

<b>Subject:</b>	<b>Methodical approach of transformation plans</b>
Short description:	<i>This document describes a methodical approach for a transformation plan</i>
Date of last update:	10.07.2023
Authors:	Stefan Hay; Daniel Heiler, AGFW
Region, country	Baden-Württemberg, Germany
Partners involved	Solites, HIR
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a>

## Initial situation

The model region Baden-Württemberg (BW) has some 11 Mio. inhabitants. According to the "climate protection law" of BW every city with more than 20.000 inhabitants is obliged to conduct a heat plan, which includes the heat demand of the entire city. This obligation applies to 103 cities with some 5,6 Mio. inhabitants together. Out of these 5,6 Mio. inhabitants, 2,3 Mio. are living in cities, which have district heating (dh) networks. The rest is normally supplied via individual heating sources, mostly gas- or oil fired. One of the challenging tasks is to convince the cities without dh networks to switch from individual heating sources to dh networks. One of the measures, to support the change to dh networks is the introduction of CO<sub>2</sub> prices for fossil fuels. Nevertheless this fact sheet concentrates only on cities with already existing dh networks and which are obliged to perform a heat plan. The heat plan should serve as a basis for the future heating infrastructure and the transition plan and has to include the following aspects:

- Inventory analysis of heat demand and supply infrastructure
- Potential analysis of renewable energies and waste heat
- Establishment of climate-neutral target scenario in 2040, with intermediate step for 2030; 2030 has already an agreed target with 45% of renewable heat for district heating
- Municipal heat transition strategy with catalog of measures, to decarbonize the heat generation

The transformation plan itself has to include, besides the heat plan, a decarbonisation strategy for the whole dh network, as well as a reduction of the network temperatures which influences the customer's side also; that is why, a methodical approach for a transition plan is needed.

## Objectives

The main objectives are already mentioned in the "Initial situation", above. The first very concrete objective is to have 45% of renewable heat for the district heating generation by 2030 and to be climate neutral by 2040.



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

To reach these targets a transformation plan with all necessary measures has to be conducted. To accelerate the transformation in the district heating (dh) sector the German Government wants to introduce a new guideline, which is called "Richtlinie für die Bundesförderung für effiziente Wärmenetze, (BEW)", "guideline for federal funding of efficient heating networks", which should come into force this year. In the draft of the BEW a minimum of 75% renewable heat has to be integrated in a dh network, in order to get funding according to the BEW.

Besides the technical aspects, the communication with stakeholders and the public is inescapable, especially when it comes to special techniques, like deep geothermal or solar thermal. As the reality shows, it is not always easy, to convince people and to create acceptance; it takes time and slows the whole process down.

### Description of the measure

Initially a literature research needs to be done to elaborate the methodical approach to the transformation of existing dh systems (ca. 1 month). The result will afterwards be discussed with the RES-DHC Team as well as experts of AGFW. The main challenges are to create an approach that is able to be adapted to the local conditions of the district heating system as well as to the upcoming national funding programmes (ca. 1 month).

After the methodical approach was elaborated, it is planned to test it with at least two district heating systems in Baden-Württemberg. These application of the methodological approach are planned to be initial consultation, that will need further improvements by the dh utilities afterwards and besides that as a result of that the whole dh community will benefit from the lessons learned using the methodical approach in this initial consultation. The challenge is also in the acquisition of these two dh utilities. The measure to overcome these challenges is to make the dh community aware of this methodical approach as well as to start a call for initial consultation in relevant magazines (ca. 1 up to 6 month).

The target groups of the RES-DHC measure are district heating utilities, planners/engineering offices, cities and municipalities. These stakeholders / target groups need to act in the methodological approach on different stages. This has also to be considered in the methodological approach.

- Stage 1: Utility companies as well as planners/engineering services need to identify potentials open to technology
- Stage 2: Utility companies, planners/engineering services, city committees, political decision-makers (citizens' committees, etc.): Definition of objectives, rough concepts for technical implementation

Core elements of the methodological approach are:

1. Analysis of the current state
2. Potential analysis of the supply area
3. Development of targets (desirable: common elaboration with local stakeholders)



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

4. Creation of a transformation plan: Summary of the previous partial steps into a coherent document
5. Implementation of the transformation plan and achieving the targets

Goal for the methodical approach in the RES DHC model region Baden-Württemberg is to identify technology-open the potentials of RES in existing DHC systems, improving the dialogue between city/utility/citizens for creating a common objective as well as the evaluation of solutions:

- increase the renewable share in existing dh systems
- target group are primarily cities between 10.000 and 100.000 inhabitants.
- Key parameter: percentage share of renewable energy in heat supply; goal: 45% renewables in 2030

In the final report of this measure the methodologic approach will be revised based on the feedback of the target group involved. It is assumed that this methodologic approach for the transformation of exiting DH systems is highly needed and will empower stakeholders to make the best decision for increasing the share of RES in DHC in Baden-Württemberg.

## Results

In connection with measure 1, the methodological procedure was presented in four virtual workshops with four different utility companies in Baden-Württemberg. After the announcement of the search for practice partners, the companies had applied for the application via a press release and corresponding notices on the website or in social networks. By applying the methodological procedure to the four enquiries, different focal points for the local boundary conditions were identified.

- **Supplier 1: Focus on transformation strategy**
  - Operates three district heating networks
  - Decarbonisation through local RE
  - Grid expansion, interconnection of grids
- **Supplier 2: Achieving climate targets through the construction of heating grids**
  - District-scale heating grids
  - Large potential of local RE available
  - Efficiently developable through heat grids
  - New construction of heat grids required
- **Supplier 3: Efficiency increase through modernisation**
  - Operates a small district heating network
  - Modernisation of heat generation
  - Maintenance strategy for heating network
- **Supplier 4: Changed customer requirements**
  - New heating network in neighbourhood
  - Increasing the share of RE



Individual heat supply systems have historically developed due to local constraints.

Detailed workshops were conducted with two of the four utilities. The results of these workshops have been documented and published [5, 6].

**Based on this, the following result can be stated for the measures M1:**

Achieving the climate targets requires decarbonisation, transformation and further measures to optimise these existing systems. A methodical approach ensures that existing potentials for implementing the climate goals can be identified. The development of identified potentials requires suitable measures and the necessary acceptance of the acting actors. The BEW funding guideline and the municipal heat planning, which is obligatory in BW, are good tools for achieving the climate goals, for which further capacity building is necessary.

## Lessons learned & Impact



Figure 1: Challenges and tools of district heating utilities on the way to climate-neutral heat supply


The following points summarise the "lessons learned" from the measures Methodical approach to the preparation of a transformation plan for district heating systems:

- A methodical approach to increase the share of RESinDHC is the best way to achieve the climate targets.
- Status analysis and recording of local potentials are "low hanging fruits".
  - Transformation plans and the derivation of measures are simple compared to the decision-making process based on them and the subsequent implementation of the measures
- Climate goals:
  - Climate neutrality is defined as a goal in the model region of Baden-Württemberg by 2045.



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

- But the development of important milestones to reach this goal is difficult (at local level)
- Decision-making and implementation processes
  - Further investments and partly also further feasibility studies are necessary (e.g. BEW-Module I)
  - Technical challenges
  - Organisational development
  - Business development
  - Approval processes
- Uncertainties in the development of transformation strategies in the companies
  - Further investments and, in some cases, further feasibility studies are necessary (e.g. BEW-Module I)
  - F. e. Heat demand, expansion targets, future developments etc.
  - High investments are required to achieve the climate targets through the implementation of measures; existing risks hinder the decision-making process.

*The sole responsibility for the content of this website lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein.* 



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

<b>Subject:</b>	<b><i>DH companies fit for RES in DHC</i></b>
Short description:	<i>Activate and support DH companies in BW increasing the share of RES in DHC</i>
Date of last update:	10.07.2023
Authors:	Stefan Hay; Daniel Heiler, AGFW
Region, country	Baden-Württemberg, Germany
Partners involved	Solites, HIR
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a>

## Initial situation

The implementation of the political goals to achieve climate-neutral heat supply creates an enormous time and cost pressure on district heating supply companies. In the short and medium term, the companies have to cope with additional tasks such as the development of transformation strategies as well as heat plans and their implementation. At the same time, it can be assumed that the integration of renewable heat sources will increase the decentralisation of heat generation in the existing district heating systems and possibly also the volatility of the available heat generation plants, which will consequently increase the complexity of the system. Under these circumstances, it is a challenge for the companies to make responsible and long-term decisions in connection with high investments.

## Objectives

The main objective is to bring the target group of district heating supply companies and expert planners into action through expert events, as well as to offer assistance for the implementation of measures to increase the share of RES in their heating networks. On the one hand, the migration of research results / practical examples should contribute to the reduction of inhibitions towards RES technologies in the target group and thus enable a technology-open solution path. On the other hand, the events contribute to making key actors fit for RES in DHC and prepare them for future tasks. At the same time, the events help to qualify companies for the future challenges and, for example, to identify personnel bottlenecks in grid operators, technical planners and implementation companies for the implementation of the developed measures at an early stage. The RES-DHC activity also aims to offer companies a platform for exchanging experiences.

## Description of the measure

Successful measures to increase the RES share in DHC require adjustments of the system components heat generation, heat distribution and heat consumption. The planned events for district heating suppliers and planners are thematically divided into these three areas and will start with heat generation: An online seminar on the topic of heat extraction is scheduled for 18.08.2021. The AGFW member companies in Baden-



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*



Württemberg and the members of the RES-DHC RSAG Model Region BW have been invited to attend. The members of the RSAG, as multipliers and representatives of other target groups in BW, were additionally encouraged to distribute the invitation to members, partners and interested parties. Based on the initiating online event, an exchange of experiences between the interested companies is planned until December 2021, in which the current measures for the integration of renewable heat generation technologies in the district heating networks of the individual companies will be discussed.

In the first half of 2022, the RES-DHC activity will focus on technical measures to adapt heat consumption. The user behaviour of heat consumers offers various possibilities for increasing the efficiency of existing district heating systems: In addition to increasing the share of renewable heat generators, CO<sub>2</sub> savings can also be achieved through optimised operation. For this purpose, operating data must be collected, processed and made usable for demand side management. In addition, technical solutions for lowering operating temperatures through customer measures will be discussed during the events.

An event on the effects of corresponding measures on heat distribution is planned for the second half of 2022, building on the topics of heat generation and heat consumption. The changes to the hydraulics of the heating network, changed requirements and suitable installation systems will be discussed and the necessary specialist knowledge will be imparted.

It is planned to organise the series of events according to the needs of the utilities and, starting with a general overview, to repeatedly offer more in-depth opportunities. This can take place, among other things, in the workshops planned for WP 3 and / or in technical excursions planned for 2022 or 2023.

## Results

The implementation of political goals to achieve a climate-neutral heat supply creates enormous time and cost pressure on district heating utilities. Successful measures to increase the share of RE in the district heating system require adjustments to the system components of heat generation, heat distribution and heat consumption. In the short and medium term, the companies have to cope with additional tasks (e.g. transformation plans). Under these circumstances, it is a challenge for the companies to make responsible and long-term decisions in connection with high investments.

Contacts have been made with the utilities and the companies have signalled great interest. In the personal exchange with these utilities it became clear that there is already a lot of knowledge about the use of RESinDHC in the companies. Despite the great theoretical knowledge of the RES-DHC project partners, the implementation of the planned workshops in measure M2 would only have been possible by bringing in external experts and additional personnel and financial resources.

In addition, the personnel load of the employees in the companies is currently high due to the limited human resources in the companies. This is also shown by the fact that the companies could not participate in the expert excursion "Geothermal energy and municipal heat planning" due to the high number of appointments in the companies.



Taking into account the current workload of the experts in the companies, the RES-DHC partners decided to reduce the planned three meetings to one meeting on 20 July 2023. The DH operators in BW were invited to participate in this workshop.

Based on an exchange of experience between the utilities on instruments such as municipal heat planning and the BEW subsidy, the workshop is to formulate impulses for the industry to achieve the climate targets. These are then to be documented in the report on the results and thus mirrored to the European Commission.

## Lessons learned & Impact

The following points form the "lessons learned" from M2 "District heating suppliers fit for renewable energies in district heating":

- District heating utilities have extensive expertise on RES in DHC.
- They are interested in solving current challenges for further detailed analysis (BEW, municipal heat planning, feasibility studies, etc.) and would like to discuss solutions for their local system in particular here
- Despite the great theoretical knowledge of the RES-DHC partners, achieving the objectives of the measure requires a much greater level of detail due to the high demands or expectations of the utilities. This would have required additional personnel and financial efforts (e.g. involvement of external experts), which cannot be considered feasible with the available project funds.
- In connection with this is also the high workload in the companies Effort/Benefit
- Based on these developments, a new concept for a practice-oriented workshop was developed. This new concept will do more justice to the needs of the utilities under the current developments.

└ The sole responsibility for the content of this website lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein. ┘



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*



<b>Subject:</b>	<b><i>Helpdesk (direct support) for RES in DHC</i></b>
Short description:	<i>Give DH companies and planners the opportunity to ask questions concerning RES in DHC by having a direct contact person on the national webpage</i>
Date of last update:	10.07.2023
Authors:	Stefan Hay, AGFW
Region, country	Baden-Württemberg, Germany
Partners involved	Solites, HIR
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a>

## Initial situation

The implementation of the political goals to achieve a climate-neutral heat supply by 2040 in Baden-Württemberg poses enormous challenges for utilities, planners, investors and cities or municipalities: The electricity, heating and transport sectors must be decarbonised and transformed. Existing district heating networks can make a major contribution to this. In the various organisations, the people involved largely have a basic knowledge of RES in DHC that is insufficient to meet the challenges and as a basis for important long-term corporate decisions. As a result, it can be assumed that trade actors will become aware of the RES-DHC project during their research.

## Objectives

The activity of the immediately support for RES in DHC pursues the goal of supporting stakeholders and decision-makers in their process as quickly as possible. The experience of the RES-DHC partners from past research and implementation projects shows that there are many questions to be answered in this process, which can be accelerated by impulses from research or implementation projects as well as the mediation of experts, e.g. in a short telephone call. The activity is aimed at all groups involved in finding solutions to the issue of increasing the share of RES in DHC. In addition to technical, legal and funding policy issues, the RES-DHC partners can refer experts for any issue through their existing network.

## Description of the measure

The national project website has been created and initial technical information and online seminars have been held to raise awareness of the RES-DHC project. The next step is to create a direct contact person on the national website for questions about RES in DHC. Interested stakeholders can contact this person. If the enquirer sends an e-mail, they will first receive an acknowledgement of receipt of their enquiry. After the enquiry has been processed, appropriate measures are initiated. The following measures are envisaged here:



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

- Direct reply by the processor,
- forwarding to a suitable RES-DHC partner,
- Arrangement of a telephone or web appointment (max. 30 min.),
- Mediation of contacts to suitable experts,
- Reference to suitable literature or practical examples,
- Reference to RES-DHC workshops and events,
- Offer of individual support, e.g. organisation of a joint workshop / initial consultation by the RES-DHC project.

The requests will be collected and evaluated in the processing of the project. It is expected that the activity will identify further challenges and bottlenecks in the implementation of RES in DHC. If the results of this evaluation are representative, recommendations can be developed based on the needs of the practice and used to improve the framework conditions.

## Results

The Helpdesk measure was launched with the press release on 01.02.2022 and since then it has been possible to send requests to the German consortium via the RES-DHC website. So far, three enquiries have been received and the partners have been able to answer them. All enquiries were made immediately after the press release was published. Since then, no further enquiries have been received via the helpdesk.

Based on this experience, the German RES-DHC partners have decided to support the community through online webinars, information e.g. via LinkedIn & professional excursions. The LinkedIn activities have shown that the RES-DHC project can extend the reach and support of the DHC community by disseminating workshops, professional excursions and reports on current topics via social networks.

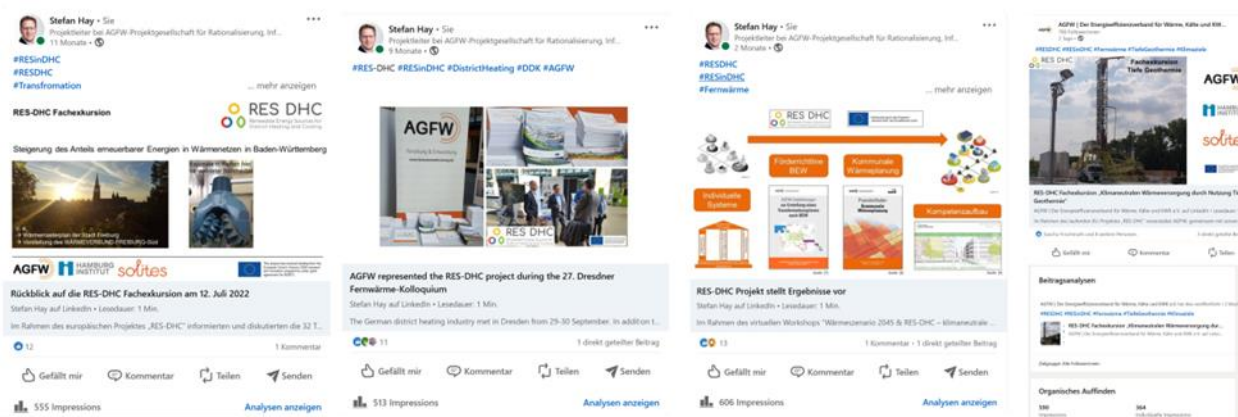


Figure 1: Proof of LinkedIn activities and people reached based on statistics



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.

## Lessons learned & Impact

As a result of the measure, it can be stated that

- The helpdesk is not used.
- Companies and actors obtain information on RESinDHC via social media, (online) workshops and field trips. Consequently, such offers are suitable formats to reach interested professional audiences
- During the events and workshops held for the model region
  - discussions took place
  - open questions could be clarified
  - participants benefit from the operational experience / lessons learnt of others
  - participants were able to expand their personal network through exchange with others.

In future projects, the focus for knowledge dissemination should be on social media, workshops (virtual / present) and excursions.

┐ *The sole responsibility for the content of this website lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein.* ┐



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

Subject:	Qualitative assessment of municipal heat planning
Short description:	<i>Defined quality criteria are reviewed on the basis of at least one accompanied municipal heat planning process in Baden-Württemberg and, if necessary, further criteria are derived. An evaluation of the process flow and the results will be transferred into possible recommendations for action.</i>
Date of last update:	31.08.2023
Authors:	Sabine Ott, Patrick Geiger, Michael Kübler, Dirk Mangold (Solites)
Region, country	Baden-Württemberg, Germany
Partners involved	AGFW, HIR
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a>

## Initial situation

In the target region of Baden-Württemberg, municipal heat planning has been mandatory for all urban districts and large district towns since the beginning of 2020 as part of the amendment to the national climate protection law (KSG BW). For all non-compulsory municipalities, a corresponding funding programme has been adopted as an incentive to carry out municipal heat planning.

Heat planning is a valuable instrument for municipal climate protection and provides a suitable basis for the transformation and decarbonisation of existing heating networks. Heat planning includes four essential steps:

1. status analysis
2. potential analysis
3. development of a target scenario
4. heat transition strategy.

For all municipalities, in addition to the personnel challenge and the lack of specialised personnel, there is also the demand for high-quality heat planning. This is where this action should come in and support the holistic execution and implementation.

## Objectives

To assure a high quality of heat planning, defined criteria will be reviewed on the basis of at least one accompanied project and further evaluation criteria are derived. It will be analysed whether the introduced municipal heat planning in Baden-Württemberg is suitable as an instrument for the transformation and decarbonisation of existing heating networks. Specifically, the essential factors as to how the heat planning



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

must be carried out in order to be able to deliver the best possible results with regard to a realisable decarbonisation of the heating sector will be worked out. These findings as well as the elaborated evaluation criteria will be prepared for the partner countries within the framework of RES-DHC in order to initiate municipal heat planning or similar instruments there and to achieve a high quality of the measures from the very beginning.

Municipal representatives, urban- and energy planners and other specialised planners are seen as the target group.

### Description of the measure

In a first step, possible existing quality requirements for municipal heat planning are evaluated on a theoretical basis and further quality requirements are developed on this basis.

Possible criteria are, for example:

- Compliance with a structured process (e.g. KEA-BW action guidelines on the heat transition).
- Compliance with legal requirements such as KSG BW §§ 7c, 7d
- Use of suitable data sources for the collection of relevant parameters and validation of the collected data, which correspond to the state of the art (e.g. comparison of several sources).
- Use of suitable methods and data sources for potential analyses
- Application of relevant standards/guidelines such as VDI 2067, DIN 4701 and others

With the professional support of the heat planning of at least one concrete municipality, the developed criteria are applied, analysed and continuously evaluated and supplemented on the basis of the knowledge gained. For this purpose, the process is monitored and discussions are held with those responsible and those involved. In addition, the problems and obstacles that arise, as well as the driving factors during the entire process of municipal heat planning, are analysed in order to derive recommendations for actions for the respective municipality on the basis of a SWOT analysis.

In addition to the technical feasibility of measures to decarbonise the heating sector, non-technical aspects are also considered at the municipal level in order to obtain a holistic picture of the course of heat planning.

Non-technical parameters are for example:

- Personnel utilisation through heat planning
- Targeted measures to facilitate processes (e.g. founding of working groups)
- Availability of necessary know-how and competences

The entire findings of the qualitative assessment of municipal heat planning are processed into generalised recommendations for action to optimise and improve the process. The main recommendations for action will be prepared in order to promote and support similar concepts in the RES-DHC model regions.



Possible key topics are, for example:

- Procedures and templates for data collection
- Recommendations for action regarding suitable tools (see HW KEA-BW)
- Collection of suitable technical measures
- Criteria catalogue for the evaluation of heat planning on the basis of defined parameters

The definition and criteria development was targeted to be completed in early summer 2022. Based on this, monitoring of the project began in parallel. The outcomes differ in some parts from the expected criteria as listed above.

## Results

The following results are not only based on the findings of the heat planning of at least one municipality, but on the exchange in a network for heat planning consultancies that was initiated and is driven by the energy agency of the Country of Baden-Württemberg.

The heat planning in the model region Baden-Württemberg began slowly based on the fact that the model region was the first country in Germany that legally asked for heat planning in all cities with more than 20.000 inhabitants. Some pioneer cities started even earlier as asked for, some others decided to never start although they are obliged.

The public authorities have to tender the consultant for executing the heat planning. This tendering process mainly regards the cost and not the references or the expected quality of the promised results. Thus the market for heat planning consultancies had to find its way which companies can offer what kind of work to what cost. Thus especially the extend of the final results for heat planning differs in a broad range between the different already finalized heat plans.

An important basis is the guideline for heat planning that is published by the energy agency of the Country of Baden-Württemberg and updated several times. These guidelines could ensure a basic quality of the obtained heat plans.

One main obstacle occurred in the question of the heat planning process should not only focus on the result where to realize a district heating network and where the single houses has to solve the decarbonisation of the heating sector by their own but in addition on the answer how to produce the renewable heat that is needed for the district heating networks. When woodchips are not the main heat source, most renewable energies need land to build solar thermal systems, PV systems, geothermal systems, heat storages etc. on. The clearance of the availability of land area for that purpose was intended to be solved within the heat plan consultancy. The reality showed that this could be solved in only very few heat planning processes. One of the main reasons herefore is that the clearance of land availability needs different authorities not only of the city



but also of the district or region. To coordinate all tasks for that and to derive results needs much time and was often not possible to finish within the year that was available for the heat planning process.

### Lessons learned & Impact

The following lessons learned are not only based on the findings of the heat planning of at least one municipality, but on the exchange in a network for heat planning consultancies that was initiated and is driven by the energy agency of the Country of Baden-Württemberg.

- A guideline for heat planning that is (more or less) obligatory to follow in the heat planning process is a necessary basis for the tendering cities and for the consultancies to develop a same understanding of what to do, how to proceed and which results are to be expected. The guideline should be issued by an independent authority like the energy agency of the country or equal.
- The tendering process for a heat planning consultant should not only focus on the lowest cost but also on the professional capability of the providers. Heat planning is in some aspects a new task so that not all consultants may be aware of the tasks they have to manage.
- It should clearly be defined from the beginning if the main target is only to derive priority areas for the realization of district heating networks and as alternative for individual solutions to decarbonise the heating of houses or if the target is more comprehensive with including the clearance of the renewable energy sources for the district heating systems and for the individual houses.
- When targeting the entire decarbonisation of the heating sector, most cities need quite an amount of land to build renewable energy productions like solar thermal systems, PV systems, heat storages etc. These land areas have to be close to the heat sinks and thus in or nearby the cities. This task is in most cases totally new for the consultancies, the city planners, authorities etc. They all have a high need for information about the new technologies and training how to handle them.

└ The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein. ┐



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*



Subject:	Practical technical issues for the integration of solar thermal systems into district heating networks
Short description:	<i>Development and presentation of specific solution options for the technical integration of large-scale solar thermal systems into an existing heating network. In addition to the different integration options (centralised/decentralised), the requirements for the feed-in point in the heating network are described.</i>
Date of last update:	31.08.2023
Authors:	Sabine Ott, Patrick Geiger, Dirk Mangold (Solites)
Region, country	Baden-Württemberg, Germany
Partners involved	AGFW, HIR
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a>

## Initial situation

In Germany, a total of 44 large-scale solar thermal plants with a collector area of around 107,000 m<sup>2</sup> and an output of around 75 MW were in operation in district heating at the end of 2020. The share of renewable energies in the district heating supply is around 10 %, whereby this share is mainly covered by biomass combustion and waste heat from waste incineration plants. So far, solar thermal energy played a minor role in the generation park. The solar thermal potential is enormous. Covering the summer demand alone, which accounts for about 15 % of district heating generation, could already make a significant contribution to CO<sub>2</sub> reduction with an expansion of large-scale solar thermal plants and their integration into heating grids. For such a scenario, about 30 million square metres of collector surface would still have to be built and installed in Germany.

A lack of knowledge about large-scale solar thermal systems is sometimes one reason for the insufficient discussion of this technology, which makes the conceptualisation and planning of such systems more difficult. Especially the integration into existing heating networks seems to be a challenging task for many operators and planners. In addition to fundamental land-use discussions, the search for a suitable location is above all also technically motivated. The hydraulic requirements for integrating a large-scale solar thermal system into existing heating networks, and which implementation and solution options come into question, are often still unknown in the market.



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

## Objectives

The aim of the action is to provide detailed information on the basic and hydraulic integration of large-scale solar thermal systems in heating grids and thus to improve and deepen the knowledge of the target group. On the one hand, this enables more frequent exploitation of the potential for the use of solar thermal energy in heating networks, and on the other hand, it improves the quality of the planning and implementation of solar thermal systems and their integration into heating networks.

The measures of this action contribute to an even greater awareness of large-scale solar thermal plants as an essential renewable heat generation system and to a better assessment and consideration of the necessary boundary conditions from the outset.

The extended goal is to increase the share of large-scale solar thermal plants and thus the total share of renewable energies in existing heating grids in Baden-Württemberg and beyond.

The target group of the action are urban utilities, heating network operators and specialist planners.

## Description of the measure

- First of all, the basic technical contents are developed. This includes, for example, the following focal points: Development and preparation of the basics of decentralised and centralised integrations of large-scale solar thermal systems into urban heating networks. The different integration options are described and defined on the basis of boundary conditions that are decisive for the connection options to an existing heating network.
- Elaboration and preparation of the technical framework conditions and prerequisites for the different, predefined integration options of large-scale solar thermal plants in urban heating networks.
- Presentation of different integration options including the corresponding hydraulic concepts. Feasibility and implementation success of the different hydraulic integration options are described and evaluated on the basis of realised projects. The technical functionality (is the result corresponding to the planning?) and the complexity (technical and temporal expenditure) of the implementation are used for the evaluation.
- Elaboration and description of the advantages and disadvantages of the respective integration options on the basis of the evaluation of realised projects.
- Compilation of relevant standards and guidelines for the planning and design of large-scale solar thermal systems (VDI 6002, VDI 2067, etc.).

The prepared content is made available to the target group via existing communication channels:



- Reference materials for download on the homepage. On the one hand, a guide for planners and energy engineers is to be produced with all the topics worked out, and on the other hand, several "at a glance" fact sheets can be made available for different focal points dealt with as clear summaries.
- Contribution to a training course for heat network planners (e.g. training course on "Renewable and energy-efficient heat networks").
- Publication of a technical article in a relevant journal
- Contribution (technical lecture) at further technical events for suppliers and operators.

Completion of the basic content described was planned for mid-2022 and could be achieved. After that, dissemination of the prepared content and knowledge transfer began as described.

Indicators for measuring the impact are the download numbers on the homepage and the reach of the respective dissemination activities (audience of expert lectures, circulation of journal).

## Results

Based on a market scan for realized solar thermal plants their system integration was in detail analysed. Focus was put on two main parts: the hydraulic system integration and the control strategy for that. It was found that only the consideration of both aspects in combination could describe the single solutions in such a comprehensive way that the results are useful for the practise.

A first structuring of the obtained system documentations gave 16 different subsystems that are theoretically possible for a solar thermal system integration into a district heating network. Some of them showed up to be not applied in practise due to the facts that they are too costly, too complex or very similar to another variant.

The final catalogue describes five solutions for a so called centralized system integration of a solar thermal plant. This means that the solar thermal plant is integrated in the system on the heat production side. If being integrated on the heat supply side directly into the district heating network, these systems are called decentralized solar thermal systems for district heating. Six typical systems are shown in the catalogue. The catalogue is expanded by technical guidelines for large scale solar thermal systems to give first information for beginners and, in a second step, more detailed information for advanced in the integration of solar thermal technologies into district heating systems.

## Lessons learned & Impact

The analyses of the system integration of realized solar thermal systems for district heating showed that the detailed technical solutions are rarely available. The final hydraulic scheme and the final detailed description of the control strategy are very seldom publicly published. Utilities as the investors, planners and the solar thermal companies do not like to give detailed information even if the research institute that asks for that offers confidentiality. Despite of this for Solites it was possible to gather a broad variety of different technical solutions that were realized in the market.



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

These technical solutions differ in a broad range in technical details of the system integration. Reasons for that are that every district heating network has its own characteristics, the different utilities follow specific technical strategies and the different solar thermal companies offer specific technical solutions for system integration. But nevertheless a structured catalogue for the task could be obtained.

The knowledge for solar thermal system integration in the market for district heating varies in a very large range. This fact has to be regarded when developing technology transfer and information measures for utilities, consultancies and planners.

└ The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein. ┐



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

# Fact sheet strategy and performed actions

## D-6 Solar thermal sites – Approach to identifying plant locations

Subject:	Solar thermal sites – Screening approach to identifying plant locations
Short description:	<i>What are the critical factors when placing solar thermal plants? Finding suitable areas can be a huge barrier for realizing projects in Germany. With a methodological approach that includes a screening of the regional surface area as well as including relevant stakeholders from the early project phase, the site identification can be managed straight-forward and more projects can be realized</i>
Date of last update:	29.06.2023
Authors:	Paula Möhring, HIR
Region, country	Baden-Württemberg, Germany
Partners involved	Hamburg Institut Research (HIR)
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a> <a href="https://erneuerbare-bw.de/de/termine/veranstaltungen/vortraege">https://erneuerbare-bw.de/de/termine/veranstaltungen/vortraege</a>

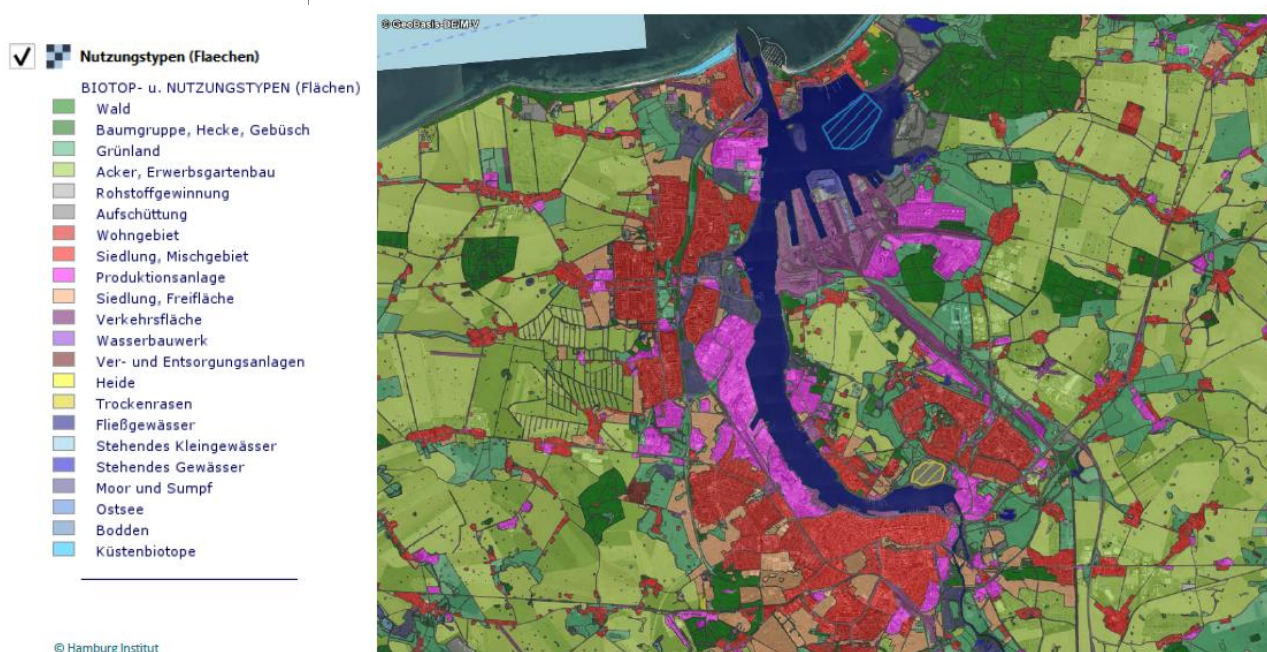


Figure 1: Surface area use types of Rostock (Northern Germany).

## Initial situation

Realising renewable district heating and cooling projects can be hindered by different barriers. One of the main challenges for solar thermal projects in many cases is finding suitable areas to install the collector fields. Despite solar thermal heat being a very efficient form of producing renewable heat in terms of surface area used, the plant is visible in the landscape. Additionally, solar thermal plants have to be placed in proximity to the district heating grid – at least within several kilometers – unlike photovoltaic modules, which don't require



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*



close proximity to urban areas. Clearly, placing solar collector fields in proximity to densely populated areas can become a disputed topic in some cases – and many times, projects are stopped before they even really start, because there is no space.

## Objectives

As described above, identifying solar thermal site locations is often difficult. This is why a simple methodology is developed in order to support the implementation of solar district heating projects in Baden-Württemberg. The method is not entirely universal for every region and municipality in Baden-Württemberg, because regional and municipal area planning might foresee special rules and conditions for solar plants.

The planning of the federal state Baden-Württemberg (Landesentwicklungsplan; LEP) as well as the 12 regional plans will be scanned for the conditions for solar thermal plants, which overall conform with the conditions for photovoltaic plants. Nevertheless, while for photovoltaic plants a special decree (Freiraumöffnungsverordnung FFÖ-VO 2017) permits PV plants on special underprivileged areas<sup>1</sup>, there is no such rule explicitly for solar thermal plant. Once more, they have been not thought of in the planning and policy making. This ought to be changed with the described initiative "Solar thermal sites".

## Description of the measure

The methodology for "solar thermal sites" consists of several steps.

First, the site/placement conditions for solar thermal plants in Baden-Württemberg (LEP) and in the 12 regions are displayed. Depending on the region that the municipality with the potential solar plant is located in, the correspondent conditions have to be considered. Additionally, planning conditions of the municipality itself have to be taken into account: in general this is the *Flächennutzungsplan*, the municipal urban planning. In a next step, it is important to collect cartographic material such as the type of land use, the nature conservations areas, the compensating areas for interference in nature, as well as closed waste disposal sites etc. This material can be found partly online to download publicly. In order to obtain some cartographic material and especially in smaller cities and villages, it might be advisable to start the communication with local authorities. In fact, it is the perfect opportunity to communicate the project from early on and to start the political convincing process. Involving local authorities is a key success factor and should be started from the very early project period.

The measure outcome is the presentation and the discussion of the results with interested stakeholders in a workshop.

In cooperation with Plattform Erneuerbare Energien Baden-Württemberg and Städtetag Baden-Württemberg, the Hamburg Institute developed the program for a web seminar and requested and coordinated the other

---

<sup>1</sup> [https://www.clearingstelle-eeg-kwkg.de/sites/default/files/BW\\_FF%C3%96-VO.pdf](https://www.clearingstelle-eeg-kwkg.de/sites/default/files/BW_FF%C3%96-VO.pdf)  
[http://www.lwl-bw.de/pb/site/pbs-bw-new/get/documents/MLR.LEL/PB5Documents/lwl/Abteilung\\_3/Agrarstruktur/TOEB/Erneuerbare%20Energien/Photovoltaik/LUBW\\_Karte%20benachteiligte%20Gebietskulisse%20BW.pdf](http://www.lwl-bw.de/pb/site/pbs-bw-new/get/documents/MLR.LEL/PB5Documents/lwl/Abteilung_3/Agrarstruktur/TOEB/Erneuerbare%20Energien/Photovoltaik/LUBW_Karte%20benachteiligte%20Gebietskulisse%20BW.pdf)



speakers. The focus of the seminar was to present and discuss solutions to the lack of available space for solar thermal plants as well as for other RE plants.

## Results

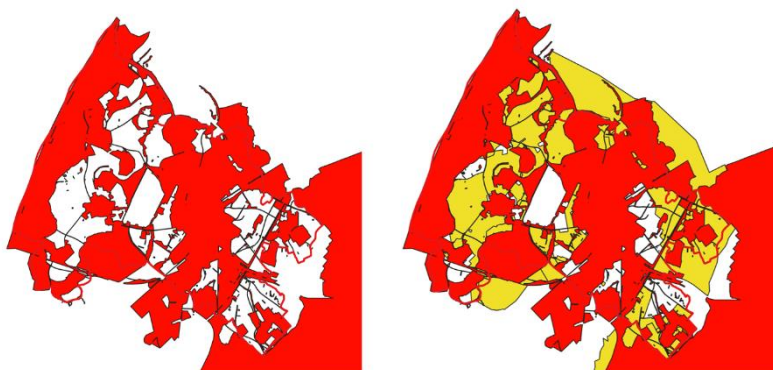
First, various obstacles and solutions were identified:

- Aesthetic obstacles (blighting the landscape) → Solution approach: enclosing the plants (greening); offensive and positive approach to open space plants as part of a new cultural landscape
- Economic barriers to land acquisition → Possible solutions: Financial participation of land owners; Provision of municipal land, land swaps.
- High competition for use of existing land (commercial, residential, agricultural, local recreation / leisure / tourism, etc.) → Possible solutions: Structured land analysis; land provision for heat generation as a planning task; ecological upgrading of land; multiple use ("multicoding") of land.

In the seminar, the procedure for area analysis was presented:

1. evaluate planning specifications; define search space and criteria.
2. collect data and present them in GIS-system
3. merge layers according to criteria; create differences/intersections
  - a. Identify categories in GIS map with tabu criteria: These are categorically excluded. These include, for example, nature reserves, forest areas, and biotopes.
  - b. Filter out areas to which positive criteria apply: including contaminated sites, highway strips, etc.
  - c. Intersection of taboo criteria and positive areas: Cluster into different prioritization groups
  - d. Take a closer look at remaining positive areas, highlight suitable areas through further prioritization if necessary via individual case analysis.
4. presentation, classification and communication of the results

The area analysis has been carried out on the basis of a concrete example; the figures show the taboo areas and the positive areas that remain. Figure 2 and Figure 3 show an example from a city area in Baden-Württemberg.



*Figure 2: Nogo-criteria (hard criterias in red e.g. nature parks, forests and soft criterias in yellow e.g. water protection areas, compensation areas)*





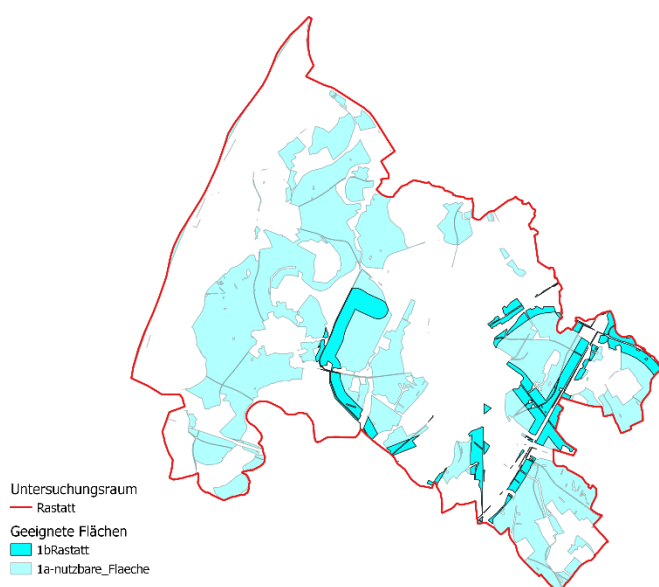


Figure 3. Remaining areas in light blue for a possible usage of solar thermal plants

## Lessons learned & Impact

A generally applicable procedure and criteria for the location search for solar thermal plants were developed and published. The area analysis was carried out and published using the example of a city in the model region.

The high number of participants showed the particularly great interest in the topic of land availability.

⌋ The sole responsibility for the content of this website lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein. ⌋



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.

# Fact sheet strategy and performed actions

## D-7 Guideline on surface water heat pumps for district heating systems

Subject:	<i>Webinar on the topic surface water heat pumps in district heating systems</i>
Short description:	<i>A web seminar for DH suppliers, planners and interested stakeholders offers information on technical, financial, and regulatory aspects and examples of surface water heat pumps in Baden-Württemberg</i>
Date of last update:	29.06.2023
Authors:	Paula Möhring, HIR
Region, country	Baden-Württemberg, Germany
Partners involved	Hamburg Institut Research gGmbH (HIR)
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a> <a href="https://erneuerbare-bw.de/de/termine/veranstaltungen/vortraege">https://erneuerbare-bw.de/de/termine/veranstaltungen/vortraege</a>



Figure 1: 180 MW Värtan Ropsten sea water heat pump in Stockholm, Sweden. Source: Friothersm

### Initial situation

In district heating systems, heat pumps will take a major role for decarbonisation. In the coming years, many heat pumps will have to be installed in order to transform district heating systems towards carbon neutrality. Heat pumps utilize ambient heat or waste heat, boosting the temperature level of the heat source to supply the heating grid.

As heat sources, various options are possible: ambient air, soil, and surface water are commonly used examples. In Germany, not many heat pumps are installed in general, and less so heat pumps utilizing surface water. Surface water bodies such as lakes, rivers and the sea, make excellent heatsources, because their temperature reacts slowly to changes of the air temperature. Also during the winter period, it is possible to extract heat from lakes and rivers on many days.



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

## Objectives

While in Baden-Württemberg there are many potential surface water heat sources, such as Lake Konstanz, Schluchsee, Federsee (in total, there are more than 50 lakes >10 ha) and rivers (e.g. Donau, Neckar, Rhine), there are few examples of implemented projects utilizing thermal energy from surface water bodies. For villages and cities that are located alongside rivers and lakes, it might be interesting to install surface water heat pumps that feed into a district heating system.

With a better knowledge of the technological, financial and legal aspects, there is a higher chance of successful projects in Baden-Württemberg.

It is also of great importance that DH suppliers and planners are confronted with project examples of surface water heat pumps in order to show that the implementation is feasible and to learn from previous experiences.

## Description of the measure

The measure consists of the development and implementation of a web seminar "Water heat pumps - potentials, challenges and successful implementation".

The web seminar addresses various aspects of large-scale heat pumps that use surface water (lakes, rivers) and wastewater. Technological, economic as well as legal and licensing issues will be addressed. The target group of the web seminar are municipal utilities and energy supply companies as well as cities and planning offices.

The seminar entitled "Water heat pumps - potentials, challenges and successful implementation" took place on May 8 with 70 participants. A total of four different presentations were put together, representing a wide variety of topics and projects.

Among other things, possible system configurations, licensing aspects and implementation examples of very different scales were presented. There was a lively discussion and numerous questions.

## Results

Permit eligibility and surface water withdrawals:

- Clarify responsibilities
- Involve authorities to be involved at an early stage, e.g. lower water authority, lower nature conservation authority, riparians, port authorities, waterways and navigation authorities, regional authorities
- Challenge: lack of experience of authorities in the field
- Clarify type of permit required
- Define required expert opinions
- Coordinate user agreement and fees

When using surface waters, special attention must be paid to the following:



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

# Fact sheet strategy and performed actions

## D-7 Guideline on surface water heat pumps for district heating systems

- Environmental compatibility of the technology used
- Fouling in the heat exchanger
- Fouling in the pipelines
- filtration and disinfection
- Auxiliary energy and additional periphery (water withdrawal and reintroduction)

The following can be summarized in concrete terms with regard to the permissibility of coastal waters using the example of Schleswig-Holstein:

- According to § 9 WHG, the withdrawal of water from a coastal water does not constitute a use and therefore does not require a permit.
- The reintroduction of the previously extracted and cooled water is to be considered as a discharge of substances and thus constitutes a use according to § 9 WHG.
- Since the water comes from land, the responsibility of issuing the permit lies with the lower water authority of the district.
- Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz Schleswig-Holstein if the heat pump would be floating in the water.
- Water-legal permission for water uses according to §§ 8-13 WHG (Water Resources Act)
- Water-legal permission according to § 23 LWG, if plant is built in or at the water body

Implementation example heat pump Bühnsee: a very small heat pump (lake collector) in Malsch, Karlsruhe. Artificial lake (1985), foil sealing, fish and duck population, average lake depth approx. 0.7 m, thermally usable lake surface approx. 1500 m<sup>2</sup>, climate data set location Karlsruhe, geothermal heat flux 0.14 W/m<sup>2</sup> (Upper Rhine Graben)

Implementation example river heat pump MVV

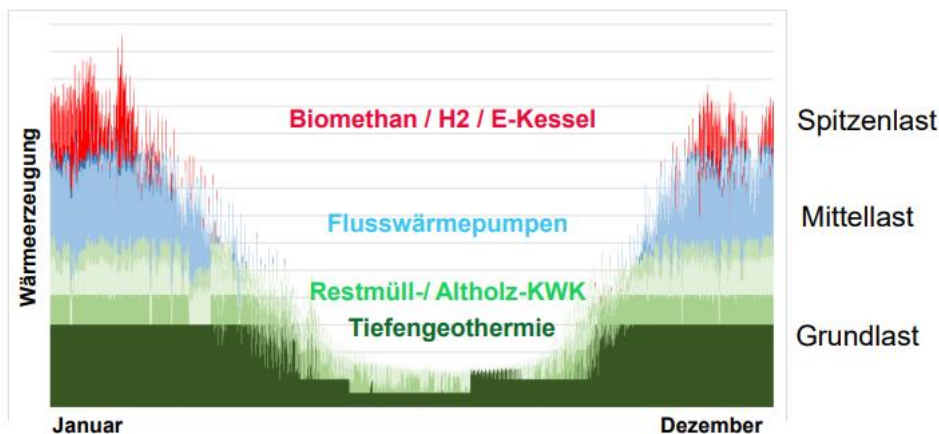


Figure 2: River heat pumps at MVV could provide around a quarter of the heat in the future.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.

## Lessons learned & Impact

- The web seminar showed through the presented implementation examples that water heat pumps are implemented both in flowing and standing waters and in very small as well as large scale in BW.
- The high number of questions, for example regarding the future permission of certain refrigerants (fluorinated hydrocarbon) showed that the topic of water heat pumps is on the one hand already represented by some pioneer projects in BW, but there is still much potential in the provision of information, the dissemination of experience and implementation.

└ The sole responsibility for the content of this website lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein. ┐



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*

Subject:	<b>Webinar on Guarantees of origin for district heating</b>
Short description:	<i>A webinar on the topic of introducing Guarantees of Origin (GO) for district heating is offered to interested stakeholders (DH suppliers, associations, municipalities, customer protection associations) with the objective to inform and discuss the new market mechanism and its future implementation.</i>
Date of last update:	29.06.2023
Authors:	Paula Möhring, HIR
Region, country	Baden-Württemberg, Germany
Partners involved	Hamburg Institut Research (HIR)
Document download:	<a href="http://www.res-dhc.eu/">www.res-dhc.eu/</a> <a href="https://erneuerbare-bw.de/de/termine/veranstaltungen/vortraege">https://erneuerbare-bw.de/de/termine/veranstaltungen/vortraege</a>

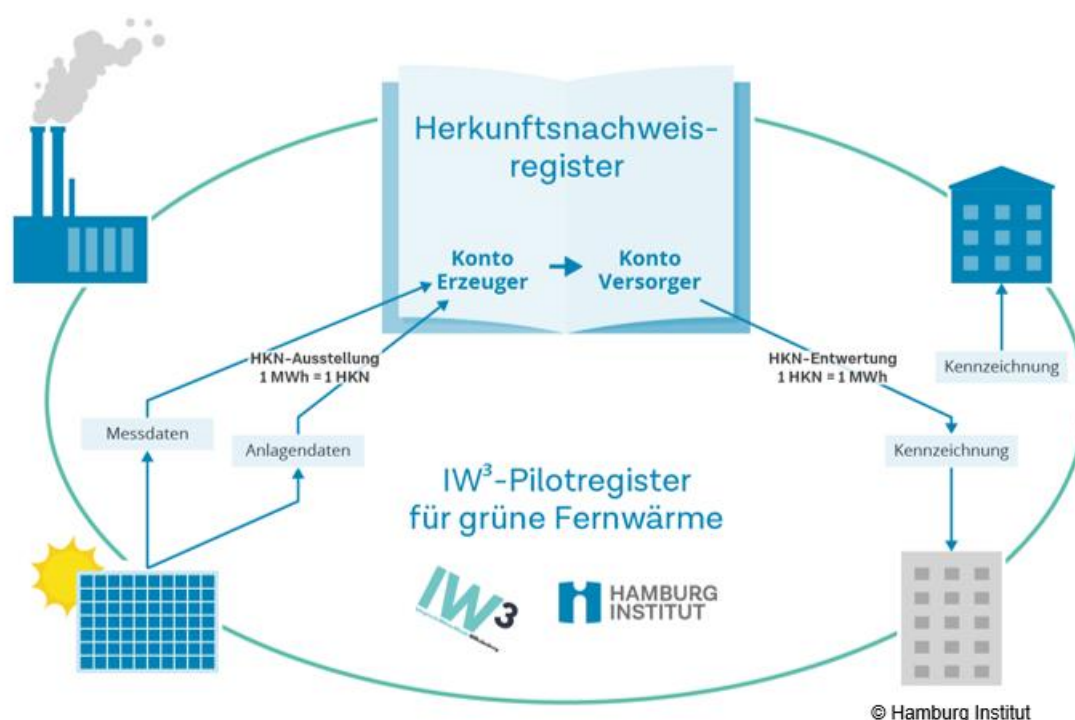


Figure 1: Principle of operation of the application of GOs in the DH network.

## Initial situation

One of the barriers for RES DHC in Baden-Württemberg is the initial financing of projects.

The cost of generating district heating may vary depending on the set of installed heat generation units and their full load hours. In order to finance heat generation and to adapt the customer pricing to price changes on



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*



the market, endorsements in the customer contracts are common. Nevertheless, the price of heat should remain at a level which is acceptable and makes district heating an accessible option. District heating, and especially renewable district heating, should remain competitive as compared to other heating options.

When new renewable heat generation units are installed in an existing DH system, their positive effect on the primary energy factor and the renewable share of the system are relatively small in many cases. This showcases another possible barrier: the time period that is necessary to transform an entire DH system towards 100 % carbon neutrality. In some cases, the (possibly new) customers of DH have a demand for a high share of renewables in their heating (e.g. for meeting building requirements set by the government or the requirements for obtaining financial incentives from state support schemes).

The question is: How can the installation of RES DHC units be driven by the demand side, which is increasingly calling for renewable heat supply? Accessing customers' willingness to pay for green DH can initiate and enhance the transformation of entire DH systems.

## Objectives

A possible answer to this question, which could contribute towards overcoming initial financing obstacles, is marketing distinct green heating products backed by the cancellation of Guarantees of Origin (GO). Suppliers cancel GOs on behalf of specific customers, who receive the right to claim the renewable energy attributes associated with the MWh for which a GO was issued. In the electricity sector, GOs are already the established instrument for disclosing renewable energy attributes of supply to consumers. The recast Renewable Energy Directive 2018/2001/EU (RED II) extends the application of GO systems to heating and cooling as well as gases and hydrogen from renewable energy sources.

GOs, which can be issued for each MWh of heat production, record the characteristics of generated heat. By cancelling GOs, these characteristics are allocated to a specific consumer, thereby excluding multiple consumption claims on the green attributes of a specific MWh. The marketing of green DH products backed by GO cancellation can influence the financing of RES DHC projects. In particular, if a new RES-based heating plant is connected to the DH system, GOs would allow for an allocation of the renewable characteristics of heat production to consumers with the willingness to pay a green price premium. This offers the possibility to answer the demand for green heating in the short term, in the period when the entire DH system is not yet transformed to 100 % carbon neutral heat generation. Therefore GOs can be drivers for RES DHC technologies and their connection to DH systems.

The objective of the Webinar is to inform relevant stakeholders about the status quo of the implementation of the Guarantees of Origin system in the DH sector and to explain the prevalent mechanisms. Another goal is to communicate possible opportunities and challenges for the use of GOs. The concept itself is not entirely new, as it is already implemented in the electricity sector. However, its application to the heating sector is groundbreaking and opens new possibilities, but can also provoke questions. The proposed Webinar aims to inform about the topic, to discuss recent and possible future developments, and assess the relevance to





stakeholders. Potentially, it could be assessed if the exchange could lead to new model or pilot projects of implementing GOs in a region.

## Description of the measure

The measure is implemented by holding a webinar on the topic for interested stakeholders (DH suppliers, organisations, associations, municipalities, consumer protection associations). The webinar will consist of a keynote speech by an expert on the topic, followed by an open forum to address questions of the audience.

Possible barriers are that the complexity of the topic and its status (not yet implemented, but still being developed) could potentially make it seem too distant and irrelevant from the implementation perspective (DH suppliers, municipalities, etc.), so they might show minor interest or not actively involve in the Q&A. This barrier can be overcome by showing the potential impact GOs could have for marketing green district heating, the important role of stakeholders in the process leading up to a future implementation of a DH GO system in Germany, as well as their scope of action. Moreover, stakeholders will be encouraged to actively take part in the webinar discussions.

Monitoring of implementation progress and indicators: e.g. getting feedback after the webinar session.

The seminar was held on June 21 and had 13 participants.

## Results

Contents were a presentation on the current implementation status of Guarantees of Origin in Germany and a virtual tour through the IW3 pilot register for heat certificates.

This was followed by a discussion with the participants. When implementing a HKN system, design decisions have to be made within the framework of the European requirements (Art. 19 of RED II and EN 16325). This includes, for example, the question of whether the physical grid connection between generation and consumption should be a prerequisite for the use of heat HCNs for labeling purposes.

## Lessons learned & Impact

The rather small number of participants showed that the topic of guarantees of origin is still somewhat unknown at the time of the workshop or meets with less interest.

The discussion with the participants, which could be conducted very intensively due to the small number of participants, made clear that there is generally rather agreement for a limitation of the tradability of HKNs to a physically connected heating network.

⌋ *The sole responsibility for the content of this website lies with the authors. It does not necessarily reflect the views by the institutions of the European Union. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein.* ⌋



*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952873.*