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Ready4Heat

D.2.1.2: CONCEPT ON THE PILOT ACTION IMPLEMENTATION

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Ready4Heat

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1. The summary

With the Ready4Heat project, the four pilot cities in Central Europeare – besides elaborating heat action plans for their cities - also implementing pilot actions in order to make their cities more resilient against heat waves. The main purpose of the pilot actions is to protect vulnerable target groups among their citizens from heat and furthermore to transfer the knowledge, gained throughout the implementation of the pilot actions, to other European cities. Here is a brief description of the pilot actions:

The city of **Hajdúböszörmény** in Hungary is planning the creation of 47 green islands. The green islands will be placed in public areas and around public buildings. The 47 units will be installed at 20 different locations. The locations have been selected using heat maps with the cooperation of stakeholders involved in citizen engagement. The green islands will have a bench to rest under the shade created by the plants growing on a wooden structure. The municipality is also planning to plant trees next to the green islands in order to have a bigger shade in the future.

In Slovenia, **Maribor** is constructing two pergolas to be placed in two different kindergartens. The first one will protect the south oriented part of the building from the heat in summer days. The second one will be installed in the second kindergarten and will provide shade over the sandbox. Two different plants will be tested and compared (kiwi and white Isabella vine). The pergolas will be made of local wood.

The Austrian city of **Weiz** invests in the feasibility of an innovative and sustainable cooling solution for buildings. In order to determine the feasibility, a solar-assisted cooling solution will be installed at the pilot location (nursing home). The operation of the system will be monitored and energy data will be collected in order to be able to compare the performance of the pilot system with other types of building cooling.

The city of **Worms** in Germany is establishing long term structures for raising awareness on heat and health among the citizens. The pilot action will test how a network with relevant actors can be kept alive in a long run. The purpose of the network is to develop and implement a district concept for heat reduction in a particularly affected part of the city. This includes the designation of cool places, the creation of support structures for older people, neighbourhood assistance and cooperation with stakeholders such as associations, initiatives, churches and others.

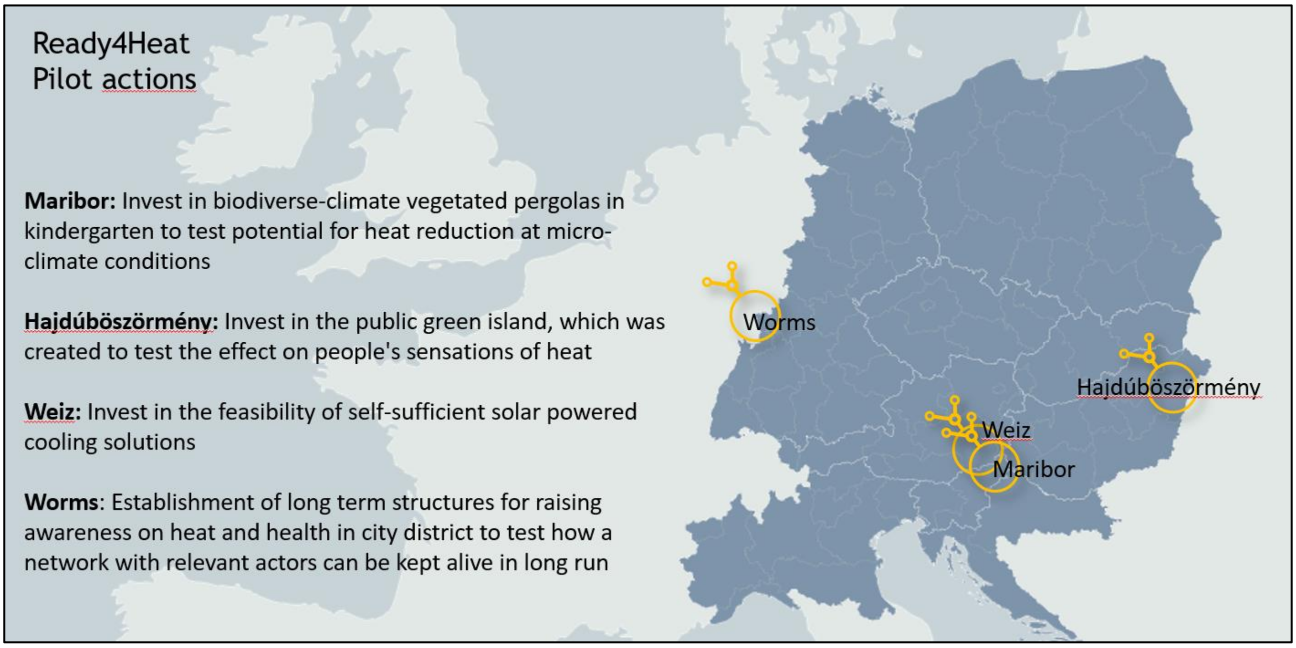
2. Introduction

Heat waves in Europe have become more frequent and intense due to climate change, leading to a range of health, environmental, and economic challenges. These extreme weather events are characterized by prolonged periods of excessively high temperatures. The impact on public health is significant, with increased risks of heatstroke, dehydration, and cardiovascular issues, especially among vulnerable population groups like elderly people and those with pre-existing bad health conditions.

Urban areas often face the urban heat island effect, where temperatures are higher than in surrounding rural areas due to human activities and dense infrastructure. This exacerbates the discomfort and health risks for city dwellers during heat waves. From 1998-2017, more than 166.000 people died due to heatwaves, including more than 70.000 who died during the 2003 heatwave in Europe (World Health Organization).

To address the health issue, the cities of Hajdúböszörmény (Hungary), Maribor (Slovenia), Weiz (Austria) and Worms (Germany) are working on pilot actions in order to try out suitable and transferable measures helping to combat heat. Together with the elaboration and implementation of heat action plans, these four cities will enhance their resilience against rising temperatures and will mitigate the impacts of future heat waves for the most vulnerable groups of citizens.

The aim of this document is to present the concepts of the pilot actions to be implemented in the four pilot cities. The document begins with a brief description of the municipalities in order to give the reader a general idea of the climatic and geographical situation in the pilot cities. Furthermore, the topic of the pilot actions and the target groups that will benefit from the pilot action, will be described. For example, in Maribor the target group are the children of two kindergartens. A more detailed information on the pilot actions and the key performance indicators (KPIs), that will be used for the monitoring and evaluation of the pilot actions, will also be part of the document. The graphic below shows the location of the pilot cities and the title of the pilot actions to be implemented.



The next chapter focusses on the methodology used by each pilot city to gather data for monitoring and evaluating the pilot actions. The results will be presented in the evaluation of the pilot action in an upcoming document. The last two chapters of the document are the presentation of the joint activities through the co-working carried out within the project partners in order to jointly develop the concepts of the pilot actions and the conclusions' chapter.

3. Hajdúböszörmény

3.1 Description of the municipality

Main data of Hajdúböszörmény: population 29,574 (as of 1 January 2023), administrative area 370.76 km2 population density 83.48 persons / km2.

Hajdúböszörmény is a town and district seat in Hajdú-Bihar County, its second most populous settlement with a rich history. It is the largest settlement in the Hajdúság region, which is why it is also called the "capital of Hajdúk". The structure of the settlement is special due to its 'circular' design. The settlement, which has had town status since 1609, has a district court, a museum, three secondary schools and an outsourced pedagogical faculty of the University of Debrecen.

It is a typical lowland farming town. The outskirts of the lowlands belong geographically to Nyírség, known for its forests, to Hajdúság, known for its excellent arable land, and to Hortobágy, known for its grasslands, in the west. Its significant surface waters are some low-flow natural veins and some artificial fishponds, as well as the Eastern Main Channel. It is bordered by 7 smaller nature reserves of local importance and 3 Natura 2000 sites. Most of it consists of intensively cultivated monoculture agricultural areas and economic forests.

The settlement includes three small settlements with a population of a few hundred inhabitants each, 8-15 km away from the city: Pród, Hajdúvid and Bodaszőlő.

The economy of the city is determined by its agricultural character, but several light and food industry companies and smaller service companies are also significant employers locally. In the future, the automotive industry investments currently under construction in the county seat may bring new industrial plants.

Its most important road access route is the M35 motorway and main road No. 35 (connecting the county capitals of Debrecen and Miskolc). It is connected to Debrecen 20 km away by a satisfactory intercity bus transport, which is regularly used by a significant part of the population for commuting (commuting to work and school). It can be reached by rail on the Debrecen-Tiszalök branch line, which has 3 stops in the administrative area of the city (Zelemér stop, Hajdúböszörmény railway station, Hajdúvid station).

The climate of the city is characterized by a moderately hot and dry climate. The average annual temperature is 9.8 °C and annual rainfall is 530–550 mm. The prevailing wind direction is North-East, with an average velocity of 2 to 3 m/s.
We do not have specific data on heatwaves in Hajdúböszörmény, but there is information regarding Hungary.

The latest annual summary of heatwave days for the year 2021 is available on the website of the Hungarian State Meteorological Service - National Meteorological Service. At that time, there were 22 days with at least a second-degree heat alarm in Hungary. After 2021, we had unusually hot summers last year and the year before and we suspect that the number of heat days may have increased by 1-2 days, which fits into a long trend when looking at several decades. If we look at a longer period than this, the trend is even more striking in terms of the increase in the number of heat days. The effect of climate change has increased the average summer temperature by almost 1.4 Celsius degrees since 1901.

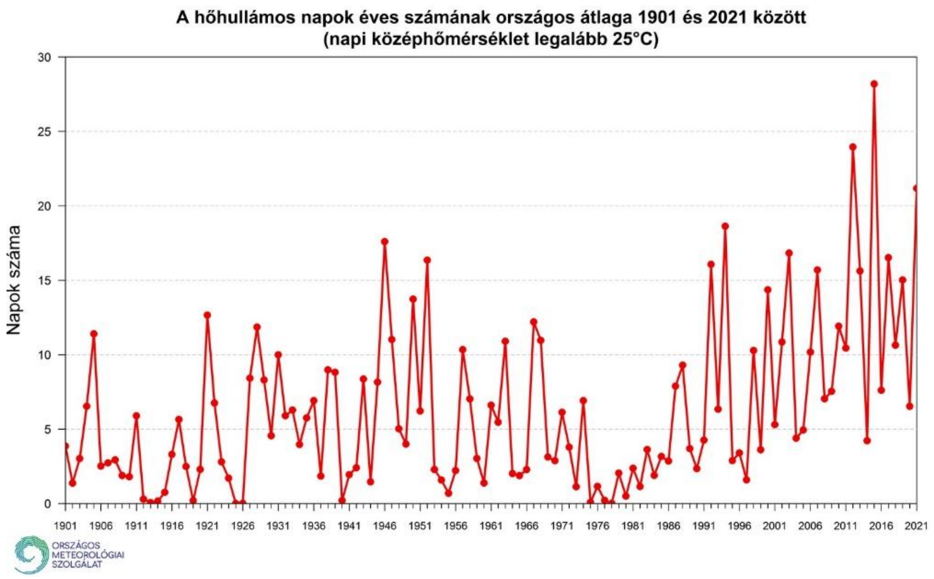


Figure 1: National average annual number of heatwave days between 1901 and 2021

Days with a daily mean temperature of at least 25 degrees Celsius are called heatwave days. Figure 1 illustrates the national average of the annual totals for these days from the beginning of the 20th century until 2021. You can clearly see the increase. Since 1901, the number of heatwave days in Hungary has increased by more than 7 days, estimated by a linear trend. The highest number of heatwave days occurred in 2015, when the National Meteorological Service detected an average of 28 such days.

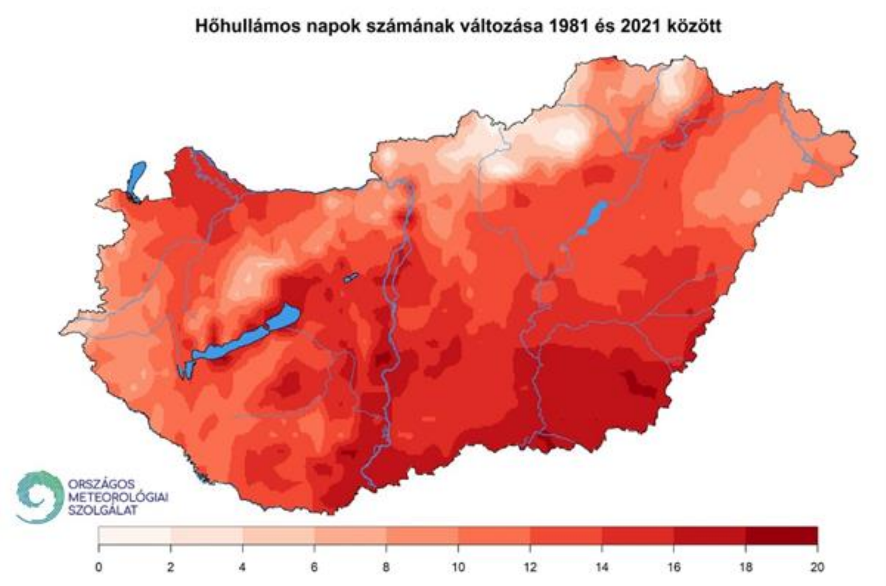


Figure 2: Change in the number of heatwave days 1981 and 2021 (during the examination of the change, we assumed a linear trend)

Similarly to Figure 1, Figure 2 is used to characterise heatwave days, but for a shorter period starting in 1981 and ending in 2021, and regional characteristics can also be traced in this figure. There is a positive trend throughout the country (however, the topography and latitude influence are already visible on this).

3.2 Topic of the pilot action

The city of Hajdúböszörmény aims to create green islands with shading through pilot operations, which are placed at several points of the settlement, in public areas and selecting community and institutional areas. Green islands are basically rectangular wooden containers in which herbaceous and woody plants of carefully selected species composition are planted. In addition, elevated surfaces – vertical pergolas – are also created for shading, on which shading surfaces can be created by running up certain herbaceous plants. In addition, street furniture connected to the islands for relaxation (e.g. bench seats) will be installed as an additional element. The islands will be placed at points used by local residents and everyone else and are expected to help compensate for the effects of heatwaves on the human body during summer heatwaves and hot spells. The planned nature-based development will be implemented on a pilot basis, the effects of which will be researched during the project, and we will help share its experiences with other settlements and climate adaptation organizations in Hungary and internationally

3.3 Target groups

The primary beneficiary of the development is the nearly 30,000 inhabitants of the city of Hajdúböszörmény, as well as visitors and tourists using the city's public spaces. In summer, the local beach bath – which also has medicinal thermal waters – and the campsite connected to it attract tourists. In addition, employees who do not live locally but work in the city also benefit from the development. Furthermore, young people studying in the city who do not live in Hajdúböszörmény, but use the public spaces of Böszörmény as commuters or collegium members. Although they only visit regularly from September to June, they also benefit from the small-scale development.

The project focuses on some of the target groups most affected by the total population. Small groups of representatives of these focus groups and stakeholder support professionals will be strongly involved. Small groups are given the opportunity to get involved during problem identification, planning, and implementation.

The infrastructure to be implemented during the pilot action – the creation of green shady islands in several parts of the city – affects the selected target groups in the following ways:

1) chronically ill people, residents with health problems – patients who are particularly vulnerable to the danger of heat:

- *We also plan a green island around a doctor's office, where there is a high proportion of people with chronic illnesses or health problems.*

2) elderly people – older people with health problems and living alone:

- *The area around healthcare service institutions was detailed in the previous point, and the information described there also applies to this focus group.*
- *The spacious courtyard of the nursing home maintained by the local government – the Gábor Fazekas Nursing Home – is a popular daytime resting place for the elderly in residence, where the placement of some shade is justified.*
- *The city market is a popular meeting place for the elderly living in the city, where they go more than just shopping. It is also justified to create several rest areas at the location where elderly people can cool off during the summer season.*

3) expectant mothers, parents of children, as well as the children themselves:

- *A health service for expectant mothers has been set up in a building in the municipal market, as has a paediatric clinic. The market is therefore a priority location not only for the elderly but also for this focus group.*
- *The nurseries, kindergartens and schools are priority sites for the project, although children living in the city do not use their yards during the summer. However, in May and early summer, as well as after the start of school in the autumn, a number of hot days can be expected.*

4) workers working outdoors in summer, even in the scorching sun:

- *Some municipal workers are employed to work in public places, so the installation of green islands in the community and public places is expected to have a positive impact on them.*

Playgrounds, public squares, public transport stops, community, and leisure centres: for example, beach bath, library, etc. are all places frequented by the target groups, and therefore green islands placed on their territory will affect them all as well as other visitors and citizens.

3.4 Specific territory of the pilot action

The planned pilot development will be located in the administrative area of the city of Hajdúböszörmény at a total of 23 locations, 47 green islands planted with plants providing shade and coolness. The islands are located in public areas, courtyards of public institutions and recreational facilities, and public transport stops, where there are regular crowds of people and little or no shade.

The following locations have been selected based on our previous project plan and the recommendations of the stakeholders of the workshops in the frame of citizen engagement.

1. István Bocskai Elementary School of Hajdúböszörmény (Main building), courtyard

Number of islands: 2

Address: Bocskai Square 11.

2. István Bocskai Elementary School of Hajdúböszörmény (small school), courtyard

Number of islands: 1

Address: Miklós Káplár Street 5. (entrance from János Benedek Street)

3. Dezső Baltazár Reformed School, courtyard

Number of islands: 1

Address: Bocskai Square 10.

4. Gábor Bethlen Elementary School, courtyard

Number of islands: 2

Address: Tizenháromvértanú Street 1. (around the gym on Gábor Bethlen Street)

5. **Community House (László Kertész City Library, courtyard**)

Number of islands: 2

Address: Bocskai Square 2.

6. Bocskai Square (Main square)

Number of islands: 1

Address: public area adjacent to Bocskai Square 3. Property (next to a brick building)

7. Bocskai Beach and Spa, its courtyard

Number of islands: 5

Address: Uzsok Square 1.

8. City fountain, courtyard

Number of islands: 2

Address: József Eötvös Street 11-13.

9. City market, courtyard

Number of islands: 2

Address: Endre Ady Square 10. (behind the bicycle racks near the entrance)

10. Fürdőkert Leisure Centre, its courtyard

Number of islands: 5

Address: Vásár Square 3. (on the k-i side of the accommodation building and at the two corners of the new water plumbed block)

11. Gábor Fazekas Nursing home, courtyard

Number of islands: 2

Address: dorogi Street 91.

12. Northern ASZC István Széchenyi Agricultural and Food Industry Technical School, Vocational School and College

Number of islands: 2

Address: Miklós Radnóti Street 3.

13. Csillagvár Kindergarten and Nursery (István Dobó Street site), courtyard

Number of islands: 2 + 2 (kindergarten yard and nursery yard)

Address: István Dobó Street 70-72.

14. Csillagvár Kindergarten and Nursery (site in hét vezér Street), courtyard

Number of islands: 1

Address:Hét vezér Street 58.

15. Napsugár Kindergarten (Civil Street site), courtyard

Number of islands: 2

Address: civil Street 48-50.

16. Doctor's office, public space

Number of islands: 1

Address: Balassi Bálint Street 17. (in front of the entrance, next to the bicycle rack placed on the street)

17. Tizenhárom vértanú Street, playground and community square (public space)

Number of islands: 3

Address: Tizenháromvértanú Street

18. Árpád Street fountain, public space

Number of islands: 2

Address: Árpád Street

19. Pród Leisure Park, public space

Number of islands: 3

Address: Hajdúböszörmény-pród, at the intersection of Bagota street – Rókahát Street

20. Local bus stop, public area in front of Bodogán abc (across the street)

Number of islands: 1

Address: Erdély Street 78. (next to local bus stop)

21. Local bus stop, public area in front of Baptist nursing home

Number of islands: 1

Address: external-Hadházi Road (railway station, intercity bus stop)

22. Intercity bus station, Hajdúvid (Dorogi Road)

Number of islands: 1

Address: Hajdúböszörmény outskirts, Dorogi Road (Hajdúvid branch)

23. Railway station, Zelemér stop

Number of islands: 2
Address: Hajdúböszörmény outskirts, area in front of Zelemér railway station

3.5 Detailed description of the pilot action

Description of the pilot measure planned in Hajdúböszörmény:

The green islands were created in a total of 23 locations with 47 islands. Through which we try to reduce the heat effect on the public areas of the settlement on hot days, with the shading and cooling effect of the islands.

As a significant part of the city's public spaces and community venues have been renewed in the past decade and a half, the city's leadership only contributes to the installation of high-quality street furniture. The planned green islands will thus be made of quality wood and metal materials, individually made and durable products.

The public bench will be fixed with a galvanized steel column support (40×60×2).

Quality class I sawn pine will be installed. The bench will include a 200 cm high lattice-like wall on which the running plants can climb.

Timetable for the planned action:

The islands will be established and placed in designated locations and planted with plants until the end of May 2024.

Resource requirements of the measure (personnel, material and equipment requirements):

The carpentry and landscaping works for the measure will be carried out by a company selected through a public procurement procedure at a planned cost of EUR 80 000. By providing human resources and equipment necessary for the works.

Each green shading island has a minimum area of 4 m^2 and is composed of the following elements:

- 2 spherical tree saplings (Fraxinus excelsior 'Altena')
- 2 benches made of wood material measuring 80 cm x 30 cm and 2 cm thick

Plants planted around the shading island:

- Tree saplings:

o *Fraxinus excelsior 'Altena'* 2 plants

- Shrub:

o *Thuja occidentalis 'Danica'* 1 plant

o Picea abies 'Little Gem' 1 plant

o Picea omorica 'Karel' 1 plant

- Creeping perennial shrub:

o *Hedera helix* 1 plant

o *Lonicera japonica* 1 plant

o *Wisteria sinensis* 1 plant

o *Campsis radicans* 1 plant

- Annual shade-providing climbing plant:

o *Phaseolus coccineus* 4 plants

Financial needs for investment and maintenance of the measure:

- Investment funding required for the measure: approx. EUR 80 500
- Site preparation (infrastructure): approx. EUR 26 450
- Design, manufacture, saplings (equipment): approx. EUR 54 050
- Maintenance funding requirement for the measure: EUR 13 500, which would be partly self-financed. About 50-50%

Information relating to the pilot action:

The pilot action and the other elements of the project will be promoted through a complex communication campaign consisting of:

- Short video (social media, local TV),
- PR article in local electronic press,
- A roll-up tableau about the green islands as part of an open-air travelling exhibition (presenting the exhibition of a few tableaux several times in the city).

Maintaining the results of the action and disseminating its experience:

During the maintenance period of the project, the green shade islands are maintained by an external service company from spring to autumn. At the same time, the service provider takes care of the annual replacement of annual plants, the necessary replanting of other plants.

After the maintenance period, the maintenance of green islands in public areas will be the responsibility of the local government, and in other locations the owners and trustees of the given properties. For this, during the maintenance period, the contractor's staff prepares the designated future plant caregivers.

The results will be disseminated locally through a complex communication campaign. While we are trying to meet the commitments made by local governments and climate adaptation organizations on the Internet with reports, briefings and rich images published on the Internet (a separate subpage about the project will present the objectives and results on the Internet in Hungarian and English).

Potential risks and challenges of the pilot action:

The locations and the selected vegetation and their adaptability may pose some risks to the success of the pilot measure.

Which we aim to remedy through careful and thoughtful selection. If the sites do not live up to expectations in the first year, we try to move them to the next growing season. The same applies to plant species if some species do not work. Then we also see potential for correction in their composition over time.

3.6 List of the KPIs and pilot objectives

During the pilot operation, the municipality of Hajdúböszörmény intends to establish cooling points at 23 frequented locations, where it places green islands planted with live plants and takes care of the planted plants. The aim and expected effect of green shading islands is to increase the size of shading and cooling surfaces in the administrative area of the settlement. In connection with this, we plan to measure the following performance indicators during the project period:

<u>Qualitative KPIs</u>

[1] Well-Being Questionnaire

[2] In 2 planned development areas by measuring the number of visitors in the summer months: Bath Garden (Fürdőkert) and City Beach Bath

<u>Quantitative KPIs</u>

[3] Measuring the growth of the shaded and cooling surface with the shading green islands during the summer period,

[4] Time spent on caring for shading green islands during the project period, broken down by month,

[5] Measuring the air temperature in the zone of influence of the shading green islands and outside - in the shade-free zone - during the summer period,

[6] Measurement of the surface temperature in summer on the permanently shaded ground below the shade green islands and at a non-shaded point on the island,

[7] Measurement of the average daily temperature, as well as the daily peak temperature in the city during the summer period,

[8] Size of the shaded surfaces of each shading green island at noon (11:00 – 13:00) in the summer period.

Other measurable indicators for small-scale experimental development are: number of green shading islands installed (pcs), size of shading area per island and total (m^2), amount spent on construction per island and total (EUR).

Climate change is making summers hotter and heatwaves more intense and frequent. This usually puts a significant strain on the human body, especially where there is little green shading space. Due to the urban heat island effect, the temperature difference can be significant even within a settlement. Because the paving materials used to create municipal public spaces, roads and buildings absorb much more radiation than vegetation, which would otherwise cover the surface. In addition, these artificially covered surfaces do not allow moisture and water to move from the deeper subsurface layers, so the cooling effect of evaporation cannot prevail properly. The solution to this problem is complex, but part of it is that we need to provide more space for plants, parks and other blue-green infrastructure. These not only increase the climate adaptation capacity of our cities, but also significantly improve the quality of life of their inhabitants.

One of the most important roles of vegetation is shading and, if there is sufficient water, evaporation, which significantly contributes to the cooling effect of vegetation surfaces, as the process draws heat away from the immediate environment. This greatly improves people's thermal comfort. But vegetation also plays an important role in improving urban air quality, as it can filter out pollution.

The main objectives of the pilot activity are:

- Increasing the urban green space in 23 designated areas of Hajdúböszörmény.
- Provision of additional shaded areas, mainly in public areas exposed to thermal insulation.
- Shortening the distance, a resident has to travel/walk to a green space.
- Promote summer pedestrian traffic by creating more shaded green areas.
- Improving the microclimate in the immediate vicinity of green islands.
- creating public spaces that residents can make better use of in the summer
- urban design value
- increasing the number of recreational spaces for outdoor recreation
- increasing the number of trees in the urban area
- overall increase in urban biodiversity

3.7 Methodology of measurement of KPIs

The methods selected and used for data collection in relation to the KPIs set out in each of the points of Chapter 3.6:

[1] qualitative indicator: well-being questionnaire: as the project requires

[2] Bath garden: entrance counter camera (collects data centrally by month), number of guests purchasing tickets in the area of the City Beach Bath (institutional data), for summer months

[3] for each island, using simple tape-recorded measurements taken during mid-summer (m^2),

[4] based on the data provided by the staff (company) responsible for care, with a monthly summary of the working hours expenditure (working hours/month),

[5] digital thermometers at 3 selected locations, with 2-2 measuring devices per location, with daily data series (ºC) per location between May and September,

[6] digital thermometers at 3 selected locations, with 2-2 measuring devices per location, with daily data series (ºC) per location between May and September,

[7] digital thermometers at 3 selected locations between May and September with daily data series (ºC) per location,

[8] for each island in mid-summer, during the day, simple tape measure measurements (m^2),

4. Maribor

4.1 Description of the municipality

Maribor is a university city, it is the second largest city in Slovenia and at the same time the economic, cultural centre of North-Eastern Slovenia. Maribor has app. 110.000 inhabitants and covers an area of almost 147,5 km^2. The population density was 763 people per square kilometre, which is higher than the national average. (Vir: https://www.stat.si/obcine/en/Municip/Index/94).

The Municipality of Maribor stretches along both sides of the river Drava and is surrounded by the greenery of Pohorje hills as well as vast vineyards covering the neighbouring hills all the way to the outskirts. The road and railway through Maribor connect Central and Southeastern Europe.

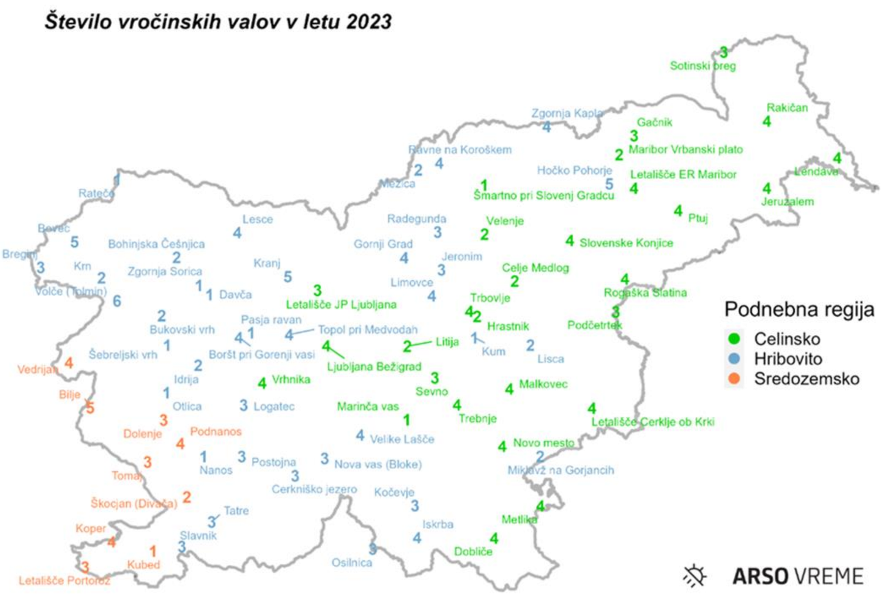
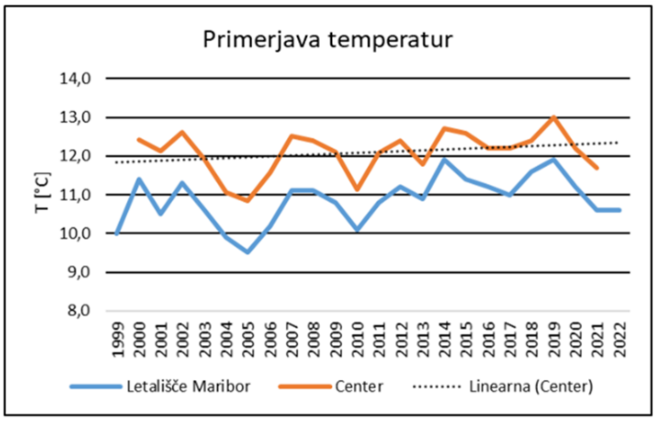


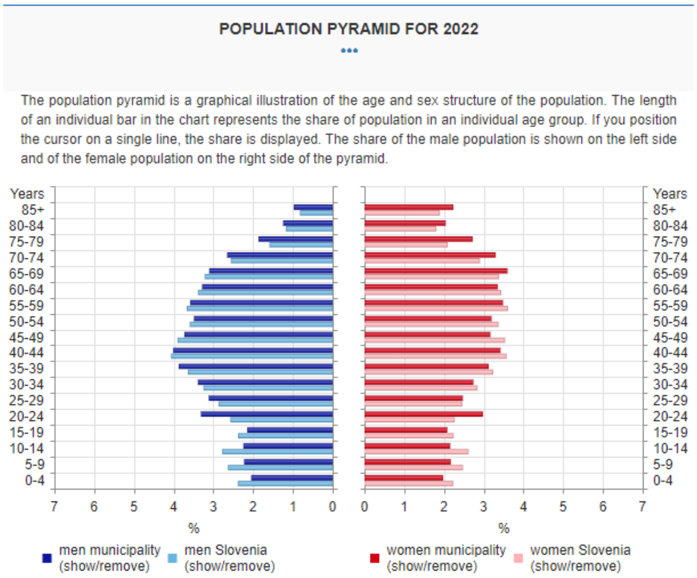
Figure 3: The number of heat waves in Slovenia in 2023 according to climate regions Maribor belongs to the continental climate.

From the graph, we can see that temperatures in the city center are almost two degrees higher than at the airport which is located in the countryside. In the last twenty years, there is a clear trend of rising temperatures at this location.



Slika1: Primerjava temperatur

(Vir: https://okolje.maribor.si/delovna-podrocja/podnebne-spremembe/meteoroloski-in-drugi-podatki)



4.2 Topic of the pilot action

Implementation of pergolas for sun protection in kindergartens

In cooperation with the Municipality of Maribor, the kindergartens involved in this pilot action implemented measures to mitigate excessive sun exposure and overheating. The primary focus was on installing wooden pergolas with strategically selected plants to provide shade and cooling effects. The overarching goal of this initiative was to assess the effectiveness of these pergolas in creating comfortable outdoor and indoor environments during hot summer months while also fostering educational opportunities for children.

Goals and Objectives:

1. Implement biodiverse shading pergolas to mitigate excessive sun exposure and overheating.
2. Evaluate the effectiveness of shading pergolas in reducing sun exposure and overheating.
3. Assess the impact of shade provision on indoor and outdoor environments.
4. Engage children in educational activities focused on gardening, biodiversity, and local heritage.

5. Promote sustainable practices through the use of locally sourced materials and low-maintenance plants.
6. *Collect data* from 2023-2025 to inform future heatwave adaptation measures

4.3 Target groups

The pilot action in Maribor aims to benefit preschool children attending kindergartens, addressing their vulnerability to excessive sun exposure.

Key Stakeholders: The Municipality of Maribor coordinates the pilot actions and provides vital support. Kindergarten staff play a crucial role in implementing educational activities and ensuring children's well-being. Parents and teachers actively participate in initiatives and provide valuable feedback. The local community's support is essential for the success of the project. Environmental experts guide plant selection, while engineers contribute to safe and functional pergola design and installation. Educators collaborate with kindergarten staff to develop engaging educational content. Health professionals offer advice on sun exposure's health implications for children.

4.4 Specific territory of the pilot action

The pilot action will be implemented in two locations: Kindergarten "Vrtec Ivana Glinška" unit "Ribiška" and Kindergarten "Vrtec Jožice Flander" unit "Sapramiška" at Focheva street in Maribor. Kindergarten "Ribiška" is situated in the historic old town along the Drava River, characterized by its cultural heritage and proximity to green spaces. However, the area lacks sufficient shading, posing challenges for outdoor activities during hot weather. Kindergarten "Sapramiška" located in Focheva street, faces similar issues of sun exposure in its playground area. The surroundings of the kindergarten are grassy areas with playgrounds for children. The kindergarten comprises two ground-floor buildings, "Veveriček" and "Sapramiška", and a multi-storey building "Žvrgolišče" (basement, ground floor, first floor and attic).

By selecting these locations, the project aims to address the immediate need for shade provision in areas frequented by vulnerable groups like preschool children, contributing to their safety and comfort during outdoor activities. Additionally, these sites serve as ideal pilot locations due to their accessibility and visibility, allowing for effective monitoring and evaluation of the pergola installations' impact on mitigating heat exposure.

4.5 Detailed description of the pilot action

The planned pilot action involves the installation of pergolas in two kindergartens in Maribor, name "Vrtec Ivana Glinska" unit "Ribiška" and "Vrtec Jožice Flander" unit "Sapramiška," aimed at providing shade to outdoor play areas and indoor spaces:

1. Pilot action: Kindergarten "Vrtec Ivana Glinska" unit "Ribiška"

Kindergarten "Ribiška" is situated in the historic old town along the Drava River, the kindergarten installed a wooden pergola made of larch wood sourced from the Slovenian Alps. The pergola, installed in December 2023, aimed to offer shade to the playground and indoor spaces. Additionally, temperature monitoring devices were installed in October 2023 to quantify the cooling impact of the pergola. Data will be collected throughout the years 2023-2025 to assess the effectiveness of this adaptation measure.

2. Pilot action: Kindergarten "Vrtec Jožice Flander" unit "Sapramiška"

Kindergarten "Sapramiška" is located in Focheva street, the kindergarten implemented a similar pergola strategy to mitigate sun exposure. Installed in December 2023, this pergola also aimed to provide shade to the playground and indoor areas. Temperature monitoring devices were installed concurrently to assess the cooling effects.

Kiwi seedlings and White Isabella grape were planted to provide good shadowing. Additionally, these plants offer fruit production, biodiversity benefits, and opportunities for children to engage in fruit-picking activities, contributing to a rich learning environment.

Through their participation in this pilot action, the kindergartens aimed to contribute valuable insights to the Municipality of Maribor and project partners, facilitating informed decisions regarding further implementation of similar measures in other organizations and environments.

- **Approach and Methods**

The pilot action started with site assessments at the kindergartens to determine suitability. Natural heritage permit was obtained due to heritage protected area in city centre. Project documentation, including technical specifications and cost estimates, facilitated the successful implementation of the pergola installations.

- **Timeline and Schedule**

The implementation of the pilot action commenced with the installation of pergolas in December 2023. Subsequent activities include planting climbing plants and ongoing maintenance. Data collection and assessment are planned throughout the years 2023-2025.

- **Resources required, including personnel, budget, and materials**

The pergola is made of larch wood from the area of Slovenian Alps.
Personnel involved include construction workers, gardeners, and kindergarten staff for supervision. The budget covers expenses related to materials such as larch wood, climbing plants, and tools required for installation and maintenance.

- **Breakdown of the financial resources required for the pilot action**

Budget provided by the Ready4Heat project covers construction, materials, and personnel costs. The financial resources required for the pilot action include expenses for materials such as pergolas, greenery, and equipment like thermometers and electricity smart meters. Additionally, there are costs associated with labor for installation, maintenance, and monitoring. Budget allocation should cover these aspects comprehensively.

- **How information will be shared with stakeholders and the public**

Information will be shared with stakeholders and the public through various channels such as project websites, social media platforms, newsletters, and direct communication with relevant organizations and individuals. Regular updates, progress reports, and dissemination of findings will ensure transparency and engagement throughout the pilot action.

- **Consideration of how the pilot action's results can be sustained or expanded.**

The pilot action's results can be sustained or expanded by integrating successful strategies into long-term policies and practices. This involves identifying scalable solutions, securing funding for continued implementation, and fostering partnerships with relevant stakeholders.

- **Identification and assessment of potential risks and challenges.**

Identifying potential risks and challenges for the pilot action includes weather variability, technical issues, community acceptance, budget constraints, regulatory compliance, resource availability, maintenance sustainability and data management.

- **Strategies for risk mitigation**

Regular monitoring of project progress and proactive problem-solving will be implemented. Collaboration with stakeholders will address challenges promptly.

4.6 List of the KPIs and pilot objectives

Key Performance Indicators (KPIs) for the pilot action include measuring the successful implementation of the project, assessing the number of beneficiaries, counting the installed pergolas, determining the square meters of green roof surface for each pergola, evaluating the temperature difference before and after pergola installation, and monitoring electricity consumption for cooling.

During the pilot action implementation process, various aspects will be tested. These include the effectiveness of the pergolas in providing shade and reducing temperatures, the impact on energy consumption for cooling, the satisfaction level of users through feedback questionnaires, and the quality of air both indoors and outdoors as measured by weather station sensors and air quality monitoring equipment.

The pilot objectives are closely linked to these KPIs. The primary goals are to improve the outdoor and indoor environments by reducing heat exposure, enhancing comfort levels, and promoting energy efficiency. Additionally, the pilot aims to gather data on the effectiveness of pergolas in mitigating heat, assess user satisfaction, and enhance air quality within the kindergarten premises. These objectives are aligned with the overarching goal of creating healthier and more sustainable environments for children and staff in the pilot cities.

4.7 Methodology of measurement of KPIs

The methodology for gathering Key Performance Indicators (KPIs) involves a comprehensive approach to data collection before and after the installation of the pergolas. For monitoring temperature and other weather phenomena such as insolation (sun exposure), cloudiness, and rainfall, a measuring station with an external and internal unit is installed, and data is collected continuously. The collected data is analysed and processed in a way that demonstrates the impact of weather parameters on living comfort before and after the pergola installation. Data collection commenced in October 2023 and will continue until September 2025 to capture pre- and post-installation conditions accurately. This enables a comparative analysis to assess the effectiveness of the pergolas in mitigating heat exposure. At the moment, the measurements will not yet show concrete results, but these will be visible in the summer and over the years will show the benefits of pergolas.

Additionally, user satisfaction will be evaluated through feedback from kindergarten teachers and staff, collected through conversations conducted both before and after the installation. This qualitative assessment will provide insights into the impact of the pergolas on user comfort and overall satisfaction.

Weather Station Sensors and Air Quality Monitoring:

- Outdoor Sensor (Measures temperature, humidity, wind speed, wind direction, precipitation, UV index, and light intensity.)
- Indoor Sensor: Monitors temperature, humidity, and air pressure within classrooms.
- PM2.5 Sensor: Installed in classrooms for tracking airborne particle concentrations and assessing air quality. Data Transmission enables precise monitoring of outdoor and indoor weather conditions. Data can be transmitted to weather servers, apps, and websites for real-time analysis.

Air Quality Assessment:
Utilizes the AQI (Air Quality Index) based on $PM_{2.5}$ concentrations. Categorizes air quality as good, moderate, poor, or unhealthy for users' understanding.

Temperature Qualitative Assessment (according to the questionnaire on wellbeing improvement):
Described using terms like warm, hot, cold, fresh, or similar to previous days/weeks. Additional descriptions for stability, instability, gradual warming, or rapid temperature changes.

Figure 4: Overview of measurements on Weather Station

5. Weiz

5.1 Description of the municipality

Since the municipal structural reform in 2015, the municipal area of the municipality of Weiz covers a total of 17.5 km², the population as of January 1, 2021 was 11,756 inhabitants and the population density at the same time was 674 inhabitants per km². As the district capital, the municipality of Weiz is located in the center of the district (Weiz), in the east of Styria and in the southeast of Austria. In terms of climatic conditions, Weiz is located in a part of Styria where historical summer temperatures are above average as depicted in the illustrations below.

Within the Ready4Heat project a rise heat days as well as in consecutive heat days was predicted by Climate Alliance Europe according to the data that was gathered for deliverable D.1.2.1 – Analysis of the Areas (figures 1 and 2). Independent data from GeoSphere Austria also predicts a rise in summer temperatures as well as heat days in the future for the Region of Weiz. (figures 3 and 4).

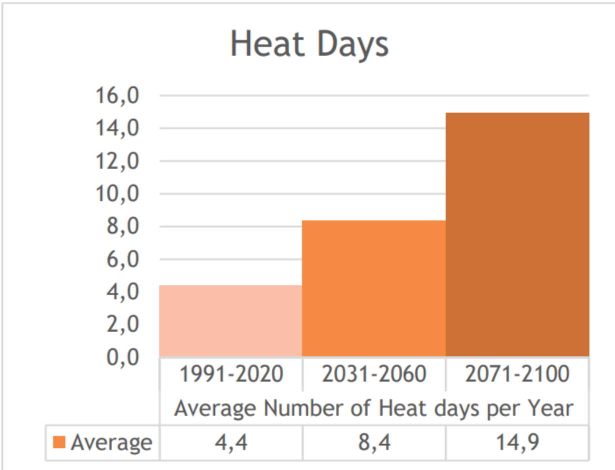


Figure 5: Number of Heat Days on average per year.

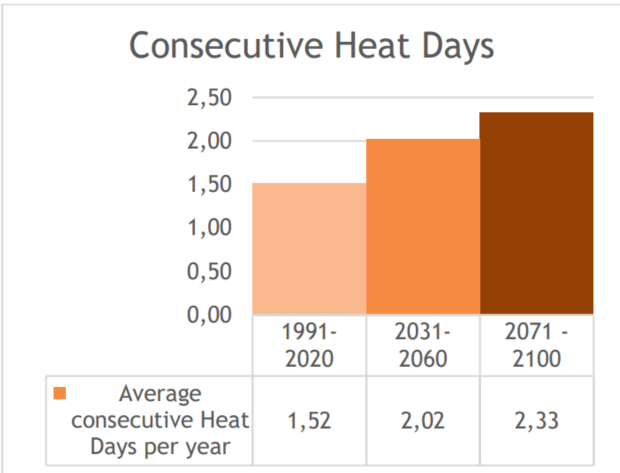


Figure 6: Consecutive number of heat days per year.

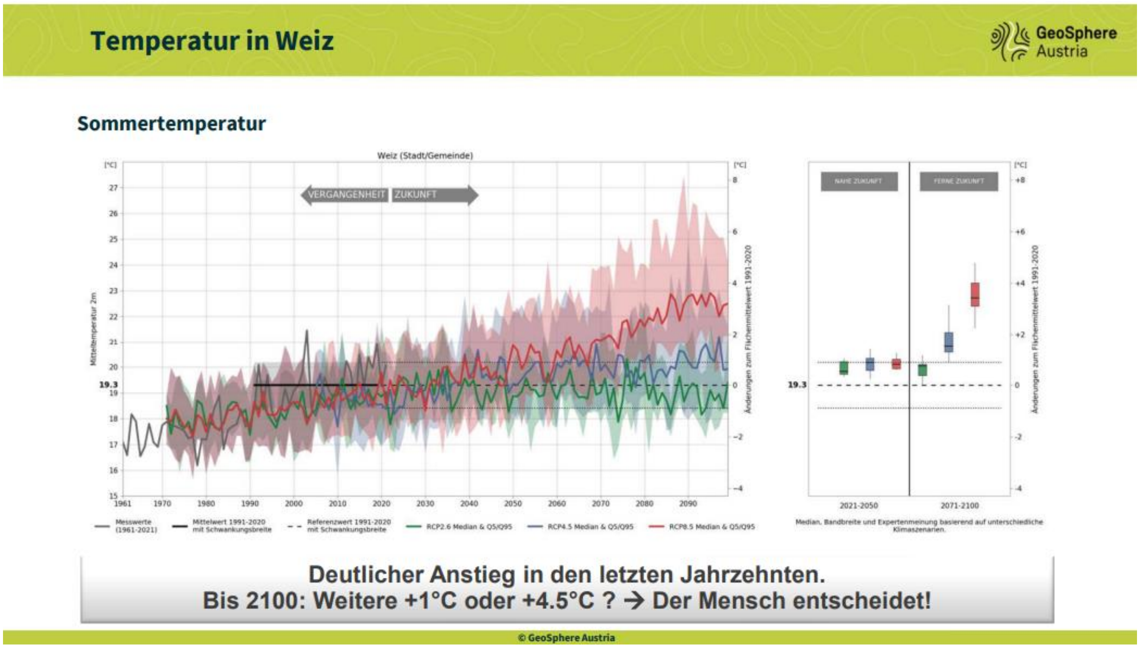


Figure 7: Future summer temperatures according to GeoSphere Austria.

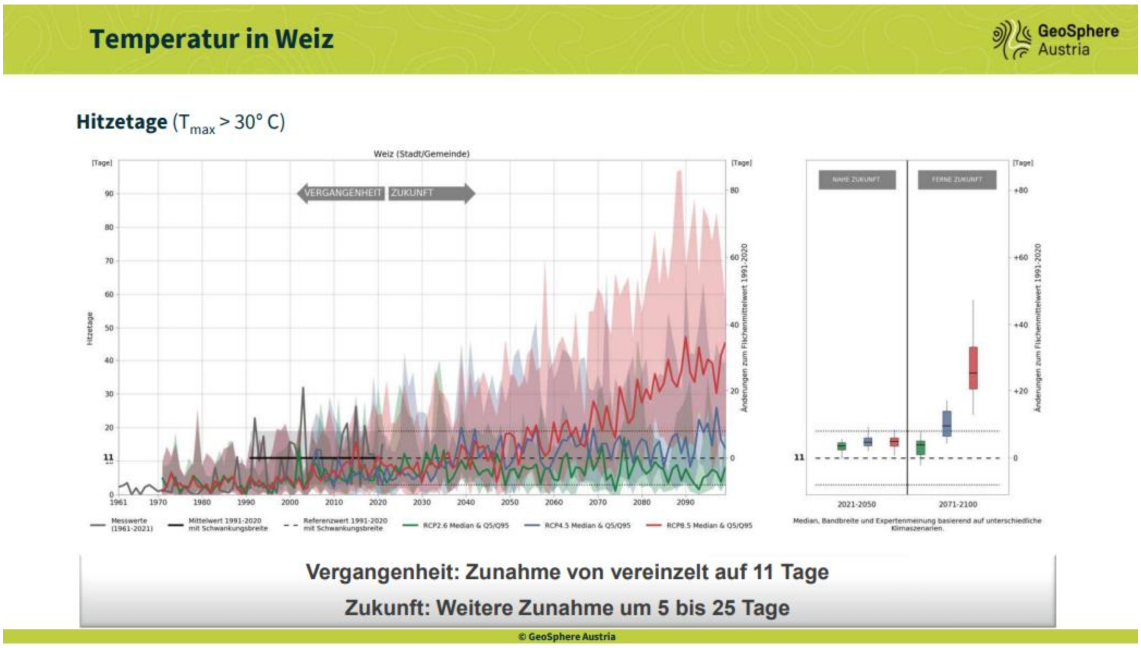


Figure 8: Future heat days according to GeoSphere Austria.

In terms of population, changes in the population pyramid, have occurred over the last 30 years. Shown in the table below for three age groups, a shift from the category “15 to under 60 years” to the category “60 years and older” can be observed, which is most likely to the declining birth rate on the one hand and on the other hand to a higher life expectancy on average. According to this population data the vulnerable group of elderly people over the age of 60 increased by 34,80% over the last 30 years.

	Wohnbevölkerung					Altersgruppen			Veränd. der Wohnbev. zur letzten VZ/RZ		
	Insgesamt	Männer	Frauen	Bevölkerungs-dichte (Einwohner je km²)	Privathaushalte	unter 15 Jahre	15 bis unter 60 Jahre	60 Jahre und älter	Insgesamt	Geburten-bilanz (Geborene - Gestorbene)	Wanderungsbilanz (Zuzug - Wegzug)
2021/(2020)*	11.756	5.704	6.052	674	5.730*	1.544	6.792	3.420	516	-411	927
2011	11.240	5.356	5.884	643	5.231	1.419	6.887	2.934	155	-427	582
2001	11.085	5.274	5.811	634	4.810	1.694	6.696	2.695	586	-82	668
1991	10.499	4.963	5.548	600	4.148	1.771	6.203	2.537	226	-7	233
Ver. 91/21	11,97%	12,99%	8,33%		38,14%	-12,82%	9,50%	34,80%			

Table 1: Resident population and sociodemographic characteristics.

The Analysis of the Area in deliverable D.1.2.1 also showed that elderly people between the ages of 65 to 85 years of age and above often live in areas associated with high to very high heat stress which is shown in the Heat Stress Map in the Annex.

5.2 Topic of the pilot action

The municipality of Weiz wants to invest in the feasibility of an innovative and sustainable solar powered cooling solution for buildings. In order to determine the feasibility, a concept for a solar-assisted cooling solution will be developed and installed at the pilot location. The operation of the system should be accompanied, monitored and energy-relevant data should be collected in order to be able to compare the performance of the pilot system with other types of building cooling. For the comparison the options for using a district cooling system to cool buildings, conventional cooling solutions for buildings as well as other sustainable or innovative cooling options should be used for the comparison.

The data that is to be collected during operation of the pilot system is explained in more detail under points 5.6 and 5.7.

For the comparison with other types of building cooling the following options should be used:

Survey on conventional cooling solutions in buildings:

- Blowers or fans
- Reduction of internal heat sources (e.g. light bulbs, uninsulated cables)
- Passive cooling options (e.g. shading measures)
- Conventional mobile refrigerators
- Split cooling units

The surge in demand for cooling services within urban areas is a multifaceted phenomenon. District cooling, with its centralized generation and distribution model, emerges as an innovative response to these challenges, aligning seamlessly with the principles of resource optimization, sustainability, and technological advancement and is therefore perfectly suited for this comparison.

Survey on district cooling should deal with the following 4 aspects:

- Basic principles: Converting heat into cold
- Technical possibilities for district cooling
- Criteria for district cooling in cities
- Assessment for retrofitting solutions of district cooling in the district heating network of the city Weiz in Styria, Austria

A detailed description of these 4 aspects can be found in the appendix at the end of this document.

Survey on other sustainable/innovative cooling options should include:

- Active component activation (e.g. ceiling cooling, wall cooling)
- Building greenery
- Window quality and energy transmittance (G value)

An overview of these systems can also be found in the Annex.

5.3 Target groups

The primary target group which profits from this pilot action will be senior citizens of the municipality of Weiz who are accommodated in an assisted living facility for elderly people as well as nursing, maintenance and support staff providing care for the elderly residents. The target group also includes visiting family members of elderly residents and health professionals like doctors. The senior citizen center for which the pilot action should be designed for, currently is home to 113 residents and employs about 120 people.

Key Stakeholders for the implementation of the pilot action are the municipality of Weiz, the facility management of the senior citizen center, the local energy network operator (solar power), equipment suppliers and regulatory authorities (building permit). Other stakeholders may include health agencies, research institutions, other organizations providing care to elderly residents and the regional government (department 8 health and care, climate protection coordination unit).

5.4 Specific territory of the pilot action

The pilot action should be implemented at the senior center Weiz, a care facility for elderly people which is operated by Volkshilfe Weiz. The senior center has 38 single and 33 double rooms, a total of 104 beds. It is currently home to 113 elderly residents and employs around 120 people (nursing-, maintenance-, supporting- staff). The facility provides around the clock care and also a variety of activities for their senior residents at their location and also regularly hosts a variety of events so they can cater to the preferences of their residents.

Geographically the facility is located in the northwest of the urban area of the municipality of Weiz near one of the biggest industrial locations of the city. Additionally, the care center is located right next to the river “Radmannsdorfbach”. In the last years some of the greenery including some trees had to be cut down because of fire safety reasons. Because of this and because the outdoor area compared to the number of residents is already small, the location is exposed to heat to a degree which is above average. The Analysis of the Area in deliverable D.1.2.1 also showed this location as one of the hotspots for heat stress for the elderly population (see figure 5 and Appendix).

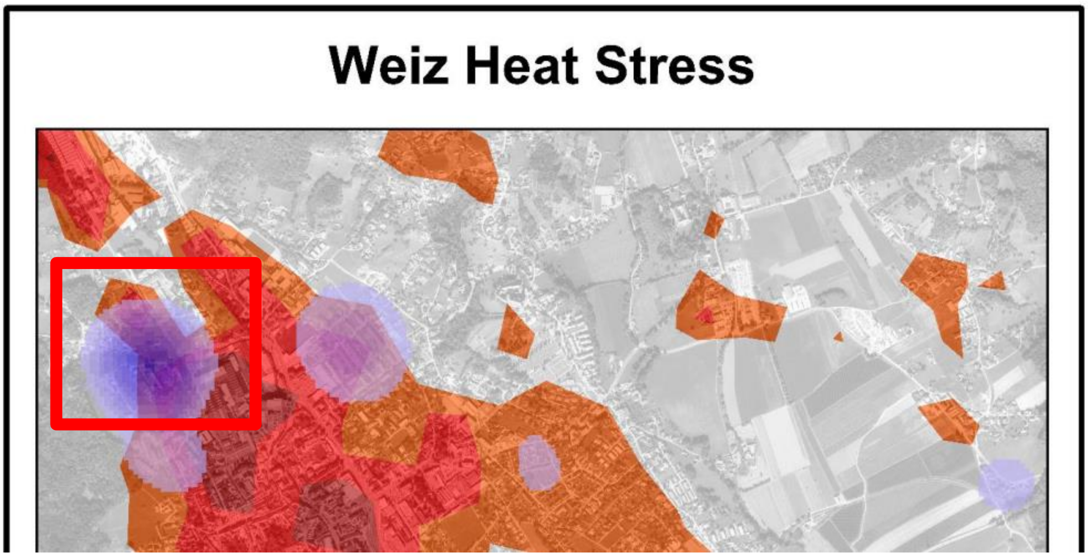


Figure 9: Heat Stress for locations with high density of elderly population.

The pilot system should be installed in the main dining room of the facility. The dining room measures 106 m² and hosts up to 40 residents for meal times at a time. Additionally, the dining room is used as a lounge room and visiting room during the day as well as for special events throughout the year. The south facing wall is mainly covered by glass and makes the room susceptible to heat buildup. Currently, there only is a recirculating air ventilation system installed which has no ability to cool the room. The only means of cooling currently possible is an outside awning that can partially cover the glass front from direct sunlight. An additional factor that contributes to heat buildup is, that the kitchen is located directly next to the dining room.

Figure 10: Location for pilot system: dining room of the elderly car facility.

5.5 Detailed description of the pilot action

The municipality of Weiz is seeking to invest in assessing the viability of an environmentally sustainable solar-powered cooling solution for buildings. To evaluate its feasibility, a conceptual solar-assisted cooling system will be developed and implemented at a designated pilot location. The system's operations will be closely monitored, accompanied by the collection of energy-related data. This data will enable a comprehensive performance comparison between the pilot system and various other building cooling alternatives, including district cooling systems, conventional building cooling solutions, and other sustainable or innovative options.

The implementation of the pilot action involves a thorough assessment of the building and spaces through on-site inspections conducted in collaboration with facility management, staff members, and building maintenance teams. The selection of an appropriate space was guided by specific criteria, including size, occupancy duration, usage patterns, sun exposure during the summer, and technical suitability for deploying a pilot cooling system. On-site inspections were already conducted in close consultation with key stakeholders such as facility management, staff, and building maintenance teams. The objective was to evaluate the suitability of various rooms and spaces for hosting the solar-assisted cooling pilot system. The room was selected according to size, occupancy duration, usage type, sun exposure and technical suitability. Decisions regarding room selection were made collaboratively, involving inputs from the facility management, staff, and building maintenance teams as well as external experts supporting municipality of Weiz. The collaborative approach ensured that the chosen space aligns with the operational needs of the care facility.

In the next step based on the selected space, a conceptual design for the solar-assisted cooling system will be developed. The design should aim to optimize energy efficiency, address specific cooling requirements, ensure seamless integration with the existing infrastructure and be as sustainable as possible. Within this process a technical assessment will need to take place in order to ensure the planned pilot system's compatibility with existing technical systems, safety protocols, and adherence to regulatory standards.

After the implementation of the pilot system continuous monitoring and data collection should take place. Post-implementation, the pilot system's operations should be monitored to collect real-time data on its performance. Parameters that should be observed are listed under point 5.6 – List of KPIs.

The last step should be the comparative analysis to determine the feasibility of solar powered cooling solutions for buildings. Data collected from the pilot system should be utilized for a comprehensive comparative analysis. The performance of the solar-assisted cooling system should be benchmarked against district cooling systems, conventional building cooling solutions, and other sustainable or innovative options.

The current planned timeline for the pilot action is planned as shown below:

Time period	Implementation steps
Already completed.	Site Assessment and Room Selection: On-site inspections in collaboration with stakeholders to assess and select suitable spaces.
Completed with March 2024	Detailed Concept Development for pilot action.
Between April and May 2024	Tendering and Procurement for Pilot System Installation: Quotation solicitation for cooling unit and photovoltaic system.
Between May and June 2024	Tendering and Procurement for Data Measurements: Commence the tendering process for the required measurements according to KPIs during the operation of the pilot system.
June to July 2024	Installation of the pilot system.
Between May 2024 and June/July 2024	Contractual Agreements with Care Facility Operator and building owner regarding the continuation of the pilot action after the project end according to the requirements of the Interreg Central Europe Program Manual.
Starting July 2024	Continuous Monitoring of the pilot system according to the required measurements for the KPIs and for

	the comparative analysis that will determine the feasibility of the solar powered cooling solution with other means of cooling buildings.
Starting September and Oktober 2025	Comparative analysis to determine the feasibility of solar powered cooling solutions for buildings (last step after the implementation of the pilot system)

- **Budget Allocation:**

Equipment Budget: €24,900: components for solar-assisted cooling system and necessary hardware.

External Support Services Budget: €55,000

Measurement services, data analysis support, and continuous monitoring of the pilot system.

Target group and stakeholder engagement and feedback collection.

- **Materials:**

Photovoltaic panels, cooling unit

Piping, insulation, and other materials for system installation

Mounting brackets, connectors, and wiring for the installation

- **External Support Services**:

External firm for precise measurements and monitoring during the pilot's operation

External experts for in-depth data analysis and performance evaluation

External support for measuring qualitative KPIs through questionnaires as defined in deliverable D.2.1.1

The Financial breakdown of the pilot action will be divided into the pilot system, data measurement and comparative analysis to determine the feasibility of a solar powered cooling solution for buildings. A rough estimate of each part can be seen below:

Part of the pilot	Estimated costs
Photovoltaic system	€ 12.500,-
Statics evaluation for pv-system	€ 2.500,-
Cooling unit	€ 9.900,-
Measurement services, data analysis support, continuous monitoring of the pilot system	€ 35.000,-
Target group and stakeholder engagement and feedback collection for qualitative KPIs	€ 4.000,-
Comparative analysis of pilot system to determine the feasibility	€ 16.000,-

In terms of information dissemination among stakeholders and the public, energy related topics have been a major theme for the city of Weiz for many years. The "Energy Showpoints" project created a few years ago and highlights innovative energy related projects within the city of Weiz. Its goal is to introduce the public to the different energy and environmental related projects in the city of Weiz. Through an appropriate and understandable approach, the aim is to introduce to the public, with a special focus on children, a future-oriented, environmentally oriented and trend-setting approach to topics such as energy efficiency, energy production and energy use, as well as to current and future application and improvement measures. In addition to project related reporting and public relations work, the new pilot system could be established as a new “Energy Showpoint” of the city of Weiz.

(*https://www.weiz.at/Stadtleben/Energieschaupunkte*)

Additionally, the City of Weiz has its own local newspaper which is published monthly and has active social media channels on Facebook, Instagram and the “Cities App”.

If the feasibility of the solar powered cooling solution for buildings is proven, the pilot system can serve as a best practice example for other care facilities or for other rooms within the same care facility where cooling is needed to ensure the well-being of residents. Furthermore, knowledge gained from the results of the pilot action implementation can be disseminated within work package 3 in project periods 5 und 6 which will help to sustain or expand upon the pilot action. Another way that will help sustain the pilot action is the contract between the City of Weiz and the care facility operator and the building owner to ensure a continuation of the pilot action after project end.

5.6 List of the KPIs and pilot objectives

KPIs were defined in deliverable D.2.1.1:

Quantitative KPIs

The quantitative KPIs will provide exact information on the pilot actions. This information will be very helpful for the evaluation of the pilot action implementation in period 5.

General KPIs:

- Action implemented
- Estimated number of people benefiting from the pilot action

Specific KPIs for the City of Weiz:

- Temperature reduction in the cooled building/rooms
- Energy consumption compared with conventional air conditioning
- Energy efficiency of the cooling device
- Cost efficiency / cost use bill compared with conventional air conditioning

Qualitative KPIs

To complement the figures gained with the quantitative KPIs, qualitative KPIs will give us information on the well-being of the target groups of the pilot actions. Climate Alliance Styria has developed a uniform questionnaire in order to obtain information on the well-being of the target groups benefiting from the pilot actions. Weiz will adapt the template according to the specific needs of the pilot action.

5.7 Methodology of measurement of KPIs

Quantitative KPIs:

- Action Implemented: documenting project milestones and completion of predefined tasks as outlined in the project plan.

- Estimated Number of People Benefiting: documenting the number of individuals benefiting based on the capacity of the cooled room and occupancy. Collecting room occupancy data and facility management records
- Temperature Reduction in Cooled Rooms: Continuous monitoring of temperature levels within the cooled room compared to a baseline measurement. Data collection via Temperature sensors, real-time monitoring system.
- Energy Consumption Compared with Conventional Air Conditioning: Metering and monitoring energy consumption of the solar-powered cooling system and comparing it with traditional air conditioning methods (is also part of the feasibility). Data collection via Energy meters, historical energy consumption data for conventional systems.
- Energy Efficiency of the Cooling Device: Calculating the Coefficient of Performance (COP) or a similar energy efficiency metric for the solar-powered cooling device. Data Collection: System performance data, energy production and consumption metrics. Energy production data can be measured via the data from the solar inverter. Energy consumption data can be measured via a electricity meter like a Smart Meter.
- Cost Efficiency / Cost Use Bill: Evaluating the total expenses associated with the pilot action and the operating costs of the pilot system and comparing them to the quantifiable benefits. Data that can be collected: budget for pilot system implementation, operating costs, amortization period based on the savings through solar powered support.

  Measurements regarding temperature and system performance (energy production vs consumption and cooling performance) should be integrated within an automated digital measuring system to make data management easy and convenient.

<u>Qualitative KPIs:</u>

- Well-being of Target Groups: Administering the well-being questionnaire adapted for the specific needs of the pilot action to the target groups. Data collected via responses from tailored questionnaires, qualitative feedback sessions at the facility are also an option.

6. Worms

6.1 Description of the municipality

Worms is located on the western bank of the Rhine in the Upper Rhine Graben north of Mannheim at an altitude of around 95 metres above sea level. Within Germany, the Upper Rhine region is one of the regions most affected by heat. The annual mean temperature in the Vorderpfalz region was 11.2 °C in the most recent 30-year average (1991 - 2020) and thus significantly above the respective mean values of the federal states (range from 8.6 to 10 °C). The high heat load also becomes clear when looking at individual exceptional weather events. In the hot years of 2003 and 2015, the 40° Celsius mark was exceeded in Worms. In addition, the years 2003 and 2018 stand out with a particularly high number of summer days and hot days. Worms is located in one of the warmest regions in Germany and already affected by summer heatwaves. Forecasts predict that climate change will increase the number of hot days in Worms from 10 to 40 by 2100. Tropical nights, in which the temperature does not cool down below 20 °C, will also increase significantly. Due to the high heat load in the city, the installation of heat protection measures is considered to be extremely urgent.

According to the population register, 86,667 people lived in Worms on 1 January 2019. Due to the increased vulnerability, the age groups 0-2 (2,619 infants) and 3-5 years (2,454 toddlers), as well as the age groups

65-79 (12,073 people) and 80+ (5,199 people) are particularly relevant for heat protection measures. According to demographic forecasts, the number of people over 80 who are more sensitive to heat will also double, making up to 10% of Worms' total population.

Total Worms	0-2	3-5	6-9	10-64	65-79	80+
86.667	2.619	2.454	3.046	61.276	12.073	5.199
In percent:	3,0 %	2,8 %	3,5 %	70,7 %	13,9 %	6,0 %

Fig.10: Total population of Worms by age group

6.2 Topic of the pilot action

The topic of heat and the associated impact on health has become the focus of public attention in recent years. However, in order to create long-term awareness and address the issue of heat and health sustainably at a local level, it is necessary to involve local stakeholders for a long time. For this reason, it is planned to set up a network with stakeholders who deal with people who are vulnerable to heat. This should ensure a good flow of information on the topic of heat and health, as well as creating structures for long-term cooperation. Only if stakeholders know each other and know who works how and with which target groups can potentials be recognised in order to spread the topic of heat and health and jointly expand the range of support structures. So the aim of the pilot action is the establishment of long term structures for raising awareness on heat and health in a city district to test how a network with relevant actors can be kept alive in long run. An important aspect of this will be cross-sector and cross-divisional cooperation between a wide range of players: municipal players from the administration, social and medical sectors, health insurance companies, aid organisations, associations and clubs.

6.3 Target groups

The target group for the pilot action are first and foremost all stakeholders who deal with heat-vulnerable groups of people in the selected urban area. To start with, there will be a particular focus on older people, as they need special protection from heat. Key players in the network are the municipal health department as well health insurance companies, as they are particularly well placed to assess the needs of older people. Volunteers as well as associations and aid organisations should also be involved in the network as well as the implementation of some measures to create commitment in the network. An initial overview of potential stakeholders in the pilot action area was drawn up:

Multipliers / Stakeholder	Further role of the stakeholders	Number in Pilot Action area
Pharmacies	• Distribution of information material • Advice to customers during heat events that medication intake should be adjusted • Invitation to network activities	**Number: 7** Apotheke Klose in der Kaiserpassage Paulus Apotheke Adler Apotheke Worms Apotheke Klose im Wormser Einkaufs-Park Martin Apotheke Schwanen Apotheke Rheingold Apotheke
General doctors	• Passing on information and information material to your patients	**Number: 9** Gemeinschaftspraxis Römerstraße Hans-Jürgen Kraft Klaus-Michael Döll

	• Distribution point for information materials • Invitation to network activities	Bernd-Michael Deißler Johannes Glemann Jörg Steinmann Jörg Appelshäuser Peter Graffy Phillipp Deppert
Care services	• Distributing a postcard with heat tips to their clients • Using a checklist for visits to clients • Invitation to network activities	**Number: 6** Rosis ambulanter Pflegedienst Pflegezeit Intensiv Evangelische Sozialstation Ambulante Pflege Sozialstation St. Lioba-Caritasverband Worms SAWO - Pflegedienst und Tagespflege Comitum Pflegedienst
Health insurance companies	• Establishing collaborations to jointly organise training courses and events on the topic of heat and health • Mutual support with materials to publicise the topic of heat • Utilising their networks and members for communication	**Number: 5** IKK Südwest Worms BARMER DAK-Gesundheit Servicezentrum Worms AOK Rheinland-Pfalz/Saarland DVK Deutsche Krankenversicherung Romeo Pennese
Churches	• Distributor for information material • Potential cool location • Use of a checklist for heat-adapted events	t.b.c.
Sports clubs	• Communicating information material to members • Adapt the sports programme in hot weather • Use of a checklist for heat-adapted events	t.b.c.
cafés, hairdressing salons, possibly retail outlets	• Provide information about tips & offers, e.g. map with cool places	t.b.c.
Tourism	• City tours in the shade • Map with cool places in the tourist information centre • Plan heat-adapted events	t.b.c.
Senior citizens' meetings & neighborhood initiatives	• Plan heat-adapted events	t.b.c.
Schools and kindergartens	• Passing on information / raising awareness • Own protective measures (ventilation, water) • Potential cool places	t.b.c.

6.4 Specific territory of the pilot action

Urban areas that are categorised as particularly sensitive to heat due to their location, nature green spaces and population structure were used to determine the pilot action protection measures. The pilot action is to be implemented in a particularly heat-stressed part of the city, namely the extended city centre. As a vulnerability analysis of the city's exposure to heat shows, this area is categorised as particularly vulnerable to heat events. The intersection of current and predicted climate development, susceptibility to heat and the social structure of the city of Worms results in particularly vulnerable areas in the city centre for various risk groups. The proportion of sealed surfaces is highest in the city centre and increases the urban heat island effect.

The area for the pilot action is bordered to the north by Siegfriedstraße and Berliner Ring and to the south by Willy-Brandt-Ring and Schönauer Straße. To the east and west, the area is bordered by the infrastructure lines of the railway line and the federal motorway 9. There are several medical facilities in this area, including 9 general practitioners, 7 pharmacies, 6 nursing services and 5 health insurance companies, which are addressed.

Fig. 11: Territory of pilot in Worms

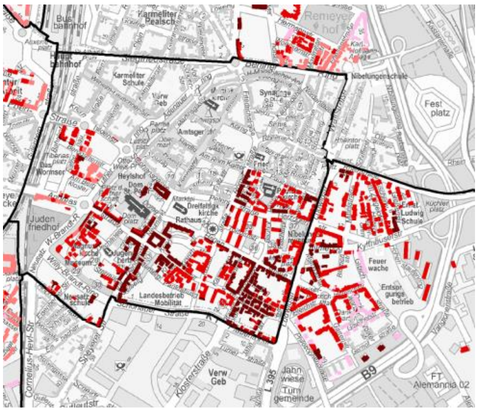


Fig. 12: Affectedness Actual state >80 years from heat action plan Worms

6.5 Detailed description of the pilot action

Building long-term structures to raise awareness of the issue of heat and health in a city district requires a systematic approach and cooperation with various stakeholders. A network needs effective leadership and governance to make decisions and ensure that the network fulfils its purpose.

- *Analysis of needs and risks: Assessment of heat stress in the neighbourhood has been carried out to identify specific risk areas. Analysis of demographic structures has been carried out to identify particularly vulnerable groups and determine their needs*
- *Actor analysis: Identification of all relevant actors in the neighbourhood*
- *Formation of partnerships: Initiate conversations and workshops to gain stakeholder interest and participation & foster collaboration by creating a shared vision for heat-adapted and health-promoting interventions*
- *Education and awareness: Creating materials/educational programmes that educate citizens about the impact of heat on health; using multiple communication channels such as workshops, information sessions, organising events that strengthen the community and emphasise the importance of collaboration*
- *Capacity building: Training for multipliers to strengthen their skills in dealing with and communicating about heat and health issues & encouraging ownership and participation*

- *Communication & outreach with a focus on multipliers: Develop an effective communication plan to keep stakeholders informed and mobilise support and establish long-term support*

For this reason, a **network manager** will be appointed to look after the network, be responsible for coordination and keep it alive in the long term. The network manager will be located at the city´s Climate Adaptation Department that is also responsible for the topic of heat and should function as a contact point for communication and contact.

A kind of **guideline for the structure** of the network is also to be drawn up, setting out how the network is structured, how responsibilities are defined and how decisions are made. In particular, this guideline should be a document for the network manager to ensure consistency in the case of any stuff changes. Among other things, this should be a practical guide to the activities carried out by the network manager throughout the year. Part of this should also include specifying how and at what intervals communication should take place and which communication channels should be used. Regular and transparent communication is crucial to keep the members of the network informed about progress, challenges and changes.

In order to give the network a structure and objectives in the **"Charta of heat & health network Worms"** are to be formulated for a common basis, which are to be recognised and signed by the participating players. This document should describe the aim, objectives and purpose of the network. These should serve as a framework, creating objectives, responsibilities, working methods and other important information for those involved. All participants should understand what the common goal and benefits are and what their role in the network is. The clear vision should support and motivate them to be part of the network and encourage cooperation.

In order to create a basis for good cooperation within the network, a **core working group** (Arbeitskreis “Klima&Gesundheit”) is to be set up to identify needs and develop and implement ideas for measures. This working group focuses on the topic of heat, will meet at regular intervals of about two months. In order to start with a specific target group, the focus will initially be on older people. In particular, the Climate Adaptation Department, the Health and Prevention Department, the Community Nurse Plus, the Seniors' Advisory Council, the Health Department and the Exercise Center should be involved. Depending on the topic of the measure, **sub-working groups** can be formed to work on these special topics.

To raise awareness of the network, various **information events and networking opportunities** will be organized throughout the year to bring together expertise on heat and health and share best practices. In addition, a large meeting is to be held up to once or twice a year at which all relevant stakeholders are invited and informed about the latest developments. Goals: Network exchange, reciprocal motivation to implement measures, building new collaborations between stakeholders, generating new ideas, exchanging information on the implementation of measures and inspiration, reflecting on what is working well and where improvements should be made.

Examples for cooperation and exchange could be measures such as a map with cool places and drinking water points in the pilot action area is to be created, on which offers from local actors for certain target groups during the hot summer months are also noted. In this way, existing offers can be given greater visibility through the network.

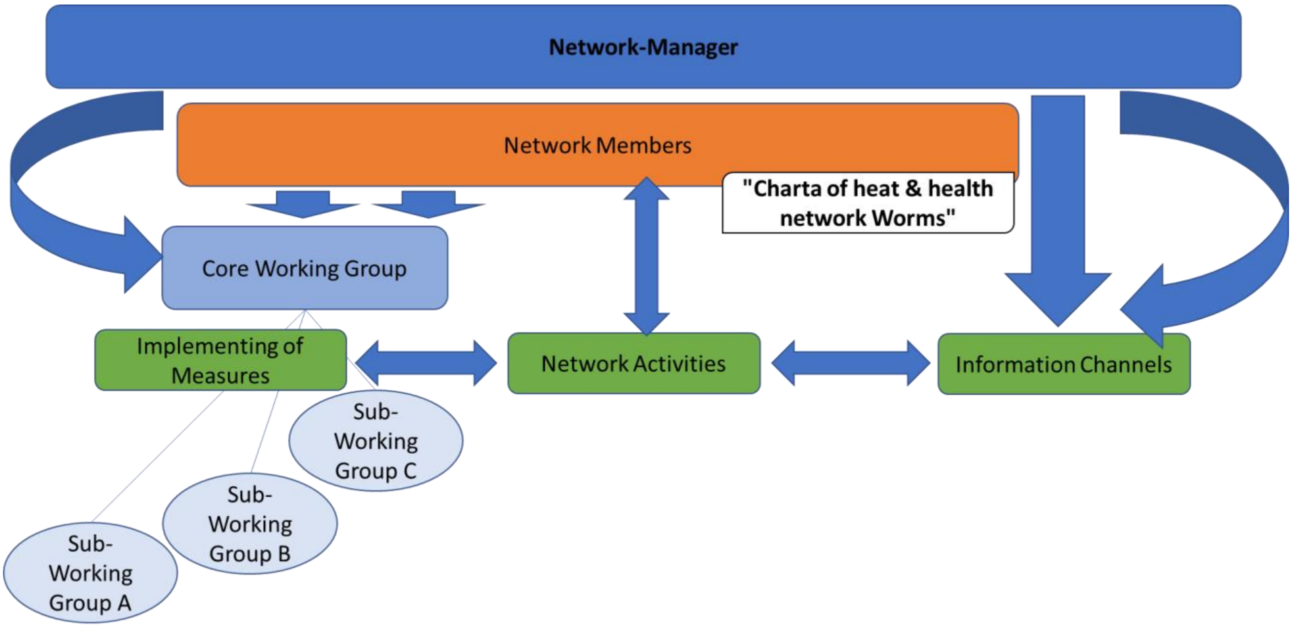


Fig.13: Network structures pilot action Worms

Time period	**Implementation steps**
Already completed	• Contact several potential members for network
Q2 2024	• Detailed Concept Development for pilot action • Core working group meeting • Establishment of sub-working groups
Q3 2024	• Core working group meeting • First product for citizens developed by working group • Charta of heat & health network Worms finalised
Q4 2024	• Core working group meeting • Meeting with all network participants
2025	• Quarterly core working group meetings • Meeting with all network participants at the end of the year

Budget planning should also include adequate control and monitoring of expenditure during project implementation to ensure that the budget is adhered to.

Type of costs	Budget
Operation and maintenance of facilities	2.500 €
Annually meetings with moderator and catering	2.000 €
Service costs and Fees for external expertise	12.000 €
Training and education	1.000 €
Communication material	1.500 €

The concept will be adopted by the city and expanded every year. By implementing the measures during the pilot phase in the city centre, successful projects can be extended to the entire city area after the end of the project. This ensures institutional co-operation both during the project and after its completion. By creating long-term structures and integrating relevant stakeholders, a sustainable network can be established that strengthens the community's resilience to extreme heat events and promotes health.

Potential risk	Strategy to mitigate that risk
People do not want that city administration enter their area of responsibility	Explain the added value of planned measures and communicate the relevance of these actions
People from the medical sector are difficult to reach, yet they are one of the main players in coping with heatwaves	Contact head organisations
Absence of heat waves	Reference to the climate forecasts of the IPCC
Lack of specialised knowledge	Bring in expertise from outside the project team
Financial issues for investments like benches, access to drinking water	There is the possibility of receiving co-financing from the state of Rhineland-Palatinate

6.6 List of the KPIs and pilot objectives

Pilot Objectives

During heat waves, vulnerable groups with the focus on elderly people (and young children) in the pilot area are sensitized about the topic of heat and health and feel more comfortable during heat waves. They take care of their health, know offers and places they can contact to get help:

Sub-targets:

1) Due to network structures there are specialised offers for elderly people
2) Through the establishment of a network, everyone in the pilot action territory (vulnerable people and multipliers) knows what to do and how to help (oneself and others) during hot days, where people can go to and get help etc.

KPIs

- Preparation of network manager´s guidelines and charta
- Number of chartas signed by network members
- Number of “core working group” meetings
- Number of large network events
- Number of participants/contacts at network activities
- Number of cooperation’s (associated actors without chartas signed)
- Number of subscribers to network information channels
- Number of measures implemented of the network, for example
    - cool places map created
    - number of cool areas in city centre
    - heat-shuttle set up
    - health check

6.7 Methodology of measurement of KPIs

- Minutes of the working group meetings
- Documentation (minutes, recording if necessary) of the network events
- Attendance lists
- Registered e-mail addresses in the distribution list
- Number of printed copies of the cool places map and other leaflets

7. Joint activities through co-working group interaction

As part of joint activities and the development of pilot activities, we held three joint meetings where we looked for common solutions and co-design of each pilot action in a moderated manner. All participating countries were involved in the development (e.g. in a co-design and co-creation process) of a pilot action. The co-design events (joint activities, 1st, 3rd and 5th were related to the pilot action development/conceptualization, along to other joint activities that were related to the joint strategy development) were carried out as part of existing events, such as partner or online meetings or train the trainer event (D.1.1.2).

All events were planned in advance as joint debates, where each partner can give their opinion and suggestions for improvements. The event took place in such a way that all partners first listened to one presentation about pilot progress, then there was a debate about this pilot, then the other pilot presentations and debates followed the same pattern.

1st joint activity

In relation to the Co-working groups 1st Joint activity has been carried out and took place on 20.6.2023 after the Train the trainer event. The activity was organized in an interactive workshop/meeting form as part of D.2.1.2: Concept on the pilot action implementation, where partnership discussed the pilots and KPIs. Pilot partners prepared a short presentation of the pilot activity, KPIs and the goals to achieve and implementation timeline, as well as the investment amount. It was also necessary to present the progress and all the activities that pilot partners have carried out so far as part of the pilot activity. Based on their presentations, the other partners gave their views, feedback and suggestions for improvements or just short comments. In order to be able to collect the responses of each partner during the presentation, we used the Miro tool. In this way, the partners could simultaneously write their comments and suggestions for improvements on the Miro board. For each pilot, they could add their opinion in four areas: KPI, stakeholders, work method and scope of the pilot. Each pilot is accompanied by a print screen from the Miro board in the following chapters, where all suggestions are written. Partners who wish to add their observations can answer the questions in the Google Form questionnaire too.

More information can be found in the enclosed Annex (minutes of the 1st joint activity).

3rd joint activity

As part of the 3rd joint activity which took place in Frankfurt (DE) in the frame of the regular project meeting on 26.-27.9.2023, the pilot partners presented the progress of the pilot activities. Above all, they had to focus on technical implementations and what data collection methodologies for the indicators they will choose.

After each presentation of the pilot, the partners freely debated about improvements, gave suggestions for the implementation of the methodology, which contributed to an improved concept of the pilot activity.

It is also agreed that the chapter on data collection methodology will be added to D.2.1.2. Also, based on the joint discussion, we agreed that in the process of conceptualizing the pilots, the indicators that will be measured can still be re-evaluated and will be re-assessed and defined in D.2.1.2. The reason is that the pilot activities can still change slightly in the conceptualization phase.

The minutes of the project meeting in Frankfurt is also enclosed to this report.

Here are the agreements regarding each pilot activity separately that were proposed:

Maribor (SI):

- Gordana (PP3) sends the already prepared measurement methodology to all partners.

  Jaume (PP6) sends to Gordana information materials on Klimabündnis Kindergarten Project in Styria.

Worms (DE):

- The city will combine the implementation of the pilot with the RIFIL project, which will cover more infrastructure.
- The debate at the German pilot took place in the direction of how to carry out the pilot in a timely manner. Namely, it turned out that there was an initial misunderstanding of when to start with conceptualization and when to start with implementation.
- The city will also have to decide whether they will keep the current questionnaire to test the well-being of the pilot's users. In principle, they are not in favour to use the questionnaires, because they don't want to bother people too much.
- The agreement is to propose new indicators by the next joint activity, which we will discuss together.

Weiz (AT):

- The city will launch the public procurement for external subcontractors to finalize their pilot concept.
- The city has found a new alternate location for the pilot, currently it is a kindergarten in Weiz.

- One of the indicators could also be the number of people who can cool down. There will also be a new indicator of life cycling costs.
- The user well-being test questionnaire will be used as part of the interviews and not as a survey questionnaire.
- The city also wants the rough draft of the pilot concept to be sent to JS for review before it is approved.

Hajdúböszörmény (HU):

- Hungarian stakeholders will decide and propose the locations of green islands as part of 9 workshops.
- The partners pointed out that the city will have to be very careful when planting seedlings (sponge tree principle) and during maintenance, especially regarding watering. The partners also advise that the city should hire an external company to do this or that the city's public company should take care of it.
- Viktor (PP9) must prepare a measurement methodology for each indicator separately. Gordana (PP3) will send him the Slovenian version.
- An external expert (landscape gardening designer) will prepare/send them a prototype of the wooden structure, which will be the main part of the green island, within 2 months.

5th Joint activity

This joint activity took place in Graz (AT) on March 5, 2024 as part of the project meeting. The debate was mainly about the AT, DE and HU pilot, the SI pilot had already been implemented at that time.

The minutes of the project meeting in Graz is also enclosed to this report.

Austrian city Weiz

The city is currently facing only one challenge, which does not affect the concept of the pilot itself. Namely, external consultants are expected to calculate the size of the PV System and the elderly home will finally after then sign the contract with the city.

They also reserve the opinion that it would be fine to extend the implementation of the pilot to two consecutive summers (2024 and 2025).

As for the before/after data, they will try to establish a parallel room, where they will also obtain temperature data for comparisons with the cooled room. Certain data on room temperatures already exist due to the storage of medicines. They will also obtain data from the existing record of the number of visitors.

In the measurement method, they will also try to measure the temperature outside the building (when it is cloudy, at night, etc.)

In principle, the AT concept is defined and does not have any strategically important problems. The concept will be ready by the end of March 2024.

Hungarian city Hajdúböszörmény

The city has prepared another design of a wooden structure for a green island, which may pose a challenge for the existing budget.

The plan is for planting to be done in the spring of 2024, or until June 2024.

The current list of indicators is not yet final. The consortium advised to eliminate all non-measurable indicators and include those that can be measured. When reviewing the existing indicators, the other partners were of the opinion that they are sufficient and that they are measurable and appropriate. They must present the latest version of the indicators in the concept.

Before preparing the concept, the city must agree with the LP regarding the financial calculations of the different types/variants of the green island. It is necessary to take into account the budget and the wishes of the city (fast-growing shrubs, or smaller young saplings or larger trees) and the application form.

Changes in the ratio of plants/trees are also possible, as this does not affect the objective of the pilot implementation itself.

German city Worms

The biggest challenge of the German city is the measurability of certain indicators and the establishment of a network of stakeholders that would be sustainable in the long term.

Peter (PP2), who has experience in establishing such networks, helped to advise on this challenge. Peter sends them examples of such networks and ToR (Terms of references). First of all, it is necessary to define the Terms of references (tasks of the network, various provisions of the network, etc.), and it is also necessary to define in the ToR the membership of the stakeholders in the network. It is necessary to explain everything in the concept in the form of a scheme/structure, in order to see who is the leader (manager or president) and which are the other committees (e.g. assembly, steering board, working board, health board, advisory board), which will be established as part of the network. In addition to the scheme, the concept also needs a descriptive part of the network, where it is also necessary to define whether individuals or organizations or both will be included in the network.

The ToR can be written more loosely at the beginning, later as the membership grows, it's fine to update it and make it more focused.

The establishment of the network is considered when the members of the network sign the accession form.

The city is leaning more towards a newly established network and not connecting to existing structures (e.g. health and prevention body).

Indicators (they should be measurable and preferably related to the establishment of a network and not so much to the communication of activities), for instance:

- No. of network
- Preparation of ToR
- Membership assigned
- No. of members
- No. of cooperation established
- No. of products of the network (e.g. communication products).

8. Conclusions

Through these four pilot actions, we aim to test various strategies/approaches to increase urban resilience against heat. The initiatives include urban greening, improving energy efficiency, and creating a sustainable network to combat heat, all of which will be evaluated in the coming years. In Weiz, the implementation of a sustainable cooling system is expected to have an immediate positive impact. However, for the pilot actions in Maribor and Hajdúböszörmény, time is required to fully realize the benefits, such as the shade provided by maturing plants. Similarly, in Worms, developing the network and executing the agreed-upon actions will take time.

By February 2025/August 2025, we anticipate having results from all four pilot approaches, allowing us to share valuable insights and lessons learned with other cities. Key questions include: Which is more effective for creating shade in kindergartens, the kiwi or the white Isabella grapevine? How does the efficiency of a solar-power cooling system compare to a conventional one? Are people using the green islands in Hajdúböszörmény, and has the well-being of residents improved during hot days? Also, how effective is the network in Worms?

These are among the questions we are asking, and we aim to provide answers in the following deliverable D.2.3.1

Joint activities this time showed that with joint efforts we can overcome all obstacles in the development of ideas and pilot implementations. The partners actively cooperated, accepted suggestions for improvement, updated their pilots based on the partners' recommendations and thus obtained the final versions of the pilot concepts. The joint pilot development process involved structured collaboration among participating countries, facilitated through multiple joint meetings/events. These meetings provided a platform for exchanging ideas, discussing progress, and refining pilot concepts in a moderated manner.

The development process emphasized co-design, wherein all participating countries contributed to shaping the pilot actions. Through interactive workshops and presentations, partners shared insights, feedback, and suggestions for improving each pilot's implementation plan, including defining key performance indicators (KPIs), stakeholder involvement, work methodologies, and scope.

The process revealed challenges such as measurability of indicators, stakeholder engagement, and budget constraints. However, collaborative problem-solving mechanisms were employed, including seeking expertise from within the consortium and proposing solutions tailored to address specific challenges encountered by each city.

9. Appendix

1. Basis principles, technical possibilities and criteria for the implementation of district cooling in cities

In the following a detailed description about the following 4 aspects of district cooling is carried out:

- Basic principles: Converting heat into cold
- Technical possibilities for district cooling
- Criteria for district cooling in cities
- Assessment for retrofitting solutions of district cooling in the district heating network of the city Weiz in Styria, Austria

9.1.1. Introduction

The increasing pace of urbanization and the global demand for cooling solutions have brought to the forefront the urgent need for pioneering technologies that can effectively address the challenges arising from the confluence of rising temperatures and burgeoning population density. As cities expand and climates become more unpredictable, the strain on conventional cooling methods becomes increasingly evident. In this context, district cooling emerges as a beacon of innovation, offering a transformative solution to meet the escalating demands for cold energy in urban landscapes.

The surge in demand for cooling services within urban areas is a multifaceted phenomenon. It is driven not only by the sheer growth in population but also by the rapid pace of urban development and the undeniable impacts of climate change. These factors collectively amplify the importance of finding sustainable and energy-efficient cooling solutions that can adapt to the evolving needs of modern cities.

Traditional cooling methods, while once effective, are now grappling with limitations that hinder their ability to provide comprehensive and environmentally friendly solutions. The inefficiencies of decentralized cooling systems and the environmental consequences of their energy consumption underscore the necessity for a paradigm shift. District cooling, with its centralized generation and distribution model, emerges as an innovative response to these challenges, aligning seamlessly with the principles of resource optimization, sustainability, and technological advancement.

District cooling is not merely a technological advancement; it represents a holistic approach to revolutionizing urban cooling systems. By consolidating the generation of cold energy and its subsequent distribution, district cooling optimizes resources, reduces energy waste, and minimizes environmental impact. This approach not only meets the immediate need for effective cooling in urban environments but also positions itself as a crucial contributor to broader goals of energy conservation and environmental responsibility.

By elaborating and describing different aspects for district cooling, the following detailed report will describe the intricacies of district cooling, exploring its mechanisms, advantages and disadvantages, environmental benefits, economic viability and transformative potential for urban landscapes. The aim is to show how district cooling can help shape the future of urban cooling systems and not only meet the challenges of today, but also prepare cities for the demands of tomorrow.

9.1.2. Basic principles: Converting heat into cold

At the beginning, the basic principles of district cooling, its mode of operation, its advantages as well as disadvantages and environmental aspects are explained.

The escalating demand for enhanced indoor climate control, particularly in office spaces and commercial structures, coupled with the expanding utilization of heat-emitting technical equipment, serves as the impetus behind the burgeoning interest in air conditioning. The conceptual framework involves the adoption of a centralized source in lieu of localized systems for individual buildings, fostering both economic and environmental advantages. District cooling emerges as an environmentally friendly, energy-conserving, and economically viable cooling method, wherein cooling is centrally generated and disseminated as cold water through a closed distribution network to each building.

How does the district cooling system operate scientifically?

In district cooling, a singular central source caters to multiple buildings. This system provides operational flexibility and convenience, allowing the use of the same supplier for electricity. Additionally, each building can utilize cooling as required without concern for chiller size or capacity. Energy efficiency is optimized through heat exchangers that efficiently transfer cold to the upper regions of buildings, minimizing losses.

Essentially, a district cooling system (DCS) allocates cooling capacity in the form of chilled water or another medium from a central source to multiple buildings via an underground pipe network for both space and process cooling. Users procure chilled water from the district cooling system operator, obviating the need for individual chiller plants. The system comprises a central chiller plant, a pump house, and a distribution pipeline network. [1,2,3]

According to experts, Europe will need about as much cooling energy as heating energy in the next twenty years. On the other hand, energy consumption is set to fall. In order to create a climate-friendly cooling option, many cities and countries are focusing on the expansion of district cooling. This modern technology, which turns heat into cold, among other things, saves up to 70 percent of energy consumption and 50 percent of CO_2-emissions compared to conventional air conditioning systems. There are dedicated district cooling centers that work very energy-efficiently. Here, the water is cooled down to 5 to 6 °C.

The same energy sources that are used to generate district heating can also be used to drive chillers. So-called absorption chillers use waste heat from industry, combined heat and power (CHP) plants or waste incineration, which is available all year. As with district heating, the properties are supplied centrally (or decentrally for consumers with higher cooling demand, where the cooling production is set up at the consumer's premises by using district heat). Insulated pipes transport the water, cooled to 6 degrees Celsius, to the customers and it flows back at around 16 degrees Celsius to be cooled down again.

Compared to conventional air conditioning systems, 4 to 10 times less primary energy is required, making district cooling a smart cooling solution. Conventional air conditioning systems use outside air to cool rooms, which costs a lot of electricity and therefore a lot of energy. They also require a lot more space - drycoolers have to be installed on roofs, which often does not comply with listed building regulations and takes up space for green plants and photovoltaic systems. [4]

District Cooling stands as an efficient and environmentally friendly utility service, delivering chilled water from a centralized cooling plant (or cold seawater) to various residential, industrial, and commercial buildings for air conditioning purposes. In regions with substantial heating demand, the plant can be designed to supply hot water, forming a District Heating and Cooling System (DHCS).

The 2 figures below illustrate how district cooling systems are working:

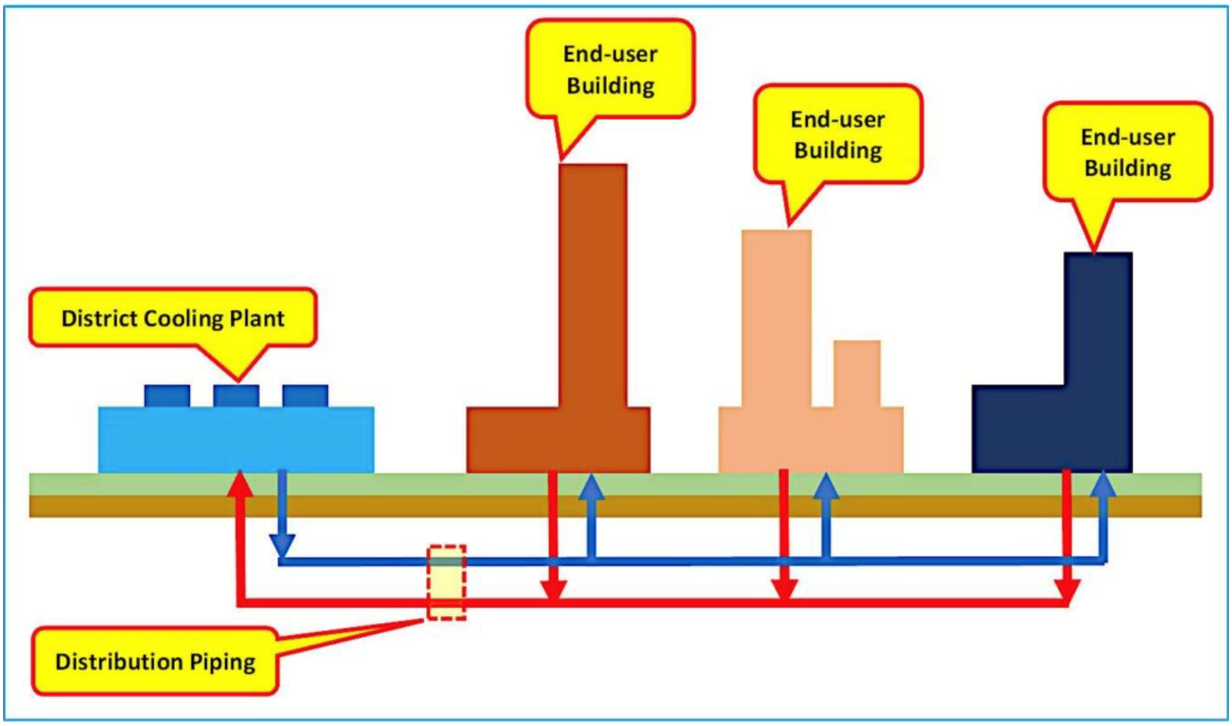


Figure 1: Mode of operation of a district cooling system, I [5]

Reference: What is District Cooling? DistrictCooling.Pro. 15 Dec. 2023:

https://districtcooling.pro/what-is-district-cooling/

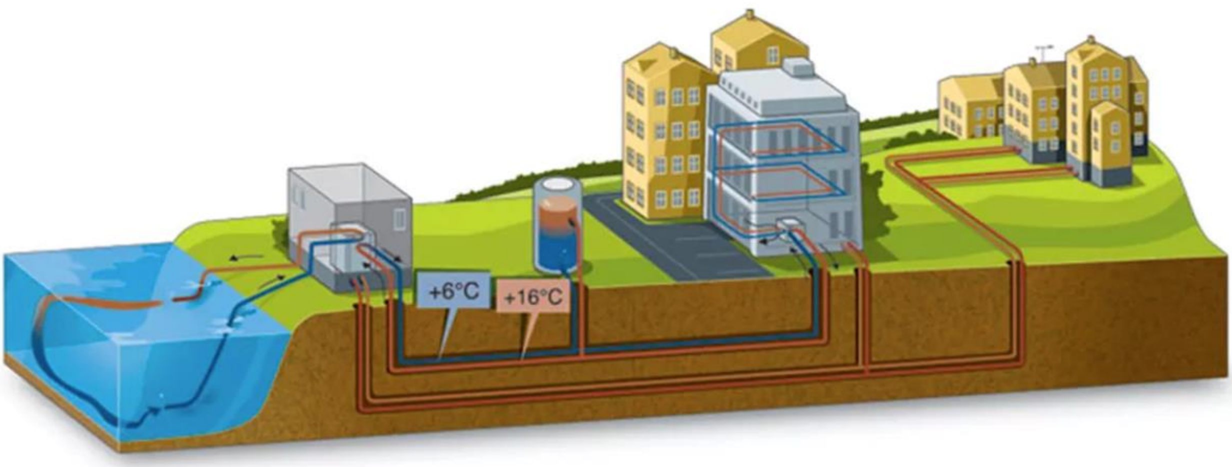


Figure 2: Mode of operation of a district cooling system, II [1]

Reference: District Cooling. DESMI. 14 Dec. 2023:

https://www.desmi.com/segments/utility/applications/district-cooling/

A standard district cooling system includes the following components:

- *Central Chiller Plant for chilled water generation*
- *Distribution Network for chilled water dissemination*
- *Consumer Substations interfacing with buildings' air-conditioning circuits*

More information to these components will be given at the ***section 'Technical possibilities for district cooling'****.*

District cooling, being the most convenient method for cooling production and distribution in commercial applications, yields both environmental and economic benefits.

- *Environmental Benefits:*

The deployment of a singular cooling unit is more environmentally advantageous than individual production units. The global phase-out of Freon, driven by regulations, incentivizes the adoption of district cooling services, as building owners would otherwise incur substantial costs for modifying or replacing their cooling equipment.

- *Economic Benefits:*

Centrally produced comfort cooling provides end-users with spatial advantages by eliminating the need for chiller investments, addressing concerns about size and capacity. Operational flexibility is heightened, allowing each building to regulate its cooling needs. The system offers a cost-efficient solution, managing issues such as maintenance and equipment redundancy centrally. [1,2,3]

In the following the different cooling sources of district cooling systems will be discussed in more detail. An absorption chiller, a cooling tower and a thermal energy storage are considered. Another novel alternative is the combination with renewable energies. [2]

Absorption Chiller: When district heat or waste heat is available, such as from waste disposal, an alternative method for achieving comfort cooling involves the use of an absorption chiller. In this application, environmentally friendly substitutes, such as water and lithium bromide, replace ozone-influencing Freon. In the evaporator, the refrigerant (water) absorbs heat/energy from the connected system, effectively cooling the air conditioning circuit within a heat exchanger. The refrigerant then enters the absorber as low-pressure vapor, where the liquid solvent (lithium bromide) absorbs it. A pump elevates the pressure, and the mixture proceeds to the interchanger, where it undergoes preheating, typically in a plate heat exchanger. The high-pressure vapor is directed to the condenser, where heat is released during the refrigerant's condensation process.

Cooling tower: In contemporary times, water qualities are on the decline due to various forms of pollution, raising the likelihood of chiller shutdowns caused by condenser operation issues. The condenser faces threats from chlorides, leading to corrosion, as well as impurities or biological activities in the water, resulting in fouling. With the growing desire for trouble-free cooling operations, exploring alternative solutions that sidestep these challenges has become increasingly compelling. One such solution involves employing an indirect system, utilizing a heat exchanger in conjunction with an open cooling tower. The advantages are low system costs, material savings in the condenser, less maintenance of the condenser, and the operation of chillers and cooling towers at an optimum temperature with an intermediate heat exchanger.

Thermal energy storage: Thermal energy storage is achieved through an ice accumulator or storage tank, allowing the accumulation of ice during one period, storage for later use, and subsequent thawing and utilization during another timeframe.

The primary motivations for employing an ice accumulator or storage system are twofold:

1. *Variable Cooling Demands: When cooling needs fluctuate throughout the day, utilizing a smaller chiller becomes feasible. Consequently, the upfront costs associated with cooling equipment can be significantly reduced.*
2. *Off-Peak Cooling Energy Purchase: Cooling energy can be procured during off-peak hours or at night. In many countries, this translates to obtaining energy at a lower cost, thereby contributing to economic efficiency.*

There are two primary types of ice accumulator systems:

1. *Systems with Internal Melting: In this type of system, an ice accumulator consists of a polyethylene tank containing coils made of the same material. The tank is filled with water. To accumulate ice, a glycol solution at -5°C is circulated through the coils. Ice forms initially around the coils and gradually extends into the tank. When additional cooling capacity is needed, the glycol solution in the coils is circulated through the system, returning to the tank at a higher temperature. This process causes the accumulated ice in the tank to melt, and the glycol solution is then re-cooled until all the ice is consumed.*
2. *Systems with External Melting: In this configuration, the tank is constructed of steel or concrete and includes coils containing glycol or a Freon coolant. Ice accumulates to a thickness of 35 mm around each coil, with the remainder of the tank filled with water. When cooling energy is required, ice water is pumped from the bottom of the tank into the system. Upon returning to the ice accumulator, the water is compelled to circulate around the ice. In this system, the pumped ice water maintains a consistent temperature throughout the circulation process.*

The choice of technology depends on various factors, including geographical location, available resources, energy sources and the specific requirements of the consumers. It often makes sense to combine different approaches to create an efficient and reliable district cooling system.

The following is a distinction between direct and indirect district cooling systems. [2]

- *Direct systems:*

The district cooling water goes directly into the internal piping system of each building. The direct one is used less than the indirect one.

- *Indirect systems:*

In an indirect system, a heat exchanger acts as a barrier between the internal and external systems. Presently, this is the most prevalent system, offering numerous advantages.

  - *Detecting leaks will be more straightforward, and in the event of a leak, the resulting damage will be minimized. There is no risk of one system contaminating the other*
  - *Clarity in responsibility lines will be enhanced, and monitoring regulations and sales becomes more straightforward with well-defined boundaries*
  - *The use of separate circuits can result in fewer fluctuations and disturbances for customers, especially during central system expansions or maintenance requirements*
  - *A reduction in static pressure, thereby functioning as a pressure interceptor.*

The next section lists some of the advantages and disadvantages of district cooling systems. [6,7]

Advantages:

- *Lower costs for cooling and air conditioning solutions at individual connections*
- *More space thanks to compact transfer stations at the points of consumption*
- *Greater convenience, as a lot of maintenance and repair work is no longer required*
- *Higher efficiency thanks to the central generation of cooling for district cooling networks*
- *Lower primary energy factor thanks to natural cooling and waste heat utilization*
- *Less heating of cities as many small air conditioning systems are no longer required*
- *Utilizing cold groundwater for heat exchange proves to be a more cost-effective alternative than employing chillers on the roofs, which encounter challenges in efficiently dissipating heat into the ambient hot air*
- *District cooling systems utilizing groundwater exhibits a discreet and silent operational profile in stark contrast to the audible and more conspicuous nature of air exchange chillers*
- *The substantially reduced electricity consumption leads to a noteworthy decrease in greenhouse gas emissions originating from power stations*
- *Annual maintenance costs are significantly lower when compared to conventional air conditioning systems*
- *Heat transfer, being a combustion-free system, contributes to the enhancement of air quality in the district*

Disadvantages:

- *The capital cost of installation is greater when compared to the alternative of installing chillers on the roofs of individual buildings*
- *Legal challenges may arise when attempting to secure agreement for the installation of a district cooling system, especially when the benefits are intended to be shared among distinct legal entities*
- *Operating prices could be higher and subscribers may have no alternative to the local network operators. They are dependent on prices and rely on the technology always working perfectly (Technical failures: Malfunctions or failures in the district cooling system can lead to interruptions that have a negative impact on connected users)*
- *There are also potential risks for nature and the environment. There is a possibility that the temperatures of groundwater, river or lake water may rise, which can affect the behavior of living creatures and have a negative impact on the ecology (To prevent this, cities and operators of district cooling networks monitor the effects very closely)*

9.1.3. Technical possibilities for district cooling

In the following the technical possibilities for district cooling are analyzed. The required components for a district cooling system are discussed, the engineering process of deep-water source cooling is described and the concept of combined heat, power and cooling processes ('Kraft-Wärme-Kälte-Kopplung' in German) is also briefly explained.

As it was mentioned before in the section **'Basic principles: Converting heat into cold'**, the standard district cooling system includes a Central Chiller Plant for chilled water generation, a Distribution Network for chilled water dissemination, and a Consumer Substations interfacing with buildings' air-conditioning circuits. The individual components are described below:

- Central Chiller Plant for chilled water generation:

Chilled water is commonly produced within a centralized chiller facility through the operation of compressor-driven chillers, absorption chillers, or alternative mechanisms such as ambient cooling or "free cooling" extracted from deep lakes, rivers, aquifers, or oceans. Typically, sets of sizable and energy-efficient water-cooled chillers are strategically positioned in a central chiller plant, leveraging economies of scale and exploiting variations in cooling demands among diverse structures within a given district. Waste heat from the central chillers can be effectively dissipated using sea water condensers or cooling towers employing fresh water. [3]

A water chiller constitutes a refrigeration system that employs water as a secondary refrigerant for regulating the cooling of various products. It is crucial to emphasize that a chiller is not a cold-generating device; rather, it functions by extracting heat. In the context of large, multi-story structures, the logistical challenges of circulating coolants through numerous air handlers are considerable. Extensive refrigerant pipe networks increase the likelihood of leaks, posing potential hazards to employees, environmental pollution, and financial waste. In lieu of this, a chiller serves as a centralized hub where the coolant efficiently extracts heat from water, providing a more controlled and efficient approach to cooling within the system.

A chiller operates with two distinct systems, each serving specific functions:

  - Chilled Water/Air Handler Side:

In this side, the coolant extracts heat from water in the air handler. Warm water from the air handler returns to the chiller, where heat is transferred from the water to a liquid refrigerant. The heat causes the liquid refrigerant to transform into a gas. The spent refrigerant moves to the compressor, where it becomes a hot vapor.

  - Condenser/Cooling Tower Side:

The refrigerant vapor exits the compressor and enters the condenser side of the chiller. Heat transfers from the hot vapor refrigerant to water and route to the cooling tower. This heat removal condenses the refrigerant back into a liquid, which is then reused to chill more water for the air handler. The coolant remains confined within the chiller, facilitating heat exchange with water. This process both cools the water for air conditioning in the handler and extracts heat from the refrigerant for recycling. [8]

The figure below shows a water chiller:

Figure 3: Water chiller [8]

Reference: Water Chiller: What Is It and How Does It Work? Veris Industries. 14 Dec. 2023: https://blog.veris.com/hvac-series-part-ii-chillers

- Distribution Network for chilled water dissemination:

Chilled water within a district is conveyed from the cooling source(s) to user stations via supply pipes and is subsequently returned after absorbing heat from the secondary chilled water systems within buildings. This distribution process is facilitated by pumps that generate a pressure differential between the supply and return lines, ensuring the effective circulation of chilled water throughout the system. The pipes are usually colder than the surroundings, which is why they must be airtight with the surrounding thermal insulation. If the airtightness of the thermal insulation is not guaranteed, condensation on the pipe can lead to corrosion damage. [3]

The figure below shows a section of a distribution network:

Figure 4: Distribution network [9]

Reference: District Cooling from groundwater in Munich's eco-friendly quarter. German Energy Solutions Initiative. 15 Dec. 2023:

https://www.german-energy-solutions.de/GES/Redaktion/EN/News/2020/20201110-district-cooling-munich.html

- Consumer Substations interfacing with buildings' air-conditioning circuits:

The point of convergence between the district cooling system and the building cooling system is commonly known as the consumer substation. Typically, a consumer substation consists of air handling units, heat exchangers, and chilled water piping within the building. Each user's building requires a consumer substation to establish the connection between the district cooling system-distributed chilled water pipe and the building. Within the consumer substation, heat exchangers are strategically installed to facilitate the exchange of heat between the chilled water supplied by the system and the air-conditioning system of the user's building. Consumer substations can be designed for either direct or indirect connection to the district cooling distribution system. In a direct connection, the district cooling water is distributed directly within the building to terminal equipment such as air handling units, fan coil units, induction units, and similar devices. On the other hand, an indirect connection involves the use of one or multiple heat exchangers positioned between the district system and the building system to facilitate the transfer of chilled water without direct contact. [3]

The figure below shows how these described components are interacting:

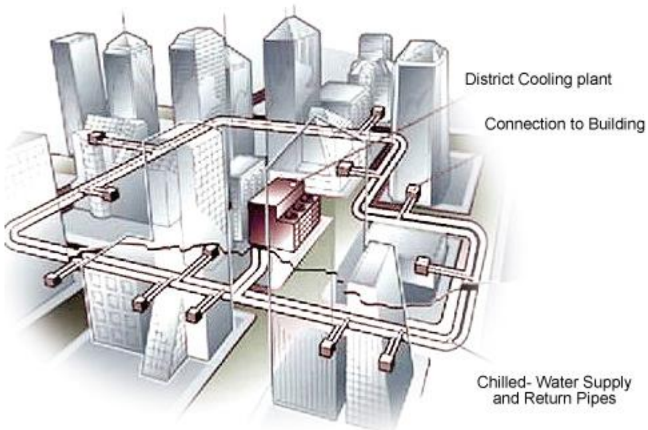


Figure 5: Interaction of the described components of a district cooling system [3]

Reference: District Cooling System (DCS). Electrical and Mechanical Service Department. 14 Dec. 2023: https://www.emsd.gov.hk/energyland/en/building/district_cooling_sys/dcs.html

Other components required for the implementation of a district cooling system are the following:

- Regulation and control elements
- Pumps and valves
- Measuring and monitoring equipment
- Emergency power supply and safety devices

However, these are not discussed in detail in this survey, as many of them are generally found in many systems and their mode of operation is generally familiar.

In the following the engineering process of cooling with deep water sources is described. This is the process behind the Deep Lake Water Cooling System (DLWC) described in the section 'Assessment for retrofitting solutions of district cooling in the district heating network of the city Weiz in Styria, Austria'.

Deep water source cooling (DWSC), also known as deep water air cooling, is a method of air cooling employed for both process and comfort space cooling. This innovative approach utilizes a substantial body of naturally cold water as a heat sink. Water, drawn from deep regions within lakes, oceans, aquifers, or rivers at temperatures ranging from 4 to 10 degrees Celsius, is pumped through one side of a heat exchanger. On the opposite side of the heat exchanger, cooled water is generated.

It is essential to note that water achieves its maximum density at 3.98 °C under standard atmospheric pressure. Consequently, as water cools below this critical temperature, its density increases, causing it to settle. Conversely, as the temperature exceeds 3.98 °C, water density decreases, leading to the water's ascent. This phenomenon explains why the bottom of most deep bodies of water, particularly those distant from equatorial regions, maintains a constant temperature of 3.98 °C.

Air conditioners, operating as heat pumps, play a crucial role in climate control. During the summer, when external air temperatures surpass the interior temperature of a building, air conditioners utilize electricity to transfer heat from the cooler building interior to the warmer exterior environment. This energy-intensive process is characteristic of residential air conditioners. In contrast, modern commercial air conditioning systems often enhance thermodynamic efficiency by incorporating evaporative cooling. In this approach, the cooling water temperature is reduced close to the wet-bulb temperature through evaporation in a cooling tower. The resulting cooled water serves as the heat sink for the heat pump. Deep lake water cooling leverages cold water extracted from the lake's bottom to act as a heat sink for climate control systems. The efficiency of heat pumps improves with colder heat sinks, allowing deep lake water cooling to decrease the electrical demands of sizable cooling systems where applicable. While akin to contemporary geothermal sinks, deep lake water cooling is generally simpler to construct when a suitable water source is available.

Notably, deep lake water cooling achieves higher thermodynamic efficiency by utilizing the colder deep lake water, which surpasses the ambient wet bulb temperature. This heightened efficiency translates into reduced electricity consumption. In certain environmental conditions, the lake water may be cold enough to enable the shutdown of the refrigeration component of air conditioning systems, with the building's interior heat directly transferred to the lake water heat sink—an approach colloquially termed "free cooling." However, it is crucial to recognize that operational components such as pumps and fans are still active during "free cooling," entailing energy consumption. An additional advantage of deep lake water cooling is its ability to conserve energy during peak load times, particularly during summer afternoons when a substantial portion of the total electrical grid load is attributed to air conditioning usage.

This has the following advantages: Deep water source cooling exhibits remarkable energy efficiency, demanding only a fraction—specifically, 1/10—of the average energy required by conventional cooler systems. As a direct consequence of this heightened efficiency, the associated running costs are significantly reduced. This system relies on a highly localized and fully renewable energy source, provided that the discharge of water and heat into the environment—often directed back into the same lake or a nearby river—does not disrupt natural cycles. Notably, deep water source cooling avoids the use of any ozone-depleting refrigerants. Tailored to the building's cooling demand and local weather conditions, deep water source cooling frequently proves capable of satisfying a substantial portion, if not the entirety, of a building's cooling requirements. This capability eliminates the need for mechanical refrigeration through a chiller, resulting in a considerable reduction in the building's electrical demand (or steam demand for applications using absorption refrigeration). Depending on specific needs and water temperatures, a combined heating and cooling approach can be considered. For instance, heat can be initially extracted from the water, effectively reducing its temperature. Subsequently, the same water can be circulated to a refrigerating unit, enhancing the efficiency of cold production. This versatile system showcases its adaptability to diverse requirements while maximizing energy utilization.

There are also some disadvantages: The implementation of deep-water source cooling necessitates access to a substantial and deep-water quantity in the vicinity. Achieving water within the temperature range of 3 to 6 °C generally requires depths ranging from 50 m to 70 m, contingent upon local conditions. The establishment of a deep-water source cooling system is characterized by its significant expense and labour-intensive nature. Moreover, the construction and placement of the system demand a substantial amount of source material. While termed "free cooling" in certain literature, it is crucial to recognize that the operational aspects of deep-water source cooling involve a notable energy expenditure, typically in the form of electricity. This energy is utilized to operate pumps with adequate head pressure to overcome frictional and minor losses in distribution piping, as well as any heat exchangers within the system. Consequently, despite the term "free cooling," the operational phase requires a considerable amount of energy to facilitate the efficient functioning of the system.

The feasibility of incorporating lakes into district systems for both cooling and heating is primarily restricted by the accessibility of suitable lakes. However, additional factors, including the spatial distribution of cooling demand and the associated costs of installation and operation, play pivotal roles in determining the techno-economic potential of lake-source district heating and cooling systems. [10]

The figure below illustrates how deep-water source cooling (DWSC) is working:

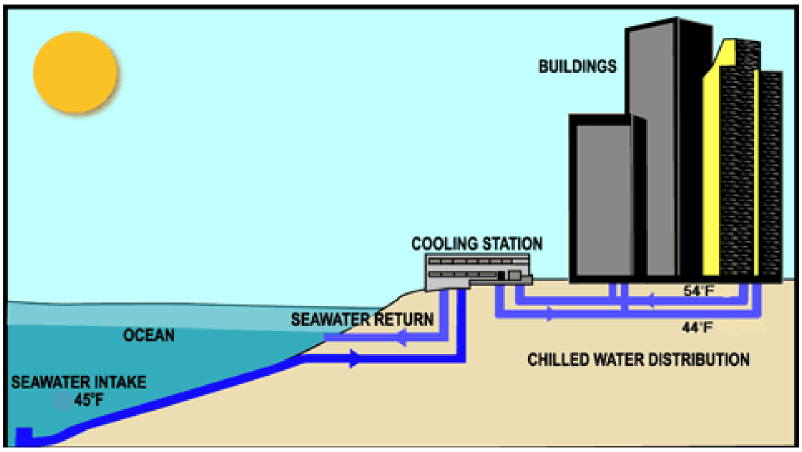


Figure 6: Mode of operation of a deep water source cooling system [11]

Reference: Pala C. "How deep sea aircon could cut the heat of climate change". The Ecologist. 15 Dec. 2023: *https://theecologist.org/2010/apr/13/how-deep-sea-aircon-could-cut-heat-climate-change*

In the following the concept of combined heat and power and cooling processes ('Kraft-Wärme-Kälte-Kopplung' in German) is explained.

Combined heat, power and cooling is an extension of combined heat and power (CHP): the heat generated by a combined heat and power plant, a solar thermal system or a geothermal system is used to operate an absorption chiller or adsorption chiller for air conditioning. The proven principal CHP is supplemented by the aspect of cooling.

The simultaneous generation of electricity, heat and cooling offers the potential to create synergies for the efficient use of resources. With the year-round demand for all three energy products, bundled systems with combined heat, power and cooling can become an economical and resource-saving alternative to separate systems at many locations.

Treated water with a flow temperature of approx. 6 °C is usually used as the cold transport medium (more on this later in the description of the most common pairs of substances). Cooling can be generated in summer to supplement heat generation in winter or, in warmer countries, all year round. In some cities, e.g. Vienna (more information is given at the section 'Assessment for retrofitting solutions of district cooling in the district heating network of the city Weiz in Styria, Austria'), combined heat, power and cooling is also operated on a large scale by feeding large absorption chillers with heat from the existing district heating network. If the cooling is generated centrally, it is distributed to the customers via a district cooling network. In most cases, cold storage facilities are also integrated into such networks in order to cover peak loads.

Although the absorption chiller requires higher investment costs than an electrically operated compression chiller and is more difficult to integrate due to the larger construction volumes, combined heat, power and cooling has its advantages. In summer, not only the hot water preparation serves as a heat sink for the combined heat, power and cooling, but also the evaporator of the absorption chiller. This can significantly increase the number of annual operating hours of the combined heat, power and cooling system and improve its efficiency. Compared to CHP and the additional operation of compression chillers, combined heat, power and cooling makes more efficient use of the primary energy sources used and thus reduces emissions. Although absorption chillers require more space, they are less maintenance-intensive and have a lower noise level. From an energetic point of view, low-energy heat is used instead of electrical energy. From an ecological point of view, no hydrofluorocarbons (HFCs) are used as refrigerants, which is positive.

A pure CHP system without a chiller only runs economically if the heat generated is also used (usually in winter). This means that its electricity generation potential is not sufficiently utilized. The use of a thermally driven chiller can counteract these problems, as the heat can also be used in summer. If the cooling in summer is driven by the heat from the CHP system, the required heat output in summer can be matched to that in winter. The annual duration curve thus extends over the whole year and the number of full load hours of the CHP increases. The peak load boiler and CHP system can then operate in a higher output range all year round and achieve more full load hours and a higher degree of utilization. Systems in this constellation work more efficiently and reduce amortization times. By using the waste heat, the use of primary energy is also reduced compared to compression chillers and CO2-emissions are reduced accordingly. In addition, you benefit in terms of economic efficiency if the heat is available very cheaply or as waste heat, which can compensate for the higher investment costs. [12,13,14]

The figure below illustrates how combined heat, power and cooling systems are working:

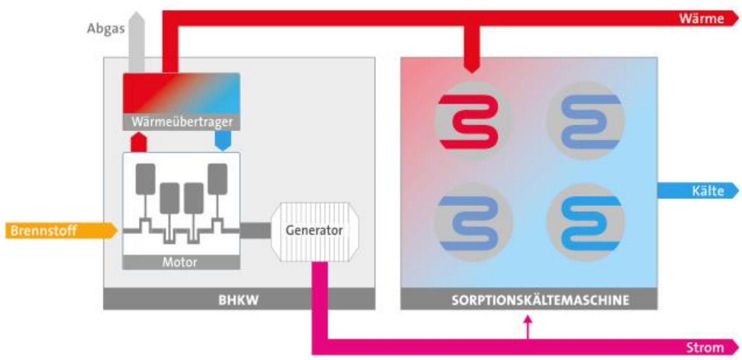


Figure 7: Mode of operation of a combined heat, power and cooling system [12]

Reference: KWKK – Kraft-Wärme-Kälte-Kopplung. ASUE. 15 Dec. 2023: https://asue.de/sites/default/files/asue/themen/gaswaermepumpe_kaelte/2019/broschueren/ASUE_Kraft-Waerme-Kaelte-Kopplung_2019-03_online.pdf

The second point concludes with a comparison of two pairs of substances that are most frequently used at combined heat, power and cooling. The first one is ammonia and water, the second one is water and lithium bromide. A table is used for the comparison.

Table 2: Most frequently used pairs of substances at combined heat, power and cooling [14]

	ammonia/water	***water/lithium bromide***
refrigerant	*NH3*	*H2O*
sorbent	*H2O*	*LiBr*
chilled water temperature	*also below 0 °C*	*> 0 °C*
power requirement solution pump	*2,5 to 6% of the cooling capacity*	*< 1% of the cooling capacity*
properties	*- NH3 is flammable and toxic, but easily recognizable by its smell* *- Increased safety requirements* *- Increased equipment costs and components for low-capacity systems sometimes not available on the market*	*- High risk of corrosion, use of inhibitors necessary* *- Virtually non-toxic and non-flammable substance pair* *- However, inhibitors are very toxic and usually a significant cost factor* *- Cost-effective design*
usage	*for chilled water temperatures below 0 °C and for compact systems*	*for air conditioning applications above approx. 0 to 5 °C*

Finally, there is a list of the advantages and disadvantages of combined heat, power and cooling systems: [12,13,14]

Advantages:

- *Energy efficiency*
- *Emission reduction*
- *Security of supply*
- *Low energy costs*
- *Flexibility*

Promotion of renewable energy Disadvantages:

- *High investment costs*
- *Size restriction*
- *Complexity*
- *Fluctuations in efficiency*

<u>Described of two best practices for district cooling</u>

At the end of this section two existing district cooling systems are described as best practices for district cooling, namely the district cooling system in Austria's capital Vienna and the so-called "Deep Lake Water Cooling System" in Toronto, Canada.

The Austrian capital Vienna is the European showcase for the use of a district cooling system, especially in the summer months. Vienna's municipal energy entity, Wien Energie, has unveiled its strategic initiative to invest significant funds in a district cooling system situated in Stubenring, signaling a noteworthy development in the realm of urban energy infrastructure. Commencing operations at the onset of the summer season 2022, this district cooling facility aligns with the principles of district heating while leveraging existing infrastructure.

Against the backdrop of escalating temperatures attributable to climate change, Vienna is proactively considering the expansion of this innovative service. The official pronouncement outlines Wien Energie's ambition to supply 300 megawatts of cooling capacity by 2030, positioning the Austrian capital as a pioneering model for cooling solutions across Europe. [17]

The figure below shows the district cooling network in Vienna:

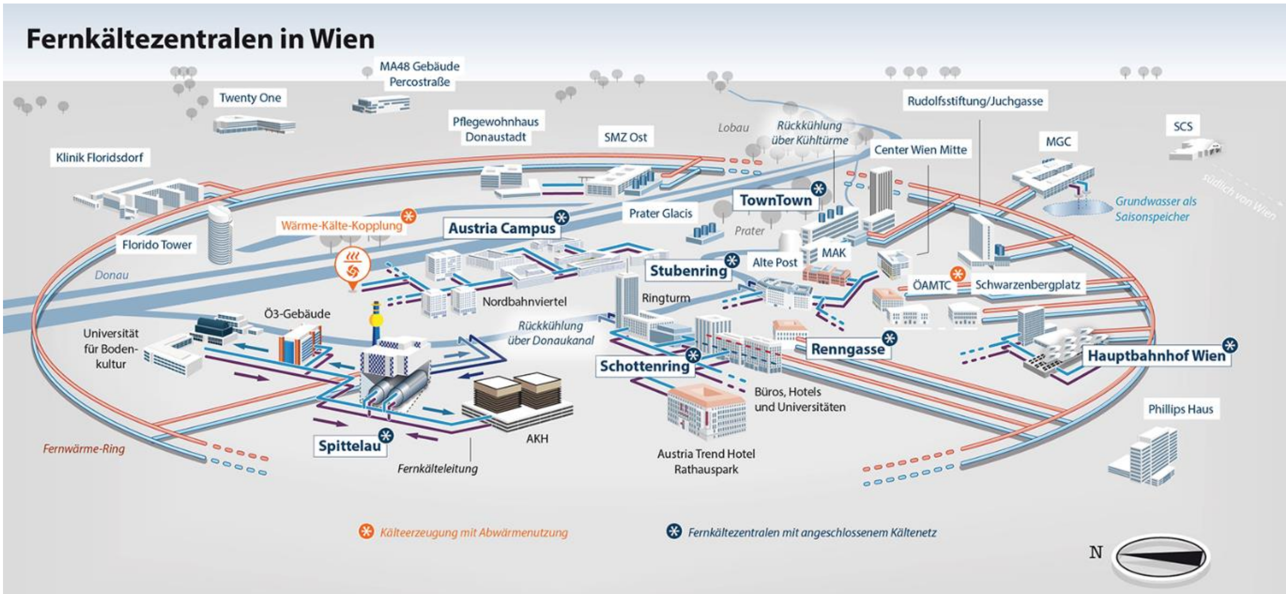


Figure 8: District cooling system in Vienna [18]

Reference: Fernkälte. Wien Energie. 14 Dec. 2023: *https://www.wienenergie.at/ueber-uns/unternehmen/energie-klimaschutz/energieerzeugung/fernkaelte/*

Vienna experienced its highest recorded temperature last June (2021), registering a sustained heat level of 30 degrees Celsius over a 12-day period. Cognizant of the rising frequency of hot days, which has doubled over the past three decades according to Wien Energie, there is a pressing need for a comprehensive solution. Over the last 15 years, Wien Energie has been systematically advancing district cooling initiatives, with a recent emphasis on long-term goals oriented towards emissions reduction.

At present, 180 buildings in Vienna have integrated district cooling, yielding an output of approximately 200 megawatts. This translates into a noteworthy 50% reduction in carbon dioxide emissions and a 70% reduction in energy consumption compared to conventional air conditioning systems. The company asserts that district cooling has effectively replaced nearly 100,000 air conditioners, thus enhancing the carbon efficiency and sustainability of the overall system. The district cooling system in Vienna is 24 kilometers long and consists of 7 district cooling centers and a further 14 decentralized cooling solutions.

The recently operational Stubenring plant, initiated in 2020, can reliably cool up to 300,000 square meters of floor space with an output capacity of 15 megawatts. In alignment with the company's vision for 2030, an official statement indicates plans to expand this capacity to 350 megawatts dedicated to district cooling. Wien Energie's CEO, Michael Strebl, outlines a substantial investment of approximately 90 million euros until 2027 to bolster production capacities within the inner city and select outlying districts.

Key beneficiaries of district cooling presently include substantial entities such as large office buildings, fitness facilities, a hotel, and a university archive. [17]

The Deep Lake Water Cooling System (DLWC) is an innovative project located in Toronto, Canada, designed for renewable energy use. This initiative entails the extraction of cold water from Lake Ontario to efficiently cool buildings in downtown Toronto, including prominent structures like office towers, the Metro Toronto Convention Centre, the Scotiabank Arena (home to NHL and NBA events), a small brewery, and a telecommunications center.

Commencing operations in August 2004, Enwave Energy Corporation, a district energy company based in Toronto, initiated the system by deploying three large pipes extending 5 kilometers into Lake Ontario, reaching a depth of 83 meters. The water at this depth maintains a constant temperature of 4 °C, shielded by a thermocline—an upper layer of water. The water is then transported to a filtration plant and subsequently to a lakeside heat-transfer station. At this station, the cold is transferred to another closed loop, comprised of smaller pipes supplying the city's financial district towers. In the process, cold lake water flows through the source side of heat exchangers located at Toronto's John Street Pumping Station. Simultaneously, a mixture of glycol and water circulates through the load circuit of the heat exchanger, facilitating a net energy transfer from the water/glycol mixture to the lake water. The chilled glycol mixture is then circulated through pumps, reaching fan-coil units in high-rise properties across Downtown Toronto. Here, it absorbs energy, repeating the cycle to provide cooling and dehumidification. A more detailed description of the deep-water source cooling has already been given in the section **'Technical possibilities for district cooling'**. [19]

The figure below shows the Deep Lake Water Cooling System in Toronto:

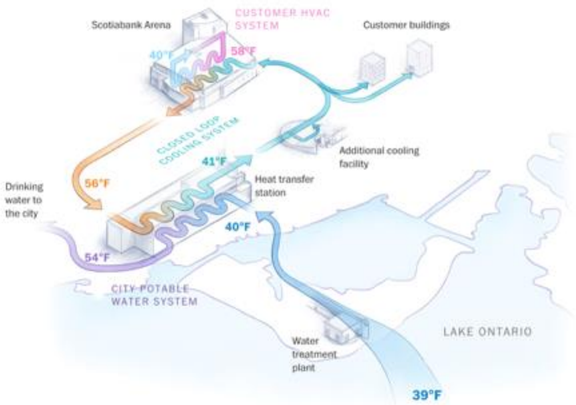


Figure 9: Deep Lake Water Cooling System in Toronto [20]

Reference: James C. M. "Deep Water Cooling Systems Provide an Alternative to Traditional Air Conditioning". Applied Economics Clinic. 15 Dec. 2023: *https://aeclinic.org/aec-blog/2021/12/9/deep-water-cooling-systems-provide-an-alternative-to-traditional-air-conditioning*

This system offers significant advantages, notably reducing or eliminating the need for chiller usage during summer and shoulder seasons, thereby lowering energy consumption. Compared to traditional air-conditioning methods, Deep Lake Water Cooling System slashes electricity use by 75%, eliminating 40,000 tonnes of carbon dioxide—equivalent to removing 8,000 cars from the streets. [19]

In addition, the implementation of district cooling systems is also increasing rapidly in Scandinavia. The Helsinki district cooling system uses the otherwise wasted heat from combined heat and power (CHP) in summer to operate absorption chillers for cooling in summer, significantly reducing electricity consumption. In winter, cooling is achieved more directly with seawater, similar to the principle just described with the Deep Lake Water Cooling System in Toronto. This idea is now also being implemented in other Finnish cities. The use of district cooling is also growing rapidly in Sweden, where it is used in a similar way to Finland. [21]

9.1.4. Criteria for the implementation of district cooling in cities

In the following a description and presentation of the criteria for implementation of district cooling in cities given. The use of district cooling in cities can offer various advantages, both in terms of environmental, economical and efficiency aspects. However, certain criteria must be considered when planning and implementing district cooling systems.

According to studies commissioned by the EU there are nine identified Key Success Factors (KSFs) that contribute to delivering a district combined heat, power and cooling system that is characterized by excellent quality, operational efficiency and long-term sustainability. [15]

The following list describes and explains each KSF: [15]

- *Adequate national policy and regulatory environment:*

National policies provide a solid basis and sufficient incentives for the development of district heating and cooling projects, for example with ambitious CO_2 reduction targets.

- *Direct/indirect financial support:*

While district cooling offers long-term savings, the initial investment can deter some stakeholders, requiring a clear communication of the system's financial advantages. Subsidies such as investment grants or taxes on fossil fuels support the expansion of district district cooling.

- *Focused local policy and coherence with urban planning:*

Local authorities promote district heating/cooling as part of their energy and climate strategies and integrate it into long-term urban planning. Navigating through local regulations and policies that pertain to energy distribution, environmental standards, and land use can pose challenges.

- *Alignment of interests/Cooperation maturity:*

Stakeholders such as authorities at national and local level, end customers and energy suppliers work together efficiently to ensure a sustainable supply.

- *Availability and relevance of local resources:*

Locally available resources have a major influence on district heating and cooling projects. These include, for example, access to renewable energy sources or waste incineration.

- *Comprehensive project development:*

The entire project, from concept to implementation, is planned and coordinated accordingly.

- *Price competitiveness against alternative energy solutions:*

District heating and cooling prices are competitive with alternative energy solutions and can hold their own on the market.

- *Flexible heat and cold production:*

Flexible production can be achieved through a mature energy mix, the use of CHP and an associated improvement in the ramp-up phases, ultimately leading to an optimized cost structure.

- *Combining technical and non-technical innovation:*

District heating and cooling systems incorporate innovations from all areas, from the use of the latest technologies to new strategic decision-making processes.

- *Consumer Acceptance:*

Educating building owners, developers, and residents about the benefits of district cooling and overcoming resistance to change can be an ongoing challenge.

Other criteria that need to be considered for the implementation of district cooling in cities are the following:

- *Technical requirements for the installation and retrofitting in the buildings / at the end users:*

In order to be able to obtain district cooling, the house requires an appropriate cooling/ventilation system, e.g. via component activation or fan coils. This retrofitting is very costly in existing buildings and can usually only be carried out as part of comprehensive refurbishments or is planned from the outset in new builds.

If a cooling system is already in place, retrofitting is possible in principle. However, there are also many factors that are relevant here: existing cooling center in the area, corresponding connection lines, suitability of the house installation, etc. For technical and economic reasons, individual apartments cannot be connected to district cooling.

- *Building density:*

A high building density is often advantageous in urban areas, as many consumers can be connected in a small space.

- *Mix of uses:*

The mix of building uses (residential areas, stores, offices) influences the demand for cooling. A balanced mix can improve the efficiency of the cooling network.

- *Cooling demand:*

Sufficient and stable cooling demand is crucial for the economic operation of a district cooling network.

- *Heat recovery:*

The ability to utilize waste heat from industrial processes or other sources can increase the efficiency of the refrigeration network.

- *Suitable temperature levels:*

District cooling needs suitable temperature levels at different sites.

Examples:

- *If a cooling source (e. g. river) is used, the temperature level needs to be low enough.*

- *If the heat from district heating is used for the operation of an absorption chiller at the cooling center, the flow temperature should be in a suitable operation range (between 80° and 130 °C) for an efficient use.*
- *If you use industrial waste heat or other heat sources for the operation of an absorption chiller at the cooling center, the temperature level should be not too low for an efficient use.*
- *…*

- *Urban planning:*

Close cooperation with urban planners is important to ensure the integration of district cooling into urban development plans.

- *Environmental impact:*

The environmental impact, especially in terms of energy consumption and emissions, should be minimized. District cooling can reduce overall energy consumption compared to local cooling systems, especially if renewable energy is used.

- *Infrastructure:*

The availability of suitable infrastructure for the construction and operation of the district cooling network, including pipelines, is an important factor. Establishing the required infrastructure, including the central plant, distribution network, and building connections, can be complex and costly.

- *Operating costs:*

The costs for the operation and maintenance of the district cooling network must be within an economically justifiable range.

- *Future growth:*

Planning should also take into account future growth and potential changes in the urban infrastructure.

- *Regulatory framework:*

Compliance with all relevant regulations and approval procedures is crucial to ensure smooth operations.

- *Technical Expertise:*

Designing, operating, and maintaining district cooling systems require specialized technical expertise that might be scarce.

- *Integration with existing Infrastructure:*

Retrofitting existing buildings to connect to a district cooling network can be logistically and technically challenging.

It is important to consider all these criteria to ensure that district cooling systems can be used effectively, efficiently and sustainably in urban environments.

9.1.5. Assessment for retrofitting solutions of district cooling in the district heating network of the city Weiz in Styria, Austria

This report concludes an assessment for retrofitting solutions of district cooling in the district heating network of the city Weiz.

<u>Description of the district heating system of the city of Weiz:</u>

Weiz, a city with around 13,000 inhabitants in eastern Styria, has a very well-functioning existing district heating network, the so-called 'Fernwärme Weiz GmbH'. The organisation was founded in 1995 as part of a new energy policy reorientation. The district heating was implemented, although a gas network existed. Due to the high demand, a continuous expansion of the district heating network was pushed forward. As the local energy supplier for the municipality of Weiz, 'Fernwärme Weiz GmbH' intends to expand its network capacities as well as renewable energies other than biomass in its generation portfolio for the security supply and ecological reasons. 800 customers are currently supplied with around 60,000 MWh/a of district heating. The heat is generated by 4 biomass boilers and an industrial feed-in.

Technical data:

- Network length: approx. 50 km (underground)
- Number of consumers: ~800 #
- Current existing heat supply systems (boiler systems): Biomass boiler + feed (bio)oil boiler + industrial waste heat
- Feed-in capacity of the existing system: 32 MW
- Flow and return temperatures:
  - Flow temperatures: 90 - 105°C
  - Return temperatures: 45 - 55°C
- Pressure in flow and return pipe at feed-in point:
  - Flow pipe: 13 [bar]
  - Return pipe: 6 [bar] [16]

<u>Retrofitting Assessment</u>

For a retrofitting of district cooling in the city Weiz several steps need to be taken into account, that are corresponding to the above-mentioned criteria in the previous section.

The following table contains an assessment for the implementation of a district cooling system in the district heating network of the city of Weiz:

Table 3: Assessment for the implementation of a district cooling system in city of Weiz

Criteria for retrofitting of district cooling	
Technical requirements for the installation and retrofitting in the buildings	very critical
Suitable temperature levels	very critical
Infrastructure	very critical
Integration with existing Infrastructure	very critical
Alignment of interests/Cooperation maturity	critical
Direct/indirect financial support	critical
Price competitiveness against alternative energy solutions	critical
Flexible heat and cold production	critical
Combining technical and non-technical innovation	critical
Urban planning	critical
Technical Expertise	critical
Consumer Acceptance	critical
Adequate national policy and regulatory environment	not critical
Focused local policy and coherence with urban planning	not critical
Comprehensive project development	not critical
Operating costs	not critical
Availability and relevance of local resources	not critical
Building density	not critical
Mix of uses	not critical
Cooling demand	not critical
Heat recovery	not critical
Environmental impact	not critical
Future growth	not critical
Regulatory framework	not critical

The assessment for the implementation of a district cooling system in city of Weiz in the table above illustrates well that a number of steps still need to be taken before implementation, although some criteria have already been (almost) completed.

It is essential to clarify the legal framework and general policy with regard to energy. It is important to clarify both the national guidelines and the guidelines of Styria. In the following local policy must also be taken into account and there must be a consensus with urban planning in general. The district heating network of the city of Weiz provides an existing infrastructure. The necessary components (see the section **'Technical possibilities for district cooling'** for more information) must be purchased and the financial conditions must be clarified.

The financial side of this project is generally the crucial point that needs to be clarified in advance before the project is planned in detail. Not only do the investment costs, which will be significant, have to be taken into account, but the ongoing operating costs also play a major role in project planning. The financial support of any kind (funding from the state, the province, etc.) and the willingness of the stakeholders involved, the city of Weiz itself and the district heating network operator to bear the costs must also be taken into account.

Once these key points have been clarified, the next step is to align the interests of all project partners involved so that comprehensive project development and planning can then begin. In this phase of the project, it is important that the structures are clarified and that it is clearly documented who has to do what for which part of the project, including time deadlines.

As this project involves an energy supply with renewable energy sources, it is also essential to clarify whether sufficient relevant local renewable resources are available. They must also be price-competitive with alternative energy solutions.

From a technical point of view, it is then necessary to clarify in the final planning phase whether flexible heating and cooling generation is possible at all (and whether this will not be too expensive if the answer is positive) and whether the combination of technical and non-technical innovation makes sense.

It also makes sense to take the city of Vienna with its existing and functioning district cooling system as an example and possibly establish contact with those responsible in order to be able to access their know-how and at the same time gain expertise in the implementation of a district cooling system. The other example described of the city of Toronto is not applicable in the city of Weiz, as the conditions for this system simply do not exist.

Roadmap for retrofitting district cooling in the city of Weiz

1. Professionally design of the overall urban energy system: At the heart of district cooling systems lies the pursuit of energy efficiency. Professionally designed systems can significantly reduce electricity consumption for cooling purposes, which is a notable concern in energy-intensive urban environments.
2. Demand estimation: Accurate estimation of cooling demand is essential to determine the appropriate capacity of the central plant. Factors such as climate, building types, occupancy patterns, and cooling loads must be thoroughly analyzed.
3. Network design: The layout of the cooling network plays a pivotal role in optimizing energy distribution. Engineers must carefully design the pipe network to minimize heat losses and ensure efficient water circulation.
4. Integration with renewable energy: Incorporating renewable energy sources into the district cooling system can enhance its sustainability profile. Solar energy, waste heat recovery, and geothermal sources can all contribute to the energy mix.
5. Environmental impact: While district cooling reduces direct emissions, its environmental impact should be holistically assessed. The energy sources powering the central plant and the materials used for the infrastructure should align with sustainability goals.
6. Cost-benefit analysis: A comprehensive cost-benefit analysis should weigh the initial investment against long-term operational savings and environmental benefits.

Conclusion

As urbanization also in the city of Weiz continues to reshape the landscape, district a cooling system emerge as a strategic solution to address energy efficiency and environmental concerns. While the planning and implementation of such a system in the city of Weiz come with their share of challenges, the potential benefits in terms of reduced energy consumption, lowered emissions, and enhanced urban sustainability are undeniable. With careful consideration of key factors and proactive mitigation of challenges, a district cooling system in the city of Weiz can pave the way for cooler, greener, and more sustainable city.

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11. List of figures

12. List of tables