancing, renewal of the control system, etc.) have already been carried out at the second largest consumer (Weizberg parish) to reduce the return temperatures. Further optimisation measures (additional heat storage tank and heat exchanger, optimisation of the control system, etc.) have already been implemented or are planned for the largest consumer (hotel operation).

In order to enable the implementation of the new control system with a coherent load management through mutual communication of all system components (boiler system, storage tank, network and decentralised storage tanks at the consumers), access to the control system of the decentralised hot water storage tanks at the consumers (see Table 4) is necessary. This agreement has already been reached with the corresponding consumers by extending the heat supply contract and the maintenance agreement.

The regulation of the district heating network and the storage will (estimated, not finally decided) most probably be the MR-12 by the company Schneid (see Figure 2). The control unit MR-12 will be used as a district heating, district cooling and heating controller. The modular structure enables simple and quick adaptation to the conditions of the system to be controlled. An expansion to seven regulated heating circuits in the PLC version is possible at any time. Optionally, a hot water tank, buffer, solar system, circulation pump, boiler with return flow increase or boiler release can also be implemented. Depending on the configuration, there are numerous possible applications. This versatility distinguishes the MR-12 control unit[2].

[2] Schneid Gesellschaft m.b.H. (2020): MR12 Basismodulregler mit AKP; https://schneid.at/product/mr12-basismodulregler-mit-akp/; last access 10.03.2020

- **Figure 2. Regulation system from the company Schneid**

In detail, the following improved operating modes for the different periods of the operating year compared to the actual situation are only made possible by the new load management in interaction with the heat storage facilities (centralised and decentralised):

Period 1 (June to September):

Boiler 1 charges the storage tank once a day in the advantageous higher full load range instead of always in low partial/low load and is then taken out of service. The rest of the daily demand is covered by the storage tank. For the target storage size of 38 m^3, the maximum storage capacity[3] is around 1327 kWh. The coverage of the energy consumption of the grid in period 1 as shown in Figure 3 can be ensured with this operating mode.

The integration of the new load management in interaction with the heat storage tanks (centralised and decentralised) ensures that boiler 1 can be operated continuously in the advantageous higher load range and still prevent the use of the grid as a thermal buffer. Excess heat from the boiler system (especially in the burnout phase) is temporarily stored in the central heat storage tank so that it can then be distributed to the consumers as required by communicating with the decentralized storage tanks (see Table 4) without increased distribution losses. In detail, the new load management and full access to the control of the decentralised DHW cylinders of the consumers enables the following operating mode in the summer months.

[3] 1,164 [kWh/(m^3K)] x 38 [m^3] x 30 [K] = 1327 [kWh]

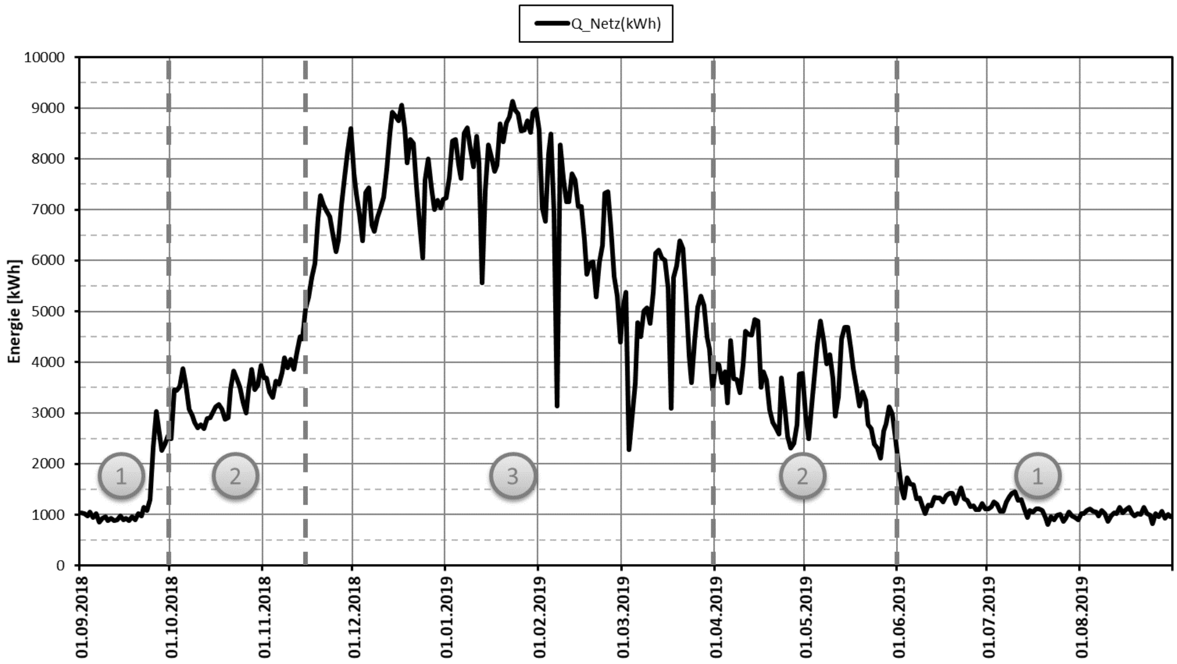


Figure 3. Daily values of the energy supplied to the grid.

During the summer months, the heating grid should only be operated when the consumers require hot water and after communication with the decentralized hot water storage tanks. During the rest of the time, the heating network should be operated with reduced temperatures and flow rates. This should reduce distribution losses on the one hand and save pump energy on the other. With an assumed maximum loading capacity of the decentralised hot water storage tanks of 550 kW (10.5 m³/h) [4] and an average daily demand of 1100 kWh (see Figure 3), the heating network would therefore only have to be operated at full load for two hours per day[5]. The remaining time the heating network is operated with flow temperatures of 45°C, at a reduced volume flow of 0.8 m³/h[6].

Period 2 (October to mid-November, April and May):

Boiler 1, instead of boiler 2 in the disadvantageous partial/low load range, is operated continuously in the advantageous higher load range and the occurring individual load peaks in this period are covered by the storage tank. In this way, peak loads of 400 kW, for example, can be covered by the storage tank for a period of about 3.3 h and the heat supply can be ensured[7].

The integration of the new load management in interaction with the heat storage tanks (central and decentralised) ensures that boiler 1 can be operated continuously in the advantageous higher load range and still prevent the use of the grid as a thermal buffer. Excess heat from the boiler system (especially in the burnout phase) is temporarily stored in the central heat storage tank so that it can then be distributed to the consumers as required by communicating with the decentralised storage tanks without increased distribution losses.

[4] 1,164 [kWh/(m³K)] x 38 [m³] x 30 [K] = 1327 [kWh]

[5] 1100 [kWh] / 550 [kW] = 2 [h]

[6] To avoid damage to the district heating pipeline due to thermal expansion, the network cannot be completely shut down. Therefore, the network must be operated with a minimum volume flow.

[7] 1,164 [kWh/(m³K)] x 38 [m³] x 30 [K] / 400 [kW] = 3,3 [h]

Period 3 (mid-November to March):

Boiler 2 is operated continuously in the advantageous higher load range and the occurring individual load peaks in this period are covered by the storage tank and a connection of boiler 1 in the disadvantageous partial/low load range is no longer necessary. The storage tank can, for example, cover power peaks of 600 kW for a period of about 2.2 h and ensure the heat supply[8].

The integration of the new load management in interaction with the heat storage tanks (central and decentralised) ensures that boiler 2 can be operated continuously in the advantageous higher load range and still prevents the use of the grid as a thermal buffer. Excess heat from the boiler system (especially in the burnout phase) is temporarily stored in the central heat storage tank so that it can then be distributed to the consumers as required by communicating with the decentralised storage tanks without increased distribution losses.

The integration of the new load management system and the central heat storage tank has the following positive effects:

- Use of the heating network as a thermal buffer is avoided → lower heat losses (distribution losses), surplus heat from the boiler plant is used optimally
- Operation of the heating network during the summer months only at certain times when hot water is required and after communication with the decentralised storage facilities at the consumers → Lower heat losses (distribution losses) and savings of pump energy
- Generally, more dynamic operation of the local heating network possible → Consumers can be served more quickly with the required temperatures without the inertia of the boiler plant

Furthermore, the planned measures by load balancing and peak load coverage will prevent or reduce the disadvantageous partial/low-load operation of the boiler plant and thus achieve the following positive effects

- Increase of the efficiency of the fuel boilers → Saving of primary energy (fuel savings) → CO2 savings through lower energy expenditure for the provision of the wood chips (production, transport, etc.)
- Lower emissions of pollutants (carbon monoxide (CO), dust, NOx and volatile organic carbon compounds (CnHm))
- Increase of the service life of the plant components → Significant saving of ecological resources, which would result from an early complete renewal of the boiler plant
- Increase of sweeping intervals (more time windows are available due to the on/off operation of the boiler plant) → Increase of efficiency, reduction of pollutant emissions
- Extension of maintenance intervals → lower maintenance costs

The tool developed within WP T3 will further enable to achieve higher benefits in operation of the plant. With the help of the tool it will be possible to compute the optimal schedule of boilers operation throughout the day in terms of their power and their switch-on and switch-off times. Needed inputs will be the predicted daily heat consumption profile of the consumers (jointly, sum of all consumptions) as well as the admissible starting temperature interval and flow. In this way it will be possible to re-assure that the qualitatively described boiler section operation strategy is indeed optimal and to eventually quantitatively assess the switch-on and switch-off times for the boilers as well as their operating powers when in on-state throughout the day.

[8] 1,164 [kWh/(m³K)] x 38 [m³] x 30 [K] / 600 [kW] = 2,2 [h]

The plant operators will be able to enter the planned daily consumption profile in the tool and based on it get the profile of boilers operation for the next day they would then need to schedule on the plant automation system. If the operation proves useful to follow, it may be possible to raise the tool usage to a higher level of automation in the future, foremost by including the automated heat consumption profile predictor attached to the module and automated computed schedules entry into the automation system.

4.5. Energy and urban policy frames

At the Weizberg pilot site, a thermal storage tank for the local biomass heating network is being built. The planned or currently constructed water buffer storage is necessary, because there are currently too high emission loads, there is no emergency boiler and in general the lifetime of the system, energy efficiency and the use of renewable energy sources should be increased. As described in the following chapters, there is a great possibility to implement the planned system in other HUCs. In general, storage technologies are important pieces of the puzzle for a sustainable energy system, as it is also stated in the energy plans of the City of Weiz, the KEM Weiz-Gleisdorf and the Catholic Church of Styria. Hence, the pilot project is fully integrated into the regional climate and energy strategies of the City of Weiz, the KEM Weiz-Gleisdorf and the Catholic Church of Styria. The main points of these strategies are briefly summarised below:

(1) Municipality of Weiz

The municipality of Weiz has set itself the goal of reducing per capita CO_2 emissions by 40 % by 2030 compared to 1990. This means a transformation of the energy supply away from conventional, easily controllable fossil energy sources towards fluctuating energy sources that are difficult to control in terms of generation, combined with storage technologies and energy efficiency measures. Although the share of renewables is increasing, especially in the electricity and heating sectors in Weiz, there is an increasing demand in transport, industry and above all in listed buildings and districts.

(2) Catholic Church Styria

One of the main customers of the biomass heating plant Weizberg is the parish Weizberg with the basilica Weizberg. The climate and energy strategy of the Catholic Church of Styria was put into effect by Bishop Dr. Wilhelm Krautwaschl on 1 October 2018. The basis for this climate and energy strategy was laid down in the resolutions of the Austrian Bishops' Conference of 11 November 2015 in three ecological goals:

a) Reduction of energy demand,

b) Increase of energy efficiency, and

c) Coverage of the remaining energy demand by renewable energies.

(3) KEM Weiz-Gleisdorf

The higher-level climate and energy model region "Energy Region Weiz-Gleisdorf" pursues an efficient use of the available resources with the goal of 100 % resource use for electricity, heat and mobility through renewable energy sources by 2050. The achievement of these goals also requires an optimization of the existing systems with regard to the local heat expansion, the associated use of storage as well as the increase in energy efficiency, as can also be seen from the statements of the local development concept:

a) A drastic increase in energy efficiency is necessary in all sectors, this is the only way to reduce energy consumption - especially in the building sector (refurbishment)".

b) Storage technologies must be developed strategically to improve the integration of renewables".

In this context, the area of the heating plant (Gst. Nr. 1185/1, KG 68266 Weiz, EZ 2153) in the historical city centre of Weizberg is located in a protected area according to the zoning plan (see Figure 4). In Austria, the protection of historic sites and monuments in historic urban centres or other districts is subject to the Building[9] and Regional Planning Act[10] of the Federal State and the Austrian Monument Protection Act[11]. In this context, the preservation of the local image and of historical monuments in the respective local image protection zones[12] is performed by a local image expert in the context of building permits. Structural changes in protected areas therefore require a building permit including a positive assessment of the protected area.

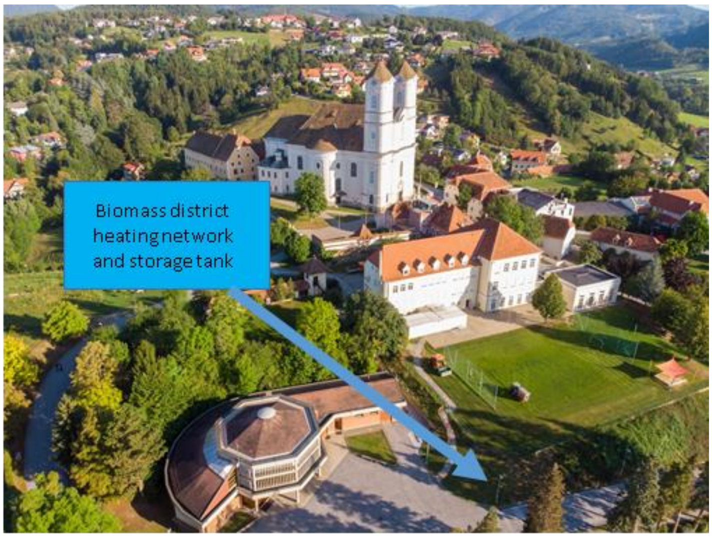
Figure 4. Excerpt from the zoning plan for the focus area Weizberg (Source: zoning plan No. 1.0 - Stadtgemeinde Weiz, as at: 26.09.2019, Original: http://www.weiz.at/files/stadt-weiz/dokumente/Verordnungen/fwp_weiz_kl_1.pdf)

The planned extension of the pilot Weizberg (see Figure 5) for the accommodation of a heat storage tank, a machine room, a switch room, a retaining wall as well as the associated changes in the terrain on the southwest side of the boiler house, behind the laying-out hall, thus directly influence the existing townscape. Therefore, the following requirements have to be fulfilled by special structural measures due to the approval situation (see Figure 6):

- The aim should be to implement the building, mostly underground, below ground level,
- Utilization of existing buildings to cover the extension and associated restrictions regarding the dimensions of the extension,
- Specially adapted design of the visible facades with regard to colour and geometry while complying with the requirements for weather resistance,
- Minimally invasive integration, in order not to influence existing natural conditions such as trees and bushes.

The innovative structural integration of the storage facility in the historic urban centre, which is protected as a landscape protection zone, is intended to meet all these requirements and to ensure that the extension blends in unobtrusively with the overall view and does not have any negative effects on the landscape.

[9] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrStmk&Gesetzesnummer=20000070
[10] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrStmk&Gesetzesnummer=20000069
[11] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10009184
[12] http://www.umwelt.steiermark.at/cms/beitrag/10025584/686638/



- Figure 5. Storage location

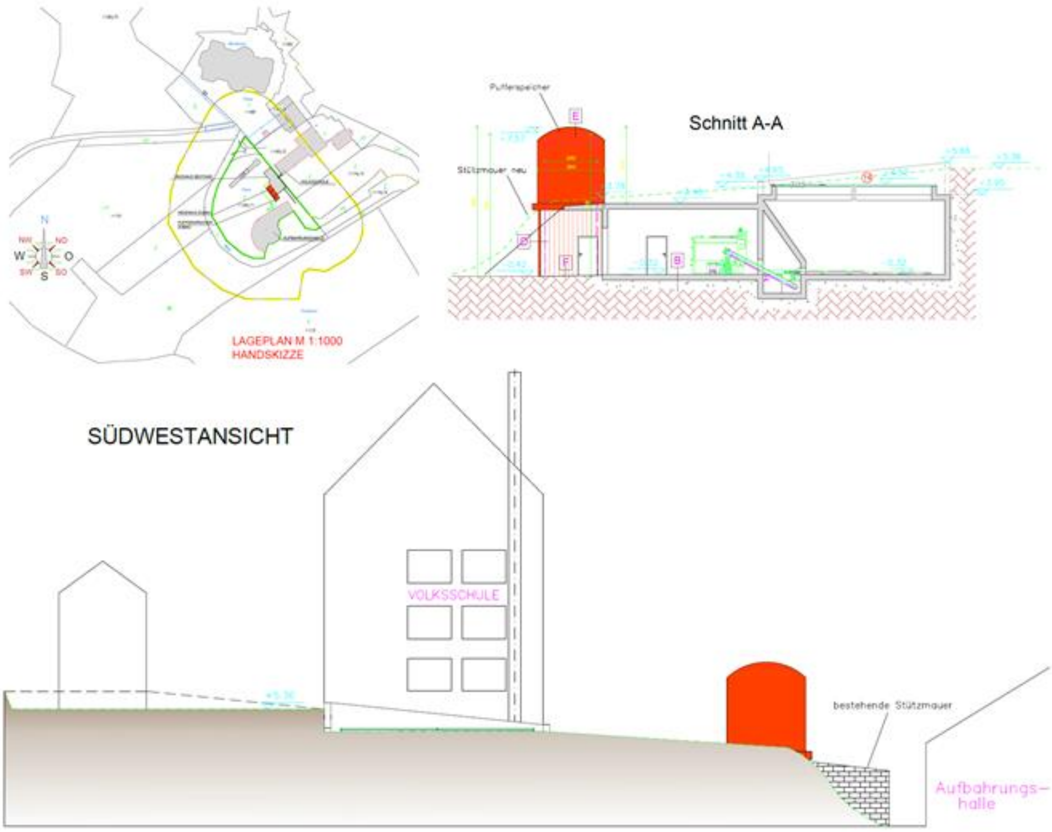


Figure 6. Draft plans of the implementation of the storage

4.6. Stakeholders‘ involvement

The biomass heating plant Weizberg has been operated by 24 innovative farmers for 20 years (founded in 1999). Through the use of regional wood chips, the added value remains in the region. The heating plant supplies a total of twelve objects on the hill of Weizberg, including the elementary school as well as some commercial enterprises and residential buildings. Using renewable energy, the guiding principle of the farmer cooperative is "Energy from the region for the region".

The following tables show the time-wise stakeholder cooperation, and the tasks for each of them within the project. The identified stakeholders have been summarized in groups with similar activities. The tables (Table 6 to Table 11) will be used as living documents for the future deployment desks, which means that they will be updated during the project time. As far as they are already known, the planned activities are listed.

Table 6: Stakeholder 1: WEIZ (employees of WEIZ)

Actions	
1.	Establishing of the feasibility study and investment specification
2.	Organization of deployment desk meetings
3.	Lead the implementation process, local support
4	Support within the implementation of actions

Table 7: Stakeholder 2: 4ward Energy Research (employees of 4ward Energy Research)

Actions	
1	Evaluate self-sustainability of different pilot options in the pilot preparatory phase – together with WEIZ
2	Providing other consulting services – support of WEIZ

Table 8: Stakeholder 3: Technicians (Gerald Hutter (Varicon), Günther Grabner (Innoplan), Johann Haas (Ing. HAAS GesmbH)

Actions	
1.	Technical organization in terms of energy management; regularly
2.	Checking with WEIZ and the regional actors the installations progress and perform final verification
3	Approve the planned investments within the project after the planning phase is finished

Table 9: Stakeholder 4: local authorities in reach of WEIZ, cities and municipalities representatives from Weiz, Thannhausen and Almenland, KEM Weiz-Gleisdorf and the Catholic Church of Styria

Actions	
1.	Knowledge transfer of the pilot to make it relevant also for other sites

Table 10: Stakeholder 5 members of the biomass network

Actions	
1.	Knowledge transfer of the pilot to make it relevant also for other sites
2.	Investor of the measures and the storage

Table 11: Stakeholder 6 researcher and biomass experts (AEE INTEC)

Actions	
1.	Feasibility study
2.	Pre investment concept
3.	Providing other consulting services based on experience from investments in historical urban centers

Technicians of technical offices (Günter Grabner, Gerald Hutter, and Johann Haas) are regional experts in planning of biomass storages, EMS Systems and energy efficiency measurements. They will gain extra knowledge, and experiences in implementation of renewable energy systems and storages in the envisaged historical urban area.

Other Styrian cities and municipalities will be educated about the benefits of energy efficiency and the use of renewable energy sources as well as on storages in buildings under cultural heritage protection. The pilot will provide a good showcase to the local authorities which will also benefit in sense of improved energy efficiency, increased usage of renewable energy sources and lower costs for energy.

The members of the biomass district heating systems will be educated how to enable further development of projects dedicated to renewable energy sources on other cultural heritage buildings and will gain knowledge about possible technologies of district heating networks.

Nevertheless, the stakeholder involvement process is still ongoing. Participation in external events by means of presentations to promote the project results (Rostock, Vienna, Bolzano, Graz) are also important measures within the framework of the stakeholder engagement process. In this context, the energy infrastructure companies Fernwärme Weiz and Energienetze Steiermark are to be increasingly integrated in the future. A cross-fertilization event organised by the Climate Alliance Styria, with contribution of the W.E.I.Z., was also held in Weiz. In addition, at the project's ending, further publicity events are to be implemented locally.

4.7. Transferability of the pilot action

With the innovative approach described here and despite additional effort of the used approach, it is to be shown that flexibility and energy efficiency measures in general, but especially for biomass heating plants in historical and listed districts, are both economically and technically feasible.

The aim of this project is to integrate the planned water buffer tank unobtrusively into the overall picture. It can thus be shown that large thermal energy storage systems will in future also be a technically and economically viable option for the provision of heating and cooling in buildings or districts under preservation order, especially with regard to the integration of renewable energy sources. Only the integration of the central heat storage unit will also enable the implementation of fully integrated, intelligent load management, which will lead to a massive increase in the flexibility and efficiency of the system.

As a result of the pilot Weizberg, the integration of a central heat storage unit and new load management to increase efficiency can be made possible, following the Weizer model, in districts under a preservation order and listed buildings, and therefore at numerous locations, through an off-road integrated construction of the plant and through access to the regulation of the consumers.

The number of cities with historical city centres in Austria currently amounts to 44[13]. In addition, 26[14] monuments are protected in Weiz, and 38,367[15] in Austria. Therefore, this innovative integration has a high market potential and multiplicativity.

In the next few years, the plant can and should therefore serve as an innovative best-practice plant and as a model for simplified technical and above all economic implementation at these protected sites and lead to a significant increase in the proportion of renewable energy sources and the economic efficiency of local heating networks.

As of today, no project outputs and results have been passed on to other target audiences and territories. This process will begin in the coming weeks and months.

4.8. Impact of the pilot action

It is challenging to provide a low carbon energy supply in cities in a style of energy storages. Especially in historical urban centres it is very difficult to achieve these results, because interventions in this specific area meet strict architectural protection constraints, involve higher implementation costs and often come in conflict with town planning policies. Therefore, the main objective of the Store4HUC project is to improve and enrich energy and spatial planning strategies targeting historical city centres by focusing on integration of energy storage systems to enhance the public institutional and utility capabilities.

The degree of energy self-sufficiency achieved with the implementation of these measures varies in the different pilots depending on the local climatic conditions, type of technology, previous energy consumption, etc. Each demonstration site is combining locally available renewable energy sources with storage units. Even though the used technologies are proven and well established, the way they are combined is innovative and will produce new knowledge. This has been advertised and disseminated via two conferences by presenting the Store4HUC poster on the SSPCR conference in Bolzano on 10-12-19 as well as oral and poster presenting of Store4HUC on the CEBC 2020 conference in Graz on 24-01-20 (dissemination material distributed at events).

[13] https://de.wikipedia.org/wiki/Liste_von_St%C3%A4dten_mit_historischem_Stadtkern#%C3%96sterreich

[14] https://bda.gv.at/fileadmin/Dokumente/bda.gv.at/Publikationen/Verordnungen/Steiermark/Verordnung_-Weiz.pdf

[15] https://bda.gv.at/denkmalverzeichnis/

Mutual learning sessions of Store4HUC let benefit the participating audiences among the consortium via project meetings and stakeholders via deployment desk meetings. In Weiz the implementation measures have already started and are nearly finished. Due to the Corona virus the construction work and all planned stakeholder engagement meetings are stopped for the time being. Results of the „Store4HUC energy management tool for operation planning and evaluation" of PP9 underline the planning conclusions made so far. The envisaged pilot will facilitate the acceptance of the related activities in the neighbourhood or in other interested cities, while providing attractive motives. Hence, smart technologies that take advantage of Weiz as a model will be deployed within the project and abroad. Local authorities are involved in the procurement and communication processes as harbingers providing the necessary permits of the site and for future other projects. Pilot-related socio-economic aspects are investigated during and after the construction work.

The expected energy savings are calculated with: 9 % of biomass fuel, 2 % grid losses, and 12 % electricity. The pilot serves as a lighthouse for other municipalities as biomass district heating systems in the context of historical centres are widespread in Styria, one of 9 counties in Austria. Other regional municipalities have already announced a clear interest on the project results e.g. on the CEBC 2020 conference in Graz on 24-01-20 and via usual communication channels.

Dedicated structures for the implementation have been developed in order to fulfil the energy consumption of all connected buildings whilst maximising the efficiency of the district heating system. All relevant local institutions have been involved at the early stage of the pilot project and are still informed about amendments due to necessary planning adaptations e.g. from the monumental protection office. The consortium has put a significant effort on making the pilot replicable in other historical cities even with a different local context and culture.

The benefits of the regions will be presented in the deliverable D.T2.3.1 Transnational evaluation by fellow specialists of research. Two of four surveys for the pilots in Cuneo and Bracak are already performed so far. The surveys of Lendava and Weiz will follow. All interview results are connected to the WPT2 - Systematic procedures for implementation of energy storages in HUC to better understand favourable conditions for the implementation of the demonstration measures. The transnational cooperation within Store4HUC allows to get higher visibility at regional, national and European level.

4.9. KPIs (Key Performance Indicators)

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. As already stated in chapter 3, the 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
- **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 12. Complete list of KPIs

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	[-]

4.9.1. 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:

$\mathbf{KPI_1}$ = $\mathbf{E_{c,tot}}$ = 1,833,500 [kWh]

Background and assumptions:

- Consumed wood chips by heating plant in business year 18/19 (01.07.-30.06.): 1930 [$m^3_{(loose)}$]
- Lower heating value (LHV): 950 [$kWh/m^3_{(loose)}$]
    - Calculated according to [[16]]
- 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):

$\mathbf{KPI_1}$ = $\mathbf{E_{c,tot}}$ = 1,726,607 [kWh]

Background and assumptions:

- Predicted savings with planned measures: 5.83 [%]

[16] Working group QM Holzheizwerke, Quality Management Holzheizwerke - Planning Handbook, (2008).

4.9.2. 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] 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 $E_{c,tot}$ [kWh] 3. External thermal/electrical cost of peak power taken from external sources 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 P_{peak} [kW] 5. Calculation of Key Performance Indicator: $KPI_2 = \sum [C_E(E_{c,i}) + C_P(P_{peak})]$
Measurement Unit	[€]
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:

$KPI_2 = \sum [C_E(E_{c,i}) + C_P(P_{peak})] = 51{,}338$ [€]

Background and assumptions:

- The wood chips boilers are the only energy source for the local heating network. Therefore, there is no peak load boiler or similar → C_P and P_{peak} are zero.
- Consumed wood chips by heating plant in business year 18/19 (01.07.-30.06.): 411 [$t_{(dry\ matter)}$]
  - Conversion factor: 4.7 [$m^3_{(loose)}/t_{(dry\ matter)}$] (with 25% water content)
- Wood chips price in business year 18/19 (01.07.-30.06.): 125 [€/$t_{(dry\ matter)}$] or 26.60 [€/$m^3_{(loose)}$] or 0.028 [€/kWh]
  - constant over the whole year

Target (prediction):

$\mathbf{KPI_2 = \Sigma\ [C_E(E_{c,i}) + C_P(P_{peak})]}$ = 48,345 [€]

Background and assumptions:

- Also, in future there is no peak load boiler or similar planned → $\mathbf{C_P}$ and $\mathbf{P_{peak}}$ are zero.
- Predicted wood chips price: 125 [€/$t_{(dry\ matter)}$] or 0.028 [€/kWh]
    - Represents the wood chips price for the business year 19/20 and according to the heating plant operator the price will stay constant for the next few years.

4.9.3. KPI3: Yearly CO2 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:

$\mathbf{KPI_3 = E_{c,tot} \times EF}$ = 29.34 [t CO_2]

Background and assumptions:

- **EF** = 16×10^{-6} [t CO_2/kWh]
  - Mean value of the emission factors of [16], [17] und [18], as the emission factors from the literature fluctuate considerably.

Target (prediction):

$\mathbf{KPI_3 = E_{c,tot} \times EF}$ = 27.63 [t CO_2]

[17] Austrian Institute for Building Technology, OIB Guideline 6 - Energy Saving and Thermal Insulation OIB-330.6-009/15, (2015). https://www.oib.or.at/sites/default/files/richtlinie_6_26.03.15.pdf (accessed May 28, 2018).

[18] ÖNORM EN ISO 52000-1, Energy performance of buildings - Specifications for the assessment of energy performance of buildings - Part 1: General framework and methodology, Vienna, 2018.

4.9.4. 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 are wood chips, provided 100% by local farmers → $E_{TOT} = E_{c,tot}$.**

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.

4.9.5. 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 $E_{\text{self-RES}}$ [kWh] 2. Calculation of Key Performance Indicator: $KPI_5 = E_{\text{self-RES}}$
Measurement Unit	[kWh]
References	-

Status quo:

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

Background and assumptions:

- **See KPI_4.**

Target (prediction):

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

Background and assumptions:

- **See KPI_4.**

4.9.6. 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 $N_{no\_interrupt}$ [h] 2. Total number of hours of local energy consumption systems operation on yearly basis N_{tot} [h] 3. Calculation of Key Performance Indicator: $KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \%$
Measurement Unit	[%]
References	-

Status quo:

$KPI_6 = N_{no\_interrupt} / N_{tot} \times 100\ \% = 99.23\ [\%]$

Background and assumptions:

- N_{tot} = 8760 [h]
    - The heating plant is operated the whole year.
- $N_{no\_interrupt}$ = 8692.17 [h]
    - The $N_{no\_interrupt}$ was derived from the evaluation of monitoring data for one year (reference year: 01.09.2018 – 31.08.2019). It was assumed that a interruption/discomfort or under-temperature occurs when the flow temperature of the network drops below 65 [°C] for at least 100 [min].
    - There were 67.83 [h] with interruptions, of which 12.5 [h] occurred during regular maintenance (sweeping), which were not removed from the calculation because at the same time there were under-temperatures in the network.

Target (prediction):

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

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.

4.9.7. 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 $\mathbf{P}_{\mathbf{peak,month}}$ [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:

KPI_7 = 476 [kW]

Background and assumptions:

$P_{peak,January}$	591	[kW]
$P_{peak,February}$	551	[kW]
$P_{peak,March}$	646	[kW]
$P_{peak,April}$	481	[kW]
$P_{peak,May}$	639	[kW]
$P_{peak,June}$	336	[kW]
$P_{peak,July}$	218	[kW]
$P_{peak,Augus}$	211	[kW]
$P_{peak,September}$	275	[kW]
$P_{peak,October}$	641	[kW]
$P_{peak,November}$	598	[kW]
$P_{peak,December}$	525	[kW]

- $P_{peak,month}$ for each month are derived from the evaluation of monitoring data for one year (reference year: 01.09.2018 – 31.08.2019).
- Max values of the power provided from the boilers to the network (measured at the heat meter of the network) were taken.

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

KPI_7 = 400 [kW]

Background and assumptions:

- In future, the operating year can be devided into 3 periods and the boilers and heating plant should be operated as follows:
  - Period 1 (June to September): Only boiler 1 (300 kW) is in operation and ensures the heat supply in interaction with the storage.
  - Period 2 (October to mid-November & April & May): Only boiler 1 is in operation and ensures the heat supply in interaction with the storage.
  - Period 3 (mid-November to March): Only boiler 2 (540 kW) is in operation and ensures the heat supply in interaction with the storage.
- Assuming the max power of the boiler in operation leads to following $P_{peak,month}$:

$P_{peak,January}$	540	[kW]
$P_{peak,February}$	540	[kW]
$P_{peak,March}$	540	[kW]
$P_{peak,April}$	300	[kW]
$P_{peak,May}$	300	[kW]
$P_{peak,June}$	300	[kW]
$P_{peak,July}$	300	[kW]
$P_{peak,Augus}$	300	[kW]
$P_{peak,September}$	300	[kW]
$P_{peak,October}$	300	[kW]
$P_{peak,November}$	540	[kW]
$P_{peak,December}$	540	[kW]

4.9.8. KPI8: Profitability

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
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):

KPI_8 = NPV / I_0 = 2.66 [-]

Background and assumptions:

- I_0 = 292,402.53 [€]
  - Estimated costs of planned measures on the basis of the offers obtained from vendors.
- R_t = 77,220.72 [€]
  - Difference between net cash inflow (revenue from sold heat) and net cash outflow (expenditures for fuel, operation and maintenance)

- 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 thermal pilot (defined in KPI_9)
- i = 3 [%]
    - Assumption
- NPV = 778,266.88 [€]
    - Net Present Value after t time periods

4.9.9. KPI9: Stimulation of the local economy

Applicability for objects of assessment

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

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):

$KPI_9 = (CAPEX+OPEX) * r / K = 1.50$ [-]

Background and assumptions:

- *CAPEX* = 292,402.53 [€]

- Estimated costs of planned measures on the basis of the offers obtained from vendors

- *OPEX* = 6,906 [€]
  - Operational expenses only related to the storage were taken into account for a technical lifetime of 15 years of the thermal pilot.
  - Estimated total operational expenses (all costs for the operation of the entire heating plant, not only for the storage, excl. fuel costs) per year: 15,346 [€/a]
  - Estimated proportion of operational expenses for storage only (estimate of an expert in this field): 3 [%]

5. CONCLUSIONS

As with all construction measures at sites listed as monumental and landscape protected, the greatest challenge for the Weizberg biomass heating plant was to harmonise the additional regulations and requirements of monument and landscape protection with the objectives of the implementation. Due to the special requirements, however, it was possible to apply for KEM funding scheme (Austrian funding scheme for innovative storage technologies) for heat storages in order to raise additional funds to finance the project. In order to be eligible for funding under the "Thermal Storage" pilot programme, the storage system must go beyond the usual state of the art (material, size, temporal use, etc.) and thus exhibit a high degree of innovation and be technically and economically multipliable. As the only project in Austria, it was a great achievement for the Austrian Store4HUC team, as well as its local partners and stakeholders, that the storage expansion project in Weizberg received the "KEM Thermal Storage" funding, with the maximum eligible rate of 45% of the investment costs.

The construction phase started in February 2020 and was completed with the installation of the water buffer storage at the end of June 2020. All challenges resulting from the implementation of the extension were excellently mastered by the measures taken. During the construction phase, partnerships were established between W.E.I.Z. (Andrea Dornhofer, Rafael Bramreiter), AEE INTEC (Michael Reisenbichler), "Biomasse Heizwerk Weizberg" (Johannes Schinagl & Johann Neuhold), TB Haas (Johann Haas) and the Weizberg parish (Anton Herk-Pickl & Herbert Ederer), which will hopefully be continued successfully in future projects and cooperations. As there were no major problems during the construction phase, the commissioning of the system has started as planned and should be completed before the heating season starts. An inauguration ceremony is planned for the autumn to officially commission the expanded biomass heating plant and thus initiate an energy-efficient and climate-friendly future for the energy supply on the Weizberg and hopefully also on many other places under monument and landscape protection.