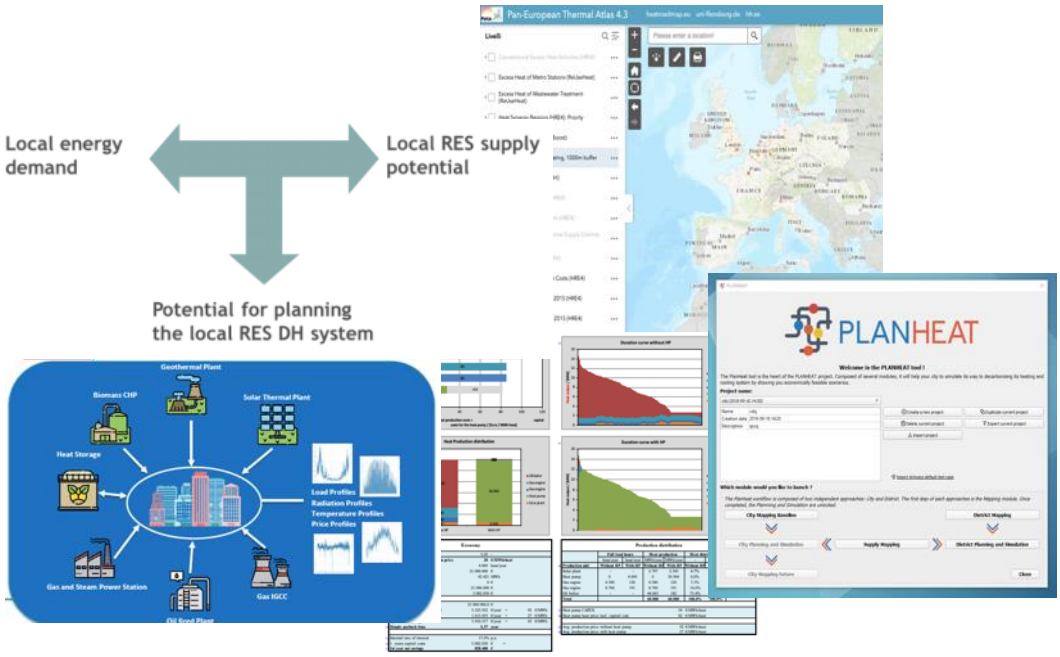
RES DHC

Renewable Energy Sources for District Heating and Cooling

Transformation of existing urban district heating and cooling systems from fossil to renewable energy sources

Renewable Energy Sources in District Heating and Cooling

Factsheets of available tools



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1. INTRODUCTION

Within the RES-DHC project, stakeholders in the 6 pilot areas will foster the market development for renewables in district heating and cooling networks.

For reaching this objective, they could also benefit from a number of already existing tools on the topic of DHC (District Heating and Cooling) by RES (Renewable Energy Sources), often developed within the framework of other European projects. Therefore, one of the RES-DHC activities is the collection and systematisation of these tools, which are listed and described in this document.

The choice of the tools to be included in this deliverable was made basing on different criteria:

- Specific tools related to RES-DHC and not more general tools, for example on energy planning.
- A wide variety of typologies for the tools, such as planning, design, policy, training, etc.
- Different categories of target groups (policy makers, professionals, district heating sector, etc.).
- Suggestions from RES-DHC project partners.
- Specific needs and requests by the RES-DHC pilot areas, also discussed within the Regional Stakeholder Advisory Groups.
- Preferably non-commercial tools.

Regarding the last point, commercial tools which can be useful for working on RES by DHC were anyway summarised in the Appendix.

2. TOOLS: LIST AND CHARACTERISTICS

The following table summarises the key characteristics of the tools included in this document.

NUMBER	NAME OF TOOL	TYPOLOGY	LANGUAGE	TARGET GROUPS	LINK
1	POTENTIAL FOR RENEWABLE HEATING AND COOLING (ENTRAIN)	Guidelines	English	Public administrations, project developers	https://programme2014-20.interreg-central.eu/Content.Node/ENTRAIN.html
2	COUNTRY HEAT MAPS AND ATLASES (HEAT ROADMAP EUROPE)	Map	English	Ministries, associations of DH operators, networks of cities and regions	https://heatroadmap.eu/maps/
3	ONLINE PACKAGE FOR VIRTUAL STUDY TOURS (ENTRAIN)	Videos	Various	Mayors and other representatives of Municipalities, Regions and other Public Authorities, district heating utilities and experts, renewable energy professionals, consumer associations, environmental NGOs	https://programme2014-20.interreg-central.eu/Content.Node/ENTRAIN.html
4	ECONOMICS OF HEAT PUMPS IN DISTRICT HEATING	Calculation tool	English, Danish (full document with instructions in Danish)	Utilities, technical personnel of Local Authorities	https://www.danskfjernvarme.dk/groen-energi/projekter/drejebog-om-store-varmepumper
5	OPEN SOURCE TOOL FOR MAPPING AND PLANNING OF ENERGY SYSTEMS (HOTMAPS)	Calculation tool	English	Public administrations, energy agencies, planners, district heating and renewable energy associations	https://www.hotmaps.eu/

6	QUALITY MANAGEMENT SYSTEM FOR RENEWABLE DISTRICT HEATING (ENTRAIN)	Documents	English, Croatian, German, Italian, Polish, Slovenian	Regulatory bodies, Ministries, regional administrations, energy agencies, technical managers of the utilities, designers and planners	https://programme2014-20.interreg-central.eu/Content.Node/ENTRAIN.html https://www.gmholzheizwerke.ch/home.html
7	SOLAR DISTRICT HEATING – PLANT DATABASE	Database	English	Researchers, technical personnel of Municipalities, utilities, ESCOs, engineering companies and single professionals	https://www.solar-district-heating.eu/en/plant-database/
8	PERFORMANCE ASSESSMENT OF DHC SYSTEMS (WEDISTRICT)	Document	English	Researchers, technical personnel of the utilities, local, regional and national authorities	https://www.wedistrict.eu/new-publication-performance-assessment-of-district-energy-systems-with-common-elements-for-heating-and-cooling/
9	THERMOS SOFTWARE	Calculation tool	English	Planners, utilities and university researchers	https://www.thermos-project.eu/thermos-tool/tool-access/
10	Solar District Heating in cities	Guidelines	English, Bulgarian, French, Italian, Polish	Managers of utilities, policy makers at the local, regional and national levels, planners	https://www.solar-district-heating.eu/wp-content/uploads/2018/05/20171116-3-SDHp2m_Implementation-of-SDH-in-Cities-with-DH_27.11.2017.pdf (English version)
11	Guideline for a spatial multicriteria analysis	Guidelines	English	Planners, utilities, Public Authorities	https://programme2014-20.interreg-central.eu/Content.Node/ENTRAIN.html

12	Guide for strategy development	Guidelines	English	Public Authorities (in charge of the planning processes)	https://www.res-dhc.com/wp-content/uploads/2021/09/RES-DHC_WP3_Task3.1_D3.1_Guideline-for-strategy-development-4.pdf
13	EnerMaps Open Data Management Tool	Data tool	English	Energy planners, utilities, managers and consultants, public administration officers, research, data providers, policy decision makers and social innovation experts	https://enermaps.eu/data-tool/
14	Heat Planning Toolbox	Toolbox	English	Planners, Public Authorities	https://planenergi.dk/download/toolbox_1-3_apr22/
15	Solar district heating guidelines	Guidelines	English	Professionals, utilities	https://www.solar-district-heating.eu/wp-content/uploads/2018/06/SDH-Guidelines_update_09.2017.pdf

Table 1: Characteristics of the tools

3. TOOL 1: POTENTIAL FOR RENEWABLE HEATING AND COOLING (ENTRAIN)

The tool at a glance

Within the framework of the ENTRAIN project, supported under the Interreg Central Europe programme, specific guidelines were prepared for assessing the potential for exploiting renewable energy sources for heating and cooling, with a special focus on district heating networks. The scope of such a potential assessment could be at different scales: local, regional or even national.

The tool is available for free here.

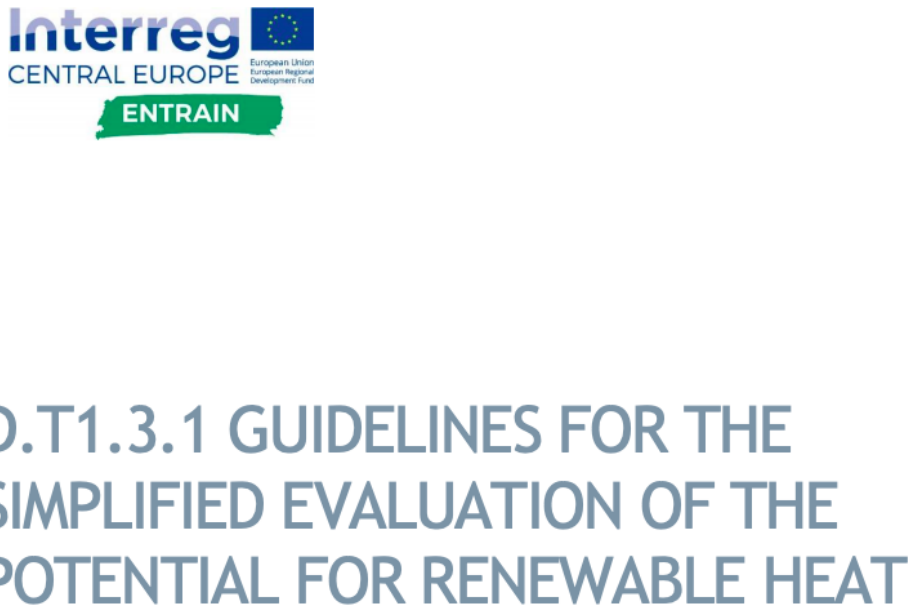

Figure 1: Front cover of the guidelines

Tool description

The potential guidelines aim at supporting, and at the same time motivating, potential stakeholders and local communities to seek better and more efficient solutions to meet local heat demand. The purpose is not to provide a comprehensive methodology for performing a detailed assessment but rather to give an overview of the necessary information prior to deciding on the investments and initiating projects.

For each one of the key topics of the guidelines (heat demand, heat supply, external aspects), the main questions which should be answered for carrying out a good potential analysis are presented, together with a list of tools and references, collected from a number of projects and publications.

Figure 2: The basic scheme of the guidelines

A thorough analysis of energy supply and demand in the targeted area lays the foundation for further planning of renewable DH system. Initial energy balance in the targeted areas helps to identify the needs of the communities, as well as to evaluate potential solutions to the current state. Therefore, guidelines for determining heat demand and supply are given as the primary steps of such evaluation.

In the heat demand step, additional attention is given to the territorial aspect of the target area, i.e. climate of the area, urbanisation, industrial areas, which all provide important elements to consider when planning the DH systems. Heat supply step provides an overview of the locally available renewable energy sources (biomass, solar heat, geothermal, waste heat and heat pumps) each with a set of questions, which can help determine the potential for each in the target region.

Finally, the last step of the evaluation is combining the inputs and insights gathered in the two previous phases in order to reach some conclusions on the potential for using DH from renewables in the target area.

The reader may also be interested in having a look at the potential reports, also developed within ENTRAIN, on the renewable heat potential in the 5 pilot areas in the project (in DE, HR, IT, PL and SI). The reports are available here, under the 'TARGET REGIONS' section.

Target groups

This tool is mainly addressing public administrations at different levels, such as Municipalities, Regions, Provinces, National Ministries, etc.

Furthermore, it could be used by local stakeholders (for example DH project developers) for assessing the DH potential at a smaller scale (urban regeneration for a single district or block, heat supply for a small suburb, etc.).

4. TOOL 2: COUNTRY HEAT MAPS AND ATLASES (HEAT ROADMAP EUROPE)

The tool at a glance

The Horizon 2020 funded Heat Roadmap Europe project developed a set of tools basically divided into two main sections:

- An interactive map providing a variety of resources for heat planning in 18 EU countries.
- A Pan-European Thermal Atlas reporting, for 14 EU countries, the heat demand density for performing potential analysis.

The tools are available for free here.

Figure 3: A screenshot of the interactive map

Tool description

This set of tools was developed mainly within the Heat Roadmap Europe project, supported within the Horizon 2020 programme.

The goal is to provide stakeholders, especially at national level, with useful resources to evaluate the potential for renewable district heating and cooling as well as to create strategies for market development. The main difference with the previous tool, therefore, is the wider scope of the analysis, shifting from the local or regional scale to the national level.

First of all, the set of tools includes an interactive map with a variety of resources related to 18 EU countries: Atlases, maps, country presentations, roadmaps and other sources of information useful for heat planning (see, in the screenshot below, the example for Italy on the list of the available resources).

Italy

- Excess Heat Activities
- Heat Demand
- Heat Synergy Regions
- Excess Heat Ratio
- District Heating Investment cost
- District Cooling Investment cost
- HRE4 Country Presentation
- HRE4 Country Roadmap
- STRATEGO Country report
- Distribution cost curves

Figure 4: An example: The list of resources available for Italy

The second part of the set is a Pan-European Thermal Atlas (PETA), now available in its 4.3 version here. This atlas reports, for the 14 EU countries included in the analysis, heat density maps. Although the resolution is 100 m grid size, the atlas authors warn that the confidence level of the actual values on this scale is too low. Therefore, when looking at small scales, the heat demand figures can be only indicative, while a better level of confidence can be expected for larger resolutions, for example 1 km.

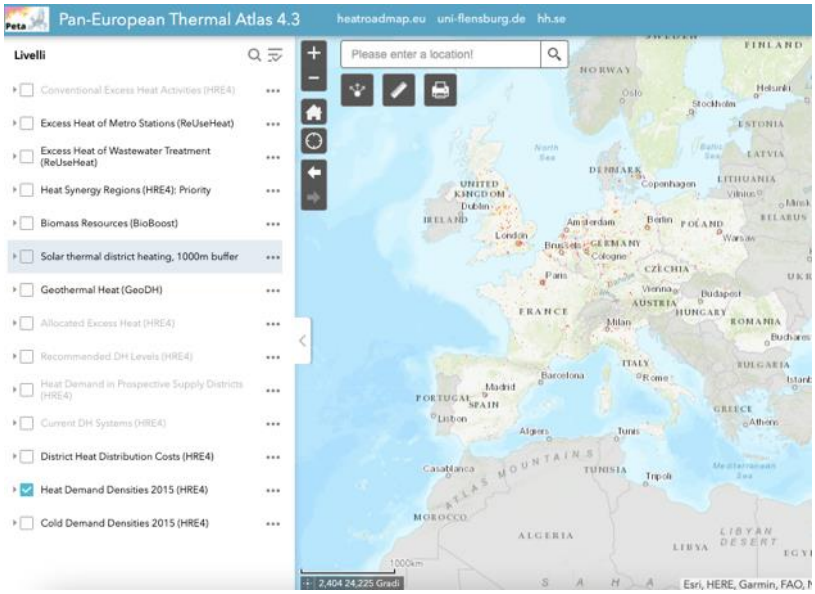

Figure 5: A screenshot of PETA4

Finally, a version 5.1 of the PETA was also developed containing, at the moment, preliminary data which are subject to validation.

Target groups

Given the scale of the available data and of the analysis, the Heat Roadmap Europe set of tools is mainly targeting key stakeholders of the district heating market operating at national level, therefore including, for example, Ministries, associations of DH operators, networks of cities and regions, etc.

5. TOOL 3: ONLINE PACKAGE FOR VIRTUAL STUDY TOURS (ENTRAIN)

The tool at a glance

This tool, developed within the ENTRAIN project, offers an online collection of videos, from all over Europe, on district heating and cooling networks run on renewable energies.

The tool is available for free here.

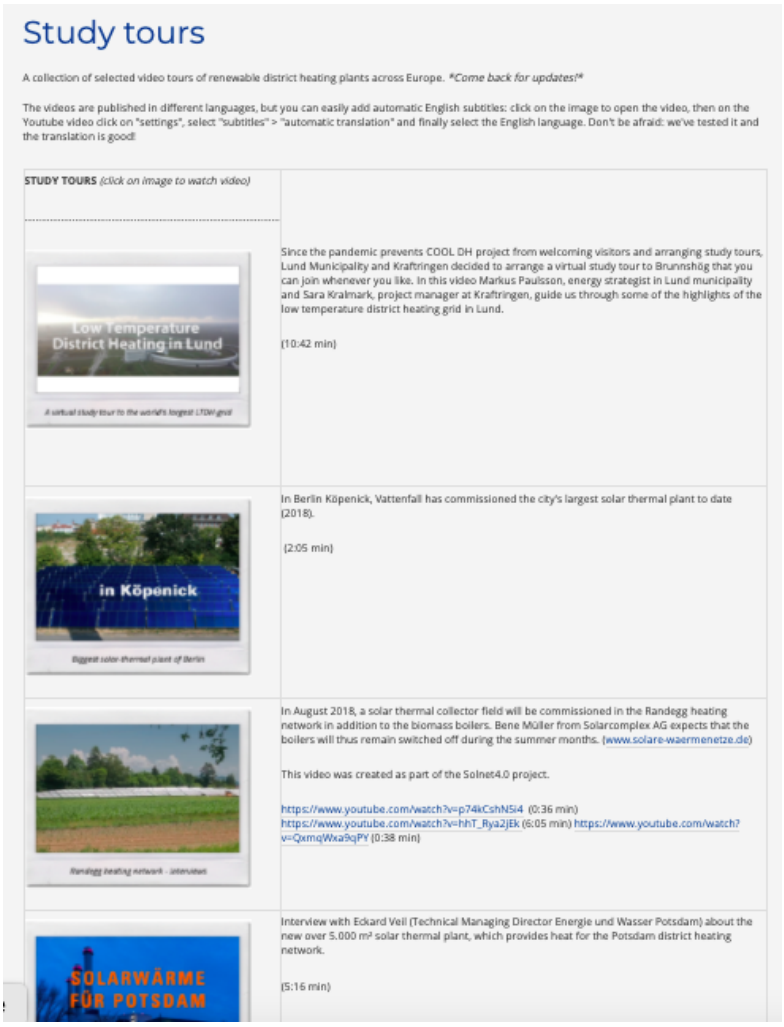

Figure 6: Partial screenshot of the webpage on virtual study tours

Tool description

The idea of this virtual package was born soon after the COVID-19 pandemic, since this sudden emergency prevents many projects, initiatives and single DH operators from welcoming visitors and arranging study tours.

It includes, at the moment, 10 examples in Europe of district heating systems using different solutions with renewables, namely solar thermal, biomass, waste heat, etc. The videos usually report not only the technical details of the heating plant and of the connected network but also the story of how the project was initiated, which where the barriers to be overcome, the opportunities to be exploited, etc.

The number of available videos, however, will constantly grow since the package is being continuously updated.

In many cases, furthermore, you can hear directly from the stakeholders involved in the project, such as DH utilities, Mayors of the Municipalities, citizens as users of the system, etc.

The videos are published in different languages but, since they are all available on YouTube, automatic English subtitles can be easily added just by clicking on the image to open the video and then, on the YouTube video, by clicking on "settings", selecting "subtitles" > "automatic translation" and finally selecting the English language.

Target groups

The virtual package is addressing all stakeholders who want to learn about how renewables are used in practice for supplying district heating and cooling systems.

Therefore, the targeted recipients belong to a wide variety of actors: Mayors and other representatives of Municipalities, Regions and other Public Authorities, district heating utilities and experts, renewable energy professionals, consumer associations, environmental NGOs, etc.

6. TOOL 4: ECONOMICS OF HEAT PUMPS IN DISTRICT HEATING

The tool at a glance

This tool was developed by PlanEnergi as part of the update to the script for the large heat pumps ordered by the Danish Energy Agency. It allows to perform an initial and simple calculation of the economics of electrically driven heat pump projects in district heating.

The original tool in Danish is available for free here. Within the RES-DHC project, the Excel spreadsheet was translated in English and coupled with a short document summarising the instructions for filling in the sheet.

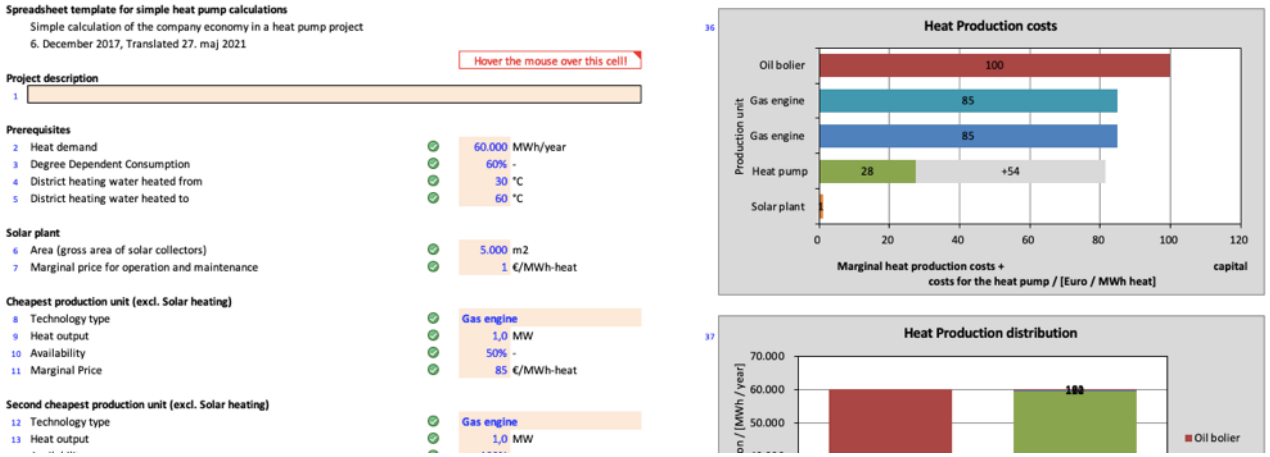

Figure 7: Partial screenshot of the tool spreadsheet

Tool description

In connection with the document "Guide to large heat pump projects in district heating", the Danish Energy Agency also developed a spreadsheet-based tool, which can be used for a simple calculation of the economics of electrically driven heat pump projects in district heating.

First of all, it should be stressed that the actual economics of a project may differ significantly from the tool outcomes. It should be used, therefore, only at an initial stage of a project and the calculated results should always be validated through other studies before being used for investment decisions.

The spreadsheet, developed in Microsoft Excel, consists of one tab. It is recommended to zoom the spreadsheet so that the whole tab can be seen on the screen.

The purpose of the spreadsheet is to calculate the cost-effectiveness of a heat pump project in an already existing heating plant, which can consist of up to four different production units, one of which is a solar heating plant.

The calculation is based on user-based inputs in the 35 sand-coloured cells on the left side of the user interface. The calculation results are shown in the four graphs on the right side of the interface, as well as in the light blue tables.

Economy

COP - hot (year average)	3,92	-		
Heat pump average production price	28	€/MWh-heat		
Heat pump	4.069	hour/year		
Gross investment	21.000.000	€		
Energy saving	42.421	MWh		
Value of energy saving	0	€		
Net investment	21.000.000	€		
L. years capital costs	3.082.030	€		
Total net investment	21.000.000,0	€		
Operating costs without project	5.525.952	€/year	=	92 €/MWh
Operating costs with project	1.615.435	€/year	=	27 €/MWh
Operational savings	3.910.517	€/year	=	65 €/MWh
Simple payback time	5,37	year		
Internal rate of interest	17,9%	p.a.		
L. years capital costs	3.082.030	€	=	
1st year net savings	828.488	€		

Production distribution

	Full load hours		Heat production		Heat distribution		Heat production prices
	hour/year	hour/year	MWh/year	MWh/year	-	-	
Production unit	Without HP	With HP	Without HP	With HP	Without HP	Project	€/MWh
Solar plant	-	-	2.797	2.543	4,7%	4,2%	1
Heat pump	0	4.069	0	56.964	0,0%	94,9%	28
Gas engine	4.380	120	4.380	120	7,3%	0,2%	85
Gas engine	8.760	191	8.760	191	14,6%	0,3%	85
Oil boiler	-	-	44.063	182	73,4%	0,3%	100
Total			60.000	60.000	100,0%	100,0%	
Heat pump CAPEX					54	€/MWh-heat	
Heat pump heat price incl. capital cost.					82	€/MWh-heat	
Avg. production price without heat pump					92	€/MWh-heat	
Avg. production price with heat pump					27	€/MWh-heat	

Figure 8: Graphs and tables showing the calculation results

It is recommended that, before calculating a project example through this tool, the user read carefully all the details reported in the document “Spreadsheets instructions for simple heat pump calculations“.

Target groups

Due to the expertise and competencies needed to fill in the spreadsheet correctly, this calculation tool is mainly addressing technical actors dealing with district heating as, for example, utilities or technical personnel of Local Authorities in charge of a first evaluation of the economic feasibility of a project.

7. TOOL 5: OPEN SOURCE TOOL FOR MAPPING AND PLANNING OF ENERGY SYSTEMS (HOTMAPS)

The tool at a glance

The HotMaps project developed a toolbox to support interested stakeholders in strategic heating and cooling planning at local, regional and national levels, in line with European energy policies.

The toolbox is accessible for free here.

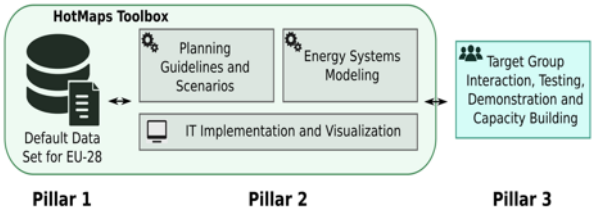

Figure 9: The concept of the HotMaps toolbox

Tool description

The HotMaps toolbox is an open source software, for studying the integration of RES in DH by providing datasets, as well as tools for estimating demand reduction scenarios and analysing dispatch and related performance indicators for various supply portfolios under different conditions.

Another feature of this tool is that it is user-driven since it was developed, within the HotMaps project, in collaboration with 7 pilot areas. Furthermore, the scope of the tool is very wide, being applicable to all cities and other areas in EU-27 + the UK.

The tool provides the users with a large array of open source data sets for EU-27 countries + the UK, including many different layers, such as energy supply sources (geothermal, solar thermal, municipal solid waste, etc.), load profiles (residential loads for both space heating and domestic hot water, industrial energy needs, etc.), economic information (fuel costs, technology costs, electricy price scenarios, etc.), etc.

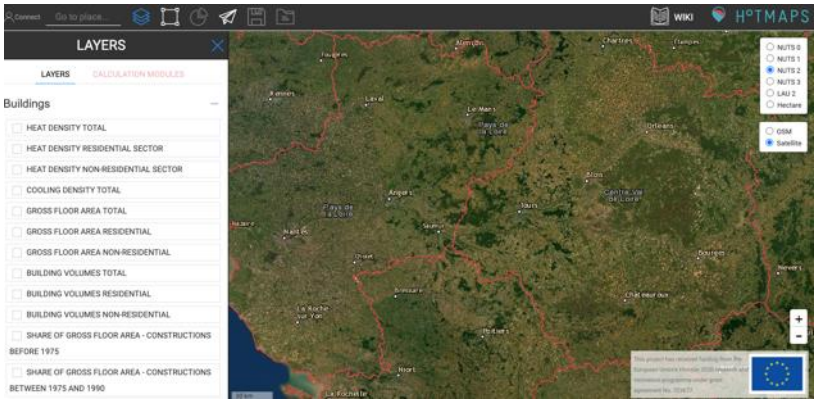

Figure 10: Screenshot of the tool in use

HotMaps also features a DH dispatch model available in three different versions. This model, accessible in the online browser tool via the “Calculation Modules” button, allows to look into the details of the demand side and to perform hourly-based calculation. It is possible to project the future heat demand based on scientific data on demographic and energy efficiency effects. It is also suitable for studies and analyses on both sector coupling and temperature levels in the DH networks.

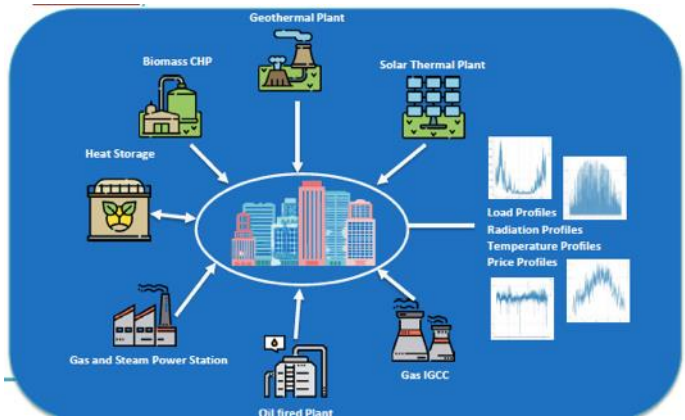

Figure 11: The HotMaps district heating dispatch model

Target groups

The key beneficiaries of this tool are the main actors in strategic heating and cooling planning, namely public authorities at different levels, energy agencies and planners, as well as other interested and relevant stakeholders, such as district heating and renewable energy associations.

While some features such as the heat demand and potential analyses are simple to use, the calculation modules require more skilled knowledge of the topic.

8. TOOL 6: QUALITY MANAGEMENT SYSTEM FOR RENEWABLE DISTRICT HEATING (ENTRAIN)

QM Biomass DH-Plants – The tool at a glance

In 1998, Swiss experts were commissioned by the Swiss Federal Office of Energy and some cantons to develop a QM system for larger wood heating systems. After the storm "Lothar" of 26 December 1999, which left devastated forests with firewood for many years, the QM system was prescribed by the federal government and the cantons for larger subsidised wood heating plants and continuously developed under the name “QM Holzheizwerke” or in English “QM Biomass DH-Plants” (QM).

The QM system was later continued within an international working group between Switzerland, Austria and Germany (regions Bavaria and Baden-Württemberg). Since 2021 Italian, namely the region Friuli-Venezia Giulia, joined the ongoing working group. The international working group’s goal is to develop the system further and to support all the important stakeholders within the DHC sector on technical, regulatory, economical and political level.

The application of QM can allow a more efficient realisation and operation of DH systems especially for the implementation with biomass boilers. Compliance with the QM system allows to reach several key objectives at the same time, namely reliable and low-maintenance operation, precise and stable system control, highest possible degree of utilisation and low distribution losses, low emissions in all operating states and, finally, ecological and economic sustainability for both the operator and the customers.

ENTRAIN project

Thanks to the work done within the ENTRAIN project, the key documents and tools of the QM systems were translated first in English and then in the national languages of the project pilot areas in (Croatian, Italian and Polish).

One more action, carried out within the ENTRAIN framework, was the extension of the quality system from biomass only to all the potential renewable energy sources, including the recovery of waste heat, which can be used to feed DH systems.

The QM guidelines (describing the process and the quality requirements), the economic profitability calculation tool, two different tools for estimating heat losses, an information sheet on measurement equipment and, finally, a QM informative leaflet describing the key features and benefits of this quality system.

QM Documents and Tools

All the details on this system are available on the official website (https://www.qm-biomass-dh-plants.com/home.html), where you can find documents, tools and regional contacts. The most important documents and tools are available in German, French, Italian and English. Some documents are also available in Croatian, Italian, Polish.

There are guidelines, handbook's, templates for tendering and heat supply contracts, Excel spreadsheets for demand assessments as well as budgeted income statement and budgeted balance sheet and many more.

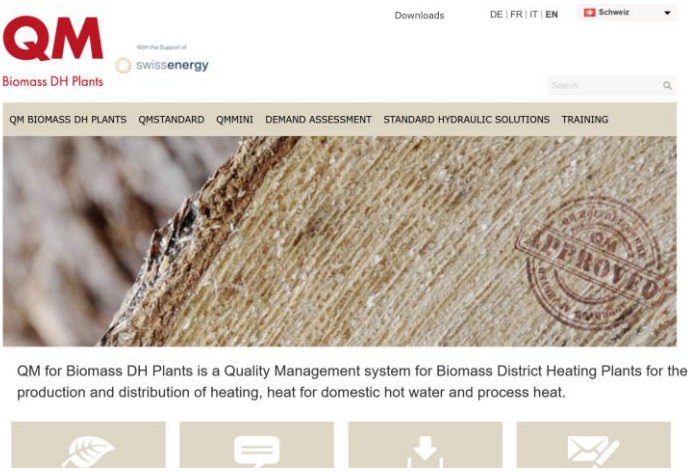

Figure 12: Screenshot of the "current main page of QM Holzheizwerke"

Figure 13: The Italian page of the QM system, run by the energy agency of Friuli-Venezia Giulia

QM District Heating

"QM District Heating" is a platform for technical and economic issues in connection with thermal networks in general and supplements the Q-system of "QM Biomass DH-Plants". QM District Heating offers training courses, documents and tools as well as technical support and consultancy for the development, implementation and operation of thermal networks. The working group, founded by Verenum AG and several other experts from Switzerland, is mainly operating and consulting in Switzerland but also offers its knowledge internationally.

The following documents and tools are available on the website www.qmfernwaerme.ch (available languages in brackets):

- Fact Sheet on Thermal Networks in General and the situation in Switzerland (German, French, Italian)
- Handbook on Planning of District Heating Networks (German, French, English)
- Questionnaire for a possible connection to a thermal network (template in German, French, English)
- Checklists for the project procedure (template in German, French, English)
- Guide to district heating transfer stations (German, French)
- Excel-Tool additional consumption (German, French, Italian, English)
- Excel-Tool THENA (Thermal Network Analysis, only in German)
- Excel-Tool for the evaluation of offered services of district heating transfer stations (German)
- Excel-Tool Sensi for simple illustration of the sensitivity of the most important parameters on the costs of heat distribution for nominal diameters from DN 20 to DN 250 (German).

In addition, various publications, articles and contributions are available or linked on the website.

Target groups

As a matter of fact, such a system could help in improving the quality of the DH sector at national or regional level and, therefore, it could be introduced as a compulsory system or as a voluntary one, possibly linked to the granting of incentives for the realisation of a new DH system (as well as for its extension or revamping), as it is implemented for example in Austria and Switzerland. From this point of view, the target groups of this tool are the national or regional authorities regulating the sector and the related incentives (regulatory bodies, Ministries, regional administrations, energy agencies, etc.).

Once in use, the system targets mainly technical and economical subjects in charge of developing DH projects. Therefore, the main target groups are technical managers of the utilities, designers and planners of biomass and district heating systems as well as investors and decisionmakers in the development of new or for the expansion of existing thermal networks.

9. TOOL 7: SOLAR DISTRICT HEATING – PLANT DATABASE

The tool at a glance

This database presents the basic data for several solar district heating plants in many different countries.

The tool is accessible for free here.

Ranking List Overview

Column visibility | CSV | Excel | PDF | Print

Country

Search:

Plant	Operation start	Owner	Country	City	Apert. area in m^2	Capacity in kW_{th}
Fjärås Vetevägen						
Åsa	1985	EKSTA Bostads	Sweden	Åsa	1 030	721
Kullavik	1987	EKSTA Bostads	Sweden	Kullavik	1 185	830
Ry	1988	Ry Varmeværk	Denmark	Ry	3 040	2 128
Saltum	1988	Saltum Fjernvarme	Denmark	Saltum	1 005	704
Tubberupvænge	1991	Herlev Boligselskab	Denmark	Herlev	1 030	721
Odensbacken	1991	Örebro Energi	Sweden	Odensbacken	1 000	700
Säter	1992	Säter Energi	Sweden	Hedemora	1 250	875
La Cité Solaire	1995	Plan-les-Ouates	Switzerland	Plan-les-Ouates	1 668	1 200

Figure 14: A screenshot of a part of the database

Tool description

The database includes basic information on 195 solar district heating plants in operation in many different countries. The set of data includes: Name of the plant, year of operation start, owner, Country, city, aperture area of the solar collector field (in m^2) and thermal capacity (in kW_{th}).

The database can be downloaded as both a sheet (CSV or Excel) or a pdf file.

Target groups

The database is especially targeting technical stakeholders, such as researchers, technical personnel of Municipalities, utilities, ESCOs, engineering companies and single professionals.

10. TOOL 8: PERFORMANCE ASSESSMENT OF DHC SYSTEMS (WEDISTRICT)

The tool at a glance

This tool is rather a methodology, summarised in a detailed scientific paper, for calculating different DHC key performance indicators (KPIs), distinguishing between heating and cooling ones.

The paper is described and downloadable for free here.

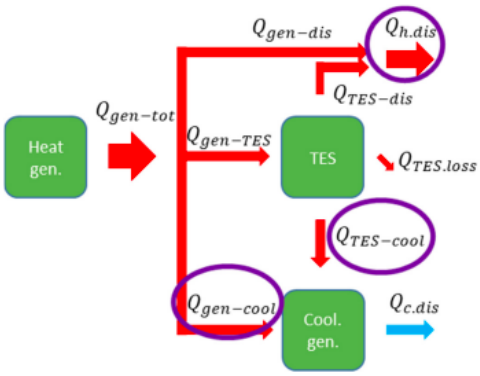

Figure 15: Heat fluxes in the proposed methodology

Tool description[1]

The assessment of a DHC system is challenging when the same equipment or system elements are used for purposes of producing heating and cooling, either simultaneously or alternatively. This is particularly the case for complex systems, which involve different energy sources and technologies in a single district energy system.

Many components of such a system may be used for both heating and cooling: Reversible heat pumps, heat generation or recovery applied to thermally driven cooling technologies, geothermal probes coupled with ground source heat pumps, photovoltaics, etc. Moreover, a growing endeavour of energy vector coupling, including renewable heat, electricity, green hydrogen, and syngas, is going to lead to even more complex district energy systems.

As for now, there is no comprehensive methodology for performance analysis of combined DHC systems. This paper, therefore, proposes a methodology for calculating different DHC key performance indicators (KPIs), distinguishing between heating and cooling ones. A total of 11 indicators

[1] Text slightly edited from the original one, available at https://www.wedistrict.eu/new-publication-performance-assessment-of-district-energy-systems-with-common-elements-for-heating-and-cooling/

are organised under four categories: Energy, environment, economy and socio-economy. The methodology proposes demand-based and investment-based share factors that facilitate the heating and cooling KPI calculation.

Target groups

Given its very technical and scientific approach, this tool / paper is addressing researchers working on DHC and technical personnel of the utilities.

However, as a second priority, this methodology for DHC performance evaluation could be also used in support schemes managed by local, regional and national authorities and, therefore, though indirectly, they could also be regarded as target groups of this tool.

11. TOOL 9: THERMOS SOFTWARE

The tool at a glance

This free online tool aims at helping to accelerate the decarbonisation of heating and cooling networks by supporting engineers, planners and other actors to create and optimise low-carbon heating and cooling solutions.

The geographical scope of the tool is worldwide.

The tool is accessible for free here.

Figure 16: The software logo

Tool description[2]

THERMOS has been developed by the EU-funded project by the same name. The project software version (version 8) is freely available as an open-source code.

THERMOS main features include:

- Network optimisation model for identifying a cost-optimal network design; Users can estimate energy output or cost over time through different demand profiles and tariffs.
- OpenStreetMap for easy map creation and analysis or the possibility to upload own GIS data.
- Tool for generating heat and cold maps.
- Demand estimation method operating with limited data input in any location.
- Representation of variable pipe and dig costs and network heat losses.
- Incorporation of capital costs for plant, pipes and connection, set against revenues from heat sales and monetised emissions.
- Interoperability with GIS formats for model results and map export.
- Nearly comprehensive documentation of data requirements and model operation.
- Network supply model, for a more detailed modelling of the heat supply.

[2] Text slightly edited from the original one, available at https://www.thermos-project.eu/thermos-tool/tool-access/

Target groups

The THERMOS software has, as first target group, technical actors in the field of DHC, such as planners, utilities and university researchers.

Figure 17: A video tutorial of THERMOS

12. TOOL 10: SOLAR DISTRICT HEATING IN CITIES

The tool at a glance

These guidelines describe the implementation of solar district heating integrated in existing district heating systems in cities.

This tool, therefore, is not including all renewable energy sources in DHC but it rather focuses on solar thermal only.

The document is downloadable here, searching in the database for “SDH in cities”. Alternatively, the English version of the guidelines is directly accessible here.

Tool description[3]

The manual describes the steps for integrating medium and large-scale solar thermal plants in existing district heating (SDH) systems in cities.

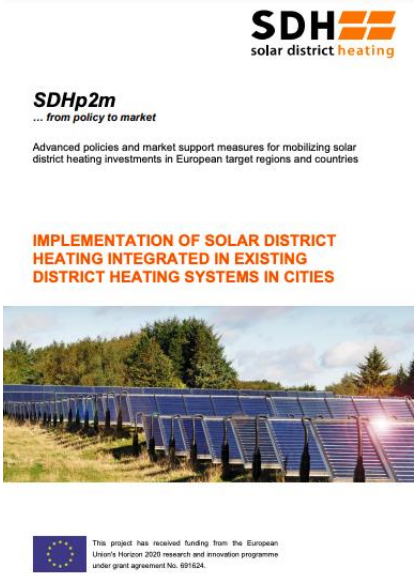

Figure 18: The cover of the SDH guidelines

When starting SDH projects in existing district heating there are two key problems. The first one is that the summer load, that is when the solar output is higher, is normally already produced by the utility through power production or other sources of excess heat.

[3] Text slightly edited from the document introduction.

The second barrier is that it is often difficult and sometimes expensive to find areas where to place the solar collectors.

Of course, that does not mean that it is impossible to integrate SDH in cities, especially because more and more cities want to change their heat supply from fossil fuels to RES. In order to reach this goal, for instance, DHC systems often need to have thermal storages in place and, in that case, large SDH plants can play a role, as they are one of the cheapest heating technologies.

These guidelines are divided into development steps following the decision-making process. After each step, a decision has to be made by the process stakeholders whether or not to continue the process, basing this decision on economic, social and logistic parameters.

Target groups

This manual is targeting both technical actors and decision makers such as, for example, managers of utilities, policy makers at the local, regional and national levels, planners, etc.

13. TOOL 11: GUIDELINE FOR A SPATIAL MULTICRITERIA ANALYSIS

The tool at a glance

These guidelines, developed within the ENTRAIN project, shows a methodology for applying a multi-criteria analysis approach for the development of biomass and solar thermal plants connected to small and medium district heating network. The document is downloadable here.

Tool description

Multi-criteria analysis (MCA) refers to decision-making among several alternatives, depending on several criteria, which are weighted differently depending on the strength of influence on the result.

In the field of spatial energy planning, multi-criteria analyses can be applied in the site assessment for example of solar thermal and biomass plants connected to local district heating networks.

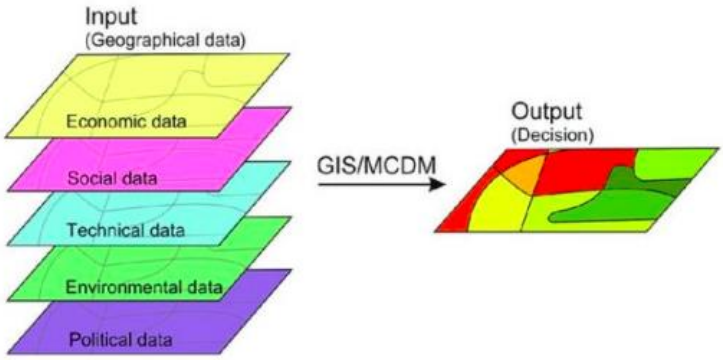

Figure 19: Criteria as geodata layers

Depending on the object, the criteria can be completely different and they can be seen as different layers of geodata. The choice of the used criteria is very important. The planners should therefore take enough time to consider which criteria should be considered.

On the one hand, expert knowledge in the field of heat supply is essential (to cover the technical aspect), on the other hand, non-technical factors (e.g., visibility and disturbed residents) should also be included. Therefore, close coordination with the municipalities is also necessary.

Target groups

These guidelines are targeting planners in the field of energy (with a specific interest in DH), other technical actors (e.g. utilities) and Public Authorities (Municipalities, Regions, etc.).

14. TOOL 12: GUIDE FOR STRATEGY DEVELOPMENT

The tool at a glance

This document, developed within the RES-DHC project itself, proposes an adaptive methodology for developing regional market development strategies and planning the corresponding actions on RES DHC. The methodology should bring support in the development of strategies that are adapted to the identified barriers, feasible and efficient. However, the process is flexible to make sure that all regional peculiarities can be tackled.

The document is downloadable here.

Tool description

Though the process is divided in four steps, it is important to note that the result is not final. Step 4 takes place after implementation start and then the action plan should be continuously updated to include new developments and concretise the actions further.

This process should be undergone collecting ideas and opinions of relevant market actors, possibly through a regional stakeholder advisory group, involved all along the process.

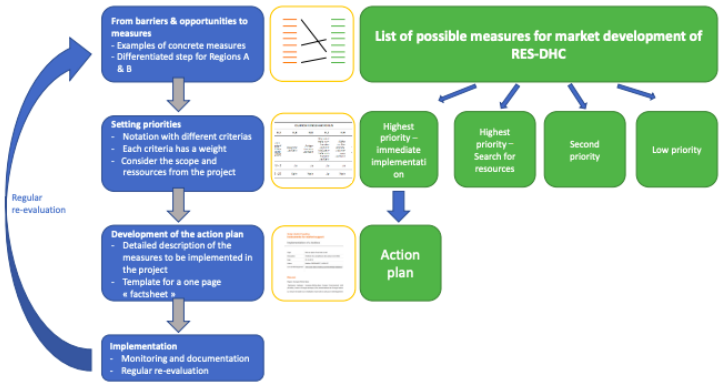

Figure 20: Process overview

Target groups

The key targeted stakeholders are the managing authorities of the planning processes on the territory, namely Municipalities, Provinces, Regions, etc.

15. TOOL 13: ENERMAPS OPEN DATA MANAGEMENT TOOL

The tool at a glance

The EnerMaps Open Data Management Tool, developed within the Horizon 2020 project EnerMaps, aims at improving data management and accessibility in the field of energy research for the renewable energy industry.

The tool is accessible here.

Tool description

The EnerMaps tool accelerates and facilitates the energy transition offering a qualitative and user-friendly digital platform to the energy professionals.

The tool is based on the FAIR data principle which requires data to be Findable, Accessible, Interoperable and Reusable.

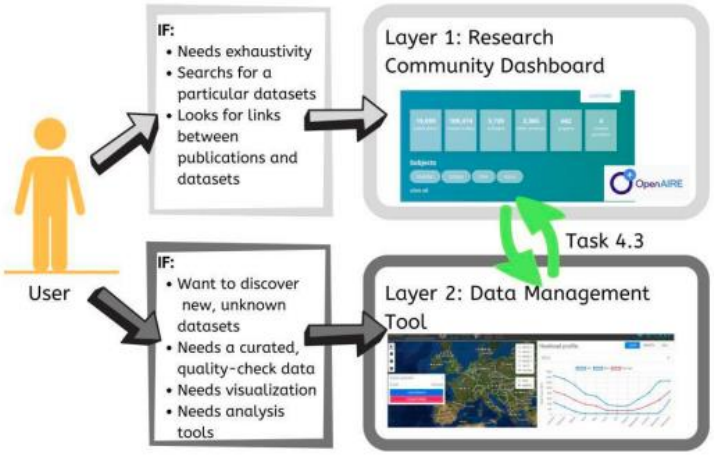

Figure 21: Layers of the EnerMaps tool

Target groups

The key targeted stakeholders are energy planners, utilities, managers and consultants, public administration officers, research, data providers, policy decision makers and social innovation experts.

16. TOOL 14: HEAT PLANNING TOOLBOX

The tool at a glance

This toolbox for heat planning was developed by PlanEnergi for the German State of Baden- Württemberg and financed by the Danish Ministry of Foreign Affairs. The toolbox is accessible here.

Tool description

The toolbox offers tools and advices for a full heat planning process, from the initial steps to the mapping, going then to the analysis and comparison of the scenario, to finally close with the planning and implementation of the most relevant measures.

Since the tool was prepared for a German region, the main scope of the heat planning is meant to be regional but the same approach can be used also at smaller and larger levels (e.g. municipal or national).

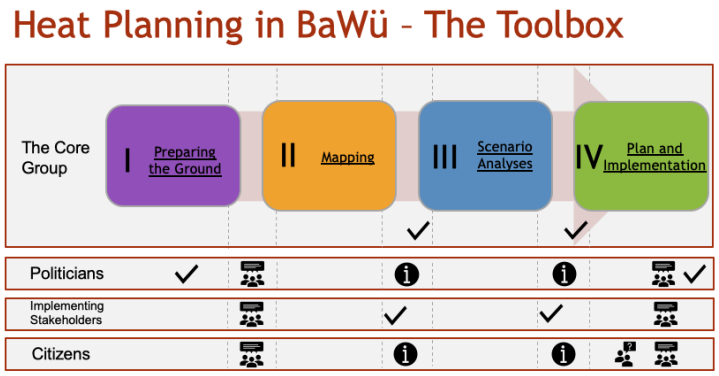

Figure 22: Structure of the toolbox

Target groups

The key targeted stakeholders are energy planners and Public Authorities.

17. TOOL 15: SOLAR DISTRICT HEATING GUIDELINES

The tool at a glance

The tool is a collection of various factsheets, divided by topic, tackling the different aspects and steps of developing a solar thermal plant connected to a district heating network.

The document is downloadable here.

Tool description

The guidelines are structured in several chapters: Overview of the implementation steps, preliminary investigations, permissions, tendering, contracts and guarantees, implementation, system, components, precautions and miscellaneous.

The document is full of technical graphs and tables to guide the designer with reference values in all the steps of the project development.

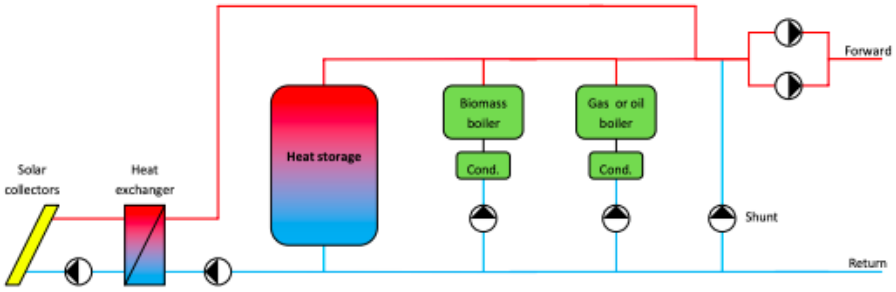

Figure 23: A technical scheme reported in the guidelines

Target groups

The key targeted stakeholders are professionals (plant designers) and utilities.

18. APPENDIX I: FEEDBACK ON TOOLS

Detailed feedback has been collected for 2 key tools in the above reported collection: Hotmaps and QM Heizwerke.

The feedback on the Hotmaps tool was collected during a training course held in May 2021, during the period of the RES-DHC project and it is attached as an annex to this report.

Regarding the QM Heizwerke quality management system, the feedback was given by Stefan Thalmann from Verenum, RES-DHC project partner and Deputy Head for the QM Heizwerke, and directly integrated into chapter 8 (tool 6).

19. APPENDIX II: HOW TO EVALUATE RES DHC POLICIES?

The problem: Measurements are needed

To increase resilience against the rising energy prices and to provide customers with cleaner thermal energy, policies for the decarbonization of district heating networks are more and more common.

Such policies could be developed at utility level, thus including all the networks managed by a single company, or at geographical level, of course at different scales, such as a regional project for reducing district heating carbon footprint or a municipal initiative for increasing the share of renewables in all the DH networks on the territory.

One of the key questions with these policies, however, is: How to measure their effectiveness? Out of this initial question, then, other may easily pop up: How often should we calculate our indicators? When could we say that we are satisfied with the obtained results? Which further improvements could we expect and should we aim at?

This appendix presents a simplified methodology for answering, at least partially, all these questions by providing the actors carrying out the RES DHC policies with ideas on what to measure, how often, which targets to set, etc.

The solution: A flexible methodological approach

First of all, policies for fostering RES DHC are complex activities, thus needing an equally complex system for evaluating their results.

In fact, these results could and should include many different fields affected by such policies: Energy production, effects on the environment, social and economic outcomes, etc.

Though the implementation of this methodology will be quite different depending, for example, on the scope and size of the study boundaries, some common steps for performing an evaluation of any RES DHC policy can be identified, as in the following, by a series of *guiding questions* that any developer of a specific policy should ask itself. Each question can also be regarded as a step in the implementation of the methodology.

Before going into the description of the necessary steps, however, it is worth to mention a couple of pre-requirements that should be satisfied by the local context for developing and effective policy:

- There should be a perfect agreement and a shared vision between all the involved stakeholders about the scope, the objective, the expected results, etc.
- There should be enough budget resources already reserved for developing the policy.

STEP 1 – Defining the scope: What is the scope of your policy?

As above described, the scope of the policy you need to evaluate could be the set of DH networks managed by a single utility (or part of it), a regional or municipal territory, etc.

However, a more comprehensive definition of the policy scope would also include a detailed analysis of the involved stakeholders, for example by identifying the following actors: Who will benefit from the policy? Who owns and manages the DHC networks? Who is planning, managing and implementing the policy? To whom the policy evaluation should be reported?

When defining the scope, bottlenecks should also be defined, above all the acceptance of citizens for the implementation of measures and their willingness to connect to the DHC networks.

STEP 2 – Set the goals of the policy: What are your general objectives?

The policy objectives can be different depending on the answer to the previous question. In the case of a utility, for example, one of its priority goals would be for sure to maintain a fair heat price (if not lowering it) to the customer, while a regional authority designing a policy may want to set a different priority, for instance increasing the regional economy by activating supply chain for the local energy sources.

The policy objective should also be part of the wider picture, including the environmental goals at different levels, from the involved territory up to the national scale.

One could also say that, in line with the more general EU policies about energy, the final goal should be anyway to reach the climate neutrality of the territory which the policy refers to and, therefore, the only question left would be in which time period the policy plans to reach this objective.

In this step, it is also important to describe the specific context in which the policy will be developed, since many factors could interact with the policy effectiveness and with the chosen indicators (see steps below).

STEP 3 – Choosing the indicators: How should you measure the policy effectiveness?

Defining the objective should immediately bring to the choice of the indicators which should be used to measure the effectiveness of the policies, exactly against the objectives set in performing step 2.

In the next chapter of this appendix, some suggestions for possible indicators to be included are reported. It may sound inconsistent not to 'oblige' policy developers to use the same set of indicators because, with such a flexible approach, it would be much harder to compare different policies.

However, one should consider that most probably comparing the results of policies characterized by different scopes and objectives simply does not make sense, since they are clearly *not comparable*.

In spite of that, the approach here suggested (see below) which focuses on *percentage improvements* and *satisfaction levels* can partially reduce this inconsistency by allowing a fair comparison even among quite different plans.

STEP 4 – Defining the time intervals: How often should you evaluate your policy?

Once again, there is no general rule on the time periods between the different evaluations you want to perform about your policy.

However, such policies are normally planned with long time horizons and, therefore, setting a time step of, for example, 1 year may be reasonable.

Of course, the time step for measurement also depends on the total duration foreseen for the policy. While 5 or 7-year plan can easily be measured and evaluated every year, the same interval does not make any sense for a short-term policy lasting, for example, 18 months.

For the evaluation, the responsible partner should set up a spreadsheet where to include all indicators (see also step 5 and the last paragraph of this chapter) on the lines and the values reached in the different periods on the columns.

STEP 5 – Assess the policy: When should you be satisfied about the results?

The almost obvious initial remark about this step is that setting absolute values for targets to be reached through performance indicators is rarely a good idea.

In fact, the first assessment to perform for setting a satisfaction goal is to define a baseline scenario: Where are we starting from? Where we would evolve to in absence of a specific RES DHC policy?

Once we agree on that, we can then set some quantified objectives, probably in terms of *percentage improvements* with respect, for example, to the starting point (baseline) or to the business-as-usual scenario.

Again, the suggestions here is not to go for a single target value to be reached but rather to choose a set of *satisfaction levels*. For example, the developer can decide, for each indicator, 3 target values or ranges for its percentage improvement, which correspond to 'not satisfied', 'moderately satisfied', 'fully satisfied'.

Let's examine this in detail with an example, taking as indicator the amount of district heating generated by renewables in a region. The developer decides that, thanks to the specific policy under preparation, this amount should increase at least by 10% with respect to the business-as-usual scenario. The satisfaction levels could then be as follows:

- 'Fully satisfied': More than +15%
- 'Moderately satisfied': From +10% to 15%
- 'Not satisfied': Less than +10%

This approach, more flexible than a 'go / no go' setting for the target values, also makes the following fine-tuning step (see step 6) easier and more productive.

Of course, this step is related to an internal assessment, which should be flexible enough to also allow for changes (see following step). Nevertheless, the external communication of the policy assessment could be done through more absolute and precise values (therefore not using ranges), which may suit best to, for example, a communication at political level.

To perform the evaluation, you may want to use already existing tools such as, for example, the one developed within the SmartEnCity project.

Finally, as already discussed in Step 2, the policy effectiveness, and therefore the corresponding satisfaction level, should be evaluated against the starting point, that also includes the specific context in which the policy is being implemented. By referring to this context analysis, the policy assessment will be more transparent and helpful.

STEP 6 – Improving the measurements: Are you doing fine enough?

As happens in all consistent methodology, a feedback loop should be used, with the consequent fine-tuning action. Depending on the results obtained in the evaluations at the various time steps and/or on the comments by stakeholders (see also the stakeholder group, included in the following chapter on indicators), the policy developer may want to modify something in the assessment methodology: 1) Reduce or enlarge the time step; 2) Exclude some indicators which proved to be meaningless or too imprecise to measure; 3) Include additional indicators whose relevance the developer had not been aware of; 4) Modify the levels of satisfaction (see question 5); 5) Any other changes in the approach.

Special attention should be also given to anomalies in the results, which could imply errors in the measurements.

These changes could also be needed because of possible variations of the technical, economic, financial and social framework and, therefore, of the corresponding goals and ambitions of the policy itself.

It is important to define who is involved in the process of the implementation as well as of the assessment and review of the policies: All the stakeholders should be fully represented and a committee should be created to evaluate the trend and elaborate strategies for mitigation of unsuccessful implementation or risks from other events and sources (e.g. Market contingencies).

ADDITIONAL STEP – Communicating the policy: How will you let people know about it?

A key activity, which should be carried out in parallel to all the other steps described above, is a correct ,complete and transparent communication about the policy: Why it has been planned, with which goals, which benefit it will bring to the territory, what role the stakeholders will play, how you can contribute, what is the current status of development, which results have been obtained so far, etc.

The communication tools may vary depending on the type of policy and on the general communication strategy: specific website, social media accounts, newsletter of the Municipal Administration, launch events, etc.

The performance indicators: Hints and tips

As explained above, the table reported below list a series of possible indicators for measuring the effectiveness of RES DHC policies. However, each policy developer should decide about its set of indicators according to the criteria exposed in the previous chapters.

Some of the indicators in the table could be redundant, so it is up to the policy developer to choose the solutions which better suit to their objectives.

Depending on the scope and objective, the policy developer could also include more technical and specific indicators: A utility, for example, when transforming its DH networks towards decarbonisation, could evaluate the average decrease of the operating temperature of the networks thanks to the implementation of the policy.

Regarding the emission indicators, it is crucial that the policy developer checks the official approach used at the national/regional/local levels for calculating the CO_2 emissions by the biomass cycle.

All the indicators, except for the social ones, can be also split among the different energy sources: For example, there could be more than one figure on renewable energy production in GWh/year, calculating separate indicators for biomass, solar thermal, heat pumps, waste heat, etc.

Furthermore, it is worth to mention the study *Consumers in district heating and cooling – Background report on how to evaluate the sustainability of district heating and cooling*[4] by JRC, where different calculation methodologies and indicators are presented, quantifying energy performance and RES share of the DHC network.

Finally, to close this chapter, it could be interesting to look at a practical example, showing a plan for evaluating a subsidy scheme (the information is available in German only): https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/evaluierungsfragen.html

[4] European Commission, Joint Research Centre, Toleikyte, A., Jiménez Navarro, J., Carlsson, J., *Consumers in district heating and cooling: Background report on how to evaluate the sustainability of district heating and cooling*, Publications Office of the European Union, 2023.

CATEGORY	INDICATOR	UNIT
Energy	Additional thermal power installed	MW
Energy	Primary energy savings	GWh/year
Energy	Renewable energy production	GWh/year
Energy	Installed renewable heat (total)	GW (or GW/year)
Energy	Installed renewable heat (with subsidies)	GW (or GW/year)
Energy	Installed renewable heat (without subsidies)	GW (or GW/year)
Energy	Renewable energy share in DHC	%
Energy	Average temperature in the networks	°C
Energy	Share of flats/users connected to DHC	%
Energy	Total number of flats/users connected to DHC	Units
Environment	Heat supply emission factor	kg CO_2/MWh of delivered heat
Environment	CO_2 emissions avoided	t/year
Environment	Other air emissions avoided (e.g. NO_x, particulate, etc.)	t/year
Economic	Investments (CAPEX)	M€/year
Economic	Average district heating price (for the consumer)	€/MWh of delivered heat
Economic	Average district heating production cost (for the utility)	€/MWh of delivered heat
Economic	Cost of the district heating grid	€/m
Economic	Specific investment cost for RES in DHC	€/unit (e.g. MW installed)
Economic, social	Job occupation	FTE
Economic, social	Saved fuel imports	M€/year
Social	Quantity of relevant stakeholders activated	No./year
Social	Increase of stakeholders' know-how	Semi-quantitative measurement to be defined
Social	Involvement of consumers	Semi-quantitative measurement to be defined
Organisational	Process completeness	Completeness check, e.g. 1) Is there a planning document for the policy? 2) Is there a participation process going on? 3) Has a stakeholder advisory group been set up?

Table 1: Examples of performance indicators for RES DHC policies

20. APPENDIX II: LIST OF COMMERCIAL TOOLS

The table below summarises some of the most well-known commercial tools and pieces of software which can support the work on DHC by RES.

NAME OF TOOL	SYNTHETIC DESCRIPTION	LINK
Sympheny	Optimal energy supply solutions.	https://www.sympheny.com/
Dymola	Modelling and simulation of integrated and complex systems.	https://www.3ds.com/products-services/catia/products/dymola/
IDA-ICE	Wwhole-year detailed and dynamic multi-zone simulation application for study of thermal indoor climate as well as energy consumption of entire buildings.	https://www.equa.se/en/ida-ice
EnergyPro	Modelling complex energy projects with combined supply of electricity and thermal energy (process heat, hot water and cooling).	https://www.emd.dk/energypro/modules/

Table 2: List of some commercial tools