Integrated Infrastructure
Vienna
Deliverable D5.4.1
Version 1.0 - English Version

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# Revision Chart and History Log

## Versions

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Deliverable quality review

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<td>CHP</td>
<td>Combined Heat and Power</td>
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<td>EIWOG</td>
<td>Elektrizitätswirtschaftsgesetz (Austrian Electricity Business Act)</td>
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<td>GUFO</td>
<td>Gebietsumformer</td>
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<td>HBW</td>
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<td>HVAC concept</td>
<td>Heating, Ventilation, and Air Conditioning concept</td>
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<td>ICT</td>
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<td>VSC</td>
<td>Vienna Scientific Cluster</td>
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<td>WLAN</td>
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### SMARTER TOGETHER BENEFICIARIES

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EXECUTIVE SUMMARY

As part of the EU project SMARTER TOGETHER smart solutions for a city district are developed, which also affect the infrastructure. One focus concerns energy supply, such as the use of waste heat or the integration of renewable energies. Only a part of the planned projects in this area could be realized despite high efforts. Nonetheless, promising concepts have been developed and important insights gained that will enable their realization in the future.

The waste heat of a data centre in the project area should be fed into the district heating network. Since implementation was not possible, another data centre near the project area was considered. Detailed concepts were developed for both cases, but they could not be realized. On the one hand, the restrictions of the network for the year-round absorption of waste heat lead to high costs. On the other hand, the operators of the data centres do not give a sufficiently long location guarantee. However, the results can be used for further future projects. Also, the return line of the district heating in a new building could not be realized due to the already advanced planning of the construction. It would be necessary to integrate a low-temperature floor heating system when planning the building. The feed-in of solar thermal energy on the roof of the school into the district heating is going to be realized. The densification of district heating in already connected buildings has also taken place. The findings will be used for replication, especially for the residential buildings owned by the city. From all these insights and experiences, the future of district heating is defined. This includes densification, feeding in renewable energy sources and waste heat as well as the use of the return for heat supply.

In the course of the project, a successful implementation of PV projects was achieved. Two of the refurbishment projects as well as the new logistics centre of the beverage company Ottakringer are using solar energy to generate electricity. In addition, the project area has begun to switch public street lighting to high-efficiency LED. In the forecourt of the school so-called solar benches were installed to raise awareness of renewable energy. This is a street furniture that has integrated PV with batteries and provides a port for charging mobile phones. However, there were challenges in terms of responsibilities and liability issues, as well as in procurement, construction and ongoing support.
The Energy Planning Department of the City of Vienna carried out an investigation of the energy-relevant data of the area - a so-called energy assessment (“Gebietscreening”). The information generated from this, such as the energy demand or the potential of renewable energy sources, generated strong interest in the issue. This showed the importance of an appealing presentation of energy-related data as a communication tool. Building on this, the City of Vienna was able to develop an improved energy data model. Thanks to the individual implementation projects, whose linkage was hardly possible, important insights into the control of the energy supply of the building stock and urban development could be gained. The need for integrative solutions for refurbishments that extend beyond the building and that also consider a possible switch in energy supply, was strongly carried out. The knowledge generated is used in ongoing processes for the implementation of energy planning in the City of Vienna. The aim is to coordinate spatially and temporally the efficient use of the pipe infrastructure (district heating and gas) by avoiding double supply as well as the integration of renewable energy sources both in new buildings and in existing buildings. Ultimately, this is a major contribution to the decarbonization of energy supply.
1. Objectives and framework conditions

1.1 Initial situation

The main focus of the EU project SMARTER TOGETHER is on the implementation of smart solutions in the field of renovation, energy, mobility and participation. Smart urban redevelopment requires far-reaching additional projects, such as the adaptation of energy supply, the provision of new mobility solutions and the full participation of residents. They should go beyond the individual project and include the environment. In contrast to the new building, interventions in the building stock have many restrictions and associated obstacles have to be overcome.

The implementation projects influence each other and should be developed in an integrative way. This approach is intended to give the affected district in Simmering new impetus in the meaning of a Smart City. An important role is played by the energy supply infrastructure associated with the individual projects. Currently, the energy supply of existing urban areas, as it is also the Lighthouse District, based on pipe infrastructure (gas, district heating) or decentralized heat supply with fossil fuels (mainly gas, rarely oil). In most urban areas, both gas and district heating pipes are available. The unbundling of dual infrastructures and the transformation to non-fossil energy sources is therefore THE priority issue.

The related concepts, solutions and activities are further explained in this report.

1.2 Framework conditions

Since a linked integrated infrastructure is of central importance for a Smart City, all related activities and projects of the Vienna Work Package have been assigned to a separate "Integrated Infrastructure" task. This task was done in parallel with other tasks such as "Low Energy District", "Monitoring", "Mobility". The task has been divided into the following implementation projects:

- Analyse and implement waste heat from two data centres
- Plan and implement "Solar Benches"
- Evaluate, plan and implement central data platform
- Plan additional green space networking
- Plan and implement WLAN access points
- Plan and implement innovative lighting
- Investigate ICT infrastructure in the existing area

The italicized projects are covered in this report. A deliverable "5.4.2 Central data management system" already exists for the data platform.
In addition, the energy planning department conducted a study of the area’s energy-related data, which was referred to as “energy assessment” (Gebietsscreening). Across these projects, attention was paid to networking and replication in the work package “integrative energy planning” (Energieraumplanung). The description of this completes the report.

In the parallel “Low Energy District” task, the feed-in of solar thermal energy into district heating was investigated (district heating 4.0), district heating densification was pushed forward, and the construction of a zero-energy gym was planned and implemented. The refurbishments foreseen in this task also include energy aspects. Therefore, findings from this task should also be integrated from the perspective of energy. The details of these projects can be found in the deliverable 5.3.1 “Report on activities and results on the refurbished buildings including energy performance certificates and on-site improvements and monitoring” (short name “Low Energy District”).

Roles

The management of this task was taken over by the Energy Planning Department of the City of Vienna. The Energy Planning Department works on strategies for the efficient and renewable energy supply of Vienna and is jointly responsible for the implementation of the climate and energy goals of the City of Vienna. The implementation of the Solar Benches and the analysis of underlying data (energy assessment) was also the responsibility of the City of Vienna. The work package “integrative energy planning” intends to ensure the linkage of the projects as well as the integration in current processes for the implementation of the integrative energy planning in the city of Vienna.

The projects for the use of waste heat, the adaptation and densification of district heating as well as the analysis of the IT infrastructure were managed by Wiener Stadtwerke (WSTW). As a fully integrated public transport provider and energy provider for gas, district heating and electricity on the generation, network and customer side, WSTW has the relevant infrastructure to make the described individual projects and the connection between them sustainable and intelligent. On the one hand, KELAG Energie & Wärme GmbH with BWSG and on the other hand WSTW with Ottakringer were responsible for the implementation of the PV systems. The city of Vienna tried to promote further projects for the installation of PV in the project area (for instance on the roof of the Siemens building).

The individual projects and their links are very complex and require a strong coordination of the cross-thematic projects. The coordination therefore required intensive resources from the project partners. It was only in this way possible to ensure an integrated consideration and partial implementation of projects.
1.3 Objectives

The basic objective of the task, and thus of the City of Vienna, was to find and if possible, implement efficient energy supply solutions as well as to visualize and use renewable energy in public spaces. Particular emphasis was placed on the further development of district heating and its adaptation by feeding in waste heat and renewable energies as well as by lowering the temperature in the pipeline network. Any networking of the individual projects was also pursued. In addition, the IT as well as the green infrastructure and their future role were examined more closely.

The results of the energy-related projects (for example, the share of renewable energies that was used locally or fed into the grid) should be made visible in a subsequent monitoring. The data from the projects (including the reduction of energy consumption after the refurbishments) should be automatically imported into the data platform.

The aims of Wiener Stadtwerke in this project were:

- To use the "laboratory situation" of the project in order to test and apply solutions beyond the classical renovation of buildings with thermal insulation. The aim is to achieve an even better result of energy efficiency as well as to exploit synergies with other issues such as mobility. This should provide suitable solutions for various applications, which can be converted into a regular operation.

- The identification of structural hurdles and possible solutions such as processes and responsibilities or criteria of economic efficiency or legal obstacles. Insofar as solutions are not already found in the project, the findings from the research project make a significant contribution to visibly bringing the challenges to the surface in order to subsequently process them.
2. District heating and waste heat

This chapter explains all SMART TOGETHER projects related to district heating, waste heat and solar thermal energy. The history and structure of district heating in Vienna will be presented as an introduction.

2.1 District heating in Vienna - an overview

2.1.1 History and structure of district heating

The start of the development of the city of Vienna with district heating took place in 1969. That was compared to other European cities a few decades later. Some buildings and boiler houses of local grids were transferred to the company Heizbetriebe Wien “HBW” at that time.

After founding, the city area was quickly developed. The main reason for this was a district heating framework agreement with the Republic of Austria for federal buildings. The development was carried out by the newly built waste incineration plant Spittelau towards the city centre Innere Stadt. At that time, the high-pressure hot water network was not yet operated in a sliding way but with a constant temperature of 130 °C.
The 1980s were all about the connection of Municipal Housing buildings in Vienna to district heating. In order to reduce costs, the concept of area converter stations and secondary networks has been developed, which is not available in any other city in the world in this pronounced way as far as known.
Current key figures, operating conditions:

- **Primary network:**
  - Total length of the network: 562 km
  - Total volume of the network: 89,900 m³
  - Sliding pre-flow temperature: 80 °C to 145 °C, max. 25 bar pressure

- **Secondary networks:**
  - Total length of the network: 630 km
  - Total volume of the network: 21,400 m³
  - Sliding pre-flow temperature: 63 °C to 90 °C, max 6 resp. 10 bar pressure

- **Capacity, heat sales, stations, customers:**
  - Installed capacity: 3,285 MW
  - Maximal capacity (March 2018): 2,414 MW
  - Heat sales: 6,134 GWh
Number of converter stations 3,758
Number of transfer stations 5,261
Number of private customers (apartments) 336,902
Number of business clients 6,602

Wien Energie covers about one third of the heating market in Vienna with district heating. The expansion is currently focused on urban development areas with high heat densities and densification occurring in two different forms. In the first densification variant, not yet connected buildings can be newly developed within the network structure. The second possibility concerns the retrofitting of apartments with district heating of already connected buildings. This concerns above all apartments owned by the City of Vienna as well as municipal housing. In the case of refurbishment and associated upgrading of the apartment category as well as the change of tenants, the heating system is converted from gas into district heating. The basic installation for district heating in residential buildings has already been carried out for numerous apartments.

2.1.2 Thermal generation of district heating

The heat is fed into the district heating network at a total of 11 locations. The base load of the heat demand is covered by the waste incineration and the biomass while in the heating period it is covered by the combined heat and power (cogeneration) plants (CHP). These systems achieve high full load hours. In contrast, district heating plants cover the peak load and compensate for short-term load fluctuations.
### Capacity of the thermal generation facilities of Wien Energie (as of 2017):

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<tbody>
<tr>
<td>Cogeneration</td>
<td>1,300 MW</td>
</tr>
<tr>
<td>District heating plants</td>
<td>1,277 MW</td>
</tr>
<tr>
<td>Waste incineration incl. Pfaffenu</td>
<td>238 MW</td>
</tr>
<tr>
<td>Wood-biomass</td>
<td>37 MW</td>
</tr>
<tr>
<td>Electric heater</td>
<td>20 MW</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,872 MW</strong></td>
</tr>
</tbody>
</table>

**Heat generation 2017:**

<table>
<thead>
<tr>
<th>Source: Wien Energie Jahrbuch 2017</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cogeneration</td>
<td>3,432 GWh</td>
</tr>
<tr>
<td>District heating plants, electric heater, industrial waste heat</td>
<td>657 GWh</td>
</tr>
<tr>
<td>Wood-biomass</td>
<td>238 GWh</td>
</tr>
<tr>
<td>Waste incineration incl. Pfaffenu</td>
<td>1,736 GWh</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,064 GWh</strong></td>
</tr>
</tbody>
</table>

Figure 5: Distribution of heat generation by plant types 2017  
(Source: Wien Energie Jahrbuch 2017)
2.1.3 Challenges

Wien Energie already covers 32.5% of its district heating generation from waste incineration, industrial waste heat and the combustion of biomass. However, to achieve the long-term goal of the city of Vienna by 2050 to reduce final energy consumption per capita by 40 percent compared to 2005 and the switch to renewable energy sources (Smart City Vienna Framework Strategy) as well as the intended decarbonization, further steps are also required in the field of district heating. The solution does not come in a single, centralized technology - as has been the case in the past, e.g. Cogeneration was - to look for, but it is a set of measures to take.

On the one hand, Wien Energie systematically examines the potential of all types of renewable energy sources in the urban area. This includes geothermal energy, the waste heat from the sewage system, the use of water bodies like rivers for large heat pumps. On the other hand, efforts are also needed in the existing system of district heating. This concerns above all the very high temperature level in the district heating system. The integration of local waste heat sources and data centres is made by this more difficult. However, district heating offers the decisive advantage of utilizing this waste heat even in summer - for example, for heating drinking water or for generating district cooling.

2.2 Waste heat of a data centre

2.2.1 Data centres as a steady waste heat source

For economic assessment, whether it is useful to integrate a waste heat source in the district heating system, there are several factors to consider. An important point is the temperature level of the heat source. Ideally, the heat can be taken over without reheating. In the Vienna primary network, this means temperatures of over 100 °C - a level that is only rarely available. With the many secondary networks, however, there is the possibility of using sources with temperatures of 65 ° to 90 °C or to increase the level with heat pumps. Indeed, it should be taken into account that in secondary grids only as much heat can be fed in as it is taken at the same time.

A second issue is the availability of the heat source. From a district heating operator’s point of view, it is important to have the heat available even at maximum load, i.e. at low outside temperatures. Only then is it permissible to consider this feeder in the "n-1" performance analysis. "N-1" means that the supply can be maintained even if the largest feeder fails.
Data centres are almost ideal for feed-in due to the year-round continuous operation. Only the temperature level has to be raised with heat pumps. When fed into low temperature networks ("Anergienetze") even that would be omitted. From the point of view of data centre operators, it is almost always necessary to take full advantage of the power in summer. This limits the possible feed-in to larger secondary networks. In return, the operators save at least partially the cost of cooling systems. The essential parameter in this context is the price of cooling.

2.2.2 First attempt - Data centre Spardat

Data centres, as well as the one of the IT solutions AT Spardat GmbH (hereafter referred to as Spardat), are major power consumers. The electricity is converted into heat in the computers, which must be dissipated. This waste heat can be used inside the building for heating purposes, for example. Spardat has already implemented these internal energy efficiency measures. Nevertheless, additional waste heat remains, which must be recooled with chillers. Especially in summer, there are hardly any internal heat consumers within the data centre, so that an enormous amount of energy is released into the environment.

As described above, data centres are ideally suited for the use of waste heat because they have no seasonal fluctuations and constant performance is available throughout the year. On the other hand, this heat has to be safely removed throughout the year. The existing district heating secondary network, to which the Spardat is also connected, only fulfils these requirements during the heating season. In summer, the demand of residential buildings for domestic water heating is too low. Therefore, an additional feed option into another secondary heating network is required.
Requirements, strategic background of the company’s IT-solutions AT Spardat GmbH

Technical requirements:
- Continuous, year-round third party (external) use of constant 1MW power
- Temperature level in the cooling circuit of approx. 30 °C

Necessary construction measures at Spardat:
- Installation of a heat pump for raising to the required temperature level of the local area converter station (DE: Gebietsumformer / GUFO):
  - 65 °C in summer operation,
  - 80 °C in winter at -15 °C (with "natural" admixture on the entry point)
- Network pumps for decentralized supply
- Digital control with data exchange to control the GUFO stations
  - Challenge: Controlled parallel operation of the pumps of the individual locally separate feeders (Spardat, GUFO(s))

Strategic statements
- Basically, waste heat utilization is considered by Spardat positive, however, the economic viability must be ensured

A possible use of waste heat is only one part of the issues discussed at Spardat within the general renewal of the technical infrastructure. As a substitute for the new purchase of a cooling unit with a capacity of 1 MW, the waste heat can be fed into the heating network. Nevertheless, the location of the centre is not secured.

From the energy supplier’s point of view, profitability would require a long-term guaranteed term of at least 15 years. This would have to be guaranteed by Spardat contractually. The Spardat provides the data centre for the Erste Bank Group. Due to changes in the organizational and spatial structure at Erste Bank, the location is not ensured on a longer term.

The technical concept and the investigated solution variants (load cases) are explained in more detail below.
Technical concept for the local district heating network

The heat requirement in the affected local secondary network of the GUFO GRM303 is too low in summer to ensure a continuous feed-in capacity of 1 MW.

Figure 6: Summer load local secondary network Spardat (Source: Wien Energie)

In summer operation, heat from the district heating network is only needed to cover the hot water requirements of the connected customers. On average, the required power is about 350 kW. The minimum loads are only 200 kW at night.

Therefore, in order to increase the potential feed-in power, the possibilities and requirements for the interconnection of the secondary network "Faradaygasse" (GRM303) with the secondary grids "Am Kanal" (GRN002) and "Lorystraße" (GRN003) were examined.
For the secured acceptance of a power of 1 MW also in the summer months, all 3 secondary networks (GRM303, GRN002, and GRN003) would have to be merged. The following table contains some characteristic values for these networks.

<table>
<thead>
<tr>
<th>Local area Converter Station (GUFO)</th>
<th>Name of the secondary network</th>
<th>Geodetic height secondary line at the GUFO</th>
<th>Pressure maintenance lower limit</th>
<th>Pressure maintenance upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1030 Wien, Faradaygasse 6</td>
<td>GRM303</td>
<td>39 m</td>
<td>4 bar</td>
<td>4.5 bar</td>
</tr>
<tr>
<td>1110 Wien, Am Kanal 35</td>
<td>GRN002</td>
<td>21.1 m</td>
<td>4.2 bar</td>
<td>4.8 bar</td>
</tr>
<tr>
<td>1110 Wien, Lorystraße</td>
<td>GRN003</td>
<td>12.7 m</td>
<td>3.8 bar</td>
<td>4.4 bar</td>
</tr>
</tbody>
</table>

Table 1: Key figures of the affected secondary networks (Source: Wien Energie)
Figure 8: local secondary network GRM303 and additional adjacent networks GRN002 and GRN003 (Source: Wien Energie)

The height difference of the converters GRM303 and GRN003 is 26.3 m. In this case, a detailed network calculation showed that the permissible operating pressure is exceeded at some points in the interconnected network. The pressure losses in the lines, the pump delivery height, the pressure maintenance setting and the geodetic heights have to be taken into account.

The recalculation for the summer operation results in some places in the network operating pressures above 6 bar. For secondary networks, the maximum technical operating pressure of 6 bar was stated in the technical guidelines until 1998, and from 10 bar as of 1999. In the analysis of the pressure conditions in summer operation, an operating pressure of over 6 bar results for some transfer stations. Some of these transfer stations were put into operation before 1999. So, it cannot be ruled out that radiators with maximum permissible operating pressure of 6 bar are in operation here. For safety reasons, this operating pressure must not be exceeded. The three possible load cases are explained in more detail below.
Investigation of critical load cases (SPARDAT supplies the entire network area)

The load cases describe the situation in the secondary network with a feed-in of the waste heat and the associated solution variants.

- **Load case 1:**
  - Summer operation
  - Merger of two secondary networks: GRM303 and GRN002
  - Feeder: Spardat total requirement 1MW
  - Spread: 5K

- **Load case 2:**
  - Summer operation
  - Merger of 3 secondary networks: GRM303, GRN002 and GRN003
  - Feeder: Spardat total requirement 1MW
  - Spread: 5K

- **Load case 3:**
  - like load case 2, connecting pipe DN200 instead of DN150

**Results Load Case 1**

![Site plan, local distribution of customers for load case 1](Source: Wien Energie)

Figure 9: Site plan, local distribution of customers for load case 1 (Source: Wien Energie)
Merger of the secondary grids GRM303 + GRN002:

- Distribution of the amount of water over ratio of customer connection values
- Customer use 8% of the connected value
- Lowest differential pressure 1 bar
- Required differential pressure SPARDAT: 1.35 bar
- Critical line section DN150
  - Specific pressure loss 1.7 bar / km
  - Speed 1.74 m / s

Figure 10: Simulation result Transfer stations Load case 1 (Source: Wien Energie)

Figure 10 shows the simulation results in load case 1. The columns represent the pressure of the individual transfer stations for the pipe and of the object in the flow and return respectively. The red line describes the permissible limit of 6 bar. For some transfer stations, the permissible operating pressure would be exceeded. The differential pressure can be seen in the axis downwards.
Results Load Case 2

Merger of secondary networks GRM303 + GRN002 + GRN003:

- Customers use 5% of the connected value
- Lowest differential pressure 1 bar
- Required differential pressure SPARDAT: 1.7 bar
- Critical line section DN150
  - Specific pressure loss 2.4 bar / km
  - Speed 2.3 m / s
Figure 10 shows the simulation results in load case 2. Again, the allowable operating pressure would be exceeded for some transfer stations.

**Results Load Case 3**

Figure 13: Site plan, local distribution of customers for load case 3 (Source: Wien Energie)
Merger of secondary networks GRM303 + GRN002 + GRN003:

- Assumption of partial increase of the permissible limit to 8 bar
- Customers use 5% of the connected value
- Lowest differential pressure 1 bar
- Required differential pressure SPARDAT: 1.66 bar
- Critical line section DN200
  - Specific pressure loss 0.7 bar / km
  - Speed 1.26 m / s

Since 6 bar cannot be maintained here either, the permissible limit for two subnetworks was raised to 8 bar in this variant. In this case, the operating pressure of the individual transfer stations would be within the permissible range. The extension of the critical performance pipe section in its dimension from DN150 to DN200 leads to lower pressure ratios than in load case 2. However, testing for actual feasibility would require a costly on-site analysis of each individual station.
Summary of the results of the network evaluation

- The supply of the interconnected secondary networks with the waste heat of the data centre is basically possible (load case 3).
- Depending on the load case, the critical pipe section with dimension DN150 (length: approx. 300m) has a specific pressure drop between 1.4 and 2.7 bar/km (load case 1 or 2) and can be reduced to 0.7 bar/km in the case of a DN200 pipe dimension (load case 3).
- The pressure losses in the other pipe sections are comparatively very low.
- For the suggested operation should be the dimension of the critical pipe section increased to DN250.
- The 6 bar limit cannot be met in any of the calculated load cases. Only an increase of the limit to 8 bar would be possible in the third load case, since each transfer station is below 7 bar. For this, however, each transfer station would have to be examined in detail, if there are no heating systems (radiators) that are designed only to a maximum of 6 bar.
- In order to stay below the 6 bar limit, a theoretically costly network separation with heat exchangers would be necessary.
- Each solution variant that is technically feasible would require complex reconstruction measures in the network as well as a detailed analysis of each individual station.
Estimation of costs

- Rough cost estimate of the interconnection of the GUFO (Local area Converter Station) grids GRM303 and GRN002 in DN200 by Wiener Netze
  - Variant 1:
    (about parking lot of Fa. Lidl ...), but possible problems with Servitudes, pipeline partially on private land:
    - € 720,000 pipes
    - € 50,000 connection shaft with shut-off valves, differential pressure measurement
    __________
    € 770,000 total
  - Variant 2:
    Pipes in the public area, MA28, MA46, ÖBB, safe variant
    - € 840,000 pipes
    - € 50,000 connection shaft with shut-off valves, differential pressure measurement
    __________
    € 890,000 total

Required erection time for connecting pipe: 12 months from decision (planning, tendering, construction)

- Spardat:
  In the concept it was intended to use the existing house connection DN200 also for the feed in.

  Heat pump: € 400,000
  Pumps, regulation, data connection: € 50,000
  Piping, separation exchanger: € 200,000
  __________
  € 650,000 total

- Adaptation GUFO(s)
  Changing/construction of electrical control, pressure maintenance, Flow measurement, speed control of the pumps, data connection Programming effort (internal performance Wien Energie)
  __________
  € 150,000 total

Necessary total investment: € 1,690,000
According to Wien Energie's internal economic calculations, the maximal costs for the necessary investments for the utilization of waste heat potential amount to around € 800,000 per MW of connected load. The cost estimate of the present concept is twice as high for the necessary investments.

Conclusion and decision

Successful business relationships have existed for some time between WSTW and Erste Bank Group. Therefore, all those involved as well as the city of Vienna were mindful of the successful implementation of the project right from the start. Also, the time with the upcoming renewal of the cooling system is ideal. Therefore, there were initially very good conditions.

In order for Wien Energie to be able to guarantee an output of 1 MW throughout the year, the merger of the Faradaygasse secondary network (which is supplied by Spardat) with two other secondary networks is required. The analysis of the pressure conditions in the combined overall network shows that during summer operation pressure ratios may well be too high for some elements of the heating system within the buildings (for example radiators) which are suitable for a maximum operating pressure of 6 bar. The technical feasibility would be given only by economically unacceptable measures.

Apart from the critical pressure ratios resulting from the necessary merger into an overall network, the cost estimation results in approximately twice as high specific investment costs as are permissible for the economic use of waste heat for Wien Energie. Furthermore, due to ongoing internal structural changes, the operator of the data centre did not give a 15-year site guarantee and thus no binding commitment for the guaranteed feed-in of waste heat. For these three reasons, in the course of the research project SMARTER TOGETHER, this subproject ended with the conception phase.
2.2.3 Second attempt - data centre of the Vienna University of Technology (TU Wien, VSC)

After deciding not to use waste heat from the Spardat data centre, the Vienna Scientific Cluster (“VSC”) of the Vienna University of Technology was identified as another possible source of waste heat in the project area of SMARTER TOGETHER. The VSC is located in Building 214 in the Arsenal in close proximity to a district heating infrastructure (see following figure). The waste heat is to be fed into the secondary network of the area converter (GUFO) GRM303.

![VSC - Objekt 214](image)

![GUFO GRM303 - Entfernung zu VSC ca. 210 m](image)

**Figure 15: Site map, data centre VSC and secondary network GRM303 (Source: Wien Energie)**

**Development Steps:**

- Different concepts were developed for integrating the waste heat of the data centre VSC. Both solutions for the connection to the in-house high temperature line as well as the low temperature line of the data centre cooling were developed.
- The project results from the preliminary project “Spardat” were used to assess the absorption capacity of the waste heat in the adjacent district heating network GRM303.
- For the infeed, a hydraulic concept has been developed that enables the reuse of the existing primary network section. This was achieved by a local transfer of the area converter station into the building of the VSC.
Results upon completion of the Concept Elaboration:

- The technical feasibility is basically given
- Temperature and performances have been jointly decided upon
- Performance limits of the contract partners Wien Energie - TU Wien have been defined
- Economic conditions were calculated. The necessary investment requirements amount to approximately € 2 million due to the extensive construction measures.

Final result - Rejection of the implementation 30.01.2018

The following causes led to a rejection of the implementation:

- It is not possible to move the area converter station to the data centre or to surrounding buildings. The rooms in the basement of the data centre are intended for the internal use. Therefore, an economically unfavourable alternative replacement area would have to be used for the area converter station. The main option was an underground installation at the future parking lot opposite the data centre.
- The contract period was limited by the data centre operator to a maximum of 7 years. For the profitability from the point of view of the Wien Energie also 15 years would be necessary here. This is the usual assumption of the minimum running time for district heating projects in order to cover the high investment costs. In the case of a shorter term, the price of cooling would increase massively and thus stand out of competition with conventional cooling at the moment.
- Due to the approx. 2.7 times the annual operating costs compared to the standard operation with a 7-year term, the TU Wien as well as Wien Energie consider that the use of waste heat is not useful for economic reasons.
Outlook

- Due to the planned real estate development as well as the change in use of the buildings in the Arsenal area, a comprehensive consideration of an energy concept is desirable. The already for decades existing district heating infrastructure, especially the transformer stations, reach their technical end. A punctual renewal in the event of damage does not make sense in the long term, since a general lowering of the temperature level is desirable in order to enable the use of waste heat sources.

The findings from the project will be used to provide a comprehensive view of the district heating supply and waste heat potentials throughout the area “Arsenal”.

2.2.4 Lessons learned regarding the use of waste heat

Project environment

A clear written commitment at the management level of all participants for a specific goal is an important starting point. This can counteract to some extent changed objectives, for example due to staff turnover. In the case of complex projects with many contact persons, greater attention must be paid from the beginning to the involvement of all knowledge and decision-makers. In the specific case of the VSC, the property owners were BIG, the operators were the GUT of the TU Wien and the data centre operator of the VSC (scientific management), with unclear responsibilities and divergent intentions for Wien Energie.

Contract period

For district heating infrastructure projects, the minimum contract duration for an economic presentation is typically 15 years. This is often incompatible with operational optimization and efficiency measures of private companies. Their economic approach has a horizon of 3 to 5 years. If the use of waste heat is also a system-relevant component of, for example, a low energy grid (“Anenergienetz”), which cannot be replaced by other feeders during decommissioning, then in terms of supply security, additional measures must be taken during the construction phase, which cause additional costs.
2.3 Integration of renewable energies - solar thermal

In Vienna, there have been a number of measures and initiatives in recent years for the integration of renewable heat into the district heating network. The largest project in this field implemented in Austria is a forest biomass heating power plant, which decouples up to 35 MW heat output and feeds it centrally into the district heating network at the power plant site Simmering.

Geothermal energy has perhaps the greatest potential for decarbonizing district heating. Therefore, within the framework of the national funded project GeoTief Vienna¹, a precise geological 3D model of the Vienna subsoil will be created on a total area of 175 square kilometres, which will provide information on the location and size of potential aquiferous rock layers.

Due to the limited and high-priced areas, a large-scale use of solar thermal systems for the central feed-in in Vienna is difficult compared to other areas in Europe where installations of this kind have been realized in recent years. So far in Vienna, with the exception of one plant within the Simmering power plant (700 m², 0.5 MW), there is not a single solar heating system that feeds heat into the district heating network.

2.3.1 Framework conditions for the integration of solar heat

Despite many years of available support programs for solar heating systems with coupling to heating networks, systems of this type are currently almost not economically competitive on roofs. Even megawatt systems with comparatively low specific costs have heat production costs of around € 50 per MWh without subsidy² are well above the amounts with which the customer Wien Energie has to assess this heat in its network. However, the economic efficiency of the plants is closely linked to the installed capacity. The larger the system is dimensioned, the sooner an economic viability is achieved. In Vienna, there is currently no information on official feed-in tariffs.

The technical conditions are similar to those for waste heat usage. The temperature conditions in the Viennese district heating network allow integration without after-heating for non-concentrated solar heat practically only in the secondary network. Here, the temperature level in the main harvest time of the solar energy outside the heating period in the flow is about 65 °C. In the secondary networks, however, only as much heat can be fed in as is taken at the same moment. Therefore, the permanent demand of district heating in summer is the decisive criterion for the amount of heat that can be fed in and thus for the dimensioning of the solar system.

2.3.2 Project „Neue Mittelschule Enkplatz“ (NMS Enkplatz / New Secondary School Enkplatz)

Basically, gyms are not suitable for the installation of solar thermal energy if this is to be used only for the supply in the building. In the sunny holiday season, the demand is too
low. The resulting plant shutdowns have a negative impact on the efficiency and service life of the components in the collector circuit.

Only a combination of technologies and uses lead to a meaningful integration of solar thermal energy. The energy generated by solar thermal energy can either be given to direct customers in the building (space heating and hot water preparation) or used to regenerate the soil in summer using the stored geothermal energy in winter. Another possibility is the feed into the district heating network. This idea was followed at the implementation project Neue Mittelschule Enkplatz (NMS Enkplatz), where the school building is expanded and a zero-energy gym is built. On the basis of the demonstration building a technically meaningful integration of a solar thermal plant with feed-in possibility into the secondary network of the district heating Vienna is to be implemented.

An evaluation of the data in the area converter substation recorded a summer band load of approximately 300 kW and a fairly stable, year-round temperature level in the return of the secondary network of 55 °C. The decrease of about 300 kW leads to a sufficient size of plant, which, when funded, can be represented economically.

For the new construction of the gym, the Wien Energie commissioned a project study including heating-air-conditioning-sanitary concept (Heating, Ventilation, and Air Conditioning concept / HVAC concept), which provides heat supply to the building primarily via heat pumps using ambient heat from water or soil (deep wells) and solar heat. The cover of the electricity demand of the building is supposed to take place mainly through a photovoltaic system, so that a zero-energy balance for the new building can be achieved as a planning target. In the pre-project phase, a building technology and hydraulic concept was coordinated and a rough energy balance of the building was calculated. This was the best possible division of space between solar thermal and photovoltaic made. With the aim of keeping the specific costs as low as possible, a roof space of at least 700 m² was set up for the solar collectors on the roof of the school building as part of the architectural competition.
After starting the tender, a refinement of the building technology concept was carried out with the building technology planner of the winning consortium and initial simulations of the solar yields were carried out. Because, according to the developer, the temperature level in the geothermal wells/probes (around 150 m² depth) should be used for surface cooling in summer, the original option of regenerating the soil by geothermal wells with solar heat in the building during the summer months was abandoned. The initial aim was to optimize the efficiency of the solar system through cascading heat utilization at two temperature levels (feeding into the district heating network and low-temperature heat dissipation and geothermal wells regeneration on the building side). In the final concept, the solar heating system provides heat in a buffer, which is to be used primarily for the heating of the building during the transitional period. Simulations of the solar system show that about 75% of the solar energy must be fed into the district heating network due to a lack of use in the building.

As a result of the strong dependence on the feed-in, the output simulations and economic considerations showed that more expensive vacuum tube collectors are preferable to the flat-plate collectors preferred in Austria. The higher outputs, due to low radiation losses at the comparatively high collector mean temperatures, outweigh the additional costs for this collector technology in the profitability analysis.

A solar heating system with 320 m² of absorber area is being implemented, which is to go into operation in the first half of 2019 together with the other technical services of the school building. In the course of the operational optimization, in consultation with the technical staff, who oversees the school's building services, in the next few years it will be examined whether the calculated heat consumption in the space heating can be realized and possibly also a later regeneration of the geothermal wells is considered to be useful. More use at a low temperature level, as would be possible through use in the school building, would improve the efficiency and thus the harvested energy of the solar system.

### 2.3.3 Lessons learned from use of solar thermal energy

Without the joint project goal within the framework of SMARTER TOGETHER as well as the ongoing efforts of the project management from the city of Vienna to organize joint planning and coordination meetings from the pre-project phase, the solar system would probably not have been realized.
The integral planning of the architecture and building technology concept with the clear separation of a high-temperature and low-temperature line in the heat output can be mentioned is demonstrated in an exemplary manner. As a result, the grid connection of a solar thermal system becomes more efficient, because in some cases low grid return temperatures can be achieved in the solar cycle despite grid connection and thus higher specific outputs are possible. The simultaneous use of heat pumps with simultaneous availability of district heating as already is foreseen would not be economically useful without zero-energy balance target.

In the implemented project of “Neue Mittelschule Enkplatz”, Wien Energie acts as installer and operator of the solar system as well as heat consumer. In this way, interfaces were reduced. Despite the significant subsidy rate by the EU, which is still significantly higher than that of the current Austrian subsidy programs, the cost-effectiveness of the plant under the given project-related conditions was not achieved.

Due to the given framework, projects of this type and size on roofs are not suitable for multiple replication as a "business model" by the energy supplier. Only larger dimensioned systems that are erected on open spaces are turning into nearly economic efficiency. Within the framework of research and promotion, however, the "small" projects also set a great sign in the direction of the city of Vienna towards decarbonisation. From the point of view of Wien Energie as grid, heating and power plant operator, decentralized feeders will be further prioritized as medium-term solutions for the future which have a year-round energy supply and are not available primarily in summer.

### 2.4 Densification of district heating

In comparison with natural gas-fired heating systems (as central heating system or single boiler in the apartment), the heat supply of residential buildings with district heating has ecological advantages. The share of renewables of district heating will continuously rise. Therefore, district heating will improve the environmental balance of energy supply.

#### 2.4.1 Technical aspects of the densification

Due to the widespread distribution of pipes (primary and secondary network), it is possible to connect a heating system to district heating in most of the Vienna’s urban area. There are essentially three options in the densely populated area for utilizing district heating in the building and for densification of the connected load in the distribution network.

The first variant of the densification is the connection of a new building. In the case of new buildings after demolition while using subsidies for housing, it is often economically most reasonable to connect to existing district heating due to eligibility criteria for builders. The district heating system in the building has to be built according to the technical guidelines for new buildings. The result is a uniform technical standard.
Typically, a central hot water supply is used as well as radiators with thermostatic valves and heads for space heating. In order to increase the efficiency of the system, the use of low-temperature heating systems such as underfloor heating, which also entail advantages for the feed-in of renewable energy sources, is suitable for new buildings.

The second variant of the densification is the conversion of a central heating system. If a central heating system is available, it can be replaced by a district heating connection at the end of the service life of a (gas) boiler. The heat distribution in this case can remain untouched until it comes to a more comprehensive renovation of the building.

The third variant of the densification relates to new apartments in buildings with existing districting heating supply. In about 50% of Vienna’s existing flats there is no central heating system. In these apartments, the heat supply takes place primarily via separate boilers with natural gas. In buildings with these requirements, the third possibility of densification comes into play. In the past, Wien Energie, as a district heating network operator and heat supplier, has retrofitted distribution pipes in the stairwells in a large number of these buildings. This offers tenants or owners of apartments the opportunity to introduce the district heating instead of their previous central combined apartment heating system or in some cases by means of instantaneous water heaters. Technically, this is in most cases associated with a renewal of the heat delivery system in the homes to radiators with thermostatic valves and heads. The flow of the distribution pipes in the buildings is provided year-round heat with a base temperature of 65 °C in order to allow a home-own hot water in small tanks.

Because this heating installation is directly connected to the secondary network of the grid operator without hydraulic separation by means of a heat exchanger and the installation work is carried out by various installation companies, the technical requirements in the technical guidelines of the grid operator are clearly defined.

Ideally, retrofitting can also switch the cooking area, which is often gas-fired, to an electric stove, so that the natural gas connection for the apartment and ultimately at 100% connection rate can be shut down for the entire property.
2.4.2 Economic - organizational aspects of densification

In the third variant of the densification described above, in addition to densify the connection rate in the secondary network, there is also the aspect of densifying the connection rate within the building. In this way, the investment made by Wien Energie in advance for the infrastructure is re-financed.

The City of Vienna is committed to favouring highly efficient energy systems, such as district heating. However, the City of Vienna deliberately refrains from implementing a compulsory connection of existing homes to existing district heating pipelines. By granting investment subsidies for the initial installation costs, the city administration ensures that in a full-cost accounting, district heating is at the same or somewhat lower energy cost to the homeowner than heat from a combined-cycle gas fired by natural gas.

At first glance, however, upgrading to a technical installation-compliant apartment installation involves some initial financial investment of around € 4,000. This includes the costs for the connection to the distribution pipes, the installation of new radiators and the adaptation of the hot water treatment. Apart from the subsidies, the connection rate and thus utilization of the available supply lines is the responsibility of the energy supplier.

After a high connection rate of about 75% in the first years after the provision of the distribution pipes within the building, there is stagnation. Financially weak households, that are many in the SMARTER TOGETHER project area, only act when the existing equipment is defective and the level of information is high enough that district heating is likely to be less expensive than a cheap new combined heating system.

Apart from the tenants that can be accessed with this information, there is a window of opportunity during retrofits, moving out of tenants or vacancies without disturbing the residents. In this case, the building owners and property managers of Wiener Wohnen and BWSG that are involved in the SMARTER TOGETHER project are responsible for implementation. However, Wiener Wohnen has been practiced for years to connect apartments to district heating in the case of switching tenants or during refurbishment works.

2.4.3 Lessons learned within SMARTER TOGETHER

The primary focus of the SMARTER TOGETHER project was on organizational measures to promote the densification of district heating in buildings with existing distribution pipes in the project area. By merging the experience of the stakeholders united in the project team, possible measures were discussed. The starting point was primarily the provision of financial incentives and joint communication by the project partners. The approach and results are described in more detail in the parallel report Deliverable 5.3.1 Low Energy District.
On the technical and strategic level regarding the future of the district heating network, the aspect of an appropriate low return temperature is for planning particularly important. These are prerequisites for an increase in efficiency in grid operation (power for pumping stations and heat losses) and provide potential for the future integration of heat sources at a lower temperature level into the district heating network. In order to achieve low return temperatures, it is necessary to provide and control clear specifications for the proper equipment of the hydraulic system, which in the case of retrofitting extends into the individual apartments.

Wien Energie provides information and proven technical concepts. In addition, Wien Energie provides technical specifications for the implementing companies. The technology used for this purpose, such as radiators equipped with thermostats and compatible hot water storage tanks tested by Wien Energie, is comparatively simple and standardized. The distribution pipes are also very sturdy which need only differential pressure regulators, motor-driven actuator and electrical control.

The ongoing operation and maintenance of many thousands of such installations poses a challenge. Due to cost pressure on potential customers, in the case of retrofitting it was without central measurement technology and remote monitoring. It takes 2 to 3 months between the manual readings at the central heat meters. Furthermore, the control of the return temperature limiters, which are basically critical system component for the return temperature, takes place every several years. Regarding this in the context of SMARTER TOGETHER (in coordination with programs for the modernization of the monitoring of secondary networks internally run at Wien Energie), exemplary installations with high-resolution data recording were implemented at the central heat meter and at the distribution pipes. The primary purpose is the test of a fully automated detection of defects in the housing installations.

Aspects of the dual provision of supply infrastructure for buildings using natural gas and district heating questioned. The building managers in this project assess this aspect as financially insignificant to the user on the basis of calculations. For this reason, they refrain from pushing the connection rate up to 100%. For buildings with a few, individual remaining units using natural gas, however, Wiener Wohnen is considering creating incentives and support for the conversion of the units (electricity for cooking, district heating for heating and domestic water) in order to shut down the natural gas supply.
From the point of view of the city of Vienna, the decommissioning of “underused” natural gas pipelines - and thus more intensive utilization of existing district heating pipelines - is an aspired objective. A dual supply of buildings with gas and district heating should be avoided - both for new buildings and in existing buildings. This corresponds to the aims of the Vienna Energy Framework Strategy 2030. On the one hand, this contributes to decarbonisation, provided that district heating is promoted towards renewable heat sources. On the other hand, it increases the overall economic efficiency of the energy system for generation, distribution and use. In other words, (public) economic costs are better utilized.

2.5 Use of district heating return for heat supply

2.5.1 Idea and concept

The level of the return temperature is hardly relevant in the existing high-temperature district heating system for the combustion processes in waste incineration plants and district heating plants. Even in combined heat and power plants, a minimum temperature of 55 °C for the return line is sufficient to comply with the emission limits and prevent flue gas condensation. A low return temperature was previously only important in the case of bottlenecks in district heating distribution.

This situation has changed significantly with concepts for the economic and efficient integration of renewable energy sources. This aspect becomes particularly clear with the use of geothermal energy: Without changing the temperature level, water with a temperature of 60 °C would currently be retumed to the underground in Vienna - thus much energy of the thermal water would not be used.

Similarly, the conditions in other waste heat sources must be brought to the necessary level with heat pumps due to their relatively low temperature. The smaller the temperature difference between the heat source and the heat sink for a heat pump, the less electrical energy has to be expended for the heat supply.
Lowering the return temperature

The return temperature depends essentially on the technical design and operation of the heating system of the connected district heating customers. Frequently, many boiler houses in Vienna were converted to district heating for the rapid distribution of district heating, without having to take any further measures in the distribution system. The necessary conversion measures related to construction works (such as weather-dependent control technology in the building to lower the temperature level of the heating system) for a more efficient use of district heating were and are hardly carried out because there are few incentives for the owners. The energy costs are taken by the users and not by the owners. For this reason, despite many efforts in the service sector, a barely measurable effect has remained in the overall system in recent years.

Idea of return utilization

The most effective measure to reduce the temperature in the grid is the utilization of the return line. A temperature level between 55 to 60°C is sufficient for floor-space heating in buildings.

2.5.2 Use case Hörbigergründe

A new residential complex has been started to build during SMARTER TOGETHER project implementation time at the location of the already relocated company Hörbiger. This property is located in the middle of the project area and close to two branches of a secondary network. For the use of the return line heating water is taken from a branch and fed to the heat transfer station as a flow. The return water of the station is fed back at the other line branch. This circuit concept is perfect for residential buildings with surface heating systems. For the heating of the domestic water, the supply of the secondary network is additionally integrated.
Figure 16: Site plan, residential complex Hörbigergründe (Source: Wien Energie)

Figure 17: Site plan of the housing complex Hörbigergründe in detail - the red marked buildings (Stadthaus 5 and component south) were intended for the return connection (Source: EGW / Wien Energie)
The area of the Hörbigergründe is developed on both sides of the Braunhubergasse. In the research project, it was planned to equip the building “Stadthaus 5” as a pilot plant and to use building “Süd” as reference object for the technical assessment.

**Pilot object building “Stadthaus 5”:**
- Property developer EGW
- 67 residential units (4,841 m² floor space)
- Central DHW heating, separation exchanger for underfloor heating

**Reference object building “Süd”:**
- 120 residential units + restaurant (9,177 m² floor space)
- Decentralized home stations, radiator heating

At the time of the conception of the return temperature utilization, the planning of the building had already taken place. The construction of the heating system had already been assigned. The change in the heating system of radiators to floor heating would have resulted in a significant cost increase, which was not economically feasible. In order to be able to incorporate the return into the heating system of a building in time, this would have to be included at the beginning of the building design.

### 2.6 District heating 4.0

#### 2.6.1 Lessons learned

The SMARTER TOGETHER research projects clearly show that they are much more difficult to implement compared to business-as-usual projects. This applies both to the feed-in of heat (generation) and the heat usage in connection with more complex energy systems in buildings (heat consumption). The decisive factor for all projects was the earliest possible involvement of all relevant partners in the project. For each partner an individual (usually monetary) benefit has to be presented. It is therefore important to identify all relevant partners early on and include them in the conception phase.

For waste heat projects of data centres, which are based on existing buildings and infrastructure, the time component was added as an additional difficulty. On the one hand in order not to jeopardize ongoing operation, the integration into the district heating system is possible only at a certain time, such as the renewal of part of the cooling system or expansion of the data centre. On the other hand, these measures must be calculated with much shorter periods of time than it is usually possible regarding the depreciation period for infrastructure projects. In most cases, it is only through supporting measures such as special subsidies that the projects are economically viable.
2.6.2 Outlook and strategy

Vienna’s Smart City Framework Strategy sets out the general direction towards a decarbonized energy supply for the city of Vienna (see also Section 2.1.3). The district heating system as an important part of heat supply is essential for achieving these goals. On the one hand, enormous efforts are needed in order to convert to renewable energy sources. On the other hand, the district heating system offers the possibility to use heat sources beyond the boundaries of the property - be it waste heat from trade and industry, from cooling systems or local renewable energy sources - throughout the year, thus saving much more final energy. The district heating network offers the possibility of incorporating thermal storage, which does not need to be in the same place as the local producer and consumer, and thereby compensate for seasonal and short-term fluctuations.

Instead of the central structure of the previous system that is characterized by a district heating with a restricted number of central waste incineration plants, power stations and heating plants, there will be in the future many more decentralized feed-in points. For efficient integration - especially in systems with heat pumps - the temperature level in the district heating system is of fundamental importance. Wien Energie can only influence this to a small extent because the high return temperature in the network is almost entirely determined by the heating systems in the buildings. Here, incentives and perhaps even obligatory measures can lead to the goal of, for example, modernizing the heating system as part of the thermal renovation of buildings.

From the point of view of currently available technologies, it will also be necessary in the longer term to cover the power peaks to maintain the high standard of supply security for electricity and district heating, gas-powered combined heat and power plants (CHP systems) and peak boilers in the system. The gas can certainly come from renewable sources ("green gas" from waste gasification, methanation, etc.). The district heating system offers the advantage of coupling the sectors "heat" and "electricity" and thus increasing the overall efficiency.
3. Renewable electricity and lighting

3.1 PV in Vienna’s project area

3.1.1 Framework conditions for PV

With the price of PV modules falling sharply in recent years and consistent subsidies by the province (Land) of Vienna, the use of solar energy has become common also in Vienna. As a priority, roof space for solar energy should be used in Vienna, as the technical potential on the roofs of the city is high. This will become increasingly important with the increasing use of heat pumps, new electronic solutions and electromobility. However, framework conditions such as monument protection, cityscape protection or the statics of existing roofs often inhibit the expansion of PV. Nonetheless, a significant increase can be observed in subsidized investments in Vienna.

Renewable electricity production from PV increased from 0.2 GWh in 2005 to 38 GWh in 2015 (City of Vienna, Energy Report 2017, p.117). Thus, the share of PV systems in total renewable electricity production is 2.9% (2015). The following chart shows the number of installed facilities and their installed capacity over time for Vienna in total.

Figure 18: Number (black dots line) and performance (green line) of installed PV systems, 1989–2015; (Source: Stadt Wien, Energiebericht 2017, S.120)
The installed capacity in the 11th district of Vienna was 1,510 kWp. With 25.6 W per inhabitant Simmering stands in the fourth place of the districts. PV systems within the framework of SMARTER TOGETHER will increase this value significantly.

![Figure 19: Performance of running PV systems by districts, 2015;](Source: Stadt Wien, Energiebericht 2017, S.121)

The subsidies of the Land of Vienna are investment subsidies and are currently in the amount of EUR 275 - per kWp. They are available to businesses and private individuals. In addition, the state of Austria at the federal level has in recent years, in limited timeframes, likewise granted subsidies on a similar level.

A recent change in the Austrian Electricity Business Act (DE: Elektrizitätswirtschaftsgesetz / EWOG) is expected to further increase the use of PV, as community PV installations in multi-family homes are now possible and the electricity produced can be used directly by the residents. There are the first projects in Austria, the corresponding business models and the necessary contractual agreements for operating companies are being implemented.

For some years now, the City of Vienna has elaborated a solar potential cadastre, which can be used to query the technical potential of the roof areas. There is basically potential for PV use in the Lighthouse District in Simmering, there are some larger commercial areas and also the roof areas of residential buildings would provide a good output (see also chapter 4.1).
3.1.2 PV systems on industrial sites

Originally, a 90 kWp PV system was planned in the SMARTER TOGETHER project on the premises of Siemens, which is also a project partner. The project could not be implemented because Siemens Real Estate as property owner and Wien Energie GmbH (also project partner) as installer and operator of the PV system did not come to an agreement. The main reason was different operational concepts regarding the contract period. It has been proven on numerous occasions that a long-term contractual commitment on the part of the company providing its roof space (in this case Siemens Real Estate) is not taken into consideration in the business model of Wien Energie GmbH as well as it is not attractive for Siemens. As a result, in the course of exchange, Siemens Real Estate was not willing to install a PV system on this site.

Further large area potential for a PV system in the Lighthouse District can be found on a shopping centre on the Simmeringer Hauptstraße and at the operating area of the Austrian Federal Railways ÖBB. The ÖBB have expressed interest in a PV project, but implementation in the project period of SMARTER TOGETHER is unlikely. However, part of the ÖBB site was sold to a brewery company - Vöslauer / Ottakringer - which is building a new logistics centre there. On the roof of these warehouses, a large PV system (see below) is being implemented in cooperation with Wien Energie GmbH.

3.1.3 PV system Vöslauer/Ottakringer

The logistics centre for Vöslauer / Ottakringer is a new construction of the company “Del Fabro & Kolarik & Leeb GmbH” on the former site of ÖBB in Grillgasse. To increase the share of renewables of the annual energy demand, large parts of the roof are used for photovoltaic. The capacity installed on the flat roof (green roof) is approx. 310 kWp. Within the scope of the "SolarKraft-EinfachNutzen" contract, Wien Energie will finance, plan, set up and maintain the system over the course of the contract.

In the first year around 316,000 kWh will be generated by the photovoltaic system - that is around one third of the expected annual electricity demand. Over the entire period of 25 years 7,700 MWh are generated. This avoids CO2 emissions of about 108 tons per year. The investments for the photovoltaic system amount to a total of € 360,000. A modern remote monitoring system guarantees a particularly high availability and constantly displays the current production.

All new buildings in Vienna should be equipped as far as possible with renewable energies. The City of Vienna commits to the use of renewable energy sources such as solar systems for the construction of commercial buildings (§ 118 (3b) Building Code for Vienna/Bauordnung für Wien). According to this regulation - 0.7 kWp per 100 m² of conditioned gross floor space - a system with a capacity of 110.8 kWp would have had to be installed. This value is exceeded by a factor of 3.
The photovoltaic system requires significant lower power consumption from the public grid and thus reduces the network load by about one third. Most of the electricity produced is consumed directly at the site. About 80% can be used to cover local power consumption. A further increase of this share is possible through the planned e-filling stations. Directly at the Grillgasse 48A location, it will be possible to refuel electric vehicles using solar energy from the roof of the logistics centre. The electricity, which cannot be used directly on site, is fed into the grid as green electricity, thereby contributing to a decentralized electricity supply.

The concepts of regenerative energy supply and sustainable mobility can be perfectly combined and ensure that the new logistics centre fits perfectly into the SMARTER TOGETHER project area in Vienna Simmering.

3.1.4 PV systems on residential buildings

At the beginning of the project, there were already three subsidized solar thermal systems (with a total of 56.5 m² collector area), but no PV systems in the project area. As part of SMARTER TOGETHER, additional solar systems were planned for the renovation of the residential buildings in Hauffgasse and in Lorystraße.
In the course of the renovation of the BWSG-estate in Hauffgasse the district heating transfer stations and hot water treatment plants have to be renewed. The residential complex consists of three buildings of flats with a total of 486 apartments. All buildings, in addition to the refurbishment, will be densified by additional floors on the top consisting of 79 apartments at all. The energy is supplied via a local district heating network operated by project partner KELAG Energie & Wärme GmbH. It is fed by three gas condensing boilers with a capacity of 30 MW. In order to increase the renewable part, a solar thermal system was planned on the roof. Further measures such as the renewal of the heating technology in the buildings should increase the efficiency of the overall system. The concept and the execution were taken over by the energy provider of the housing complex KELAG Energie & Wärme GmbH. Due to the statics of the lightweight structures and the lack of space for a buffer tank, a new solution had to be found instead of solar thermal. Initially, a PV system was designed on the roof as well as on the facade with 150 kWp. But even this system proved to be too heavy on the roof and the facade elements did not meet the criteria of seismic safety. In the course of a research, lightweight PV panels were identified, but they did not meet the necessary certificates and criteria to be used on high-rise buildings. Ultimately, the energy supplier KELAG Energie & Wärme GmbH reduced its size by half to 75 kWp. The weight of this smaller system can certainly be absorbed by the new roofs, after additionally the old ceiling covering was shrunk off. On building block 1, a panel area of 275 m² was installed in September 2018. The later renovated block 3 is expected to be supplied from April 2019 with 80 m² of PV area. The planned PV power of around 65-70 MWh per year is used for hot water treatment. That would be about 10% of the total domestic hot water consumption. The total cost of the PV system is € 220,000. The four new hot water stations come to around € 200,000, - and the renewal of the heating stations is about € 250,000, -.
The second refurbishment property is the residential building Lorystraße of the city of Vienna. On the building erected in the 1960s, a PV system of 7 kWp will be installed.

### 3.2 Solar Benches

#### 3.2.1 Starting Position

In terms of quality of life, the city of Vienna pays much attention to attractive design and use of public space. Therefore, within the SMARTER TOGETHER project, the promotion of renewable energy sources and the appreciation of public space should be linked. The intention was to invite people to linger and bring them in contact with photovoltaics with street furniture that offers seating and electricity at the same time. Photovoltaics and wind are the best-known renewable energy sources. In this case, solar energy should be given a positive image on behalf of all other renewable sources.
3.2.2 Process

There are now several models of street furniture on the market that have integrated PV modules. SMARTER TOGETHER initially chose a product from Serbia, the Strawberry Tree from Strawberry Energy.

Figure 22: The Strawberry Tree has an attractive design and offers shaded seating (Source: Strawberry Energy)

However, this model would have needed a foundation and therefore costly construction preparation work and finally relatively large space. The discussion also included wind and snow load. Furthermore, the tree produces a larger amount of electricity which would be lost in the case of no grid connection. Therefore, the smaller version, the "Strawberry smart bench" was taken into consideration, which would take up much less space, could only be set up and anchored in the ground and run on single operation with grid connection.
The Strawberry smart bench has an appealing design for the public space and is also much cheaper than a tree.

Three possible locations for the street furniture were discussed:

▪ forecourt of a new middle school (Enkplatz),
▪ the environment of a rapid transit station in the area where a Mobility Point was also planned or
▪ at the top of the forecourt of the adult education centre (see picture above, photomontage)

Besides the matter of location within the city administration responsibilities for procurement, construction, operation and maintenance had to be clarified. In addition, it had to be decided who would pay for the financing of the operation, maintenance and disposal after the end of the EU project.

Nevertheless, the biggest hurdle for Strawberry Energy was the lack of CE certification for their products and the import from a non-EU country (Serbia) to Austria. For these reasons, the city of Vienna decided against the Serbian product, an alternative was sought and at the same time the location determined: the benches were to be erected on the school forecourt at the Enkplatz.
There were several reasons why the location was chosen: the school forecourt was expected to have a high frequency of use, because on the one hand students are staying there, but on the other hand it can also be used publicly. In addition, the topic of renewable energy can be incorporated into the classroom using the Smart Benches. It is expected that the multiplier effect of the students will be high as they bring what they have learned and experienced into the families and thus reach much more people.

The location in front of the school was ultimately also crucial for the choice of the product. The "Solar Bench" of the Dutch company Ecotap was ordered. This simple table and bench combination made of sturdy concrete visually matches the appearance of the square - see the following figure - and stands up to unsparing use by the students.

![Solar Bench at the school forecourt in Simmering](source: Hemis H. MA20)

The table-bench combinations were set up in November 2017 using a crane. The response in the first days after the installation was great, also supported by the press conference and press release.

3.2.3 Lessons learned and outlook

In summary, the expectation to quickly order and install an attractive urban furniture was not fulfilled.

Procurement abroad has proved to be difficult for several reasons: The most difficult is to place an order in non-EU countries (e.g. Serbia) if the company does not have a branch in an EU country. In addition, linguistic barriers also prevent the simple handling of a
procurement procedure. The technical standards that a product has to fulfil on the European market (especially necessary CE certifications) also represent a hurdle for a start-up outside the EU.
But even placing orders in another EU country carries certain risks, as emerged after the construction of the Solar Bench by Ecotap. The experience of recent months shows that the Netherlands are very far away in the event of a required repair. Due to the distance and the resulting costs of the manufacturer in the context of a warranty case, the repair is significantly delayed. Here, it ultimately took almost 5 months from the time the trouble was reported in March, until the benches were operational again. The recommendation for any further PV furniture is, if possible, to hire a company in Austria or a company with a branch office in Austria. The loss of image of the photovoltaic in the event of a charging fault over a longer period of time is considerable and does not support the positive perception of renewable energies in public.

As it is a combination of street furniture and electrical installation, the responsibilities in the city administration were unclear. A precise administrative unit had to be appointed to procure the product. Furthermore, it had to be clarified which department would be responsible for operation and maintenance and who reports or informs the company. The financing issue after the end of the EU project and the issue of dismantling and disposal also concerned the city administration. For the distribution of responsibilities, however, a process could be defined for further installations.

As the damage to the two ordered table-bank combinations shows, the technology of the PV furniture seems not yet mature enough to withstand low temperatures in winter unscathed. Currently, due to the above problems, a roll-out of such street furniture is avoided, although there is a strong interest in replication.

### 3.3 Public lightning

#### 3.3.1 Starting position

Vienna’s streets are illuminated by a total of 154,000 lamps. The partially outdated lighting needs a lot of maintenance, financing and energy. So, the so-called rope suspension lights shape the cityscape for about 5 decades. These almost 50,000 lamps, which are mounted on cable or wire tension over a roadway, are exchanged for more energy-efficient LED. The city of Vienna has developed the low-maintenance and efficient “Viennese standard luminaire” for this purpose.
The exchange of lamps started in 2017 as part of SMARTER TOGETHER in Simmering and should be completed in 2020 for the whole city. In the meantime, almost all luminaires have been exchanged in the project area, and the exchange is also well advanced in other districts.

### 3.3.2 Implementation

The implementation started at the end of 2017 directly in front of the “Neue Mittelschule” on Enkplatz. The city of Vienna expects the LED offensive to save energy by around 60% and significantly increase the life of the luminaires. The traffic routes should be illuminated as best as possible with this standard Viennese lamp and people should be minimally blinded.

See the References section for an overview of the already exchanged lights throughout the city offers.

### 3.3.3 Outlook

By 2020, the old rope suspension lamps are to be replaced. In the following years, the remaining 100,000 lamps will be replaced by LED lighting. Successively, the energy saving potential should be further exploited and the quality of light on Vienna’s traffic routes improved.
4. **Integrative energy planning - outlook and strategy**

SMARTER TOGETHER implements many energy-related projects that would not have been directly related if they had been handled in the classic “line context”.

Up to now, there has been no higher-level controlling/management of the energy supply beyond the individual building in existing buildings for refurbishments. Therefore, usually, no integrative energy concept for the entire project area or selected building blocks is worked out in advance, thus no integrated implementation is supported. For these reasons, the City of Vienna launched within SMARTER TOGETHER the research work package on integrative energy planning (so-called “Energieraumplanung”) in order to meet the mentioned requirements of conception and management.

4.1 **Energy assessment (“Gebietsscreening”) as a starting point**

In order to provide a first basis for integrated energy solutions in the target area, a so-called energy assessment (screening of the area) was initially carried out in an order from the MA20 Energy Planning Department. In this framework, basic information such as the probable energy demand (focus on heat demand), the probable energy supply as well as the potential heat sources (potentials of renewable energies and waste heat in the area) were developed. Based on a non-refurbished inventory of buildings, scenarios of heat demand of simulated full refurbishment were also calculated. The potentials of renewable energies were aggregated at the building block level (solar energy) or disaggregated (geothermal and groundwater) and compared with the calculated demand. For the first time, it was possible to determine the potential level of coverage at the level of building blocks from local resources. In addition, it was also analyzed whether the target values from the Smart City Vienna Framework Strategy can be achieved at the building block level during a refurbishment or transformation from gas to district heating.
Figure 27: Solar energy potential of roofs on building and building block level; solar thermal on the left, photovoltaic on the right (Source: Stadt Wien, MA20)

Figure 28: Potential coverage of the energy demand (heating, hot water, building services) for the unrefurbished housing stock (HEB bar) and simulates the refurbished housing stock (HEBsan bar) by solar thermal and geothermal probe field on building block level (Source: Stadt Wien, MA20)

On the one hand, the results and presentations generated strong interest. On the other hand, there are many incorrectness and omissions in the underlying data. Therefore, it was not possible to provide accurate statements and deduce direct measures, let alone a coordinated strategy. However, the methodology and breaking down of superior goals to the local level provide a good starting point for further analysis and presentations. The MA20 takes this assignment as a basis to develop an energy data model for the whole city and to improve the underlying data. Only then is sufficient information available to allow accurate statements and to serve as a basis for the application of energy planning instruments - such as e.g. the planning of energy infrastructure based on pipes.
4.2 Lessons learned

The following findings were generated from the work package and the ongoing activities:

Data and fundamentals

- The underlying data is currently not sufficient to be able to make a decision on energy sources or supply systems at building, site, building block or neighbourhood level. For a precise statement, there is missing information about the condition and the actual energy supply of the building and the consumption. For legal reasons, it was not possible to include real consumption data in the calculations within the scope of the project. Therefore, resources must be invested in improving and editing the input data. Georeferenced correct building data on floor space, cubature, usage and building age play a key role. Consumption data allow a calibration of the demand calculation and allow a conclusion on the use and condition of the building.

- In order to obtain data on the energy supply, a corresponding agreement with the grid operator and the energy providers is necessary. Although this could not be achieved within the framework of the project, such an agreement will be reached in the near future. This will support fundamentally the development of an appropriate energy data model of the entire city.

- Treating energy issues spatially in attractive maps increases the sensitivity and facilitates discussions. Therefore, representations in the form of maps can be considered as an attractive communication tool.

Strategies, processes and solutions at district level

- There is a lack of instruments and resources to support and implement a holistic energy concept. Therefore, a higher level of coordination is necessary to jointly think and develop new buildings, refurbishments, structural densification in a neighbourhood, building block or district (management for integrated solutions from conception to implementation). The different interests and time horizons of the building owners hardly make this possible so far. At present, this cannot be achieved with the currently available instruments and structures. The development of an energy district concept, which incorporates the results of the block refurbishment studies, would be a first approach. The incentives for cross-building solutions in the stock should be massively increased. In order to better bundle the interests of the stakeholders, ownership communities and in-depth participation of all stakeholders are to be considered.

- The projects could not be directly linked due to structural, technical or temporal reasons. As a result of the spatial distance, the waste heat sources could not be directly connected to the renovated buildings. The example of Hörbigergärünge...
also illustrates this. The new buildings were designed independently of SMARTER TOGETHER without using the potential of an innovative heat supply. Therefore, urban planning and redevelopment processes as well as refurbishments should also include elements that allow potentials from the environment, especially heat sources, to be incorporated at the right time.

- During construction and refurbishment procedures, the potential for changing the energy system should always be investigated - for example as part of an energy check or even an energy concept. These should include, for example:
  - age and efficiency of the existing heating and cooling system,
  - potential to convert a decentralized system to a central heating system,
  - potential for linking heating heat, hot water preparation and cooling,
  - possibilities of district heating densification,
  - unbundling of gas and district heating,
  - integration of solar energy and geothermal energy,
  - conversion and linking of the heating and ventilation system,
  - integration of storages for better load balancing,
  - waste heat sources in close distances,
  - linkage and synergies of possible refurbishments in the environment

- There are currently no legally binding requirements to prescribe a specific energy supply system in a building. The instruments used consist of funding and information. However, the requirements of the Vienna Building Code limit the choice of possible systems. Only in the case of new buildings and comprehensive refurbishments fossil solutions are hardly possible. Changing the energy system in the case of a simple refurbishment is not required. In order to achieve the goal of decarbonisation, a systematic conversion of the energy supply in the housing stock is necessary. However, this cannot be made dependent solely on refurbishment cycles, as basically a complete conversion for a building block or an area is to be carried out simultaneously. This is counteracting by the different construction age, construction status and approaches from owners of the buildings. Energy planning is the instrument to enable such a spatially coordinated changeover.

Lessons learned from the perspective of stakeholders

Wiener Stadtwerke (WSTW)

The individual service areas of the WSTW Group (energy supply, grid connection, public transport services) are not "bundled" under normal circumstances. The demand comes in the course of a renovation of different actors (developers, tenants, other public transport providers such as car sharing operators). Therefore, it would be beneficial for the WSTW
Group, in the event of extensive refurbishments, to face cross-management to develop, offer and execute integrated solutions.

City of Vienna

The City of Vienna has influence over the subsidised refurbishment process and the legal requirements under construction law (Building Code for Vienna). The requirements for energy efficiency are already demanding from the Vienna Building Code as well as from the funding schemes for refurbishments and subsidized housing (thermal insulation, U-value, windows, ...). As already mentioned, there is a need to catch up with regard to the conversion of the building's energy supply towards decarbonisation. Here, the city needs improved incentives and new tools to overcome the structural and legal hurdles.

The block refurbishment areas identified in the course of refurbishment subsidies and the studies carried out in these areas offer a starting point to intervene more strongly here and also to take up the issue of energy supply (for example, energy assessment). In addition, there is a need for urban structures which enable to manage the complexity of territorial redevelopment and offer support to owners. The focus must be on the establishment of a central coordinating body. This can be located both directly in the city administration as well as a new facility, which is carried in each area by various actors on the ground. In any case, it should ensure the link between different services, wohnfonds_wien, the territorial authorities, the owners, the building manager, the districts, the WSTW and other utilities as well as other stakeholders in the context of integrated solutions.
5. Conclusion and lessons learned

5.1 Strategy of integrative energy planning

On the way to decarbonization, changing the building stock is the biggest challenge. On the demand side, innovative redevelopment measures are needed to massively reduce energy consumption and integrate renewable energy sources. From perspective of generation, the further development of the district heating network - such as the reduction of the return temperature - and the feed-in of waste heat and renewable energy sources are essential. In appropriate areas, priority should be given to renewable district heating. Where no district heating is possible, fossil highly efficient solutions should not be forced. The gas network should only be maintained where the supply of "green" gas is efficiently possible and other sustainable systems are not counteracted. Because, "green" gas is mainly used as a process gas for energy intensive companies and cannot cover the entire demand even with the best forecasts.

An amendment to the Vienna Building Code recently made it possible to issue urban energy plans. These instruments will regulate for new buildings in which zones district heating or another highly efficient energy system should be used instead of fossil gas. This leads to a spatial coordination of the energy supply. The underlying data model is currently being built. The regulation of these energy plans is prepared. This instrument has the potential to coordinate the changeover in the building stock.

Such regulations increase planning security for all parties involved and utilities can offer clear solutions that meet the requirements of the city.

5.2 SMARTER TOGETHER - Replication

Some of the projects will be monitored until 2021 in order to better assess the effectiveness of the measures taken.

The findings from the individual implementation projects as well as in their entirety are to be replicated in other parts of the city. Ideally, further projects of this kind are possible within the project area. This mainly concerns about energy:

- Innovative refurbishment with conversion of the energy system and integration of renewable energies with simultaneous re-densification of the building such as additional floors with apartments or by increasing the connection rate of an existing district heating connection
- Further feed-in of renewable energies into the district heating network through use of the roofs (at the beginning the examination of public buildings such as schools already provides empirical values for rapid implementation)
- New buildings or comprehensive refurbishments at the beginning of the planning process, which can use the return of the district heating for heat supply
- Application of the learned methodology for the integration of waste heat especially from data centres (if possible, an establishment of a heat-producing company close to customers or ideal entry points of the grid)
- Making renewable energy visible in other public places (including in the form of street furniture) and possibly co-operating with other European cities for a centralized ordering of high-performance products
- Forcing PV systems in operating areas and shopping centres by activating the owners
REFERENCES

i **GeoTied Wien**: National research project lead by Wien Energie with numerous research partners. Project website: [http://www.geotiefwien.at/eportal3/](http://www.geotiefwien.at/eportal3/)

ii **SDHp2m, Einbindung von solartermie in bestehende städtische fernwärmesysteme** (“Integration of solar termie in existing urban remote heating systems”, in German), April 2018: [https://www.solar-district-heating.eu/wp-content/uploads/2018/05/20180418-3-SDHp2m_SDH_Fernwärme.pdf](https://www.solar-district-heating.eu/wp-content/uploads/2018/05/20180418-3-SDHp2m_SDH_Fernwärme.pdf)

iii **Solar potential cadastre of Vienna**, online access (in German only): [https://www.wien.gv.at/stadtentwicklung/stadtvermessung/geodaten/solar/index.html](https://www.wien.gv.at/stadtentwicklung/stadtvermessung/geodaten/solar/index.html)

iv **Overview of the already exchanged lights** throughout the city offers (in German): [https://www.wien.gv.at/stadtplan/grafik.aspx?bookmark=BB8CRk10-cKUMN31GvRqEqRu5J_Cq-b-b&lang=de&bmadr=](https://www.wien.gv.at/stadtplan/grafik.aspx?bookmark=BB8CRk10-cKUMN31GvRqEqRu5J_Cq-b-b&lang=de&bmadr=)

v **Smart City Vienna Framework Strategy**: the goals of the framework strategy for 2050 include: Reducing greenhouse gas emissions by 80% or increasing energy efficiency and reducing final energy consumption per capita in Vienna by 40% by 2050 compared to 2005. Dedicated webpage with access to the document: [https://smartcity.wien.gv.at/site/en/the-initiative/framework-strategy/](https://smartcity.wien.gv.at/site/en/the-initiative/framework-strategy/)

vi **Refurbishment or transformation from gas to district heating**: the detailed result report can be requested from the project team or directly from the MA20 (only in German available).

vii **Block refurbishment studies**: block refurbishment studies are studies commissioned by wohnfonds wien for selected areas with high need for refurbishment. The quality of the buildings and building blocks and the potential for refurbishment, densification and improvement of the structure are taken into account. It includes also social and architectural aspects. This analysis is rounded off with specific recommendations for the individual buildings as well as for the building blocks and the area as a whole.